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LIMNOLOGY OF KAMLOOPS LAKE

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ABSTRACT

A limnological survey of Kamloops Lake was undertaken during the 1962 and 1963 period for the purpose of determining the physical, chemical and biological features of the lake. These data are to be used to assess the effect of any subsequent introduction of pollutants into Kamloops Lake.

The most outstanding feature of the lake was the high rate of inflow. This resulted in the rapid movement of advected water through the basin, particularly when the lake was thermally stratified. This high rate of inflow and its turbidity apparently resulted in a rather low standing crop of zooplankton during 1963.

Levels of dissolved oxygen were generally high although some depletion occurred in the deepest parts of the lake near the end of the period of stratification.

TABLE OF CONTENTS

LIMNOLOGY OF KAMLOOPS LAKE

INTRODUCTION

Proposed industrial developments for the Kamloops area of Central British Columbia may result in pollution which would bring about environmental changes in local waters tributary to the Fraser River. Before possible effects of effluents on these environments can be determined it is necessary to have background information on the physical and chemical features of these environments and on present biological productivity.

The major basin in the region into which pollutants would be discharged is Kamloops Lake (FIGURE 1) which is part of the Thompson River system. This lake serves as a rearing area for juvenile Pacific salmon of three species, (coho, chinook and sockeye) and it lies on the migration route of the abundant Adams River stock of Fraser River sockeye. Adult sockeye pass through the lake en route to the spawning areas and smolts travel through it on their seaward migration. For these reasons, environmental changes in Kamloops Lake could have serious consequences for Fraser River sockeye.

The purpose of this report is to provide a background of information concerning the physical features of Kamloops Lake, its chemistry and its general biological productivity. Seasonal changes in temperature, flushing rate and plankton will be considered.

DESCRIPTION OF THE AREA AND THE LAKE

Kamloops Lake is a long, deep body of water located in semi-arid plateau country in the valley of the Thompson River, one of the major tributaries of the Fraser River (FIGURE 1). Several small streams enter the lake but their contribution is minor. The average annual precipitation measured at Kamloops Airport is 10.2 inches. Highest precipitation occurs in June (1.4 inches). In March and April the monthly average is less than 0.5 inches (Fraser River Board, 1956). As a result of these conditions, flow into Kamloops Lake is largely from the Thompson River which drains a mountainous region to the north and east, an area having relatively high precipitation.

A map of Kamloops Lake is shown in FIGURE 2 and some physical characteristics are listed in TABLE 1. Although the lake lies in the highly productive Southern Interior Plateau Limnological Region (Northcote and Larkin, 1956), it is not a eutrophic lake. Probable reasons for low productivity are the high maximum and mean depths which are characteristic of lakes with small standing crops of net plankton (Rawson, 1953) and the low total dissolved solids. Measurements of total dissolved solids made in August and October, 1956 averaged 70 ppm, which is well below the general level for the smaller and shallower lakes in the region.

FIGURE 1—Fraser River watershed showing areas utilized by major populations of spawning sockeye salmon.

TABLE 1—Morphometry of Kamloops Lake

Area	13,800 acres
Shoreline	38.5 miles
Mean Depth	243 feet
Maximum Depth	495 feet
Maximum Length	17.2 miles
Volume	3,352,000 acre-feet
Elevation Above Sea Level	1,125 feet

During the winter of 1962-1963 very little ice formed even around the shore of the lake and there is no record of it having complete ice cover since the relatively cold years of 1955-1956 and 1956-1957.

Annually the lake has two periods of circulation, one in the early spring and another in the fall. During the spring, summer and early fall the lake shows marked direct temperature stratification. Thermal stratification is well advanced in April and is still present in November. During the period of thermal stratification circulation and turbulence are confined mainly to the surface stratum. Temperature data for both November, 1962 and 1963, shown in FIGURE 3 indicate that the lake was nearly uniform in temperature and complete circulation would shortly take place. In fact, the relatively high bottom temperatures in November, 1963 indicate that mixing had already occurred down to a depth of over 400 feet.

The January temperature curve indicates inverse stratification; that is water colder than 39.2°F overlying slightly warmer, denser water. This situation indicates partial circulation. Winter stagnation did not occur during 1962-1963 because no ice cover formed. In March, 1963 the lake was about 37.0°F throughout indicating that complete circulation occurred in the spring of 1963 at a temperature well below that of maximum density of pure water (39.2°F).

In the period between April and November a well defined and stable hypolimnion was present (FIGURE 3). The upper margin occurred at a depth of about 150 feet. The thermocline and epilimnion were not well defined in Kamloops Lake except in September and October when the surface water was cooling rapidly and sinking thus producing a well-defined thermocline (FIGURE 3). Records of temperatures at all stations and of the inflowing and outflowing rivers are given in APPENDIX A.

SAMPLING PROGRAM

The location of sampling stations at Kamloops Lake and the Thompson River are shown in FIGURE 2. Bimonthly visits were made to the lake beginning in mid-November, 1962 and continuing until March, 1963. From mid-March to mid-November, 1963, visits were made at monthly intervals. Initially work was conducted at Stations A, B, C, D, E, and F, but in March, 1963 another lake station was established at G which was subsequently also sampled at monthly intervals.
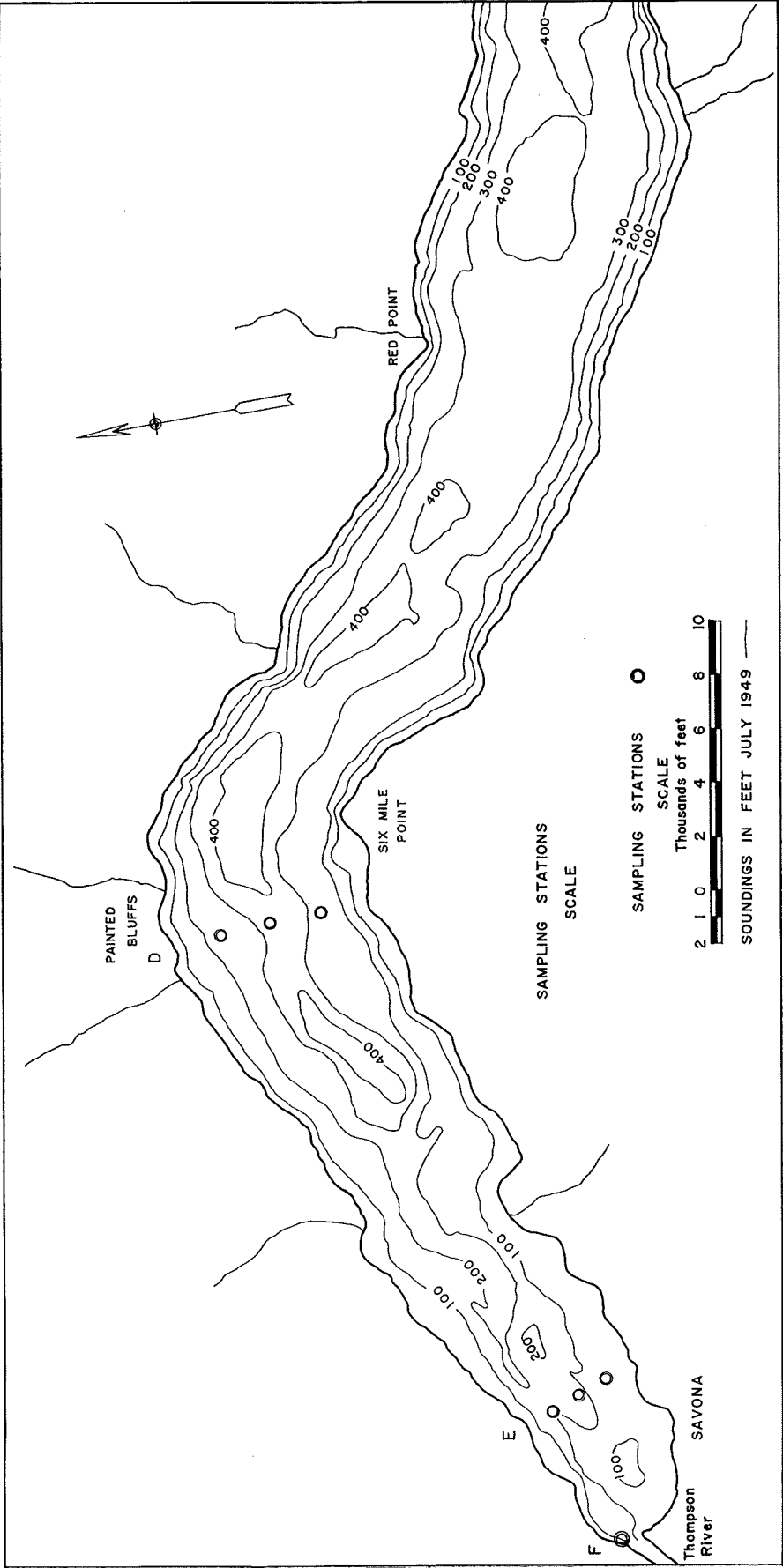
FIGURE 2—Kamloops Lake showing the sampling stations.

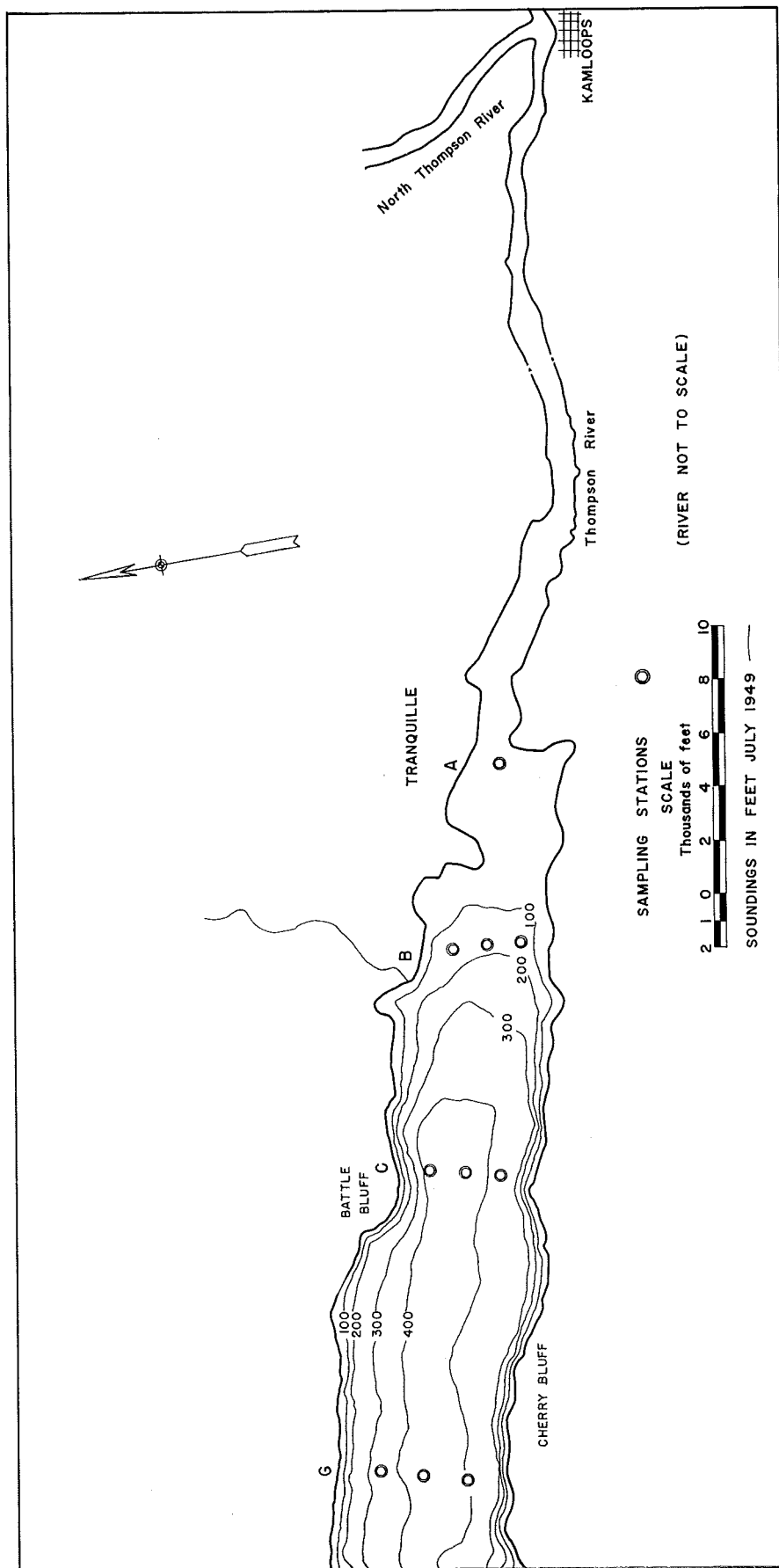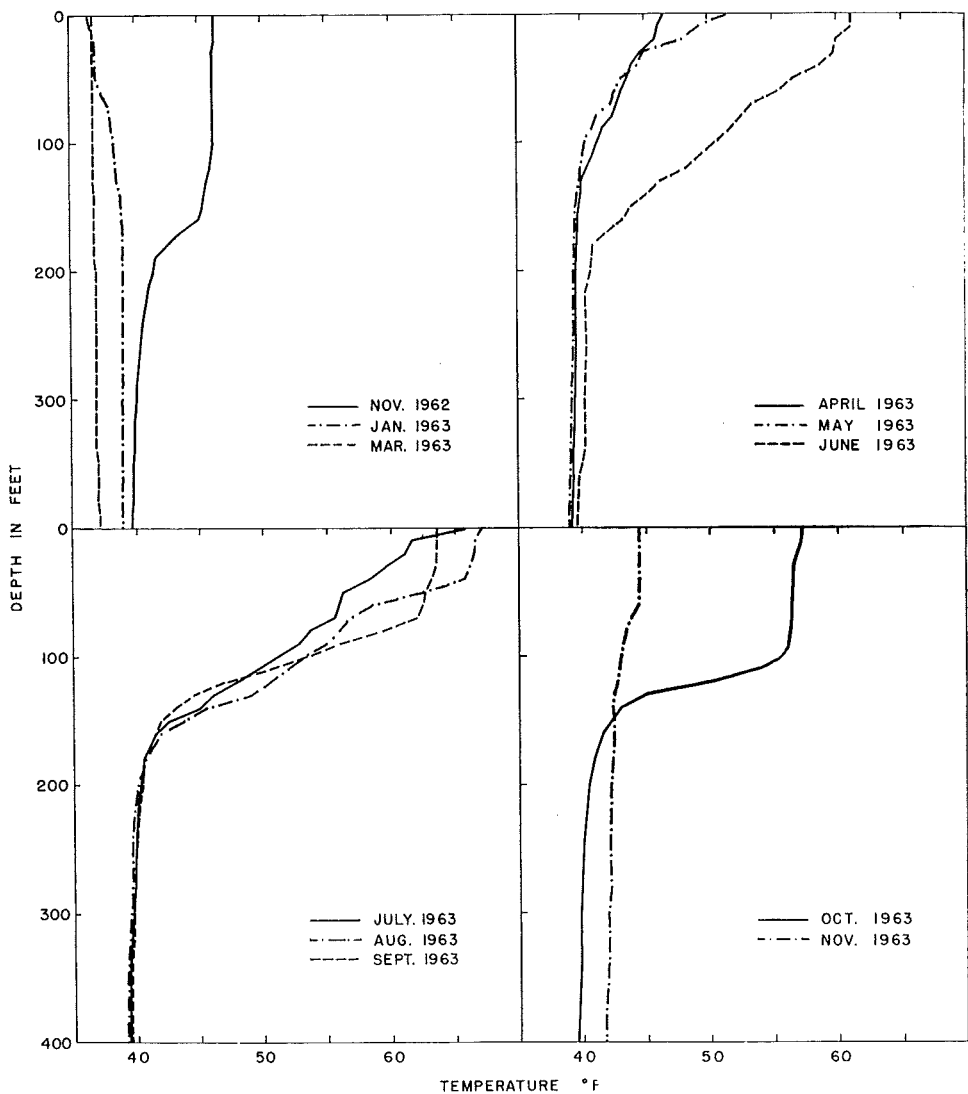FIGURE 2a—Kamloops Lake showing the sampling stations.

FIGURE 3—The vertical distribution of temperature at Station C-2 during 1962 and 1963.

The vertical distribution of temperature was determined at all positions at each station using a bathythermograph. At the river stations, A and F, temperatures were measured using a standard laboratory thermometer, calibrated in tenths of degrees Fahrenheit.

Water samples were collected from various depths at the central position (No. 2) at each lake station with two exceptions (as noted below) for the purpose of measuring dissolved oxygen levels. During the November 1962 and January 1963 visits, water samples for dissolved oxygen analysis were collected at E-1 instead of E-2. During August and September, water samples for measurement of dissolved oxygen were collected adjacent to the bottom as well as at intermediate depths at central positions for all lake stations. Five hundred milliliter plastic Frautschy bottles were used to collect water samples for dissolved oxygen analysis at lake stations. Water samples for oxygen determinations were taken from the surface at the river stations, A and F, during each visit to the area.

Water samples for chemical analyses were collected at Stations A, C-2 and D-2 in mid-March, July and October. At Station A samples were taken at the surface but at C and D water samples for chemical analyses were taken at two depths; 10 feet and 400 feet at C-2 and at 10 and 300 feet at D-2.

On each visit, beginning in March, 1963, water samples were collected at C-2 and D-2 for phosphorus and nitrogen analyses. At these stations samples were collected at two depths: at C-2; 10 feet and 400 feet and at D-2; 10 feet and 300 feet. An additional sample to be analysed for phosphorus and nitrogen was collected from the surface at Station A in October. These water samples were collected with a plastic four liter Van Dorn type sampler.

Plankton collections were made at Stations C-2, G-2 and D-2. Sampling was initiated at C-2 and D-2 in November, 1962 and subsequently collections were made during each visit. Sampling began at G-2 in April, 1963, and was continued until termination of the program. Collections were made with a Wisconsin type net (No. 10 mesh silk) hauled vertically from a depth of 100 feet. Six consecutive hauls were made at each station during each sampling. Plankton was preserved in five per cent formalin solutions.

In addition to vertical plankton sampling, horizontal tows were made at three depths with Clarke-Bumpus samplers equipped with No. 10 mesh nylon nets. Tows were made with nets set at approximately 150, 37 and 7 feet depths. Duplicate tows in opposite directions were made between Stations B and C and D and E. Duration of tows, depending on plankton concentrations, varied between 10 and 20 minutes. Sampling began in March and was continued thereafter. Collections were preserved as above.

In addition to the regular sequences of sampling described in the preceding paragraphs, the pH of water samples was determined on many occasions, and some carbonate-bicarbonate determinations were made. The transparency of the surface water of Kamloops Lake was determined from Secchi's Disc measurements made at each station on each visit.

With the exception of oxygen, alkalinity and pH determinations all chemical analyses were made by the British Columbia Research Council.

PASSAGE OF THOMPSON RIVER WATER THROUGH KAMLOOPS LAKE

Essentially, Kamloops Lake is a wide, deep section of the Thompson River. However, because of the physical characteristics of the basin and the temperature regimes of the lake and incoming water, the distribution of inflowing water changes seasonally. Similarly, the origin of discharge from the basin fluctuates seasonally as a result of temperature produced differences in the vertical distribution of water density. These seasonal differences in the distribution of inflowing water within the basin, in the origin of the discharge and in the amount of water exchanging in the basin, result in major variations in the rate of movement of newly advected water through the basin. The seasonal pattern of events is considered in following sections.

Distribution of Inflow

Seasonal changes in the vertical distribution of inflowing water can be inferred from an inspection of the temperature curves at Station C-2 in FIGURE 3 and from the known average temperatures of the inflow.

The temperatures of incoming water during each visit to the lake and the depth at which water of the same temperature was found at C-2 during the same visit are shown in TABLE 2.

TABLE 2—Temperatures of the Thompson River at Tranquille and the depth at which water of the same temperature was found at Station C-2, Kamloops Lake.

DATE	THOMPSON RIVER TEMPERATURE °F	DEPTH (FEET)
November 1962	42.3	180
January 1963	33.5	—
March	38.8	—
April	48.5	—
May	50.4	5
June	56.4	50
July	56.0	60
August	62.6	50
September	58.6	75
October	54.3	110
November	34.1	—

As seen in TABLE 2 incoming water apparently sank to a considerable depth during November, 1962; however, it could not sink to the bottom since it was still warmer and therefore lighter than the water below 180 feet. In January, 1963 the incoming water, because it was colder than water at C-2 and also colder than 39.2°F (the temperature at maximum density), mixed in the surface stratum of the lake soon after entry. The converse situation existed in March. The incoming water was warmer but heavier than the lake water. Under these conditions it sank

to the bottom, mixing with the deepest waters currently in the basin. During the months from April to October inclusive, the lake was thermally stratified and the incoming water was warmer and lighter than hypolimnial water. Consequently, the inflow was confined to strata above the hypolimnion. In November, 1963, the incoming water was colder and lighter than the lake and was mixing with surface water and sinking. As can be seen in FIGURE 3, the lake was nearly at a uniform temperature at this time.

Spring Stratification and Energy Budget

For the purpose of explaining spring stratification it is convenient to begin by considering the situation applying in the lake and in the North and South Thompson Rivers in early spring at the beginning of vernal heating.

The temperatures of the North and South Thompson Rivers during March and April, 1963 are shown in FIGURE 4. The mean daily temperature in each stream rose above 40°F for the first time on March 21. During the period March 19 to 22, the mean temperature of Kamloops Lake was 37.0°F and the mean temperature from the surface to 50 feet was 37.1°F. After March 21 the warmer inflowing water, being lighter, remained on the lake surface. The isotherms depicted in the April temperature profile presented in FIGURE 5 indicated that by April 17 to 22 the warmer newly arrived river water composed a significant proportion of the eastern part of the lake. By May warmed water formed the surface layers of Kamloops Lake as a whole (FIGURE 5).

The temperature of the Thompson River at Savona increased abruptly on April 25 (FIGURE 4). It is suggested this was the first day that recently warmed water, originating from the North and South Thompson Rivers after March 21, had formed an appreciable fraction of the discharge from the lake. Briefly, it is suggested that the travel time for the front of warm inflowing water through the lake was 36 days, from March 21 to April 25. The evidence provided by the river temperature curves taken in conjunction with the temperature profile in April (FIGURE 5) indicated that cold lake water was becoming effectively sealed from the surface by the warmer incoming river water. As a consequence initial thermal stratification in Kamloops Lake in the spring of 1963 was caused principally by incoming river water and apparently energy exchanges at the surface resulting from solar radiation played a secondary role in heating the lake during the early spring.

Additional evidence indicating that initial thermal stratification was caused mainly by incoming river water can be obtained by computing the energy budget of Kamloops Lake during the March 21 to April 25 interval. Terminology and methods used in calculating the energy budget were primarily based on methods described by Raphael (1961).

There are two major means of energy exchange in a lake. One means is through the various surface energy exchanges associated with solar radiation and exchange of heat with the atmosphere. The second means of energy exchange is through advection from the inflow and outflow streams.
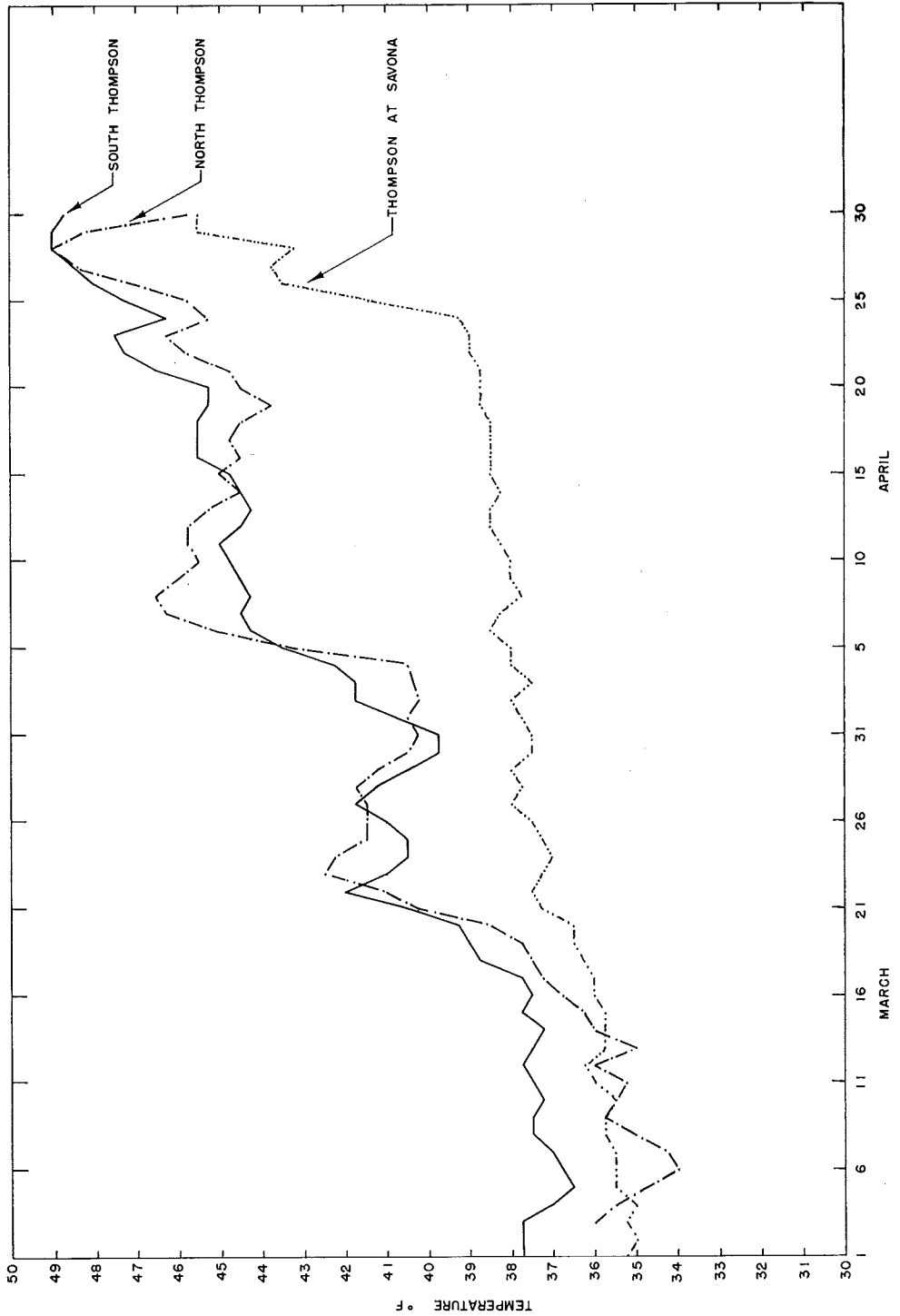
FIGURE 4—Temperatures of the N. Thompson, S. Thompson and Thompson (at Savona) Rivers in the spring of 1963.
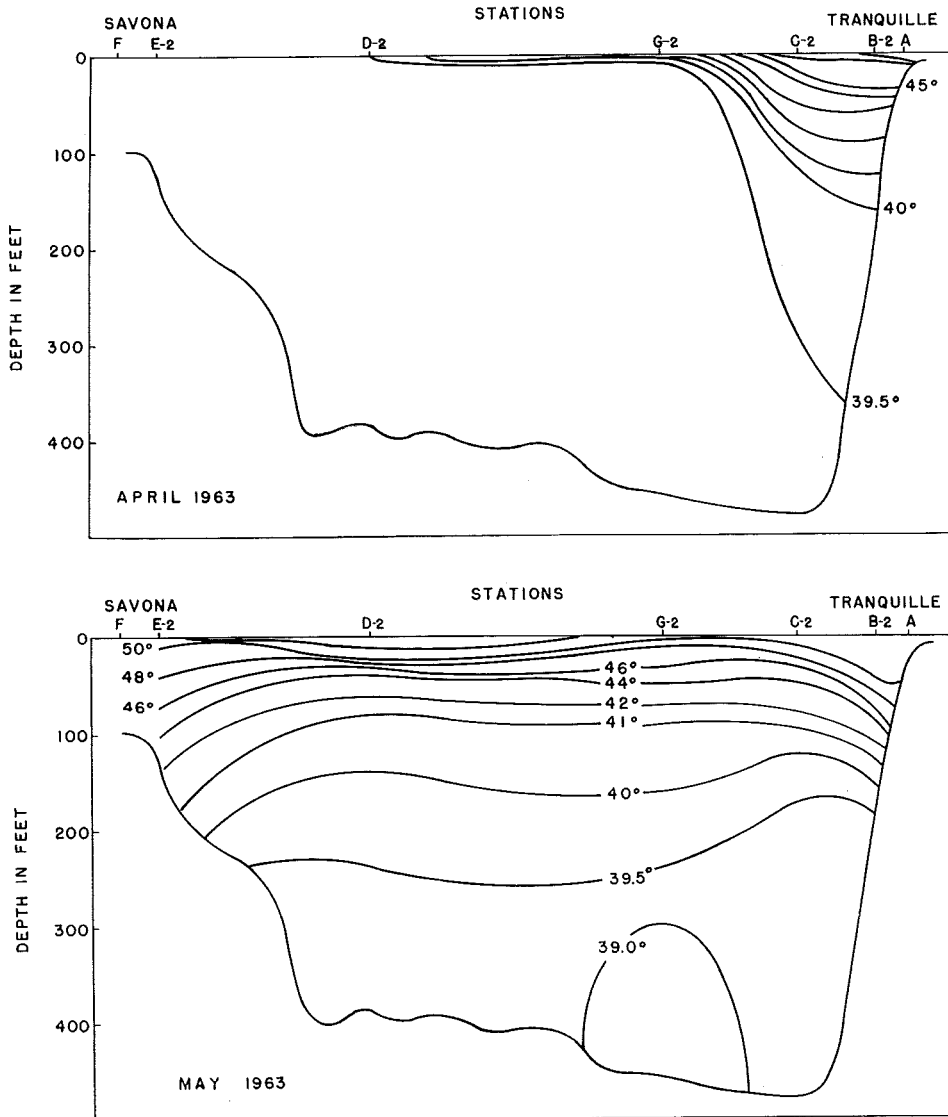
FIGURE 5—Section through the East-West axis of Kamloops Lake showing the positions of isotherms in April 1963 (°F) and the positions of isotherms in May 1963.

A simple expression describing energy exchange at the surface of a lake is:

$$Q_T = Q_S - Q_R - Q_B - Q_H - Q_E$$

where Q_T = the increase in energy stored in the water;

Q_S = the solar radiation incident to the surface;

Q_R = the reflected solar radiation;

Q_B = the net energy lost through the exchange of long wave radiation from the water to the atmosphere;

Q_H = the energy convected and conducted from the water to the atmosphere;

Q_E = the energy used for evaporation.

Values for terms on the right side of the foregoing equation were computed as described in the following paragraphs.

SHORT WAVE RADIATION

Theoretical methods are available for measuring incident solar radiation (Q_S) reaching the surface of a body of water (for example, see Sverdrup, Johnson and Fleming, 1942); however, sufficient data were at hand for a more direct method to be used here. Records of total daily solar radiation received on a horizontal surface were available for the Summerland, B. C., weather station (Meteorological Observations in Canada) which is located in the same general climatic area as Kamloops Lake. At both the Summerland station and at Kamloops Airport daily records of the hours of bright sunlight are kept *(ibid.)*. Using 1963 daily records of solar radiation and hours of bright sunlight from Summerland a regression was calculated. The period of interest was from March 21 to April 25. The equation was

$$\hat{Y} = 191.856 + 3.377\,X$$

where X = daily hours of bright sunshine measured at Summerland, B. C.;

Y = amount of solar radiation reaching a horizontal surface in cal/cm²/day (langleys).

The relationship seemed adequate for the purpose of prediction since r = 0.849 and r^2 = 0.721. The regression of solar radiation on hours of bright sunshine accounted for over 70 per cent of the variability in solar radiation reaching a horizontal surface.

Using the regression equation and daily values of hours of bright sunshine at Kamloops, estimated daily values of solar radiation reaching a horizontal surface at Kamloops were computed. From these, a daily mean was calculated for the period from March 21 to April 25.

Since the altitude and latitude of Kamloops Airport was different from the Summerland station, adjustments based on values in tables shown on page 371 of Hutchinson (1957) were made. The altitude of Kamloops Airport is only a few feet higher than the average elevation of the lake and the airport is located near the east end of the lake, therefore no further adjustments were necessary.

The radiation measurements include both sun and sky radiation; however, some of the energy reaching the water surface is reflected and scattered. Hutchinson (1957) reports that losses of ten per cent in winter and six per cent in summer takes place. An eight per cent adjustment was made to the estimate. Finally, the estimated values were converted from langleys per day to Btu/sq. ft./hour.

The primary source of error in the method results from lack of precision in the regression of radiation on sunlight. Even with this obvious source of error, there seem to be real advantages in this method of computation over more theoretical procedures. For example, no assumptions concerning the effects of cloud cover need be made. Furthermore the actual calculations are simple and direct.

LONG WAVE BACK RADIATION

A major loss term in the energy budget results from net long wave back radiation, Q_B. Raphael (1961) states, "Effective back radiation may be defined as the difference between Q_W the long wave radiation leaving the body of water, and Q_A the long wave radiation from the atmosphere being absorbed by the body of water." Raphael's (1961) methods were used to compute Q_B values for Kamloops Lake.

Estimates of Q_A were calculated as follows:

$$Q_A = (1.66 \times 10^{-7} T_a^4) B$$

where T_a = the air temperature, $°A$;

B = the atmospheric radiation factor.

Values of the factor $1.66 \times 10^{-7} T_a^4$ for the desired Kamloops air temperatures were taken from tables given in Raphael (1961). Estimates of B were also obtained from Raphael using appropriate Kamloops air vapor pressure values and cloud cover data.

Estimates of Q_W were obtained from the expression:

$$Q_W = 1.66 \times 10^{-7} T_W^4$$

Tabled values of $1.66 \times 10^{-7} T_W^4$ were obtained from Raphael's (1961) Table 3 using appropriate Kamloops Lake surface water temperature measurements (t_W) in $°F$.

From these values of Q_A and Q_W the net long wave energy exchange estimates, Q_B were obtained by subtraction ($Q_B = Q_W - Q_A$).

CONVECTION AND CONDUCTION

Heat, when there is a temperature difference, is transferred to or from the water. The amount of heat exchanged depends on the temperature difference and upon wind velocity at the water surface.

Estimates of Q_H (heat exchanged between air and water) were computed from the equation given in Raphael (1961).

$$Q_H = 0.00407 \; UP \; (t_a - t_w)$$

where Q_H = the heat conducted from air to water (Btu/sq. ft./hour);

     U   = the wind velocity in knots;

     P   = the atmospheric pressure in inches Hg;

     t_a = the air temperature, °F;

     t_w = the water surface temperature, °F.

Wind, air temperature and pressure data were obtained from the Kamloops Airport records.

EVAPORATION AND CONDENSATION

Evaporation occurs when the vapor pressure of the air is less than the saturated vapor pressure of air at the temperature of the water surface. The most important heat lost in this process is the loss of the energy required to evaporate water. A minor loss term which will not be considered in this study is the loss of energy caused by the removal of heat contained in the evaporated water.

The equation used to calculate estimates of Q_E, energy lost in evaporating water, was taken from Raphael (1961):

$$Q_E = 12 \, U \, (e_w - e_a)$$

where U = the wind speed, in knots;

     e_w = the saturated vapor pressure of air at the temperature of the water surface in inches of Hg;

     e_a = the vapor pressure of the air in inches of Hg.

Values of e_a were obtained from the weather records taken at Kamloops Airport. Vapor pressure values for saturated air at the appropriate air temperatures were adjusted according to the prevailing relative humidity. Estimates of e_w were the saturated vapor pressure values appropriate to the water surface temperatures of Kamloops Lake. Values for saturated vapor pressures at various temperatures were taken from Raphael (1961).

NET ENERGY EXCHANGE AT THE SURFACE

Estimates of Q_T were obtained by subtracting or adding, according to the sign, the various loss terms (Q_B, Q_R, Q_H, Q_E) from the solar radiation value (Q_S). All values were in Btu/sq. ft./hour.

ADVECTED ENERGY

As mentioned earlier advected energy may influence the energy budget of a lake as well as surface energy exchanges. At Kamloops Lake gain and loss of energy through advection from the inflow and outflow streams was of major importance during the period from March 21 to April 25.

Both the volume and average temperature of the inflowing Thompson River were known but only the temperature of the outflowing Thompson River at Savona was recorded. The volume of discharge during the period under consideration was calculated by means of changes in the lake level measured from gauge height records, the area of the lake and the known volume of inflowing water. The following equation was used to calculate the volume of discharge from the lake:

$$V_e = V_i - [A (h_2 - h_1)]$$

where V_e = the volume of discharge from the lake in acre-feet during the period n;

V_i = the volume of inflow in acre-feet during period n;

A = the average area of the lake in acres;

h_2 = the gauge height in feet at the end of period n;

h_1 = the gauge height in feet at the beginning of period n.

The net change in advected energy during a period was estimated by using the following equation:

$$\Delta t = \frac{V_i t_i - V_e t_e}{V}$$

where Δt = the temperature change in °F due to advection during period n;

V_i = the volume of inflow in acre-feet during period n;

V_e = the volume of outflow in acre-feet during period n;

V = the volume of the lake in acre-feet which receives the inflow and contributes to the discharge;

t_i = the temperature of the inflowing water in °F;

t_e = the temperature of the outflowing water in °F.

Results computed according to the foregoing energy budget analysis indicated that an increase of 1.3°F could be assigned to energy exchanges at the lake surface during the 36 days from March 21 to April 25. Net advected energy (from inflowing and outflowing water) resulted in an additional increase of 1.9°F. Since

the initial average temperature of the lake on March 21 was 37.0°F, the computed average temperature at the end of the period was 40.2°F. Actual temperature measurements gave an estimated mean temperature of 40.3°F. Evidently advected energy played an important part in changing the average lake temperature.

The outflow temperature increased abruptly from a mean of 39.3°F on April 24 to 41.4°F on April 25 (FIGURE 4). This sudden increase could not be entirely due to the effects of increased solar radiation but must have been caused largely by the arrival of water warmed initially beyond the confines of the basin, which correlates well with the energy budget calculations.

On the basis of the observational data, substantiated by the energy budget computations, it can be concluded that initial thermal stratification in Kamloops Lake in 1963 was caused by advected heat energy in the form of inflowing water warmed outside the lake basin. As a consequence of this situation, it has been possible to estimate that water entering the lake on March 21, 1963 had a residence time of 36 days. The short time period involved and the relatively low river discharge at the time of year support the observational data that this newly warmed water was on the surface and that the outflow was largely drawn from the surface waters.

Residence Time of Inflow Entering Between Spring Stratification and Autumn Circulation

To determine the rate of movement of inflow during the period of thermal stratification (April through September), it was necessary to estimate the volume of water in the lake which was affected by net inflow and discharge. Two methods were used to estimate these moving volumes and they will be discussed in following sections. One method was based on the assumption that the inflow was homogeneously mixed in the strata lying above the hypolimnion. This method gave maximum residence times since the assumption of homogeneous mixing was unlikely. The second method was based on two assumptions: first, inflow remained unmixed and on the surface during residence in the lake; second, the method of computation of the moving volumes was based on the depth to which lake water would be drawn to provide outflowing river water of the observed temperature. This method gave minimum residence times because some mixing of inflow with previously advected water must have occurred.

RESIDENCE TIME BASED UPON HOMOGENEOUSLY MIXED STRATA ABOVE THE HYPOLIMNION

To determine the residence time for newly advected water in the basin during the period from mid-April to mid-October it was necessary to determine the volume of moving water, i.e. the volume of water that received inflow and contributed to discharge. This volume overlaid the hypolimnion, which neither received inflow nor contributed to discharge.

A major characteristic of the hypolimnion of a temperate lake is its uniformly cold temperature. This feature was used to delimit the hypolimnion from the surface waters. The upper limit of the hypolimnion at each position and on each station during the period under consideration was defined as the median position on the lower knee of the temperature curve; that is, the point where temperature began to increase rapidly with decreasing depth.

Estimates of the mean depth of the upper limit of the hypolimnion are listed below in TABLE 3.

TABLE 3—Estimated depth in feet of the upper limit of the hypolimnion at each station in Kamloops Lake.

DATE	STATION				
	B	C	G	D	E
May 14-17	125	128	93	77	125
June 18-21	130	170	143	147	150
July 17-19	—	150	157	160	140
Aug. 16-19	—	160	157	163	—
Sept. 17-19	—	147	147	153	140
Oct. 16-19	—	153	150	150	130

For the purpose of computing moving volumes the lake was divided into four sections; Stations A to C, Stations C to G, Stations G to D and Stations D to A. The mean depth of the upper limit of the hypolimnion was determined from data in TABLE 3. The volume of water above this mean depth in each section was determined from areas at each 50 foot contour. The volume estimates made in each section were then summed to obtain an estimate of the volume above the hypolimnion for the whole lake during a particular sampling period.

A sample calculation is given below. As an example, the volume calculation for section A to C for the month of May will be made. The mean depth of the hypolimnion at B was 125 feet and at C it was 128 feet. The mean depth of the hypolimnion over this whole section was taken to be the mean of the two values at B and C—in this case, 127 feet. The areas of this section of the lake at each 50 foot contour from the surface to 150 feet are as follows:

0 — 2,117 acres;

50 — 1,329 acres;

100 — 1,195 acres;

150 — 1,053 acres.

The volumes between 50 foot contours were calculated according to the formula:

$$V = \frac{h}{3} (a_1 + a_2 + \sqrt{a_1 a_2})$$

where V = the volume between two contours;

  h = the vertical distance between contours;

  a_1 = the area at the upper contour;

  a_2 = the area at the lower contour.

In the example, volumes between 50 foot contours were:

$$0 \text{ to } 50 — 78,405 \text{ acre-feet;}$$
$$50 \text{ to } 100 — 57,903 \text{ acre-feet;}$$
$$100 \text{ to } 150 — 51,574 \text{ acre-feet.}$$

The volume above the hypolimnion was then:

$$V = 78,405 + 57,903 + 27/50 \times 51,574$$
$$= 164,158 \text{ acre-feet.}$$

Estimates of the moving volume at the time of each visit during the period between spring and fall circulation are shown in TABLE 4.

TABLE 4—Estimated volume of Kamloops Lake receiving inflow and contributing discharge at monthly visits made between spring and fall circulation.

PERIOD	VOLUME (ACRE-FEET)
May 14-17	1,177,842
June 18-21	1,714,226
July 17-19	1,777,723
Aug. 16-19	1,827,301
Sept. 17-19	1,716,662
Oct. 16-19	1,713,200

The method for estimating residence time depended on a knowledge of the moving volume and on discharge data. The average moving volume between visits was assumed to be the mean of the volumes estimated at the time of each visit. The initial volume on April 25 was assumed to be the volume between the 0 and 50 foot contours (644,492 acre-feet). This estimate was based on an inspection of the April 22 temperature profile of the lake. The volume of discharge from the lake between visits was determined, as described earlier under *Advected Energy*, from changes in lake gauge height and from inflow data.

Residence times (RT) were obtained by multiplying the number of days between visits by the ratio of mean moving volume to discharge, i.e. for the April-May period:

$$RT = 911,167/1,221,132 \times 27$$
$$= 21 \text{ days}$$

The procedures described above actually lead to maximum estimates of residence time since it was assumed that waters above the hypolimnion were homogeneous. This was almost certainly an inaccurate assumption. Water near the surface probably contributed mostly to discharge, therefore actual residence times were somewhat shorter than those given in TABLE 5 because moving volumes were actually less than those estimated.

TABLE 5—Estimated total discharge from Kamloops Lake, estimates of the mean moving volume and estimates of the mean residence time of inflow water between visits for the period between spring and fall circulation. Residence time based upon assumption of homogeneously mixed strata above the hypolimnion.

Period	Days between visits	Discharge acre-feet	Mean Moving Volume—acre-feet	Residence Time (days)
April - May	27	1,221,132	911,167	21
May - June	35	4,103,819	1,446,034	13
June - July	28	3,226,540	1,745,975	15
July - Aug.	31	2,424,614	1,802,512	22
Aug. - Sept.	31	1,502,143	1,771,982	36

RESIDENCE TIME BASED UPON UNMIXED SURFACE INFLOW

The foregoing estimates of residence time were based upon the assumption that advected water was homogeneously mixed in the moving volume above the hypolimnion. As mentioned earlier an alternative method of computing residence time can be based on the average temperature of discharge water and upon the assumption that no mixing of advected water occurs.

The depth of the moving volume of water was determined by computing the depth to which water must have been drawn from the lake to provide water of the temperature of the Thompson River at its outlet (Savona). As a first step in computing the depth of the moving volume the area at each ten foot contour of a cross-section of the lake at Station E was computed. Then for each sampling period, based on the vertical distribution of temperature at Station E, a weighted temperature at each strata was computed. The necessary number of weighted values were combined to give the number of strata necessary to provide water at the same average temperature as the discharge from the lake. An example is given below (TABLE 6).

TABLE 6—Area between ten foot contours, average temperature and weighted average temperatures (°F) at Station E, Kamloops Lake on May 17, 1963.

CONTOUR	AREA (sq. ft.)	PERCENTAGE OF TOTAL AREA	MEAN TEMP. °F
0 - 10	45,000	18.6	51.8
10 - 20	41,500	17.1	49.8
20 - 30	36,000	14.9	49.2
30 - 40	33,500	13.8	48.7
40 - 50	31,000	12.8	47.9
50 - 60	28,500	11.8	47.2
60 - 70	26,500	10.9	46.3
Total	242,000	99.9	48.9 (weighted average)

Since the average temperature of the Thompson River at Savona was 49.1°F on this date it is evident that the river water was derived from the top 70 feet of the lake (average temperature of 48.9°F). The volume of the lake down to this 70 foot contour was then assumed to be the moving volume at this particular time. The volume above the 70 foot contour was 871,798 acre-feet.

In June, water down to a depth of 100 feet provided the discharge. The moving volume was 1,214,534 acre-feet in June and the mean May-June volume was 1,043,166 acre-feet. Since the discharge during this period of 35 days was 4,103,819 acre-feet (TABLE 5), the estimated residence time was 9 days.

Using this method residence times for the period between spring and fall circulation were:

April - May	— 17 days;
May - June	— 9 days;
June - July	— 7 days;
July - August	— 9 days;
August - September	— 18 days.

These values are, in most cases, considerably smaller than those obtained by the previously described method. Indeed, since no mixing was assumed, they must be minimum values just as the values in TABLE 5 were maximum values.

MEAN RESIDENCE TIMES BETWEEN SPRING AND AUTUMN CIRCULATION

Two methods of computing residence time have been presented. One method gave a maximum value while the other gave a minimum. For comparison these extreme values are presented in TABLE 7 along with their means, which are probably good approximations of actual residence times. During the period of thermal stratification it is evident that residence times for newly advected water are relatively brief. Even estimates of minimum rates of movement were based on residence times of only slightly more than one month.

TABLE 7—Residence times and rates of movement of newly advected water through Kamloops Lake for periods between April 25 and mid-September 1963.

PERIOD	RESIDENCE TIME (in days)			RATE OF MOVEMENT (miles per day)		
	Maximum	Minimum	Mean	Minimum	Maximum	Mean
April - May	21	17	19	0.82	1.01	0.91
May - June	13	9	11	1.32	1.91	1.56
June - July	15	7	11	1.15	2.46	1.56
July - Aug.	22	9	16	0.78	1.91	1.07
Aug. - Sept.	36	18	27	0.48	0.96	0.64

Residence Time of Inflow Entering Between Autumn
and Spring Circulation

During winter, rates of movement were much lower than during the strati-
fication period. The rate of exchange of water through the basin was low because
inflow and discharge were at the annual minimum. In addition, a large portion of
the lake was involved in the exchange.

The depth of the upper limit of the hypolimnion on November 18, 1962 was
approximately 200 feet below the surface (FIGURE 3). The maximum moving
volume in these circumstances would be 2,193,793 acre-feet. On the next visit to
the lake on January 17, 1963, the lake was inversely stratified. The surface temper-
ature was 36.2°F and the temperature near the bottom was 39.2°F. Density
differences in this temperature range are minor (Page 33, Welsh, 1935). It is
probable that considerable vertical mixing occurred. For this reason it was assumed
that inflow was mixing in the whole volume of the lake and that the whole volume
was contributing to discharge. The mean moving volume between November 18
and January 17, a 60 day period, was 2,773,029 acre-feet, the mean of the initial
and final moving volumes. Discharge during the period was 1,446,686 acre-feet
and the estimated residence time was 115 days.

Water temperature in the Thompson River at Savona did not reach 39.2°F,
the temperature at which water is at its maximum density, until December 26.
It was assumed that on this date the lake was homothermous and there were
no density differences. Under these assumptions the total volume of the lake
(3,352,265 acre-feet) would be involved in flow through the basin. Since the
moving volume on January 17 was also assumed to be the total volume, the mean
moving volume for the 23 day period was 3,352,265 acre-feet. Discharge was
454,350 acre-feet and the estimated residence time was 170 days.

The remaining winter period extended from January 17 to March 21. During
this 63 day period the discharge was 995,208 acre-feet. The lake was virtually
homothermous in March so the average moving volume was 3,352,265 acre-feet,
the total lake volume. The estimated residence time was 212 days.

The various estimates of residence time during the November to March
interval, particularly those which are of long duration can be misleading. These
estimates are estimates of rates applying only for the specified periods. For example,

TABLE 8—Residence times and rates of movement of newly advected water through
Kamloops Lake for periods between November 18, 1962 and March 21, 1963.

PERIOD	RESIDENCE TIME (days)	RATE OF MOVEMENT (miles per day)
Nov. - Jan.	115	0.15
Dec. - Jan.	170	0.10
Jan. - March	212	0.08

the estimated residence time for the January-March period cannot apply after this period. As shown, thermal stratification occurred, trapping previously advected water in the hypolimnion while newly advected water passed rapidly through the basin on the surface. Estimated rates of movement as well as residence times are shown in TABLE 8.

OXYGEN REGIME OF KAMLOOPS LAKE

In lakes with two periods of circulation virtual stagnation occurs in the hypolimnion during the period between vernal and autumnal circulation. The stagnation period in Kamloops Lake in 1963 was long, lasting from approximately April 25 until the middle of November. Considerable oxygen deficits can occur in the hypolimnion of eutrophic lakes in these circumstances as a result of respiration and the high oxygen demand of abundant decomposing organic matter found both in solution and on the bottom. Since Kamloops Lake is not eutrophic and has an extensive hypolimnion such deficits are unlikely to occur. However, deficits could occur in localized areas as a result of introduction of oxygen consuming materials and organisms.

Dissolved oxygen content of water samples was determined by the unmodified Winkler method (Standard Methods, 1955). Levels of oxidizing and reducing agents in Kamloops Lake were so low that interferences could be ignored. The Winkler method reagents were added at the time the water samples were obtained and the maximum interval between addition of these reagents and titration with thiosulfate was approximately ten hours.

Percentage saturation with oxygen was determined from values computed by Harvey (1963). He used absorption coefficients given in the Handbook of Chemistry and Physics (1940), the oxygen fraction (0.2095) as recommended by Hutchinson (1957) and he also corrected for water vapor pressure. Saturation values used in this report were adjusted for the average atmospheric pressure at the surface of Kamloops Lake (altitude: 1,125 feet above sea level).

The oxygen content of a body of water at great depth depends in part on conditions of temperature and pressure which prevailed at the time it was influenced directly by surface conditions; therefore expressing the percentage saturation in terms of surface conditions at the time of sampling can be misleading. However, the most important aspect of dissolved oxygen to be considered in this report involved not the percentage saturation but the actual amount dissolved per unit volume of water.

A complete listing of dissolved oxygen measurements in ppm accompanied by per cent saturation values is given in TABLE 9. Surface values of oxygen were closely related to water temperature. During the winter when surface temperatures were low, levels of dissolved oxygen were high. For example, at C-2 in January, the sample contained 12 ppm and the water temperature was 36.5°F. The

sample was 93 per cent saturated. In the summer the amount of oxygen dissolved in the surface waters had dropped sharply but remained at a high level of saturation. At C-2 in August the amount of dissolved oxygen was 8.6 ppm but the sample was 98 per cent saturated at the surface temperature of 67°F. The seasonal variations in amount of dissolved oxygen at Station C-2 are shown in FIGURE 6.
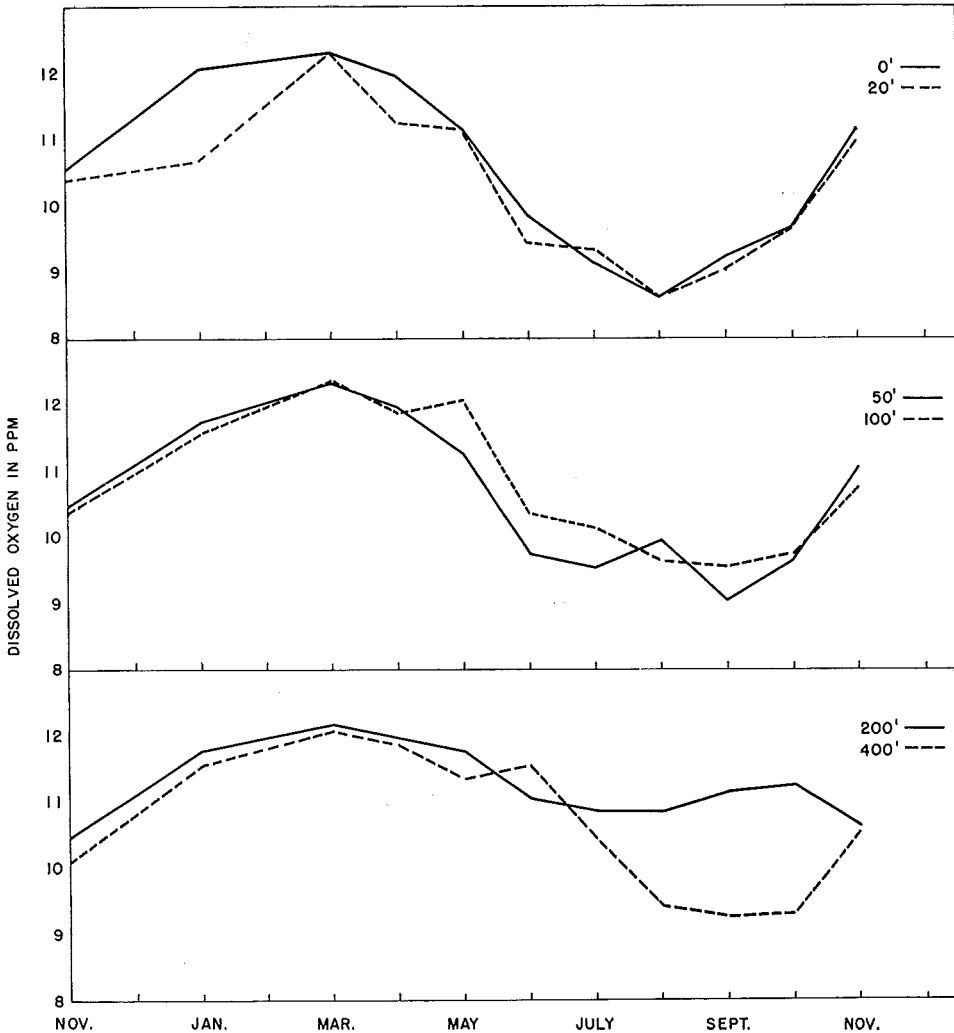
FIGURE 6—Seasonal variation in dissolved oxygen content (in ppm) of Kamloops Lake water (Station C-2) at 6 depths.

From the surface to a depth of about 150 feet the same general situation applied, although apparent anomalies occurred. In a few instances a relatively high degree of supersaturation pertained and, less frequently, oxygen minima occurred. For example, at G-2 on May 14 (TABLE 9), the surface and 20 foot samples had 11.1 and 11.0 ppm respectively (104.5 and 99.1 per cent saturated) but at 50 feet oxygen had dropped to 9.1 ppm (79% saturated) but increased again

TABLE 9—Distribution, amount and percentage saturation of oxygen in Kamloops Lake.

STATION	DEPTH (in Ft.)	NOV. 1962		JAN. 1963		MARCH		APRIL		MAY	
		ppm.	% Sat.	ppm.	% Sat.	ppm.	% Sat.	ppm.	% Sat.	ppm.	% Sat.
A	0	11.45	95.9	13.28	97.6	11.76	93.8	11.05	100.9	10.94	102.3
B—2	0	11.35	100.1	12.36	93.6	12.42	97.2	12.06	106.3	12.46	117.2
	20	11.00	96.7	12.36	95.4	12.36	96.7	11.96	105.5	10.95	102.1
	50	11.00	96.7	12.26	97.4	12.36	96.7	11.45	98.3	10.74	100.0
	100			11.86	93.4	12.31	96.6	11.65	96.7	11.35	97.2
	120	11.65	100.0	11.76	92.5	12.31	96.8	11.76	96.9	11.55	95.3
	148										
C—2	0	10.54	93.3	12.06	92.8	12.31	95.2	11.96	106.3	11.15	105.8
	20	10.39	92.0	10.69	82.6	12.31	95.2	11.25	98.9	11.15	101.0
	50	10.44	92.3	11.71	90.8	12.31	95.2	11.96	102.1	11.25	95.4
	100	10.34	91.4	11.65	92.4	12.36	95.6	11.86	98.1	12.06	98.3
	200	10.44	86.6	11.76	94.0	12.16	94.3	11.96	96.4	11.75	94.5
	400	10.08	81.4	11.55	92.3	12.06	93.8	11.86	95.1	11.35	90.7
	468										
G—2	0					12.36	95.6	12.06	102.0	11.20	104.5
	20					12.11	93.7	11.96	96.1	11.09	99.1
	50					12.26	94.9	11.96	96.1	9.22	79.1
	100					12.36	95.6	12.06	96.6	13.67	112.2
	200					12.26	94.9	11.96	95.8	11.85	95.9
	400					12.21	94.9	11.75	93.9	11.55	92.3
	430										
D—2	0	10.64	95.4	11.45	91.0	12.36	96.7	12.46	100.4	10.84	107.2
	20	10.64	95.4	11.65	92.4	12.36	95.9	12.16	97.2	11.25	105.7
	50	10.59	95.0	11.30	89.6	12.36	95.6	12.16	97.2	11.45	96.9
	100	10.59	94.1	10.95	86.8	12.36	95.6	12.66	101.2	11.75	96.4
	200					12.26	94.9	12.26	98.0	11.96	96.4
	300	10.34	84.2	11.41	91.4	12.06	93.3	11.76	94.0	11.55	93.1
	350										
E—1 & 2	0	10.29	91.7	11.76	93.3	12.31	95.5	12.31	98.4	11.15	108.5
	20	10.24	91.3	11.65	92.4	12.36	95.9	12.16	97.2	11.15	103.0
	50	9.98	89.0	11.65	92.4	12.42	96.3	12.46	99.6	11.55	102.8
	100	10.13	90.3	11.55	92.4	12.36	95.9	12.16	97.2	11.35	97.4
	130	10.13	86.7								
F	0	10.69	96.1	11.76	92.5	12.31	96.3	12.46	99.6	11.55	106.2

DEPTH (in Ft.)	JUNE		JULY		AUG.		SEPT.		OCT.		NOV.	
	ppm.	% Sat.	ppm.	% Sat.	ppm.	% Sat.	ppm.	% Sat.	ppm.	% Sat.	ppm.	% Sat.
0	9.93	100.2	9.62	96.5	9.32	101.1	9.63	99.7	10.04	98.6	12.87	95.7
0	9.53	102.8	9.32	99.2	8.51	96.7	9.12	100.4	9.43	95.4	11.37	96.3
20	9.33	98.9	9.52	100.4	9.20	103.9	8.92	97.1	9.43	95.9	11.37	96.3
50	9.93	101.8	9.52	94.4	9.20	102.2	9.32	99.6	9.63	97.2	11.37	98.1
100	10.04	94.3	9.73	92.3	9.42	91.2	9.63	91.7	9.83	98.6	11.68	96.3
120	10.13	92.0	10.03	89.6	9.62	89.6	9.93	88.7	9.93	98.7	11.91	97.9
148					9.32	81.3						
0	9.83	104.6	9.12	103.4	8.61	97.8	9.22	100.8	9.68	98.1	11.15	95.0
20	9.43	99.3	9.32	99.3	8.61	97.7	9.02	99.1	9.68	98.1	10.95	94.4
50	9.73	98.4	9.52	95.9	9.93	107.6	9.02	98.1	9.63	97.2	11.04	95.2
100	10.34	96.9	10.13	95.5	9.62	93.1	9.53	92.5	9.73	97.7	10.74	90.9
200	11.05	90.4	10.84	88.3	10.84	89.4	11.15	90.9	11.25	91.7	10.64	88.9
400	11.55	93.1	10.43	83.9	9.42	75.5	9.28	75.0	9.32	75.1	10.54	87.5
468					8.31	66.5	8.37	67.6				
0	9.42	104.0	9.12	99.3	8.81	102.8	9.02	99.1	9.43	96.4		
20	9.73	99.6	9.12	96.5	8.51	96.5	9.02	99.6	9.43	96.0		
50	10.04	97.9	9.22	96.5	8.71	97.2	8.82	97.2	9.73	98.6		
100	10.04	91.9	9.83	94.3	9.32	93.3	9.42	93.2	9.43	94.1		
200	11.15	90.3	10.84	87.8	11.04	89.4	10.04	81.7	11.15	91.2		
400	11.05	89.1	10.94	87.7	10.13	81.2	9.53	76.8	11.55	93.3		
430							9.53	76.8				
0	9.73	103.6	9.42	106.2	8.81	100.7	9.22	100.7	9.53	96.9	11.74	95.0
20	9.73	102.0	9.42	98.9	9.22	104.5	9.12	100.2	9.53	98.3	11.74	92.3
50	10.04	99.3	9.42	96.1	8.51	92.7	8.92	96.5	9.63	99.3	11.74	92.3
100	10.13	95.7	9.73	93.8	9.32	94.8	9.02	92.5	9.73	92.9	11.74	94.1
200	11.05	89.5	11.14	90.0	10.74	87.8	10.94	89.3	10.84	88.3	11.74	94.1
300	11.45	92.5	10.44	83.9	11.04	89.4	10.84	87.3			11.82	91.7
350					11.04	89.2	10.84	87.3				
0	9.63	98.6	9.12	104.3	8.71	98.3	9.12	100.6	9.63	99.0	11.04	92.5
20	9.93	101.0	9.62	101.3	8.61	96.7	9.22	101.5	9.73	99.6	10.84	91.7
50	9.93	98.2	9.42	96.1	8.61	93.8	9.02	98.2	9.53	94.8	10.84	91.7
100	10.13	95.7	10.03	96.9	8.92	91.9	8.92	92.6	9.73	90.7	10.95	92.6
130					9.62	85.1	9.93	87.3				
0	9.83	97.5	9.72	104.8	8.82	98.0	9.02	98.3	9.53	96.2	10.74	92.2

to 13.3 ppm at 100 feet (112.2% saturated). Since the lake had been calm for at least two days prior to this it is likely that very little vertical mixing had occurred. In these circumstances both the minimum dissolved oxygen at 50 feet and the maximum dissolved oxygen at 100 feet may have resulted from biological activity. The minimum probably resulted from respiration and the maximum from oxygen evolved during photosynthesis.

Below a depth of about 150 feet the temperature of the lake remained relatively constant throughout the year, therefore this depth can be considered as approximating the upper limit of the hypolimnion when the lake is stratified. In the upper portion of this region, at a depth of 200 feet, levels of dissolved oxygen remained relatively constant throughout the year (FIGURE 6). At C-2 values varied from 10.6 ppm to 12.2 ppm, a range of 1.6 ppm. In contrast values at the 100 foot level varied from 12.4 ppm to 9.5 ppm, a range of 2.9 ppm. Near the bottom, at the deep stations, a wide seasonal change occurred. At C-2 at 400 feet values ranged from 12.1 ppm to 9.3 ppm, a difference of 2.8 ppm.

During the warm months, when the lake was stratified there could not be much vertical exchange into the hypolimnion, therefore most of the oxygen below this depth must represent oxygen which went into solution during the spring turnover which apparently occurred in March in 1963. If it is assumed that the maximum annual amount of oxygen was present in solution when samples were taken in March, subsequent differences can be expressed as percentages of this initial level, thus indicating the degree of depletion. In the case of 200 foot samples at C-2 the maximum depletion was 1.6 ppm from 12.1, a 13 per cent reduction. Temperatures at this level in March when the maximum occurred was 37.0°F and in November 1963, 42.2°F. In contrast, a much greater loss took place at the 400 foot level of C-2 although temperature change was minor. The maximum depletion was 2.8 ppm from the March maximum of 12.1 ppm or a loss of 23 per cent of the initial dissolved oxygen. Temperatures at 400 feet were respectively 37.3 and 40.4°F in March and September. Although dissolved oxygen was still abundant at the 400 foot level in September (9.3 ppm) it was much reduced in comparison with the 200 foot minimum (10.6 ppm). This differential depletion suggests that oxidative processes were functioning near the bottom of Kamloops Lake.

In summary, Kamloops Lake was well oxygenated at all depths and at all seasons. Even at the bottom in the very deepest water (C-2 in September at 468 feet) after a long period of stratification the oxygen level was still relatively high (FIGURE 7). This condition and location is apparently about the worst an organism requiring oxygen would meet during the year. At other times and at other depths much higher levels of oxygen would be encountered.

The oxygen requirements of animals vary greatly. Some fish can survive under much greater oxygen deficits than other species (Fry, 1957). In addition, given sufficient acclimatization time, fish species can live under a range of conditions (Shepard, 1955). Although salmonids in general have high oxygen requirements there is enough dissolved oxygen for them to exist freely in any part of Kamloops Lake.
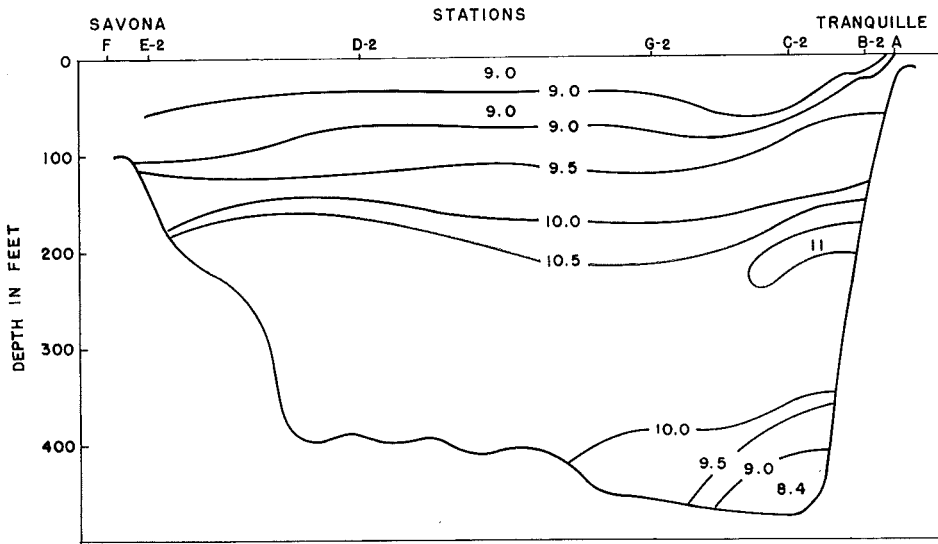
FIGURE 7—A section through the East-West axis of Kamloops Lake showing the distribution of oxygen (ppm) in September 1963.

RESULTS OF ANALYSES OF KAMLOOPS LAKE WATER

Results of chemical analyses of Kamloops Lake water are presented in TABLE 10. Values of total dissolved solids (TDS) were relatively low, indicating, according to the data of Northcote and Larkin (1956), that the lake is oligotrophic.

Some of the factors measured seem to undergo seasonal changes. For example, TDS in the surface strata at C-2 and D-2 seems to decline during the summer and fall. Deep water at C-2 and D-2 did not vary to the same degree. More frequent sampling would be required to determine if these apparent changes do, in fact, occur.

The concentration of three heavy metal ions; lead, copper and zinc are shown in TABLE 10. Analyses for these metals were made on a combined sample of shallow and deep water from Station C-2 taken in March. The concentrations were very low, being definitely below the levels generally considered to be harmful to fish.

Frequent sampling for levels of phosphorus and nitrogen was conducted during the study and results are given in TABLE 11. Nitrate in particular shows a well defined seasonal change in the surface water at both C-2 and D-2. Values were at a maximum in March and October and a minimum in September. Similar changes occurred in the deep water at C-2 and D-2 but they were not as pronounced as in the surface waters (FIGURE 8). Ammonia and total nitrogen, excluding nitrate, did not show measurable seasonal changes in concentration.

TABLE 10—Results of analyses of water samples from Kamloops Lake and the Thompson River at Tranquille. Values are given as ppm.

FACTOR	MARCH 19-22					JULY 16-20					OCTOBER 16-18				
	A	C-2 10 ft	C-2 400 ft	D-2 10 ft	D-2 300 ft	A	C-2 10 ft	C-2 400 ft	D-2 10 ft	D-2 300 ft	A	C-2 10 ft	C-2 400 ft	D-2 10 ft	D-2 300 ft
Total Dissolved Solids	68.8	63.4	62.8	61.0	59.8	38.1	43.7	60.0	43.0	49.6	52.4	50.8	55.4	40.1	56.8
Volatile Solids	27.3	26.3	26.8	27.0	22.2	18.6	20.9	26.0	20.2	27.7	20.4	19.8	17.9	13.8	21.8
Fixed Solids	41.5	37.1	36.0	34.0	37.6	19.5	22.8	34.0	22.8	21.9	32.0	31.0	37.5	26.3	35.0
Silica (SiO$_2$)	2.6	2.3	2.3	2.2	2.1	2.8	3.7	3.5	4.7	3.9	0.4	0.5	0.4	0.4	0.5
Total Iron	0.1	0.1	0.1	0.1	0.1	1.0	0.6	0.8	0.7	1.0	4.5	1.8	2.0	1.6	1.8
Calcium	15.7	13.9	13.8	13.3	13.3	9.0	10.4	13.1	10.3	10.9	12.0	12.0	13.5	11.1	13.1
Sodium	2.4	2.3	2.4	2.0	2.0	1.2	1.2	2.1	1.9	1.7	1.7	1.3	1.3	0.8	1.3
Magnesium	2.5	2.1	2.2	2.0	2.2	1.3	1.5	2.3	1.5	1.8	2.0	2.0	2.5	1.9	2.5
Sulphate (SO$_4$)	7.7	7.1	7.9	6.4	6.4	6.6	6.9	11.0	6.5	7.0	7.9	7.3	7.9	7.4	8.1
Potassium	< 1.0	< 1.0	< 1.0	< 1.0	<1.0	0.9	0.8	1.1	0.8	1.0	0.9	0.8	0.9	0.8	0.8
Chloride	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
Lead							< 0.002								
Zinc			< 0.001												
Copper			0.001												

TABLE 11—Levels (in ppm) of Phosphorus and Nitrogen in Kamloops Lake in 1963.

DATE	C-2 10 ft.					C-2 400 ft.					D-2 10 ft.					D-2 300 ft.				
	Nitrate	NH₃	N¹	PO₄²	PO₄³	Nitrate	NH₃	N¹	PO₄²	PO₄³	Nitrate	NH₃	N¹	PO₄²	PO₄³	Nitrate	NH₃	N¹	PO₄²	PO₄³
March	0.44	0.012	0.07	<0.003		0.40	0.012	0.06	<0.003		0.44	0.018	0.07	<0.003		0.44	0.012	0.06	<0.003	
April	0.34	<0.04	0.10	<0.004		0.35	<0.02	0.07	<0.001		0.35	<0.01	0.07	<0.001		0.35	<0.02	0.07	<0.003	
May	0.27	0.02	0.11	0.006	0.020	0.18	0.02	0.11		0.007	0.18	0.01	0.14		0.020	0.18	0.010	0.09		0.007
June	0.34	<0.01	0.10	<0.003	0.023	0.47	<0.01	0.08	<0.003	0.018	0.42	<0.01	0.10	<0.003	0.023	0.42	0.020	0.09	<0.003	0.030
July	0.18	<0.01	0.07	<0.002	0.012	0.35	<0.02	0.07	<0.002	0.013	0.18	<0.01	0.09	<0.002	0.013	0.31	<0.02	0.06	<0.002	0.012
August	0.18	0.03	0.11	<0.002	0.015	0.35	0.05	0.07	<0.002	0.019	0.18	<0.02	0.10	<0.002	0.018	0.27	<0.02	0.08	<0.002	0.016
September	0.09	<0.01	0.09	<0.002	0.019	0.35	<0.02	0.09	<0.002	0.023	0.09	<0.01	0.09	<0.002	0.017	0.27	<0.02	0.08	<0.002	0.022
October	0.35	<0.02	0.08	0.007	0.026	0.61	<0.01	0.07	0.009	0.084	0.26	<0.01	0.07	0.009	0.053	0.61	<0.01	0.07	0.006	0.040
November	0.28	0.01	0.07	0.007	0.011	0.44	<0.02	0.05	0.007	0.011	0.30	<0.01	0.09	0.007	0.010	0.44	<0.02	0.06	0.007	0.011

1 Total Nitrogen other than nitrates.
2 Inorganic Phosphate.
3 Total Phosphate.
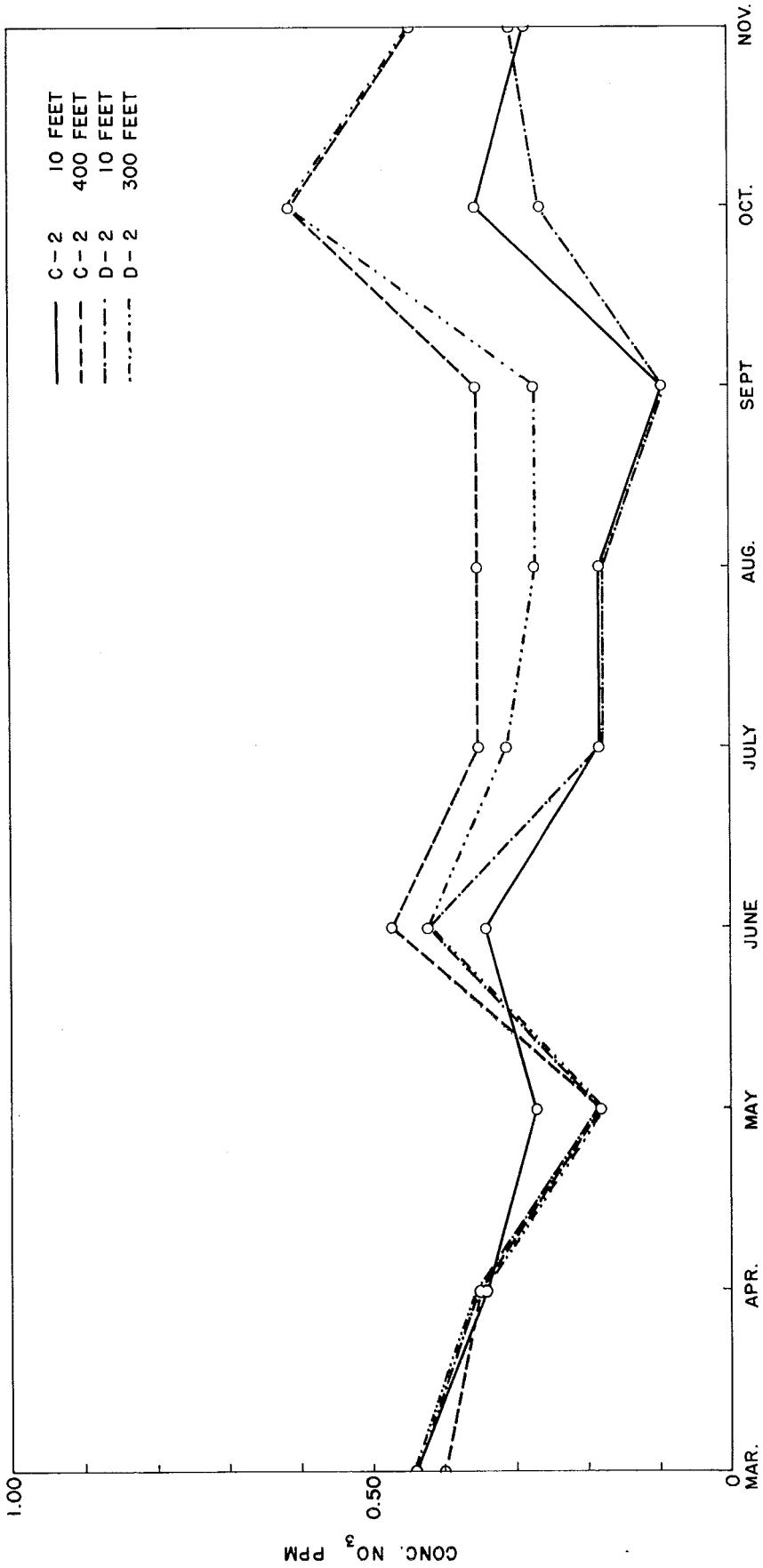
FIGURE 8—Seasonal changes in nitrate levels at two depths in Kamloops Lake in 1963.

Two explanations are available for the seasonal change in nitrate concentrations. Summer depletions in the upper layers might be caused by the incorporation of nitrate-nitrogen into the plankton community located primarily in the upper euphotic zone. Another explanation is that the large volume of incoming water during spring and summer was lower in nitrates than the underlying hypolimnial water which had been advected previously during a low river flow period. Both these explanations have merit and it is likely that both are involved in bringing about low levels of nitrate in the surface waters during the period of stratification. For instance, the difference in concentrations between surface and deep water increased with time, suggesting a progressive decline characteristic of the effects of biological activity. If dilution was primarily involved, the minimum nitrate levels in the upper water should have occurred in June when the rate of inflow was at a maximum. On the other hand, in October the nitrate level in the incoming Thompson River water at Tranquille was 0.44 ppm, lower than the hypolimnial concentration (0.61 ppm) suggesting dilution of the upper layers.

Total phosphate and inorganic phosphate were generally at their lowest levels in the summer and fall months. Contrary to the nitrate data, depletion of inorganic phosphorus seemed to occur at all depths. The role of the phosphorus cycle in the growth and decline of phytoplankton communities is not clearly established. The primary purpose of the determinations made in 1963 was to establish current levels of these factors.

Determinations of pH at several depths were made in May, July and August (TABLE 12). The instrument used to make these measurements was a Beckman Pocket pH meter.

Analyses for alkalinity were also made on several occasions. Bicarbonate in solution in the lake waters at all depths and throughout the study averaged about 40 ppm. Free CO_2 concentrations were generally less than 2 ppm.

TABLE 12—Measurements of the pH of Kamloops Lake water samples in 1963.

DATE	STATION AND DEPTH			
	A	C-2 Surface	C-2 400 Ft.	F
May	7.8	7.7	7.7	7.6
July	8.4	8.0	8.3	8.3
August	8.2	7.7	7.4	7.7

ABUNDANCE OF PLANKTON

Both vertical and horizontal tows were made with Wisconsin and Clarke-Bumpus gears to obtain samples of plankton from Kamloops Lake. Vertical tows were made and samples taken were treated in accordance with procedures described by Ward (1957). Samples taken with the Clarke-Bumpus horizontal samplers were treated differently. Excess preservative was removed. Samples were then washed in distilled water and decanted. They were then placed in a drying oven

at 60°C for 48 hours or until a consistent weight per sample was reached. These consistent weights were recorded as dry weights of plankton (in milligrams) per liter of lake water.

In the case of the vertical hauls, catches were treated to remove phytoplankton (Ward, 1957). This procedure was not followed with the horizontal samples, however, the mesh size of the nets was so large (No. 10) that the catches were largely representative of the adult crustacean component of the plankton community. Small zooplankters and the immature stages of the crustacean component along with most of the phytoplankton passed through the meshes of the net. Neither gear sampled phytoplankton quantitatively, therefore following discussions are restricted to a consideration of the composition and abundance of adult crustacean zooplankters.

Composition of the crustacean component of the zooplankton in the pelagic region of Kamloops Lake was obtained from analyses of samples from vertical hauls. The mean volumes of centrifuged plankton samples obtained in these vertical tows were also compared with similar data from Shuswap Lake. Mean dry weights of plankton obtained from horizontal tows made at different depths, were used to describe the daytime vertical distribution of zooplankton. Catches from these horizontal tows were also related to the concentration of inorganic phosphate in the lake waters.

Composition of the Zooplankton

The common pelagic zooplankters of Kamloops Lake in 1963 were:

CLADOCERA

Daphnia longispina
Bosmina longirostris
Leptodora kindtii
Holopedium gibberum

COPEPODA[1]

Cyclops thomasi
Tropocyclops prasinus
Diaptomus aschlandi
Epishura nevadensis

During the summer months of 1963 *Holopedium* was the most common Cladoceran but the Copepod, *Diaptomus,* was abundant during spring as well as the summer and fall. *Cyclops* was numerous in the samples only during the spring.

An unexpected feature of the Kamloops Lake zooplankton community was the abundance of *Holopedium.* This species was not present in samples taken in the open waters of Shuswap Lake during 1954, 1955, and 1956, although Clemens *et al.* (1937) reported the presence of *Holopedium* in Shuswap Lake. In the Kamloops Lake samples, *Holopedium* was more abundant during the summer of 1963 than either *Daphnia* or *Bosmina.*

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[1] Identified by Dr. Mildred S. Wilson, Arctic Health Research Center, U. S. Public Health Service, Anchorage, Alaska.

Quantitative Sampling

As described, two methods of quantitative zooplankton sampling were conducted at Kamloops Lake. Each month, both vertical and horizontal tows were made.

Shown in TABLE 13 are mean monthly volumes of centrifuged zooplankton taken on Kamloops and Shuswap Lakes stations by vertical 100 foot tows during 1963. Each value is the mean of six vertical hauls.

TABLE 13—Measurements of the standing crop of zooplankton (mean centrifuged volume per 100 foot haul in milliliters) in Kamloops and Shuswap Lakes during 1963. Also shown are the standard errors of the means.

| MONTH | KAMLOOPS | | | SHUSWAP | |
| | Station | | | Station | |
	C-2	G-2	D-2	Sicamous	Sorrento
March	0.28 ± 0.02		0.26 ± 0.02		
April	0.23 ± 0.02	0.18 ± 0.03	0.24 ± 0.02	0.41 ± 0.04	0.81 ± 0.04
May	0.20 ± 0.02	0.08 ± 0.01	0.10 ± 0.03	0.92 ± 0.04	1.17 ± 0.09
June	3.42 ± 0.10	0.77 ± 0.08	0.50 ± 0.06	1.94 ± 0.14	1.22 ± 0.06
July	0.80 ± 0.08	0.33 ± 0.06	0.18 ± 0.04	2.08 ± 0.10	1.30 ± 0.06
August	0.84 ± 0.07	0.18 ± 0.04	0.56 ± 0.04	1.90 ± 0.23	1.10 ± 0.05
September	0.78 ± 0.04	0.57 ± 0.04	0.78 ± 0.08	1.22 ± 0.07	0.75 ± 0.05
October	0.12 ± 0.01	0.26 ± 0.01	0.35 ± 0.03		
November	0.78 ± 0.05	0.28 ± 0.01	0.16 ± 0.01	0.69 ± 0.04	0.48 ± 0.03
Apr.-Sept. Mean	1.05	0.35	0.39	1.41	1.06

On Stations C-2 and G-2 catches of zooplankton were greatest during the June sampling period; however, the peak standing crop at D-2 occurred during the September sampling period (TABLE 13). The standing crop was generally largest at C-2. With the exception of the June sample from C-2, it is evident that values were generally lower for Kamloops Lake. For example, the April-September means for both the Sicamous and Sorrento stations were much larger than the Kamloops means excepting the C-2 value. In this case the high mean resulted from the very large value obtained during the June sampling.

These data indicate that the standing crop of zooplankton in Kamloops Lake was lower than in Shuswap.

The chief difference between the two lakes is the higher flush rate applying to Kamloops Lake. Possibly summer zooplankton blooms could not become established before the animals are carried out of the basin. Kamloops Lake surface temperatures (TABLE 14) are also lower during the summer but warmer water was found at greater depths than in Shuswap Lake. The average temperature from the surface to ninety feet tended to be higher in Kamloops Lake, suggesting that the trophogenic zone in Kamloops Lake might have been deeper than in Shuswap Lake.

The apparently deeper productive layer in Kamloops Lake was probably counterbalanced by the greater turbidity of the water as indicated by reduced transparency (TABLE 15). This feature tended to restrict production to the surface layers where temperatures were lower than in Shuswap Lake. As can be concluded from the data obtained from horizontal tows (TABLE 16) most zooplankters in Kamloops Lake were between a depth of 40 feet and the surface during the daylight hours when horizontal tows were made.

The lower standing crop of zooplankton in Kamloops Lake as compared with production in Shuswap Lake seems to result primarily from the amount and nature of the spring and summer inflow. The large inflow volume results in a high flush rate and relatively low surface temperatures. These features contribute to the relatively low zooplankton production. The high turbidity of the surface water during spring and summer may also limit the size of the standing crop of phytoplankton, thereby limiting zooplankton production.

TABLE 14—Average surface temperatures and average surface to ninety feet temperatures (°F) at Kamloops and Shuswap Lakes, 1963.

MONTH	KAMLOOPS		SHUSWAP			
			Sicamous		Sorrento	
	Surface	0-90'	Surface	0-90'	Surface	0-90'
April	44.1	41.4	42.0	40.0	41.0	40.2
May	52.4	46.5	51.0	45.7	50.5	44.6
June	61.2	56.4	67.0	50.0	54.0	47.1
July	64.8	58.3	68.5	53.6	69.0	51.9
August	67.4	63.0	73.5	57.7	72.0	53.6
September	63.9	62.2	68.5	56.2	67.5	56.1
October	58.0	56.7	—	—	—	—
November	44.2	44.0	47.5	46.3	49.0	49.4

TABLE 15—Secchi's Disc readings at Kamloops and Shuswap Lakes in 1963.

MONTH	KAMLOOPS					SHUSWAP	
	Station					Station	
	B-2	C-2	G-2	D-2	E-2	Sicamous	Sorrento
April	6.0'	11.5'	27.5'	40.8'	33.5'	44.4'	43.7'
May	9.5'	12.0'	12.0'	15.7'	14.5'	32.4'	36.4'
June	7.0'	8.5'	10.0'	10.0'	8.0'	25.8'	32.8'
July	7.5'	11.0'	10.0'	12.5'	12.5'	26.1'	26.3'
August	6.0'	5.3'	9.0'	13.0'	14.0'	34.3'	40.5'
September	8.6'	8.0'	7.8'	12.7'	15.0'	25.6'	28.3'
October	19.5'	18.7'	19.5'	21.0'	18.7'		
November	17.5'	17.5'		21.5'	21.5'	28.4'	33.3'

TABLE 16—Catches of plankton (mg/1 dry weight) by three samplers towed horizontally at different depths in Kamloops Lake in 1963.

STATION	DEPTH	MONTH							
		April	May	June	July	Aug.	Sept.	Oct.	Nov.
B-C	7	0.0031	0.0060	0.0947	0.2284	0.1089	0.0748	0.0412	0.0053
	37	0.0092	0.0036	0.0193	0.0104	0.0148	0.0149	0.0045	0.0321
	148	0.0043	0.0026	0.0115	0.0097	0.0061	0.0038	0.0043	0.0099
D-E	7	0.0025	0.0072	0.0262	0.0235	0.0596	0.0291	0.0200	0.0057
	37	0.0022	0.0041	0.0043	0.0062	0.0134	0.0246	0.0158	0.0057
	148	0.0024	0.0025	0.0013	0.0015	0.0024	0.0006	0.0016	0.0026

Although Kamloops Lake had a smaller standing crop of adult crustacean zooplankters than Shuswap Lake, in this respect it compared favorably with some major sockeye producing lakes. For example, the mean volume of centrifuged zooplankton in Chilko Lake in 1963 based on sampling at eight stations in May, June, August and September was 0.44 ml. The mean volume at Kamloops Lake for comparable sampling periods was 0.73 ml.

During most of the 1963 season, the standing crop of net plankton near the surface of Kamloops Lake was higher at the eastern or inlet end of the lake (TABLE 16). For example, in July the catch in the surface net at Station B-C was 1.3844 mg/1 dry weight but at D-E the catch was only 0.1427 mg/1 dry weight. Catches of plankton were also greater at B-C in June, August, September and October. The reason for this greater production at the inlet end of the lake is not evident.

The relationship between dissolved nutrients and the level of the standing crop of zooplankton were not obvious. There was some evidence for an inverse relationship between the amount of dissolved inorganic phosphate present in surface layers of Kamloops Lake and the average dry weight of plankton per liter of water in the trophogenic zone; however, the phosphorus cycle in lakes is not well understood (Rigler, 1964).

DISCUSSION

The most outstanding physical feature of Kamloops Lake was the large inflow relative to the size of the basin. This feature alone seemed to determine many of the physical, chemical and biological characteristics of the lake.

Even the establishment of thermal stratification in the spring was caused by the volume and temperature regime of the inflowing Thompson River. This thermal stratification took place earlier in the season than it would have had the energy increase resulted mostly from exchanges at the surface rather than from advected energy. Thus the volume and character of the inflow resulted in a longer growing season.

Vertical density stratification and the density of the incoming water caused the inflow during spring, summer and fall to be restricted to waters above the hypolimnion. Discharge was also drawn from the upper stratum of the lake. In these circumstances, flush rates were very high since the net exchange was restricted to the surface layers. Average residence times during peak inflow periods were less than two weeks and rates of movement were as high as 1.6 miles per day (Table 7).

Another possible result of high inflows during the growing season was the dilution of nutrients in the trophogenic zone. In the spring, inflowing water was largely melt water and was probably more dilute in terms of dissolved nutrients than in the fall or winter. Anderson and Pritchard (1951), have noted this dilution effect in waters entering Lake Mead during the spring runoff period. Dilution of surface lake water could limit the growth of zooplankton populations; at least, relative to lakes of similar chemistry and morphometry but with less inflow.

The high flush rate alone might tend to limit biological productivity. McMynn and Larkin (1953) have suggested that high flush rates might have limited the biological productivity in two lakes in British Columbia. Whether or not plankton population growth is limited directly by rapid, forced emigration from the basin or, more indirectly, by particular chemical or physical features of the inflowing water is not apparent. However, it does seem that relatively low plankton standing crops are associated with rapid rates of water replacement in lake basins.

Considering Kamloops Lake specifically, the temperature of the incoming water during the summer was generally colder than the lake surface. Wind produced mixing of surface water with this cool newly advected water probably caused additional surface cooling and as a result of the large inflow volume, the average surface temperature of the lake was relatively low. For example, the average surface temperature of Kamloops Lake was considerably lower during the summer months than at Shuswap Lake (Table 14).

Another feature of the incoming river water was its high turbidity (Table 15). In conjunction with the other characteristics of the inflow, turbidity might also have acted to limit the standing crop of plankton in Kamloops Lake.

The observed pattern of passage of water through the basin has important implications concerning the distribution and residence time of dissolved and suspended materials. After spring stratification, materials dissolved or suspended in the inflowing water would be rapidly carried through the basin and discharged down the Thompson River at Savona. Meanwhile, materials advected prior to stratification could not be discharged from the hypolimnion until the fall circulation. During most of the winter, based on temperature-density relationships, dissolved and suspended substances would tend to mix throughout most of the volume of the lake.

SUMMARY

As a result of proposed industrial developments in the Kamloops area, a limnological investigation of Kamloops Lake, the basin into which pollutants would be discharged, was started in November, 1962. This basin acts as a rearing area and a migration route for Fraser River sockeye salmon. The purpose of the investigation was to provide background information on the physical, chemical and biological features of the environment.

Kamloops Lake is located in semi-arid plateau country. The basin, of glacial origin, is long, narrow and deep. An outstanding feature of the lake was the high inflow relative to the volume of the lake.

The lake had two periods of circulation, but the method of establishment of thermal stratification in the spring was unusual. Inflowing water became warmer and lighter before the lake surface warmed. As a consequence, inflowing water remained on the surface after entry, eventually sealing off the underlying colder water from the surface. In this way the lake became thermally stratified. In the spring of 1963 it was estimated that it required approximately 36 days for the front of newly warmed advected water to travel the length of the basin to the outlet.

Maximum and minimum residence times of inflowing water during the period from spring stratification to autumn circulation were computed. The true residence times were estimated to be approximately the means of the maximums and minimums. After fall circulation, the lake was virtually of uniform density from surface to bottom, therefore residence times were a function of discharge and total lake volume. Because of the large volume receiving inflow and contributing to discharge and also the low rate of discharge, residence times during the winter were about ten times as long as those during thermal stratification and extended to the subsequent period of thermal stratification.

Except in the deepest parts of the basin near the end of the period of stratification, oxygen levels in Kamloops Lake were largely a function of water temperature. During the whole period of stratification, the major part of the hypolimnion was well oxygenated.

The heavy metal ions lead, zinc and copper were present in Kamloops Lake in very small amounts. Levels of nitrate in the surface waters showed more pronounced variations than in the hypolimnion and the minimum occurred during the summer months. Decline in nitrate in the surface waters may have been caused by dilution by the spring-summer runoff of melt water and the uptake of nitrate by the plankton community.

Levels of inorganic phosphate were lowest both in surface and deep waters during the summer. Cause for the change in phosphate levels was not evident.

The standing crop of net plankton in Kamloops Lake in 1963 was lower than in Shuswap Lake. This lower level of the standing crop seemed to be associated with the amount and character of the inflowing water. During the growing season inflowing water was colder than previously advected lake surface water thus leading to additional cooling. Kamloops Lake surface water was considerably colder and more turbid than Shuswap Lake surface water. These features in conjunction with the brief residence time of surface water in the basin may have accounted for the relatively low standing crop of net plankton. Both catches from horizontal and vertical plankton hauls indicated that the standing crop of plankton was highest in the eastern section of the lake.

The outstanding characteristic of Kamloops Lake was the large volume of inflow relative to the size of the basin. The volume and characteristics of this inflowing water had important immediate effects on the physical, chemical and biological limnology of the basin, accounting for thermal stratification, short residence times for inflowing water, perhaps dilution of dissolved nutrients and, perhaps, the observed relatively low levels of standing crops of net plankton.

Dissolved and suspended substances in newly advected water during the period between spring and fall circulation would tend to travel through the basin rapidly in the surface layers. Similar substances advected during the winter would tend to remain longer and some of this material would be trapped in the hypolimnion during the next period of thermal stratification.

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APPENDIX A

Water Temperatures (°F) at Kamloops Lake Sampling Stations

Station	Depth	Nov. 1962	Jan.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.
A	0	42.3	33.5	38.8	48.5	50.4	56.4	56.0	62.6	58.6	54.3	34.1
B-1	0	46.1	36.2	37.8	46.1	52.0	61.2	60.7	68.5	64.5	56.9	45.8
	10	46.0	36.2	37.8	46.1	50.3	60.3	58.0	66.2	63.0	56.9	45.8
	20	45.9	36.1	37.8	46.1	50.1	58.0	57.9	66.1	63.0	56.8	45.8
	30	45.8	36.1	37.8	46.0	50.0	56.0	57.1	64.5	62.0	56.4	45.8
	40	45.7	36.4	37.8	46.0	49.9	55.9	56.7	63.8	61.1	56.4	45.8
	50	45.7	36.9	37.9	45.8	49.8	55.9	56.2	63.6	60.6	56.1	45.7
	60	45.5	37.0	37.9	45.1	49.8	55.8	56.0	62.8	60.0	56.0	45.6
	70	45.3	37.1	37.9	44.2	49.8	55.6	55.8	61.0	59.6	55.9	45.5
	80	45.0	37.2	37.9	43.0	48.0	54.4	55.7	56.8	56.3	55.8	45.5
	90	44.7	37.3	38.0	41.5	45.3	53.9	55.7	54.0	53.9	55.7	45.5
	100	44.5	37.4	38.1	41.5	44.0	52.5	50.0	52.8	50.4	55.6	45.5
	110	44.5	37.6	38.1	41.4	42.8		47.2	50.8		55.5	45.5
	120	44.1	38.0	38.2		41.5			50.7			45.4
	130	43.8		38.2		41.0						
	140	43.7				40.9						
B-1A	0		36.5	37.3	46.0	51.9	61.4	61.0	69.2	63.5	57.0	45.8
	10		36.5	37.3	45.8	50.5	57.9	59.3	66.8	63.3	57.0	45.8
	20		37.0	37.3	45.7	50.4	57.6	58.8	66.7	63.0	57.0	45.8
	30		37.2	37.3	45.7	50.3	57.5	58.6	66.2	61.9	56.7	45.8
	40		37.2	37.3	45.6	50.2	57.6	58.0	65.8	61.2	56.5	45.8
	50		37.2	37.3	45.5	50.1	57.3	56.7	64.2	61.0	56.3	45.8
	60		36.6	37.4	45.2	50.1	57.9	55.1	61.6	60.8	56.2	45.8
	70		36.0	37.8	45.0	47.5	55.9	54.2	59.0	60.0	56.1	45.8
	80		35.8	37.8	42.0	46.0	54.0	53.9	56.3	58.7	56.1	45.5
	90		35.8	37.9	41.7	44.0	51.2	53.3	55.3	53.5	56.0	45.0
	100		35.9	37.9	41.7	43.2	50.6	52.2	53.2	51.1	55.9	44.4
	110		35.7		41.5	42.2	49.3	50.2	51.5	50.5	55.7	44.0
	120		36.1			41.5	47.5	49.0	51.1		53.0	42.5
	130		37.5			40.8	44.7	45.0	48.0		50.7	42.5
	140						44.9		46.1			
B-2	0	46.0	35.5	37.6	46.5	51.0	62.0	60.9	67.5	63.8	57.0	45.8
	10	46.0	36.0	37.6	46.0	50.5	61.2	60.2	66.2	63.3	57.0	45.8
	20	45.9	36.7	37.6	46.0	50.3	60.6	60.2	66.2	62.8	57.0	45.8
	30	45.9	37.5	37.6	45.7	50.2	59.5	60.1	66.1	62.5	56.7	45.8
	40	45.8	38.2	37.6	45.0	50.1	59.1	57.0	66.0	62.0	56.6	45.8
	50	45.8	38.7	37.6	44.0	50.0	58.0	55.1	64.5	61.4	56.5	45.8
	60	45.7	38.7	37.6	43.0	49.0	55.6	54.2	60.0	61.2	56.4	45.7
	70	45.5	38.7	37.7	42.7	47.4	53.2	54.0	56.9	59.0	56.3	45.4
	80	45.5	38.6	37.7	42.5	46.5	51.9	53.8	56.0	56.1	56.3	44.2
	90	45.3	38.2	37.7	42.3	45.5	51.4	53.1	55.2	53.7	56.1	44.0
	100	45.2	38.2	37.7	41.7	43.9	50.7	51.7	53.2	52.0	55.9	44.6
	110	44.8	37.9	37.9	41.5	42.8	50.1	49.7	51.5		55.8	41.9
	120	44.5	37.9	38.0	41.2	41.2	48.5	47.0	51.0		55.2	
	130	44.0	38.0	38.0	41.0	40.9	47.0	45.5	48.1		55.0	
	140	44.0	38.0	38.0	40.7		46.0	42.6	45.4			
	150			38.0	40.5		43.0	42.1				

Appendix A (Continued)

Water Temperatures (°F) at Kamloops Lake Sampling Stations

Station	Depth	Nov. 1962	Jan.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.
B-2A	0		35.4	37.0	46.7	50.9	62.2	61.2	67.3	64.2	57.0	45.9
	10		36.2	37.0	46.7	50.6	61.8	60.0	66.3	63.7	57.0	45.9
	20		38.5	37.0	46.5	50.3	61.3	59.3	66.2	63.1	57.0	45.9
	30		38.6	37.0	46.0	50.2	60.5	59.0	66.1	62.9	56.8	45.9
	40		38.6	37.1	45.0	50.0	59.7	56.0	65.9	62.6	56.5	45.9
	50		38.6	37.1	43.5	49.9	57.1	55.1	63.3	62.1	56.4	45.9
	60		38.7	37.2	43.0	48.5	53.7	54.4	60.0	61.9	56.4	45.9
	70		38.7	37.2	42.9	47.0	52.1	54.0	57.2	59.8	46.4	45.9
	80		38.7	37.2	42.3	46.0	51.3	53.9	56.6	56.0	56.2	45.9
	90		38.8	37.2	42.1	43.3	51.1	53.5	55.2	53.5	56.0	45.9
	100		38.8	37.2	41.6	42.5	50.6	52.3	53.7	52.0	55.9	45.1
	110		38.8	37.2	41.6	41.8	50.0	50.6	51.8	51.5	54.5	44.6
	120		38.8	37.2	41.5	41.0	48.7	49.2	51.0	49.0	53.0	44.0
	130		38.9	37.3	41.2	40.9	47.2	46.0	47.8	47.0	43.2	42.6
	140			37.3	41.2	40.8	46.3	42.3	45.5			39.8
	150						43.5		42.8			
B-3	0	46.5	36.5	37.1	45.4	52.0	62.2	62.0	67.9	64.5	57.0	46.0
	10	46.5	37.0	37.0	45.0	50.5	62.0	61.2	66.2	63.6	57.0	46.0
	20	46.5	38.0	37.0	44.8	50.2	61.5	61.3	66.1	63.5	57.0	46.0
	30	46.3	38.5	37.0	44.3	50.0	59.0	58.8	66.0	63.2	56.9	46.0
	40	46.3	38.7	37.0	43.5	49.8	57.0	56.6	65.8	63.0	56.9	46.0
	50	46.2	38.7	37.0	43.0	49.5	54.5	55.7	64.9	62.5	56.8	46.0
	60	46.2	38.8	37.0	42.7	49.0	53.0	54.8	60.2	62.0	56.7	46.0
	70	46.2	38.8	37.2	42.4	48.0	52.0	54.3	58.3	57.9	56.7	46.0
	80	46.1	38.9	37.3	42.2	46.0	51.5	54.0	56.2	55.0	56.6	45.5
	90	46.1	38.9	37.4	42.0	43.5	51.4	53.7	55.0	53.0	56.5	45.1
	100	46.1	38.9	37.5	41.8	42.5	51.1	52.6	53.7	52.6	56.1	43.7
	110	46.0	38.9	37.5	41.5	41.7	50.4	50.5	51.6	51.6	53.8	42.8
	120	46.0	39.0	37.5	41.2	41.2	49.1	48.3	50.1	49.7	45.9	42.6
	130	45.9	39.0	37.6	41.1	41.0	48.0	43.2	47.8	46.1	43.2	41.7
	140	45.8		37.7	41.0	40.2	45.7	42.2	46.3		41.8	41.5
	150	45.5		37.8	41.0		41.3					
	160	45.0		37.8								
C-1	0	46.5	36.1	36.7	46.0	50.8	61.0	66.0	67.0	63.8	56.5	44.2
	10	46.5	36.1	36.7	45.9	50.4	60.3	61.4	66.9	63.8	56.5	44.2
	20	46.5	36.1	36.7	45.7	50.3	59.7	60.5	66.3	63.8	56.5	44.2
	30	46.5	36.1	36.7	45.2	50.2	59.2	59.8	66.0	63.4	56.5	44.2
	40	46.4	36.3	36.7	44.1	50.0	58.1	59.2	65.4	63.2	56.5	44.2
	50	46.4	36.4	36.7	43.7	49.0	56.8	57.5	63.8	62.5	56.4	44.2
	60	46.3	36.6	36.7	43.5	47.6	55.6	55.7	60.5	62.3	56.4	44.2
	70	46.2	36.7	36.7	43.0	47.5	54.0	54.9	58.3	61.9	56.3	44.2
	80	46.1	36.9	36.7	42.0	46.5	53.2	54.4	56.3	59.7	56.2	44.2
	90	46.0	37.0	36.7	41.5	45.0	52.5	53.7	55.0	58.5	56.2	44.2
	100	45.9	37.5	36.7	41.1	42.5	50.8	51.5	53.8	54.0	56.1	44.2
	110	45.8	37.6	36.7	40.9	42.3	48.6	49.2	52.8	50.0	53.9	44.2
	120	45.6	37.6	36.7	40.5	41.8	47.5	47.3	51.3	46.0	51.0	43.5
	130	45.5	37.7	36.8	40.1	41.2	46.3	46.1	49.8	43.5	44.5	43.1
	140	45.3	37.9	36.9	39.8	40.5	45.4	44.4	46.0	42.5	43.1	42.9
	150	45.3	38.0	37.0	39.8	40.4	43.3	43.0	43.5	41.4		

Appendix A (Continued)

Water Temperatures (°F) at Kamloops Lake Sampling Stations

Station	Depth	Nov. 1962	Jan.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.
C-1	160	45.0	38.2	37.0	39.7	40.2	42.4	41.9	42.3	41.0	41.4	42.2
	180	43.0	38.5	37.0	39.7	40.0	40.7	40.3	40.9	40.5	40.9	42.1
	200	42.0	38.5	37.0	39.7	39.8	40.5	40.2	40.3	40.3	40.4	42.0
	220	41.3	38.7	37.0	39.7	39.7	40.2	40.2	40.0	40.2	40.2	41.5
	240	40.8	38.8	37.0	39.7	39.7	40.1	40.2	39.9	40.1	40.0	41.5
	260	40.6	39.0	37.0	39.7	39.6	40.1	40.0	39.9	40.1	40.0	41.5
	280	40.4	39.0	37.0	39.7	39.6	40.0	40.0	39.9	40.0	39.9	41.5
	300	40.3	39.0	37.0	39.6	39.6	40.0	39.9	39.8	39.9	39.8	41.6
	320	40.2	39.0	37.0	39.6	39.6	40.0	39.8	39.7	39.8	39.7	41.5
	340	40.1	39.0	37.0	39.6	39.5	39.9	39.8	39.6	39.7	39.7	41.6
	360	39.9	39.0	37.0	39.5	39.5	39.9	39.7	39.5	39.6	39.6	41.5
	380	39.9	38.9	37.1	39.5	39.4	39.6	39.6	39.5	39.5	39.5	41.4
	400	39.8		37.2	39.5	39.2	39.5	39.5	39.5	39.5	39.5	41.4
C-2	0	46.3	36.5	36.8	46.5	51.6	61.2	66.2	67.2	63.5	57.2	44.5
	10	46.3	36.7	36.8	46.0	49.4	61.2	61.7	66.6	63.6	57.1	44.5
	20	46.3	36.9	36.8	45.8	48.0	60.1	61.2	66.5	63.6	56.8	44.5
	30	46.2	37.0	36.8	44.7	45.0	59.8	59.7	66.2	63.5	56.5	44.5
	40	46.2	37.0	36.8	44.0	44.5	58.7	58.4	65.8	63.2	56.5	44.5
	50	46.2	37.1	36.8	43.7	43.2	56.7	56.3	62.5	62.7	56.5	44.5
	60	46.2	37.5	36.8	43.2	42.7	55.5	55.9	58.6	62.5	56.4	44.4
	70	46.2	38.0	36.8	42.8	42.4	53.5	55.6	56.8	62.1	56.3	43.8
	80	46.2	38.2	36.8	42.5	41.3	52.6	53.7	56.0	59.5	56.3	43.4
	90	46.2	38.3	36.8	41.7	41.0	51.7	52.8	55.0	56.0	56.2	43.2
	100	46.2	38.5	36.8	41.3	40.4	50.6	51.2	53.2	53.5	56.0	43.0
	110	46.1	38.5	36.8	41.0	40.2	49.5	49.5	52.0	50.5	54.0	42.8
	120	45.9	38.6	36.8	40.5	40.0	48.3	47.9	50.5	47.0	50.0	42.7
	130	45.7	38.7	36.8	40.0	40.0	46.2	46.0	48.8	44.5	45.0	42.5
	140	45.5	38.9	36.9	40.0	39.7	45.2	45.0	45.5	43.0	43.0	42.3
	150	45.3	39.0	36.9	39.9	39.6	43.9	42.5	43.7	41.9		
	160	45.0	39.0	36.9	39.8	39.6	43.3	41.5	41.9	41.5	41.6	42.4
	180	42.5	39.1	36.9	39.7	39.5	40.9	40.5	40.7	40.6	40.9	42.3
	200	41.5	39.1	37.0	39.6	39.5	40.7	40.3	40.1	40.5	40.5	42.2
	220	41.0	39.0	37.0	39.6	39.5	40.3	40.0	39.8	40.2	40.3	42.2
	240	40.7	39.0	37.0	39.6	39.5	40.3	39.9	39.7	40.0	40.1	42.1
	260	40.5	39.0	37.0	39.6	39.4	40.4	39.8	39.6	39.9	40.0	42.1
	280	40.3	39.0	37.0	39.6	39.4	40.3	39.8	39.6	39.8	39.9	42.1
	300	40.2	39.0	37.0	39.5	39.4	40.2	39.7	39.5	39.7	39.8	42.0
	320	40.0	39.0	37.0	39.5	39.2	40.2	39.5	39.4	39.7	39.8	42.0
	340	40.0	39.0	37.0	39.4	39.2	40.2	39.4	39.3	39.5	39.8	41.9
	360	39.9	39.0	37.2	39.4	39.2	39.8	39.4	39.2	39.5	39.7	41.8
	380	39.9	39.0	37.2	39.3	39.1	39.7	39.4	39.2	39.5	39.6	41.7
	400	39.8	39.0	37.3	39.2	39.1	39.6	39.4	39.2	39.5	39.5	41.7
C-3	0	46.5	36.5	36.8	46.5	52.0	61.5	66.0	67.9	63.6	57.4	44.8
	10	46.5	36.6	36.8	46.0	51.2	61.1	61.2	67.3	63.6	57.4	44.8
	20	46.5	36.7	36.8	45.8	50.5	60.8	61.0	67.1	63.6	57.3	44.8
	30	46.5	37.0	36.8	45.0	49.8	60.2	60.5	66.7	63.6	57.1	44.7
	40	46.5	37.5	36.8	43.2	49.5	58.1	58.0	66.0	63.5	57.0	44.4
	50	46.5	38.0	36.8	42.7	48.7	55.7	56.1	62.5	63.2	57.0	44.0

Appendix A (Continued)

Water Temperatures (°F) at Kamloops Lake Sampling Stations

Station	Depth	Nov. 1962	Jan.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.
C-3	60	46.5	38.4	36.8	42.6	47.8	54.3	55.0	59.0	63.0	56.9	43.8
	70	46.5	38.5	36.8	42.5	46.5	53.1	54.9	57.2	61.5	56.3	43.8
	80	46.5	38.5	36.8	42.2	45.7	52.3	53.5	56.2	57.3	56.3	43.3
	90	46.5	38.5	36.8	42.0	45.0	51.9	52.5	55.0	55.1	56.3	42.9
	100	46.5	38.6	36.8	41.5	44.8	50.6	51.6	53.7	52.8	56.2	42.5
	110	46.4	38.7	36.8	41.0	44.3	49.7	50.9	52.5	50.4	55.0	42.5
	120	46.3	38.8	36.8	40.1	43.2	48.8	48.3	50.7	49.1	50.0	42.4
	130	46.3	38.9	36.8	40.0	42.1	47.8	46.7	48.0	45.0	44.8	42.3
	140	46.2	39.0	36.8	39.9	41.0	44.8	43.8	46.0	42.8	43.4	42.3
	150	43.2	39.0	36.8	39.8	41.2	42.8	42.7	43.3	41.7		
	160	42.8	39.1	36.8	39.6	40.9	41.6	41.4	42.0	41.3	42.0	42.2
	180	42.2	39.1	36.8	39.5	40.1	40.6	40.5	40.8	40.5	41.0	42.1
	200	41.9	39.1	36.9	39.5	40.0	40.2	40.1	40.4	40.2	40.8	42.1
	220	41.3	39.1	36.9	39.2	39.9	40.1	40.0	40.2	40.1	40.3	42.1
	240	41.0	39.1	36.9	39.0	39.8	40.0	39.9	40.1	40.0	40.2	42.1
	260	40.7	39.1	37.0	39.0	39.8	40.0	39.8	40.0	39.9	40.1	42.0
	280	40.3	39.1	37.2	39.3	39.6	40.0	39.7	40.0	39.8	40.1	42.0
	300	40.3	39.0	37.3	39.3	39.6	40.0	39.6	39.9	39.7	40.0	42.0
	320	40.0	39.0	37.3	39.3	39.6	39.7	39.5	39.8	39.7	40.0	42.0
	340	39.8	39.0	37.3	39.2	39.5	39.4	39.4	39.6	39.6	39.8	41.9
	360			37.3	39.1	39.5	39.4		39.5		39.8	41.9
	380				39.0				39.5		39.8	
	400				39.0							
G-1	0				44.5	52.0	64.0	63.7	69.4	64.5	58.7	
	10				39.7	49.5	59.1	60.9	66.8	64.2	57.2	
	20				39.4	48.0	58.0	60.6	66.6	64.0	57.1	
	30				39.4	47.5	57.8	60.0	65.6	63.8	57.0	
	40				39.4	46.3	55.7	59.3	65.5	63.6	56.9	
	50				39.4	44.7	54.8	59.0	65.3	63.5	56.8	
	60				39.4	44.2	54.6	58.6	64.0	63.5	56.7	
	70				39.4	43.0	54.4	57.3	62.9	62.5	56.6	
	80				39.4	42.0	53.1	54.1	61.5	60.6	56.6	
	90				39.4	41.4	52.3	53.7	58.3	59.5	56.2	
	100				39.4	40.7	50.4	53.3	55.0	56.3	55.0	
	110				39.4	40.6	47.4	52.7	50.9	51.5	54.5	
	120				39.4	40.3	45.6	51.0	47.5	46.5	54.0	
	130				39.4	40.2	43.5	49.5	44.5	43.2	47.0	
	140				39.4	40.0	42.0	45.5	43.2	42.0	45.0	
	150				39.4	39.9	41.2	42.8	41.3	41.3	43.0	
	160				39.4	39.8	40.8	41.3	40.8	40.8	41.9	
	180				39.3	39.7	40.3	40.1	40.2	40.5	41.0	
	200				39.2	39.5	39.8	39.7	39.9	40.0	40.4	
	220				39.2	39.4	39.9	39.6	39.8	39.9	40.1	
	240				39.2	39.3	39.8	39.5	39.8	39.8	40.1	
	260				39.2	39.3	39.8	39.5	39.7	39.7	40.0	
	280				39.2	39.3	39.7	39.4	39.7	39.7	39.9	
	300				39.2	39.2	39.5	39.3	39.6	39.7	39.8	
	320					39.2	39.5				39.8	
	340						39.5				39.7	
	360										39.6	
	380										39.5	
	400										39.5	

Appendix A (Continued)

Water Temperatures (°F) at Kamloops Lake Sampling Stations

Station	Depth	Nov. 1962	Jan.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.
G-2	0			36.8	46.5	51.0	64.9	63.3	69.4	64.1	58.8	
	10			36.8	39.4	48.2	59.3	60.6	66.8	64.0	57.2	
	20			36.8	39.4	47.0	57.9	60.4	66.6	64.0	57.2	
	30			36.8	39.4	46.2	56.9	60.3	65.6	63.9	57.1	
	40			36.8	39.4	45.2	55.7	60.0	65.5	63.8	57.1	
	50			36.8	39.4	44.0	53.8	59.5	65.3	63.8	56.9	
	60			36.8	39.4	42.9	53.8	59.0	64.0	63.6	56.9	
	70			36.8	39.4	42.3	53.2	56.5	62.9	63.4	56.9	
	80			36.8	39.4	41.7	52.7	54.0	61.5	62.2	56.9	
	90			36.8	39.2	41.0	51.5	52.7	58.3	58.5	56.4	
	100			36.8	39.2	40.8	48.8	52.5	55.0	54.8	55.6	
	110			36.8	39.2	40.6	47.1	51.6	50.9	48.8	54.5	
	120			36.8	39.2	40.5	45.8	49.7	47.5	45.6	51.0	
	130			36.8	39.2	40.3	43.7	47.5	44.5	44.0	47.0	
	140			36.8	39.2	40.2	42.5	45.0	43.2	42.6	45.0	
	150			36.8	39.2	40.1	41.8	43.3	41.3	41.5	43.3	
	160			36.8	39.2	40.0	41.2	42.0	40.8	41.0	42.5	
	180			36.8	39.2	39.9	40.3	40.5	40.2	40.5	41.1	
	200			36.8	39.2	39.8	40.0	40.0	39.9	40.2	40.6	
	220			36.8	39.0	39.7	40.0	39.8	39.8	40.1	40.5	
	240			36.8	39.0	39.5	39.7	39.7	39.8	39.9	40.3	
	260			36.8	39.0	39.4	39.6	39.5	39.7	39.8	40.1	
	280			36.8	39.0	39.2	39.6	39.5	39.7	39.8	40.0	
	300			36.8	39.0	39.0	39.5	39.4	39.6	39.7	40.0	
	320			36.8	39.0	39.0	39.5	39.3		39.7	39.9	
	340			36.9	39.0	39.0	39.5	39.3		39.7	39.8	
	360			37.1	39.0	39.0	39.5	39.2		39.6	39.8	
	380			37.2	39.0	39.0	39.5	39.2		39.6	39.8	
	400			37.3	39.0	39.0	39.5	39.2		39.6	39.7	
G-3	0				45.5	50.2	67.4	63.3	69.4	64.5	58.8	
	10				39.8	47.8	60.5	60.9	66.9	64.2	57.2	
	20				39.8	47.0	58.1	60.7	66.7	64.0	57.2	
	30				39.8	46.3	57.0	60.6	66.5	64.0	57.1	
	40				39.8	45.5	55.2	60.3	66.1	64.0	57.1	
	50				39.8	44.2	53.9	59.5	64.6	64.0	56.9	
	60				39.8	43.5	53.7	59.0	64.0	63.9	56.9	
	70				39.7	42.6	53.2	57.0	59.2	63.6	56.9	
	80				39.6	42.3	52.4	54.9	57.0	63.1	56.9	
	90				39.6	41.5	50.7	53.9	56.7	61.0	56.4	
	100				39.5	41.2	49.5	53.0	54.9	56.0	55.6	
	110				39.5	41.1	48.6	51.6	53.3	50.0	54.5	
	120				39.5	41.0	47.0	50.2	51.5	46.0	51.0	
	130				39.4	40.9	44.0	49.0	49.0	44.2	47.0	
	140				39.4	40.5	42.8	45.2	46.9	42.9	45.0	
	150				39.4	40.3	41.6	43.6	44.2	41.5	43.3	
	160				39.4	40.0	41.0	42.2	42.3	41.3	42.5	
	180				39.4	39.8	40.7	40.8	41.0	40.3	41.1	
	200				39.2	39.5	40.5	40.4	40.0	40.2	40.6	
	220				39.2	39.4	40.2	40.0	39.8	40.1	40.5	

Appendix A (Continued)

Water Temperatures (°F) at Kamloops Lake Sampling Stations

Station	Depth	Nov. 1962	Jan.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.
G-3	240				39.2	39.3	40.0	39.9	39.8	40.0	40.3	
	260				39.2	39.3	39.8	39.9	39.6	40.0	40.1	
	280				39.2	39.1	39.7	39.7	39.5	40.0	40.0	
	300				39.1	39.0	39.7	39.6	39.5	40.0	40.0	
	320				39.0	39.0	39.6	39.5	39.4	40.0	39.9	
	340				39.0	39.0	39.5	39.5	39.4	39.8	39.8	
	360				39.0	39.0	39.4	39.4	39.4	39.6	39.8	
	380				39.0	39.0	39.4	39.4	39.4	39.6	39.8	
	400							39.4		39.6	39.7	
D-1	0	47.2	38.8	37.2	40.0	55.0	60.0	68.7	67.0	64.5	58.0	44.2
	10	47.2	38.8	37.1	39.0	50.3	59.2	61.9	66.8	64.0	58.0	44.2
	20	47.2	38.8	37.0	39.0	50.0	58.6	60.4	65.6	63.7	58.0	44.2
	30	47.2	38.9	36.9	39.0	49.2	58.3	59.0	65.1	63.6	58.0	44.2
	40	47.2	38.9	36.9	39.0	48.8	57.0	58.0	65.0	62.5	57.8	44.2
	50	47.2	38.9	36.9	39.0	47.0	54.2	57.6	64.0	62.3	57.5	44.2
	60	47.2	38.9	36.9	39.0	46.0	54.0	56.9	62.6	62.0	57.3	44.2
	70	47.2	38.9	36.9	39.0	45.0	53.7	56.8	61.5	61.7	56.2	44.2
	80	47.2	38.9	36.9	39.0	44.5	53.6	55.5	60.5	61.5	54.1	44.2
	90	46.9	38.9	36.9	39.0	43.8	52.8	55.1	59.1	59.0	53.2	44.2
	100	45.7	38.9	36.9	39.0	42.3	52.0	53.7	57.2	57.0	52.7	44.2
	110	45.0	38.9	36.9	39.0	41.9	50.0	52.7	53.5	54.7	50.1	44.1
	120	44.9	38.9	36.9	39.0	41.6	48.3	50.0	49.9	50.0	49.1	44.0
	130	44.7	38.9	36.9	39.0	41.5	46.8	47.0	47.2	45.5	45.0	44.0
	140	44.5	38.9	36.9	39.0	41.0	43.1	44.5	46.0	43.0	43.5	43.9
	150	44.0	38.9	36.9	39.0	40.9	41.9	42.3	44.4	42.0		
	160	43.8	38.9	36.9	39.0	40.8	41.0	41.0	43.0	41.5	41.2	43.8
	180	43.0	39.0	36.9	39.0	40.5	40.2	40.0	41.0	40.6	40.8	43.8
	200	42.1	39.2	36.9	39.0	40.0	39.8	39.6	40.4	40.2	40.7	43.8
	220	41.7	39.2	36.9	39.0	40.0	39.7	39.6	40.0	40.0	40.3	43.7
	240	41.2	39.3	36.9	39.0	40.0	39.5	39.5	39.9	40.0	40.0	43.7
	260	40.8	39.3	36.9	39.2	39.6	39.4	39.4	39.8	39.9	39.9	43.7
	280	40.7	39.2	36.9	39.2	39.5	39.4	39.3	39.7	39.9	39.9	43.7
	300	40.7	39.1	36.9	39.2	39.4	39.3	39.3	39.7	39.8	39.9	43.7
	320		39.1	36.9	39.1	39.4	39.3	39.2		39.7	39.8	43.0
	340			36.9	39.0			39.2		39.7	39.8	42.0
	360			36.9	38.9			39.2			39.7	41.8
	380			36.9								41.6
	400											41.5
D-2	0	47.3	38.6	37.5	42.0	54.9	60.3	66.9	67.3	63.9	58.1	43.6
	10	47.3	38.5	37.0	39.0	51.7	60.1	62.0	67.3	63.7	58.2	43.6
	20	47.3	38.5	37.0	39.0	50.7	59.8	59.9	66.5	63.6	58.2	43.6
	30	47.3	38.4	37.0	39.0	46.0	59.5	58.5	66.2	63.5	58.2	43.5
	40	47.3	38.4	36.9	39.0	44.2	58.0	58.0	64.9	63.2	58.3	43.5
	50	47.3	38.4	36.8	39.0	43.0	54.9	57.4	62.9	62.3	58.3	43.5
	60	47.2	38.5	36.8	39.0	42.0	54.0	57.0	62.1	61.9	58.1	43.5
	70	47.2	38.5	36.8	39.0	41.2	53.2	56.6	61.8	61.6	57.8	43.5
	80	47.2	38.5	36.8	39.0	41.0	53.0	55.8	59.7	61.0	55.0	43.5
	90	47.0	38.5	36.8	39.0	40.9	52.2	54.9	57.5	60.0	52.8	43.5
	100	46.5	38.5	36.8	39.0	40.9	51.3	52.9	57.0	58.0	52.2	43.5
	110	45.5	38.5	36.8	39.0	40.8	50.4	51.6	53.8	55.0	50.3	43.5

Appendix A (Continued)

Water Temperatures (°F) at Kamloops Lake Sampling Stations

Station	Depth	Nov. 1962	Jan.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.
D-2	120	44.9	38.5	36.8	39.0	40.3	49.8	50.9	49.0	48.2	48.0	43.5
	130	44.5	38.5	36.8	39.0	40.2	46.5	47.9	47.1	46.0	44.9	43.5
	140	44.2	38.5	36.8	39.0	39.8	43.0	45.0	46.2	44.0	43.9	43.5
	150	43.7	38.6	36.8	39.0	39.7	41.1	42.8	44.1	42.0		
	160	43.6	38.6	36.8	39.0	39.6	40.8	41.3	42.5	41.5	41.5	43.5
	180	42.5	38.7	36.8	39.0	39.6	40.2	40.2	41.1	40.9	40.7	43.5
	200	42.0	39.0	36.8	39.0	39.6	40.0	39.8	40.7	40.4	40.2	43.5
	220	41.8	39.1	36.8	39.0	39.6	40.0	39.5	40.2	40.0	40.2	43.4
	240	41.0	39.1	36.8	39.0	39.5	39.9	39.3	40.0	39.9	40.2	43.4
	260	40.7	39.3	36.8	39.0	39.5	39.8	39.3	40.0	39.8	40.1	43.1
	280	40.4	39.4	36.8	39.0	39.5	39.7	39.3	39.9	39.7	40.0	43.0
	300	40.3	39.2	36.8	39.0	39.5	39.7	39.3	39.9	39.6	39.9	42.9
	320	40.2	39.2	36.8	39.0	39.5	39.5		39.8	39.6	39.8	42.7
	340	40.2	39.2	36.8			39.4		39.8	39.6		42.5
	360								39.7			
D-3	0	47.0	38.1	36.9	39.0	54.5	61.4	66.9	67.8	63.7	58.0	43.9
	10	47.0	38.1	36.9	39.0	51.3	61.1	62.0	67.6	63.7	58.0	43.9
	20	47.0	38.0	36.9	39.0	51.0	60.9	59.9	67.3	63.5	58.0	43.9
	30	47.0	38.0	36.9	39.0	50.0	60.3	59.2	67.2	63.4	58.1	43.9
	40	47.0	38.0	36.9	39.0	42.5	60.1	57.7	67.0	63.4	58.2	43.8
	50	47.0	38.0	36.9	39.0	41.6	54.7	56.9	63.5	63.1	58.2	43.8
	60	47.0	38.0	36.9	39.0	41.0	53.8	56.6	61.0	62.3	58.2	43.8
	70	47.0	38.0	36.9	39.0	41.0	52.7	56.1	60.2	61.8	58.1	43.8
	80	46.5	38.0	36.9	39.0	40.7	52.0	55.5	59.1	59.9	56.0	43.8
	90	46.0	38.0	36.9	39.0	40.5	51.6	55.1	57.2	59.4	52.2	43.7
	100	45.2	38.0	36.9	39.0	40.6	50.9	53.3	54.9	57.7	51.6	43.6
	110	44.6	38.0	36.9	39.0	40.4	49.6	51.5	53.2	52.0	49.2	43.6
	120	44.3	38.0	36.9	39.0	40.3	47.5	50.1	51.0	49.5	47.5	43.5
	130	44.3	38.0	36.9	39.0	40.0	44.5	47.9	48.5	45.0	44.2	43.5
	140	44.0	38.0	36.9	39.0	39.7	41.7	45.2	46.2	43.0	43.0	43.5
	150	43.7	38.0	36.9	39.0	39.7	40.7	43.3	44.9	41.7		43.5
	160	43.4	38.0	36.9	39.0	39.6	40.3	41.9	42.5	41.2	41.8	43.5
	180	42.8	38.0	36.9	39.0	39.6	40.0	40.5	41.3	40.6	40.7	43.5
	200	42.7	38.0	36.9	39.0	39.5	39.7	39.7	40.9	40.2	40.2	43.5
	220	42.3	38.0	36.9	38.6	39.5	39.5	39.2	40.4	39.9	40.0	43.4
	240	41.8			38.8	39.4	39.5	39.1	39.9	39.9	39.9	43.4
E-1	0	46.8	38.5	37.2	39.0	54.8	56.8	66.8	66.1	64.3	58.8	43.0
	10	46.8	38.5	37.2	39.0	50.0	56.7	65.5	65.9	63.8	57.6	43.0
	20	46.8	38.5	37.1	39.0	49.5	56.5	59.5	65.1	63.6	57.4	43.0
	30	46.8	38.5	37.1	39.0	49.0	55.9	58.8	64.5	63.5	56.3	43.0
	40	46.7	38.5	37.0	39.0	48.5	55.3	58.4	63.5	63.3	55.6	43.0
	50	46.7	38.5	37.0	39.0	47.0	55.0	57.2	62.8	62.7	55.2	43.0
	60	46.7	38.6	37.1	39.0	46.7	54.6	57.0	62.0	62.3	55.0	43.0
	70	46.7	38.9	37.1	39.0	46.1	53.8	56.0	61.0	61.9	54.6	43.0
	80	46.7	39.0	37.1	39.0	46.0	53.2	55.0	59.5	61.4	54.2	43.0
	90	46.7			39.0	44.8	52.7	54.0	58.1	60.6	51.5	43.0
	100	46.7					52.3	52.6	56.0	58.5	49.3	42.8
	110	46.7					51.2		53.4		46.5	42.6

Appendix A (Continued)

Water Temperatures (°F) at Kamloops Lake Sampling Stations

Station	Depth	Nov. 1962	Jan.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.
E-1	120	46.5					50.0		51.1			42.6
	130	45.0					45.1					42.1
	140	43.9					43.7					42.1
	150	43.8					41.3					42.1
	160	43.5					40.6					
	180	43.3					40.3					
E-2	0	46.8	38.3	37.1	39.0	53.6	57.8	66.9	66.2	64.3	59.0	42.9
	10	46.8	38.4	37.1	39.0	50.0	57.4	65.0	66.0	64.0	57.9	42.9
	20	46.8	38.4	37.1	39.0	49.4	57.0	60.0	65.7	63.8	57.8	42.9
	30	46.8	38.4	37.1	39.0	49.0	55.4	59.2	64.2	63.5	57.2	42.9
	40	46.8	38.4	37.1	39.0	48.3	55.2	59.0	63.7	63.3	56.2	42.9
	50	46.8	38.5	37.1	39.0	46.8	54.8	57.3	63.0	62.7	55.2	42.9
	60		38.5	37.0	39.0	46.8	54.3	57.0	62.0	62.5	55.0	42.9
	70		38.5	37.0	39.0	46.0	53.6	56.2	60.7	61.9	54.7	42.9
	80		38.5	37.0	39.0	45.5	53.1	55.1	59.9	61.6	53.9	42.9
	90		38.5	37.0	39.0	44.5	52.6	54.1	58.6	61.0	52.3	42.9
	100		38.6	37.0	39.0	44.0	51.3	53.0	58.2	59.0	50.2	42.9
	110	38.6	37.0			43.2	48.7	50.9	55.5	53.2	47.2	42.9
	120	38.7	37.0			43.0	47.5	48.0	53.0	50.0	45.6	
	130	38.8				41.6	46.0	45.1	49.0	45.8	44.2	
	140					41.6		43.9		43.8	44.0	
	150					41.6		43.2		43.1		
	160							43.0		42.8	43.7	
	180							42.3		41.9		
E-3	0	46.8	37.0	37.5	39.5	54.0	58.7	66.5	66.1	64.0	58.7	42.8
	10	46.8	37.8	37.3	39.0	49.9	58.3	64.2	66.1	63.5	57.9	42.8
	20	46.8	37.9	37.3	39.0	49.1	57.2	60.9	65.7	63.3	57.8	42.8
	30	46.8	37.9	37.3	39.0	49.0	55.2	59.0	63.7	63.2	57.5	42.8
	40			37.4	39.0	48.5	55.0	58.0	63.4	63.0	55.5	42.7
	50					47.1	54.5	57.3	63.3	62.8		
	60					46.5	54.3					
	70					44.9	53.7					
	80						53.2					
	90						51.3					
	100						50.5					
	110						49.0					
	120						48.2					
	130						44.5					
	140						43.6					
F	0	47.5	38.0	37.6	39.0	49.1	55.0	62.0	64.5	63.0	56.5	44.0