



Water-Supply Bulletin 42, Part 6

DATA ON SELECTED LAKES IN WASHINGTON

Part 6

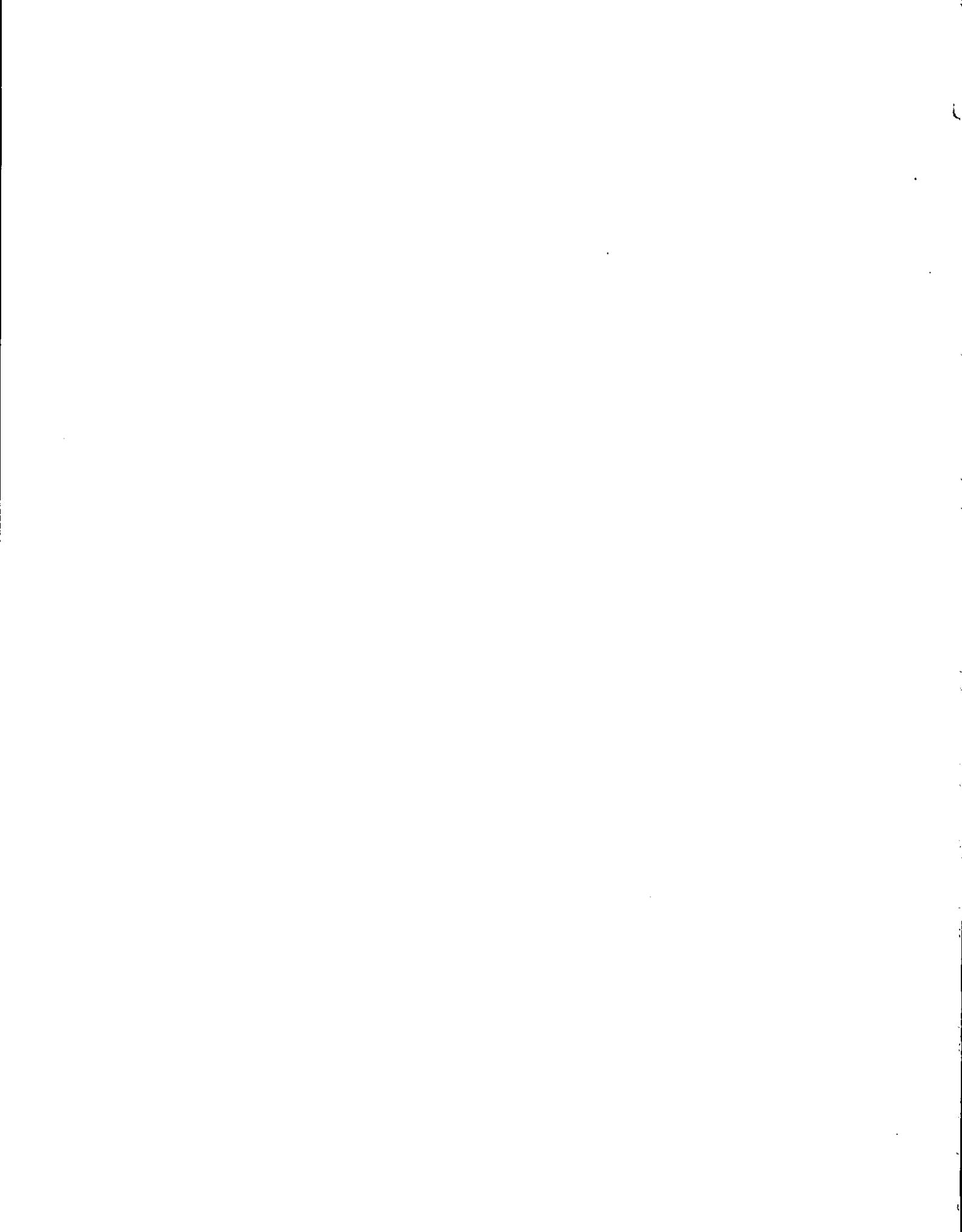


WASHINGTON STATE DEPARTMENT OF ECOLOGY

■ 1980

Prepared cooperatively by the
United States Department of the Interior
Geological Survey





STATE OF WASHINGTON
Dixy Lee Ray, Governor
DEPARTMENT OF ECOLOGY
Wilbur G. Hallauer, Director

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By

N. P. Dion, G. C. Bortleson, and J. K. Innes

of the
United States Geological Survey

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ILLUSTRATION

FIGURE 1. Map showing locations of lakes studied----- 3

METRIC CONVERSION TABLE

<u>Multiply</u>	<u>By</u>	<u>To obtain</u>
foot (ft)	0.3048	meter (m)
acre	0.4047	hectare (ha)
acre	0.004047	square kilometer (km ²)
square mile (mi ²)	2.590	square kilometer (km ²)
acre-foot (acre-ft)	0.001233	cubic hectometer (hm ³)
cubic foot (ft ³)	0.02832	cubic meter (m ³)
cubic foot per second (ft ³ /s)	0.02832	cubic meter per second (m ³ /s)
pound (lb)	0.4536	kilogram (kg)

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ABSTRACT

This report, the sixth in a series, contains physical, chemical, and biological data collected from 24 lakes in eastern and western Washington during 1975. For each lake is given a description of the physical setting, a general discussion of water quality, a bathymetric map, and an aerial photograph. The basic data include depth profiles of dissolved-oxygen concentration and temperature.

INTRODUCTION

Washington has more than 7,800 lakes, ponds, and reservoirs (Wolcott, 1964 and 1965), many of which provide exceptional recreational opportunities and supply water for agricultural, municipal, and industrial purposes. These water bodies constitute an important part of the State's total water resources and are an integral part of the hydrology of many drainage basins. As more demands are placed on these lakes, their basins, or their shorelines, problems of nutrient enrichment and water-quality deterioration become more likely. In order to detect any present or potential conditions of water-quality impairment, it is essential that existing conditions in Washington's lakes be investigated and defined.

Purpose and Scope

Although both the importance and value of the Washington lakes are widely recognized, the quantity and type of information currently available for most of the lakes are not adequate to provide the understanding needed for wise management of the lakes. Thus, the need to obtain additional information about lakes resulted in the initiation in 1970 of a cooperative program between the Washington Department of Ecology and the U.S. Geological Survey, whereby selected lakes in Washington would be investigated.

In general, the study consists of a data-collection program designed to (1) document the present water quality and the overall status of the lakes, and (2) provide basic data pertaining to the physical, cultural, and water-quality characteristics of lakes in order to establish a base of reference that will allow periodic appraisals of future lake conditions.

This is the sixth in a series of reports on selected lakes in Washington. The first five reports (Collings, 1973; Bortleson and others, 1974; Bortleson and others, 1976; McConnell and others, 1976; and Dion and others, 1976) discuss 117 lakes throughout the State, and this report discusses an additional 24 lakes in the State (fig. 1).

Acknowledgments

The authors gratefully acknowledge the assistance of the State of Washington Department of Game for permission to reproduce many of the lake bathymetric maps. Other bathymetric maps were reproduced from reports by Wolcott (1964, 1965) and Canning and others (1976).

Data Collected and Definitions

Most of the field data were collected during (1) the winter water-mixing period; (2) spring, shortly after thermal stratification begins; (3) summer, during advanced thermal stratification; and (4) late summer, at maximum thermal stratification. One lake (Wapato, at Tacoma) was sampled seven times during the February-September period. The sample sites were generally near the deepest part of the lake and are considered to be reasonably representative of the physical and chemical characteristics of the entire lake. Three of the lakes were each sampled at two sites. Data to define variations in temperature and dissolved-oxygen (DO) concentration at different depths were collected in the field with portable instruments. Water samples for mineral, nutrient, pH, and color analyses were collected at depths of 3 feet below the water surface and 4 to 5 feet above the lake bottom. The mineral and nutrient analyses were performed by U.S. Geological Survey laboratories using procedures described by Brown, Skougstad, and Fishman (1970). Analyses for chlorophyll a and fecal-coliform bacteria were performed using procedures described by Slack and others (1973). Samples for algae identification were collected about 1 foot below the lake surface by use of a number 10-mesh size plankton net (160 micrometers). The samples were preserved in Lugol's solution and stored in the dark until examined.

Before presenting the results of each lake survey, an explanation of terms used in describing individual lakes is given below. The definitions of additional limnological and hydrological terms used throughout the report are found in the glossary (p.11). The parameters are discussed in the sequence they appear on the data sheets.

Lake name. The lake name was taken from U.S. Geological Survey topographic maps. In common usage the term "Lake" or "Reservoir" may either precede or follow the proper name. However, throughout this report all water bodies are referred to as "lakes," and the lake's name is given first. The lakes are discussed in alphabetical sequence.

Identification number. The number associated with each lake is in accordance with a numbering system used nationwide by the U.S. Geological Survey to designate data-collection stations in stream basins. Each lake has a unique number which, like the lake name, is a means of identification.

Location. Unless noted otherwise, the location given is for the lake outlet. For lakes without outlets, the southernmost shoreline point is used. Directions and distances from prominent landmarks are provided to aid in rapid, easy location. Latitude, longitude, township, range, section, and altitude were determined from U.S. Geological Survey topographic maps. The name and scale of the topographic quadrangle on which the lake appears, as well as the lake's major drainage system, are indicated.

Physical characteristics of lake. The following physical parameters were determined from a bathymetric map of the lake:

Surface area (A).--The surface area of the lake, in acres, was obtained from planimetry of the lake outline.

Volume (V).--Lake volume, in acre-feet, was obtained by computing and then summing the volumes of each stratum of water between successive contours on the bathymetric map. Because lake volume can vary between seasons and from year to year, the volume figures reported (as well as other morphometric data) are intended only to describe the general size of the lake.

Mean depth (\bar{Z}).--The mean depth, in feet, for a specified lake stage is obtained by dividing the volume of the lake by its area.

Maximum depth (Z_m).--The difference, in feet of elevation, between the bottom and the surface of the lake.

Length of shoreline (L).--The distance around, or perimeter, in miles, of the water surface touching the shore at a specified lake stage.

Shoreline configuration (D_L).--A dimensionless ratio of length of shoreline to the circumference of a circle having an area equal to that of the lake, given as

$$D_L = \frac{L}{2\sqrt{\pi A}}$$

This quantity may be regarded as an index of the geological and littoral processes affecting the shape of the lake.

Nearly circular lakes have values near unity, subcircular lakes have slightly greater D_L values, and elongate lakes have the highest D_L values. High D_L values are common to lakes formed along old drainages or by the damming of streams to form a lake in the valley behind the dam.

High values for shoreline configuration suggest the presence of shallow water and protected bays--areas suitable for plant growth--and also indicate an increase in contact between land and water. Therefore, shoreline configuration is often an indirect indicator of plant growth capacity and enrichment potential from nearshore development and runoff.

Development of volume (D_V).--The development of volume is defined as the ratio of the mean depth (\bar{Z}) to the maximum depth (Z_m). Thus, lakes with a low D_V ratio are usually conical depressions, whereas lakes with high D_V ratio are steep-sided and have flat bottoms. Shallow lakes with large D_V values tend to provide greater opportunity for exposure of bottom sediments to overlying water and for circulation of bottom nutrients.

Bottom slope (Z_r).--The slope profile of a lake bottom, expressed as a percentage ratio of the maximum depth to the mean lake diameter, referred to by Hutchinson (1957, p. 167) as relative depth, given as

$$Z_r = \frac{Z_m \times 50 \times \sqrt{\pi}}{\sqrt{A}}$$

Rooted aquatic plants often grow more profusely in a lake with a gradually sloping bottom than in a deep lake with steep sides.

Drainage basin. The drainage basin is the area that contributes water to the lake.

Size.--The drainage area was delineated on U.S. Geological Survey topographic maps and measured by planimeter. The size of the drainage area is reported in square miles.

Geology.--Information on basin geology was obtained from existing geologic maps and reports.

Soils.--Information on basin soils was obtained from existing soil-survey reports.

Land use.--The drainage basins of the lakes were partitioned into various generalized land-use categories. Values given reflect the percentages of the basin used primarily for forests or for residential urban, residential suburban, or agricultural development. The lake surface is also given as a percentage of the total drainage basin. A general description of the land-use categories is as follows:

- a. Residential urban.--Predominant use is for single-family residences on small lots, where apartment complexes and commercial or industrial activities also may be present.
- b. Residential suburban.--Predominant use is single-family residences.
- c. Agricultural.--Pasture or cropland.
- d. Forest or unproductive.--Public and private forest lands and tree farms. Lands may include cleared or fallow unproductive lands, meadows, wetlands, and seasonal recreational areas.
- e. Lake surfaces.--Includes the surface areas of the lake and upstream tributary lakes.

Nearshore development.

Number of nearshore homes.--The number of nearshore homes was determined from field observations and from aerial photographs.

Nearshore residential development.--The percentage of the shoreline occupied by residential development was determined from field observations and from aerial photographs.

Littoral bottom. The composition of the littoral bottom is given for each lake. The composition of the littoral bottom determines in large part the type and extent of aquatic macrophytes found in that zone.

Hydrology.

Surface-water inflow and outflow.--Miscellaneous measurements of outflow, reported in cubic feet per second (ft^3/s), are given for lakes in which the outflow is controlled by natural conditions; inflow volumes were estimated. All discharge measurements made during the 1975 water year were published by the U.S. Geological Survey (1976).

Lake stage fluctuations.--The maximum variation in lake stage, in feet, is given, based on observations of stage made at the time of lake sampling. The stages of Alta and Pine Lakes are monitored on a daily basis; the lake-stage variations reported for those lakes were the maximum observed in the 1975 calendar year.

Aquatic plants.

Macrophytes.--These are large plants that can be seen without magnification. The rooted aquatic-plant growth was assessed according to the percentage of the shoreline and water-surface area covered by emerged and (or) floating plants and the percentage of the lake bottom covered by submersed plants. Examples of emerged plants include cattails and sedges in which the leaves or other structures extend above the water surface. In this report, rooted aquatic plants with floating leaves, such as waterlilies and watershield, are considered emerged. Submersed plants, such as waterweed and pondweed, complete their life cycle and live entirely under the surface of the water. Most macrophytes were identified to genus level according to the descriptions of Steward, Dennis, and Gilkey (1963) and Fassett (1969).

Algae.--These are small, simple plants that usually cannot be seen without magnification. The algal plant growth was assessed qualitatively by project personnel according to the percentage composition of the sample collected. Algae were identified to genus level according to the descriptions of Smith (1950) and Prescott (1970).

Bathymetric map. Depth-contour maps were prepared either by the State of Washington Department of Game from data obtained by sounding the lake, by the U.S. Geological Survey from data obtained by use of a recording-chart fathometer, or by the modification of maps published in various reports.

The water-quality site (symbol \blacksquare) and fecal-coliform bacteria sampling sites (symbol \bullet) are shown on the bathymetric map of each lake. The presence and location of a public boat access (symbol \blacktriangle) is shown near the shoreline contour of the map. The locations and directions of inflow and outflow streams are shown graphically.

Aerial photograph. Vertical- or oblique-view black-and-white photographs are included for each lake. The date of each photograph is indicated, along with the approximate scale of the vertical-view photographs.

Water-quality data. The water-quality variables measured are reviewed briefly for each parameter.

Major chemical constituents.--In freshwater, the principal cations are calcium, sodium, magnesium, potassium and, to a lesser extent, iron and aluminum. Silicon, too, is abundant in water but almost always occurs as the compound silicon dioxide (silica). These cations are associated with the principal anions--bicarbonate, carbonate, sulfate, chloride, fluoride, and, to a lesser extent, nitrate nitrogen and orthophosphate phosphorus.

Nutrients.--A nutrient is any chemical element, ion, or compound that is required by an organism for the continuation of growth, reproduction, and other life processes. Many elements and compounds act as nutrients to supply the food for aquatic plants. Nitrogen and phosphorus, however, usually are considered the limiting nutrients for aquatic plant growth--algae in particular--and as such received the most emphasis in this study. Whatever nutrient is limiting algal growth, the concentrations of nitrogen and phosphorus are useful in evaluating the trophic conditions of a lake (Lee, 1972). The nutrient concentrations that were determined at top and bottom sampling depths included nitrate, nitrite, ammonia, organic nitrogen, total phosphorus, and orthophosphate phosphorus. Samples collected for orthophosphate analysis were filtered immediately through a 0.45- μ m (micrometer) Millipore¹ filter. The nutrient samples were iced in the field and later refrigerated at 4°C (Celsius) until analyzed.

Suspended solids.--Suspended solids are those retained on a 0.45- μ m filter.

Hardness.--Water hardness is defined as the sum of the polyvalent cations expressed as the equivalent quantity of calcium carbonate (CaCO₃). As a general rule, hard-water lakes are more productive of plants and animals than soft-water lakes, but there are many exceptions.

Specific conductance.--Specific conductance is a measure of the water's ability to conduct an electric current and is used as an approximation of the dissolved-solids concentration in the water.

¹The use of a brand name in this report is for identification purposes only and does not imply endorsement by the U.S. Geological Survey.

pH. --pH is the negative logarithm of the effective hydrogen-ion concentration, expressed as a number from 0 to 14. A pH of 7 is neutral, a pH of less than 7 is acidic, and a pH of greater than 7 is basic.

Color.--Color is one control of light transmission through water. High color values in many lakes result from the decomposition of vegetation, which gives the water a brown, tea-like color. Color is determined by a comparison of the water with standardized colored-glass discs and is reported in platinum-cobalt (Pt-Co) units.

Chlorophyll a.--Chlorophyll a is a green photosynthetic pigment present in plant cells, including algae. The concentration of chlorophyll a in water is a commonly accepted indicator of algal biomass (Lee, 1972). Samples for chlorophyll a (0.5-2 liters) were filtered immediately in the field using a 0.45- μ m Millipore filter. The filters containing the pigment were stored immediately in a dessicator and iced in the field and later stored in a dessicator at -20°C. Analyses were performed on samples from 1 to 20 days after collection.

Fecal coliform bacteria.--Fecal coliforms are that part of the total coliform group derived from the feces of warm-blooded animals, including man; their presence in water generally is accepted as an indicator of recent fecal-waste contamination. Samples were collected approximately 100 feet offshore at a depth of 1 foot at two to five stations at each lake. The sample locations are shown on the bathymetric map. The reporting unit is the number of colonies per 100 milliliters of water.

Total organic carbon.--The amount of organic carbon present in a lake often is related to the primary productivity of the lake. Organic carbon also may be derived from bottom sediments or it may be transported into the lake from outside sources.

Water temperature profiles.--Water temperature, which varies in lakes with depth and time of year, is an important controlling factor for life processes and chemical-reaction rates as well as many physical events that occur in the aquatic environment.

Generally, the water-temperature profiles of the lakes studied show total mixing during the winter--nearly uniform temperatures from top to bottom--and thermal stratification during the summer. Temperature profiles in lakes during midsummer, when thermal stratification may be marked, generally follow one of two common patterns. In shallow lakes, well exposed to the wind, temperatures will be found to be practically constant from top to bottom. This uniformity of temperature indicates that the waters are well mixed throughout. The other common pattern occurs in deeper lakes, where three characteristic thermal layers, or zones, are present: (1) an upper zone (epilimnion) of generally warmer water in which temperature is more or less uniform throughout; (2) an intermediate zone (metalimnion) in which temperature declines rapidly with depth; and (3) a lower zone (hypolimnion) of colder water in which temperature is again more or less uniform throughout.

Of special significance is the temperature of the deep-water layer (hypolimnion) during midsummer because (1) temperature stratification and water circulation affect the vertical distribution of nutrients, and (2) water temperatures affect the potential of cold-water fisheries resources.

Secchi-disc visibility.--Secchi-disc visibility is the depth at which a white-and-black disc (8 inches in diameter) disappears from view when lowered into the water. Secchi-disc visibility depth is a measure of water transparency or clarity. Because changes in biological production can cause changes in the color and turbidity of a lake, Secchi-disc visibility often is used as a gross measure of the plankton in the water.

Dissolved-oxygen profiles.--The concentration of DO in a lake varies with time of year and depth of water and is a function of many factors including the water temperature, atmospheric pressure, and salinity of the water. Also, oxygen in water is continually being altered by life processes, such as photosynthesis and respiration, and by complex chemical reactions. Of special biological significance is the amount of DO in the deep water during midsummer. The organisms in the lighted upper layers of water produce organic matter which settles to the bottom where bacteria consume oxygen to degrade the organic materials, thereby reducing the DO concentration in the hypolimnion. The hypolimnetic-oxygen deficit frequently is related to the production or plant growth in the upper waters (Hutchinson, 1957). For good growth and general health of trout, salmon, and other species of cold-water biota, the DO concentrations should not be less than 6.0 mg/L (milligrams per liter) according to the Federal Water Pollution Control Administration (1968).

GLOSSARY OF LIMNOLOGICAL AND HYDROLOGICAL TERMS

Acre-foot. Volume of water required to cover 1 acre to a depth of 1 foot, and equal to 43,560 ft³.

Algal bloom. A large number—often 0.5 to 1 million cells per liter—of a particular algal species which may form objectionable scums and odors upon decomposition.

Bathymetric. Relating to the measurement of water depths, as for a lake.

Epilimnion. The upper, relatively warm, circulating zone of water in a thermally stratified lake.

Flushing rate. The rate at which the water volume of a lake is replaced as a result of inflows and outflows.

Genus, genera. The taxonomic category below family, consisting of one to many species.

Hypolimnion. The lower, relatively cold, non-circulating water zone in a thermally stratified lake.

Intermittent or seasonal stream. Flows at certain times of the year when it receives water from springs or from some surface source, such as melting snow in mountainous areas.

Limnology, limnological. The study of freshwater, especially that of lakes.

Littoral. The shoreward region of a body of water.

Lugol's solution. A preserving solution for algae made from iodine crystals, potassium iodide, glacial acetic acid, and distilled water.

Metalimnion. The middle layer of water in a thermally stratified lake, in which temperature decreases rapidly with depth.

Morphometry. Definition of physical shape and size, as of a water body.

Muck. A mixture containing highly decomposed organic material in which the original plant parts are not recognizable. Contains more mineral matter, and is usually darker, than peat.

Planimetry. Relating to the measurement of areas.

Plankton. Suspended organisms that drift with the water currents.

Production, productivity. The total amount of living matter produced in an area per unit time regardless of the fate of the living matter.

Secchi disc. A metal disc 8 inches in diameter and painted in white and black alternating quadrants, used to measure light transparency in lakes.

Thermal stratification. A temperature distribution characteristic of many lakes in which the water is separated into three horizontal layers: A warm epilimnion at the top, a metalimnion in which the temperature changes rapidly with depth, and a cold hypolimnion at the bottom.

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LAKE DATA

Alta Lake near Pateros (12450000)Location.

3.5 miles southwest of Pateros; Okanogan County. Lat 48°00'42", long 119°56'19"; SE¼NW¼ sec.15. T.29 N., R.23 E.; location is for southernmost shoreline point of lake. Columbia River basin; 1,163 feet altitude. Brewster quadrangle (1:62,500 scale).

Physical characteristics of lake.

Surface area-----	180 acres	Length of shoreline-----	2.9 miles
Volume-----	7200 acre-ft	Shoreline configuration-----	1.5
Mean depth-----	39 ft	Development of volume-----	0.50
Maximum depth-----	79 ft	Bottom slope-----	2.5 percent

Drainage basin.

Size: 5.01 mi².

Geology: Predominantly metamorphic rock (Huntting and others, 1961).

Soils: Shallow to deep loams, silt loams, and sandy loams (U.S. Soil Conservation Service, 1968).

Land use	Percent
Urban	0
Suburban	0
Agricultural	.14
Forest or unproductive	80
Lake Surface	6

Nearshore development.

Number of nearshore homes: 21

Nearshore residential development: 19 percent

Littoral bottom.

Predominantly rock, gravel, and sand, with local areas of silt and muck.

Hydrology.

The lake has no natural surface-water inflow or outflow; there is some diversion out of the lake for irrigation and domestic uses, and since 1973 water has been pumped out of the Methow River into Alta Lake to maintain the stage.

The U.S. Geological Survey has monitored the lake stage since 1954. In 1975 the lake stage rose 5.7 feet from Jan 1 to Dec 21.

Aquatic Plants.

Shoreline-----	51-76 percent
Lake surface-----	1-10 percent
Lake bottom-----	26-50 percent

Macrophytes observed (8/1/75): bulrush (*Scirpus* sp.)*, muskgrass (*Chara* sp.)*, smartweed (*Polygonum* sp.), cattail (*Typha* sp.), sedge (*Cyperaceae*), coontail (*Ceratophyllum* sp.), and water milfoil (*Myriophyllum* sp.).

*Asterisk indicates dominant aquatic plants.

Summary and conclusions.

Alta Lake is in a sheltered valley between ridges. There is no natural surface-water inflow or outflow but, because of man's influence, large stage fluctuations are common. A State park and resort facilities are located at the lake, and recreational use of the water is heavy.

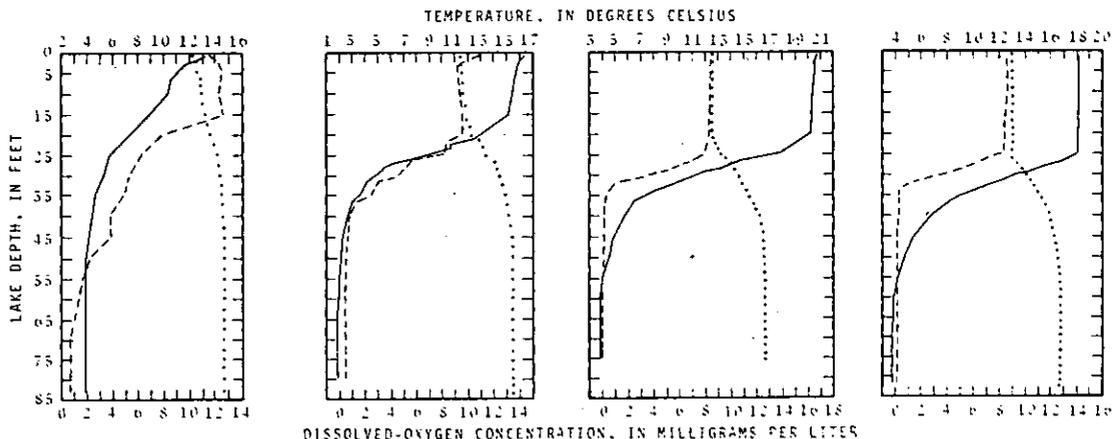
The biological productivity of the lake was low to moderate. With the exception of the May 1 sample, chlorophyll a concentrations were less than 1 µg/L. The water clarity was very high; Secchi-disc readings during the summer months were 18-25 feet. Thermal stratification was well established by May. The dissolved-oxygen concentration in the hypolimnion was near zero on all four sampling dates and hydrogen sulfide was detected in that zone. Submersed macrophytes (chiefly muskgrass) covered the littoral bottom and extended to depths of about 25 feet.

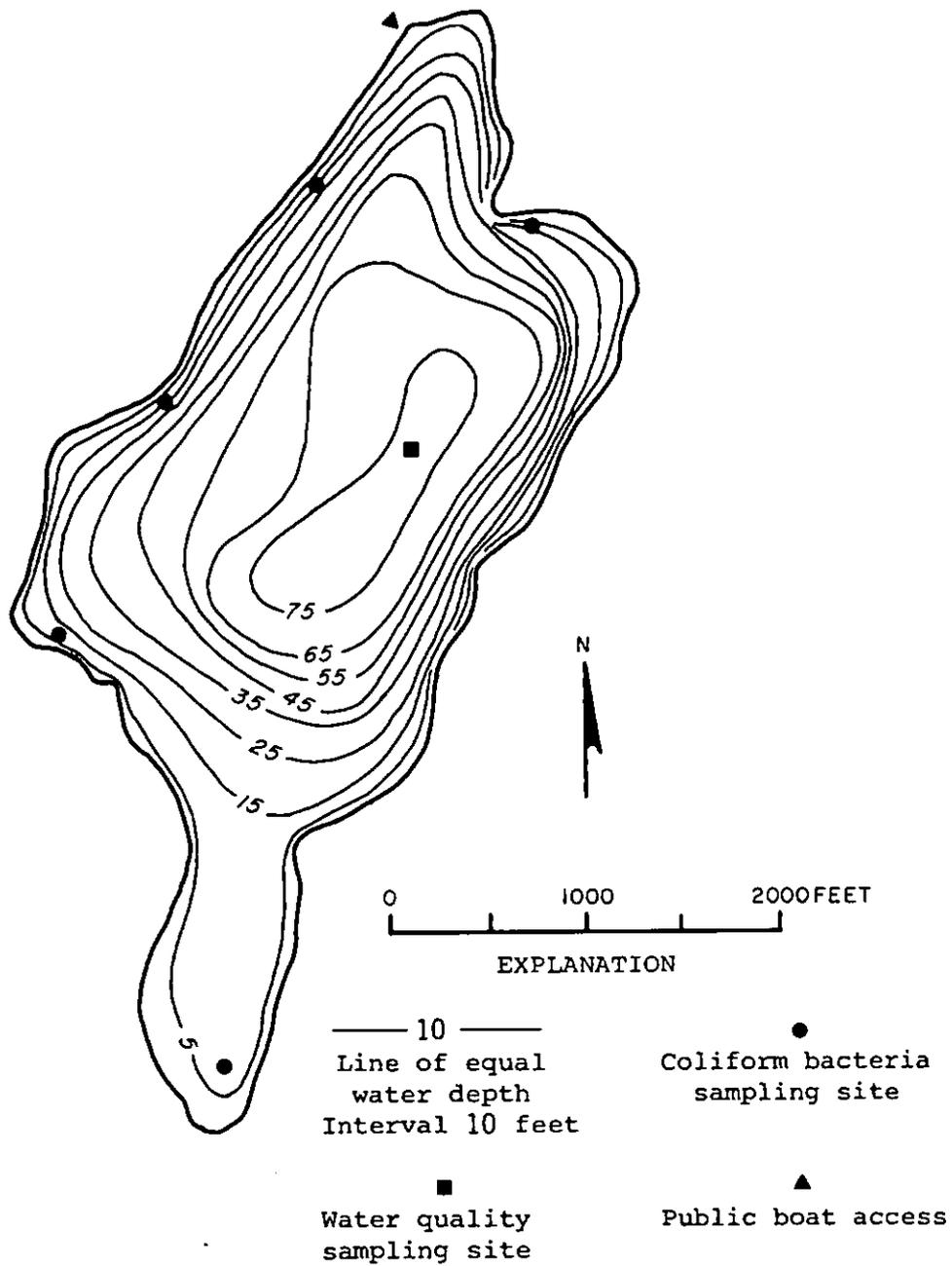
Water-quality data for Alta Lake

[Milligrams per liter unless otherwise indicated]

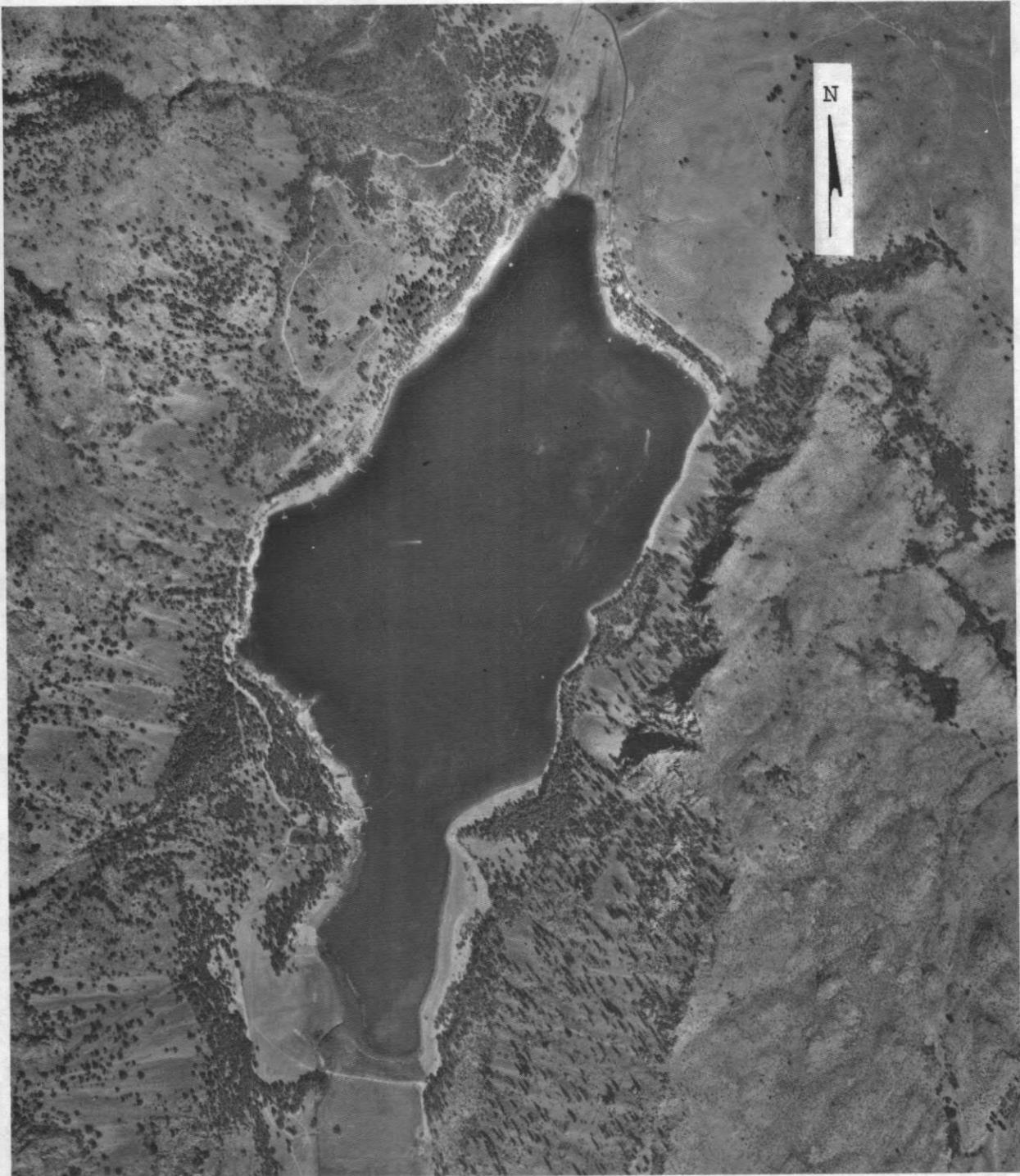
Date of collection (1975)-----	May 1		June 6		August 27		September 25	
	3	80	3	76	3	72	3	80
Water depth (ft)-----								
Silica (SiO ₂)-----	2.8	5.3	2.7	5.7	3.9	6.1	3.8	8.5
Dissolved iron (Fe), in µg/L--	10	20	10	50	20	30	10	40
Dissolved manganese (Mn)----- (in µg/L)	10	300	10	250	0	220	10	270
Calcium (Ca)-----	46	--	--	--	--	--	45	--
Magnesium (Mg)-----	23	--	--	--	--	--	24	--
Sodium (Na)-----	26	--	--	--	--	--	28	--
Potassium (K)-----	8.3	--	--	--	--	--	8.7	--
Bicarbonate (HCO ₃)-----	136	155	140	142	132	149	144	170
Carbonate (CO ₃)-----	0	--	--	--	--	--	0	--
Sulfide (S)-----	--	~1.5	--	~4	--	>5	--	>5
Sulfate (SO ₄)-----	150	--	--	--	--	--	160	--
Chloride (Cl)-----	3.4	--	--	--	--	--	3.2	--
Nitrate nitrogen (as N)-----	.00	.00	.01	.01	.00	.00	.01	.01
Nitrite nitrogen (as N)-----	.00	.00	.00	.00	.00	.00	.00	.01
Ammonia nitrogen (as N)-----	.11	1.4	.07	1.3	.03	1.5	.05	4.0
Organic nitrogen (as N)-----	.74	.40	.51	.80	.54	.50	.51	.00
Total phosphorus (as P)-----	.020	.130	.014	.140	.005	.180	.008	.380
Orthophosphate (as P)-----	.002	.100	.005	.120	.002	.150	.001	.340
Suspended solids (110°C)-----	24	--	--	--	--	--	8	--
Hardness as CaCO ₃ (Ca,Mg)-----	210	--	--	--	--	--	210	--
Specific conductance----- (micromhos at 25°C)	493	503	1,335	715	514	501	516	514
pH (pH units)-----	8.4	7.4	8.4	7.1	7.7	6.7	7.8	6.8
Water temperature (°C)-----	11.7	3.8	15.9	1.8	20.9	3.8	18.3	3.8
Color (Pt-Co scale)-----	5	5	15	15	0	0	20	30
Secchi-disc (ft)-----	-- 4.0 --	--	-- 20 --	--	-- 25 --	--	-- 18 --	--
Dissolved oxygen (DO)-----	12.2	.6	11.1	.4	8.4	0	8.8	<.1
Chlorophyll <i>a</i> in photic zone- (µg/L)	-- 14 --	--	--	--	-- .63 --	--	-- .78 --	--
Fecal coliform Range-- (col. per 100 mL) Mean--	-- <1- <1 -- -- <1 --	--	-- <1-6 -- -- 1 --	--	-- <1-25 -- -- 8 --	--	-- <1-1 -- -- 1 --	--
Total organic carbon (as C)--	9.4	--	6.2	--	6.1	--	5.4	--

EXPLANATION
 _____ Temperature
 - - - - - Dissolved oxygen concentration
 Dissolved oxygen concentration at 100 percent saturation





Alta Lake, Okanogan County.
 From Washington Department of Game,
 January 3, 1950.



Alta Lake, Okanogan County. June 6, 1973. Approx. scale 1:12,000.

Angle Lake near Des Moines (12113342)Location.

2.1 miles northeast of Des Moines, King County, Lat 47°25'30", long 122°17'32"; SE¼NE¼ sec.4. T.22 N., R.4 E.; location is of southernmost shoreline point of lake. Green-Duwamish River basin; 363 feet altitude. Des Moines quadrangle (1:24,000 scale).

Physical characteristics of lake.

Surface area-----	100 acres	Length of shoreline-----	2.2 miles
Volume-----	2600 acre-ft	Shoreline configuration----	1.5
Mean depth-----	25 ft	Development of volume-----	0.48
Maximum depth-----	52 ft	Bottom slope-----	2.2 percent

Drainage basin.

Size: 0.80 mi².

Geology: Glacial till, and outwash deposits of sand and gravel (Luzier, 1969).

Soils: Gravelly sandy loam (Poulson and others, 1952).

Land use	Percent
Urban	67
Suburban	8
Agricultural	0
Forest or unproductive	5
Lake Surface	20

Nearshore development.

Number of nearshore homes: 185

Nearshore residential development: 100 percent

Littoral bottom.

Predominantly gravel, cobble, and sand, with local areas of silt.

Hydrology.

The lake has no surface-water inflow or outflow. The lake stage rose 0.46 feet from Feb 18 to Apr 7, 1975, and then declined 2.02 feet from Apr 7 to Sep 9, 1975.

Aquatic plants.

Shoreline-----	11-25 percent
Lake surface-----	<1 percent
Lake bottom-----	51-75 percent

Macrophytes observed (8/5/75): white lily (*Nymphaea* sp.)*, muskgrass (*Chara* sp.)*, yellow lily (*Nuphar* sp.), cattail (*Typha* sp.), bulrush (*Scirpus* sp.), sedge (Cyperaceae), waterweed (*Elodea* sp.), quillwort (*Isoetes* sp.), and pondweed (*Potamogeton* sp.).

*Asterisk indicates dominant aquatic plants.

Summary and conclusions.

Angle Lake is a deep lake situated in an urban residential area. The lake is fed chiefly by ground water and has no surface-water inflow or outflow.

The lake was low to moderate in productivity. Secchi-disc visibility was good, ranging from 12 to 24 feet. Although the lake had very little emerged plant growth, the east arm of the lake had an extensive growth of submersed aquatic plants, chiefly muskgrass.

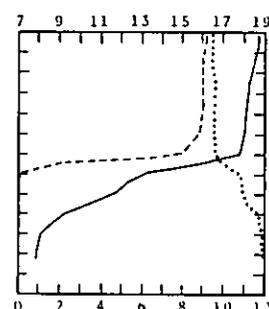
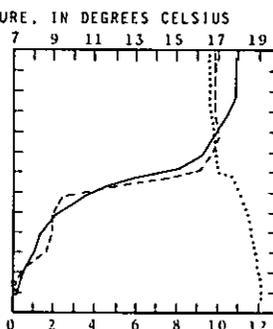
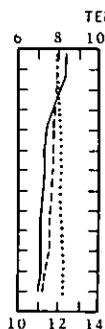
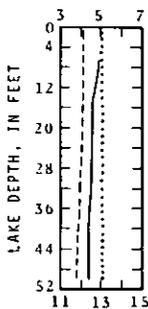
Nitrate nitrogen concentrations were low; total phosphorus concentrations were generally low to moderate but increased in the bottom water during summer.

Water-quality data for Angle Lake

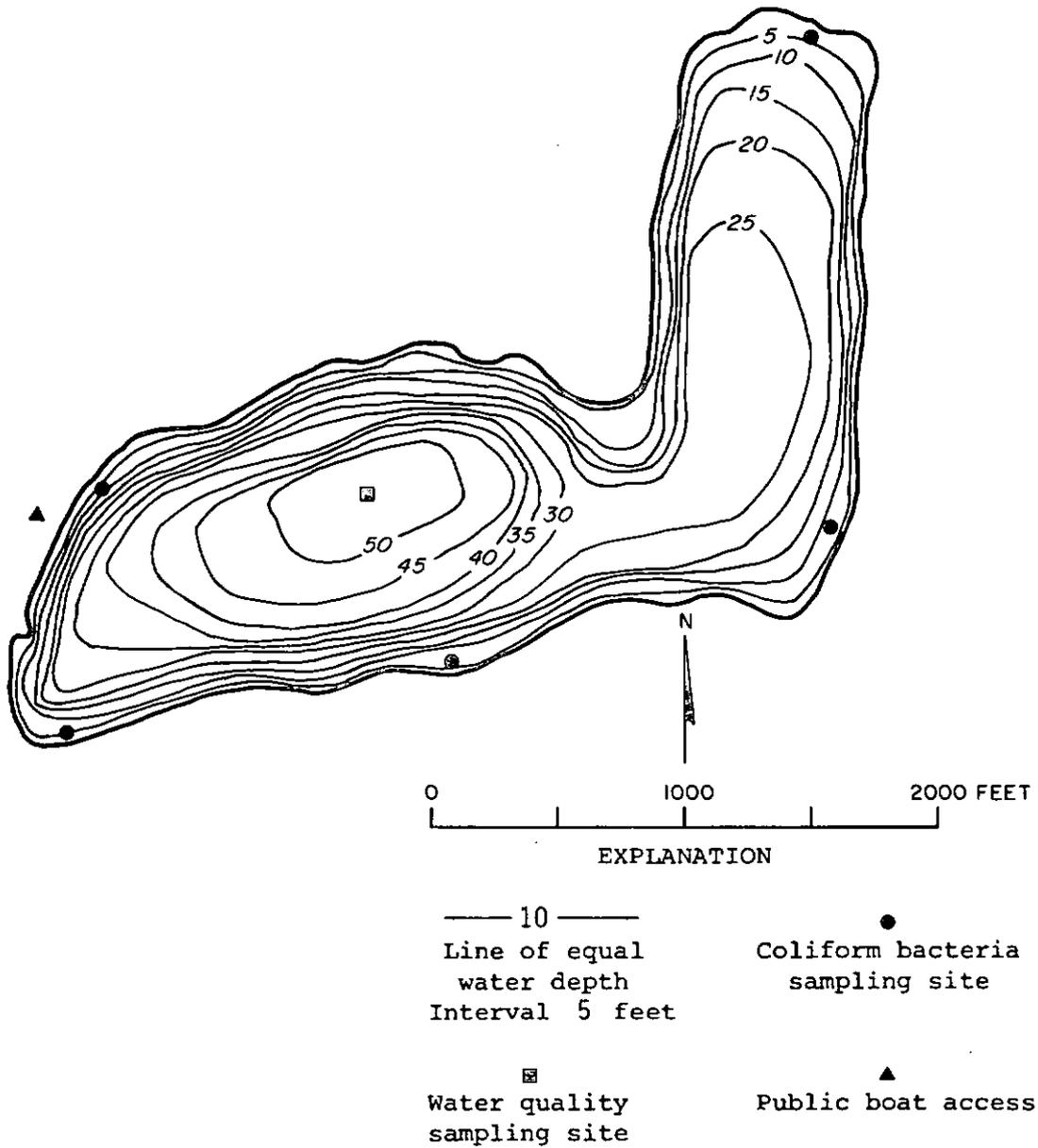
(Milligrams per liter unless otherwise indicated)

Date of collection (1975)-----	February 18		April 7		July 2		September 9	
	3	48	3	45	3	46	3	43
Water depth (ft)-----								
Silica (SiO ₂)-----	0.2	0.0	0.0	0.0	0.1	0.3	0.2	0.5
Dissolved iron (Fe), in µg/L--	10	130	20	30	40	280	40	690
Dissolved manganese (Mn)----- (in µg/L)	20	0	0	20	10	80	10	130
Calcium (Ca) -----	6.2	--	--	--	--	--	8.8	--
Magnesium (Mg) -----	1.7	--	--	--	--	--	1.6	--
Sodium (Na) -----	3.6	--	--	--	--	--	3.9	--
Potassium (K) -----	1.6	--	--	--	--	--	1.4	--
Bicarbonate (HCO ₃) -----	14	14	16	15	11	25	19	19
Carbonate (CO ₃)-----	--	--	0	0	--	--	0	--
Sulfide (S)-----	--	--	--	--	--	--	--	--
Sulfate (SO ₄)-----	13	--	--	--	--	--	12	--
Chloride (Cl)-----	4.0	--	--	--	--	--	3.6	--
Nitrate nitrogen (as N)-----	.16	.15	.18	.18	.00	.10	.00	.01
Nitrite nitrogen (as N)-----	.00	.00	.00	.00	.00	.00	.00	.00
Ammonia nitrogen (as N)-----	.07	.06	.05	.05	.03	.32	.04	.37
Organic nitrogen (as N)-----	.32	.51	.30	.34	.24	.17	.33	.22
Total phosphorus (as P)-----	.014	.013	.012	.013	.011	.022	.006	.025
Orthophosphate (as P)-----	.002	.002	.001	.001	.002	.006	.001	.002
Suspended solids (110°C)-----	0	--	--	--	--	--	4	--
Hardness as CaCO ₃ (Ca,Mg)----	22	--	--	--	--	--	29	--
Specific conductance----- (micromhos at 25°C)	68	68	68	67	72	73	70	74
pH (pH units)-----	7.3	7.5	6.9	7.4	8.0	6.3	6.4	6.1
Water temperature (°C)-----	4.9	4.4	8.2	7.1	17.8	7.3	18.6	7.9
Color (Pt-Co scale)-----	10	10	5	5	10	10	15	30
Secchi-disc (ft)-----	--	12	--	24	--	14	--	19
Dissolved oxygen (DO)-----	12.0	11.8	10.9	10.3	9.8	.2	9.0	0
Chlorophyll <i>a</i> in photic zone-- (µg/L)	--	7.8	--	2.1	--	.48	--	.92
Fecal coliform Range-- (col. per 100 mL) Mean---	-----	-----	--	<1-2	--	1-26	--	2-59
				<1		13		33
Total organic carbon (as C)---	5.9	--	4.4	--	6.0	--	3.8	--

EXPLANATION
 _____ Temperature
 - - - - - Dissolved oxygen concentration
 Dissolved oxygen concentration at 100 percent saturation



DISSOLVED-OXYGEN CONCENTRATION, IN MILLIGRAMS PER LITER



Angle Lake, King County.
From Washington Department of Game,
January 31, 1949.



Angle Lake, King County. May 18, 1970. Approx. scale 1:12,000.

Badger Lake near Amber (13351495)Location.

3.2 miles southeast of Amber, Spokane County. Lat 47°20'19"; long 117°38'47"; NW¼SW¼ sec.4. T.21 N., R.41 E.; location is of southernmost point of lake. Palouse River basin; 2,170 feet altitude. Cheney quadrangle (1:62,500 scale).

Physical characteristics of lake.

Surface area-----	250 acres	Length of shoreline-----	7.0 miles
Volume-----	11,000 acre-ft	Shoreline configuration-----	3.2
Mean depth-----	46 ft	Development of volume-----	0.44
Maximum depth-----	110 ft	Bottom slope-----	2.8 percent

Drainage basin.

Size: 10.8 mi².

Geology: Black, dense basalt flows (Hunting and others, 1961).

Soils: Silty clay loams, stony silt loams, gravelly silt loams, silt loams, and some marsh and muck. (Donaldson and Giese, 1968).

Land use	Percent
Urban	0
Suburban	<1
Agricultural	59
Forest or unproductive	37
Lake surface	4

Nearshore development.

Number of nearshore homes: 54

Nearshore residential development: 15 percent

Littoral bottom.

Mostly rock and gravel, with silt and muck at the northeast and southwest ends.

Hydrology.

The lake has one unnamed inflow at the northeast end of the lake. On Apr 17 and May 20, 1975, the inflow volumes were estimated to be 4.2 and 2.5 ft³/s, respectively. On Aug 13 and Oct 1, 1975, the inflow channel was dry. The lake has no well-defined surface-water outlet.

The lake stage declined 1.83 feet from May 20 to Oct 1, 1975.

Aquatic plants.

Shoreline-----	11-25 percent
Lake surface-----	1-10 percent
Lake bottom-----	11-25 percent

Macrophytes observed (7/17/75): bulrush (Scirpus sp.)*, pondweed (Potamogeton sp.)*, yellow lily (Nuphar sp.)*, sedge (Cyperaceae), smartweed (Polygonum sp.), cattail (Typha sp.), and water milfoil (Myriophyllum sp.).

*Asterisk indicates dominant aquatic plants.

Algae observed:

4/17/75: None

5/20/75: Diatoms (Tabellaria sp.), greens (Rhizoclonium sp.), and yellow browns (Dinobryon sp.).

8/13/75: None

10/1/75: Blue-greens (Anabaena sp.), and diatoms (Fragillaria sp.).

Summary and conclusions.

Badger Lake is a long, narrow, deep lake that lies in a coulee on basalt lava flows. The northern part of the lake has a steep and rocky shoreline. The amount of nearshore residential development is small and localized.

The biological productivity of the lake was low to moderate. Chlorophyll *a* concentrations were high in April but low the remainder of the year. Organic nitrogen and total phosphorus concentrations were high on all sampling dates. The dominant aquatic macrophytes observed were bulrush, pondweed, and yellow lily.

The lake was well stratified in August and October and the dissolved oxygen in the bottom water was near zero.

LAKE DATA

Water-quality data for Badger Lake

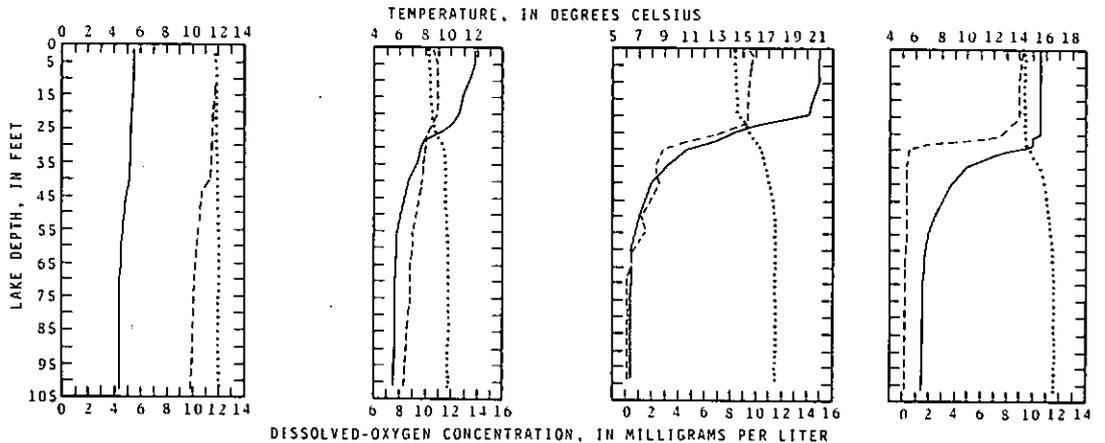
[Milligrams per liter unless otherwise indicated]

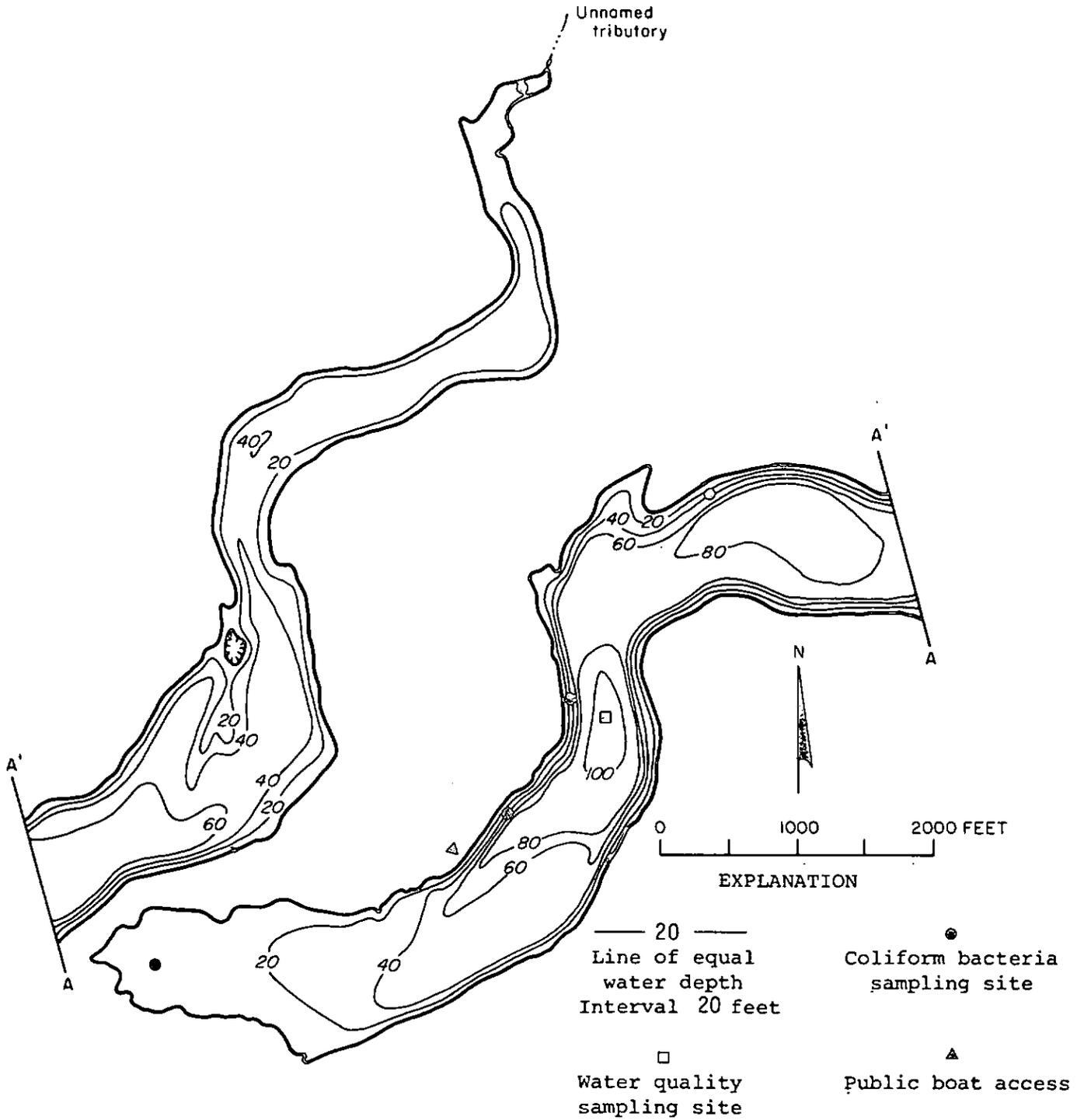
Date of collection (1975)-----	April 17		May 20		August 13		October 1	
	3	100	3	99	3	96	3	100
Water depth (ft)-----								
Silica (SiO ₂)-----	8.8	9.3	9.3	9.3	5.8	13	5.8	14
Dissolved iron (Fe), in µg/L--	50	80	40	90	30	390	50	1,500
Dissolved manganese (Mn)----- (in µg/L)	20	60	10	50	0	440	10	520
Calcium (Ca)-----	16	--	--	--	--	--	15	--
Magnesium (Mg)-----	7.8	--	--	--	--	--	8.3	--
Sodium (Na)-----	9.4	--	--	--	--	--	9.9	--
Potassium (K)-----	5.3	--	--	--	--	--	5.6	--
Bicarbonate (HCO ₃)-----	106	106	105	106	108	105	111	114
Carbonate (CO ₃)-----	0	0	0	--	0	--	0	--
Sulfide (S)-----	--	--	--	--	--	--	--	0
Sulfate (SO ₄)-----	6.6	--	--	--	--	--	5.0	--
Chloride (Cl)-----	1.6	--	--	--	--	--	2.2	--
Nitrate nitrogen (as N)-----	.00	.00	.00	.00	.00	.15	.02	.02
Nitrite nitrogen (as N)-----	.00	.00	.00	.00	.00	.01	.00	.00
Ammonia nitrogen (as N)-----	.07	.10	.04	.12	.03	.27	.03	.63
Organic nitrogen (as N)-----	.44	.30	.39	.32	.38	.33	.45	.37
Total phosphorus (as P)-----	.034	.039	.023	.035	.015	.13	.014	.34
Orthophosphate (as P)-----	.003	.004	.004	.010	.002	.081	.004	.30
Suspended solids (110°C)-----	0	--	--	--	--	--	20	--
Hardness as CaCO ₃ (Ca,Mg)----	72	--	--	--	--	--	72	--
Specific conductance----- (micromhos at 25°C)	163	162	165	125	171	167	170	171
pH (pH units)-----	9.4	9.2	8.4	7.5	9.0	7.6	8.1	6.7
Water temperature (°C)-----	5.4	4.3	11.8	5.5	21.0	6.2	15.6	6.3
Color (Pt-Co scale)-----	25	20	15	20	0	0	0	0
Secchi-disc (ft)-----	-- 10 --		-- 13 --		-- 13 --		-- 10 --	
Dissolved oxygen (DO)-----	11.9	9.8	10.7	8.4	9.8	.1	9.1	.1
Chlorophyll <i>a</i> in photic zone- (µg/L)	-- 12 --		-- 3.8 --		-- 3.4 --		-- 3.8 --	
Fecal coliform Range-- (col. per 100 mL) Mean--	-- <1-2 --		-- <1-<1 --		-- <1-12 --		-- 1-17 --	
	-- <1 --		-- <1 --		-- 2 --		-- 6 --	
Total organic carbon (as C)--	6.5	--	4.7	--	8.7	--	5.3	--

EXPLANATION

Temperature

 Dissolved oxygen concentration
 - - - - -
 Dissolved oxygen concentration at 100 percent saturation
 ······





Badger Lake, Spokane County.
From Washington Department of Game,
February 10, 1948.



Badger Lake, Spokane County. July 3, 1968. Approx. scale 1:60,000.

Canal Lake near Othello (12471610)Location.

6.6 miles north of Othello, Grant County. Lat 46°55'12", long 119°11'23"; SW¼NW¼ sec. 33. T.33 N., R.29 E.; location is of southernmost shoreline point of lake. Crab Creek basin; 984 feet altitude. Soda Lake quadrangle (1:24,000 scale).

Physical characteristics of lake.

Surface area-----	61 acres	Length of shoreline-----	3.7 miles
Volume-----	990 acre-ft	Shoreline configuration-----	3.3
Mean depth-----	16 ft	Development of volume-----	0.25
Maximum depth-----	65 ft	Bottom slope-----	3.5 percent

Drainage basin.

Size: 4.23 mi².

Geology: Predominantly basalt flows with minor amounts of glaciolacustrine deposits of fine-grained silt and sand (Hunting and others, 1961).

Soils: Silt loam, sandy loam, loam, and sandy soils from wind-laid silts (U.S. Soil Conservation Service, 1968).

Land use	Percent
Urban	0
Suburban	0
Agricultural	95
Forest or unproductive	3
Lake surface	2

Nearshore development

Number of nearshore homes: 0

Nearshore residential development: 0 percent

Littoral bottom.

Predominantly silt and rock, with local areas of gravel.

Hydrology.

The principal inflow is from the northeast, from Windmill Lake. Drainage is southward through a culvert and under Potholes East Canal to a closed depression south of the canal. On April 23, May 29, Aug 19, and Sept 17, 1975, the outflows through the culvert were estimated to be 9.0, 4.0, 6.0, and 4.0 ft³/s, respectively.

The lake stage rose 0.25 foot from April 23 to Aug 19, 1975, and then declined 0.21 foot from Aug 19 to Sept 17, 1975.

Aquatic plants.

Shoreline-----	11-25 percent
Lake surface-----	1-10 percent
Lake bottom-----	51-75 percent

Macrophytes observed (8/19/75): cattail (*Typha* sp.)*, pondweed (*Potamogeton* sp.)*, muskgrass (*Chara* sp.), coontail (*Ceratophyllum* sp.), sedge (Cyperaceae), and bulrush (*Scirpus* sp.).

Algae observed:

4/23/75: Blue-greens (*Aphanizomenon* sp.)*, and diatoms (*Synedra* sp.).

5/29/75: Blue-greens (*Aphanizomenon* sp.)*, and diatoms (*Synedra* sp.).

8/19/75: None

9/17/75: None

*Asterisk indicates dominant aquatic plants.

Summary and conclusions.

Canal Lake is a seepage lake formed as an indirect result of irrigation. Recreational use of the lake, primarily by fishermen, is heavy. There is no residential development of the shoreline.

The biological productivity of the lake was moderate to high. Chlorophyll a concentrations were high in April (46 µg/L) but moderate on other sampling dates. Secchi-disc readings were low throughout the year. A large part of the lake bottom was covered with aquatic macrophytes, chiefly pondweed, to a depth of about 12 ft.

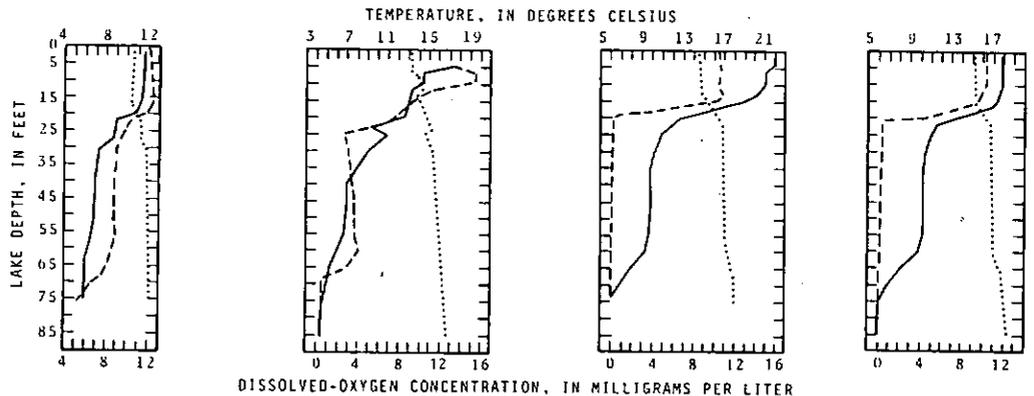
Thermal stratification was weakly developed in May; by August the lake was well stratified and dissolved oxygen in the bottom water was depleted.

Water-quality data for Canal Lake

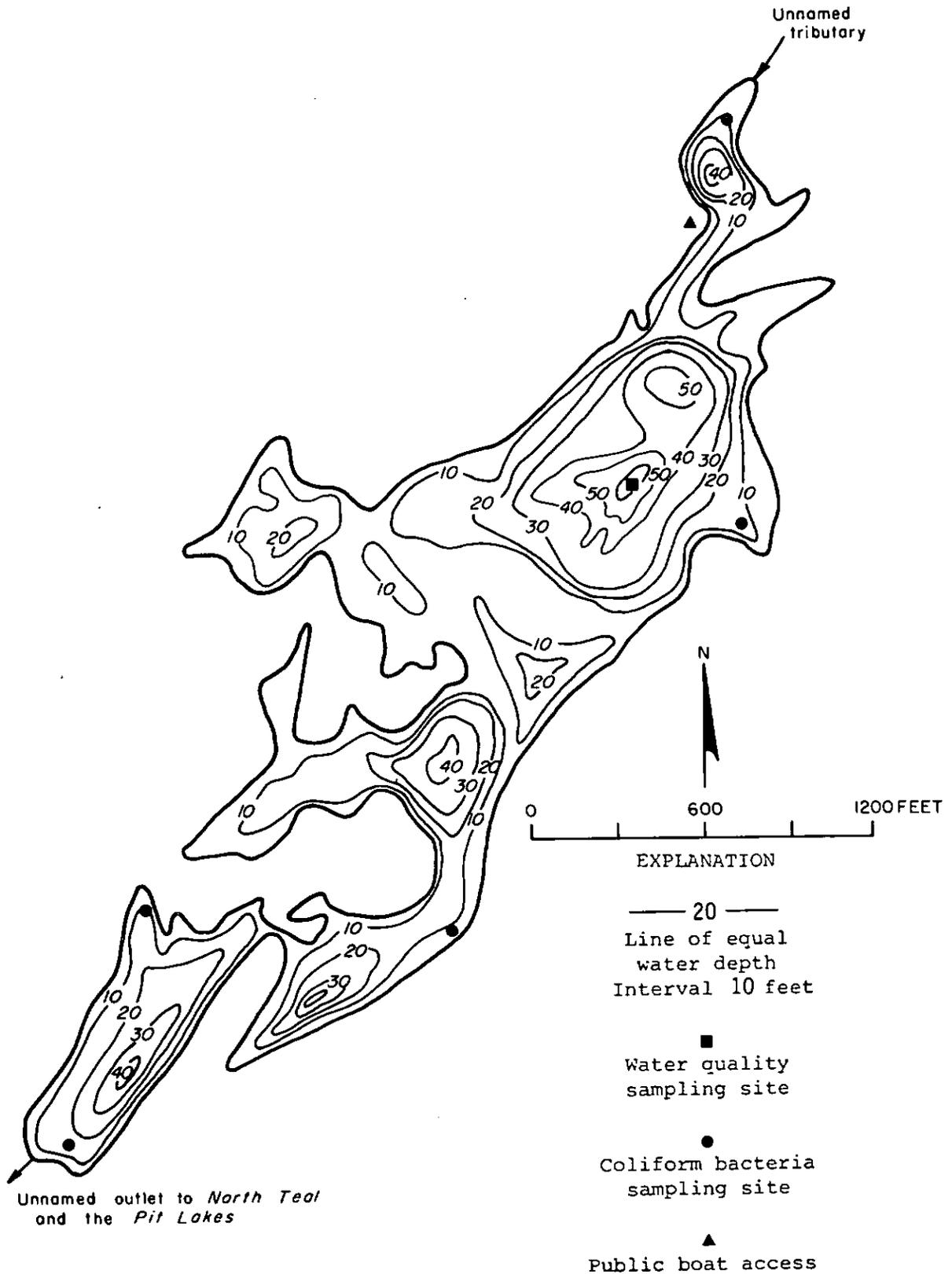
[Milligrams per liter unless otherwise indicated]

Date of collection (1975)-----	April 23		May 29		August 19		September 17	
	1	72	3	82	3	71	3	82
Water depth (ft)-----								
Silica (SiO ₂)-----	29	30	26	33	31	34	31	34
Dissolved iron (Fe), in µg/L--	10	20	30	60	10	10	20	30
Dissolved manganese (Mn)----- (in µg/L)	4	20	20	430	20	210	10	410
Calcium (Ca) -----	32	--	--	--	--	--	15	--
Magnesium (Mg) -----	24	--	--	--	--	--	23	--
Sodium (Na) -----	60	--	--	--	--	--	58	--
Potassium (K) -----	8.7	--	--	--	--	--	9.7	--
Bicarbonate (HCO ₃) -----	222	245	219	246	119	249	196	251
Carbonate (CO ₃)-----	8	--	0	--	38	--	7	--
Sulfide (S)-----	--	--	--	~3	--	~3	--	>5
Sulfate (SO ₄)-----	59	--	--	--	--	--	61	--
Chloride (Cl)-----	28	--	--	--	--	--	27	--
Nitrate nitrogen (as N)-----	.00	.16	.00	.00	.00	.22	.01	.02
Nitrite nitrogen (as N)-----	.00	.01	.00	.01	.00	.06	.00	.01
Ammonia nitrogen (as N)-----	.09	.20	.07	1.7	.04	1.0	.04	2.3
Organic nitrogen (as N)-----	1.5	.68	.62	.70	.58	.27	.59	.40
Total phosphorus (as P)-----	.061	.052	.033	.12	.020	.11	.025	.24
Orthophosphate (as P)-----	.007	.009	.003	.084	.005	.092	.003	.22
Suspended solids (110°C)-----	12	--	--	--	--	--	0	--
Hardness as CaCO ₃ (Ca,Mg)----	180	--	--	--	--	--	130	--
Specific conductance----- (micromhos at 25°C)	544	537	540	620	475	533	474	537
pH (pH units)-----	8.8	8.1	8.9	7.6	9.2	7.8	8.8	7.1
Water temperature (°C)-----	11.5	5.8	17.7	4.4	22.0	6.3	17.8	5.8
Color (Pt-Co scale)-----	5	10	25	25	0	0	20	30
Secchi-disc (ft)-----	--	3.8	--	4.2	--	5.0	--	6.5
Dissolved oxygen (DO)-----	12.2	6.2	13.1	.2	10.4	0	10.3	0
Chlorophyll <i>a</i> in photic zone- (µg/L)	--	46	--	7.4	--	3.1	--	6.8
Fecal coliform Range-- (col. per 100 mL) Mean---	--	<1-1	--	<1-2	--	<1-50	--	<1-4
		<1		1		12		3
Total organic carbon (as C)--	19	--	9.6	--	5.8	--	5.1	--

EXPLANATION
 _____ Temperature
 - - - - - Dissolved oxygen concentration
 Dissolved oxygen concentration at 100 percent saturation



DISSOLVED-OXYGEN CONCENTRATION, IN MILLIGRAMS PER LITER



Canal Lake, Grant County.
 From U.S. Geological Survey,
 March 3, 1975.



Canal Lake, Grant County. Aerial photograph from
U.S. Geological Survey, May 25, 1974.

Chambers Lake near Olympia (12079994)Location.

2.3 miles southeast of Olympia, Thurston County. Lat 47°01'21", long 122°50'04"; NE¼NW¼ sec.29, T.18 N., R.1 W. Deschutes River basin; 194 feet altitude. Lacey quadrangle (1:24,000 scale).

Physical characteristics of lake.

Surface area-----	60 acres	Length of shoreline-----	2.2 miles
Volume-----	270 acre-ft	Shoreline configuration-----	2.0
Mean depth-----	5 ft	Development of volume-----	0.57
Maximum depth-----	8 ft	Bottom slope-----	0.44 percent

Drainage basin.

Size: 0.83 mi².

Geology: Sandy and silty recessional outwash with lenses of gravel, gravelly clay, fine-grained detritus, and peat. (Noble and Wallace, 1966).

Soils: Gravelly sandy loam, fine sandy loam, loamy fine sand, loamy sand, peat, and muck which overlies dense clay (Ness, 1958).

Land use	Percent
Urban	0
Suburban	16
Agricultural	33
Forest or unproductive	40
Lake surface	11

Nearshore development.

Number of nearshore homes: 42 (includes 27 mobile homes)
Nearshore residential development: 22 percent

Littoral bottom.

Predominantly muck with local areas of silt on east shore.

Hydrology.

The lake has no visible surface-water inflow. Drainage is eastward to nearby Little Chambers Lake. The outflow was not measured.

The lake stage declined 1.80 feet from Feb 20 to Sept 10, 1975.

Aquatic plants.

Shoreline-----	76-100 percent
Lake surface-----	26-50 percent
Lake bottom-----	76-100 percent

Macrophytes observed (8/8/75): yellow lily (Nuphar sp.)*, muskgrass (Chara sp.)*, watershield (Brasenia sp.), cattail (Typha sp.), smartweed (Polygonum sp.), white lily (Nymphaea sp.), bulrush (Scirpus sp.), arrowhead (Sagittaria sp.), sedge (Cyperaceae), waterweed (Elodea sp.), pondweed (Potamogeton sp.), and water milfoil (Myriophyllum sp.).

*Asterisk indicates dominant aquatic plants.

Summary and conclusions

Chambers Lake is a shallow lake that has no surface-water inflow. There is a large marsh west of the lake and residential development east of the lake is heavy.

The biological productivity of the lake was high. The lake bottom, which is muck, supported a heavy growth of emersed and submersed aquatic plants. The entire bottom is covered with submersed plants, chiefly muskgrass. Organic nitrogen and total phosphorus concentrations were high throughout the year.

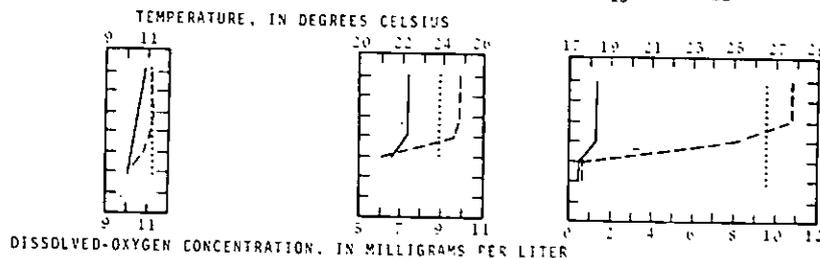
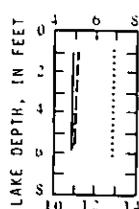
The lake is too shallow to stratify thermally, but in September dissolved-oxygen concentrations in the bottom were low (0.6 mg/L).

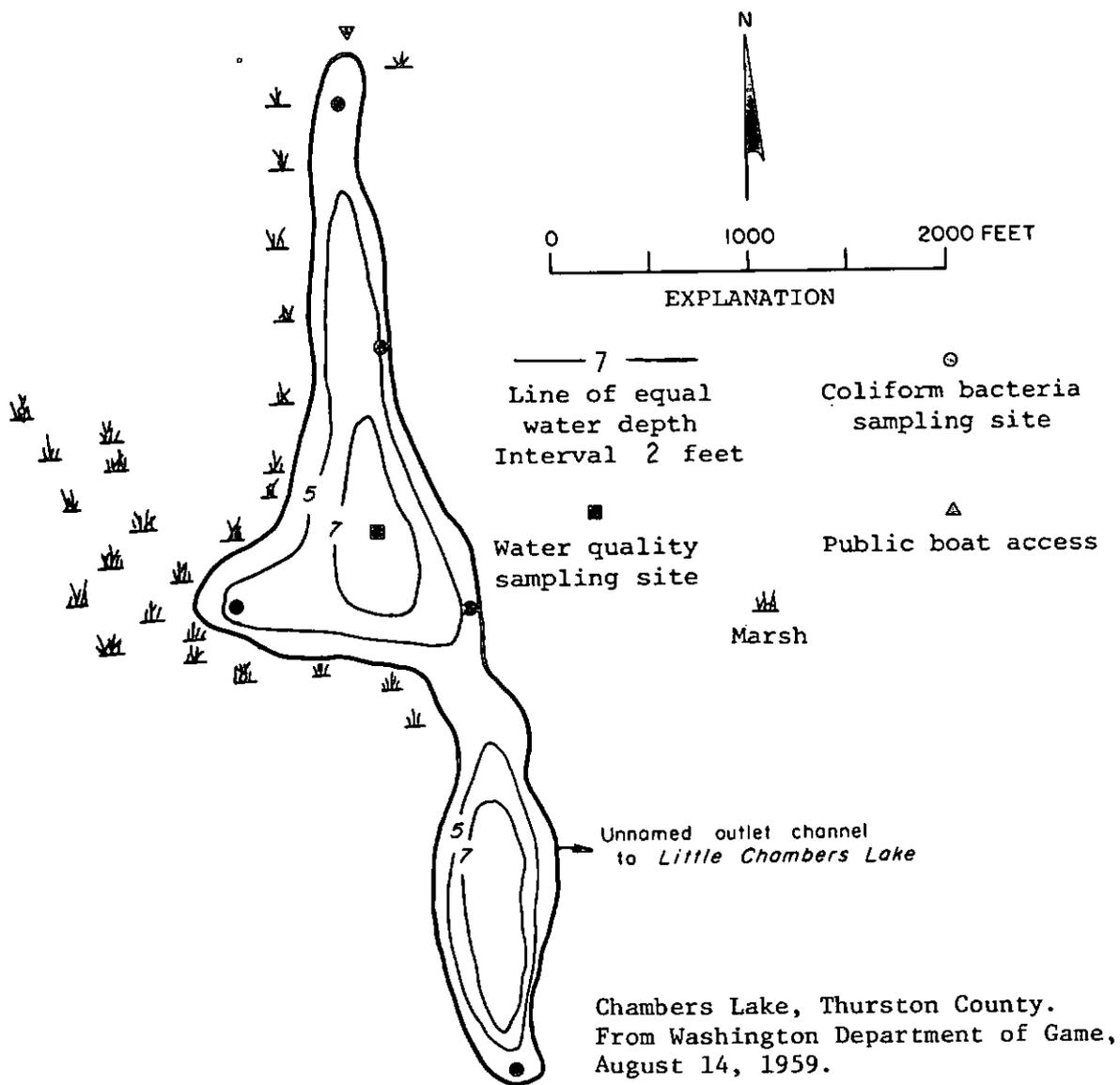
Water-quality data for Chambers Lake

[Milligrams per liter unless otherwise indicated]

Date of collection (1975)-----	February 20		April 10		July 10		September 10	
	3	5	3	5	3	5	3	5
Water depth (ft)-----								
Silica (SiO ₂)-----	0.7	0.8	0.3	0.1	0.1	0.1	0.1	0.2
Dissolved iron (Fe), in µg/L--	20	780	810	800	450	460	280	490
Dissolved manganese (Mn)----- (in µg/L)	30	20	20	30	50	40	60	130
Calcium (Ca) -----	3.6	--	--	--	--	--	5.1	--
Magnesium (Mg) -----	1.4	--	--	--	--	--	1	--
Sodium (Na) -----	1.9	--	--	--	--	--	2.1	--
Potassium (K) -----	1.2	--	--	--	--	--	.1	--
Bicarbonate (HCO ₃) -----	11	10	14	14	21	16	15	17
Carbonate (CO ₃)-----	0	--	0	0	--	--	0	--
Sulfide (S)-----	--	--	--	--	--	--	--	--
Sulfate (SO ₄)-----	3.1	--	--	--	--	--	2.6	--
Chloride (Cl)-----	2.5	--	--	--	--	--	2.1	--
Nitrate nitrogen (as N)-----	.01	.01	.01	.01	.00	.00	.00	.02
Nitrite nitrogen (as N)-----	.00	.00	.00	.00	.00	.00	.01	.00
Ammonia nitrogen (as N)-----	.22	.20	.15	.14	.11	.11	.10	.12
Organic nitrogen (as N)-----	.45	.46	.59	.62	.53	.55	.81	.88
Total phosphorus (as P)-----	.025	.030	.036	.044	.033	.030	.031	.031
Orthophosphate (as P)-----	.002	.002	.007	.004	.004	.002	.004	.003
Suspended solids (110°C)-----	0	--	--	--	--	--	0	--
Hardness as CaCO ₃ (Ca, Mg)----	15	--	--	--	--	--	17	--
Specific conductance----- (micromhos at 25°C)	28	28	31	31	31	44	32	33
pH (pH units)-----	6.9	7.5	7.1	7.2	6.6	6.8	6.7	6.6
Water temperature (°C)-----	4.9	4.9	10.5	10.2	22.3	21.6	18.3	17.5
Color (Pt-Co scale)-----	60	60	50	55	55	55	45	45
Secchi-disc (ft)-----	--	5.0	--	5.1	--	4.8	--	7.0
Dissolved oxygen (DO)-----	11.1	11.0	11.2	10.8	9.8	6.0	10.8	.6
Chlorophyll <i>a</i> in photic zone- (µg/L)	--	15	--	11	--	2.9	--	6.3
Fecal coliform Range-- (col. per 100 mL) Mean---	-----	-----	--	1-33	--	2-80	--	1-6
Total organic carbon (as C)--	11	--	13	--	10	--	13	--

EXPLANATION
 _____ Temperature
 - - - - - Dissolved oxygen concentration
 Dissolved oxygen concentration at 100 percent saturation







Chambers Lake, Thurston County. May 12, 1972. Approx. scale 1:12,000.

Chambers, Little Lake near Olympia (12079996)Location.

2.9 miles southeast of Olympia, Thurston County. Lat 47°01'05", long 122°49'56"; NW¼SE¼ sec.29 T.18 N., R.1 W. Deschutes River basin; 194 feet altitude. Lacey quadrangle (1:24,000 scale).

Physical characteristics of lake.

Surface area-----	58 acres	Length of shoreline-----	1.2 miles
Volume-----	240 acre-ft	Shoreline configuration-----	1.1
Mean depth-----	4 ft	Development of volume-----	0.58
Maximum depth-----	7 ft	Bottom slope-----	0.39 percent

Drainage basin.

Size: 1.51 mi².

Geology: Sandy and silty recessional outwash with lenses of gravel and poorly-sorted gravel and sand (Noble and Wallace, 1966).

Soils: Gravelly sandy loam, fine sandy loam, loamy fine sand, loamy sand, peat, and muck which overlies dense clay (Ness, 1958).

Land use	Percent
Urban	6
Suburban	22
Agricultural	31
Forest or unproductive	29
Lake Surface	12

Nearshore development.

Number of nearshore homes: 26

Nearshore residential development: 28 percent

Littoral bottom.

Mostly muck with local areas of silt.

Hydrology.

The lake receives inflow from nearby Chambers Lake. Drainage is southwestward via an unnamed stream to the Deschutes River. Estimated outflows on Feb 21, April 10, and July 10, 1975, were 3.9, 1.4 and less than 0.1 ft³/s, respectively.

The lake stage declined 1.57 feet from Feb 21 to July 10, 1975.

Aquatic plants.

Shoreline-----	76-100 percent
Lake surface-----	1-10 percent
Lake bottom-----	76-100 percent

Macrophytes observed (8/8/75): yellow lily (Nuphar sp.)*, arrowhead (Sagittaria sp.), pondweed (Potamogeton sp.)*, watershield (Brasenia sp.), sedge (Cyperaceae), waterweed (Elodea sp.), white lily (Nymphaea sp.), wild celery (Vallisneria sp.), cat-tail (Typha sp.), muskgrass (Chara sp.), and bushy pondweed (Najas sp.).

*Asterisk indicates dominant aquatic plants.

Algae observed:

2/21/75: Blue-greens (Anabaena sp.) and yellow-browns (Dinobryon sp.).

4/10/75: Diatoms (Asterionella sp.) and yellow-browns (Dinobryon sp.).

Summary and conclusions.

Little Chambers Lake is a shallow lake partly surrounded by marsh. It is connected to Chambers Lake by a narrow channel.

The biological productivity of the lake was high. Submersed aquatic plants, chiefly pondweed, covered nearly the entire lake bottom. A high density of blue-green algae was observed in February. Organic nitrogen and total phosphorus concentrations were high throughout the year.

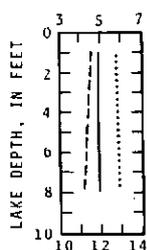
The lake is too shallow to stratify thermally. Temperature and dissolved-oxygen concentrations were nearly uniform from top to bottom throughout the year.

Water-quality data for Little Chambers Lake

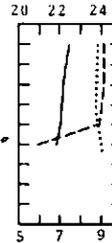
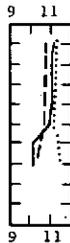
[Milligrams per liter unless otherwise indicated]

Date of collection (1975)-----	February 21		April 10		July 10		September 10	
	3	6	3	5	3	5	3	5
Water depth (ft)-----								
Silica (SiO ₂)-----	1.2	1.3	1.0	1.0	0.4	0.3	0.1	0.1
Dissolved iron (Fe), in µg/L --	10	510	600	610	740	750	410	350
Dissolved manganese (Mn)----- (in µg/L)	50	40	70	70	50	50	80	90
Calcium (Ca) -----	2.7	--	--	--	--	--	4.3	--
Magnesium (Mg) -----	1.1	--	--	--	--	--	1.2	--
Sodium (Na) -----	2.7	--	--	--	--	--	2.8	--
Potassium (K) -----	.9	--	--	--	--	--	.4	--
Bicarbonate (HCO ₃) -----	12	12	16	16	17	18	18	18
Carbonate (CO ₃)-----	--	--	0	0	--	--	0	--
Sulfide (S)-----	--	--	--	--	--	--	--	--
Sulfate (SO ₄)-----	2.7	--	--	--	--	--	2.6	--
Chloride (Cl)-----	2.5	--	--	--	--	--	1.6	--
Nitrate nitrogen (as N)-----	.06	.06	.04	.03	.00	.00	.00	.00
Nitrite nitrogen (as N)-----	.00	.00	.00	.00	.00	.00	.01	.01
Ammonia nitrogen (as N)-----	.20	.22	.18	.18	.10	.09	.11	.11
Organic nitrogen (as N)-----	.54	.50	.56	.47	.39	.39	.50	.54
Total phosphorus (as P)-----	.042	.032	.040	.040	.027	.025	.022	.024
Orthophosphate (as P)-----	.003	.003	.005	.011	.001	.002	.002	.003
Suspended solids (110 °C)-----	7	--	--	--	--	--	4	--
Hardness as CaCO ₃ (Ca, Mg)-----	11	--	--	--	--	--	16	--
Specific conductance----- (micromhos at 25 °C)	35	35	36	37	40	40	40	40
pH (pH units)-----	7.4	7.2	7.3	7.3	7.4	7.2	6.6	6.6
Water temperature (°C)-----	4.9	4.9	11.0	10.8	22.2	22.0	18.8	18.5
Color (Pt-Co scale)-----	40	40	35	40	55	55	50	50
Secchi-disc (ft)-----	-- 5.0 --		-- 7.0 --		-- 4.9 --		-- 4.5 --	
Dissolved oxygen (DO)-----	11.5	11.4	10.7	10.6	9.2	8.9	9.6	9.8
Chlorophyll <u>a</u> in photic zone- (µg/L)	-- 17 --		-- 7.8 --		-- 7.7 --		-- 3.6 --	
Fecal coliform Range-- (col. per 100 mL) Mean---	-----	-----	-- <1-5 --	-- 3 --	-- 2-16 --	-- 7 --	-- <1-8 --	-- 3 --
Total organic carbon (as C)---	6.7	--	8.3	--	9.6	--	8.5	--

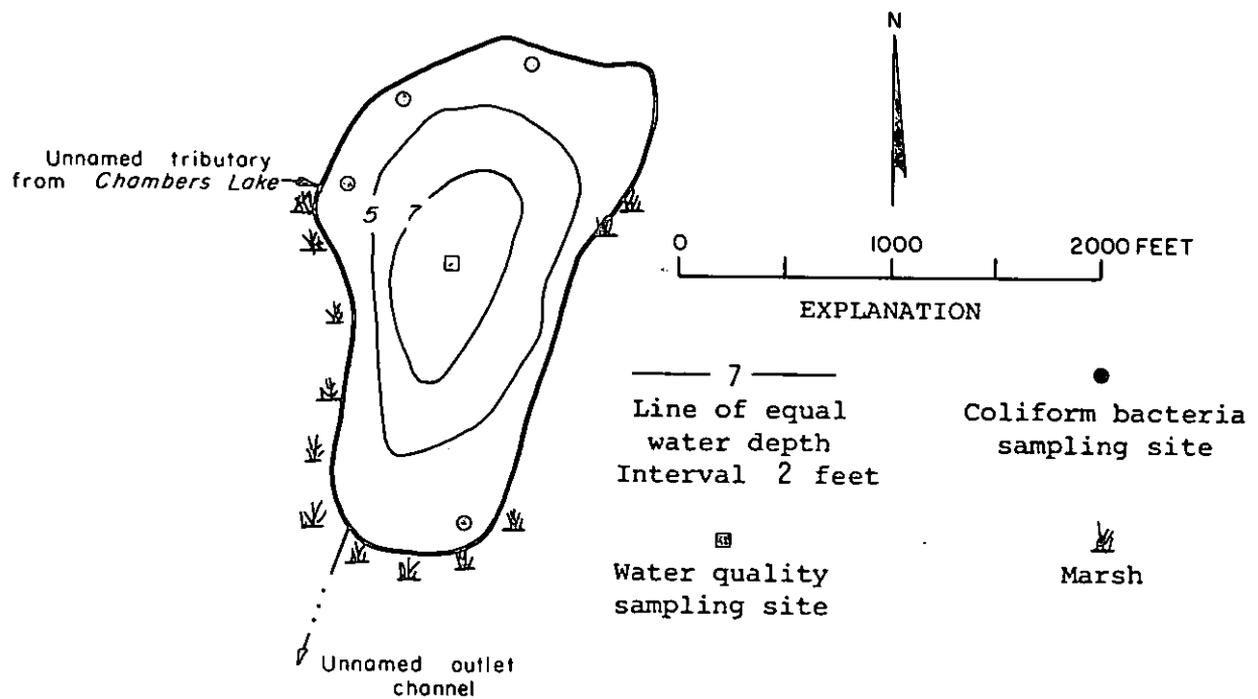
EXPLANATION
 _____ Temperature
 - - - - - Dissolved oxygen concentration
 Dissolved oxygen concentration at 100 percent saturation



TEMPERATURE, IN DEGREES CELSIUS



DISSOLVED-OXYGEN CONCENTRATION, IN MILLIGRAMS PER LITER



Chambers, Little Lake, Thurston County.
 From Washington Department of Game,
 August 14, 1959.



Chambers, Little Lake, Thurston County. May 12, 1972. Approx. scale 1:12,000.

Chopaka Lake near Nighthawk (12442310)Location.

5.0 miles southwest of Nighthawk, Okanogan County. Lat 48°54'13", long 119°41'33", SE¼SE¼ sec. 4. T.39 N., R.25 E. Okanogan River basin; 2,921 feet altitude. Loomis quadrangle (1:62,500 scale).

Physical characteristics of lake.

Surface area-----	160 acres	Length of shoreline-----	3.8 miles
Volume-----	3700 acre-ft	Shoreline configuration----	2.1
Mean depth-----	23 ft	Development of volume-----	0.31
Maximum depth-----	73 ft	Bottom slope-----	2.4 percent

Drainage basin.

Size: 1.98 mi².

Geology: Lake is bordered on the east by intrusive and extrusive igneous and metamorphic rocks, and on the west by flood plain and terrace deposits of till and unconsolidated materials. (Walters, 1974).

Soils: Shallow to deep, sandy loam to silt loam soils (U.S. Soil Conservation Service, 1968).

Land use	Percent
Urban	0
Suburban	0
Agricultural	19
Forest or unproductive	68
Lake surface	13

Nearshore development.

Number of nearshore homes: 0

Nearshore residential development: 0 percent

Littoral bottom.

Chiefly silt and muck with local areas of coarse sand, gravel, and rock.

Hydrology.

The lake has no surface-water inflow. Drainage is southward to Chopaka Creek but the outflow channel was either dry or filled with stagnant water on all sampling dates.

The lake stage declined 0.84 foot from June 4 to Sept 23, 1975.

Aquatic plants.

Shoreline-----	51-75 percent
Lake surface-----	1-10 percent
Lake bottom-----	26-50 percent

Macrophytes observed (7/30/75): bulrush (*Scirpus* sp.)*, muskgrass (*Chara* sp.), pondweed (*Potamogeton* sp.)*, bog moss (*Sphagnum* sp.), sedge (Cyperaceae).

*Asterisk indicates dominant aquatic plants.

Algae observed (8/28/75):

Blue-greens (*Osillatoria* sp.)

Summary and conclusions.

Chopaka Lake is a long, sheltered lake that is situated between high ridges. The only shore development is a public campground on the west side of the lake.

The dissolved-solids content on the water was high; specific conductance for the four sampling dates averaged over 1,000 $\mu\text{mhos/cm}$. The Secchi-disc transparency ranged from 12 to 21 feet.

The biological productivity of the lake was low to moderate. Chlorophyll *a* concentrations were moderate in April but low the remainder of the year. Submersed aquatic plants, chiefly pondweed, were observed in the shallow south end of the lake. Total phosphorus concentrations were moderate in the upper water but high in the bottom water.

The lake was thermally stratified by June. Dissolved-oxygen concentrations in the bottom water were low throughout the year. Hydrogen sulfide was detected in the bottom water on all sampling dates.

Water-quality data for Chopoka Lake

[Milligrams per liter unless otherwise indicated]

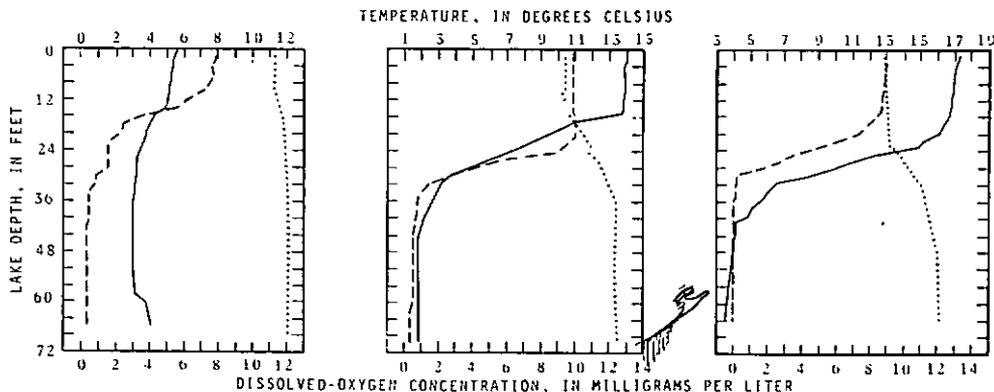
Date of collection (1975)-----	April 29			June 4			August 28		
	3	50	64	3	50	64	3	50	62
Water depth (ft)-----									
Silica (SiO ₂)-----	4.3	6.0	9.9	1.5	6.6	10	1.5	8.1	9.8
Dissolved iron (Fe), in µg/L--	30	20	20	40	40	60	20	20	20
Dissolved manganese (Mn)----- (in µg/L)	20	80	160	10	150	160	10	170	140
Calcium (Ca)-----	11	--	--	--	--	--	--	--	--
Magnesium (Mg)-----	110	--	--	--	--	--	--	--	--
Sodium (Na)-----	85	--	--	--	--	--	--	--	--
Potassium (K)-----	27	--	--	--	--	--	--	--	--
Bicarbonate (HCO ₃)-----	513	677	739	620	670	732	511	686	704
Carbonate (CO ₃)-----	42	1	0	83	--	--	54	--	--
Sulfide (S)-----	--	~1	>5	--	>5	>5	--	>5	>5
Sulfate (SO ₄)-----	200	--	--	--	--	--	--	--	--
Chloride (Cl)-----	9.7	--	--	--	--	--	--	--	--
Nitrate nitrogen (as N)-----	.03	.00	.00	.02	.01	.01	.00	.16	.00
Nitrite nitrogen (as N)-----	.00	.00	.00	.00	.00	.00	.00	.00	.01
Ammonia nitrogen (as N)-----	.20	.47	3.1	.16	.94	2.7	.07	1.4	2.4
Organic nitrogen (as N)-----	1.4	1.3	.60	.93	1.1	1.9	1.1	1.2	1.5
Total phosphorus (as P)-----	.022	.034	.20	.033	.053	.46	.012	.091	.20
Orthophosphate (as P)-----	.005	.001	.17	.018	.005	.22	.002	.032	.16
Suspended solids (110°C)-----	16	--	--	--	--	--	--	--	--
Hardness as CaCO ₃ (Ca, Mg)-----	480	--	--	--	--	--	--	--	--
Specific conductance----- (micromhos at 25°C)	1,071	1,186	1,396	1,337	833	901	1,148	1,209	1,230
pH (pH units)-----	9.3	9.1	8.8	8.6	8.3	8.0	8.6	8.2	7.8
Water temperature (°C)-----	5.4	2.9	3.9	14.0	1.7	1.7	17.0	3.8	3.5
Color (Pt-Co scale)-----	20	15	15	5	5	40	0	0	0
Secchi-disc (ft)-----		12			21			12	
Dissolved oxygen (DO)-----	7.8	.3	.3	9.8	.4	.3	9.0	.0	.0
Chlorophyll <i>a</i> in photic zone- (µg/L)		3.7			1.0			1.8	
Fecal coliform Range-- (col. per 100 mL) Mean--		<1-1			<1-1			<1-1	
Total organic carbon (as C)--	24	--	--	19	--	--	19	--	--

EXPLANATION

Temperature

Dissolved oxygen concentration

Dissolved oxygen concentration at 100 percent saturation

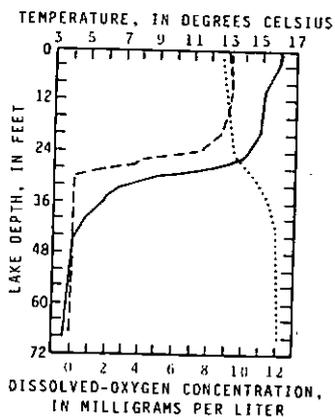


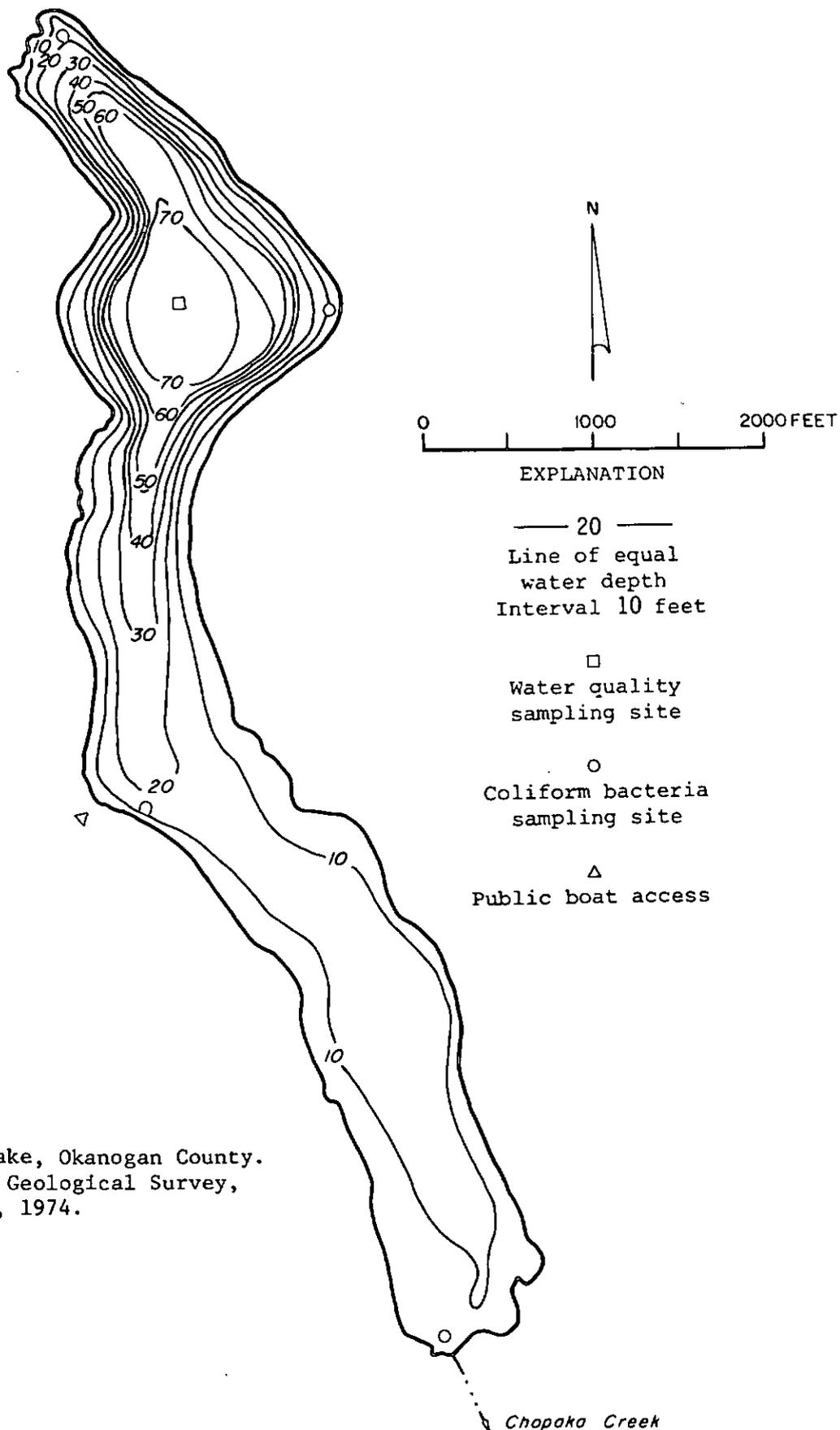
Water-quality data for Chopaka Lake--continued

[Milligrams per liter unless otherwise indicated]

Date of collection (1975)-----	September 23		
	3	50	66
Water depth (ft)-----			
Silica (SiO ₂)-----	1.1	8.1	10
Dissolved iron (Fe), in µg/L--	40	30	20
Dissolved manganese (Mn)----- (in µg/L)	20	200	160
Calcium (Ca) -----	14	--	--
Magnesium (Mg) -----	130	--	--
Sodium (Na) -----	90	--	--
Potassium (K) -----	30	--	--
Bicarbonate (HCO ₃) -----	492	700	722
Carbonate (CO ₃)-----	71	--	--
Sulfide (S)-----	--	>5	>5
Sulfate (SO ₄)-----	230	--	--
Chloride (Cl)-----	10	--	--
Nitrate nitrogen (as N)-----	.00	.00	.00
Nitrite nitrogen (as N)-----	.00	.01	.03
Ammonia nitrogen (as N)-----	.11	1.5	2.9
Organic nitrogen (as N)-----	1.1	1.3	1.7
Total phosphorus (as P)-----	.013	.10	.24
Orthophosphate (as P)-----	.002	.059	.16
Suspended solids (110°C)-----	20	--	--
Hardness as CaCO ₃ (Ca,Mg)----	570	--	--
Specific conductance----- (micromhos at 25°C)	1,119	1,156	1,192
pH (pH units)-----	8.5	7.9	7.6
Water Temperature (°C)-----	16.0	3.9	3.6
Color (Pt-Co scale)-----	10	30	55
Secchi-disc (ft)-----	-----	14	-----
Dissolved oxygen (DO)-----	9.1	<.1	.0
Chlorophyll <i>a</i> in photic zone- (µg/L)	-----	0.69	-----
Fecal coliform Range-- (col. per 100 mL) Mean--	-----	<1-1	-----
Total organic carbon (as C)--	19	--	--

EXPLANATION
 _____ Temperature
 - - - - - Dissolved oxygen concentration
 Dissolved oxygen concentration at 100 percent saturation





Chopaka Lake, Okanogan County.
 From U.S. Geological Survey,
 August 13, 1974.



Chopaka Lake, Okanogan County. June 4, 1973. Approx. scale 1:12,000.

Coffeepot Lake near Odessa (12464900)Location.

11 miles northeast of Odessa; Lincoln County. Lat 47°28'47", long 118°36'07"; SE¼SW¼ sec.13. T.23 N, R.33 E. Crab Creek basin; 1,814 feet altitude. Coffeepot Lake and Swanson Lake quadrangles (1:24,000 scale).

Physical characteristics of lake.

Surface area-----	320 acres	Length of shoreline-----	7.5 miles
Volume-----	12,000 acre-ft	Shoreline configuration-----	3.0
Mean depth-----	39 ft	Development of volume-----	0.51
Maximum depth-----	75 ft	Bottom slope-----	1.8 percent

Drainage basin.

Size: 98.6 mi².

Geology: Primarily dense basalt flows, with minor amounts of till, outwash, and associated deposits (Hunting and others, 1961).

Soils: Shallow to deep loam and silt loam soils, with local gravelly and stony areas (U.S. Soil Conservation Service, 1968).

Land use	Percent
Urban	0
Suburban	0
Agricultural	98
Forest or unproductive	1
Lake Surface	1

Nearshore development.

Number of nearshore homes: 1

Nearshore residential development: 1 percent

Littoral bottom.

Predominantly muck with some gravel, sand, and silt. Rock and gravel, with some muck, along the north and southeast shores.

Hydrology.

The principal inflow to the lake is from Lake Creek. On April 15 and May 21, 1975, the inflows were 18.0 and 10.0 ft³/s, respectively. On subsequent sampling trips the water in the inflow channel was stagnant. Drainage is southwestward via Lake Creek to Deer Creek. On April 15 and May 21, 1975, the outflows were 38.5 and 23.4 ft³/s, respectively. On subsequent sampling trips the water in the outflow channel was stagnant.

The stage declined 1.52 feet from May 21 to Oct 2, 1975.

Aquatic plants.

Shoreline-----	51-75 percent
Lake surface-----	1-10 percent
Lake bottom-----	26-50 percent

Macrophytes observed (7/18/75): bulrush (Scirpus sp.)*, coontail (Ceratophyllum sp.), pondweed (Potamogeton sp.)*, water milfoil (Myriophyllum sp.), cattail (Typha sp.), bushy pondweed (Najas sp.), sedge (Cyperaceae), waterweed (Elodea sp.), smartweed (Polygonum sp.).

*Asterisk indicates dominant aquatic plants.

Algae observed:

8/14/75: Blue-greens (Aphanizomenon sp.).

10/2/75: Blue-greens (Aphanizomenon sp.).

Summary and conclusions.

Coffeepot Lake is a long lake composed of two, almost distinct, segments. The lake is situated in a coulee cut into basalt lava flows, and the shoreline is locally steep and rocky. The only nearshore residential development is a privately owned resort on the north shore of the lake.

The biological productivity of the lake was moderate to high. Chlorophyll a concentrations were very high (128 µg/L) in April but low the remainder of the year. A dense concentration of blue-green algae was observed in April; the Secchi-disc visibility at that time was 4.2 feet. Most of the bottom of the eastern segment of the lake was covered with submersed aquatic plants, chiefly pondweed, to a depth of about 12 feet.

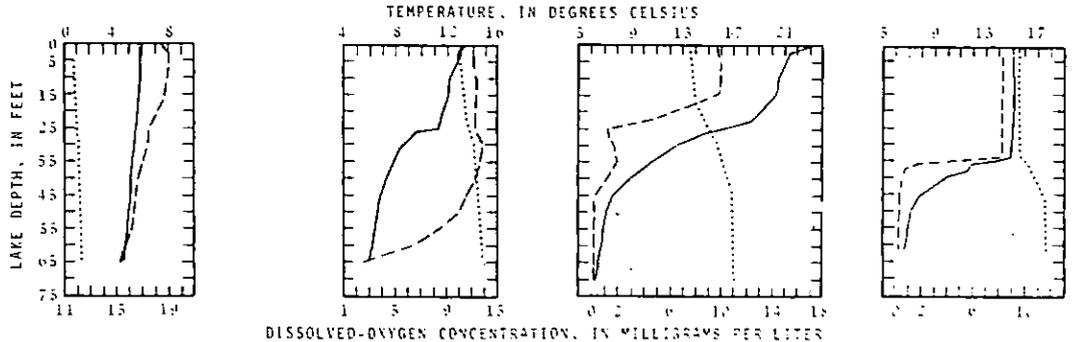
Thermal stratification was weakly developed in May. By August the lake was well stratified and the dissolved-oxygen concentration in the bottom water was near zero.

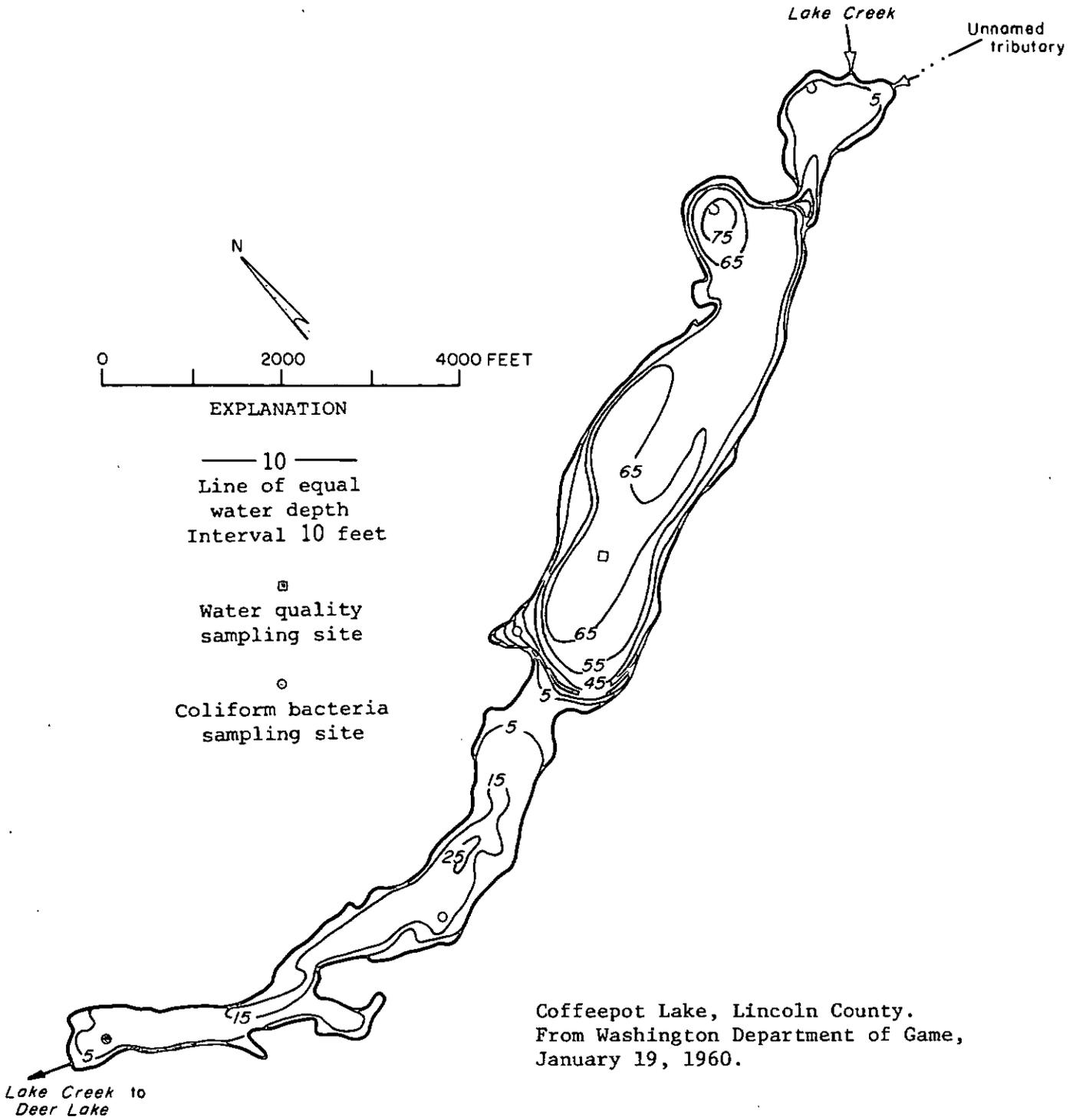
Water-quality data for Coffeepot Lake

[Milligrams per liter unless otherwise indicated!]

Date of collection (1975)-----	April 15		May 21		August 14		October 2	
	2	62	3	62	3	67	3	60
Water depth (ft)-----								
Silica (SiO ₂)-----	13	15	9.0	11	11	13	11	14
Dissolved iron (Fe), in µg/L--	20	40	0	30	10	30	30	30
Dissolved manganese (Mn)----- (in µg/L)	20	30	10	80	0	260	10	290
Calcium (Ca) -----	32	--	--	--	--	--	25	--
Magnesium (Mg) -----	14	--	--	--	--	--	14	--
Sodium (Na) -----	28	--	--	--	--	--	29	--
Potassium (K) -----	6.8	--	--	--	--	--	7.6	--
Bicarbonate (HCO ₃) -----	200	194	190	202	197	197	203	220
Carbonate (CO ₃)-----	0	2	7	0	8	--	0	--
Sulfide (S)-----	--	--	--	--	--	15	--	15
Sulfate (SO ₄)-----	23	--	--	--	--	--	19	--
Chloride (Cl)-----	8.4	--	--	--	--	--	7.7	--
Nitrate nitrogen (as N)-----	.00	.21	.00	.00	.00	.00	.05	.00
Nitrite nitrogen (as N)-----	.01	.01	.00	.00	.00	.00	.00	.00
Ammonia nitrogen (as N)-----	.07	.14	.21	.63	.03	1.7	.05	2.4
Organic nitrogen (as N)-----	1.2	1.1	.70	.97	.69	.70	.68	.60
Total phosphorus (as P)-----	.11	.12	.038	.13	.019	.33	.014	.40
Orthophosphate (as P)-----	.003	.025	.018	.086	.001	.18	.002	.37
Suspended solids (110 °C)-----	12	--	--	--	--	--	24	--
Hardness as CaCO ₃ (Ca, Mg)-----	140	--	--	--	--	--	150	--
Specific conductance----- (micromhos at 25 °C)	339	339	358	265	335	358	334	363
pH (pH units)-----	9.1	9.0	8.1	8.8	9.0	7.5	8.0	6.8
Water temperature (°C)-----	5.9	4.6	12.8	6.1	21.5	6.4	15.1	6.8
Color (Pt-Co scale)-----	30	40	30	30	10	30	30	40
Secchi-disc (ft)-----	--	4.2	--	19	--	10	--	13
Dissolved oxygen (DO)-----	19.0	15.4	11.0	4.4	9.8	.1	8.4	.2
Chlorophyll <i>a</i> in photic zone- (µg/L)	--	128	--	2.8	--	2.6	--	1.3
Fecal coliform Range-- (col. per 100 mL) Mean--	--	<1-2	--	<1-3	--	<1-18	--	1-40
		1		1		4		18
Total organic carbon (as C)--	14	--	8.4	--	12	--	8.3	--

EXPLANATION
 ——— Temperature
 - - - - - Dissolved oxygen concentration
 Dissolved oxygen concentration at 100 percent saturation







Coffeepot Lake, Lincoln County. June 2, 1970. Approx. scale 1:63,000.

Conconully Lake near Omak (12446480)Location.

17 miles northwest of Omak, Okanogan County. Lat 48°32'16", long 119°44'50", NE¼NW¼ sec.18 T.35 N., R.25 E. Okanogan River basin; 2,281 feet altitude. Tiffany Mountain and Conconully quadrangles (1:62,500 scale).

Physical characteristics of lake.

Surface area-----	430 acres	Length of shoreline-----	3.9 miles
Volume-----	12,000 acre-ft	Shoreline configuration-----	1.3
Mean depth-----	29 ft	Development of volume-----	0.56
Maximum depth-----	51 ft	Bottom slope-----	1.0 percent

Drainage basin.

Size: 120 mi².

Geology: Primarily intrusive and extrusive igneous and metamorphic rocks, with local areas of flood plain and terrace deposits of unconsolidated materials (Walters, 1974).

Soils: Shallow to deep loams, sandy loams and silt loam soils (U.S. Soil Conservation Service, 1968).

Land use	Percent
Urban	<1
Suburban	<1
Agricultural	2
Forest or unproductive	97
Lake surface	1

Nearshore development.

Number of nearshore homes: 36

Nearshore residential development: 16 percent

Littoral bottom.

Predominantly rock and gravel with some sand and silt. The north end and southwest corner of the lake are mostly sand and silt.

Hydrology.

Inflow to the lake is from Salmon Creek and spillage from Conconully (Salmon) Lake. On May 1, June 5, Aug 30, and Sept 22, 1975, the estimated combined inflows from these sources were 26, 72, 21, and 6.6 ft³/s, respectively. The outflow, via Salmon Creek, is controlled by an earth-filled dam.

The lake stage, which is regulated, declined 11.4 feet from May 1 to Sept 22, 1975.

Aquatic plants.

Shoreline-----	1-10 percent
Lake surface-----	1-10 percent
Lake bottom-----	1-10 percent

Macrophytes observed (7/31/75): sedge (Cyperaceae)*, pondweed (Potamogeton sp.)*, muskgrass (Chara sp.).

Algae observed:

8/30/75: Blue-greens (Aphanizomenon sp.)*

9/22/75: Blue-greens (Aphanizomenon sp.)*, Nostoc sp.), and diatoms (Asterionella sp., Tabellaria sp.).

*Asterisk indicates dominant aquatic plants.

Summary and conclusions.

Conconully Lake is a man-made reservoir formed by a dam on Salmon Creek. The water is used for irrigation purposes and large water-level fluctuations are common. There are resort facilities and a State Park at the north end of the lake.

The biological productivity of the lake was low to moderate. Chlorophyll a concentrations were low, except on June 5, when the concentration was 10 µg/L; the Secchi-disc visibility on that date was reduced to 5.0 feet. Most of the submersed aquatic macrophytes observed were at the north end of the lake.

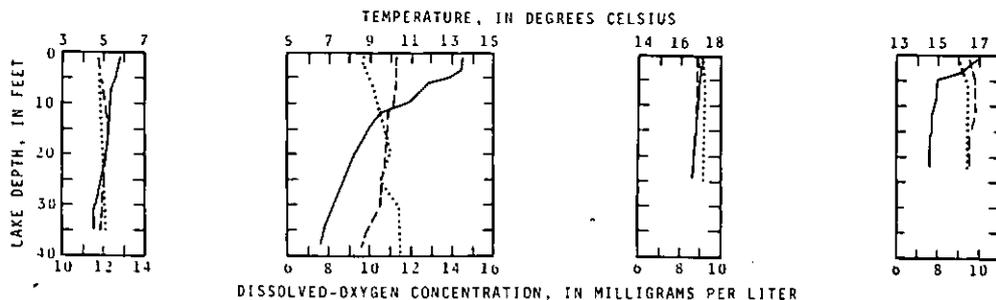
The lake did not stratify completely, possibly as a result of the high flushing rate of its water, although weak stratification was observed on June 5. The dissolved-oxygen concentration was uniform throughout the water column and near saturation on all sampling dates.

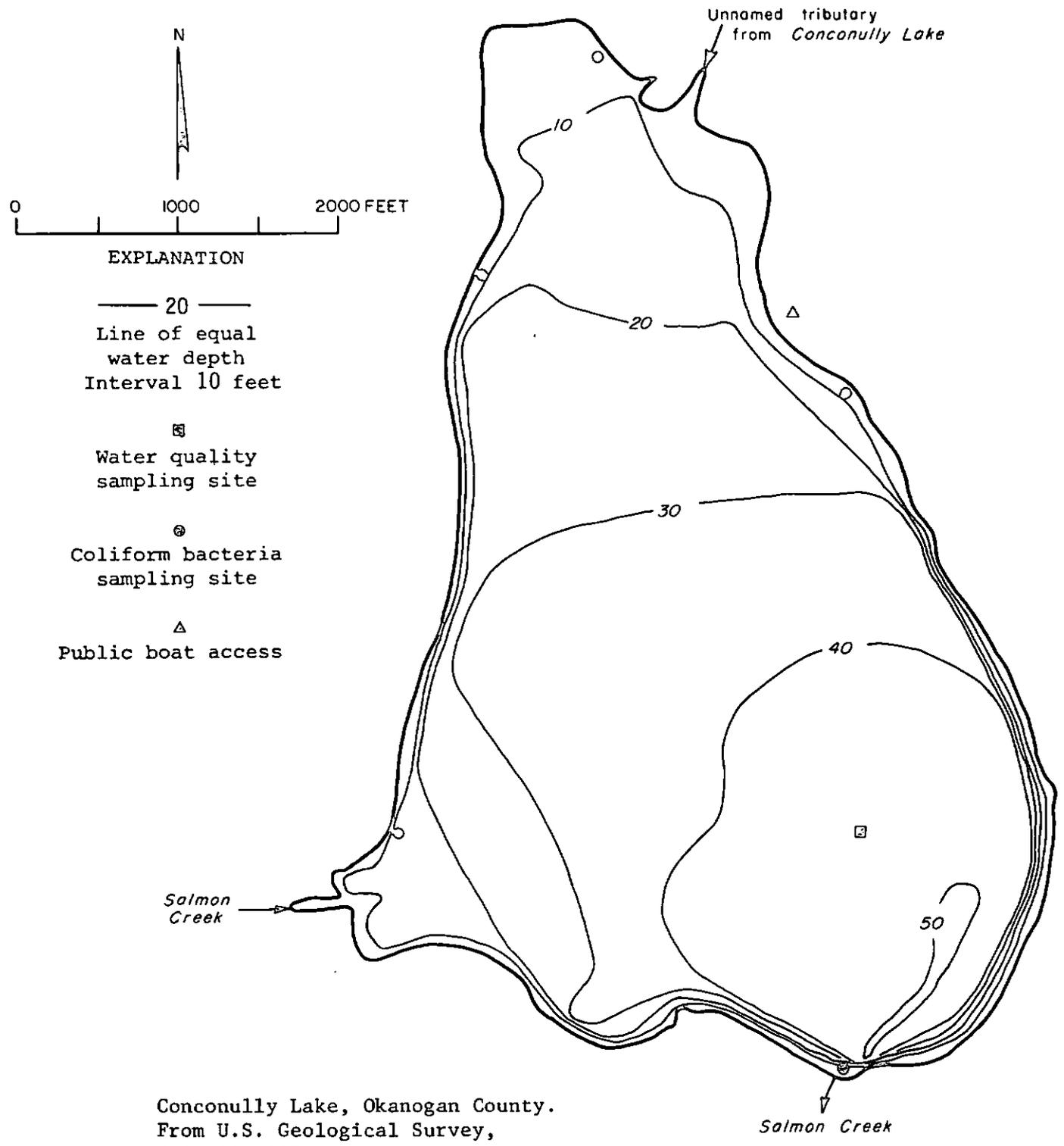
Water-quality data for Conconully Reservoir

[Milligrams per liter unless otherwise indicated]

Date of collection (1975)-----	May 1		June 5		August 30		September 22	
	1	32	3	38	3	22	3	20
Water depth (ft)-----								
Silica (SiO ₂)-----	13	13	16	16	14	14	15	14
Dissolved iron (Fe), in µg/L	70	70	60	100	70	70	70	140
Dissolved manganese (Mn)----- (in µg/L)	10	20	10	0	0	900	10	10
Calcium (Ca) -----	21	--	--	--	--	--	19	--
Magnesium (Mg) -----	5.2	--	--	--	--	--	4.2	--
Sodium (Na) -----	5.5	--	--	--	--	--	4.8	--
Potassium (K) -----	2.5	--	--	--	--	--	2.3	--
Bicarbonate (HCO ₃) -----	89	92	67	72	73	73	81	83
Carbonate (CO ₃)-----	0	--	--	--	--	--	0	--
Sulfide (S)-----	--	--	--	--	--	--	--	--
Sulfate (SO ₄)-----	14	--	--	--	--	--	9.3	--
Chloride (Cl)-----	1.1	--	--	--	--	--	1.6	--
Nitrate nitrogen (as N)-----	.00	.00	.00	.02	.00	.00	.01	.01
Nitrite nitrogen (as N)-----	.00	.00	.01	.00	.00	.00	.00	.00
Ammonia nitrogen (as N)-----	.03	.03	.16	.04	.01	.04	.04	.03
Organic nitrogen (as N)-----	.22	.14	.42	.20	.25	.20	.25	.31
Total phosphorus (as P)-----	.012	.012	.043	.015	.008	.009	.013	.013
Orthophosphate (as P)-----	.000	.000	.018	.002	.003	.002	.003	.002
Suspended solids (110 °C)-----	8	--	--	--	--	--	12	--
Hardness as CaCO ₃ (Ca, Mg)-----	74	--	--	--	--	--	65	--
Specific conductance----- (micromhos at 25 °C)	159	155	291	223	137	134	138	140
pH (pH units)-----	7.2	7.2	8.4	7.5	7.6	7.6	7.5	6.8
Water temperature (°C)-----	5.7	4.5	13.4	6.5	16.9	16.7	16.2	14.6
Color (Pt-Co scale)-----	0	0	30	30	20	20	20	20
Secchi-disc (ft)-----	--	8.8	--	5.0	--	10	--	10
Dissolved oxygen (DO)-----	11.8	11.8	11.2	9.5	8.8	8.6	9.7	9.4
Chlorophyll <i>a</i> in photic zone- (µg/L)	--	3.0	--	10	--	2.3	--	2.3
Fecal coliform Range-- (col. per 100 mL)	--	<1-<1	--	1-5	--	<1-3	--	<1-<1
Mean---	--	<1	--	3	--	1	--	<1
Total organic carbon (as C)--	6.0	--	5.5	--	3.6	--	3.2	--

EXPLANATION
 ----- Temperature
 - - - - - Dissolved oxygen concentration
 Dissolved oxygen concentration at 100 percent saturation







Conconully Lake, Okanogan County. July 11, 1973. Approx. scale 1:12,000.

Deep Lake near Maytown (12029015)Location.

3.1 miles northeast of Maytown, Thurston County. Lat 46°54'33", long 122°54'54"; NW¼NE¼ sec.3. T.16 N., R.2 W.. Chehalis River basin; 195 feet altitude. Maytown quadrangle (1:24,000 scale).

Physical characteristics of lake.

Surface area-----	66 acres	Length of shoreline-----	1.4 miles
Volume-----	770 acre-ft	Shoreline configuration-----	1.3
Mean depth-----	12 ft	Development of volume-----	0.69
Maximum depth-----	17 ft	Bottom slope-----	0.89 percent

Drainage basin.

Size: 1.17 mi².

Geology: Recessional outwash deposits of poorly sorted sand and gravel, with some stratified deposits of same materials in center of basin (Noble and Wallace, 1966).

Soils: Gravelly sandy loam, gravelly loam, clay loam, loam, loamy fine sand, peat, and muck (Ness, 1958).

Land use	Percent
Urban	0
Suburban	<1
Agricultural	38
Forest or unproductive	53
Lake surface	9

Nearshore development.

Number of nearshore homes: 3 (plus a resort)
Nearshore residential development: 6 percent

Littoral bottom.

Mostly rock, gravel, and sand, with silt and muck along the west and southwest shores.

Hydrology.

The lake has one unnamed tributary on the south side. Drainage is northwestward via an unnamed stream to Scott Lake. The estimated outflows on April 8, July 3, and Sept 12, 1975, were 7.4, 3.0, and 1.5 ft³/s, respectively.

The lake stage, which is controlled by a weir with flashboards, declined 0.28 foot from Feb 19 to Sept 12, 1975.

Aquatic plants.

Shoreline-----	26-50 percent
Lake surface-----	1-10 percent
Lake bottom-----	76-100 percent

Macrophytes observed (8/7/75): yellow lily (*Nuphar* sp.)*, cattail (*Typha* sp.), muskgrass (*Chara* sp.)*, waterweed (*Elodea* sp.), sedge (Cyperaceae), pondweed (*Potamogeton* sp.), bulrush (*Scirpus* sp.).

*Asterisk indicates dominant aquatic plants.

Algae observed (4/8/75):
Diatoms (*Asterionella* sp.)

Summary and conclusions.

Deep Lake has a maximum depth of about 17 feet. A State park is on the north shore of the lake, and a resort complex is on the east shore. Recreational use of the lake in summer is heavy.

The biological productivity of the lake was moderate to high. An algal bloom of diatoms was observed in April; the chlorophyll *a* concentration at that time was high (28 µg/L). A dense growth of submersed aquatic macrophytes, chiefly muskgrass, covered nearly the entire lake bottom. In July, the heavy growth of muskgrass produced enough oxygen to cause supersaturated conditions near the lake bottom.

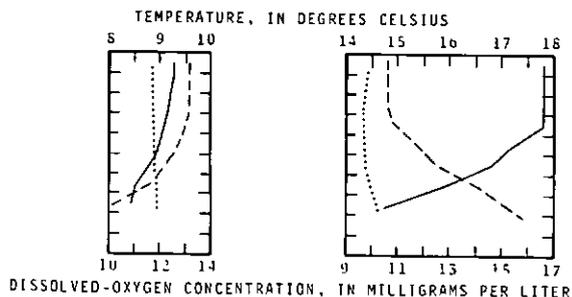
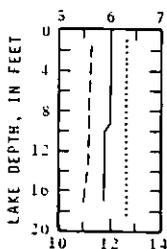
Thermal stratification was well established by July, although the lake does not appear to be deep enough to develop a true hypolimnion.

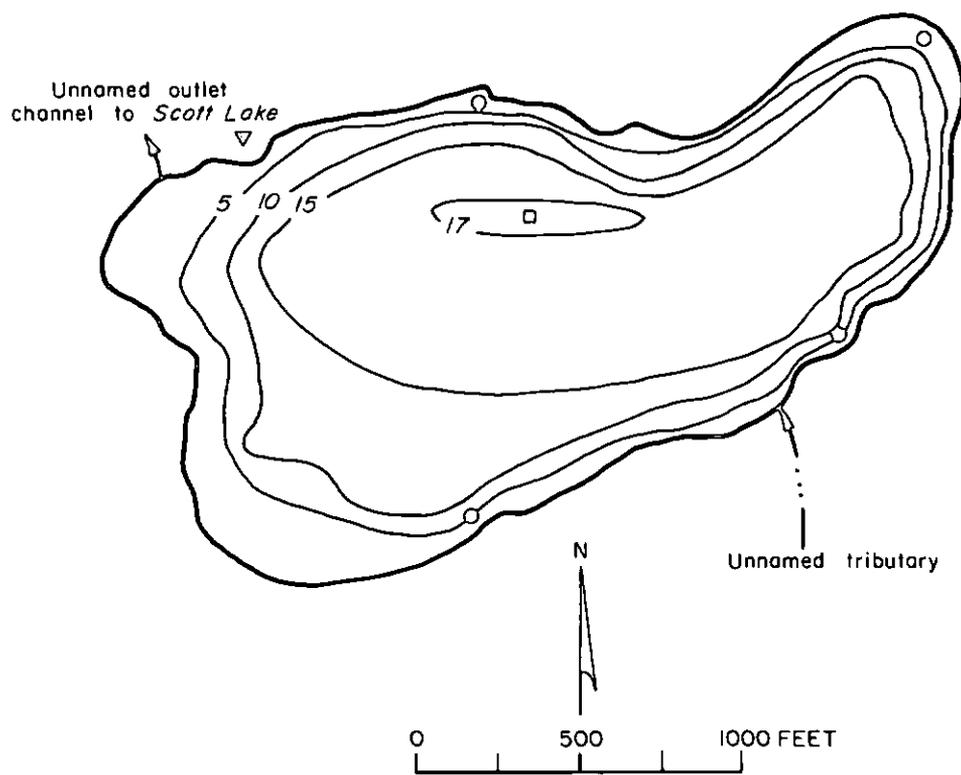
Water-quality data for Deep Lake

[Milligrams per liter unless otherwise indicated]

Date of collection (1975)-----	February 19		April 8		July 3		September 12	
	3	13	3	13	3	13	3	12
Water depth (ft)-----								
Silica (SiO ₂)-----	18	18	16	16	7.1	6.9	3.6	3.5
Dissolved iron (Fe), in µg/L--	130	60	40	40	50	40	20	30
Dissolved manganese (Mn)----- (in µg/L)	20	0	0	10	20	10	20	40
Calcium (Ca)-----	7.8	--	--	--	--	--	9.7	--
Magnesium (Mg)-----	2	--	--	--	--	--	2	--
Sodium (Na)-----	4.4	--	--	--	--	--	5.1	--
Potassium (K)-----	1.2	--	--	--	--	--	.5	--
Bicarbonate (HCO ₃)-----	23	22	24	25	24	23	28	28
Carbonate (CO ₃)-----	--	--	0	0	--	--	--	--
Sulfide (S)-----	--	--	--	--	--	--	--	--
Sulfate (SO ₄)-----	8.5	--	--	--	--	--	9.4	--
Chloride (Cl)-----	4.3	--	--	--	--	--	3.6	--
Nitrate nitrogen (as N)-----	.41	.41	.19	.20	.02	.02	.01	.07
Nitrite nitrogen (as N)-----	.01	.01	.01	.01	.00	.00	.00	.00
Ammonia nitrogen (as N)-----	.06	.08	.04	.05	.05	.05	.05	.08
Organic nitrogen (as N)-----	.56	.21	.42	.41	.23	.26	.29	.25
Total phosphorus (as P)-----	.033	.015	.023	.025	.017	.018	.011	.022
Orthophosphate (as P)-----	.002	.002	.003	.011	.003	.002	.002	.004
Suspended solids (110 °C)-----	0	--	--	--	--	--	0	--
Hardness as CaCO ₃ (Ca, Mg)-----	28	--	--	--	--	--	32	--
Specific conductance----- (micromhos at 25 °C)	71	70	70	70	72	70	77	76
pH (pH units)-----	7.2	7.4	7.3	7.4	6.1	6.1	7.2	6.8
Water temperature (°C)-----	6.0	5.9	9.2	8.5	17.8	16.0	18.9	17.7
Color (Pt-Co scale)-----	5	5	30	30	15	15	0	15
Secchi-disc (ft)-----	--	11	--	6.5	--	11	--	10
Dissolved oxygen (DO)-----	11.2	11.2	13.0	11.6	10.8	14.0	9.0	8.8
Chlorophyll a in photic zone- (µg/L)	--	11	--	28	--	3.1	--	3.0
Fecal coliform Range-- (col. per 100 mL) Mean--	-----	-----	--	<1-<1	--	<1-47	--	<1-3
			--	<1	--	12	--	2
Total organic carbon (as C)--	5.0	--	5.3	--	5.0	--	2.7	--

EXPLANATION
 ----- Temperature
 - - - - - Dissolved oxygen concentration
 Dissolved oxygen concentration at 100 percent saturation





EXPLANATION

— 10 —
Line of equal
water depth
Interval 5 feet

□
Water quality
sampling site

○
Coliform bacteria
sampling site

△
Public boat access

Deep Lake, Thurston County.
From Washington Department of Game,
August 12, 1947.



Deep Lake, Thurston County. June 29, 1974. Approx. scale 1:4800.

Goose Lake, Upper, near Othello (12471505)Location.

9.3 miles northwest of Othello, Grant County. Lat 46°55'55", long 119°17'20";
NW¼SE¼ sec.27, T.17 N., R.28 E. Crab Creek basin; 858 feet altitude.
Corfu quadrangle (1:62,500 scale).

Physical characteristics of lake.

Surface area-----	110 acres	Length of shoreline-----	2.9 miles
Volume-----	5000 acre-ft	Shoreline configuration-----	1.9
Mean depth-----	45 ft	Development of volume-----	0.47
Maximum depth-----	95 ft	Bottom slope-----	3.8 percent

Drainage basin.

Size: not measured because water is imported from outside the drainage basin.
Geology: Dark, dense, basalt flows (drainage basin near lake) (Hunting and others, 1961).
Soils: Deep, sandy soils (drainage basin near lake) (U.S. Soil Conservation Service, 1968).

Land use	Percent
Urban	
Suburban	Not measured because water is imported
Agricultural	from outside the drainage basin.
Forest or unproductive	
Lake surface	

Nearshore development.

Number of nearshore homes: 0
Nearshore residential development: 0 percent

Littoral bottom.

Predominantly rock, gravel, and sand, with local areas of silt and muck. The south and southwest shores are muck.

Hydrology.

The lake is fed intermittently by small, unnamed tributaries and by waste water from the West Canal. Drainage is southward to Lower Goose Lake. The outflow, which is controlled by a low dike, was not measured because of the inaccessibility of the channel.

Records of lake stage are incomplete. The stage declined 0.40 foot from May 28 to Aug 20, 1975, and then rose 0.43 foot from Aug 20 to Sept 16, 1975.

Aquatic plants.

Shoreline-----	1-10 percent
Lake surface-----	1-10 percent
Lake bottom-----	1-10 percent

Macrophytes observed (7/24/75): sedge (*Cyperaceae*)*, pondweed (*Potamogeton* sp.), cattail (*Typha* sp.), waterweed (*Elodea* sp.), bulrush (*Scirpus* sp.), water milfoil (*Myriophyllum* sp.).

*Asterisk indicates dominant aquatic plants.

Algae observed:

4/22/75: Diatoms (*Fragillaria* sp.)
9/16/75: Blue-greens (*Nostoc* sp.)

Summary and conclusions.

Upper Goose Lake was built about 1905 for irrigation purposes by diverting Crab Creek into a dry coulee. The lake is fed in part by waste water from West Canal and is separated from Lower Goose Lake by a low dike. There is no nearshore residential development, but recreational use of the lake, chiefly by fishermen, is heavy.

The biological productivity of the lake was low to moderate. The Secchi-disc visibility averaged more than 18 feet for the April, May, and August sampling dates, but had decreased to 6.5 feet by September. Very little of the lake surface or lake bottom were covered with aquatic macrophytes.

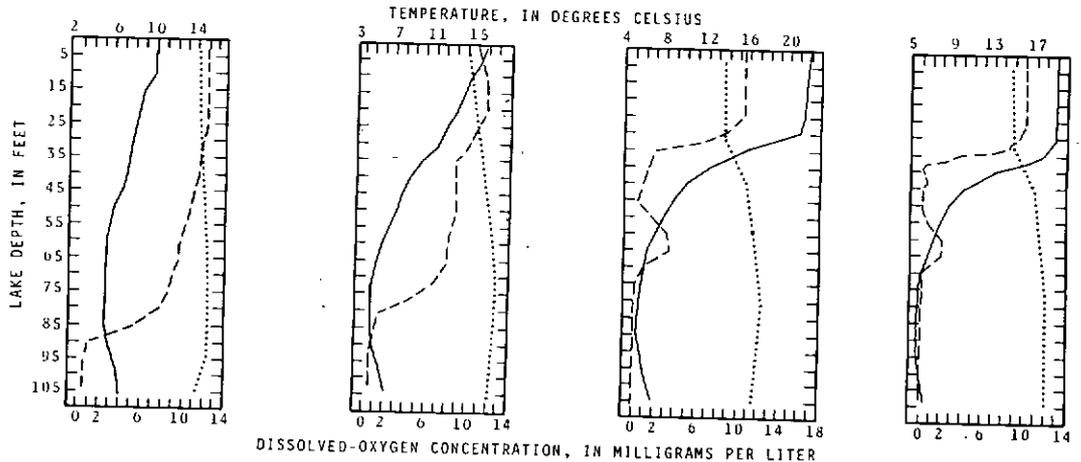
Thermal stratification was weakly developed in May; in August and September the lake was well stratified and the dissolved-oxygen concentration in the bottom water was zero.

Water-quality data for Upper Goose Lake

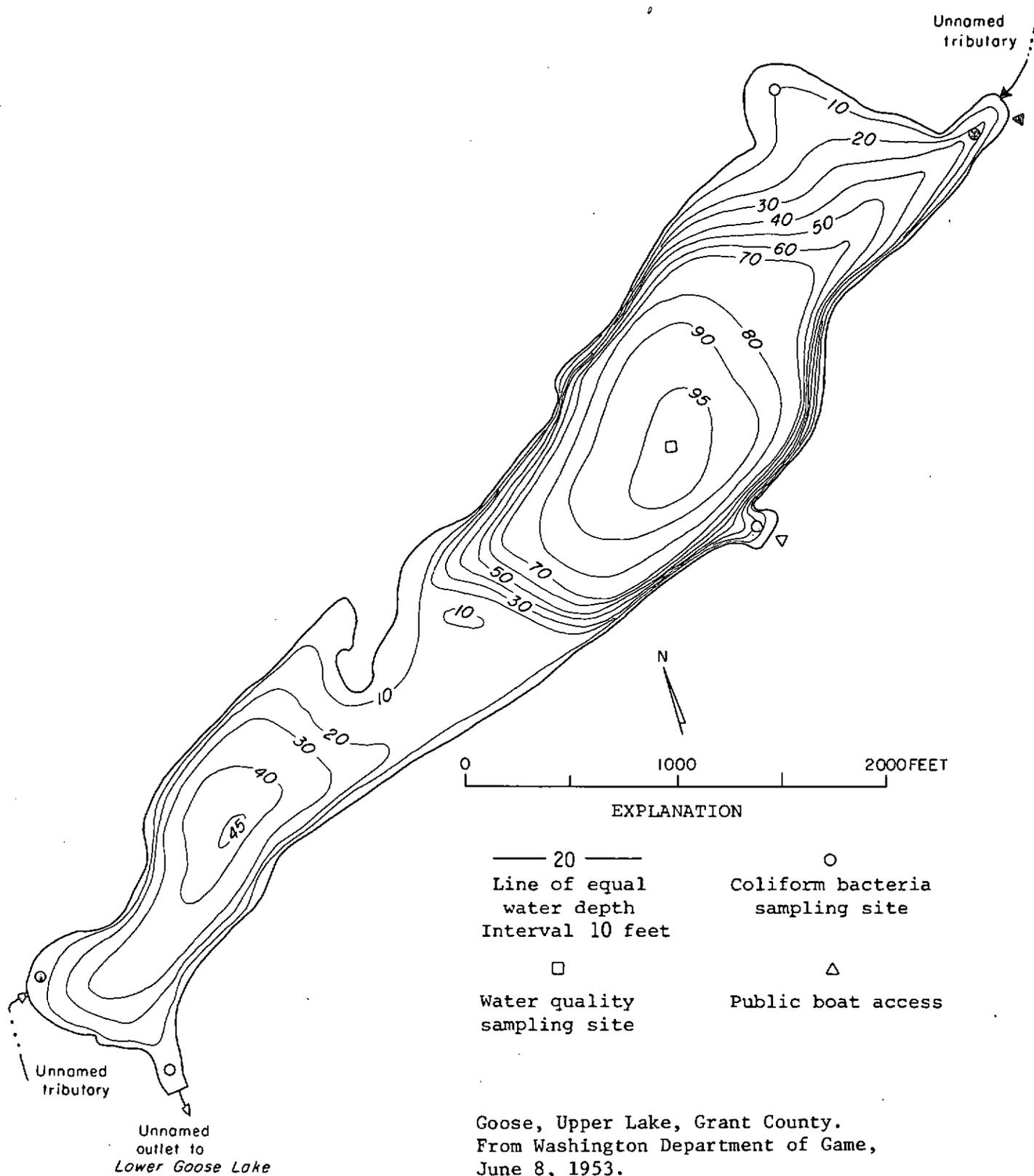
[Milligrams per liter unless otherwise indicated]

Date of collection (1975)-----	April 22		May 28		August 20		September 16	
	3	103	3	101	3	101	3	100
Water depth (ft)-----								
Silica (SiO ₂)-----	16	46	13	41	14	38	13	35
Dissolved iron (Fe), in µg/L--	10	1,300	30	150	10	130	40	100
Dissolved manganese (Mn)----- (in µg/L)	2	340	0	400	0	350	10	340
Calcium (Ca) -----	28	--	--	--	--	--	23	--
Magnesium (Mg) -----	29	--	--	--	--	--	27	--
Sodium (Na) -----	91	--	--	--	--	--	82	--
Potassium (K) -----	14	--	--	--	--	--	16	--
Bicarbonate (HCO ₃) -----	221	3,650	220	1,660	159	1,470	152	1,250
Carbonate (CO ₃)-----	1	--	1	--	18	--	17	--
Sulfide (S)-----	--	>5	--	>5	--	>5	--	>5
Sulfate (SO ₄)-----	110	--	--	--	--	--	120	--
Chloride (Cl)-----	60	--	--	--	--	--	55	--
Nitrate nitrogen (as N)-----	.17	.00	.88	.00	.23	.01	.47	.05
Nitrite nitrogen (as N)-----	.02	.15	.01	.19	.01	.01	.01	.13
Ammonia nitrogen (as N)-----	.08	81	.05	28	.06	29	.09	26
Organic nitrogen (as N)-----	.49	5.0	.39	.00	.42	.40	.50	.00
Total phosphorus (as P)-----	.019	31	.014	7.7	.008	6.8	.011	5.2
Orthophosphate (as P)-----	.003	25	.002	7.6	.003	6.7	.003	5.2
Suspended solids (110°C)-----	8	--	--	--	--	--	16	--
Hardness as CaCO ₃ (Ca,Mg)----	190	--	--	--	--	--	170	--
Specific conductance----- (micromhos at 25°C)	720	7,690	650	7,500	746	7,930	632	7,630
pH (pH units)-----	8.7	7.6	8.6	7.5	8.9	7.4	8.6	7.3
Water temperature (°C)-----	10.0	6.9	15.3	5.7	21.8	6.4	19.0	6.3
Color (Pt-Co scale)-----	0	>500	5	95	0	100	10	60
Secchi-disc (ft)-----	--	17	--	18	--	20	--	6.5
Dissolved oxygen (DO)-----	11.8	.4	10.9	.3	10.4	0	10.1	0
Chlorophyll <i>a</i> in photic zone- (µg/L)	--	4.6	--	2.0	--	2.3	--	5.7
Fecal coliform Range-- (col. per 100 mL) Mean--	--	<1-8	--	--	--	<1-5	--	<1-9
Total organic carbon (as C)--	32	--	7.7	--	35	--	6.8	--

EXPLANATION
 ——— Temperature
 - - - - - Dissolved oxygen concentration
 Dissolved oxygen concentration at 100 percent saturation



DISSOLVED-OXYGEN CONCENTRATION, IN MILLIGRAMS PER LITER





Goose, Upper Lake, Grant County. Aerial photograph from
U.S. Geological Survey, May 30, 1974.

Grimes Lake near Mansfield (12463690)Location.

6.5 miles southeast of Mansfield, Douglas County. Lat 47°43'18", long 119°35'59"; SE¼NE¼ sec.30. T.26 N., R.26 E.; location is of southernmost shoreline point of lake. Douglas Creek basin; 1,831 feet altitude. Jameson Lake East quadrangle (1:24,000 scale).

Physical characteristics of lake.

Surface area-----	180 acres	Length of shoreline-----	3.1 miles
Volume-----	4200 acre-ft	Shoreline configuration-----	1.7
Mean depth-----	24 ft	Development of volume-----	0.35
Maximum depth-----	67 ft	Bottom slope-----	2.1 percent

Drainage basin.

Size: 31.8 mi².

Geology: Primarily till, outwash, and related deposits, with basalt bordering the lake (Hunting and others, 1961).

Soils: Moderately deep and deep loam soils (U.S Soil Conservation Service, 1968).

Land use	Percent
Urban	0
Suburban	0
Agricultural	99
Forest or unproductive	0
Lake surface	1

Nearshore development.

Number of nearshore homes: 0

Nearshore residential development: 0 percent

Littoral bottom.

The east shore is underlain by rock and gravel with some silt. The west shore is underlain by silt with some rock and gravel.

Hydrology.

The lake receives minor inflow from an unnamed, intermittent tributary. Drainage is southwestward to Bennett Lake and eventually to Jameson Lake. No outflow was observed on the four sampling dates in 1975.

The lake stage declined 1.20 feet from April 24 to Sept 18, 1975.

Aquatic plants.

Shoreline-----	26-50 percent
Lake surface-----	<1 percent
Lake bottom-----	1-10 percent

Macrophytes observed (8/21/75): sedge (Cyperaceae), pondweed (Potamogeton sp.)

Summary and conclusions.

Grimes Lake is situated between high basalt cliffs of Moses Coulee.

The lake is reportedly too alkaline to support fish life. The pH and specific conductance averaged about 9.0 and 10,000 μ mhos/cm, respectively. Although the nitrate concentrations in nearly all samples taken were zero, the concentrations of organic nitrogen, total phosphorus, and orthophosphate were very high. The chlorophyll *a* concentration was high (28 μ g/L) in April, but low on all other sampling dates. Aquatic macrophyte growth was light.

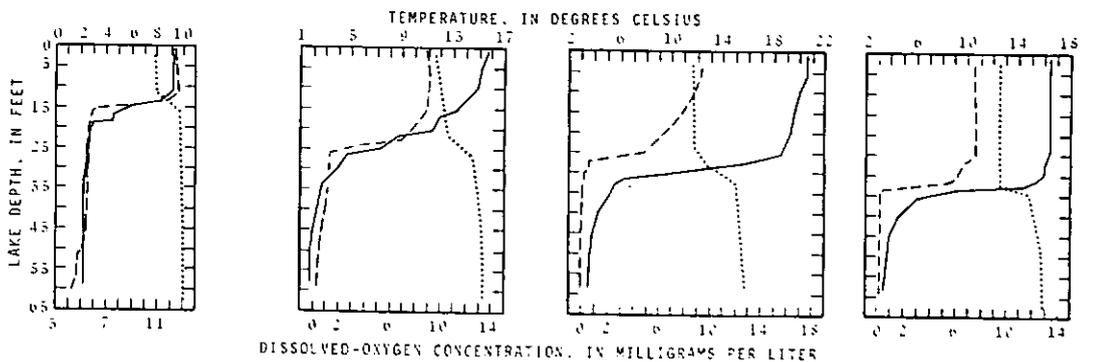
Thermal stratification was established by late April and dissolved-oxygen concentration was near zero below a depth of 30 feet during summer. Hydrogen sulfide was detected in the bottom water in August and September.

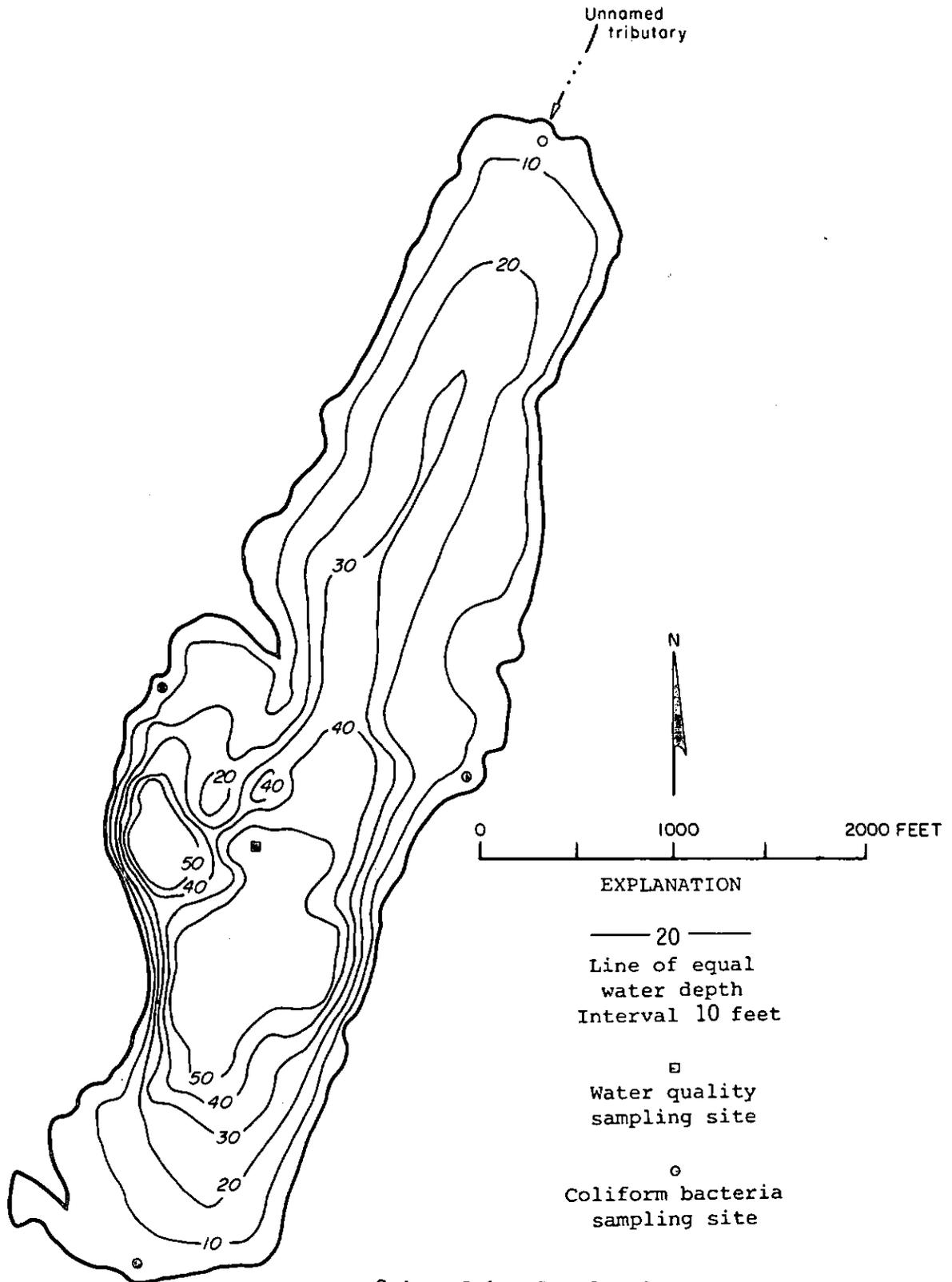
Water-quality data for Grimes Lake

[Milligrams per liter unless otherwise indicated]

Date of collection (1975)-----	April 24		May 30		August 21		September 18	
	3	56	3	55	3	56	3	56
Water depth (ft)-----								
Silica (SiO ₂)-----	12	12	--	13	8.6	13	8.3	15
Dissolved iron (Fe), in µg/L--	40	40	50	70	20	30	20	30
Dissolved manganese (Mn)----- (in µg/L)	2	20	10	20	10	20	10	20
Calcium (Ca) -----	18	--	--	--	--	--	7.6	--
Magnesium (Mg) -----	38	--	--	--	--	--	41	--
Sodium (Na) -----	2,400	--	--	--	--	--	2,600	--
Potassium (K) -----	210	--	--	--	--	--	230	--
Bicarbonate (HCO ₃) -----	1,460	1,700	1,290	1,630	1,620	1,630	1,610	1,640
Carbonate (CO ₃)-----	404	385	529	416	420	405	441	410
Sulfide (S)-----	--	--	--	--	--	>5	--	>5
Sulfate (SO ₄)-----	2,300	--	--	--	--	--	2,700	--
Chloride (Cl)-----	920	--	--	--	--	--	990	--
Nitrate nitrogen (as N)-----	.00	.03	.00	.00	.00	.00	.00	.00
Nitrite nitrogen (as N)-----	.00	.01	.01	.03	.00	.01	.01	.01
Ammonia nitrogen (as N)-----	.09	.53	.15	.68	.08	1.5	.14	1.8
Organic nitrogen (as N)-----	3.7	3.4	3.1	2.4	2.9	2.6	3.0	2.8
Total phosphorus (as P)-----	2.2	2.4	2.3	2.7	2.1	2.5	2.2	2.6
Orthophosphate (as P)-----	1.8	2.2	2.0	2.3	2.0	2.4	2.1	2.5
Suspended solids (110°C)-----	20	--	--	--	--	--	16	--
Hardness as CaCO ₃ (Ca,Mg)----	200	--	--	--	--	--	190	--
Specific conductance----- (micromhos at 25°C)	9,300	10,300	10,380	10,180	10,980	10,040	10,850	10,190
pH (pH units)-----	9.3	9.2	9.2	9.1	9.0	8.8	9.0	8.8
Water temperature (°C)-----	9.1	2.1	15.4	1.8	20.6	3.4	16.4	3.5
Color (Pt-Co scale)-----	30	20	20	25	5	0	5	25
Secchi-disc (ft)-----	--	4.0	--	15	--	15	--	13
Dissolved oxygen (DO)-----	12.7	4.6	8.9	.3	9.2	0	7.6	.1
Chlorophyll <u>a</u> in photic zone- (µg/L)	--	28	--	2.2	--	2.5	--	3.7
Fecal coliform Range-- (col. per 100 mL) Mean--	--	<1-16	--	<1-3	--	<1-3	--	<1-3
		4		2		1		1
Total organic carbon (as C)--	41	--	30	--	57	--	39	--

EXPLANATION
 _____ Temperature
 - - - - - Dissolved oxygen concentration
 Dissolved oxygen concentration at 100 percent saturation





Grimes Lake, Douglas County.
From U.S. Geological Survey,
May 16, 1974.



Grimes Lake, Douglas County. June 1, 1970. Approx. scale 1:63,000.

Heart Lake near Othello (12471600)Location.

7.2 miles north of Othello, Grant County. Lat 46°55'44", long 119°11'16"; SE¼SW¼ sec.28. T.17 N., R.29 E.; location is of southernmost shoreline point of lake. Crab Creek basin; 978 feet altitude. Soda Lake quadrangle (1:24,000 scale).

Physical characteristics of lake.

Surface area-----	27 acres	Length or shoreline-----	1.1 miles
Volume-----	940 acre-ft	Shoreline configuration-----	1.5
Mean depth-----	35 ft	Development of volume-----	0.53
Maximum depth-----	65 ft	Bottom slope-----	5.3 percent

Drainage basin.

Size: 4.23 mi².

Geology: Black, dense basalt flows, commonly showing columnar jointing (Huntington and others, 1961).

Soils: Silt loam, sandy loam, loam, and sandy soils from wind-laid silts (U.S. Soil Conservation Service, 1968).

Land use	Percent
Urban	0
Suburban	0
Agricultural	95
Forest or unproductive	4
Lake surface	1

Nearshore development.

Number of nearshore homes: 0

Nearshore residential development: 0 percent

Littoral bottom.

Predominantly rock on steep slopes, with local areas of sand and muck. Silt at north and south ends of lake.

Hydrology.

The lake has no surface-water inflow or outflow.

The lake stage declined 0.25 foot from April 23 to May 29, 1975, and then rose 0.47 foot from May 29 to Sept 17, 1975.

Aquatic plants.

Shoreline-----	11-25 percent
Lake surface-----	< 1 percent
Lake bottom-----	26-50 percent

Macrophytes observed (8/19/75): sedge (*Cyperaceae*)*, pondweed (*Potamogeton* sp.), muskgrass (*Chara* sp.)*, coontail (*Ceratophyllum* sp.), cattail (*Typha* sp.), waterweed (*Elodea* sp.), white lily (*Nymphaea* sp.).

*Asterisk indicates dominant aquatic plants.

Algae observed (4/23/75):

Diatoms (*Fragillaria* sp.)

Summary and conclusions.

Heart Lake is situated near Potholes East Canal and is surrounded by low basalt cliffs. Although there is no residential development, recreational use of the lake, chiefly by fishermen, is heavy.

The biological productivity of the lake was low to moderate. Chlorophyll *a* concentrations were moderate in April but low on subsequent sampling dates. About 30 percent of the lake bottom was covered with submersed aquatic macrophytes, chiefly muskgrass.

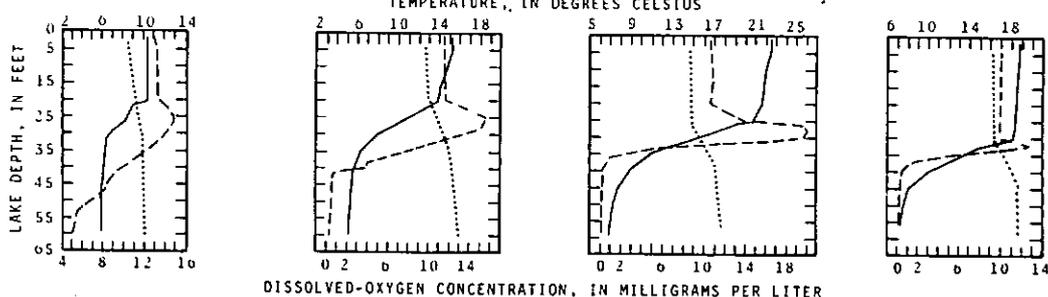
Thermal stratification was weakly developed in April, moderately developed in May, and strongly developed in August. Dissolved-oxygen concentration in the bottom water was near zero in August and September.

Water-quality data for Heart Lake

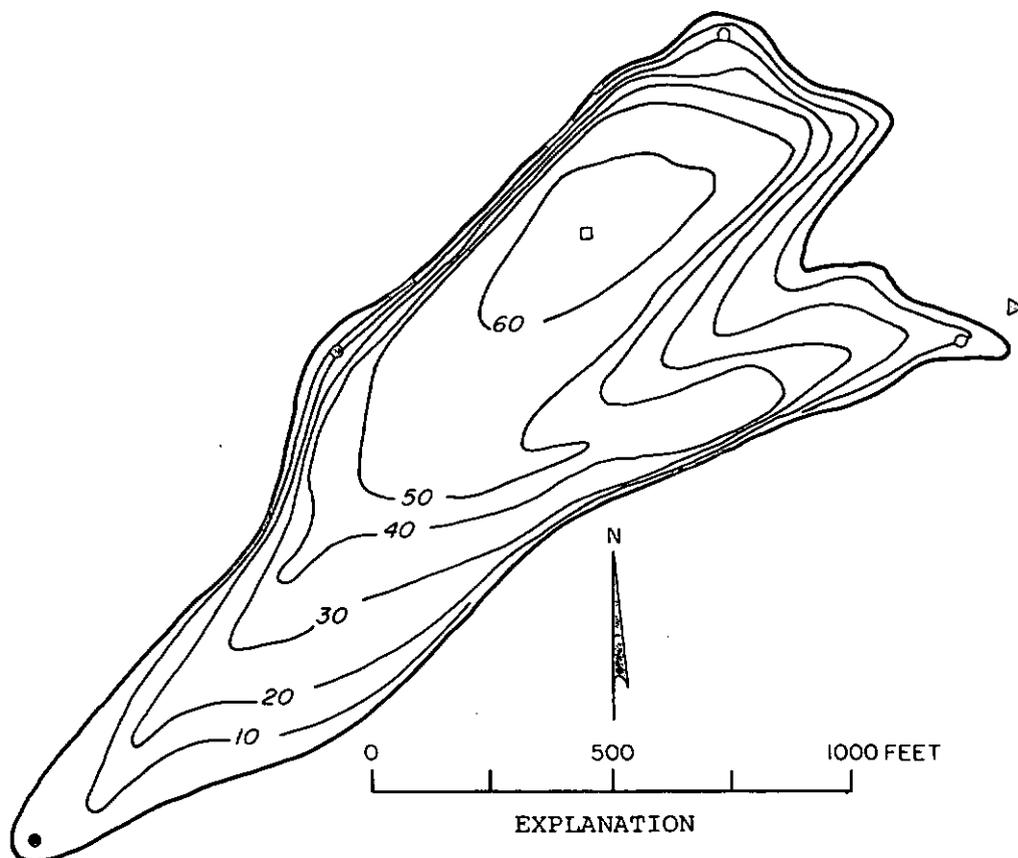
[Milligrams per liter unless otherwise indicated]

Date of collection (1975)-----	April 23		May 29		August 19		September 17	
	3	56	3	56	3	56	3	52
Water depth (ft)-----								
Silica (SiO ₂)-----	21	22	20	24	23	28	23	28
Dissolved iron (Fe), in µg/L--	10	20	20	60	0	30	20	20
Dissolved manganese (Mn)----- (in µg/L)	0	40	10	250	0	270	10	350
Calcium (Ca) -----	23	--	--	--	--	--	13	--
Magnesium (Mg) -----	32	--	--	--	--	--	32	--
Sodium (Na) -----	75	--	--	--	--	--	78	--
Potassium (K) -----	12	--	--	--	--	--	12	--
Bicarbonate (HCO ₃) -----	210	229	202	234	152	270	141	273
Carbonate (CO ₃)-----	10	--	12	--	25	--	33	--
Sulfide (S)-----	--	--	--	~3	--	>5	--	>5
Sulfate (SO ₄)-----	89	--	--	--	--	--	100	--
Chloride (Cl)-----	49	--	--	--	--	--	51	--
Nitrate nitrogen (as N)-----	.11	.14	.14	.00	.00	.00	.02	.00
Nitrite nitrogen (as N)-----	.01	.01	.01	.00	.00	.00	.00	.01
Ammonia nitrogen (as N)-----	.03	.18	.05	.75	.03	1.7	.04	1.7
Organic nitrogen (as N)-----	.73	.57	.50	.85	.58	1.0	.52	.60
Total phosphorus (as P)-----	.015	.020	.009	.032	.008	.035	.007	.044
Orthophosphate (as P)-----	.005	.005	.002	.002	.004	.003	.002	.030
Suspended solids (110 °C)-----	40	--	--	--	--	--	0	--
Hardness as CaCO ₃ (Ca, Mg)-----	190	--	--	--	--	--	160	--
Specific conductance----- (micromhos at 25 °C)	647	629	680	750	601	638	680	740
pH (pH units)-----	8.8	7.8	8.9	7.5	8.9	7.4	8.4	7.4
Water temperature (°C)-----	10.3	5.9	15.2	5.1	22.4	6.9	18.8	7.2
Color (Pt-Co scale)-----	5	5	25	25	0	5	5	10
Secchi-disc (ft)-----	--	14	--	26	--	17	--	20
Dissolved oxygen (DO)-----	12.0	5.4	11.4	.3	10.6	.1	10.0	<.1
Chlorophyll <i>a</i> in photic zone- (µg/L)	--	11	--	1.6	--	2.9	--	1.7
Fecal coliform Range-- (col. per 100 mL) Mean--	--	<1-1	--	<1-1	--	<1-20	--	<1-2
Total organic carbon (as C)--	39	--	9.8	--	34	--	8.3	--

EXPLANATION
 _____ Temperature
 - - - - - Dissolved oxygen concentration
 Dissolved oxygen concentration at 100 percent saturation



DISSOLVED-OXYGEN CONCENTRATION, IN MILLIGRAMS PER LITER



EXPLANATION

<p>— 20 — Line of equal water depth Interval 10 feet</p>	<p>○ Coliform bacteria sampling site</p>
<p>□ Water quality sampling site</p>	<p>△ Public boat access</p>

Heart Lake, Grant County.
From U.S. Geological Survey,
March 3, 1975.



Heart Lake, Grant County. June 1, 1970. Approx. scale 1:63,000.

Jameson Lake near Mansfield (12463695)Location.

9.5 miles south of Mansfield, Douglas County. Lat 47°40'13", long 119°37'48", SW¼SE¼ sec.12. T.25 N., R.25 E.; location is of southernmost shoreline point of lake. Douglas Creek basin; 1,781 feet altitude. Jameson Lake East and Jameson Lake West quadrangles (1:24,000 scale).

Physical characteristics of lake.

Surface area-----	620 acres	Length of shoreline-----	5.2 miles
Volume-----	15,000 acre-ft	Shoreline configuration-----	1.5
Mean depth-----	24 ft	Development of volume-----	0.38
Maximum depth-----	64 ft	Bottom slope-----	1.1 percent

Drainage basin.

Size: 77.9 mi².

Geology: Chiefly till, outwash, and related deposits, with basalt bordering the lake (Hunting and others, 1961).

Soils: Moderately deep and deep loam soils (U.S. Soil Conservation Service, 1968).

Land use	Percent
Urban	0
Suburban	0
Agricultural	98
Forest or unproductive	0
Lake surface	2

Nearshore development.

Number of nearshore homes: 1

Nearshore residential development: 3 percent

Littoral bottom.

Predominantly rock, gravel, and sand, with local areas of muck.

Hydrology.

The lake receives intermittent inflow from several small, unnamed tributaries; part of the inflow is from Bennett and Grimes Lakes. Drainage is southward by overflow to Jameson Pothole Lake; at high lake stages the two lakes merge to form a single water body. No outflow to Jameson Pothole Lake was observed on the four sampling dates in 1975.

The lake stage declined 3.90 feet from April 24 to Sept 18, 1975.

Aquatic plants.

Shoreline-----	26-50 percent
Lake surface-----	<1 percent
Lake bottom-----	11-25 percent

Macrophytes observed (8/22/75): quillwort (*Isoetes* sp.)*, pondweed (*Potamogeton* sp.), sedge (Cyperaceae), water milfoil (*Myriophyllum* sp.), bulrush (*Scirpus* sp.).

Algae observed:

4/24/75: Diatoms (*Navicula* sp.)

5/30/75: None

8/22/75: Greens (*Zygenema* (?) sp.)* and blue-greens (*Polycystis* sp.).

9/18/75: Blue-greens (*Aphanizomenon* sp.*, *Oscillatoria* sp., *Polycystis* sp.).

*Asterisk indicates dominant aquatic plants.

Summary and conclusions.

Jameson Lake is situated in Moses Coulee. The lake receives intermittent inflow from Bennett and Grimes Lakes.

The biological productivity of the lake was moderate. Dissolved-mineral concentrations were high, as evidenced by specific-conductance values that averaged almost 4,000 µmhos/cm. Chlorophyll *a* concentrations were generally high, ranging from 13-24 µg/L; however, the concentration was only 0.7 µg/L in May. The Secchi-disc visibility was correspondingly higher in May, probably as a result of a decrease in algal density. Concentrations of total phosphorus and orthophosphate in the bottom water were high in August and September.

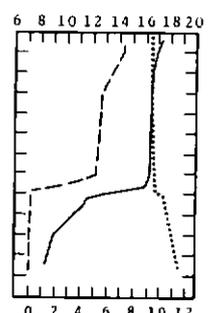
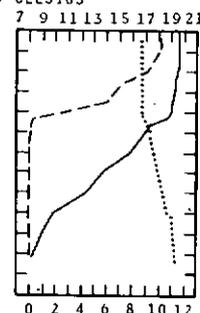
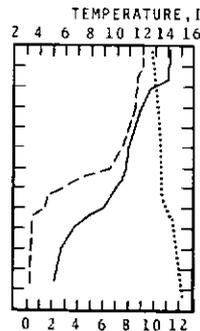
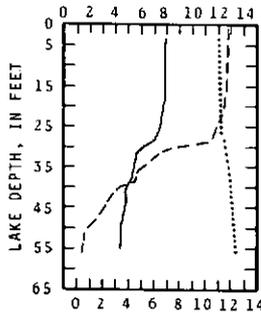
On May 30, 1975, the dissolved-oxygen concentration in the bottom water had been reduced to near zero and hydrogen sulfide was detected in that zone. On this same date, a fecal-coliform bacteria sample had a count of 121 colonies per 100 ml.

Water-quality data for Jameson Lake

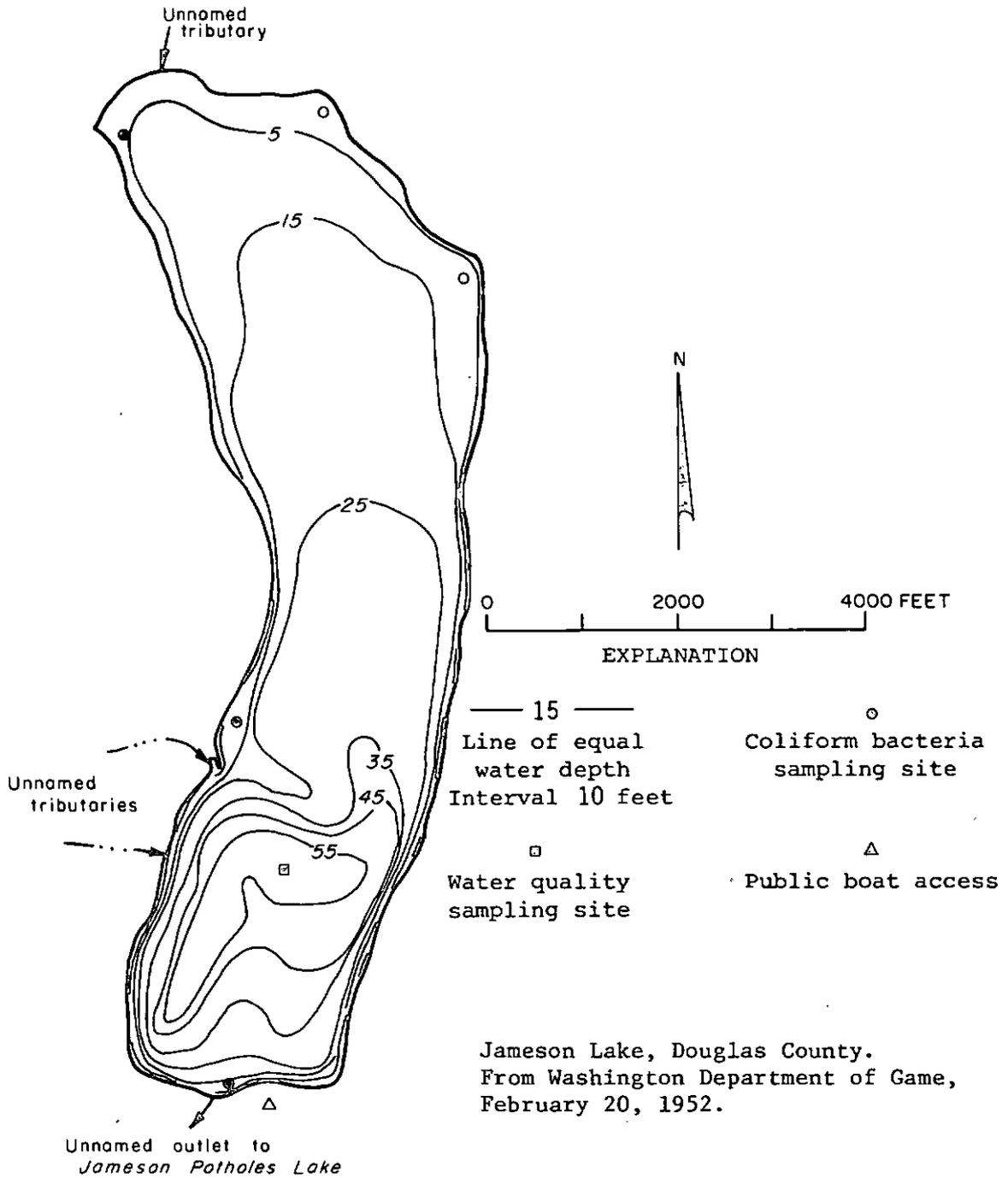
[Milligrams per liter unless otherwise indicated]

Date of collection (1975)-----	April 24		May 30		August 22		September 18	
	3	52	3	55	3	54	3	55
Water depth (ft)-----								
Silica (SiO ₂)-----	0.5	2.7	2.3	4.4	6.8	8.0	8.5	8.9
Dissolved iron (Fe), in µg/L--	10	10	40	40	10	20	20	0
Dissolved manganese (Mn)----- (in µg/L)	0	50	0	60	20	70	30	70
Calcium (Ca)-----	17	--	--	--	--	--	15	--
Magnesium (Mg)-----	54	--	--	--	--	--	59	--
Sodium (Na)-----	320	--	--	--	--	--	330	--
Potassium (K)-----	67	--	--	--	--	--	71	--
Bicarbonate (HCO ₃)-----	563	752	624	670	600	763	637	785
Carbonate (CO ₃)-----	81	0	55	32	78	0	61	--
Sulfide (S)-----	--	--	--	.4	--	>5	--	>5
Sulfate (SO ₄)-----	280	--	--	--	--	--	290	--
Chloride (Cl)-----	110	--	--	--	--	--	110	--
Nitrate nitrogen (as N)-----	.01	.01	.00	.00	.00	.00	.03	.00
Nitrite nitrogen (as N)-----	.00	.00	.01	.01	.01	.02	.00	.03
Ammonia nitrogen (as N)-----	.06	.71	.11	.81	.09	3.0	.24	4.8
Organic nitrogen (as N)-----	1.24	1.1	.99	1.2	1.7	.70	1.6	1.1
Total phosphorus (as P)-----	.063	.13	.063	.18	.061	.46	.078	.66
Orthophosphate (as P)-----	.003	.069	.023	.13	.002	.43	.004	.64
Suspended solids (110°C)-----	20	--	--	--	--	--	8	--
Hardness as CaCO ₃ (Ca,Mg)----	260	--	--	--	--	--	280	--
Specific conductance----- (micromhos at 25°C)	3,970	3,980	3,800	4,000	4,100	3,930	4,010	4,020
pH (pH units)-----	9.2	9.0	8.9	8.7	9.0	8.5	8.8	8.1
Water temperature (°C)-----	8.0	4.3	14.1	5.2	19.6	8.3	17.1	8.3
Color (Pt-Co scale)-----	15	20	10	25	25	25	10	10
Secchi-disc (ft)-----	--	8.2	--	16	--	5.0	--	6.2
Dissolved oxygen (DO)-----	11.8	.7	9.0	.2	10.1	0	7.2	0
Chlorophyll <i>a</i> in photic zone- (µg/L)	--	14	--	7	--	24	--	13
Fecal coliform (col. per 100 mL) Range--	--	<1-3	--	2-121	--	<1-9	--	<1-6
Mean--	--	1	--	51	--	3	--	2
Total organic carbon (as C)--	32	--	12	--	12	--	15	--

EXPLANATION
 ——— Temperature
 - - - - - Dissolved oxygen concentration
 Dissolved oxygen concentration at 100 percent saturation



DISSOLVED-OXYGEN CONCENTRATION, IN MILLIGRAMS PER LITER





Jameson Lake, Douglas County. June 1, 1970. Approx. scale 1:63,000.

Lawrence Lake near Rainier (12078940)Location.

5.6 miles southeast of Rainier, Thurston County. Lat 46°50'57", long 122°34'51"; NW¼NE¼ sec.29. T.16 N., R.2 E. Deschutes River basin; 428 feet altitude. Lake Lawrence quadrangle (1:24,000 scale).

Physical characteristics of lake.

Surface area-----	330 acres	Length of shoreline-----	4.0 miles
Volume-----	4400 acre-ft	Shoreline configuration-----	1.6
Mean depth-----	13 ft	Development of volume-----	0.51
Maximum depth-----	26 ft	Bottom slope-----	0.61 percent

Drainage basin.

Size: 3.35 mi².

Geology: Recessional outwash deposits of poorly sorted sand and gravel, with gravelly clay in the northern and eastern parts of the basin and flood plain deposits in the south (Noble and Wallace, 1966).

Soils: A complex pattern of sandy loams, loamy sand, gravelly loam, gravelly sandy loam, and peat (Ness, 1958).

Land use	Percent
Urban	0
Suburban	4
Agricultural	19
Forest or unproductive	63
Lake surface	14

Nearshore development.

Number of nearshore homes: 117

Nearshore residential development: 39 percent

Littoral bottom.

The composition of the littoral bottom is highly variable and locally includes silt, sand, gravel, cobble, and muck.

Hydrology.

The lake has no visible surface-water inflow. Drainage is southwestward via an unnamed stream to the Deschutes River. The outflow on April 8, 1975 was estimated to be 2.5 ft³/s; on subsequent sampling trips the outflow channel was dry.

The lake stage, which is controlled by a weir with flashboards, declined 1.82 feet from Feb 19 to Sept 12, 1975.

Aquatic plants.

Shoreline-----	51-75 percent
Lake surface-----	1-10 percent
Lake bottom-----	26-50 percent

Macrophytes observed (8/7/75): cattail (Typha sp.)*, white lily (Nymphaea sp.), pondweed (Potamogeton sp.)*, muskgrass (Chara sp.), bulrush (Scirpus sp.), waterweed (Elodea sp.), sedge (Cyperaceae), wild celery (Vallisneria sp.), yellow lily (Nuphar sp.), water milfoil (Myriophyllum sp.), arrowhead (Sagittaria sp.), bushy pondweed (Najas sp.).

Algae observed:

2/19/75: Blue-greens (Aphanizomenon sp.* and Anabaena sp.)

4/8/75: Blue-greens (Aphanizomenon sp. and Anabaena sp.) and diatoms (Asterionella sp.)

7/3/75: None

9/12/75: Diatoms (Fragillaria sp.) and blue-greens (Merismopedia (?) sp.).

*Asterisk indicates dominant aquatic plants.

Summary and conclusions.

Lawrence Lake is a large, spring-fed lake that receives heavy recreational use. The nearshore residential development is restricted in part by marshy conditions on the southeast and west-central shores.

The biological productivity of the lake was moderate to high. Blooms of blue-green algae were observed in February and April. The chlorophyll *a* concentration decreased from 53 µg/L in Feb to 3.2 µg/L in July. Submersed aquatic macrophytes covered about one-third of the lake bottom. Large amounts of decaying vegetation were observed in the southwest bay in August.

During summer the lake was weakly stratified and the dissolved-oxygen concentration was reduced to less than 4.0 mg/L below depths of 16 feet.

Lawrence Lake was sampled four times in 1975 by the U.S. Geological Survey; the results of that investigation are presented in a report by Dion and others (1976).

LAKE DATA

Water-quality data for Lawrence Lake

[Milligrams per liter unless otherwise indicated]

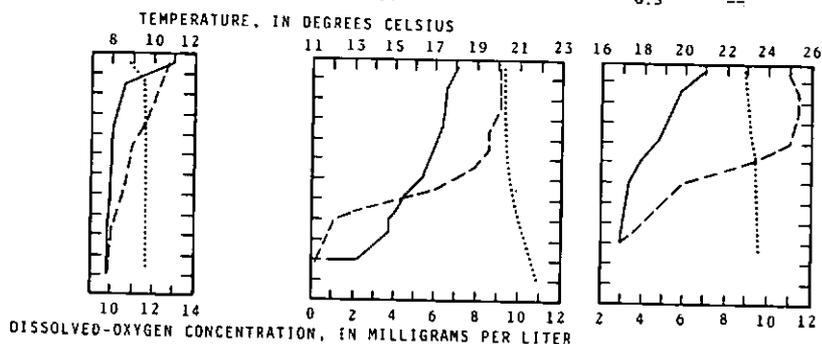
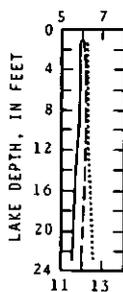
Date of collection (1975)-----	February 19		April 8		July 3		September 12	
	3	20	3	20	3	19	3	16
Water depth (ft)-----								
Silica (SiO ₂)-----	4.0	3.9	3.8	4.2	3.3	3.9	0.6	1.3
Dissolved iron (Fe), in µg/L--	660	50	180	220	360	940	420	710
Dissolved manganese (Mn)----- (in µg/L)	10	0	0	0	50	150	30	60
Calcium (Ca) -----	4.5	--	--	--	--	--	6.8	--
Magnesium (Mg) -----	2.3	--	--	--	--	--	4.3	--
Sodium (Na) -----	3.3	--	--	--	--	--	3.9	--
Potassium (K) -----	.9	--	--	--	--	--	.9	--
Bicarbonate (HCO ₃) -----	30	30	35	31	29	32	37	38
Carbonate (CO ₃) -----	--	--	0	0	--	--	--	--
Sulfide (S)-----	--	--	--	--	--	--	--	--
Sulfate (SO ₄)-----	2.2	--	--	--	--	--	--	--
Chloride (Cl)-----	3.2	--	--	--	--	--	1.0	--
Nitrate nitrogen (as N)-----	.01	.01	.01	.02	.02	.02	.01	.02
Nitrite nitrogen (as N)-----	.00	.00	.01	.00	.00	.00	.00	.00
Ammonia nitrogen (as N)-----	.16	.11	.14	.10	.14	.47	.08	.28
Organic nitrogen (as N)-----	.74	.69	.96	.67	.39	.50	.46	.50
Total phosphorus (as P)-----	.044	.040	.052	.039	.018	.027	.018	.036
Orthophosphate (as P)-----	.003	.002	.006	.002	.004	.005	.004	.008
Suspended solids (110°C)-----	2	--	--	--	--	--	4	--
Hardness as CaCO ₃ (Ca, Mg)---	21	--	--	--	--	--	35	--
Specific conductance----- (micromhos at 25°C)	56	56	6.1	59	66	91	72	73
pH (pH units)-----	7.4	7.6	7.6	7.5	7.2	6.8	8.7	6.8
Water temperature (°C)-----	5.8	5.5	8.6	7.8	17.5	13.1	19.8	17.1
Color (Pt-Co scale)-----	10	10	30	30	30	40	40	50
Secchi-disc (ft)-----	--	4.0	--	2.0	--	14	--	8.0
Dissolved oxygen (DO)-----	12.1	12.0	12.3	9.9	9.1	0	11.4	4.1
Chlorophyll <u>a</u> in photic zone- (µg/L)	--	53	--	44	--	3.2	--	5.9
Fecal coliform Range-- (col. per 100 mL) Mean---	-----	-----	--	<1-<1	--	<1-29	--	<1-8
	-----	-----	--	<1	--	6	--	3
Total organic carbon (as C)--	11	--	11	--	7.6	--	6.3	--

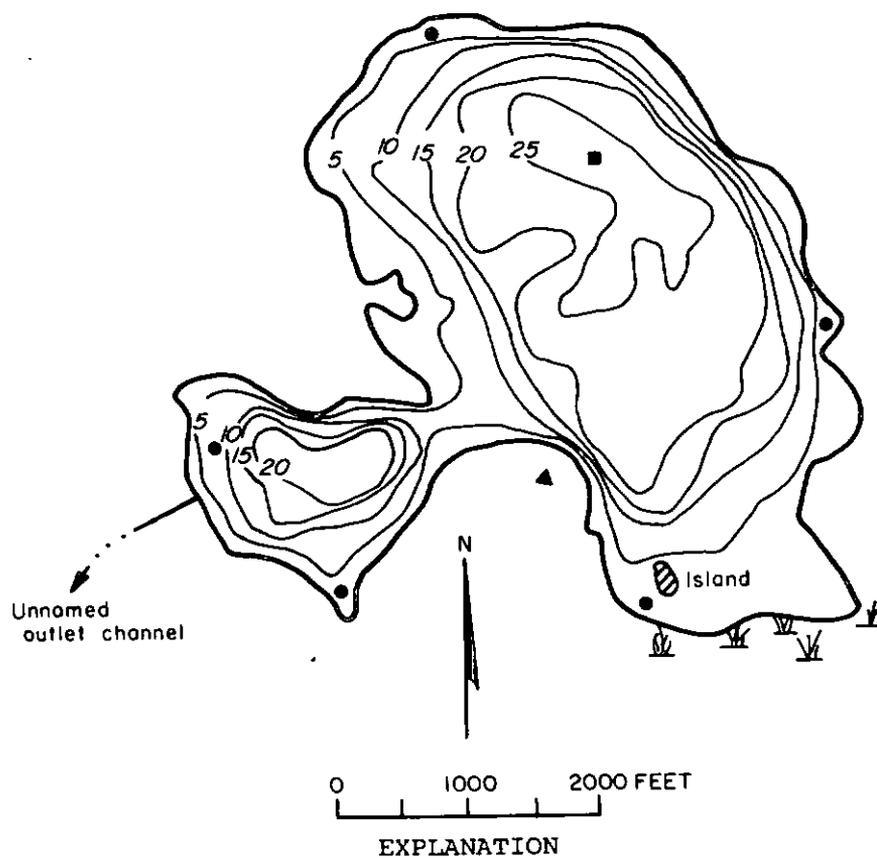
EXPLANATION

Temperature

 Dissolved oxygen concentration

 Dissolved oxygen concentration at 100 percent saturation





— 10 —
 Line of equal
 water depth
 Interval 5 feet

■
 Water quality
 sampling site

⌵
 Marsh

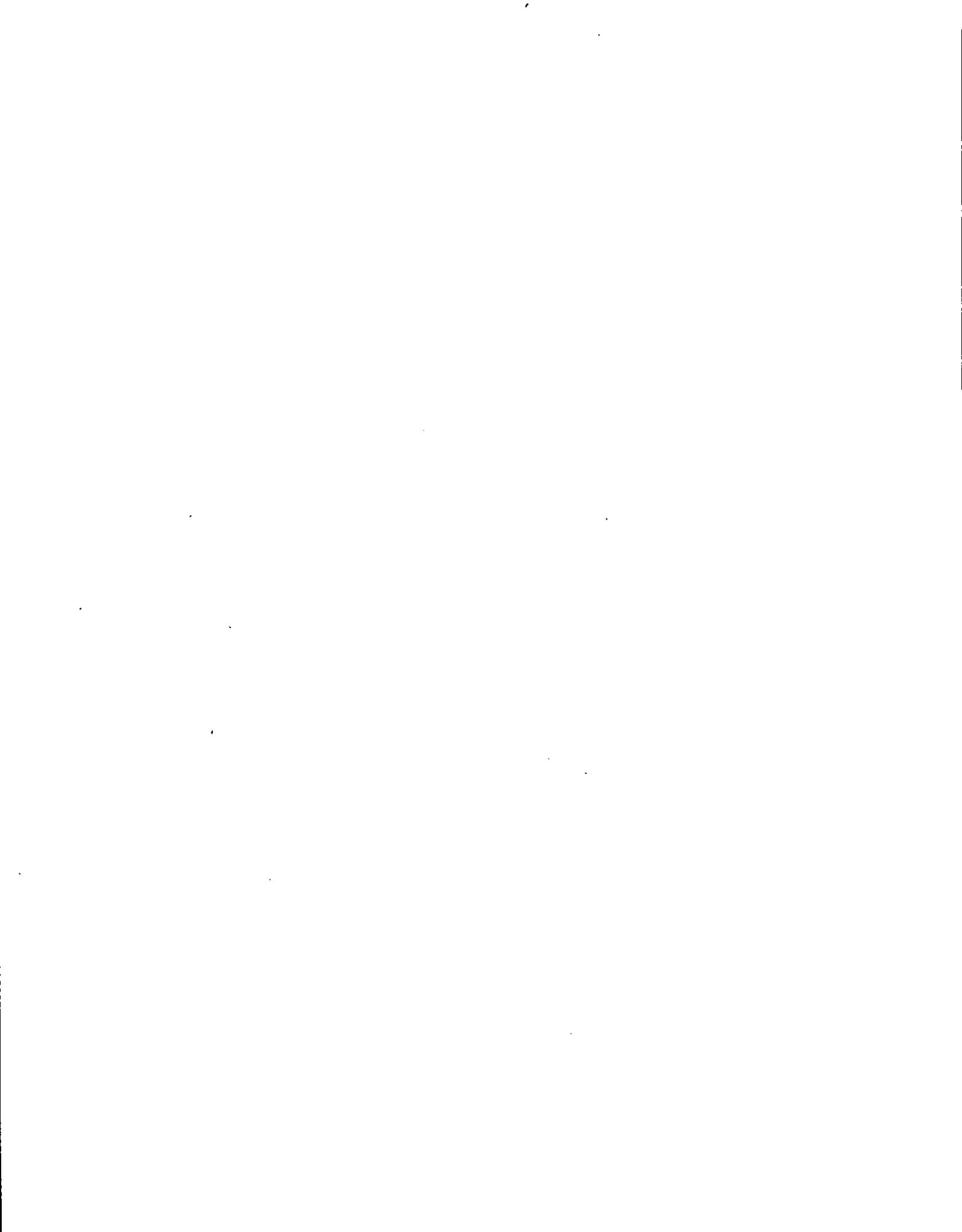
●
 Coliform bacteria
 sampling site

▲
 Public boat access

Lawrence Lake, Thurston County.
 From Washington Department of Game,
 June 5, 1951.



Lawrence Lake, Thurston County. May 13, 1972. Approx. scale 1:12,000.



Palmer Lake near Nighthawk (12442400)Location.

6.1 miles south of Nighthawk, Okanogan County. Lat 48°54'39", long 119°38'43"; NE¼ND¼ sec.2. T.39 N., R.25 E. Okanogan River basin; 1,145 feet altitude. Loomis quadrangle (1:62,500 scale).

Physical characteristics of lake.

Surface area-----	2,100 acres	Length of shoreline-----	9.9 miles
Volume-----	110,000 acre-ft	Shoreline configuration-----	1.5
Mean depth-----	51 ft	Development of volume-----	0.64
Maximum depth-----	79 ft	Bottom slope-----	0.73 percent

Drainage basin.

Size: 296 mi.²

Geology: Principally intrusive and extrusive igneous rocks, metamorphic rocks, and flood plain and terrace deposits of till and unconsolidated materials (Walters, 1974).

Soils: Sandy loam soils, with loam and silt (U.S. Soil Conservation Service, 1968).

Land use	Percent
Urban	
Suburban	
Agricultural	Not determined because of the
Forest or unproductive	very large drainage basin.
Lake surface	

Nearshore development.

Number of nearshore homes: 25

Nearshore residential development: 9 percent

Littoral bottom.

Chiefly sand, gravel, and rock with local areas of silt. Silty clay with some muck at north end.

Hydrology.

The lake is fed by Sinlahekin Creek and by several smaller tributaries. On April 29, August 28, and Sept 23, 1975, the inflows from Sinlahekin Creek were estimated to be 2.0, 15, and 15 ft³/s, respectively. Drainage is northward via Palmer Creek to the Similkameen River. On April 29, August 28, and Sept 23, 1975, the outflows were estimated to be 30, 15, and 15 ft³/s, respectively. On June 4, 1975 it was observed that the stage of the Similkameen River was relatively high and water was flowing back into Palmer Lake via Palmer Creek.

The lake stage declined 14.3 feet from June 4 to Sept 23, 1975. The stage was monitored by the U.S. Geological Survey from April 1956 to June 1968.

Aquatic plants.

Shoreline-----	11-25 percent
Lake surface-----	<1 percent
Lake bottom-----	<1 percent

Macrophytes observed (7/30/75): sedge (Cyperaceae)*, Iris (*Iris* sp.), yellow lily (*Nuphar* sp.)*, bulrush (*Scirpus* sp.), pondweed (*Potamogeton* sp.)*, water milfoil (*Myriophyllum* sp.).

*Asterisk indicates dominant aquatic plants.

Algae observed:

4/29/75:	Blue-greens (<i>Aphanizomenon</i> sp.)
6/4/75:	Blue-greens (<i>Aphanizomenon</i> sp.)
8/28/75:	Blue-greens (<i>Anabaena</i> sp.) and yellow-browns (<i>Dinobryon</i> sp.)
9/23/75:	Blue-greens (<i>Anabaena</i> sp.)

Summary and conclusions.

Palmer Lake is a large, natural lake that provides pondage for the Similkameen River during high stages. Upstream of the lake some of the inflow is diverted for irrigation purposes. Because of its large size, the lake was sampled at two sites.

The biological productivity of the lake was moderate to high. Phosphorus concentrations were highest in spring and algal densities, as measured by chlorophyll a analyses, were highest in summer. Blue-green algae were dominant on all four sampling dates. The growth of aquatic macrophytes was generally light but a few dense beds of pondweed and water milfoil were observed in the northwest bay.

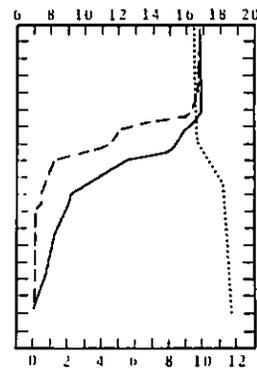
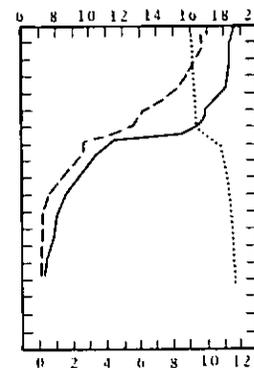
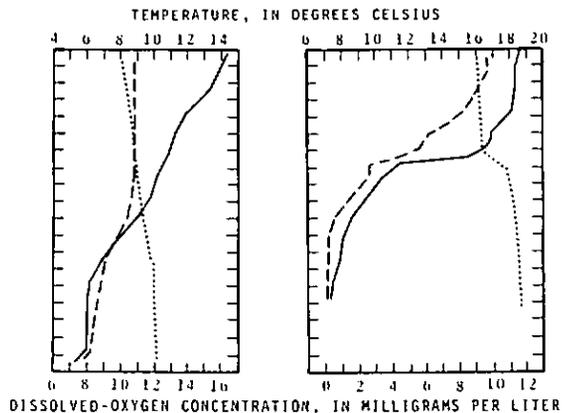
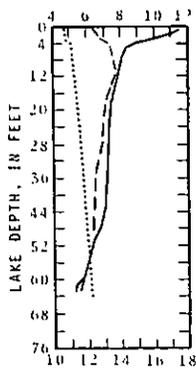
Thermal stratification was well developed by August and dissolved-oxygen concentration was nearly depleted below the 45-foot depth. Concentrations of iron, manganese, ammonia, and total phosphorus were significantly higher in the deoxygenated bottom water relative to the surface water during summer.

Water-quality data for Palmer Lake - Site 1 (North Arm)

[Milligrams per liter unless otherwise indicated]

Date of collection (1975)-----	April 29		June 4		August 28		September 23	
	3	62	3	71	3	56	3	65
Water depth (ft)-----								
Silica (SiO ₂)-----	8.3	9.3	5.5	9.4	6.9	14	7.1	14
Dissolved iron (Fe), in µg/L--	20	40	170	90	40	110	30	60
Dissolved manganese (Mn)----- (in µg/L)	40	120	0	120	10	1,900	10	2,000
Calcium (Ca)-----	38	--	--	--	--	--	34	--
Magnesium (Mg)-----	9.1	--	--	--	--	--	7.9	--
Sodium (Na)-----	8.9	--	--	--	--	--	7.5	--
Potassium (K)-----	2.6	--	--	--	--	--	2.3	--
Bicarbonate (HCO ₃)-----	138	142	112	140	115	143	125	147
Carbonate (CO ₃)-----	0	--	--	--	0	--	0	--
Sulfide (S)-----	--	--	--	--	--	--	--	--
Sulfate (SO ₄)-----	38	--	--	--	--	--	29	--
Chloride (Cl)-----	1.4	--	--	--	--	--	1.7	--
Nitrate nitrogen (as N)-----	.00	.04	.02	.13	.00	.22	.01	.09
Nitrite nitrogen (as N)-----	.00	.01	.00	.00	.00	.01	.00	.05
Ammonia nitrogen (as N)-----	.05	.07	.07	.05	.06	.21	.06	.33
Organic nitrogen (as N)-----	.28	.21	.28	.21	.43	.21	.39	.21
Total phosphorus (as P)-----	.067	.070	.021	.060	.020	.29	.021	.28
Orthophosphate (as P)-----	.039	.049	.004	.049	.003	.28	.004	.28
Suspended solids (110 °C)-----	8	--	--	--	--	--	0	--
Hardness as CaCO ₃ (Ca, Mg)-----	130	--	--	--	--	--	120	--
Specific conductance----- (micromhos at 25 °C)	276	269	254	218	234	277	239	280
pH (pH units)-----	8.4	8.2	8.2	7.5	8.5	7.4	8.2	6.9
Water temperature (°C)-----	9.8	5.4	14.0	5.8	18.5	7.3	16.8	7.2
Color (Pt-Co scale)-----	5	5	30	20	10	0	30	30
Secchi-disc (ft)-----	--	5.0	--	6.0	--	6.0	--	6.0
Dissolved oxygen (DO)-----	12.8	11.3	10.8	8.2	9.5	.1	9.8	<.1
Chlorophyll a in photic zone- (µg/L)	--	6.4	--	3.4	--	14	--	10
Fecal coliform Range-- (col. per 100 mL) Mean--	--	<1- <1	--	6-45 18	--	<1-6 2	--	<1- <1
Total organic carbon (as C)--	9.2	--	5.6	--	7.3	--	4.3	--

EXPLANATION
 ——— Temperature
 - - - - - Dissolved oxygen concentration
 ······ Dissolved oxygen concentration at 100 percent saturation

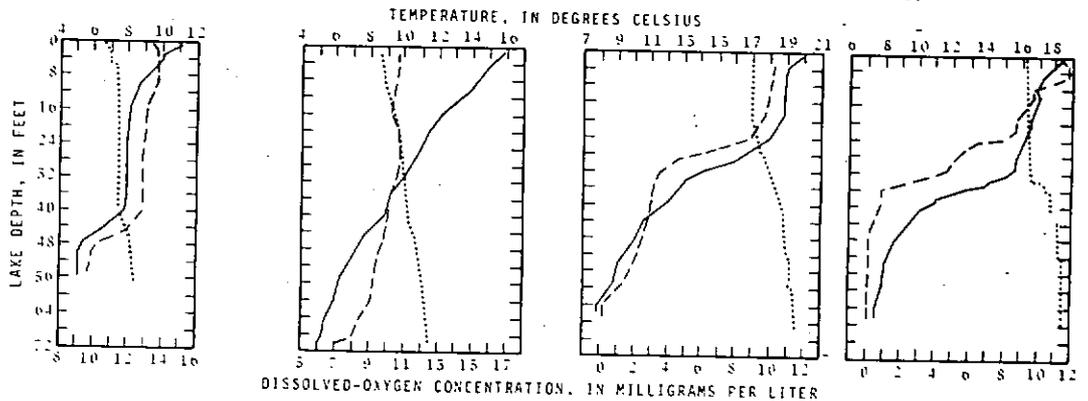


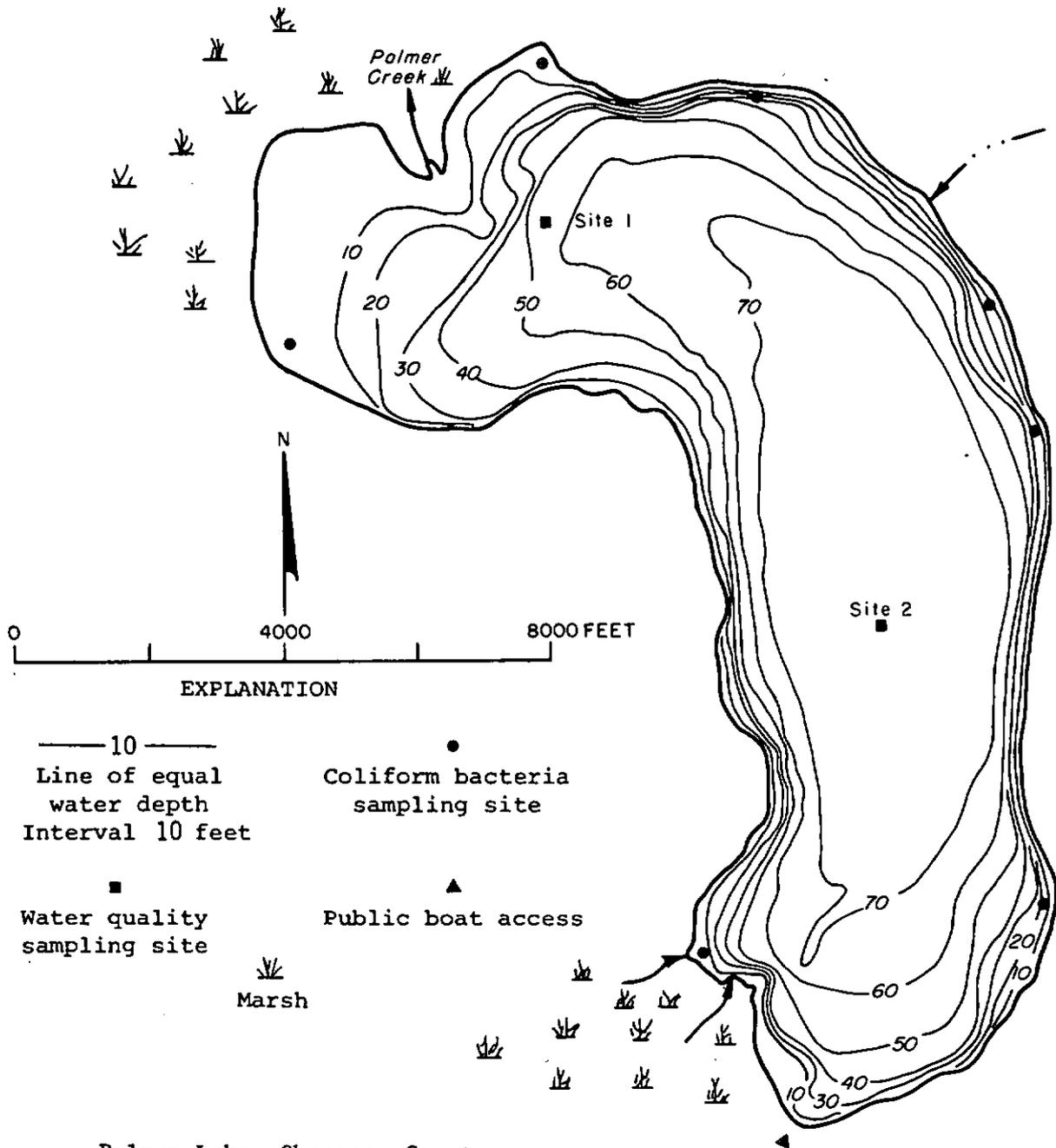
Water-quality data for Palmer Lake - Site 2 (South Arm)

[Milligrams per liter unless otherwise indicated]

Date of collection (1975)-----	April 29		June 4		August 28		September 23	
	3	54	3	68	3	60	3	60
Water depth (ft)-----								
Silica (SiO ₂)-----	8.2	11	5.4	9.3	6.8	12	7.0	15
Dissolved iron (Fe), in µg/L--	20	80	110	60	40	50	30	290
Dissolved manganese (Mn)----- (in µg/L)	30	470	10	40	10	300	10	2,300
Calcium (Ca) -----	38	--	--	--	--	--	34	--
Magnesium (Mg) -----	9.2	--	--	--	--	--	8.1	--
Sodium (Na) -----	8.9	--	--	--	--	--	7.7	--
Potassium (K) -----	2.6	--	--	--	--	--	2.4	--
Bicarbonate (HCO ₃) -----	139	141	112	141	120	135	125	151
Carbonate (CO ₃)-----	0	--	--	--	0	--	2	--
Sulfide (S)-----	--	--	--	--	--	--	--	--
Sulfate (SO ₄)-----	37	--	--	--	--	--	30	--
Chloride (Cl)-----	2.7	--	--	--	--	--	1.7	--
Nitrate nitrogen (as N)-----	.00	.12	.02	.14	.00	.28	.01	.05
Nitrite nitrogen (as N)-----	.00	.01	.00	.00	.00	.00	.00	.02
Ammonia nitrogen (as N)-----	.06	.12	.08	.08	.45	.01	.06	.44
Organic nitrogen (as N)-----	.35	.25	.37	.21	.06	.28	.51	.25
Total phosphorus (as P)-----	.072	.079	.045	.067	.017	.12	.021	.42
Orthophosphate (as P)-----	.036	.053	.010	.046	.003	.12	.005	.40
Suspended solids (110 °C)-----	16	--	--	--	--	--	12	--
Hardness as CaCO ₃ (Ca, Mg)----	130	--	--	--	--	--	120	--
Specific conductance----- (micromhos at 25 °C)	286	271	274	214	236	272	248	308
pH (pH units)-----	8.4	7.2	8.2	7.6	8.8	7.4	8.4	7.0
Water temperature (°C)-----	9.9	5.1	15.1	5.2	19.0	7.9	17.8	7.5
Color (Pt-Co scale)-----	5	5	30	20	10	0	30	30
Secchi-disc (ft)-----	--	7.5	--	7.1	--	5.8	--	5.0
Dissolved oxygen (DO)-----	13.6	9.7	10.6	8.0	10.2	.2	11.6	5.1
Chlorophyll <i>a</i> in photic zone- (µg/L)	--	11	--	3.2	--	15	--	21
Fecal coliform Range-- (col. per 100 mL) Mean---	--	<1-40	--	2-6	--	<1-8	--	<1-1
		10		4		2		1
Total organic carbon (as C)--	13	--	8.6	--	6.3	--	5.7	--

EXPLANATION
 ----- Temperature
 - - - - - Dissolved oxygen concentration
 Dissolved oxygen concentration at 100 percent saturation





Palmer Lake, Okanogan County.
From U.S. Geological Survey,
August 6, 1974.



Palmer Lake, Okanogan County. September 15, 1967. Approx. scale 1:60,000.

Pine Lake near Issaquah (12121800)Location.

3.9 miles north of Issaquah, King County. Lat 47°35'10", long 122°03'05";
NW¼NW¼ sec.9. T.24 N., R.6 E. Sammamish River basin; 390 feet altitude.
Issaquah quadrangle (1:24,000 scale).

Physical characteristics of lake.

Surface area-----	86 acres	Length of shoreline-----	2.4 miles
Volume-----	1700 acre-ft	Shoreline configuration-----	1.8
Mean depth-----	20 ft	Development of volume-----	0.51
Maximum depth-----	39 ft	Bottom slope-----	1.8 percent

Drainage basin.

Size: 1.04 mi².
Geology: Glacial till (Liesch and others, 1963).
Soils: Gravelly sandy loam, fine sandy loam, silty clay, and peat (Poulson and others, 1952).

Land use	Percent
Urban	0
Suburban	9
Agricultural	35
Forest or unproductive	43
Lake surface	13

Nearshore development.

Number of nearshore homes: 117
Nearshore residential development: 96 percent

Littoral bottom.

The littoral zone of the main body of the lake is underlain by gravel, sand, and silt, with local areas of muck. The bays are underlain by muck and silt.

Hydrology.

A small tributary enters the lake from a marsh that adjoins the lake on the southwest side. Drainage is by an unnamed stream to Sammamish Lake. The outflows on Feb 18 and April 7, 1975, were 3.60 and 0.80 ft³/s, respectively. The outflow channel was dry on subsequent visits.

The U.S. Geological Survey has monitored the lake stage since 1956. In 1975 the stage rose 2.40 feet from Sept 30 to Dec 4, 1975.

Aquatic plants.

Shoreline-----	26-50 percent
Lake surface-----	1-10 percent
Lake bottom-----	11-25 percent

Macrophytes observed (8/5/75): watershield (*Brasenia* sp.)*, *Iris* (*Iris* sp.), yellow lily (*Nuphar* sp.)*, white lily (*Nymphaea* sp.), bushy pondweed (*Najas* sp.)*, pondweed (*Potamogeton* sp.), cattail (*Typha* sp.), waterweed (*Elodea* sp.), sedge (Cyperaceae), quillwort (*Isoetes* sp.).

Algae observed:

2/18/75: Green (*Microspora* sp.), blue-green (*Aphanizomenon* sp.) and diatoms (*Asterionella* sp.).
4/7/75: Blue-greens (*Aphanizomenon* sp.*), *Anabaena* sp.) and diatoms (*Asterionella* sp.).
7/2/75: Blue-greens (*Nostoc* sp.).
9/9/75: Blue-greens (*Nostoc* sp.).

*Asterisk indicates dominant aquatic plants.

Summary and conclusions.

The nearshore residential development of Pine Lake is very high (96 percent). A county park is situated on the east shore and recreational use of the lake in summer is heavy.

The biological productivity of the lake was high. Chlorophyll *a* concentrations were high in February and April and moderate in July and September. Nitrate nitrogen and total phosphorus concentrations were high during winter and early spring. High counts of fecal-coliform bacteria were observed in September.

Thermal stratification was well developed by July and dissolved-oxygen concentrations were generally depleted in the bottom water. A build-up of iron and phosphorus occurred in the bottom water during summer thermal stratification.

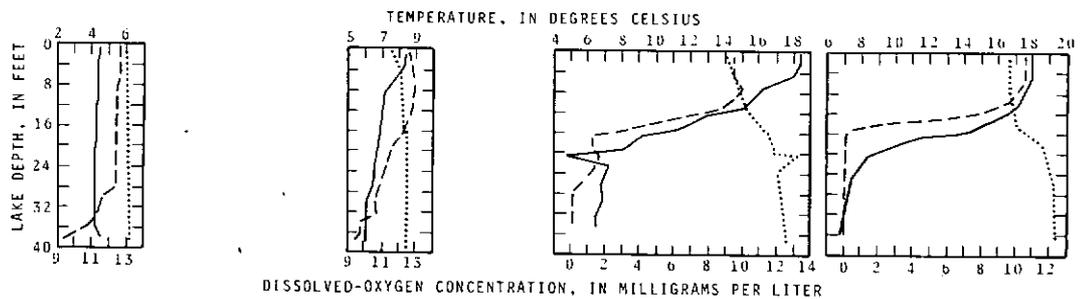
Seattle's METRO (Municipality of Metropolitan Seattle) studied Pine Lake intensively in 1973 (Uchida and others, 1976).

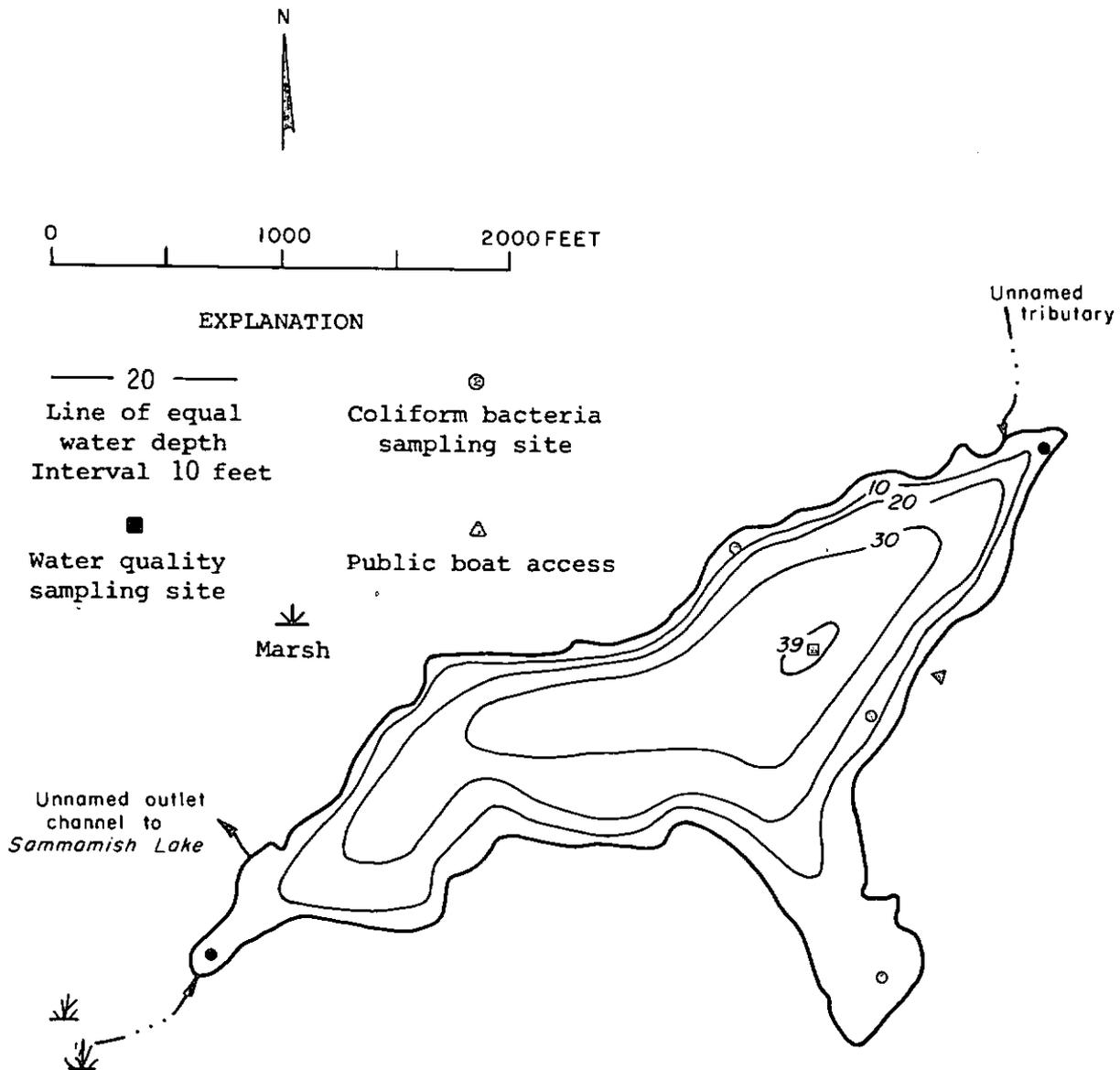
Water-quality data for Pine Lake

[Milligrams per liter unless otherwise indicated]

Date of collection (1975)-----	February 18		April 7		July 2		September 9	
	3	36	3	36	3	35	3	34
Water depth (ft)-----								
Silica (SiO ₂)-----	0.0	0.1	0.1	0.1	0.3	0.5	0.3	0.8
Dissolved iron (Fe), in µg/L--	0	210	50	60	80	560	20	1,000
Dissolved manganese (Mn)----- (in µg/L)	30	0	0	10	10	120	10	160
Calcium (Ca) -----	4	--	--	--	--	--	4.5	--
Magnesium (Mg) -----	1.1	--	--	--	--	--	1.1	--
Sodium (Na) -----	2.6	--	--	--	--	--	2.8	--
Potassium (K) -----	1.5	--	--	--	--	--	1.3	--
Bicarbonate (HCO ₃) -----	11	11	15	13	14	7	16	15
Carbonate (CO ₃)-----	0	--	0	0	--	--	0	--
Sulfide (S)-----	--	--	--	--	--	0	--	>5
Sulfate (SO ₄)-----	5.1	--	--	--	--	--	6.5	--
Chloride (Cl)-----	3.0	--	--	--	--	--	2.6	--
Nitrate nitrogen (as N)-----	.38	.38	.20	.23	.01	.12	.00	.00
Nitrite nitrogen (as N)-----	.00	.00	.00	.00	.00	.00	.00	.01
Ammonia nitrogen (as N)-----	.10	.13	.05	.10	.10	.36	.08	1.0
Organic nitrogen (as N)-----	.47	.60	.63	.40	.42	.35	.46	.40
Total phosphorus (as P)-----	.036	.060	.037	.028	.016	.061	.011	.059
Orthophosphate (as P)-----	.004	.008	.002	.006	.004	.036	.002	.030
Suspended solids (110 °C)-----	4	--	--	--	--	--	12	--
Hardness as CaCO ₃ (Ca, Mg)----	15	--	--	--	--	--	16	--
Specific conductance----- (micromhos at 25 °C)	37	37	43	43	46	53	45	61
pH (pH units)-----	7.2	7.2	7.3	7.5	7.1	6.1	6.4	6.0
Water temperature (°C)-----	4.5	4.2	8.2	6.1	18.3	6.3	17.9	6.9
Color (Pt-Co scale)-----	35	50	35	35	30	40	30	45
Secchi-disc (ft)-----	--	6.0	--	6.5	--	6.6	--	10.3
Dissolved oxygen (DO)-----	12.6	10.4	12.7	9.7	9.5	.1	10.5	.0
Chlorophyll a in photic zone- (µg/L)	--	19	--	14	--	5.9	--	2.7
Fecal coliform Range-- (col. per 100 mL) Mean---	-----	-----	--	<1-13	--	4-46	--	10-214
	-----	-----	--	3	--	23	--	78
Total organic carbon (as C)---	10	--	8.0	--	7.7	--	9.2	--

EXPLANATION
 _____ Temperature
 - - - - - Dissolved oxygen concentration
 Dissolved oxygen concentration at 100 percent saturation





Pine Lake, King County.
From Washington Department of Game,
January 20, 1949.



Pine Lake, King County. June 1, 1970. Approx. scale 1:12,000.

DATA ON SELECTED LAKES IN WASHINGTON, PART 6

Silver Lake at Medical Lake (13351300)Location.

2.8 miles southeast of town of Medical Lake, Spokane County. Lat 47°32'10", long 117°39'13"; NE¼NE¼ sec.32. T.24 N., R.41 E.; location is of southernmost shoreline point of lake. Crab Creek basin; 2,341 feet altitude. Medical Lake quadrangle (1:24,000 scale).

Physical characteristics of lake.

Surface area-----	490 acres	Length of shoreline-----	8.7 miles
Volume-----	14,000 acre-ft	Shoreline configuration-----	2.8
Mean depth-----	30 ft	Development of volume-----	0.37
Maximum depth-----	80 ft	Bottom slope-----	1.5 percent

Drainage basin.

Size: 19.0 mi².

Geology: Basalt flows, metamorphic and granitic rocks, and small amounts of till, outwash, and associated deposits (Hunting and others, 1961).

Soils: A complex pattern of silt loams, sandy loams, loamy sands, and marshes (Donaldson and Giese, 1968).

Land use	Percent
Urban	12
Suburban	<1
Agricultural	84
Forest or unproductive	<1
Lake surface	4

Nearshore development.

Number of nearshore homes: 83

Nearshore residential development: 25 percent

Littoral bottom.

The northern part of lake is mostly rock with some gravel, sand, and silt; the southern part is gravel, sand, and silt.

Hydrology.

The lake has no surface-water inflow or outflow.

The lake stage, which was monitored continuously by the U.S. Geological Survey from Sept 1958 to Aug 1975, declined 2.32 feet from April 7 to Oct 1, 1975.

Aquatic plants.

Shoreline-----	26-50 percent
Lake surface-----	1-10 percent
Lake bottom-----	26-50 percent

Macrophytes observed (7/17/75): bulrush (Scirpus sp.)*, water milfoil (Myriophyllum sp.), pondweed (Potamogeton sp.)*, waterweed (Elodea sp.), cattail (Typha sp.), muskgrass (Chara sp.), smartweed (Polygonum sp.), coontail (Ceratophyllum sp.), sedge (Cyperaceae).

*Asterisk indicates dominant aquatic plants.

Algae observed:

4/17/75:	None
5/20/75:	Blue-greens (<u>Anabaena</u> sp.)
8/14/75:	None
10/1/75:	Blue-greens (<u>Anabaena</u> sp.)

Summary and conclusions.

Silver Lake is deep and narrow and situated southeast of the town of Medical Lake. The lake has no surface-water inflow or outflow. There are several resorts, and recreational use of the lake is heavy.

The biological productivity of the lake was moderate. Chlorophyll a concentrations were high (33 µg/L) in April but low to moderate on other sampling dates. The Secchi-disc visibility was correspondingly lower in April than on subsequent sampling dates. About 35 percent of the bottom at the south end of the lake was covered by submersed aquatic macrophytes, chiefly pondweed, to depths of about 8 feet.

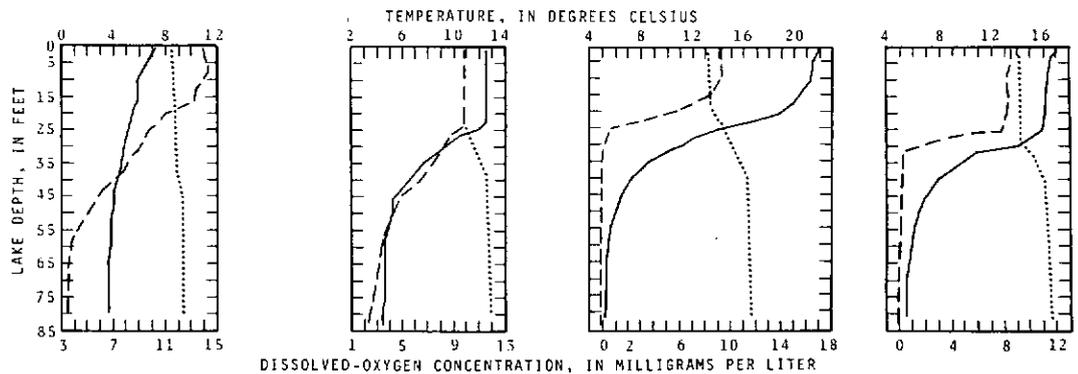
Thermal stratification was weakly developed in May; by August the lake was strongly stratified and the dissolved-oxygen concentration in the bottom water in August and October was zero.

Water-quality data for Silver Lake

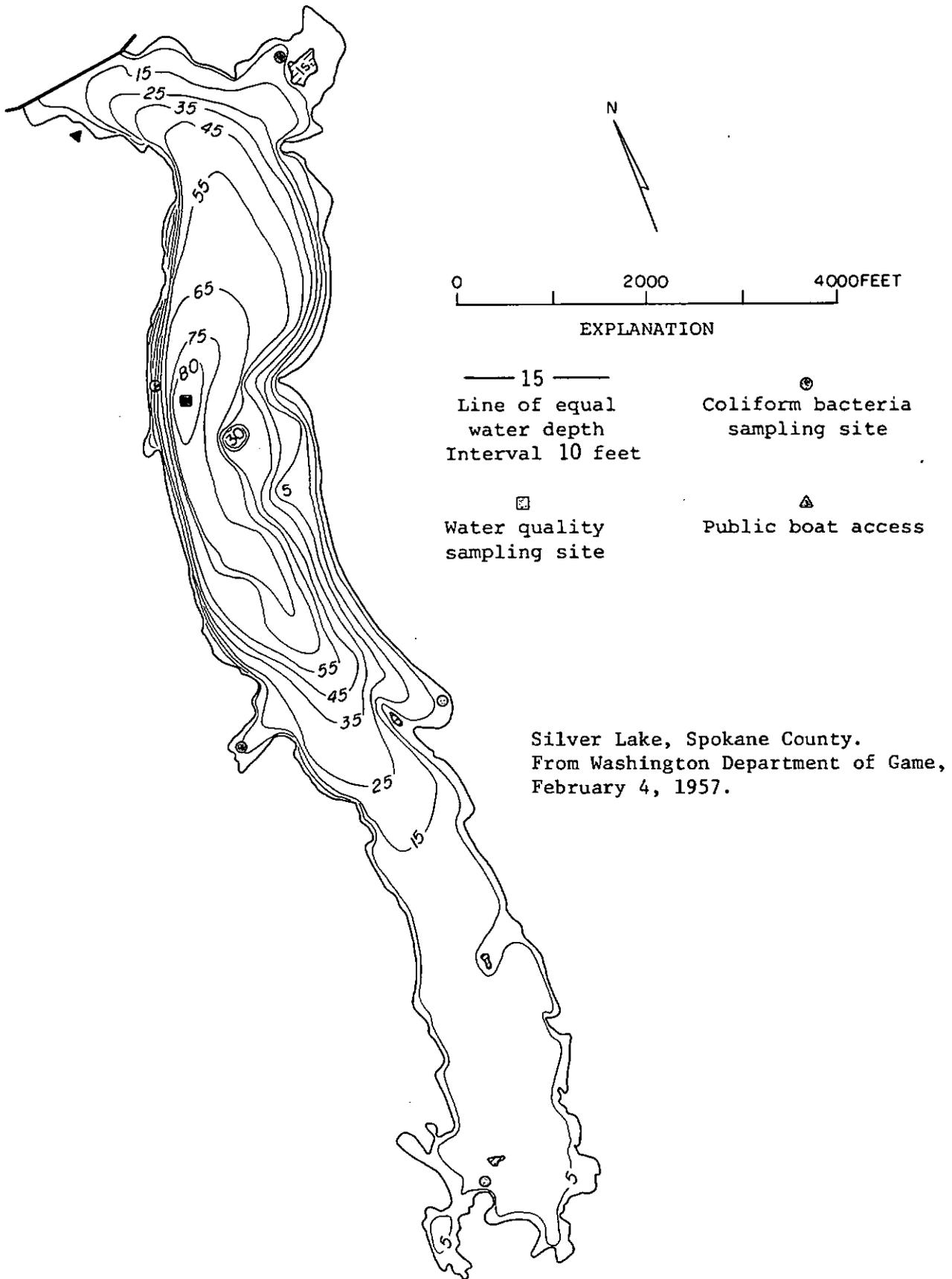
[Milligrams per liter unless otherwise indicated]

Date of collection (1975)-----	April 17		May 20		August 14		October 1	
	3	76	3	81	3	80	3	78
Water depth (ft)-----								
Silica (SiO ₂)-----	3.2	5.3	2.9	5.2	6.2	7.2	6.3	7.8
Dissolved iron (Fe), in µg/L--	70	30	20	40	20	20	20	20
Dissolved manganese (Mn)----- (in µg/L)	20	100	10	120	10	200	10	250
Calcium (Ca)-----	24	--	--	--	--	--	24	--
Magnesium (Mg)-----	45	--	--	--	--	--	49	--
Sodium (Na)-----	52	--	--	--	--	--	55	--
Potassium (K)-----	19	--	--	--	--	--	21	--
Bicarbonate (HCO ₃)-----	382	417	371	403	364	405	411	421
Carbonate (CO ₃)-----	0	--	10	--	19	--	0	--
Sulfide (S)-----	--	--	--	--	--	~1	--	>5
Sulfate (SO ₄)-----	37	--	--	--	--	--	31	--
Chloride (Cl)-----	11	--	--	--	--	--	11	--
Nitrate nitrogen (as N)-----	.00	.04	.00	.07	.00	.00	.01	.01
Nitrite nitrogen (as N)-----	.01	.01	.00	.02	.00	.00	.00	.00
Ammonia nitrogen (as N)-----	.09	.30	.12	.46	.06	1.2	.06	1.6
Organic nitrogen (as N)-----	1.8	1.6	1.1	1.2	1.2	1.5	1.3	1.3
Total phosphorus (as P)-----	.080	.100	.032	.095	.029	.23	.022	.32
Orthophosphate (as P)-----	.005	.054	.004	.057	.001	.21	.002	.29
Suspended solids (110°C)-----	28	--	--	--	--	--	8	--
Hardness as CaCO ₃ (Ca, Mg)----	250	--	--	--	--	--	260	--
Specific conductance----- (micromhos at 25°C)	609	652	616	441	595	591	593	587
pH (pH units)-----	6.7	7.4	8.6	8.1	8.6	7.6	8.2	7.1
Water temperature (°C)-----	6.9	3.7	12.5	4.3	21.7	5.2	16.6	5.6
Color (Pt-Co scale)-----	35	30	20	20	5	5	0	0
Secchi-disc (ft)-----	--	5.2	--	14	--	13	--	16
Dissolved oxygen (DO)-----	14.0	3.3	9.8	2.4	9.2	0	8.4	0
Chlorophyll <i>a</i> in photic zone- (µg/L)	--	33	--	4.3	--	1.9	--	2.1
Fecal coliform Range-- (col. per 100 mL) Mean---	--	<1-1	--	<1-5	--	<1-8	--	<1-18
		<1		2		4		5
Total organic carbon (as C)--	21	--	13	--	17	--	9.1	--

EXPLANATION
 ——— Temperature
 - - - - - Dissolved oxygen concentration
 Dissolved oxygen concentration at 100 percent saturation



DISSOLVED-OXYGEN CONCENTRATION, IN MILLIGRAMS PER LITER





Silver Lake, Spokane County. July 3, 1968. Approx. scale 1:60,000.

Soda Lake near Othello (12471510)Location.

9.5 miles northwest of Othello, Grant County. Lat 46°57'27", long 119°13'44"; SE¼SW¼ sec.18. T.17 N., R.29 E. Crab Creek basin; 998 feet altitude. Soda Lake quadrangle (1:24,000 scale).

Physical characteristics of lake.

Surface area-----	180 acres	Length of shoreline-----	4.0 miles
Volume-----	8800 acre-ft	Shoreline configuration-----	2.1
Mean depth-----	50 ft	Development of volume-----	0.41
Maximum depth-----	120 ft	Bottom slope-----	3.9 percent

Drainage basin.

Size: Not measured because water is imported from outside the drainage basin.
 Geology: Dark, dense basalt flows (drainage area near lake) (Hunting and others, 1961).
 Soils: Moderately deep and deep silt loam, loam, sandy loam, and sandy soils (drainage basin near lake) (U.S. Soil Conservation Service, 1968).

Land use	Percent
Urban	
Suburban	
Agricultural	Not determined because water is
Forest or unproductive	imported from outside the drainage
Lake surface	basin.

Nearshore development.

Number of nearshore homes: 0
 Nearshore residential development: 0 percent

Littoral bottom.

Predominantly rock and silt, with some gravel. The north end is rock and gravel, with some silt.

Hydrology.

The lake is situated along Potholes East Canal and therefore has a large inflow and outflow. No discharge measurements were made or estimated.

Records of stage fluctuations are incomplete. The stage, which is regulated by a dam at the southeast end of the lake, rose 1.36 feet from April 22 to May 28, 1975.

Aquatic plants.

Shoreline-----	1-10 percent
Lake surface-----	<1 percent
Lake bottom-----	<1 percent

Macrophytes observed (7/24/75): cattail (Typha sp.)*, sedge (Cyperaceae), pondweed (Potamogeton sp.)*.

Algae observed:

4/22/75: Diatoms (Asterionella sp., Diatomella sp., Fragillaria sp.) and greens (Microspora sp.).
 5/24/75: Diatoms (Fragillaria sp.*, Asterionella sp.) and greens (Microspora sp.).
 8/20/75: Blue-greens (Aphanizomenon sp.*, Oscillatoria sp.) and diatoms (Asterionella sp., Fragillaria sp., (Navicula sp.).
 9/16/75: Blue-greens (Aphanizomenon sp.*, Anabaena sp., Oscillatoria sp.) and diatoms (Fragillaria sp.).

*Asterisk indicates dominant aquatic plants.

Summary and conclusions.

Soda Lake is situated along Potholes East Canal and was formed by a U.S. Bureau of Reclamation dam about 1950. The lake has a large inflow and outflow and the flushing rate is relatively high. Although the water is used for irrigation purposes, recreational use of the lake is heavy.

The biological productivity of the lake was moderate. Chlorophyll *a* concentrations ranged from 8.8 to 21 µg/L; the dominant algae observed were diatoms and blue-greens. Very few aquatic macrophytes were observed.

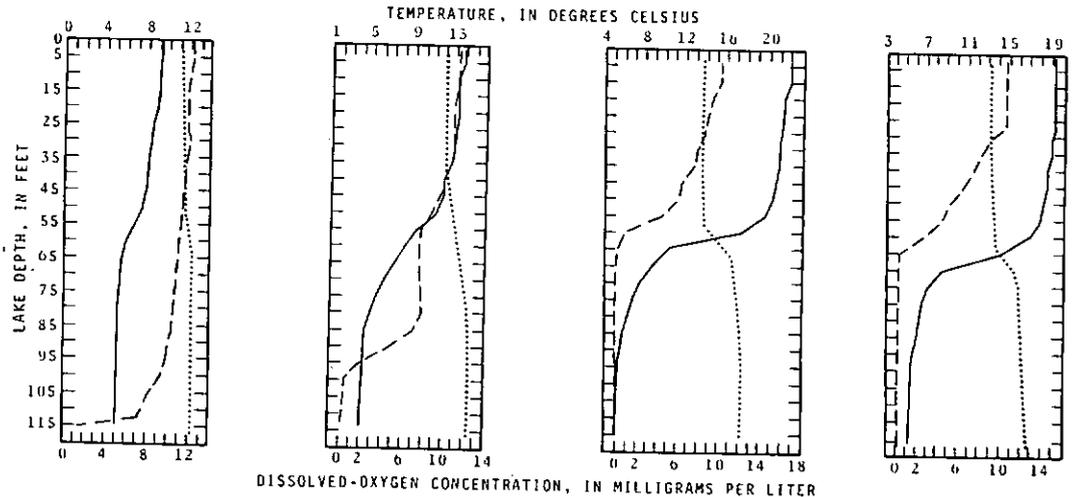
Despite the large inflows and outflows, thermal stratification was weakly developed in May and strongly developed in Aug and Sept. The dissolved-oxygen concentration in the bottom water during summer was depleted.

Water-quality data for Soda Lake

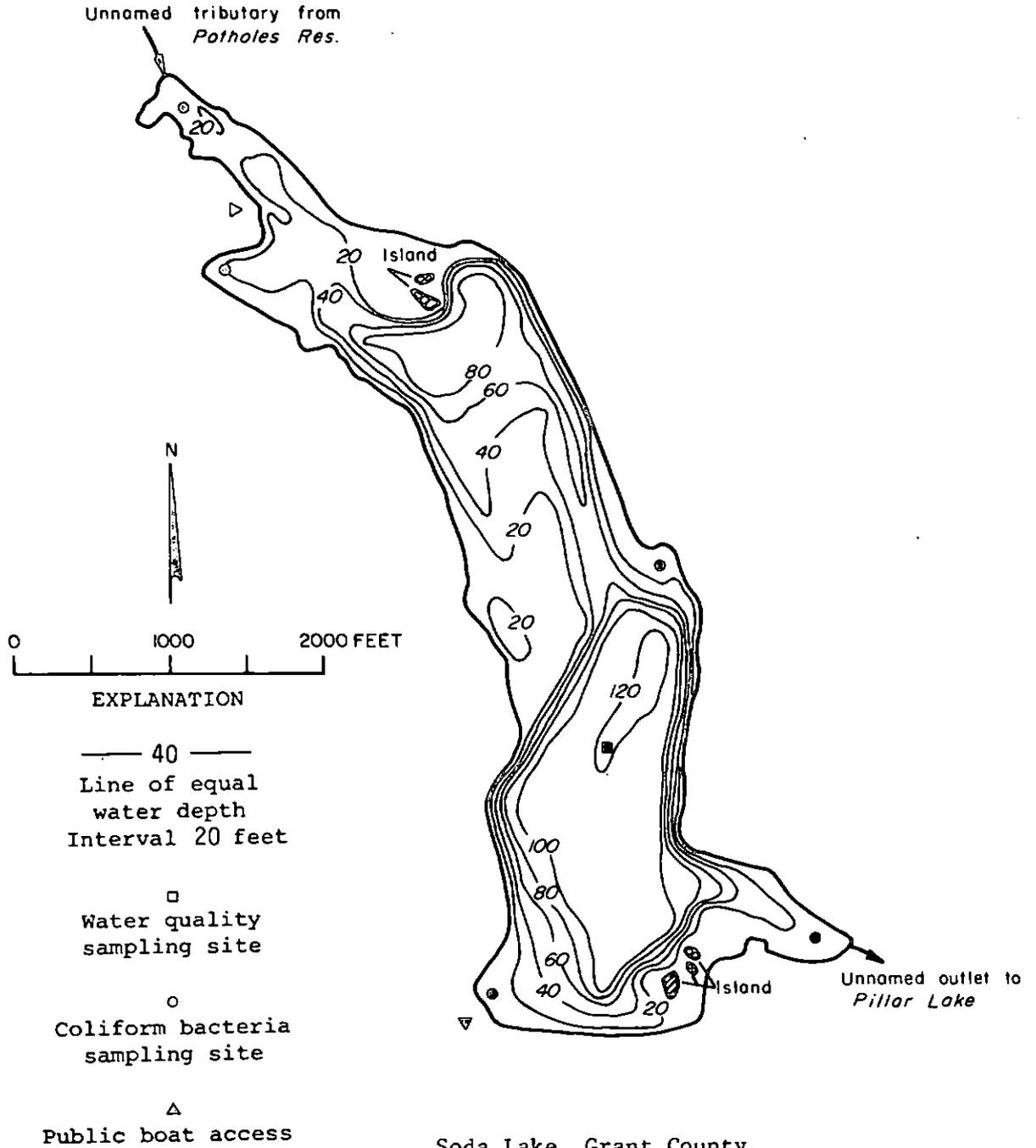
[Milligrams per liter unless otherwise indicated]

Date of collection (1975)-----	April 22		May 28		August 20		September 16	
	3	112	3	112	3	112	3	113
Water depth (ft)-----								
Silica (SiO ₂)-----	8.8	11	2.7	12	13	14	12	13
Dissolved iron (Fe), in µg/L--	50	60	120	70	30	130	30	170
Dissolved manganese (Mn)----- (in µg/L)	4	160	20	830	20	1,300	10	1,300
Calcium (Ca) -----	34	--	--	--	--	--	34	--
Magnesium (Mg) -----	21	--	--	--	--	--	19	--
Sodium (Na) -----	39	--	--	--	--	--	37	--
Potassium (K) -----	6.1	--	--	--	--	--	7.4	--
Bicarbonate (HCO ₃) -----	196	219	200	226	200	233	193	237
Carbonate (CO ₃)-----	3	--	0	--	--	--	0	--
Sulfide (S)-----	--	--	--	0	--	>5	--	>5
Sulfate (SO ₄)-----	54	--	--	--	--	--	45	--
Chloride (Cl)-----	16	--	--	--	--	--	13	--
Nitrate nitrogen (as N)-----	.17	.17	.78	.14	.21	.00	.01	.01
Nitrite nitrogen (as N)-----	.02	.02	.02	.00	.03	.01	.02	.00
Ammonia nitrogen (as N)-----	.04	.43	.07	2.9	.15	3.2	.11	3.7
Organic nitrogen (as N)-----	.58	4.0	.49	.30	.53	.50	.84	.50
Total phosphorus (as P)-----	.026	.095	.025	.23	.024	.46	.050	.57
Orthophosphate (as P)-----	.003	.036	.000	.16	.002	.44	.003	.54
Suspended solids (110°C)-----	12	--	--	--	--	--	8	--
Hardness as CaCO ₃ (Ca,Mg)----	170	--	--	--	--	--	160	--
Specific conductance----- (micromhos at 25°C)	444	456	455	545	409	478	390	493
pH (pH units)-----	8.9	8.3	8.7	7.4	8.2	7.4	8.4	7.2
Water temperature (°C)-----	9.1	5.0	13.8	4.1	22.0	5.0	19.3	5.1
Color (Pt-Co scale)-----	5	5	5	5	0	0	20	25
Secchi-disc (ft)-----	--	7.0	--	6.0	--	6.5	--	3.0
Dissolved oxygen (DO)-----	12.2	7.2	11.3	.2	10.3	0	10.6	<.1
Chlorophyll <i>a</i> in photic zone- (µg/L)	--	12	--	10	--	8.8	--	21
Fecal coliform Range-- (col. per 100 mL) Mean--	--	<1-2	--	--	--	<1-7	--	<1-10
Total organic carbon (as C)--	21	--	9.9	--	4.6	--	8.2	--

EXPLANATION
 Temperature
 Dissolved oxygen concentration
 Dissolved oxygen concentration at 100 percent saturation



DISSOLVED-OXYGEN CONCENTRATION, IN MILLIGRAMS PER LITER



Soda Lake, Grant County.
From U.S. Geological Survey,
August 22, 1974.



Soda Lake, Grant County. Aerial photograph from
U.S. Geological Survey, May 29, 1974.

Spectacle Lake near Loomis (12443800)Location.

5.2 miles east of Loomis, Okanogan County. Lat 48°48'55", long 119°31'20";
SW¼SE¼ sec.2. T.38 N., R.26 E. Okanogan River basin; 1,363 feet altitude.
Loomis quadrangle (1:62,500 scale).

Physical characteristics of lake.

Surface area-----	310 acres	Length of shoreline-----	6.3 miles
Volume-----	9800 acre-ft	Shoreline configuration-----	2.6
Mean depth-----	32 ft	Development of volume-----	0.53
Maximum depth-----	60 ft	Bottom slope-----	1.4 percent

Drainage basin.

Size: Not measured because water is imported from outside the drainage basin.
Geology: Mostly unconsolidated sand, gravel, and silt with some igneous rock
(drainage basin near lake) (Walters, 1974).
Soils: Moderately deep and deep loam, silt loam, and sandy loam soils (drainage
basin near lake) (U.S. Soil Conservation Service, 1968).

Land use	Percent
Urban	
Suburban	
Agricultural	Not determined because water is imported
Forest or unproductive	from outside the drainage basin.
Lake surface	

Nearshore development.

Number of nearshore homes: 11
Nearshore residential development: 9 percent

Littoral bottom.

Chiefly rock and gravel with local areas of silt and sand. The littoral bottom
at the east end is composed of silt and sand with some gravel and rock.

Hydrology.

Both the inflow to and outflow from the lake are controlled; the lake is used for
the storage of irrigation water. Natural inflow is from several small, unnamed
tributaries.

The lake stage, which is controlled, declined 9.45 feet from April 28 to Sept 24,
1975. The stage was monitored intermittently by the U.S. Geological Survey from
April 1956 to June 1971.

Aquatic plants.

Shoreline-----	1-10 percent
Lake surface-----	<1 percent
Lake bottom-----	26-50 percent

Macrophytes observed (7/30/75): bulrush (*Scirpus* sp.)*, pondweed (*Potamogeton* sp.),
waterweed (*Elodea* sp.)*, muskgrass (*Chara* sp.), cattail (*Typha* sp.), water mil-
foil (*Myriophyllum* sp.).

Algae observed:

4/28/75: Diatoms (*Synedra* sp., *Asterionella* sp.) and yellow-browns (*Dinobryon*
sp.).
6/3/75: None
8/29/75: Diatoms (*Tabellaria* sp.)*, and blue-greens (*Aphanizomenon* sp., *Anabaena*
sp.).
9/24/75: Blue-greens (*Aphanizomenon* sp.* *Anabaena* sp.).

*Asterisk indicates dominant aquatic plants.

Summary and conclusions.

Spectacle Lake is a long, narrow lake comprised of two, almost distinct, basins, and
therefore the lake water was sampled at two sites. The lake has three resorts and
receives heavy recreational use. In addition, the lake is used for the storage of
irrigation water.

The biological productivity of the lake was moderate to high. Chlorophyll a concen-
trations were moderate to high in April and September but considerably lower in June
and August. Secchi-disc visibilities were correspondingly higher in June and August.
Emerald aquatic plants were thinly scattered but submersed plants, chiefly waterweed,
covered about one-third of the lake bottom.

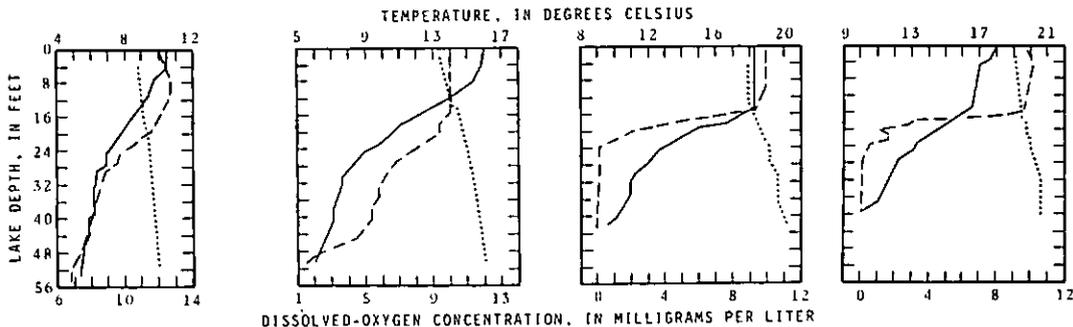
Thermal stratification was well established by June. In August and September dissolved-
oxygen concentration in the bottom water was severely depleted. Phosphorus concentrations
in the bottom water during summer increased significantly in relation to the surface
water.

Water-quality data for Spectacle Lake - Site 1 (West Arm)

[Milligrams per liter unless otherwise indicated]

Date of collection (1975)-----	April 28		June 3		August 29		September 24	
	3	51	3	48	3	40	3	37
Water depth (ft)-----								
Silica (SiO ₂)-----	11	12	9.3	13	6.5	15	7.1	16
Dissolved iron (Fe), in µg/L--	30	30	40	60	20	130	30	60
Dissolved manganese (Mn)----- (in µg/L)	20	90	0	100	20	640	20	830
Calcium (Ca) -----	40	--	--	--	--	--	31	--
Magnesium (Mg) -----	13	--	--	--	--	--	11	--
Sodium (Na) -----	9.5	--	--	--	--	--	8.6	--
Potassium (K) -----	2.8	--	--	--	--	--	2.3	--
Bicarbonate (HCO ₃) -----	145	156	144	151	107	144	125	152
Carbonate (CO ₃)-----	0	0	--	--	0	--	0	--
Sulfide (S)-----	--	--	--	--	--	--	--	--
Sulfate (SO ₄)-----	47	--	--	--	--	--	40	--
Chloride (Cl)-----	2	--	--	--	--	--	1.8	--
Nitrate nitrogen (as N)-----	.03	.09	.00	.05	.00	.00	.00	.01
Nitrite nitrogen (as N)-----	.00	.02	.00	.00	.00	.00	.00	.00
Ammonia nitrogen (as N)-----	.05	.10	.07	.10	.03	.21	.07	.37
Organic nitrogen (as N)-----	.31	.21	.24	.20	.31	.27	.39	.25
Total phosphorus (as P)-----	.031	.049	.065	.060	.010	.18	.015	.21
Orthophosphate (as P)-----	.003	.026	.010	.037	.002	.16	.002	.19
Suspended solids (110°C)-----	12	--	--	--	--	--	0	--
Hardness as CaCO ₃ (Ca,Mg)----	150	--	--	--	--	--	120	--
Specific conductance----- (micromhos at 25°C)	607	625	371	250	239	330	260	306
pH (pH units)-----	9.4	8.6	8.3	7.6	8.7	7.5	8.1	6.8
Water temperature (°C)-----	10.4	5.3	15.9	6.2	18.2	10.1	17.6	11.0
Color (Pt-Co scale)-----	10	0	15	10	5	5	35	35
Secchi-disc (ft)-----	--	6.8	--	17	--	10	--	8.5
Dissolved oxygen (DO)-----	12.3	6.9	10.0	2.4	9.9	0	10.0	<.1
Chlorophyll <i>a</i> in photic zone- (µg/L)	--	8.2	--	1.8	--	3.5	--	7.9
Fecal coliform Range-- (col. per 100 mL) Mean---	--	<1- <1	--	1-61 17	--	1-9 4	--	<1-11 3
Total organic carbon (as C)---	9.6	--	6.0	--	5.3	--	6.0	--

EXPLANATION
 ——— Temperature
 - - - - - Dissolved oxygen concentration
 Dissolved oxygen concentration at 100 percent saturation

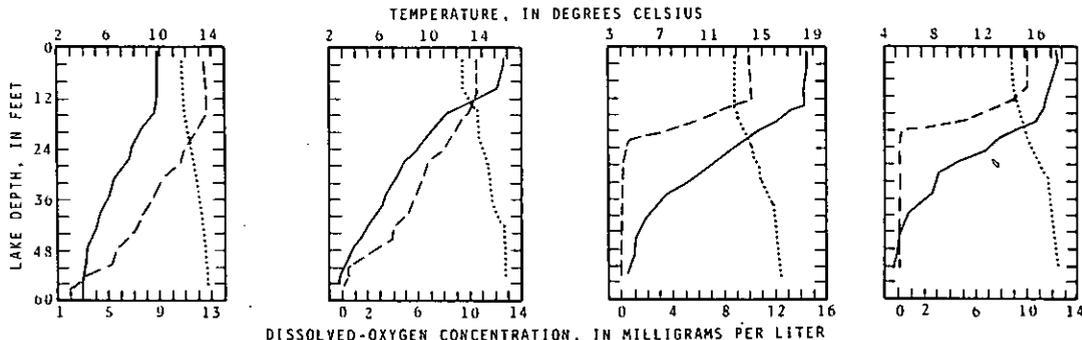


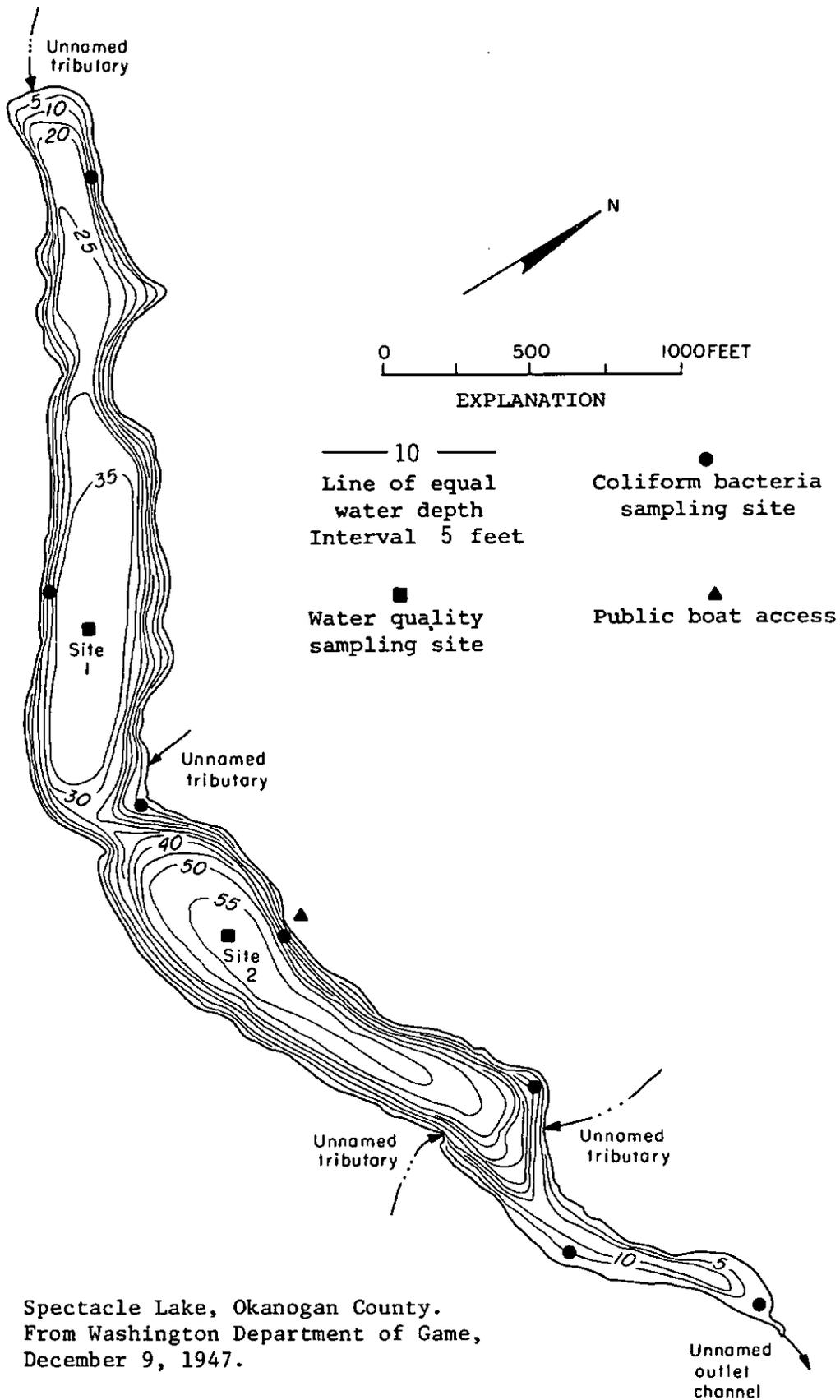
Water-quality data for Spectacle Lake - Site 2 (East Arm)

[Milligrams per liter unless otherwise indicated]

Date of collection (1975)-----	April 28		June 3		August 29		September 24	
	3	56	3	54	3	52	3	50
Water depth (ft)-----								
Silica (SiO ₂)-----	11	12	9.3	13	6.3	15	6.7	15
Dissolved iron (Fe), in µg/L--	30	10	80	50	20	110	50	40
Dissolved manganese (Mn)----- (in µg/L)	20	130	0	110	20	1,100	20	1,300
Calcium (Ca)-----	39	--	--	--	--	--	41	--
Magnesium (Mg)-----	13	--	--	--	--	--	11	--
Sodium (Na)-----	9.6	--	--	--	--	--	8.4	--
Potassium (K)-----	2.7	--	--	--	--	--	2.3	--
Bicarbonate (HCO ₃)-----	149	160	145	160	109	155	124	173
Carbonate (CO ₃)-----	0	0	--	--	--	--	0	--
Sulfide (S)-----	--	--	--	--	--	>5	--	>5
Sulfate (SO ₄)-----	44	--	--	--	--	--	42	--
Chloride (Cl)-----	3	--	--	--	--	--	1.8	--
Nitrate nitrogen (as N)-----	.01	.15	.01	.22	.00	.00	.01	.01
Nitrite nitrogen (as N)-----	.00	.03	.00	.00	.00	.00	.00	.00
Ammonia nitrogen (as N)-----	.08	.13	.15	.15	.06	.83	.07	.88
Organic nitrogen (as N)-----	.42	.23	.18	.16	.25	.27	.39	.22
Total phosphorus (as P)-----	.050	.064	.019	.091	.009	.19	.015	.20
Orthophosphate (as P)-----	.003	.047	.004	.072	.002	.17	.002	.19
Suspended solids (110°C)-----	0	--	--	--	--	--	8	--
Hardness as CaCO ₃ (Ca,Mg)-----	150	--	--	--	--	--	150	--
Specific conductance----- (micromhos at 25°C)	604	659	378	232	239	352	256	350
pH (pH units)-----	9.4	8.6	8.2	7.3	8.4	7.0	8.1	7.0
Water temperature (°C)-----	9.9	3.9	15.8	2.9	18.4	4.7	17.6	4.9
Color (Pt-Co scale)-----	10	5	15	10	10	10	30	30
Secchi-disc (ft)-----	--	5.8	--	18	--	11	--	8.5
Dissolved oxygen (DO)-----	12.4	2.4	10.6	.4	10.0	0	10.2	<.1
Chlorophyll <i>a</i> in photic zone- (µg/L)	--	16	--	1.9	--	3.2	--	7.3
Fecal coliform Range-- (col. per 100 mL) Mean--	--	<1-<1	--	1-4	--	1-3	--	<1-5
		<1		2		2		2
Total organic carbon (as C)--	12	--	1.9	--	5.6	--	4.7	--

EXPLANATION
 ----- Temperature
 - - - - - Dissolved oxygen concentration
 Dissolved oxygen concentration at 100 percent saturation





Spectacle Lake, Okanogan County.
From Washington Department of Game,
December 9, 1947.



Spectacle Lake, Okanogan County. August 4, 1967. Approx. scale 1:60,000.

Sprague Lake near Sprague (13351800)Location.

6.9 miles southwest of Sprague, Adams County. Lat 47°14'24", long 118°06'04"; NE¼SW¼ sec.12. T.20 N., R.37 E. Palouse River basin; 1,878 feet altitude. Sprague Lake and Palm Lake quadrangle (1:24,000 scale).

Physical characteristics of lake.

Surface area-----	1,800 acres	Length of shoreline-----	15 miles
Volume-----	19,000 acre-ft	Shoreline configuration-----	2.5
Mean depth-----	11 ft	Development of volume-----	0.54
Maximum depth-----	20 ft	Bottom slope-----	0.20 percent

Drainage basin.

Size: 2.88mi².

Geology: Primarily basalt flows and preglacial eolian deposits, with some granite and metamorphic rocks (Hunting and others, 1961).

Soils: Silt loams, loams, and coarse sandy loams, with rocky silt loams and gravelly soils (Lenfesty and others, 1967).

Land use	Percent
Urban	<1
Suburban	1
Agricultural	89
Forest or unproductive	9
Land surface	1

Nearshore development.

Number of nearshore homes: 0

Nearshore residential development: 0 percent

Littoral bottom.

Predominantly rock and gravel, with some sand and silt. The northeast and southwest ends of the lake are underlain by sand and silt, with some rock and gravel.

Hydrology.

The principal surface-water inflow to the lake is Negro Creek. On April 16 and May 19, 1975, the inflows were estimated to be 9.0 and 30 ft³/s, respectively. On Aug 13 and Sept 30, 1975, the water in the outflow channel was stagnant. Drainage is southwestward via Cow Creek; the outflow was not measured.

The lake stage, which was monitored by the U.S. Geological Survey during Sept 1958-Sept 1975, declined 3.07 feet between April 27 and Sept 30, 1975.

Aquatic plants.

Shoreline-----	51-75percent
Lake surface-----	<1 percent
Lake bottom-----	0 percent

Macrophytes observed (7/16/75): bulrush (Scirpus sp.)*, cattail (Typha sp.), yellow lily (Nuphar sp.), smartweed (Polygonum sp.).

Algae observed:

4/16/75: Diatoms (Asterionella sp., Navicula sp., Tabellaria sp.) and greens (Microspora sp.).
 5/19/75: Greens (Microspora sp.)*, blue-greens (Aphanizomenon sp.), and diatoms (Asterionella sp., Diatomella sp.).
 8/13/75: Greens (Microspora sp.)* and blue-greens (Aphanizomenon sp., Anabaena sp.).
 9/30/75: Blue-greens (Aphanizomenon sp.*, Nostoc sp.) and greens (Microspora sp.).

Summary and conclusions.

Sprague Lake, partly in Lincoln County, is long, narrow and relatively shallow. The lake is generally considered to be the head of Cow Creek. Lake levels are regulated by a small dam at the outlet. A marsh adjoins the lake at the southwest end. Because of its length the lake was sampled at two sites.

The biological productivity of the lake was high. Chlorophyll *a* concentrations at both sites ranged from 15 to 35 µg/L. Secchi-disc visibility was low, averaging only 2.8 feet. The dominant algae observed were greens in spring and summer and blue-greens in autumn. No submersed aquatic macrophytes were observed but about 71 percent of the shoreline was occupied by emersed aquatic macrophytes.

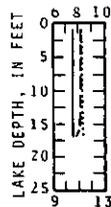
Because of the shallowness of the lake, thermal stratification did not develop completely; the lowest dissolved-oxygen concentration observed was 3.8 mg/L, in the bottom water at site 2.

Water-quality data for Sprague Lake - Site 1 (West Arm)

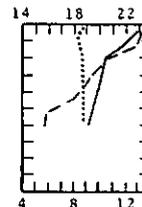
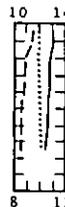
(Milligrams per liter, unless otherwise indicated)

Date of collection (1975)-----	April 16		May 19		August 13		September 30	
	3	15	3	16	3	13	3	11
Water depth (ft)-----								
Silica (SiO ₂)-----	10	10	3.3	3.3	1.9	4.5	2.6	2.8
Dissolved iron (Fe), in µg/L--	90	140	250	310	130	170	230	240
Dissolved manganese (Mn)----- (in µg/L)	50	50	30	40	20	30	30	40
Calcium (Ca) -----	31	--	--	--	--	--	33	--
Magnesium (Mg) -----	15	--	--	--	--	--	15	--
Sodium (Na) -----	19	--	--	--	--	--	23	--
Potassium (K) -----	6.7	--	--	--	--	--	8.7	--
Bicarbonate (HCO ₃) -----	193	195	195	196	217	217	220	217
Carbonate (CO ₃)-----	3	3	0	0	0	0	2	--
Sulfide (S)-----	--	--	--	--	--	--	--	--
Sulfate (SO ₄)-----	12	--	--	--	--	--	13	--
Chloride (Cl)-----	5	--	--	--	--	--	5.5	--
Nitrate nitrogen (as N)-----	.01	.01	.00	.00	.01	.00	.01	.01
Nitrite nitrogen (as N)-----	.01	.01	.00	.00	.01	.01	.00	.00
Ammonia nitrogen (as N)-----	.15	.21	.10	.13	.15	.15	.06	.06
Organic nitrogen (as N)-----	.85	.79	.90	.87	.79	.83	1.3	1.2
Total phosphorus (as P)-----	.064	.070	.091	.10	.075	.10	.11	.094
Orthophosphate (as P)-----	.003	.003	.004	.004	.002	.010	.003	.003
Suspended solids (110 °C)-----	44	--	--	--	--	--	28	--
Hardness as CaCO ₃ (Ca, Mg)----	140	--	--	--	--	--	140	--
Specific conductance----- (micromhos at 25 °C)	318	320	326	326	331	345	341	338
pH (pH units)-----	9.1	9.1	8.6	8.6	9.0	8.6	8.5	8.4
Water temperature (°C)-----	7.6	7.6	13.1	12.6	21.8	19.4	15.3	15.0
Color (Pt-Co scale)-----	15	15	15	15	5	5	25	30
Secchi-disc (ft)-----	--	3.8	--	2.0	--	2.1	--	1.5
Dissolved oxygen (DO)-----	11.2	11.1	9.4	8.6	12.8	6.0	10.5	9.9
Chlorophyll <i>a</i> in photic zone- (µg/L)	--	24	--	20	--	16	--	20
Fecal coliform Range-- (col. per 100 mL) Mean---	--	<1-4	--	1-5	--	<1-118	--	<1-28
Total organic carbon (as C)--	14	--	7.9	--	16	--	11	--

EXPLANATION
 ----- Temperature
 - - - - - Dissolved oxygen concentration
 Dissolved oxygen concentration at 100 percent saturation



TEMPERATURE, IN DEGREES CELSIUS



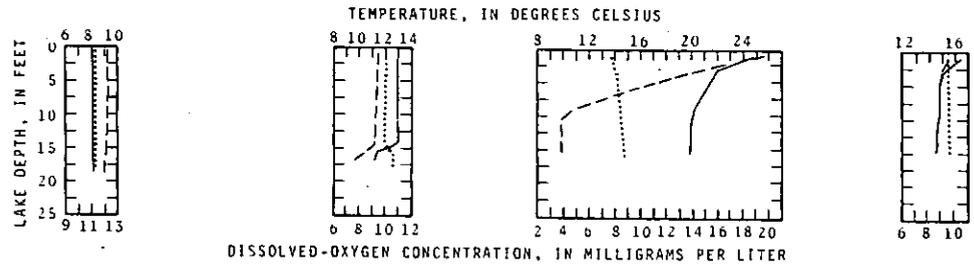
DISSOLVED-OXYGEN CONCENTRATION, IN MILLIGRAMS PER LITER

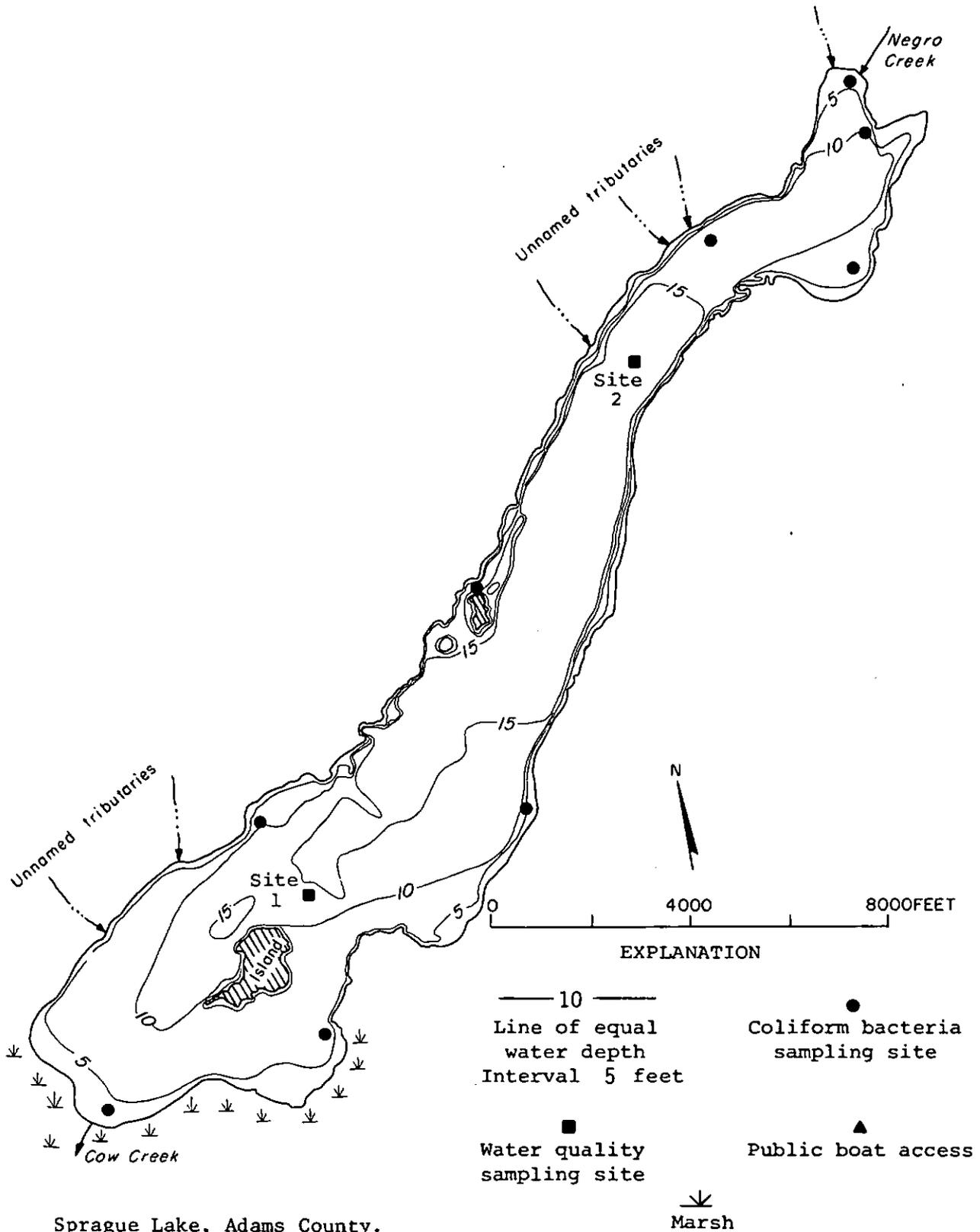
Water-quality data for Sprague Lake - Site 2 (East Arm)

[Milligrams per liter unless otherwise indicated]

Date of collection (1975)-----	April 16		May 19		August 13		September 30	
	3	16	3	15	3	14	3	13
Water depth (ft)-----								
Silica (SiO ₂)-----	13	14	4.8	5.3	0.4	5.6	2.5	2.9
Dissolved iron (Fe), in µg/L--	80	90	190	200	130	340	260	290
Dissolved manganese (Mn)----- (in µg/L)	30	30	30	30	30	50	30	40
Calcium (Ca)-----	29	--	--	--	--	--	34	--
Magnesium (Mg)-----	14	--	--	--	--	--	15	--
Sodium (Na)-----	19	--	--	--	--	--	22	--
Potassium (K)-----	6.9	--	--	--	--	--	8.8	--
Bicarbonate (HCO ₃)-----	189	189	196	196	202	215	224	223
Carbonate (CO ₃)-----	0	0	0	0	0	--	0	--
Sulfide (S)-----	--	--	--	--	--	--	--	--
Sulfate (SO ₄)-----	13	--	--	--	--	--	12	--
Chloride (Cl)-----	4.8	--	--	--	--	--	5.2	--
Nitrate nitrogen (as N)-----	.07	.06	.00	.00	.00	.00	.01	.02
Nitrite nitrogen (as N)-----	.01	.01	.00	.00	.01	.01	.01	.01
Ammonia nitrogen (as N)-----	.15	.13	.08	.13	.29	.32	.07	.08
Organic nitrogen (as N)-----	.75	.73	.80	.82	1.7	.78	1.1	1.1
Total phosphorus (as P)-----	.061	.067	.083	.084	.10	.12	.081	.082
Orthophosphate (as P)-----	.003	.004	.004	.006	.005	.12	.005	.005
Suspended solids (110 °C)-----	24	--	--	--	--	--	32	--
Hardness as CaCO ₃ (Ca, Mg)-----	130	--	--	--	--	--	150	--
Specific conductance----- (micromhos at 25 °C)	308	309	321	320	304	341	338	337
pH (pH units)-----	8.9	9.1	8.6	8.6	9.1	8.4	8.2	8.1
Water temperature (°C)-----	8.1	8.1	13.0	12.4	22.2	20.0	15.1	14.7
Color (Pt-Co scale)-----	20	20	15	15	30	20	25	30
Secchi-disc (ft)-----	-- 3.5 --	--	-- 2.8 --	--	-- 1.9 --	--	-- 1.8 --	--
Dissolved oxygen (DO)-----	12.2	12.0	9.4	9.0	14.4	3.8	8.9	8.7
Chlorophyll <i>a</i> in photic zone- (µg/L)	-- 35 --	--	-- 23 --	--	-- 29 --	--	-- 15 --	--
Fecal coliform Range-- (col. per 100 mL) Mean---	-- <1-12 -- -- 4 --	--	-- 1-3 -- -- 2 --	--	-- <1-20 -- -- 6 --	--	-- <1-14 -- -- 6 --	--
Total organic carbon (as C)---	8.5	--	8.6	--	22	--	--	--

EXPLANATION
 _____ Temperature
 - - - - - Dissolved oxygen concentration
 Dissolved oxygen concentration at 100 percent saturation

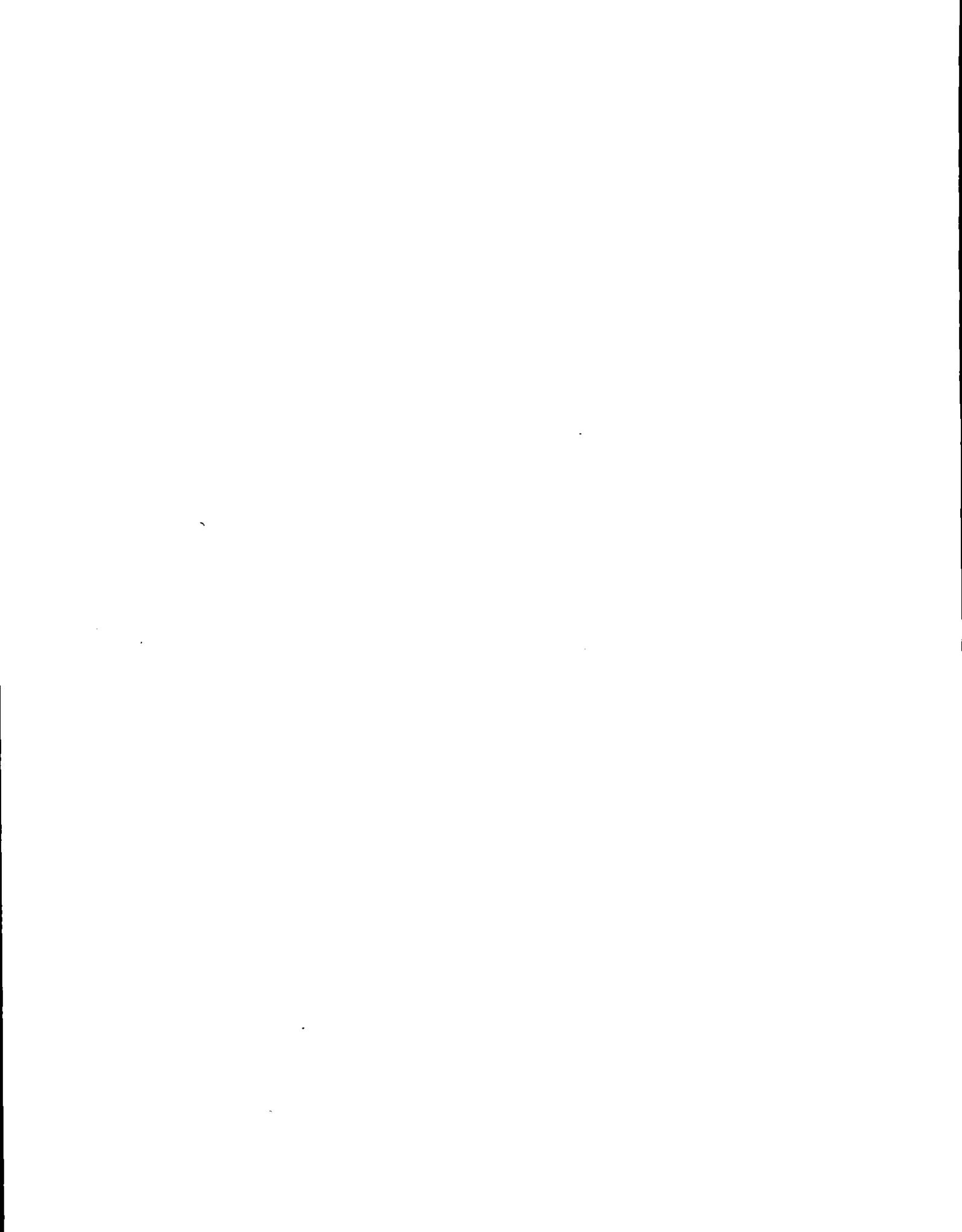




Sprague Lake, Adams County.
From U.S. Geological Survey,
September 24, 1974.



Sprague Lake, Adams County. June 3, 1970. Approx. scale 1:63,000.



Wannacut Lake near Oroville (12443980)Location.

6.0 miles southwest of Oroville, Okanogan County. Lat 48°52'05", long 119°30'54"; SW¼NW¼ sec.24. T.39 N., R.26 E.; location is for southernmost shoreline point of lake. Okanogan River basin; 1,880 feet altitude. Loomis quadrangle (1:62,500 scale).

Physical characteristics of lake.

Surface area-----	410 acres	Length of shoreline-----	5.4 miles
Volume-----	23,000 acre-ft	Shoreline configuration-----	1.9
Mean depth-----	55 ft	Development of volume-----	0.35
Maximum depth-----	160 ft	Bottom slope-----	3.3 percent

Drainage basin.

Size: 20.0 mi².

Geology: Mostly intrusive and extrusive igneous rocks and metamorphic rocks, with flood plain and terrace deposits (Walters, 1974).

Soils: Deep silt loam and loam soils (U.S. Soil Conservation Service, 1968).

Land use	Percent
Urban	0
Suburban	0
Agricultural	8
Forest or unproductive	89
Lake surface	3

Nearshore development.

Number of nearshore homes: 11

Nearshore residential development: 8 percent

Littoral bottom.

Chiefly rock, gravel, and firm sand with local areas of silt and muck. The littoral bottoms of the bays along the west shore are composed of silt.

Hydrology.

Inflow to the lake is by several small, unnamed tributaries. On April 30 and June 5, 1975, the combined inflows were estimated to be less than 0.1 ft³/s. On Aug 29 and Sept 24, 1975, the inflow channels were dry. The lake has no surface-water outflow.

The lake stage declined 0.92 foot between June 5 and Sept 24, 1975.

Aquatic plants.

Shoreline-----	26-50 percent
Lake surface-----	1-10 percent
Lake bottom-----	26-50 percent

Macrophytes observed (7/31/75): bulrush (Scirpus sp.)*, bushy pondweed (Najas sp.), muskgrass (Chara sp.)*, pondweed (Potamogeton sp.), sedge (Cyperaceae)*.

*Asterisk indicates dominant aquatic plants.

Algae observed (8/29/75): Blue-greens (Oscillatoria sp.).

Summary and conclusions.

Wannacut Lake is large and deep, and lies in a sheltered valley between high ridges. There are several resorts, and recreational use of the water, chiefly by fishermen, is heavy.

The biological productivity of the lake was low. Chlorophyll a concentrations ranged from 0.2 to 1.4 µg/L. Secchi-disc visibility ranged from 20 to 43 feet and was the highest of all the lakes studied in 1975. The high water clarity was probably a major factor in promoting the growth of submersed plants at depth; about 39 percent of the lake bottom was covered with muskgrass to depths of 60 feet.

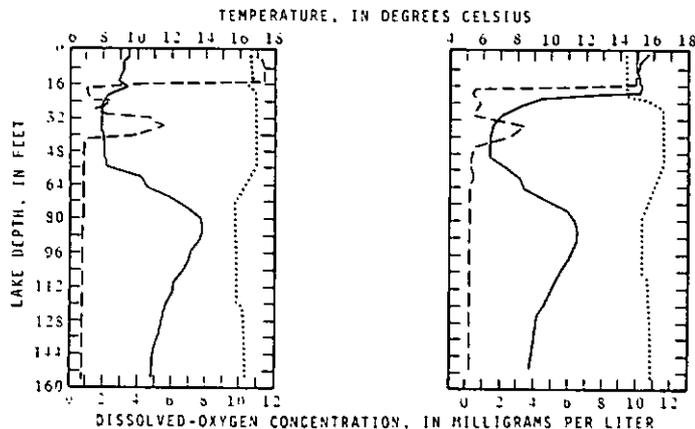
As indicated by the high specific-conductance values, the bottom waters of the lake are saline; this creates a layer of dense water at depth and prevents the complete circulation of the lake water. Below a depth of about 45 feet the lake was devoid of oxygen, and hydrogen sulfide was detected in this zone on all sampling dates.

Water-quality data for Wannacut Lake

[Milligrams per liter unless otherwise indicated]

Date of collection (1975)-----	April 30			June 5		
	3	50	150	3	50	150
Water depth (ft)-----						
Silica (SiO ₂)-----	13	9.4	46	12	9.4	46
Dissolved iron (Fe), in µg/L--	40	40	160	50	60	210
Dissolved manganese (Mn)----- (in µg/L)	10	60	1,100	20	50	990
Calcium (Ca) v-----	220	--	--	--	--	--
Magnesium (Mg) -----	740	--	--	--	--	--
Sodium (Na) -----	460	--	--	--	--	--
Potassium (K) -----	85	--	--	--	--	--
Bicarbonate (HCO ₃) -----	248	228	2,670	258	220	2,650
Carbonate (CO ₃)-----	--	--	--	--	--	--
Sulfide (S)-----	--	--	>5	--	.1	4
Sulfate (SO ₄)-----	4,100	--	--	--	--	--
Chloride (Cl)-----	49	--	--	--	--	--
Nitrate nitrogen (as N)-----	.00	.00	.00	.00	.00	.00
Nitrite nitrogen (as N)-----	.00	.00	.33	.00	.00	.14
Ammonia nitrogen (as N)-----	.95	2.1	57	1.3	1.9	52
Organic nitrogen (as N)-----	.25	.10	2.0	.00	.50	3.5
Total phosphorus (as P)-----	.010	.006	2.7	.004	.012	2.8
Orthophosphate (as P)-----	.002	.000	2.6	.002	.006	2.6
Suspended solids (110°C)-----	16	--	--	--	--	--
Hardness as CaCO ₃ (Ca, Mg)----	3,600	--	--	--	--	--
Specific conductance----- (micromhos at 25°C)	7,600	15,000	68,000	8,000	16,000	70,000
pH (pH units)-----	--	--	--	8.3	7.8	7.1
Water temperature (°C)-----	9.3	8.0	10.8	15.4	6.2	8.7
Color (Pt-Co scale)-----	0	0	70	15	10	50
Secchi-disc (ft)-----		43		25		
Dissolved oxygen (DO)-----	11.3	.9	.8	10.0	.3	.2
Chlorophyll <u>a</u> in photic zone- (µg/L)		0.2		1.4		
Fecal coliform Range-- (col. per 100 mL) Mean---		<1-<1		<1-<1		<1
Total organic carbon (as C)---	21	--	--	9.5	--	--

EXPLANATION
 _____ Temperature
 - - - - - Dissolved oxygen concentration
 Dissolved oxygen concentration at 100 percent saturation

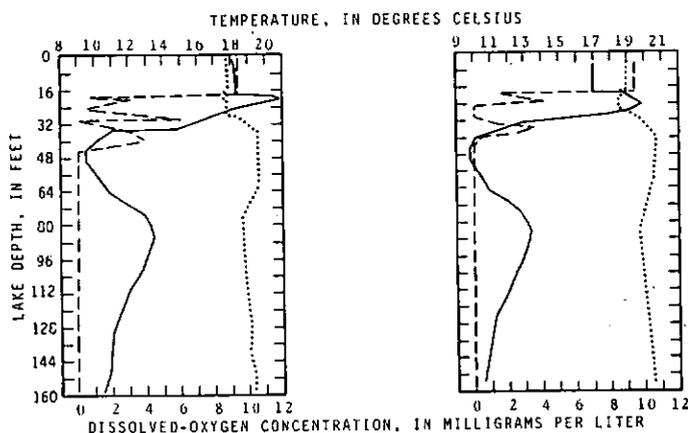


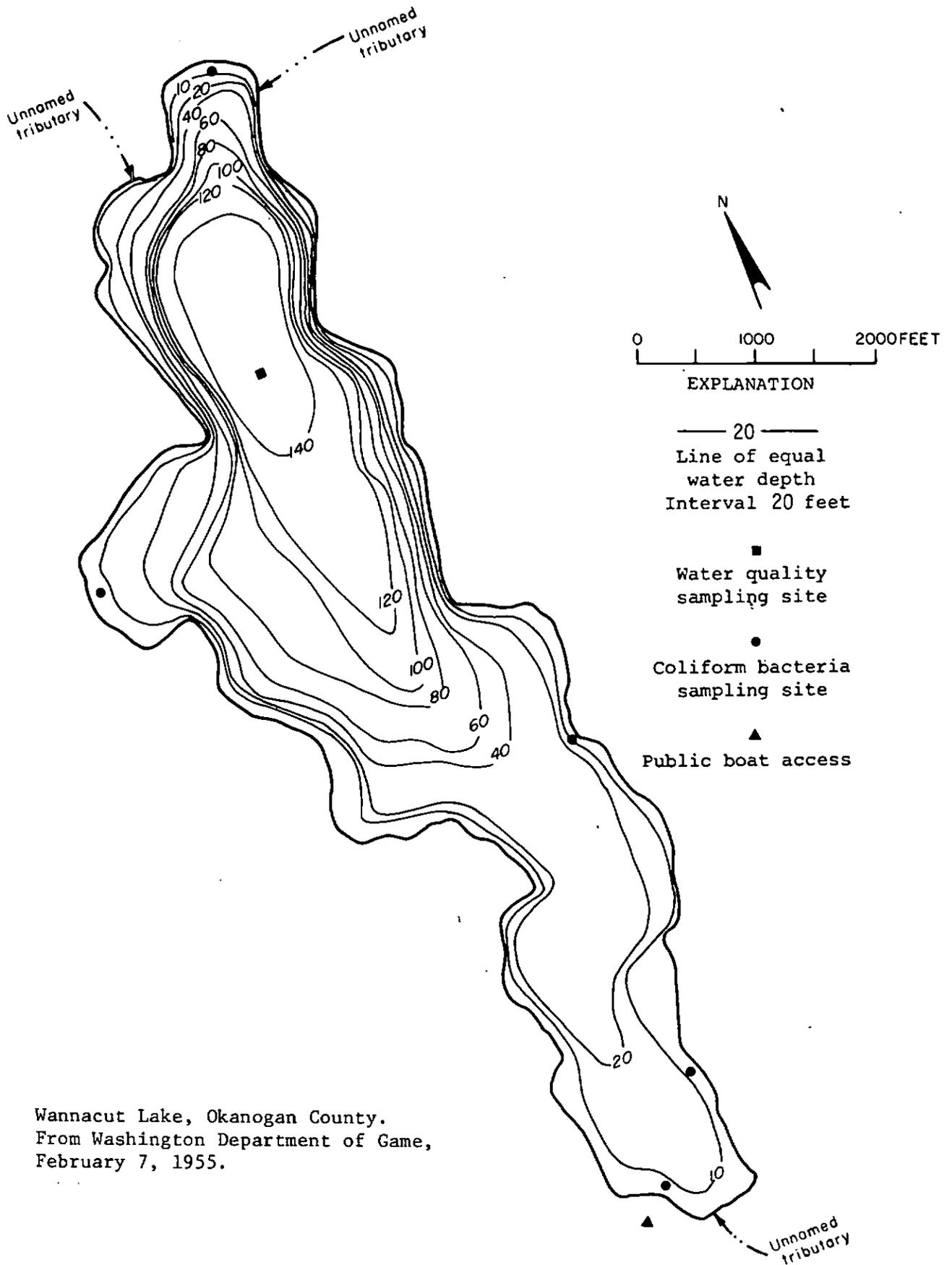
Water-quality data for Wannacut Lake--continued

[Milligrams per liter unless otherwise indicated]

Date of collection (1975)-----	August 29			September 24		
	3	50	150	3	50	150
Water depth (ft)-----						
Silica (SiO ₂)-----	9.6	9.8	40	9.2	9.8	39
Dissolved iron (Fe), in µg/L--	50	40	180	40	50	260
Dissolved manganese (Mn)----- (in µg/L)	10	60	700	20	60	1,100
Calcium (Ca) -----	20	--	--	230	--	--
Magnesium (Mg) -----	--	--	--	1,400	--	--
Sodium (Na) -----	--	--	--	560	--	--
Potassium (K) -----	--	--	--	98	--	--
Bicarbonate (HCO ₃) -----	282	222	2,660	234	245	2,700
Carbonate (CO ₃)-----	18	--	--	0	--	--
Sulfide (S)-----	--	--	>5	--	--	>5
Sulfate (SO ₄)-----	--	--	--	5,400	--	--
Chloride (Cl)-----	--	--	--	59	--	--
Nitrate nitrogen (as N)-----	.00	.00	.00	.00	.00	.00
Nitrite nitrogen (as N)-----	.00	.00	.30	.00	.00	.22
Ammonia nitrogen (as N)-----	.39	.26	50	.65	2.2	43
Organic nitrogen (as N)-----	1.5	1.5	3.0	.55	2.1	11
Total phosphorus (as P)-----	.005	.005	3.0	.007	.010	2.7
Orthophosphate (as P)-----	.002	.000	3.1	.001	.004	2.7
Suspended solids (110 °C)-----	--	--	--	24	--	--
Hardness as CaCO ₃ (Ca,Mg)----	--	--	--	6,100	--	--
Specific conductance----- (micromhos at 25 °C)	7,000	15,000	67,000	7,200	15,000	68,000
pH (pH units)-----	8.6	8.0	7.1	8.2	7.6	6.9
Water temperature (°C)-----	18.2	9.3	10.7	17.0	9.7	10.6
Color (Pt-Co scale)-----	5	10	50	0	0	35
Succhi-disc (ft)-----	----- 5 -----			----- 23 -----		
Dissolved oxygen (DO)-----	9.4	.1	0	9.4	0	0
Chlorophyll <u>a</u> in photic zone- (µg/L)	----- .56 -----			----- <1-1 -----		
Fecal coliform Range-- (col. per 100 mL) Mean--	----- <1-14 ----- ----- 5 -----			----- <1-1 ----- ----- <1 -----		
Total organic carbon (as C)--	9.2	--	--	17	--	--

EXPLANATION
 _____ Temperature
 - - - - - Dissolved oxygen concentration
 Dissolved oxygen concentration at 100 percent saturation





Wannacut Lake, Okanogan County.
From Washington Department of Game,
February 7, 1955.



Wannacut Lake, Okanogan County. August 4, 1967. Approx. scale 1:60,000.



Wapato Lake at Tacoma (12090800)Location.

In Wapato Park, South 72nd St., Tacoma, Pierce County. Lat 47°11'34", long 122°27'20"; SE¼NW¼ sec.29. T.20 N., R.3 E.; location is for southernmost shoreline point of lake. Puget Sound basin; 314 feet altitude. Tacoma South quadrangle (1:24,000 scale).

Physical characteristics of lake.

Surface area-----	29 acres	Length of shoreline-----	1.3 miles
Volume-----	190 acre-ft	Shoreline configuration-----	1.80
Mean depth-----	6 ft	Development of volume-----	0.46
Maximum depth-----	13 ft	Bottom slope-----	1.0 percent

Drainage basin.

Size: 1.98 mi².

Geology: Compact glacial till (Walters and Kimmel, 1968).

Soils: Gravelly sandy loam, gravelly loamy sand, gravelly loam, and peat (Anderson and others, 1955).

Land use	Percent
Urban	79
Suburban	2
Agricultural	0
Forest or unproductive	17
Lake surface	2

Nearshore development.

Number of nearshore homes: 20

Nearshore residential development: 23 percent

Littoral bottom.

Predominantly firm silt with local areas of sand and gravel. Muck along the west shore.

Hydrology.

The lake receives storm runoff from the Ainsworth Street drainage conduit. The lake level and outflow are controlled by an adjustable weir.

The lake stage declined 1.70 feet between Feb 20 and July 1, 1975. A rise in stage after July 1 resulted in a net decline of 0.53 foot by Sept 11, 1975.

Aquatic plants.

Shoreline-----	26-50 percent
Lake surface-----	1-10 percent
Lake bottom-----	76-100 percent

Macrophytes observed (8/11/75): yellow lily (Nuphar sp.)*, white lily (Nymphaea sp.), cattail (Typha sp.)*, waterweed (Elodea sp.), coontail (Ceratophyllum sp.)*, water milfoil (Myriophyllum sp.), smartweed (Polygonum sp.), bushy pondweed (Najas sp.), sedge (Cyperaceae).

Algae observed:

2/21/75: None
 4/11/75: Greens (Volvox sp.).
 7/1/75: Blue-greens (Aphanizomenon sp.)* and flagellates (Ceratium sp.).
 9/11/75: Blue-greens (Polycystis sp.).

*Asterisk indicates dominant aquatic plants.

Summary and conclusions.

Wapato Lake is small and situated in an urban section of Tacoma; most of the lake lies within the boundaries of a municipal park. The lake is fed primarily by ground water but also receives surface inflow from storm drainage.

The biological productivity of the lake was high. Much of the lake bottom was covered with submersed aquatic macrophytes, chiefly coontail. Most of the emerged macrophytes observed were at the north end of the lake. A bloom of blue-green algae was observed in July. The nitrate concentration was high in winter but low the rest of the year. The total phosphorus concentration was high throughout the year; the average concentration from seven sampling dates was 51 µg/L.

An intensive study of Wapato Lake by Canning and others (1976) indicates that the lake sediments contain significant amounts of oil and lead derived from urban drainage.

Water-quality data for Wapato Lake

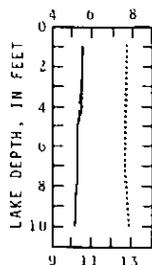
(Milligrams per liter unless otherwise indicated)

Date of collection (1975)-----	February 20		March 26		April 11		May 14	
	3	7	3	7	3	7	3	7
Water depth (ft)-----								
Silica (SiO ₂)-----	4.3	4.1	--	--	3.2	3.3	--	--
Dissolved iron (Fe), in µg/L--	60	20	--	--	160	150	--	--
Dissolved manganese (Mn)----- (in µg/L)	10	0	--	--	60	60	--	--
Calcium (Ca) -----	6.6	--	--	--	--	--	--	--
Magnesium (Mg) -----	1.5	--	--	--	--	--	--	--
Sodium (Na) -----	3.4	--	--	--	--	--	--	--
Potassium (K) -----	1	--	--	--	--	--	--	--
Bicarbonate (HCO ₃) -----	24	22	--	--	26	25	--	--
Carbonate (CO ₃)-----	--	--	--	--	0	0	--	--
Sulfide (S)-----	--	--	--	--	--	--	--	--
Sulfate (SO ₄)-----	6.8	--	--	--	--	--	--	--
Chloride (Cl)-----	3.9	--	--	--	--	--	--	--
Nitrate nitrogen (as N)-----	.49	.48	.02	.01	.01	.03	.01	.01
Nitrite nitrogen (as N)-----	.01	.013	.00	.01	.00	.00	.00	.00
Ammonia nitrogen (as N)-----	.21	.16	.09	.08	.07	.07	.05	.07
Organic nitrogen (as N)-----	.33	.40	.37	.33	.60	.30	.37	.40
Total phosphorus (as P)-----	.089	.088	.063	.051	.031	.032	.046	.054
Orthophosphate (as P)-----	.009	.010	.005	.004	.005	.008	.006	.006
Suspended solids (110 °C)-----	16	--	--	--	--	--	--	--
Hardness as CaCO ₃ (Ca, Mg)-----	23	--	--	--	--	--	--	--
Specific conductance----- (micromhos at 25 °C)	65	65	--	--	70	70	--	--
pH (pH units)-----	7.1	6.8	--	--	7.0	7.2	--	--
Water temperature (°C)-----	5.5	5.3	7.8	7.8	10.9	10.8	17.5	17.0
Color (Pt-Co scale)-----	25	25	--	--	10	10	--	--
Secchi-disc (ft)-----	-- 1.2 --		-- 3.6 --		-- 9.0 --		-- 6.5 --	
Dissolved oxygen (DO)-----	10.4	10.3	--	--	9.4	9.4	--	--
Chlorophyll <i>a</i> in photic zone- (µg/L)	-- 26 --		-- 9.6 --		-- 3.4 --		-- 3.2 --	
Fecal coliform Range-- (col. per 100 mL) Mean--	-----		-----		-- 1-38 --		-----	
Total organic carbon (as C)-----	6.8	--	--	--	5.1	--	--	--

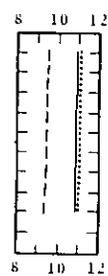
EXPLANATION

 Temperature
 - - - - -
 Dissolved oxygen
 concentration

 Dissolved oxygen
 concentration at
 100 percent saturation



TEMPERATURE, IN DEGREES CELSIUS



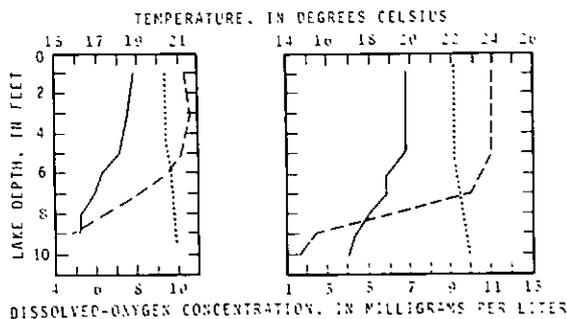
DISSOLVED-OXYGEN CONCENTRATION, IN MILLIGRAMS PER LITER

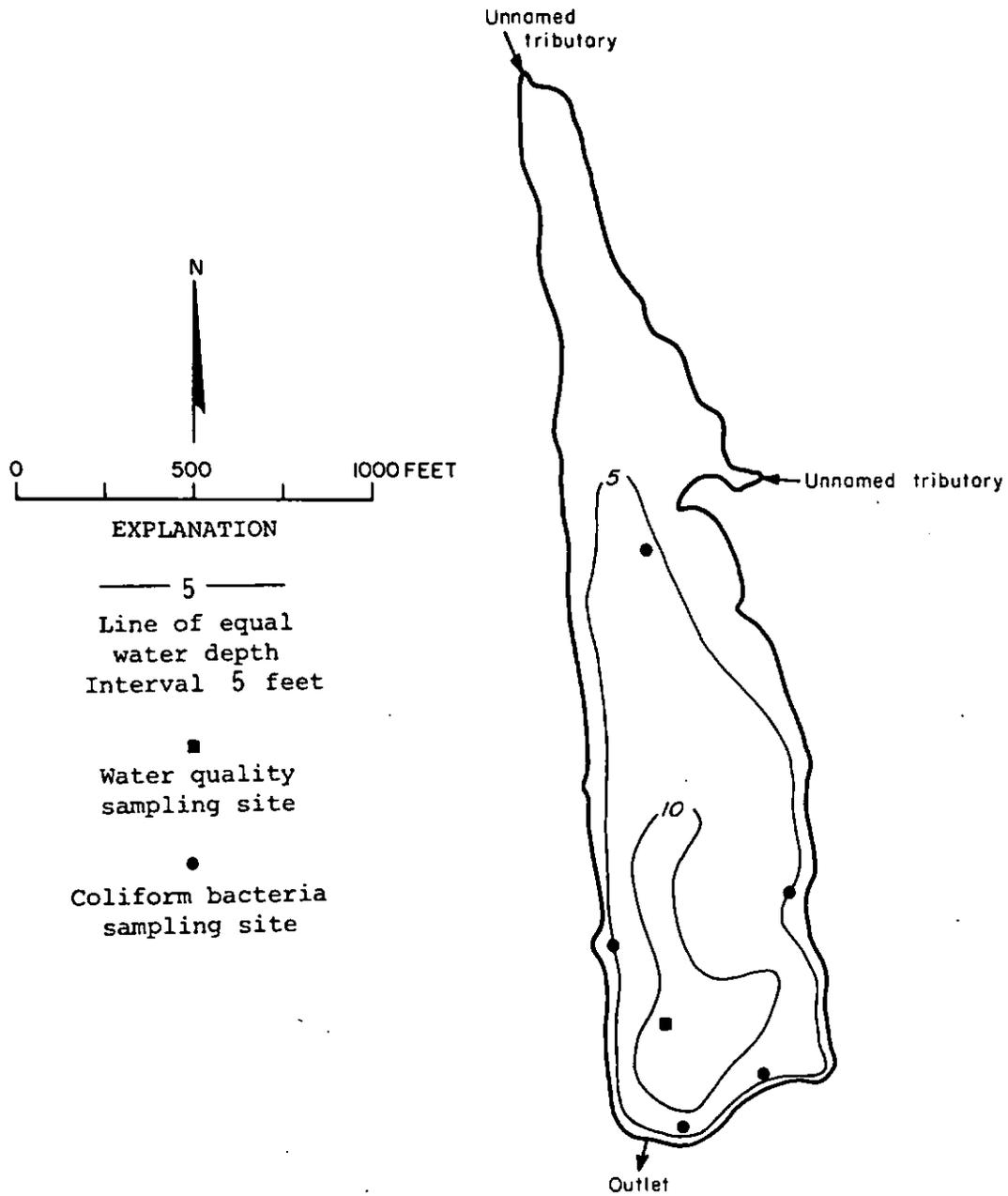
Water-quality data for Wapato Lake--continued

[Milligrams per liter unless otherwise indicated]

Date of collection (1975)-----	June 20		July 1		September 11	
	3	7	3	7	3	8
Water depth (ft)-----						
Silica (SiO ₂)-----	--	--	2.5	2.4	0.3	0.4
Dissolved iron (Fe), in µg/L--	--	--	290	300	130	150
Dissolved manganese (Mn)----- (in µg/L)	--	--	30	30	20	20
Calcium (Ca) -----	--	--	--	--	7.2	--
Magnesium (Mg) -----	--	--	--	--	1.9	--
Sodium (Na) -----	--	--	--	--	3.3	--
Potassium (K) -----	--	--	--	--	1.2	--
Bicarbonate (HCO ₃) -----	--	--	30	26	34	34
Carbonate (CO ₃)-----	--	--	--	--	0	--
Sulfide (S)-----	--	--	--	--	--	--
Sulfate (SO ₄)-----	--	--	--	--	4	--
Chloride (Cl)-----	--	--	--	--	2.7	--
Nitrate nitrogen (as N)-----	.02	.02	.01	.02	.02	.02
Nitrite nitrogen (as N)-----	.00	.00	.00	.001	.00	.00
Ammonia nitrogen (as N)-----	.10	.16	.09	.12	.10	.08
Organic nitrogen (as N)-----	.30	.26	.45	.44	.46	.51
Total phosphorus (as P)-----	.044	.088	.040	.038	.041	.040
Orthophosphate (as P)-----	.012	.010	.009	.006	.008	.009
Suspended solids (110°C)-----	--	--	--	--	32	--
Hardness as CaCO ₃ (Ca,Mg)-----	--	--	--	--	26	--
Specific conductance----- (micromhos at 25°C)	--	--	74	74	68	69
pH (pH units)-----	--	--	7.4	7.2	6.6	6.5
Water temperature (°C)-----	17.8	17.8	18.5	16.9	19.8	18.0
Color (Pt-Co scale)-----	--	--	30	25	35	35
Secchi-disc (ft)-----	-- 8.0 --		-- 6.6 --			
Dissolved oxygen (DO)-----	--	--	10.5	8.1	11.0	2.5
Chlorophyll <i>a</i> in photic zone- (µg/L)			-- 5.5 --		-- 5.4 --	
Fecal coliform Range-- (col. per 100 mL) Mean--			-- 14-29 -- -- 21 --		-- 7-61 -- -- 25 --	
Total organic carbon (as C)---	--	--	8.1	--	4.1	--

EXPLANATION
 _____ Temperature
 - - - - - Dissolved oxygen concentration
 Dissolved oxygen concentration at 100 percent saturation





Wapato Lake, Pierce County. Modified from a map by Canning and others (1976), dated October 21, 1976.



Wapato Lake, Pierce County. April 3, 1973. Approx. scale 1:4800.

Warden Lake near Warden (12471440)Location.

6.4 miles west of Warden, Grant County. Lat 46°57'46", long 119°10'25"; SW¼NW¼ sec.15. T.17 N., R.29 E.; location is of southernmost shoreline point of lake. Crab Creek basin; 1,076 feet altitude. Soda Lake quadrangle (1:24,000 scale).

Physical characteristics of lake.

Surface area-----	200 acres	Length of shoreline-----	5.3 miles
Volume-----	5300 acre-ft	Shoreline configuration-----	2.7
Mean depth-----	27 ft	Development of volume-----	0.37
Maximum depth-----	71 ft	Bottom slope-----	2.1 percent

Drainage basin.

Size: Not measured because water is imported from outside the drainage basin.
 Geology: Dark, dense basalt flows (drainage area near lake) (Hunting and others, 1961).
 Soils: Moderately deep and deep silt loam, loam, sandy loam, and sandy soils (drainage basin near lake) (U.S. Soil Conservation Service, 1968).

Land use	Percent
Urban	
Suburban	
Agricultural	Not determined because water is
Forest or unproductive	imported from outside the drainage
Lake surface	basin.

Nearshore development.

Number of nearshore homes: 14
 Nearshore residential development: 10 percent

Littoral bottom.

Predominantly silt with local areas of rock, gravel, sand, and muck. The east and northwest shores are rock, gravel, and silt, with some sand.

Hydrology.

The lake has no surface-water inflow, and is fed primarily by ground-water seepage of irrigation water. Drainage is northward by a culvert to an irrigation canal. The outflows through the culvert on April 21 and May 27, 1975, were estimated to be 1.9 and 6.0 ft³/s, respectively. On subsequent sampling trips the culvert was completely submerged and discharge measurements or estimates were not made.

Records of lake stage are incomplete; the stage rose 1.89 feet between May 27 and Sept 15, 1975.

Aquatic plants.

Shoreline-----	26-50 percent
Lake surface-----	<1 percent
Lake bottom-----	26-50 percent

Macrophytes observed (7/23/75): cattail (Typha sp.)*, bulrush (Scirpus sp.), pondweed (Potamogeton sp.)*, water milfoil (Myriophyllum sp.), sedge (Cyperaceae), muskgrass (Chara sp.).

Algae observed:

4/21/75: Diatoms (Navicula sp.*, Asterionella sp., Synedra sp.).
 5/27/75: Diatoms* (Asterionella sp., Amphora sp., Cyclotella sp., Cymbella sp., Diatomella sp., Fragillaria sp., Gomphonema sp., Navicula sp., Pinnularia sp., Synedra sp.), blue-greens (Nodularia sp., Aphanizomenon sp., Oscillatoria sp., Spirulina sp.), and greens (Pediastrum sp., Scenedesmus sp.).

*Asterisk indicates dominant aquatic plants.

Summary and conclusions.

Warden Lake is a relatively recent lake that is not shown on existing topographic maps; the lake formed as a result of ground-water seepage of irrigation water. Recreational use of the lake, chiefly by fishermen, is heavy.

The biological productivity of the lake was moderate to high. Chlorophyll a concentrations ranged from 4.2 to 19 µg/L. In May an algal bloom of diatoms was observed which contained a wide variety of diatom genera. Submersed aquatic macrophytes, chiefly pondweed, covered about 31 percent of the lake bottom to a depth of about 12 feet.

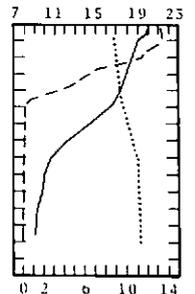
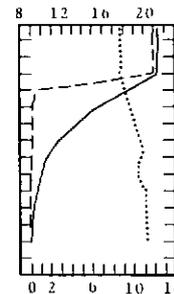
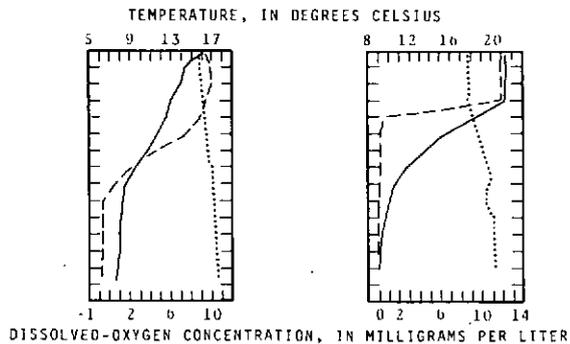
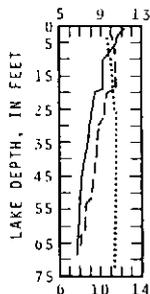
Despite the fact that thermal stratification was only weakly developed in May, the dissolved-oxygen concentration in the bottom water at that time was low. By August, stratification was well developed, dissolved oxygen in the bottom water was completely depleted, and hydrogen sulfide was detected in that zone.

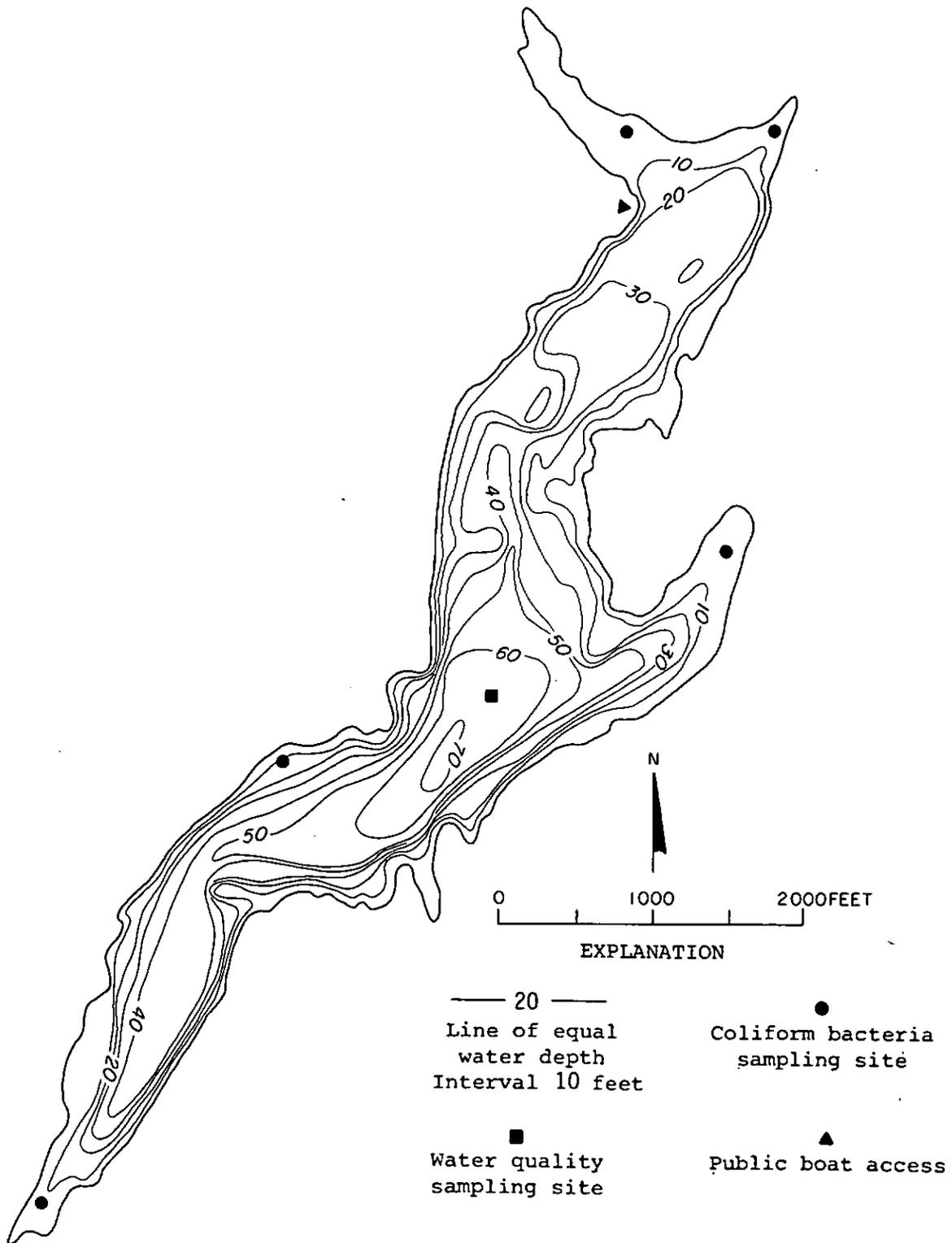
Water-quality data for Warden Lake

[Milligrams per liter, unless otherwise indicated]

Date of collection (1975)-----	April 21		May 27		August 18		September 15	
	3	66	3	66	3	62	3	60
Water depth (ft)-----								
Silica (SiO ₂)-----	29	29	26	30	26	31	27	31
Dissolved iron (Fe), in µg/L--	20	30	30	40	30	20	20	40
Dissolved manganese (Mn)----- (in µg/L)	4	70	20	260	20	290	20	270
Calcium (Ca) -----	26	--	--	--	--	--	19	--
Magnesium (Mg) -----	27	--	--	--	--	--	27	--
Sodium (Na) -----	71	--	--	--	--	--	74	--
Potassium (K) -----	8.7	--	--	--	--	--	10	--
Bicarbonate (HCO ₃) -----	253	200	256	280	164	297	256	307
Carbonate (CO ₃)-----	10	0	6	--	43	--	0	--
Sulfide (S)-----	--	--	--	--	--	>5	--	>5
Sulfate (SO ₄)-----	71	--	--	--	--	--	77	--
Chloride (Cl)-----	22	--	--	--	--	--	22	--
Nitrate nitrogen (as N)-----	.18	.13	.93	.16	.00	.00	.01	.00
Nitrite nitrogen (as N)-----	.01	.01	.02	.09	.01	.01	.00	.00
Ammonia nitrogen (as N)-----	.06	.23	.08	.80	.09	2.4	.11	2.9
Organic nitrogen (as N)-----	.55	.69	.57	.50	1.0	.60	.71	.9
Total phosphorus (as P)-----	.022	.030	.020	.024	.040	.16	.028	.21
Orthophosphate (as P)-----	.003	.002	.002	.001	.001	.14	.004	.18
Suspended solids (110°C)-----	24	--	--	--	--	--	12	--
Hardness as CaCO ₃ (Ca,Mg)----	180	--	--	--	--	--	160	--
Specific conductance----- (micromhos at 25°C)	592	578	630	660	531	584	532	580
pH (pH units)-----	9.2	9.2	8.8	7.9	9.4	7.4	9.0	7.2
Water temperature (°C)-----	10.7	6.8	14.9	7.7	21.4	9.0	19.9	9.1
Color (Pt-Co scale)-----	20	20	20	20	35	20	10	5
Secchi-disc (ft)-----	--	8.0 --	--	9.5 --	--	2.7 --	--	3.5 --
Dissolved oxygen (DO)-----	11.0	8.0	10.8	.3	11.9	0	13.4	0
Chlorophyll <i>a</i> in photic zone- (µg/L)	--	6.8 --	--	4.2 --	--	19 --	--	7.9 --
Fecal coliform Range-- (col. per 100 mL) Mean---	--	<1-<1 -- <1 --	--	<1-<1 -- <1 --	--	8-448 -- 109 --	--	2-64 -- 15 --
Total organic carbon (as C)--	--	--	7.9	--	11	--	12	--

EXPLANATION
 _____ Temperature
 - - - - - Dissolved oxygen concentration
 Dissolved oxygen concentration at 100 percent saturation





Warden Lake, Grant County.
 From U.S. Geological Survey,
 August 23, 1974.



Warden Lake, Grant County. Aerial photograph from
U.S. Geological Survey, May 28, 1974.



