INTRODUCTION

East Lake Tohopekaliga, one of the major lakes in central Florida, is located in the upper Kissimmee River basin in northeast Osceola County. It is one of numerous lakes in the upper basin used for flood control, in addition to recreation and some irrigation of surrounding pasture. This report is fourth in a series of lake reconnaissance studies in the Kissimmee River basin prepared in cooperation with the South Florida Water Management District. This report was preceded by reports on Cypress Lake (Gaggiani and McPherson, 1978), Lake Tohopekaliga, located southwest of East Lake Tohopekaliga (Phelps, 1982), and Lake Butler, located in southwest Orange County (Smoot and Schiffer, 1985). The purpose of this report is to provide government agencies and the public with a brief summary of the lake's hydrology and water quality.

Data-collection sites used in this study are shown in figure 1. Site information is given in table 1 and includes map number (fig. 1), site name, location, and type of data available. The U.S. Geological Survey maintained a lake stage gaging station on East Lake Tohopekaliga from 1942 to 1968. The South Florida Water Management District has recorded lake stage since 1963. Periodic water-quality samples have been collected from the lake by the South Florida Water Management District and the U.S. Geological Survey. Water quality and discharge data have been collected for one major tributary to the lake, Boggy Creek. Although few ground-water data are available for the study area, results of previous studies of the ground-water resources of Osceola County are included in this report.

To supplement the water-quality data for East Lake Tohopekaliga, water samples were collected at selected sites in November 1982 (dry season) and in August 1983 (rainy season). Samples were taken at inflow points, and in the lake, and vertical profiles of dissolved oxygen and temperature were measured in the lake. A water budget from an EPA (U.S. Environmental Protection Agency) report on the lake (Environmental Protection Agency, 1977) is also included in this report.

PHYSICAL AND GEOLOGIC SETTING

East Lake Tohopekaliga is located within the physiographic region called the Osceola Plain. The Kissimmee River passes through the length of the Osceola Plain. From Lake Kissimmee northward, the river valley opens into a group of lakes (White, 1970). These lakes were originally depressions in the sea floor that were left when the sea withdrew at the end of the Pleistocene Epoch (approximately 10,000 years ago) (Parker and others, 1955, p. 122). These depressions became filled with freshwater from ground-water seepage, rainfall, and surface-water inflows.

The Kissimmee River basin was originally characterized by high storage capacities in the lakes and wetlands, and low surface-water runoff. Flow from one lake to another occurred only during high-water conditions in the form of sheet flow because of the generally flat topography of the basin. Over the years, the natural drainage pattern of the upper Kissimmee River basin has been modified. The original overland flow drainage in the basin was first altered in the late 1800's by Hamilton Disston, a saw industrialist from Philadelphia, who constructed canals that drained millions of acres of wetlands in south Florida, including the Kissimmee River basin (Harner, 1973). The loss of storage in the wetlands increased surface-water runoff, and construction of canals connecting the lakes in the upper basin allowed flow between the lakes (without high-water conditions). According to one account, the surface of East Lake Tohopekaliga dropped 3 feet within 30 days after the canal was opened connecting it to Lake Tohopekaliga, and cypress and marsh surrounding the lake gave way to pasture (Hetherington, 1980). In the early 1960's, the canals in the Kissimmee River basin were improved and control structures were added for flood control.

Geohydrology

Osceola County is underlain by two primary water-bearing zones separated by a confining layer. The upper water-bearing zone, or surficial aquifer, consists of unconsolidated deposits of sand and shell beds with some silt and clay interspersed and varies in thickness throughout the county. Under East Lake Tohopekaliga, these unconsolidated deposits are approximately 50 to 100 feet thick. The confining layer is the Miocene Hawthorn Formation, consisting mostly of greenish clays and shell in the upper parts and weathered, impure limestone below. This confining bed is 50 to 100 feet thick in the vicinity of East Lake Tohopekaliga. The Floridan aquifer system, the primary source of water for domestic, industrial, and agricultural uses in the county, underlies the Hawthorn Formation and is composed of 1,000 feet or more of porous to dense limestone and dolomitic limestone. In the area of East Lake Tohopekaliga, the Eocene Avon Park Formation is the top of the Floridan aquifer system. The Eocene Ocala Limestone that generally overlies the Avon Park Formation, though present to the east, is absent in the East Lake Tohopekaliga vicinity because it has been removed by erosion. Under East Lake Tohopekaliga, the top of the Floridan ranges from 100 to 150 feet below sea level. A geologic cross section of the area just south of the lake is given in a report on the ground-water resources of Osceola County by Frazee (1980).

Ground Water

The potentiometric surface of the Floridan aquifer system slopes from west to east across Osceola County. In the East Lake Tohopekaliga area, the unconsolidated deposits which overlie the limestone of the Floridan aquifer system allow little recharge from the surficial aquifer and the lake, except for a small area along the northern shore of the lake and an area east of the lake where moderate recharge occurs (Frazee, 1980). Upward leakage from the Floridan aquifer system through the confining layer and surficial deposits to the lake rarely occurs because the potentiometric surface is nearly always below the lake surface.

HYDROLOGIC SETTING

Lake Characteristics and Land Use

East Lake Tohopekaliga has a drainage area of 308 mi². The total surface area of the lake is 18.7 mi² (at lake elevation 57 feet). Figure 2 shows depth contours for East Lake Tohopekaliga, at an elevation of 57 feet, as measured in March 1983. The map was prepared from data collected during several lake traverses in a boat equipped with a chart-recording fathometer and a supplementary nonrecording depth finder. The contour map resembles the map by Kenner (1964), indicating no major changes in lake bottom configuration since 1964. Figure 2 is more detailed than Kenner's map because a 2-foot rather than a 5-foot contour interval was drawn. The maximum depth shown by Kenner (19 feet at a lake elevation of 57 feet) was not found during the traverses in 1983. The maximum depth recorded in 1983 was 17 feet in the northern part of the lake and north of Kenner's maximum depth. The difference in maximum depths shown on the maps may be because of the difference in equipment and location of traverses.

Land use into the drainage basin is predominantly pasture, forest, and citrus groves. There are numerous small lakes and wetlands in the basin. The only urbanized area in the basin is the city of St. Cloud.

Rainfall, Lake Evaporation, and Lake Stage

Rainfall stations operated by NOAA (National Oceanic and Atmospheric Administration) are located near Kissimmee and at Lake Hart, 8 miles west and 8 miles northeast of East Lake Tohopekaliga, respectively (fig. 1). The Lake Hart site was discontinued in 1979, but was used for analysis in this study because of its length of record and because it is located in the upper basin of East Lake Tohopekaliga. Figure 3 shows average monthly rainfall and lake evaporation, and the difference between rainfall and lake evaporation for the two sites. Lake evaporation was computed by Lichtler and others (1968) by multiplying average pan evaporation at Orlando (as determined by the Weather Bureau) by monthly coefficients determined from evaporation studies at Lake Okeechobee between 1941 and 1946. Evaporative losses are highest in summer months, but this is also the time of maximum rainfall, so the rainfall exceeds evaporation. High evaporative losses occur in April and May, before the summer rains start, and cause a net deficit in the difference between rainfall and evaporation.

The average monthly rainfall at Lake Hart for the years 1941-70 and average monthly rainfall for the Kissimmee rainfall station for 1931-82 were both compared to lake evaporation to determine if a difference exists. A net deficit of 1.34 inches between rainfall and evaporation occurred at Kissimmee and a surplus of 1.26 inches occurred at Lake Hart. These data indicate that rainfall and lake evaporation are probably about equal.

Figure 4 shows a rainfall hydrograph for Kissimmee for the period of record for East Lake Tohopekaliga (1942-82). Hydrographs for the lake stage and a Floridan well are also shown for comparison. The hydrograph for the lake shows that the range in stage has decreased since 1963 when a control structure was installed on the outlet of the lake (S-59). Although the lake stage still responds to rainfall, the response is controlled, as indicated by the lower maximum stages and higher minimum stages since 1963.

The water level in the Floridan aquifer system corresponds generally to rainfall (fig. 4), as does the lake stage. However, because the potentiometric surface of the Floridan aquifer system is nearly always lower than the lake surface elevation, and because of the confining layer beneath the lake, variations in the potentiometric surface of the aquifer most likely do not affect (increase) the lake stage. Little data are available about the recharge potential from the surficial aquifer. Topographic relief in the vicinity of the lake is small, indicating that the gradient of the water table of the surficial aquifer is small, thus limiting potential recharge. Most of the water entering the lake is from runoff.

Stage and Flow Characteristics

The major inflows to East Lake Tohopekaliga are Boggy Creek, which enters the lake on the northwest, and the Ajay-East Tohopekaliga Canal, which flows into Fells Cover on the northeast. Minor tributaries are Jim Branch, which flows into Fells Cove, and a small canal that connects Lake Runnymede to East Lake Tohopekaliga on the southeast (fig. 2). This canal equalizes the stage of the two lakes and is not a significant inflow source. The drainage divide of East Lake Tohopekaliga basin (fig. 1) is indefinite because of a control structure on a canal between Alligator Lake and Lake Gentry. When lake levels are high, the control structure may be opened, allowing water to flow south to Canoe Creek. When the control structure is closed, the flow follows a horseshoe-shaped path through Alligator Lake, Brick Lake, Lake Conlin, and Cat Lake, then north through a chain of smaller lakes to Lake Mary Jane and Lake Hart, then south to Ajay Lake (fig. 1), and the Ajay-East Tohopekaliga Canal into East Lake Tohopekaliga.

A flow-duration curve for Boggy Creek (1960-82) is shown in figure 5. Median flow from Boggy Creek was 17.5 ft³/s, maximum daily flow recorded was 3,680 ft³/s (March 18, 1960) and minimum daily flow was 0.10 ft³/s which occurred several times. The shape of a flow-duration curve is an indication of hydrologic and geologic characteristics of the drainage basin (Searcy, 1959). The flow-duration curve for Boggy Creek is moderately flat. The shape of the curve indicates the presence of ground-water or surface-water storage, which tends to equalize flow, that is, peak flows are attenuated and base flow is increased. The flatness at the upper end of the curve is typical of streams draining swampy areas.

The Ajay-East Tohopekaliga Canal has a total drainage area of 171 mi² or about 55 percent of the total drainage area of the lake. Monthly discharge measurements and stage observations were made at a gaging station on the canal from May 1942 through July 1956. The median discharge for this period was 93.5 ft³/s, and the flow ranged from -0.25 (reverse flow) to 1,050 ft³/s (September 30, 1953). Several miscellaneous measurements have been made since 1956, including one in March 1960, when record stages and discharges were common throughout central Florida. The discharge measured at that time was 1,420 ft³/s. According to records for the period 1942-56, the mean flow at Ajay-East Tohopekaliga Canal (formerly published as Hart-East Tohopekaliga Canal) was 170 ft³/s and the mean outflow at St. Cloud Canal (formerly published as East Tohopekaliga-Tohopekaliga Canal) was 238 ft³/s. Based on these data, the canal inflow comprised 72 percent of the lake's total inflow. Although these flow data represent conditions before the regulation of outflow from the lake started in 1963, they do indicate the relatively large contribution of inflow to the lake through the Ajay-East Tohopekaliga Canal.

Outflow from East Lake Tohopekaliga is through the St. Cloud Canal to Lake Tohopekaliga. Median annual mean flow for the period 1942-67 was 226 ft³/s, and the maximum daily flow recorded was 1,600 ft³/s (September 30, 1960). In some years, there has been no flow into the canal for many days.

Stage-duration curves for East Lake Tohopekaliga (fig. 6) were computed from daily values before and after the control structure S-59 was installed in the St. Cloud Canal. The period of record used for the preregulation curve was 1941-63. The postregulation curve is based on a 5-year period (1963-68) of daily values. Although the postregulation period of record is relatively short, the effect of the control structure on the lake stage is noticeable, particularly at the extreme ends of both curves. The difference between the median lake stage values before and after regulation is only about 0.25 foot, but the difference between maximum stages is 3 feet, and between minimum stages, is more than 2 feet. However, the reason for the lower maximum stages (0-20 percentile) may have been the below average annual rainfall for the years 1963 through 1968.

Water Budget

A water budget for East Lake Tohopekaliga was computed by the Geological Survey for the EPA during the National Eutrophication Survey (Environmental Protection Agency, 1977). The water-budget data presented below was based on data collected from March 1973 through February 1974. The budget included in the final report did not specifically identify flow from the Ajay-East Tohopekaliga Canal which is a major inflow point. Instead, it was included with flow from minor tributaries and immediate drainage. The sum of the drainage areas for all the tributaries did not equal the drainage area given for the St. Cloud Canal. This may be because of the drainage area contributing directly to the canal above the location at which the total outflow drainage area was measured. The budget is shown below.

Tributaries	Drainage area (mi²)	Mean flow ft³/s
Boggy Creek	88.8	58.2
Inflow from Lake Runnymede	5.2	4.2
Minor tributaries and immediate drainage	195.0	157.4
Outflow		
St. Cloud Canal	308.0	219.8

WATER QUALITY

Water samples from East Lake Tohopekaliga have been analyzed periodically since 1954. Data for two sites in the lake (center and Fells Cove) are summarized in table 2, as well as available data for Boggy Creek near Taft (site 1) and St. Cloud Canal at S-59 (site 7), a major inflow and outflow, respectively. Other sites referred to in this report that did not have sufficient data to include in a statistical summary, are not shown in table 2. Mean values for selected constituents and physical properties are similar in magnitude for all four sites, with the exception of selected nutrients and color, discussed later in this report.

To augment existing data, selected sites were sampled in November 1982 and August 1983. Values of selected physical properties and chemical constituents for the November samples are summarized in figure 7.

There was very little variability in specific conductance at the six sites. The pH of the waters was acidic at all sites, but Boggy Creek (site 1) generally had higher pH values. This may be because Boggy Creek receives some treated wastewater from an Orange County sewage treatment plant. The original source of the treated water is ground water from the Floridan aquifer system which typically has a pH in the range of 6.0 to 8.5 (Hem, 1970). Mean concentrations of organic carbon, total phosphorus, and orthophosphorus were also higher at the Boggy Creek site (table 2), also possibly because of the treated wastewater input. Wetlands upstream of the site and organic soils may also be a source of nutrients in the water.

Color in water at the six sites is probably due mostly to release of tannic acids from cypress trees in swamps and the leaching of organic debris. The color of the water in Fells Cove (site 3) has a value three times higher than the value for the lake center. The inflow of more highly colored water from Jim Branch (site 2) and the Ajay-East Tohopekaliga Canal (site 4) probably affects the color in Fells Cove. The higher nitrogen values in these tributaries may also be a result of the swampy land in the basin, and waste from cattle that are raised in parts of the basin. The color in the lake water (site 6A) originates from the blending of these various sources. The lower value of color in the lake may be due to a high percentage of the inflow coming from low-color sources (ground water, rainfall) or to chemical processes (adsorption) and settling. The Secchi-disk estimates the transparency of the water which is inversely related to the color and suspended solids content of the water. Therefore, the lower Secchi-disk value in Fells Cove may be due to the color.

The concentration of phosphorus in the lake center (site 6A) is in the range reported by EPA to be typical for most relatively uncontaminated surface waters (0.01 to 0.03 mg/L) (Environmental Protection Agency, 1976). The mean phosphorus concentration of 0.029 mg/L (table 2) is also within the EPA range.

DO (dissolved oxygen) and temperature profiles measured in November 1982 and August 1983 at lake sites 3 and 6A are shown in figure 8. Little stratification is evident in the November profiles, but in August, the DO changes with depth, possibly because of benthic demand and biological activity. However, the range in DO from top to bottom is less than 1 mg/L.

Major Ions

The distribution of major dissolved ions at selected sites is represented by the Stiff diagrams (Hem, 1970) in figure 9. The date of the analysis and the specific conductance of each sample are also shown by each Stiff diagram. Because not all samples were collected at the same time, recent rainfall, or lack of rainfall, may have affected the chemistry of the water. The Stiff diagrams readily show that the major ionic composition of ground water from the Floridan aquifer system (site 8) differs greatly from that of surface water. Water in the aquifer is typically high in relative concentrations of calcium and bicarbonate, whereas the surface-water sites appear to be predominantly sodium chloride in water type.

The specific conductance of the Boggy Creek near Taft (195 µS/cm) and East Lake Tohopekaliga (136 µS/cm) samples shown in figure 9 are considerably higher than the average values presented in table 2. The diagrams in figure 9 probably do not represent average conditions because rainfall had been below average from 1980 through 1982 (fig. 4).

Minor Elements

Concentrations of selected minor elements in samples collected from East Lake Tohopekaliga, August 4, 1983, were compared to recommended limits of the FDER (Florida Department of Environmental Regulation) for Class III waters (recreation, propagation, and maintenance of a healthy, well balanced population of fish and wildlife) (Florida Department of Environmental Regulation, 1983). The concentrations and FDER limits are listed in table 3. Dissolved concentrations of copper and zinc were included because no data were available for total concentrations of these elements. All the minor element concentrations were well below the recommended limits. The low concentrations of these elements indicate that they are probably from natural sources.

Trend Analysis and Regression

The Seasonal Kendall test developed by Kendall and adapted for seasonally grouped data by Hirsch and others (1981) is useful for detecting monotonic trends in time series that may have missing values, or seasonality. Boggy Creek and East Lake Tohopekaliga have sufficient long-term water-quality records to determine possible trends or changes in water quality with time. Selected water-quality indicators used in trend analysis were nitrate nitrogen, specific conductance, pH, and alkalinity. In addition to the Seasonal Kendall test, time plots of the parameters were inspected visually for trends.

The p-level or p-value is a measure of the risk in stating a trend exists if there were no trend in the data (Crawford and others, 1983). Thus, a low p-level indicates that the conclusion that there is a trend is probably correct. High p-levels (depending on the situation, anything above 0.05 or 0.10) would indicate that there is a greater chance of assuming a trend when in fact there is no trend. Visual inspection and application of the Seasonal Kendall test to the data indicated that only specific conductance showed a trend. A highly significant increasing trend (p-level of 0.001) in specific conductance values was indicated for the Boggy Creek site with an increase of about 1.4 units (µS/cm) per year. For the 23-year period of record, this amounts to an increase of 33 µS/cm.

A significant increasing trend was indicated at the East Lake Tohopekaliga site (p-level of 0.03). An increase of about 1.2 µS/cm per year for the lake also yielded a total increase of 33 µS/cm for the 28-year period of record. Most of the increase in specific conductance appeared to occur before 1972 (fig. 10).

Because the plots of specific conductance values with time indicated a change of slope in about 1972, the Seasonal Kendall test was applied to the data collected before and after 1972 for both sites. Based on visual inspection of the plotted data, a significant trend was expected before 1972, but not for the later period. However, when the Seasonal Kendall test was applied to the data for the two sites, only the data for the early period at Boggy Creek had a significant trend (p-level of 0.001). No trend was indicated for the specific conductance of the lake for either period. The detection of no trend may be due to a wide scatter of data points in each period. When the entire period of record for the lake was used, the consistently higher values after 1975 apparently produced a significant test statistic (p-level less than 0.10). Thus, the trend in values for the lake was only significant when the entire period of record was considered; that is, there is not sufficient statistical evidence to conclude that there is a trend in specific conductance values in the earlier period for the lake, but there is for Boggy Creek.

Specific conductance and lake stage may be inversely related because of the dilution of lake water at higher lake stages with rainwater. To determine if a relation exists for East Lake Tohopekaliga, specific conductance values were regressed against monthly lake stage data. If more than one value of specific conductance existed per month, an average value was used. Four models were used to fit the data. These are linear-linear, log-linear, linear-log, and log-log. All the models indicated a relation between specific conductance and lake stage at a significance level of 0.0001. The log-linear model had the best fit of the four, with 34 percent of the variation in specific conductance explained by the model. The highest value for specific conductance was 165 µS/cm, observed on 1962 which also was a record low lake stage (fig. 4, lake stage hydrograph). The lowest value of specific conductance was 49 µS/cm, observed in 1960, at a monthly mean lake stage of 61.5 feet, a value exceeded only once in the period from 1941 to 1981 (mean stage for October 1953 was 61.71 feet). Although a relation apparently exists between specific conductance and lake stage, other factors also affect conductance.

Changes in land use in the drainage basin could increase dissolved solids loads to the lake, thus increasing conductance. Sources of dissolved solids would include stormwater runoff from urbanized areas, fertilizer from agricultural land and residential areas, and treated wastewater from sewage treatment plants.

To determine if the long-term trend in specific conductance was only caused by a change in lake stage in the same time period, the residual values for the specific conductance lake-stage models were analyzed using the Seasonal Kendall test. This test of the residuals indicated a significant trend with time, implying that there is a trend in specific conductance with time, apart from any affects due only to changes in lake stage. Additionally, the Seasonal Kendall test was applied to the lake stages for which specific conductance values were available, and no significant trend was found, further supporting the indication of a true trend in specific conductance values with time. Thus, the long-term trend in specific conductance is not related to a change in lake levels, but is increasing with time for other reasons.

Bottom Sediments

Bottom sediments in East Lake Tohopekaliga were sampled in June of 1979 and in April 1980 for organic compounds and metals. The only organic compound detected was DDE. Lead, zinc, manganese, cadmium, and chromium concentrations were 10 µg/g or less.

The bottom sediments were sampled for nutrient concentrations in 1979, 1980, and 1982. Total phosphorus concentrations ranged from 38 to 210 µg/g. Total nitrogen concentrations ranged from 1,300 to 3,800 µg/g. Of this total, the ammonia nitrogen fraction ranged from 11 to 84 µg/g, and nitrate + nitrite ranged from 1.6 to 3.7 µg/g. The remaining 98 or greater percent of the total nitrogen in the bottom sediments was in the organic form. A comparison of samples of bottom sediments from Cypress Lake (fig. 1), and Lake Tohopekaliga that were collected in 1976 indicate that nutrient concentrations in bottom sediments of East Lake Tohopekaliga are similar to those in Lake Tohopekaliga, but were only one-fourth the magnitude of nutrient concentrations in Cypress Lake. However, no inferences can be supported by data from only one sample.

ASSESSMENT OF LAKE WATER QUALITY

In 1972, the EPA initiated the National Eutrophication Survey to investigate the nationwide threat of accelerated eutrophication to freshwater lakes and reservoirs (Environmental Protection Agency, 1977). As part of this survey, 41 lakes in the State of Florida were sampled in 1973 and ranged in order of decreasing quality using a combination of six water-quality indicators, including selected nutrients, chlorophyll, Secchi-disk transparency, and DO. East Lake Tohopekaliga ranked second in overall quality. Lake Tohopekaliga ranked 28 in the same comparison, indicating a large difference in water quality of the two lakes. East Lake Tohopekaliga ranked fourth in Secchi-disk transparency and was ranked within the top ten for the other indicators except for DO (ranked 19th). The lower DO may be due to low productivity in the lake which is indicated also by the low nutrient concentrations and high Secchi-disk transparency measurements. Despite the ranking of East Lake Tohopekaliga, the National Eutrophication Survey data indicated the lake is mesotrophic.

A limnological survey of 165 Florida lakes was made by the University of Florida's Center for Aquatic Weeds between September 1979 and August 1980 to determine trophic state characteristics (Canfield, 1981). One major conclusion in the report of the survey was that a strong relation exists between the mineral composition of Florida's lakes and the surface geology and physiography. Based on this relation, the University of Florida report grouped the lakes surveyed by physiographic regions in the State. East Lake Tohopekaliga is in the "lake district" of the Osceola Plain, as well as Lake Gentry, Lake Hart, Lake Mary Jane, Alligator Lake, and numerous small lakes in south-central Orange and north-central Osceola Counties. All these lakes are soft-water lakes and naturally productive. Sodium is the dominant cation and chloride is the dominant anion. The report on the survey concluded that most of Florida's lakes are either mesotrophic (42 percent) or eutrophic (35 percent). Mean values of the water-quality indicators for East Lake Tohopekaliga during this survey indicate that the lake is in a mesotrophic condition.

A study of 55 lakes (Shannon and Brezonik, 1972) in north-central Florida categorized the lakes into four types according to selected water-quality characteristics. Data from the present study were compared to data in the Shannon and Brezonik study of Florida lakes. Of the four lake types, (colored-acid, colored-alkaline, clear-alkaline, clear-soft water), the values for East Lake Tohopekaliga from the present study most nearly resemble the clear, soft-water lake type. The four lake types were further subdivided into trophic state groups. For clear lakes, these trophic state groups were oligotrophic, mesotrophic, and eutrophic. Seven water-quality indicators were used to group the lakes. These indicators were primary production, chlorophyll a, total phosphate, total organic nitrogen, inverse Secchi-disk transparency, conductivity, and the cation ratio (magnesium plus calcium to sodium plus potassium). The values for East Lake Tohopekaliga most nearly resembled values for lakes that were within the mesotrophic group. This classification agrees with the previous two studies cited. Thus, data collected for the present study support earlier assessments of lake water quality in East Lake Tohopekaliga.

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ABBREVIATIONS AND CONVERSION FACTORS

For those readers who may prefer to use metric units (SI) rather than inch-pound units, the conversion factors for the terms used in this report are listed below.

Multiply	By	To obtain
inch (in.)	25.40	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
square mile (mi²)	2.590	square kilometer (km²)
cubic foot per second (ft³/s)	0.02832	cubic meter per second (m³/s)

Additional abbreviations used in this report are listed below:

milligrams per liter (mg/L)
micrograms per liter (µg/L)
micrograms per gram (µg/g)
microsiemens per centimeter at 25 degrees Celsius (µS/cm at 25°C)

Temperature in degrees Celsius can be converted to degrees Fahrenheit as follows:

$$°F = 1.8\ °C + 32$$

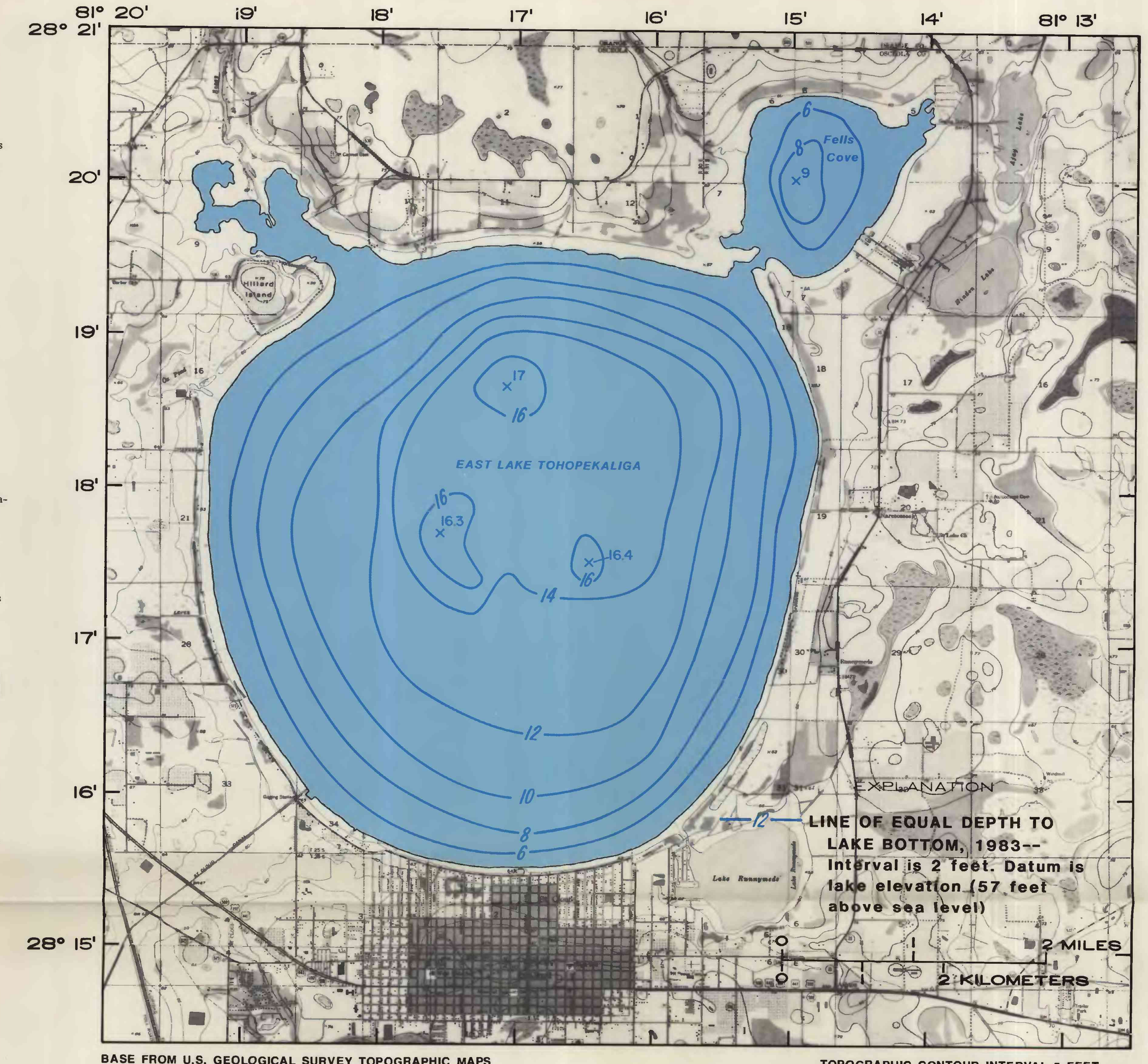

Figure 2.--Depth of East Lake Tohopekaliga and topographic features.

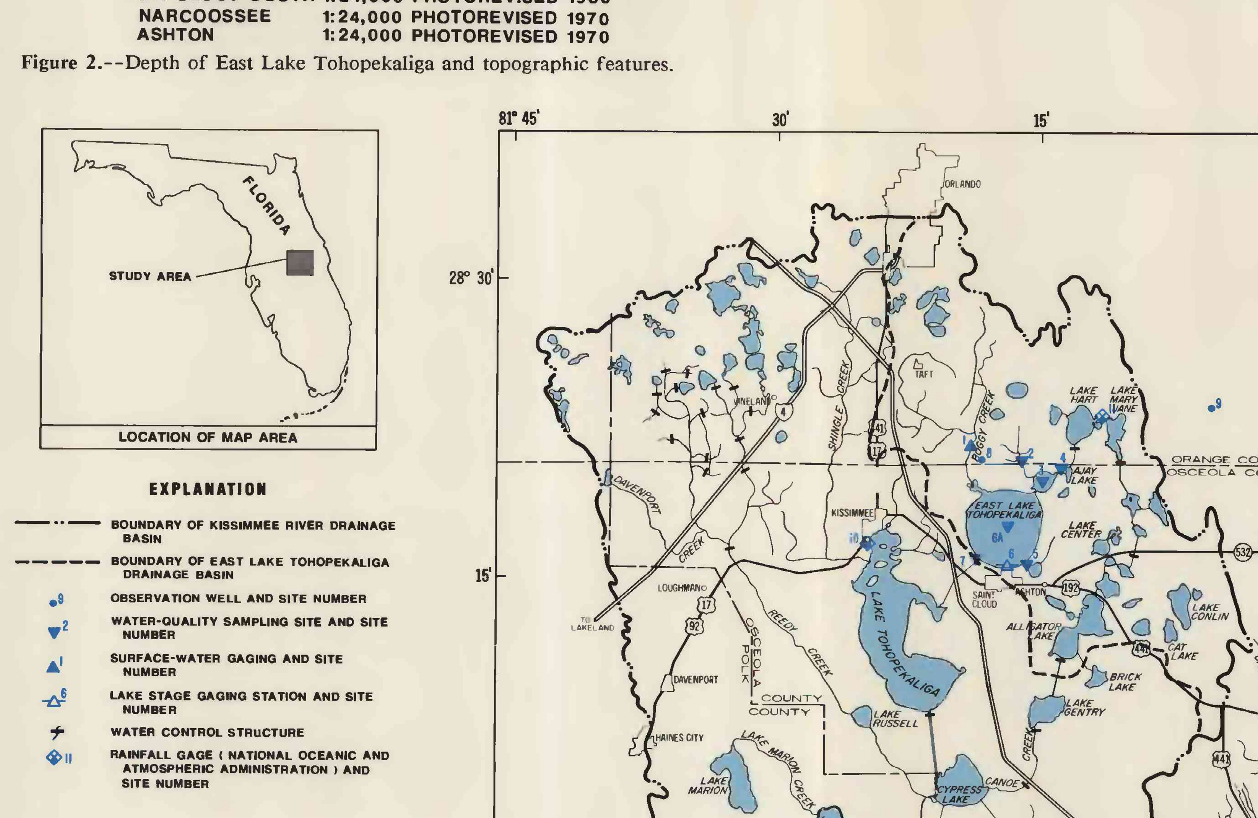

Figure 1.--Study area, location of data sites, and drainage area.

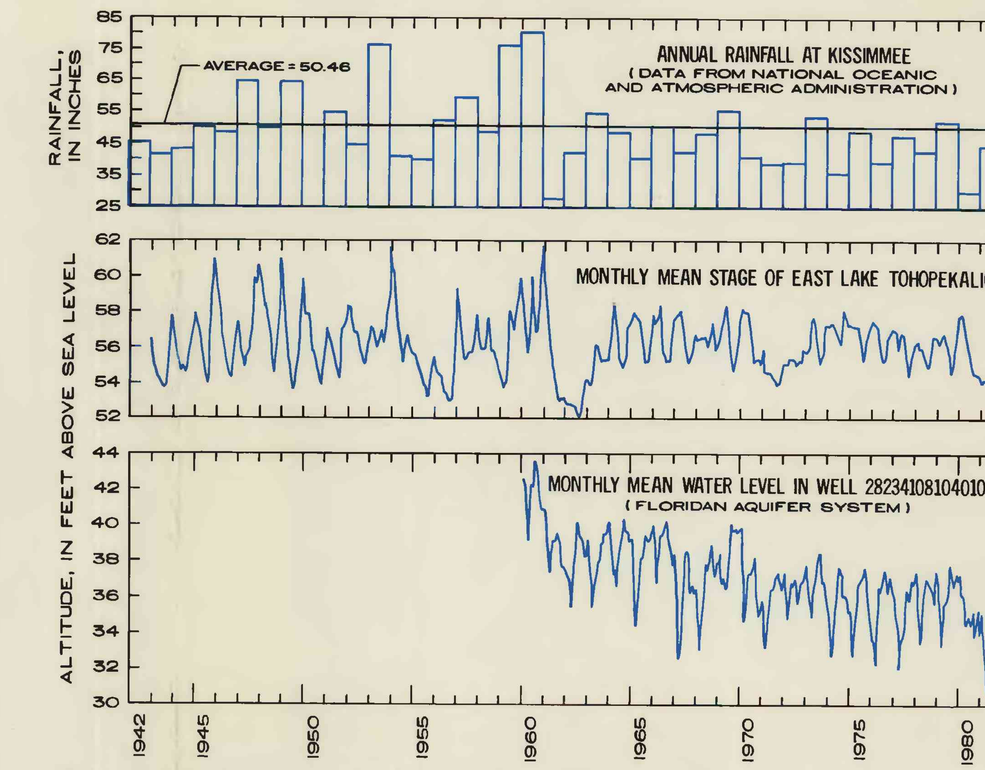

Figure 4.--Hydrographs of rainfall at Kissimmee, stage of East Lake Tohopekaliga, and monthly mean water level in a well tapping the Floridan aquifer system.

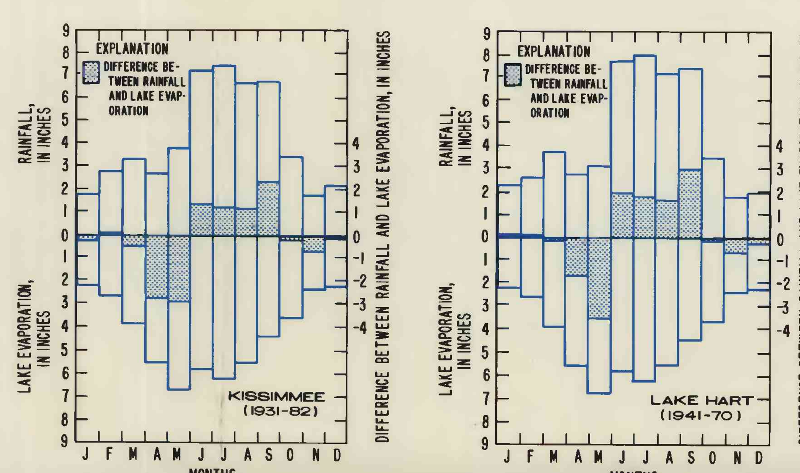

Figure 3.--Average monthly rainfall, lake evaporation, and net difference for the Kissimmee and Lake Hart National Oceanic and Atmospheric Administration stations.

Table 1.--Data-site information

Map No.	Site identification	Site name	Latitude	Longitude	Station type	Data type
1	02262900	Boggy Creek near Taft	28°22'16"	81°18'39"	Surface water	Quality & discharge
2	02262504	Jim Branch near Narcoosee	28°20'41"	81°16'00"	do.	Quality
3	282004081145500	East Lake Tohopekaliga Fells Cove	28°20'04"	81°14'55"	do.	Do.
4	02262500	Ajay-East Tohopekaliga Canal near Narcoosee	28°20'23"	81°13'42"	do.	Do.
5	281545081154500	Lake Runnymede inflow to East Lake Tohopekaliga	28°15'45"	81°15'45"	do.	Do.
6	02263400	East Lake Tohopekaliga	28°15'30"	81°16'57"	do.	Stage
6A		East Lake Tohopekaliga, center	--	--	do.	Quality
7	02263500	St. Cloud Canal at S-59	28°15'56"	81°18'38"	do.	Do.
8	282051081183401	ORF-15	28°20'51"	81°18'34"	Ground water	Do.
9	282341081040101	Cocoa A	28°23'41"	81°04'01"	do.	Do.
10	NOAA 4625	Kissimmee	28°17'00"	81°25'00"	Rainfall	Quantity
11	NOAA 3840	Lake Hart	28°23'00"	81°11'00"	do.	Do.

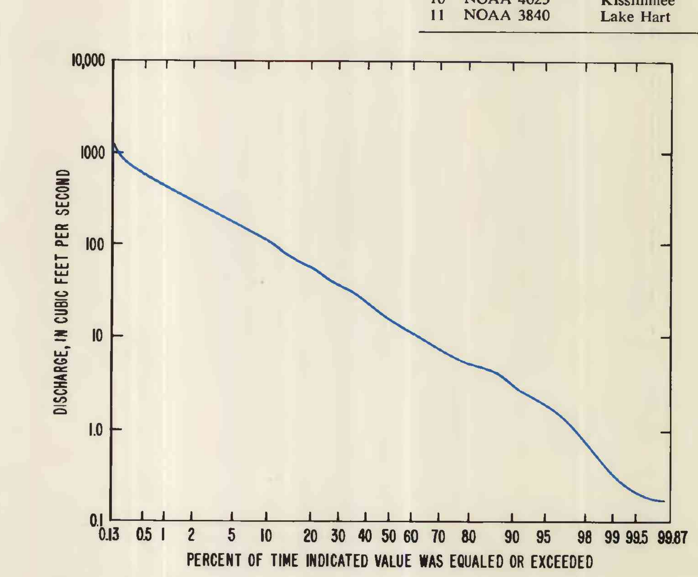

Figure 5.--Flow-duration curve, Boggy Creek near Taft.

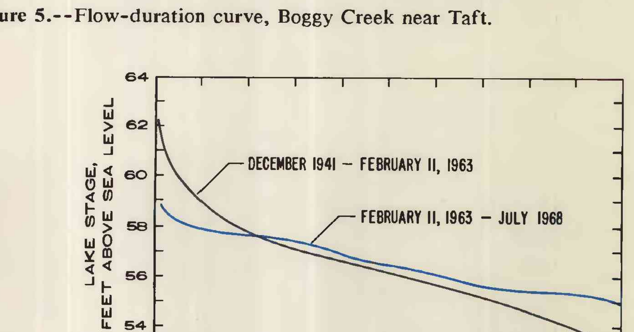

Figure 6.--Stage-duration curves for East Lake Tohopekaliga before and after regulation.

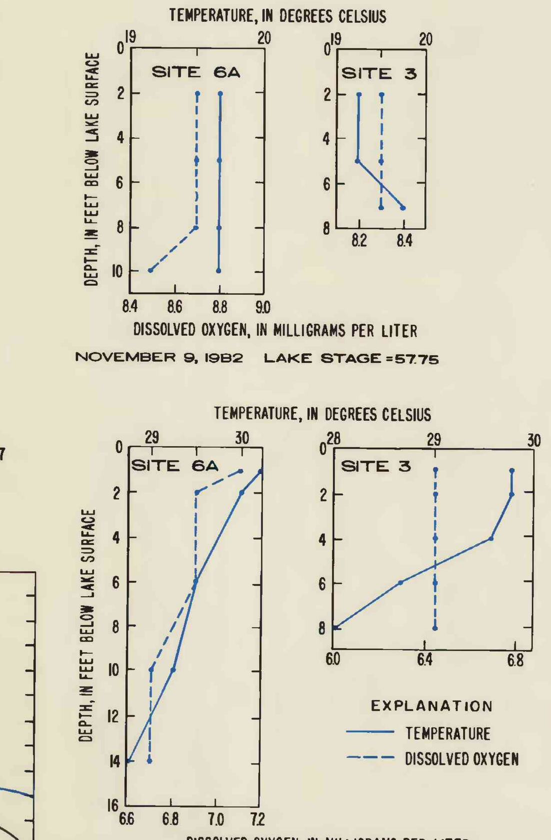

Figure 8.--Depth profiles of dissolved oxygen and temperature for East Lake Tohopekaliga.

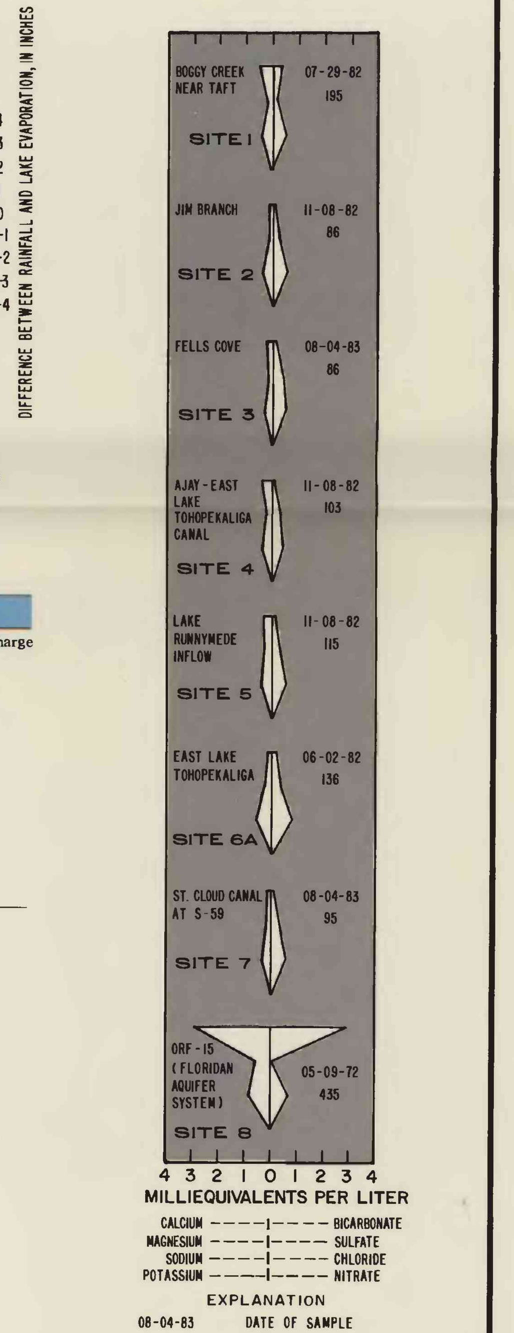

Figure 9.--Major dissolved constituents in water from selected sites.

Table 3.--Minor element concentrations and Florida Department of Environmental Regulation limits for Class III waters.

[Values are for samples collected August 4, 1983, at site 6A, center of lake. Symbol, < , indicates value less than level of laboratory detection. Concentrations are in micrograms per liter]

Minor elements	Concentration	Limit
Cadmium, total	<1	0.8
Copper, dissolved	3	30
Iron, total	360	1,000
Lead, total	9	30
Manganese, total	10	[1]100
Nickel, total	2	100
Zinc, dissolved	<10	30
Aluminum, total	120	1,500
Mercury, total	<0.1	0.2

[1]Limit is for Class II waters.

Table 2.--Summary of selected water-quality properties and constituents for East Lake Tohopekaliga, Fells Cove, Boggy Creek, and St. Cloud Canal

[Concentrations in milligrams per liter, except as noted]

	Specific conductance (µS/cm at 25°C)	pH (units)	Alkalinity	Turbidity (formazin turbidity units)	Color (platinum cobalt units)	Secchi-disk transparency (inches below water surface)	Dissolved oxygen	Hardness, total	Chloride, dissolved	Sodium, dissolved	Calcium, dissolved	Magnesium, dissolved	Potassium, dissolved	Sulfate, dissolved	Nitrogen, total as N	Nitrogen, total organic as N	Ammonia, total as N	Nitrate, total as N	Nitrite, total as N	Carbon, total organic	Phosphorus, ortho, total as P	Phosphorus, total as P
East Lake Tohopekaliga, Center[1] (Site 6A)																						
Mean	107	6.3	6.0	3.0	52.9	60	8.3	20.4	15.6	9.4	4.5	2.2	1.5	11.1	0.68	0.66	0.02	0.01	0.01	11.5	0.013	0.029
Maximum	165	7.8	8.0	12.0	240	108	10.4	36.0	26.0	14.0	10.0	4.8	2.4	29.0	1.46	1.30	.08	.11	.02	26.0	.03	.050
Year observed	1962	1977	1957	1980	1976	1983	1977	1962	1982	1982	1962	1977	1977	1962	1976	1976	1978	1976	1976	1976	1976	1976
Minimum	49	5.3	1.0	.5	10	31	6.1	12	8.0	4.3	2.4	1.0	0.5	1.8	.34	.32	0	0	0	5.8	.01	.010
Year observed	1960	1976	1963	1982	1977	1980	1976	1954	1960	1960	1956	1957	1959	1955	1981	1981	1980	1976	1980	1981	1976	1982
Number of observations	74	47	28	16	31	19	63	29	30	20	29	29	20	30	19	22	22	21	22	19	22	19
Period of record	54-82	54-82	54-81	78-83	54-82	76-83	67-83	54-83	54-83	58-83	54-83	54-83	58-83	54-83	76-82	76-83	76-83	76-83	76-83	76-82	76-83	76-82
East Lake Tohopekaliga, Fells Cove[1] (Site 3)																						
Mean	99	6.1	--	2.2	240	27	7.6	--	16.0	8.2	5.2	2.2	1.1	16.0	--	0.92	0.02	0.03	0.007	8.0	0.013	0.016
Maximum	118	6.8	--	2.4	--	31	8.4	--	--	--	--	--	--	--	--	1.1	.02	.05	.01	--	.02	.02
Year observed	1972	1972	--	1983	--	1982	1983	--	--	--	--	--	--	--	--	1983	1982	1983	1982	--	1983	1983
Minimum	86	5.5	--	2.1	--	22	6.6	--	--	--	--	--	--	--	--	.71	.01	0	0	--	.01	.01
Year observed	1983	1982	--	1982	--	1983	1972	--	--	--	--	--	--	--	--	1972	1983	1972	1972	--	1972	1982
Number of observations	3	3	--	2	1	3	7	--	1	1	1	1	1	1	--	3	3	3	3	1	22	19
Period of record	72-83	72-83	--	78-83	82	72-83	72-83	--	83	83	83	83	83	83	--	72-83	72-83	72-83	72-83	72	72-83	72-83
Boggy Creek near Taft[1] (Site 1)																						
Mean	112	6.6	16.4	2.15	104	30	6.9	24.1	15.4	10.0	6.5	1.9	1.6	5.8	0.68	0.67	0.02	0.02	0.008	20.2	0.17	0.22
Maximum	242	8.0	35.0	7	210	36	11.4	35	23	16.0	12.0	4.3	3.0	14.0	1.9	1.9	.05	.09	.02	31.0	.43	.46
Year observed	1977	1960	1968	1979	1962	1981	1981	1976	1981	1968	1976	1963	1967	1978	1981	1981	1980	1979	1979	1979	1981	1981
Minimum	40	5.7	7.0	0	40	24	3.7	13	.1	5.5	3.6	.7	.23	1.2	.24	.24	.01	0	0	13.0	.05	.06
Year observed	1978	1977	1963	1980	1962	1981	1982	1960	1959	1959	1960	1959	1976	1959	1980	1980	--	1980	--	1981	1982	1982
Number of observations	97	84	38	17	33	2	57	39	38	38	37	37	38	39	22	27	24	24	24	17	24	33
Period of record	59-83	59-83	59-81	78-83	59-81	81-81	67-83	59-82	59-82	59-82	59-82	59-82	59-82	59-83	[2]-82	[2]-83	[2]-83	[2]-83	[2]-83	[2]-82	[2]-83	[2]-82
St. Cloud Canal at S-59[1] (Site 7)																						
Mean	97	6.3	7.0	1.0	57.5	--	8.0	27.2	16.6	8.9	3.6	2.2	1.3	9.4	--	0.59	0.01	--	0.01	--	0.01	0.02
Maximum	237	6.6	10.0	--	90	--	8.8	64	18.0	9.5	3.9	2.6	1.7	12.0	--	--	--	--	--	--	--	--
Year observed	1962	1962	1962	--	1966	--	1967	1962	1968	1968	1966	1983	1983	1983	--	--	--	--	--	--	--	--
Minimum	75	6.1	3.0	--	40	--	7.2	17	15.0	8.6	3.0	1.9	1.1	8.0	--	--	--	--	--	--	--	--
Year observed	1967	1966	1968	--	1962	--	1983	1967	1966	1966	1983	1967	1966	1967	--	--	--	--	--	--	--	--
Number of observations	17	4	4	1	4	--	3	5	5	4	4	4	4	4	--	1	1	--	1	--	1	1
Period of record	62-68	62-68	62-68	1983	62-68	--	67-83	62-83	66-83	66-83	66-83	66-83	66-83	66-83	--	1983	1983	--	1983	--	1983	1983

[1]Sampling location.
[2]Year of first sample not available.

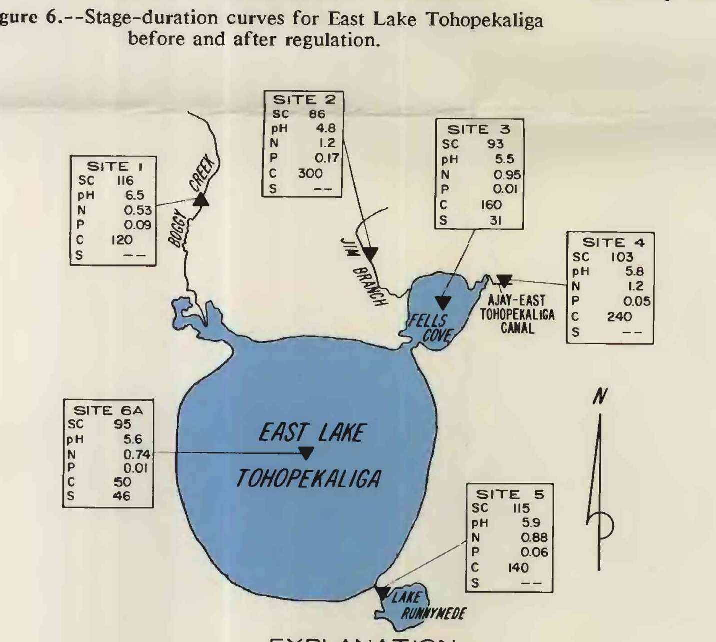

Figure 7.--Selected chemical constituents and physical properties in East Lake Tohopekaliga and major inflow locations.

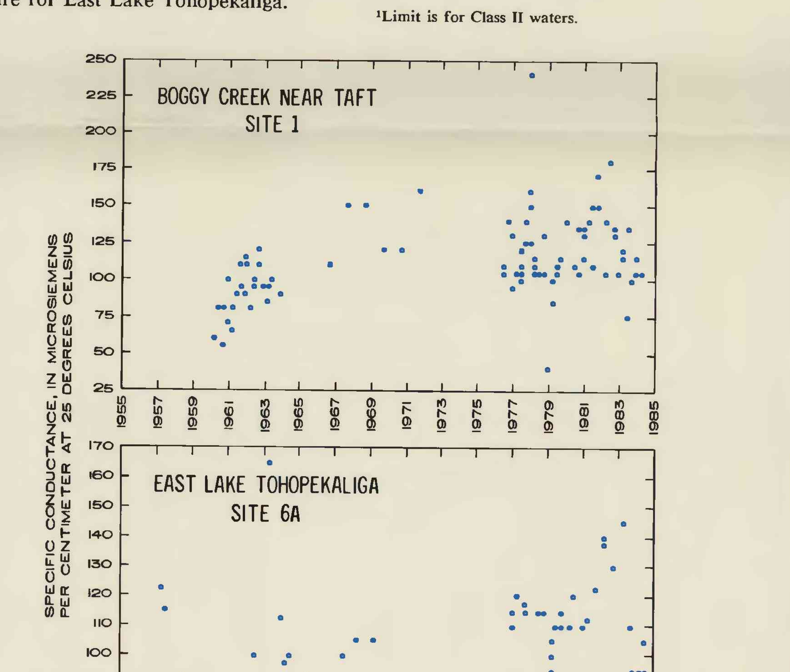

Figure 10.--Temporal variation of specific conductance for Boggy Creek near Taft and East Lake Tohopekaliga sites.

HYDROLOGY AND WATER QUALITY OF EAST LAKE TOHOPEKALIGA, OSCEOLA COUNTY, FLORIDA

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1987

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