

LIMNOLOGICAL CHARACTERISTICS OF CYPRESS LAKE, UPPER KISSIMEE RIVER BASIN, FLORIDA

By
Neville Gaggiani and Benjamin F. McPherson

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U.S. GEOLOGICAL SURVEY
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SOUTH FLORIDA
WATER MANAGEMENT DISTRICT

INTRODUCTION

Increased urbanization, channelization, and a reduction in the extent of marsh lands in the upper Kissimmee River basin have resulted in a growing public concern over the quality of water in the lakes of the basin. Nutrients and toxic materials have been added to some of the lakes from nearby urban areas. Excessive nutrient input into lake often accelerates enrichment, leading to an eutrophic condition in which water quality is impaired by low dissolved oxygen, algal blooms, and an accumulation of organic debris. Toxic materials may further degrade the water by eliminating desirable aquatic life or by increasing pollutant concentrations, by contaminating water and fish intended for human consumption. Management of a lake and its surroundings can reduce the input of harmful compounds, protect surrounding wetlands, and thus minimize the undesirable effects of urbanization. Limnology—a study of the physical, chemical, meteorological, and biological characteristics of the lake—provides information useful for effective lake management.

To evaluate these characteristics of the lakes of the Kissimmee River basin, the U.S. Geological Survey, in cooperation with the South Florida Water Management District, is making a reconnaissance of as many of the lakes in the basin as is feasible each year. The reconnaissance is made at the end of the summer, usually a time of maximum lake productivity. In addition to the reconnaissance, existing limnological data are summarized and analyzed, with particular emphasis on factors relating to the trophic condition of the lakes.

Cypress Lake was chosen as the first lake for reconnaissance because (1) it is a major lake directly connected with other large lakes in the upper basin, (2) it has been studied less than most other lakes in the basin, and (3) it is immediately down-drainage from the other lakes and is affected by runoff from areas given over to urban development.

PURPOSE AND SCOPE

The purpose of this map report is to summarize limnological data on Cypress Lake and to evaluate the lake's trophic condition. It is designed to be a guide for public officials and private interests with the lake's physical and chemical characteristics.

Considerable background hydrologic and water-quality data on Cypress Lake were available. In addition, water-quality measurements specifically related to the trophic status of the lake were made in September 1975 and should reflect conditions during a biologically productive period.

GEOGRAPHIC SETTING

The Kissimmee River drains about 2,300 mi² of central Florida, from Orlando to Lake Okechobee (fig. 1). The lower part of the Kissimmee River basin, from Lake Kissimmee to Lake Okechobee, is a wide, marshy flood plain. The Kissimmee River, the through-flowing stream of the lower part of the basin, was channelized in the 1860's. The meandering channel was straightened and deepened to about 30 ft, and six control structures were built to regulate flow to Lake Okechobee. River basins are several hundred years old, but the Kissimmee River basin is the youngest and heaviest rainfall. These lakes range from a few acres to 54 mi², and occupy more than 10 percent of the basin area (Lamonds, 1976). Today, the larger lakes in the upper basin are connected by canals.

The Kissimmee River basin, north of Lake Kissimmee outlet, is about 1,600 mi². Cypress Lake is one of the four large, connected lakes in the upper basin. It has an area of 6.4 mi². The surrounding area is predominantly wetland, rangeland, and pastureland (figs. 2 and 3).

GEOLOGIC SETTING AND GROUND-WATER CONDITIONS

Surface soils in the upper Kissimmee River basin are mainly clay, well-drained, and are composed of sand and organic muck and peat in the lower marshes and swamps. The sand and muck have been leached of most of the easily dissolved minerals, and surface runoff is low in these dissolved constituents. Because the concentrations of organic compounds in runoff from the muck soils are high, the water is colored.

A shallow aquifer, consisting mainly of Pleistocene marine and estuarine sedimentary deposits, lies at or near the land surface of the upper basin. The Floridan aquifer underlies the shallow aquifer at depths of about 20 to 300 ft. It is a limestone formation containing moderately hard to hard (61 to 180 mg/L hardness as CaCO₃) calcium-carbonate water. Dissolved minerals are between 100 and 300 mg/L (Lamonds, 1975, p. 14).

Water of the Floridan aquifer, under artesian pressure, has a potential for seeping upward into the shallow aquifer and into the lakes and streams of the basin. Water from the Floridan aquifer, either pumped or allowed to flow from wells, is used extensively in the basin for municipal and private water supplies, irrigation, and other agricultural uses. Much of this water eventually enters the canals, lakes, and streams of the basin. Lakes and streams that receive substantial amounts of water from the Floridan aquifer have comparatively high concentrations of dissolved solids that will exceed 250 mg/L during low-flow periods (Lamonds, 1975, p. 14).

MAN'S ACTIVITIES IN THE BASIN

In the late 1800's, drainage canals were dug in the upper basin to connect some of the lakes. In 1909 a channel 3 ft deep and 30 ft wide was completed between the city of Kissimmee and Lake Tohopekaliga and a point about 18 mi north of Lake Okechobee (Lamonds, 1975, p. 8). The greatest alteration of water flow in the basin occurred between April 1962 and July 1971 when canals connecting the major lakes were rechanneled and control structures were built. This alteration was intended to limit rises in lake levels to 2 ft during floods (Lamonds, 1975, p. 9).

Before the drainage activities of the 1960's, much of the upper Kissimmee basin was flooded periodically during the rainy season. After the drainage canals and control structures were built, flooding was greatly reduced. Regulation of water level in the upper basin was begun in 1964 when control structure S-65 at the outlet of Lake Kissimmee became operational.

The increased flood protection in the Kissimmee River basin has encouraged land development and population growth. Between 1960 and 1970, the number of people in the six counties partly drained by the Kissimmee increased by nearly 153,000, a 36 percent increase. Also, the number of cattle in these counties increased by nearly 174,000, or 51 percent, between 1960 and 1969 (Lamonds, 1975, p. 14).

The northern part of the upper Kissimmee River basin, which includes part of Orlando, is the most heavily populated part of the basin (fig. 2). About 35 percent of the total metropolitan area contributes runoff to the basin (Division of State Planning, 1975).

HYDROLOGIC SETTING

Rainfall in the basin averages about 52 in. of which 55 percent falls between June and October. Annual rainfall varies from less than 32 in. to over 100 in. Figure 4 shows the rainfall at Kissimmee for 1942-75.

Cypress Lake receives water from direct rainfall, ground-water seepage, surface-water runoff from adjacent land, and from three tributaries (fig. 6). Ready Creek, South Port Canal (C-35) and Canal Creek (C-34). The South Port Canal, which drains southward from Lake Tohopekaliga, had an average annual flow southward at S-61 toward Cypress Lake of 272,000 cu ft between 1960 and 1975. Average annual flow at S-63 from Lake Gentry toward Cypress Lake during 1967-75, was 36,000 acre-ft. Figure 5 shows the monthly discharge at S-61 and S-63. Water leaves Cypress Lake as surface-water outflow through the Hatchineha Canal (C-36), as ground-water seepage, and by evapotranspiration. Before Cypress Lake was regulated by locks and dams at the outlets of Lake Kissimmee (S-65) and Lake Tohopekaliga (S-61) its level fluctuated widely, from more than 57 ft (mean sea level) to nearly 48 ft (fig. 6). The lake level, now controlled, barely exceeds 54 ft during rainy periods.

Shannon and Breonik (1972) analyzed 55 lakes from north-central Florida. They divided these lakes into four basic categories: (1) clear alkaline, (2) clear soft water, (3) colored acid, and (4) colored alkaline lakes. The clear lakes and the colored lakes were then divided separately into trophic groups. The clear lakes formed three apparently natural groups interpreted as the classical trophic categories: oligotrophic, mesotrophic, and eutrophic. The colored lakes were more variable and less easily interpretable in terms of classical groupings. Shannon and Breonik divided colored lakes into five trophic groups as (1) oligotrophic, (2) mesotrophic, (3) oligomesotrophic, (4) dystrophic, and (5) residual.

Cypress Lake would be a colored, alkaline lake (table 4). The average color in Cypress Lake (79 on the platinum-cobalt scale) was lower than that of Shannon and Breonik's colored lakes, which averaged 114 platinum-cobalt units. However, Cypress Lake does not correspond to any of the five trophic groups given by Shannon and Breonik (table 6). Two indices, chlorophyll-a and orthophosphate, indicate an oligotrophic or oligomesotrophic state. Four other indices, total organic nitrogen, inverse secchi disk, cation ratio, and specific conductance indicate a mesotrophic, dystrophic (mesent), or residual trophic state. Although the classical trophic state of Cypress Lake cannot be specified, increases in trophic indicators such as specific conductance and dissolved solids between the 1950's and the 1970's indicate an appreciable increase in enrichment during this period.

In the Kissimmee River basin pesticides are used on citrus groves, crops, pasture, around homes, for mosquito control, and for control of aquatic weeds. Many pesticides are persistent and remain in the environment after being applied.

Two samples of bottom sediment were collected in Cypress Lake for pesticide analysis. Because pesticides are generally insoluble in water, bottom sediment samples usually provide a better indication of pesticide contamination than samples of the overlying water. The bottom sediment samples were analyzed for chlorinated hydrocarbons, a group of highly persistent insecticides, two industrial organic pollutants (PCBs, PCNs) and for selected nutrients. The only pesticides detected in the two bottom sediment samples from Cypress Lake were DDD and DDE; these were in low concentrations. No industrial pollutants (PCBs and PCNs) were found (table 6).

Many trace elements occur in the waters and bottom sediments in the aquatic environment. Some are essential for life processes; others are nonessential of which some are highly toxic.

Two bottom sediment samples and two water samples were collected in Cypress Lake for trace element determinations. Analyses were made for 26 elements (table 7). Most elements were in low concentrations, or were not detected. In water, only iron and aluminum exceeded 100 µg/L. In sediment, iron concentrations exceeded 1,000 µg/L. The higher concentrations are within natural ranges expected in Florida waters and bottom sediments. For example, the average concentrations of aluminum and iron in unfiltered samples from the Kissimmee River basin was 300 µg/L and 660 µg/L, respectively (Gosaly and others, 1976).

WATER QUALITY

The quality of water in a lake is affected by many factors including its geological surroundings, climate, size, depth, drainage basin size and runoff characteristics, and land use in that basin (Eaton, 1959). Under natural conditions the rate of eutrophication is usually slow.

By increasing the nutrient load to water bodies, and by disturbing the existing aquatic environment, man may increase the rate of enrichment and hasten deterioration of water quality.

Numerous morphological factors determine a lake's potential to become eutrophic. Borison and others (1974) listed seven morphological factors, in addition to 4 cultural and 13 water-quality factors, in developing a relative classification to assess the eutrophic potential and condition of lakes in the state of Washington. The seven morphological factors they used are: (1) mean depth, (2) volume of water, (3) bottom slope, (4) shoreline configuration, (5) ratio of drainage area to volume, (6) altitude, and (7) water renewal time. Except for altitude, these factors are useful in studying Florida lakes.

Table 1 lists several morphological and hydrologic characteristics of Cypress Lake. The meaning or derivation of most of these factors is obvious; definitions for the few which may not be readily apparent are given in the text.

Bottom slope.—Slope of the lake bottom defined as the ratio of the maximum depth to the mean lake diameter expressed as a percentage.

$\text{Slope} = \frac{\text{maximum depth} \times \sqrt{\pi}}{\text{lake diameter}}$

where A = area of the lake.

Mean depth.—Lake volume divided by the surface area.

Shoreline configuration ratio.—A measure of shoreline irregularity and defined as the ratio of the length of shoreline to the circumference of a circle having an area equal to that of the lake surface.

$\text{Ratio} = \frac{\text{length of shoreline}}{\sqrt{4\pi A}}$

where A = area of the lake.

Water renewal time.—Theoretical time required to completely replace the volume of water in the lake with an equal volume of inflowing water.

$\text{Renewal time} = \frac{\text{lake volume}}{\text{annual basin runoff}}$

On the basis of these morphological factors (Borison and others, 1974), Cypress Lake has a relatively high potential to become eutrophic. The ratio of drainage area to lake volume in large (table 1), indicating that the lake has a large potential source of nutrients, but has only a relatively small volume of water for dilution. Also, the shallowness of the lake allows nutrient-rich bottom sediment to readily mix with water at the surface, to provide nutrients for aquatic vegetation production. The shoreline, gentle bottom slope, and shoreline configuration are also conducive to the prolific growth of aquatic plants. Such excessive plant production in a lake that is used for recreation as water supply is a nuisance and reduces the value of the lake for these purposes. In general, the smaller the lake and the larger the basin, as noted above, the more the lake is subject to water-quality deterioration and eutrophication problems. For Cypress Lake, however, even though the drainage area is large and the lake volume small, the drainage area provides a large quantity of runoff having low concentrations of nutrients and the water in the lake is renewed frequently, a factor that must, of course, slow the trend toward eutrophication caused by the fairly large nutrient load.

Cypress Lake is not subject to prolonged water stratification (Millosev, 1975). Vertical profiles of dissolved oxygen and temperature over 24 hours on September 9-10, 1975 at the sites shown on figure 3 indicated only small changes with depth or over time. Concentrations of dissolved oxygen ranged from 5.6 and 6.8 mg/L, with 6.8 at the surface and between 4.3 and 5.7 mg/L at depths greater than 8 ft, near the bottom. Changes in temperature during the period were less than 0.7°. The small changes in dissolved oxygen and temperature with depth and over the 24-hour cycle indicate possible rapid mixing by wind. On some of the profiles no difference in dissolved oxygen or temperature were detected with depth.

The lakes of the upper Kissimmee River basin have been increasingly affected by urbanization during the 1960's and 70's. Municipal sewage treatment plants of Orlando discharge annually 1.5 million pounds of nitrogen and 1.1 million pounds of phosphorus directly to the surface water of the upper basin. Additionally, about 35 percent of the Orlando metropolitan area contributes urban runoff to the surface waters of the basin. (Division of State Planning, 1975, p. 12). The urban runoff contains high concentrations of coliform bacteria, suspended solids, nutrients, heavy metals, and polychlorinated biphenyls (PCBs) and a high BOD (biochemical oxygen demand). Much of the urban pollution enters Lake Tohopekaliga through Shingle Creek and through Buggy Creek by way of East Lake Tohopekaliga (fig. 5).

The increased loads of pollutants from urban development have adversely altered water quality in Lake Tohopekaliga, which is 5 mi upstream from Cypress Lake and drains into Cypress Lake through the South Port Canal (C-35). Because of the deterioration in quality Lake Tohopekaliga was drawn down artificially in 1971. Although some physical and biological properties of the water indicated an improved condition in the lake after the drawdown, most chemical indicators did not. The continued deterioration of chemical water quality after the drawdown was due to the increased discharge of sewage. Sewage discharge to Lake Tohopekaliga increased 52 percent from 1971 to 1974 (Florida Game and Fresh Water Fish Commission, 1974). A chemical gradient from north to south is evident in Lake Tohopekaliga. Concentrations of nutrients generally are highest at the north end of the lake where major sewage effluent sources enter. Millosev (1975) reported that in 1973-74 concentrations of orthophosphate and total phosphate were usually ten or more times greater at the north end of the lake than at the south end. Also, he reported that nitrate, nitrite, some major cations, chloride, and silica were higher at the north end than at the south end. The Florida Game and Fresh Water Fish Commission (1974) found a similar chemical gradient in 1972-73, but reported that in 1974 concentrations of major cations and organic nitrogen had increased at the south end of Lake Tohopekaliga to values exceeding those at the north end.

Although Cypress Lake is remote from urban development and intensive agriculture, concern about its enrichment is well founded because of its direct connection with Lake Tohopekaliga. In general, in the upper basin chain of lakes (fig. 5), the concentrations of nutrients and dissolved solids decreased downstream from Lake Tohopekaliga to Lake Kissimmee (Lamonds, 1975).

Tables 2 and 3 give concentrations of nitrogen and phosphorus compounds as well as some other constituents and characteristics of the water in Cypress Lake. Concentrations of nitrogen and phosphorus are relatively low and are within limits expected for Florida lakes that are not greatly enriched. Concentrations of total nitrogen and phosphorus averaged 1.8 and 0.07 mg/L in Cypress Lake. For comparison, the average for the entire South Florida Water Management District area (1972 to 1975) are 1.82 mg/L for total nitrogen and 0.15 mg/L for total phosphorus (Gosaly and others 1976).

When compared with water-quality criteria for 12 trace elements, only iron in water exceeded the maximum recommended concentrations for public water supplies and aquatic life. The other trace elements were either less than the recommended concentration limit or there was no limit given (National Academy of Sciences, National Academy of Engineering, 1970).

AQUATIC VEGETATION

Emergent marsh vegetation covers almost all the shoreline of Cypress Lake. It extends shoreward about 300 ft or more and merges with wet prairie, pasture, or cypress forest, or in places such as near Buggy Creek, continues as marsh much farther from the lake.

The aquatic vegetation around Cypress Lake occurs as several distinct bands. The outer band of vegetation, that extends farthest into the lake, is a sparse stand of the grass (*Paspalum gramineum*) with scattered cattail (*Typha sp.*), panic grass (*Panicum* sp.) and bulrush (*Scirpus* sp.). The inner band is usually made up of a second, more discontinuous, band of aquatic vegetation, located landward of the first band and separated from it by an open-water area with few vascular plants. This band is characterized by dense to moderately-dense stand of emergent and floating marsh vegetation. Dominant plants are cattail, bulrush, panic grass, pickerelweed, (*Potamogeton*), smartweed, (*Polygonum punctatum*), and water hyacinth (*Eichhornia crassipes*). This band is extensive and well developed along the northwest and western edges of the lake. In places, the band is not distinct, and marsh vegetation merges into wet prairie or pasture. The wet prairie or pastures extend farther shoreward and comprise much of the land that drains directly to the lake. A discontinuous band of Cypress (*Taxodium* sp.) trees encircles the south and east edges of the lake shoreward of the wet prairie. Under regulated lake conditions the cypress is flooded about half the time. Before regulation it was flooded about 75 percent of the time.

Submerged vascular plants are scarce in the lake, and cover less than 5 percent of the lake bottom. The high color of the lake water may restrict submerged vascular plant germination and growth.

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Figure 2—Land use and land cover in upper Kissimmee River basin.

Figure 3—Cypress Lake bottom contours, sampling sites, and dominant aquatic vegetation.

Figure 4—Rainfall at Kissimmee, Florida, 1942-75.

Figure 5—Stage-duration curves for Cypress Lake before and after lake level regulations.

Figure 6—Specific conductance and dissolved solids in Cypress Lake, 1964-75.

Figure 7—Morphological and hydrologic characteristics of Cypress Lake at a stage of 52 feet above mean sea level.

Figure 8—Concentrations of trace elements in bottom sediments and water at two sites on Cypress Lake, September 1975.

Figure 9—Concentrations of pesticides, organic chemicals, and nutrients in bottom sediments and water at two sites on Cypress Lake, September 1975.

Figure 10—Direction of surface-water flow in the upper Kissimmee River basin and average monthly discharge at three sites.

Figure 11—Selected chemical characteristics of Cypress Lake and four general lake types from north-central Florida.

Figure 12—Concentrations of nutrients, dissolved oxygen, and color in water in Cypress Lake between 1964 and 1975.

Figure 13—Selected chemical and physical characteristics of five sites on Cypress Lake, September 15, 1975.

Figure 14—Trophic state indicators for Cypress Lake, Lake Tohopekaliga, and four colored, alkaline lakes in north-central Florida (Shannon and Breonik, 1972).

Figure 15—Trophic state indicators for Cypress Lake, Lake Tohopekaliga, and four colored, alkaline lakes in north-central Florida (Shannon and Breonik, 1972).

Figure 16—Trophic state indicators for Cypress Lake, Lake Tohopekaliga, and four colored, alkaline lakes in north-central Florida (Shannon and Breonik, 1972).

Figure 17—Trophic state indicators for Cypress Lake, Lake Tohopekaliga, and four colored, alkaline lakes in north-central Florida (Shannon and Breonik, 1972).

Figure 18—Trophic state indicators for Cypress Lake, Lake Tohopekaliga, and four colored, alkaline lakes in north-central Florida (Shannon and Breonik, 1972).

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Figure 20—Trophic state indicators for Cypress Lake, Lake Tohopekaliga, and four colored, alkaline lakes in north-central Florida (Shannon and Breonik, 1972).

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Figure 32—Trophic state indicators for Cypress Lake, Lake Tohopekaliga, and four colored, alkaline lakes in north-central Florida (Shannon and Breonik, 1972).

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Figure 34—Trophic state indicators for Cypress Lake, Lake Tohopekaliga, and four colored, alkaline lakes in north-central Florida (Shannon and Breonik, 1972).

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Figure 79—Trophic state indicators for Cypress Lake, Lake Tohopekaliga, and four colored, alkaline lakes in north-central Florida (Shannon and Breonik, 1972).

Figure 80—Trophic state indicators for Cypress Lake, Lake Tohopekaliga, and four colored, alkaline lakes in north-central Florida (Shannon and Breonik, 1972).

Figure 81—Trophic state indicators for Cypress Lake, Lake Tohopekaliga, and four colored, alkaline lakes in north-central Florida (Shannon and Breonik, 1972).

Figure 82—Trophic state indicators for Cypress Lake, Lake Tohopekaliga, and four colored, alkaline lakes in north-central Florida (Shannon and Breonik, 1972).

Figure 83—Trophic state indicators for Cypress Lake, Lake Tohopekaliga, and four colored, alkaline lakes in north-central Florida (Shannon and Breonik, 1972).

Figure 84—Trophic state indicators for Cypress Lake, Lake Tohopekaliga, and four colored, alkaline lakes in north-central Florida (Shannon and Breonik, 1972).