Prepared in cooperation with the
SOUTHWEST FLORIDA WATER MANAGEMENT DISTRICT

INTRODUCTION

Lake Placid, in Highlands County of central Florida (fig. 1), is the third largest lake in the county. The lake is the southernmost large lake in a series of interconnected lakes that drain northward to Josephine Creek. Josephine Creek flows to Lake Istokpoga. These lakes are generally located along the northwest-southeast trending Highlands Ridge. The ridge forms a divide between the drainage basins of the Peace and Kissimmee Rivers. Lake Placid is east of the divide and is in the Kissimmee River basin. The drainage basin for the 3,281-acre lake encompasses about 38.2 mi^2 (12,500 acres).

The primary use of Lake Placid is for recreation, but it has been an important source of water for agricultural irrigation. Use of water from the lake for municipal or industrial purposes is insignificant.

The U.S. Geological Survey began collecting hydrologic information on Lake Placid in 1945 and has been collecting water-quality information since 1956. In 1979, the U.S. Geological Survey began a hydrodynamic conditions study of selected lakes in the Upper Peace and Upper Kissimmee River Basins in cooperation with the Southwest Florida Water Management District. Lake Placid is the fifth lake studied under this project. The objective of the study was to document current hydrologic conditions of Lake Placid and the surrounding area. Available data were evaluated, and additional hydrologic data were collected during the study. Available data included climatological data, water-quality analyses, altitude of the water surface of Lake Placid and nearby lakes and wells, and data on geology, biology, and water use. Lake Placid's lake bottom was mapped during the study and additional water-quality data collected. Wells were drilled into the surficial aquifer around the lake and were monitored monthly in an attempt to define the relation of the surficial aquifer to the lake level.

Previous Studies

Previous studies of the Lake Placid area began with a study of the Lake Placid drainage system by the U.S. Department of Agriculture (1938) for flood-control purposes. Their study was updated by the Central and Southern Florida Flood Control District (1955). Youngberg (1967) was among the first to study Lake Placid (Childin) and the surrounding area. The purpose of his study was to determine the best way to permanently lower the water surface of Lake Placid.

Alexander Blair, an engineer who worked for John A. Roebling II at what is now the Archbold Biological Station 5 miles south of the southern shoreline of Lake Placid and 8 miles south of the town of Lake Placid, collected lake-altitude information on Lake Placid from 1931 to 1941. In addition to lake altitudes, Blair kept detailed records of daily climatological events. A report by Robust and Meyer (1959) discussed the relation of ground water to lake level in the Lake Istokpoga and Lake Placid areas from 1955 to 1959. Bishop (1980) described the geology and ground-water resources of Highlands County. Fish and Stokes (1981) described the ecology, limnology, and biological characteristics of the lake. The Lake Placid chain of lakes was studied again for flood control by Emily Black and Associates, Inc. (1980); Geraghty and Miller, Inc. (1980), conducted a hydrologic investigation of the Highlands Ridge area to determine the cause of water-level declines in many of the ridge area lakes, including Lake Placid.

Acknowledgments

The authors would like to thank Patricia Lagori, Consolidated-Teneco Land Co., for her cooperation and help and for providing rainfall data, historical maps of the Lake Placid area, and the 1927 report by Gilbert Youngberg. We would also like to thank Dr. James Layne, Fred Lohrer, and the staff at Archbold Biological Station for providing historical water-level records for Lakes Placid and Annie, rainfall records, and other information about the area. The late Alexander Blair meticulously collected and recorded the historical water-level and rainfall data for Lakes Placid and Annie.

Description of the Area

The shoreline of Lake Placid is composed of sandy beaches and areas where vegetation grows to the water's edge. The bottom of the lake consists of a white sand. Deeper areas contain large deposits of soft, mucky, detrital material overlying the sand.

The area near Lake Placid (fig. 2) is generally agricultural with large citrus groves on the north and east sides of the lake. There are about 1,100 acres of citrus groves in the drainage basin. According to a land-use study (U.S. Geological Survey, 1979), the area south and west of the lake is mainly rangeland with some cropland and pasture. Some wetlands are interspersed throughout the area. Residential development has been limited to the northern and western lakeshore areas. Some residential developments are being constructed west of the lake and to the north between Lake Placid and Lake Josephine.

Most surface-water inflow to Lake Placid is from Lake Annie, a small lake to the south, and from two small surface drainages southwest of the lake. Occasionally, the gradient of the surficial aquifer in the vicinity of Mirror Lake north of Lake Placid will reverse in response to high recharge from precipitation, and water normally flowing from Lake Placid to Mirror Lake will flow from Mirror Lake to Lake Placid. The amount of overland runoff into Lake Placid is small, except during periods of heavy precipitation.

Surface water discharges intermittently from Lake Placid through the swamp northeast of the lake, Catfish Creek, and normally to Mirror Lake. When the stage of Lake Placid exceeds approximately 93 feet above sea level, water flows via Catfish Creek to Lake June in Winter (fig. 2). Prior to channelization of Catfish Creek in 1930, natural drainage from Lake Placid was northeastward to Lake Istokpoga. The U.S. Lake Huntley Culverts under State Highway 27 are now largely blocked by sand and vegetation growth.

The relation between Lake Placid and the surficial aquifer system is the most significant aspect of the hydrology of the lake. Robust and Meyer (1959) state this Lake Placid is simply an exposed surface expression of the local water table of the surficial aquifer. Hammett (1981) also supports this conclusion as does work completed during the study.

Geology

In the vicinity of Lake Placid, the underlying rocks range in age from Eocene to Holocene and consist of four major units. Three are, in ascending order: (a) the lower part of the Avon Park Formation, which is generally the sub-Floridan confining bed; (b) the upper part of the Avon Park Formation and Oculla and Suwannee Limestones that make up the main part of the Floridan aquifer; (c) the lower part of the Hawthorn Formation, which contains the intermediate aquifer and is the upper confining layer of the Floridan aquifer; and (d) the upper part of the Hawthorn Formation and the surficial sediments, which contain the surficial aquifer.

The surficial aquifer is composed mainly of a medium to coarse, fossil quartz sand in the undifferentiated deposits of Holocene and Pliocene and Pleistocene age and the upper part of the Hawthorn Formation of Miocene age. More specific information from a test well (RGMP28X) about three-fourths of a mile east of the north end of Lake Placid, drilled into the Avon Park Formation by the Southwest Florida Water Management District, indicates that a dolomitic limestone may act as a confining bed between the upper and lower parts of the Floridan aquifer and is first encountered in the Avon Park Formation at an altitude of −1,000 feet. The Floridan aquifer is about 600 feet thick, the intermediate aquifer and upper confining layer are about 270 feet thick, and the surficial aquifer is approximately 300 feet thick (Southwest Florida Water Management District, written commun., 1983). A generalized geologic section near Lake Placid is located in figure 1 and shown in figure 3.

Climate

The climate of the Lake Placid area is subtropical and humid and is characterized by a period of high temperatures and frequent rainfall (June through September) from localized afternoon and evening thunderstorms and a period of cool temperatures and relatively little rainfall (October through May) from frontal storms that are areal in nature. Climatic records used for the study area are from the National Oceanic and Atmospheric Administration (U.S. Department of Commerce, 1942–83) and Archbold Biological Station.

Long-term rainfall (1932–83) at the Archbold Biological Station (fig. 4) averages about 54.24 inch/yr and is representative of the upper part of the Lake Placid drainage basin. Short-term rainfall records (1940–49) from the Lake Placid 2SW station in the town of Lake Placid about 1 mile north of the lake indicated an average of 52.52 inch/yr. Concurrent records from the Archbold Biological Station indicated an average 56.99 inch/yr. This comparison indicates that the rainfall in the vicinity of the town of Lake Placid is less than at the Lake Placid 2SW station was higher than the long-term average. The short-term record at the Lake Placid 2SW station was adjusted to the 1931–83 period by linear regression with concurrent monthly data for the Archbold Biological Station. The long-term average precipitation at the town of Lake Placid, based on the regression, is approximately 50.67 inch/yr. Long-term average rainfall during the June-September period was 32.20 inch/yr at the Archbold Biological Station and 29.67 inch/yr at the town of Lake Placid. The long-term average rainfall during the October-May period was 21.94 inch/yr at the Archbold Biological Station and 21.00 inch/yr at the town of Lake Placid.

The average annual air temperature at the Archbold Biological Station (1931–83) is 72.1 °F, whereas the June-September average temperature averages 81.2 °F and the October-May temperature averages 69.5 °F.

Area History

"The area around Lake Placid was first surveyed in 1838 by John Jackson. In 1868, J.W. Childin subdivided the area and established meander lines for Lake Placid, which are survey lines that generally follow the mean high-water mark of a lake or stream. At the time of these surveys, the general vegetation patterns were noted. The land on the sand ridges around the lake was covered with saw palmetto, oak scrub, and a few small pines. The undeveloped land west of Lake Placid probably looks much like it did in the past.

"The quality of the land in this township is very poor. In the western and northeastern portion it consists of low white-sand ridges with scrub and cactus. Through the central part of the township, it is mostly flatpine woods... The outlet of Lake Childin is a creek and begull running nearly northwest through sections 13, 12, and 11 into Lake Stanzes."

J.W. Childin, 1870

(Florida Department of Natural Resources, written commun., 1980).

In 1916–17, the Atlantic Coast Line Railroad built a road and railway through the area. A railway station was built at what is now the town of Lake Placid and was called Wauo. In 1919, Wauo's name was changed to Lake Stanzes, after M.S. Stanzes, an early Florida Surveyor General. Lake June in Winter was also known as Lake Stanzes at the time. Lake Placid was known as Lake Childin since 1870, after J.W. Childin. In 1920, the land west of Lake Placid was resurveyed by A.W. Brown. He noted that the soil northeast of Lake Placid was mostly sandy loam and sandy-clay loam and was valuable citrus land. The land south of Lake June in Winter and west of Lake Placid was rolling, sandy, flat woods (Florida Department of Natural Resources, written commun., 1980).

Dr. Melvin Dewey, founder and president of the Lake Placid Club in the 1920's, visited the area and established a Club South. An article in the New York newspaper, After Selecting Lake Childin (Placid) as the site for a new resort, he convinced the municipal government of the town of Lake Stanzes (Placid) to change the name of the town, post office, and railroad station to Lake Placid. In 1927, a State legislative act (Skats of Florida, 1927) abolished the municipal government of Lake Stanzes and established a municipal named Lake Placid. Jurisdiction was given to fix or change the name of any lake or stream within the government's boundaries and to control water levels in any lake or stream within the boundaries. Shortly after this law of Florida was enacted, Lake Childin was renamed Lake Placid, and Lake Stanzes was renamed Lake June in Winter. Despite the name change made in 1927, many residents of the area still refer to Lake Placid as Lake Childin.

To improve Lake Placid's shoreline for the planned resort, plans were made to permanently lower the water level by a few to expose a white sand beach. In 1928, Gilbert Youngberg, an engineer, was commissioned to study the lowering of Lake Placid. Youngberg's report recommended that the lake be completely diked and drained. Secondary purposes of lowering the water levels were for flood and mosquito control. Youngberg's recommendations to channelize Catfish Creek were accepted, and, in 1930, channelization was complete. Catfish Creek was widened and deepened between Lake Placid and June in Winter. A wooden weir control with removable stop logs was installed to regulate water levels. That structure was destroyed by fire a few years later and was not replaced until 1965. Prior to 1965, wave action built a sand bar at the outlet of Lake Placid, which acted to control lake levels. The present outflow control from Lake Placid to Lake June in Winter is 300 feet from Lake Placid and consists of four 81- by 41-inch arch-pipe culverts. The invert altitude of the culverts is 93.0 feet.

Water from Lake Placid has been used for citrus irrigation since 1940. The lowering of Lake Placid to expose much of the lake bottom prompted water from the lake since late 1981. In addition, many lakeside residents use lake water to irrigate their lawns, and some use the water for drinking.

CHARACTERISTICS OF LAKE PLACID

Bathymetric information on Lake Placid is necessary for analysis of lake hydrology. A bathymetric map with a 10-foot contour interval was previously published by Renner (1966). A bathymetric survey for this study was completed on January 24 and 25, 1983. The stage of Lake Placid during the survey was 91.91 feet above sea level. The results of the survey are plotted on the photomosaic base map (fig. 2). Depths referenced are feet below the lake stage of 91.91 feet above sea level. The bathymetric data collected for this study indicate that little or no dredging of the lake bottom has occurred. The maximum recorded depth of 34 feet indicates that the depth of the lake is about 4 feet less than the depth outlined in the survey by Renner (1966) in March 1964. The difference in depth may be due to the accumulation of detrital materials or differences in location of bathymetric survey lines. Fathometer recordings indicate a secondary bottom at several points in the lake. Samples of bottom material collected at the deeper areas of the lake are of soft organic material.

The bathymetric mapping for this study was done by runs on a 10-second latitude interval with longitude intervals varied 15 rows over 130 seconds of longitude, using a chart-recording fathometer and a LORAN position-locating instrument. The mapping identified several distinguishable natural depressions in the lake bottom that are assumed to be "daughter" sinks that were formed after collapse of the major sinkhole from which Lake Placid was formed. These sinks can be seen as irregularities in the lake bottom along the southern shoreline and elsewhere in the lake.

Lake Placid has a mean depth of 16 feet at the mean stage of 93.76 feet above sea level in about 22.0 feet. The maximum measured depth of the lake is 34 feet near the center of the lake.

Stage-volume and stage-area curves, determined from the bathymetric data, are shown in figure 5.

Stage data have been collected at Lake Placid since 1931, except during the periods 1941–46 and 1971–79. The record from April 1946 to September 1975 and from October 1979 to the current year (1983) were collected by the U.S. Geological Survey. The frequency of collection varied from once-weekly readings to continuous recording. The data are in the U.S. Geological Survey files and are published in annual data reports. The record from June 1931 to September 1941 are once-weekly readings made by Alexander Blair.

The stage hydrograph (fig. 4) is plotted from month-end data for the last 50 years. The mean monthly, as well as the maximum and minimum monthly stages and the year of their occurrence, are shown in figure 6. The minimum monthly stage occurred in March 1962 (fig. 6) after the previous 2 years had a cumulative precipitation deficit of more than 27 inches (fig. 4). As shown, all minimum monthly stages occurred during 1981 and 1982. Six of the maximum monthly stages occurred during 1941; four occurred during 1960; and one each occurred during 1933 and 1983. The maximum monthly stage occurred in 1941 and was 2.6 feet higher than the next highest monthly stage in the long-term average at the Archbold Biological Station. The highest mean monthly stages generally occur in September or October at the end of the normal rainy season. The lowest mean monthly stages generally occur in May at the end of the normal dry season. The years of missing stage record were years of nearly average precipitation. If records had been available, they probably would not significantly affect the mean monthly, maximum monthly, or minimum monthly stage values.

Statistics from the stage record indicate the response of Lake Placid to the area hydrology and are shown in figures 7 through 9. The maximum stage recorded was 96.05 feet above sea level on September 11, 1960, whereas the minimum stage was 89.95 feet above sea level on March 26, 1962. The mean stage for the period of record is 92.76 feet above sea level, whereas the median stage is 92.90 feet above sea level. The mode is 93.00 feet above sea level.

A stage-frequency curve, based upon a Pearson type III frequency distribution analysis (U.S. Water Resources Council, 1981) of annual maximum stages for the period of record, is shown in figure 8. From this analysis, the stage that can be expected to be equaled or exceeded for a specific recurrence interval can be determined. For example, over a long period of time, it can be expected that a stage of 93.9 feet above sea level will be exceeded on the average once every 2 years. Stages of 95.0, 95.5, and 96.2 feet above sea level will be exceeded once every 5, 10, and 50 years, respectively.

Generally, there is no surface-water discharge from the Lake Placid-Mirror Lake system except during periods when the stage is higher than 93.0 feet above sea level. This has occurred about 46 percent of the time since 1932, as indicated in figure 7.

From the stage-volume curve (fig. 5), the volume of Lake Placid at the mean stage of 92.76 feet above sea level is about 73,000 acre-feet and the area is 3,281 acres.

The stage of Lake Placid reflects the composite effects of rainfall and surficial aquifer flow. Lake Placid shows immediate response to the wet-season rainfall in June due to surface-water inflow and overland flow with a small rise during this month. Inflow to the lake during the remainder of the wet season (July, August, and September) increases due to the addition of increased ground-water flow to the lake from the surficial aquifer that results from increased recharge during previous months. When the wet season ends in September, a significant decrease in inflow from surface water and overland flow result in a decrease in the amount of surface-water supplied to the lake. Although precipitation is less than the total of evaporation and water use from the lake for the period October through May, it continues to be a significant rainy season. Lake Placid's lowest stages generally occur during this period.

The level of Lake Placid shows a direct relation to the annual departure of precipitation, as shown in figure 4. The lake level usually follows the departure of the previous year. Also, from the lake stage hydrograph in figure 4, a sequence of low stages can be seen to occur periodically about every 5 to 6 years.

HYDROGEOLOGY

Recharge

The principal source of recharge to the surficial aquifer is rainfall. The only other source of recharge is from water not consumptively used that is pumped for irrigation from the Floridan aquifer. The amount of water pumped for all purposes in that part of Highlands County within the Southwest Florida Water Management District boundaries is shown in figure 10. The amount of water that is not consumptively used and, therefore, may be available for recharge is not known.

Recharge to the underlying Floridan aquifer may occur from percolation of water from the intermediate and surficial aquifers through the confining layer and through fractures or breaches of the confining layer that were caused by collapse of the confining layer into cavities in the Floridan aquifer. Most lakes in this area are the result of sinkhole collapse, as shown schematically in figure 11. The potential for recharge to the Floridan aquifer through lakes is high, but cannot be assumed to occur in all cases.

Recharge to the Floridan aquifer from the intermediate and surficial aquifers cannot be accurately quantified from available data. Further, the relation between the levels of Lake Placid and the surficial aquifer and Floridan aquifer cannot be accurately determined from existing data. Robust and Meyer (1959) state that drawdown caused by pumping from the Floridan aquifer produces a "small but recognizable effect upon the water levels of the lakes." That statement was based upon analysis of water levels in a well in the Floridan aquifer located about 35 miles north of Lake Placid and water levels of Lake Placid. Generally, it can be assumed that the surficial aquifer is recharged by the Floridan aquifer if the potentiometric surface of the Floridan aquifer is higher than the water level in the lake. Tibbals (1981) estimated a predevelopment area-recharge rate of about 5 in/yr, whereas current area-recharge rates are estimated at 7 to 9 in/yr (C.H. Tibbals, U.S. Geological Survey, written commun., 1983). Robust and Meyer (1959), in a monthly water-budget analysis, estimated that leakage to the Floridan aquifer through the bottom of Lake Placid is 2 to 3 inches per month. The estimates were computed as the residual after other elements in the budget were accounted for.

Winter (1980, 1981) gives some examples of possible errors associated with water budgets. These errors vary widely depending upon (1) the type of geologic and climatic setting, (2) the method of analysis, (3) the time period considered for the water budget, and (4) the types of instrumentation used for the collection of data. In general, since geology and climate are fixed for a particular lake, the accuracy of a water budget depends on the representativeness of hydrologic systems over the appropriate time period. This means that no component of a water budget should be computed as the residual, since this residual will inherently include errors in measurement for all other water-budget components. As a general rule, the least accurate are water budgets based upon use of a coefficient to adjust rain evaporation; streamflow discharge computed from miscellaneous measurements; time periods of less than 1 year; using rainfall from a single distant site; and computing the ground-water component as the residual. The preferred and most accurate method for a water budget includes continuous discharge measurements of streamflow, energy budget techniques for computation of evaporation and transpiration, utilization of an adequate and continuous precipitation monitoring network within the system, and determination and utilization of representative specific yields and appropriate aquifer digital model to determine the ground-water flow component.

Summarily, the errors in a water budget determined by the rest common method, as mentioned above, are of little value and can sometimes be deceptive and misleading because the magnitude of the errors involved are often greater than the component that was desired (most often ground water) and computed as the residual. These large errors prohibit computation of a realistic water budget for Lake Placid with the data that are available. Also, because of flow reversal in the surficial aquifer, as observed during the spring of 1981 at Lake Placid, it can be shown that simple water budgets are not adequate in flow-through lakes (lakes receiving ground-water inflow and discharging to ground water) as described by Anderson and Munter (1981).

Movement

The surficial aquifer allows relatively free horizontal and vertical movement of water. Unless rainfall is intense, most water percolates into the surficial materials. Therefore, overland flow rarely occurs except when the water table is near land surface, as in low-lying wetlands, or when antecedent rainfall conditions have saturated these materials. Estimated values of hydraulic conductivity and specific yield of this type of aquifer are 100 ft/d and 0.2, respectively (Lohman, 1979).

Movement of water in the surficial aquifer is indicated by contours of the water table (fig. 12), and cross sections of the water table and the lake altitude (fig. 13) indicate that the general direction of movement of water in the surficial aquifer is to the north and east. During periods of above average precipitation, however, a ground-water mound may develop to the north and east of Lake Placid and prevent flow in that direction.

Unusually heavy precipitation during January, February, and March 1983 caused a reversing of the water table north of Mirror Lake that resulted in a flow from Mirror Lake to Lake Placid for a short distance (fig. 12). At the time, the stage of Mirror Lake was 93.07 feet above sea level and the stage of Lake Placid was 93.13 feet above sea level. This reversal of flow was observed in March, April, and May 1983. Inspection of data collected from 1956 to 1983 did not indicate a reversal of flow during this period, although 1983 also had unusually heavy precipitation. In addition, Lake Placid is shown to be the exposed expression of the water table (figs. 12 and 13). Normally, there is not a significant ground-water divide to the north and east of Lake Placid because the topographic highs in these areas are well drained.

Hydrographs of water levels in selected surficial aquifer wells and Lake Placid and Mirror Lake are shown in figure 14. Three hydrographs show different responses of the local water table. Some water levels (wells 1, 11, and 324) exhibit a pattern similar to fluctuations in the level of Lake Placid. Other wells (3, 4, and 9) are generally different and have an unexplained drawdown in the water level in July 1982.

Discharge

Water discharges from the surficial aquifer by downward leakage to the Floridan aquifer by evaporation from wetland areas and other vegetation, and by horizontal flow from areas of higher levels to areas of lower levels. The increasing use of the surficial aquifer as a source of water for irrigation may have a long-term effect on the quantity of water discharged through springs at the base of the Highlands Ridge.

A major ground-water discharge point in this area occurs at a spring on Hickory Branch about 1 to 2 miles southeast of the Lake Placid drainage basin (fig. 1) at the base of the Highlands Ridge at an altitude of about 100 feet. Ground-water discharge from springs in Hickory Branch Spring Run and discharge of about 5,000 gallons (11 ft³/s), which is equivalent to a second magnitude spring (Meinzer, 1927). The probable source of the water, since the potentiometric surface of the Floridan aquifer in this area is about 50 to 60 feet above sea level, is the surficial aquifer. Although the water-table contours (fig. 12) do not indicate any ground-water flow toward Hickory Branch from within Lake Placid's drainage boundary, some ground water that could flow into the basin from the south is probably captured and discharged through Hickory Branch Spring.

Historically, the surficial aquifer and Lake Placid have been important sources of water for domestic and agricultural use. Water from the surficial aquifer is used for irrigation of citrus. It is estimated that 80 percent of all citrus irrigation in Highlands County is supplied by wells completed in the surficial aquifer (Fish and Stokes, 1981; Southwest Florida Water Management District, oral commun., 1983). More recently, however, irrigation wells have been constructed in the deeper Floridan aquifer.

The Floridan aquifer is composed mainly of beds of limestone. Water in the limestone generally moves along fractures and bedding planes and creates solution channels and sometimes large cavities that allow storage and movement of large amounts of water. Because there are upper and lower confining beds that contain the Floridan aquifer, it is largely an artesian system. Estimated values for transmissivity (Tibbals, 1981) and storage coefficient (Lohman, 1979) range from 500,000 to 200,000 ft²/d and 10^{-4}, respectively. However, a recently (1983) completed aquifer test of a well about 1 mile southeast of Lake Placid indicated an estimated transmissivity of 40,500 ft²/d, leakance of 1.0×10^{-4} (ft/d)/ft, and a storage coefficient of 2.5×10^{-4} (ft, ft). The wide range in values of transmissivity and storage coefficient may be explained by possible radial anisotropy.

Generalized areal water-level changes in the Floridan aquifer for the Highlands Ridge area are presented by Tibbals (1983). Tibbals (1983) has indicated a long-term (1964–80) decline of water levels in the Floridan aquifer of about 10 feet, as shown in figure 15. Figure 15 also shows the water-level contours for May and September 1982 (Barr and Schiner, 1983a; 1983b). These contours show that the movement of water in the Floridan aquifer near Lake Placid is generally from north to south.

Discharge from the Floridan aquifer in this area is from deep wells drilled for agricultural, municipal, and industrial purposes. Water also moves downgradient out of the Highlands Ridge area through the Floridan aquifer to the south at the toe of the Highlands Ridge. However, at the base of the Highlands Ridge, water moves either to the east or the west and southward.

WATER QUALITY AND AQUATIC BIOLOGY OF LAKE PLACID

Water samples have been collected at Lake Placid by the U.S. Geological Survey since 1956. Results of the analyses of these samples are listed in tables 1 through 6. Millemon (1978), collected water samples at Lake Placid and six other lakes from 1974 to 1976 as part of a limnological investigation of the Istokpoga drainage basin. In addition, McCiffitt (1980) described the limnology of Lake Placid, Annie, and Francis, based on analyses of monthly water samples collected between September 1976 and June 1977.

Major plant communities in the lighted shallow shore region (littoral zone) of Lake Placid were identified by Millemon (1978). Plant coverage was measured from aerial photographs taken in 1974 and from field observations. At that time, the total littoral zone measured 161 acres, about 5 percent of the lake surface area. Of the 161 littoral acres, 3 percent contained plants in the littoral zone was *Panicum hemitomon* (maidencane), *Hydrocotyle umbellata* (water pennywort) and *Pontera cordata* (umbrella grass) were also common. Land cover directly landward of the littoral zone was other native vegetation (22 percent), citrus (29 percent), or residential (49 percent). The dominant benthic organism found by Millemon (1978) was the chironomid larvae, *Glyptotendipes paripes* (midge fly), which is an important food source for young and adult fish (Pennak, 1978).

Millemon (1978) found that the phytoplankton population and chlorophyll a (a photosynthetic pigment) concentration in Lake Placid is distributed relatively uniformly throughout the photosynthetic zone of the water column. Blue-green algae (Cyanophyta) made up 90 percent of the cells in the phytoplankton population. Both Millemon (1978) and McCiffitt (1980) found chlorophyll a concentrations to be uniform (6.2 mg/m³ and 6.4 mg/m³, respectively) throughout their sample periods. The dominant organisms in the phytoplankton collected by McCiffitt (1980) from 1976 to 1977 were from the Division Chlorophyta (green algae), such as *Pediastrum*, *Dinoscenus*, *Ulothrix*, and *Oeniogonium*. Nutrient enrichment experiments showed Lake Placid phytoplankton to be limited by both nitrogen and phosphorus (McCiffitt, 1980).

Phytoplankton samples have been collected intermittently by the U.S. Geological Survey since 1976 (table 1). Of 15 samples collected between 1976 and 1982, all showed the Division Cyanophyta (blue-green algae) as the dominant taxon. The species composition of all but one sample was at least 90 percent Cyanophyta. The exception was a sample collected on May 12, 1976, was 87 percent Cyanophyta and 14 percent Chlorophyta. The difference between these results may be due to sample locations and collection methods and analyses.

Statistical analysis of water samples collected since 1966 shows a trend toward increasing ionic composition and dissolved solids in the water (fig. 16, table 3). The major ions are sodium and chloride. The water may be classified as soft ($CaCO_3$ less than 60 mg/L), neutral to slightly acidic, with very low alkalinity and salinity. Nutrient concentrations are also low with no noticeable increase in concentration since 1966 (table 3).

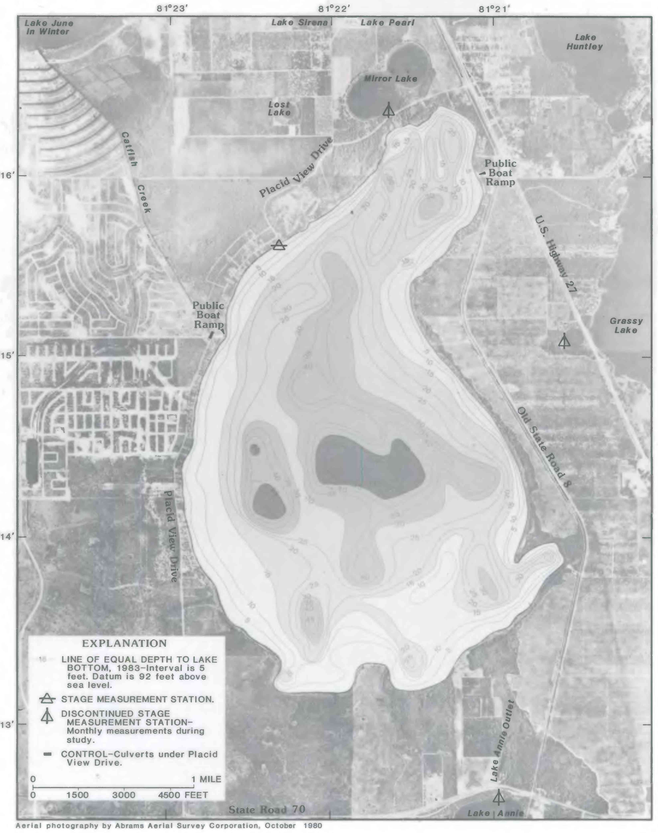
ABBREVIATIONS AND CONVERSION FACTORS

Factors for converting inch-pound units to International System of Units (SI) and abbreviation of units

Multiply	*By*	*To obtain*
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
acre	0.4047	hectare (ha)
square foot per day (ft²/d)	0.0929	square meter per day (m²/d)
cubic foot per second (ft³/s)	0.02832	cubic meter per second (m³/s)
gallon (gal)	0.003785	cubic meter (m³)
million gallons per day (Mgal/d)	0.04381	cubic meter per second (m³/s)
micromho per centimeter at 25° Celsius (µ/cm at 25°C)	1.000	microsiemens per centimeter at 25° Celsius (µS/cm at 25°C)
ton per acre-foot (ton/acre-ft)	7.354x10⁶	cubic hectometers (hm³)
	7.354x10⁶	megagram per liter (Mg/L)

To convert degree Fahrenheit (°F) to degree Celsius (°C), use the following equation:

$$°C = (°F - 32)/1.8$$



Aerial photography by Abrams Aerial Survey Corporation, October 1980

Figure 2.—Photomosaic map of the Lake Placid area.

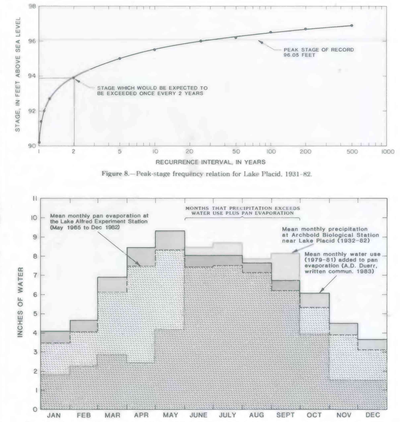


Figure 8.—Peak-stage frequency relation for Lake Placid, 1931–82.

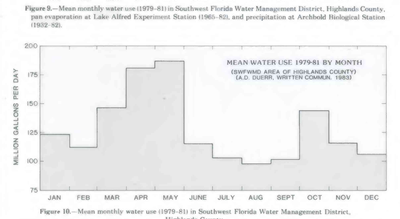


Figure 9.—Mean monthly water use (1979–81) in Southwest Florida Water Management District, Highlands County, pan evaporation at Lake Alfred Experiment Station (1965–82), and precipitation at Archbold Biological Station (1932–82).

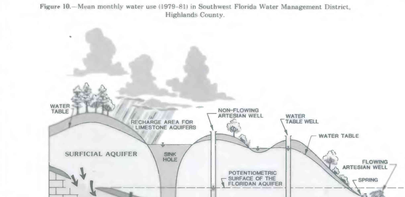


Figure 10.—Mean monthly water use (1979–81) in Southwest Florida Water Management District, Highlands County.

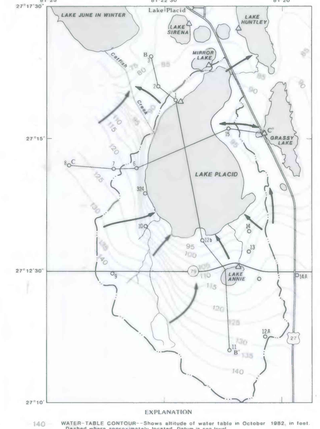


Figure 12.—Altitude of the water table in the Lake Placid drainage basin.

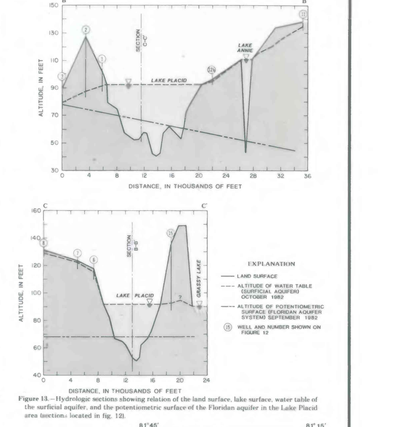


Figure 13.—Hydrologic sections showing relation of the land surface, lake surface, water table of the surficial aquifer, and the potentiometric surface of the Floridan aquifer in the Lake Placid area (see locations located in fig. 12).

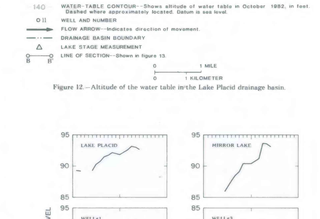


Figure 15.—Altitude of the potentiometric surface of the Floridan aquifer in May and September 1982, and the decline of the potentiometric surface of the Floridan aquifer from 1964 to 1980 in the Southwest Florida Water Management District area of Highlands County.

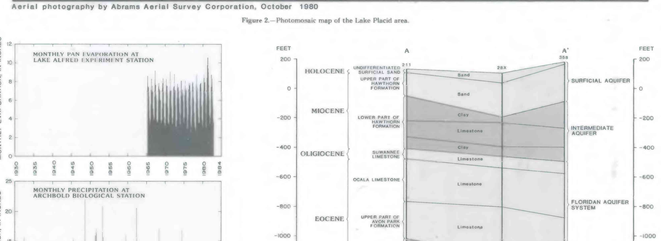


Figure 5.—Stage-volume and stage-area relations for Lake Placid.

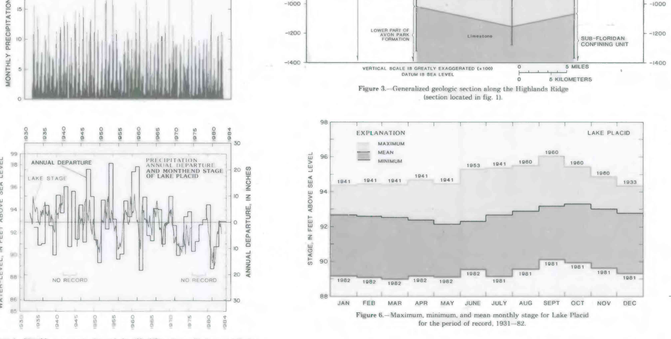


Figure 4.—Monthly pan evaporation at Lake Alfred Experiment Station, precipitation at Archbold Biological Station, annual departure from average annual precipitation, and month-end stage at Lake Placid.

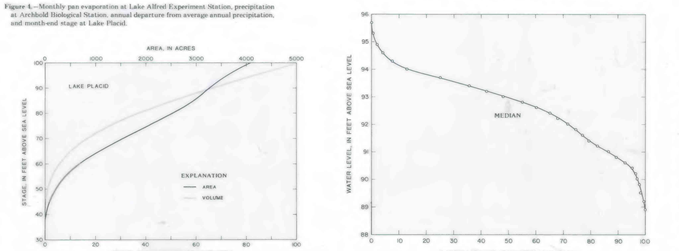


Figure 7.—Duration-relation for Lake Placid.

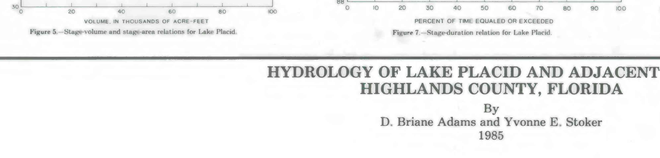


Figure 1.—Location of Lake Placid and the major physiographic features of Highlands County.

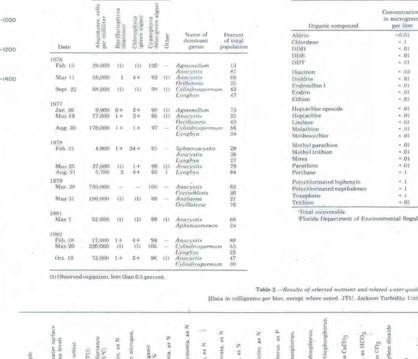


Figure 3.—Generalized geologic section along the Highlands Ridge (section located in fig. 1).

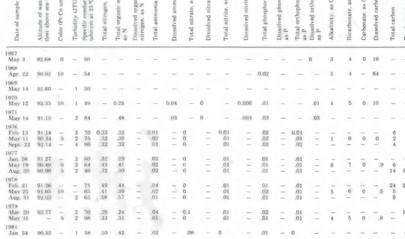
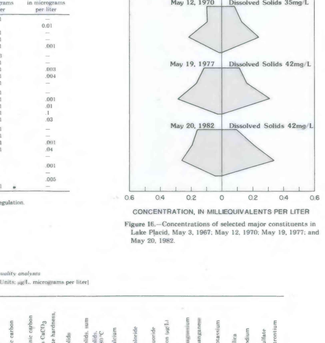


Figure 6.—Maximum, minimum, and mean monthly stage for Lake Placid for the period of record, 1931–82.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