81°48'

STATION

EXPLANATION

STAGE-MEASUREMENT STATION

CONTINUOUS-RECORD GAGING

INTRODUCTION

Lake Hancock is in west-central Polk County near the geographic center of peninsular Florida (fig. 1). The lake is part of the headwaters of the Peace River. Saddle Creek (fig. 2) flows through the lake and then joins Peace River. Lake Hancock, with a surface area of 4,540 acres, is the largest lake in the Peace River basin and the fourth largest in Polk County. Lake Hancock is the 10th in a series of lakes selected for study as part of a continuing cooperative project between the U.S. Geological Survey and the Southwest Florida Water Management District. The objective of the accomplish this objective, available data were evaluated to describe the hydrology of Lake Hancock and its environment. A map of the lake bottom was prepared from bathymetric data collected as part of the study. Existing climatological and hydrologic data were used in water-budget analysis to determine the relation of the lake to ground-water and surface-water conditions. Water-quality data were collected and analyzed to document past and current water-quality conditions in the lake. The hydrology and geology of the Lake Hancock area have been described in several publications by the U.S. Geological Survey. Heath recorded extremes of stage for Lake Hancock and of discharge for Saddle Creek. A comprehensive description of the ground-water resources of Polk County was provided by Stewart (1966). Kaufman (1967) reported on the hydrologic effects of ground-water pumpage in the Peace River basin. Robertson (1973) presented a brief discussion of stage fluctuations of Lake Hancock in his report on hydrologic conditions in the Lakeland Ridge area of Polk County. Hutchinson (1977) reported on shallow ground-water resources in the upper Peace River basin. Several other governmental agencies and co reports on the Lake Hancock area. The Peace River Valley Water Conservation and Drainage District (1960) presented a plan for improvement and development in the Peace River basin, including a recommendation for regulating the stage of Lake Hancock. Flood-plain information for Saddle Creek was published by the U.S. Army Corps of Engineers (1974). The

Hancock. Ardaman and Associates (1976) compiled locations of recently reported sinkholes in Polk County. Hydrologic data reports are published on a regular basis by the U.S. Geological Survey. Maps showing the potentiometric surface of the Floridan aquifer are published twice a year through a cooperative program with the Southwest Florida Water Management District. Water levels for Lake Hancock, discharges for Saddle Creek, and water-quality data are published annually in the series "Water Resources Data for Florida." All elevations in this report are referenced to NGVD of 1929 (National Geodetic Vertical Datum of 1929), a geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called "mean sea level." NGVD of 1929 is referred to as sea level in this report.

Southwest Florida Water Management District (1976) estimated flood-

stage frequency relations for several lakes in Polk County, including Lake

Hancock, and in the same report presented wind-tide effects on Lake

AREA DESCRIPTION

Polk County is part of the highland area that trends along the north-south axis of peninsular Florida. Within the county, three ridges are separated by relatively flat lowland areas. Lake Hancock is in the lowland area between the western and central ridges (fig. 1). The climate of the Lake Hancock area is subtropical with humid, rainy summers and dry, mild winters. Average monthly temperatures range from 61°F in January to 82°F in July and August. About half the annual rainfall occurs during June through September.

There has been an extended period of below normal precipitation in the Lake Hancock area and in central Florida generally since 1960. Average annual precipitation for the National Weather Service station at Bartow, about 3 miles south of Lake Hancock, is 53.95 inches, based on records from 1887 to 1977. Annual departures from average precipitation are shown in figure 3. Annual precipitation exceeded the average only twice from 1961 to 1977, resulting in a cumulative precipitation deficit of Lake Hancock receives inflow from several streams. Saddle Creek originates east of Lakeland, flows generally south through a swampy area

and enters Lake Hancock about 0.2 mile southeast of State Road 540 (fig. 2). Lake Lena Run originates at the outlet of Lake Lena in Auburndale and enters Lake Hancock on the northeast side. Banana Lake, located about 1 mile northwest of Highland City, discharges into Banana Lake Overflow Canal that enters the west side of Lake Hancock. The shoreline of Lake Hancock has an elevation of slightly less than 100 feet above sea level. Within 1 mile of the eastern and western shores of the lake, land-surface elevations exceed 130 feet above sea level. North and south of the lake the land is relatively flat and swampy. Along the shoreline there is a strip of swampland (fig. 2) generally less than 300 feet wide. At

than 1,000 feet. On the north end, where Saddle Creek enters the lake, Unlike many lakes in central Florida, the shoreline around Lake Hancock has not been developed into lakefront homesites. Along the eastern and southern shores of the lake there has been extensive strip shore. The public does not have ready access to the lake. Lake Hancock and the surrounding area are underlain by a layer of sand, clay, and limestone, ranging in thickness from about 100 feet to 400 feet. This surficial layer is underlain by several thousand feet of limestone and dolomite (Stewart, 1966). The formations can be divided into three hydrogeologic units: (1) the surficial aquifer, (2) secondary artesian aquifers and confining beds, and (3) the Floridan aquifer. Two generalized hydrogeologic sections are presented in figure 4. The sections are based on geologic data from wells described by Stewart (1966) and on well logs from the Florida Bureau of Geology. Locations of the sections are shown in

phosphate deposits, which in Polk County have been strip mined extensively. The thickness of the surficial aquifer ranges from about 20 feet near the shore of Lake Hancock to about 130 feet at the west end of section A-A' The secondary artesian aquifers and confining beds of Tertiary age are composed of clay, dolomite, and limestone of the Hawthorn Formation and the Tampa Limestone. The thickness of the secondary artesian aquifers and confining beds ranges from about 50 feet near Lake Hancock to about

The surficial aquifer is composed of sand, sandy clay, and pebble

150 feet at the west end of section A-A' (fig. 4). Limestone and dolomite of the Suwannee Limestone. Ocala Limestone, and Avon Park Limestone of Tertiary age make up the Floridan aquifer. Drilling logs described by Stewart (1966) indicate that zones within the limestone and dolomite contain numerous cavities and honeycomb features. These result from dissolution of the carbonate rock by circulating ground water. Weaknesses in the geologic structure caused by dissolution are commonly responsible for sinkhole collapses. Ardaman and Associates (1976) reported that between 1956 and 1975 there were more than 20 sinkhole collapses within 2 miles of Lake Hancock. According to Hutchinson (1977), ground water in the surficial and

secondary artesian aquifers flows from the ridge areas and discharges into the streams of the lowland areas. A depression in the potentiometric surface of the Floridan aguifer is described by Stewart (1966, p. 99) as indicating a general zone of upward leakage from the Floridan aquifer into Saddle Creek, Peace River, and swampy lowland areas. However, when the level of Lake Hancock is above the potentiometric surface of the secondary artesian and Floridan aquifers, as it was in 1959-60 (Stewart, 1966, p. 88-97), there would be downward leakage from the lake into the underlying aquifer systems.

LAKE CHARACTERISTICS

The bottom of Lake Hancock was mapped in August 1978 using a sounding rod. Lake stage at the time of the soundings was 98.6 feet above sea level. Depth contours shown on the photograph base map, however, are referenced to the average stage for the period of record (1960-77), 97.68 feet above sea level. deep trough, which lies 500 to 1,500 feet from the western shore. This eastern and northern sides of Lake Hancock, a firm sand bottom slopes gradually from shoreline to a depth of about 3 feet, 1,000 to 3,500 feet from

The bottom of Lake Hancock is covered with a layer of organic material extending from the 3-foot depth contour on the east to the submerged stream channel on the west. Depth soundings for the lake were reached the top of the organic layer. Kenner (1964) presented bottom maps of 16 lakes in Polk County, all of which were at least 8 feet deep. It is probable that Lake Hancock has a morphometry similar to that of the kes described by Kenner. If so, the organic layer may be more than 5 feet thick near the center of the lake. Ardaman and Associates (1976) reported a sinkhole near the center of the lake. Soundings did not provide any evidence of a sinkhole. Stage records of Lake Hancock have been collected by the U.S. Geological Survey since 1960. Average lake stage for 1960–77 was 97.68

level, occurred on September 16, 1960, as a result of Hurricane Donna. Minimum stage of record, 93.98 feet above sea level, occurred on May 23, Maximum, minimum, and mean monthly stages of Lake Hancock are shown in figure 5. The mean monthly stage is lowest in May and highest in September. Maximum stages for six of the months occurred in 1960, four of which were related to extensive flooding throughout central Florida due to Hurricane Donna. Minimum monthly stages occurred mostly in 1968 and 1977 after long periods of deficient rainfall. The volume of water in Lake Hancock varies with lake stage, as indicated by the stage-volume curve in figure 6. Because of the flatness of the lake bottom, a small increase in lake stage, about 95 feet above sea

feet above sea level. The maximum stage of record, 101.88 feet above sea

level, results in a relatively large increase in surface area and in the volume of water in the lake. At a stage of 97 feet above sea level, the lake contains about 10,000 acre-feet of water. At a stage of 99 feet above sea level, there is about 20,000 acre-feet of water in the lake. Outflow from Lake Hancock into Saddle Creek is regulated by Structure P-11, operated under the jurisdiction of the Southwest Florida Water Management District. Structure P-11, completed in August 1963, replaced the previous control, a concrete and timber weir. It is composed of two 20-foot by 7-foot radial gates atop a concrete spillway. In August 1966, the Governing Board of the Southwest Florida Water Management District (Resolution Number 165) adopted 95.0 feet above sea level as minimum desirable stage and 98.6 feet above sea level as maximum desirable stage. Operation of the structure is generally dependent on lake stage and weather conditions. During periods of low stage, however, one gate may be

opened slightly to provide water for livestock downstream. cock is shown in figure 7. Because of the short period of record, the stage-frequency curve for Lake Hancock was verified through two indeannual maximum stages of Lake Hancock with annual maximum stages at the streamflow station, Peace River at Bartow, about 4 miles downstream from Lake Hancock. The second independent estimate of peakstage frequency was determined from step-backwater computations (Chow, 1959) on Saddle Creek, downstream from Lake Hancock. Flood profiles for Saddle Creek and Lake Hancock were developed through backwater analysis, starting with stages and discharges of known recurrence interval for Peace River at Bartow (Murphy and others, 1978). Both estimates agree closely with the frequency distribution presented in

The frequency curve (fig. 7) should not be used to estimate the used in defining the curve are not independent. Annual maximum stages of Lake Hancock have been subject to effects of regulation in the past. The magnitude and frequency of flooding may be affected if regulation is changed in the future. Stage-frequency data shown in figure 7 may not accurately reflect actual flood levels under an altered regulatory schedule. Three stage-duration curves for Lake Hancock are shown in figure 8. Curves for total days of record, for September days of record, and for May days of record are presented to show average, high, and low conditions respectively. Figure 8 illustrates the narrow range of stage fluctuations of Lake Hancock. For total days of record, stage is within 0.5 foot of average stage (97.68 feet above sea level) about 40 percent of the time. Lake stages for September and May are about 0.5 foot higher and lower, respectively, than stages for total days of record for the same probability of exceedance Records of daily discharge for Saddle Creek at Structure P-11 have

September 1977 was 50.1 ft³/s (cubic feet per second). The maximum discharge of record, 516 ft³/s, occurred on August 13–14, 1965. There are many days of no flow in some years. Maximum, minimum, and mean monthly discharges of Saddle Creek at Structure P-11 are shown in figure 9. The mean monthly discharge is lowest in May and highest in September, at the end of the wet summer season. The year of occurrence is noted above the curve in figure 9. Minimum discharge is zero for all months except September, which has a

minimum discharge of 0.03 ft³/s.

been collected since 1964. Average daily discharge for October 1964 to

Saddle Creek flow-duration curves for total days of record, September days of record, and May days of record are shown in figure 10. The September and May curves represent high and low conditions, respecin May, about 40 percent of the time during the period 1964-77, and about 65 percent of the time in September. Median discharges (50 percent exceedance) are about 0.01, 0.3, and 130 ft³/s for the May curve, total-days curve,

WATER BUDGET

and September curve, respectively.

The volume of water in Lake Hancock fluctuates in response to precipitation, evaporation, inflow, and outflow. This relationship can be expressed by water-budget equation:

 $Net\ ground-water\ flow=Ground-water\ inflow-Ground-water\ outflow$ The amount of water in each element of the water budget was evaluated by month, for the period 1964-77, to provide a basis for understanding the hydrology of the lake system. No other factors, such as diversions and consumptive use, are known to significantly affect Lake The volume of water in Lake Hancock is a function of lake stage as

shown in figure 5. Monthly changes in volume were determined from

lake-stage data (fig. 11) and the stage-volume relation. Monthly precipitation data (fig. 11) used in the water-budget analysis were taken from National Weather Service records for Bartow. During the budget period, 1964-1977, annual precipitation exceeded the long-term budget period was 74.73 inches, or an average of 5.34 inches per year. from about 2.5 inches in December to about 5.6 inches in July (fig. 12). Estimates were based on average annual evaporation of 50 inches from shallow lakes in central Florida (Kohler and others, 1959, plate 2) proportioned relative to average monthly pan evaporation for West Palm Beach (Linsley and Franzini, 1972). Although monthly evaporation varies from year to year, the variations are not considered critical. Average monthly rates were, therefore, used throughout the analysis. Based on an annual average evaporation of 50 inches, evaporation losses from Lake Hancock exceeded total annual precipitation for 10 of the 14 years in the budget

Monthly mean surface-water outflow (fig. 11) was calculated from daily discharge records for Saddle Creek at Structure P-11. Monthly mean surface-water inflow (fig. 11) was estimated from about 25 miscellaneous measurements of Saddle Creek upstream from Lake Hancock. These measurements were made between 1955 and 1974. The measurements were correlated with measurements from the continuous record station, Peace Creek Drainage Canal near Alturas, about 8 miles southeast of Lake Hancock, and with measurements from Peace River at Bartow, a continuous record station about 4 miles downstream from Lake Hancock. Two estimates of monthly inflow through Saddle Creek were generated from the two correlations. The arithmetic average of the two correlation estimates was adjusted by a drainage area ratio to account for additional surface-water inflow to Lake Hancock from Banana Lake Overflow, Lake Lena Run, and the adjacent swamps. Net ground-water flow represents the difference between ground-

water inflow and outflow. Ground-water inflow and outflow were not measured directly. The net exchange between Lake Hancock and the ground-water system was, instead, estimated by solving the water-budget equation for net ground-water flow. Because it is computed as a residual, the accuracy of the net ground-water term is dependent upon the cumulative errors of the other water-budget components. Results of water-budget calculations for three 9-month periods are listed below. September 1967 to May 1968 represents a period of declining lake levels. June 1968 to February 1969 represents a period of rising lake levels, and August 1971 to April 1972 represents a period during which the level of Lake Hancock stayed relatively constant. All values are in inches over the surface area of the lake, assumed constant at 4,540 acres.

5/68 ing -32.24 18.03 33.98 39.96 16.76 -39.49 2/69 Rising 40.32 46.95 35.44 176.37 114.77 -32.79 4/72 stant - 0.05 33.76 33.83 62.32 76.96 14.66

The lake-stage decline from September 1967 to May 1968 followed successive years of deficient precipitation (fig. 3) and coincides with a decline in well levels (fig. 13). There was no surface-water outflow through Structure P-11 between September 23, 1967, and June 30, 1968, and, uently, there was a net gain to the lake from the surface-water system. The water-budget analysis indicates that the lake-stage decline during this period was primarily the result of a net loss of water from the lake to the ground-water system. Similar conditions in mid-1975 also resulted in a lake-stage decline. The increase in lake stages from June 1968 to February 1969 coincided with an increase in well levels. During this period precipitation was about 3 inches above normal. There was a net gain to the lake from the

surface-water system and a net loss from the lake to the ground-water Lake stage remained relatively unchanged from August 1971 to April 1972. Precipitation was about normal during this period. Outflow through Structure P-11 ranged from 0 ft³/s to 281 ft³/s and averaged about 54 ft³/s. Inflow averaged about 43 ft³/s, resulting in a net loss to the surface-water system during the period. Ground-water levels were high, and net gains from the ground-water system offset losses to the surface-water system. During the 1964-77 budget period, Lake Hancock's stage increased an average of 0.08 inch per year. Annual precipitation averaged 48.61 inches, and evaporation averaged 50.00 inches. Surface inflow averaged 132.49 inches per year and surface outflow averaged 106.30 inches per year for an average annual gain of 26.19 inches from the surface-water system. There was an average net loss to the ground-water system of 24.72 inches per

WATER QUALITY

Water-quality data available for Lake Hancock and Saddle Creek for the period 1965-71 (table 1) include: major ions, dissolved oxygen, and a few physical parameters. Specific conductance and temperature data are available for 1972-77. Analysis of nutrients, physical parameters, dissolved oxygen, radium, and phytoplankton are available for August 1978 Calcium is the predominant cation and bicarbonate the predominate anion (table 1) in the chemical analysis of water from Lake Hancock.

Several other lakes in Polk County have a similar ionic composition. According to Hutchinson (1977), water in the surficial, secondary artesian, and Floridan aquifers also is a calcium bicarbonate type. Some of the water-quality parameters in table 2 indicate undesirable characteristics. According to Brown and others (1970), ammonia nitrogen greater than 0.1 mg/L (milligrams per liter) usually indicates organic ation. Dissolved oxygen concentrations are, in some cases, less than the 5 mg/L minimum recommended by the U.S. Environmental Protection Agency (1976) for maintaining a varied fish population. In August 1978, pH exceeded the limits (8.5 units) set by Florida Department of State 1978) for waters used for recreation and the propagation and management of fish and wildlife. The phytoplankton analysis shows a predominance of blue-green algae. Water with high concentrations of blue-green algae, such as Anacystis and Anabaena, is suspected of being toxic to some animals (McKee and Wolf, 1963).

Esthetically, Lake Hancock is in poor condition. Except for a firm sand bottom near the shorelines, the lake bottom is covered by organic material that will not support much weight. Water hyacinths make boat launching and manuevering difficult. Wind tends to stir up bottom material so that the lake becomes turbid. Algal blooms are a frequent occurrence. Brezonik (1976) used phosphorus, nitrogen, dissolved oxygen, and as indicators to rank 41 Florida lakes according to degree of eutrophication. Of the 41 lakes, ranked from least eutrophic to most eutrophic, Lake Hancock was thirtieth. Although eutrophication occurs naturally in lakes. the process can be accelerated through addition of nutrients such as nitrogen and phosphorus. Eutrophication is generally considered to be undesirable because it reduces the esthetic qualities of lakes; it may change fish populations to less desirable species; and, it creates problems of growth of aquatic vegetation.

Wastewater treatment plant effluent appears to be a major source of nutrient addition in Lake Hancock. The Florida Board of Conservation (1966 and 1970) listed streams and lakes receiving effluent from wastewater treatment plants in Polk County, Following secondary treatment effluent from Lakeland is discharged into Banana Lake, which is connected to Lake Hancock by a canal. Auburndale discharges wastewater effluent from its secondary treatment plant into Lake Lena Run, which empties into Lake Hancock, Sylvester Shores subdivision at Lakeland uses secondary treatment and then discharges its treated effluent directly into Lake Hancock, Of the 11 lakes that were ranked by Brezonik (1976) as more eutrophic than Lake Hancock, nine receive wastewater effluent.

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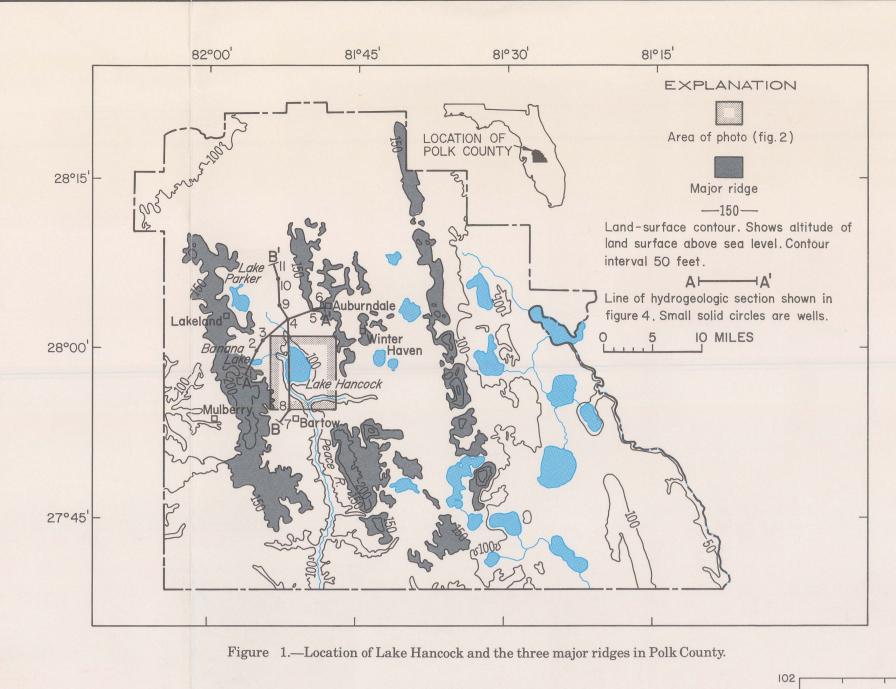
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ARTESIAN AQUIFERS and CONFINING BEDS

5 MILES

Example: Daily mean stage has exceeded

98 feet above sea level about

50 percent of the time in Septem-

ber, about 17 percent of the time

in May, and about 38 percent of

the time during the period 1960-

September days

Minimum is zero for all

Example: Daily mean discharge has

exceeded 20 ft³/s about

20 percent of the time in

May, about 65 percent of

about 40 percent of the

time from 1964-77.

of record

September days

the time in September, and

of record

of record

PERCENTAGE OF TIME STAGE WAS EXCEEDED

JAN FEB MAR APR MAY JUNE JULY AUG SEPT OCT NOV DEC

Figure 9.—Maximum, minimum, and mean monthly discharges of Saddle Creek at

May days

PERCENTAGE OF TIME DISCHARGE WAS EXCEEDED

Figure 10.—Duration of daily mean discharges for Saddle Creek at Structure

P-11, 1964-77, and for May and September.

of record

Figure 8.—Duration of daily mean stages, 1960–77, and for May and September.

FLORIDAN AQUIFER

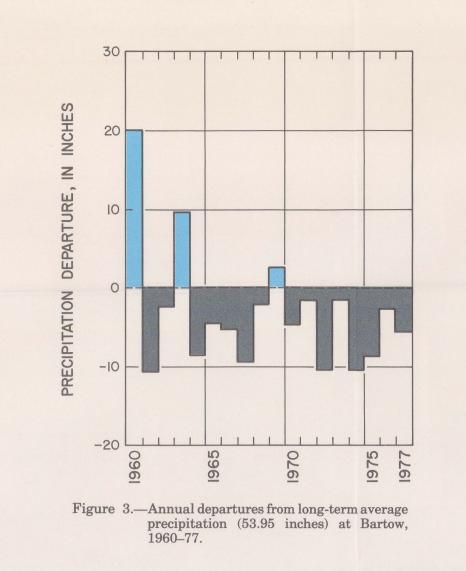
SECONDARY ARTESIAN AQUIFERS and CONFINING BEDS

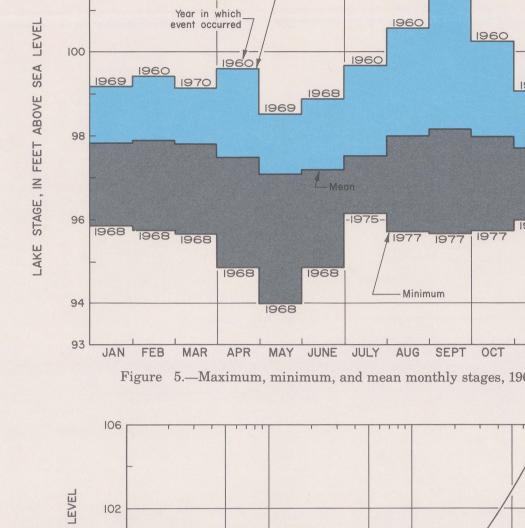
FLORIDAN AQUIFER

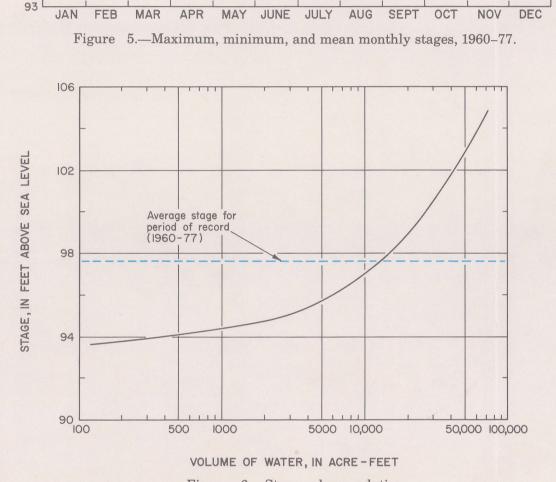
VERTICAL SCALE GREATLY EXAGGERATED

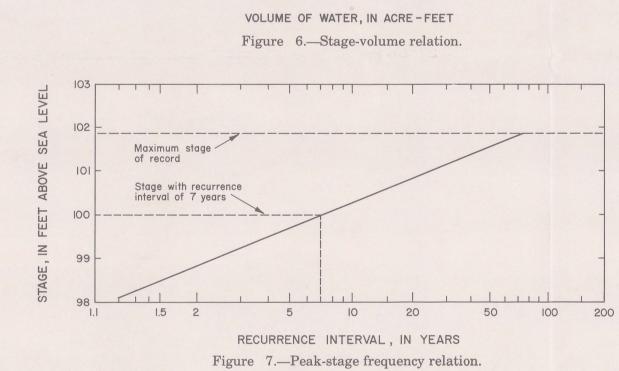
Figure 4.—Generalized hydrogeologic sections across the Lake Hancock area.

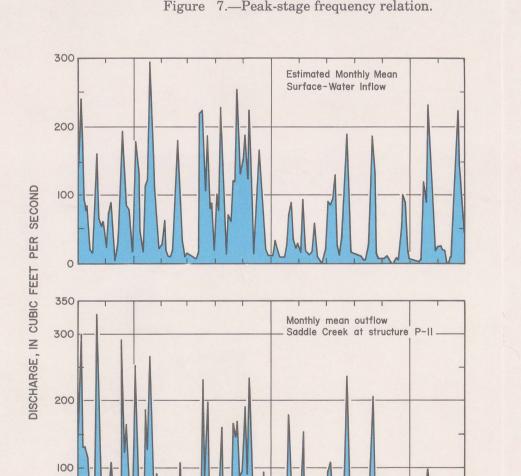
LOCATION OF SECTIONS IS SHOWN IN FIGURE I

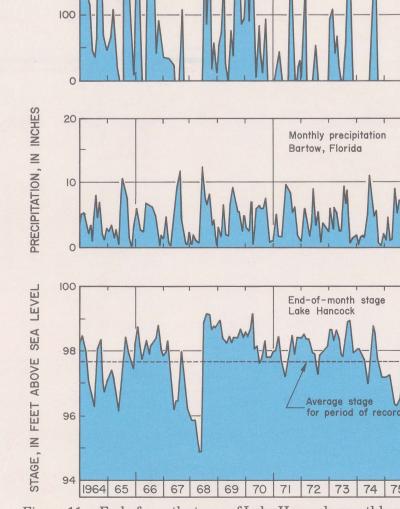




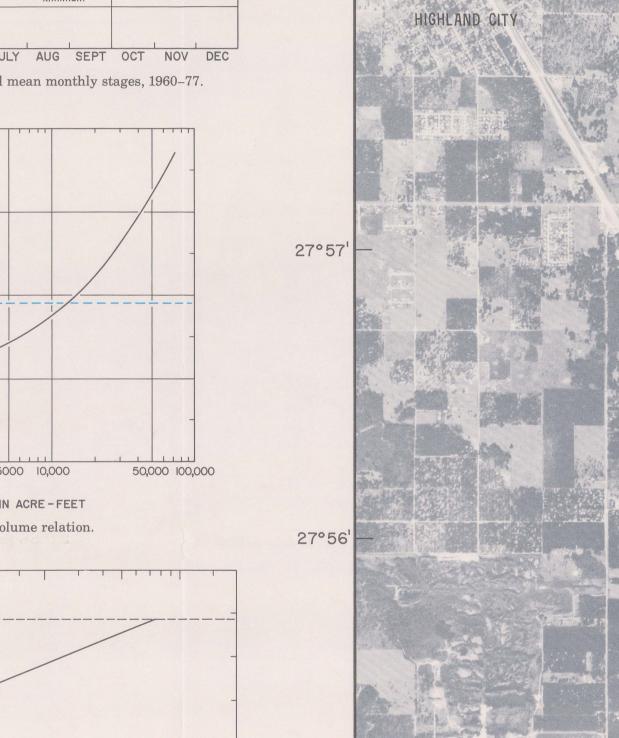


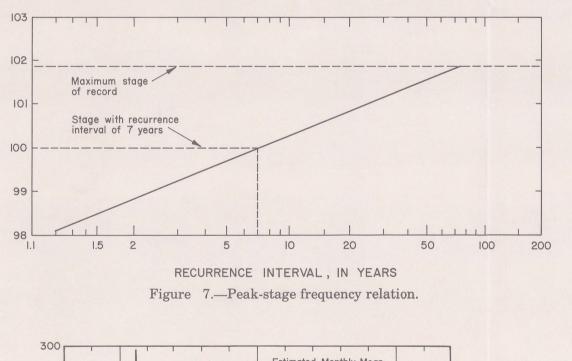


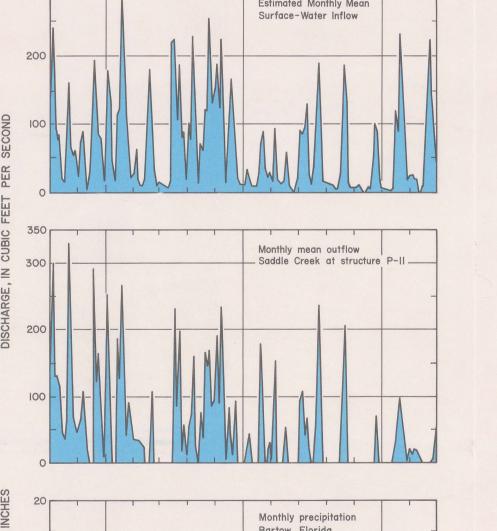


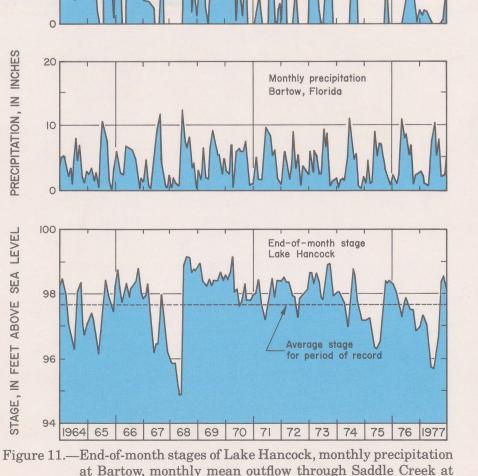


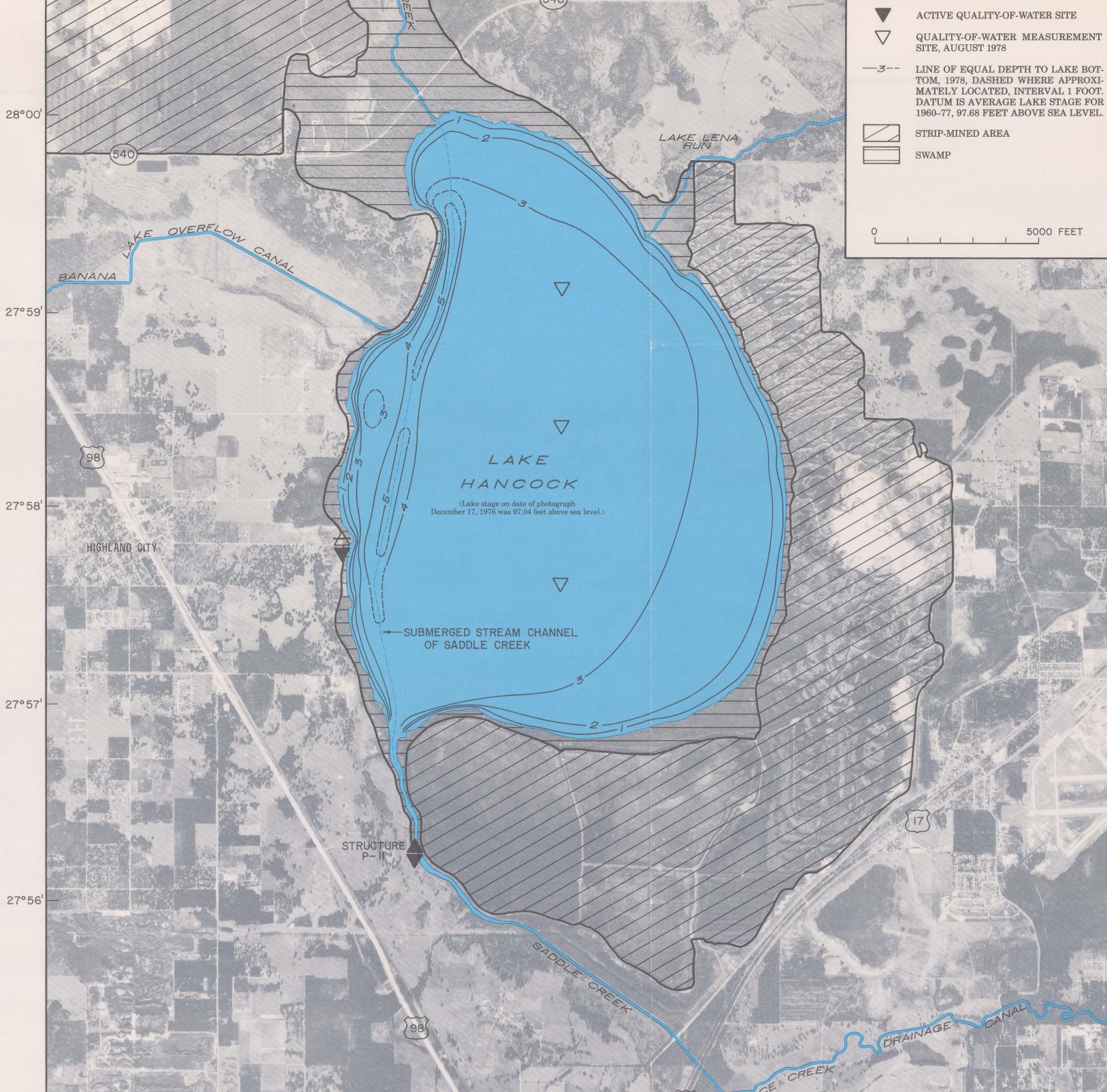
inflow, 1964-77.







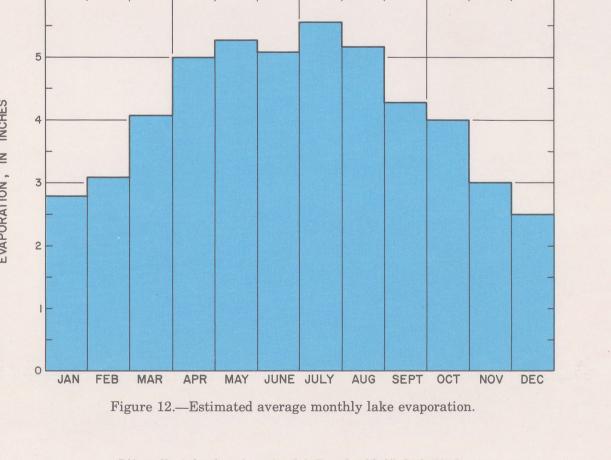


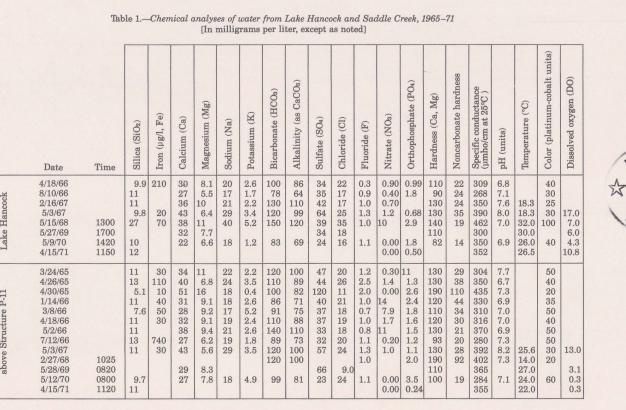


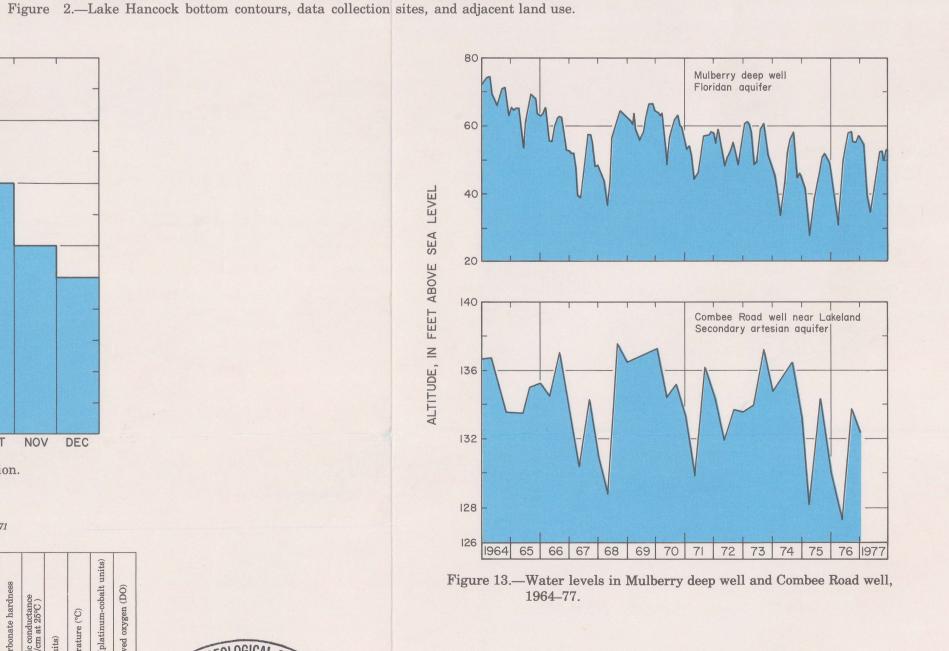
81°50'

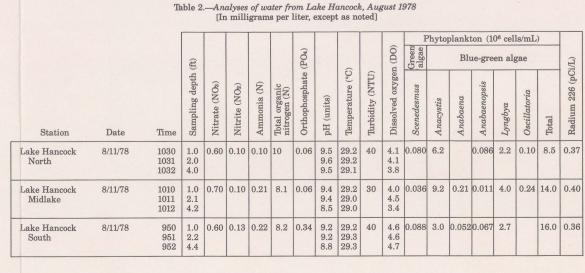
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81°51'







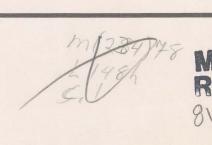


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HYDROLOGIC DESCRIPTION OF LAKE HANCOCK, POLK COUNTY, FLORIDA

Structure P-11, and estimated monthly mean surface-water

K. M. HAMMETT, L. J. SNELL, AND B. F. JOYNER



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