DEPARTMENT OF THE INTERIOR
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SOUTHWEST FLORIDA WATER MANAGEMENT DISTRICT

WATER-RESOURCES INVESTIGATIONS
REPORT WRIR 86-4315

INTRODUCTION

Island Ford Lake is in the Brooker Creek watershed in northwest Hillsborough County, Fla. (fig. 1). The 91-acre lake is 14 miles from the center of Tampa and about 11 miles from the populous Gulf of Mexico beaches in Pinellas County. The entire Tampa Bay area has experienced rapid and continuous urban expansion during 1970–84, and area lakes are especially attractive for the aesthetic and recreational benefits they provide. This report documents lake characteristics and assesses the relation of the lake to the ground-water and surface-water systems in the area.

This report is the 20th in a series of lake investigations by the U.S. Geological Survey conducted in cooperation with the Southwest Florida Water Management District (SWFWMD). The objectives of the investigation were to describe the general hydrology of the lake and to provide a data base for future assessment of cultural changes that may affect the lake. Previous lake investigations were conducted based on specific areas of concern that varied with each lake. Island Ford Lake was chosen because of its potential for future residential development, the fact that it is an integral part of the Brooker Creek watershed, and because the lake is midway between two major public-supply well fields that could affect lake stages or flow to and from the lake. Preliminary assessment of these aspects of the lake environment should provide water-resource managers and others a more complete understanding of the lake and its response to variations in the hydrologic setting. This report analyzes the relation of the lake to the regulated flow of Brooker Creek, addresses possible trends in quantity and quality of water in the lake, and describes the relation of the lake to areal ground-water levels.

Analyses in this investigation made use of file data on lake stages, ground-water levels, pumpage figures, and water-quality for sites within about 5 miles of Island Ford Lake. Daily discharge data from sites on Brooker Creek were analyzed in conjunction with stage and stage-regulation data from the lake. Additional water-quality data were collected from the lake during the investigation, and water levels were monitored at 11 lakes or ponds and at 8 shallow wells.

The hydrology of northwest Hillsborough County has been the subject of many investigations, primarily related to either the development and operation of public-supply well fields or the many lakes of the area. Reports referenced herein are listed at the end of this report. Many investigations of the well-field areas and the effects of ground-water withdrawals have been completed by consulting firms and are available at local government offices.

AREA DESCRIPTION

Island Ford Lake is near the northwestern corner of Hillsborough County, immediately north of Keystone Lake, the second largest lake in the county (420 acres). Brooker Creek forms east of the lake and flows through Keystone Lake and Island Ford Lake before emptying into Lake Tarpon in Pinellas County. Although the northwest corner of Hillsborough County is a predominantly rural area, urban development from the west, south, and east continues to move closer to the lake. Eldridge-Wilde well field, 4 miles west of the lake (fig. 1), supplied 30.7 Mgal/d to Pinellas County in 1984. Come well field supplied 10.9 Mgal/d to St. Petersburg in 1984 from wells within 4 miles south and southeast of the lake. Island Ford Lake and the entire Brooker Creek watershed will continue to be affected by the demands on water resources by the increasing population and development in this area.

Island Ford Lake is in the Gulf Coastal Lowlands of west-central Florida, an area of marine terraces formed by higher ancient sea levels. The topography of the Brooker Creek watershed east of the lake is that of a slightly undulating plain characterized by many lakes, ponds, and cypress swamps. Land surface slopes generally west-southwest toward the coast at about 4 feet per mile, falling from about 60 feet above sea level in the Brooker Creek headwaters to the shoreline of Island Ford Lake at about 40 feet above sea level. The lower Brooker Creek basin, west of Island Ford Lake, is a flat, swampy plain with few lakes and consists primarily of mixed cypress-hardwood forest.

Land use in the upper Brooker Creek basin consists primarily of citrus groves, cypress swamps, and lakes, with some pasture or rangeland. Heavy freezes in December 1983 and January 1985 damaged most of the citrus trees and many groves are either dormant or have been replanted with seedlings. Residential areas occur adjacent to the numerous lakes or along Gunn Highway, County Road 587. West of Island Ford Lake to the Pinellas County line, rangeland and pasture are most common. West from the county line to near Lake Tarpon, the mixed cypress-hardwood swamps dominate land use. Pasture land along McMullen-Booth Road has increasingly been converted to residential development.

The shoreline of Island Ford Lake is primarily residential. The north side of the lake is characterized by small lots and numerous homes, whereas the south side has generally much larger lots and fewer homes (fig. 2). A thin strip of relatively high ground on the west bank of the lake is residential. Adjacent to this high ground is a large cypress swamp. Citrus groves surround most of the lake outside the perimeter of the residential area. Brooker Creek flows from Keystone Lake through a control structure into the southeast corner of the lake and leaves the lake through a canal and second control structure on the western side. Excess water from Crescent Lake and Lake Wastena, northeast of Island Ford Lake, flows due south through a swamp and marsh into the lake.

Much of the land in northwest Hillsborough County is internally drained through numerous cypress domes or depressions caused by sinkhole development, or by the many lakes, themselves the result of collapse of surficial material into solution holes in the underlying limestone of the area. Brooker Creek drains about 30 mi² of land to Lake Tarpon and through an excavated canal to Tampa Bay. The area north of the Brooker Creek basin drains west to the Gulf of Mexico by way of the Anclote River. Rocky Creek and Brushy Creek drain the area east and southeast of the Brooker Creek basin. The area south of the basin is drained by Double Branch.

Two major public-supply well fields are within 4 miles of Island Ford Lake (fig. 1). Eldridge-Wilde well field, west of the lake, began supplying Pinellas County with water in 1959. Pumpage rose steadily from an average of about 6 Mgal/d in 1956 to over 35 Mgal/d in 1972–73. Annual average permitted pumping from the well field in 1985 was 35.2 Mgal/d from 58 wells located in both Pinellas and Hillsborough Counties. Come well field began production in 1950, pumping about 1 Mgal/d from 6 wells. By 1957, 23 production wells had been constructed near Gunn Highway, from just east of Calm Lake south and then southeast past along Race Track Road (fig. 1). Pumpage from the well field increased to over 19 Mgal/d in 1961–62. Pumpage in 1975–76 averaged 9.1 Mgal/d, although the average permitted pumping rate is 19 Mgal/d. There are eight other major well fields in Pasco and northern Pinellas and Hillsborough Counties, but effects of their withdrawals on Island Ford Lake are minimal compared with those of the previously mentioned well fields.

The climate of the Island Ford Lake area is subtropical with warm, humid summers and cool, relatively dry winters. The majority of annual rainfall occurs during June through September as a result of convective afternoon thunderstorms. Historically, precipitation associated with hurricanes has been a significant factor in long-term rainfall, but Hurricane Donna in 1960 was the last hurricane to cause significant flooding near Tampa. Monthly average temperatures range from 59.8 °F in January to 82.3 °F in August. Snowfall is rare and a typical winter has only one or two days below freezing.

The two long-term precipitation stations closest to the lake are the National Oceanic and Atmospheric Administration station at Tarpon Springs and the station at the Come well field operated by the city of St. Petersburg. Coincident records began in 1931 when the Come station was installed. The Tarpon Springs station is 10.6 miles due west of Island Ford Lake, and the Come station is 3.9 miles south of the lake. Normal annual rainfall (1951–80) at the Tarpon Springs station was 51.97 inches (U.S. Department of Commerce, 1951–84). Rainfall at the Come station averaged 53.51 inches for the same period. August is typically the wettest month of the year, with an average precipitation of 8.55 inches at Tarpon Springs and 9.57 inches at Come. April and November are the two driest months, averaging just over 2 inches of rainfall at each site. The wettest year on record at each station was 1959; rainfall was 83.20 inches at Tarpon Springs and 82.12 inches at Come. The driest year at both stations was in 1956 when 32.89 inches of rainfall was measured at Tarpon Springs and 33.19 inches at the Come station. Rainfall amounts discussed in the rest of this report will be the average of these two stations.

Figure 3 shows the annual departure of precipitation from the 1951–80 average of 52.74 inches, computed from Island Ford Lake monthly stage data. Rainfall for 1971–84, the period of record for stage data at Island Ford Lake, was slightly higher than normal, averaging 54.18 inches. Annual departures from normal rainfall indicate that 1972 was the driest year since the start of stage data collection—10.28 inches below normal. The wettest year during the period was 1983 when rainfall was 20.34 inches above normal.

Annual evaporation from lakes in the Island Ford Lake area has been estimated to average 45 inches per year (Farnsworth and others, 1982). Of the rainfall that falls on the ground, it is estimated that 25 to 35 inches per year either evaporates or is transpired by plant life before it reaches the water table. Hence, most rainfall that occurs each year returns to the atmosphere and is not retained by either lakes or the surrounding ground-water system. During drier years, there is a net loss of water from the lakes to evaporation.

BROOKER CREEK

Because Brooker Creek flows through Island Ford Lake, any discussion of the lake must consider the effects of Brooker Creek flow characteristics on the lake. Brooker Creek flow to Island Ford Lake from Keystone Lake is controlled by two vertical lift gates, each 12 feet wide, with inverts at 37.2 feet above sea level. If the gates are kept closed, flow to Island Ford Lake would occur over the tops of the gates if Keystone Lake rose above 40.7 feet above sea level. Outflow from Island Ford Lake to Brooker Creek is regulated by three 6-foot lift wide vertical gates on the west side of the lake. The invert of these gates is 35.0 feet above sea level. An overflow weir between the canal between the lake and control structure isolate the lake from the effects of the lake stage falls below about 36.5 feet above sea level. Prior to January 1976, the outlet control was a fixed-crest weir, 36 feet wide, at elevation 40.0 feet above sea level.

The U.S. Geological Survey has, at various times since April 1946, operated four daily discharge sites on Brooker Creek (fig. 1). Brooker Creek near Lake Fern (site BC-2), 2.9 miles below the outlet control of Island Ford Lake, is the station most pertinent to this investigation. A record of discharge for October 1970 through September 1984 is 7.59 ft³/s, or 6.06 inches of runoff per year. From the 17-mi² drainage basin. Of this drainage area, 85 percent, or 14.4 mi², is above the Island Ford Lake outlet, and 15 percent of the area (2.6 mi²) is between the lake and discharge site. The adjustable outlet control at Island Ford Lake was completed in January 1976, and during January 1976–September 1984, discharge at site BC-2 averaged 7.94 ft³/s. During periods when the Island Ford Lake outlet was closed, discharge at site BC-2 averaged 1.2 ft³/s, or 15 percent of the overall average discharge. This corresponds with the ratio of drainage areas above and below the outlet from the lake and indicates about 6.7 ft³/s of water from either Brooker Creek or from Crecent Lake passed through Island Ford Lake during the period.

The percentage of time that a given discharge was equaled or exceeded at site BC-2 is shown graphically in figure 4. The curve for June 1971 through December 1975 covers the period from the start of record at Island Ford Lake to the time when the gated structure replaced the fixed crest weir. The curve for January 1976 through December 1984 indicates the duration of daily discharge during operation of the gated structure. The center curve is for the entire period, June 1971 through December 1984. A discharge of 1.0 ft³/s at site BC-2 was equaled or exceeded about 27 percent of the time during 1971–75 and about 45 percent of the time during 1976–84. Maximum daily discharge recorded at site BC-2 during 1971–84 was 283 ft³/s during September 1979.

Maximum discharge from Island Ford Lake is limited more by channel controls downstream from the lake than by manipulation of the vertical lift gates of the outflow control structure. Water levels below the outlet control of the lake rise quickly and control the flow from the lake during periods when the outlet gates are open. Flow at site BC-2 and water levels above the control are known, so water levels below the control can be estimated using a theoretical discharge rating for the control structure. These analyses indicate that, for all periods when the control gates were open, the water level immediately below the structure was less than 0.4 foot lower than the lake stage. Channel controls somewhere between the structure and discharge site BC-2 are the limiting factor for maximum outflow from the lake. Maximum lake stages, therefore, are partially subject to channel controls downstream from the lake.

LAKE CHARACTERISTICS

Stage

The stage of Island Ford Lake fluctuates in response to rainfall, evaporation, surface-water flow to or from Brooker Creek or Crescent Lake, and exchange of water with the ground-water system. Because surface-water inflow and outflow are regulated by the operation of control structures, rising or falling stages do not respond solely to natural hydrologic conditions. Operation of the control structures are guided, however, by a combination of criteria to limit the effects of flooding, to decrease possible drought effects, and to maintain the biologic integrity of the lake. These criteria are based on analyses of past stage characteristics in relation to the natural and cultural characteristics of the lake shoreline.

Stage data have been collected at Island Ford Lake since June 1971. Through December 1984, the stage of the lake averaged 39.9 feet above sea level. The maximum stage during this period was 42.02 feet above sea level on September 28 and 29, 1979. The minimum stage for 1971–84 was 37.68 feet above sea level on July 15, 1977. In June 1985, the stage of the lake was observed at a new minimum of 36.3 feet above sea level. Daily stage readings, however, are not available for this period, so analyses in this report are based on stage data ending December 31, 1984.

Analysis of monthly stage characteristics allows a general comparison of the lake levels to other lakes or aspects of the area hydrology. Stages at Island Ford Lake are lowest for May and June, averaging 39.3 feet above sea level for each of these months. The lower stages result from the typically dry spring months in west-central Florida, and most streams, lakes, and ground-water levels are lowest at this time of year before the typical summer thunderstorms begin. Maximum stages occur in September following the summer rains and average 40.47 feet above sea level. Island Ford Lake stage has averaged 0.15 foot lower than the stage of Crescent Lake during May and 0.89 foot lower than Crescent Lake during January. The difference between the higher Keystone Lake and Island Ford Lake has been greatest in March (0.75 foot) and least in October (0.45 foot).

The duration of daily stages for Island Ford Lake for 1971–84 is shown graphically in figure 5. Also shown are stage-duration curves for 1971–75 when the outlet control for the lake was a fixed weir and for 1976–84 when the gated control structure was operational. These curves indicate the percentage of time that a given daily lake stage was equaled or exceeded for each of the three periods. During 1971–75, for example, the lake stage was equal to or greater than 39.90 feet 24 percent of the time. In comparison, during 1976–84, with the new gated control structure, the lake stage was equal to or greater than 39.90 feet 61 percent of the time. Average rainfall for the two periods was within one-half inch, so precipitation would not be expected to be the cause of the increased stages. The operation of the gated control structure is responsible for the increased stage duration after 1975.

The recurrence interval of observed peak stages for the period 1971–84, determined by a log-Pearson Type III frequency distribution (U.S. Water Resources Council, 1981), is shown graphically in figure 6. The curve indicates the recurrence interval, in years, that a peak stage was equaled or exceeded. If the lake stage were not regulated by the inflow and outflow control structures, the curve would indicate the recurrence probability of future peak stages. Although peak discharge from the lake outlet control is partially limited by downstream channel conditions in Brooker Creek, peak lake stages can still be significantly affected by control operations preceding and during periods of heavy precipitation or runoff. The curve indicates that a stage of 42.0 feet had an expected recurrence interval of about 7 years during 1971–84.

Operation of the control structure inlets from Crescent Lake and Brooker Creek by the SWFWMD is based on relative stages between the lakes, hydrologic conditions, and a set of regulatory lake levels adopted by the SWFWMD. These regulatory levels were chosen to minimize physical and economic damage to existing shoreline structures while providing protection for the aesthetic, recreational, and biologic aspects of the lakes. Subject to hydrologic conditions, the stage of Island Ford Lake is generally kept between 39.0 feet and 41.0 feet. A cyclic fluctuation schedule generally allows the lake to fall to 37.0 feet above sea level about once every 5 years and allows the lake stage to rise to about 41.5 feet above sea level once each cycle. During drought conditions, both inlets and control structures of Island Ford Lake become dry, and the control structures are ineffective.

Bathymetry

Depth soundings of Island Ford Lake were collected in June and July 1985 using a sonic fathometer. The stage of the lake during collection of depth data was 36.3 feet above sea level. Depths and depth contours shown in figure 2, however, are referenced to the mean lake stage of 39.9 feet above sea level. Areas near the mean-stage shoreline were dry during data collection, and depths shown for these shallow areas were estimated from contour maps, interpolation between the lower and higher shorelines of aerial photographs, and field observations. Forty-five fathometer transects were completed on the lake, as well as miscellaneous reconnaissance runs.

The lake is characterized by two deeper bodies of water joined by a shallow neck of water near the center (fig. 2). Much of the area between the two deeper bodies of water is less than 4 feet deep. Depths and depth contours are generally greater than 4 feet in the northern and eastern parts of the lake. The deepest area of the lake is in the northeast corner of the lake, where depths of 12 feet are recorded at the mean lake stage of 39.9 feet above sea level. Depths and depth contours are generally less than 4 feet in the southern and western parts of the lake. The 4-foot depth corresponds with an elevation of about 36 feet above sea level. Most of the eastern part of the lake is 10 to 11 feet deep, or about 30 feet above sea level. The bottom of the lake in the narrow neck area between the eastern and western parts of the lake is at an elevation of about 35 feet above sea level, about 4 feet below the mean stage of the lake. If the stage of the lake were to fall below this elevation, the lake would be divided into two separate bodies of water. There was no indication of a defined creek channel anywhere on the lake bottom.

Dredged areas were encountered off most of the residential shoreline, indicated during collection of the soundings by erratic, abrupt changes in both depth and shape of the lake bottom. These areas are generally too small and irregular to contour accurately. The spot sounding of 17.4 feet in the northwest corner of the lake is in one of these small dredged holes in an area where the natural depth of the lake is about 8 feet. The deeper areas of the lake (those with depth contours of 20 feet or more) are generally larger and of more consistent slope than dredged areas encountered in other lakes. Whether these deeper areas are natural or the result of dredging is unknown. The deepest spot sounded in the lake was 22.6 feet in the depression near the east end.

The irregular bottom near the west side of the lake is markedly different from the general bowl- or trough-like relief observed in the rest of the lake. An area of shallower water extends from the bank east and southeast from near the outlet canal. The 14-foot contour that defines the majority of the western part of the lake in this area extends eastward and the bottom rises to depths of less than 10 feet. The troughs and ries of this area are probably caused by irregular dissolution of the underlying limestone.

Relations between lake stage, surface area, and volume of Island Ford Lake are shown in figure 7. Bathymetric contours shown in figure 2 and 1-foot contour topographic maps were used to determine the surface area and volume variations of the lake with stage. At the mean stage of 39.9 feet, the surface area of the lake is 91 acres and the volume of water in the lake is 965 acre-ft. Dividing this volume by the corresponding surface area yields a mean lake depth of 10.6 feet. Above a stage of 42.7 feet, the lake would overflow in the northwest corner to the swamp west of the lake. The change in slope of the stage-area curve near stages of 26 and 30 feet above sea level is due to the relatively large flat areas of the bottom of the lake occurring at depths slightly greater than 14 feet and 10 feet, respectively.

Knowing the volume of the lake, a quantitative assessment of the surface-water inflow to the lake can be made. For example, the average outflow from the lake during 1976–84 was previously estimated to be 6.7 ft³/s, or 4,850 acre-ft per year. During the same period, annual evaporation from the lake was about 47 inches (356 acre-ft) and annual rainfall on the lake averaged 54.06 inches (410 acre-ft). Therefore, during the period 1976–84, annual net inflow to the lake from evaporation and rainfall averaged 54 acre-ft per year. The majority of outflow resulted from surface flow into the lake from Brooker Creek, combined with some smaller, unknown quantity of inflow from Crescent Lake or from the surficial aquifer. If inflow to the lake was 6.7 ft³/s and lake stage remained constant at 39.9 feet, all of the water in Island Ford Lake would be replaced on the average every 73 days. During September 1979, after 26 inches of rain in 2 months, estimated inflow averaged about 80 ft³/s, or a rate that would replace the 965 acre-ft of water in the lake every 6 days.

GEOHYDROLOGY

Aquifer Characteristics

Island Ford Lake is in a karst terrain underlain by three primary hydrogeologic units: (1) the surrounding and underlying sand, silt, and clay that comprise the surficial aquifer; (2) an areawide layer of relatively impermeable clay beneath the surficial aquifer; and (3) beneath the layer of clay, hundreds of feet of permeable limestone known as the Floridan aquifer system (fig. 8). In the area of Island Ford Lake, the freshwater-bearing part of the Floridan aquifer system is known as the Upper Floridan aquifer. The exchange of water between the lake and the two aquifers can affect the quantity and quality of lake water. Understanding the hydraulic characteristics and interrelations of the three geologic units is important in evaluating the effects of the ground-water system on the hydrology of the lake.

The surficial aquifer extends from land surface to a depth of about 50 feet. This hydrogeologic unit is saturated from the underlying clay layer upward to within 10 feet of land surface in well-drained or topographically high areas. Adjacent to lakes or swamps, the saturated zone approaches land surface. The top of the saturated zone is referred to as the water table. Recharge to the surficial aquifer is primarily by rainfall, but some recharge comes from lakes, streams, or irrigation. Most of the water that enters the aquifer in the Island Ford Lake area is returned to the atmosphere by evaporation or transpiration by plants and trees. Other loss of water from the surficial aquifer occurs as leakage to streams or lakes or downward leakage through the clay layer to the Upper Floridan aquifer. Wells finished in the surficial aquifer are used for small-scale irrigation or domestic supplies, but the quantities of water withdrawn do not significantly affect the water table.

Hydraulic characteristics of the surficial aquifer depend on the size, shape, and stratification of the materials present. Sinchir (1974) augered 59 test holes through the surficial aquifer in northwest Hillsborough County to determine hydraulic properties of the aquifer. Test holes were generally concentrated in an area about 6 miles east of the lake, but some were completed within 2 miles of the lake. Clay content in the surficial aquifer increased with depth below land surface and there was a corresponding decrease in permeability and specific yield. Laboratory determinations indicated values of vertical hydraulic conductivity ranging from 13.1 ft/d in the upper sands to 0.001 ft/d in areas of high clay or silt content or in those areas where clay was found in thin horizontal luminae within the aquifer (Sinchir, 1974). Average specific yield of samples ranged from 34.6 percent for sand to 10.4 percent for clay. Stewart (1968) reported comparable hydraulic properties for the surficial aquifer for test sites near Eldridge-Wilde well field.

Separating the sands and clays of the surficial aquifer from the underlying limestone is a layer of dense, relatively impermeable clay known as the intermediate confining unit. This clay layer has an average thickness of about 14 feet near Island Ford Lake (fig. 8). Reichenbaugh (1977) states that thickness of the clay layer ranges from 6 to 13 feet near Keystone Lake. Test wells 6 miles east of the lake indicate that the intermediate confining unit was absent at 12 of 39 test sites but, where present, averaged 4 feet in thickness with an average vertical hydraulic conductivity of $1x10^{-4}$ ft/d. This clay confining unit retards movement of water between the surficial aquifer and Upper Floridan aquifer. Where the unit is absent or has been disrupted by dissolution and collapse of underlying limestone, the potential for exchange of water between the two aquifers is increased.

Underlying the mantle of sand and clay is a series of near-horizontal limestone formations of the Upper Floridan aquifer. These limestones are highly permeable and extend for hundreds of feet below land surface. The uppermost formation, know as the Tampa Limestone, is of Miocene age and averages about 120 feet thick in areas near the lake. Beneath this formation is the Suwannee Limestone of Oligocene age. It ranges from 150 to 200 feet in thickness. Both formations have moderate to high permeability, and most domestic wells in the area are finished in either the Tampa or Suwannee Limestones. Wells in the Eldridge-Wilde and Come well fields are open to these formations and derive the majority of water from these limestones (Stewart, 1968, p. 23). The Eocene Ocala Limestone underlies the Suwannee Limestone and has a thickness of about 150 feet but does not yield as much water as the overlying formations. The Eocene Avon Park Formation extends from about 300 to 1,100 feet below sea level. This formation has high permeability near the top of the formation due largely to highly fractured zones that easily transmit water to wells. The lower part of the Avon Park Formation is less permeable and is considered the base of the Upper Floridan aquifer.

Hydraulic characteristic of the Upper Floridan aquifer and upper confining unit are determined by monitoring and analyzing water-level changes in the aquifers during pumping tests. Wolansky and Corral (1985) reported on three Upper Floridan aquifer tests within 5 miles of Island Ford Lake. Transmissivities determined by the tests ranged from 33,000 to 58,300 ft²/d. Storage coefficients ranged from $9x10^{-4}$ to $1.3x10^{-3}$. Leakance values computed for two Eldridge-Wilde test sites were $6.4x10^{-4}$ ft/d/ft and less than $1.0x10^{-3}$ ft/d/ft.

Ground Water

Island Ford Lake is a water-table lake hydraulically connected to waters of the surficial aquifer. In areas near the lake where the water table is above the lake surface, water in the surficial aquifer moves toward the lake. Water from the lake seeps into the surficial aquifer in areas adjacent to the lake where water levels are lower than the lake. Because the lake stage and surrounding water table are higher than the potentiometric surface of the underlying Upper Floridan aquifer, some water from the lake and surficial aquifer moves downward to recharge the Upper Floridan aquifer. Because of these relations, lowered ground-water levels, whether in the surficial or Upper Floridan aquifers, will result in less ground water flowing to the lake and more lake waters flowing to the ground-water system. Some lakes have been significantly lowered by a decline in ground-water levels caused by ground-water withdrawals at public-supply well fields (Stewart, 1968). Understanding the relations of the lake to water in the ground-water system is necessary to assess potential impacts on the lake.

The water table in the surficial aquifer fluctuates in response to rainfall, evapotranspiration, horizontal movement downgradient within the aquifer, and downward percolation to the underlying Upper Floridan aquifer. Water levels in the surficial aquifer also respond to changes in stage of regulated lakes. A water-level monitoring network was established to define the areal and temporal variations of water levels near Island Ford Lake. Water levels were collected monthly between May and September 1984 at 11 ponds or lakes and 8 shallow wells that were installed during the investigation.

The configuration of the water table on September 26, 1984, is shown in figure 9. On this date, the stage of Island Ford Lake was 39.7 feet above sea level. Water levels in the surficial aquifer east and south of the lake are higher than water in the lake, and flow in the surficial aquifer is generally toward the lake. West and northwest of the lake, the water table is lower than the lake stage, and water from the lake is a source of recharge to the aquifer in these areas. Water-level data collected on other dates were both higher and lower than on September 26, but configurations of water-table contours and indicated flow patterns are generally the same.

Regulation of stage by manipulation of the control structures also can alter water levels and flow between the lake and surficial aquifer. If the inflow controls to Island Ford Lake are opened and the stage rises, inflow gradients in the surficial aquifer decrease, or reverse, and outflow gradients from the lake to the aquifer increase. If the lake stage were lowered, the opposite effect would occur in the surficial aquifer, and more water would flow from the surficial aquifer to the lake.

Water levels in wells shown in figure 9 ranged from 3.1 to 9.8 feet below land surface during May through September 1984. Water levels averaged 4.9 feet below land surface south of the lake and 9.4 feet below land surface northeast of the lake. The average increase in water levels near the lake was 1.4 feet from May until August 1984, when all water levels were highest. Island Ford Lake was only 0.66 foot higher in August than in May because of stage regulation.

Approximate elevations of the potentiometric surface of the Upper Floridan aquifer for September 1984 are shown in figure 10. Throughout the area near Island Ford Lake, the potentiometric surface, although artesian, is lower than ground surface or water levels in the surficial aquifer. Movement of water within the aquifer is downgradient from areas of higher potentiometric surface to areas of lower potentiometric surface. Generally, flow would be at right angles to the contour lines or toward the southwest. The potentiometric surface at Island Ford Lake was at about 32 feet above sea level in September 1984, and the lake was at a stage of about 40 feet. The 8-foot water-level difference, or head difference, between the potentiometric surface and lake is generally at an annual minimum when both the potentiometric surface and the lake are at their annual maximum levels.

The effects of large withdrawals of water from the Upper Floridan aquifer can be seen in figure 10 near the Eldridge-Wilde and Come well fields. In September 1984, 11.8 Mgal/d were withdrawn from the Come well field. The irregular shape of the 30-foot contour line and the depression in the potentiometric surface below 25 feet in the main part of the well field are the result of this pumpage. Pumpage of 30.3 Mgal/d from the Eldridge-Wilde well field resulted in an area of water levels less than 5 feet above sea level. The effects of both well fields overlap to extend beyond well-field boundaries and decrease with distance from the well fields.

Ground-Water Surface-Water Relations

There are insufficient data to directly evaluate the long-term effect of the potentiometric surface on lake-stage characteristics. Large-scale ground-water withdrawals began in 1930 at the Come well field. Eldridge-Wilde well field began production in 1956. Stage data for Island Ford Lake were not collected until 1971, long after the potentiometric surface near the lake would have responded to well-field withdrawals. There are, however, indirect methods to assess whether ground-water levels have been lowered and whether lake stages have been altered by lower ground-water levels.

Topographic maps based on U.S. Geological Survey 1942 aerial photographs show the stage of Island Ford Lake at 39 feet above sea level. Average daily stage of the lake in the Come well field had been less than 5 Mgal/d through 1942, and drawdown of the potentiometric surface near the lake was probably negligible. Outflow from the lake was through the natural control of the swamp west of the lake before 1956, which was probably at a lower elevation than the present control. The average stage for 1971–84 was 39.9 feet above sea level. This simple comparison indicates that no long-term lowering of lake stage has occurred.

Hutchinson (1984) used a quasi-three-dimensional ground-water model to estimate the effects of well-field pumping in a 932-mi² area north of Tampa that includes 10 municipal well fields as well as the Island Ford Lake area. With all well fields pumping at their maximum permitted rates, model-simulated drawdown in the potentiometric surface of the Upper Floridan aquifer near Island Ford Lake was 10 to 12 feet below predevelopment levels. Model simulation results indicate that the maximum permitted pumping would lower the elevation of the water table between 2 and 5 feet, depending on the rate of recharge to the surficial aquifer. Because actual pumping at the two closest well fields to Island Ford Lake was less than that simulated by the ground-water model, drawdowns should be less than those computed by the model.

Monthly water levels in the Patterson Road deep well for 1963–80 are shown in figure 11. This Upper Floridan aquifer well (site R-2, fig. 10) was chosen for its proximity to the lake, length of record, and location about equidistant from the center of well-field withdrawals. Water levels at this site averaged over 23 feet above sea level during 1964–66 before declining to about 18 feet above sea level in 1972–73. This decline corresponds with increasing pumpage at Eldridge-Wilde and Come well fields, which peaked in 1972–73. Total pumpage at the two well fields increased from 23.2 Mgal/d in 1966 to 53.5 Mgal/d in 1972 and 46.5 Mgal/d in 1973. Combined pumpage at the two well fields averaged 40.0 Mgal/d during the following years of record, as shown in figure 11.

The elevation of the potentiometric surface of the Upper Floridan aquifer at Island Ford Lake was estimated as the average of monthly average water levels at wells R-2 and R-3 (fig. 10). Coincident water-level data for these sites were available for 1974–80. Continuous water-level data for site R-2 began in 1963. Estimates of ground-water levels at the lake were extended to 1963 based on water levels at this site.

Comparison of the annual average elevations of the potentiometric surface at the lake with the average combined pumpage at the Come and Eldridge-Wilde well fields yields a distinct correlation between elevation of the potentiometric surface and pumpage (fig. 12). Using only the annual average pumping rate from the two well fields, the average potentiometric-surface elevation at the lake can be estimated within 1.4 feet for any year during 1964–80. Analyses show that annual rainfall is insignificant in estimating the annual average elevation of the potentiometric surface; the relation in figure 12 includes years with rainfall ranging from 12.2 inches below normal to 13.6 inches above normal.

A lowered potentiometric surface in the Upper Floridan aquifer increases downward movement of water from the lake or surficial aquifer to the Upper Floridan aquifer. In 1964, the estimated average potentiometric surface was 32.4 feet above sea level at Island Ford Lake. Assuming the lake was near its mean stage of 39.9 feet above sea level, the head difference between water in the lake and potentiometric surface at the lake averaged 7.5 feet in 1964. In 1972, the estimated average elevation of the potentiometric surface was 26.8 feet above sea level, whereas the lake averaged 39.3 feet above sea level, or a head difference of 12.8 feet. This increase of about 70 percent in head difference between 1964 and 1972 would increase downward leakage from the lake to the Upper Floridan aquifer proportionately. Based on figure 12 and combined pumpage of 41.6 Mgal/d from the well fields in 1984, the average potentiometric-surface elevation at the lake was about 28.4 feet above sea level in 1984. The average head difference between the lake and potentiometric surface was about 11.7 feet.

Extrapolation of the relationship in figure 12 to zero pumpage and to the maximum permitted average rate of 54.2 Mgal/d would yield potentiometric-surface elevations of 37.0 and 25.8 feet above sea level, respectively. These elevations indicate that maximum well-field withdrawals would lower the potentiometric surface about 11.2 feet below predevelopment elevations. This estimate agrees well with the model-simulated drawdown of the potentiometric surface referenced earlier (Hutchinson, 1984).

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)
square foot (ft²)	0.0929	square meter (m²)
acre	0.4047	hectare (ha)
mile (mi)	1.609	kilometer (km)
square mile (mi²)	2.590	square kilometer (km²)
cubic foot per second (ft³/s)	0.02832	cubic meter per second (m³/s)
million gallons per day(Mgal/d)	0.04381	cubic meter per second (m³/s)
acre-feet (acre-ft)	1,233.6	cubic meters (m³)

Temperature in degrees Fahrenheit (°F) can be converted to degrees Celsius (°C) as follows:

°C = 5/9 (°F - 32)

National Geodetic Vertical Datum of 1929 (NGVD 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.

A comparison of the 5-year moving average of annual rainfall to hydrologic data at three sites is shown in figure 13. These hydrologic data include annual average discharges of Brooker Creek near Tarpon Springs (site BC-1, fig. 1), annual average water levels at the Patterson Road deep well, and annual average stages of Keystone Lake. Using a 5-year moving average of these data eliminates extreme fluctuation caused by very dry or wet individual years. The graphs are drawn with the average for the period of record for each data set aligned with average rainfall for the period. Stage data for Keystone Lake rather than Island Ford Lake are used because of the longer period of record at Keystone Lake. Coincident records for the two sites indicate that the stage of Island Ford Lake fluctuates closely with Keystone Lake and has averaged values 0.70 foot of Keystone Lake stage. The 5-year moving average of the annual average discharge of Brooker Creek plots above rainfall for 1955–71, then remains below the rainfall graph for 1973–84. Annual average water levels in Patterson Road deep well and Keystone Lake show a declining trend through 1975 and then recovery from 1976 through 1984. Minimum annual water levels at each site actually occurred in 1973.

Comparison of these three graphs shows a change in the relation between rainfall and water levels or discharge during the early 1970's. Recovery of ground-water levels by 1980, though still lower than those of the late 1960's, was probably due to decreased pumpage at the well fields. Stage at Keystone Lake and Island Ford Lake recovered as more water from Brooker Creek was kept in the lakes by operation of the control structures. The decrease in discharge of Brooker Creek near Tarpon Springs could have two causes: (1) lowered ground-water levels that decrease flow in the creek, and/or (2) more water retained in Keystone Lake and Island Ford Lake. If more water from Brooker Creek is necessary to maintain desired lake stages—given the observed rainfall trend—then lowered ground-water levels would be the probable cause. In summary, the effects of the ground-water system have not caused a continued decline in the stage of Island Ford Lake. However, flow in Brooker Creek has decreased as more water is lost to the ground-water system, either directly, or indirectly by maintaining lake stages.

WATER QUALITY

The value of lakes for aesthetic, recreation, and biological uses is as dependent on the quality of water in the lakes as on the quantity of water. As a lake or creek basin is changed from its natural state to one influenced or controlled by the activities of man, the potential for degradation of the water quality increases. Surface-water runoff from agricultural or residential areas can contain chemicals that make a lake unsuitable for humans or the diverse biologic community associated with healthy natural waters. Airborne pollutants can make their way to the lake as either dust or rain or rainwater. Although historical water-quality data for Island Ford Lake are sparse, water-quality samples collected as part of this investigation generally describe the present condition of Island Ford Lake as well as serve as a benchmark for assessing future water-quality changes in the lake.

Specific-conductance readings for Island Ford Lake were collected approximately five times per year during 1973–78 and 1981–84. Specific-conductance values ranged from 59 to 123 µS/cm and the 34 readings averaged 92 µS/cm. No increasing or decreasing trends could be detected since 1973. In comparison, specific conductance in Keystone Lake during the same period averaged 84 µS/cm, and the average specific conductance for Crescent Lake was 147 µS/cm. Other lakes in the vicinity where specific conductance was measured have average readings that range from 84 µS/cm for Lake Taylor to 208 µS/cm for Calm Lake (fig. 1). Specific conductance for Brooker Creek near Lake Fern (site BC-2, fig. 1), downstream from Island Ford Lake, has averaged 120 µS/cm for the 74 measurements since 1973.

Values of temperature, dissolved oxygen, pH, and specific conductance were measured throughout the water column at seven locations in the lake each sampling trip (fig. 2). Transparency of the lake water was measured using Secchi disc visibility readings. Field measurements of lake water quality varied temporally but showed little spatial variation. Results of these field determinations were as follows: Maximums and minimums shown include the extremes recorded both areally and vertically. The six samples include two collected when there was inflow from Brooker Creek, two collected shortly after cessation of inflow, and two collected during long-term no-flow conditions. The data show that the lake waters are well mixed both areally and vertically regardless of inflow conditions.

Six samples were collected during this investigation for determining dissolved ion concentrations in the lake waters. Historic samples for these constituents were not available, but samples were collected at the Brooker Creek inflow to the lake during 1966–70 (site BC-3, fig. 1). A sample from the creek also was collected in 1984. Analyses results for both sites are presented in table 2. Inflow to the lake from the surficial aquifer or from Brooker Creek can also affect lake water quality. Average ionic concentrations are presented in graphical form (Stiff diagrams) in figure