DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

HYDROLOGY OF THE CITRUS PARK QUADRANGLE,

HILLSBOROUGH COUNTY, FLORIDA

By Miguel A. Corral, Jr., and T.H. Thompson

Accompanying text for map report
Water-Resources Investigations Report 87–4166

Prepared in cooperation with the
SOUTHWEST FLORIDA WATER MANAGEMENT DISTRICT

Tallahassee, Florida
1988

ABBREVIATIONS AND CONVERSION FACTORS

The inch-pound units used in this report may be converted to metric (International System) units by the following factors:

Multiply inch-pound unit	By	To obtain
inch (in.)	25.4	millimeter (mm)
inch per year (in/yr)	25.4	millimeter per year (mm/yr)
foot (ft)	0.3048	meter (m)
foot per day per foot [(ft/d)/ft]	1.0	meter per day per meter [(m/d)/m]
mile (mi)	1.609	kilometer (km)
acre	0.4047	hectare (ha)
square foot (ft^2)	0.0929	square meter (m^2)
square foot per day (ft^2/d)	0.0929	square meter per day (m^2/d)
square mile (mi^2)	2.590	square kilometer (km^2)
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
gallon (gal)	0.003785	cubic meter (m^3)
gallon per minute (gal/min)	0.00006309	cubic meter per second (m^3/s)
million gallons per day (Mgal/d)	0.0438	cubic meter per second (m^3/s)

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

$$°F = 1.8\,°C + 32$$

* *

Sea level: In this report, "sea level" refers to the 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 of 1929."

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INTRODUCTION

The Citrus Park quadrangle comprises an area of about 65 mi^2 in west-central Florida (fig. 1). This area is a rapidly developing suburb northwest of Tampa that includes the highly urbanized, unincorporated communities of Carrollwood, Northdale, Carrollwood Village, the northern part of Town and Country, and The Plantation. The northwestern part of the Citrus Park quadrangle is rural, dotted with orange groves and pasture lands, but is becoming urbanized at a rapid rate. The area is drained by Sweetwater, Rocky, Brushy, and Dick Creeks. The northwest and north-central parts of the area contain numerous lakes that range in size from less than 1 acre to about 93 acres.

There are three well fields in the study area: Cosme, Section 21, and Northwest Regional. The Cosme and Section 21 well fields are concentrated centers of pumping where several wells are less than 1,000 feet apart. The Northwest Regional well field has distributed pumping centers where the wells are 2,000 feet apart or more (fig. 1).

The rapid increase in population and development has caused many hydrologic changes in the study area. Urbanization and channelization have diminished the amount of agricultural and forested lands, cypress swamps, and wetlands. At the same time, the demand for water has increased, resulting in an increase in the amount of water withdrawn from the aquifers for consumptive use.

In 1984, the U.S. Geological Survey, in cooperation with the Southwest Florida Water Management District, began a study to describe the hydrogeology of the Citrus Park area. The purpose of this report is to summarize the hydrologic and geologic data available for the area. Elements of the hydrologic system are interrelated, and a change in one element generally results in a change in the others. The report describes the principal aquifers, ground-water levels and movement, and the location of well fields and their impact on the hydrology of the area. Rainfall and major drainage features are described, and streamflow characteristics of the two largest streams are given. Selected water-quality data are given for both ground and surface water, and the position of the saltwater-freshwater interface is shown. These data will aid government agencies, consultants, water managers, and others in assessing the hydrologic problems that are related to development and in managing water resources of the area.

Previous Investigations

The hydrogeology of the Citrus Park quadrangle is discussed in varying detail in numerous reports by the Florida Bureau of Geology, the U.S. Geological Survey, and private organizations. Menke and others (1964) describe the hydrology of Hillsborough County and provide general information on the Upper Floridan aquifer and the effects of pumping. Cherry and others (1970) authored a report on the Middle Gulf area in which the general hydrology of Sweetwater Creek and Rocky Creek basins is presented. The hydrologic characteristics of the surficial aquifer in northwest Hillsborough County are described by Sinclair (1974).

The effects of using public-supply wells to maintain lake levels during periods of below normal rainfall are described by Stewart and Hughes

(1974). Impacts of Rocky Creek landfill for the period January 1974–October 1977 are discussed by Fernandez and Hallbourg (1979), and for the period January 1969–December 1973, by Duerr and Stewart (1981). Estimated water use in southwest Florida during 1981 and a summary of actual water use for 1970, 1975, and 1977–81 are given in a report by Duerr and Sohm (1983).

Hutchinson (1984) presents a quasi-three-dimensional finite-difference model for simulation of steady-state ground-water flow in two aquifers throughout a 932-mi^2 area that contains 10 municipal well fields; the Citrus Park quadrangle is included in this model. Piercefield-Amaden and Associates, Inc., and Reynolds, Smith, and Hills (1983) completed a feasibility study, with recommendations, of the drainage and drainage improvement for the Sweetwater Creek watershed. Results of testing for water quality and quantity from a well located south of Gunn Highway near The Plantation are described by CH2M Hill (1984).

Physiography, Topography, and Climate

The Citrus Park area is in the Gulf Coastal Lowlands physiographic province (White, 1970). Land-surface altitudes range from zero at the coast of Old Tampa Bay in the southwestern part of the area to 60 feet in the northeastern part of the Citrus Park area. Over 400 closed depressions, indicative of karst topography, occur in the quadrangle. Parts of the study area are poorly drained and remain wet throughout most years. The northwestern part contains numerous lakes, swamps, and cypress domes.

The climate of the area is characterized by warm, humid summers and mild, relatively dry winters. Summer thunderstorms frequently occur during June through September. Based on records from the Tampa weather station, about 4 miles southeast of the Citrus Park area, the mean monthly temperature ranged from 59.8 °F in January to 82.2 °F in August for the 30-year period from 1951 to 1980 (National Oceanic and Atmospheric Administration, 1982). The mean annual temperature for the period was 72.0 °F.

Figure 2 shows the annual rainfall at two sites – Cosme well field, in the northwest corner of the study area, and the Tampa Airport, just south of Town and Country at latitude 27°58′, longitude 82°32′. Rainfall at Tampa ranged from 28.89 inches in 1956 to 76.57 inches in 1959, and averaged 46.69 in/yr for the 35-year period 1951 through 1985. During the same period, rainfall at Cosme well field ranged from 33.19 inches in 1956 to 82.17 inches in 1959 and averaged 54.49 in/yr. Rainfall at the Cosme well-field station exceeded the rainfall at the Tampa station in 32 years of the 35-year period. More than 50 percent of the total annual rainfall occurs in the four summer months, June through September. At the Tampa station, total rainfall during the four summer months averages 26.50 inches. The average for the balance of the year is 20.19 inches.

HYDROGEOLOGY

Peninsular Florida is underlain by a thick sequence of sediments whose structure, lithology, and geologic history influence the occurrence, quality, and movement of water within it. The sediments, whose age ranges from Holocene to Paleocene, probably overlie a pre-Mesozoic basement of igneous and metamorphic rock (Applin, 1951). Table 1 shows the stratigraphic and related hydrogeologic units of the study area.

The principal stratigraphic units range in age from Holocene to Eocene. They are, from youngest to oldest, the surficial deposits (Holocene, Pleistocene, and Pliocene), Hawthorn Formation (middle Miocene), Tampa Limestone (lower Miocene), Suwannee Limestone (Oligocene), Ocala Limestone (upper Eocene), Avon Park Formation (middle Eocene), Oldsmar Formation (lower Eocene), and Cedar Keys Formation (Paleocene).

Hydrogeologic units of the area consist of the surficial aquifer, the intermediate confining unit, and the Floridan aquifer system (table 1). The Floridan aquifer system includes the Upper Floridan aquifer, the middle confining unit, and the Lower Floridan aquifer (Miller, 1986). Principal hydrogeologic units that contain potable water in the study area are the surficial aquifer and the Upper Floridan aquifer, which are discussed in the following section. They are separated by the intermediate confining unit that retards movement between the aquifers. The middle confining unit occurs below the Upper Floridan aquifer and is marked by the occurrence of gypsum and anhydrite filling voids in the limestone and dolomite. The Lower Floridan aquifer, which occurs below the middle confining unit, contains saline water and is not used for supply in the study area.

Figure 3 shows geologic sections A–A′ and B–B′ (located in figure 4) that generally run north-south and east-west, respectively. The sections show the general thickness of the surficial aquifer, the upper confining unit, and the top of the Upper Floridan aquifer. Following are descriptions of the individual hydrogeologic units.

Surficial Aquifer

Drillers' logs indicate that the surficial aquifer ranges in thickness from more than 50 feet to less than 5 feet in the study area and is generally less than 40 feet thick (fig. 3). It is comprised of marine and nonmarine, unconsolidated quartz sand, clay, and shells that range in age from Holocene to Pliocene. Use of water from the aquifer is generally limited to lawn irrigation and stock watering. Water is commonly obtained from small diameter, driven wells that are generally less than 25 feet deep. Yields from most wells are less than 5 gal/min.

Water levels in the surficial aquifer fluctuate seasonally in response to rainfall. Water levels decline during the dry season (October through May), generally attaining the lowest levels in May; the highest levels occur in September at the end of the rainy season.

Intermediate Confining Unit

The intermediate confining unit, comprised of sandy clay and marl, separates the surficial aquifer from the Upper Floridan aquifer. This layer ranges in thickness from less than 5 feet to 40 feet (fig. 3). The intermediate confining unit generally retards movement of water between the surficial and Upper Floridan aquifers. The leakances used by Hutchinson (1984) in a steady-state ground-water flow model of the Upper Floridan aquifer at three well fields in the study area are as follows:

Well field	Leakance [(ft/d)/ft]
Cosme	0.0003
Section 21	0.0004
Northwest	0.0003–0.0004

A leakance of 0.0003 (ft/d)/ft means that about 0.8 gal of water per year would pass through each square foot of the top of the Upper Floridan aquifer if water levels differed by 1 foot between the surficial and Upper Floridan aquifers. Assuming an average head difference of 6 feet over the 65-mi^2 study area, about 9 billion gallons of water per year (25 Mgal/d) would flow to the Upper Floridan aquifer. Water levels and differences are discussed in more detail in the section "Ground-water levels and movement."

Upper Floridan Aquifer

The top of the Upper Floridan aquifer in the Citrus Park area ranges from 40 feet below sea level to 10 feet above sea level (fig. 4). The top few feet is usually weathered limestone, sometimes referred to by drillers as "white clay" or marl because it has the appearance and texture of clay and is white in color.

The Tampa Limestone and the Suwannee Limestone are the stratigraphic units that most production wells in the area are open to (table 1). The thickness of the Tampa Limestone varies erratically from about 100 to 240 feet in short distances. The Suwannee Limestone, which immediately underlies the Tampa Limestone, has a thickness of about 200 feet (Stewart, 1968). The deeper units, the Ocala and Avon Park Limestones, may yield large quantities of water.

The Upper Floridan aquifer is an important source of water for domestic, municipal, and industrial use. The water in this aquifer is potable and available in large quantities. Large diameter municipal wells that range in depth from about 300 to 600 feet may yield up to 3,000 gal/min. Transmissivity is a measure of the ability of the aquifer to transmit water equal to conductivity times thickness. Transmissivities computed from aquifer tests in the area by Wolansky and Corral (1985, p. 65–73) range from 33,000 to 71,000 ft^2/d. Estimated average transmissivities used by Hutchinson (1984) in a steady-state ground-water flow model of the Upper Floridan aquifer at three well fields in the study area are as follows:

Well field	Transmissivity (ft^2/d)
Cosme	57,000
Section 21	51,800
Northwest	25,900–51,800

GROUND WATER

Ground-Water Levels and Movement

Rainfall either leaves an area as overland flow or streamflow, evaporates, is transpired by plants, or seeps into the ground. Recharge occurs when rainfall seeps into the ground and moves into the zone of saturation. Ground water, like streamflow, moves from local upgradient areas of high potential energy (head) toward areas of lower potential energy. It may move vertically downward to recharge an underlying aquifer, upward to an overlying aquifer, or laterally to discharge to a river or spring at the surface.

Ground water occurs either under unconfined (water table) conditions or under confined (artesian) conditions. In northwest Hillsborough County, water in the surficial aquifer is generally unconfined, whereas water in the Upper Floridan aquifer is confined.

Figure 5 shows the configuration of the water table based on water levels measured in shallow wells during May 13 to 17 and September 11 to 15, 1985. The water table in the surficial aquifer generally represents a subdued expression of the local topography. Rainfall is the principal factor that determines seasonal variations in the water table. The direction of flow in the surficial aquifer is generally to the south and southwest but may vary locally where the aquifer discharges into lakes and streams.

The Upper Floridan aquifer contains artesian water (confined between relatively impermeable beds) that rises in wells above the level at which the aquifer is penetrated. Depending on the artesian pressure and altitude of land surface, wells tapping the Upper Floridan aquifer may or may not flow at land surface. The imaginary surface indicating the level to which water in artesian wells rises is called the potentiometric surface. The potentiometric surface of the Upper Floridan aquifer is shown in figure 6. The general direction of flow in the Upper Floridan aquifer in the Citrus Park quadrangle flows from the northeast to the southwest.

Ground-water levels in the surficial aquifer are affected by rainfall, evapotranspiration, and leakance (recharge) to the Upper Floridan aquifer. Water levels in the Upper Floridan aquifer are affected by leakance and pumpage. Figure 7 shows the relation of water levels in a well open to the surficial aquifer (Cosme 1C6 shallow well, 23 feet deep) and a well open to the Upper Floridan aquifer (Cosme 3 deep well, 354 feet deep). Water levels are generally parallel during seasonal fluctuations and have nearly the same magnitude in the well field, indicating good hydraulic connection between aquifers. Water levels in the surficial aquifer are higher than levels in the Upper Floridan aquifer throughout most of the study area. The surficial aquifer recharges the Upper Floridan aquifer except near Old Tampa Bay where the potentiometric surface of the Upper Floridan aquifer is at or above land surface.

Well Fields and Ground-Water Development

The Upper Floridan aquifer is capable of supplying considerable amounts of potable water. There is concern though that the resulting drawdown in water levels induced by supply wells may cause ecological damage. The problem of excessive drawdown of the water table and potentiometric surface due to concentrated areal pumpage during dry years can be reduced by controlling pumping rates from a particular well or well fields and distributing the wells over a large area. By following these steps, drawdowns between wells and between respective well fields can be reduced, thus minimizing possible ecological impacts such as drying-up wetland areas and avoiding socio-economic problems related to lowering lake and ground-water levels.

Figure 1 shows the location of well fields in the study area and the approximate location of production wells in each well field. Wells in the Cosme, Section 21, and Northwest Regional well fields range in depth from 300 to 700 feet. Most are 12 inches in diameter and are cased from the surface to top of rock (60 to 100 feet).

Long-term records of water levels are available for Hillsborough 13 well in the Section 21 well field (fig. 1). Water levels, collected since 1944, are shown in the hydrograph of Hillsborough 13 well (fig. 8), which is 347 feet deep. Stewart (1968, p. 63) reports that water levels from 1935 through 1954 fluctuated seasonally and averaged about 48 feet above sea level. However, no significant trends or changes occurred during this period except during periods of low rainfall in 1935 and 1945 when water levels declined to about 44 feet above sea level.

Some of the impact of pumping at the Section 21 well field can be seen in figure 8. Prior to 1960, levels fluctuated seasonally between 44 and 49 feet. In 1960, drainage improvements were made in the well field (W.B. Smith, Southwest Florida Water Management District, oral commun., 1986). Rainfall was below average in 1961, and the ground-water level declined to 42 feet. Starting in February 1963 and extending through 1972, increased pumping at the Section 21 well field was the primary cause of water-level declines of about 16 feet, from 48 to 32 feet, at the Hillsborough 13 well. A brief recovery in water levels occurred in 1967 when pumpage at the Section 21 well field was decreased because the pumping was causing declines in the level of four lakes, including Round Lake and Starvation Lake (fig. 1). Water levels rose again in March 1973 when pumpage from Section 21 again decreased as the Pasco well field north of the study area began operation (fig. 8). The upward trend in the amount of ground water being pumped from areas in and around the Citrus Park quadrangle is shown in figure 9. Pumpage increased from an average of 2.3 Mgal/d in 1931 to 81.1 Mgal/d in 1980.

The impacts of well-field pumping on the potentiometric surface near Tampa was studied by Hutchinson (1984). Drawdowns caused by well-field pumping under various pumping rates and recharge conditions were simulated using a quasi-three-dimensional, finite-difference, ground-water flow model. The drawdowns shown in figure 10 (Hutchinson, 1984, p. 44) reflect the cumulative effect of pumping at the average annual permitted rate from each well field in and adjacent to the Citrus Park quadrangle during average recharge conditions. The potentiometric surface is most impacted in the well fields, but the surface is affected throughout the study area.

SURFACE WATER

Streams

There are four streams in the Citrus Park area: Sweetwater Creek, Rocky Creek, Dick Creek, and Brushy Creek. The average annual discharge of Sweetwater Creek near Sulphur Springs (site 1, fig. 1) (drainage area of 7.43 mi^2), for the period October 1951 to September 1984, was 6.56 ft^3/s. Data were collected at the gaging station 160 feet upstream from Gunn Highway. The maximum discharge for the period was 438 ft^3/s and occurred March 17, 1960. The maximum gage height (stage elevation) of 35.57 feet above sea level occurred May 18, 1979. Sweetwater Creek was dry during the entire month of June 1956 and has registered no flow for many days in some years. Since February 10, 1953, flow has been affected by a control structure situated above the gaging station. Occasionally, streamflow from Curiosity Creek in the Hillsborough River basin is diverted into the upper part of the Sweetwater Creek basin to relieve flood conditions. Figure 11 shows the average monthly discharge of Sweetwater Creek near Sulphur Springs since 1951. Since January 1970, flow from the Sweetwater Creek basin has been diverted through channel "G" (below the gaging station) to Rocky Creek.

In October 1985, a gaging station was established at Sweetwater Creek near Tampa (site 2, fig. 1) on channel "G" with a drainage area of 14.3 mi^2. From April 1964 through September 1981, discharge measurements only were collected at a nonrecording gage at the site.

The average annual discharge of Rocky Creek near Sulphur Springs (site 3, fig. 1) is 36.9 ft^3/s. Flow is measured at the gaging station approximately 1,000 feet downstream from Linebaugh Avenue and about 5.8 miles upstream from the mouth. The drainage area above the gage is 35 mi^2. The maximum discharge and gage height during the period January 1953 to September 1984 were 2,840 ft^3/s and 17.03 feet above sea level, respectively, on July 29, 1960. Rocky Creek had no flow from April 7 to May 5, 1967. Figure 11 shows the average monthly flow since 1953. Rocky Creek has been channelized (Channel "A") from the gaging station to the mouth.

Flow of Brushy Creek near Tampa (site 4, fig. 1) has been measured since October 1981. The recording gage is in Carrollwood Village, 1.0 mile south of Ehrlich Road and 2.4 miles upstream from the confluence with Rocky Creek; the drainage area at the gaging station is 13.4 mi^2. Since 1960, flow from a 6.21-mi^2 drainage area has been diverted from the Hillsborough River basin to Brushy Creek through an interceptor canal from Lake Heather, 1 mile southeast of Starvation Lake (fig. 1). The average discharge of Brushy Creek is 17.12 ft^3/s, and the maximum discharge during the period October 1981 to September 1984 was 441 ft^3/s on June 18, 1982, at which time the gage height was 36.19 feet above sea level. The minimum discharge of 0.24 ft^3/s was recorded on May 17–18, 1984, at a gage height of 32.39 feet above sea level.

Dick Creek is the smallest of the streams in the study area and has a drainage area of 0.7 mi^2. This stream has not been gaged.

Drainage Channels

The study area contains two large drainage channels, channel "A" and channel "G" (fig. 1), and numerous small channels (finger channels). The Southwest Florida Water Management District has measured 248,000 linear feet of dredged canals in the Citrus Park quadrangle from aerial photographs dated January 1971 (W.B. Smith, Southwest Florida Water Management District, written commun., 1986). Most of these channels were constructed between 1967 and 1972 by the U.S. Soil Conservation Service to reduce flooding and facilitate drainage. Both channels "A" and "G" have salinity barrier control structures near their discharge points to Old Tampa Bay. The barriers prevent seawater from Old Tampa Bay from moving up the channels during high tides and recharging the ground water with saline water. In addition to carrying floodwaters, the channels drain marshy areas and, during the wet season, maintain lower water levels in the surficial aquifer in the vicinity of the channels.

Channel "A" has a drainage area of 43.68 mi^2 (William Saalman, U.S. Soil Conservation Service, written commun., 1985). During the dry season, the salinity barrier control structure in channel "A" (dam) between State Highway 580 and Memorial Highway (fig. 1) keeps the elevation of the freshwater on the upstream side higher than preconstruction levels. U.S. Geological Survey records show a minimum gage height of 1.04 feet above sea level for Rocky Creek near Sulphur Springs (at Linebaugh Avenue just upstream from channel "A") on November 3, 1963, before construction of channel "A". On May 17, 1985, during a dry period, the water-surface elevation was 5.27 feet above sea level.

Channel "G" starts near Dale Mabry Highway, intercepts Sweetwater Creek, and joins Rocky Creek about 1,000 feet east of Sheldon Road. Channel "G's" total drainage area above the junction with Rocky Creek is 19.35 mi^2. There is a salinity barrier control structure on channel "G" about 0.25 mile upstream from Sheldon Road (fig. 1).

Lakes

There are more than 25 lakes in the study area. The lakes range in size from less than 1 acre to about 93 acres (Lake Rogers). Lakes are an important part of the development of the study area. People prefer to live near lakes because of their recreational and aesthetic values. However, residents living on lakes may become alarmed when lake levels rise or drop, threatening to inundate their property or leave their docks "high and dry." This was especially evident in the early 1970's when pumping combined with drought caused two lakes in the Section 21 well field to nearly go dry (Stewart and Hughes, 1974). Some lakes in the area have been dredged and the dredging material used as fill for development purposes. Figure 12 shows the shape of a lake bottom in its natural, undredged state. Contours of the lake bottom in figure 13 show the impacts of dredging. The closeness of the crescent-shaped contour lines in figure 13 is an indication that the lake has been dredged.

There are two types of lakes in the area, defined by their relation to the aquifers. Water-table lakes are hydraulically connected to the surficial aquifer and respond mainly to changes in the water table. Sinkhole lakes are hydraulically connected directly or through a semiconfining layer to the Upper Floridan aquifer. Changes in the water levels of these lakes reflect changes in the rate of loss to the potentiometric surface due to pumping and seasonal variations.

Factors Influencing Lake Levels

Lake levels may be affected by several factors including rainfall; evaporation and transpiration; surface inflow and outflow; ground-water inflow and outflow, which are affected by changes in water levels of the surficial and Upper Floridan aquifers; control structures; and augmentation. Of these, the two factors that most affect levels are rainfall and evaporation.

Rainfall is the main factor in determining the seasonal trend of water levels in the surficial aquifer and recharge to the Upper Floridan aquifer. During the rainy season, ground-water levels and, therefore, lake levels are generally at their highest (June through September). During the dry season (March through May), the levels are generally at their lowest. Figure 14 shows annual rainfall at the Cosme well field and the monthly average lake stage for Starvation Lake in the northeastern part of the study area and Lake Rogers in the northwestern part of the study area. These graphs indicate that extended dry periods, such as 1955–56 and 1965–71, will result in extremely low lake levels, whereas above normal rainfall, such as 1959–60 and 1983–84, will result in high lake levels.

Evaporation and transpiration are generally the least variable of the factors that influence lake levels. Although ground-water levels may vary several feet and rainfall several inches, evapotranspiration rates will vary only a few inches month to month. Normally, the maximum rates of evaporation and transpiration occur during the months of May and June, and the minimum rates occur during the months of December and January.

Surface runoff to a lake is influenced by the duration and intensity of rainfall, amount of saturation of the soils in the drainage basin, size of the drainage basin, topography, soil type, and the type and amount of vegetation. The change in lake level from runoff depends on the size of the lake, the slope of the banks, and the amount of outflow from the lake during the period of inflow.

Recharge to the Upper Floridan aquifer may occur through the semiconfining layer between the surficial and Upper Floridan aquifers. Occasionally, the confining layer beneath a lake may be breached by sinkholes. If such a collapse occurs beneath a water-table lake and the potentiometric surface is lower than the water table, as occurs in the study area, the lake could go dry in a relatively short period of time.

Levels in at least two lakes in the area are controlled by manmade structures to maintain a level above the natural overflow or discharge level. The structures help sustain or prolong levels above levels that would occur naturally without regulation.

Effects of Pumping on Lake Levels

Pumping of ground water from the Upper Floridan aquifer lowers the potentiometric surface (the greatest decline being at the pumping well) and may induce downward leakage from the water table into the Upper Floridan aquifer, lowering the water table. Lake levels in the affected area may decline as a result. Pumping of wells at great distances from a lake may not induce leakage directly from the lake but may reduce the flow of ground water that would normally flow into the lake.

According to Stewart (1968, p. 116) "Factors that determine the magnitude of the effects of pumping on lake stages and the time delay of this response include: (1) the distance between areas of pumping and lakes, (2) the rate and duration of pumping, (3) the geologic and hydrologic characteristics of the aquifer, (4) the vertical permeability and thickness of the confining beds, (5) the difference in head established between the Floridan aquifer and the shallow aquifer, and (6) the degree of interconnection between lake bottoms and the underlying unconsolidated sediments and the limestone." Hence, not all lakes respond the same way to pumping. According to M.A. Lopez (U.S. Geological Survey, oral commun., 1986), there is good statistical correlation among the potentiometric surface, pumping, lake levels, and rainfall. Changes in lake levels can be related to climatic factors and the potentiometric surface based upon regression analysis of data from lakes, wells, pumpage from well fields, and climatic data in and adjacent to the study area.

FLOOD-PRONE AREAS

Hurricanes and tropical storms can cause flooding in the study area because of tidal surges in coastal areas and overflow of streams due to heavy runoff. Isolated, heavy thunderstorms may produce local flooding.

Frequency analyses of river stage and discharge data are used for design of roads and bridges and for setting flood insurance rates. Although a structure such as a bridge or culvert is designed to carry a specified flood discharge, a rare flood event may destroy the structure. Risk, as defined by the U.S. Water Resources Council (1977), is "the probability that one or more events will exceed a given flood magnitude within a specified period of years."

Figure 15 is a composite of four flood maps published by the Federal Emergency Management Agency (1980). This figure shows low-lying areas in the north-central part of the study area that are subject to flooding from excessive rainfall and runoff during a 100-year flood event and the coastal southwest part of the study area that is subject to flooding by storm tides during the 100- and 500-year flood events. These are floods that have a probability of occurring once in 100 years and once in 500 years, respectively.

Figure 16 shows the flood-frequency curves for Rocky Creek and Sweetwater Creek. These curves indicate the frequency at which an annual peak discharge of a certain size may be expected to occur. For example, a discharge of 1,250 ft^3/s on Rocky Creek near Sulphur Springs may occur once in 10 years.

WATER QUALITY

There are areal and vertical variations in the chemical character of water from the Upper Floridan and surficial aquifers. The mineral content generally increases with depth, with distance from the recharge area, and with proximity to the coastal margins (Corral, 1983). Chloride concentration also increases with depth and proximity to the coastal margins. There are several reasons for these variations: (1) water deep in the aquifer has been in contact with rock formations longer than shallow or upgradient water, allowing soluble minerals in the aquifer to dissolve and increase the mineral content; (2) saline connate water (water that was trapped in rocks when they were formed) leaks upward into the aquifer; and (3) along the coast, seawater mixes with fresh ground water (Causseaux and Fretwell, 1983).

Most water from deep domestic and production wells in the study area meet Federal primary and secondary drinking water regulations (U.S. Environmental Protection Agency, 1975; 1977). Water from wells open to the surficial aquifer may be high in iron content. Near some landfills, water in the surficial and Upper Floridan aquifers locally contains dissolved constituents that exceed the standards. Table 2 shows the chemical quality of ground water at selected sites. Most of the wells listed in table 2 are within or near landfills (fig. 17).

Two surficial aquifer wells, sites 15 and 16, near Citrus Park (fig. 17) were sampled to detect possible contamination by organic pollutants that may be associated with citrus groves in the area. All constituents analyzed for were below detection levels.

Water-quality samples collected by Hillsborough County, Pinellas County, and the West Coast Regional Water Supply Authority from well fields in the study area indicate that ground water in the Upper Floridan aquifer is generally of potable quality. Water from these public supply wells contains concentrations ranging from 188 to 456 mg/L (milligrams per liter) for dissolved solids, from 11.5 to 107 mg/L for chloride, and from 0.05 to 3.0 mg/L for sulfate. Little background data for wells away from the landfills and well fields are available for further water-quality comparison in the Citrus Park quadrangle.

The quality of surface water generally varies with discharge. At low flow, the quality approaches that of ground water. Table 3 shows selected water-quality data for Rocky Creek near Sulphur Springs. The second highest observed dissolved constituents (196 mg/L) occurred in 1980 when discharge (3.9 ft^3/s) was the lowest observed during sampling. Conversely, the two lowest observed dissolved solids (88 and 109 mg/L) occurred during the two highest observed discharges (47 and 45 ft^3/s). Except for iron and color, the quality meets primary and secondary standards for the constituents analyzed. These data, and those published in annual data reports (U.S. Geological Survey, 1980 through 1985), suggest that there is an increase in dissolved solids transported by the stream.

LANDFILLS

Rocky Creek and Gunn Highway landfills (fig. 17) are the largest landfills in the study area. Rocky Creek landfill (also referred to as the Northwest landfill) began operations in 1970. The landfill is in the west-central part of the study area in an area that is becoming urbanized at a rapid rate. The site consists of 206.6 acres, of which 80 acres was used for the disposal of refuse and 2 acres was used for the disposal of septic-tank waste materials. The Rocky Creek landfill ceased disposal operations near the end of 1981 and has served as a refuse transfer station since 1982. Rocky Creek is at the northern and western boundaries of the landfill site, and Linebaugh Avenue forms the southern boundary (fig. 17). There are several privately owned wells about 3.25 miles southeast of the landfill that supply a small subdivision. Three public-supply well fields are in the area, one about 1 mile south of the landfill, one about 3.5 miles north of the landfill, and one about 5.5 miles northeast of the landfill.

Stewart and others (1983, p. 31–37) documented movement of leachate in the surficial aquifer away from the landfill beginning in 1974. Leachate is a malodorous liquid that results from water that has been in contact with or has flowed through refuse so that dissolved and suspended materials from the refuse are entrained by the water. Stewart and others (1983) indicated that there had been very little change in the quality of the water in the Upper Floridan aquifer at the site between 1970 and 1977. A drainage ditch that borders the landfill discharges leachate directly to Rocky Creek.

Gunn Highway landfill is about 3 miles east of the Rocky Creek landfill. This 14-acre landfill is on the west side of Gunn Highway and about 400 feet north of Sweetwater Creek (fig. 17). Hillsborough County operated this trench and fill type landfill from about 1960 to 1962. Nearly 20 years after the landfill was closed and converted to a pasture, a study by Stewart and others (1983, p. 80–85) showed that water from the surficial aquifer near the landfill had specific conductance ranging from 600 to 4,500 μS (microsiemens) indicating high concentrations of chemical constituents. The slow rate of leachate movement in the surficial aquifer makes both Gunn Highway and Rocky Creek landfills long-term, potential hazards.

SINKHOLES AND SUBSIDENCE

Sinkholes and closed depressions are common surface features in the Citrus Park area. Over 400 depressions and sinks have been observed in the quadrangle. The Upper Floridan aquifer in the area consists of limestone and dolomite that are susceptible to slow dissolution by acidic water moving through the pore spaces, fractures, and other openings in these rocks. As water continues to flow and dissolution enlarges the openings, a network of conduits and cavities develop through which ever increasing volumes of water may be transported (Sinclair, 1982).

Subsidence or collapse of the overlying materials may occur as acidic water continues to dissolve the limestone and dolomite. The land-surface depressions and related structural features thus formed are referred to as sinkholes. Sinkholes can serve as conduits for water that moves from the surficial aquifer into the Upper Floridan aquifer. Most of the lakes and cypress heads (wetland areas containing cypress trees) in the study area are remnants of old sinkholes (Sinclair and others, 1985).

Most of the study area has a relatively thick cover of materials overlying the limestone, and cover-collapse sinkholes are the predominant type rather than subsidence depressions (Sinclair and others, 1985, p. 58). The hydrogeologic sections in figure 3 show the approximate amount of cover material overlying the limestone. A collapse can be prompted by a decline in water levels that removes part of the support of the overlying materials. There were 64 small sinks reported to have formed within a 1-mile radius of the Section 21 well field in 1964 shortly after pumping was increased from 5 Mgal/d to 14 Mgal/d (Sinclair, 1982).

SALTWATER ENCROACHMENT

Saltwater encroachment into freshwater of the Upper Floridan aquifer along the coast in the study area is a major concern of water managers. Cooper and others (1964) demonstrated that freshwater overlies saltwater along the coast in a wedge that diminishes in thickness seaward. The zone of mixing of saltwater and freshwater caused by mechanical dispersion and chemical diffusion is known as the zone of transition. Boundaries of the zone of transition from saltwater (19,000 mg/L chloride) to freshwater (25 mg/L chloride) can fluctuate with changes in recharge to the aquifer and discharge and pumpage from the aquifer. Figure 17 shows the position of the 250-mg/L chloride-concentration boundary at a depth of about 100 feet in the Upper Floridan aquifer (Causseaux and Fretwell, 1982). The boundary was chosen because the maximum recommended chloride concentration for drinking water is 250 mg/L (Florida Department of Environmental Regulation, 1983).

Reduction in ground-water recharge or excessive pumpage from the aquifer can cause a reduction in freshwater head (potentiometric surface) and could cause a reduction or reversal in hydraulic gradient (slope of the potentiometric surface). The reduced freshwater head and gradient will allow saltwater to move inland. Hydraulic gradient and hydraulic characteristics of the aquifer are the most important factors in determining the rate and extent of the landward movement of saltwater.

Causseaux and Fretwell (1983) state "Water from wells open within or near the zone of transition will increase in chloride concentration if freshwater head is reduced. If the natural balance of the system is not disturbed and mixing due to pumping does not occur, chloride may return to its original concentration after the return of normal head. However, if mixing has occurred owing to pumping of water from the zone of transition, high concentration of chlorides may continue for a long period of time."

Two wells (2 and 3, fig. 17) near the interface show increases in chloride concentration during the period of record. Figure 18 shows that average chloride concentrations in water from well 3 have increased from about 300 to 340 mg/L between 1977 and 1985. Chloride concentrations in well 2, east of well 3, have increased from about 2,100 to about 2,400 mg/L between 1972 and 1985 (fig. 18).

SUMMARY

The Citrus Park quadrangle comprises an area of about 65 mi^2. Rapid urbanization and channelization of this area have altered drainage, and there has been an increase in demand for ground water for potable use.

The area is in the Gulf Coastal Lowlands, and topographic features range from an altitude of zero near the coast to 60 feet in the northeastern part of the study area. Climate of the area is characterized by warm, humid summers and mild, dry winters. More than 50 percent of the average annual rainfall occurs between June 1 and September 30.

Because the Upper Floridan aquifer is comprised mainly of rocks that are susceptible to slow dissolution by acidic water moving through the pore spaces, fractures, and other openings in the rocks, sinkholes and closed depressions are common surface features of the Citrus Park area. Some of the lakes in the area are remnants of sinkholes.

Four streams drain the study area, two of which have been channelized. The other two have been affected by diversions or channel improvements. The two largest streams in the area are Rocky

Creek and Sweetwater Creek, with average annual discharges of 36.9 ft^3/s and 6.56 ft^3/s, respectively.

Tropical storms and hurricanes can cause some localized flooding in the area by creating tidal surges and overflow of streams due to heavy runoff. The risk of flooding, however, has been diminished with the construction of two drainage channels in the lower part of the study area.

Channelization can lower the water level in the surficial aquifer and can be responsible for the lowering of lake levels in certain areas. Most of the lakes in the area are water-table lakes that reflect water-level changes in the surficial aquifer. Water levels in these lakes are mainly affected by rainfall and evaporation but also are affected by transpiration, ground-water inflow and outflow, control structures, and augmentation.

The magnitude of the effect of pumping on lake levels is influenced by (1) the distance between areas of pumping and lakes, (2) the rate and duration of pumping, (3) the geologic and hydrologic characteristics of the aquifer, (4) the vertical hydraulic conductivity and thickness of the confining beds, (5) the difference in head established between the Upper Floridan aquifer and the surficial aquifer, and (6) the degree of interconnection between lake bottom and underlying aquifers.

Water from the surficial aquifer generally is used for lawn irrigation. Wells of small diameter, driven less than 25 feet, commonly yield less than 5 gal/min, and the water generally has a high iron concentration. Leakance from the surficial aquifer is an important source of recharge to the Upper Floridan aquifer.

Potable water in sufficient amounts for most purposes comes from the Upper Floridan aquifer. Most production wells in the area tap 300 to 700 feet of the Upper Floridan aquifer.

Pumping either from the Upper Floridan or the surficial aquifers will result in lowered water-table levels and will capture some water that otherwise may have been lost to evapotranspiration from land, vegetation, and water surfaces. Consequently, pumping induces recharge and adds to the useable water supply of the area but may stress vegetation and lower lake levels. Heavy pumping may induce saltwater intrusion in areas close to the coast. Heavy pumping also may prompt sinkhole development by reducing hydrostatic support and allow a collapse of overlying materials into subsurface solution cavities.

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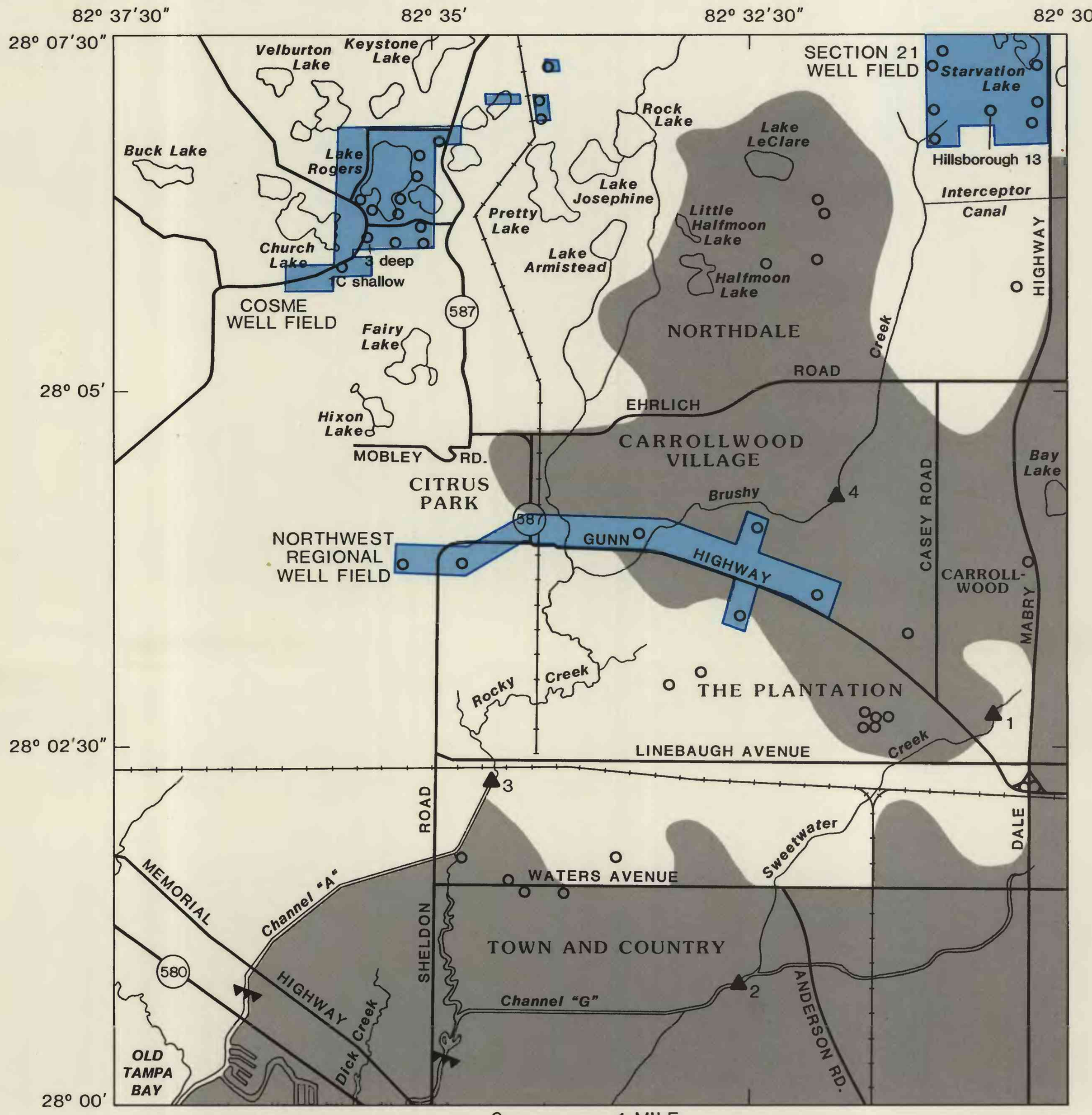
DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

Prepared in cooperation with the
SOUTHWEST FLORIDA WATER MANAGEMENT DISTRICT

WATER-RESOURCES INVESTIGATIONS
REPORT WRIR 87-4166 (one map sheet with accompanying text)



LOCATION OF STUDY AREA

0 1 MILE
0 1 KILOMETER

EXPLANATION

- Production wells, Hillsborough County
- Streamflow station and number
- Salinity barrier, water-level control structure
- Approximate area of well fields
- Approximate extent of urbanized areas, 1985

Figure 1.—Location of the Citrus Park quadrangle, well fields and production wells, streamflow stations, salinity barriers, and extent of urbanized areas.

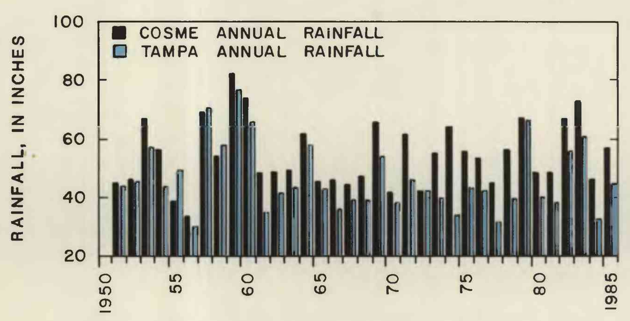


Figure 2.—Yearly rainfall at Tampa and Cosme well field.

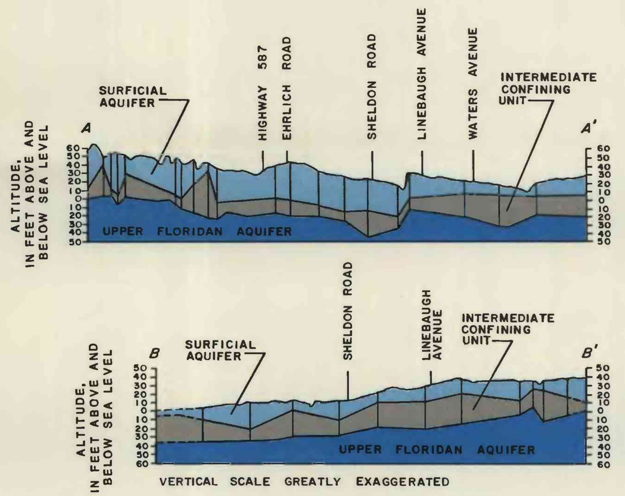


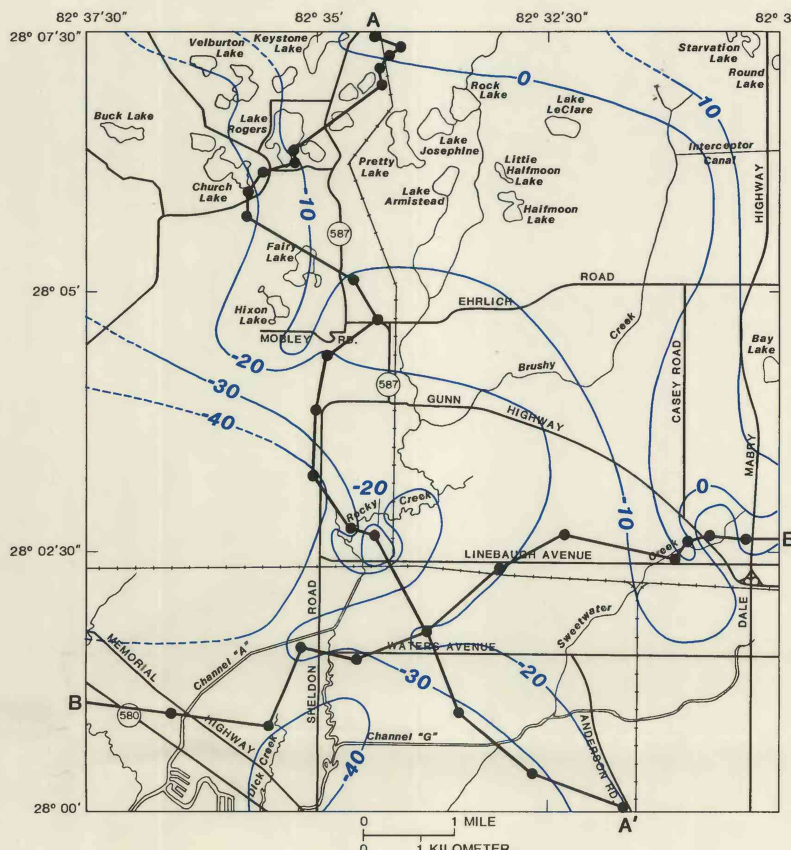
Figure 3.—Hydrogeologic sections A-A' and B-B'. (Lines of sections are shown in fig. 4.)

Table 1.--Hydrogeologic framework

[Modified from Hutchinson, 1984]

Series	Stratigraphic unit	Hydrogeologic unit		Approximate thickness (feet)	Hydrogeologic characteristics
Holocene Pleistocene Pliocene	Surficial sand and clay	Surficial aquifer		20-40	Marine and nonmarine unconsolidated quartz sand, clay, and shells. Wells generally yield less than 5 gal/min. Water is used for lawn irrigation. Contains high concentration of iron. Unit is not used for public supply.
Miocene	Hawthorn Formation; Tampa Limestone	Intermediate confining unit		10-40	Clay with traces of sand and silt. Retards downward movement of water from the surficial to Upper Floridan aquifer.
Oligocene	Suwannee Limestone	Upper Floridan aquifer	FLORIDAN AQUIFER SYSTEM	1,100	Limestone and dolomite. Production wells yield up to 3,000 gal/min. Water quality is good except where affected by saltwater intrusion near coast. Upper 600 feet is tapped by production wells. Water levels are affected by regional pumping for irrigation and municipal supply.
Eocene	Ocala Limestone; Avon Park Formation[1]				
		Middle confining unit		400	Limestone and dolomite with intergranular gypsum and anhydrite. Extremely low and low permeability. Water quality is poor.
	Oldsmar Formation	Lower Floridan aquifer		1,700	
Paleocene	Cedar Keys Formation				

[1]Based on nomenclature defined by Miller (1986).



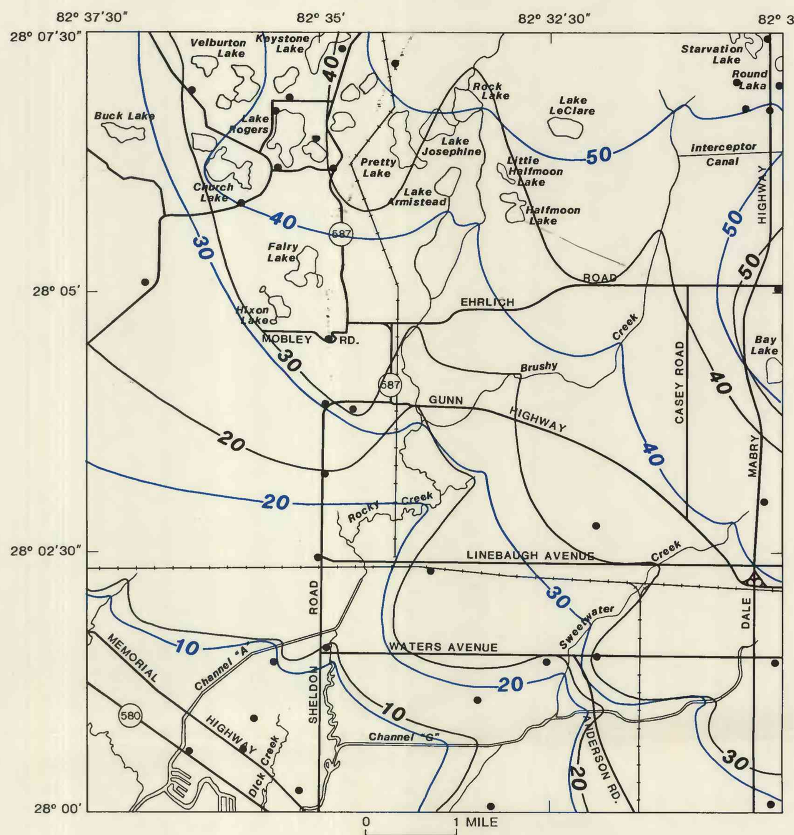
0 1 MILE
0 1 KILOMETER

EXPLANATION

--40-- STRUCTURE CONTOUR--Shows altitude of top of the Upper Floridan aquifer, dashed where approximate. Interval is 10 feet and datum is sea level

A—A' LOCATION OF HYDROGEOLOGIC SECTIONS

Figure 4.—Generalized configuration of the top of the Upper Floridan aquifer and location of hydrogeologic sections A-A' and B-B' shown in figure 3.



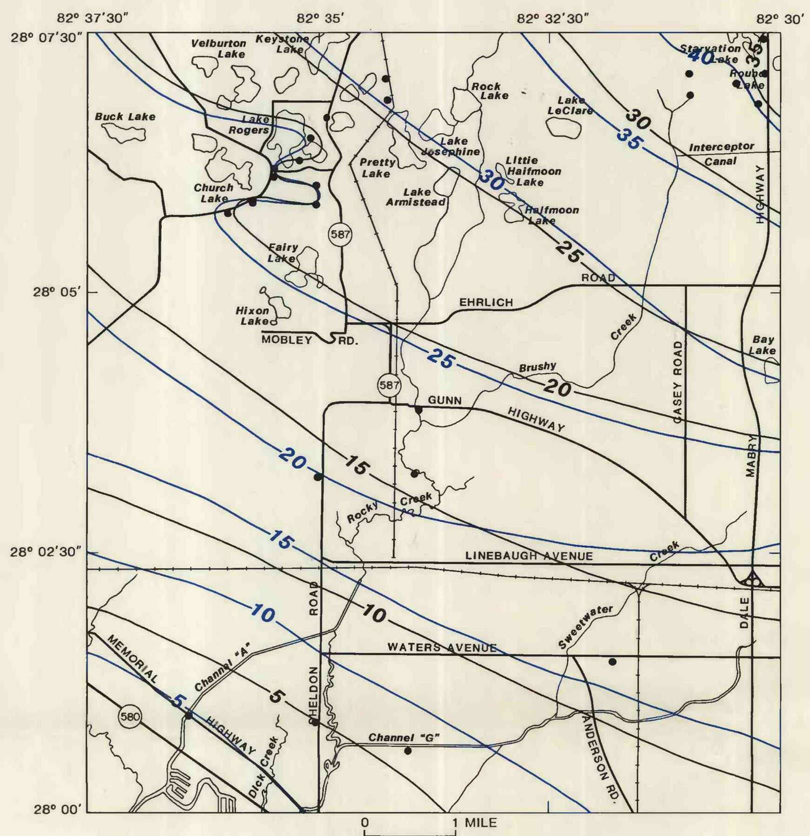
EXPLANATION

—10— MAY WATER-TABLE CONTOUR-- Shows altitude of water table in the surficial aquifer, May 1985. Contour interval 10 feet. Datum is sea level

—10— SEPTEMBER WATER-TABLE CONTOUR--Shows altitude of water table in the surficial aquifer, September 1985. Contour interval 10 feet. Datum is sea level

• DATA-COLLECTION POINT

Figure 5.—Water table of the surficial aquifer, May and September 1985.



EXPLANATION

—5— MAY POTENTIOMETRIC-SURFACE CONTOUR--Shows altitude of water levels as they would occur in a tightly cased well open to the Upper Floridan aquifer, May 1985. Contour interval 5 feet. Datum is sea level

—5— SEPTEMBER POTENTIOMETRIC-SURFACE CONTOUR--Shows altitude of water levels as they would occur in a tightly cased well open to the Upper Floridan aquifer, September 1985. Contour interval 5 feet. Datum is sea level

• DATA-COLLECTION POINT

Figure 6.—Potentiometric surface of the Upper Floridan aquifer, May and September 1985.

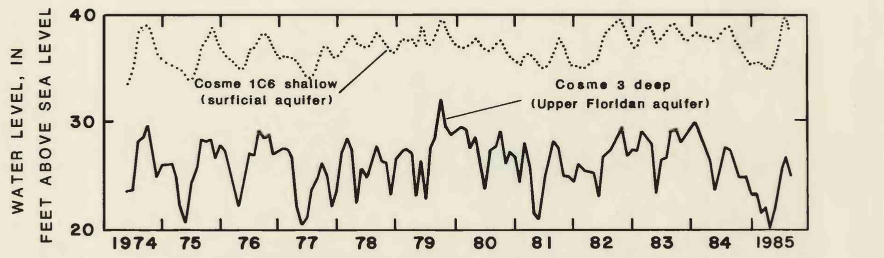


Figure 7.—Monthly means of maximum daily water levels at Cosme 1C6 shallow well and Cosme 3 deep well.

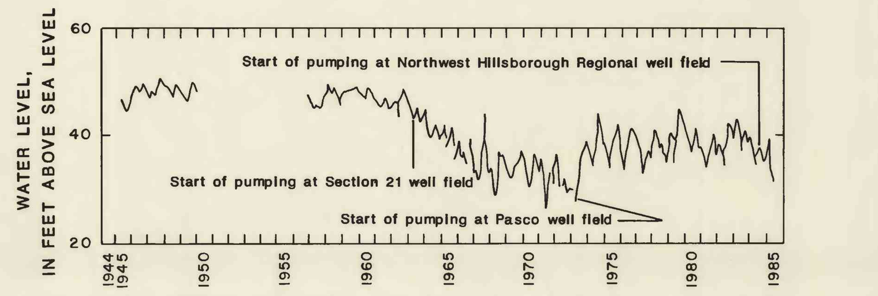


Figure 8.—Monthly means of maximum daily water levels in Hillsborough 13 well, tapping the Upper Floridan aquifer, Section 21 well field (fig. 1).

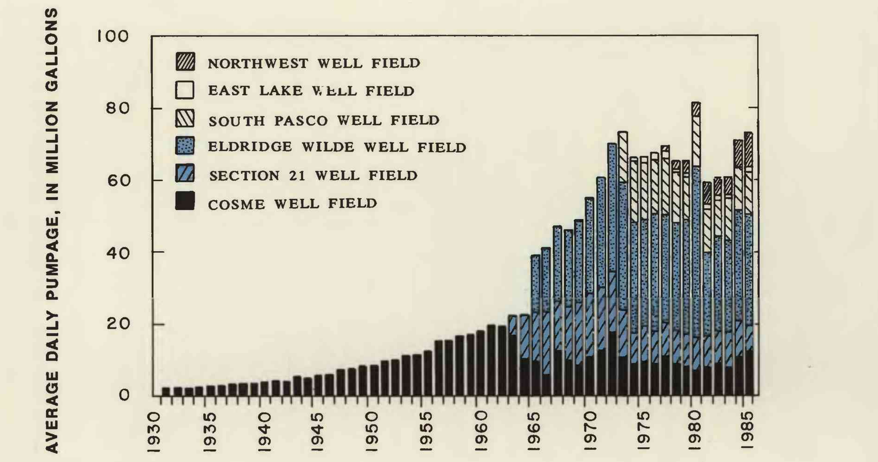
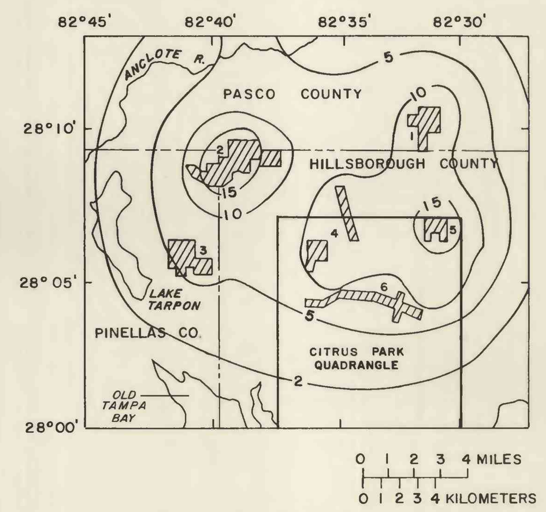


Figure 9.—Combined pumpage in the Citrus Park area.



0 1 2 3 4 MILES
0 1 2 3 4 KILOMETERS

EXPLANATION

WELL-FIELD AREA AND NUMBER-- 1 Pasco County, 2 Eldridge-Wilde, 3 East Lake, 4 Cosme, 5 Section 21, 6 Northwest

POTENTIOMETRIC SURFACE DRAWDOWN-- Simulated drawdown in the potentiometric surface of the Upper Floridan aquifer with field pumping at the annual average permitted rate, and recharge conditions are average

Figure 10.—Location of the Citrus Park quadrangle with respect to municipal well fields and model-simulated drawdown due to pumpage. (Modified from Hutchinson, 1984.)

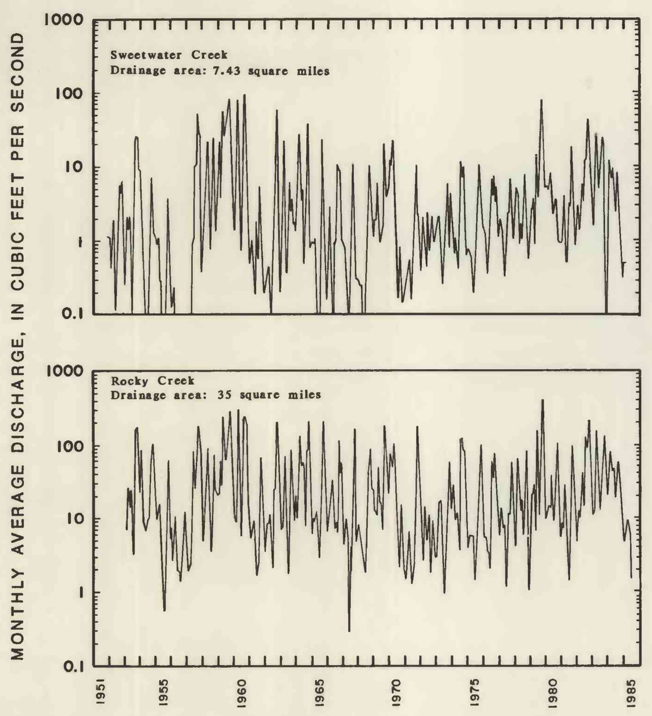
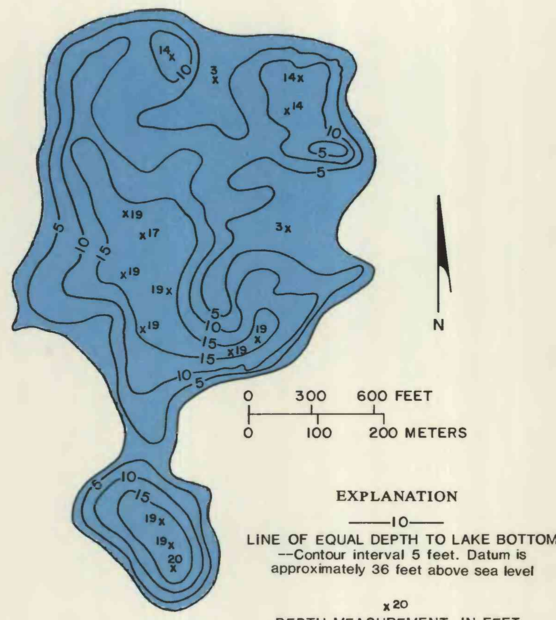


Figure 11.—Discharge of Sweetwater and Rocky Creeks near Sulphur Springs.



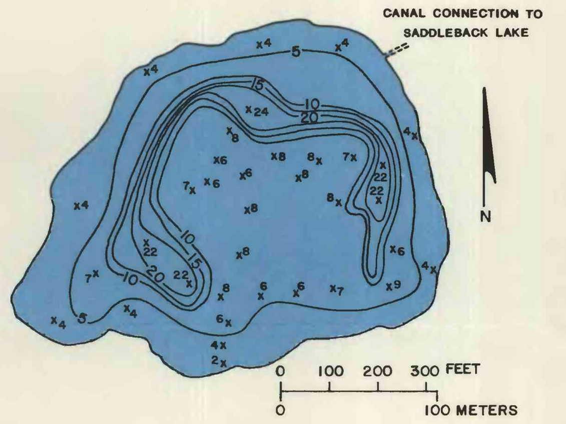
0 300 600 FEET
0 100 200 METERS

EXPLANATION

—10— LINE OF EQUAL DEPTH TO LAKE BOTTOM.--Contour interval 5 feet. Datum is approximately 36 feet above sea level

x20 DEPTH MEASUREMENT, IN FEET

Figure 12.—Bottom configuration of Lake Rogers. (Southwest Florida Water Management District, 1986.)



0 100 200 300 FEET
0 100 METERS

EXPLANATION

LINE OF EQUAL DEPTH TO LAKE BOTTOM, JANUARY 19, 1972--Contour interval 5 feet. Datum is 53.3 feet above sea level

x8 DEPTH MEASUREMENT, IN FEET

Figure 13.—Bottom configuration of Round Lake. (From Stewart and Hughes, 1974.)

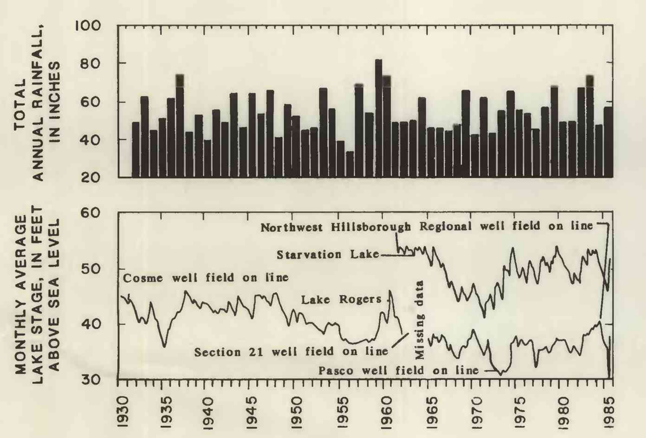
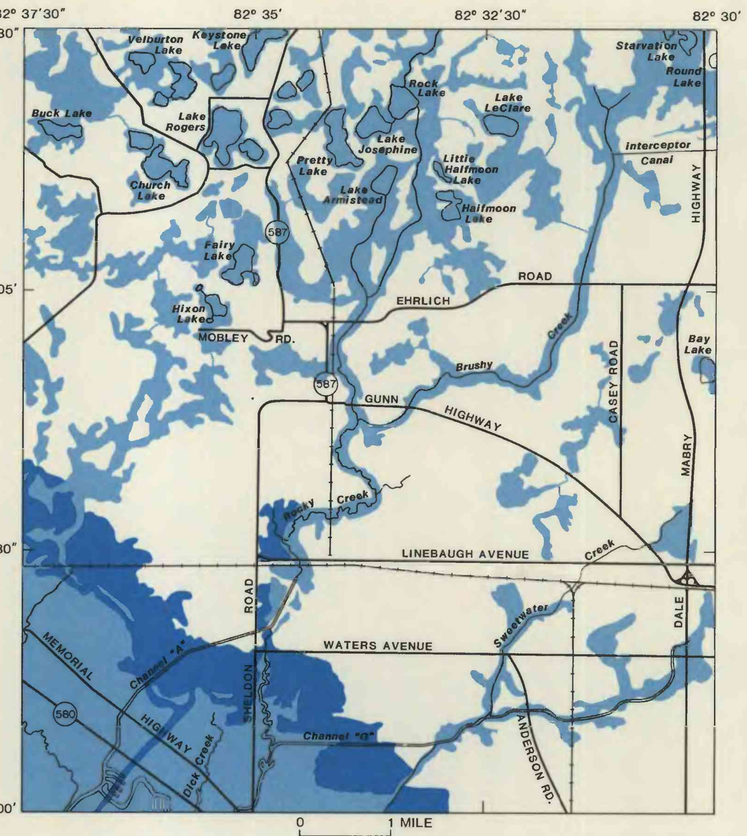


Figure 14.—Total annual rainfall at Cosme well field and monthly average lake stage of Starvation Lake and Lake Rogers, 1930-85.



0 1 MILE
0 1 KILOMETER

EXPLANATION

- Area inundated by 100-year flood
- Coastal area inundated by 500-year flood

Figure 15.—Generalized flood distribution in the Citrus Park quadrangle. (Modified from flood maps published by the Federal Emergency Management Agency, 1980.)

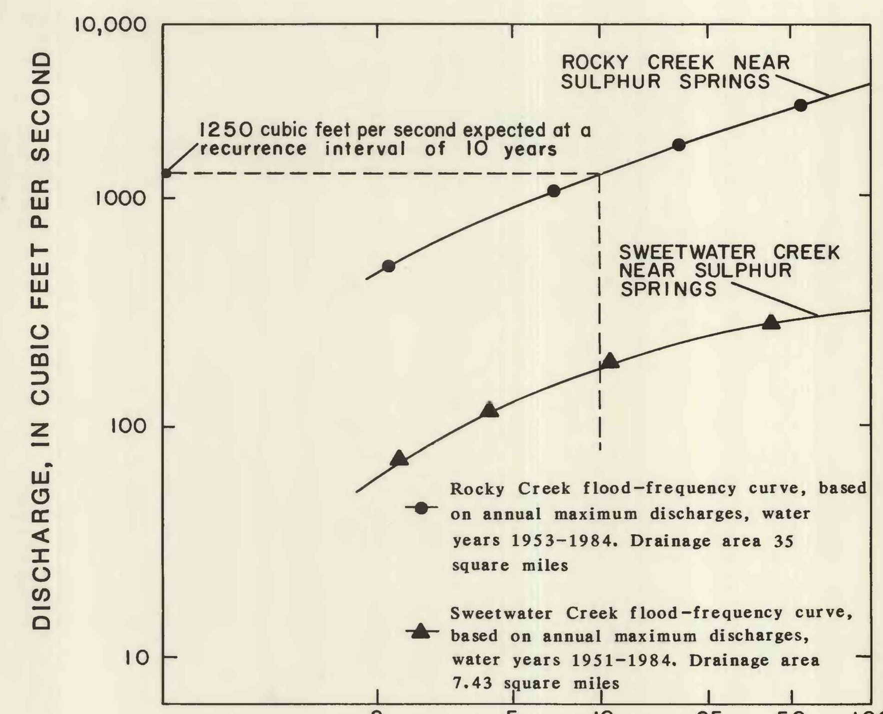


Figure 16.—Flood-frequency curves for Rocky and Sweetwater Creeks.

Table 2.--Chemical quality of ground water at selected sites

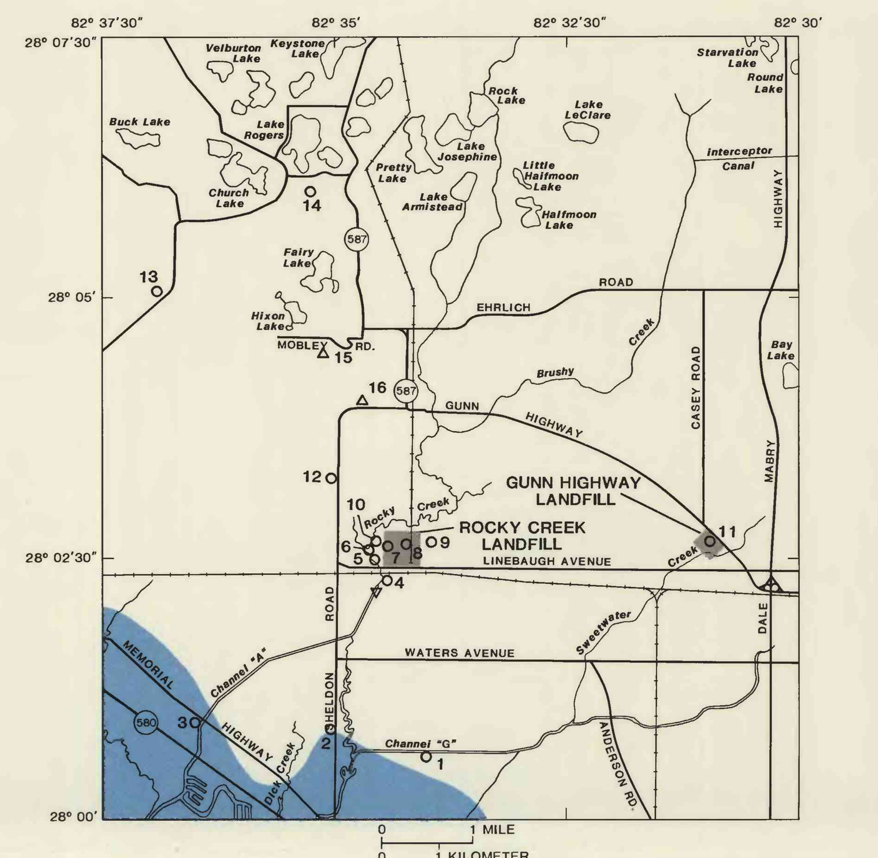
[µS/cm, microsiemens per centimeter; mg/L, milligrams per liter; µg/L, micrograms per liter; col/100 mL, colonies per 100 milliliters; K, nonideal count]

Site No. (fig. 17)	Latitude-longitude	Date sampled	Specific conductance (µS/cm)	Nitrogen, organic, total (mg/L as N)	Nitrogen, ammonia, total (mg/L as N)	Phosphorus, total (mg/L as P)	Hardness (mg/L as $CaCO_3$)	Calcium, dissolved (mg/L as Ca)	Magnesium, dissolved (mg/L as Mg)	Potassium, dissolved (mg/L as K)	Chloride, dissolved (mg/L as Cl)	Arsenic, total (µg/L as As)	Copper, total recoverable (µg/L as Cu)	Iron, total recoverable (µg/L as Fe)	Lead, total recoverable (µg/L as Pb)	Sulfate, dissolved (mg/L as SO_4)	Coliform, total (col/100 mL)	Streptococci, fecal (col/100 mL)	Solids, dissolved (mg/L)	Depth of well (feet)
1	280038082340201	6-08-83	4,250	--	--	--	--	--	--	--	1,200	--	--	--	--	230	--	--	--	--
		12-05-83	4,300	--	--	--	--	--	--	--	1,200	--	--	--	--	240	--	--	--	
		5-09-84	4,800	--	--	--	--	--	--	--	1,300	--	--	--	--	260	--	--	--	
2	280053082350202	4-04-83	7,750	--	--	--	--	--	--	--	2,400	--	--	--	--	420	--	--	--	330
		7-25-83	8,200	--	--	--	--	--	--	--	2,400	--	--	--	--	440	--	--	--	
3	280056082362701	4-06-83	1,500	--	--	--	--	--	--	--	340	--	--	--	--	74	--	--	--	121
		12-09-83	1,510	--	--	--	--	--	--	--	350	--	--	--	--	85	--	--	--	
		5-09-84	1,520	--	--	--	--	--	--	--	380	--	--	--	--	120	--	--	--	
4	280221082342901	4-20-70	375	--	--	0.06	100	38	1.9	0.6	10	--	--	--	--	.0	--	--	185	58
		10-23-70	382	--	--	--	49	18	1.0	.4	11	0.00	0.00	460	0.00	.3	--	--	171	
		12-09-75	384	--	0.45	.06	180	66	4.4	.9	11	--	--	190	--	.4	K16	<1	204	
		11-01-77	385	1.04	.38	.08	190	70	4.6	1.0	12	--	--	140	--	--	--	--	95	
		6-18-80	390	--	.41	.09	180	65	4.1	.9	12	--	--	--	--	--	--	--	90	
5	280231082343601	2-04-70	385	--	--	.01	190	70	4.2	1.5	10	10	.00	350	.00	.0	--	--	220	50
		6-15-71	375	--	--	--	--	--	--	--	20	--	--	1,200	--	--	--	--	159	
		10-25-72	360	--	--	--	390	140	9.6	.9	8.5	--	--	--	--	--	--	--	165	
	280231082343602	2-04-70	164	--	--	.18	67	23	2.4	2.4	10	--	--	--	--	7.2	--	--	87	24
		9-04-75	400	--	--	.18	130	44	5.5	1.3	89	--	--	17,000	--	--	--	--	182	
		6-19-80	430	2.4	3.10	.70	71	24	2.6	1.8	88	--	--	--	--	--	--	--	166	
	280231082343603	4-15-76	384	--	.43	.10	190	70	3.8	.8	9.2	--	--	160	--	--	K30	43	90	13
		5-17-77	395	--	.45	.15	190	71	4.1	.9	9.0	--	--	--	--	--	--	--	91	
6	280237082343801	4-24-73	357	--	--	--	170	60	4.5	1.3	13	--	--	--	--	1.6	--	--	197	49
	280237082343802	2-04-70	334	--	--	.01	160	61	1.8	.9	6.0	.00	.00	--	90	10	--	--	199	23
		4-24-73	105	--	--	--	42	15	1.0	.6	8.0	--	--	--	--	8.0	--	--	60	
	280237082343803	2-04-70	91	--	--	--	32	11	1.0	.9	4.5	10	.00	840	.00	6.0	--	--	51	14
7	280238082342601	2-02-70	285	--	--	.20	140	50	3.1	1.3	6.0	--	10	190	10	8.0	--	--	159	41
		10-22-70		--	--	--	180	64	4.1	1.2	8.0	30	.00	1,200	.00	1.9	--	--	195	
		8-13-73	385	--	--	--	180	67	3.5	1.1	7.0	--	--	--	--	--	--	--	86	
		4-09-75	447	--	--	.57	170	63	3.3	1.1	11	--	--	19,000	--	--	--	--		
		11-01-77	440	.32	.69	.12	220	83	3.8	2.1	8.8	--	--	9,700	--	--	--	--	106	
	280823808234602	2-02-70	108	--	--	--	20	6.1	1.2	.2	5.5	10	10	130	.00	.0	--	--	70	54
		10-22-70	75	--	--	--	15	4.4	.9	.3	4.0	10	.00	1,000	.00	6.3	--	--	41	
		8-27-74	128	--	.15	.04	32	8.9	2.4	<.1	27	--	--	16,000	--	--	K8,100	<1	56	
		4-16-76	220	--	.17	.14	39	10	3.4	.2	42	--	--	14,000	--	--	--	--	24	
		11-01-77	865	1.1		.04	160	33	18	10	110	--	--	18,000	--	--	--	--	249	
8	280240082343201	10-24-73	123	--	--	.02	49	18	1.1	.5	9.5	--	--	--	--	--	2	--	39	21
		8-28-74	106	--	--	3.90	44	16	.9	1.0	9.9	--	--	6,700	--	--	4,800	<1	42	
9	280241082335901	8-30-74	63	--	--	.08	11	2.9	.9	.2	12	--	--	28,000	--	--	--	--	42	18
		1-27-75	52	--	--	.11	15	4.7	.9	.1	13	--	--	21,000	--	--	--	--	37	
	280241082335902	5-15-74	457	--	--	--	240	88	5.3	.8	9.5	--	--	--	--	--	--	--	110	110
10	280242082343501	6-15-71	370	--	--	--	--	--	--	--	10	--	--	1,000	--	--	--	--	147	49
		8-08-72	370	--	--	--	200	72	4.6	.8	8.0	--	--	--	--	--	130	0.00	92	
	280242082343502	3-16-72	230	--	--	--	110	36	3.8	.5	--	--	--	--	--	--	--	--	41	20
		9-06-72	90	--	--	--	120	42	3.1	12	12	--	--	--	--	--	5,400	550	73	
11	280243082305701	7-01-70	210	--	--	--	25	6.8	2.0	3.0	27	.00	.00	--	.00	4.4	--	--	98	46
		6-24-80	68	--	--	--	--	2.0	2.6	1.8	2.0	--	--	--	--	--	--	--	--	
		6-24-80	170	.63	.01	.33	38	10	3.2	.7	14	--	--	--	--	--	--	--	40	
	280243082305702	7-01-70	198	--	--	--	25	4.9	3.1	2.2	32	10	.00	--	20	.0	--	--	93	33
		6-24-80	430	2.2	10.0	.18	71	21	4.5	8.2	34	--	--	--	--	--	--	--	70	
	280243082305703	7-02-70	765	--	--	--	110	24	12	3.6	100	20	.00	--	30	.0	--	--	373	18
		6-24-80	1,080	3.9	7.30	.19	190	49	17	3.7	75	--	--	--	--	--	--	--	275	
12	280316082345801	5-26-83	15,000	--	--	--	--	--	--	--	4,100	--	--	--	--	1,700	--	--	--	1,120
		10-05-83	13,800	--	--	--	--	--	--	--	4,500	--	--	--	--	1,700	--	--	--	
		5-09-84	16,300	--	--	--	--	--	--	--	5,000	--	--	--	--	1,900	--	--	--	
		8-07-84	13,200	--	--	--	--	--	--	--	4,500	--	--	--	--	1,800	--	--	--	
13	280504082365501	7-27-83	408	--	--	--	--	--	--	--	10	--	--	--	--	17	--	--	--	1,200
14	280614082352601	4-30-75	65	--	--	--	14	1.5	1.1	.3	10	2	3	310	1	5.1	--	--	40	20

Table 3.--Selected water-quality data for Rocky Creek near Sulphur Springs

[°C, degrees Celsius; ft^3/s, cubic feet per second; µS/cm, microsiemens per centimeter; mg/L, milligrams per liter; µg/L, micrograms per liter; --, no data]

Water-quality parameter	May 1978	October 1978	October 1979	October 1980	October 1981	October 1982	October 1983	October 1984	October 1985
Temperature (°C)	26.0	21.0	25.5	24.0	21.5	22.5	25.0	24.0	24.0
Streamflow (ft^3/s)	28.0	5.2	45.0	3.9	8.1	47.0	44.0	14.0	37.0
Stream stage (feet above datum)	5.86	5.37	5.81	5.29	--	5.77	6.23	5.65	5.29
Color (platinum-cobalt units)	180	50	120	50	50	110	--	40	120
Specific conductance (µS/cm)	178	278	102	335	120	158	245	418	265
Solids, residue at 180 °C, dissolved (mg/L)	113	187	88	196	165	109	131	229	182
Solids, sum of constituents, dissolved (mg/L)	80	160	65	170	--	80	--	--	--
Alkalinity, field (mg/L as $CaCO_3$)	21	65	36	--	--	--	--	--	--
Hardness (mg/L as $CaCO_3$)	47	84	30	84	74	44	--	--	--
Hardness, noncarbonate (mg/L as $CaCO_3$)	26	20	0	10	--	--	--	--	--
Sodium adsorption ratio	.5	1.0	.5	1.0	.9	.7	--	--	--
Potassium, dissolved (mg/L as K)	2.7	4.7	3.6	6.7	6.1	3.1	3.5	--	5.0
Chloride, dissolved (mg/L as Cl)	15	39	10	43	30	19	22	53	37
Sulfate, dissolved (mg/L as SO_4)	19	14	7.7	13	19	10	13	16	14
Fluoride, dissolved (mg/L as F)	.10	.10	.10	.10	.20	.20	.10	.20	.20
Silica, dissolved (mg/L as SiO_2)	4.0	6.9	4.4	6.2	7.5	3.9	5.2	5.3	6.0
Arsenic, total (µg/L as As)	1	1	4	1	2	2	2	1	2
Manganese, total recoverable (µg/L as Mn)	<10	30	10	50	70	10	<10	40	30
Manganese, dissolved (µg/L as Mn)	<10	20	10	50	61	9	10	32	14
Manganese, suspended recoverable (µg/L as Mn)	0	10	0	0	9	1	--	--	20
Nickel, total recoverable (µg/L as Ni)	4	5	1	1	3	3	<1	1	3
Strontium, dissolved (µg/L as Sr)	80	100	30	90	90	79	120	--	120
Zinc, dissolved (µg/L as Zn)	20	20	7	0	82	10	20	10	19
Aluminum, total recoverable (µg/L as Al)	2,500	230	70	160	190	450	170	170	10
Oxygen, dissolved (mg/L)	3.2	1.1	4.2	.5	4.7	5.5	4.3	.6	2.1
Oxygen, dissolved (percent saturation)	--	--	51	6	53	63	--	--	--
Oxygen demand, biochemical, 5 day (mg/L)	1.4	1.3	1.0	1.1	--	--	1.6	--	--
pH (standard units)	6.5	6.4	6.5	6.9	6.8	6.2	6.5	7.0	7.8
Carbon dioxide, dissolved (mg/L as CO_2)	13	50	--	--	--	--	--	--	--
Carbon, organic, total (mg/L as C)	25	13	17	12	15	12	11	7.8	20
Carbon, inorganic, total (mg/L as C)	10	22	--	--	--	--	--	--	--
Carbon, total (mg/L as C)	35	35	--	--	--	--	--	--	--
Calcium, dissolved (mg/L as Ca)	15	28	8.9	28	24	14	21	--	23
Magnesium, dissolved (mg/L as Mg)	2.4	3.5	1.8	3.3	3.4	2.1	2.3	--	2.9
Sodium, dissolved (mg/L as Na)	8.4	25	6.3	27	17	11	14	--	23
Cadmium, total recoverable (µg/L as Cd)	<2	--	<1	<1	<1	1	<1	1	1
Copper, dissolved (µg/L as Cu)	4	<2	4	3	<1	5	3	<1	2
Iron, suspended recoverable (µg/L as Fe)	--	250	--	290	280	150	130	--	110
Iron, total recoverable (µg/L as Fe)	570	430	560	980	420	410	300	810	390
Iron, dissolved (µg/L as Fe)	230	180	370	690	140	260	170	160	280
Lead, dissolved (µg/L as Pb)	23	4	1	<1	2	<1	1	1	2
Lead, suspended recoverable (µg/L as Pb)	0	5	1	<1	1	--	<1	--	<1
Lead, total recoverable (µg/L as Pb)	17	9	2	<1	3	7	1	1	2
Nitrogen, total (mg/L as N)	.68	.68	1.3	2.0	1.2	1.2	--	--	--
Nitrogen, organic, total (mg/L as N)	.54	.49	1.1	.95	.63	.79	--	--	--
Nitrogen, ammonia, total (mg/L as N)	.120	.230	.02	.85	.10	.07	.23	.07	.08
Nitrogen, nitrite, total (mg/L as N)	.010	.020	.01	.04	.02	.02	.04	.02	.01
Nitrogen, nitrate, total (mg/L as N)	.00	.14	.14	.11	.48	.29	--	--	--
Nitrogen, ammonia + organic, total (mg/L as N)	.66	.72	1.1	1.8	.73	.86	.80	.79	.98
Nitrogen, nitrite + nitrate, total (mg/L as N)	.02	.16	.15	.15	.50	.31	.60	.41	.34



0 1 MILE
0 1 KILOMETER

EXPLANATION

- Location of wells and group identification numbers used in table 2
- Stream water-quality sampling site shown in table 3
- Location of wells sampled for organic pollutants
- Approximate area of landfills
- Approximate area where chloride concentrations exceed 250 milligrams per liter at a depth of 100 feet below land surface

Figure 17.—Locations of landfills, water-quality sampling sites, and position of the saltwater-freshwater interface.

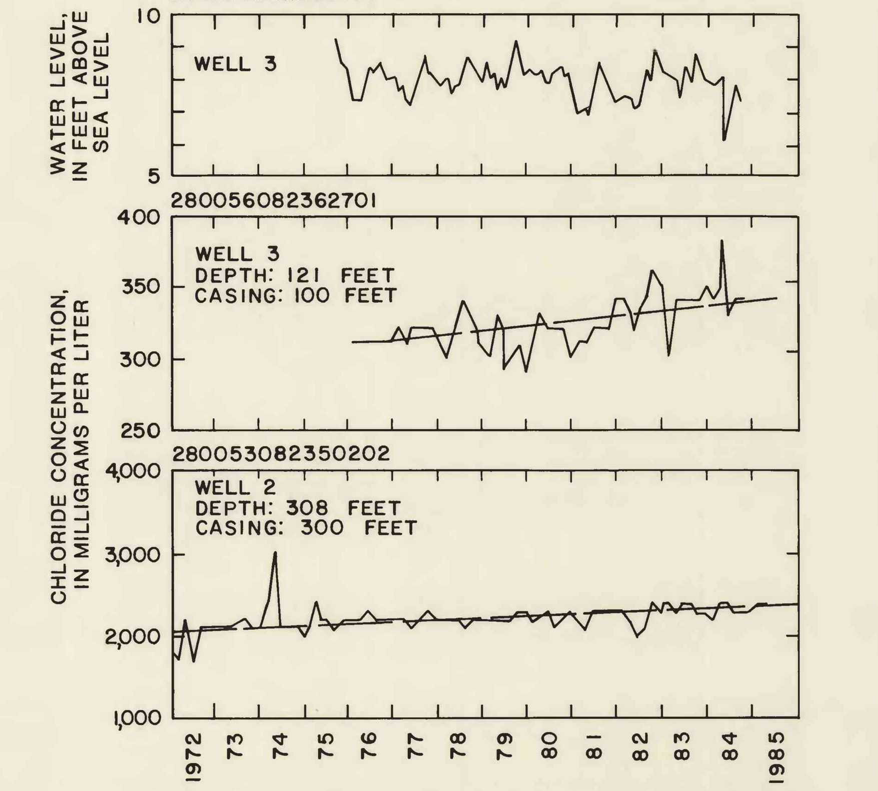


Figure 18.—Changes in water levels in well 3 (fig. 17) and changes in chloride concentration in wells 2 and 3 (fig. 17) that tap the Upper Floridan aquifer near the saltwater-freshwater interface.

HYDROLOGY OF THE CITRUS PARK QUADRANGLE, HILLSBOROUGH COUNTY, FLORIDA

By
Miguel A. Corral, Jr., and T.H. Thompson

1988