Prepared in cooperation with the
CITY OF TAMPA, FLORIDA

INTRODUCTION

The Sulphur Springs area encompasses about 56 mi² in west-central Florida and includes a highly urbanized section of the north-central part of the city of Tampa in west-central Hillsborough County (fig. 1). The area includes the city of Temple Terrace and the University of South Florida, several industrial and commercial plant sites, and a large commercial recreational site. The Hillsborough River flows southwesterly along the eastern and southern parts of the area. Most of the western half contains numerous lakes and is partly urbanized. The northeast quarter is largely swampy, but much of it is proposed for subdivision development. The northwest quarter is mostly rural, but is gradually becoming urbanized. The southeast quarter includes Temple Terrace and is highly urbanized. The west-central part has numerous sinkholes, an internally drained area, and an area that is subject to flooding. Storm runoff from two residential areas in Tampa is diverted into sinkholes that connect with the Floridan aquifer in the southwestern part of the area. Sulphur Springs, a large spring on the north side of the Hillsborough River near Interstate 275, is used as a supplemental water supply for the city of Tampa and is also a recreational area.

In 1980, the U.S. Geological Survey, in cooperation with the city of Tampa, began a study to determine the hydrogeology of the Sulphur Springs area. The purpose of the study was to provide hydrologic and geologic information that would assist managers in (1) protecting the water resources of the area, and (2) developing plans for control of construction and development where a high-water table and other hydrologic conditions are a factor. The information could be useful to evaluate the hydrologic impact of using sinkholes as stormwater retention basins, the design and construction of storm-runoff detention basins, the design and improvement of sanitary sewage system, and the location of underground utilities.

Previous and Present Investigations

Information on the hydrology and water quality of the area is included in a report by Menke and others (1961). Map reports of Lake Magdalene (Hunn and Reichenbaugh, 1972) and Lake Carroll (S.E. Henderson, U.S. Geological Survey, written commun., 1982) describe the general hydrology and geology at these lakes. Stewart and Hughes (1974) evaluated the effects on the Floridan aquifer of using ground water to maintain lake levels in the northwestern part of the area. Goetz and others (1978) evaluated the water-supply potential of the lower Hillsborough River. Maps that show the water table of the surficial aquifer and the potentiometric surface of the Floridan aquifer are prepared twice a year through a cooperative program with the Southwest Florida Water Management District. Hydrologic reports that contain data for several hydrologic monitoring stations in the area are published annually by the Geological Survey.

During this investigation (1981), field work included an inventory of wells and sinkholes, collection of water samples for coliform bacteria analyses from Sulphur Springs and three sinks, determination of peak water levels of the 1979 flood in the area, and measurements of water levels in wells for use in preparation of water-level and potentiometric-surface maps.

Climate

The climate of the area is characterized by warm, humid summers and mild, dry winters. An outstanding feature of the climate is the summer thunderstorms that frequently occur late in the afternoon during June through September. Based on records for the 40-year period from 1941 to 1980 at the Tampa weather station about 5 miles west of Sulphur Springs, the mean monthly temperature ranged from 60.9°F in January to 82.0°F in August (National Oceanic and Atmospheric Administration, 1981). The mean annual temperature for the period was 72.2°F. The average annual minimum and maximum temperatures were 63.3°F and 81.1°F, respectively. During the 40-year period, the mean monthly precipitation ranged from 1.61 inches in November to 8.01 inches in August. The mean annual precipitation was 48.71 inches, of which about 60 percent occurred during June through September.

Topography

Land-surface elevations range from less than 5 feet above sea level near the Hillsborough River in the southwestern part of the area below the Tampa Dam to 75 feet above sea level at Temple Terrace. The 5-, 25-, 35-, 50-, and 75-foot land contours are shown in figure 1. A conspicuous feature is the 8-mi² swampy area in the northeastern part of the area (fig. 1). Parts of the swamp are 25 to 35 feet above sea level, but most are less than 25 feet above sea level. Much of this area is poorly drained and remains wet throughout most years. Land-surface elevations are less than 25 feet above sea level in an internally drained sinkhole complex and several lakes in the west-central part of the area.

Streams

The principal stream in the Sulphur Springs area is the Hillsborough River. The average annual discharge of the river at the Tampa Dam (fig. 1) was 593 ft³/s for the period 1938 to 1978. The maximum discharge was 16,500 ft³/s in September 1933. The river did not have any flow for short periods during several years. Monthly mean discharges of the river at the Tampa Dam are shown in figure 2. The Hillsborough River is the principal source of water for the city of Tampa.

Other streams in the area include Cypress Creek and its principal tributary, Thirteenmile Run, in the northeastern part of the area; Sweetwater Creek in the northwestern part; and Curiosity Creek in the west-central part. The average daily discharge of Cypress Creek, about 5 miles northeast of Sulphur Springs, was 91.4 ft³/s from 1964 to 1980. The maximum discharge was 1,750 ft³/s that occurred in August 1965; periods of no flow occur during most years. The headwater of Sweetwater Creek is a series of interconnected lakes (fig. 1) that include Chapman Lake, Lake Magdalene, Bay Lake, and Lake Ellen. The creek discharges into Old Tampa Bay about 8 miles southwest of Lake Ellen. The average daily discharge of Sweetwater Creek at a station about 3.5 miles southwest of Lake Ellen was 7.3 ft³/s from 1951 to 1979. Extremes in discharge ranged from 438 ft³/s in March 1960 to periods of no flow during some years. Curiosity Creek is an intermittent stream that begins in a swampy area on the east side of Sweetwater Creek near Lake Gass (fig. 1). The creek drains an area of 3.45 mi² and flows into a sinkhole in an internally drained area about 3 miles south of the lake. During calendar years 1979-80, the maximum flow of Curiosity Creek from 1.37 mi² of its basin was 28 ft³/s, but there were extended periods of no flow during both years.

Lakes

All lakes are in the western half of the study area. Lakes Carroll and Magdalene, the largest lakes (fig. 1), are in a highly urbanized area. Lake Carroll has a surface area of about 195 acres and Lake Magdalene about 232 acres. During 1946-80, the maximum daily elevation of Lake Carroll was 40.08 feet above sea level, and the minimum daily elevation was 32.35 feet. During the same period, the maximum daily elevation of Lake Magdalene was 51.00 feet above sea level, and the minimum daily elevation was 41.96 feet. Depths of Lake Carroll and Lake Magdalene are shown in figures 3 and 4. Lakes Charles, Saddleback, Round, and Crenshaw in the extreme northwest corner of the study area (fig. 1) are augmented with water pumped from Floridan aquifer wells (Stewart and Hughes, 1974). Depths of Saddleback Lake and Lake Charles are shown in figures 5 and 6.

GENERAL GEOLOGY

The Sulphur Springs area is overlain by surficial deposits of sand and clay that range in thickness from less than 30 feet near the Hillsborough River to more than 90 feet at Temple Terrace (fig. 7). The lower part of the surficial deposits consists of clay, sandy clay, and clayey sand that confine the Floridan aquifer throughout most of the area. The confining layer is about 10 feet thick near the south-central part of the area, about 40 feet thick in the northeastern and southwestern parts, and about 20 feet thick south of the Hillsborough River (fig. 8). Generally, the confining layer is thicker in the western half than in the eastern half. Carr and Alverson (1959) report the occurrence of patches of the Hawthorn Formation (confining layer) in the southeastern corner of the area, largely at Temple Terrace. Isolated patches of the Hawthorn Formation also occur along the south side of the Hillsborough River south of Temple Terrace. In the Sulphur Springs area, the Tampa Limestone forms the upper part of the Floridan aquifer. The generalized configuration of the top of the Floridan aquifer ranges from 60 feet below sea level in the northwestern part to about 20 feet above sea level in the western part (fig. 9). Geologic formations below the Tampa Limestone, in descending order, are the Suwannee Limestone, Ocala Limestone, Avon Park Limestone, and the Oldsmar Limestone.

Generalized geologic sections of the study area are shown in figures 10 and 11. Section A-A′ (fig. 10) extends from the lake area in the west to the large swampy area in the northeast. The confining layer is fairly uniform along the section and ranges in thickness from about 20 to 30 feet. Section B-B′ is south of the lake area, and the confining layer is thickest in the western part (about 40 feet) and is thinnest in the eastern part (about 20 feet).

Extensive cavity systems have been encountered during test drilling and during excavating for commercial and industrial plant sites between Busch Boulevard and Fletcher Avenue, about 2 miles east of Interstate 275. Large quantities of cement have been pumped into the cavities to strengthen structure foundations. There is an extensive cavity system in the Floridan aquifer from Sulphur Springs northward for about 2 miles or more and a fairly extensive and well-developed cavernous zone at depths of 120 to 180 feet below land surface in the Temple Terrace area (Stewart and others, 1978).

HYDRAULIC PROPERTIES OF THE FLORIDAN AQUIFER

The quantity of water that an aquifer will yield to wells depends, in part, upon the hydraulic characteristics of the aquifer and its overlying and underlying confining beds. The principal characteristics are: transmissivity (the ability of the aquifer to transmit water), storage coefficient (the ability of the aquifer to store water), leakance (the ability of the confining beds to transmit water vertically from an underlying or overlying aquifer into the pumped aquifer), and hydraulic conductivity (the ability of the aquifer to transmit water through a unit area of the aquifer).

The transmissivity of the Floridan aquifer in the Sulphur Springs area is for the most part high, but variable. Stewart and others (1978) reported a transmissivity of 1.3×10^5 ft²/d and a storage coefficient of 3.4×10^{-4} for the Temple Terrace area. Ryder and others (1980) derived a transmissivity of 6×10^5 ft²/d from model calibration of a well field that included the northeastern part of the Sulphur Springs area. The leakage coefficient ranges from 2×10^{-4} to 8×10^{-3} (ft/d)/ft. Hutchinson and others (1981) derived a transmissivity of 2×10^5 ft²/d from a two-dimensional model that included part of the area along the Hillsborough River.

A hydraulic conductivity of 1.9×10^6 ft/d was obtained for a cavernous area north of Sulphur Springs using the results of two dye tests. It appears that most ground-water flow in this area is in the upper 100 to 200 feet of the Floridan aquifer. Because of the highly developed cavity system, estimated transmissivity for the Floridan aquifer is on the order of 2×10^6 ft²/d. The storage coefficient is estimated to be 1×10^{-3}.

The transmissivity of the Floridan aquifer in the northwestern part is 7.3×10^4 ft²/d, the storage coefficient is 5×10^{-4} (Stewart, 1968), and the leakage coefficient is 2.0×10^{-4} (ft/d)/ft. In an area 2-1/2 miles east of the northeastern part of the study area, Stewart (1977) reported a transmissivity of 1.3×10^5 ft²/d and a storage coefficient of 2×10^{-4} from test pumping a large-diameter sinkhole about three-fourths of a mile south of the Hillsborough River.

Based on the above studies completed in or near the Sulphur Springs area, transmissivity ranges from 7.3×10^4 ft²/d in the northwestern part to 1.3×10^5 ft²/d in the northeastern part and to 2×10^6 ft²/d north of Sulphur Springs. The transmissivity is generally highest near the Hillsborough River. Values obtained for transmissivity, leakage coefficient, and hydraulic conductivity indicate that the Floridan aquifer is highly productive in the study area.

WATER LEVELS

Water levels of the surficial aquifer and the potentiometric surface of the Floridan aquifer for May 1981 are shown by figures 12 and 13. Water levels in the surficial aquifer ranged from 20 feet above sea level in the southern part to 60 feet above sea level in the Temple Terrace area (fig. 12). High water levels in the southeastern part of the area are due largely to the low hydraulic conductivity of the greenish-gray clayey sands of the Hawthorn Formation. The material has a low permeability and restricts vertical movement of water from the surficial aquifer to the Floridan aquifer. Water levels in the surficial aquifer throughout the area ranged from 5 to 45 feet above the potentiometric surface. The highest water levels occur in topographically high areas, and the lowest water levels occur in topographically low areas. An area of low water levels, indicated by the 20- and 25-foot contours near Interstate 275, extends south of Fowler Avenue to the Hillsborough River and includes several well-developed and prominent sinkholes north of Sulphur Springs.

During May 1981, water levels in the surficial aquifer below Tampa Dam were less than 20 feet above sea level near the Hillsborough River and probably were less than a foot above sea level where the aquifer discharged into the river. In the tidal reach below the dam, the stage of the Hillsborough River ranged from less than 2 feet below sea level to less than 3 feet above sea level. Water levels in the surficial aquifer above the dam were less than 25 feet above sea level near the river and were less than 16 feet above sea level at the river. The stage of the Tampa reservoir was 16 feet above sea level. Thus, the surficial aquifer in the area is a source of ground-water discharge to the river, both upstream and downstream from the Tampa Dam.

In May 1981, the potentiometric surface of the Floridan aquifer ranged from 10 feet above sea level in the southern part of the area to 45 feet above sea level in the northern part. Figure 13 shows the general direction of ground-water movement by flow lines drawn normal to the contour lines. Ground-water movement is southerly from a potentiometric high in the northwestern part. In the southern part, most ground-water flow lines tend to converge towards Sulphur Springs and the Hillsborough River.

During May 1981, the potentiometric surface along the Hillsborough River channel below Tampa Dam was about 10 feet above the stage of the river. The head difference between the river and the Floridan aquifer indicates an upward pressure gradient along this part of the channel and represents potential discharge of water from the Floridan aquifer to the river. However, a test hole drilled in the riverbed in 1961, about half a mile southwest of Sulphur Springs, penetrated a green, sandy clay from 8 to 18 feet below sea level. This material forms the confining bed that overlies parts of the Floridan aquifer in the southeastern part of the area and, if unbreached, would restrict upward movement of Floridan aquifer water. Above the dam, the potentiometric surface of the Floridan aquifer under the reservoir area was 3 to 6 feet lower than the stage of the reservoir. Under this condition and assuming an absence of a confining layer, a potential exists for the reservoir to recharge the Floridan aquifer. Conversely, if the reservoir stage declines below the potentiometric surface, then the aquifer has the potential to discharge to the reservoir. The Floridan aquifer in the study area is recharged by leakage from the surficial aquifer and through sinkholes in internally drained areas that are directly and indirectly connected with the Floridan aquifer.

Based on the May 1981 potentiometric map, a ground-water gradient of about 15 feet in 1.8 miles (30- to 15-foot contours, fig. 13) exists west of Interstate 275 between Fletcher Avenue and Busch Boulevard. Immediately south, the gradient decreases to 5 feet in 1.5 miles, or a reduction of about 60 percent. The decrease in gradient is due (1) to an increase in transmissivity of the Floridan aquifer in the southern part of the area, and (2) to a change from an area of lateral or downward ground-water flow in the northern part of the area to one of upward ground-water discharge at Sulphur Springs and the Hillsborough River.

FLOODS

The west-central part of the Sulphur Springs area between Fowler Avenue and Busch Boulevard and west of Florida Avenue has flooded on numerous occasions during the past 25 years. Pride (1962) delineated the September 1960 flood areas along the Hillsborough River; Murphy and others (1982) prepared a report that delineated areas that were flooded during August-October 1979; and the city of Tampa Public Works Department (D.J. Terp, Chief Engineer, written commun., 1981) prepared maps that show areas flooded during floods occurring between September 1957 and September 1979. The 1960 and 1979 flood areas are shown in figure 1. These dates were selected to show flooding that occurred along the Hillsborough River and in the Fowler Avenue-Busch Boulevard area west of Florida Avenue.

WATER USE

In 1980, the city of Tampa pumped an average of 48.5 Mgal/d from the Hillsborough River Reservoir above the Tampa Dam (Duerr and Trommer, 1981). An additional 5 Mgal/d was pumped from Sulphur Springs in October, and 11.5 Mgal/d was pumped in November. The city also pumped 15.2 Mgal/d from its Morris Bridge well field located about 9 miles northeast of Sulphur Springs and about 1 mile east of the northeast corner of the study area. Sulphur Springs is used as a source of supplemental water supply during periods of low flow in the river and when water demands are high. The water from the spring is carried by pipeline and discharged into the Tampa Reservoir near the dam.

Water use in the area in 1980 (Duerr and Trommer, 1981) included the following:

	Quantity pumped (Mgal/d)
Ground water	
Public water supplies:	
City of Tampa (Sulphur Springs)	1.38
City of Temple Terrace	2.13
Florida Citrus Water Company (Carrollwood area)	.77
University of South Florida	.40
Industrial and commercial	1.50
Irrigation	1.00
Air conditioning	.02
Total ground water	7.20
Surface water	
Public water supply:	
City of Tampa (Hillsborough River)	48.5
Total surface water	48.5

SPRINGS

One large spring, Sulphur Springs, and two small springs, Lowry Park Spring and Temple Terrace Spring, are near the Hillsborough River (fig. 1). Sulphur Springs is about a quarter of a mile east of Interstate 275; its discharge ranged from 22 to 39 Mgal/d during 1980. Lowry Park Spring (discharge less than 10 gal/min) is on the west side of the river about two-thirds of a mile west of Interstate 275. Temple Terrace Spring, on the north side of the Hillsborough River in Temple Terrace, discharges about 75 gal/min. This spring was the original water supply for the city of Temple Terrace, but its use as a source of water was discontinued in the early 1940's.

Sulphur Springs is about 300 feet north of the Hillsborough River (fig. 1). The spring pool is used for swimming and is about 30 feet deep. The swimming area consists of a 90-foot circular pool with concrete retaining walls. The pool level is controlled by two fixed-crest weirs and a hand-operated gate. The average discharge based on records for 21 years (1960 through 1980) was 27.1 Mgal/d. The extremes in discharge during the 21 years were 91.4 Mgal/d in 1945 and 2.5 Mgal/d in 1971. The monthly mean discharge of the spring into the Hillsborough River for 1961-80 and the monthly mean diversion to Tampa Reservoir are shown in figure 14.

The discharge of Sulphur Springs is related to the elevation of the potentiometric surface of the Floridan aquifer. A linear relation between spring discharges and water levels at well 66, 1.5 miles northwest of the springs (fig. 1), has an average multiple correlation coefficient of 0.90 and an average standard error of estimate of 53 percent. Analyses of spring discharge and stages of Tampa Reservoir do not show any significant relation.

Rosenau and others (1977) stated that water-quality data collected at Sulphur Springs from 1946 to 1972 showed a gradual deterioration in quality. During the 26-year period, specific conductance increased from 260 to 1,240 micromhos per centimeter (μmho/cm); dissolved solids concentrations increased from 480 to 680 milligrams per liter (mg/L); sulfate concentrations increased from 60 to 100 mg/L; and chloride concentrations increased from 160 to 230 mg/L. Menke and others (1961) stated that a hydraulic connection may exist between the spring and other aquifers at depths greater than that penetrated by existing wells in the area. The source of the mineralized water in the spring probably originates in the deep zones of the Floridan aquifer at depths below the bottoms of existing wells in the area.

A pump was installed in Sulphur Springs in May 1964 to provide Tampa with a supplemental water supply of about 20 Mgal/d during periods when the stage of the Hillsborough River is low and water demands are high.

According to Menke and others (1961), concentrations of dissolved materials in Sulphur Springs fluctuate with the stage and discharge of the spring. Specific conductance and chloride and dissolved solids concentrations showed increases during periods when the water level in the pool was lowered. Plots of discharges and concentrations of selected constituents for the period 1946-80 are shown in figure 15. Specific conductance had the largest change with increased discharge of the spring; chloride and sulfate concentrations had the smallest changes with increased discharge. The pool level in Sulphur Springs is controlled by a hand-operated gate on the west side of the pool. If the spring pool is artificially lowered, discharge of the spring is increased for any given potentiometric head, and the quality of the water differs from that during like discharges at high or normal pool levels. The scattering of points showing chloride and sulfate concentrations and specific conductance in figure 15 is due to sampling of the spring when the pool level was artificially lowered below normal operating level. The data illustrate that the chemical quality of water in Sulphur Springs is related to the head of water maintained in the spring pool.

TOURIST CLUB WELL

A plot of chloride concentrations versus specific conductance of water from an unused Floridan aquifer well about 440 feet southeast of Sulphur Springs and 140 feet north of the Hillsborough River is shown in figure 16. The well is 318 feet deep and is cased to 80 feet, or about 60 feet into the upper part of the Floridan aquifer. A linear regression equation of chloride concentrations as a function of specific conductance, determined for the well, is as follows: chloride (mg/L) = $-336 + 0.334 \times$ specific conductance (μmho/cm). The correlation coefficient is 0.97.

Specific conductance and chloride concentrations of water in the well have increased steadily since about 1971. During the period 1959-81, chloride concentrations ranged from 200 to 4,800 mg/L (fig. 17). During the same period, specific conductance ranged from 1,000 to 15,500 μmho/cm. The high values of specific conductance and chloride concentrations indicate that mineralized water occurs below 80 feet (bottom of well casing) and, in all probability, at a depth greater than several hundred feet. Menke and others (1961) indicated that highly mineralized water in the area is derived from below the Ocala Limestone and is related to connate water in older rocks that has not been flushed by freshwater.

A plot of the potentiometric head in the Tourist Club well and the discharge of Sulphur Springs for the period 1963-81 is shown in figure 18. The data are included to show the relation between the discharge of the spring to corresponding changes in potentiometric head in the well. Data for the Tourist Club well were used because minimum pool levels were not available for Sulphur Springs. For spring discharges of less than 45 ft³/s, the potentiometric head in the well ranged from 7.8 to 10.7 feet above sea level; for discharges greater than 45 ft³/s, the potentiometric head ranged from 7.2 to 12.0 feet above sea level. The plotted points in figure 20 indicate that the potentiometric head at the well approached equilibrium during periods when spring discharge was less than about 45 ft³/s. Large increases in spring discharge occurred during maximum opening of the gate. The scattering of points in figure 18 resulted from periodic and erratic opening of the gate to flush the spring pool.

SINKHOLES

Sinkholes are common surface features in the karst area of Sulphur Springs. The Floridan aquifer in the area consists of limestone and dolomite, rocks that are susceptible to slow dissolution by acidic water that moves through pore spaces, fractures, and other openings in the rocks. The enlarged openings develop a network of conduits or cavities through which increasingly large volumes of sediments are transported by the water (Sinclair, 1981). As the limestone and dolomite continue to dissolve, the overlying material begins to subside and eventually collapses into the rock openings. A decline in water levels in the area removes part of the support of the overlying material causing it to lose competence and collapse. This results in the development of a depression or opening at land surface. Water moves by gravity into the depression. These openings or depressions, commonly referred to as sinkholes, are avenues by which surface water may move rapidly into the Floridan aquifer.

Numerous sinkholes have developed in the Sulphur Springs area. Most are located between Fletcher Avenue and the Hillsborough River (fig. 1) in the southwestern part of the area. The sinkholes generally average less than 15 feet in diameter and range in depth from about 10 to 15 feet. The most active area of sinkhole development is a 1-mile-wide strip along both sides of Interstate 275 that extends from the Hillsborough River northward about 4 miles.

Curiosity Sink

Curiosity Sink is 2.2 miles north-northwest of Sulphur Springs (fig. 1) and is the terminus of Curiosity Creek. The sink is reported to be about 25 feet deep and 40 feet in diameter. The overall sink area is about 500 feet in length and 100 feet in width. The Curiosity Sink area is internally drained, and under normal conditions, water that discharges into the sink area flows downward to the Floridan aquifer. However, overflow from the sink area occurs on the west side when water levels exceed an elevation of 29 feet above sea level.

The depth of the southern part of the Curiosity Sink area was sounded in 1980, shortly after it was cleaned and deepened by the city of Tampa. Depths averaged 6 to 8 feet below the water surface in the northern part, 4 feet in the central part, and 12 feet in the southern part. A pumping station with an 18-inch discharge pipe was installed in the southern part of the sink area in 1980 to reduce flooding. During high-water levels in the sink, water is pumped into a shallow basin east of the sink and is then discharged into the Hillsborough River by a pipeline. Water levels in the sink area averaged about 19 feet above sea level during nonpumping periods and 17 feet during periods of pumping at an average rate of about 5,000 gal/min. Based on a pumping rate of 5,000 gal/min and a drawdown of 2 feet in the sink, the specific capacity of the sink is about 2,500 gal/min per foot of drawdown.

Blue Sinks

Blue Sinks refers to an area of numerous small sinks 1,000 to 1,800 feet south of Curiosity Sink. A cluster of five of the more prominent sinkholes is shown in figure 1. The area has no surface streams and is drained entirely by sinkholes. A low area on the west side of the sink cluster near the 25-foot land-surface contour appears to be the former streambed of Curiosity Creek (fig. 1).

The site was visited several times by the senior author in 1963-64; at that time, the sinks were 20 to 30 feet deep, and water was observed to be flowing at the bottoms of two of the sinkholes. The sinkholes have since been filled with refuse and in 1981 were less than 6 feet deep and dry.

Orchid Street Sink

Orchid Street Sink (also known as Linebaugh Sink), which is about 6,600 feet north of Sulphur Springs (fig. 1), receives runoff from a residential area. The sink is 60 feet long, 50 feet wide, and bottoms at 24 feet below a general land surface of 26 feet above sea level. When the sink was sounded in March 1981, the water level in a 20-foot circular pool on the south side was 13 feet above sea level. The deepest sounding was 11 feet.

Poinsettia Street Sink

Poinsettia Street Sink (Trinity Springs), which is about 1,100 feet north of Orchid Street Sink (fig. 1), receives urban runoff from a residential area. The sink is 75 feet long, 50 feet wide, and bottoms at about 35 feet below a general land surface of 28 feet above sea level. A 30-foot circular pool of water on the west side of the sink was sounded in March 1981 and found to have a maximum depth of 20 feet when the water level in the sink was about 13 feet above sea level.

Tenth Street Sink

Tenth Street Sink is 1,900 feet north-northeast of Sulphur Springs and about 700 feet east of Nebraska Avenue (fig. 1). The sink is 25 feet in diameter and 27 feet deep below a general land surface of about 10 feet above sea level. Land-surface elevation is the lowest observed at a sink in the area. The sink was sounded in March 1981 when its water level was about 5 feet above sea level.

Greco Sink

Greco sink is in the southeastern part of Temple Terrace, about half a mile west of the Hillsborough River (fig. 1). The sink is 110 feet in diameter and bottoms at 32 feet below a general land surface of 45 feet above sea level. The deepest hole sounded was 18 feet below the water level in the sink, or 7 feet above sea level. Quality of a water sample collected at the bottom of the hole suggests a hydraulic connection between the sinkhole and the Floridan aquifer (Stewart and others, 1978).

Hillsborough River Sinks

A profile of the Hillsborough River from Tampa Dam to Fletcher Avenue (Goetz and others, 1978) shows several holes in the bed of the river from 0.7 to 6.9 miles upstream from the dam (fig. 1). The holes range in depth from about 5 to 18 feet below the riverbed and bottom at elevations that range from 6 feet above sea level to 12 feet below sea level. The bottom of a hole 0.7 mile upstream from Tampa Dam is about 6 feet below the riverbed. The deepest hole is 4.4 miles upstream of Tampa Dam or about 0.3 mile east of 56th Street. The hole is 18 feet below the riverbed and bottoms at about 1 foot below sea level.

A deep hole (locally known as Hannah's Swirl) is in a sharp bend of the river about a mile downstream from Tampa Dam and about 0.8 mile southeast of Sulphur Springs (fig. 1). Although the hole may be due to scouring of the river bottom, local residents report the hole to be about 20 feet deeper than the river bed.

A seismic reflection survey of the Hillsborough River in 1981 did not indicate any unreported sinkholes in the river in the Sulphur Springs area (R.M. Wolansky, U.S. Geological Survey, oral commun., 1981).

DYE TESTS

In January and March 1958, the city of Tampa injected fluorescein dye into Curiosity Sink and Blue Sink 5 (fig. 1), about 2 miles north of Sulphur Springs, to determine the rate and direction of ground-water movement. For the January test, 8 pounds of dye were injected into Curiosity Sink, and for the March test, 3.5 pounds of dye were injected into Blue Sink 5. Blue Sink 5 is 1,800 feet south-southeast of Curiosity Sink. During the tests, dye followed a general course toward Sulphur Springs, corresponding to the regional flow patterns shown in figure 13, but its course from Blue Sink 5 to Orchid and Poinsettia Street Sinks was altered somewhat by local structural controls in the aquifer system (Menke and others, 1961). The alteration in course probably was due to an extensive and well-developed cavity system that connects Sulphur Springs with several sinkholes as much as 2 miles north of Sulphur Springs. The time observed for dye to arrive at Sulphur Springs, Poinsettia Street Sink, and Orchid Street Sink after injection and the rates of ground-water movement are given in table 1. During the Curiosity Sink test, ground-water velocities ranged from 5,100 to 7,600 ft/d; for the Blue Sink 5 test, velocities ranged from 4,200 to 9,200 ft/d. Dye was not detected in Tenth Street Sink during the tests.

SULPHUR SPRINGS COLIFORM INDICATOR BACTERIA

The Sulphur Springs swimming pool has been closed temporarily in May or June of most years during the past decade because of high bacteria counts. The pool was closed to swimming on May 19, 1981, when the total coliform bacteria count exceeded the accepted contact level of 1,000 colonies per 100 milliliters (col/100 mL) of water. Usually, the pool is closed shortly after the spring is pumped to augment the city's water supply during the high water-demand period in May and June. The usual pumping rate is estimated to be 20 Mgal/d. Coliform bacteria counts of 1,000 col/100 mL or greater may occur throughout the year. Data collected by the city of Tampa Water Department (Ernie Wilder, Technical Services Supervisor, city of Tampa, written commun., 1981) for the period 1974-81 show that the annual period of heaviest concentration of bacteria in Sulphur Springs is January through August, and the lowest concentration is September through December. The lowest bacteria counts in Sulphur Springs for 1974-81 were observed during November, the driest month, and the highest counts were observed during April and May, moderately wet months. The bacteria count of water in Sulphur Springs probably is related to rainfall and the quality of runoff into sinkholes.

Water from Sulphur Springs and the Orchid Street and Tenth Street Sinks to the north (fig. 1) was sampled twice in May 1981 and once in July 1981. The Sulphur Springs pool is about 30 feet deep, and water samples were collected near the top, middle, and bottom of the pool; Orchid Street Sink is about 11 feet deep, and water samples were collected at middepth in the pool; Tenth Street Sink is 22 feet deep, and samples were collected near the top, middle, and bottom of the pool.

The ratio of fecal coliform to fecal streptococci (FC/FS) for samples from Sulphur Springs, Orchid Street Sink, and Tenth Street Sink are listed below.

Date (1981)	FC/FS at Sulphur Springs	Orchid Street Sink	Tenth Street Sink	Remarks
May 26	17:1-33:1	29:1	0.9:1-1.6:1	After dry period.
May 28	10:1-22:1	2.8:1	3.5:1-5.4:1	After heavy rain.
July 23	1:1	14:1	0.2:1-6:1	After moderate wet period.

Ratios of FC/FS higher than 4:1 are good indicators that pollution is derived from domestic wastes, which are largely composed of man's body wastes, laundry wastes, and food refuse (Geldreich, 1966). Wet and dry conditions at Orchid Street and Tenth Street Sinks were probably the same as that observed at Sulphur Springs.

Ground-water velocities north of Sulphur Springs range from approximately 4,000 to 9,000 ft/d. These high velocities probably are adequate for most bacteria to survive the 28 to 40 hours required to travel approximately 1 to 2 miles from the sinkholes to Sulphur Springs.

A 36-inch sewer line parallels the Hillsborough River from Sulphur Springs westward. Major sewer junctions are about 200 and 500 feet north of Sulphur Springs. The junctions are reported to have been installed at depths of about 2.0 and 2.5 feet above sea level, well below the water table of the surficial aquifer (fig. 12). The top of rock in the area is about 10 feet below sea level (fig. 9), or about 12 feet below the sewer lines. Data were not available to determine if the sewer line leaks. However, it would be expected that the bacteria count in the spring pool would not vary appreciably if the major source of bacteria was the sanitary sewer.

ESTIMATED RUNOFF LOADS

Orchid Street and Poinsettia Street Sinks are used as retention basins for urban runoff from areas around the sinks. Estimated loads of selected constituents that drain into the sinkholes were computed using average base flow and storm-runoff concentrations and runoff volumes based on data collected at nine urban watersheds in the Tampa Bay area (R.F. Giovannelli and M.A. Lopez, written commun., 1981).

Orchid Street Sink receives drainage from a 77-acre residential area through a 3-foot diameter concrete pipe on the eastern side, a 4-foot diameter concrete pipe on the northern side, and a 1-foot diameter aluminum corrugated pipe on the western side. The sink, when visited in March 1981, contained scattered refuse in the bottom. Estimated loads of selected constituents that drained into the sinkhole in 1979 are listed in table 2.

Poinsettia Street Sink receives drainage from a 64-acre residential area through a 4-foot diameter concrete pipe on the eastern side. Estimated loads of selected constituents that drained into the sink in 1979 are listed in table 2.

SUMMARY AND CONCLUSIONS

The Sulphur Springs area is highly urbanized in the southern part and largely rural in the northeastern part. The University of South Florida, part of the city of Tampa, and all of the city of Temple Terrace are in the area.

Curiosity Sink is in a flood-prone area near the northwestern limit of the city of Tampa; it has flooded on numerous occasions. Much of the Curiosity Sink area drains through sinkholes to the Floridan aquifer. Most sinkholes are located between Fletcher Avenue and the Hillsborough River in the southern part of the study area. The city of Tampa uses Orchid Street and Poinsettia Street Sinks as retention basins for storm runoff.

The surficial aquifer is the principal source of recharge to the Floridan aquifer, but recharge also occurs through sinkholes and through the Tampa Dam Reservoir on the Hillsborough River.

The transmissivity of the Floridan aquifer in the Sulphur Springs area is high, but variable, and ranges from 7.3×10^4 ft²/d in the northwestern part to 1.3×10^5 ft²/d in the northeastern and southeastern parts. The transmissivity is generally highest near the Hillsborough River. The leakage coefficient ranges from 2×10^{-4} to 8×10^{-3} (ft/d)/ft.

In 1980, Tampa pumped an average of 48.5 Mgal/d from the Hillsborough River. Total ground-water pumpage was 7.2 Mgal/d, of which 4.68 Mgal/d was for public supplies, 1.5 Mgal/d was for industrial and commercial uses, 1 Mgal/d was for irrigation, and 0.02 Mgal/d was for air conditioning.

A fairly extensive and well-developed cavity system occurs in the Floridan aquifer in the Temple Terrace area and the area north of Sulphur Springs between the Hillsborough River and Fowler Avenue. Ground-water velocities of 1 to 2 miles per day were determined from two dye tests conducted in the Hillsborough River-Fowler Avenue area. Sulphur Springs is a supplemental water-supply source for the city of Tampa and a public recreation area. The spring pool has been temporarily closed to swimming in the spring of most years because coliform bacteria counts exceeded the contact limit of 1,000 col/100 mL. Bacteria counts greater than 1,000 col/100 mL occur most months.

Although the source of the coliform bacteria entering Sulphur Springs was not fully established, indications are that sinkholes north of the spring are the principal sources. The high ratio of fecal coliform and fecal streptococci for Sulphur Springs and two sinkholes north of the spring indicate that the high bacteria count is due to domestic waste. The exceptionally high ground-water velocities obtained for the area probably are adequate for most bacteria to survive the 1- to 2-day underground traveltime needed to reach Sulphur Springs.

REFERENCES

Carr, W.J., and Alverson, D.C., 1959, Stratigraphy of middle Tertiary rocks in part of west-central Florida: U.S. Geological Survey Bulletin 1092, 111 p.
Duerr, A.D., and Trommer, J.T., 1981, Estimated water use in the Southwest Florida Water Management District and adjacent areas, 1980: U.S. Geological Survey Open-File Report 81-1060, 60 p.
Geldreich, E.E., 1966, Sanitary significance of fecal coliforms in the environment: U.S. Department of the Interior, Federal Water Pollution Control Administration, Water Pollution Control Research Series Publication WP-20-3, 122 p.
Goetz, C.L., Reichenbaugh, R.C., and Ogle, J.K., 1978, Water-supply potential of the lower Hillsborough River, Florida, 1976: U.S. Geological Survey Water-Resources Investigations 78-29, 25 p.
Hunn, J.D., and Reichenbaugh, R.C., 1972, A hydrologic description of Lake Magdalene, near Tampa, Florida: Florida Bureau of Geology Map Series 49.
Hutchinson, C.B., Johnson, D.M., and Gerhart, J.M., 1981, Hydrogeology of well-field areas near Tampa, Florida, phase 1—development and documentation of a two-dimensional finite-difference model for simulation of steady-state ground-water flow: U.S. Geological Survey Open-File Report 81-630, 129 p.
Menke, C.G., Meredith, E.W., and Wetterhall, W.S., 1961, Water resources of Hillsborough County, Florida: Florida Geological Survey Report of Investigations 25, 101 p.
Murphy, W.R., Jr., Evans, R.P., and Whalen, J.K., 198—, Flooding in northwestern Hillsborough and southern Pasco Counties, Florida, in 1979: U.S. Geological Survey Open-File Report 82-96 [in press].
National Oceanic and Atmospheric Administration, 1981, Local climatological data, 1980, Tampa, Florida: U.S. Department of Commerce, National Climatic Center, Asheville, N.C.
Pride, R.W., 1962, Floods at Tampa, Florida: U.S. Geological Survey Hydrologic Investigations Atlas HA-66, 2 sheets.
Rosenau, J.C., Faulkner, G.L., Hendry, C.W., Jr., and Hull, R.W., 1977, Springs of Florida (revised): Florida Bureau of Geology Bulletin 31, 461 p.
Ryder, P.D., Johnson, D.M., and Gerhart, J.M., 1980, Model evaluation of the hydrogeology of the Morris Bridge well field and vicinity in west-central Florida: U.S. Geological Survey Water-Resources Investigations 80-29, 92 p.
Sinclair, W.C., 1981, Sinkhole development resulting from ground-water withdrawal in the Tampa area, Florida: U.S. Geological Survey Water-Resources Investigations 81-50, 19 p.
Stewart, J.W., 1968, Hydrologic effects of pumping from the Floridan aquifer in northwest Hillsborough, northeast Pinellas, and southwest Pasco Counties, Florida: U.S. Geological Survey Open-File Report FL-68005, 241 p.
———1977, Hydrologic effects of pumping a deep limestone sink near Tampa, Florida, U.S.A.: International Association of Hydrogeologists, Twelfth International Congress, Karst Hydrogeology, Huntsville, Ala.
Stewart, J.W., Goetz, C.L., and Mills, L.R., 1978, Hydrogeologic factors affecting the availability and quality of ground water in the Temple Terrace area, Hillsborough County, Florida: U.S. Geological Survey Water-Resources Investigations 78-4, 38 p.
Stewart, J.W., and Hughes, G.H., 1974, Hydrologic consequences of using ground water to maintain lake levels affected by water wells near Tampa, Florida: Florida Bureau of Geology Report of Investigations 74, 41 p.
Yobbi, D.K., and Woodham, W.M., 1981, Ground-water levels in selected well fields and in west-central Florida, May 1981: U.S. Geological Survey Open-File Report 81-1106, 2 sheets.
Yobbi, D.K., Woodham, W.M., and Schiner, G.R., 1981, Potentiometric surface of the Floridan aquifer, Southwest Florida Water Management District, May 1981: U.S. Geological Survey Open-File Report 81-1006, 1 sheet.

ABBREVIATIONS AND CONVERSION FACTORS

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

Multiply	By	To obtain
inch (in)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
square mile (mi²)	2.590	square kilometer (km²)
acre	0.4047	hectare (ha)
foot per hour (ft/h)	0.3048	meter per hour (m/h)
foot per day (ft/d)	0.3048	meter per day (m/d)
foot squared per day (ft²/d)	0.09290	meter squared per day (m²/d)
cubic foot (ft³)	0.2832	cubic meter (m³)
gallon (gal)	0.003785	cubic meter (m³)
million gallons per day (Mgal/d)	0.04381	cubic meter per second (m³/s)
gallon per minute (gal/min)	0.6309	liter per second (L/s)
	0.00006309	cubic meter per second (m³/s)
pound (lb)	453.6	gram (g)
micromho per centimeter at 25°C (μmho/cm at 25°C)	1.000	microsiemen per centimeter at 25°C (μS/cm at 25°C)

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

$$(°F-32)0.556 = °C$$

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 the text of this report.

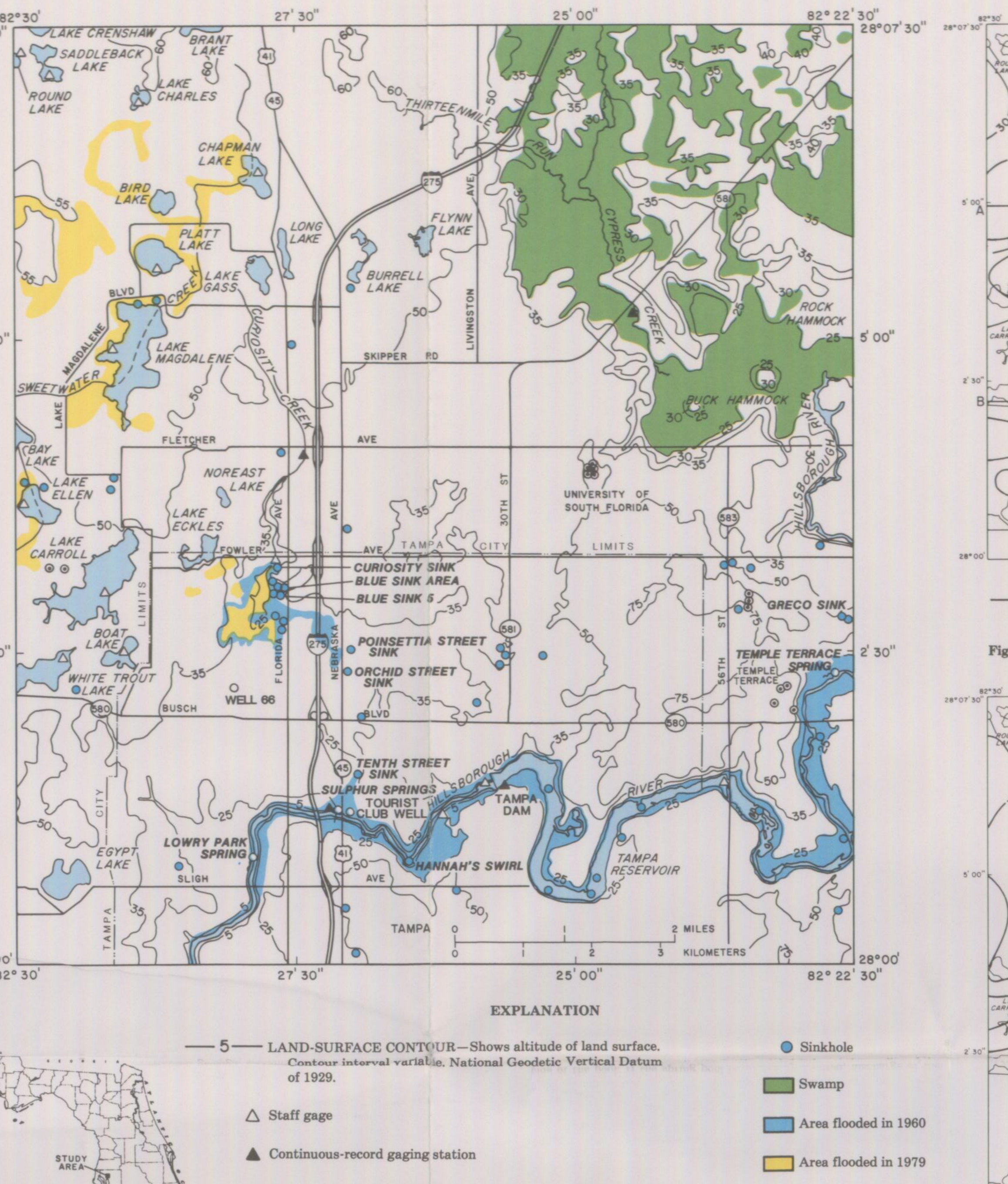

Figure 1.—Sulphur Springs area showing physiographic features and locations of observation and public water-supply wells.

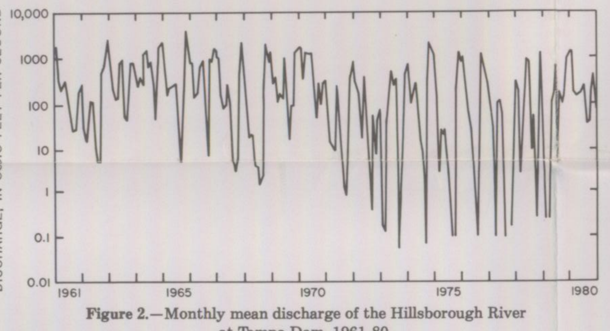

Figure 2.—Monthly mean discharge of the Hillsborough River at Tampa Dam, 1961-80.

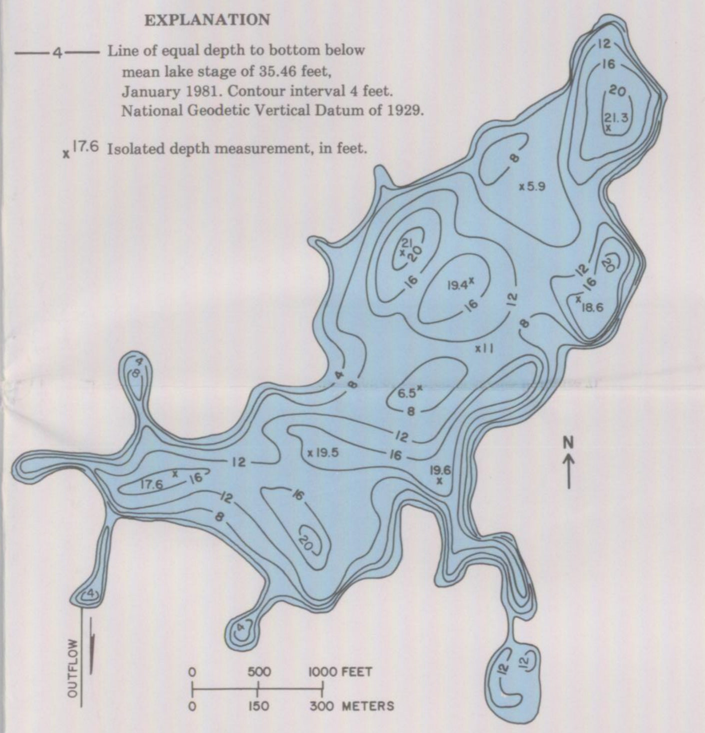

Figure 3.—Depth of Lake Carroll, January 1981 (modified from Henderson and others, 1982).

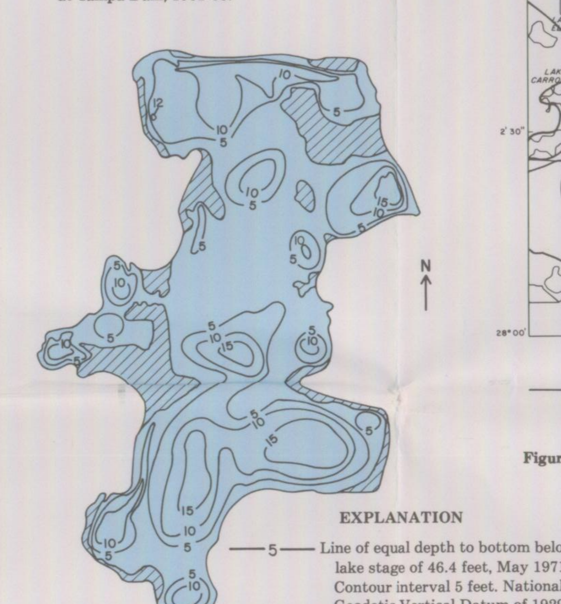

Figure 4.—Depth of Lake Magdalene, May 1971 (from Hunn and Reichenbaugh, 1972).

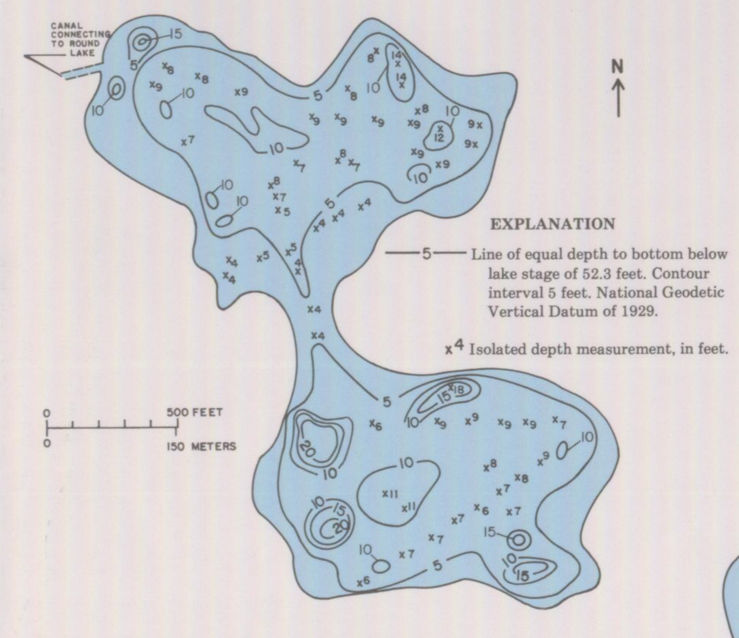

Figure 5.—Depth of Saddleback Lake, April 1966 (from Stewart and Hughes, 1974).

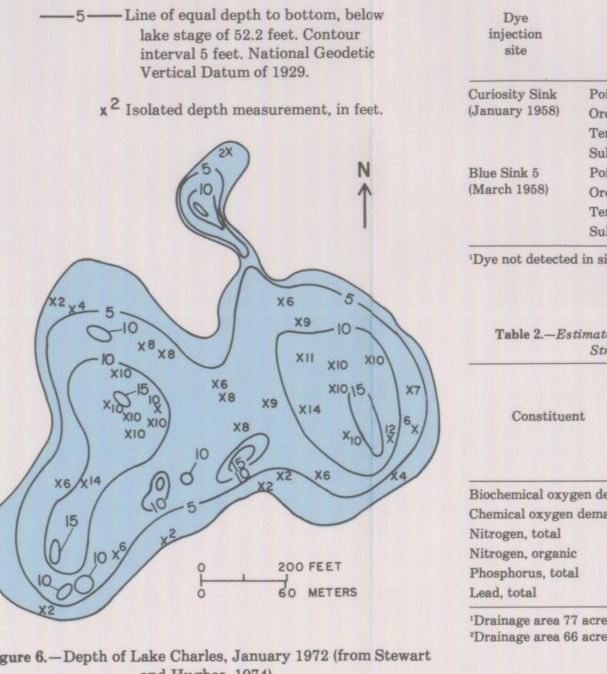

Figure 6.—Depth of Lake Charles, January 1972 (from Stewart and Hughes, 1974).

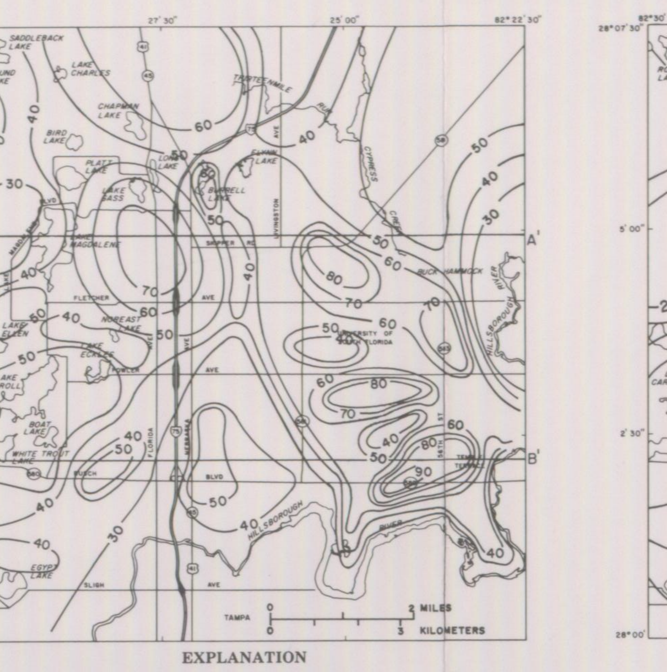

Figure 7.—Thickness of surficial deposits (includes confining layer).

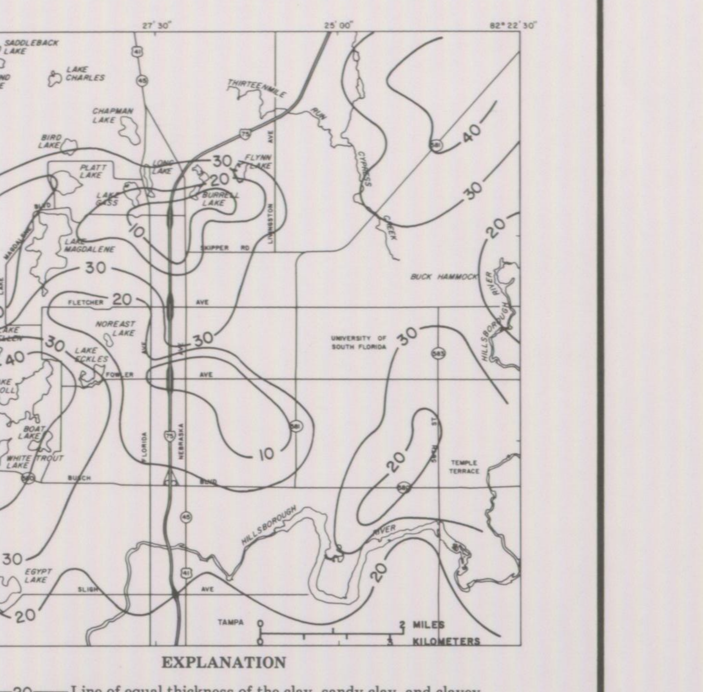

Figure 8.—Generalized thickness of the clay, sandy clay, and clayey sand confining layer.

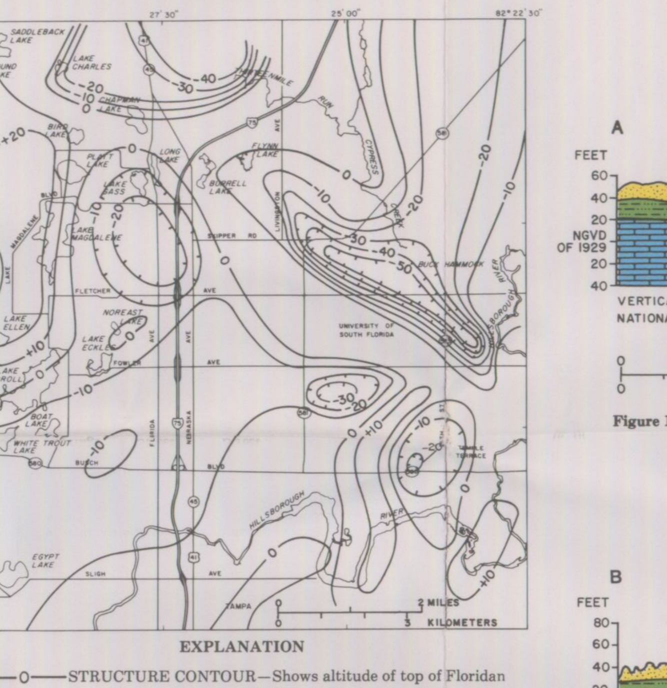

Figure 9.—Generalized configuration of the top of the Floridan aquifer.

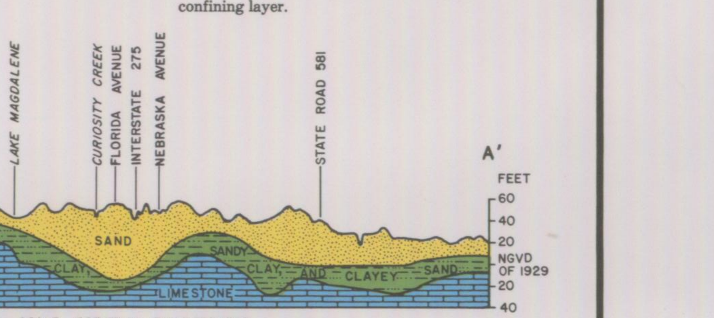

Figure 10.—Generalized geologic section of the northern part of the study area (location of section is shown in figure 7).

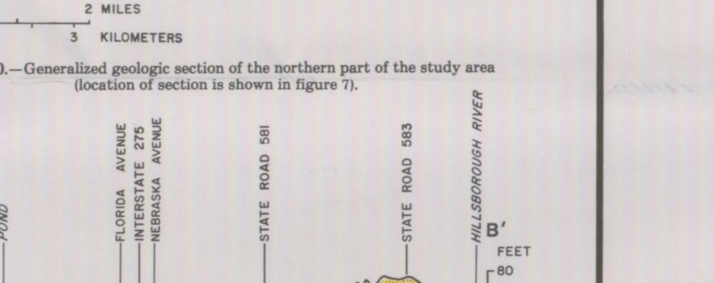

Figure 11.—Generalized geologic section of the southern part of the study area (location of section is shown in figure 7).

Figure 12.—Generalized configuration of water table in the surficial aquifer, May 1981 (modified from Yobbi and Woodham, 1981).

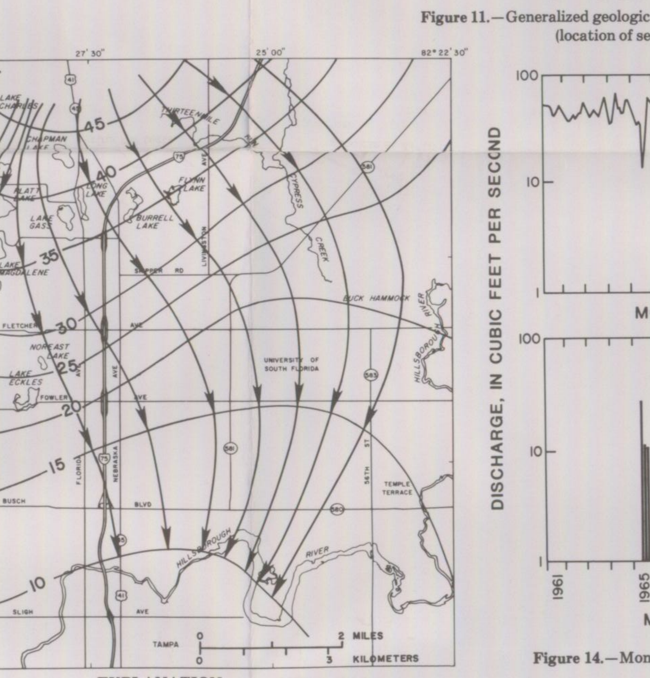

Figure 13.—Potentiometric surface of the Floridan aquifer, May 1981 (modified from Yobbi and others, 1981).

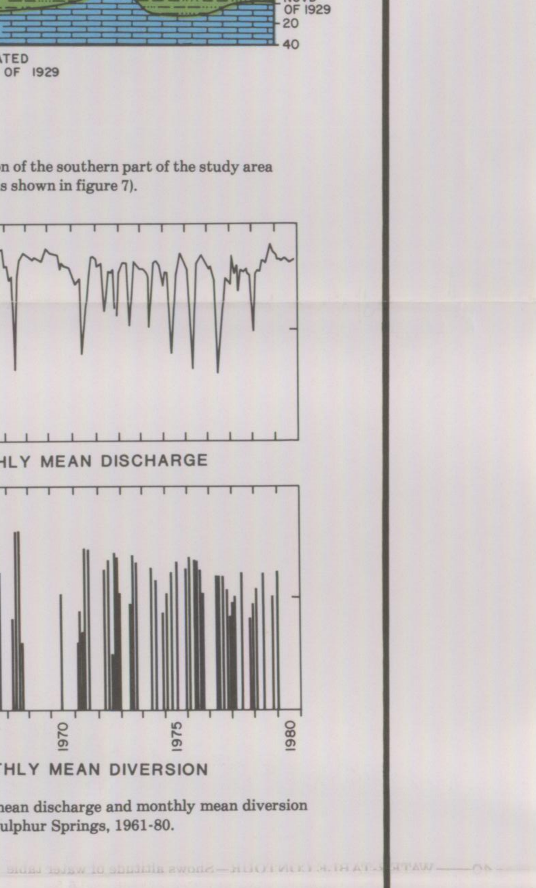

Figure 14.—Monthly mean discharge and monthly mean diversion of Sulphur Springs, 1961-80.

Table 1.—*Results of fluorescein dye tests, Sulphur Springs area*

Dye injection site	Dye detection site	Distance from injection site (ft)	Time of arrival (h)	Velocity (ft/h)	Velocity (ft/d)
Curiosity Sink (January 1958)	Poinsettia Sink	5,400	25.4	210	5,100
	Orchid Sink	6,300	27.9	230	5,400
	Tenth Street Sink[1]	11,100	—	—	—
	Sulphur Springs	12,700	40.0	320	7,600
Blue Sink 5 (March 1958)	Poinsettia Sink	4,500	25.5	180	4,200
	Orchid Sink	5,000	23.9	210	5,000
	Tenth Street Sink[1]	9,600	—	—	—
	Sulphur Springs	10,000	28.1	380	9,200

[1]Dye not detected in sinkhole.

Table 2.—*Estimated load of selected constituents discharged into Orchid Street and Poinsettia Street Sinks in 1979*

Constituent	Pounds: Orchid[1] Street Sink	Pounds: Poinsettia[2] Street Sink	Pounds per acre: Orchid[1] Street Sink	Pounds per acre: Poinsettia[2] Street Sink
Biochemical oxygen demand	3,200	2,200	42	34
Chemical oxygen demand	6,900	1,200	90	19
Nitrogen, total	1,300	1,100	17	17
Nitrogen, organic	390	120	5.1	1.9
Phosphorus, total	80	26	1.0	.4
Lead, total	17	2	.2	.03

[1]Drainage area 77 acres.
[2]Drainage area 66 acres.

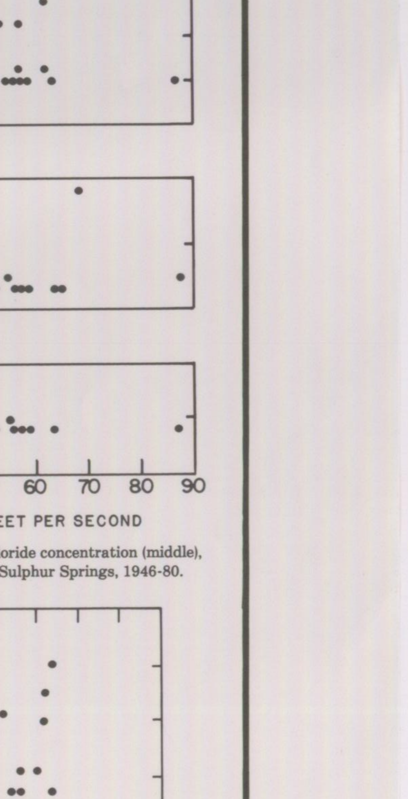

Figure 15.—Relation of specific conductance (top), chloride concentration (middle), and sulfate concentration (bottom) to discharge of Sulphur Springs, 1946-80.

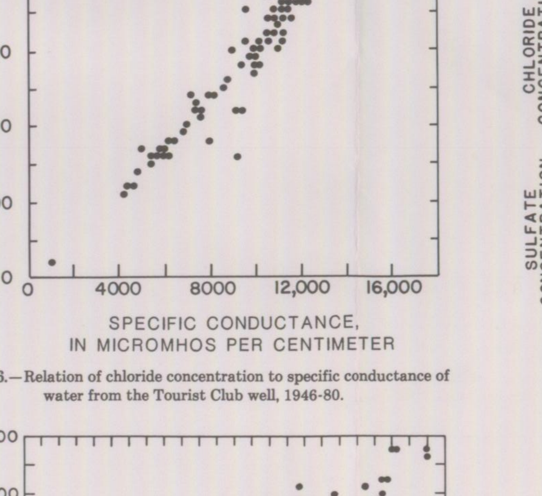

Figure 16.—Relation of chloride concentration to specific conductance of water from the Tourist Club well, 1946-80.

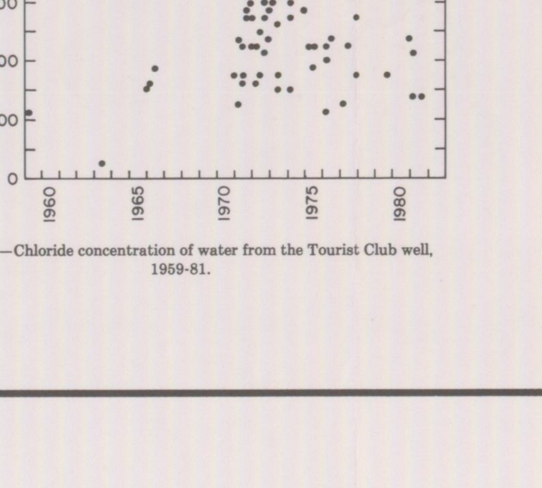

Figure 17.—Chloride concentration of water from the Tourist Club well, 1959-81.

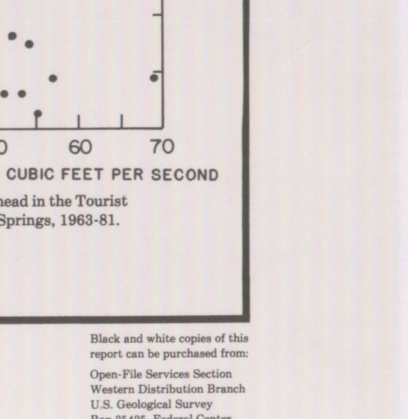

Figure 18.—Relation of potentiometric head in the Tourist Club well to the discharge of Sulphur Springs, 1963-81.

HYDROGEOLOGY OF THE SULPHUR SPRINGS AREA, TAMPA, FLORIDA

By
J.W. Stewart and L.R. Mills
1984

Black and white copies of this report can be purchased from:
Open-File Services Section
Western Distribution Branch
U.S. Geological Survey
Box 25425, Federal Center
Denver, Colorado 80225
(Telephone: (303) 234-5888)