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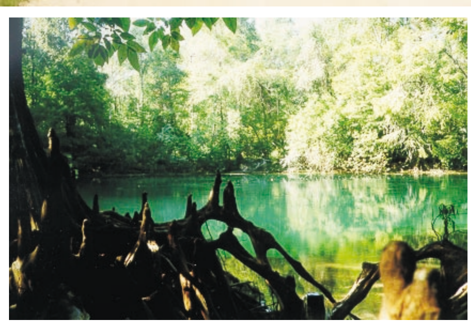
Lake County Water Authority
St. Johns River Water Management District
Southwest Florida Water Management District

Ground-Water Quality of the Surficial Aquifer System and the Upper Floridan Aquifer, Ocala National Forest and Lake County, Florida, 1990-99

Water-Resources Investigations Report 01-4008



U.S Department of the Interior
U.S. Geological Survey

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By James C. Adamski *and* Leel Knowles, Jr.

U.S. GEOLOGICAL SURVEY

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Tallahassee, Florida
2001

U.S. DEPARTMENT OF THE INTERIOR
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CONTENTS

Figures

Tables

CONVERSION FACTORS, VERTICAL DATUM, ABBREVIATIONS, AND ACRONYMS

Multiply	By	To obtain
	Length	
foot (ft)	0.3048	meter
inch (in.)	25.4	millimeter
	Area	
square mile (mi^2)	2.590	square kilometer (km^2)
	Flow	
inch per year (in/yr)	25.4	millimeter per year
million gallons per day (Mgal/d)	0.04381	cubic meter per second

Temperature in degrees Fahrenheit (°F) may be converted to degrees Celsius (°C) as follows: °C=(°F-32)/1.8.

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 Sea Level Datum of 1929.

Acronyms and additional abbreviations:

MCL	Maximum Contaminant Level
mg/L	milligrams per liter
IQR	Inter Quartile Range
NOAA	National Oceanic and Atmospheric Administration
NSDWR	National Secondary Drinking Water Regulations
Ocala NF	Ocala National Forest
RASA	Regional Aquifer-System Analysis
SJRWMD	St. Johns River Water Management District
TDS	total dissolved solids
USGS	U.S. Geological Survey

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ABSTRACT

Data from 217 ground-water samples were statistically analyzed to assess the water quality of the surficial aquifer system and Upper Floridan aquifer in the Ocala National Forest and Lake County, Florida. Samples were collected from 49 wells tapping the surficial aquifer system, 141 wells tapping the Upper Floridan aquifer, and from 27 springs that discharge water from the Upper Floridan aquifer. A total of 136 samples was collected by the U.S. Geological Survey from 1995 through 1999. These data were supplemented with 81 samples collected by the St. Johns River Water Management District and Lake County Water Resources Management from 1990 through 1998.

In general, the surficial aquifer system has low concentrations of total dissolved solids (median was 41 milligrams per liter) and major ions. Water quality of the surficial aquifer system, however, is not homogeneous throughout the study area. Concentrations of total dissolved solids, many major ions, and nutrients are greater in samples from Lake County outside the Ocala National Forest than in samples from within the Forest. These results indicate that the surficial aquifer system in Lake County outside the Ocala National Forest probably is being affected by agricultural and (or) urban land-use practices. High concentrations of dissolved oxygen (less than 0.1 to 8.2 milligrams per liter) in the surficial aquifer system underlying the Ocala National Forest indicate that the aquifer is readily recharged by precipitation and is susceptible to surface contamination.

Concentrations of total dissolved solids were significantly greater in the Upper Floridan aquifer (median was 182 milligrams per liter) than in the surficial aquifer system. In general, water quality of the Upper Floridan aquifer was homogeneous, primarily being a calcium or calcium-magnesium-bicarbonate water type. Near the St. Johns River, the water type of the Upper Floridan aquifer is sodium-chloride, corresponding to an increase in total dissolved solids. Dissolved-oxygen concentrations in the Upper Floridan aquifer ranged from less than 0.1 to 7.3 milligrams per liter, indicating that, in parts of the aquifer, ground water is rapidly recharged by rainfall and is susceptible to surface contamination.

Median concentrations of nutrients in the Upper Floridan aquifer were not significantly different between the Ocala National Forest and the area of Lake County outside the Forest. The maximum nitrate concentration in the Upper Floridan aquifer in Ocala National Forest was only 0.20 milligram per liter, whereas, 9 of 39 samples from the Upper Floridan aquifer in Lake County had elevated nitrate concentrations (greater than 1.0 milligram per liter). Hence, nitrate concentrations of the Upper Floridan aquifer appear to be affected by land use in Lake County.

INTRODUCTION

Ground water is an important resource in central Florida. Ground water from the Floridan aquifer system, particularly the Upper Floridan aquifer, is used extensively as a source of drinking water. Ground water, which discharges to lakes, springs, and streams throughout central Florida, also is used for agricultural, commercial, and industrial purposes. Hence, the quality of ground water is important for its numerous uses and for the aquatic environment of central Florida.

The ground water underlying large areas of central Florida, however, had not been studied recently. The most recent comprehensive hydrologic study of Lake County was published by Knochenmus and Hughes in 1976. Because of recent growth in population, a comprehensive study of Lake County was needed to assess the current conditions of ground-water quality and to better understand the effects of land use on ground-water quality. A comprehensive hydrologic study of the Ocala National Forest (Ocala NF) was needed to document water quality in a relatively pristine area. This report is the compilation of results from two comprehensive investigations of the hydrology of the Ocala NF and the hydrology of Lake County. The objectives for this part of the two studies are to (1) describe current conditions of the ground-water quality of the Ocala NF and Lake County and (2) determine the natural and anthropogenic factors affecting ground-water quality.

The study area is in north-central Florida and includes all of Lake County and parts of Marion and Putnam Counties that lie within the Ocala NF (fig. 1). The study area includes numerous growing towns and communities including Clermont, Eustis, Tavares, Leesburg, Mount Dora, and Lady Lake in Lake County; and the communities of Lynne, Salt Springs, and Astor Park, which lie within the Proclamation Boundary (perimeter) of the Ocala NF. Agriculture, including citrus farming, nurseries (horticulture), and livestock, is an important land use in the study area, excluding the Ocala NF.

The Ocala NF is about 690 square miles (mi^2) of relatively pristine second-growth forests. The Ocala NF, owned and operated by the U.S. Forest Service, has a sparse population and little anticipated population growth. Ground-water quality of the Ocala NF was not extensively studied prior to the current investigation. A comprehensive study of the Ocala NF was needed to describe the natural conditions of the ground-water quality of central Florida.

Lake County is about 1,150 mi^2 in area. Northeastern Lake County overlaps with the Ocala NF. The rest of Lake County is directly south of the Ocala NF (fig. 1). Lake County is directly west and northwest of metropolitan Orlando.

Purpose and Scope

The purpose of this report is to describe the ground-water quality of the Ocala NF and Lake County with regard to concentrations of major ions and nutrients. The report contains a brief description of the environmental setting of the study area, including climate, physiography, hydrogeology, and major land uses. The report also contains a description of data-collection and analytical methods. A discussion of the natural and anthropogenic factors affecting water quality of the surficial aquifer system and the Upper Floridan aquifer is included. This report is the result of two comprehensive studies of the water resources of Ocala NF and Lake County, Florida.

Previous Investigations

Fenneman (1938) described the topographic and geomorphic features of Florida. Cooke (1945) described the geomorphology, geology, and stratigraphy of Florida, and White (1970) further described the geomorphology of the Florida peninsula. Matson and Sanford (1913) and Stringfield (1933 and 1936) were the first to investigate the hydrogeology of Florida. Rosenau and others (1977) described the location, discharge, and water quality of numerous springs.

Later hydrogeologic investigations included the Regional Aquifer-System Analysis (RASA) of the Floridan aquifer system, in which the hydrogeologic framework of the Floridan aquifer system was described by Miller (1986). Tibbals (1990) simulated the ground-water flow in the Floridan aquifer system in east-central Florida using a model area that included most of the Ocala NF and Lake County.

Sprinkle (1989) described the geochemistry of the Floridan aquifer system. Katz (1992) investigated the geochemistry of the Upper Floridan aquifer throughout the State of Florida. Rutledge (1987) and German (1997) investigated the relation of land use and ground-water quality. German (1997) compared ground-water quality underlying areas of agricultural and urban land use in parts of Lake and Orange Counties to ground-water quality underlying parts of the Ocala NF. Toth (1999) investigated the geochemistry and isotopic composition of selected springs in the Ocala NF and Lake County.

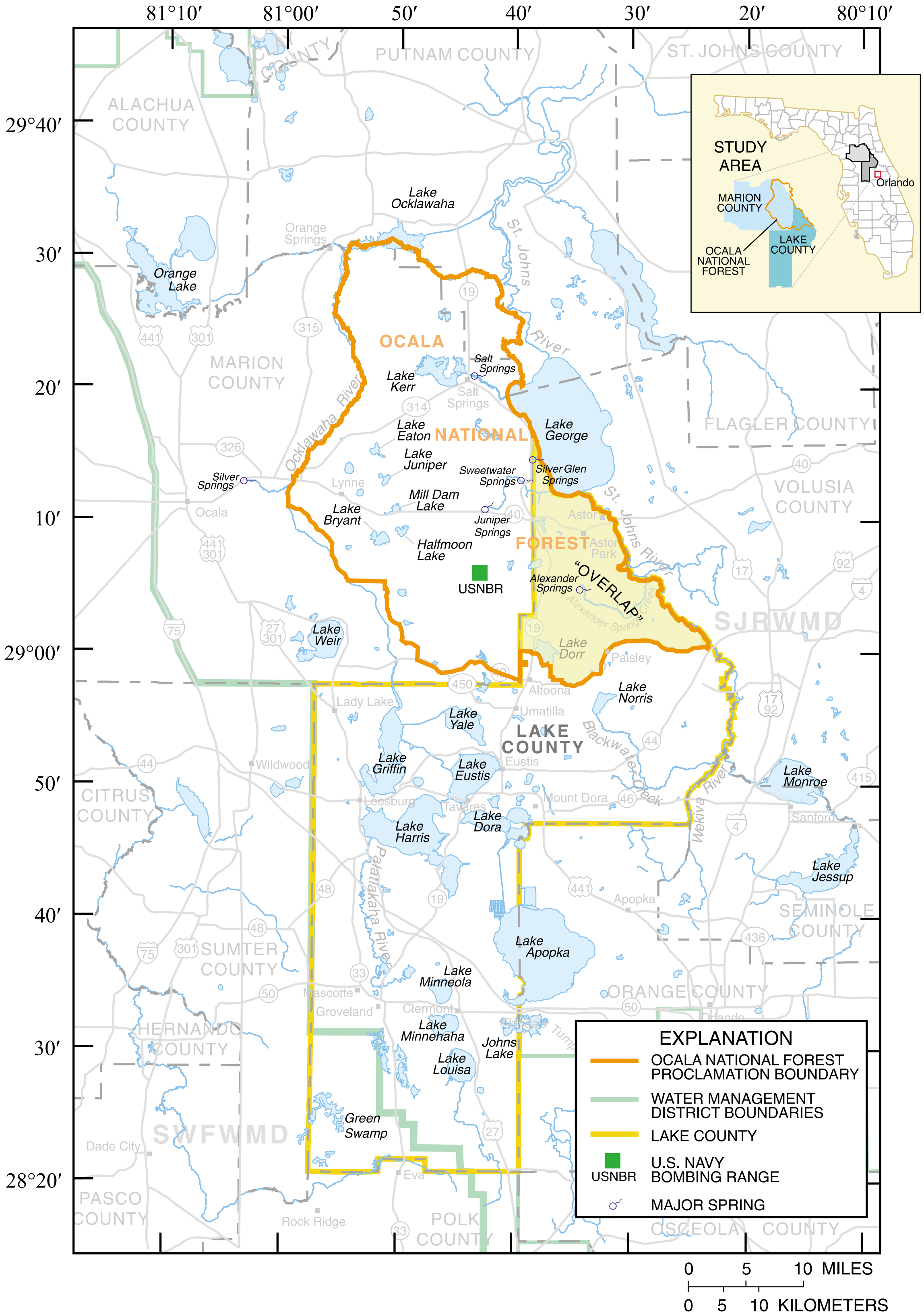

Figure 1. Location of the Ocala National Forest and Lake County, Florida.

Faulkner (1973) described the hydrogeology of northwestern Ocala NF during a study for the cross-Florida barge canal. Phelps (1994) investigated the hydrogeology and water quality of the Silver Springs basin, just west of Ocala NF. Knowles (1996) estimated evapotranspiration of the Silver Springs basin. Knochenmus and Hughes (1976) investigated ground water, surface water, and water quality of Lake County. Murray and Halford (1996) simulated ground-water flow in parts of Lake County. Few other studies of the water resources of the Ocala NF or Lake County are available.

Acknowledgments

The authors are grateful to the St. Johns River Water Management District, Southwest Florida Water Management District, and Lake County Board of Commissioners for information and hydrologic data made available for this investigation. Personnel at the U.S. Forest Service assisted with site access, data collection, and information. Finally, the authors are grateful to land and well owners for access to sites.

ENVIRONMENTAL SETTING

The study area has a subtropical climate characterized by hot humid summers and mild winters. The mean annual air temperature is 70.7 degrees Fahrenheit (^{o}F) (National Oceanic and Atmospheric Administration (NOAA), 1992). Minimum air temperatures during the winter months occasionally drop below freezing, but rarely are less than 20 ^{o}F. Maximum air temperatures during the summer months are commonly greater than 90 ^{o}F, and occasionally exceed 100 ^{o}F locally.

Average precipitation (from 1961 to 1990) ranges from about 52 inches per year (in/yr) in Ocala to less than 51 in/yr in Clermont (NOAA, 1992). The average precipitation for the entire study area is slightly more than 51 in/yr. Annual precipitation can vary greatly from the average, ranging from a minimum of 32 inches (in.) in 2000 to a maximum of 71 in. in 1964. Typically, more than half of the precipitation occurs during the summer as isolated thunderstorms and from tropical systems. The remainder of the precipitation generally occurs during winter months from frontal systems. A large part of precipitation is balanced by evapotranspiration. For example, in 1998, precipitation in the study area was about 57 in., about 35 in. of which were balanced by evapotranspiration.

Physiography

Land-surface elevations in the Ocala NF and Lake County range from less than 10 feet (ft) to more than 300 ft above sea level. The highest point in the Florida peninsula (312 ft) is located on the north end of the Lake Wales Ridge in Lake County (fig. 2) (Knochenmus and Hughes, 1976). Topography of the study area ranges from flat-lying lands to gently rolling hills.

The study area is located in the Central Highlands topographic division (Cooke, 1945) and contains three basic land forms—ridges, valleys, and uplands (fig. 2). Parts of the Mount Dora and the Lake Wales Ridges are located in the study area. These ridges, which are quasi-linear features, are a series of gently rolling hills that trend northwest-southeast with elevations ranging from 100 to more than 300 ft above sea level. The two ridges are parallel and separated by the Central Valley, an area of relatively low relief and land-surface elevations (White, 1970). In addition to the Central Valley, the St. Johns and Wekiva River valleys form the eastern boundary of the study area (fig. 1). The Lake Upland and Marion Upland areas present in the study area contain gently rolling hills with elevations ranging from 50 to 200 ft. above sea level (White, 1970; Knochenmus and Hughes, 1976).

In addition to these major land forms, numerous karst features including sinkholes, springs, and caves are present in the study area. Sinkholes are abundant along the flanks of the ridges and uplands of the study area. Sinkholes can be dry or water-filled internally drained depressions that commonly are areas of high recharge to the underlying aquifers.

Hydrology and Hydrogeology

Surface-water resources are abundant throughout most of the study area. Except for the southwestern corner of Lake County, most of the study area is drained by the St. Johns River and its tributaries. The St. Johns and Wekiva Rivers form the eastern boundaries of Lake County and the Ocala NF. The Ocklawaha River forms the northwestern part of the Proclamation Boundary of the Ocala NF. Smaller tributaries discharge surface and ground-water to the St. Johns and Wekiva Rivers. These tributaries include Alexander Springs Creek and Blackwater Creek.

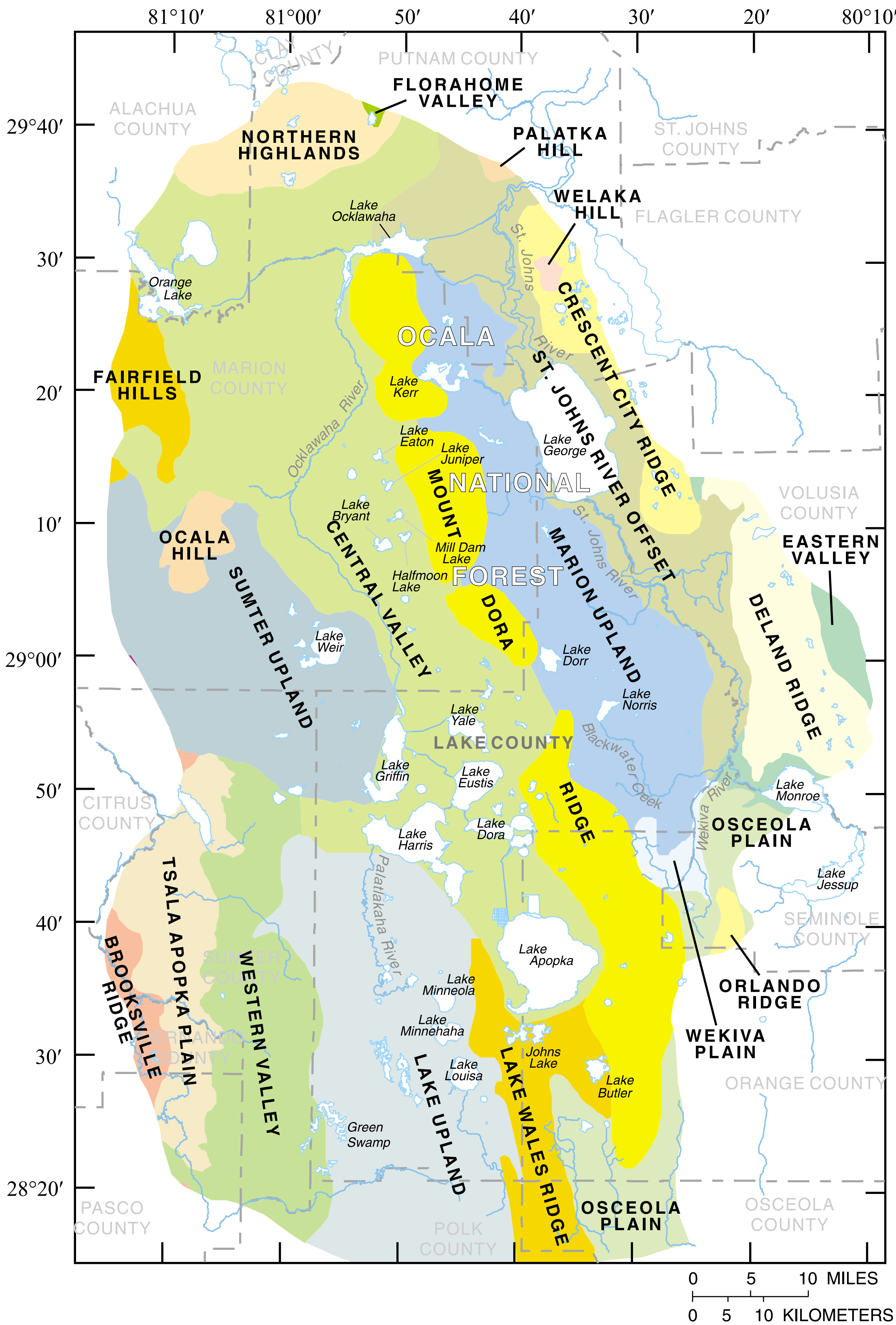

Figure 2. Physiography of the study area (modified from White, 1970).

Springs, which represent locations of ground-water discharge, are abundant, and possibly located along subsurface fracture systems of the Ocala Uplift (Faulkner, 1973). Most springs are located along or near the Ocklawaha, St. Johns, and Wekiva Rivers. A few small springs are located in central Lake County. Silver Springs is located just west of the study area, near the city of Ocala. Some of the larger springs, such as Alexander, Salt, and Silver Glen, issue from visible cavities or conduits formed from dissolution of the carbonate rock.

In addition to streams and springs, the study area is characterized by abundant lakes. These lakes range in size from small, water-filled sinkholes and depressions to large water bodies such as Lake Eustis, Lake Griffin, and Lake Harris in Lake County, and Lake Dorr and Lake Kerr in the Ocala NF (fig. 1). Furthermore, Lake Apopka and Lake George are present on the eastern boundaries of Lake County and the Ocala NF, respectively.

Wetlands also are abundant in the study area. Wetlands are present along major streams and the perimeters of the lakes. The Green Swamp is a wetland area that covers a large part of southern Lake County (fig. 1).

Much of the Mount Dora Ridge in the Ocala NF is drained internally through sinkholes and depressions. Streams are noticeably absent from the area. Runoff in this area probably is minimal, with most of the precipitation being balanced by evapotranspiration and ground-water recharge.

Lithologic descriptions of well cuttings, borehole geophysical logs, and well completion reports were analyzed to describe the extent, thickness, and lithology of the major hydrogeologic units in the study area. These hydrogeologic units include the surficial and Floridan aquifer systems (fig. 3).

The surficial aquifer system consists of unconsolidated, siliclastic sediments of Pliocene through Recent age. The sediments are primarily quartz sand, but locally, the aquifer also contains silt, clay, chert, shell, or organic deposits that range in thickness from less than 25 to more than 100 ft. In general, these sediments are thicker under the Mount Dora and Lake Wales Ridges than under adjacent areas.

The surficial aquifer system is recharged primarily by precipitation. Ground water in the surficial aquifer system flows laterally to discharge into streams and lakes, and vertically to recharge the underlying Upper Floridan aquifer. The elevation of the water table in the surficial aquifer system ranges from near sea level along the St. Johns River to more than 165 ft above sea level in areas underlying the Mount Dora Ridge. The elevation of the water table in the surficial aquifer system can fluctuate greatly within a short time, particularly in areas of higher elevation. For example, the water-table elevation in one surficial well located in the northern part of the Ocala NF (number 401 in appendix) increased more than 8 ft from September 1997 to May 1998.

SYSTEM	SERIES		STARTIGRAPHIC UNIT	THICKNESS (FEET)	LITHOLOGY	HYDROGEOLOGIC UNIT	
QUATERNARY	RECENT		UNDIFFERENTIATED DEPOSITS	25 - 100	Quartz sand, unconsolidated; locally can contain clay, chert, shell, and organic deposits.	SURFICIAL AQUIFER SYSTEM	
	PLEISTOCENE						
TERTIARY	PLIOCENE						
	MIOCENE		HAWTHORN FORMATION	20 - 100	Phosphatic, green to gray clay; locally can contain sand and carbonate units.	INTERMEDIATE CONFINING UNIT	
	EOCENE	UPPER	OCALA LIMESTONE	<50 - 200	Limestone, white, tan, or cream, fossiliferous, soft to hard; locally fractured dolomitic; highly porous.	FLORIDAN AQUIFER SYSTEM	UPPER FLORIDAN AQUIFER
		MIDDLE	AVON PARK FORMATION	POORLY KNOWN	Limestone, light brown to brown, porous, fossiliferous, locally dolomitic and carbonaceous; can contain minor amounts of gypsum.		MIDDLE SEMI-CONFINING UNIT
		LOWER	OLDSMAR FORMATION	POORLY KNOWN	Limestone, white to light brown, porous, fossiliferous, interbedded with dolomite; minor amounts of gypsum present.		LOWER FLORIDAN AQUIFER

Figure 3. Geologic and hydrogeologic units in the study area (modified from Tibbals, 1990).

The Floridan aquifer system is separated from the overlying surficial aquifer system by the intermediate confining unit (fig. 3). The intermediate confining unit consists primarily of clay, silt, and carbonate units of Miocene age, but can include clay units of Pliocene through Pleistocene age where these younger units are vertically continuous. Thickness of the intermediate confining unit ranges from less than 20 ft to more than 100 ft.

The Floridan aquifer system consists of a thick sequence of carbonate rocks of Eocene age (fig. 3) that is divided into the Upper Floridan and Lower Floridan aquifers (Tibbals, 1990). This study focused primarily on water quality in the Upper Floridan aquifer because (1) the Upper Floridan aquifer is the primary source of drinking water in the area, (2) the Upper Floridan aquifer is more susceptible to contamination than the Lower Floridan aquifer, and (3) data available for the Lower Floridan aquifer are sparse.

The depth to the top of the Ocala Limestone, which generally coincides with the top of the Upper Floridan aquifer, averages from less than 100 ft to more than 200 ft throughout most of the study area (Tibbals, 1990). Just west of the study area, near the city of Ocala and along parts of the Ocklawaha River upstream of Lake Ocklawaha, the Ocala Limestone is exposed at land surface; in areas of northeast Lake County, and near Lake George, the Ocala Limestone is within 50 ft of land surface.

Locally, the range of depth to the top of the Upper Floridan aquifer can be large. Information from geologic and geophysical well logs indicate that the depth to the top of the Upper Floridan aquifer can range several hundred feet over relatively small (less than a mile) spatial distances. The top of the Upper Floridan aquifer probably is rather hummocky as a result of dissolution of the carbonate rocks. Although many of these dissolution features are buried by clastic deposits in a type of terrain known as mantled karst, sinkholes, springs, and caves present in parts of the study area result from, and are indicative of, carbonate-rock dissolution.

The Upper Floridan aquifer is recharged primarily by downward leakage from the surficial aquifer system through the intermediate confining unit. This recharge can be rapid in places with abundant sinkholes or where the intermediate confining unit is thin or breached by collapse into underlying dissolution cavities. Just west of the study area, near the city of Ocala and in Sumter County, the Upper Floridan aquifer is within 25 ft of land surface. Hence, in these areas, recharge probably occurs rapidly from precipitation, which could allow the aquifer to be susceptible to surface contamination.

Water levels in the Upper Floridan aquifer range from near sea level in the St. Johns River basin to more than 100 ft above sea level in southern Lake County. Ground water generally flows northward in southern Lake County, and northeastward elsewhere in the study area (Sepulveda, 1997; Merritt, 1998; Adamski, 1998). In the Ocala NF, ground-water flow generally is from the west and southwest toward Lake George (fig. 4). Discharge from the Upper Floridan aquifer occurs in areas where the potentiometric surface is higher than the water table of the surficial aquifer-system—at springs, from flowing wells, and by slow leakage through the intermediate confining unit into the surficial aquifer system.

Land and Water Use

Land use in the Ocala NF primarily consists of relatively pristine forests and wetlands that are designated as multi-use lands and managed for recreational use and silviculture. In 1994, second-growth pine and hardwood forests accounted for 65 percent, and water and wetlands accounted for 19 percent of the land use (Agustin Sepulveda, U.S. Geological Survey (USGS), written commun., 2000). A U.S. Naval bombing range occupies an area of about 9 mi^2 in the south-central part of the Ocala NF (fig. 1), and is not open to the general public.

Land use within the Ocala NF Proclamation Boundary ranges from wilderness to residential. Land administered by the U.S. Forest Service covers about 89 percent of the area contained by the Proclamation Boundary. Of the land owned by the U.S. Forest Service, more than 71 percent is used for timber management/harvest, about 7 percent for wilderness, about 1 percent for U.S. Navy bombing practices, less than 1 percent for recreational sites, and about 20 percent is used as transportation corridors and access roads (2,300 miles) (Richard B. Shellfer, U.S. Forest Service, oral commun., 1999). Several communities (Astor, Astor Park, Lynne, Paisley, and Salt Springs) are located along or within the Proclamation Boundary of the Ocala NF and account for about 11 percent of the land is private residential. Although mining currently is not practiced in the Ocala NF, a few small claypits are used for road maintenance within the forest area.

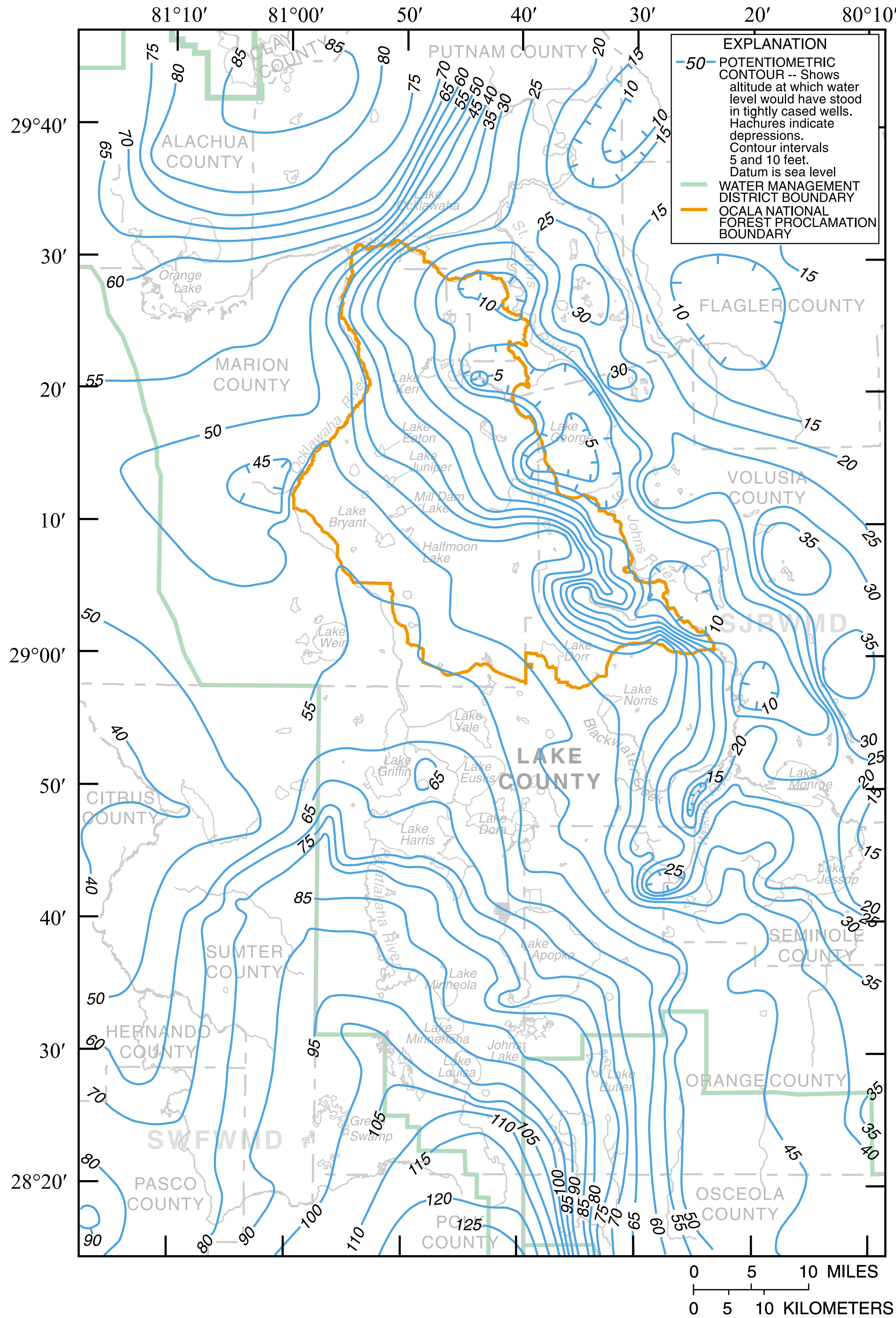

Figure 4. Potentiometric surface of the Upper Floridan aquifer in the Ocala National Forest, Lake County, Florida, and vicinity, May 1998 (modified from Adamski, 1998).

Land use in Lake County is a mixture of agriculture, forests, rangeland, urban, open water, and wetlands. The percentages of these land uses, however, have changed over time. For example, agriculture (predominantly citrus) was about 43 percent of the land use in 1977, but was less than 30 percent of the land use in 1994. The decrease in agriculture during this period was related to several severe winter freezes, which had adverse effects on the citrus industry. Other types of land use increased from 1977 to 1994 as a result of the decrease in agricultural land use (Agustin Sepulveda, USGS, written commun., 2000). For example, forest increased from 15 percent to 18 percent, rangeland from 2 to 7 percent, and urban from 4 to 6 percent. Urbanization of Lake County has been rapidly increasing in recent years. Population of Lake County has increased from 86,720 in 1975 to an estimated population of 206,500 in 2000 (Richard L. Marella, USGS, written commun., 2000). Hence, present (2000) urban land use in Lake County probably is greater than 6 percent. Water and wetlands have remained constant since 1977 at nearly 36 percent of the land use (Agustin Sepulveda, USGS, written commun., 2000).

Nearly all water withdrawn from the Ocala NF is from the Upper Floridan aquifer and is used for domestic and recreation use. Numerous private residences are distributed within the Proclamation Boundary of the Ocala NF. In 1998, residences and recreation sites used nearly 2 million gallons per day (Mgal/d) of ground water and returned about 60 percent to the ground-water system by septic systems (Richard Marella, USGS, written commun., 2000; Brian McGurk, St. Johns River Water Management District (SJRWMD), written commun., 1999).

Lake County obtains most of its water from the Upper Floridan aquifer. In 1998, Lake County pumped more than 100 Mgal/d. Agricultural land use accounts for more than 50 percent; municipal, domestic, and recreation use accounts for nearly 40 percent; and commercial/industrial use accounts for less than 10 percent of the total water pumped. Currently, about 40 percent of all water pumped from the Upper Floridan aquifer in Lake County is estimated to be returned to the ground-water system by land application and by septic systems (Richard Marella, USGS, written commun., 2000; Brian McGurk, SJRWMD, written commun., 1999).

DATA COLLECTION AND ANALYSIS

Water-quality data from springs and wells in Ocala NF and Lake County were compiled to assess current ground-water quality conditions in the study area. The assessment included collection of water-quality samples, compilation of existing data, and statistical analysis of the final data set.

Water-quality samples were collected by the USGS from 1995 through 1999. Samples were collected from wells and springs located in the Ocala NF and (or) Lake County; locations are shown in figures 5 and 6, respectively. The number of samples collected in the forest and county areas and where these two areas overlap is listed in table 1. A total of 23 samples were collected from wells in the surficial aquifer system, 25 samples were collected from springs, and 88 samples came from wells in the Upper Floridan aquifer (figs. 5 and 6, table 1, appendix).

Existing data were compiled from samples collected by the SJRWMD and the Lake County Water Resources Management. These samples were collected from wells and springs located in the Ocala NF and (or) Lake County, and are shown in figures 5 and 6, respectively. A total of 26 samples were collected from wells in the surficial aquifer system (fig. 5, table 1). Two samples were collected from springs (fig. 6) and 53 samples from wells in the Upper Floridan aquifer (fig. 5, table 1, appendix). The samples analyzed and evaluated for this study were collected after 1990; samples collected prior to 1990 were not considered representative of current ground-water conditions, especially outside the relatively undeveloped Ocala NF.

Table 1. Number of water-quality samples from wells and springs in the Ocala National Forest and Lake County, Florida

[USGS, U.S. Geological Survey; SJRWMD, St. Johns River Water Management District; Ocala NF, Ocala National Forest (outside of Lake County); Lake, Lake County (outside of Ocala National Forest); Overlap, area of Ocala National Forest within Lake County]

Collecting agency	Aquifer and site type	Ocala NF	Lake	Over-lap	Total
USGS (1995-99)	Surficial aquifer system, wells	17	1	5	23
	Upper Floridan aquifer, wells	26	48	14	88
	Upper Floridan aquifer, springs	8	15	2	25
SJRWMD and Lake County (1990-98)	Surficial aquifer system, wells	4	20	2	26
	Upper Floridan aquifer, wells	13	29	11	53
	Upper Floridan aquifer, springs	0	1	1	2

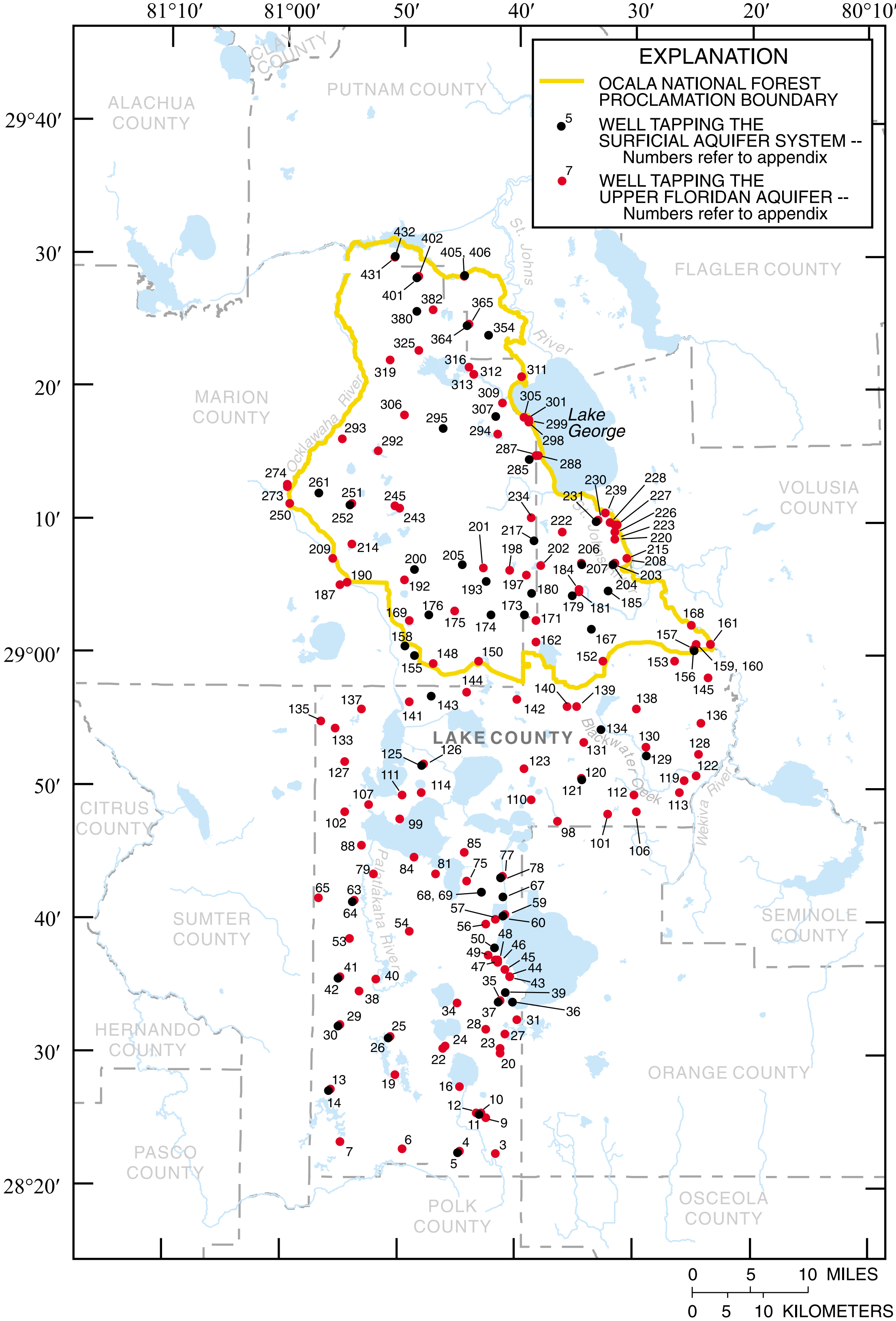

Figure 5. Location of wells with water-quality data.

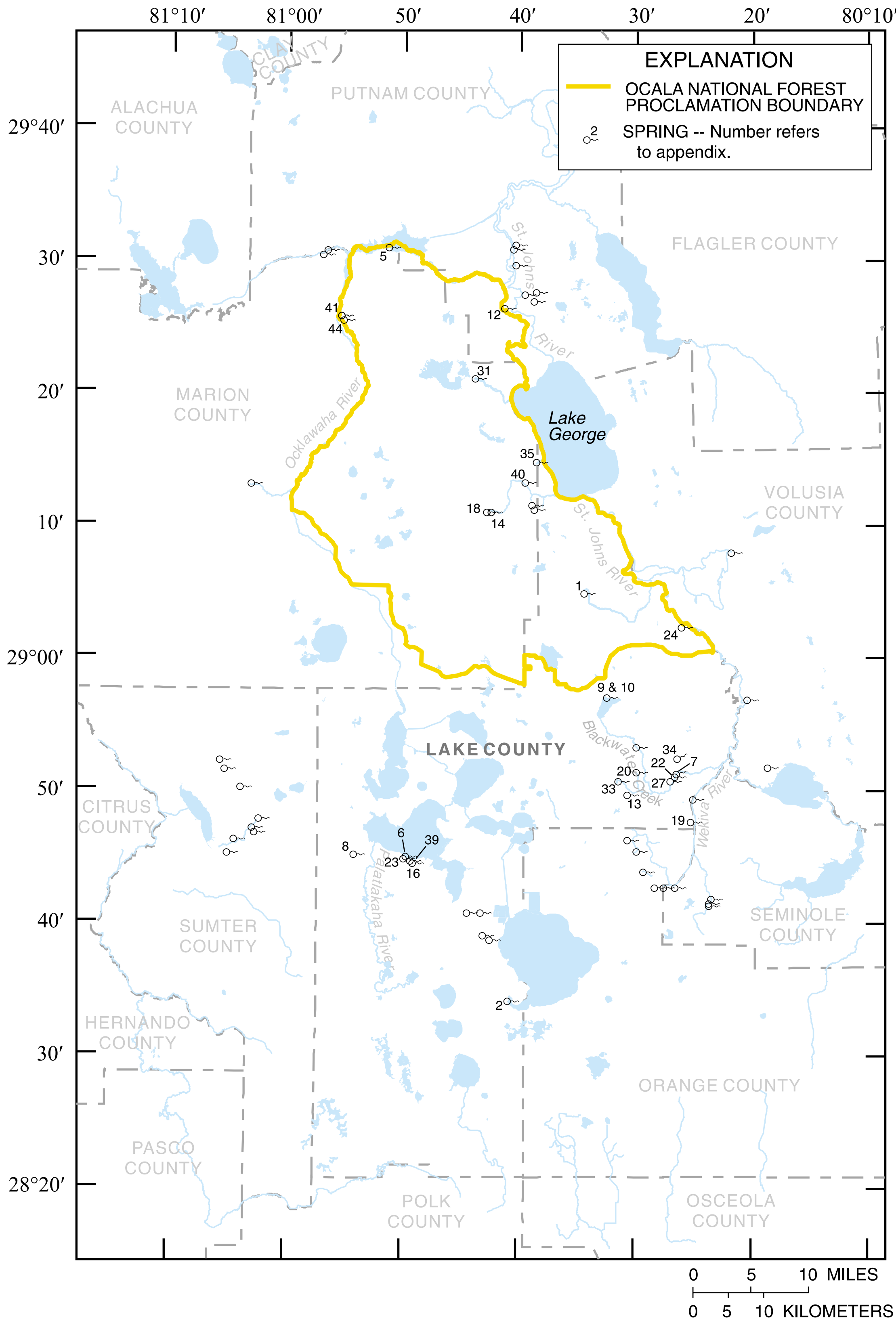

Figure 6. Location of springs including those with water-quality data.

Water samples from wells were collected by the USGS using either an existing submersible pump or a portable 2-inch diameter stainless steel submersible pump with silicone tubing. Field measurements of temperature, pH, and specific conductance were made on ground-water samples at all sites. Dissolved oxygen also was measured in the field. Samples were collected after purging the well of at least three casing volumes and (or) after stabilization of the field measurements. Samples from springs were collected from inside the orifice either with sample bottles or a churn splitter and processed using a peristaltic pump with silicone tubing. Samples were filtered using a 0.45-micrometer pore-size disposable capsule filter. All samples were analyzed for major ions (calcium, magnesium, sodium, potassium, sulfate, and chloride), alkalinity, and total dissolved solids; bicarbonate concentrations were calculated from alkalinity. Samples for cation analysis were acidified with nitric acid to adjust the pH to less than 2. Samples for nutrient analysis [nitrite plus nitrate as nitrogen (hereafter referred to as “nitrate” because nitrite generally was below detection limits), Kjeldahl nitrogen (ammonia plus organic nitrogen as nitrogen), and phosphate] were chilled and delivered overnight to the USGS laboratory in Ocala, Florida.

Some sites were sampled more than once over a period of several years. Only the most recent, analytically complete sample was included in this study. The resulting data set (USGS and SJRWMD data) includes samples collected over a period of nearly 10 years using various methods and techniques. For example, some samples apparently were not filtered prior to analysis. Laboratory-measured pH and alkalinity were used if field-measured pH and alkalinity were not available. In addition, many of the 217 samples were incomplete with respect to major-ion analyses. Calcium, magnesium, and sodium concentrations were available for only 174 samples, bicarbonate concentrations were available for only 145 samples, chloride concentrations were available for 203 samples, and sulfate concentrations were available for 199 samples. Nitrate concentrations were available for 98 samples, Kjeldahl nitrogen concentrations were available for 81 samples, and phosphate concentrations were available for 71 samples. Data used in this report are shown in the appendix.

Simple linear regression indicated that total dissolved solids (TDS) concentrations of samples from both aquifers were significantly correlated to specific conductance ($r^2>0.99$) (fig. 7). If TDS concentrations were not available, TDS was calculated as a function of specific conductance using the following equation:

$$TDS = -27 + 0.65(\text{specific conductance}).$$

Results plotted in figure 7 illustrate that the correlation was not as good for samples with specific conductance less than 100 microsiemens per centimeter.

The non-parametric Kruskal-Wallis test was used to statistically identify differences in water quality between the aquifers, between site types (springs and wells), and between geographic locations (Helsel and Hirsch, 1992). For statistical purposes, samples from sites located in the area of overlap between the Ocala NF and Lake County (table 1) were grouped with sites in the Ocala NF because land use in this area of northern Lake County is similar to the rest of the Ocala NF. Medians of groups of data are assumed significantly different from one another if the probability (p-value) is less than 5 percent (<0.05) that the difference occurs by chance. The non-parametric Spearman’s rho (r) rank correlation coefficient was used to determine monotonic relations between water-quality variables.

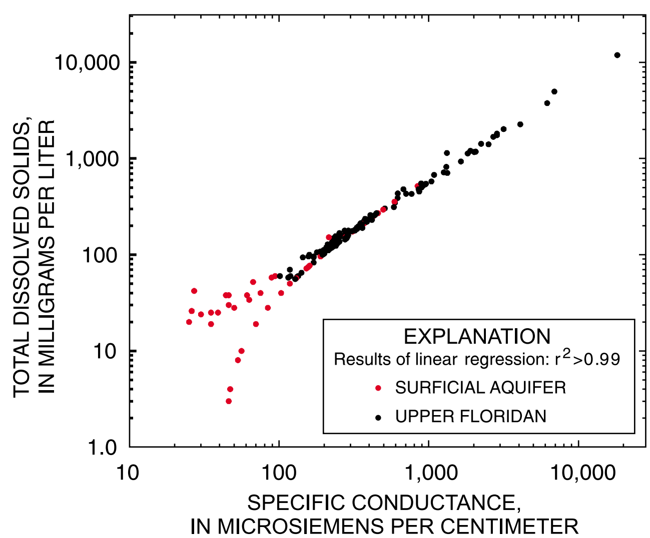

Figure 7. Relation of concentrations of total dissolved solids to specific conductance in ground-water samples from the surficial aquifer system and the Upper Floridan aquifer.

GROUND-WATER QUALITY

The Ocala NF is a relatively pristine area. Hence, the ground-water quality conditions of the Ocala NF probably approximate the natural ground-water quality of north-central Florida. As noted, the land use of Lake County is primarily a mixture of agriculture, forest, and rangeland with increasing urbanization. The compilation of data from these two areas allows for the comparison of water quality with respect to land use.

Surficial Aquifer System

Ground water in the surficial aquifer system generally has low concentrations of major ions and total dissolved solids. The water type of the surficial aquifer system is laterally diverse; results indicate that in places the ground water in the surficial aquifer can be calcium bicarbonate, sodium-chloride, or mixed cation and mixed anion (figs. 8 and 9). TDS concentrations of all samples ranged from 3 to 356 milligrams per liter (mg/L), with a median of 41 mg/L (table 2, fig. 10). More than 75 percent of the samples had TDS concentrations less than 100 mg/L. None of the samples had concentrations that exceeded the National Secondary Drinking Water Regulations (NSDWR) for TDS (500 mg/L), chloride (250 mg/L), or sulfate (250 mg/L). NSDWRs are non-enforceable drinking water standards issued for taste or aesthetic purposes (U.S. Environmental Protection Agency, 2000). Water in the surficial aquifer system is slightly acidic, with a pH of 6.1 or less in 50 percent of the samples (table 2). Three samples had a pH of 4.5 or less. Furthermore, pH was significantly correlated to concentrations of TDS (r = 0.64). In 18 of 19 samples with pH less than or equal to 6.0, TDS concentrations were less than or equal to 60 mg/L.

The median TDS concentrations in the surficial aquifer system is significantly greater (p = 0.01) in samples from Lake County (96 mg/L) than in samples from the Ocala NF (36 mg/L). In addition, median pH and concentrations of calcium, magnesium, potassium, bicarbonate, and sulfate in the surficial aquifer system are significantly greater (p<0.01, <0.01, <0.01, <0.01, <0.01, and 0.04, respectively) in samples from Lake County than in samples from the Ocala NF (figs. 11 and 12). pH and concentrations of sulfate, chloride, and total dissolved solids (fig. 10) in the surficial aquifer system are lowest in the central part of the Ocala NF and increase toward the St. Johns and Ocklawaha Rivers.

Table 2. Summary statistics of ground-water quality of the surficial aquifer system

[µS/cm, microsiemens per centimeter; °C, degrees celsius; mg/L, milligrams per liter; N, nitrogen; P, phosphorus; <, less than; --, missing information]

Constituent	Units	Lake County				Ocala National Forest			
		Number of samples	Minimum	Median	Maximum	Number of samples	Minimum	Median	Maximum
Specific conductance	µS/cm	19	47	190	590	26	25	52	496
pH	standard units	15	5.0	6.4	7.9	26	4.4	5.8	8.8
Temperature	°C	21	20.0	23.8	25.5	26	21.6	23.1	26.1
Dissolved oxygen	mg/L	0	--	--	--	11	<0.1	5.5	8.2
Calcium	mg/L	20	3	14	91	25	<1	2	28
Magnesium	mg/L	20	0.6	4.7	21	25	<.1	0.9	4.1
Sodium	mg/L	20	1.9	6.0	48	25	.7	4.4	93
Potassium	mg/L	20	.21	1.7	9.7	24	<.1	.25	5.3
Bicarbonate	mg/L	7	17	27	164	21	4	11	85
Sulfate	mg/L	16	.2	6.7	52	27	.1	3	64
Chloride	mg/L	16	2.9	7.8	24	27	1	7	42
Fluoride	mg/L	14	<.1	0.1	1.7	25	<.1	<.1	0.6
Dissolved solids, total	mg/L	18	4	96	356	26	3	36	294
Nitrite plus nitrate	mg/L as N	10	.02	.07	4.2	15	<.02	.1	1.6
Kjeldahl nitrogen	mg/L as N	8	.21	.28	1.0	12	<.2	.24	.88
Phosphate	mg/L as P	2	.06	.1	0.14	12	.01	.04	.96

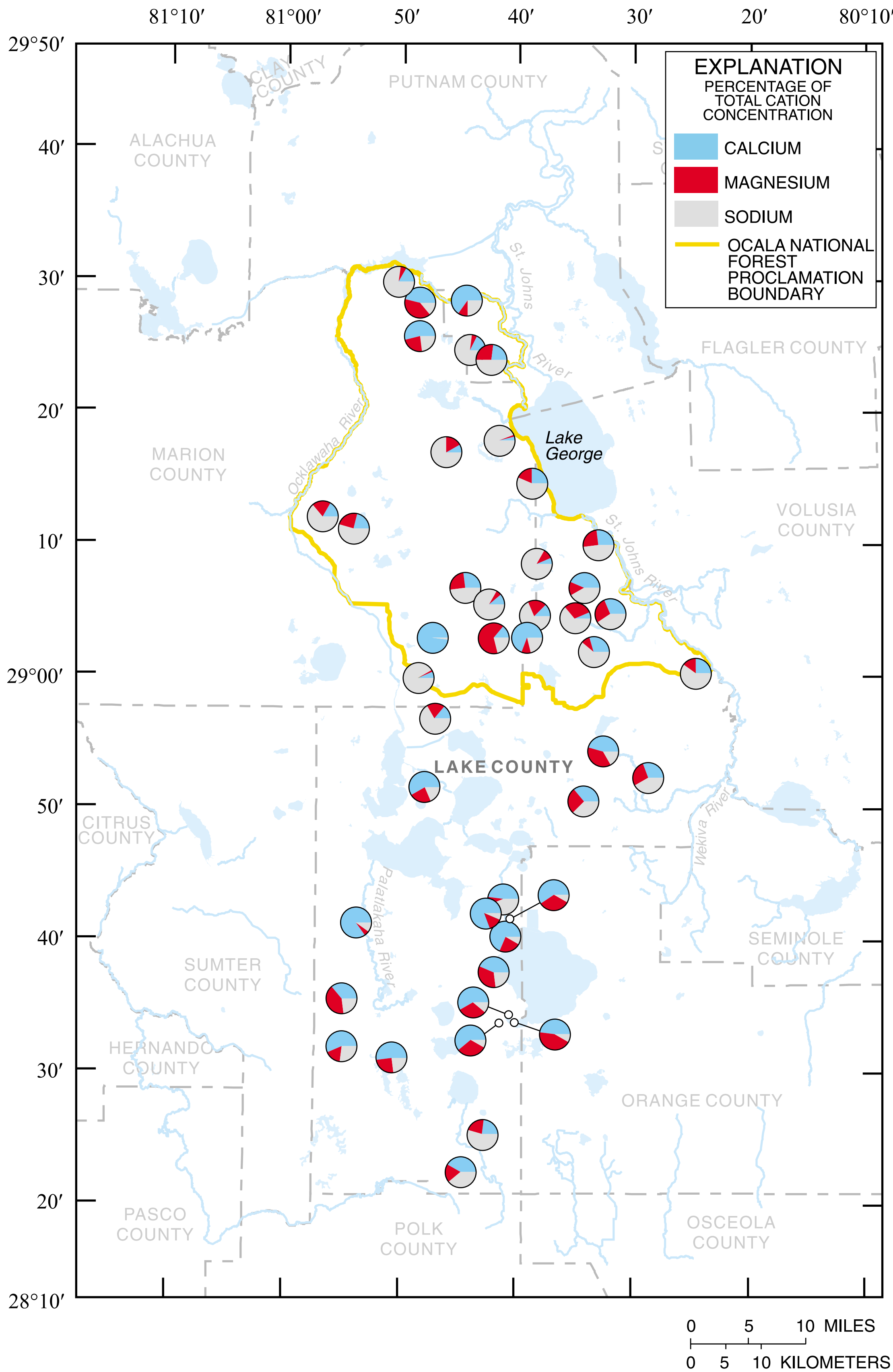

Figure 8. Relative concentrations of calcium, magnesium, and sodium in samples from wells tapping the surficial aquifer system.

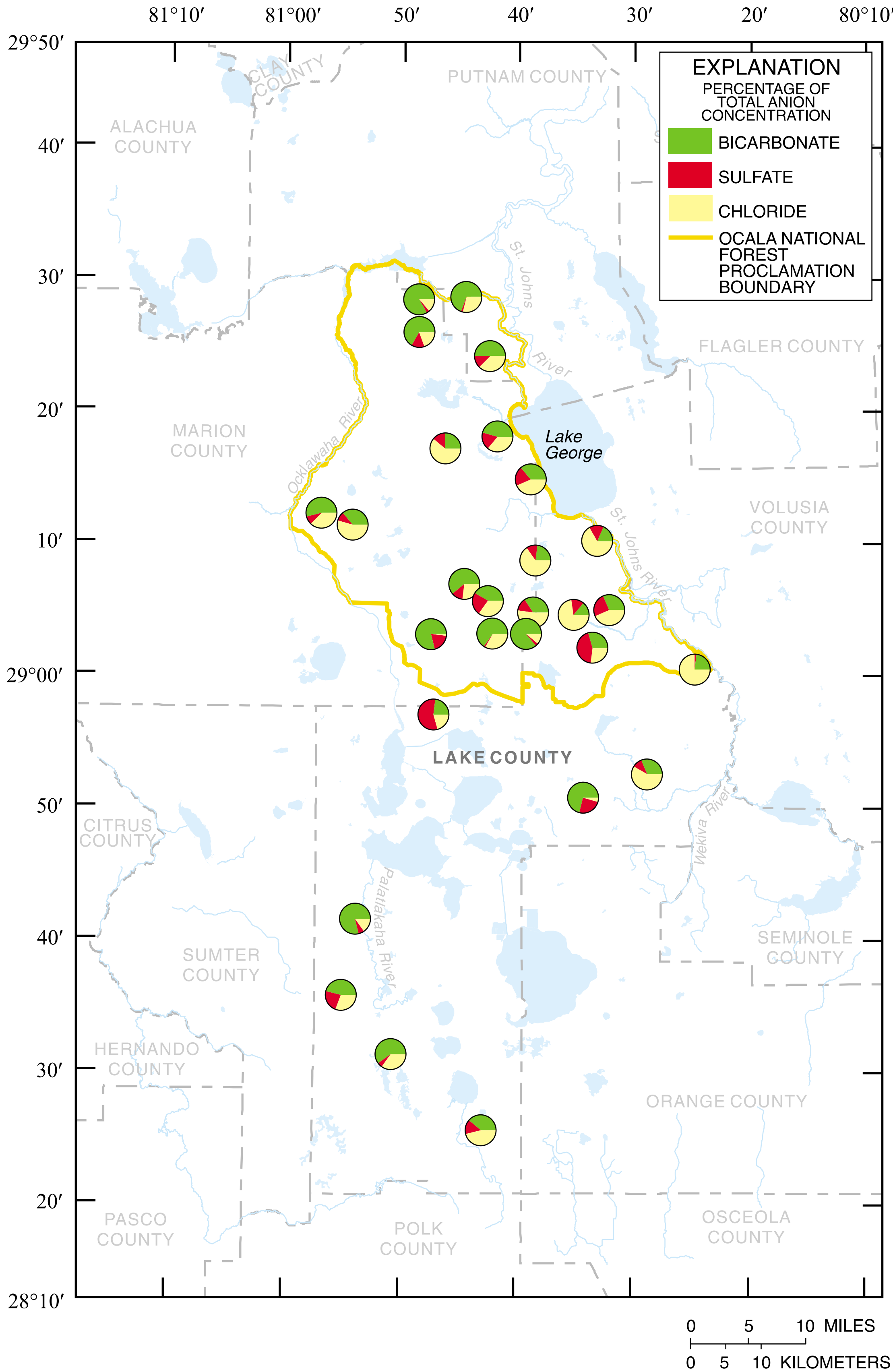

Figure 9. Relative concentrations of bicarbonate, sulfate, and chloride in samples from wells tapping the surficial aquifer system.

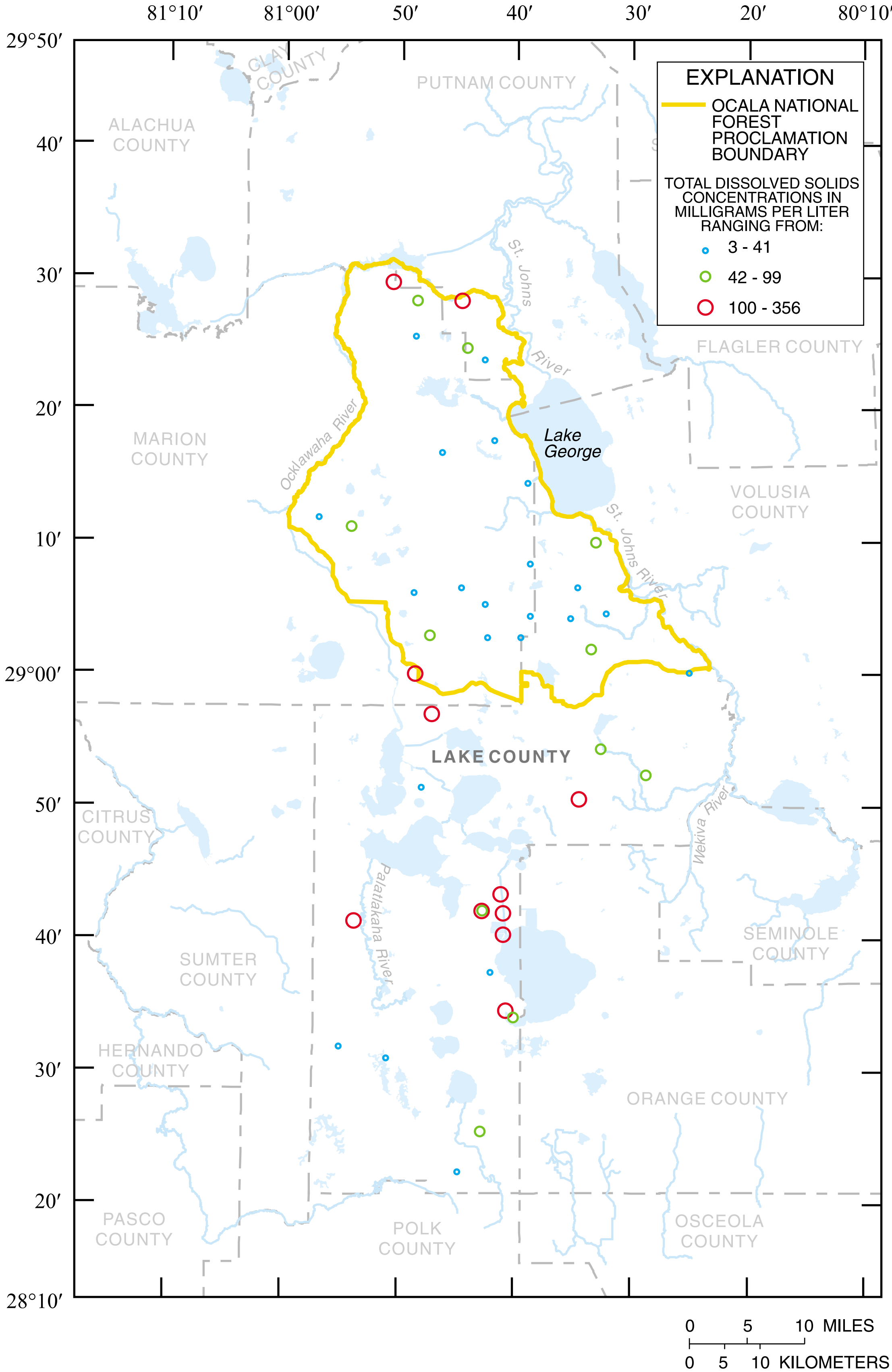

Figure 10. Concentrations of total dissolved solids in samples from wells tapping the surficial aquifer system.

Dissolved oxygen is abundant in the surficial aquifer system underlying the Ocala NF. Nine samples had dissolved-oxygen concentrations ranging from 3.1 to 8.2 mg/L; only two samples had dissolved-oxygen concentrations less than 0.1 mg/L. Dissolved-oxygen data were not available for any samples collected from Lake County.

Concentrations of nutrients in the surficial aquifer system generally are low. Nitrate concentrations in samples from the Ocala NF range from less than 0.02 to 1.6 mg/L with a median of 0.1 mg/L (table 2, fig. 13). None of the samples had nitrate concentrations that exceeded the Maximum Contaminant Level (MCL) of 10 mg/L (U.S. Environmental Protection Agency, 2000). Nitrogen constituents (nitrate and Kjeldahl nitrogen) were detected in 67 percent of the samples. The low median concentration probably is a result of the pristine, relatively undeveloped conditions in the area. Nitrate and Kjeldahl nitrogen were detected at higher concentrations and more frequently in the surficial aquifer system in Lake County than in the Ocala NF. Nitrate concentrations in Lake County range from less than 0.02 to 4.2 mg/L, with a median of 0.07 mg/L (figs. 13 and 14). Nitrate was detected in nearly 80 percent of the samples, and Kjeldahl nitrogen was detected in 75 percent of the samples.

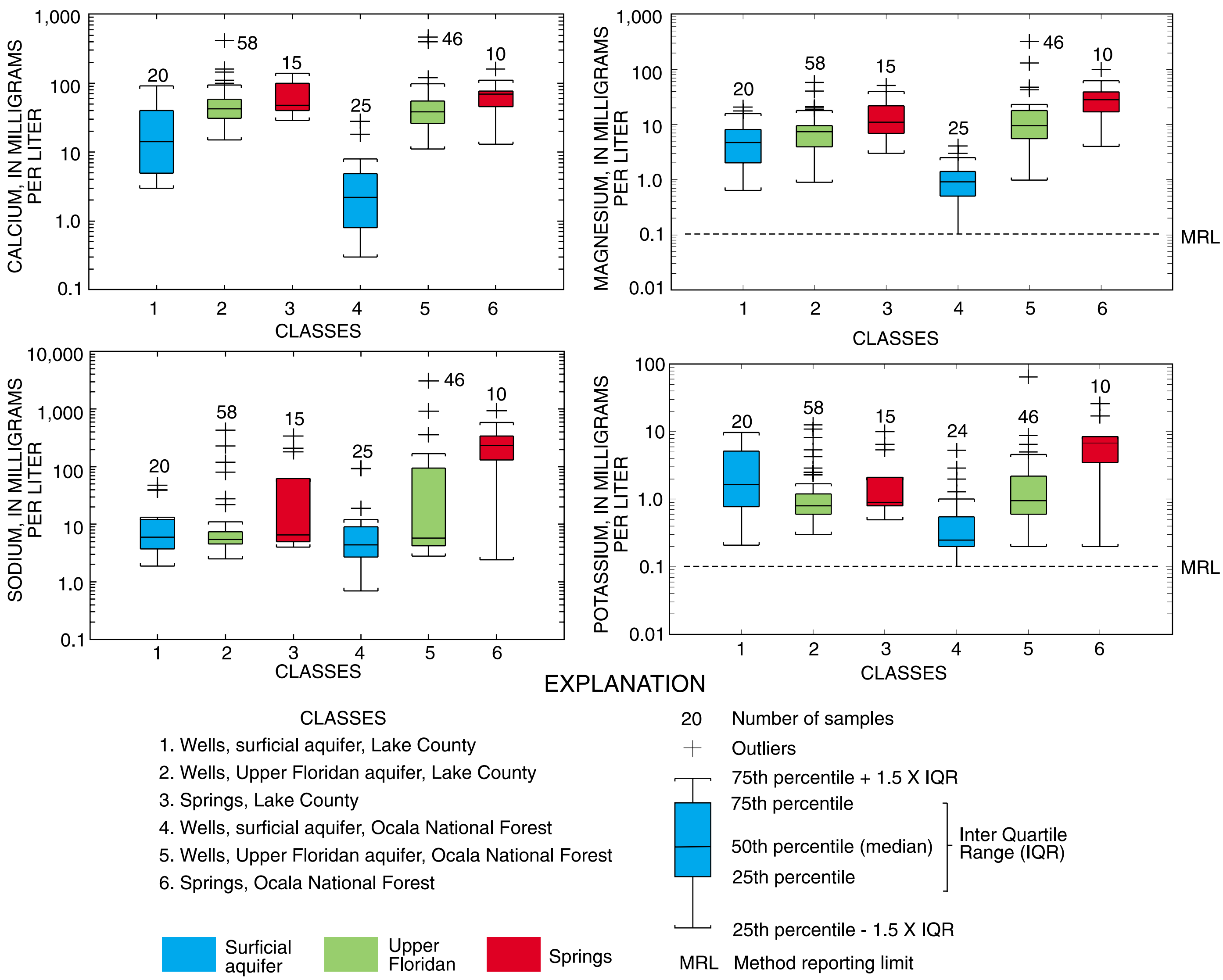

Figure 11. Distribution of calcium, magnesium, sodium, and potassium in springs and in wells tapping the surficial aquifer system and the Upper Floridan aquifer.

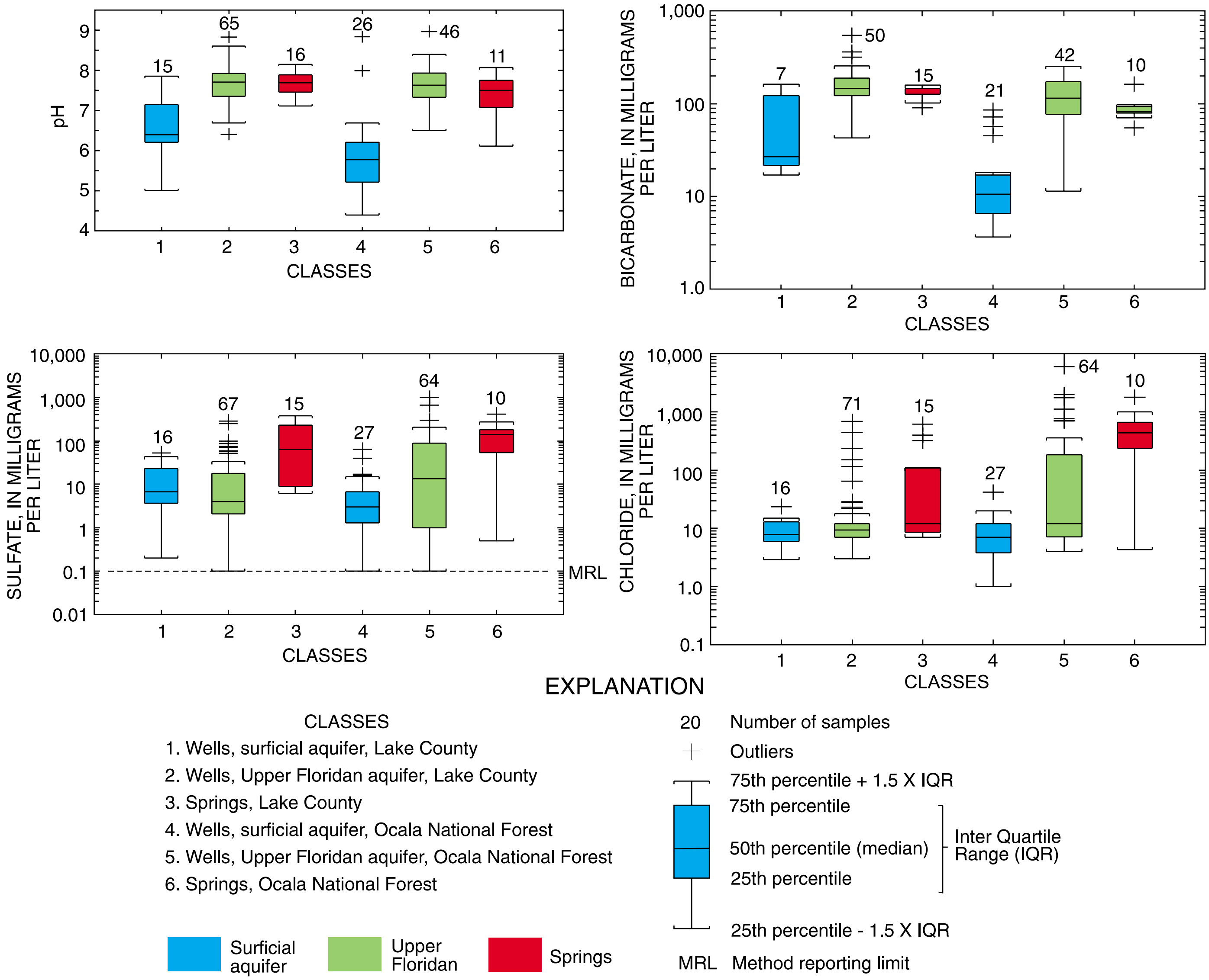

Figure 12. Distribution of pH, bicarbonate, sulfate, and chloride in springs and in wells tapping the surficial aquifer system and the Upper Floridan aquifer.

Phosphate was greater than or equal to 0.02 mg/L in more than 85 percent of the samples. The source of phosphate in the aquifer could be anthropogenic or natural phosphatic sands in the surficial aquifer system and underlying Hawthorn Formation.

The water quality of the surficial aquifer system likely can be attributed to a number of factors including rainfall quality, the lithology of the aquifer, mixing of water from the surficial aquifer system with water discharging or leaking from the Upper Floridan aquifer, and effects of land use. Low concentrations of dissolved solids (less than 100 mg/L) probably originate in precipitation recharging the aquifer. Precipitation chemistry in peninsular Florida generally is acidic (pH ranging from about 4.5 to 5.0 in 1999) with concentrations of major ions generally less than 1 mg/L. For example, in 1999 calcium concentrations in rainfall ranged from 0.08 to 0.25 mg/L, sodium concentrations ranged from 0.14 to 0.33 mg/L, and chloride concentrations ranged from 0.26 to 0.58 mg/L (National Atmospheric Deposition Program, 2000). These ions are concentrated in the aquifer through evapotranspiration processes. The low pH and TDS of most samples in the Ocala NF indicate that the quartz-sand lithology of the surficial aquifer system is unreactive and does not significantly affect the geochemistry of the ground water. As previously noted, the surficial aquifer system in Lake County can contain clay and shell units that can

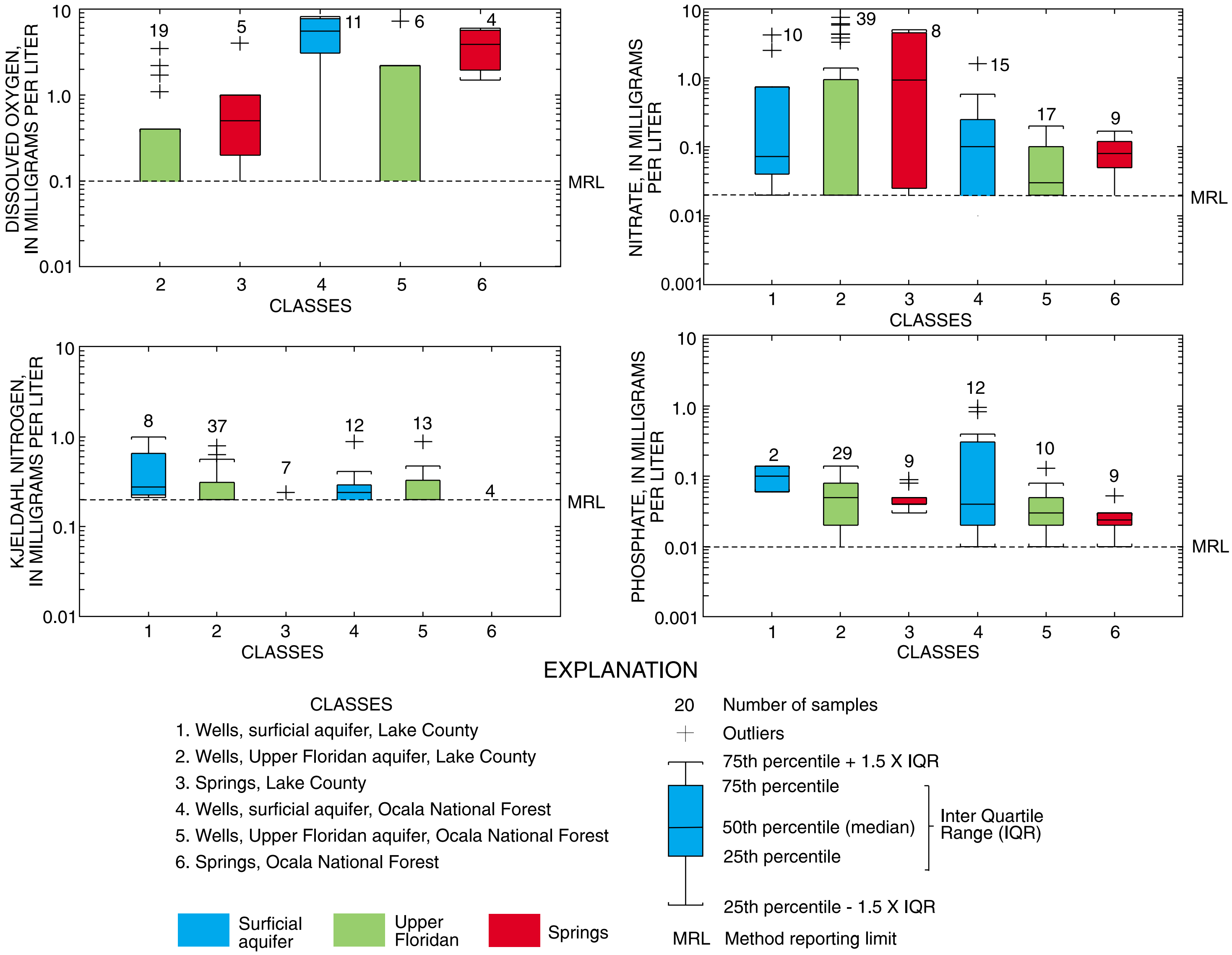

Figure 13. Distribution of dissolved oxygen, nitrate, Kjeldahl nitrogen, and phosphate in springs and in wells tapping the surficial aquifer system and the Upper Floridan aquifer.

contribute to the concentrations of major ions and TDS of the aquifer. However, the number of samples collected for analysis of most water-quality constituents of the surficial aquifer system in Lake County is 20 or less; hence, determining the primary factors affecting water quality is difficult.

An important process affecting water quality in the surficial aquifer system in the Ocala NF is mixing with water from the Upper Floridan aquifer. For example, water-level data from a pair of wells (405 and 406 in fig. 5) near the northern boundary of the Ocala NF indicated that water levels were consistently higher in the Upper Floridan aquifer than in the surficial aquifer system. Hence, calcium-magnesium-bicarbonate water present in the surficial aquifer system at that location (figs. 8 and 9) could be the result of water discharging from the Upper Floridan aquifer upward into the surficial aquifer system.

The primary source of dissolved oxygen in ground water is precipitation that recharges the aquifer (Hem, 1989). Dissolved-oxygen concentrations in ground water generally decrease over time as the oxygen in the water reacts with minerals and organic material. Hence, the abundance of dissolved oxygen in the surficial aquifer system indicates rapid ground-water recharge and (or) the lack of reactive minerals in the aquifer. Rapid ground-water recharge can allow the aquifer to be susceptible to surface contamination.

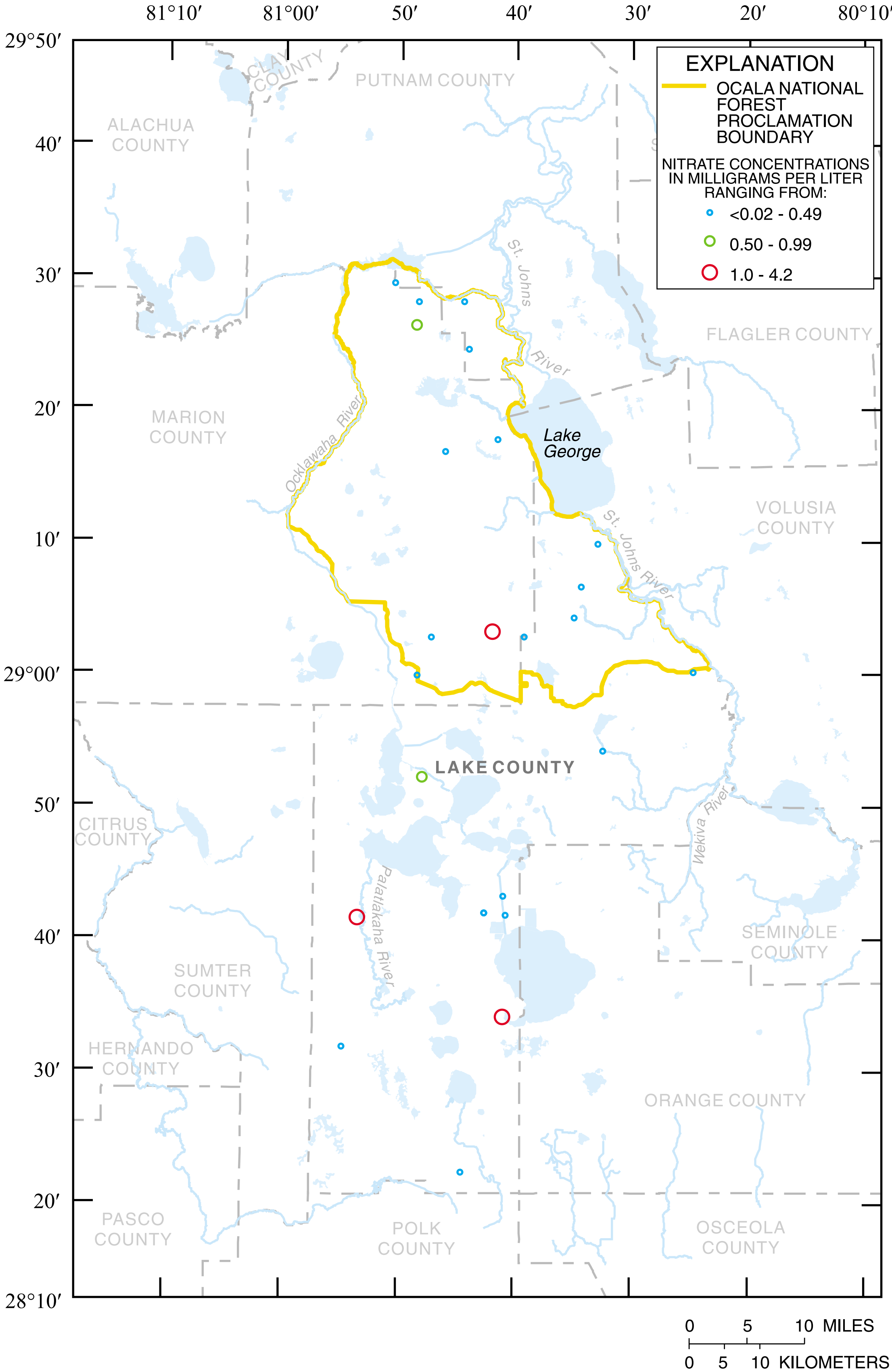

Figure 14. Nitrate concentrations in samples from wells tapping the surficial aquifer system.

Differences in water quality of the surficial aquifer system in Ocala NF and Lake County possibly is related to land use. Locally, nitrate concentrations in the surficial aquifer system are elevated. Nitrate concentrations are greater than 1.0 mg/L in two samples from Lake County and one sample from the Ocala NF (fig. 14). Nitrate concentrations greater than 1.0 mg/L in ground water generally are related to land-use practices, such as septic systems or land application of fertilizers. Hence, the water quality of the surficial aquifer system in parts of the study area could be affected by present and (or) past land use. Because constituents such as nitrate can remain in ground water for many years, elevated concentrations of nitrate in ground water do not necessarily indicate the effects of present land use, but could have resulted from previous land-use practices.

Applications of fertilizer and pumping water from the Upper Floridan aquifer to irrigate citrus groves in Lake County also could be increasing the pH and concentrations of major ions in the surficial aquifer system. Nitrate concentrations in the surficial aquifer system in Lake County were positively correlated to pH (r = 0.75); however, sample size was only 13 (fig. 15). These results are in agreement with German (1997) who determined that concentrations of major constituents and nitrate in the surficial aquifer system were greater in areas underlying citrus groves in Lake and Orange Counties than in a forested area in the Ocala NF.

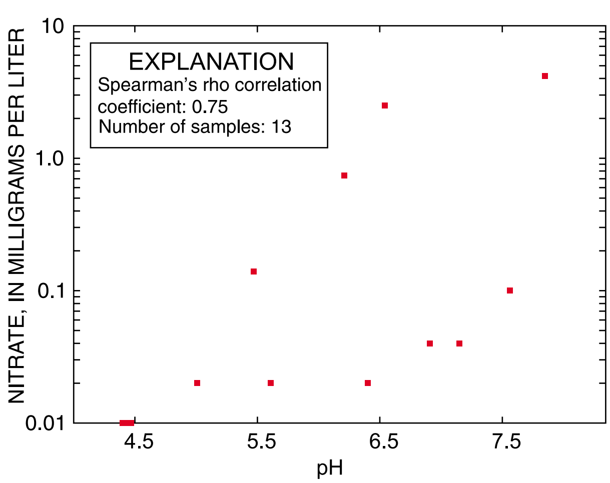

Figure 15. Relation of nitrate concentrations to pH in wells tapping the surficial aquifer system in Lake County, Florida.

Upper Floridan Aquifer

Water throughout most of the Upper Floridan aquifer is a calcium-bicarbonate or calcium-magnesium-bicarbonate type (figs. 16 and 17). Concentrations of TDS were less than 250 mg/L in 77 percent of the samples collected throughout the study area. Near the St. Johns River and Lake George, TDS concentrations ranged from about 2,000 to nearly 12,000 mg/L (fig. 18). A total of 14 of 111 samples from wells had concentrations of TDS that exceeded the NSDWR of 500 mg/L. A total of 14 of 135 samples had chloride concentrations that exceeded the NSDWR of 250 mg/L, and 5 of 131 samples had sulfate concentrations that exceeded the NSDWR of 250 mg/L.

In general, water-quality conditions and the concentrations of most major ions in the Upper Floridan aquifer do not differ significantly between samples collected in the Ocala NF and Lake County. In southern Lake County, the dominant cation was calcium, whereas further north in Lake County and the Ocala NF, the dominant cations were calcium and magnesium. Bicarbonate concentrations generally were greater in samples from wells in Lake County than in samples from the Ocala NF. Near the St. Johns and Wekiva Rivers, sodium, chloride, and sulfate were the dominant ions (figs. 16 and 17). This change to a sodium-chloride-sulfate water type corresponds to the increases in concentrations of sulfate, chloride, and TDS observed in these areas (figs. 18, 19, and 20).

Concentrations of most major ions and TDS generally are greater in the Upper Floridan aquifer than in the surficial aquifer system (tables 2 and 3; figs. 11 and 12). Throughout the Ocala NF and Lake County, median pH and concentrations of calcium, magnesium, and bicarbonate are significantly greater ($p<0.01$) in samples from the Upper Floridan aquifer than in samples from the surficial aquifer system. In addition, in the Ocala NF, median concentrations of sodium, potassium, sulfate, and chloride also are significantly greater ($p<0.01$) in samples from the Upper Floridan aquifer than in samples from the surficial aquifer system. In Lake County, potassium concentrations are greater ($p = 0.04$) in the samples from the surficial aquifer system than in samples from the Upper Floridan aquifer. Most of the water-quality differences between the surficial aquifer system and the Upper Floridan aquifer probably are related to differences in lithology and the greater solubility of carbonate rocks in comparison to quartz sand.

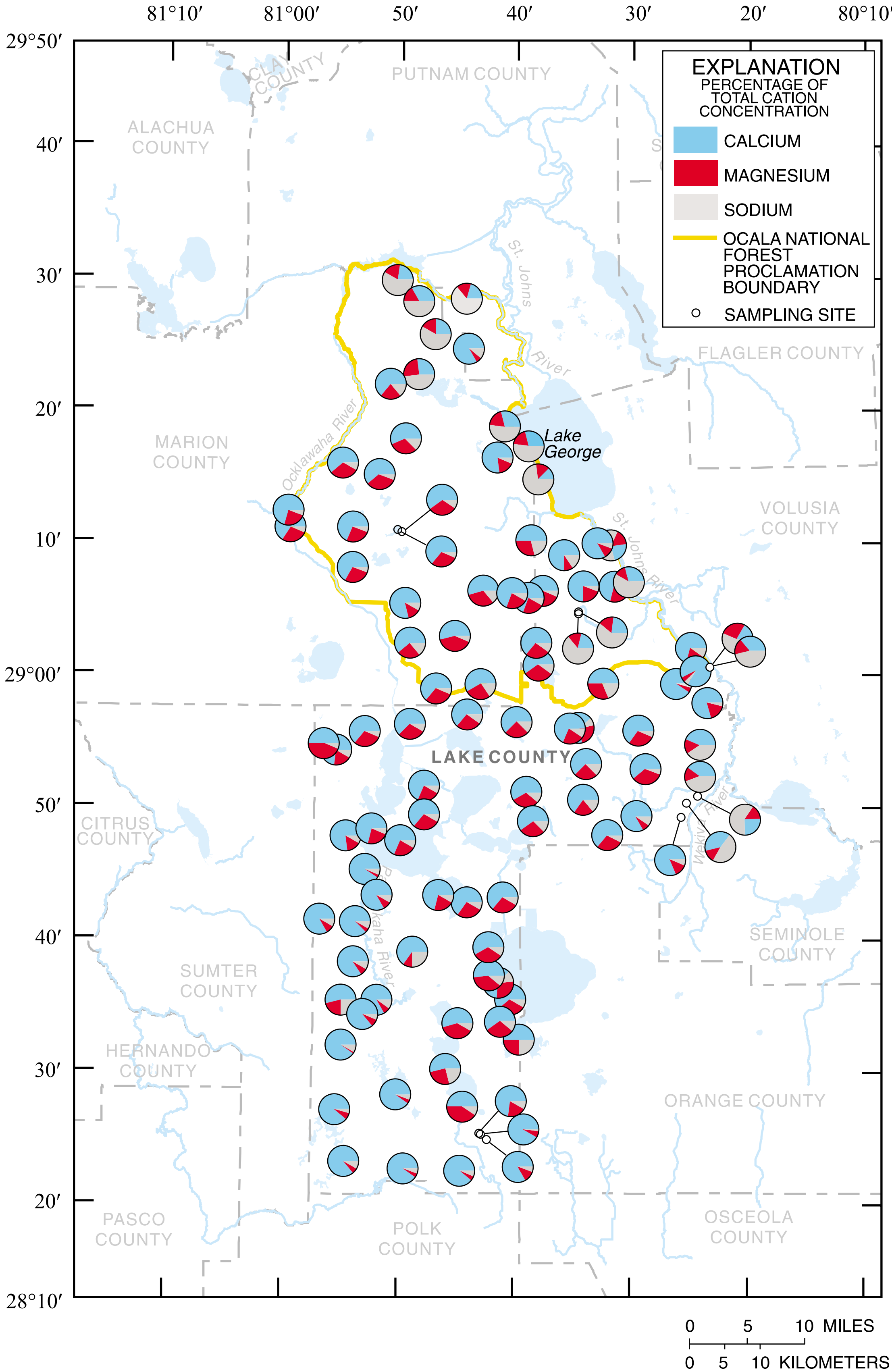

Figure 16. Relative concentrations of calcium, magnesium, and sodium in samples from wells tapping the Upper Floridan aquifer.

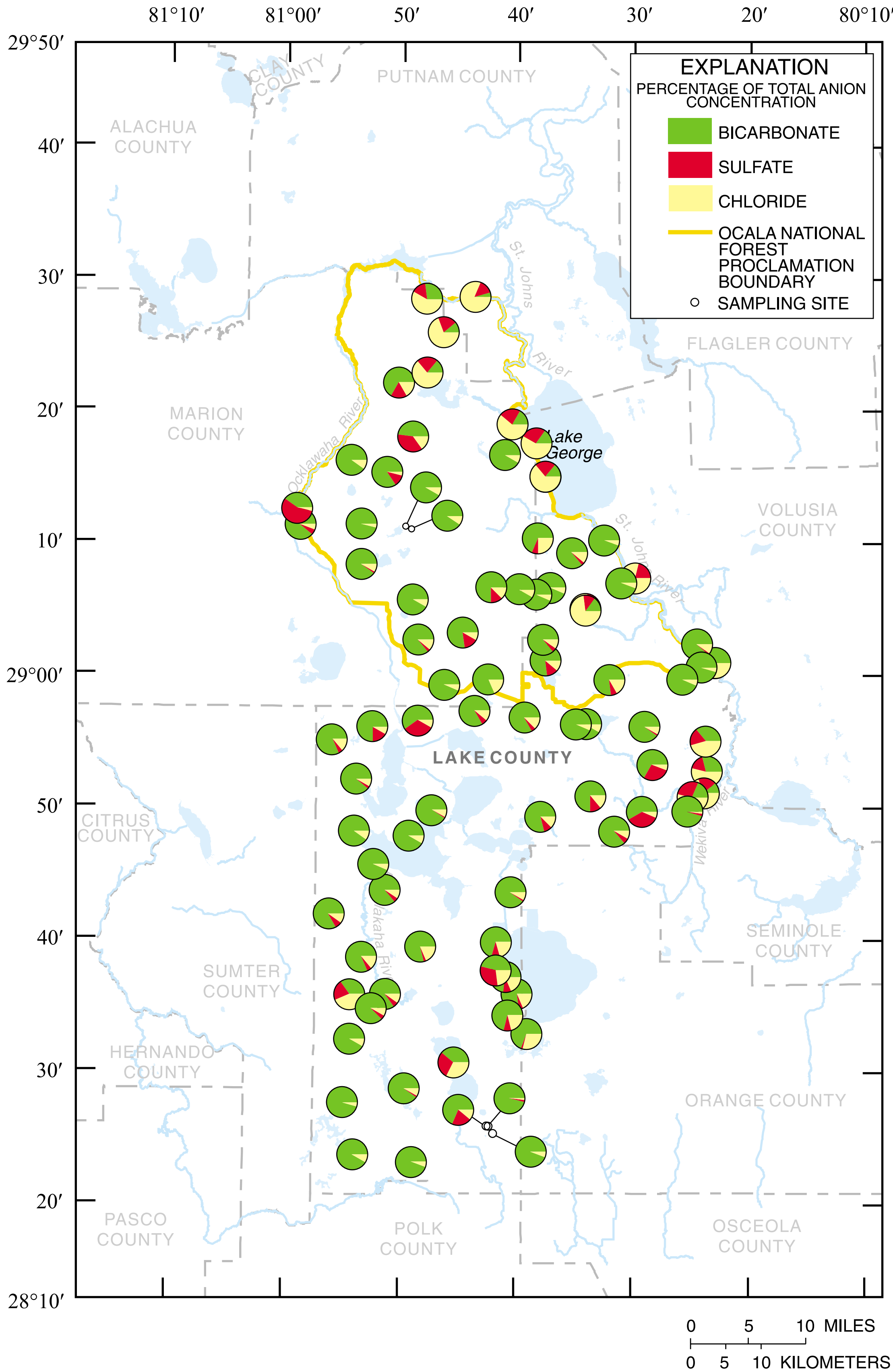

Figure 17. Relative concentrations of bicarbonate, sulfate, and chloride in samples from wells tapping the Upper Floridan aquifer.

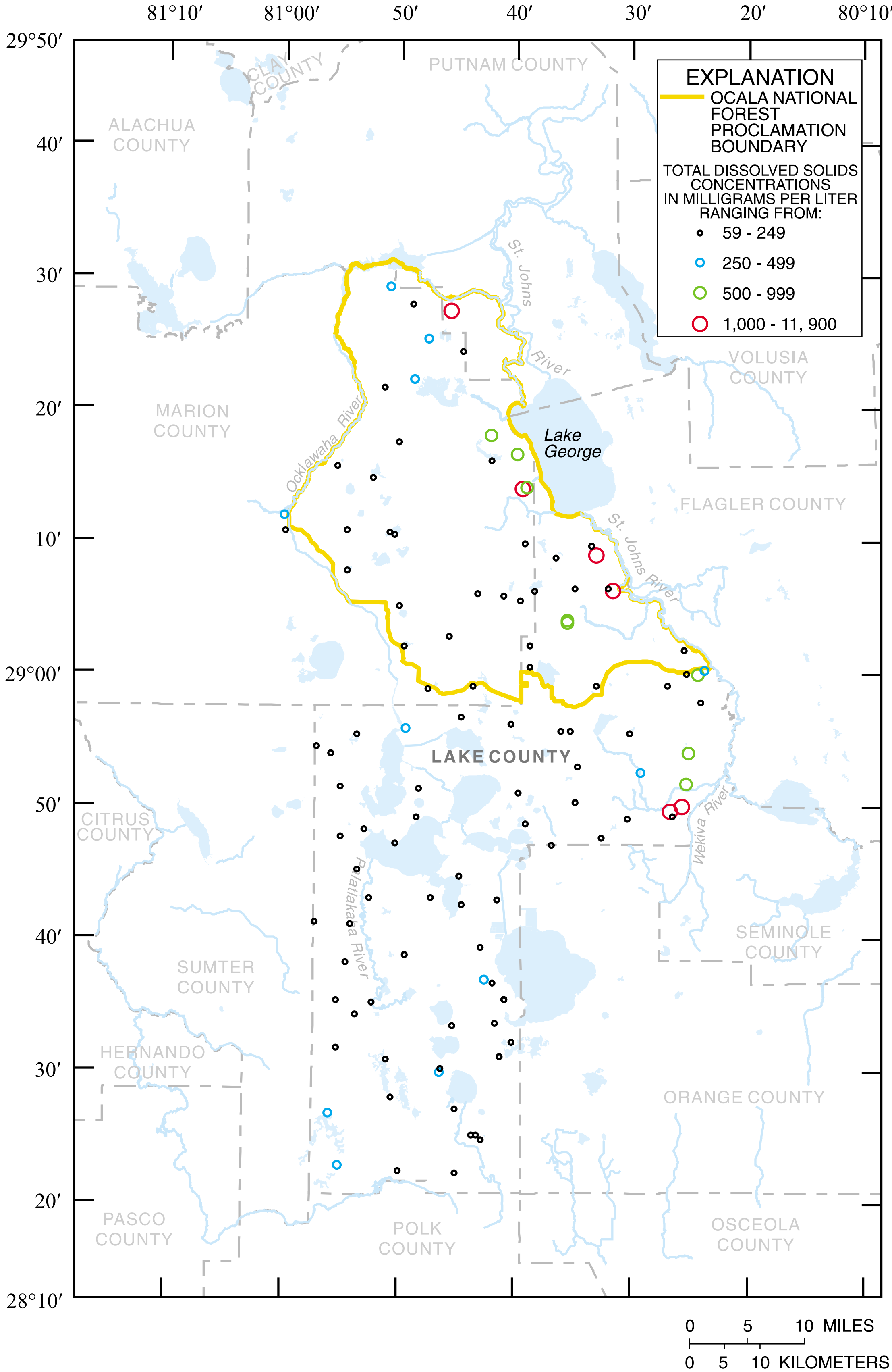

Figure 18. Concentrations of total dissolved solids in samples from wells tapping the Upper Floridan aquifer.

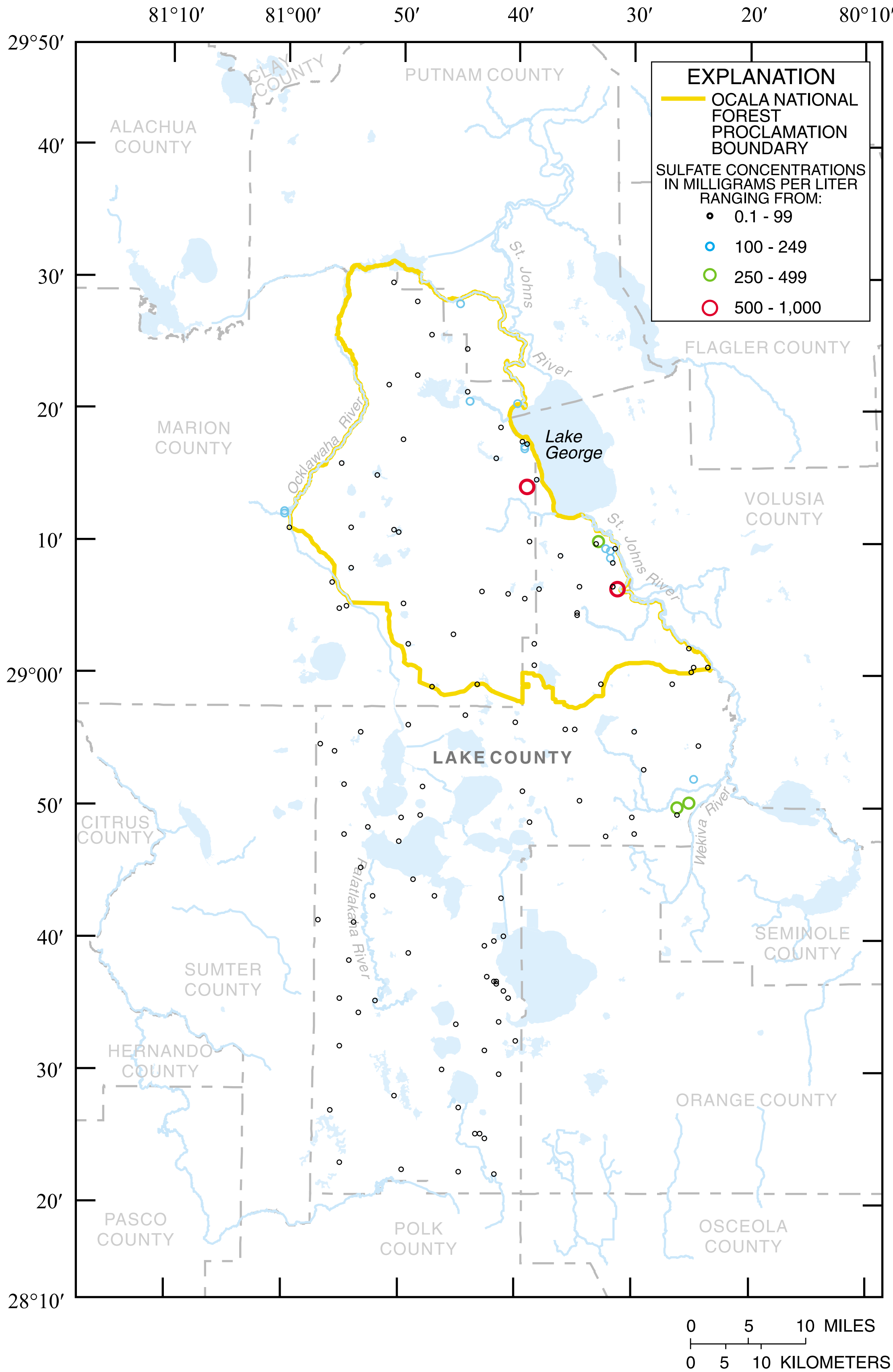

Figure 19. Sulfate concentrations in samples from wells tapping the Upper Floridan aquifer.

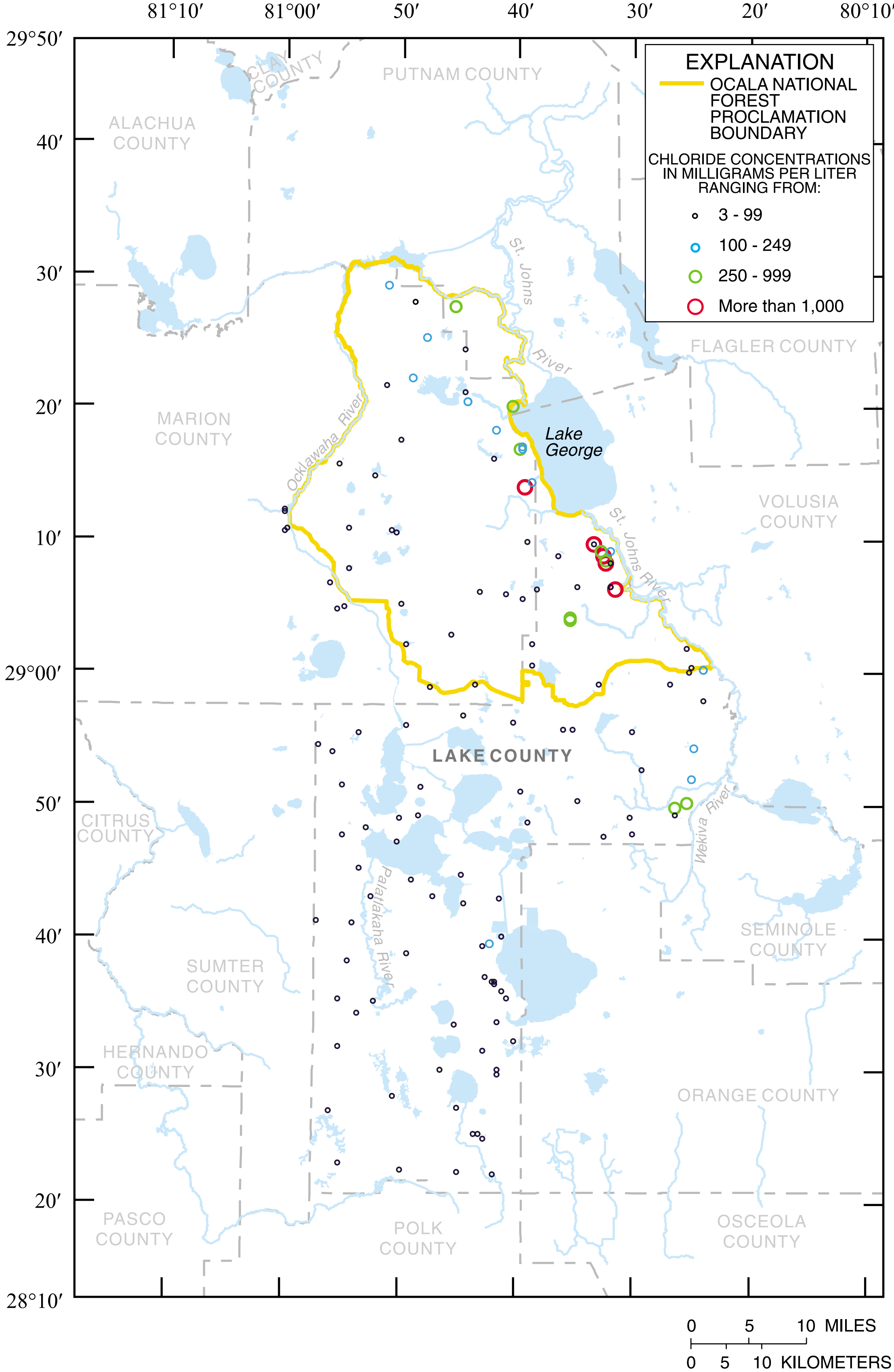

Figure 20. Chloride concentrations in samples from wells tapping the Upper Floridan aquifer.

Table 3. Summary statistics of ground-water quality from Upper Floridan aquifer springs and wells

[µS/cm, microsiemens per centimeter; °C, degrees celsius; mg/L, milligrams per liter; N, nitrogen; P, phosphorus; <, less than]

Constituent	Units	Lake County				Ocala National Forest			
		Number of samples	Minimum	Median	Maximum	Number of samples	Minimum	Median	Maximum
Specific conductance	µS/cm	81	132	289	3,160	57	101	360	18,200
pH	standard units	81	6.4	7.7	8.8	57	6.1	7.6	9.0
Temperature	°C	81	20.7	23.7	27.4	54	15.7	22.6	24.0
Dissolved oxygen	mg/L	24	<0.1	<0.1	4.0	10	<0.1	1.8	7.3
Calcium	mg/L	73	15	44	417	56	11	43	470
Magnesium	mg/L	73	.9	7.6	58	56	1	12	320
Sodium	mg/L	73	2.5	5.6	430	56	2.4	7.7	3,100
Potassium	mg/L	73	.3	.8	13	56	.2	1.0	65
Bicarbonate	mg/L	65	43	139	551	52	11	101	254
Sulfate	mg/L	82	.1	6.6	380	74	.1	18	1,000
Chloride	mg/L	86	3	10	695	74	4	18	6,000
Fluoride	mg/L	72	<.1	.19	0.35	55	<.1	0.1	0.4
Dissolved solids, total	mg/L	81	59	176	2,022	57	56	204	11,900
Nitrite plus nitrate	mg/L as N	47	<.02	.04	7.5	26	<.02	.05	.2
Kjeldahl nitrogen	mg/L as N	44	<.2	.15	.79	17	<.2	.2	.88
Phosphate	mg/L as P	38	<.01	.05	.14	19	.01	.03	.13

Water-quality data were available from a total of 27 springs. In 8 of 10 springs within the Ocala NF, the water type is sodium-chloride or sodium-chloride-sulfate (figs. 21 and 22). The water type of springs in central Lake County is calcium bicarbonate. Median concentrations of magnesium, sodium, potassium, sulfate, chloride, and total dissolved solids in samples from springs were significantly greater ($p<0.01$) than in samples from wells tapping the Upper Floridan aquifer (figs. 11 and 12). These results are probably related to the geographical distribution of springs and do not indicate significant hydrogeologic differences between springs and wells. Most springs are located in the discharge areas of the Upper Floridan aquifer near the St. Johns and Wekiva Rivers. As previously noted, the aquifer in this area has relatively high concentrations of sodium, chloride, and total dissolved solids. A comparison of samples from springs and nearby wells tapping the Upper Floridan aquifer indicates that both have similar geochemistry (figs. 16, 17, 21, and 22).

Dissolved-oxygen concentrations measured in samples from wells tapping the Upper Floridan aquifer ranged from less than 0.1 to 7.3 mg/L. Although the data are not evenly distributed geographically (fig. 23), the samples indicate that dissolved oxygen is present in parts of the Upper Floridan aquifer in the Ocala NF and Lake County. The presence of dissolved oxygen indicates relatively rapid recharge in some parts of the Upper Floridan aquifer.

Concentrations of nutrients generally are low in the Upper Floridan aquifer in the Ocala NF (table 3). Nitrate concentrations in samples ranged from less than 0.02 to 0.20 mg/L with a median of 0.03 mg/L (fig.13). In contrast, nitrate concentrations in samples from the Upper Floridan aquifer in Lake County ranged from less than 0.02 to 7.5 mg/L with a median of 0.02 mg/L (fig. 13, table 3). Kjeldahl nitrogen in the Upper Floridan aquifer ranged from less than 0.2 to 0.88 mg/L in the Ocala NF, and from less than 0.2 to 0.79 mg/L in Lake County. Phosphate ranged from 0.01 to 0.13 mg/L with a median of 0.03 mg/L in samples from the Ocala NF. In samples from Lake County, phosphate concentrations were not significantly different, ranging from less than 0.01 to 0.14 mg/L with a median of 0.05 mg/L.

Median concentration of Kjeldahl nitrogen was significantly greater ($p<0.01$) in samples from wells in the Ocala NF than in samples from springs (fig. 13). Concentrations of nutrients were not significantly different between samples from the surficial aquifer system and the Upper Floridan aquifer in either the Ocala NF or Lake County, possibly because of the paucity of data for the surficial aquifer system.

Similar to the surficial aquifer system, water-quality conditions of the Upper Floridan aquifer probably are related to the lithology of the aquifer, the mixing of fresh recharge water with saline water from deeper in the aquifer, and the effects of land use.

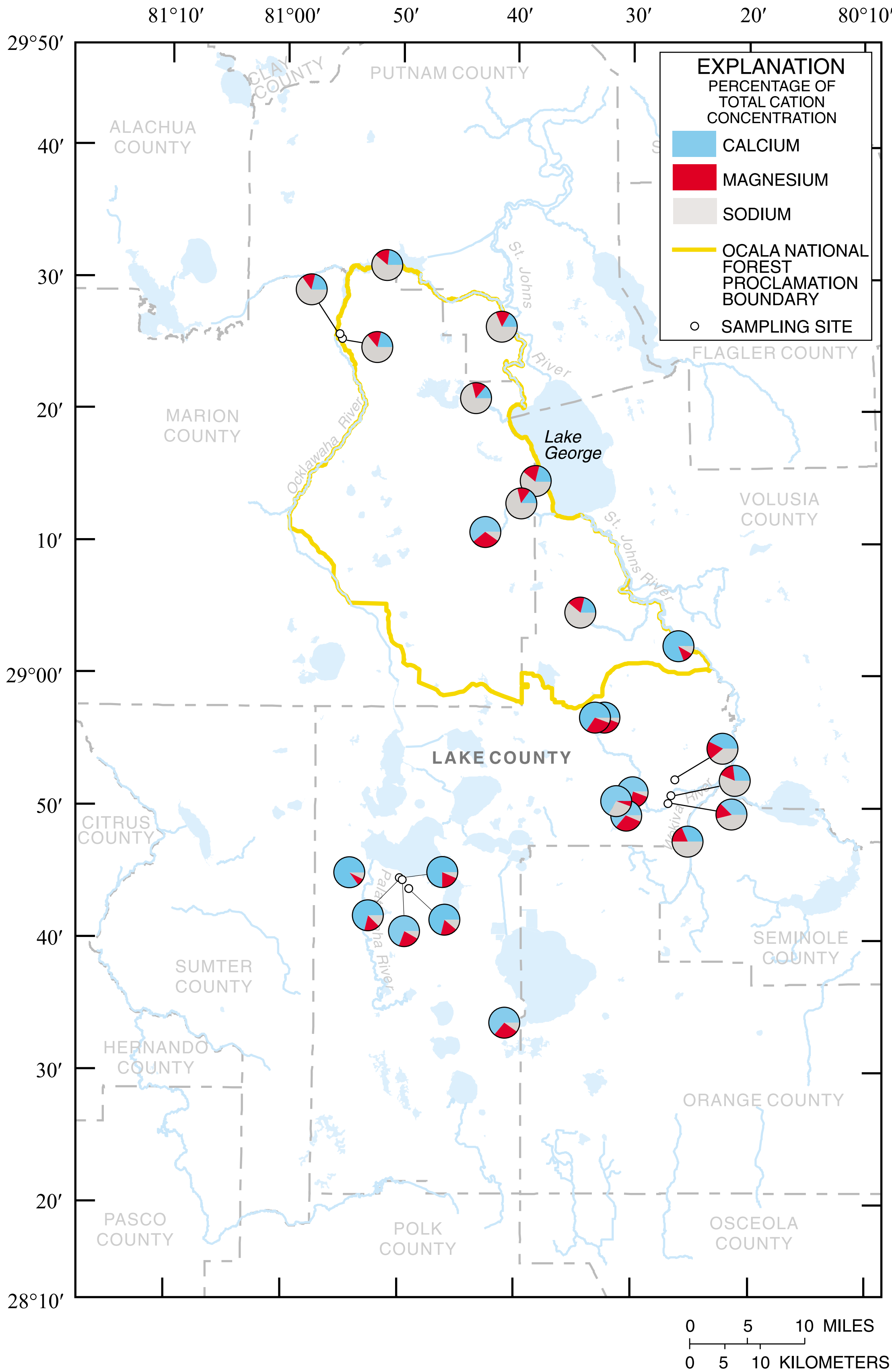

Figure 21. Relative concentrations of calcium, magnesium, and sodium in samples from springs discharging from the Upper Floridan aquifer.

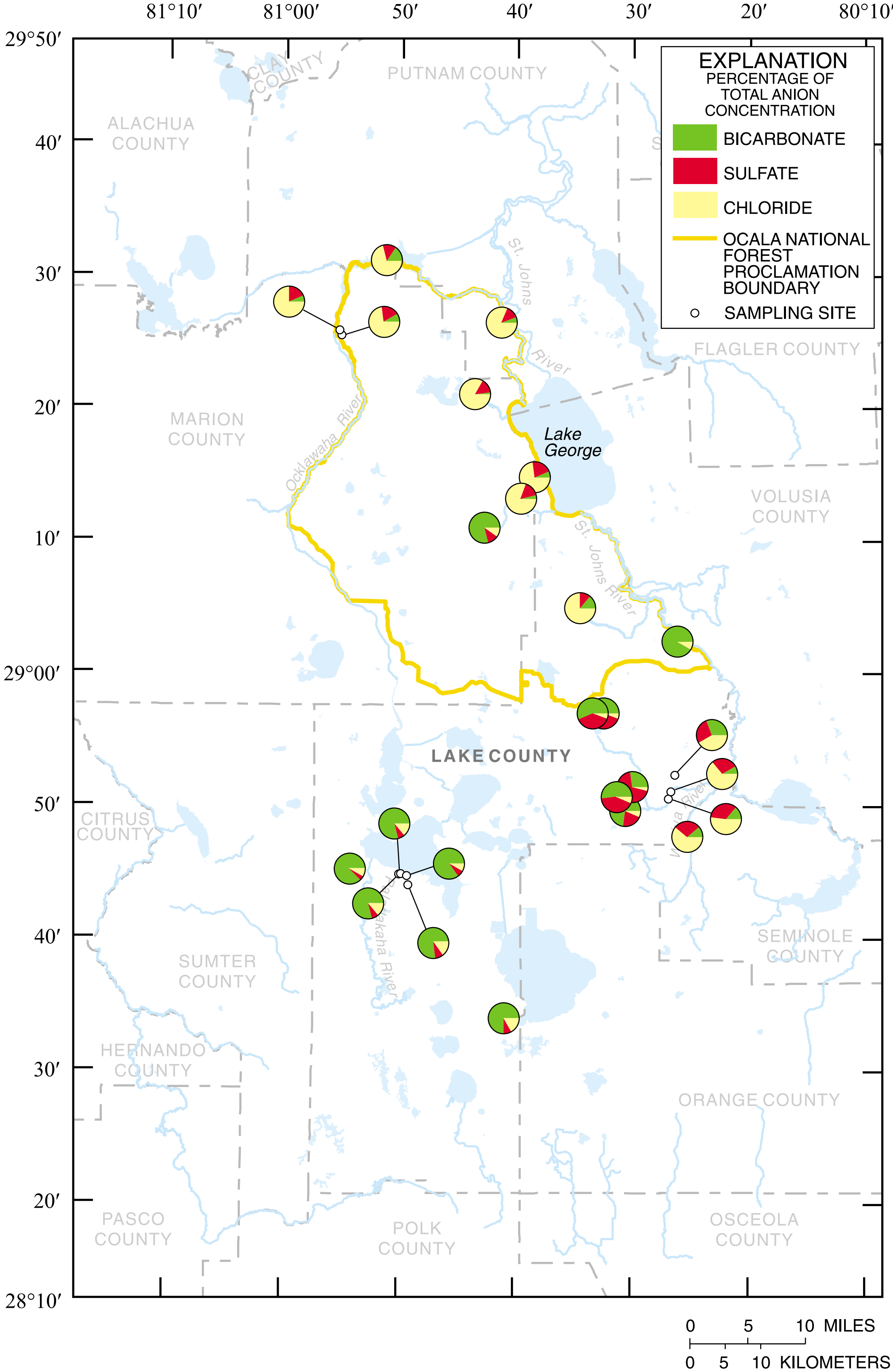

Figure 22. Relative concentrations of bicarbonate, sulfate, and chloride in samples from springs discharging from the Upper Floridan aquifer.

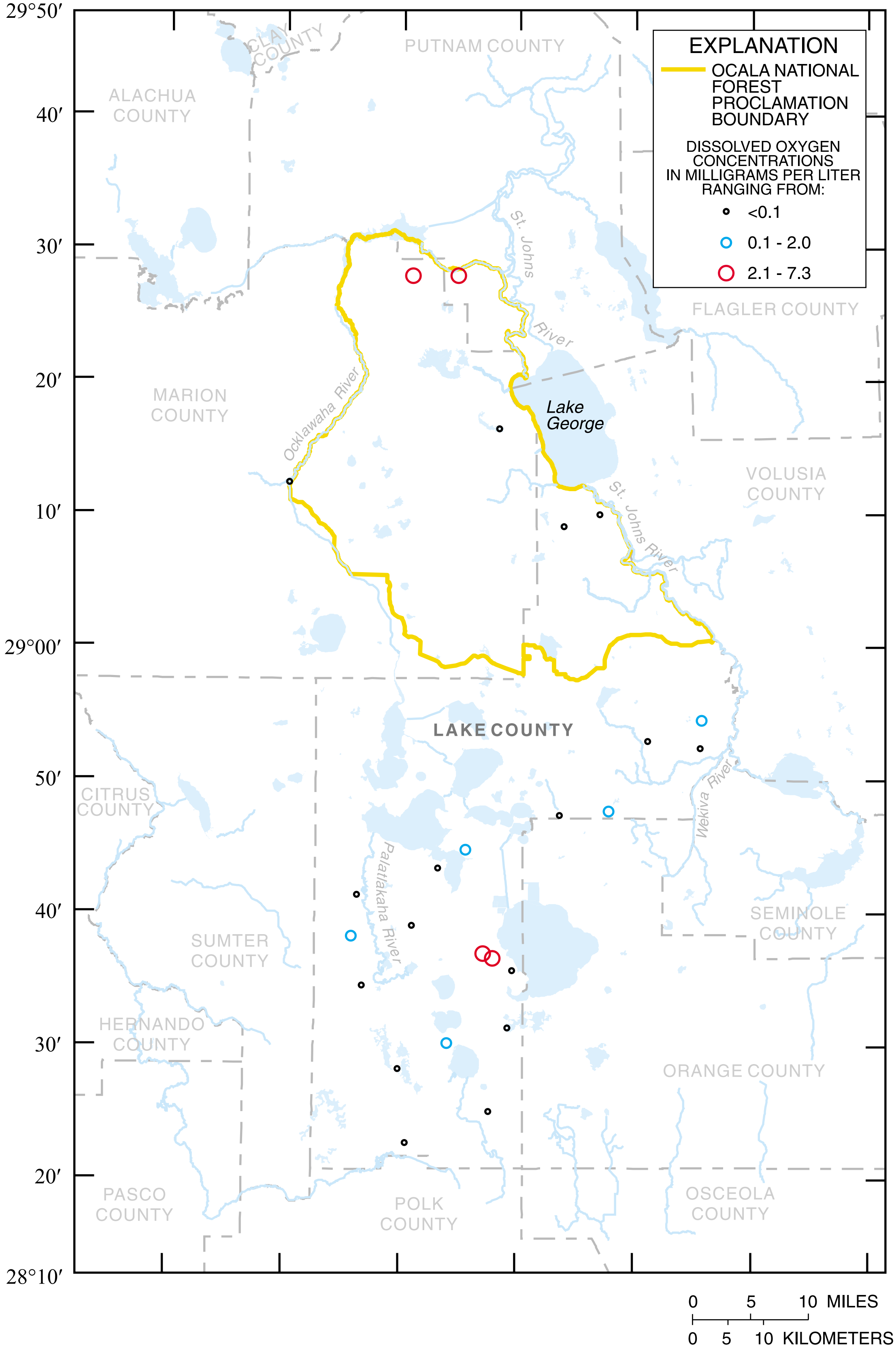

Figure 23. Concentrations of dissolved oxygen in samples from wells tapping the Upper Floridan aquifer.

The calcium-magnesium-bicarbonate water type of most samples indicates dissolution of the carbonate rocks that form the aquifer. The change in cation distribution from calcium to calcium-magnesium probably is related to an increase of dolomite in the carbonate sequence of the aquifer. The difference in bicarbonate concentrations between samples from the Ocala NF and Lake County also are related to the amount of dolomite in the sequence. Because dolomite is less soluble than limestone (Drever, 1988), a relatively larger amount of dolomite in the sequence would result in a lower concentration of bicarbonate. Nonetheless, the overall quality of water is similar between the Ocala NF and Lake County, and is indicative of the relatively homogeneous lithology of the Upper Floridan aquifer.

The sodium-chloride water and high concentrations of TDS near the St. Johns River probably result from upward migration of saline water, probably relict sea water from high stands of sea level. The sodium-chloride water and high concentrations of TDS in the Upper Floridan aquifer are spatially isolated near the St. Johns River. Ground water east of the St. Johns River in Putnam and Volusia Counties is calcium bicarbonate with TDS concentrations less than 200 mg/L (Tibbals, 1990). Hence, lateral migration of saline water from the Atlantic Ocean is unlikely.

As in the surficial aquifer system, the presence of dissolved oxygen in the Upper Floridan aquifer indicates rapid recharge and (or) lack of reactive mineral constituents. In water from springs, the presence of dissolved oxygen indicates that shallow, rapidly recharging ground water is mixing with relict water from deeper in the aquifer, confirming the conclusions of Toth (1999). Hence, the presence of dissolved oxygen in parts of the Upper Floridan aquifer indicates that the aquifer is susceptible to surface contamination.

Water quality of the Upper Floridan aquifer appears to be affected by land use. For example, the maximum nitrate concentration in samples from wells in the Ocala NF is only 0.20 mg/L. Low concentrations of nutrients in the Upper Floridan aquifer in the Ocala NF probably are a result of the pristine, forested land use of the area. In contrast, nitrate concentrations were greater than 1.0 mg/L in 9 of 39 (23 percent) samples from wells in Lake County outside the Ocala NF (fig. 24). Hence, nitrate concentrations of the Upper Floridan aquifer appear to be related to land use in Lake County.

SUMMARY

This report describes water-quality conditions in the surficial aquifer system and the Upper Floridan aquifer underlying the Ocala National Forest and Lake County, Florida, from 1990-99. Data from two comprehensive water-resources studies, one of the Ocala National Forest and the other of Lake County, are presented. The study area, which contains numerous lakes, is drained by the St. Johns River and its tributaries. Numerous karst features are present in parts of the study area including sinkholes, springs, and caves.

The surficial aquifer system, which is unconfined, is recharged by precipitation and discharges to nearby lakes and streams. The Upper Floridan aquifer is recharged by the surficial aquifer system either by slow leakage through the intermediate confining unit, or more rapidly in places where the intermediate confining unit is missing or breached. Discharge from the Upper Floridan aquifer occurs in places where the potentiometric surface is higher than the water table, at springs, flowing wells, and by diffuse leakage to the overlying surficial aquifer system.

As of 1994, land use in the Ocala National Forest consisted primarily of second-growth forests (65 percent), and water and wetlands (19 percent). In contrast, land use in Lake County was more diverse. In 1994, land use in Lake County was a mixture of agriculture (30 percent), forest (18 percent), rangeland (7 percent), urban (6 percent), and water and wetlands (36 percent). Population in Lake County has been increasing in recent years, and present (2000) urban land use probably is greater than 6 percent.

Ground-water samples were collected by the U.S. Geological Survey from 23 wells tapping the surficial aquifer system, and from 25 springs and 88 wells tapping the Upper Floridan aquifer. These data were supplemented with samples collected by the St. Johns River Water Management District and Lake County Water Resources Management from 26 wells tapping the surficial aquifer system, and from 2 springs and 53 wells tapping the Upper Floridan aquifer. Most samples were analyzed in the field for temperature, pH, and specific conductance, and in the laboratory for major ions (calcium, magnesium, sodium, potassium, sulfate, and chloride), alkalinity, and total dissolved solids. A total of 98 samples were analyzed for nitrite plus nitrate, 81 samples were analyzed for Kjeldahl nitrogen, and 71 samples for phosphate.

The data were statistically analyzed using non-parametric procedures to identify differences in water quality between the aquifers, between site types (springs and wells), and between geographic locations.

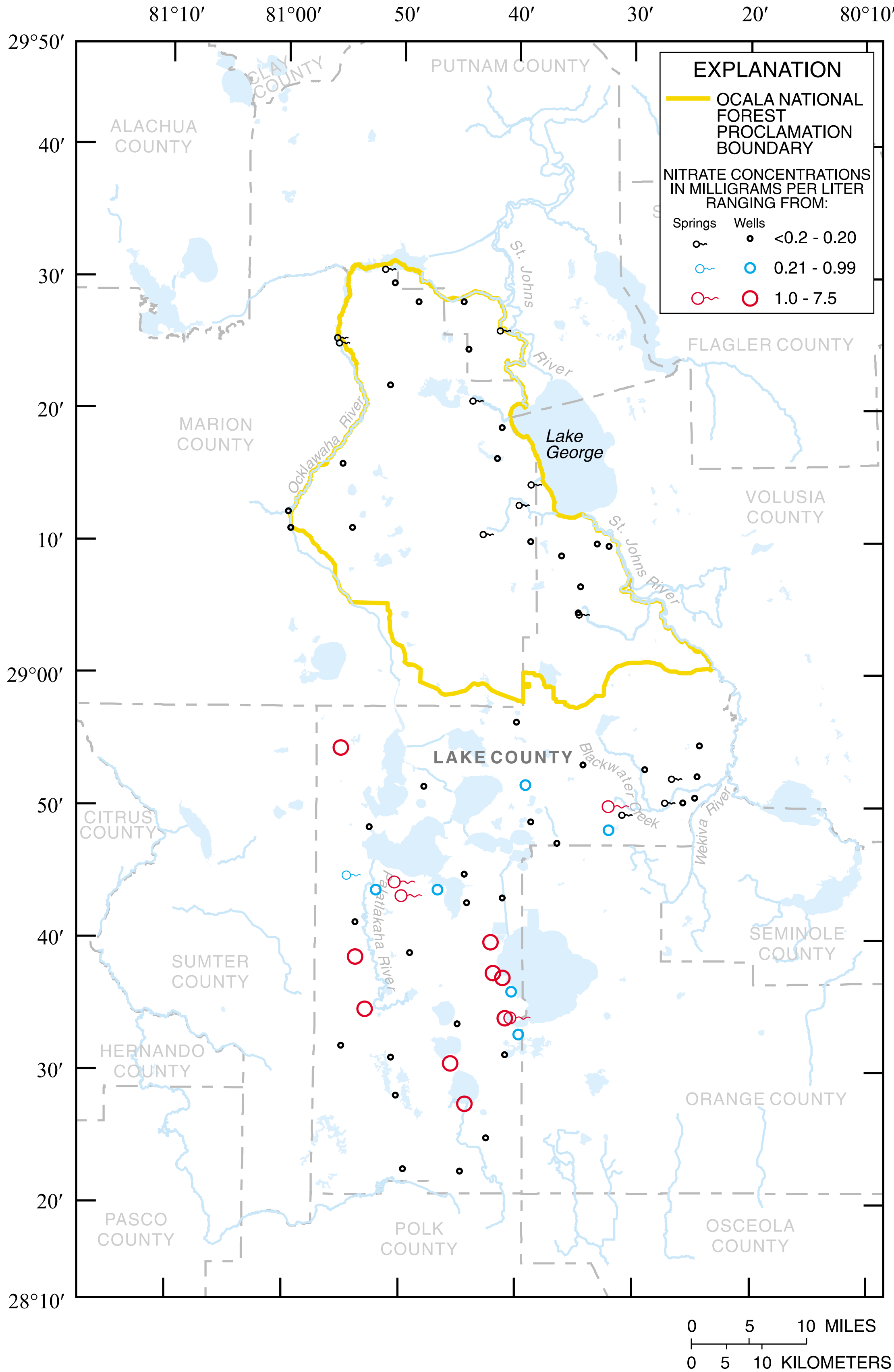

Figure 24. Nitrate concentrations in samples from springs and from wells tapping the Upper Floridan aquifer.

Medians of groups of data were assumed significantly different from one another if the probability (p-value) was less than 5 percent that the difference occurs by chance.

Water type throughout most of the Upper Floridan aquifer is calcium-bicarbonate or calcium-magnesium-bicarbonate. Near the St. Johns and Wekiva Rivers, however, sodium, chloride, and sulfate are the dominant ions. Total dissolved solids concentrations were low (less than 250 milligrams) throughout most of the aquifer, but increased to nearly 12,000 milligrams per liter near the St. Johns and Wekiva Rivers. Concentrations of most major ions and total dissolved solids are significantly greater in the Upper Floridan aquifer than in the surficial aquifer system. A total of 14 of 111 samples had concentrations that exceeded the National Secondary Drinking Water Regulations for total dissolved solids, 14 of 135 samples had concentrations that exceeded the National Secondary Drinking Water Regulations for chloride, and 5 of 131 samples had concentrations that exceeded the National Secondary Drinking Water Regulations for sulfate.

The water type within the surficial aquifer system is laterally diverse, and can be calcium-bicarbonate, sodium-chloride, or mixed cations and mixed anions. Concentrations of major ions and total dissolved solids are generally low; total dissolved solids concentrations ranged from 3 to 356 milligrams per liter with a median of 41 milligrams per liter. None of the samples had concentrations of total dissolved solids, chloride, or sulfate that exceeded any National Secondary Drinking Water Regulations. In general, pH and concentrations of calcium, magnesium, potassium, bicarbonate, sulfate, and total dissolved solids in the surficial aquifer system are significantly greater in samples from Lake County than in samples from the Ocala National Forest.

Dissolved-oxygen concentrations in the surficial aquifer system in the Ocala National Forest ranged from less than 0.1 to 8.2 milligrams per liter. No data were available for the surficial aquifer system in Lake County.

Concentrations of nutrients in the surficial aquifer system in the Ocala National Forest generally were low—below 1.0 milligrams per liter in most samples. Nitrate and Kjeldahl nitrogen were detected more frequently in the surficial aquifer system in Lake County than in the Ocala NF.

Nitrogen concentrations are elevated in parts of the Upper Floridan aquifer outside the Ocala National Forest. Nitrate concentrations in samples ranged from less than 0.02 to 7.5 milligrams per liter, Kjeldahl nitrogen in samples ranged from less than 0.20 to 0.88 milligram per liter, and phosphate ranged from less than 0.01 to 0.14 milligram per liter.

Dissolved oxygen is present in parts of the Upper Floridan aquifer. Concentrations ranged from less than 0.1 to 7.3 milligrams per liter. Dissolved oxygen present in the Upper Floridan aquifer indicates rapid ground-water recharge and (or) a lack of reactive mineral constituents. In springs, the presence of dissolved oxygen indicates a mixing of shallow, rapidly recharging ground water with the deep, connate sea water. The presence of dissolved oxygen in samples from springs and wells in the Upper Floridan aquifer indicates that the aquifer is susceptible to surface contamination.

Water-quality conditions probably can be attributed to a number of factors. Most water-quality differences between the surficial aquifer system and the Upper Floridan aquifer probably are related to differences in lithology. Calcium-magnesium-bicarbonate water type throughout most of the Upper Floridan aquifer results from the dissolution of the carbonate rocks, which form the aquifer. The high concentrations of sodium and chloride in the Upper Floridan aquifer near the St. Johns River probably result from the upward migration of saline water. Relatively high concentrations of sodium, chloride, and sulfate in samples from many of the springs probably are related to the geographical proximity of most springs to the St. Johns and Wekiva Rivers. Comparison of samples from springs and nearby wells tapping the Upper Floridan aquifer indicate similar geochemistry of both site types.

Water quality of the Upper Floridan aquifer also appears to be affected by land use. Nitrate concentrations were elevated (greater than 1 milligram per liter) in 9 of 39 samples (23 percent) collected from wells in Lake County. In contrast, nitrate concentrations in samples from the Upper Floridan aquifer in the Ocala National Forest did not exceed 0.20 milligram per liter.

In summary, the Ocala National Forest and Lake County contain abundant ground-water resources. These ground-water resources are important for agriculture, domestic and public supply, recreation, and for the aquatic ecology of the study area. The surficial aquifer system and Upper Floridan aquifer, however, are susceptible to surface contamination. Present and (or) past land uses in parts of Lake County could have affected the ground-water quality as indicated by elevated concentrations of nitrate. Further studies to better quantify the effects of land use on ground-water quality, particularly with respect to the rapid urbanization of parts of the study area, would be beneficial.

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APPENDIX

Appendix. Site identification, well construction information, and water-quality data from the surficial aquifer system and the Upper Floridan aquifer

[mg/L, milligrams per liter; ^{o}C, degree Celsius; µS/cm, microsiemens per centimeter at 25 ^{o}C; <, less than; --, unknown or not analyzed. Collecting agency: LC, Lake County; SJRWMD, St. Johns River Water Management District; USGS, U.S. Geological Survey. Aquifer: F, Upper Floridan aquifer; S, surficial aquifer system. Map numbers shown in figures 5 and 6]

Site identification number	Map number	Site name	Collecting agency	County	Date of sample	Well depth (feet below land surface)	Casing length (feet)	Aquifer	Water temperature (^{o}C)	Specific conductance (µS/cm)	Dissolved oxygen (mg/L)
		WELLS									
282225081413101	3	L-0623	SJRWMD	Lake	04/15/93	437	262	F	--	--	--
282241081443901	4	Sand Mine deep L-0051 near Horsehead Pond	SJRWMD	Lake	08/02/93	115	85	F	24.0	200	--
282241081443902	5	L-0050	SJRWMD	Lake	08/02/93	35	25	S	23.5	84	--
282245081492601	6	Eva 6” deep	USGS	Lake	02/05/97	192	18	F	23.9	290	<.1
282318081544003	7	L-0555 Green Swamp 4” deep (Hayes Grubb-LK751W/LK7425)	USGS	Lake	02/02/97	190	64	F	22.5	594	--
282502081422301	9	Lykes Bros. Replacement (S. Burger) 4” deep near Keene Lake	USGS	Lake	12/12/96	--	--	F	22.0	207	<.1
282528081424801	10	L-0709	SJRWMD	Lake	08/12/98	101	81	F	23.9	244	--
282528081424802	11	L-0710	SJRWMD	Lake	08/13/98	--	--	S	25.4	118	--
282533081430801	12	L-0677	SJRWMD	Lake	08/14/98	485	160	F	24.0	322	--
282717081553101	13	ROMP 101 deep L-0056 near Bay Lake	USGS	Lake	02/12/97	404	118	F	22.5	508	--
282717081554401	14	USGS 2” shallow, SWFWMD site near Bay Lake	USGS	Lake	05/07/98	15	5	S	22.3	545	--
282729081443301	16	Lake Louisa State Park 4” deep L-0053	SJRWMD	Lake	08/03/93	85	70	F	23.2	253	--
282823081500401	19	D. Patton 6” deep near Eva Firetower	USGS	Lake	12/12/96	390	96	F	22.0	230	<.1
283003081411401	20	L-0476	SJRWMD	Lake	07/26/92	543	100	F	--	--	--
283019081455701	22	LCFD District 9 Station 1 4” deep near Crescent Lake, Clermont	USGS	Lake	05/30/97	--	--	F	24.9	619	--
283024081410901	23	L-0459	SJRWMD	Lake	07/07/92	213	85	F	--	--	--
283028081454701	24	Country Garden Nursery (S. Tyner) 4” deep, Clermont	USGS	Lake	09/08/99	--	--	F	24.2	359	1.7
283114081503401	25	Bernard DuFrene 2” deep near Groveland	USGS	Lake	09/27/99	329	123	F	23.8	365	--
283114081503901	26	Johns Lake 4” deep L-0052	SJRWMD	Lake	04/14/97	44	24	S	22.5	103	--
283128081404701	27	Johns Lake Well near Clermont	USGS	Lake	09/22/99	155	--	F	23.7	289	<.1
283149081422801	28	L-0646	SJRWMD	Lake	03/28/94	--	--	F	--	--	--
283204081544901	29	Mascotte 6” deep L-0062 near Mascotte	USGS	Lake	02/12/97	160	66	F	23.8	316	--
283204081544902	30	Mascotte 6” shallow near Mascotte L-0041	SJRWMD	Lake	05/06/93	30	16	S	22.9	47	--
283232081394101	31	Edgewater Beach 4” deep near East Johns Lake	USGS	Lake	01/23/97	--	--	F	24.3	243	--
283349081445001	34	L-0596	SJRWMD	Lake	05/04/93	918	605	F	24.6	218	--
283355081411701	35	Site 38 Turnpike, Waits Junction 4” deep L-0199	SJRWMD	Lake	08/18/98	146	110	F	25.8	230	--
283355081411702	36	Site 38 Turnpike, Waits Junction 4” shallow L-0044	SJRWMD	Lake	05/05/93	--	--	S	24.5	--	--
283403081400002	37	L-0320	SJRWMD	Lake	12/05/90	35	30	S	23.5	190	--
283432081530601	38	City of Mascotte 8” deep	USGS	Lake	02/14/97	291	143	F	23.3	346	<.1
283443081404002	39	L-0325	SJRWMD	Lake	11/09/90	25	20	S	25.5	422	--

Appendix. Site identification, well construction information, and water-quality data from the surficial aquifer system and the Upper Floridan aquifer--Continued

[mg/L, milligrams per liter; °C, degree Celsius; µS/cm, microsiemens per centimeter at 25 °C; <, less than; --, unknown or not analyzed. Collecting agency: LC, Lake County; SJRWMD, St. Johns River Water Management District; USGS, U.S. Geological Survey. Aquifer: F, Upper Floridan aquifer; S, surficial aquifer system. Map numbers shown in figures 5 and 6]

Site identification number	Map number	pH (standard units)	Alkalinity (mg/L as $CaCO_3$)	Bicarbonate (mg/L as $CaCO_3$)	Ammonia plus organic nitrogen (mg/L as N)	Nitrite plus nitrate (mg/L as N)	Phosphate (mg/L as P)	Calcium (mg/L)	Magnesium (mg/L)	Sodium (mg/L)	Potassium (mg/L)	Chloride (mg/L)	Sulfate (mg/L as SO_4)	Silica (mg/L)	Dissolved solids, total (mg/L)	Dissolved solids, calculated (mg/L)
WELLS																
282225081413101	3	--	--	--	--	--	--	--	--	--	--	13	3.0	--	--	--
282241081443901	4	8.0	--	--	.20	.02	--	34	.89	3.2	2.3	7.0	5.5	13	103	103
282241081443902	5	5.0	--	--	.23	.02	--	4.5	1.3	4.8	1.8	8.7	14	2	28	28
282245081492601	6	7.6	143	174	<.20	<.02	.08	56	2.1	4.1	1.5	6.8	.1	14	178	161
282318081544003	7	6.9	297	362	--	--	--	110	4	11	.7	18	.1	12	348	358
282502081422301	9	7.9	100	122	.47	<.02	.11	35	2.7	3	.6	4.6	.4	10	120	107
282528081424801	10	7.4	452	551	--	--	--	416	19	8.0	2.3	9.1	2.9	--	131	131
282528081424802	11	5.6	18	22	--	--	--	4.1	2.2	11	.81	15	6.3	--	50	50
282533081430801	12	7.3	113	137	--	--	--	48	7.3	5.5	1.6	12	33	--	182	182
282717081553101	13	6.7	262	320	--	--	--	100	3.2	6.4	.80	10	.10	14	303	303
282717081554401	14	6.3	--	--	--	--	--	--	--	--	--	--	--	--	--	327
282729081443301	16	8.2	--	--	.20	3.8	.02	23	12	4.5	.40	17.	2.3	12	137	137
282823081500401	19	7.9	106	129	<.20	.04	.07	42	1.0	3.6	.80	6.6	3.1	11	148	122
283003081411401	20	--	--	--	--	--	--	--	--	--	--	3.0	4.0	--	--	--
283019081455701	22	7.2	107	131	--	--	--	61	18	28	11	64	87	10	388	375
283024081410901	23	--	--	--	--	--	--	--	--	--	--	13	--	--	--	--
283028081454701	24	7.2	--	--	.22	6.1	.10	--	--	--	--	--	--	--	206	206
283114081503401	25	6.9	--	--	<.20	.05	.03	--	--	--	--	--	--	--	210	210
283114081503901	26	--	35	43	--	--	--	12	3.9	6.0	.50	14	3.0	--	40	40
283128081404701	27	7.1	--	--	.63	<.02	.01	--	--	--	--	--	--	--	161	161
283149081422801	28	--	--	--	--	--	--	--	--	--	--	11	27	--	--	--
283204081544901	29	6.7	151	184	.79	.06	--	59	1.2	5.4	.30	8.3	.30	10	178	178
283204081544902	30	5.5	--	--	.30	.14	--	3.4	.64	1.9	.25	2.9	2.6	2.9	4	4
283232081394101	31	6.4	81	99	.49	.40	.14	18	5.9	10	.8	23	1.6	17	140	131
283349081445001	34	8.0	--	--	.33	.02	--	24	9.8	3.9	.48	6.3	2.5	11.0	115	115
283355081411701	35	8.1	59	72	<.20	5.8	.02	26	7.7	5.3	.63	11	7.5	--	122	122
283355081411702	36	6.5	--	--	.47	2.5	--	21	6.4	3.2	6.4	4.3	39	7.1	--	--
283403081400002	37	6.4	--	--	--	--	--	27	14.8	6.0	9.7	--	--	--	96	96
283432081530601	38	7.4	150	183	<.20	1.4	<.01	62	2.9	5.7	.6	11	6.1	10	202	198
283443081404002	39	6.4	--	--	--	--	--	57	17.5	13	5.6	--	--	--	247	247

Appendix. Site identification, well construction information, and water-quality data from the surficial aquifer system and the Upper Floridan aquifer--Continued

[mg/L, milligrams per liter; °C, degree Celsius; µS/cm, microsiemens per centimeter at 25 °C; <, less than; --, unknown or not analyzed. Collecting agency: LC, Lake County; SJRWMD, St. Johns River Water Management District; USGS, U.S. Geological Survey. Aquifer: F, Upper Floridan aquifer; S, surficial aquifer system. Map numbers shown in figures 5 and 6]

Site identification number	Map number	Site name	Collecting agency	County	Date of sample	Well depth (feet below land surface)	Casing length (feet)	Aquifer	Water temperature (°C)	Specific conductance (µS/cm)	Dissolved oxygen (mg/L)
283530081514501	40	Dr. Phillips & Sons (Minute Maid Co.) 4” deep near Lake Lucy	USGS	Lake	12/12/96	141	73	F	21.5	350	--
283535081545201	41	G. Barton 4” deep	USGS	Lake	11/19/98	--	--	F	23.7	226	--
283538081545401	42	L-0693	SJRWMD	Lake	04/14/97	25	10	S	23.5	841	--
283540081402401	43	Montverde School 3” intermittent flow	USGS	Lake	11/22/96	180	--	F	24.0	134	--
283549081401701	44	Montverde School 6” freeflow	USGS	Lake	08/24/99	120	--	F	24.3	170	<.1
283621081405001	45	L-0674	SJRWMD	Lake	04/16/96	--	--	F	--	--	--
283652081412901	46	L-0675	SJRWMD	Lake	04/16/96	--	--	F	--	--	--
283655081412701	47	Freeflow 4” deep, Ferndale	USGS	Lake	01/29/97	123	--	F	23.7	179	2.2
283702081413801	48	L-0676	SJRWMD	Lake	09/09/96	185	53	F	--	--	--
283720081421801	49	Ferndale Baptist Church 4” deep	USGS	Lake	01/29/97	90	--	F	24.3	436	3.5
283744081415002	50	L-0308	SJRWMD	Lake	12/05/90	15	10	S	22.0	70	--
283828081535701	53	Sunset Lakes Ski Center 4” deep, N of Mascotte	USGS	Lake	12/12/96	--	--	F	23.0	253	1.1
283905081485401	54	Novelty Crystal Plant 4” deep	USGS	Lake	01/09/97	--	--	F	23.2	338	<.1
283937081422101	56	Lake Apopka Restoration Area (SJRWMD) 4” freeflow	USGS	Lake	02/05/97	141	--	F	24.0	198	--
284005081413901	57	L-0291	SJRWMD	Lake	03/21/90	100	--	F	--	--	--
284024081405301	59	L-0300	SJRWMD	Lake	05/16/90	416	92	F	--	--	--
284024081405302	60	L-0301	SJRWMD	Lake	12/05/90	22	20	S	20.0	590	--
284122081534401	63	Groveland Tower 4 deep L-0095 near Okahumpka	SJRWMD	Lake	05/05/93	364	148	F	23.9	390	<.1
284122081534402	64	Groveland Tower 4” shallow L-0096, SR 33 S of Okahumpka	SJRWMD	Lake	06/03/91	111	111	S	24.2	309	--
284134081564201	65	Sunshine Peat (prev Hi Acres) 4” deep, 4 mi N of Center Hill	USGS	Lake	01/14/97	--	--	F	23.5	331	--
284157081405401	67	L-0283	SJRWMD	Lake	06/10/93	38	33	S	23.2	240	--
284209081424401	68	L-0285	SJRWMD	Lake	06/27/90	14	4	S	24.5	156	--
284209081424402	69	L-0286	SJRWMD	Lake	06/15/93	33	28	S	24.1	344	--
284253081441101	75	Astatula, J. Swaffer Park, 4” deep	USGS	Lake	03/05/97	--	--	F	25.3	255	--
284320081410701	77	Apopka-Beauclair Canal 4” deep L-0139 at SJRWMD Office	USGS	Lake	01/23/97	650	575	F	24.2	224	--
284322081410301	78	Apopka Lock, Field Station, 4” shallow L-0287	SJRWMD	Lake	06/15/93	43	38	S	23.3	457	--
284328081515901	79	Creek Farms 8” deep	USGS	Lake	02/05/97	539	145	F	24.4	242	--
284330081464201	81	Town of Howey In The Hills 14” deep #3 L-0591	SJRWMD	Lake	05/04/93	350	162	F	23.9	366	<.1
284443081483201	84	L-0713	SJRWMD	Lake	04/15/98	--	--	F	--	--	--
284504081441501	85	Astatula 1 Landfill 4” shallow (8A)	LC	Lake	02/26/99	--	--	F	23.1	195	.4

Appendix. Site identification, well construction information, and water-quality data from the surficial aquifer system and the Upper Floridan aquifer--Continued

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Site identification number	Map number	pH (standard units)	Alkalinity (mg/L as $CaCO_3$)	Bicarbonate (mg/L as $CaCO_3$)	Ammonia plus organic nitrogen (mg/L as N)	Nitrite plus nitrate (mg/L as N)	Phosphate (mg/L as P)	Calcium (mg/L)	Magnesium (mg/L)	Sodium (mg/L)	Potassium (mg/L)	Chloride (mg/L)	Sulfate (mg/L as SO_4)	Silica (mg/L)	Dissolved solids, total (mg/L)	Dissolved solids, calculated (mg/L)
283530081514501	40	7.7	153	187	--	--	--	58	3.3	7.9	.7	15	6.2	11	212	200
283535081545201	41	6.7	35	43	--	--	--	20	4.7	11	5.4	29	21	6.6	136	120
283538081545401	42	--	14	17	--	--	--	4	2.8	3.0	2.6	7.0	7.0	--	--	--
283540081402401	43	8.0	49	60	--	--	--	15	4.4	2.9	.7	9.3	2.2	4.5	60	60
283549081401701	44	7.8	--	--	.22	.52	.01	--	--	--	--	--	--	--	83	83
283621081405001	45	--	--	--	--	--	--	--	--	--	--	8.0	2.0	--	--	--
283652081412901	46	--	--	--	--	--	--	--	--	--	--	7.0	2.0	--	--	--
283655081412701	47	8.3	59	72	<.20	4.3	.02	21	5.8	4.4	.4	11	7	9.9	106	89
283702081413801	48	--	--	--	--	--	--	--	--	--	--	6.0	8.0	--	--	--
283720081421801	49	7.9	78	95	<.20	7.5	.02	44	20	11	.6	28	51	16	258	256
283744081415002	50	--	--	--	--	--	--	3.0	1.4	2.0	6.3	--	--	--	19	19
283828081535701	53	7.6	94	115	<.20	3.3	.08	41	1.7	5.0	.4	12	4	10	168	137
283905081485401	54	7.4	147	179	.22	<.02	.06	52	4.9	22	.8	22	6.7	11	198	192
283937081422101	56	8.1	68	83	<.20	4.3	.02	24	7.3	4.7	.4	14	7	10	112	102
284005081413901	57	--	--	--	--	--	--	--	--	--	--	116	21	--	--	--
284024081405301	59	--	--	--	--	--	--	--	--	--	--	4.0	4.0	--	--	--
284024081405302	60	--	--	--	--	--	--	91	21	11	7.1	--	--	--	356	356
284122081534401	63	7.3	--	--	.49	.02	.05	68	2.4	5.7	1.7	10	1.6	11	226	226
284122081534402	64	7.9	100	122	--	4.2	.14	54	2.4	6.0	1.0	13	8.0	9	174	174
284134081564201	65	8.6	143	174	--	--	--	60	3.9	6.5	.5	12	11	13	192	188
284157081405401	67	7.2	--	--	.84	.04	--	31	9.8	5.0	1.0	7.1	1.1	14	129	129
284209081424401	68	--	--	--	--	.04	.06	16	1.9	8.2	4.7	8.8	6.4	--	74	74
284209081424402	69	7.6	--	--	1.0	.10	--	58	5.6	5.1	1.4	6.2	.20	23	196	196
284253081441101	75	7.7	122	149	<.20	<.02	.03	34	8.6	5.0	.8	7.9	--	12	154	139
284320081410701	77	7.9	104	127	<.20	<.02	.01	31	7.6	5.0	.9	7.1	2	13	118	118
284322081410301	78	6.9	--	--	.21	.04	--	47	5.4	48	.4	8.5	11	28	270	270
284328081515901	79	7.6	106	129	.21	.88	.06	40	2.3	4.5	.6	8.4	3.5	9.9	140	130
284330081464201	81	7.5	--	--	.36	.95	--	52	8.8	6.7	.8	12	6.3	15	211	211
284443081483201	84	--	--	--	--	--	--	--	--	--	--	10	3.7	--	--	--
284504081441501	85	8.8	--	--	--	<.02	--	--	--	--	--	6.8	--	--	100	100

Appendix. Site identification, well construction information, and water-quality data from the surficial aquifer system and the Upper Floridan aquifer--Continued

[mg/L, milligrams per liter; ^{o}C, degree Celsius; µS/cm, microsiemens per centimeter at 25 ^{o}C; <, less than; --, unknown or not analyzed. Collecting agency: LC, Lake County; SJRWMD, St. Johns River Water Management District; USGS, U.S. Geological Survey. Aquifer: F, Upper Floridan aquifer; S, surficial aquifer system. Map numbers shown in figures 5 and 6]

Site identification number	Map number	Site name	Collecting agency	County	Date of sample	Well depth (feet below land surface)	Casing length (feet)	Aquifer	Water temperature (^{o}C)	Specific conductance (µS/cm)	Dissolved oxygen (mg/L)
284528081530201	88	Church Of God of Prophecy 3” deep near Okahumpka	USGS	Lake	12/12/96	80	--	F	24.0	234	--
284725081361901	98	Wolf Sink (LCWA) 6” deep L-0600 near Sorrento	USGS	Lake	08/31/99	205	160	F	23.6	213	<.1
284732081495301	99	Frog Leg Ln 4” deep near Cisky Park, Leesburg	USGS	Lake	01/09/97	155	94	F	23.9	241	--
284757081320701	101	L. Knowles 4” deep, 30845 CR435, Mt. Plymouth	USGS	Lake	01/14/97	154	126	F	23.7	282	.1
284757081543002	102	C. R. Williams 4” deep, Caballo Rd., Leesburg	USGS	Lake	12/12/96	350	--	F	22.0	287	--
284813081294001	106	L-0436	SJRWMD	Lake	01/13/92	--	--	F	--	--	--
284830081522401	107	City of Leesburg, PS #6 deep, Canal St. L-0592	SJRWMD	Lake	11/02/93	390	58	F	23.4	353	--
284856081383001	110	City of Mt Dora 20” deep #3	USGS	Lake	03/05/97	752	155	F	23.3	274	--
284922081494001	111	L-0452	SJRWMD	Lake	09/11/96	180	41	F	--	--	--
284929081294901	112	Abandoned 10” freeflow off SR 46A near Sorrento	USGS	Lake	11/22/96	--	--	F	23.0	369	--
284933081255801	113	L-0038	SJRWMD	Lake	08/21/95	92	78	F	22.6	321	--
284936081475501	114	Lake-Sumter Community College QW 2” deep near Leesburg	USGS	Lake	01/24/97	--	--	F	23.2	245	--
285028081253301	119	Seminole State Forest 4” deep #1 L-0037	SJRWMD	Lake	01/10/95	363	102	F	22.4	2,240	--
285037081342002	120	L-0704	SJRWMD	Lake	08/26/98	300	280	F	24.2	132	--
285037081342003	121	L-0714	SJRWMD	Lake	11/15/98	--	--	S	25.2	372	--
285057081243201	122	L-0032	SJRWMD	Lake	10/19/94	120	96	F	21.9	3,160	--
285118081391001	123	City of Eustis Waterplant 16” deep L-0593, CR 44A	SJRWMD	Lake	11/03/93	750	274	F	23.9	251	--
285144081475001	125	Leesburg Fire Tower 4” shallow L-0289	SJRWMD	Lake	11/02/93	50	40	S	23.8	56	--
285144081475002	126	Leesburg Fire Tower deep L-0290	SJRWMD	Lake	11/02/93	400	190	F	24.0	242	--
285152081542901	127	City of Fruitland Park, Cales Mem. Recreation Complex, deep	USGS	Lake	03/05/97	300	150	F	24.0	235	--
285230081242201	128	Lower Wekiva River State Preserve 2” freeflow #2, South	USGS	Lake	01/08/97	109	102	F	22.7	1,260	<.1
285233081284502	129	L-0716	SJRWMD	Lake	11/29/98	37	22	S	24.1	189	--
285301081285401	130	Reese 4” deep near Cassia	USGS	Lake	01/27/97	--	--	F	23.0	407	<.1
285318081340601	131	Eustis Sand Co. 12” deep L-0375	USGS	Lake	01/23/97	350	--	F	25.5	244	--
285419081552801	133	City of Lady Lake Water Tower deep L-0594	SJRWMD	Lake	11/03/93	180	160	F	23.6	200	--
285425081323401	134	USGS 2” shallow L-0378, Lake Norris Rd.	SJRWMD	Lake	11/02/93	33	28	S	24.9	160	--
285452081563201	135	R. P. Rowley 5” deep near Lady Lake	USGS	Lake	01/07/97	203	--	F	24.4	170	--
285454081241201	136	Lower Wekiwa River State Preserve 2” int. flow #1, North	USGS	Lake	01/08/97	65	--	F	22.7	947	.1
285549081530601	137	Carlton Village Park Community 10” deep, Clearview Lake	USGS	Lake	02/20/97	350	203	F	23.9	283	--
285551081293601	138	B. Rogers 4” deep, Gourd Lake	USGS	Lake	01/15/97	--	--	F	22.1	321	--

Appendix. Site identification, well construction information, and water-quality data from the surficial aquifer system and the Upper Floridan aquifer--Continued

[mg/L, milligrams per liter; ^{o}C, degree Celsius; µS/cm, microsiemens per centimeter at 25 ^{o}C; <, less than; --, unknown or not analyzed. Collecting agency: LC, Lake County; SJRWMD, St. Johns River Water Management District; USGS, U.S. Geological Survey. Aquifer: F, Upper Floridan aquifer; S, surficial aquifer system. Map numbers shown in figures 5 and 6]

Site identification number	Map number	pH (standard units)	Alkalinity (mg/L as $CaCO_3$)	Bicarbonate (mg/L as $CaCO_3$)	Ammonia plus organic nitrogen (mg/L as N)	Nitrite plus nitrate (mg/L as N)	Phosphate (mg/L as P)	Calcium (mg/L)	Magnesium (mg/L)	Sodium (mg/L)	Potassium (mg/L)	Chloride (mg/L)	Sulfate (mg/L as SO_4)	Silica (mg/L)	Dissolved solids, total (mg/L)	Dissolved solids, calculated (mg/L)
284528081530201	88	7.9	112	137	--	--	--	43	1.2	3.5	.3	5.6	2.1	9.5	144	125
284725081361901	98	7.8	--	--	.26	<.02	.12	--	--	--	--	--	--	--	111	111
284732081495301	99	7.5	116	142	--	--	--	34	7.6	3.9	.6	7.2	.5	12	136	129
284757081320701	101	7.8	125	153	<.20	.36	.08	36	11	5.0	.6	8.9	8.2	7.8	148	156
284757081543002	102	8.0	133	162	--	--	--	45	5.3	5.3	.9	11	.4	11	166	159
284813081294001	106	--	--	--	--	--	--	--	--	--	--	7.0	31	--	--	--
284830081522401	107	7.7	--	--	.30	.05	--	52	9.0	6.2	1.0	9.8	2.1	14	202	202
284856081383001	110	7.9	111	135	<.20	<.02	.06	32	9.6	7.3	1.1	12	11	11	178	151
284922081494001	111	--	--	--	--	--	--	--	--	--	--	8	18	--	--	--
284929081294901	112	7.8	100	122	--	--	--	41	2.3	5.1	.6	7.5	58	9.6	224	212
284933081255801	113	7.7	169	206	--	--	--	58	4.6	6.0	1.3	4.0	1.0	--	181	181
284936081475501	114	7.9	116	142	--	--	--	35	8.8	4.6	.8	7.4	2.2	13	136	132
285028081253301	119	7.3	200	244	<.20	<.02	.03	161	40	232	8.2	448	285	--	1,426	1,426
285037081342002	120	8.6	51	62	--	--	--	21	4.3	4.5	.46	6.2	8.0	--	59	59
285037081342003	121	7.8	134	164	--	--	--	33	15	39.3	1.5	5.7	43	--	214	214
285057081243201	122	7.4	158	193	--	<.02	--	146	58	430	12	695	251	--	2,022	2,022
285118081391001	123	8.0	--	--	.23	.26	.04	29	8.8	6.2	2.5	11	19	8.5	136	136
285144081475001	125	6.2	--	--	.22	.74	--	5.4	1.3	2.1	.21	4.4	4.4	6.6	10	10
285144081475002	126	8.5	--	--	.20	.02	--	33	6.5	4.8	2.5	7.2	7.9	12	130	130
285152081542901	127	7.7	108	132	--	--	--	--	--	--	--	7.1	3.2	--	150	126
285230081242201	128	7.3	175	214	.31	<.02	.06	94	21	120	4.3	240	100	10	720	790
285233081284502	129	6.8	19	23	--	--	--	8.5	4.5	13	.74	24	5.8	--	96	96
285301081285401	130	7.5	143	174	<.20	<.02	.06	53	18	5.6	1	9	58	16	258	237
285318081340601	131	7.7	123	150	<.20	<.02	.01	31	8.6	6.6	1	--	--	19	140	131
285419081552801	133	8.1	--	--	.20	1.2	--	31	5.1	3.6	.38	5.9	3.4	11	103	103
285425081323401	134	6.4	--	--	.25	.02	--	10	4.9	4.3	3.7	6.5	32	4.3	77	77
285452081563201	135	7.8	67	82	--	--	--	17	9.2	2.5	.4	8.0	3	14	94	83
285454081241201	136	7.5	178	217	.46	<.02	.11	78	17	80	2.9	150	71	9.2	540	587
285549081530601	137	7.9	102	124	--	--	--	36	9.6	4.2	.8	8.0	22	12	152	157
285551081293601	138	7.5	155	189	--	--	--	44	12	4.8	.6	8.8	2.8	11	178	181

Appendix. Site identification, well construction information, and water-quality data from the surficial aquifer system and the Upper Floridan aquifer--Continued

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Site identification number	Map number	Site name	Collecting agency	County	Date of sample	Well depth (feet below land surface)	Casing length (feet)	Aquifer	Water temperature (^oC)	Specific conductance (µS/cm)	Dissolved oxygen (mg/L)
285602081344301	139	K. Kruckenberg 4” int. flow, Will Murphy Rd. near Paisley	USGS	Lake	01/15/97	140	65	F	20.7	348	--
285606081353601	140	Coates Tree Farm 4” irrigation deep, 40324 CR 439	USGS	Lake	01/06/97	180	84	F	22.7	356	--
285618081491101	141	G. Davis 4” deep, Emeralda Island	USGS	Lake	01/09/97	180	100	F	22.7	447	--
285628081400501	142	City of Umatilla PS Blanding deep L-0595	USGS	Lake	03/05/97	450	137	F	23.3	238	--
285659081470901	143	USGS 4” shallow L-0699, near Lake Yale	SJRWMD	Lake	04/18/97	80	60	S	23.9	281	--
285707081441101	144	J. F. Irvine Estate 4” deep L-0385 near Lake Yale	USGS	Lake	01/23/97	--	--	F	21.9	241	--
285810081234101	145	Lower Wekiva River St. Preserve 4” freeflow	USGS	Lake	11/19/98	87	83	F	21.4	324	--
285908081470101	148	Big Bass Lake Recreation Area 4” deep M-0046	USGS	Marion	02/19/97	198	--	F	22.5	278	--
285930081430901	150	Ocala Forest Campground 6” deep, SR 42 near Altoona	USGS	Marion	01/16/97	134	--	F	22.5	335	--
285933081324001	152	Paisley Fire Tower deep	USGS	Lake	01/15/97	--	--	F	15.7	119	--
285934081262501	153	LCFD (District 2 Station 2) 4” deep, Lake Mack Rd.	USGS	Lake	01/15/97	--	--	F	22.2	416	--
290002081483501	155	M-0254	SJRWMD	Marion	08/19/91	81	71	S	23.7	496	--
290025081244801	156	Ocala NF 2” shallow near River Forest pumphouse, FSR 541	USGS	Lake	12/17/98	20	10	S	23.3	46	--
290026081244701	157	River Forest deep, FSR 541 near Forest Hills	USGS	Lake	02/28/97	52	48	F	22.0	375	--
290038081491901	158	M-0233	SJRWMD	Marion	04/27/90	340	--	S	--	--	--
290043081232801	159	River Forest 2” deep L-0059 near Crows Bluff	SJRWMD	Lake	04/18/95	170	153	F	23.1	889	--
290047081232501	160	River Forest 3” deep L-0400 near Crows Bluff	USGS	Lake	11/22/96	250	--	F	24.0	863	--
290047081243401	161	L-0638	SJRWMD	Lake	05/19/93	--	--	F	--	--	--
290050081381201	162	Lake Dorr Recreation Area 4” deep	USGS	Lake	02/28/97	--	--	F	23.1	234	--
290155081332401	167	Bunch Ground Pond 4” shallow L-0702, Ocala NF	USGS	Lake	05/01/97	45	25	S	23.4	94	--
290208081250201	168	St. Francis 2” freeflow near Crows Bluff	USGS	Lake	01/06/97	--	--	F	21.5	360	--
290220081485001	169	Doe Lake Camp 6” deep	USGS	Marion	02/27/97	166	--	F	22.2	144	--
290228081382301	171	LCFD, District 4 - Station 6, 4” deep, SR 19 near Altoona	USGS	Lake	12/19/96	200	--	F	21.4	170	--
290300081391801	173	FSR 573 USGS shallow	USGS	Marion	12/21/98	60	50	S	23.2	35	5.5
290300081420901	174	Ocala NF 2” shallow, FSR 573, 0.4 mi E of FSR 566	USGS	Marion	12/18/98	70	60	S	26.1	39	8.2
290300081452001	175	Big Scrub Camp 6” deep	USGS	Marion	02/27/97	147	--	F	22.3	157	--
290300081471701	176	Ocala NF 2” shallow, FSR 573, 0.8 mi W of FSR 523	USGS	Marion	12/17/98	28	23	S	23.6	152	7.8
290425081350801	179	Ocala NF 2” shallow near Alexander Springs, Paisley Rd.	USGS	Lake	12/07/98	23	18	S	23.5	63	5.1
290436081383101	180	Railroad Grade Rd. 2” shallow, FSR 550	USGS	Marion	05/19/97	40	30	S	22.5	35	--
290445081344001	181	Alexander Springs Recreation Area supply 4” deep	USGS	Lake	02/19/97	100	--	F	23.5	1,330	--

Appendix. Site identification, well construction information, and water-quality data from the surficial aquifer system and the Upper Floridan aquifer--Continued

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Site identification number	Map number	pH (standard units)	Alkalinity (mg/L as $CaCO_3$)	Bicarbonate (mg/L as $CaCO_3$)	Ammonia plus organic nitrogen (mg/L as N)	Nitrite plus nitrate (mg/L as N)	Phosphate (mg/L as P)	Calcium (mg/L)	Magnesium (mg/L)	Sodium (mg/L)	Potassium (mg/L)	Chloride (mg/L)	Sulfate (mg/L as SO_4)	Silica (mg/L)	Dissolved solids, total (mg/L)	Dissolved solids, calculated (mg/L)
285602081344301	139	7.8	172	210	--	--	--	49	11	7.5	1	10	1	14	198	199
285606081353601	140	7.4	175	214	--	--	--	53	9.6	8.1	.8	8.0	1.1	18	208	204
285618081491101	141	7.5	138	168	--	--	--	60	17	7.8	1.1	13	74	14	270	263
285628081400501	142	8.0	100	122	.56	.02	--	28	7.4	6.3	1.2	11	5.4	12	156	128
285659081470901	143	--	22	27	--	--	--	7.0	6.4	40	2.5	13	52	--	155	155
285707081441101	144	7.4	104	127	--	--	--	32	8.4	5.9	1.2	9.8	6.5	17	140	129
285810081234101	145	7.7	164	200	--	--	--	54	7.1	4.2	.8	6.8	--	11	182	183
285908081470101	148	7.2	137	167	--	--	--	37	9.7	4.6	.8	7.3	.2	16	148	153
285930081430901	150	7.2	139	170	--	--	--	40	10	12	.8	22	.2	13	190	190
285933081324001	152	8.2	44	54	--	--	--	12	4.5	4.9	.6	7.3	3.7	10	60	50
285934081262501	153	7.3	210	256	--	--	--	83	2.8	5.0	.6	8.8	.1	9.6	230	243
290002081483501	155	8.8	--	--	--	.34	.17	4.9	1.2	93	2.9	7.3	64	9.7	294	295
290025081244801	156	4.4	3	4	.88	<.02	.22	1.5	.5	4.3	.2	7.4	.1	4.3	3	3
290026081244701	157	7.2	187	228	--	--	--	72	2.0	4.2	.5	7.6	.1	9.8	236	216
290038081491901	158	--	--	--	--	--	--	--	--	--	--	15	3.0	--	--	--
290043081232801	159	6.5	176	215	--	--	--	69	21	101	4.2	189	39	--	550	550
290047081232501	160	8.1	136	166	--	--	--	28	23	99	3.7	180	15	29	454	533
290047081243401	161	--	--	--	--	--	--	--	--	--	--	67	13	--	--	--
290050081381201	162	7.3	92	112	--	--	--	28	8.7	5.0	.7	7.9	14	10	142	125
290155081332401	167	5.2	13	16	--	--	--	4.6	1.0	11	<.1	8.4	17	1.8	60	34
290208081250201	168	7.5	168	205	--	--	--	53	9.4	8.2	1.0	14	1.5	10	190	207
290220081485001	169	8.2	63	77	--	--	--	16	4.2	4.2	1.6	5.5	2.1	23	94	67
290228081382301	171	7.6	76	93	--	--	--	22	5.7	3.4	.6	5.4	3.6	9.8	96	83
290300081391801	173	6.7	47	57	<.20	.25	.02	5.4	.5	1.8	<.1	3.4	1.7	4.1	25	<1
290300081420901	174	5.7	9	11	--	1.6	.01	.8	2.5	1.5	.4	3.2	.1	7.3	25	25
290300081452001	175	8.4	61	74	--	--	--	17	6.9	2.8	.4	4.9	10	9	96	75
290300081471701	176	6.2	59	72	.25	.10	.02	28	.05	.7	--	1	15	1.4	72	72
290425081350801	179	4.5	4	4	<.20	<.02	.01	.7	1.5	6.7	.2	13	3.4	4.3	34	14
290436081383101	180	5.1	6	7	--	--	--	.8	.6	4.4	<.1	6.4	2.1	1.9	19	<1
290445081344001	181	7.6	83	101	--	--	--	50	23	170	4.6	310	80	8.4	710	836

Appendix. Site identification, well construction information, and water-quality data from the surficial aquifer system and the Upper Floridan aquifer--Continued

[mg/L, milligrams per liter; ^{o}C, degree Celsius; µS/cm, microsiemens per centimeter at 25 ^{o}C; <, less than; --, unknown or not analyzed. Collecting agency: LC, Lake County; SJRWMD, St. Johns River Water Management District; USGS, U.S. Geological Survey. Aquifer: F, Upper Floridan aquifer; S, surficial aquifer system. Map numbers shown in figures 5 and 6]

Site identification number	Map number	Site name	Collecting agency	County	Date of sample	Well depth (feet below land surface)	Casing length (feet)	Aquifer	Water temperature (^{o}C)	Specific conductance (µS/cm)	Dissolved oxygen (mg/L)
290451081344401	184	Alexander Springs 4" deep L-0066	SJRWMD	Lake	07/18/95	102	74	F	23.6	1,308	--
290452081320001	185	Ocala NF 2" shallow, near Alexander Springs Wilderness	USGS	Lake	05/21/97	30	20	S	22.6	46	--
290508081550301	187	M-0339	SJRWMD	Marion	11/18/92	203	109	F	--	--	--
290512081542301	190	M-0331	SJRWMD	Marion	09/08/92	200	--	F	--	--	--
290526081493701	192	L. Schrimsher 4" deep, near Moss Bluff	USGS	Marion	01/07/97	--	--	F	22.2	238	--
290531081423101	193	Ocala NF 4" shallow M-0412, S of US Naval Bombing Range	USGS	Marion	04/30/97	75	65	S	23.0	61	--
290554081390501	197	Buck Lake Recreation Area handpump 4" deep	USGS	Marion	02/27/97	--	--	F	21.9	211	--
290613081402901	198	Farles Lake Recreation Area handpump 4" deep	USGS	Marion	02/27/97	--	--	F	22.1	188	--
290624081483901	200	M-0211	USGS	Marion	12/11/98	69	57	S	23.4	53	7.3
290628081425301	201	Ocala NF Lookout Tower Bombing Range 4" deep	USGS	Marion	01/21/97	206	--	F	22.8	101	--
290633081375201	202	Camp Ocala 6" deep L-0407, Sellers Lake	USGS	Lake	02/26/97	--	--	F	22.9	273	--
290646081314001	203	L-0441	SJRWMD	Lake	02/03/97	113	104	F	--	--	--
290646081314002	204	L-0446	SJRWMD	Lake	02/03/97	--	--	S	--	--	--
290646081442801	205	Ocala NF 2" shallow, FSR 584 W of US Bombing Range	USGS	Marion	04/29/97	60	50	S	23.0	26	--
290647081342101	206	Alexander Springs 4" deep L-0040	SJRWMD	Lake	11/04/93	171	143	F	21.8	325	--
290647081342102	207	L-0456	SJRWMD	Lake	03/01/94	32	22	S	21.6	88	--
290650081314001	208	Johnson deep, Levy Grant near Astor	USGS	Lake	11/22/96	--	--	F	19.5	383	--
290703081553901	209	M-0343	SJRWMD	Marion	06/14/94	--	--	F	--	--	--
290805081540801	214	D. Craft 4" deep, Tomahawk Lake near Lynne	USGS	Marion	01/07/97	150	105	F	22.8	227	--
290820081305001	215	Alco Fish Camp (Frank Saul) 2" freeflow near Astor	USGS	Lake	11/22/96	146	135	F	22.0	6,900	--
290835081383001	217	Ocala NF 2" shallow, near US Naval Tracking Station	USGS	Marion	05/19/97	40	30	S	22.0	50	--
290839081313401	220	L-0430	SJRWMD	Lake	09/11/90	--	--	F	--	--	--
290910081360001	222	Camp McQuarrie (4-H Club Foundation) 6" deep	USGS	Lake	06/17/98	152	135	F	23.1	244	<.1
290913081313301	223	L-0333	SJRWMD	Lake	09/11/90	--	--	F	--	--	--
290940081313001	226	L-0434	SJRWMD	Lake	09/11/90	--	--	F	--	--	--
290947081313801	227	L-0429	SJRWMD	Lake	09/12/90	--	--	F	--	--	--
290950081315501	228	Astor (A.G. Edwards) 6" deep L-0045	SJRWMD	Lake	08/14/91	254	204	F	23.4	2,850	--
291002081330601	230	Astor 6"deep L-0455	USGS	Lake	12/01/98	150	100	F	22.8	410	<.1
291002081330603	231	L-0460	USGS	Lake	12/07/98	30	20	S	24.5	67	<.1
291015081385001	234	DOT 49 6" deep M-0049, SR 19 and SR 40	USGS	Marion	09/12/96	166	166	F	22.5	239	--

Appendix. Site identification, well construction information, and water-quality data from the surficial aquifer system and the Upper Floridan aquifer--Continued

[mg/L, milligrams per liter; ^{o}C, degree Celsius; $\mu S/cm$, microsiemens per centimeter at 25 ^{o}C; <, less than; --, unknown or not analyzed. Collecting agency: LC, Lake County; SJRWMD, St. Johns River Water Management District; USGS, U.S. Geological Survey. Aquifer: F, Upper Floridan aquifer; S, surficial aquifer system. Map numbers shown in figures 5 and 6]

Site identification number	Map number	pH (standard units)	Alkalinity (mg/L as $CaCO_3$)	Bicarbonate (mg/L as $CaCO_3$)	Ammonia plus organic nitrogen (mg/L as N)	Nitrite plus nitrate (mg/L as N)	Phosphate (mg/L as P)	Calcium (mg/L)	Magnesium (mg/L)	Sodium (mg/L)	Potassium (mg/L)	Chloride (mg/L)	Sulfate (mg/L as SO_4)	Silica (mg/L)	Dissolved solids, total (mg/L)	Dissolved solids, calculated (mg/L)
290451081344401	184	7.7	83	101	--	.05	.03	56	22	166	2.9	359	76	4.0	821	821
290452081320001	185	5.4	7	9	--	--	--	2.2	1.2	3.4	1.0	6.7	5.3	4.7	30	3
290508081550301	187	--	--	--	--	--	--	--	--	--	--	6.0	1.0	--	--	--
290512081542301	190	--	--	--	--	--	--	--	--	--	--	4.0	22	--	--	--
290526081493701	192	7.4	114	139	--	--	--	39	4.6	3.8	1.0	6.4	1.0	17	146	128
290531081423101	193	6.1	13	16	--	--	--	1.1	.3	10	.3	7.6	6.8	5	38	13
290554081390501	197	7.9	102	124	--	--	--	30	5.6	4.2	1.1	5.0	.1	13	128	110
290613081402901	198	8.0	90	110	--	--	--	26	5.3	3.0	.6	5.5	.1	11	108	95
290624081483901	200	6.2	--	--	--	--	--	--	--	--	--	--	--	--	8	8
290628081425301	201	6.7	37	45	--	--	--	11	3.6	3.4	.7	4.5	6.4	10	60	39
290633081375201	202	7.8	131	160	--	--	--	36	9	5.0	.6	8.2	.1	9	160	150
290646081314001	203	--	--	--	--	--	--	--	--	--	--	7.0	5.0	--	--	--
290646081314002	204	--	--	--	--	--	--	--	--	--	--	7.0	3.0	--	--	--
290646081442801	205	5.5	10	12	--	--	--	1.3	.7	2.7	.2	3.3	1.9	8.8	26	<1
290647081342101	206	7.4	--	--	.34	.10	--	53	8.4	4.5	.43	7.7	.30	8.0	184	184
290647081342102	207	5.6	--	--	.41	.02	--	5.8	1.1	6.6	2.0	11	5.6	3.9	30	30
290650081314001	208	7.4	196	239	--	--	--	57	13	3.9	.8	7.4	.1	9.8	222	222
290703081553901	209	--	--	--	--	--	--	--	--	--	--	5.0	1.0	--	--	--
290805081540801	214	7.7	107	131	--	--	--	32	7.7	3.6	.6	6.1	1.8	17	128	120
290820081305001	215	7.9	9	11	--	--	--	400	130	930	8.9	2,000	660	11	4,980	4,447
290835081383001	217	5.1	5	7	--	--	--	.6	.5	8.0	<.1	11	2.4	3.3	28	6
290839081313401	220	--	--	--	--	--	--	--	--	--	--	12	2.0	--	--	--
290910081360001	222	7.7	108	132	<.20	<.02	.08	37	2.8	8.2	.6	8.4	5.4	5	131	131
290913081313301	223	--	--	--	--	--	--	--	--	--	--	764	182	--	--	--
290940081313001	226	--	--	--	--	--	--	--	--	--	--	216	40	--	--	--
290947081313801	227	--	--	--	--	--	--	--	--	--	--	1,110	186	--	--	--
290950081315501	228	7.4	--	--	--	.02	.02	120	48	360	6.5	700	110	11	1,821	1,821
291002081330601	230	6.9	208	254	.26	<.02	.04	70	6.5	5.1	.8	8.6	.1	12	239	239
291002081330603	231	4.5	5	6	.29	<.02	.04	2.7	1.4	5.5	.2	12	3.4	6.4	52	17
291015081385001	234	7.7	80	98	.25	.05	--	23	7.4	11	.7	21	6.8	8.7	124	128

Appendix. Site identification, well construction information, and water-quality data from the surficial aquifer system and the Upper Floridan aquifer--Continued

[mg/L, milligrams per liter; ^oC, degree Celsius; µS/cm, microsiemens per centimeter at 25 ^oC; <, less than; --, unknown or not analyzed. Collecting agency: LC, Lake County; SJRWMD, St. Johns River Water Management District; USGS, U.S. Geological Survey. Aquifer: F, Upper Floridan aquifer; S, surficial aquifer system. Map numbers shown in figures 5 and 6]

Site identification number	Map number	Site name	Collecting agency	County	Date of sample	Well depth (feet below land surface)	Casing length (feet)	Aquifer	Water temperature (^oC)	Specific conductance (µS/cm)	Dissolved oxygen (mg/L)
291034081322101	239	L-0627	SJRWMD	Lake	02/05/93	--	--	F	--	--	--
291051081495701	243	Mill Dam Lake Recreation Area supply 4” deep	USGS	Marion	02/21/97	--	--	F	21.7	204	--
291100081502001	245	Mill Dam Lake 6” deep (SCE-123)	USGS	Marion	01/15/97	288	--	F	21.5	286	--
291115081592501	250	Sharpes Ferry Marion, Silver Springs 6” freeflow near Ocala	USGS	Marion	09/19/96	135	135	F	23.2	344	--
291117081540501	251	Redwater Lake 4” deep M-0044	USGS	Marion	09/18/96	205	46	F	21.5	386	--
291117081540502	252	Redwater Lake 4” shallow M-0045	USGS	Marion	09/18/96	10	2	S	24.2	27	--
291204081564801	261	Ocala NF 2” shallow, Cemetary Rd. near Ocala NF Boundary	USGS	Marion	05/19/97	35	25	S	23.7	25	--
291230081594001	273	Silver Run 3” freeflow (SCE-154) near Silver Springs	USGS	Marion	09/24/98	--	--	F	23.6	621	<.1
291235081593801	274	M-0271	SJRWMD	Marion	05/10/91	--	--	F	--	--	--
291440081384801	285	Ocala NF 2” shallow, SR19 entrance to Silver Glen Springs	USGS	Marion	05/06/97	60	50	S	25.3	75	--
291448081381601	287	Juniper (Hunt) Club 4” deep near Silver Glen Springs	USGS	Lake	02/04/97	--	--	F	22.8	956	--
291449081381701	288	Juniper (Hunt) Club 6” deep near Silver Glen Springs	USGS	Lake	01/14/97	--	--	F	22.8	18,200	--
291513081515601	292	Lake Eaton handpump	USGS	Marion	02/20/97	96	--	F	22.5	333	--
291600081550001	293	Fore Lake Recreation Area CE55 4” deep M-0036	USGS	Marion	09/13/96	165	85	F	21.8	385	--
291620081415001	294	Hopkin's Prairie Recreation Area handpump 4” deep	USGS	Marion	01/06/98	215	--	F	21.9	356	<.1
291657081461501	295	Ocala NF 4” shallow (M-0408), FSR 88B & FSR 88	USGS	Marion	01/09/98	55	35	S	23.0	26	7.8
291728081390501	298	Ponderosa Club 2” freeflow M-0317 near Lisk Point, Lake George	USGS	Marion	09/12/96	--	--	F	22.6	911	--
291733081390301	299	M-0136	SJRWMD	Marion	06/26/92	134	106	F	--	--	--
291739081390501	301	M-0326	SJRWMD	Marion	06/27/92	--	--	F	--	--	--
291750081392801	305	M-0253	SJRWMD	Marion	06/28/92	--	--	F	--	--	--
291750081494001	306	CE-56 6” deep, CR 314 near Salt Springs	USGS	Marion	01/14/97	184	--	F	22.1	159	--
291751081414301	307	Ocala NF 4” shallow M-0413	USGS	Marion	01/09/98	75	60	S	22.9	46	3.1
291849081411401	309	Lake George 4” deep M-0021 near Salt Springs	USGS	Marion	09/11/96	298	268	F	22.9	897	--
292053081393401	311	M-0220	SJRWMD	Marion	01/29/90	143	124	F	--	--	--
292056081433901	312	M-0267	SJRWMD	Marion	04/02/91	43	--	F	--	--	--
292058081435101	313	M-0226	SJRWMD	Marion	06/26/92	--	--	F	--	--	--
292131081440601	316	M-0222	SJRWMD	Marion	01/29/90	126	62	F	--	--	--
292200081510001	319	CE84 6” deep M-0024 near Salt Springs	USGS	Marion	09/04/96	90	53	F	22.3	118	--
292240081483101	325	Grassy Pond Recreation Area handpump 4” deep M-0153	USGS	Marion	02/21/97	201	--	F	--	584	--
292403081422901	354	Ocala NF 2” shallow, FSR 47 & FSR 43	USGS	Putnam	05/16/97	70	60	S	22.9	30	--

Appendix. Site identification, well construction information, and water-quality data from the surficial aquifer system and the Upper Floridan aquifer--Continued

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Site identification number	Map number	pH (standard units)	Alkalinity (mg/L as $CaCO_3$)	Bicarbonate (mg/L as $CaCO_3$)	Ammonia plus organic nitrogen (mg/L as N)	Nitrite plus nitrate (mg/L as N)	Phosphate (mg/L as P)	Calcium (mg/L)	Magnesium (mg/L)	Sodium (mg/L)	Potassium (mg/L)	Chloride (mg/L)	Sulfate (mg/L as SO_4)	Silica (mg/L)	Dissolved solids, total (mg/L)	Dissolved solids, calculated (mg/L)
291034081322101	239	--	--	--	--	--	--	--	--	--	--	1,760	298	--	--	--
291051081495701	243	7.9	96	117	--	--	--	25	7.7	4.2	.6	7	.1	15	114	105
291100081502001	245	7.2	142	173	--	--	--	38	11	4.2	.5	7.4	.1	13	154	159
291115081592501	250	7.7	160	195	--	.13	.05	48	12	7.1	1	7.7	10	17	200	196
291117081540501	251	6.9	196	239	.47	.02	--	56	14	5.6	1	7.1	.1	36	232	223
291117081540502	252	5.1	3	4	--	--	--	.7	.5	2.1	1.3	3.2	.7	6.9	42	--
291204081564801	261	5.2	8	9	--	--	--	.8	.5	3.2	<.1	3.8	1.2	6.5	20	<1
291230081594001	273	7.4	134	163	<.20	<.02	.02	93	19	9.1	1.3	12	170	15	434	376
291235081593801	274	--	--	--	--	--	--	--	--	--	--	14	209	--	--	--
291440081384801	285	5.9	14	17	--	--	--	3.2	1.4	8.2	.6	12	6.8	8.8	40	22
291448081381601	287	7.5	60	73	--	--	--	47	20	100	3	200	92	8.6	546	593
291449081381701	288	7.0	91	111	--	--	--	470	320	3,100	65	6,000	1,000	12	11,900	11,774
291513081515601	292	7.6	147	179	--	--	--	42	14	4.8	.9	7.2	18	14	186	189
291600081550001	293	7.6	186	227	.33	.02	--	48	16	7.1	2.2	12	.9	29	220	223
291620081415001	294	7.3	172	210	.88	<.02	.13	55	7.6	5.9	.5	10	.1	9.2	204	204
291657081461501	295	5.8	3	4	<.20	<.02	.04	.4	.4	3.5	.2	5	1.3	6.6	26	<1
291728081390501	298	7.8	65	79	--	--	--	48	20	95	3.6	170	110	9	520	564
291733081390301	299	--	--	--	--	--	--	--	--	--	--	198	105	--	--	--
291739081390501	301	--	--	--	--	--	--	--	--	--	--	259	64	--	--	--
291750081392801	305	--	--	--	--	--	--	--	--	--	--	150	88	--	--	--
291750081494001	306	7.6	35	43	--	--	--	16	5.3	4.4	.3	7.8	26	9.8	100	76
291751081414301	307	6.2	8	10	<.20	.05	.83	.3	.1	9.1	.5	4.6	3	7.3	38	3
291849081411401	309	8.3	65	79	.20	.10	--	44	18	97	3.4	180	88	7.6	502	555
292053081393401	311	--	--	--	--	--	--	--	--	--	--	257	180	--	--	--
292056081433901	312	--	--	--	--	--	--	--	--	--	--	176	134	--	--	--
292058081435101	313	--	--	--	--	--	--	--	--	--	--	183	116	--	--	--
292131081440601	316	--	--	--	--	--	--	--	--	--	--	99	17	--	--	--
292200081510001	319	7.3	37	45	.20	.13	--	14	2.8	3.4	.2	6.3	10	8.2	70	50
292240081483101	325	8.4	41	50	--	--	--	28	14	57	2.2	120	56	11	313	352
292403081422901	354	5.7	9	11	--	--	--	1.2	.9	3.1	.2	4.6	2.2	3.3	24	<1

Appendix. Site identification, well construction information, and water-quality data from the surficial aquifer system and the Upper Floridan aquifer--Continued

[mg/L, milligrams per liter; °C, degree Celsius; µS/cm, microsiemens per centimeter at 25 °C; <, less than; --, unknown or not analyzed. Collecting agency: LC, Lake County; SJRWMD, St. Johns River Water Management District; USGS, U.S. Geological Survey. Aquifer: F, Upper Floridan aquifer; S, surficial aquifer system. Map numbers shown in figures 5 and 6]

Site identification number	Map number	Site name	Collecting agency	County	Date of sample	Well depth (feet below land surface)	Casing length (feet)	Aquifer	Water temperature (°C)	Specific conductance (µS/cm)	Dissolved oxygen (mg/L)
292447081441401	364	SR 19 near Frontier 4” deep (P-0427)	SJRWMD	Putnam	02/28/94	148	95	F	22.7	141	--
292447081441403	365	P-0820	SJRWMD	Putnam	11/08/94	60	40	S	22.7	130	--
292543081483201	380	Ocala NF 2” shallow, FSR 75 & FSR 88	USGS	Marion	01/07/98	51	41	S	21.9	44	7.4
292548081471201	382	Lake Delancy Recreation Area handpump 4” deep	USGS	Marion	02/25/97	165	96	F	22.0	854	--
292817081483601	401	Ocala NF 2” shallow, FSR 88 & FSR 31	USGS	Marion	12/12/97	60	50	S	25.0	89	3.8
292817081483602	402	USGS 6” deep M-0410, FSR 88/31	USGS	Marion	11/30/98	200	152	F	23.8	331	7.3
292824081443301	405	Johnson's Field 4” deep P-0472 near Welaka	USGS	Putnam	12/08/98	144	--	F	23.1	2,700	2.2
292824081443302	406	Johnson's Field 4” shallow P-0473 near Welaka	USGS	Putnam	12/08/98	45	--	S	21.7	215	<.1
292948081503001	431	USGS deep P-0450, Rd. 77 & 77-G	SJRWMD	Putnam	03/06/95	241	215	F	22.2	706	--
292948081503002	432	USGS shallow P-0738, Rd. 77 & 77-G	SJRWMD	Putnam	03/06/95	102	92	S	22.0	278	--
	SPRINGS										
02236095	1	Alexander Springs	SJRWMD	Lake	07/18/95	--	--	F	23.9	1,084	--
283400081405100	2	Apopka (Gourd Neck) Spring near Oakland	USGS	Lake	05/28/96	--	--	F	26.0	241	4.0
02243550	5	Blue Springs	USGS	Marion	05/18/99	--	--	F	22.8	1,040	1.5
284455081494100	6	Blue Springs, Park Dr. near Yalaha	USGS	Lake	06/10/97	--	--	F	23.6	283	1.0
285102081263900	7	Blueberry Spring, Seminole State Forest	USGS	Lake	06/11/97	--	--	F	23.7	1,898	--
02237322	8	Bugg Spring	USGS	Lake	06/19/97	--	--	F	24.0	281	<.1
285702081322400	9	Camp La-No-Che Springs vent 1 near Paisley	USGS	Lake	01/15/97	--	--	F	23.3	408	--
285702081322401	10	Camp La-No-Che Springs vent 2 near Paisley	USGS	Lake	01/15/97	--	--	F	22.7	414	--
292618081412100	12	Croaker Hole Spring near Welaka	USGS	Putnam	11/12/98	--	--	F	--	2,510	--
284940081303800	13	Droty Springs near Sorrento	USGS	Lake	06/17/97	--	--	F	23.9	306	--
02236132	14	Fern Hammock Spring	USGS	Marion	05/18/98	--	--	F	--	128	--
284424081490500	16	Holiday Springs at Yalaha	USGS	Lake	06/10/97	--	--	F	23.5	287	.5
0223610	18	Juniper Springs	USGS	Marion	02/19/97	--	--	F	21.8	106	--
284740081251701	19	Wekiva Falls Resort, Mastodon Springs	USGS	Lake	06/10/99	--	--	F	23.7	1,320	--
02235255	20	Messant Spring	USGS	Lake	05/24/95	--	--	F	25.3	677	--
285105081263800	22	Moccasin Springs, Seminole State Forest	USGS	Lake	06/11/97	--	--	F	24.9	2,850	--
284452081495400	23	Mooring Cove Springs near Yalaha	USGS	Lake	06/17/97	--	--	F	24.5	352	--
290220081260400	24	Mosquito Springs, Alexander Springs Wilderness	USGS	Lake	06/16/97	--	--	F	22.0	278	--
285038081270100	27	Palm Springs, Seminole State Forest	SJRWMD	Lake	06/11/97	--	--	F	27.4	1,820	.2
02236205	31	Salt Springs	USGS	Marion	01/06/98	--	--	F	23.7	6,190	2.4

Appendix. Site identification, well construction information, and water-quality data from the surficial aquifer system and the Upper Floridan aquifer--Continued

[mg/L, milligrams per liter; °C, degree Celsius; µS/cm, microsiemens per centimeter at 25 °C; <, less than; --, unknown or not analyzed. Collecting agency: LC, Lake County; SJRWMD, St. Johns River Water Management District; USGS, U.S. Geological Survey. Aquifer: F, Upper Floridan aquifer; S, surficial aquifer system. Map numbers shown in figures 5 and 6]

Site identification number	Map number	pH (standard units)	Alkalinity (mg/L as $CaCO_3$)	Bicarbonate (mg/L as $CaCO_3$)	Ammonia plus organic nitrogen (mg/L as N)	Nitrite plus nitrate (mg/L as N)	Phosphate (mg/L as P)	Calcium (mg/L)	Magnesium (mg/L)	Sodium (mg/L)	Potassium (mg/L)	Chloride (mg/L)	Sulfate (mg/L as SO_4)	Silica (mg/L)	Dissolved solids, total (mg/L)	Dissolved solids, calculated (mg/L)
292447081441401	364	8.2	--	--	.20	.02	--	23	.97	3.5	.68	4.6	7.5	13	65	65
292447081441403	365	6.0	--	--	.23	.12	--	4	.8	19	.3	12	16	6.4	57	57
292543081483201	380	6.6	15	18	.25	.58	.02	4.6	1.2	2.3	.2	3.1	3.2	4.4	38	2
292548081471201	382	8.2	42	51	--	--	--	36	15	94	1.9	190	73	8.4	480	527
292817081483601	401	6.6	37	45	<.20	.15	.40	7.9	4.1	2.7	.3	4.7	1	11	58	31
292817081483602	402	8.4	42	51	<.20	.20	.03	20	5.6	34	1	64	21	9.1	189	188
292824081443301	405	7.8	79	96	<.20	.07	.02	98	43	360	5	720	160	9	1,680	1,724
292824081443302	406	5.9	70	85	.24	<.02	.96	28	2.3	12	.4	20	1.3	25	152	113
292948081503001	431	9.0	--	--	--	.03	.01	29	14	88	1	177	36	8	431	431
292948081503002	432	8.0	--	--	--	.15	--	18	3	93	5.3	42	40	6.9	153	153
SPRINGS																
02236095	1	7.8	80	98	--	.07	.05	46	23	144	3.5	307	69	4	676	676
283400081405100	2	8.2	74	90	<.20	4.9	.03	29	7.5	5.2	.9	12	8.6	9.6	142	129
02243550	5	7.5	77	94	<.20	<.02	.02	42	17	130	3.6	240	53	9.6	578	648
284455081494100	6	7.9	100	122	<.20	5.0	.04	39	5.8	4.3	.7	12	10	11	174	157
285102081263900	7	7.5	--	--	--	--	--	--	--	--	--	--	--	--	1,203	1,204
02237322	8	7.9	129	157	.24	.46	.09	48	3	5.2	.8	8.3	6.1	6.5	150	155
285702081322400	9	7.7	120	146	--	--	--	58	14	6.6	.9	10	74	12	246	238
285702081322401	10	7.7	121	148	--	--	--	59	15	6.5	1	10	78	12	254	242
292618081412100	12	7.9	65	79	--	.12	.024	74	39	340	8.5	670	150	7.9	1,410	1,601
284940081303800	13	7.5	117	143	<.20	<.02	.08	41	11	5.0	.8	7.1	32	10	176	172
02236132	14	7.1	--	--	--	--	--	--	--	--	--	--	--	--	56	56
284424081490500	16	7.7	105	128	<.20	4.1	.04	40	6.2	5.9	.7	14	9	11	164	159
0223610	18	7.8	45	55	--	.08	.03	13	4.4	2.4	.2	4.3	6.3	8.5	58	48
284740081251701	19	7.4	109	133	--	--	--	110	38	210	5.4	400	230	11	1,140	829
02235255	20	7.8	104	127	--	--	.03	100	22	7.1	1	10	240	12	480	412
285105081263800	22	7.4	111	135	--	--	--	140	51	340	10	620	380	11	1,750	1,821
284452081495400	23	7.4	130	159	--	--	--	48	6.9	9.6	1.2	15	11	11	196	201
290220081260400	24	7.4	134	163	--	--	--	47	4.3	5.4	.6	8.2	.5	7.8	150	153
285038081270100	27	8.0	109	133	<.20	<.02	.04	130	40	180	6.5	320	320	12	1,130	1,153
02236205	31	7.4	67	82	<.20	.10	.03	160	100	940	26	1,800	410	12	3,770	3,987

Appendix. Site identification, well construction information, and water-quality data from the surficial aquifer system and the Upper Floridan aquifer--Continued

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Site identification number	Map number	Site name	Collecting agency	County	Date of sample	Well depth (feet below land surface)	Casing length (feet)	Aquifer	Water temperature (^{o}C)	Specific conductance (µS/cm)	Dissolved oxygen (mg/L)
02235250	33	Seminole Springs	USGS	Lake	05/24/95	--	--	F	24.3	335	--
285224081262400	34	Shark's Tooth Spring, Seminole State Forest	USGS	Lake	06/12/97	--	--	F	22.4	768	--
02236160	35	Silver Glen Springs	USGS	Lake	02/04/97	--	--	F	23.2	2,010	--
284437081491700	39	Sun Eden Spring near Yalaha	USGS	Lake	06/17/97	--	--	F	25.1	276	--
291307081393600	40	Sweetwater Springs along Juniper Creek	USGS	Marion	06/06/97	--	--	F	23.3	4,090	--
292542081552600	41	Tobacco Patch Landing Spring Group 1, Ocklawaha River	USGS	Marion	03/03/99	--	--	F	22.6	2,060	5.4
292521081551200	44	Wells Landings Springs, Ocklawaha River	USGS	Marion	03/03/99	--	--	F	22.7	1,640	6.0

Appendix. Site identification, well construction information, and water-quality data from the surficial aquifer system and the Upper Floridan aquifer--Continued

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Site identification number	Map number	pH (standard units)	Alkalinity (mg/L as $CaCO_3$)	Bicarbonate (mg/L as $CaCO_3$)	Ammonia plus organic nitrogen (mg/L as N)	Nitrite plus nitrate (mg/L as N)	Phosphate (mg/L as P)	Calcium (mg/L)	Magnesium (mg/L)	Sodium (mg/L)	Potassium (mg/L)	Chloride (mg/L)	Sulfate (mg/L as SO_4)	Silica (mg/L)	Dissolved solids, total (mg/L)	Dissolved solids, calculated (mg/L)
02235250	33	7.9	84	102	--	1.4	.05	45	11	5.0	.8	8.6	64	8.5	192	190
285224081262400	34	7.1	114	139	<.20	.04	.05	64	18	62	2.1	110	100	8.3	430	471
02236160	35	7.6	68	83	--	.05	.03	74	37	250	8.2	470	180	8.4	1,170	1,276
284437081491700	39	7.7	111	135	--	--	--	35	7	4.0	.5	8.1	7.1	11	144	152
291307081393600	40	7.7	75	92	--	.04	.02	110	62	590	17	1,000	270	8.3	2,270	2,625
292542081552600	41	6.1	66	81	<.20	.17	.01	77	30	280	7.8	540	160	8.5	1,180	1,309
292521081551200	44	6.8	58	71	<.20	.12	.01	64	26	220	5.7	410	130	8.7	932	1,037