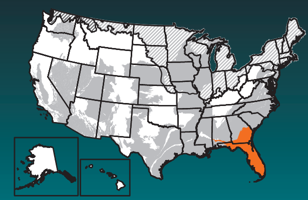
National Water Quality Program
National Water-Quality Assessment Project



Groundwater Quality in the Floridan Aquifer System, Southeastern United States

Groundwater provides nearly 50 percent of the Nation's drinking water. To help protect this vital resource, the U.S. Geological Survey (USGS) National Water-Quality Assessment (NAWQA) Project assesses groundwater quality in aquifers that are important sources of drinking water (Burow and Belitz, 2014). The Floridan aquifer system constitutes one of the important aquifer systems being evaluated.

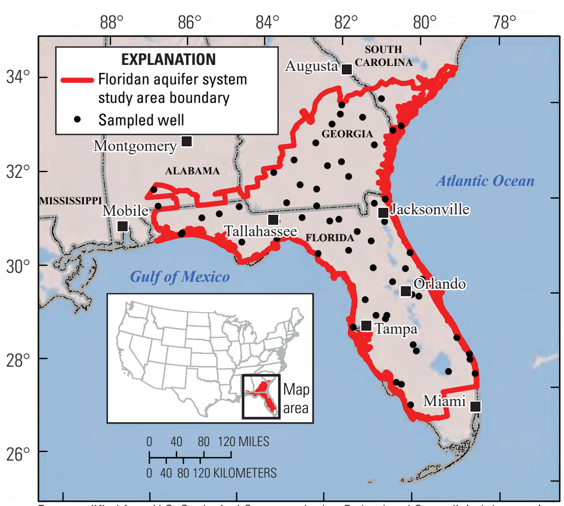
Background

The Floridan aquifer system underlies an area of about 100,000 square miles (mi^2), including all of Florida and parts of Georgia, South Carolina, and Alabama. The Floridan aquifer system is a very productive system and an important source of drinking water. The aquifer system ranks third in the Nation as a source of groundwater for public supply, with about 1,330 million gallons per day pumped for this use in 2000 (Arnold and others, 2018a). The aquifer system also is used extensively as a source of water for irrigation (Maupin and Barber, 2005). Land use in the area overlying the Floridan aquifer system is primarily undeveloped land cover (65 percent) and agricultural (20 percent), with a smaller percentage of urban (7 percent) land.

The Floridan aquifer system is composed of a thick sequence of carbonate rocks of Tertiary age (Miller, 1990). The aquifer system thickens from north to south—from about 200 feet (ft) to more than 3,000 ft in parts of southern Florida (Miller, 1990). Relatively low permeability materials that act as confining units bound the Floridan aquifer system (Miller, 1990). Depending on location, the aquifer system itself is confined, semiconfined, or unconfined.

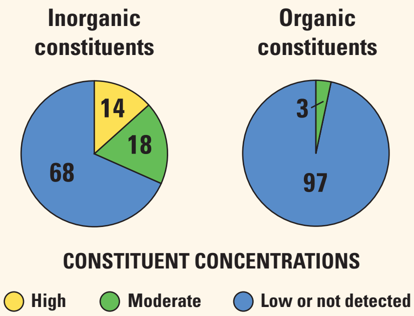
Generally, the Floridan aquifer system functions as one aquifer; however, in some locations a discontinuous confining unit separates the aquifer system into two units, the Upper Floridan and Lower Floridan aquifers (Miller, 1986; Williams and Kuniansky, 2016). Recharge to the Upper Floridan aquifer primarily occurs in outcrop areas, and the general direction of groundwater flow is from the outcrop areas towards the coast (Miller, 1990). Recharge also can occur from streams or from downward movement of water from the overlying surficial aquifer and other shallow aquifers (Williams and Kuniansky, 2016). Both aquifers were sampled to characterize groundwater used for public supply in the Floridan aquifer system.

Groundwater quality in the Floridan aquifer system was evaluated by sampling 60 public-supply wells randomly distributed in an equal area grid. For this discussion, the study area is defined as the depth zone used for public supply in the Floridan aquifer system. Water-quality data collected from these spatially distributed wells (40 in Florida, 16 in Georgia, 2 in Alabama, and 2 in South Carolina) are representative of water quality in the study area (Belitz and others, 2010). Most of the wells were located in areas where the Floridan aquifer system is confined (61 percent) or semiconfined (25 percent of wells). Results from these wells were used to estimate the percentage of the study area with concentrations that are high, moderate, and low with respect to constituent benchmarks. The accuracy of the estimates depends upon the distribution and number of wells, not on the size of the area (Belitz and others, 2010). Well depth was not available for all the wells sampled, but for those with depth information, well depths ranged from 140 to 840 ft. Samples were collected between March and August of 2015 and analyzed for many natural and man-made constituents.



Base modified from U.S. Geological Survey and other Federal and State digital data, various scales; Albers Equal-Area Conic projection, standard parallels are 29°30′ N. and 45°30′ N; North American Datum of 1983; Shaded relief from ESRI World_Shaded_Relief, 2014

Overview of Water Quality



Values are a percentage of the study area with concentrations in the three specified categories. Percentages might not sum to 100 because of rounding.

Principal Aquifer Studies are designed to evaluate untreated groundwater used for public supply prior to any treatment. Groundwater quality is assessed by comparing concentrations to benchmarks established for drinking-water quality. Benchmarks and definitions of high, moderate, and low relative concentrations are discussed in the inset box on page 3.

Many inorganic constituents are present naturally in groundwater; however, concentrations of these naturally occurring constituents can be affected by human activities. One or more inorganic constituents with human-health benchmarks were present at high concentrations in about 14 percent of the study area and at moderate concentrations in about 18 percent of the study area.

Organic constituents derived from human activities are found in products used in the home, business, industry, and agriculture. Organic constituents can enter the environment through normal use, spills, or improper disposal; however, they were detected infrequently in the study area and typically concentrations were low. One or more organic constituents with human-health benchmarks were detected at moderate concentrations in about 3 percent of the study area.

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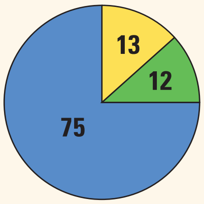
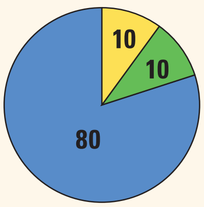
Results: Groundwater Quality at the Depth Zone Used for Public Supply in the Floridan Aquifer System

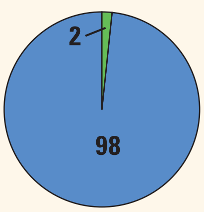
INORGANIC CONSTITUENTS



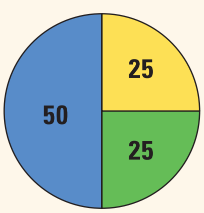
Trace elements and major and minor ions



Radioactive constituents



Nutrients



Constituents with non-health benchmarks

Inorganic Constituents With Human-Health Benchmarks

Trace elements and major and minor ions are naturally present in the minerals of rocks, soils, and sediments and in the water that comes into contact with those materials. Samples were analyzed for 34 trace elements and major and minor ions, of which 19 have human-health benchmarks. These constituents were detected at high concentrations in about 13 percent of the study area and at moderate concentrations in about 12 percent. Strontium was the only constituent detected at high concentrations relative to its human-health benchmark of 4,000 micrograms per liter (μg/L).

Radioactivity is the release of energy or energetic particles during the spontaneous decay of unstable atoms, and humans are continuously exposed to small amounts of natural radioactivity. Most of the radioactivity in groundwater comes from the decay of naturally occurring isotopes of uranium and thorium. Samples were analyzed for eight radioactive constituents, of which four have human-health benchmarks. Radioactive constituents were present at high or moderate levels in about 20 percent of the study area. Gross-alpha activity, gross-beta activity, and radium-226 plus radium-228 were the only radiochemical constituents detected at high concentrations.

Nutrients are naturally present at low concentrations in groundwater; high and moderate concentrations (relative to human-health benchmarks) generally are a result of human activities. Samples were analyzed for five nutrients, of which two (nitrate and nitrite) have human-health benchmarks. Common sources of nutrients, aside from soils, include fertilizer applied to crops and landscaping, seepage from septic systems, and human and animal waste. Nitrate was measured at a moderate concentration in one well, representing 2 percent of the study area.

Inorganic Constituents and Field Measurements With Non-Health Benchmarks

(Not included in water-quality overview charts shown on the front page)

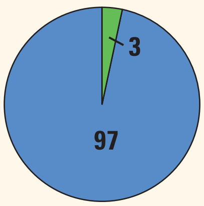
Some constituents affect the aesthetic properties of water, such as taste, color, and odor, or can create nuisance problems, such as staining and scaling. The benchmarks used for these constituents are non-regulatory secondary maximum contaminant level (SMCL) benchmarks established for public drinking water. Some constituents such as manganese have both human-health benchmarks and SMCLs. Samples were analyzed for 11 constituents that have SMCLs. One or more of these constituents were present at high concentrations in about 25 percent of the study area and at moderate concentrations in about 25 percent.

Total dissolved solids (TDS) concentration is a measure of the salinity of the groundwater based primarily on the concentrations of ions, and all water naturally contains TDS because of the weathering and dissolution of minerals in rocks and sediments. Total dissolved solids concentrations can be high because of natural factors or human activities such as some agricultural activities. Total dissolved solids were present at high concentrations relative to the SMCL in about 18 percent of the study area and at moderate concentrations in 22 percent. Chloride was present at high concentrations in about 15 percent of the study area and at moderate concentrations in 3 percent. Sulfate was present at high concentrations in 12 percent of the study area and at moderate concentrations in 5 percent. Fluoride was present at moderate concentrations relative to the SMCL in about 7 percent of the study area.

Anoxic conditions in groundwater (low concentrations of dissolved oxygen) can result in the release of naturally occurring iron and manganese from minerals into groundwater. Manganese was present at high concentrations relative to the SMCL in about 2 percent of the study area. Iron was present at high concentrations relative to the SMCL in about 7 percent of the study area and at moderate concentrations in 3 percent.

Results: Groundwater Quality at the Depth Zone Used for Public Supply in the Floridan Aquifers

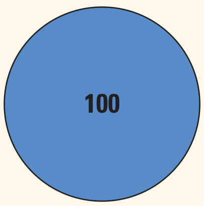
ORGANIC CONSTITUENTS



VOCs

Volatile Organic Compounds With Human-Health Benchmarks

Volatile organic compounds (VOCs) are present in many household, commercial, industrial, and agricultural products and are characterized by their tendency to volatilize (evaporate) into the air. Samples were analyzed for 90 VOCs, of which 38 have human-health benchmarks. Volatile organic compounds were not detected at high concentrations, and only two compounds, the solvents tetrachloroethylene and dichloromethane, were detected at moderate concentrations in two wells, representing 3 percent of the study area.



Pesticides

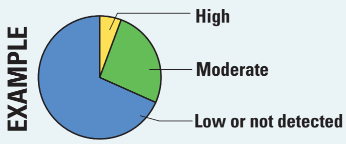
Pesticides With Human-Health Benchmarks

Pesticides, including herbicides, insecticides, and fumigants, are applied to crops, gardens and lawns, around buildings, and along roads to help control unwanted vegetation (weeds), insects, fungi, and other pests. Samples were analyzed for 227 pesticide compounds (pesticides and their breakdown products), of which 119 have human-health benchmarks. Pesticide compounds were not detected at high or moderate concentrations in the study area.

BENCHMARKS FOR EVALUATING GROUNDWATER QUALITY

The USGS NAWQA Project uses benchmarks established for drinking water to provide context for evaluating the quality of untreated groundwater. The quality of water received by customers may be different because after withdrawal, groundwater may be treated prior to delivery. Federal regulatory benchmarks for protecting human health are used for this evaluation of water quality when available. Otherwise, nonregulatory human-health benchmarks and nonregulatory aesthetic benchmarks are used. Not all analyzed constituents have associated benchmarks and thus are not considered in this context. Out of 55 inorganic constituents and properties and 317 organic constituents analyzed, 24 and 157, respectively, have human-health benchmarks.

PERCENTAGE OF STUDY AREA



Values are a percentage of the study area with concentrations in the three specified categories. Percentages might not sum to 100 because of rounding.

Concentrations are considered high if they are greater than a human-health benchmark (Toccalino and others, 2014) or SMCL. For inorganic constituents, concentrations are moderate if they are greater than one-half of a benchmark. For organic constituents, concentrations are moderate if they are greater than one-tenth of a benchmark; this lower threshold was used because organic constituents are generally less prevalent and have smaller concentrations relative to benchmarks than inorganic constituents (Toccalino and others, 2004).

Benchmark Type and Value for Selected Constituents

This table presents benchmarks for those constituents detected at high concentrations in the Floridan aquifer system. Benchmark types are regulatory U.S. Environmental Protection Agency (EPA) maximum contaminant levels (MCLs), non-regulatory health-based screening levels (HBSLs), screening levels (SL), and non-regulatory EPA secondary maximum contaminant levels (SMCLs).

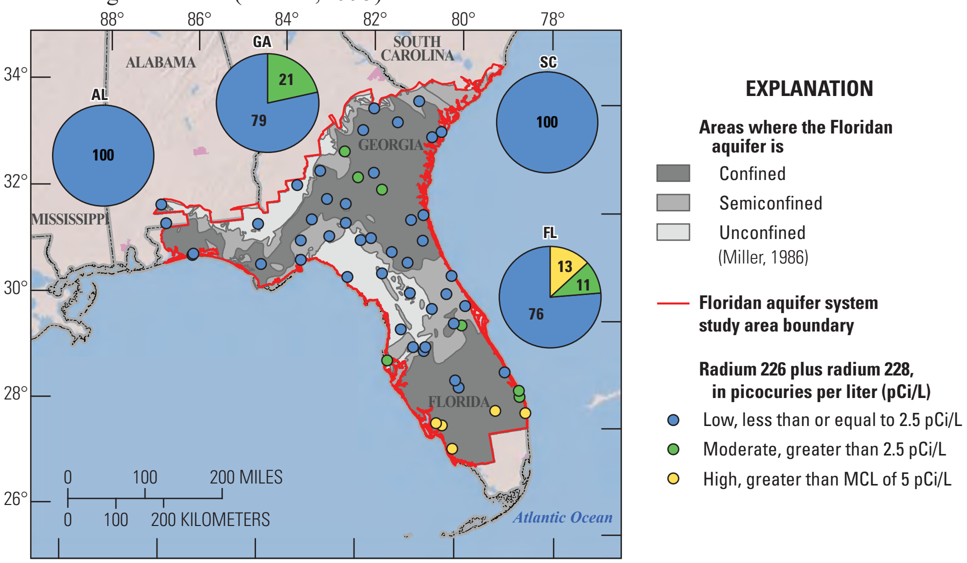
[Abbreviations: ppb, part per billion or microgram per liter (µg/L); ppm, part per million or milligram per liter (mg/L); pCi/L, picocurie per liter; mrem/yr, millirem per year]

Constituent	Health-based benchmark		Constituent	SMCL
	Type	Value		Value
Gross-alpha activity	MCL	15 pCi/L	Sulfate	250 ppm
Ra-226+Ra-228	MCL	5 pCi/L	Iron	300 ppb
Gross-beta activity	SL	4 mrem/yr	Manganese	50 ppb
Strontium	HBSL	4 ppm	Total dissolved solids (TDS)	500 ppm
			Chloride	250 ppm

Spatial Distribution of Constituents Above Human-Health Benchmarks

Inorganic constituents with health-based benchmarks were present at high or moderate concentrations in about 32 percent of the study area. The distribution of samples with moderate and high concentrations varied across the study area with most occurring in southern Florida.

For example, high concentrations of radium-226 plus radium-228 (combined radium) were found only at the southern part of the study area. Moderate concentrations of combined radium also were found in this area, as well as at three wells in Georgia. The differences in water quality across the study area may reflect differences in the composition of geologic units that make up the Floridan aquifer system or a contrast between where the system is confined versus semiconfined and unconfined. Previous sampling in southwest Florida identified elevated concentrations of radium in groundwater (Walters, 1995).



Base modified from U.S. Geological Survey and other Federal and State digital data, various scales; Albers Equal-Area Conic projection, standard parallels are 29°30′ N. and 45°30′ N; North American Datum of 1983; Shaded relief from ESRI World_Shaded_Relief, 2014

By James A. Kingsbury

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Principal Aquifer Surveys

The USGS NAWQA Project has been assessing the quality of groundwater since 1991. The NAWQA studies include Land Use Studies (LUS), Major Aquifer Studies (MAS), and Principal Aquifer Studies (PAS). These three study types are based on the sampling of networks of wells distributed across an area of interest. The LUS networks typically consist of observation wells that are relatively shallow, MAS networks typically consist of domestic-supply wells that are intermediate in depth, and PAS networks typically consist of public-supply wells that are relatively deep. A national synthesis of shallow and intermediate depth groundwater quality was reported by DeSimone and others (2014). This Fact Sheet provides a summary of PAS data for 60 public-supply wells sampled in 2015 in the Floridan aquifer system principal aquifer (data available in Arnold and others, 2018b).

The PAS assessments like this one allow for the comparison of constituent concentrations in untreated groundwater with benchmarks established for the protection of human health and for aesthetic qualities for drinking water and also provide a basis for comparison of groundwater quality among principal aquifers.

The data collected by the NAWQA Project include chemical analyses generally not available as part of regulatory compliance monitoring, including measurements at concentrations much lower than human-health benchmarks and measurement of constituents that can be used to trace the sources and movement of groundwater.

For more information

Technical reports and hydrologic data collected for the USGS NAWQA Project may be obtained from

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