Technical Publication SJ2002-1

EVALUATION OF UPPER FLORIDAN AQUIFER WATER QUALITY TO DESIGN A MONITORING NETWORK IN THE ST. JOHNS RIVER WATER MANAGEMENT DISTRICT

by

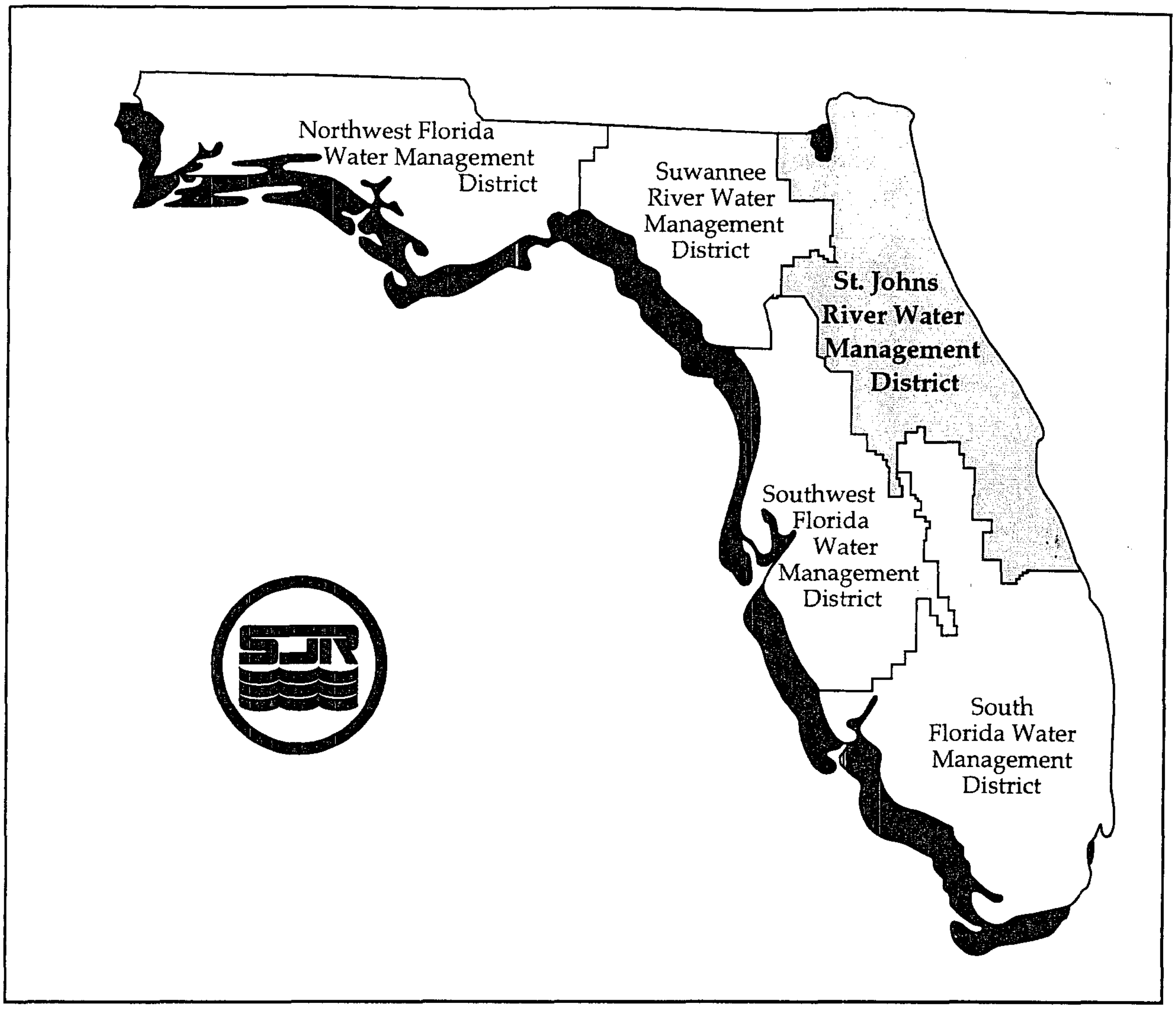
Don Boniol, P.G.

Don Boniol
Professional Geologist
License No. PG 0000560
February 22, 2002

SEAL

St. Johns River Water Management District
Palatka, Florida

2002



The St. Johns River Water Management District (SJRWMD) was created by the Florida Legislature in 1972 to be one of five water management districts in Florida. It includes all or part of 19 counties in northeast Florida. The mission of SJRWMD is to manage water resources to ensure their continued availability while maximizing environmental and economic benefits. SJRWMD accomplishes its mission through regulation; applied research; assistance to federal, state, and local governments; operation and maintenance of water control works; and land acquisition and management.

This document is published to disseminate information collected by SJRWMD in pursuit of its mission. Copies of this document can be obtained from:

Library
St. Johns River Water Management District
P.O. Box 1429
Palatka, FL 32178-1429

Phone: (386) 329-4132

EXECUTIVE SUMMARY

Water quality monitoring of the Floridan aquifer provides useful information for water resource protection and water supply planning. Water quality monitoring provides information to evaluate groundwater resources on regional and subregional scales, detect long-term trends, identify potential problem areas, and provide information to determine the effectiveness of water management programs.

Water quality in the Upper Floridan aquifer is generally good in the northern and western parts of the St. Johns River Water Management District, with chloride, sulfate, and total dissolved solids (TDS) concentrations below drinking water standards. Chloride and TDS concentrations generally exceed drinking water standards in most of Brevard and Indian River counties, in southern St. Johns and northern Flagler counties, in discharge areas along the St. Johns River south of Clay County, and in eastern Volusia County along the Atlantic coast. Sulfate concentrations also exceed secondary drinking water standards in many of these areas. The natural systems and human influences that affect water quality conditions in the Upper Floridan aquifer are described, and the distribution of chloride, sulfate, and TDS concentrations in the Upper Floridan aquifer are mapped.

Declines in potentiometric levels of the Upper Floridan aquifer in some areas have increased the potential for the upward movement of highly mineralized water from lower zones to higher zones through leaky confining beds, structural geologic features, and improperly constructed wells. Declines in the potentiometric surface which occur over large areas and over long periods of time, resulting from increased water use and/or decreased rainfall, indicate changes in the long-term balance of recharge to and discharge from the Floridan aquifer system.

Trend analysis performed on monitoring well and public supply well data show that chloride concentrations are not significantly changing or are decreasing in most areas of the St. Johns River Water Management District. However, chloride concentrations are significantly increasing in some areas. Decreases in hydraulic heads in freshwater zones resulting from water withdrawals are the probable cause of the increasing trends in chloride concentrations observed in some wells at the De Land, Deltona,

Holly Hill, New Smyrna Beach, and Ormond Beach wellfields in Volusia County, the Flagler Beach wellfield in Flagler County, the Oviedo wellfield in Seminole County, and the Cocoa wellfield in eastern Orange County. Increasing trends in chloride concentrations have also been recognized in monitoring wells at the Vero Beach wellfield in Indian River County and in agricultural areas of western St. Johns County. Structural geologic features in combination with decreasing hydraulic heads in freshwater zones are a likely cause for the variable and localized increasing trends in chloride concentrations observed in parts of east-central Duval County.

The regional water quality conditions in the Upper Floridan aquifer are assessed through a network of wells located in areas that are not significantly affected by major water withdrawals. A geostatistical analysis of available water quality data concluded that at least one well be monitored in each grid cell of a 50,000-foot hexagonal grid to adequately assess regional water quality conditions in the Upper Floridan aquifer. This more efficient network reduces the number of wells in areas that have shown little or no variability in water quality over time, freeing financial and human resources for adding and sampling wells where needed. Data from the regional network are used to describe variations in water quality due to hydrogeologic features and to explain the response of Floridan aquifer water quality conditions to changes in climate. The data can be used to assess whether the water quality in an area is suitable for the intended water use. The data could also be used as a baseline against which future water quality conditions can be compared.

On a subregional level, the monitoring network provides information on the effect that hydrogeologic features and stresses to the aquifer system, such as withdrawals, have on water quality conditions. Areas of critical concern were identified based on the distribution of chloride, sulfate, and TDS concentrations, water quality trend analysis, and projected decreases in water levels. The monitoring well network includes increased well coverage in these subregional areas of critical concern. Some of the network sites have additional wells monitoring the middle and lower parts of the Floridan aquifer, allowing for an evaluation of water quality changes with well depth.

CONTENTS

FIGURES

INTRODUCTION

The Floridan aquifer system is the primary source of water for public supply and other uses in most areas of the St. Johns River Water Management District (SJRWMD) (Figure 1). Recent water supply planning assessments have identified areas where existing and anticipated sources of water may not be adequate to supply water for all existing and future needs through 2020 without causing unacceptable impacts to groundwater resources (Vergara 1998). These potential problems are related largely to projected increases in public supply water use to serve an increasing population. As these demands on water resources increase, it is important to have a monitoring network to provide the data needed to assess groundwater quality conditions.

SCOPE

Accurate information about groundwater quality conditions in the Floridan aquifer system is essential for long-term water supply planning and water resource protection. The SJRWMD Division of Groundwater Programs is responsible for the design, construction, and maintenance of a monitoring well network for assessing the resource. Water quality information obtained from the network increases our understanding of the Floridan aquifer system and the hydrogeologic, climatic, and human factors that affect the resource.

This report evaluates existing water quality data to make representations about current water quality conditions in the Upper Floridan aquifer. Available water quality data are used to assess groundwater resources on regional and subregional scales, detect long-term trends, and identify potential problem areas. This information is the basis for designing a monitoring network to assess groundwater quality conditions on both regional and subregional scales.

METHODS

Data for the concentrations and measurements of water quality variables were compiled from SJRWMD groundwater investigations and monitoring projects and from other sources. The water quality data were evaluated using statistical, graphical, and mapping procedures. Current

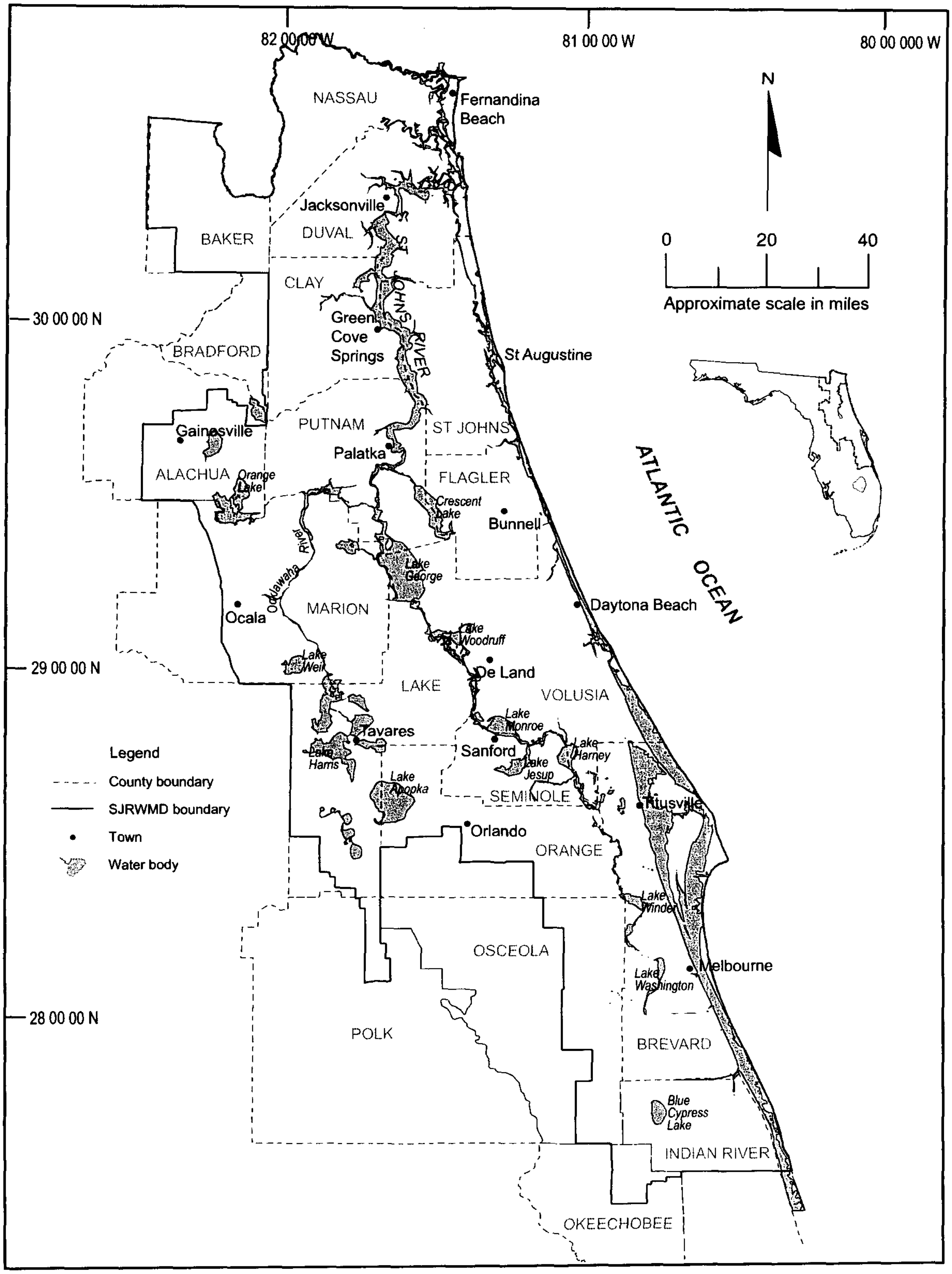


Figure 1. The St. Johns River Water Management District

water quality conditions in the Upper Floridan aquifer and the natural and human influences that affect water quality are described.

The spatial variability of chloride concentrations was analyzed geostatistically to determine optimal grid spacing for a network of wells representative of regional, baseline water quality conditions. The temporal variability of chloride concentrations was analyzed to determine the significance of an apparent trend in water quality at a specific well location and to estimate the magnitude of that trend. On a subregional level, areas of critical concern in the Upper Floridan aquifer were identified based on the distribution of chloride, sulfate, and total dissolved solids (TDS) concentrations, trend analysis, and projected decreases in water levels. The sampling frequency of the wells in the network was determined from the trend analysis of data for that well and the well location relative to areas of critical concern.

The current SJRWMD network of wells monitoring water quality in the Upper Floridan aquifer was evaluated considering the regional and subregional network design factors; some redundant wells were deleted. New well sites were proposed in conjunction with SJRWMD efforts to upgrade the Upper Floridan aquifer potentiometric network (Osburn 2000). Wells monitoring the middle and lower portions of the Floridan aquifer system were identified where these zones are used as a source of water for public supply. Supplemental groundwater quality data available from other sources are also identified. Actions to improve the current water quality monitoring network to better meet the needs of water supply planning and water resource protection are recommended.

SOURCES OF DATA

Well sampling and analysis conducted from 1990 through 2000 provided data on the cations and anions that constitute a major part of the TDS content of water, other chemically related variables, and field measurements. Cations included calcium, magnesium, sodium, and potassium; anions included chloride, sulfate, and alkalinity. Chemically related variables included TDS and hardness. Field measurements included temperature, pH, and specific conductance.

Chloride, sulfate, and TDS concentration data from SJRWMD, the South Florida Water Management District, the Southwest Florida Water Management District, the Suwannee River Water Management District, Alachua County, Brevard County, the U.S. Geological Survey (USGS), and various public supply utilities were compiled to evaluate the current water quality conditions in the Upper Floridan aquifer. While the quality assurance procedures for sampling, analysis, and data review varied among the agencies, the use of the data from all available sources was suitable for assessing current conditions. The locations of the 874 wells with water quality data and the data sources are shown in Figure 2.

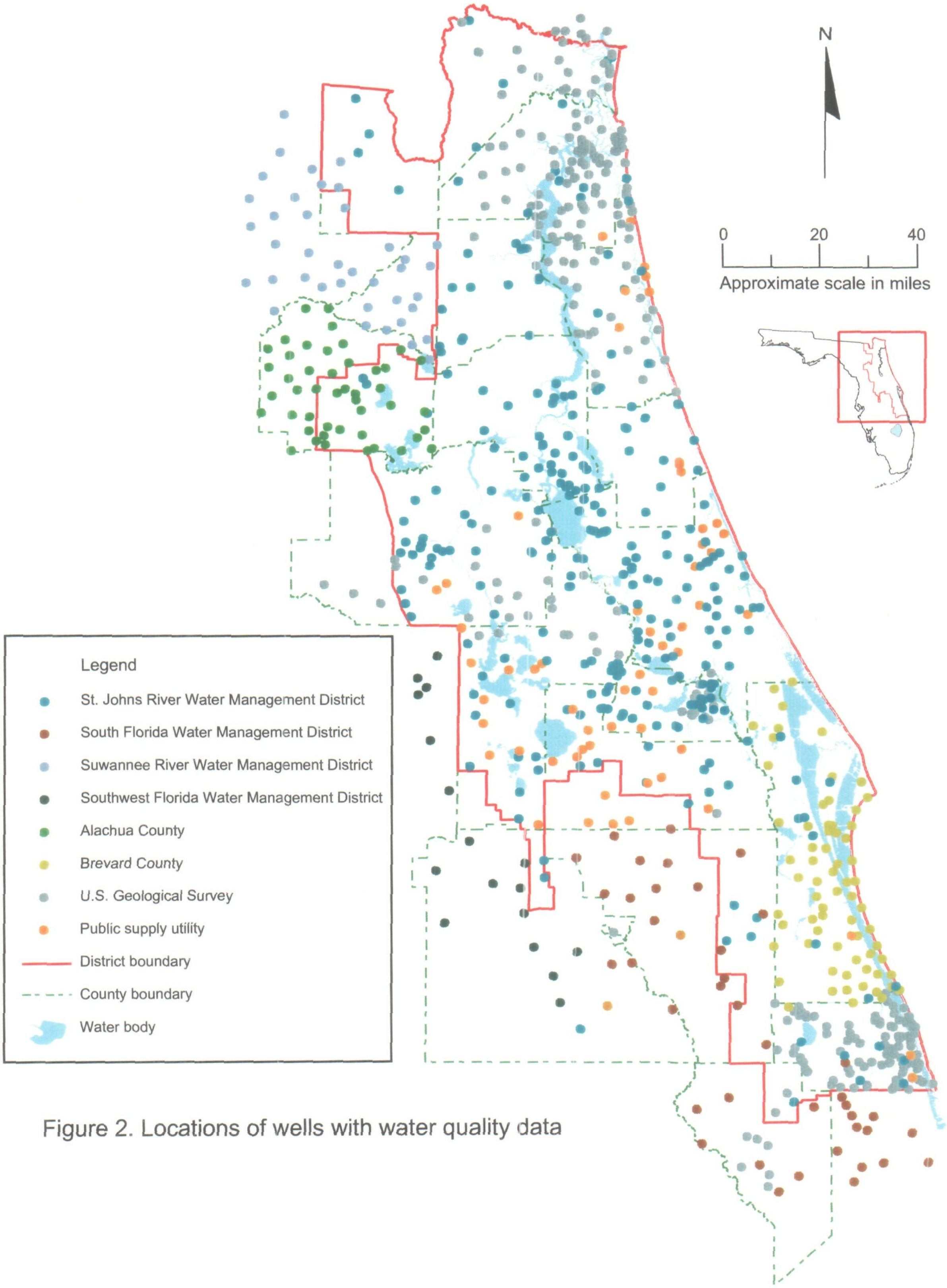


Figure 2. Locations of wells with water quality data

WATER QUALITY IN THE UPPER FLORIDAN AQUIFER

The water quality conditions in an aquifer are a result of natural systems and human influences. The water quality is determined by the chemical composition of water entering the aquifer, the composition and solubility of rocks with which the water comes in contact, and the length of time the water is in contact with the rocks. In addition, the quality of water in an aquifer can be affected by the mixing of fresh groundwater with intruded seawater, residual seawater, and residual formation water. Human influences include activities at the land surface, groundwater withdrawals, and irrigation.

The Floridan aquifer system is composed of carbonate sediments (limestone and dolostone) that include zones of high permeability (aquifers) and zones of low permeability (confining units). The Ocala Limestone, the Suwannee Limestone (in some areas), and the upper part of the Avon Park Formation comprise the Upper Floridan aquifer. The lower part of the Avon Park Formation and the Oldsmar Formation comprise the Lower Floridan aquifer. A less-permeable middle semiconfining unit separates the two zones.

The Upper Floridan aquifer is the principal source of water for public supply in the northern and central areas of SJRWMD. In these areas, water in the aquifer meets drinking water standards. The Upper Floridan aquifer is also a public supply water source in southern SJRWMD, where water of poorer quality is treated by various membrane processes, including reverse osmosis. The middle and lower portions of the Floridan aquifer system are used as a public supply water source in Duval, central and western Orange, and southern Seminole counties.

EVALUATION OF WATER QUALITY DATA

The chemical composition and the physical properties of the water in an aquifer represent the net effect of the processes that have dissolved, altered, or precipitated the chemical constituents. Major ion chemistry is used as a general indicator of groundwater quality and provides a means to identify regional differences and changes in water quality with time.

In areas of high potential recharge to the Floridan aquifer, such as the upland ridges and where the limestones of the Floridan aquifer are at or near land surface in western areas of SJRWMD, residence times for water in the Upper Floridan aquifer are relatively short. The water has not reached equilibrium conditions with aquifer materials, and water quality typically reflects recharge from the surficial aquifer, climatic conditions, soil types, and human activities. The chemical composition of water in the Floridan aquifer in high recharge areas is characteristically low in concentrations of calcium, magnesium, chloride, sulfate, TDS, and other constituents.

As water in the Floridan aquifer moves along flow paths from recharge to discharge areas, the longer residence times allow more opportunity for the chemical composition of the water to be altered and for chemical reactions between the water and aquifer materials to reach equilibrium. Hydraulic pressure conditions in discharge areas result in upward leakage of highly mineralized water into overlying formations or direct upward movement of water through faults or fractures. The chemical composition of water in the Floridan aquifer in and near discharge areas along the St. Johns River and the Atlantic coast is predominantly composed of calcium, magnesium, chloride, and sulfate, with typically high concentrations of TDS, hardness, and pH. Where water in the Floridan aquifer has come into contact with gypsum at the base of the aquifer system as it travels along deep flow paths, sulfate concentrations in discharge areas are notably high, such as in St. Johns and southern Duval counties.

The mixing of fresh groundwater in the Floridan aquifer with residual formation water still present in the aquifer results in a type of water predominantly composed of calcium, magnesium, sodium, chloride, and sulfate. This type of water occurs in St. Johns County south of St. Augustine, in northern and central parts of Flagler County, and in eastern parts of Brevard and Indian River counties. In these areas, fresh recharge waters have not replaced the highly mineralized residual formation waters of the Floridan aquifer. Lower hydraulic pressures in the Upper Floridan aquifer due to water withdrawals also result in the upward movement of highly mineralized formation water in the tri-county agricultural area of St. Johns, Flagler, and Putnam counties. A transition zone between the residual formation seawater and fresh groundwater occurs on the borders of these areas.

The mixing of fresh Floridan aquifer water with upwelling residual seawater along parts of the St. Johns River also results in a type of water predominantly composed of calcium, magnesium, sodium, chloride, and sulfate. This upwelling of highly mineralized water into upper parts of the Floridan aquifer occurs along the St. Johns River in parts of Brevard, Seminole, Orange, Lake, and Volusia counties, possibly along fault zones. A transition zone between the upwelling residual seawater and fresh groundwater in recharge areas occurs to the east and west of the St. Johns River.

In coastal areas, a wedge-shaped body of seawater underlies fresh groundwater in the Floridan aquifer. The zone between the fresh groundwater and seawater is the freshwater/saltwater transition zone. The freshwater/saltwater interface is the sloping surface between the freshwater body (chloride concentrations less than 250 milligrams per liter [mg/L]) and the underlying saltwater body.

Factors that influence chloride concentrations in the freshwater/saltwater transition zone include the characteristics of the geologic strata, recharge and discharge, groundwater flow, and pumping of wells. As water levels in the Floridan aquifer decline due to changes in hydrologic conditions or increased water withdrawals, the depth to the interface between fresh groundwater and seawater decreases and the transition zone migrates inland into areas of fresher water. This slow migration of salt water into freshwater aquifers is known as seawater intrusion. The current position of the transition zone does not reflect the full effect of current pumpage, and seawater intrusion may not become apparent for years following the stress on the aquifer.

The mixing of fresh groundwater in the Floridan aquifer with laterally intruded seawater from the Atlantic Ocean occurs in parts of Volusia and Brevard counties, resulting in a type of water predominantly composed of sodium and chloride, with very high concentrations of TDS, calcium, magnesium, sulfate, and hardness. A transition zone between intruded seawater and fresh groundwater or residual formation water also occurs in other areas along the coast.

The water quality conditions described in these hydrogeologic settings are depicted in the following maps of the distribution of chloride, sulfate, and TDS concentrations in the Upper Floridan aquifer within SJRWMD (Figures 3, 4, and 5, respectively). Secondary drinking water standards

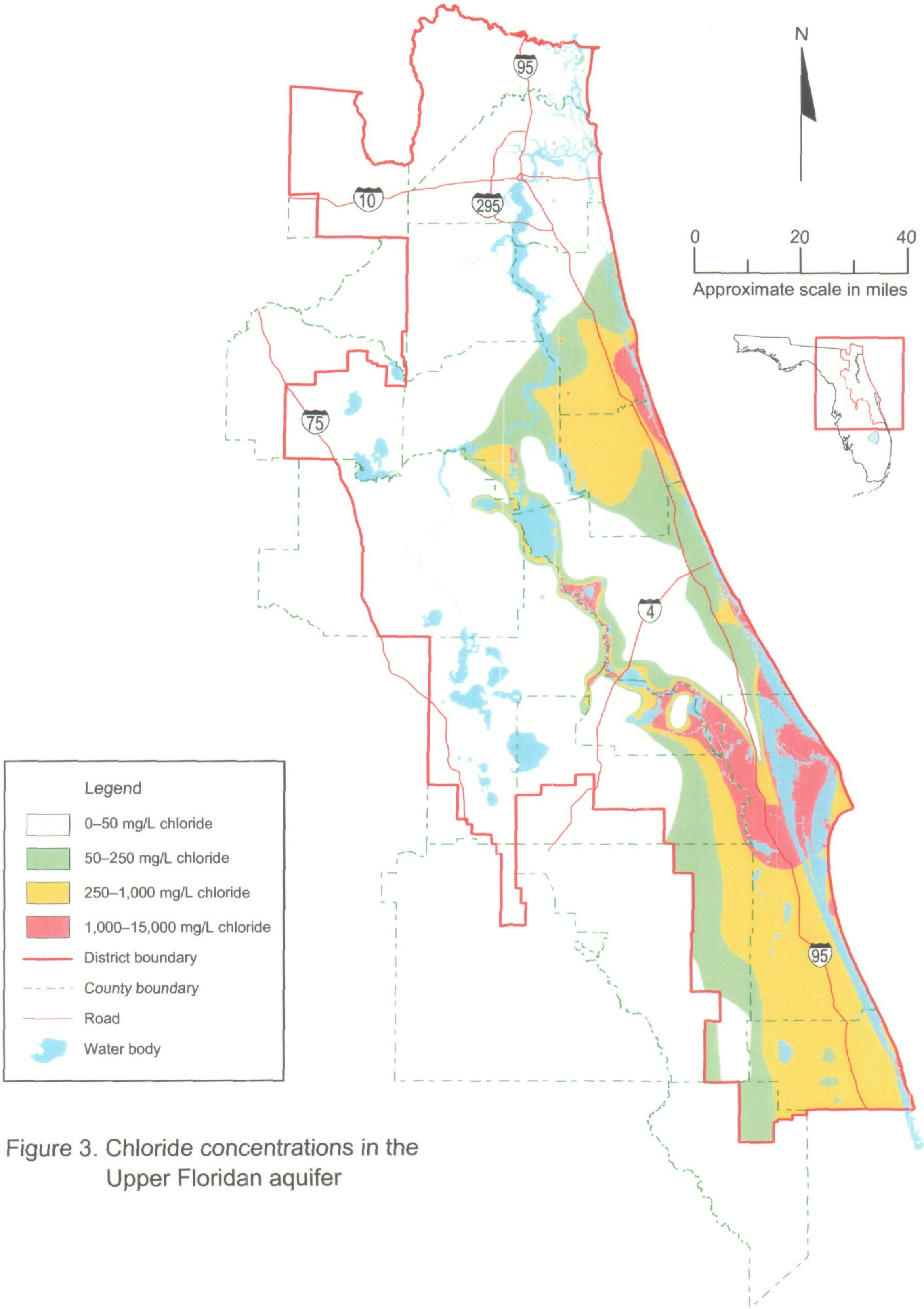


Figure 3. Chloride concentrations in the Upper Floridan aquifer

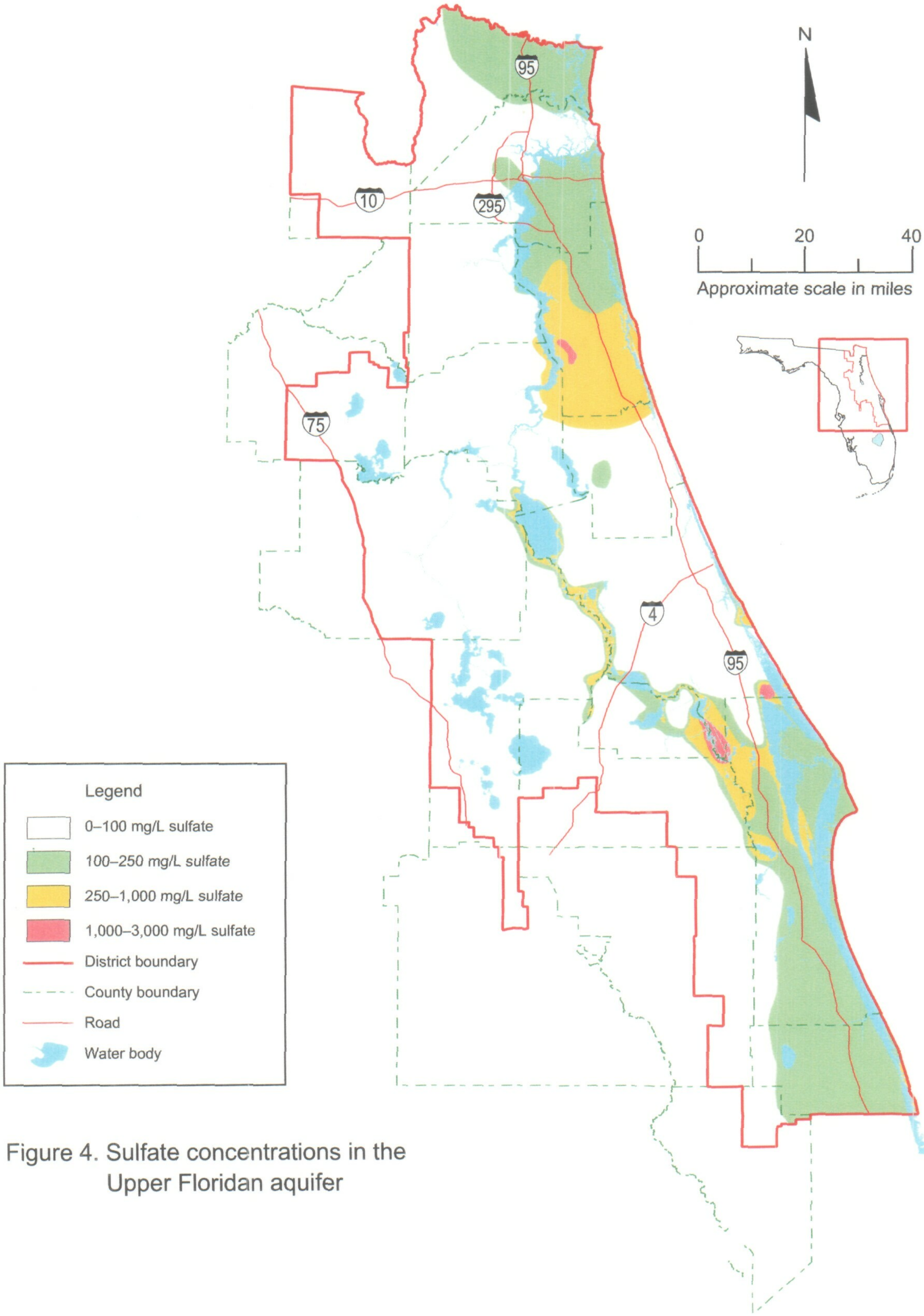


Figure 4. Sulfate concentrations in the Upper Floridan aquifer

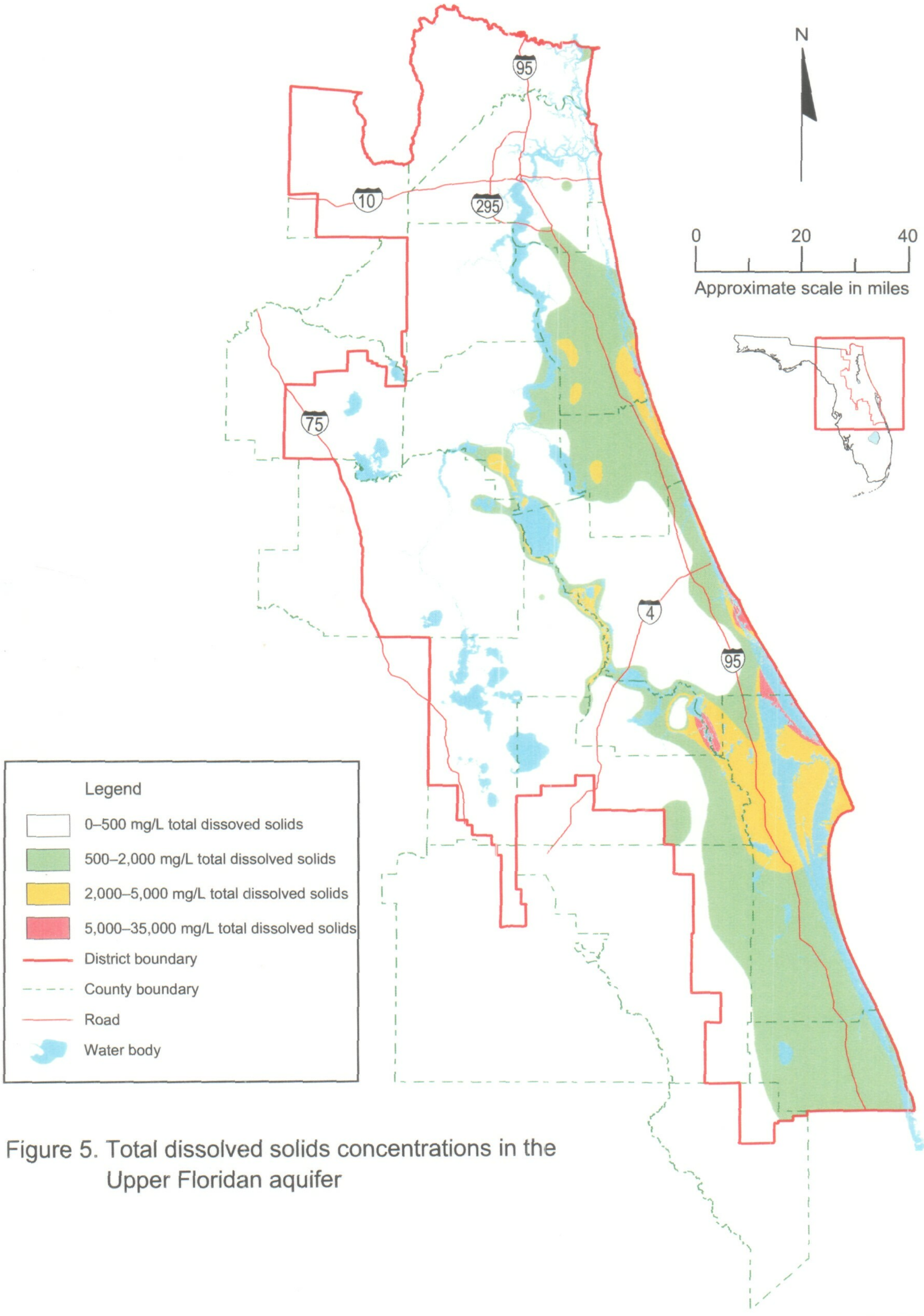


Figure 5. Total dissolved solids concentrations in the Upper Floridan aquifer

have been established for chloride (250 mg/L), sulfate (250 mg/L), and TDS (500 mg/L). These variables are of primary concern in the use of water from the Floridan aquifer for public supply. These variables are also the most useful variables in network design due to the number of wells sampled for these variables, the distribution of the wells sampled, and the sampling history of the wells.

TREND ANALYSIS

Trend analysis was used to determine the temporal variability of the sample data. A temporal trend is the general increase or decrease in observed values of a variable over time. Trend analysis is used to determine the significance of an apparent trend in water quality at a specific well location and to estimate the magnitude of that trend.

A time series plot of data for each well was used to display a variable's concentration versus time. Such a plot also provided information on the completeness of the period of record, the general level of temporal or seasonal variability, and the presence of outlier or extreme values that were obviously higher or lower than the other values in the data set. The trend analysis was performed on chloride concentration data from 181 SJRWMD monitoring wells and from 135 public supply wells. Only wells with at least eight chloride concentration analyses over a minimum of 2 years were used for the analysis of possible trends in chloride concentration.

The Mann-Kendall test for temporal trend and Sen's slope estimator components of the WQSTAT PLUS (IDT 1999) computer software were used to evaluate the correlation of chloride concentrations with time. Wells showing an increasing trend in chloride concentration with a probability level of 80% or greater are identified in Appendix A. The 32 public supply wells and 10 monitoring wells with an increasing trend slope greater than 3.0 mg/L chloride concentration per year are identified in bold to emphasize potential problem areas. Twelve example graphs of wells with significantly increasing trends are also presented.

The results of the trend analysis show that chloride concentrations are not significantly changing or are decreasing in most areas of SJRWMD. However, chloride concentrations are significantly increasing in some areas. As described previously, water quality in the Floridan aquifer generally reflects the geochemical reactions that occurred as water moves along flow paths from recharge to discharge areas. In addition to these natural variations in water quality, stresses on the aquifer system in localized areas can result in water quality changes over time. Changes in hydraulic head brought about by pumping, for example, may result in the upward movement of more mineralized water from underlying zones into freshwater producing zones.

Decreases in hydraulic heads in freshwater zones resulting from water withdrawals are the probable cause of the increasing trends in chloride concentrations observed in some wells at the De Land, Deltona, Holly Hill, New Smyrna Beach, and Ormond Beach wellfields in Volusia County, the Flagler Beach wellfield in Flagler County, the Oviedo wellfield in Seminole County, and the Cocoa wellfield in eastern Orange County. Increasing trends in chloride concentrations have also been recognized in monitoring wells at the Vero Beach wellfield in Indian River County and in agricultural areas of western St. Johns County.

Structural geologic features, such as faults or fractures, can provide pathways for the upward movement of water with high chloride concentrations into freshwater zones. Structural geologic features in combination with decreasing hydraulic heads in freshwater zones brought about by pumping are a likely cause for the variable and localized increasing trends in chloride concentrations observed in parts of east-central Duval County.

Network Design

The Upper Floridan aquifer monitoring network design is based on an analysis of the spatial and temporal variability of water quality data. This optimized network reduces the number of wells in areas that have shown little or no variability in water quality over time, freeing financial and human resources for adding and sampling wells where needed. The network provides the information needed to assess water quality conditions on a regional scale and in subregional potential problem areas.

Regional Network

Available water quality data were analyzed using geostatistics to determine optimal well spacing to adequately assess regional water quality conditions in the Upper Floridan aquifer. Geostatistics provides a framework for the analysis, characterization, and estimation of spatial data, such as water quality data. In addition to the estimation of the concentration of a water quality variable in the area of study, the geostatistical analysis quantifies the standard deviation of the estimation, and this standard deviation is then used to develop a statistically sound network design.

The procedures used conform to the standard guides for geostatistical investigations by the American Society for Testing and Materials (1994, 1996a, 1996b). ISATIS software developed by Geovariances and the Center of Geostatistics at the Paris School of Mines (Geovariances 1997) was used to perform this geostatistical analysis. Boniol and Toth (1999) contain a more detailed discussion of the geostatistical procedures.

A structural analysis was conducted to determine the spatial correlation of chloride concentration data within SJRWMD. Chloride was the water quality variable selected for geostatistical analysis because the occurrence of chloride is useful for evaluating the extent of seawater intrusion and the mixing of fresh groundwater with residual formation water. In addition, the historical chloride concentration data available from the various sources provided a good distribution of data for using a geostatistical spatial analysis to design a monitoring network.

The geostatistical analysis was accomplished through the computation and modeling of the variogram function. A variogram is a graph depicting the spatial variability between samples and the distance between samples. The use of a variogram allows assessment of how well a sample measurement at one location can be used to estimate the concentration at another location a certain distance and direction away. An appropriate model structure was fit to the experimental variogram curve. Cross-validation procedures assess the overall quality of the spatial analysis and estimation procedures by sequentially removing each actual data value, estimating the value using the variogram model, and then comparing the resulting pairs of estimated and actual values. Using the variogram model with the neighborhood data, kriging methods were used to estimate chloride concentrations and to produce the associated kriging standard deviation, which depicts the level of uncertainty in the estimations.

An evaluation of this kriging standard deviation compared to the standard deviations resulting from a series of test grid networks of varying sizes was used to determine a reasonable and practical grid size for the regional network. Olea (1984) determined that spatial networks with uniform hexagonal spacing were the most efficient. Because well data are not uniformly distributed, a stratified sampling design was used. In stratified sampling, an area is divided into grid cells and one data point per grid cell is selected for sampling. A well network based on a stratified hexagonal grid is considered to be regional in nature.

The well locations with available chloride concentration data were plotted on a series of seven hexagonal polygon grids with diameters of 20,000 feet (ft), 30,000 ft, 40,000 ft, 50,000 ft, 60,000 ft, 80,000 ft, and 100,000 ft. For each of these hexagonal grids, one well from the complete chloride data set was selected in each grid cell, resulting in seven data subsets. The data subsets resulted in a smaller number of chloride values with increasing hexagonal grid size. If a grid cell had more than one well, selection criteria were used to select the best well. Selection criteria included current sampling frequency and status of the well, history of water quality data collection at the well, location of the well relative to critical concern areas, well construction, and well use.

The estimation procedures were applied to each of the seven hexagonal grid data subsets using the same variogram model parameters as were used with the original, complete chloride data set. The kriging standard deviation of the estimated chloride concentrations was used as a measure of the effectiveness of each hexagonal grid network. There is no guideline for an acceptable standard deviation. Because there is no guideline, the standard deviation of each hexagonal grid was compared to the standard deviation that resulted from the analysis of all data in order to select a reasonable size for the regional grid network.

The standard deviations of the 20,000-ft, 30,000-ft, 40,000-ft, 50,000-ft, 60,000-ft, 80,000-ft, and 100,000-ft hexagonal networks were 0.92%, 1.76%, 5.03%, 7.06%, 13.51%, 24.67%, and 30.01%, respectively, greater than the standard deviation of the estimate using all chloride values. Because the standard deviation of the 50,000-ft-diameter hexagonal grid was only slightly greater than that of the 40,000-ft grid and considerably less than that of the 60,000-ft grid, the 50,000-ft grid was selected as the well network spacing for the regional assessment of water quality conditions. At least one well should be located in each 50,000-ft-diameter hexagonal grid to adequately assess the regional water quality conditions in the Upper Floridan aquifer. There are a total of 231 cells in the 50,000-ft hexagonal grid configuration within SJRWMD. A grid cell that was more than 50% water or that was more than 50% outside SJRWMD was not counted unless a monitoring well was already located in the cell.

Subregional Network

On a subregional level, the monitoring network also provides information on areas where hydrogeologic features and stresses to the aquifer system, such as water level drawdowns in and near public supply wellfields, may potentially impact water quality. The identification of these areas of critical concern was based on the distribution of chloride, sulfate, and TDS concentrations, water quality trend analysis, and projected decreases in water levels. The current monitoring network includes increased spatial and temporal monitoring in these areas. Specifically, critical concern areas include

- Areas of seawater intrusion into freshwater zones along parts of the Atlantic coast
- Areas where underlying water with high chloride, sulfate, and TDS concentrations mixes with fresh groundwater along parts of the St. Johns River
- Areas with significantly increasing chloride concentrations in groundwater

- The interface between potable and nonpotable water (250 mg/L chloride concentration, 250 mg/L sulfate concentration, or 500 mg/L TDS concentration)
- Areas in the Upper Floridan aquifer with projected water level drawdowns of greater than 3 ft by the year 2020

WELL LOCATIONS: EXISTING AND PROPOSED

SJRWMD currently samples 230 Upper Floridan aquifer wells (Figure 6 and Appendix B). Of these wells, 213 are dedicated monitoring wells and 17 are public supply wells. These wells fill 145 cells in the proposed 50,000-ft hexagonal grid configuration.

Drilling of new wells or the addition of existing wells within the next 5 years is planned at 52 new locations, filling an additional 33 grid cells. These new well locations meet the data collection needs of both the Upper Floridan aquifer water quality and water level networks (Osburn 2000). This leaves 53 grid cells that do not have a current or proposed well monitoring water quality. Of these 53 empty grid cells, 25 cells (shaded on Figure 6) are in areas critical for monitoring potential impacts associated with future public water supply development and are a priority for siting new wells. The remaining grid cells are a lower priority since they are in areas of poor water quality where the Floridan aquifer is not used for public supply, in areas where there is little or no spatial or temporal variability in water quality, or in areas where drilling new wells is not feasible.

Some of the current monitoring sites also have wells monitoring the middle and lower parts of the Floridan aquifer, allowing for an evaluation of water quality changes with well depth (Appendix B). These additional 42 wells are primarily located in areas where the middle and lower parts of the Floridan aquifer are used for public supply.

In addition to the SJRWMD network, USGS and various public supply utilities also perform water quality sampling of the Floridan aquifer. Twenty-two public utilities provide chloride data to SJRWMD for 186 supply wells (Appendix C). USGS samples 24 wells in Duval County and 61 wells in Orange County (Appendix D).

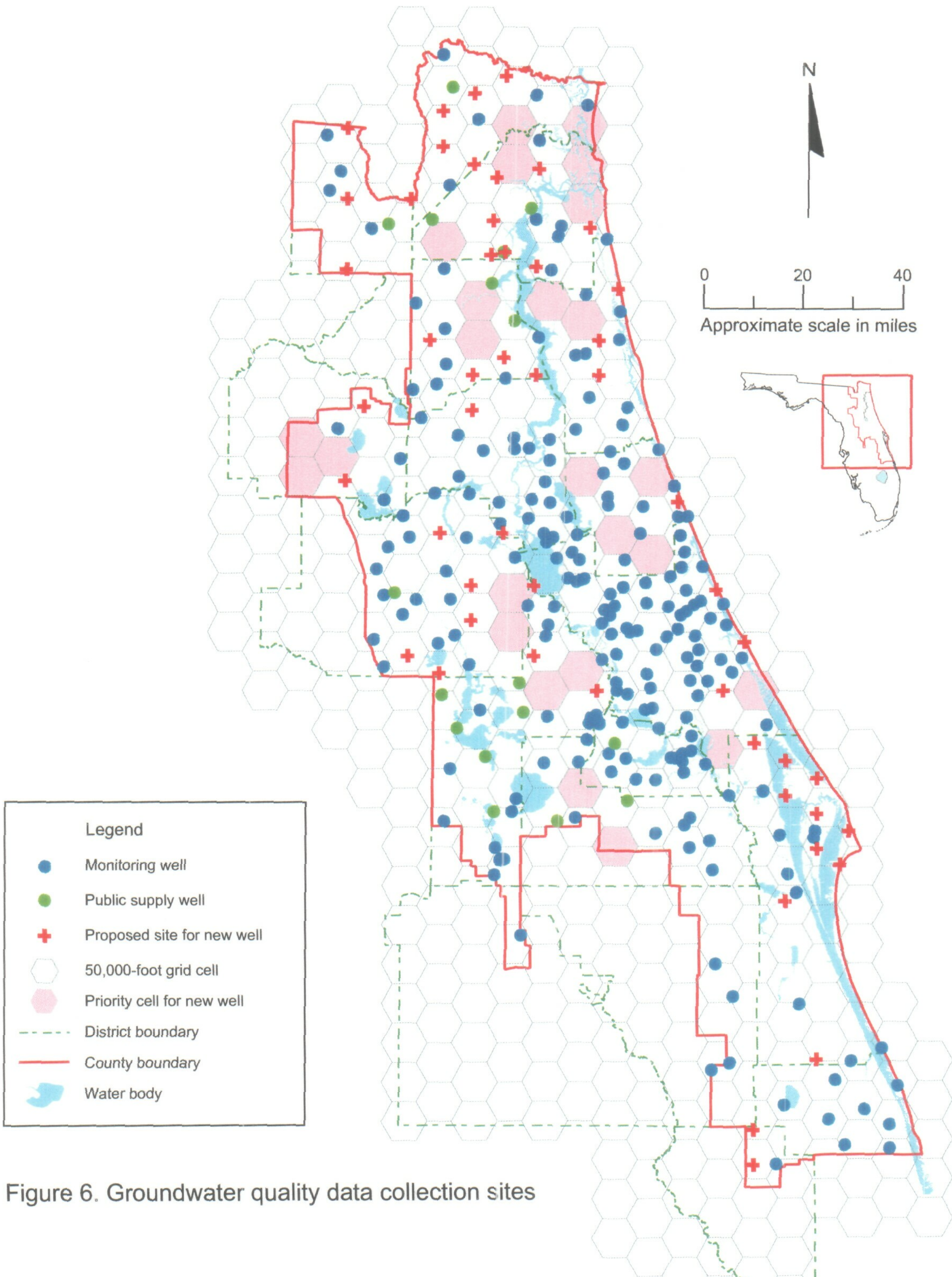


Figure 6. Groundwater quality data collection sites

SUMMARY

The purpose of water quality monitoring is to produce useful information. Water quality information obtained from the SJRWMD Upper Floridan aquifer monitoring network is used to evaluate groundwater resources on regional and subregional scales, detect long-term trends, identify potential problem areas, and provide information to determine the effectiveness of water management programs.

- Current water quality conditions in the Upper Floridan aquifer

  Water quality in the Upper Floridan aquifer is generally good in the northern and western parts of SJRWMD, with chloride, sulfate, and TDS concentrations below drinking water standards. Chloride and TDS concentrations generally exceed drinking water standards in most of Brevard and Indian River counties, in southern St. Johns and northern Flagler counties, in discharge areas along the St. Johns River south of Clay County, and in eastern Volusia County along the Atlantic coast. Sulfate concentrations also exceed secondary drinking water standards in many of these areas.

  Declines in potentiometric levels of the Upper Floridan aquifer in some areas have increased the potential for the upward movement of highly mineralized water from lower zones to higher zones through leaky confining beds, structural geologic features, and improperly constructed wells. Declines in the potentiometric surface which occur over large areas and over long periods of time, resulting from increased water use and/or decreased rainfall, indicate changes in the long-term balance of recharge to and discharge from the Floridan aquifer system.

- Potential problem areas due to increasing trends in chloride concentrations

  Trend analysis performed on data from monitoring wells and public supply wells show that chloride concentrations are not significantly changing or are decreasing in most areas of SJRWMD. However, chloride concentrations are significantly increasing in some areas. Decreases in hydraulic heads in freshwater zones resulting from water withdrawals are the probable cause of the increasing trends in chloride concentrations observed in some wells at the De Land, Deltona, Holly Hill, New Smyrna Beach, and Ormond Beach wellfields in Volusia County, the Flagler Beach wellfield in Flagler County, the Oviedo wellfield in Seminole County, and the Cocoa wellfield in eastern Orange County. Increasing trends in chloride concentrations have also been recognized in monitoring wells at the Vero Beach wellfield in Indian River County and in agricultural areas of western St. Johns County. Structural geologic features in combination with decreasing hydraulic heads in freshwater zones are a likely cause for the variable and localized increasing trends in chloride concentrations observed in parts of east-central Duval County.

Adverse impacts to groundwater resources will most likely continue to increase in the areas identified and in additional areas if artesian pressures in the upper freshwater zones of the Floridan aquifer decrease as public supply, agricultural, industrial/commercial, domestic self-supply, and recreational uses place greater demands on groundwater resources. Water management strategies to reduce water quality problems include minimizing well depths in potential problem areas, constructing new wellfields in areas with the greatest freshwater thickness, reducing drawdowns in wellfields, and plugging wells open to deep zones.

- Regional and subregional network design

A geostatistical analysis of available water quality data concluded that at least one well should be monitored in each grid cell of a 50,000-ft hexagonal grid to adequately assess regional water quality conditions that are not significantly affected by withdrawals. Data from this network are used to describe variations in water quality due to hydrogeologic features and to explain the response of Floridan aquifer water to changes in climate. The data can be used as a baseline against which future water quality conditions can be compared and to assess whether the water quality in an area is suitable for the intended use.

On a subregional level, the monitoring network provides information on the effect that hydrogeologic features and stresses to the aquifer system, such as withdrawals, have on water quality conditions. Areas of critical concern were identified based on the distribution of chloride, sulfate, and TDS concentrations, water quality trend analysis, and projected decreases in water levels. The monitoring well network includes increased well coverage in these areas of critical concern. Well clusters in these areas also monitor middle and lower zones of the Floridan aquifer system, allowing for evaluation of water quality changes with depth.

To detect possible changes in groundwater quality over time, sampling should occur often enough so that any significant variance in water quality can be identified using statistical methods. The sampling frequency of each well was determined through trend analysis of the data and well location relative to critical concern areas. Wells in the network are sampled at a frequency of once, twice, or four times per year. Additional water quality information is obtained from USGS and various public supply utilities.

RECOMMENDATIONS

To improve the Floridan aquifer monitoring network to better meet the water quality information needs for long-term water supply planning and the protection of water resources, the following actions are recommended:

- Add new or existing Upper Floridan aquifer wells to enhance the regional baseline network and add wells in the subregional areas of critical concern to improve the accuracy of the water supply planning model projections. Sites have been identified for drilling 52 new Upper Floridan aquifer wells over the next 5 years and an additional 25 priority locations have been identified for drilling new wells. The estimated cost for drilling these 77 wells is approximately $1,200,000.

- Perform ongoing analysis and evaluation of trends in water quality to assess current problem areas and to identify potential problem areas.

- Evaluate the adequacy of current water quality monitoring of the middle and lower parts of the Floridan aquifer where these zones are used for public supply in Orange, Seminole, and Duval counties.

- Compile water quality data provided to SJRWMD by well owners as part of their consumptive use permit requirements.

REFERENCES

[ASTM] American Society for Testing and Materials. 1994. *Standard guide for content of geostatistical site investigations*. D 5549-94. Philadelphia.

———. 1996a. *Standard guide for analysis of spatial variation in geostatistical site investigations*. D 5922-96. Philadelphia.

———. 1996b. *Standard guide for selection of kriging methods in geostatistical site investigations*. D 5523-96. Philadelphia.

Boniol, D.P., and D.J. Toth. 1999. *Geostatistical analysis: Water quality monitoring network for the Upper Floridan aquifer in east-central Florida*. Technical Publication SJ99-1. Palatka, Fla.: St. Johns River Water Management District.

[FDEP] Florida Department of Environmental Protection. 1994. *Groundwater guidance concentrations*. Division of Water Facilities, Bureau of Drinking Water and Groundwater Resources. Tallahassee, Fla.

Helsel, D.R., and R.M. Hirsch. 1993. *Statistical methods in water resources*. Studies in Environmental Science 49. Reston, Va.: U.S. Geological Survey.

[IDT] Intelligent Decision Technologies, Ltd. 1988. *WQSTAT PLUS user's guide*. Longmount, Colo.

Olea, R.A. 1984. *Systematic sampling of spatial functions*. Series on spatial analysis, No. 7. Lawrence, Kans.: Kansas Geological Survey.

Osburn, W.L. 2000. *Geostatistical analysis: Potentiometric network for the Upper Floridan aquifer in the St. Johns River Water Management District*. Technical Publication SJ2000-1. Palatka, Fla.: St. Johns River Water Management District.

Vergara, B., editor. 1998. *Water supply assessment*. Technical Publication SJ98-2. Palatka, Fla.: St. Johns River Water Management District.

APPENDIX A—WELLS WITH INCREASING TRENDS IN CHLORIDE CONCENTRATIONS

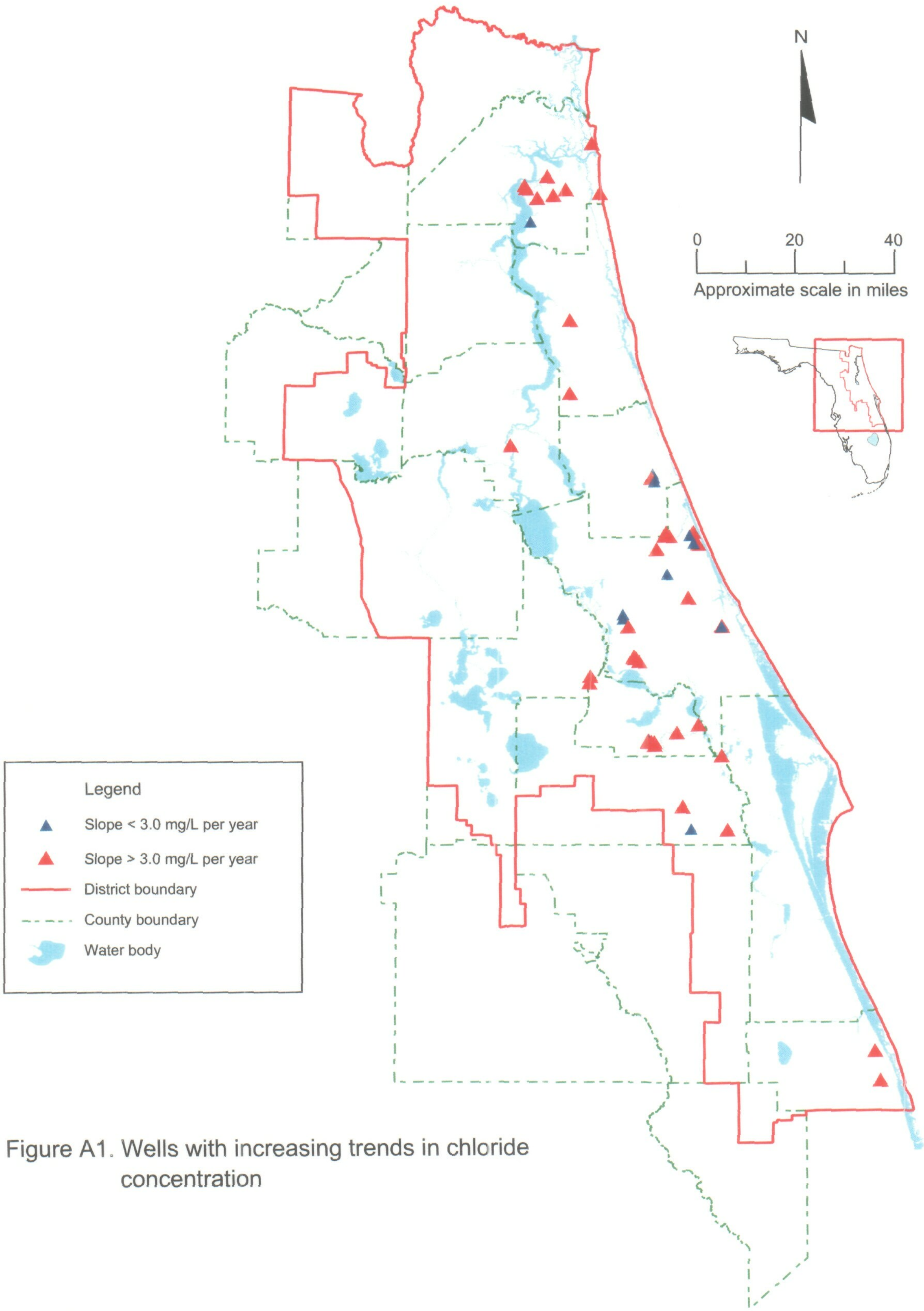


Figure A1. Wells with increasing trends in chloride concentration

Table A1. Wells with increasing trends in chloride concentrations

Well Owner	Well Number	Latitude	Longitude	Start Date	End Date	Median Chloride (mg/L)	Slope (mg/L per year)	Count	Confidence Interval (%)
Cocoa	**2**	**282323**	**805638**	**Feb 1998**	**Feb 1999**	**411**	**28.8**	**8**	**80**
Cocoa	17	282337	810355	Feb 1998	Mar 2001	58	2.1	32	80
Daytona Beach	15	290911	810903	Oct 1998	Dec 2000	59	1.3	51	99
De Land	9	290114	811758	Sept 1998	Mar 2001	13	1.5	31	99
De Land	**21**	**285944**	**811658**	**Sept 1998**	**Mar 2001**	**41**	**16.4**	**28**	**90**
De Land	7A	290200	811758	Sept 1998	Mar 2001	8	1.3	31	90
Deltona	**1**	**285419**	**811543**	**May 1999**	**Jan 2001**	**42**	**12.1**	**20**	**90**
Deltona	**2**	**285416**	**811546**	**Dec 1997**	**Jan 2001**	**62**	**26.0**	**37**	**99**
Deltona	**8**	**285406**	**811521**	**May 1999**	**Jan 2001**	**110**	**49.8**	**19**	**99**
Deltona	**27**	**285407**	**811523**	**June 1999**	**Jan 2001**	**96**	**51.8**	**17**	**99**
Deltona	**33***	**285334**	**811438**	**May 1999**	**Jan 2001**	**130**	**45.6**	**20**	**99**
Deltona	**34**	**285419**	**811545**	**May 1999**	**Jan 2001**	**43**	**28.4**	**20**	**99**
Flagler Beach	3	292704	811208	Jul 1990	Mar 2001	206	1.7	115	99
Flagler Beach	5	292644	811202	Jul 1990	Mar 2001	114	2.4	124	99
Flagler Beach	6	292634	811158	Jul 1990	Mar 2001	72	1.0	114	99
Flagler Beach	7	292625	811156	Jul 1990	Mar 2001	61	1.0	113	99
Flagler Beach	**8***	**292621**	**811225**	**Jul 1990**	**Mar 2001**	**70**	**4.8**	**118**	**99**
Flagler Beach	9	292543	811150	Dec 1990	Mar 2001	53	1.9	116	99
Holly Hill	**6**	**291433**	**810249**	**Oct 1995**	**Mar 2001**	**170**	**6.5**	**45**	**80**
Holly Hill	**12-B***	**291455**	**810316**	**Oct 1995**	**Mar 2001**	**144**	**3.3**	**56**	**90**
Holly Hill	12-C	291442	810342	Oct 1995	Mar 2001	102	1.3	58	80
Indian River County	**1**	**274402**	**802652**	**Jan 1997**	**Aug 2000**	**260**	**4.9**	**44**	**99**
Jacksonville	**5302**	**301743**	**813035**	**Mar 1994**	**Sept 1998**	**88**	**7.3**	**17**	**80**
Jacksonville	**5305**	**301749**	**813847**	**Mar 1994**	**Oct 1998**	**150**	**19.1**	**16**	**95**
Jacksonville	**5703**	**301819**	**813901**	**Oct 1995**	**Sept 1998**	**49**	**22.9**	**13**	**80**
Jacksonville	**D-1155***	**301639**	**813308**	**Oct 1986**	**Oct 1999**	**150**	**9.4**	**49**	**99**
Jacksonville	**D-313**	**301957**	**813423**	**July 1973**	**July 1999**	**79**	**3.5**	**73**	**99**
Jacksonville	**D-450**	**301608**	**813628**	**Oct 1986**	**Oct 1999**	**86**	**4.0**	**53**	**99**
Jacksonville	D-538	301157	813743	Mar 1974	Oct 1999	22	1.3	63	99
Jacksonville	**D-913**	**302557**	**812521**	**Aug 1987**	**Oct 1999**	**360**	**8.5**	**41**	**99**

Table A1—*Continued*

Well Owner	Well Number	Latitude	Longitude	Start Date	End Date	Median Chloride (mg/L)	Slope (mg/L per year)	Count	Confidence Interval (%)
Jacksonville Beach	**2**	**301703**	**812333**	**Jul 1998**	**Mar 2001**	**192**	**8.4**	**32**	**95**
New Smyrna Beach	1	285952	805748	Aug 1990	Mar 2001	95	1.4	120	99
New Smyrna Beach	**2***	**285951**	**805750**	**Jun 1990**	**Nov 2000**	**82**	**3.0**	**108**	**99**
New Smyrna Beach	3	285949	805749	Jun 1990	Mar 2001	68	1.0	105	99
New Smyrna Beach	5	285954	805751	Jun 1990	Mar 2001	100	2.7	100	99
New Smyrna Beach	6	285951	805755	Jun 1990	Mar 2001	78	1.0	122	99
New Smyrna Beach	7	285950	805801	Jun 1990	Mar 2001	72	1.0	122	99
Ormond Beach	**2***	**291644**	**810347**	**Jan 1998**	**Jan 2001**	**510**	**157.2**	**121**	**99**
Ormond Beach	15	291605	810428	June 1990	Jan 2001	115	1.8	122	99
Ormond Beach	**36**	**291633**	**810919**	**Jan 1998**	**Jan 2001**	**82**	**10.8**	**113**	**99**
Ormond Beach	**42***	**291556**	**810939**	**Jan 1998**	**Jan 2001**	**81**	**10.4**	**119**	**99**
Ormond Beach	**52**	**291333**	**811114**	**Jan 1998**	**Jan 2001**	**41**	**6.0**	**119**	**99**
Ormond Beach	**BAT C**	**291558**	**810837**	**Jan 1998**	**Jan 2001**	**78**	**9.7**	**115**	**99**
Oviedo	101	283926	811242	July 1990	Feb 2001	57	2.8	122	99
Oviedo	**102**	**283926**	**811233**	**July 1990**	**Feb 2001**	**66**	**9.4**	**124**	**99**
Oviedo	103	283934	811237	July 1990	Feb 2001	39	2.2	124	99
Oviedo	**203***	**283908**	**811206**	**July 1990**	**Feb 2001**	**133**	**13.2**	**117**	**99**
Oviedo	**204**	**283912**	**811206**	**July 1990**	**Feb 2001**	**170**	**15.6**	**110**	**99**
Oviedo	**205***	**283837**	**811127**	**Aug 1993**	**Feb 2001**	**58**	**9.2**	**84**	**99**
Oviedo	**301**	**283914**	**811246**	**July 1997**	**Feb 2001**	**48**	**4.1**	**171**	**99**
Oviedo	**303**	**283907**	**811126**	**Aug 2000**	**Feb 2001**	**29**	**3.1**	**19**	**90**
SJRWMD†	**BR1526**	**283644**	**805751**	**Oct 1996**	**Feb 2000**	**1,725**	**105.8**	**12**	**95**
SJRWMD†	**IR0313***	**273847**	**802547**	**May1985**	**July 2000**	**208**	**4.2**	**57**	**99**
SJRWMD†	**L-0032**	**285057**	**812432**	**June 1990**	**Nov 2000**	**760**	**5.5**	**32**	**99**
SJRWMD†	**OR0265**	**282734**	**810542**	**Jan 1987**	**Oct 2000**	**197**	**3.3**	**29**	**95**
SJRWMD†	**P-0395**	**293203**	**814115**	**Apr 1994**	**Mar 1998**	**148**	**18.6**	**18**	**95**
SJRWMD†	**S-0025**	**284217**	**810230**	**Sept 1998**	**July 2000**	**5,220**	**74.1**	**23**	**90**
SJRWMD†	**S-0037**	**284945**	**812442**	**Mar 1986**	**Feb 2000**	**1,370**	**49.9**	**28**	**99**
SJRWMD†	**S-1201**	**284050**	**810653**	**May 1995**	**Oct 2000**	**1,704**	**57.1**	**18**	**90**

Table A1—*Continued*

Well Owner	Well Number	Latitude	Longitude	Start Date	End Date	Median Chloride (mg/L)	Slope (mg/L per year)	Count	Confidence Interval (%)
SJRWMD†	**SJ0027***	**295427**	**812925**	**July 1987**	**Sept 2000**	**194**	**4.9**	**50**	**99**
SJRWMD†	**SJ0263**	**294128**	**812913**	**May1988**	**Sept 2000**	**1,710**	**13.1**	**40**	**80**

Note: Wells with an increasing trend slope > 3.0 milligrams per liter (mg/L) per year are in bold
*Well with accompanying example graph of trend showing Sen's slope estimator
†St. Johns River Water Management District monitoring well

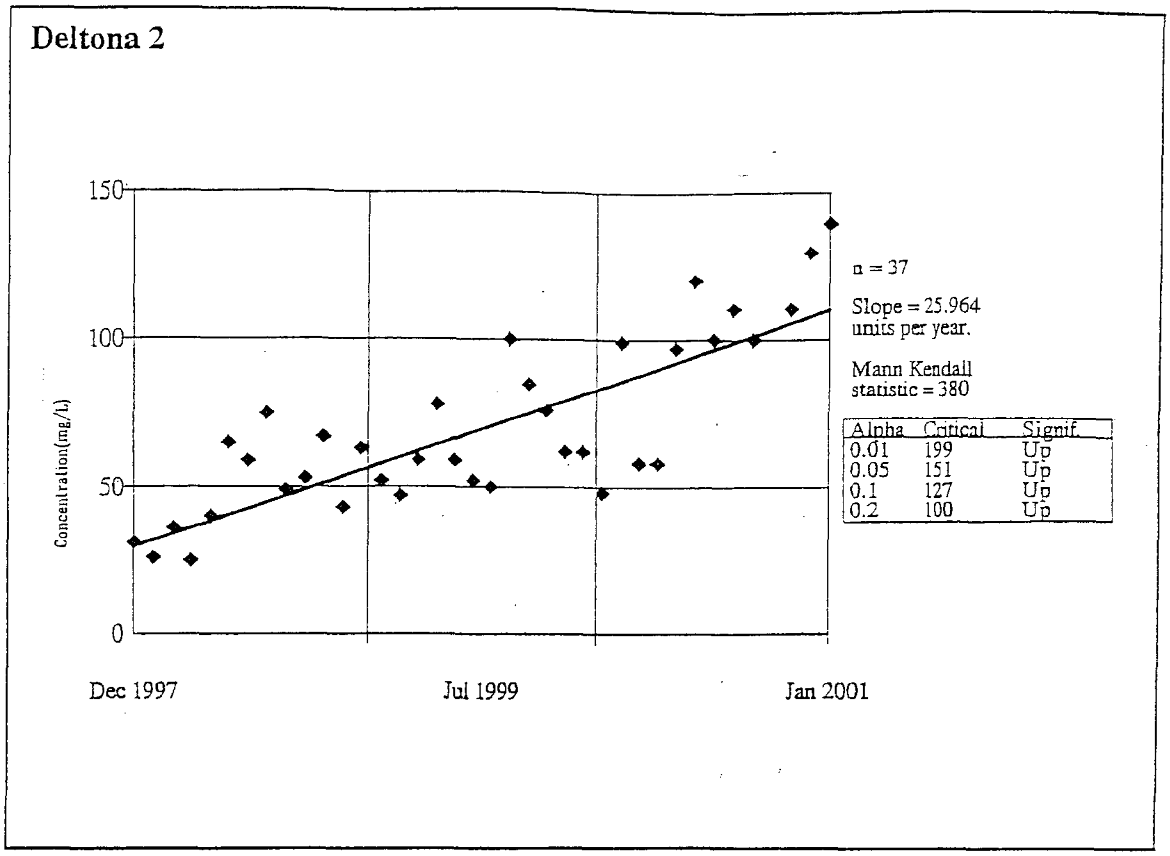


Figure A2. Sen's slope estimator graphs

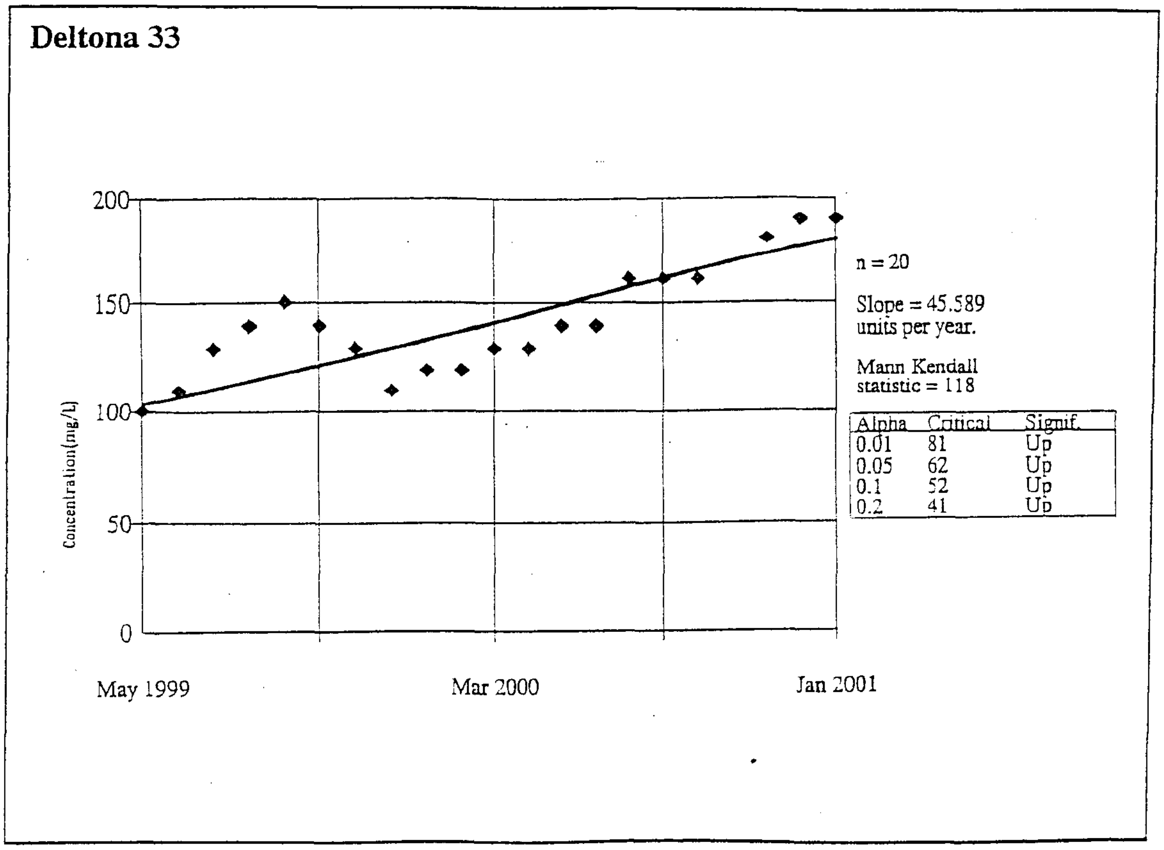


Figure A2—*Continued*

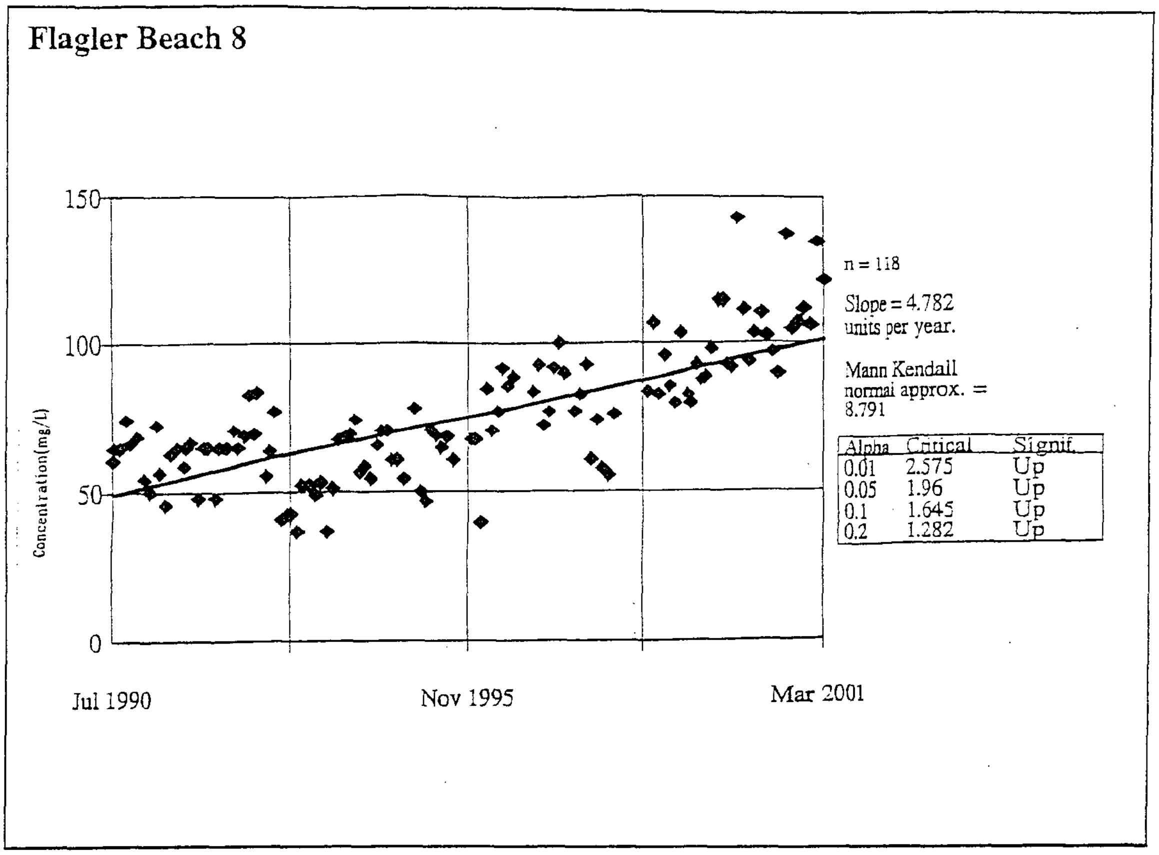


Figure A2—*Continued*

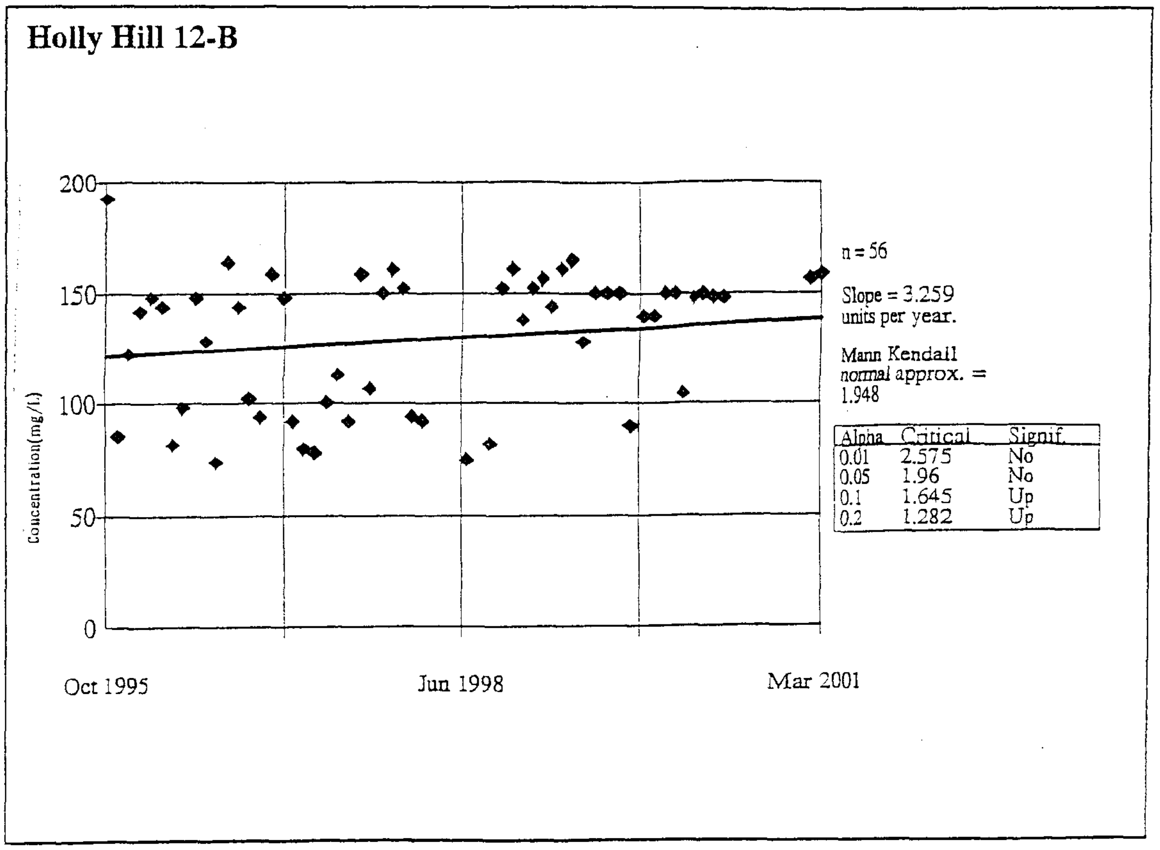


Figure A2—*Continued*

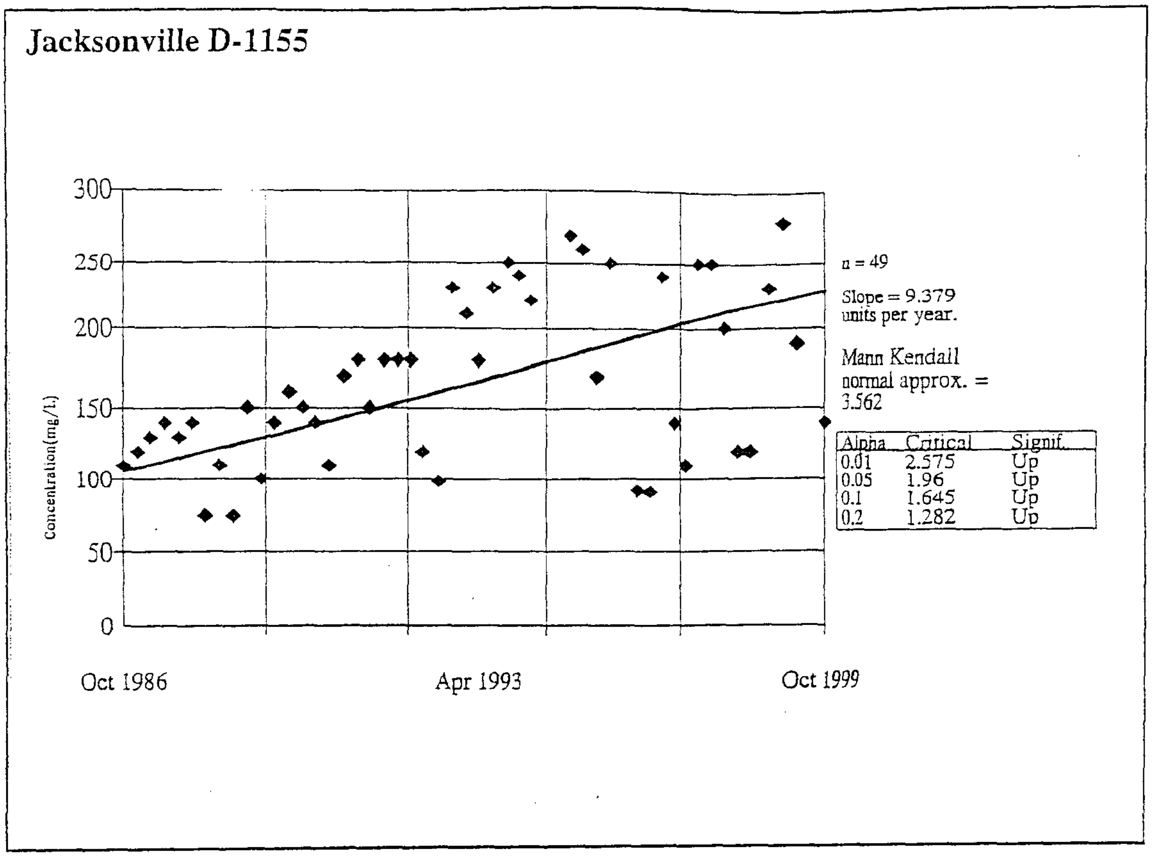


Figure A2—*Continued*

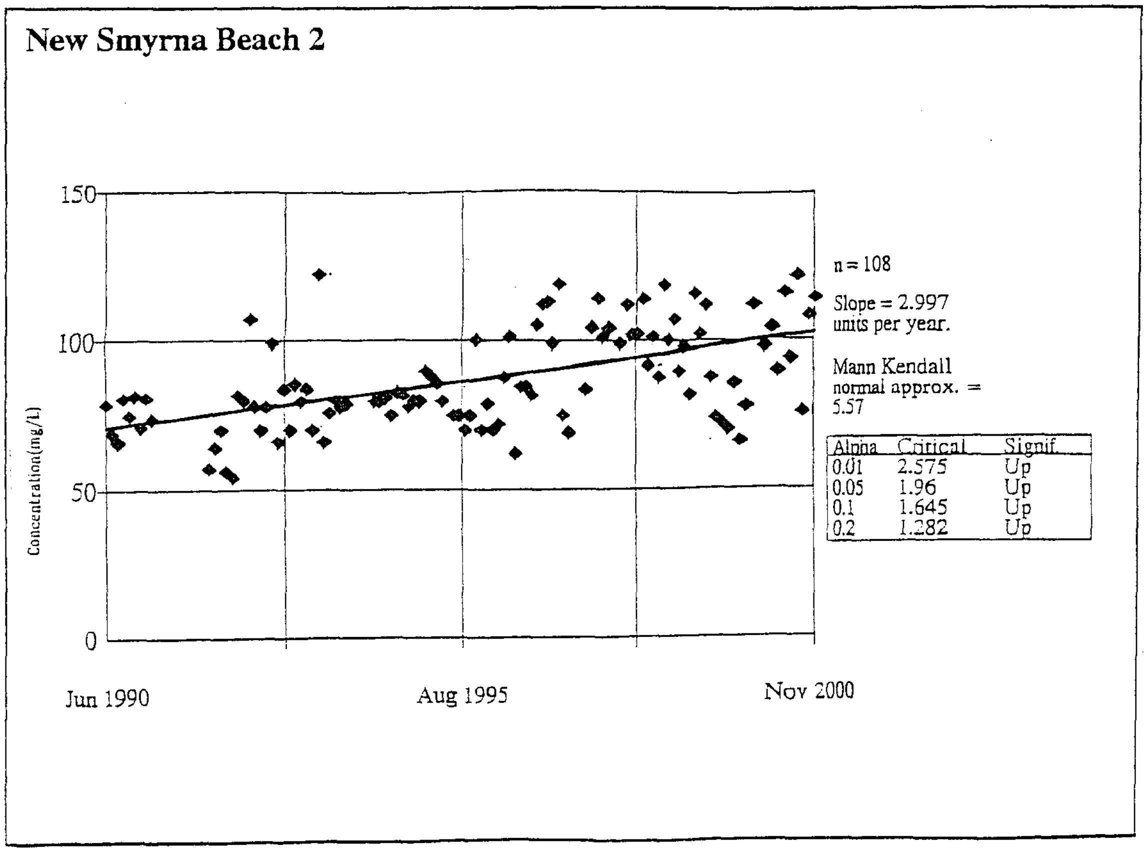


Figure A2—*Continued*

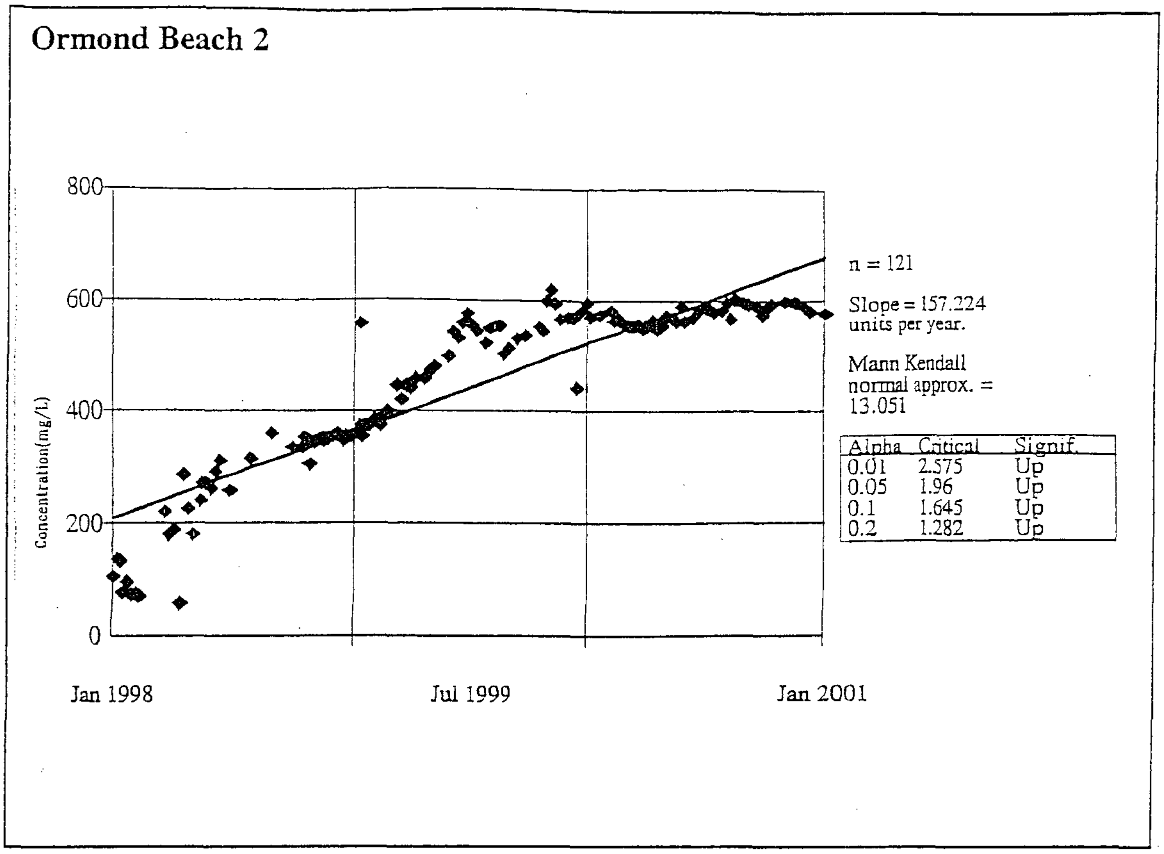


Figure A2—*Continued*

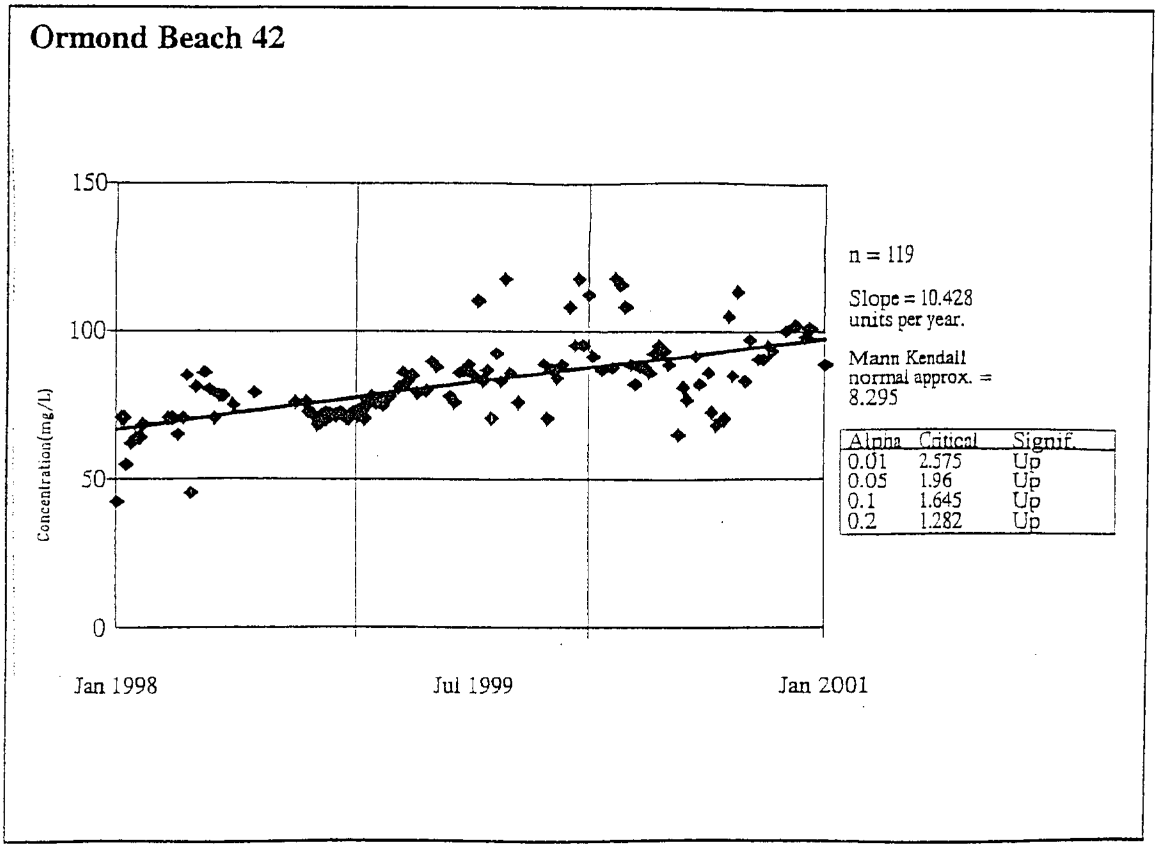
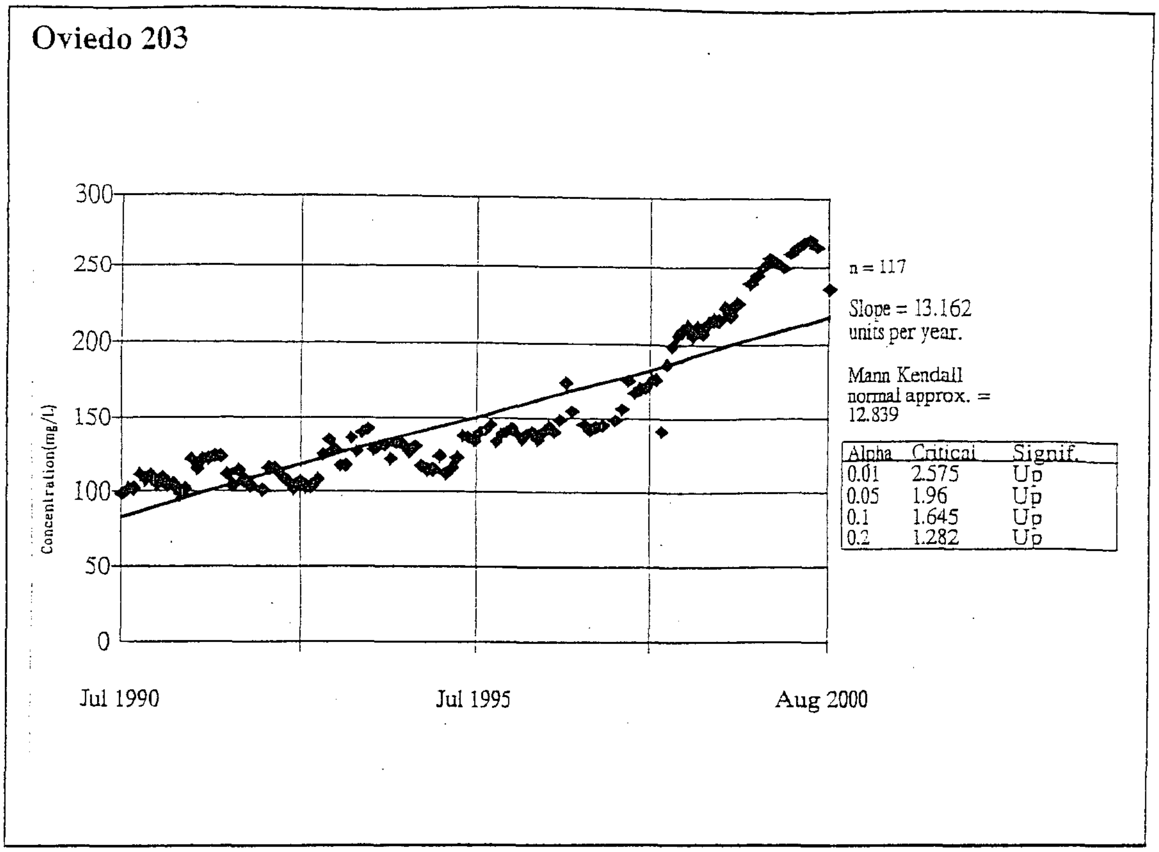


Figure A2—*Continued*



Alpha	Critical	Signif.
0.01	2.575	Up
0.05	1.96	Up
0.1	1.645	Up
0.2	1.282	Up

Figure A2—*Continued*

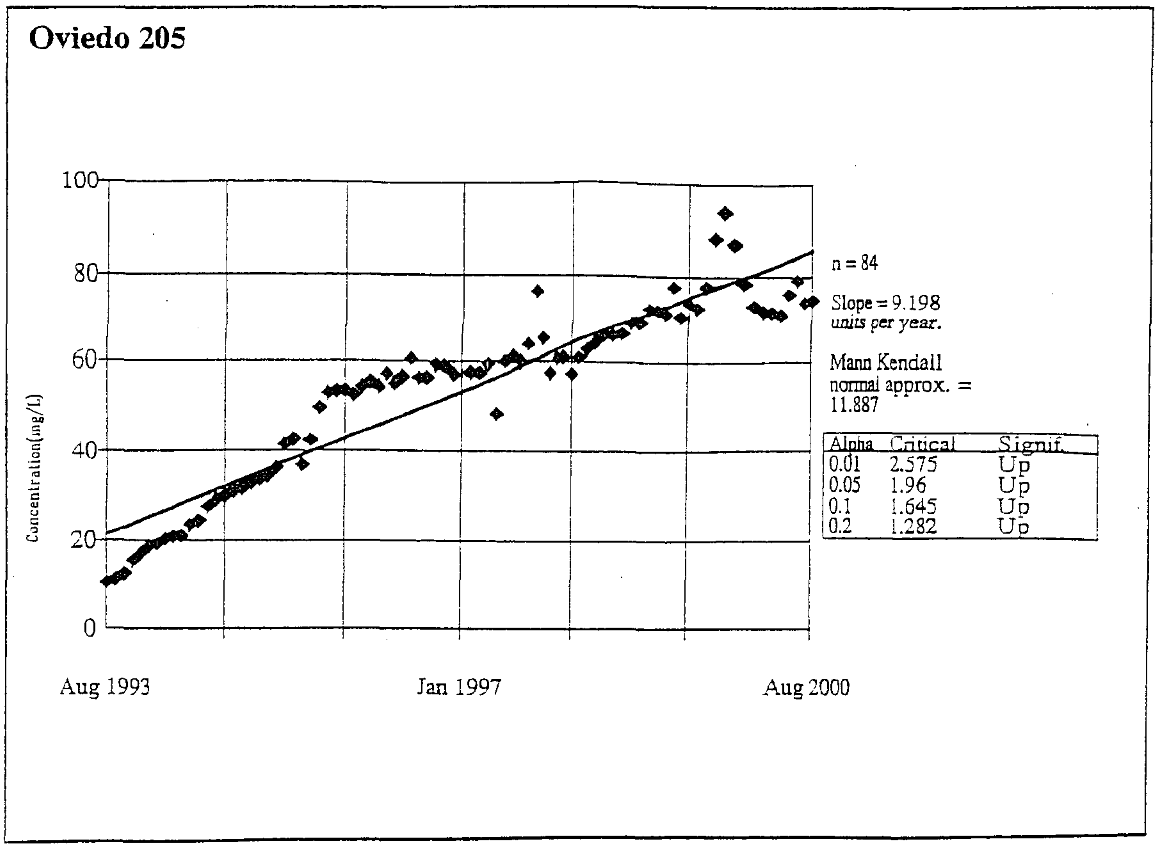


Figure A2—*Continued*

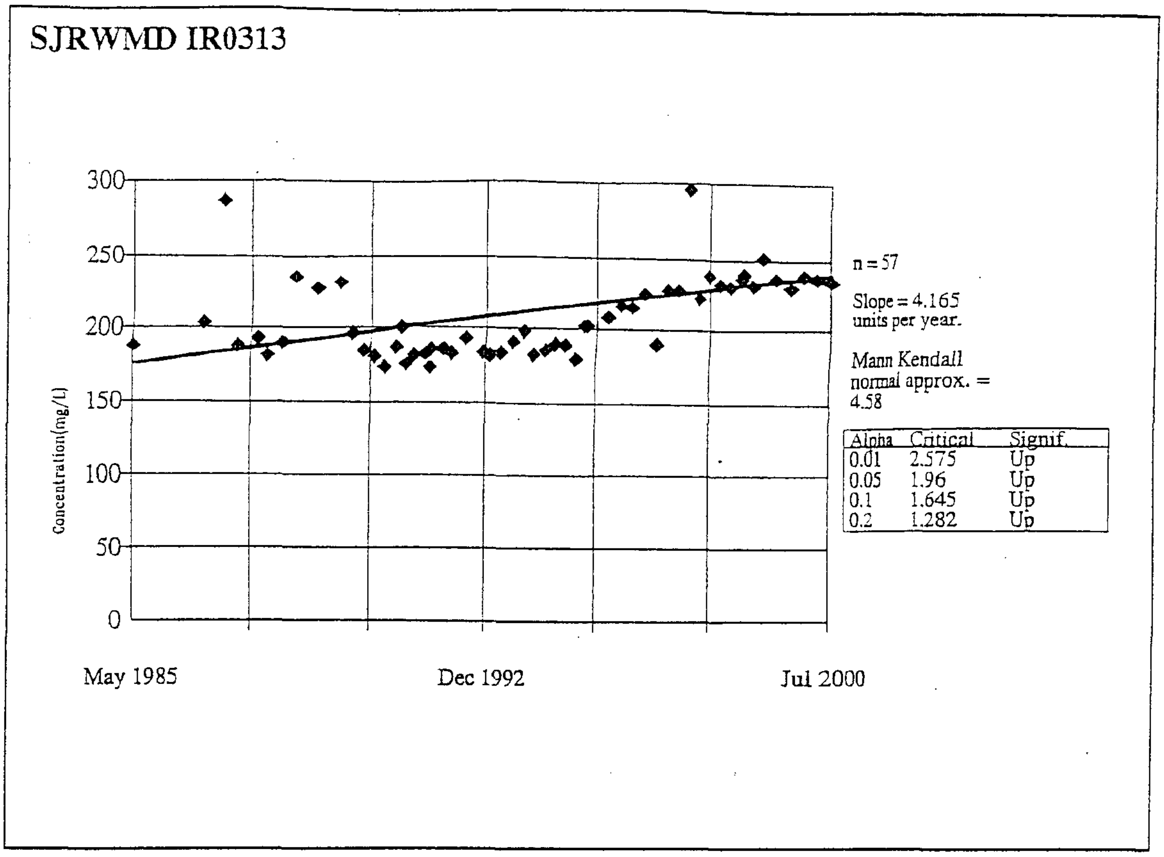


Figure A2—*Continued*

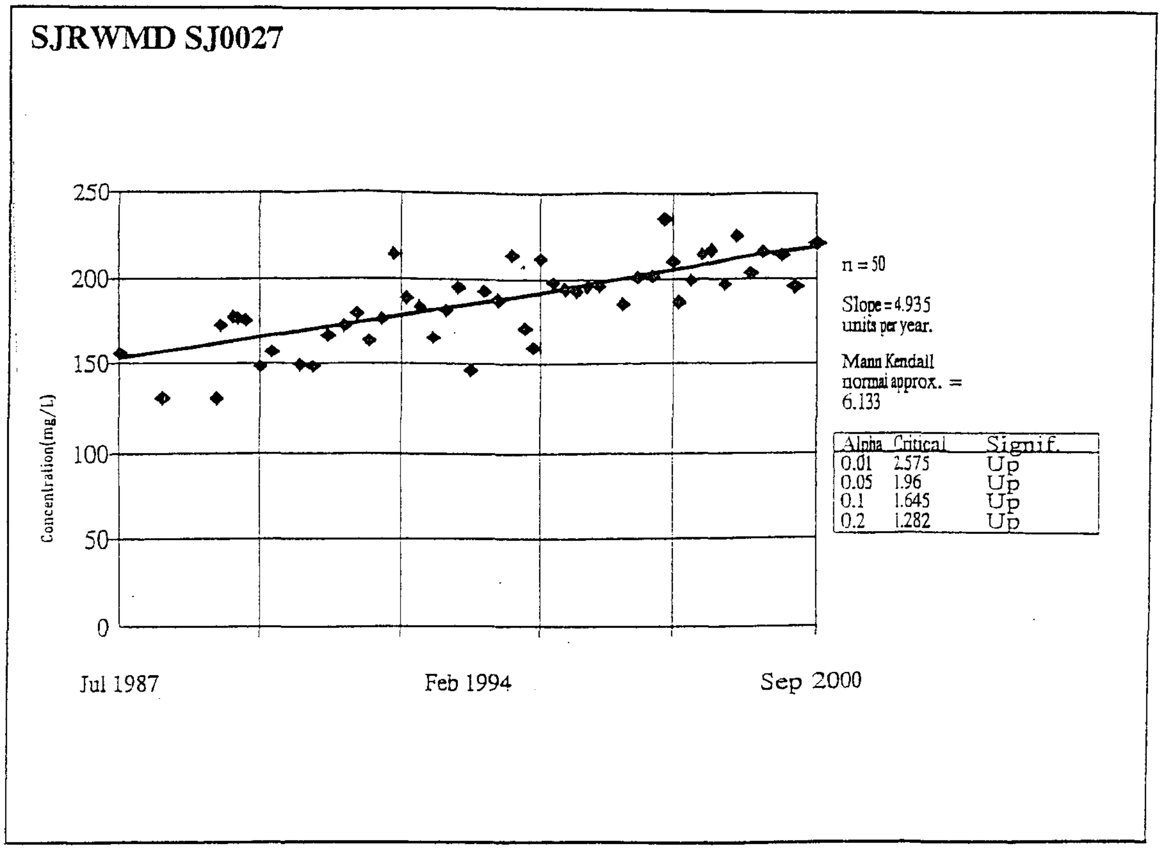


Figure A2—*Continued*

APPENDIX B—ST. JOHNS RIVER WATER MANAGEMENT DISTRICT WATER QUALITY MONITORING NETWORK

Table B1. St. Johns River Water Management District water quality monitoring network

Well Number	Location	Latitude	Longitude	Casing Depth (feet)	Total Depth (feet)	Casing Diameter (feet)	Well Use
A-0071	Hawthorne tower	293557	820432	95	113	4	MW
A-0693	Alachua County fairgrounds	294105	821713	192	440	6	MW
A-0725	Orange Lake	292838	820739	30	40	4	MW
BA0009	Taylor	302620	821735	417	898	6	MW
BA0018	Osceola National Forest 6	302251	821949	320	338	4	MW
BA0054	MacClenny tower	301618	821109	370	700	4	MW
BA0057	Eddy tower	303235	822035	360	700	4	MW
BA0107	MacClenny PS 2, Ohio Avenue	301708	820743	480	790	12	PS
BR0585	Astronaut High School	283734	805059	107	195	4	MW
BR0586	Tico airport	282945	804739	93	135	4	MW
BR0608	NASA, near gate 2	282921	804048	84	321	8	MW
BR0624*	Sebastian State Park	275210	802722	550	650	8	MW
BR0625	Sebastian State Park	275211	802716	299	454	4	MW
BR0645	Platt, near Melbourne	275955	804346	125	447	4	MW
BR1526	Seminole Ranch	283644	805751	235	300	6	MW
BR1557	Cocoa High School	282257	804601	150	190	6	MW
BR1558	Kennedy Middle School	281938	804419	140	180	6	MW
BR1559	St. Sebastian River Buffer Preserve	274958	803326	339	410	6	MW
BR1572	Astronaut High School	283732	805100	180	228	6	MW
BR1748	Ransome Road	283028	304035	170	210	6	MW
C-0094	St. Johns River Community College PS near Middleburg	300656	814634	391	1,197	8	PS
C-0120	Brooklyn Lake	294808	820208	192	227	6	MW
C-0123	Sungarden tower	295016	814333	348	457	4	MW
C-0128	Penney Farms tower	295851	815552	366	405	4	MW
C-0373	Green Cove PS, Harbour Road	300024	814150	400	1,100	18	PS
C-0453	Gold Head State Park	294911	815726	196	375	4	MW
C-0578*	Hall Property near Green Cove Springs	295733	813655	1,085	1,177	6	MW
C-0579	Hall Property near Green Cove Springs	295733	813655	320	656	6	MW
C-0583	Yellow Water Creek	300926	815616	480	540	6	MW
C-1011	Camp Blanding at County Road 315	295238	815537	290	340	6	MW
C-1017	Camp Blanding at North Road	300318	820154	175	505	6	MW
D-0547	South Side tower	301710	813235	490	740	4	MW
D-0673	Tisonia tower	303209	813718	450	857	4	MW
D-1290	RF Kennedy Youth Center PS	302012	813848	531	1,286	12	PS
D-1313	Greenland Pines Elementary School	300926	813430	374	422	6	MW
D-1342	Baldwin PS, Totman Water Works	301802	815850	456	764	10	PS
D-425T	Linden Street	301818	813748	752	1,895	8	MW
D-4609	Ortega Utility PS, Duclay WTP	301227	814411	471	950	12	PS
D-4610	South Side and Butler	301522	813313	1,009	1,218	6	MW

Table B1—*Continued*

Well Number	Location	Latitude	Longitude	Casing Depth (feet)	Total Depth (feet)	Casing Diameter (feet)	Well Use
F-0087	U.S. Geological Survey tributary 14	292751	811524	110	417	6	MW
F-0165	Old Brick Road	293529	811917	127	140	4	MW
F-0174	Flagler Beach	292608	810625	110	118	2	MW
F-0176	Bulow Ruins	292603	810824	91	120	4	MW
F-0200	Washington Oaks State Park	293754	811219	143	148	4	MW
F-0206	Container Corp. near Dinner Island	292930	812234	146	203	4	MW
F-0225	Beverly Beach	293129	810908	80	140	4	MW
F-0240	Near Codys Corner	292302	811559	92	155	4	MW
F-0251	Relay tower	291823	811902	78	147	4	MW
F-0294	Dinner Island	293344	812326	95	124	4	MW
F-0353	Westside Baptist Church	292800	812226	185	240	6	MW
IR0312	Near Oslo	273437	802550	120	568	4	MW
IR0921	Morrison, near Fellsmere Farm	274641	803636	165	541	6	MW
IR0954	St. Johns River water control district headquarters	273515	803443	432	480	6	MW
IR0955	Delta Farms	273941	803754	380	430	6	MW
IR0963	Corrigan Ranch	274126	803049	390	440	6	MW
IR0968	Blue Cypress	274217	804642	303	440	6	MW
IR1000	Wabasso Beach	274535	802408	547	869	6	MW
IR1006	Dodger Stadium	273847	802547	405	460	6	MW
L-0032	West Side	285057	812432	96	120	4	MW
L-0037	Carter east	285028	812533	102	363	4	MW
L-0038	Carter west	284933	812558	78	92	4	MW
L-0040	Near Alexander Springs	290647	813420	140	171	4	MW
L-0051	Sand Mine Horsehead Pond	282241	814439	85	115	4	MW
L-0053	Lake Louisa State Park	282729	814433	70	85	2	MW
L-0059	Crows Bluff	290043	812328	153	170	3	MW
L-0062	Mascotte	283206	815448	63	160	6	MW
L-0066	Alexander Springs	290451	813445	74	102	4	MW
L-0095	Groveland tower	284122	815344	150	365	4	MW
L-0199	Waits Junction	283355	814117	110	146	4	MW
L-0290	Leesburg tower	285144	814750	190	400	4	MW
L-0455	Astor	291002	813307	100	150	6	MW
L-0591	Howey In The Hills PS 3	284331	814641	162	350	14	PS
L-0592	Leesburg PS 6, Canal Street	284827	815224	58	390	12	PS
L-0593	Eustis PS, Easterly WTP	285118	813910	274	750	16	PS
L-0594	Lady Lake PS	285419	815528	160	180	10	PS
L-0595	Umatilla PS, Blanding well 2	285631	813957	137	450	12	PS
L-0596	Clermont PS Grand Highway	283349	814450	605	918	12	PS
L-0658	Monteverde	283608	814030	164	291	12	MW

Table B1—*Continued*

Well Number	Location	Latitude	Longitude	Casing Depth (feet)	Total Depth (feet)	Casing Diameter (feet)	Well Use
L-0677	Lykes 1	282533	814308	160	485	12	MW
L-0704*	Eustis spray field	285037	813420	280	300	6	MW
L-0705	Eustis spray field	285037	813420	130	150	6	MW
L-0709	Smokehouse Lake	282528	814248	81	101	6	MW
L-0729*	Lake Louisa State Park	282520	814340	1,295	1,410	6	MW
L-0730	Lake Louisa State Park	282520	814340	356	465	6	MW
M-0013	Moss Bluff	290456	815303	80	225	8	MW
M-0021	Near Salt Springs	291843	814109	268	277	4	MW
M-0024	Highway 316 near Eureka	292207	815057	53	90	6	MW
M-0028	Highway 14	291106	820056	124	153	6	MW
M-0031	Pedro	285908	820712	45	66	6	MW
M-0036	Fore Lake, State Road 314	291608	815500	85	165	4	MW
M-0037	State Road 464 west of State Road 36	290828	820333	51	72	4	MW
M-0041	State Road 475B	290359	820914	29	80	4	MW
M-0044	Redwater Lake	291113	815404	46	199	4	MW
M-0049	Highways 19 and 40	291008	813831	157	165	6	MW
M-0052	Fort McCoy Tower	292205	820228	60	160	4	MW
M-0063	Sparr	292020	820642	61	120	4	MW
M-0239	Northeast 10th Street, Ocala	291149	820726	65	75	4	MW
M-0322	Ocala PS, northeast 36th Avenue	291217	820514	85	265	24	PS
M-0375	Sunnyhill Farms Blue House	285939	815004	163	169	4	MW
M-0419	Marion County sheriff's north office	291625	820859	47	64	4	MW
M-0441	G&M cattle ranch near Orange Springs	292957	815730	155	210	6	MW
M-0443	Citra Ranch	292554	820345	83	115	6	MW
M-0445	Heather Island	290327	815620	160	226	6	MW
N-0121	Baker Oil, near Yulee	304005	813802	460	645	4	MW
N-0190	Fernandina Beach	303824	812731	565	1,020	12	MW
N-0199	Hilliard PS	304120	815509	447	821	10	PS
N-0220	Callahan fairgrounds	303543	814948	450	650	6	MW
N-0221	St. Marys	304700	815710	535	820	6	MW
N-0222*	St. Marys	304700	815710	1,760	1,956	6	MW
N-0236*	Callahan fairgrounds	303543	814948	1,270	1,405	6	MW
N-0237	Carey State Forest	302404	815524	450	500	6	MW
OK0001	Fort Drum	273150	804818	125	960	8	MW
OR0003	Cocoa H	282847	810138	252	495	4	MW
OR0007	Bithlo 1	283249	810534	151	492	6	MW
OR0047	Orlo Vista	283252	812832	328	350	6	MW
OR0106	Plymouth tower	284230	813453	100	395	4	MW
OR0265	Cocoa F	282734	810542	200	375	6	MW
OR0547*	Wekiva State Park	284238	812758	440	645	4	MW

Table B1—*Continued*

Well Number	Location	Latitude	Longitude	Casing Depth (feet)	Total Depth (feet)	Casing Diameter (feet)	Well Use
OR0548	Wekiva State Park	284238	812758	100	155	6	MW
OR0555	Winter Park PS 8	283547	811813	202	700	24	MW
OR0559	Ocoee PS, south #1	283215	813210	800	1,450	24	PS
OR0617	Longbranch, near Bithlo	283136	810646	210	550	12	MW
OR0618*	Longbranch, near Bithlo	283126	810646	1,140	1,280	6	MW
OR0652*	Rock Springs	284634	812620	450	506	10	MW
OR0662	Rock Springs	284634	812620	150	180	6	MW
OR0668*	Alafaya Trail WTP	283007	811227	1,490	1,537	6	MW
OR0669	Cocoa 13T	282338	810102	295	315	6	MW
OR0673*	Cocoa 13T	282338	810102	450	540	6	MW
OR0675*	Cocoa 13T	282338	810102	620	840	6	MW
OR0676*	Alafaya Trail WTP	283007	811227	1,269	1,300	6	MW
OR0678	Alafaya Trail WTP	283007	811227	420	470	6	MW
OS0004	Bull Creek Wildlife Management Area	280121	805659	202	329	4	MW
OS0025*	Bull Creek airport TM2	280658	810026	1,473	1,483	4	MW
OS0027*	Bull Creek airport D1	280657	810023	700	915	8	MW
OS0028*	Bull Creek airport D2	280657	810023	1,050	1,054	4	MW
OS0031	Bull Creek airport SJ61	280704	810027	360	460	2	MW
OS0230	Adams Ranch	274827	810109	352	392	6	MW
OS0231	Campbell Ranch	274944	805733	360	420	6	MW
P-0001	Swan Lake	294309	820025	90	170	10	MW
P-0123	SJRWMD headquarters	293951	814139	182	394	6	MW
P-0172	Orange Mills	293933	813427	112	543	6	MW
P-0246	Thunderbird airport	292828	813410	104	144	4	MW
P-0270	Fruitland Handyway	292537	813835	91	124	6	MW
P-0306	Near Kenwood	293259	815239	105	189	8	MW
P-0408	Fruitland	292859	813757	127	148	4	MW
P-0410	Jumping Gully Road	292219	813332	81	156	4	MW
P-0418	Ravine State Gardens	293802	813834	86	405	3	MW
P-0427	Highway 19, near Frontier	292439	814412	95	148	4	MW
P-0450	Forest roads 77 and 77G	292949	815029	215	241	4	MW
P-0469	Paradise Lakes	292256	813526	105	190	4	MW
P-0472	Johnson Field forest road 77	292825	814432	96	144	4	MW
P-0474	San Mateo tower	293554	813426	130	226	4	MW
P-0495	South end of Crescent Lake	292246	812843	132	246	6	MW
P-0510	Hollister work center	293732	814749	175	300	4	MW
P-0735*	Middle Road	292124	813452	330	360	6	MW
P-0736	Middle Road	292124	813452	70	100	6	MW
P-0772	Lake Grandin	294012	815259	165	200	6	MW
P-0817	Lake Broward	293207	813516	100	200	6	MW

Table B1—*Continued*

Well Number	Location	Latitude	Longitude	Casing Depth (feet)	Total Depth (feet)	Casing Diameter (feet)	Well Use
P-0891	EH Miller School	293755	814129	220	280	6	MW
P-2037	Lake Stella	292555	813050	110	160	6	MW
PO0001	Thornhill Ranch	281203	813916	108	151	4	MW
S-0001	Geneva	284247	810708	92	204	4	MW
S-0025	Kilbee 3	284217	810230	58	154	4	MW
S-0028	Cochran Forest east	284325	810840	90	205	4	MW
S-0034	Winona Drive	284440	810526	48	200	6	MW
S-0037	SM Fernandez	284945	812442	NA	41	2	MW
S-0038	Cochran Forest west	284324	810928	55	165	4	MW
S-0086	Osceola landfill	284715	810518	70	225	6	MW
S-0097	Wekiva River Haven	285001	812423	110	120	4	MW
S-0200*	Osceola landfill	284715	810518	500	550	4	MW
S-0829	Spring Hammock	284317	811827	85	180	2	MW
S-0972	Lake Mary PS 2, Rinehart Road	284554	812047	162	500	16	MW
S-1014	North Street	284052	812126	142	300	6	MW
S-1016*	North Street	284052	812126	520	700	4	MW
S-1017*	North Street	284052	812126	380	480	4	MW
S-1024*	North Street	284052	812126	1,246	1,506	6	MW
S-1056	Citrus Road	283936	811628	166	365	10	MW
S-1078*	Oviedo WTP	283933	811231	1,230	1,288	5	MW
S-1189*	Oviedo WTP	283933	811231	500	600	6	MW
S-1193	Oviedo WTP	283933	811231	87	220	6	MW
S-1200*	Snow Hill Road at Econlockhatchee River	284050	810653	500	600	6	MW
S-1201	Snow Hill Road at Econlockhatchee River	284050	810653	100	140	6	MW
S-1224*	Geneva fire station	284411	810711	540	570	6	MW
S-1225*	Yankee Lake STP	284923	812348	945	1,054	6	MW
S-1230	Yankee Lake STP	284923	812348	122	403	12	MW
S-1253	Geneva fire station	284411	810711	132	280	6	MW
S-1257*	Citrus Road	283936	811628	600	698	6	MW
S-1328*	Geneva fire station	284411	810711	340	370	6	MW
S-1329*	Citrus Road	283936	811628	1,050	1,150	6	MW
S-1351*	Lake Mary	284413	812201	1,260	1,323	6	MW
S-1397	Sanford zoo	284940	811910	120	180	6	MW
S-1398*	Sanford zoo	284943	811901	330	370	6	MW
S-1406*	Lake Mary	284413	812201	1,020	1,080	6	MW
S-1407*	Lake Mary	284413	812201	320	400	6	MW
S-1408	Lake Mary	284407	812155	150	200	6	MW
SJ0027	Bakersville tower	295427	812925	225	464	4	MW
SJ0029	Durbin tower	300509	812726	350	603	4	MW

Table B1—*Continued*

Well Number	Location	Latitude	Longitude	Casing Depth (feet)	Total Depth (feet)	Casing Diameter (feet)	Well Use
SJ0115	Old Brick Road	293731	812211	142	609	6	MW
SJ0119	Near Bakersville	295442	812722	131	188	4	MW
SJ0263	D Reid	294128	812913	117	320	6	MW
SJ0317	Sykes Farm	294701	812633	99	290	6	MW
SJ0412	St. Augustine airport	295713	812034	190	350	4	MW
SJ0516	Dupont Center	294520	811843	204	238	4	MW
SJ0548	Guana Park Wildlife Management Area	300206	812022	316	433	4	MW
SJ0602	I-95 rest stop at State Road 206	294213	811944	163	193	6	MW
SJ0754	Ponte Vedra WTP 1	301454	812314	385	857	16	MW
V-0008*	Near Daytona	290926	810602	480	496	2	MW
V-0028	Near De Land, State Road 11	290536	811749	245	259	4	MW
V-0062	Barberville	291217	812154	132	155	4	MW
V-0064	Cowarts Road	291824	812808	113	158	4	MW
V-0065	Truck road 3	291509	813028	97	180	4	MW
V-0066	Pierson Iron	291433	812842	250	365	4	MW
V-0080	Near Daytona	290920	810630	102	235	6	MW
V-0083	Blue Springs	285638	812031	84	432	6	MW
V-0085	Harbour Oaks	290651	805828	104	146	4	MW
V-0086	Indian Lake 4A	291007	811010	122	222	4	MW
V-0099	I-95 at Daytona	291023	810501	152	498	6	MW
V-0101	Alamana	285705	810540	113	121	6	MW
V-0106	West of Samsula	290107	810617	105	111	4	MW
V-0110	South of Samsula	285934	810418	105	261	3	MW
V-0113	Lake Ashby	285700	810210	90	261	3	MW
V-0115	West of De Land	290138	812031	252	350	4	MW
V-0117	North of Samsula	290225	810403	97	241	3	MW
V-0118	East of De Land	290229	811235	72	241	3	MW
V-0120	I-4 east of De Land	290445	811026	92	241	3	MW
V-0123	West of Allendale	290456	810444	90	261	3	MW
V-0127	11th Street	291302	810638	84	240	3	MW
V-0129	Jones Island	290708	812331	100	165	4	MW
V-0130	West Ormond Beach	291524	810949	82	242	3	MW
V-0147	Franklin Street	291457	812709	128	140	4	MW
V-0155	Pine Island	291835	813242	120	155	6	MW
V-0156	Glenwood	290513	812134	65	195	4	MW
V-0162	Port Orange	290806	810139	105	224	3	MW
V-0165	Took Farm	285033	810622	58	255	4	MW
V-0183*	Tomoka tower	290834	810738	445	545	4	MW
V-0184	Seville tower	291940	812942	75	100	4	MW
V-0187	Daytona Beach airport	291107	810342	97	817	8	MW

Table B1—*Continued*

Well Number	Location	Latitude	Longitude	Casing Depth (feet)	Total Depth (feet)	Casing Diameter (feet)	Well Use
V-0188	Tomoka tower	290835	810736	92	150	4	MW
V-0196	Orange City tower	285439	811815	88	234	4	MW
V-0198	Lake Ashby tower	285420	810408	88	122	4	MW
V-0200	Daytona Beach Shores	291031	805905	98	160	4	MW
V-0213	Southeast of Deep Creek	290930	812302	143	145	2	MW
V-0215	Blackwelder	291009	812058	191	450	10	MW
V-0240	Fortner	285153	811442	197	243	6	MW
V-0381	State Road 44 and I-95 Chevron	290047	805931	107	130	4	MW
V-0435	Glenco Road	285833	805717	100	174	10	MW
V-0443	Ormond Tomb	292245	810748	101	180	4	MW
V-0446	National Gardens	291949	810659	104	130	6	MW
V-0449	Ormond Beach bridge	291712	810321	92	121	2	MW
V-0508	New Smyrna Beach	290103	805519	170	210	3	MW
V-0530*	Pierson airport	291448	812749	800	1,060	16	MW
V-0531	Pierson airport	291448	812749	130	210	6	MW
V-0700	Ormond Beach, Dan Ford Road	291040	811437	85	300	12	MW
V-0742	Bob Lee airport	290616	811832	140	460	6	MW
V-0769	State Road 40 and State Road 11	291330	811914	85	440	6	MW
V-0772	Galaxy Middle School	285543	811338	100	140	6	MW
V-0774*	Galaxy Middle School	285543	811338	740	780	6	MW
V-0776*	Lake Helen	285813	811422	300	395	6	MW
V-0777	Lake Helen	285813	811422	115	193	6	MW
V-0780*	Orange City tower	285420	811814	710	800	6	MW
V-0788	Ormond Beach, State Road 40 east of State Road 11	291417	811446	111	300	4	MW
V-0801*	Osteen Ranch	284840	811157	275	317	6	MW
V-0802*	Clark Bay	290743	811436	940	1,170	6	MW
V-0808	Lake Daugharty	290552	811626	90	140	6	MW
V-0810	Snook Road	285211	811316	290	312	6	MW
V-0818	Osteen Ranch	284840	811157	128	188	6	MW
V-0819*	Tiger Bay	290707	811016	1,045	1,199	6	MW
V-0840	Migor Shiloh Road, NASA	284913	805015	145	195	6	MW
V-1030	DeLeon Springs	290831	812155	120	200	6	MW
V-1091	South of Blue Springs	285513	812028	110	200	6	MW
V-1094	Ormond Beach I-95 rest stop	291705	810735	100	155	6	MW
V-1098	Shunz Road near Spruce Creek	290611	810815	400	460	6	MW

Note: MW = monitoring well
NA = not available
NASA = National Aeronautics and Space Administration
PS = public supply well
STP = sewerage treatment plant
WTP = water treatment plant

*Well monitoring lower zones of Floridan aquifer (not plotted on Figure 5)

APPENDIX C—PUBLIC SUPPLY UTILITIES PROVIDING WATER QUALITY DATA

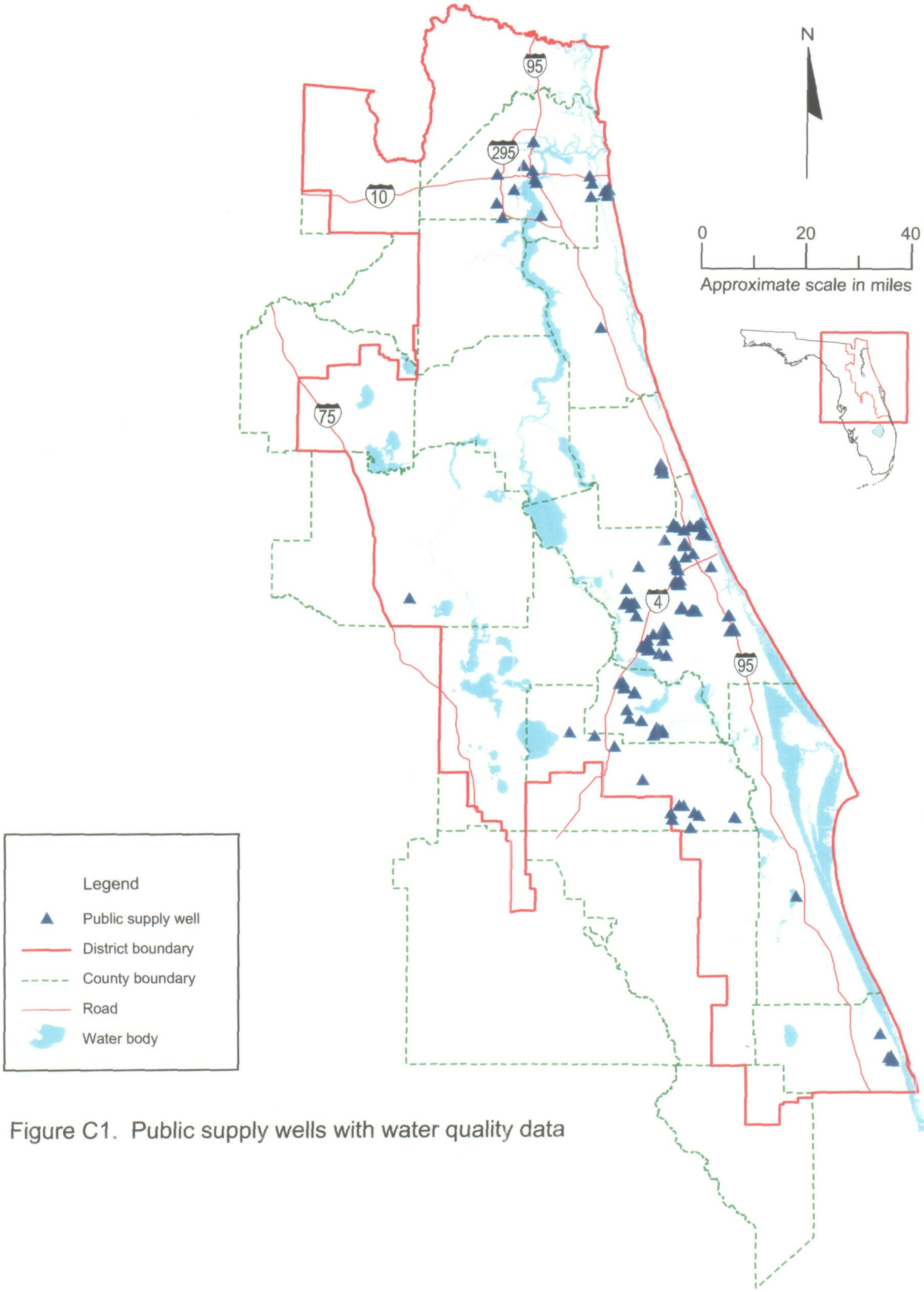


Figure C1. Public supply wells with water quality data

Table C1. Public supply utilities providing water quality data

City or County	Well Number	Latitude	Longitude
Belleview	5	290242	820339
Cocoa	2	282323	805638
Cocoa	17	282337	810355
Cocoa	21	282407	810938
Cocoa	25	282300	810924
Cocoa	44	282127	810539
Cocoa	12A	282410	810447
Cocoa	13R	282531	810757
Cocoa	7A	282529	810702
Cocoa	7T	282315	805627
Daytona Beach	1	291031	810656
Daytona Beach	8	290812	810832
Daytona Beach	10	290831	810840
Daytona Beach	15	290911	810903
Daytona Beach	20	290953	810913
Daytona Beach	45	291107	810519
De Land	3	290156	811834
De Land	4	290155	811834
De Land	5	290219	811907
De Land	6	290206	811723
De Land	8	290157	811928
De Land	9	290114	811758
De Land	10	290118	811758
De Land	21	285944	811658
De Land	27	290442	811904
De Land	28	290441	811904
De Land	31	290845	811638
De Land	33	290843	811636
De Land	20A	285944	811657
De Land	31A	290844	811637
De Land	7A	290200	811758
Deltona	1	285419	811543
Deltona	2	285416	811546
Deltona	4	285524	811437
Deltona	6	285405	811522
Deltona	8	285406	811521
Deltona	9	285632	811053
Deltona	12	285343	811405
Deltona	14	285353	811411
Deltona	15	285632	811053

City or County	Well Number	Latitude	Longitude
Deltona	16	285351	811409
Deltona	17	285635	811052
Deltona	18	285633	811051
Deltona	20	285523	811123
Deltona	21	285236	811043
Deltona	22	285257	811211
Deltona	23	285627	811328
Deltona	24	285737	811119
Deltona	27	285407	811523
Deltona	28	285635	811155
Deltona	32	285256	811213
Deltona	33	285334	811438
Deltona	34	285419	811545
Deltona	35	285258	811212
Edgewater	6	285701	805731
Edgewater	7	285701	805735
Edgewater	8	285701	805742
Edgewater	9	285701	805747
Edgewater	10	285709	805650
Edgewater	11	285714	805651
Edgewater	12	285719	805653
Edgewater	13	285724	805655
Edgewater	14	285730	805700
Edgewater	15	285735	805703
Flagler Beach	1	292724	811209
Flagler Beach	2	292715	811209
Flagler Beach	3	292704	811208
Flagler Beach	5	292644	811202
Flagler Beach	6	292634	811158
Flagler Beach	7	292625	811156
Flagler Beach	8	292621	811225
Flagler Beach	9	292543	811150
Holly Hill	11	291436	810255
Holly Hill	13	291235	810714
Holly Hill	14	291242	810711
Holly Hill	15	291248	810707
Holly Hill	16	291252	810660
Holly Hill	17	291302	810711
Holly Hill	18	291257	810706
Holly Hill	19	291246	810654

Table C1—*Continued*

City or County	Well Number	Latitude	Longitude
Holly Hill	12-A	291431	810310
Holly Hill	12-B	291455	810316
Holly Hill	12-C	291442	810342
Holly Hill	6	291433	810249
Holly Hill	7	291429	810248
Indian River County	1	274402	802652
Jacksonville	119	302019	813928
Jacksonville	301	302110	814123
Jacksonville	502	301647	814318
Jacksonville	601	302528	813927
Jacksonville	701	301932	814650
Jacksonville	803	301423	814653
Jacksonville	901	301146	814541
Jacksonville	5102	301807	813841
Jacksonville	5502	301846	813903
Jacksonville	5801	301540	812713
Jacksonville	M101	301209	813734
Jacksonville	N101	301927	812734
Jacksonville	N301	301807	812706
Jacksonville Beach	1	301715	812343
Jacksonville Beach	2	301703	812333
Jacksonville Beach	3	301656	812332
Jacksonville Beach	4	301600	812347
Jacksonville Beach	5	301614	812344
Jacksonville Beach	6	301550	812344
Jacksonville Beach	GCW	301643	812421
Melbourne-Palm Bay	F-1	280860	804360
New Smyrna Beach	1	285952	805748
New Smyrna Beach	2	285951	805750
New Smyrna Beach	3	285949	805749
New Smyrna Beach	5	285954	805751
New Smyrna Beach	6	285951	805755
New Smyrna Beach	7	285950	805801
New Smyrna Beach	8	285945	805801
New Smyrna Beach	9	290038	810437
New Smyrna Beach	10	290038	810450
New Smyrna Beach	11	290040	810501
New Smyrna Beach	12	290042	810508
New Smyrna Beach	13	290047	810522

City or County	Well Number	Latitude	Longitude
New Smyrna Beach	14	290050	810530
New Smyrna Beach	15	290126	810741
New Smyrna Beach	16	290122	810738
New Smyrna Beach	17	290118	810733
New Smyrna Beach	18	290116	810743
New Smyrna Beach	19	290104	810744
New Smyrna Beach	20	290104	810737
Orange County	IP3	283011	811523
Orange County	OV1	283842	813032
Orange County	RS3	283804	812524
Ormond Beach	2	291644	810347
Ormond Beach	11	291609	810419
Ormond Beach	15	291605	810428
Ormond Beach	17	291559	810443
Ormond Beach	22	291615	810601
Ormond Beach	24	291601	810608
Ormond Beach	28	291526	810714
Ormond Beach	36	291633	810919
Ormond Beach	42	291556	810939
Ormond Beach	52	291333	811114
Ormond Beach	BAT C	291558	810837
Oviedo	101	283926	811242
Oviedo	102	283926	811233
Oviedo	103	283934	811237
Oviedo	203	283908	811206
Oviedo	204	283912	811206
Oviedo	205	283837	811127
Oviedo	301	283914	811246
Oviedo	303	283907	811126
Oviedo	304	283900	811200
Oviedo	306	283816	811318
Oviedo	307	283811	811316
Oviedo	308	283808	811316
Port Orange	11	290844	810138
Port Orange	C1	290614	810756
Port Orange	C10	290545	810816
Port Orange	C13	290551	810840
Port Orange	C16	290529	810837
Port Orange	C21	290608	810859

Table C1—*Continued*

City or County	Well Number	Latitude	Longitude
Port Orange	C5	290528	810759
Sanford	1-11	284552	811715
Sanford	1-12	284551	811707
Sanford	1-7	284547	811714
Sanford	1-8	284544	811711
Sanford	1-9	284548	811718
Sanford	2-3	284646	811920
Sanford	2-4	284652	811920
Sanford	2-5	284657	811920
Sanford	2-6	284544	811717
Sanford	3-1	284739	811942
Sanford	3-2	284740	811936
Sanford	3-3	284743	811939
Sanford	3-4	284743	811944
Sanford	3-5	284746	811942
Sanford	4-2	284641	811920
Sanford	Twin Lake	284730	812023
St. Johns County	TR41	295158	812452
Vero Beach	14	273918	802417
Vero Beach	21	273906	802412
Vero Beach	31	273959	802438
Vero Beach	101	273916	802432
Vero Beach	102	273937	802425
Vero Beach	103	273944	802512
Winter Park	Swoop1	283607	812113
Winter Springs	3east	284049	811547
Winter Springs	5west	284112	811816
Winter Springs	6west	284245	811847

APPENDIX D—U.S. GEOLOGICAL SURVEY WATER QUALITY SAMPLING IN DUVAL AND ORANGE COUNTIES

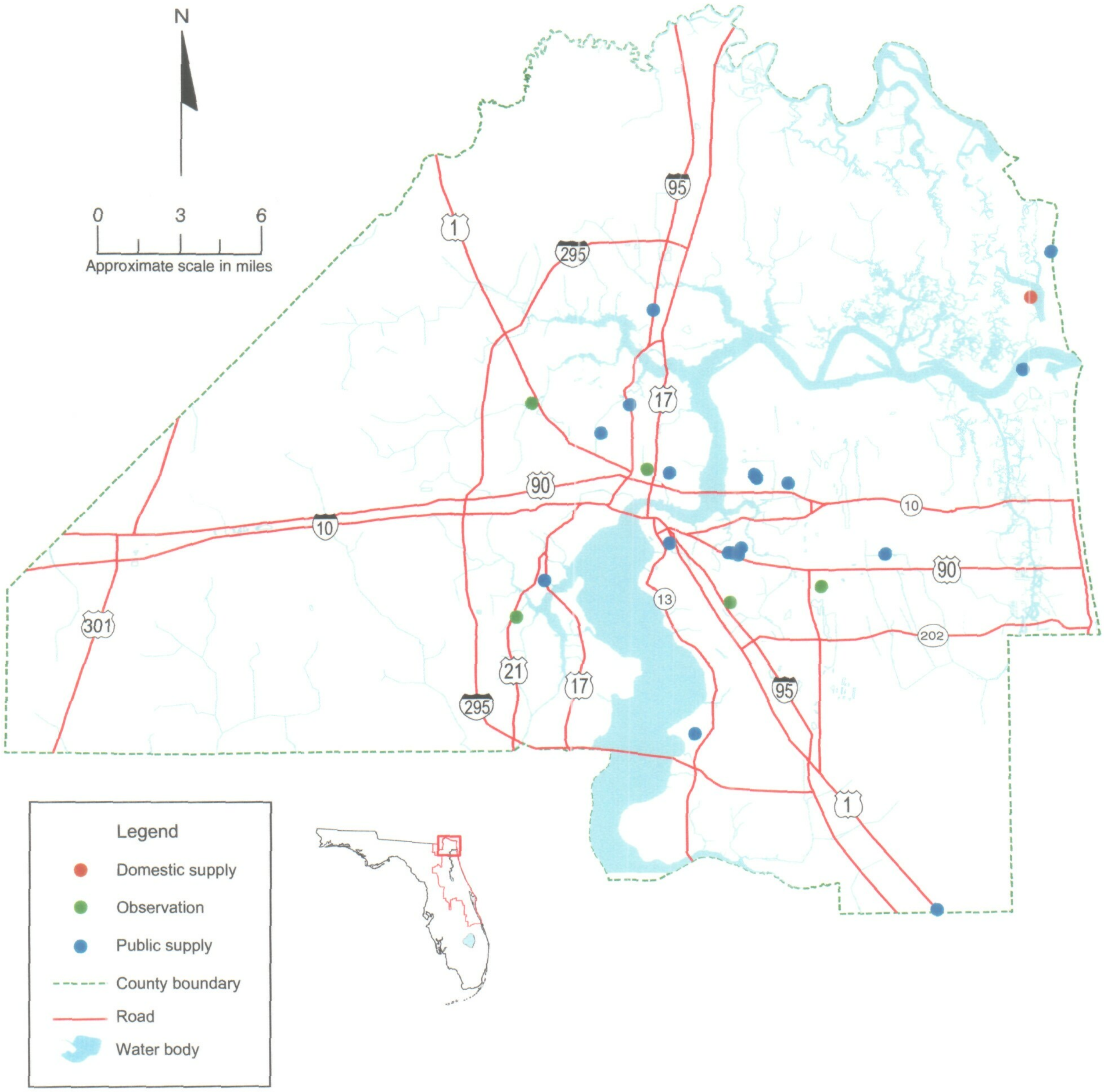


Figure D1. U.S. Geological Survey water quality sampling sites in Duval County

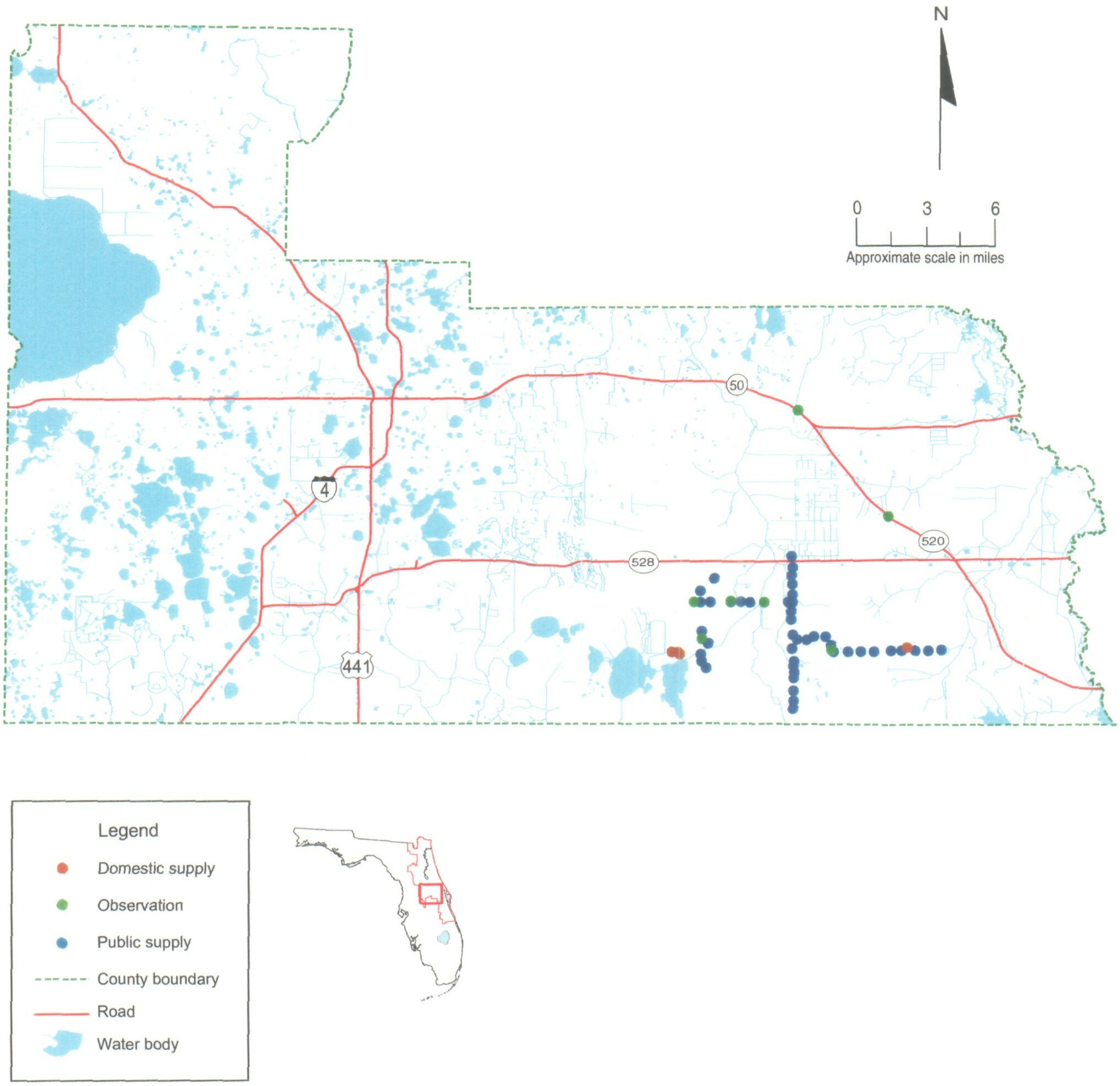


Figure D2. U.S. Geological Survey water quality sampling sites in Orange County

Table D1. U.S. Geological Survey water quality sampling in Duval County

Location	Well Number	Latitude	Longitude	Aquifer	Well Use
Lakeshore	D-103	301648	814318	Upper/Lower Floridan	PS
Southside Estates	D-1155	301639	813308	Upper/Lower Floridan	MW
Pearl and 3rd	D-176	302022	813935	Upper/Lower Floridan	MW
Beach and Spring Glen	D-2193	301744	813633	Upper/Lower Floridan	PS
Sandalwood High School	D-224	301743	813047	Upper/Lower Floridan	PS
Lake Grove Water Plant	D-225	301743	813623	Upper/Lower Floridan	PS
Beach and University	D-275	301740	813610	Upper/Lower Floridan	PS
Alderman Park	D-313	301957	813423	Upper/Lower Floridan	PS
Monaco and Dunn	D-329	302528	813925	Upper/Lower Floridan	PS
Robert Kennedy Center	D-335	302015	813845	Upper/Lower Floridan	PS
Norwood and I-95	D-336	302226	814015	Upper/Lower Floridan	PS
Little Talbot Island State Park	D-395	302724	812448	Upper/Lower Floridan	PS
Santa Monica	D-450	301608	813628	Upper/Lower Floridan	MW
Julia Street	D-464A	302339	812547	Upper/Lower Floridan	PS
Fairfax and 25th	D-46A	302130	814118	Upper/Lower Floridan	PS
Arlington Lions Club	D-479	302007	813532	Upper/Lower Floridan	PS
Beauclerc Gardens	D-538	301157	813743	Upper/Lower Floridan	PS
Lincoln Estates	D-592	302227	814350	Upper/Lower Floridan	MW
Beach and University	D-649	301752	813605	Upper/Lower Floridan	PS
Arlington and Maitland	D-673	302013	813538	Upper Floridan	PS
Confederate Point	D-75	301537	814419	Upper/Lower Floridan	MW
Dee Dot Ranch	D-909	300622	812847	Upper/Lower Floridan	PS
Port George Island	D-913	302557	812531	Upper/Lower Floridan	DS
River Oaks	D-54A	301801	813843	Upper/Lower Floridan	PS

Note: DS = domestic well
PS = public supply well
MW = monitoring well

Table D2. U.S. Geological Survey water quality sampling at the Cocoa wellfield, Orange County

Well	Latitude	Longitude	Aquifer	Well Use
Bithlo 1	283249	810532	Upper Floridan	MW
Cocoa 1	282510	810545	Upper Floridan	PS
Cocoa 10	282716	810545	Upper Floridan	PS
Cocoa 10T	282338	810245	Upper Floridan	PS
Cocoa 11	282344	810542	Upper Floridan	PS
Cocoa 11T	282337	810211	Upper Floridan	PS
Cocoa 12A	282412	810447	Upper Floridan	PS
Cocoa 12B	282404	810505	Upper Floridan	PS
Cocoa 12T	282339	810127	Upper Floridan	PS
Cocoa 13R	282531	810756	Upper Floridan	PS
Cocoa 13T	282339	810100	Upper Floridan	PS
Cocoa 14	282531	810822	Upper Floridan	PS
Cocoa 14T	282339	810025	Upper Floridan	PS
Cocoa 15	282530	810554	Upper Floridan	PS
Cocoa 15T	282339	805952	Upper Floridan	PS
Cocoa 16	282530	810914	Upper Floridan	PS
Cocoa 16T	282341	805918	Upper Floridan	PS
Cocoa 17	282530	810940	Upper Floridan	PS
Cocoa 18	282556	810940	Upper Floridan	PS
Cocoa 19	282624	810904	Upper Floridan	PS
Cocoa 2	282612	810542	Upper Floridan	PS
Cocoa 20	282424	810936	Upper Floridan	PS
Cocoa 21	282406	810936	Upper Floridan	PS
Cocoa 22	282356	810919	Upper Floridan	PS
Cocoa 23	282331	810938	Upper Floridan	PS
Cocoa 24	282315	810936	Upper Floridan	PS
Cocoa 25	282300	810924	Upper Floridan	PS
Cocoa 3	282548	810542	Upper Floridan	PS
Cocoa 38	282315	810538	Upper Floridan	PS
Cocoa 39	282304	810539	Upper Floridan	PS
Cocoa 4	282416	810541	Upper Floridan	PS
Cocoa 40	282250	810538	Upper Floridan	PS
Cocoa 41	282238	810538	Upper Floridan	PS
Cocoa 42	282208	810538	Upper Floridan	PS
Cocoa 43	282145	810538	Upper Floridan	PS
Cocoa 44	282127	810539	Upper Floridan	PS
Cocoa 4A1	282405	810530	Upper Floridan	PS
Cocoa 5	282451	810545	Upper Floridan	PS
Cocoa 5T	282412	810417	Upper Floridan	PS
Cocoa 6T	282352	810402	Upper Floridan	PS
Cocoa 7	282530	810542	Upper Floridan	PS

Table D2—*Continued*

Well	Latitude	Longitude	Aquifer	Well Use
Cocoa 7A	282529	810732	Upper Floridan	PS
Cocoa 8	282632	810545	Upper Floridan	PS
Cocoa 8T	282337	810355	Upper Floridan	PS
Cocoa 9	282650	810542	Upper Floridan	PS
Cocoa 9T	282337	810318	Upper Floridan	PS
Cocoa A	282341	810401	Upper Floridan	MW
Cocoa C—zone 1	282533	810822	Lower Floridan	MW
Cocoa C—zone 3	282533	810822	Lower Floridan	MW
Cocoa C—zone 4	282533	810822	Lower Floridan	MW
Cocoa C—zone 5	282533	810822	Upper Floridan	MW
Cocoa D	282531	810957	Upper Floridan	MW
Cocoa H	282847	810137	Upper Floridan	MW
Cocoa R	282406	810936	Lower Floridan	MW
Cocoa S—zone 1	282530	810656	Upper Floridan	MW
Cocoa S—zone 2	282530	810656	Middle semiconfining unit	MW
Cocoa S—zone 3	282530	810656	Lower Floridan	MW
DiGiovanni	282346	810046	Upper Floridan	DS
Salzman	282331	811032	Upper Floridan	DS
Johnson	282335	811037	Upper Floridan	DS
Nodorft	282336	811052	Upper Floridan	DS

Note: DS = domestic well
PS = public supply well
MW = monitoring well