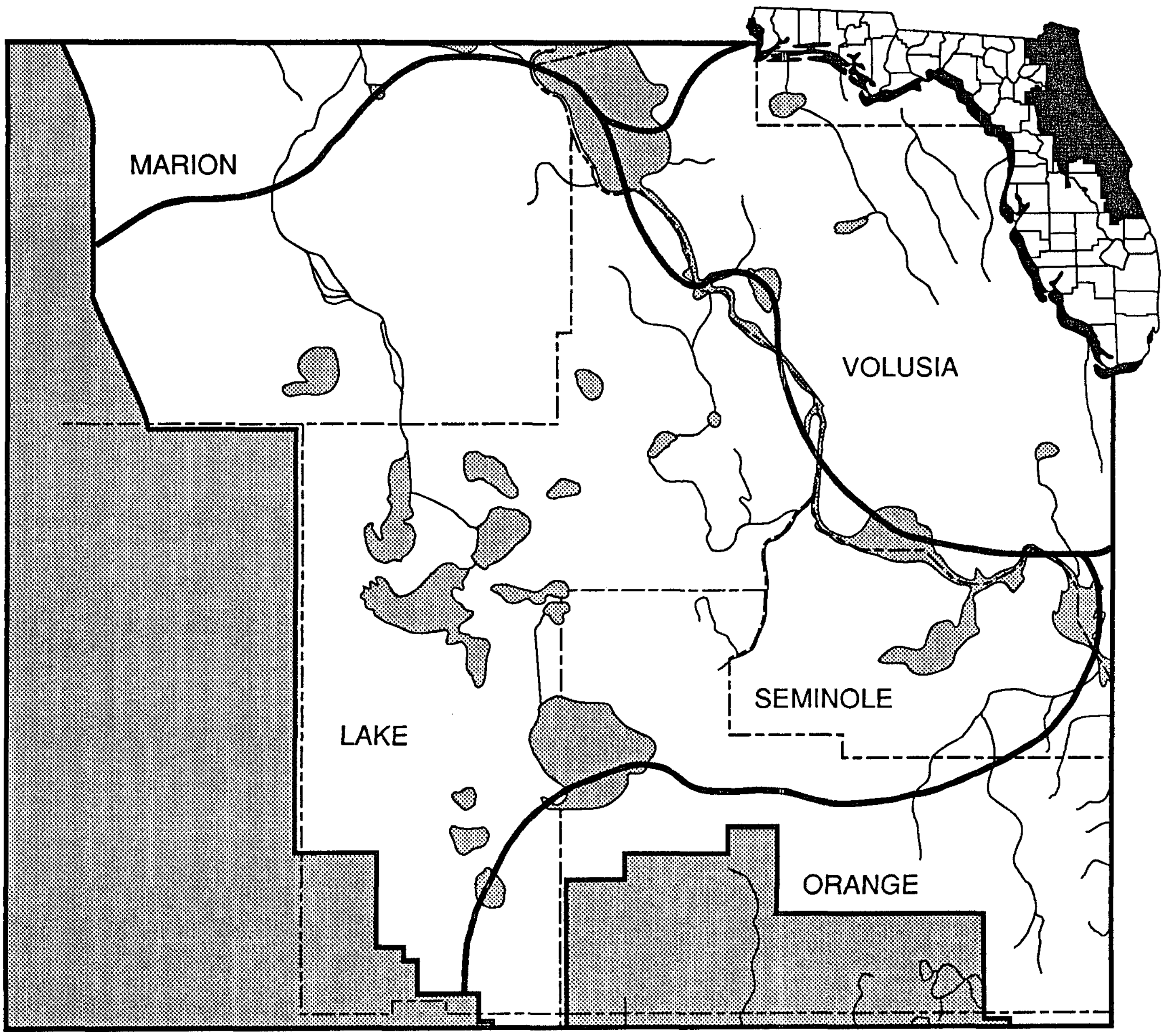
Technical Publication SJ 90-11

Middle St. Johns Ground Water Basin Resource Availability Inventory



St. Johns River Water Management District

Technical Publication SJ 90-11

MIDDLE ST. JOHNS GROUND WATER BASIN
RESOURCE AVAILABILITY INVENTORY

by

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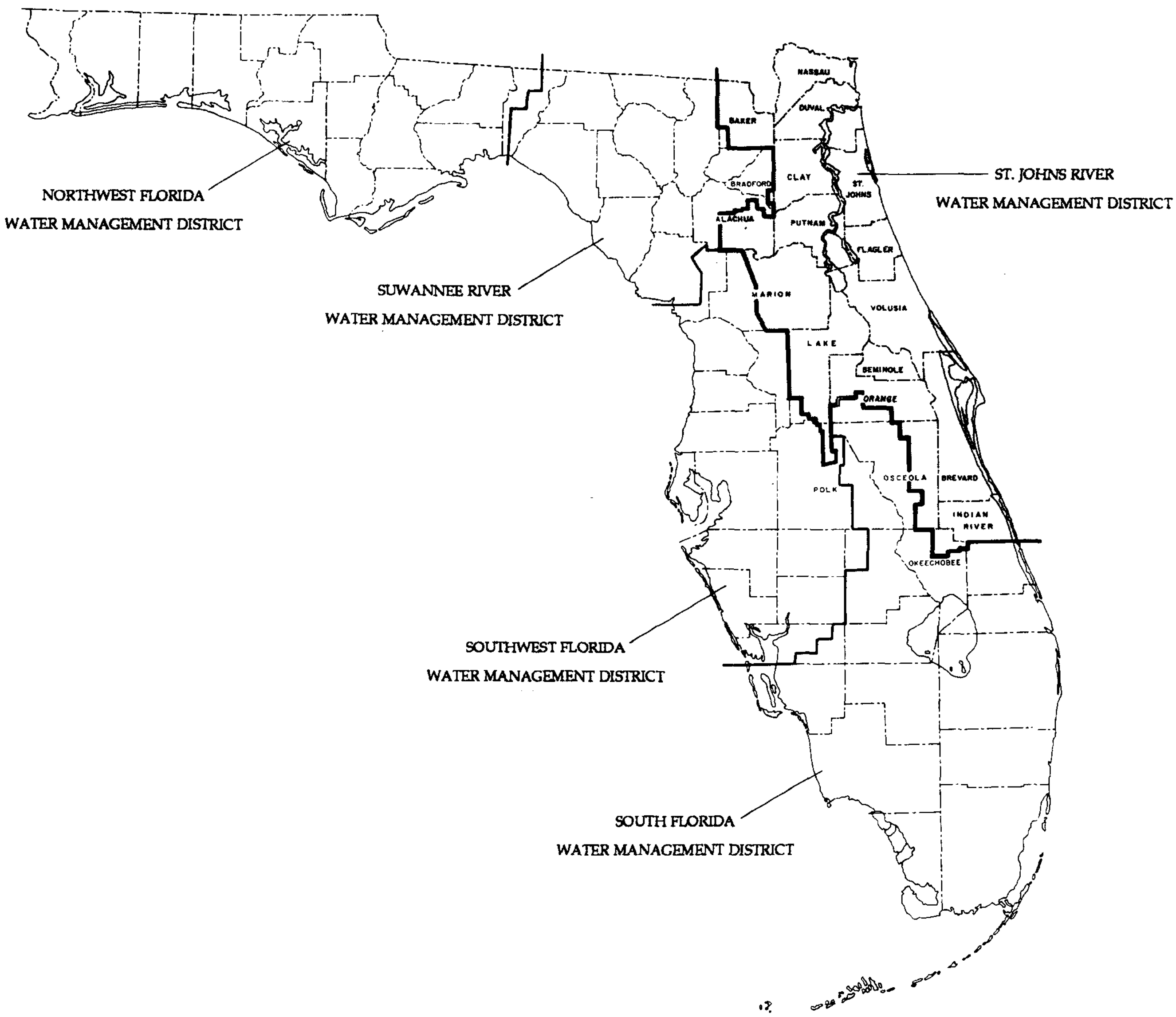
Palatka, Florida

1990



THE ST. JOHNS RIVER WATER MANAGEMENT DISTRICT

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 parts of nineteen counties in northeast Florida. The mission of SJRWMD is to manage water resources to insure their continued availability while maximizing environmental and economic benefits. It 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. Technical reports are published to disseminate information collected by SJRWMD in pursuit of its mission.

CONTENTS

FIGURES

Figure

INTRODUCTION

Rapid population growth, urban sprawl, and increased agricultural and industrial activities in recent years have resulted in significantly increased stresses on the water resources throughout the state. In response to increased awareness of water resource issues, the Florida legislature has adopted legislation with the intent to improve water resource management and guide future growth through state, regional, and local planning programs.

This legislation has created a comprehensive planning process at the state, regional, and local levels of government. Local comprehensive plans address the elements set forth in the state comprehensive plan. One of these elements is conservation--which is concerned with the conservation, use, and protection of natural resources, including water and water recharge areas (Section 163.3177, Florida Statutes).

This legislation has directed the water management districts to develop a ground water basin resource availability inventory (GWBRAI) and to disseminate the inventory to local governments and regional agencies for use in the comprehensive planning process. (Section 373.0395, F.S., see Appendix A).

This report provides a general inventory of the ground water resources of the Middle St. Johns (MSJ) ground water basin, including hydrogeologic features, recharge and discharge areas, ground water quality characteristics, present and projected water use, potential for direct water reuse, and areas suitable for future water resource development. The MSJ ground water basin is one of five ground water basins in the St. Johns River Water Management District (SJRWMD) (Figure 1). A ground water basin is a particular ground water flow system that encompasses recharge areas and the associated discharge areas. The MSJ ground water basin is located almost entirely within Lake, Seminole, Marion, and northern Orange counties (Figure 2).

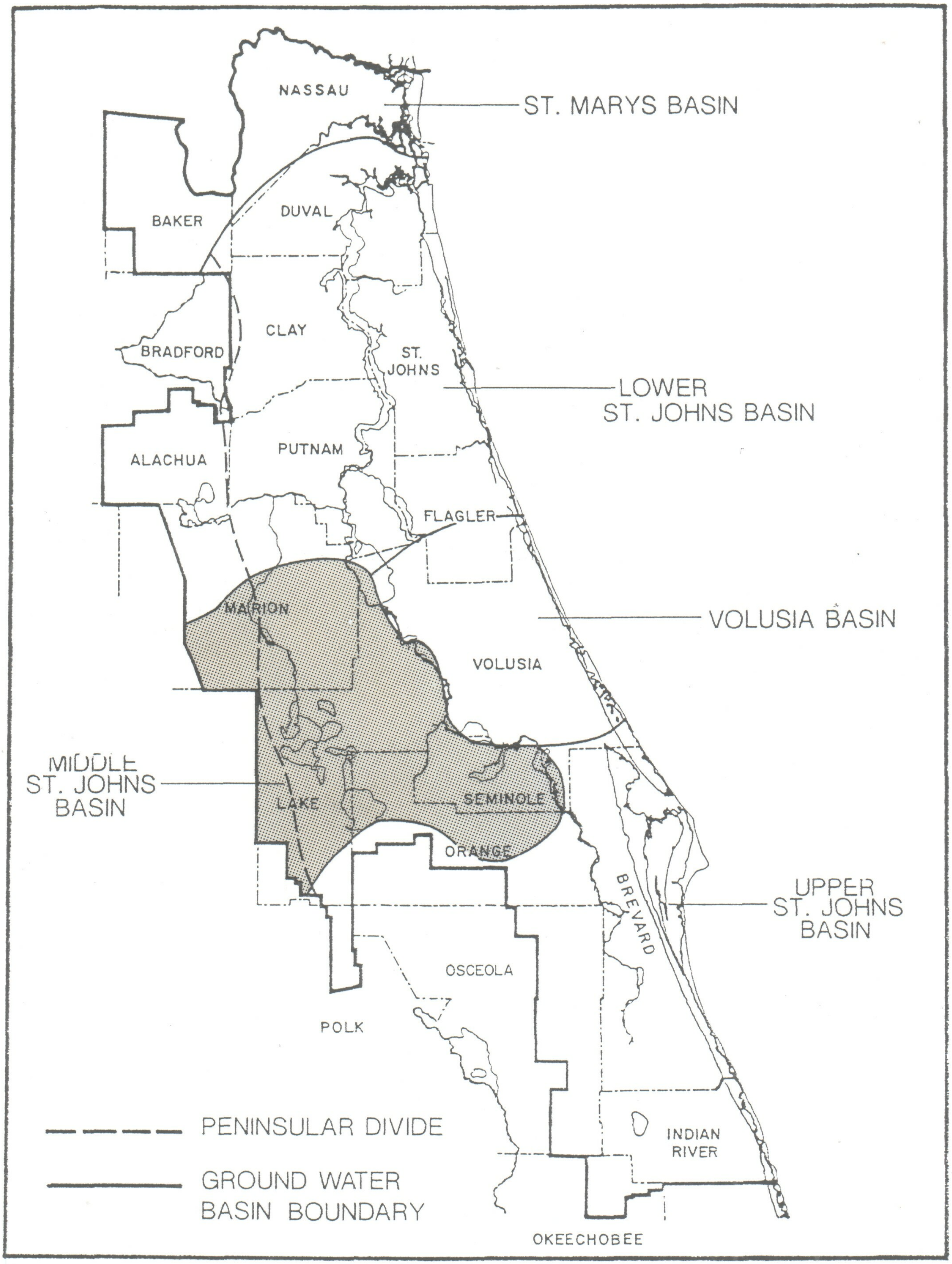


Figure 1. St. Johns River Water Management District and ground water basins

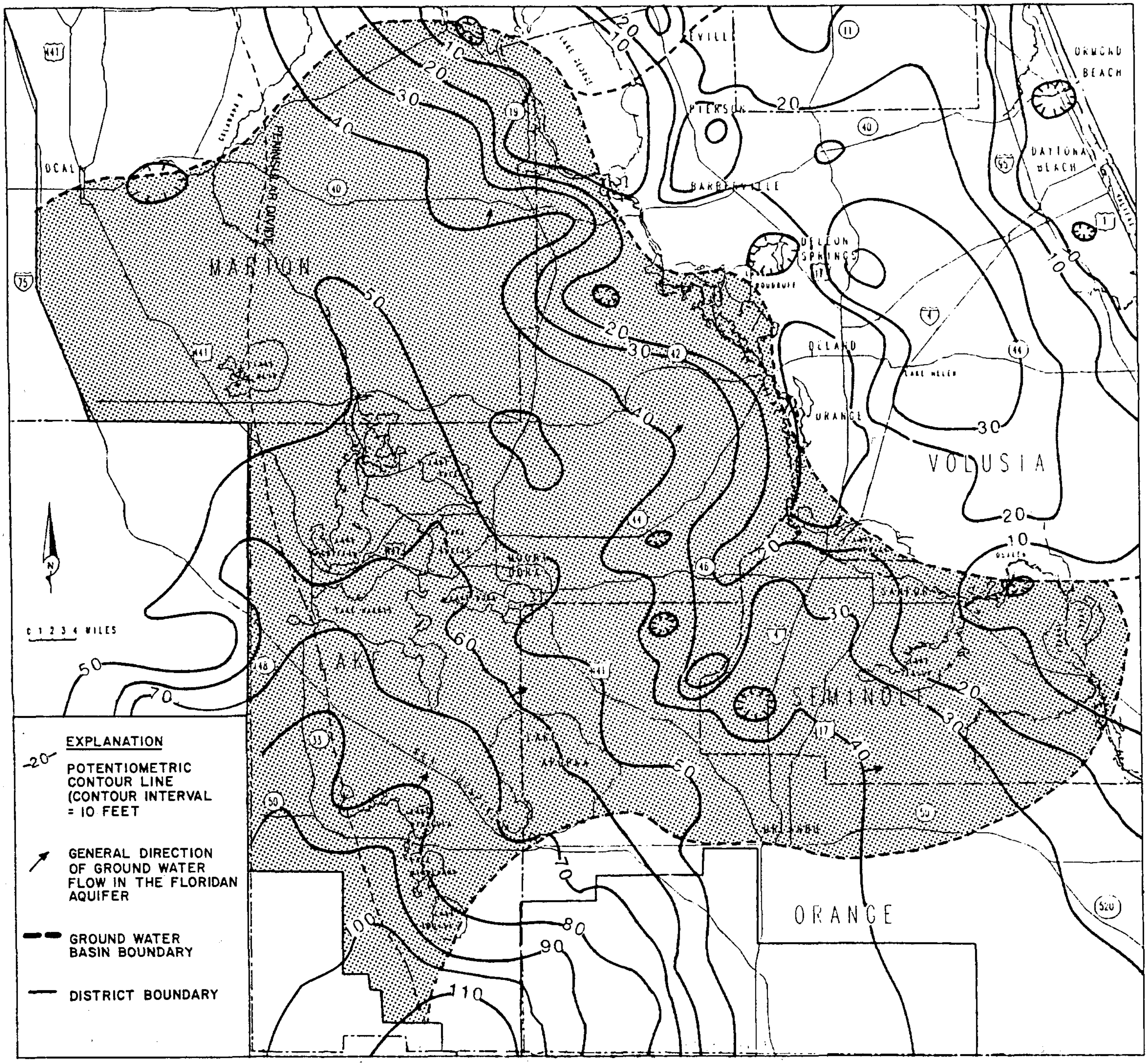


Figure 2. The Middle St. Johns ground water basin potentiometric surface for May 1987, modified from Schiner and Hayes (1981)

PHYSIOGRAPHY

The MSJ ground water basin is in the Central Highlands physiographic province (Cooke 1945). It is characterized by karst topography, valleys, and ridges (Figure 3).

Karst topography is an irregular, pitted land surface formed by the dissolution of limestone. This topography is characterized by high relief, circular lakes, sinkholes, and caves at land surface (Figure 4). Acting as reservoirs, these ridges can store surface and ground water until it is recharged into the Floridan aquifer or evaporates.

The main valley that dissects the MSJ ground water basin is the Central Valley. This valley separates the Mount Dora Ridge to the east from the Lake Wales Ridge to the west. It extends across the length of the basin in a NW to SE direction. It is characterized by the Oklawaha chain of lakes, flatlands, and high surface runoff (Knochenmus and Hughes 1976).

Ridges are present in many areas of the basin. Two major ridges extend across the basin. The ridge areas are characterized by deep lakes, low water tables, and subsurface drainage. Lake Wales Ridge, the higher of the two, with elevations of 200-300 ft, is the most prominent feature in the basin. It is located in Lake County. The second ridge, Mount Dora Ridge, is predominantly located in Marion, Lake, and Orange counties. Both ridges parallel the Atlantic coastline, implying a coastal origin (Cooke 1945). There are two smaller ridges present in the MSJ ground water basin: the Orlando Ridge and Geneva Hill in Orange and Seminole counties, respectively.

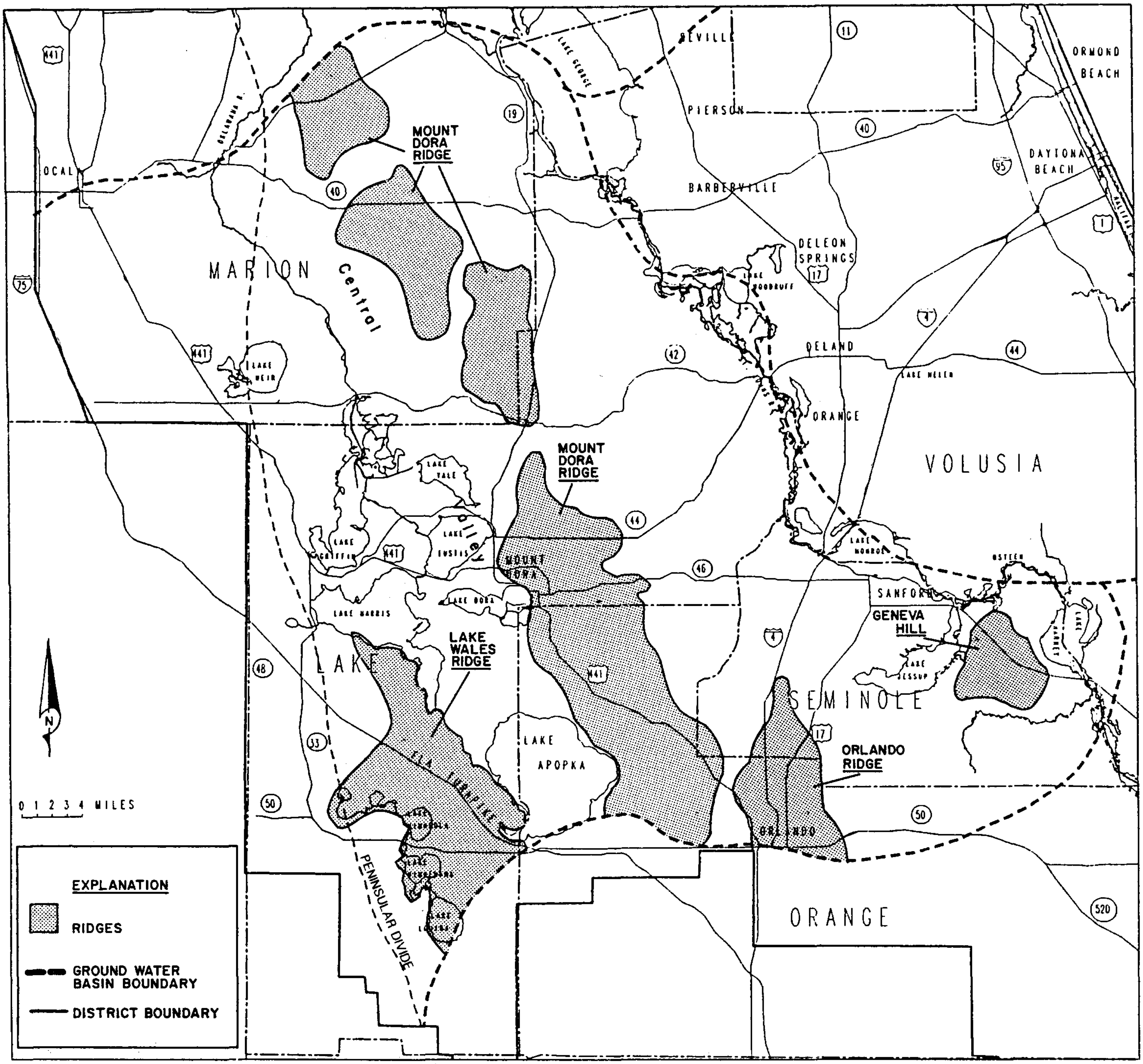


Figure 3. Physiographic features of the Middle St. Johns ground water basin, modified from Puri and Vernon (1964), and from White (1970)

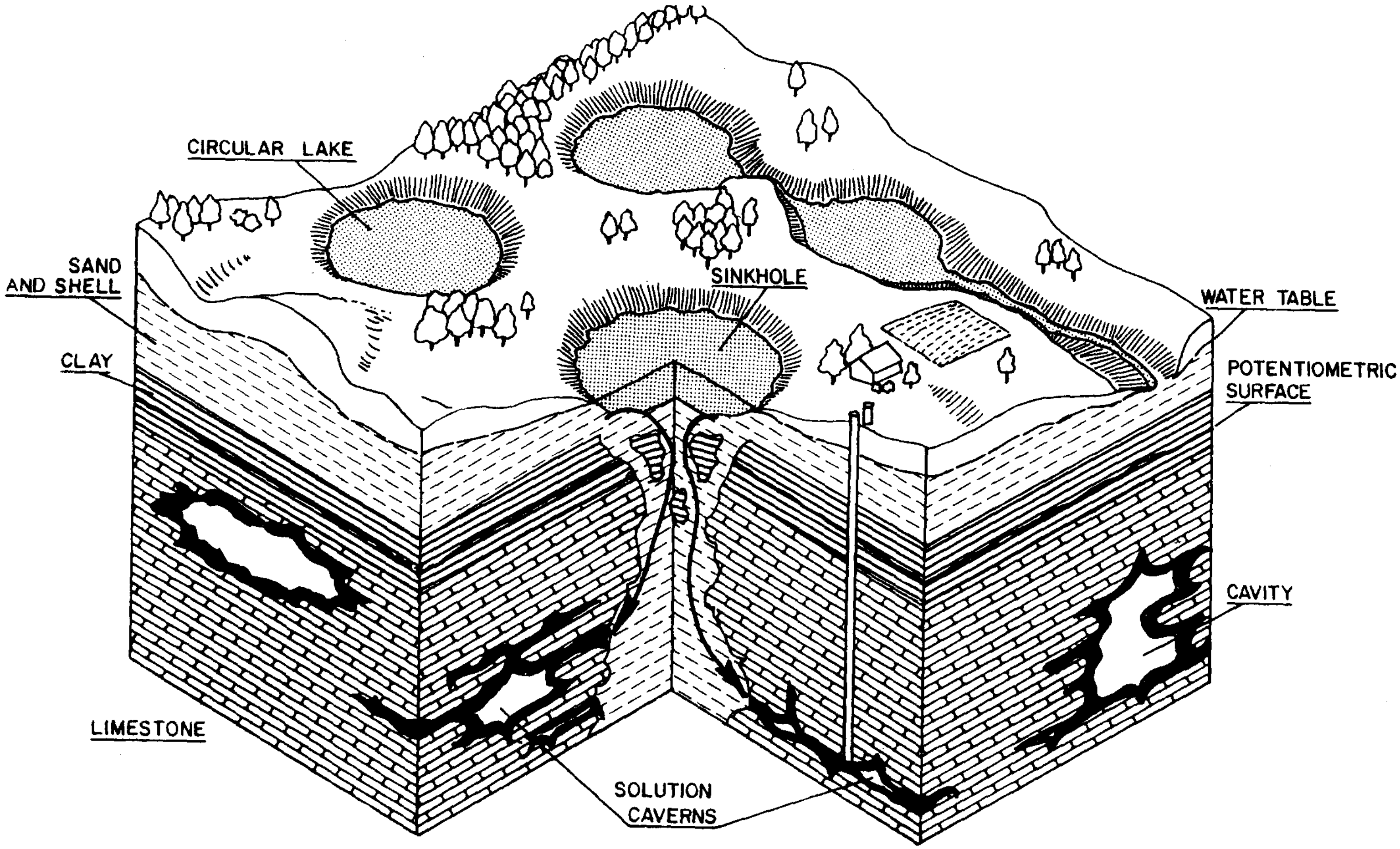


Figure 4. Generalized karst topography

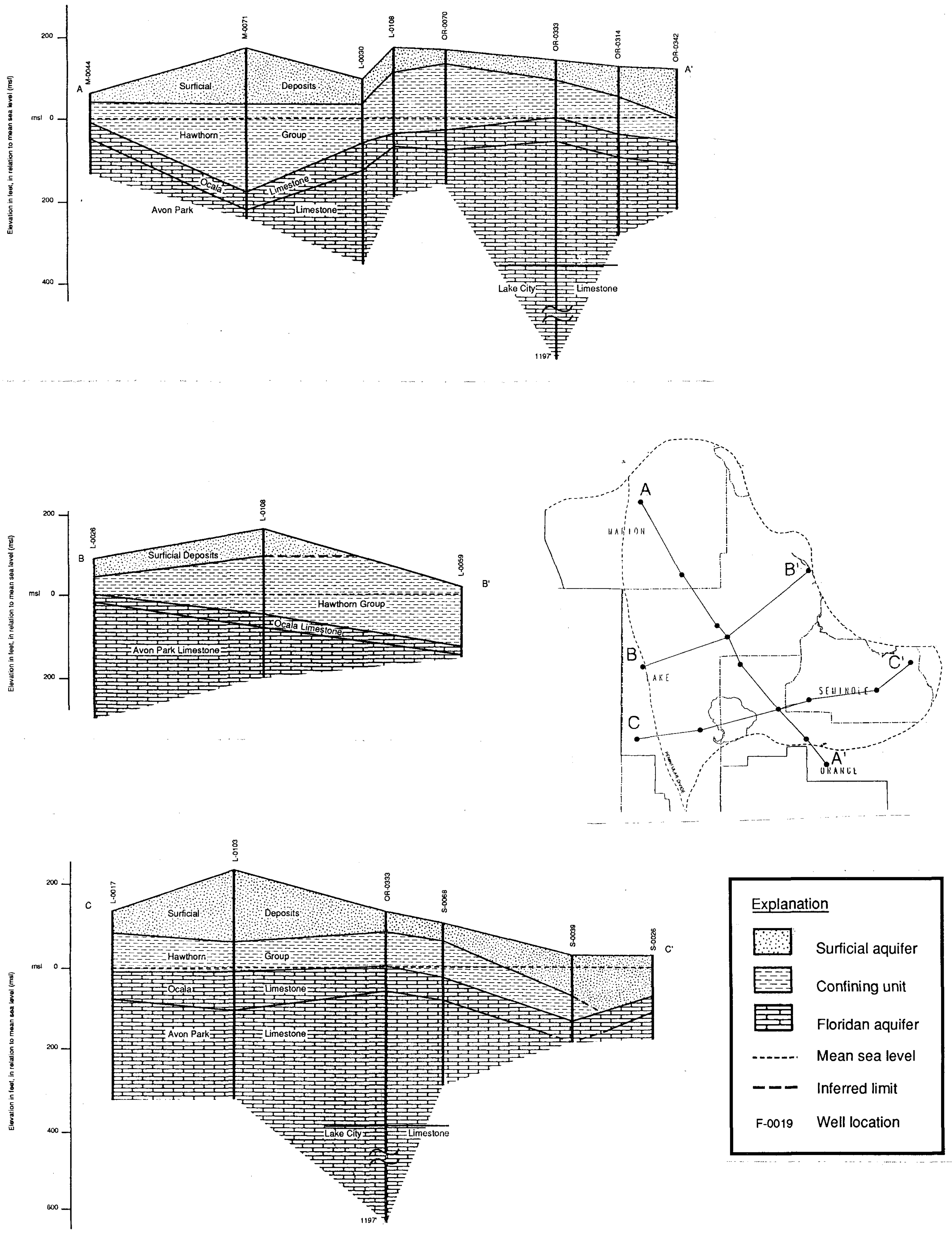
HYDROGEOLOGY

Three aquifers have been identified in the MSJ ground water basin. These are the surficial (unconfined), the intermediate, and the Floridan aquifer systems (Figure 5).

The surficial aquifer is composed of sands, shells, and some clays. The aquifer ranges in thickness from 20 ft near the St. Johns River to approximately 60 ft in the central part of the basin. Because there is no overlying confining unit, the aquifer is directly replenished by rainfall. The top of the aquifer is defined by the water table, which is free to rise and fall in response to atmospheric pressure. The water table marks the line below which all pore spaces are filled with water. Flow in the surficial aquifer usually follows the topography of the land. The surficial aquifer is an important source of water supply in areas where the Floridan aquifer contains water which exceeds the EPA recommended public drinking standards. In the MSJ ground water basin, the surficial aquifer is an important source of water for individual domestic wells and small-scale irrigation.

The intermediate aquifer, which lies between the surficial and the Floridan aquifer occurs randomly throughout the ground water basin. Composed of clays, and thin, water-bearing zones of sand, shell, and limestone, this aquifer is usually found within the confining unit above the Floridan aquifer. This aquifer occurs at 60-150 ft below land surface and supplies water to some parts of the basin (Lichtler, Anderson, and Joyner 1968). This aquifer is an important source of potable water where the Floridan aquifer contains water of marginal quality.

The Floridan aquifer is an artesian aquifer composed of limestone and dolomite. In artesian aquifers the ground water is under pressure that is greater than atmospheric pressure. This pressure is demonstrated by the potentiometric surface, which is the level to which water will rise in tightly cased wells that penetrate the aquifer. When plotted and contoured on a map this surface can be interpreted to show the direction of ground water flow (Figure 2). Ground water moves from areas of higher pressure to areas of lower pressure. Wells will flow when constructed in areas where the potentiometric surface of the aquifer is above land surface. Such flowing wells are common along the St. Johns River.



Note: The USGS combines the Lake City and Avon Park limestone, calling them the Avon Park Formation (Miller, 1982)

Figure 5. Hydrologic cross sections of the Middle St. Johns ground water basin

GROUND WATER RECHARGE

SURFICIAL AQUIFER SYSTEM

Recharge to the surficial aquifer system is controlled by local rainfall, land use, vegetation, topography, and local soils. A generalized soils map for the MSJ ground water basin provides one way to assess potential recharge to the surficial aquifer system. Areas of highly permeable, sandy soils are typically good recharge areas for the surficial aquifer system. These soils transmit fluids easily and can yield significant quantities of water. Areas characterized by impermeable soils are areas of little or no recharge to the surficial aquifers (Figure 6). The surficial aquifers can discharge into surface streams, lakes, and rivers or to deeper aquifers.

FLORIDAN AQUIFER

The Floridan aquifer is recharged by the surficial aquifer in areas where the water level in the surficial aquifer is higher than the elevation of the potentiometric surface of the Floridan aquifer. The Orlando, Lake Wales, and Mount Dora ridges have high potential for recharge to the Floridan aquifer in the MSJ ground water basin. Areas in the MSJ ground water basin have been classified according to the potential recharge capability from the surficial aquifer to the Floridan aquifer (Phelps 1984, Stewart 1980, Healy 1975) in a range from zero recharge to high recharge (Figure 7).

PRIME GROUND WATER RECHARGE AREAS

Section 373.0395, F.S., provides that the GWBRAI should include the designation of prime ground water recharge areas for the Floridan aquifer. A pilot study to delineate areas of prime recharge to the Floridan aquifer has been performed by SJRWMD (Boniol 1990). The pilot study area is the Crescent City Ridge area of southeastern Putnam County. The methodology and knowledge gained from this pilot study will be used to delineate prime recharge areas in other areas of the district. Prime ground water recharge areas to the Floridan aquifer are currently scheduled to be delineated by July 1, 1991.

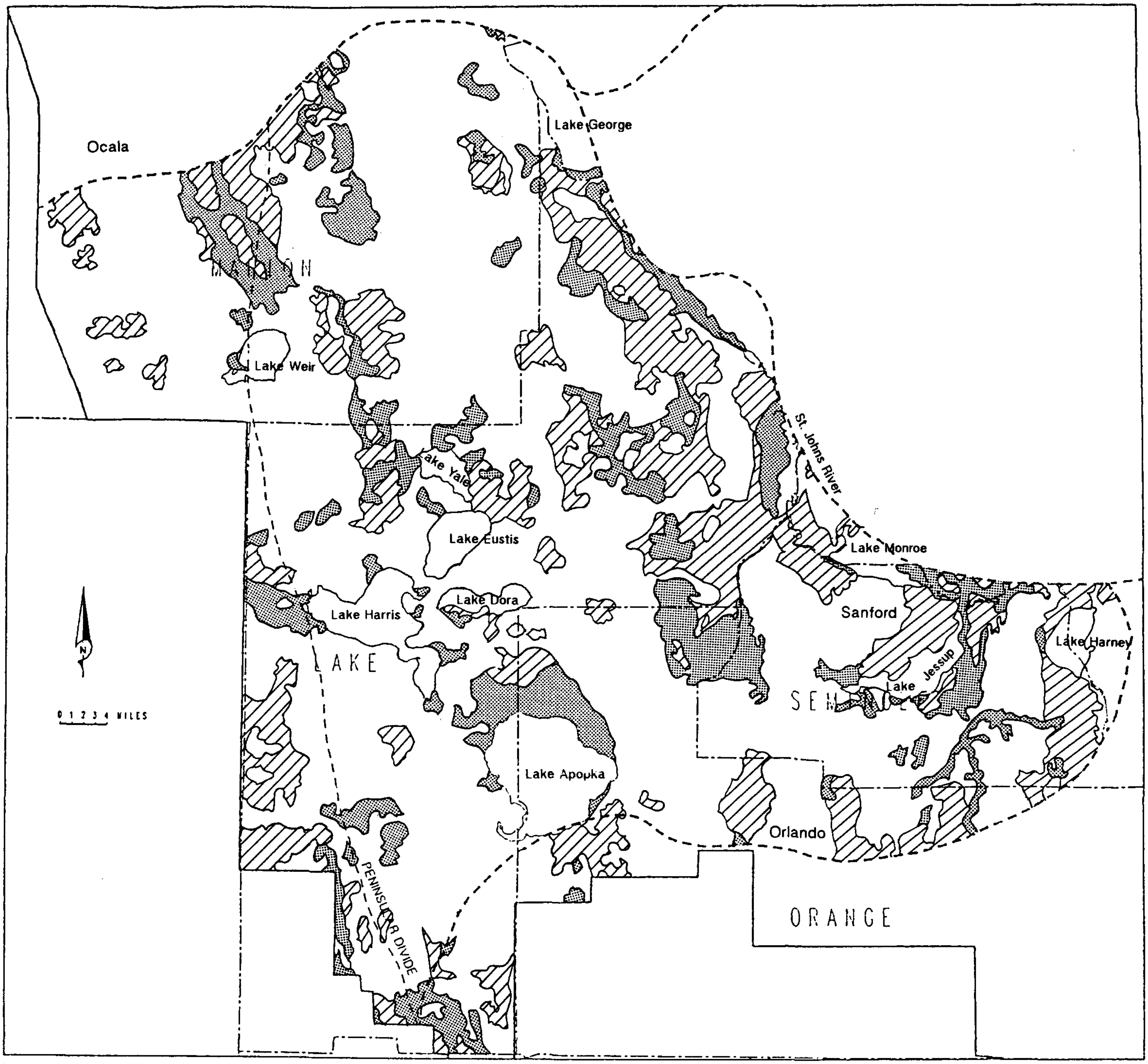


Figure 6. Permeability of soils in the surficial sediments of the Middle St. Johns ground water basin. Very permeable soils indicate areas of potential recharge to the surficial aquifer system

Explanation

Areas dominated by sandy soils: very permeable

Areas dominated by moderately drained soils

Areas dominated by poorly-drained soils: very impermeable

Basin boundary line

County line

Peninsular divide

District boundary line

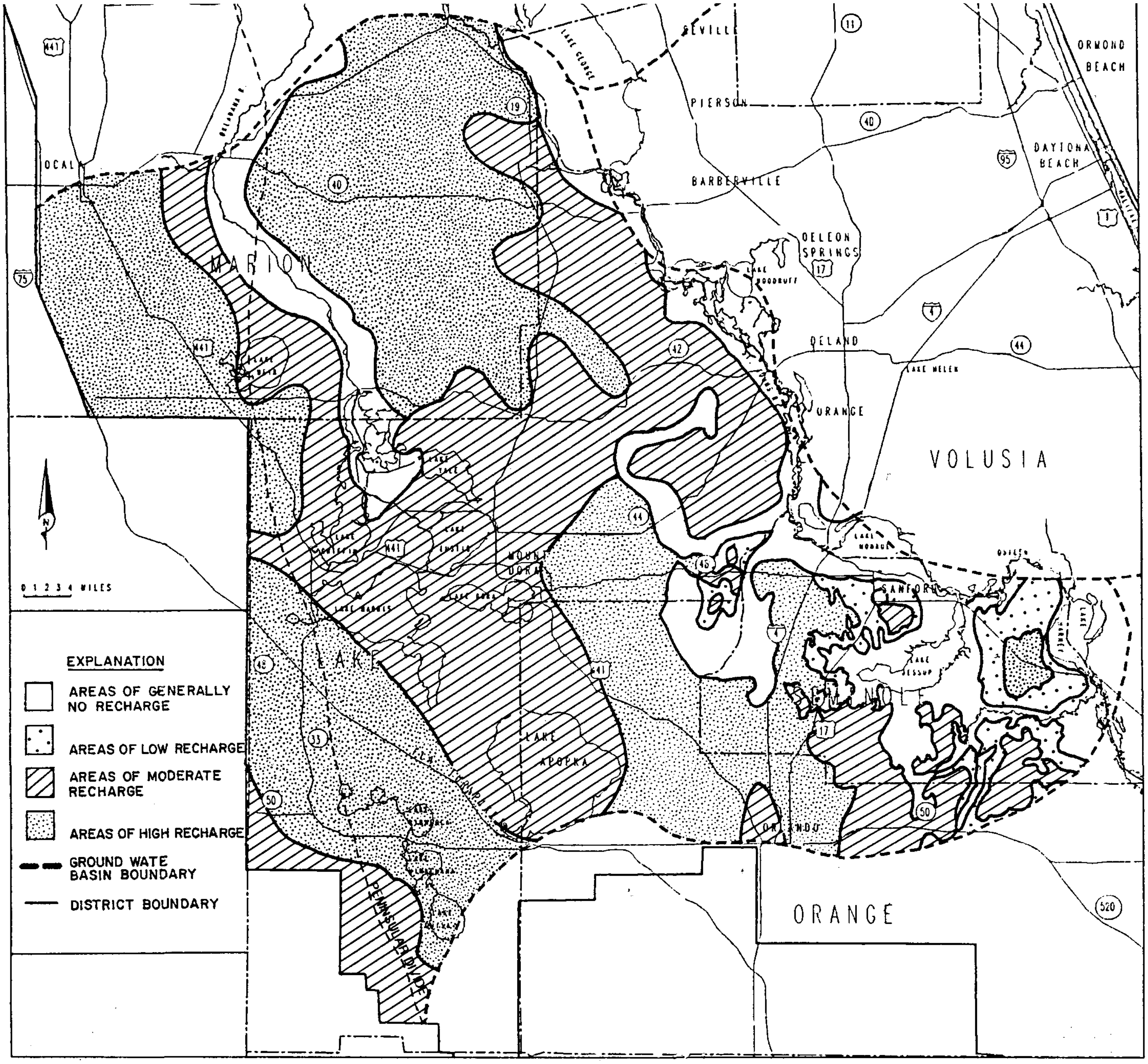


Figure 7. Approximate areas of natural recharge and discharge for the Floridan aquifer in the Middle St. Johns ground water basin, modified from Stewart (1980)

GROUND WATER QUALITY

The natural quality of ground water in the MSJ ground water basin varies greatly depending on the location and the depth from which water is obtained. A major concern in this basin is saltwater intrusion in Seminole County. The Environmental Protection Agency (EPA) has set a recommended limit of 250 milligrams per liter (mg/l) of chloride and sulfate for public water supplies.

Based on these standards, the potable water in the Floridan aquifer can be mapped. Although the MSJ ground water basin is inland from the sea and bordered on the west by the peninsular divide, there are some patches of connate salt water in the Floridan aquifer. Figure 8 shows the contour lines of the depth to the base of potable water and those patches of salt water. The depth to the base of potable water increases from northeast to southwest in the basin. Its magnitude is influenced by the freshwater-saltwater equilibrium described by the Glyben-Herzberg formula (Kashef 1986).

The reports and data used to compile this map of the potable water zone span a period from about 1950 to 1969, and no consideration was given to seasonal or long-term changes in thickness or local variations due to pumpage. Therefore, this map cannot be used to determine the exact thickness of potable water in the Floridan aquifer at any specific location or at any specific time. In areas where the potentiometric surface has declined since 1950, both the thickness and depth to the base of potable water will be less.

The quantity of potable water within the Floridan aquifer varies with fluctuations in the potentiometric surface. These fluctuations result from seasonal climatic changes (changes in recharge) and from changes in the magnitude of ground water withdrawal. The potable water in the aquifer is underlain by denser saline water. The potential exists for this saline water to move upward within the aquifer system in response to declines in the potentiometric surface (Figure 9).

In the MSJ ground water basin, chloride concentrations measured in water samples withdrawn from wells that penetrate the Floridan aquifer generally decrease from east to west and increase with depth within the aquifer. These concentrations can be nearly zero in recharge areas, but tend to be higher in discharge areas along the St. Johns River, where lenses of relict brackish water exist in the Floridan aquifer, and concentrations of chloride can exceed 1000 mg/l (Figure 10).

In addition to chloride concentrations, sulfate concentrations in the Floridan aquifer vary from nearly zero in recharge areas to greater than 250 mg/l in discharge areas (Figure 11).

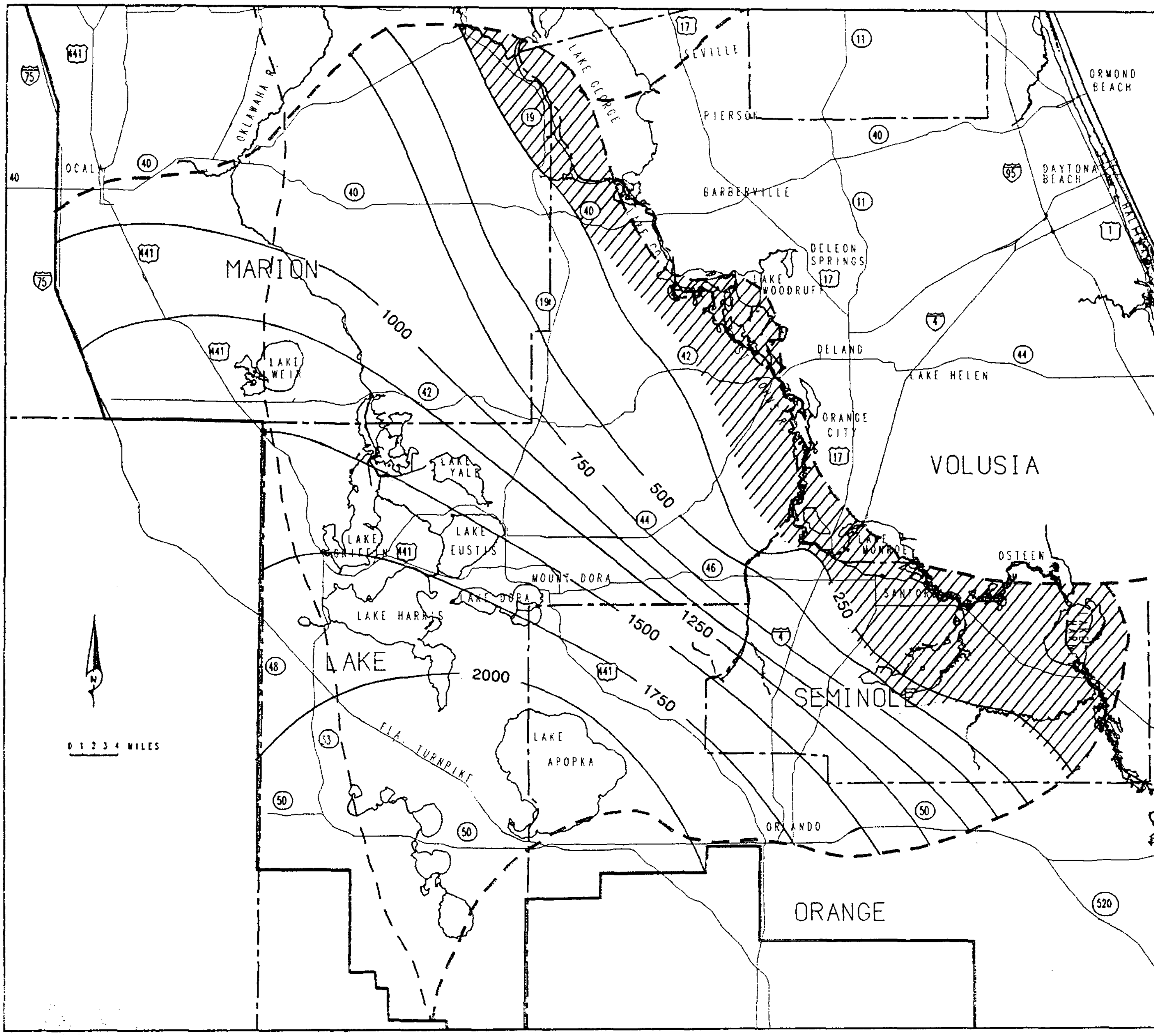


Figure 8. Depth to the base of the potable water in the Floridan aquifer in the Middle St. Johns ground water basin, from Klein 1971

Explanation

250 Zone of equal thickness of potable water, in feet (interval = 250 feet)

Area in which chloride concentration of water in upper Floridan aquifer system exceeds 250 mg/l

Basin boundary line

County line

Peninsular divide

District boundary line

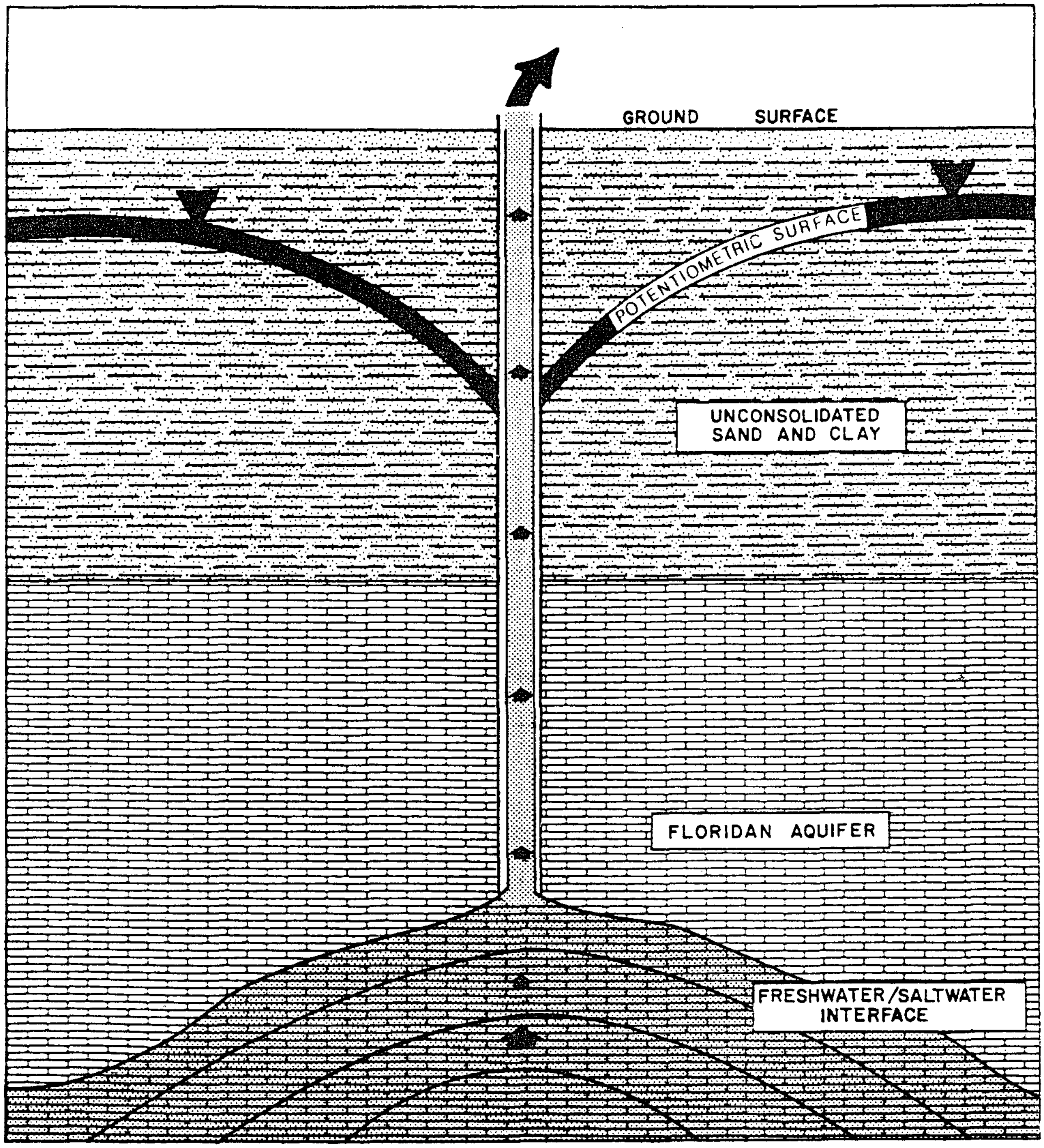


Figure 9. The movement of relict brackish water at the freshwater/saltwater interface caused by pumping

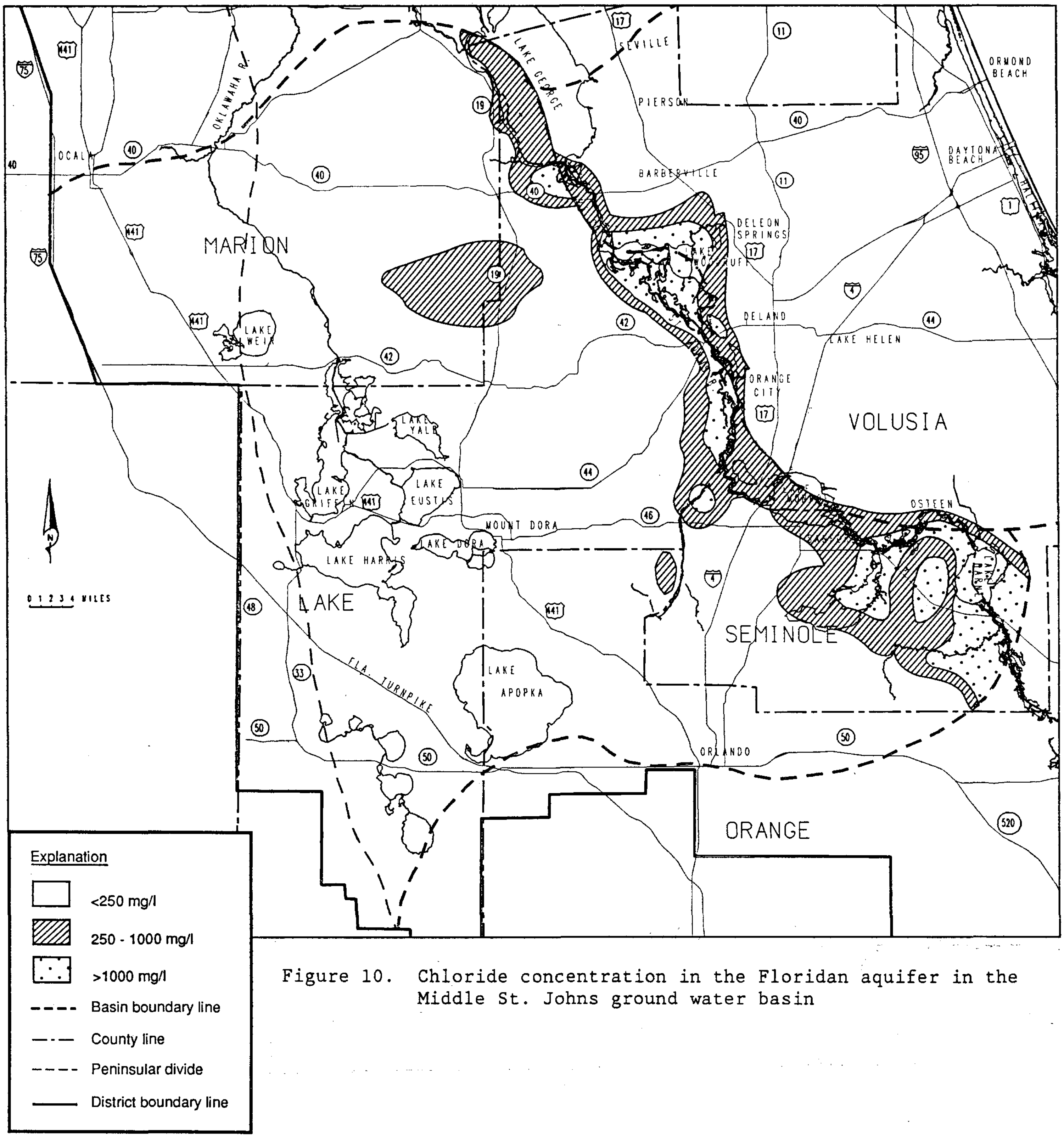


Figure 10. Chloride concentration in the Floridan aquifer in the Middle St. Johns ground water basin

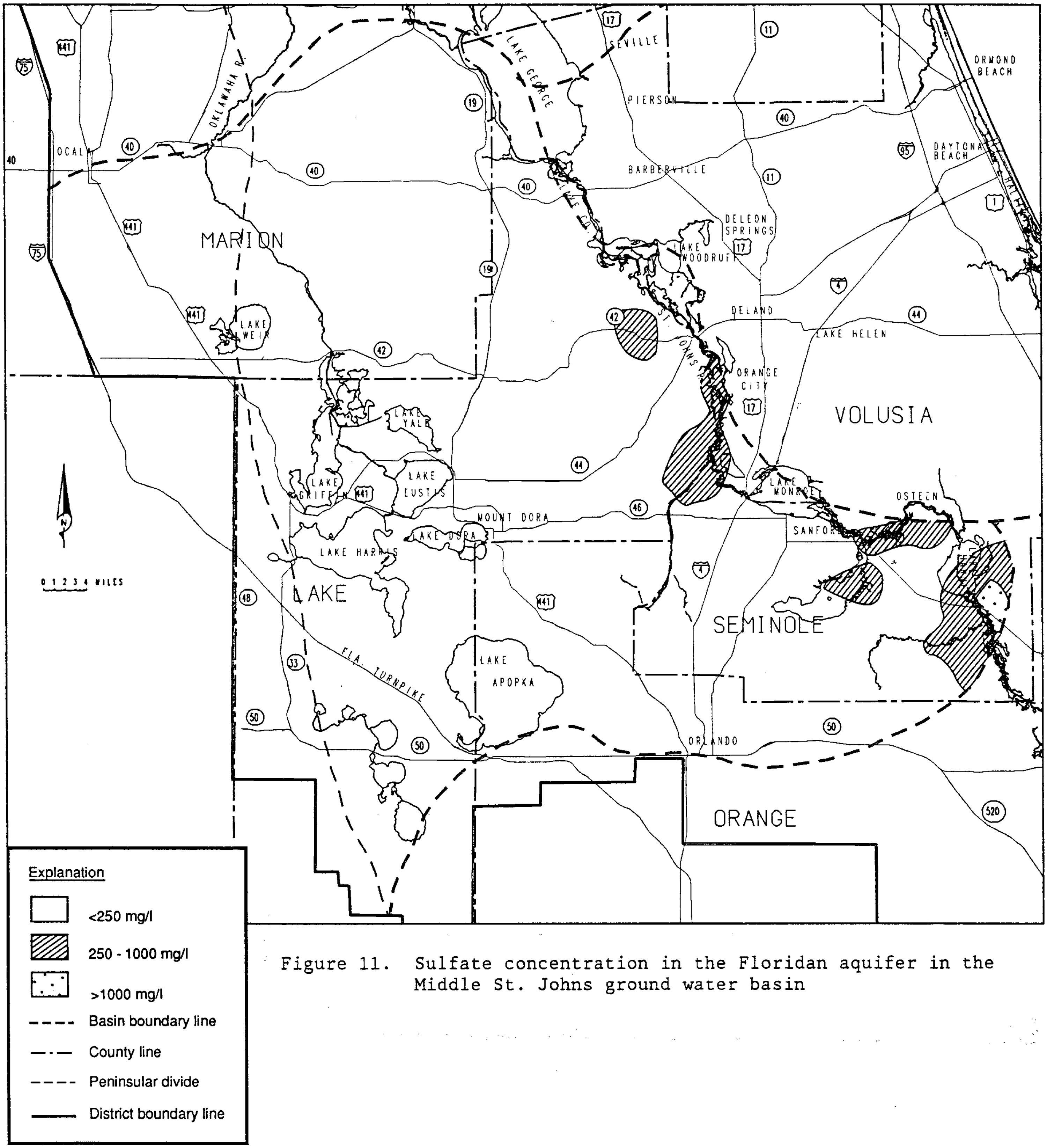


Figure 11. Sulfate concentration in the Floridan aquifer in the Middle St. Johns ground water basin

AREAS PRONE TO SALTWATER INTRUSION

The potential for saltwater intrusion exists in the MSJ ground water basin. The sources for this potential intrusion are lateral and vertical saltwater migrations that depend on changes in the potentiometric surface and in the magnitude of ground water withdrawals and climatic changes. As the potentiometric surface declines, the potential for the upward and horizontal movement of saline water is increased.

The MSJ ground water basin is underlain by several thousand feet of marine sedimentary deposits. There are three aquifer systems in it: the surficial, the intermediate, and the Floridan. The surficial aquifer system is not used as a primary water supply source because of its low yield. The two aquifers commonly penetrated by water supply wells in the MSJ ground water basin are the intermediate and Floridan aquifers. The intermediate aquifer, consisting of permeable limestone lenses within the Hawthorn Group, provides a source of water for domestic wells.

The Floridan aquifer usually has two permeable zones containing potable water in the MSJ ground water basin. The upper permeable zone consists of cavernous Ocala and Avon Park limestones and extends from approximately 200 to 500 ft below land surface. Withdrawals from the upper permeable zone are generally limited to small public supply and domestic wells because of high bacterial levels.

The lower permeable zone consists of the cavernous Lake City Limestone and extends from about 1,000 to 1,300 ft below land surface. This zone provides public supply water in the area. Between the two permeable zones, limestone and dolomite of significantly lower permeability provide a confining unit.

A deep test well drilled in 1987 at Lake Ivanhoe in Orlando encountered the freshwater/saltwater interface at a depth of 2080 ft. This saline water underlies most of the Floridan peninsula and restricts the depth of potable water wells.

High chloride/high sulfate waters unsuitable for consumption are known along the St. Johns River in Seminole, Lake, and Marion counties, along the Wekiva River in Orange, Seminole, and Lake counties, and at two sites in Marion County in the upper zone of the Floridan aquifer. The origin of these saline waters is believed to be connate water--i.e., remnants of the retreating sea remaining in cavities of the Floridan aquifer.

Former and recent investigations carried out in Seminole County by the U. S. Geological Survey (Barraclough 1962a and b, Tibbals 1977) and by the St. Johns River Water Management District (Toth, Rohrer, and Munch 1989) demonstrate that water levels fluctuate seasonally in the MSJ ground water basin, but there has been no long-term water level decline, and water quality has not changed significantly in the last decade.

In order to manage the fresh ground-water resource for future supplies it will be essential to monitor and manage withdrawals in the MSJ ground water basin.

AREAS SUITABLE FOR FUTURE WATER RESOURCE DEVELOPMENT

Water resource development is affected by such factors as the cost of developing and transporting potable water and/or the cost of treating water to an acceptable level. In addition, other factors influencing the suitability of an area for water resource development are:

- water quality
- the thickness of potable water within a given aquifer
- whether confining units above aquifer zones of supply provide protection against contamination
- whether unique geologic conditions may cause sinkholes or land subsidence, and
- the magnitude of withdrawals associated with existing consumptive use permits.

Each of these factors must be considered specifically for any given site in the ground water basin.

Pursuant to the requirements of Section 373.0931(2)(e), F.S., the district is required to prepare an assessment by July 1, 1991, of the regional water resource needs and sources for the next 20 years. This assessment should provide more information concerning the suitability of water resource development in the MSJ ground water basin.

MINIMUM GROUND WATER LEVELS

The state legislature has mandated that the water management districts establish minimum flows and levels for surface and ground water (Section 373.042, F.S.). SJRWMD is developing a technique for establishing these levels. These levels, when proposed, must be adopted through the public hearing process, which will provide an opportunity for public input. Information relating to minimum ground water levels is scheduled to be provided to local governments by July 1, 1991.

WATER USE

Almost all of Lake and Seminole counties and large parts of Orange and Marion counties are included in the MSJ ground water basin. Orange and Marion counties are subdivided by two water management districts, and those portions in the SJRWMD fall into two ground water basins: the Upper St.Johns and MSJ ground water basins in Orange County and the MSJ and Lower St. Johns ground water basins in Marion County. As data are collected and tabulated on a county basis, population projections and water use were also calculated by county.

In the SJRWMD annual water use surveys (Marella 1982, 1986, and 1990), certain established percentages were used to approximate the percentage of the area and population of the counties included in SJRWMD: 0.99 for Lake County, 0.82 for Marion County, and 0.81 for Orange County.

In 1987, the four counties in this ground water basin used 333.24 million gallons of water a day (mgd) (Figure 12). The following graphs present actual water use through 1987 from the SJRWMD annual water use surveys, and projections for 1995 and 2000 (Figure 13a-d).

The projections are based on the assumption that increases in water use will be proportional to increases in population. Population projections were taken from the medium estimates given by the Bureau of Economic and Business Research of the University of Florida (Smith and Bayya 1990).

Estimates for total water use were obtained by multiplying per capita water use by the population projections for 1995 and 2000 from Smith and Bayya (1990). Per capita water use was assumed to be the same as in the most recent (1987) published data (Marella 1990).

Water use projections for 1995 and 2000 were made using two assumptions. First, based on 1987 data (Marella 1990), agricultural and industrial/power generation water use in each county were defined as percentages of the total water use by individual households (the sum of public supply and domestic self supply). Second, it was assumed that the percentages of agricultural and industrial/power generation water use in relation to the total water use by individual households would remain the same in the 1995 and 2000 projections as in the 1987 data.

The forecast for ground water consumption shows an increase from 333 mgd in 1987 to 456 mgd in 2000. That is a 37 percent increase in water use in 2000 from 1987 water use (Figure 14).

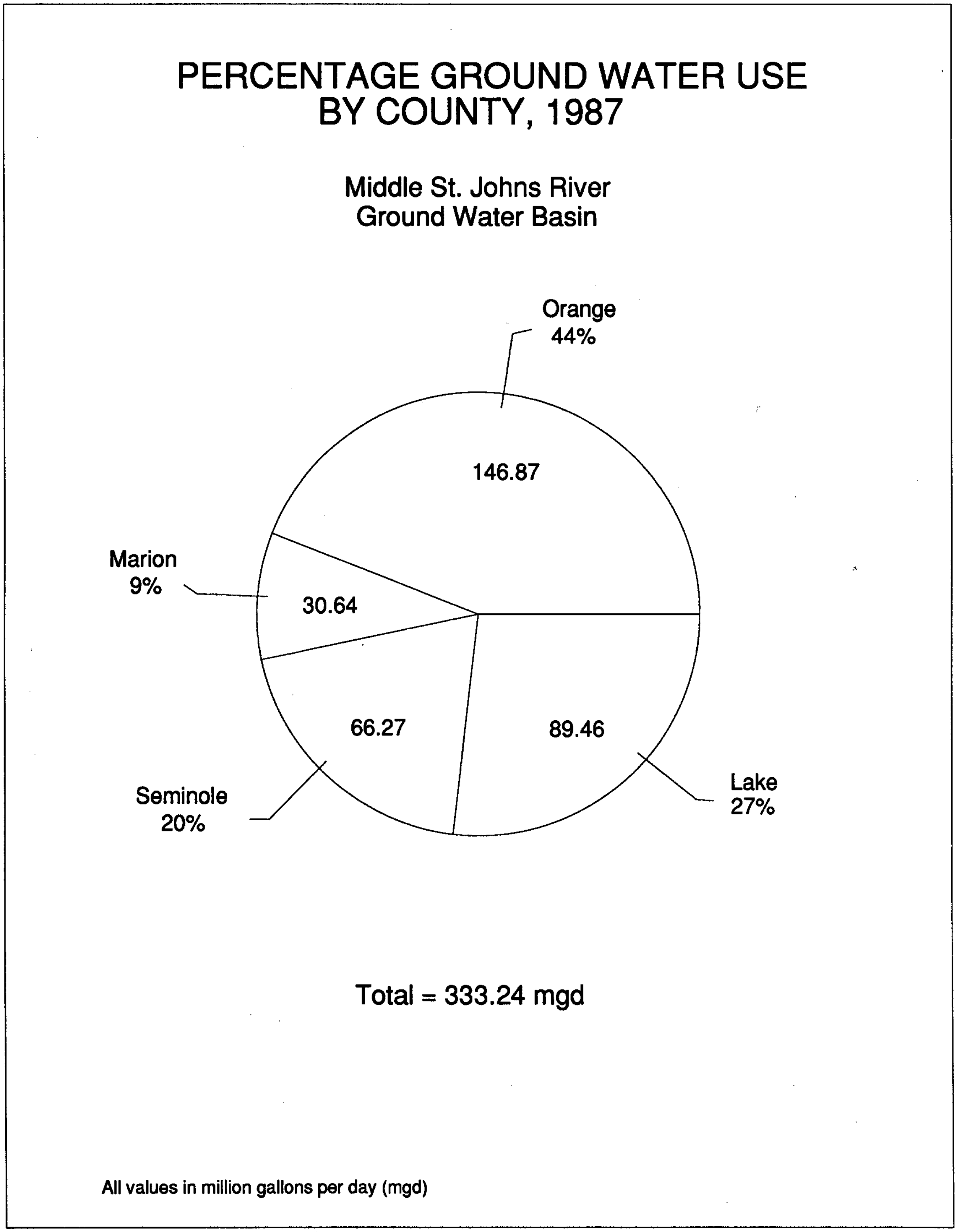


Figure 12. Percentage of ground water use in the Middle St. Johns ground water basin by county, 1987

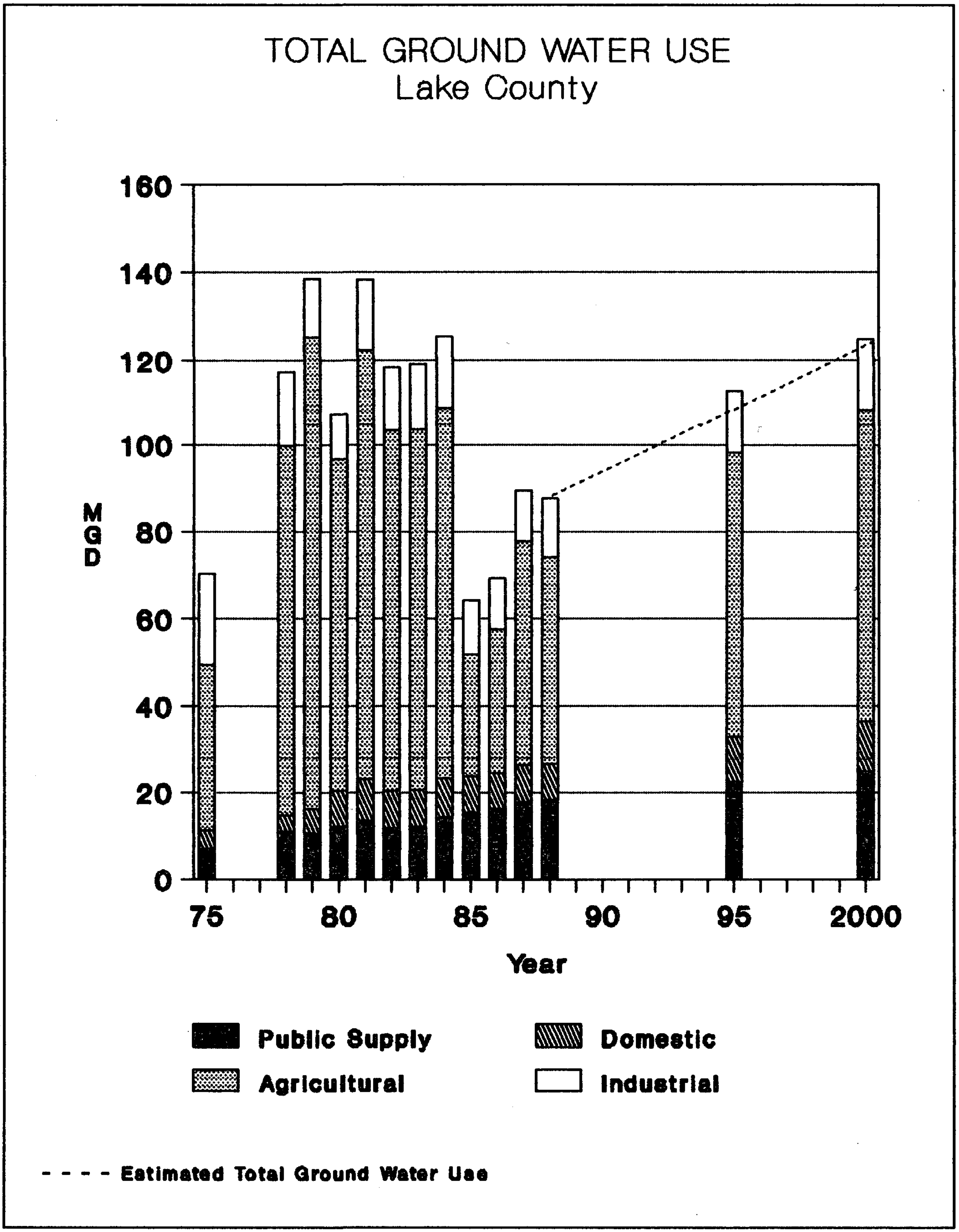


Figure 13a. Past and projected ground water use in Lake County

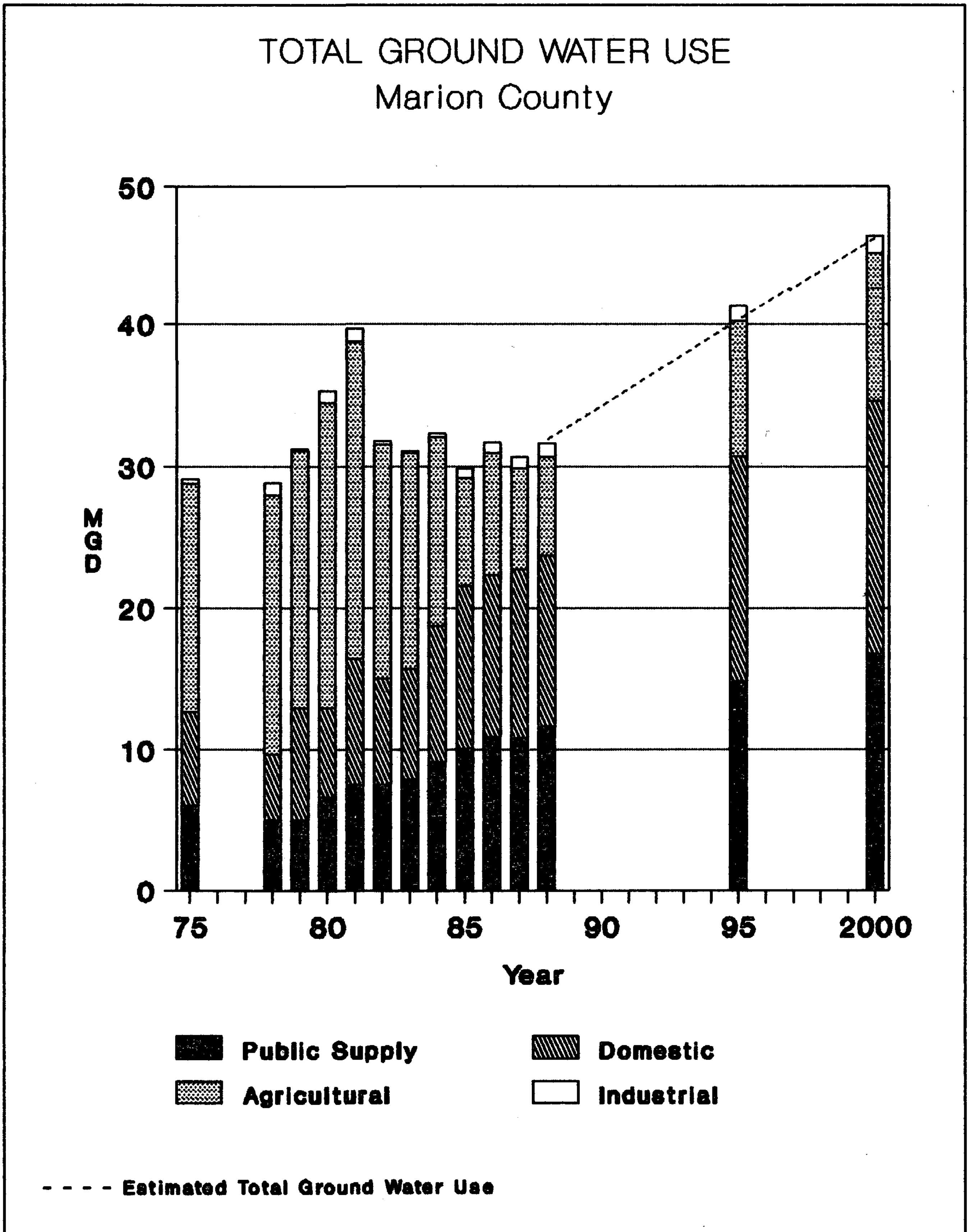


Figure 13b. Past and projected ground water use in Marion County

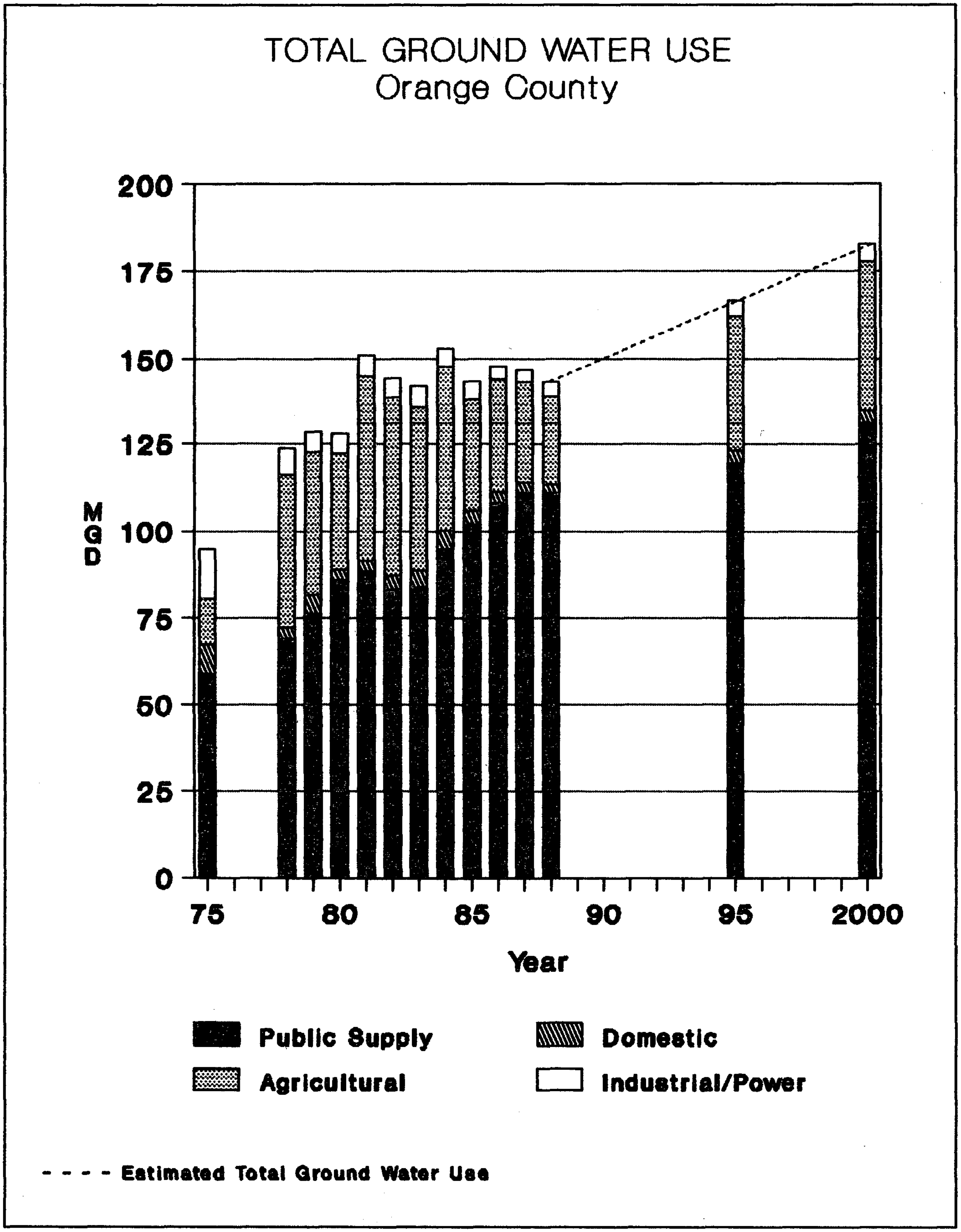


Figure 13c. Past and projected ground water use in Orange County

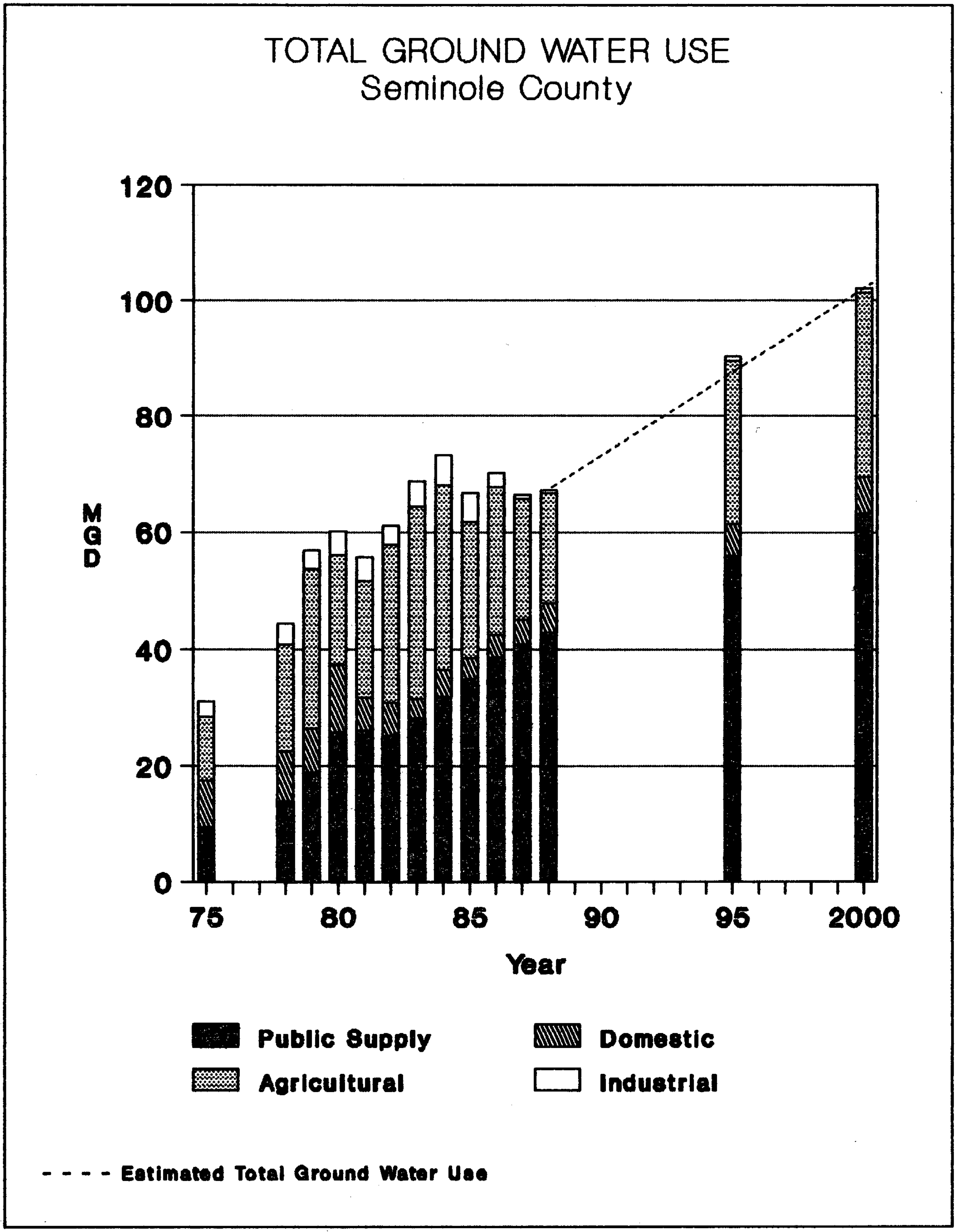


Figure 13d. Past and projected ground water use in Seminole County

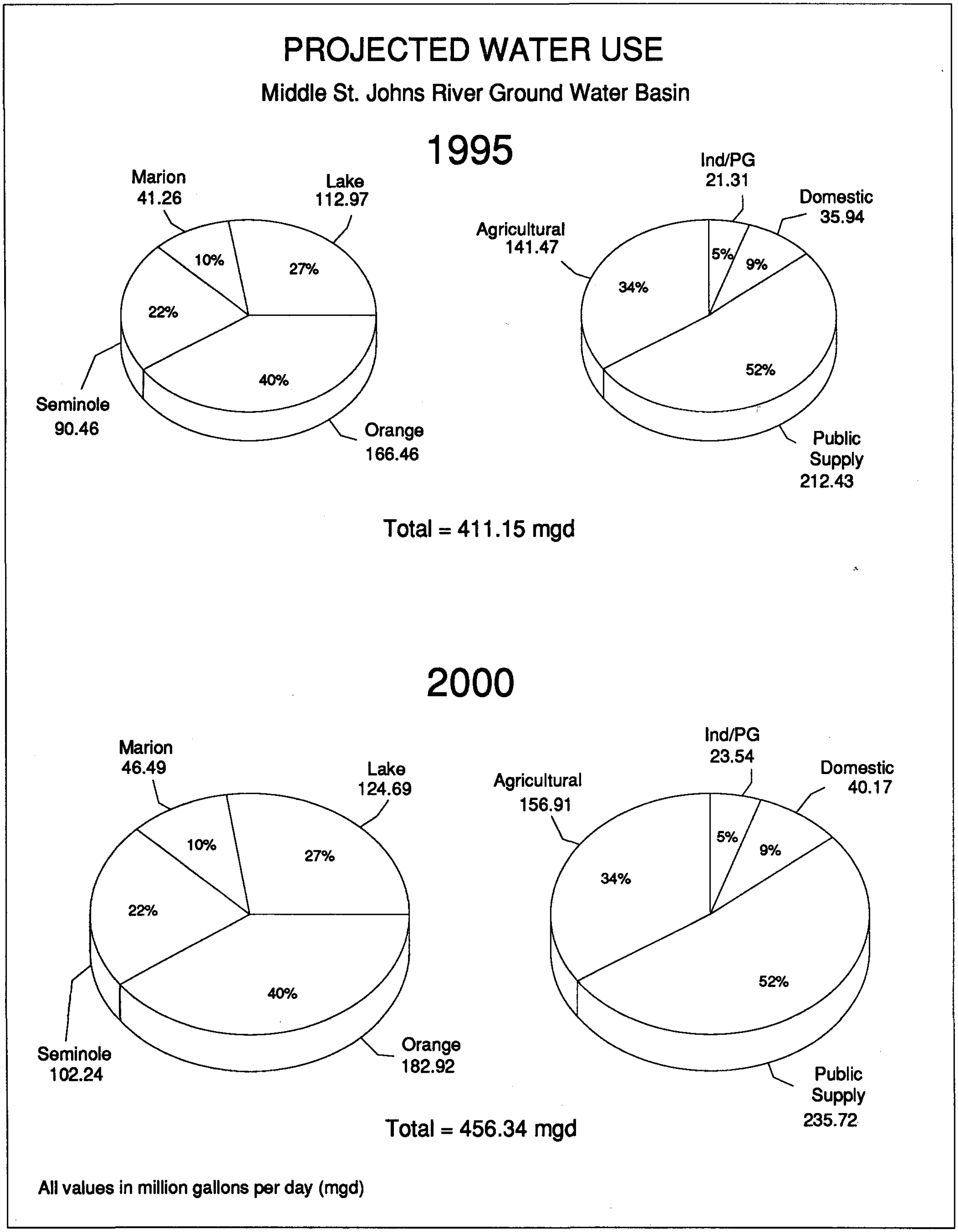


Figure 14. Projected water use for 1995 and 2000

DIRECT WATER REUSE

Effluent from a wastewater treatment plant (WWTP) can be treated to a specified level and then reapplied to land (i.e., lawns, golf courses, landscapes, and agricultural areas) or used by industry. In areas of increasing population and increasing water demands, reuse could prove to be an important conservation strategy. Agricultural irrigation, sewage treatment, and industrial processes often generate water that could be used again if treated to an environmentally acceptable level. This approach to supplementing water supply demands by utilizing reclaimed water could conserve significant quantities of fresh ground water for higher priority uses.

Reuse in the MSJ ground water basin could reduce potable water demands, help conserve water, solve problems with waste water disposal and help lessen the impact of ground water withdrawals. However, reuse can increase the cost of wastewater disposal by requiring improvements to existing wastewater treatment plants to meet higher standards of water quality treatment.

Proximity to golf courses, landscaped areas, and agricultural areas and industry are some of the important concerns when considering the cost effectiveness of a reuse program. WWTPs must have a design capacity of 1.0 mgd in order to be considered cost effective in land application of waste water (Steward 1985). Additionally, important environmental factors such as soil characteristics, depth to water table, and proximity of application site to surface waters need to be considered in a reuse program.

Orange, Lake, Marion, and Seminole counties have the potential to implement direct wastewater reuse programs in addition to existing programs (Figure 15). In 1990, these counties generated 311.90 mgd of waste water that was available for reuse. This waste water was discharged from private and municipal wastewater treatment plants and industrial-commercial facilities. In 1985, these counties used 2.96 mgd of reclaimed water. In 1988, these counties used 9.27 mgd of reclaimed water (Florence 1990) largely due to the Conserv II project in Orange County, under which the City of Orlando provides treated waste water for citrus irrigation. Orange and Marion counties have the most treated waste water available for reuse. Orange County uses 5 percent of the treated waste water available for reuse in the county, Marion County uses .01 percent, and Lake County uses 8 percent (Figure 16).

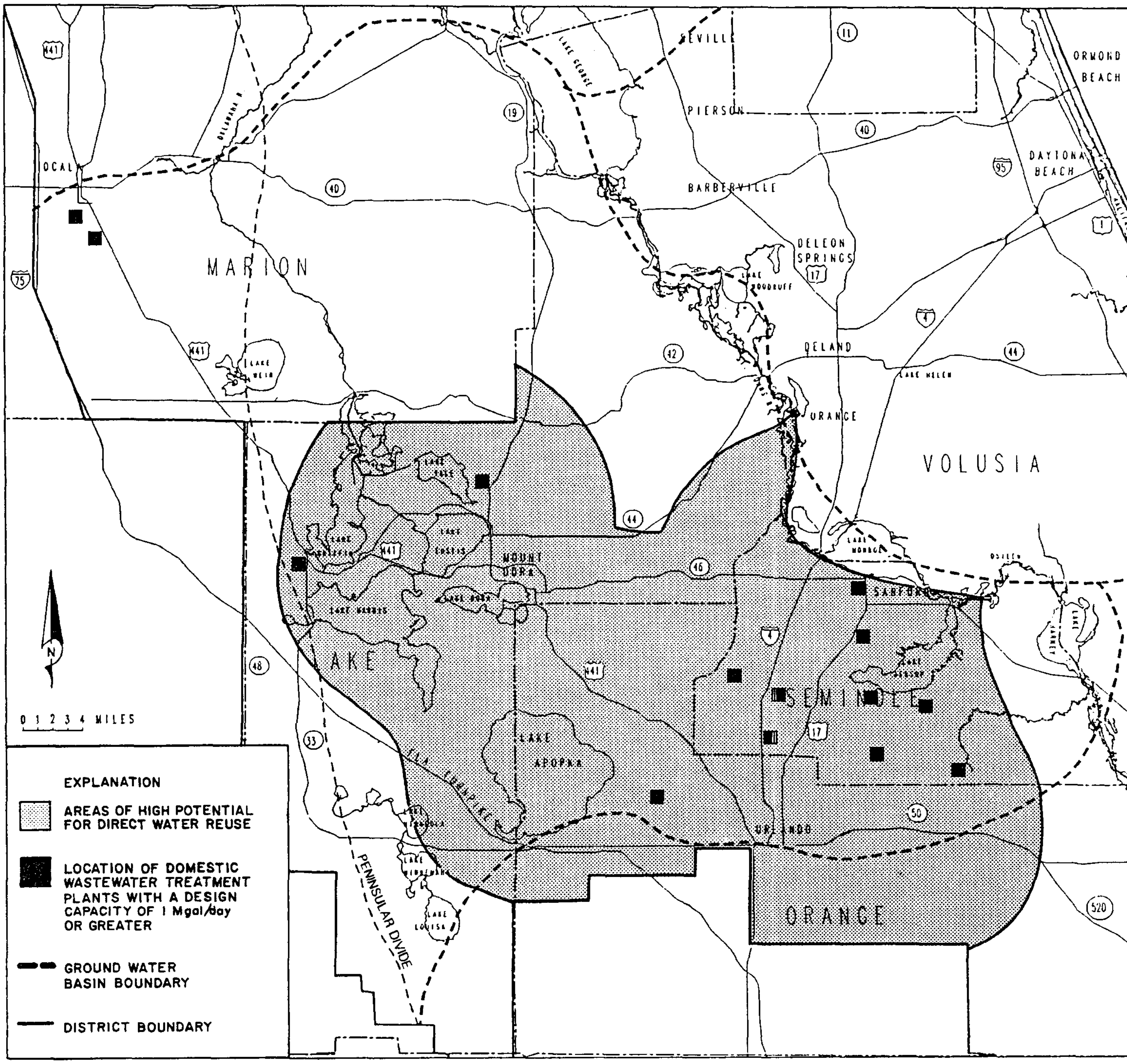


Figure 15. Areas of high potential for direct water reuse in the Middle St. Johns River ground water basin, modified from Steward (1985)

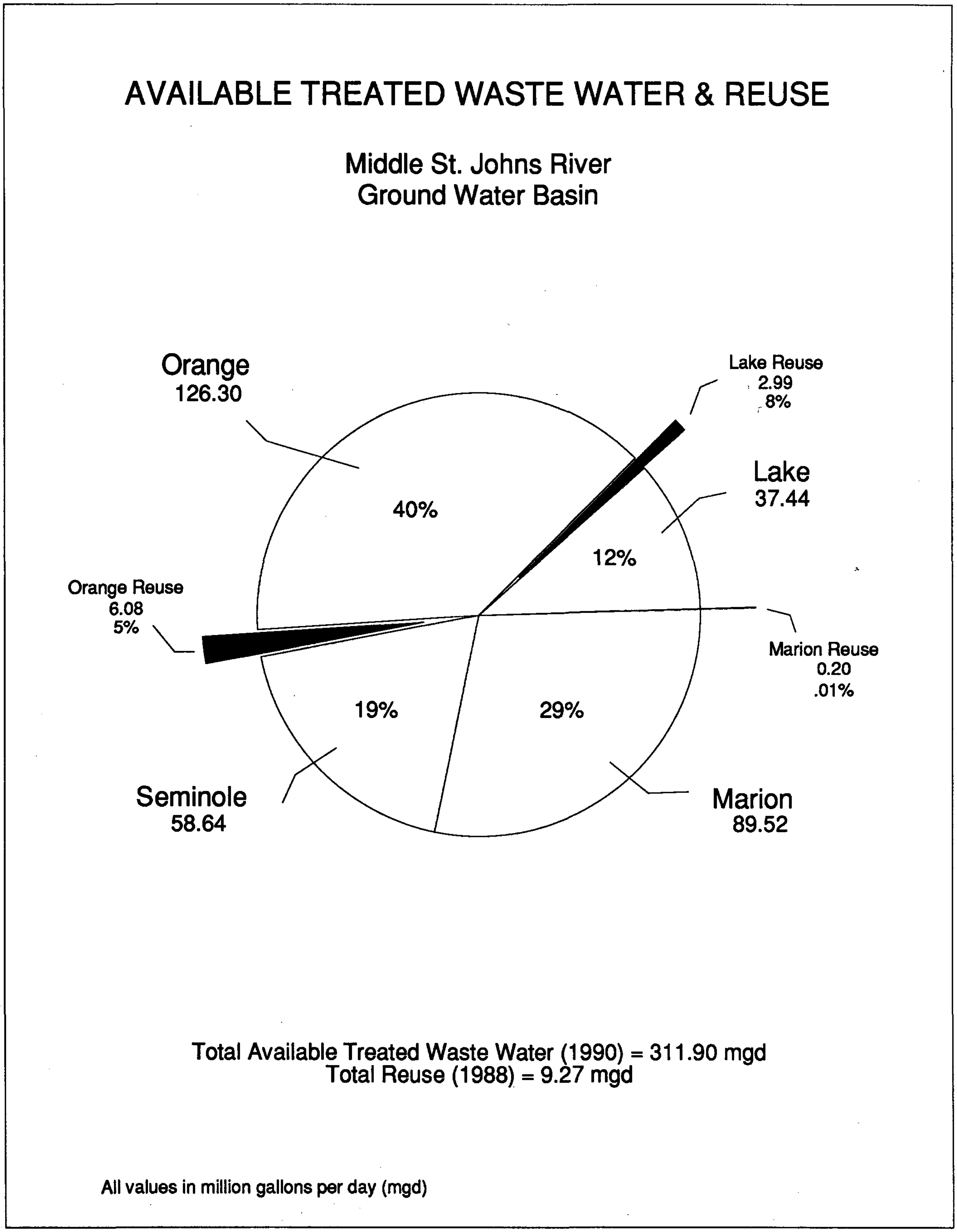


Figure 16. Treated waste water available for reuse in the Middle St. Johns ground water basin and percentage of that water reused in each county

ADDITIONAL INFORMATION

Information on the hydrogeology, water use, water quality, and direct water reuse in the MSJ ground water basin can be obtained by contacting the Ground Water Programs and Technical Support Department of the St. Johns River Water Management District.

Anderson, W. and G. H. Hughes. 1977. Hydrologic considerations in dewatering and refilling Lake Carlton, Orange and Lake counties, Florida. U. S. Geological Survey Water-Resources Investigations 76-131.

Anderson, W. and G. L. Faulkner. 1973. Quantity and quality of surface water in Marion county, Florida. Florida Bureau of Geology Map Series 55.

Anderson, W. 1971. Hydrologic considerations in draining Lake Apopka--A preliminary analysis, 1970, Florida. U. S. Geological Survey Open-File Report FL-71004.

Anderson, W. and B. F. Joyner. 1966. Availability and quality of surface water in Orange County, Florida. Florida Division of Geology Map Series 24.

Anderson, W., W. F. Lichtler, and B. F. Joyner. 1965. Control of lake levels in Orange County, Florida. Florida Geological Survey Information Circular 47.

Bradner, L. A. 1976. Water-quality monitoring of Lakes Faith, Hope, Charity, and Lucien at Maitland, Florida: April 25, 1976 to August 26, 1976. U. S. Geological Survey Open-File Report 77-194.

Bush, P. W. 1979. Connector well experiment to recharge the Floridan aquifer, east Orange County, Florida. U. S. Geological Survey Water-Resources Investigations 78-73.

Fernald, E. A., D. J. Patton. 1984. Water resources atlas of Florida. Tallahassee, Fla.: Florida State University.

Gaggiani, N. G. and A. G. Lamonds. 1978. Chemical and biological quality of Lakes Faith, Hope and Charity at Maitland, Florida, with emphasis on the effects of storm runoff and bulk precipitation, 1971-74. U. S. Geological Survey Open-File Report 77-491.

German, E. R. 1983. Water Quality of Lakes Faith, Hope, Charity and Lucien, 1971-79, in an area of residential development and highway construction at Maitland, Florida. U. S. Geological Survey Water-Resources Investigations 82-51.

Hughes, G. H. 1974. Water balance of Lake Kerr--a deductive study of a landlocked lake in north-central Florida. Florida Bureau of Geology Report of Investigations 73.

Hoy, N. D. and J. R. Teel. 1963. Hydrologic features of the Floridan aquifer in Seminole County, Florida. Florida Division of Geology Map Series 5.

Jenab, S. A., D. V. Rao, and D. Clapp. 1986. Rainfall analysis for northeast Florida, Part II: Summary of monthly and annual rainfall data. St. Johns River Water Management District Technical Report SJ 86-4. Palatka, Fla.

Knochenmus, D. D. 1975. Hydrologic concepts of artificially recharging the Floridan aquifer in eastern Orange County, Florida--a feasibility study. Florida Bureau of Geology Report of Investigations No. 72.

Leach, S. D. 1978. Source, use, and disposition of water in Florida, 1975. U. S. Geological Survey Water-Resources Investigation 78-17. Washington, D. C.

Martin, E. H. 1985. The effectiveness of a detention pond and wetlands system in reducing the amounts of lead transported by urban stormwater runoff. Stormwater Management, July 1985, Publication 85-1.

Piper, A. M. 1944. A graphic procedure in the geochemical interpretation of water analysis. Transactions American Geophysical Union, 25 (6). Washington, D. C.

Planert, M., W. R. Aucott. 1985. Water-supply potential of the Floridan aquifer in Osceola, eastern Orange, and southwestern Brevard counties, Florida. U. S. Geological Survey Water-Resources Investigations Report 84-4135.

Rutledge, A. T. and H. F. Grubb. 1978. Hydrogeologic maps of a flood detention area proposed by Southwest Florida Water Management District, Green Swamp area, Florida. U. S. Geological Survey Open-File Report 78-460.

Schiner, G. R. and E. R. German. 1983. Effects of recharge from drainage wells on quality of water in the Floridan aquifer in the Orlando area, central Florida. U. S. Geological Survey Water-Resources Investigations 82-4094.

Shermyen, A. H. and S. S. Floid. 1989. 1989 Florida Statistical Abstract 23rd ed. University of Florida, Bureau of Economic and Business Research, Gainesville, Fla.

Singleton, V. 1988. Benchmark farms program summary of agricultural pumpage data through 1988. St. Johns River Water Management District. Palatka, Fla.

Steward, J. 1985. An environmental evaluation of direct water reuse in the St. Johns River Water Management District. St. Johns River Water Management District Technical Publication SJ 85-2. Palatka, Fla.

Taylor, G. F. 1984. Distribution and occurrence of total coliform bacteria in Floridan aquifer wells, western Lake County, Florida. U. S. Geological Survey Water-Resources Investigations Report 84-4130.

Tibbals, C. H., W. D. Wood, and Snell, L. J. 1977. Overlay maps of the Forest City quadrangle, Florida: (a) Altitude of top of Floridan aquifer; (b) Potentiometric surface of the Floridan aquifer and areas of artesian flow, May 1974; and (c) Surface-drainage basins. U. S. Geological Survey Open-File Report 77-260.

Unklesbay, A. G. and H. H. Cooper, Jr. 1946. Artificial recharge of artesian limestone at Orlando, Florida. Economic Geology, 41 (4): 293-307.

U. S. Environmental Protection Agency. 1975. Natural interim primary drinking water regulation. Federal Register, 40 (248): 59566-88. Washington, D. C.: Government Printing Office.

__________. 1976. (1977). Quality criteria for water. Washington, D. C.: Government Printing Office.

Watkins, F. A., Jr. 1977. Effectiveness of pilot connector well in artificial recharge of the Floridan aquifer, western Orange County, Florida. U. S. Geological Survey Water-Resources Investigations 77-112.

Wood, W. D. and L. J. Snell. 1977. Hydrologic map of the Orlando east quadrangle, Florida. U. S. Geological Survey Water-Resources Investigations Open-File Report 77-134.

Wood, W. D. and L. J. Snell. 1977. Hydrologic map of the Orlando west quadrangle, Florida. U. S. Geological Survey Water-Resources Investigations Open-File Report 77-135.

Appendix A

LEGISLATION

LEGISLATION

Section 373.0395, Florida Statutes, provides that a Ground Water Basin Resource Availability Inventory shall include, but not be limited to, the following:

(1) A hydrogeologic study to define the ground water basin and its associated recharge areas.

(2) Site specific areas in the basin deemed prone to contamination or overdraft resulting from current or projected development.

(3) Prime ground water recharge areas.

(4) Criteria to establish minimum seasonal surface and ground water levels.

(5) Areas suitable for future water resource development within the ground water basin.

(6) Existing sources of waste water discharge suitable for reuse as well as the feasibility of integrating coastal wellfields.

(7) Potential quantities of water available for consumptive uses.

Appendix B

PUBLIC SUPPLY WITHDRAWALS BY UTILITY IN THE UPPER ST. JOHNS GROUND WATER BASIN FOR 1987

Table B. Public supply withdrawals by utility in the Middle St.Johns ground water basin for 1987

(b)	Utility/Owner	County	Water Source Primary	Water Source Secondary	1987 data (a) mgd	1987 data (a) Population	Comments
1	Astor/Astor Park Water Assoc.	Lake	Floridan		0.24	3,000	
	Brittany Estates	Lake	Floridan		0.07	213	
2	Clermont - City of	Lake	Floridan		1.30	6,379	
3	Deanza - Mid Florida Lakes	Lake	Floridan		0.65	2,725	
4	Eustis - City of	Lake	Floridan		2.97	17,250	
5	Fruitland Park - City of	Lake	Floridan		0.41	2,685	
6	Groveland - City of	Lake	Floridan		0.28	2,143	
7	Hawthorne S/D	Lake	Floridan		0.43	2,780	
8	Howey-in-the-Hills - Town of	Lake	Floridan		0.32	664	
	Lake County Utilities	Lake	Floridan		0.09	550	
	Lakeview Terrace Center	Lake	Floridan		0.04	300	
9	Leesburn - City of	Lake	Floridan		3.86	20,358	
	Mascotte - Town of	Lake	Floridan		0.18	1,770	
	Minneola - City of	Lake	Floridan		0.18	1,232	
	Molakai Park Water System	Lake	Floridan		0.04	550	
	Montverde - Town of	Lake	Floridan		0.12	464	
10	Mount Dora - City of	Lake	Floridan		2.48	9,480	
11	Orange Blossom Gardens MHP	Lake	Floridan		1.04	4,130	
12	Silver Lake Estates Utility	Lake	Floridan		0.46	948	
	South Umatilla W.A.	Lake	Floridan		0.06	375	
	Southern States Utilities	Lake	Floridan		0.22	2,343	
13	Sunlake Estates	Lake	Floridan		0.32	593	
14	Travares - City of	Lake	Floridan		1.15	7,137	
15	Umatilla - City of	Lake	Floridan		0.48	2,405	
	Utilities Inc. of Florida	Lake	Floridan		0.09	308	
	Water Oak Estates	Lake	Floridan		0.18	711	
16	Belleview - City of	Marion	Floridan		0.63	4,536	
17	GDU - Silver Springs Shores	Marion	Floridan		1.36	9,405	
	Maco Development Co.	Marion	Floridan		0.07	530	
18	Marion Utilities	Marion	Floridan		0.31	2,968	

(a) Withdrawal and population data taken from Marella 1990.
(b) Number refers to location of utility/facility on following map.
Only utilities that withdrew more than 0.25 mgd in 1987 are plotted on the map.

mgd = million gallons per day

Table B. Public supply withdrawals by utility in the Middle St.Johns ground water basin for 1987

(b)	Utility/Owner	County	Water Source		1987 data (a)		Comments
			Primary	Secondary	mgd	Population	
	McIntosh - City of	Marion	Floridan		0.07	509	
19	Ocala - City of	Marion	Floridan		7.58	44,267	
	Ocala East Villas	Marion	Floridan		0.10	580	
	Ocala Oaks Utilities	Marion	Floridan		0.23	1,790	
20	Sunshine Utilities	Marion	Floridan		0.37	3,020	
	Southern States Utilities	Marion	Floridan		0.13	1,275	
	Tradewinds Utilities	Marion	Floridan		0.05	850	
21	Apopka - City of	Orange	Floridan		4.45	20,100	
22	Eatonville - Town of	Orange	Floridan		0.65	2,700	
	Econ Utilities - Wedgefield	Orange	Floridan		0.12	854	
23	Maitland - City of	Orange	Floridan		3.19	9,945	
	Oakland - Town of	Orange	Floridan		0.09	702	
24	Ocoee - City of	Orange	Floridan		2.27	11,552	
25	Orange County Public Utilities	Orange	Floridan		11.91	69,175	SJRWMD portion only
26	Orlando Utilities Commission	Orange	Floridan		48.80	260,252	SJRWMD portion only
	Rock Springs MHP	Orange	Floridan		0.22	1,240	
	Shadow Hills MHP	Orange	Floridan		0.17	1,280	
27	Southern States Utilities	Orange	Floridan		0.68	5,959	
	Starlight Range MHP	Orange	Floridan		0.19	1,560	
	Tangerine - Town of	Orange	Floridan		0.13	408	
	Utilities Inc. of Florida	Orange	Floridan		0.11	955	
28	Winter Garden - City of	Orange	Floridan		1.38	11,250	
29	Winter Park - City of	Orange	Floridan		12.34	73,500	
30	Zellwood Station Utilities	Orange	Floridan		0.53	1,560	
	Zellwood Water Assoc.	Orange	Floridan		0.19	900	
31	Altamonte Springs - City of	Seminole	Floridan		7.73	33,156	
32	Casselberry - City of	Seminole	Floridan		4.84	35,100	
33	Central Five Utilities Inc.	Seminole	Floridan		1.06	5,440	
	Indian Creek - Seminole Pines	Seminole	Floridan		0.05	270	
	Lake Harney Water Assoc.	Seminole	Floridan		0.03	440	
	Lake Mary - City of	Seminole	Floridan		0.00	N/A	

(a) Withdrawal and population data taken from Marella 1990.
(b) Number refers to location of utility/facility on following map.
Only utilities that withdrew more than 0.25 mgd in 1987 are plotted on the map.

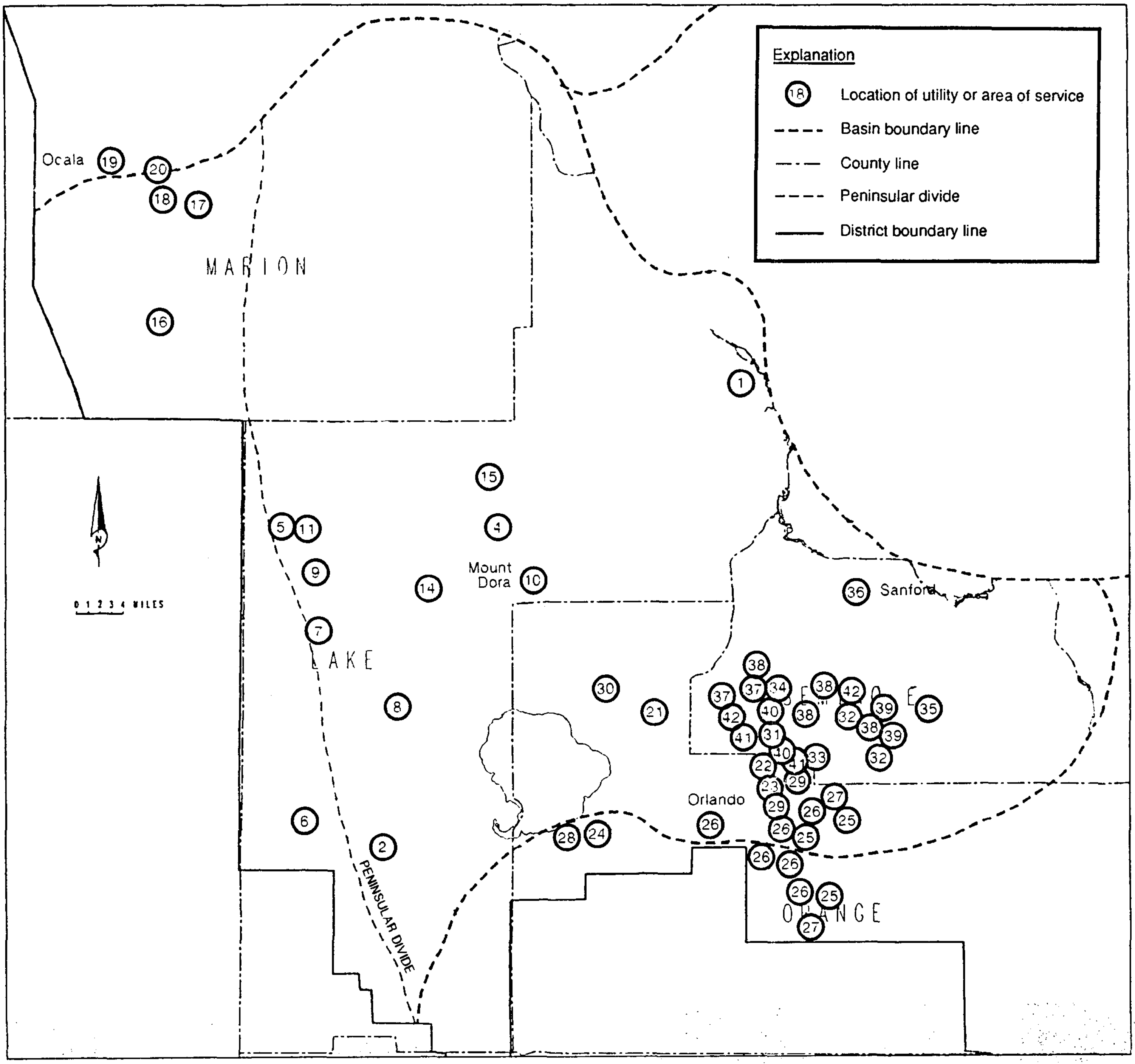
mgd = million gallons per day

Table B. Public supply withdrawals by utility in the Middle St.Johns ground water basin for 1987

			Water Source		1987 data (a)		
(b)	Utility/Owner	County	Primary	Secondary	mgd	Population	Comments
34	Longwood - City of	Seminole	Floridan		1.93	13,298	
	Luthern Haven Water System	Seminole	Floridan		0.04	435	
	Mullet Lake Water Assoc.	Seminole	Floridan		0.03	550	
35	Oviedo - City of	Seminole	Floridan		1.03	6,696	
	Palm Ventures MHP	Seminole	Floridan		0.14	687	
36	Sanford - City of	Seminole	Floridan		5.21	30,344	
37	Sanlando Utilities	Seminole	Floridan		8.40	32,849	
38	Seminole County Water & Sewer	Seminole	Floridan		5.42	34,074	
39	Seminole Utilities Inc.	Seminole	Floridan		1.58	8,520	
40	Southern States Utilities	Seminole	Floridan		1.25	8,643	
41	Utilities Inc. of Florida	Seminole	Floridan		0.90	7,626	
42	Winter Springs - City of	Seminole	Floridan		1.20	13,422	
	totals	Lake			17.66	91,493	
		Marion (c)			13.19	82,533	
		Orange (c)			88.43	473,892	
		Seminole			40.86	231,550	
					160.14	879,468	

(a) Withdrawal and population data taken from Marella 1990.
(b) Number refers to location of utility/facility on following map.
Only utilities that withdrew more than 0.25 mgd in 1987 are plotted on the map.
(c) Totals represent the withdrawal values for those utilities located in the St. Johns River Water Management District.

mgd = million gallons per day



Appendix B. Public supply wellfields and areas of service in the Middle St. Johns ground water basin. Numbers refer to Table B.

SELECTED REFERENCES

Anderson, W. and G. H. Hughes. 1975. Hydrology of three sinkhole basins in southwestern Seminole County, Florida. Florida Bureau of Geology Report of Investigations 81.

Barraclough, J. T. 1962a. Ground-water records of Seminole County, Florida. Florida Bureau of Geology Information Circular 34. Tallahassee, Fla.

________. 1962b. Ground-water resources of Seminole County, Florida. Florida Bureau of Geology Report of Investigation 27. Tallahassee, Fla.

Boniol, D., D. A. Munch, and M. Williams. 1990. Recharge Areas of the Floridan Aquifer in the Crescent City Ridge of Southeast Putnam County, Florida--A Pilot Study. St. Johns River Water Management District Technical Report SJ 90-9.

Bush, P. W. 1974. Hydrology of the Oklawaha Lakes area of Florida. Florida Bureau of Geology Map Series 69.

Cooke, C. W. 1945. Geology of Florida. Florida Geological Survey Bulletin 29. Tallahassee, Fla.

Fisk, D. Draft. Ground water flow. Map. Live Oak, Fla.: Suwannee River Water Management District.

Florence, B. 1990. Annual Water Use Survey: 1988. St. Johns River Water Management District Technical Report. Unpublished draft. Palatka, Fla.

Frazee, J. M. Jr. 1982. Geochemical pattern analysis: Method of describing the southeastern limestone regional aquifer system. In Studies of the hydrogeology of the southeastern United States, ed. B. F. Beck. Georgia Southeastern College Special Publication 1. Americus, Ga.

Grubb, H. F. 1978. Potential for downward leakage to the Floridan aquifer, Green Swamp area, central Florida. U. S. Geological Survey Water-Resources Investigations Open-File Report 77-71.

Grubb, H. F. and A. T. Rutledge. 1979. Long-term water supply potential, Green Swamp area, Florida. U. S. Geological Survey Water-Resources Investigations 78-99.

Healy, H. G. 1975. Potentiometric surface and areas of artesian flow of the Floridan aquifer of Florida, May 1974. Florida Bureau of Geology Map Series 73. Tallahassee, Fla.

Heath, R. C. and J. R. Barraclough. 1954. Interim report on the ground-water resources of Seminole County, Florida. Florida Bureau of Geology Information Circular No. 5. Tallahassee, Fla.

Joyner, B. F., W. F. Lichtler, and W. Anderson. 1968. Water in Orange County, Florida. Florida Bureau of Geology Leaflet 8.

Kashef, A. I. 1986. Groundwater Engineering. New York, N.Y.: McGraw - Hill.

Kimrey, J. O. 1978. Preliminary appraisal of the geohydrologic aspects of drainage wells, Orlando area, central Florida. U. S. Geological Survey Water-Resources Investigations 78-37.

Klein, H. 1971. Depth to base of potable water in the Floridan aquifer. Map. Tallahassee, Fla: U. S. Geological Survey.

Knochenmus, D. D. 1971. Ground water in Lake County, Florida. Florida Bureau of Geology Map Series 44.

Knochenmus, D. D. and G. H. Hughes. 1976. Hydrology of Lake County, Florida. U. S. Geological Survey Water-Resources Investigation 76-72. Washington, D. C.

Leach, S. D. 1978. Source, use, and disposition of water in Florida, 1975. U. S. Geological Survey Water-Resources Investigation 78-17. Washington, D. C.

Lichtler, W. F. and B. F. Joyner. 1966. Availability of ground water in Orange County, Florida. Florida Geological Survey Map Series 21.

Lichtler, W. F., W. Anderson, and B. F. Joyner. 1968. Water resources of Orange County, Florida. Florida Division of Geology Report of Investigation 50. Tallahassee, Fla.

Lichtler, W. F., G. H. Hughes, and F. L. Pfischner. 1976. Hydrologic relations between lakes and aquifers in a recharge area near Orlando, Florida. U. S. Geological Survey Water-Resources Investigations 76-65.

Marella, R. L. 1982. Annual water use survey: 1980. St. Johns River Water Management District Technical Report 14. Palatka, Fla.

Marella, R. L. 1986. Annual water use survey: 1985. St. Johns River Water Management District Technical Publication SJ 86-5. Palatka, Fla.

Marella, R. L. 1988. Water withdrawals, use and trends in the St. Johns River Water Management District. St. Johns River Water Management District Technical Report SJ 88-7. Palatka, Fla.

Marella, R. L. 1990. Annual Water Use Survey: 1987. St. Johns River Water Management District Technical Publication SJ 90-4. Palatka, Fla.

Parker, G. G. and C. W. Cooke 1944. Late Genezoic geology of southern Florida, with a discussion of the ground water. Florida Geological Survey Bulletin 27. Tallahassee, Fla.

Phelps, G. G. 1984. Recharge and discharge areas of the Floridan aquifer in the St. Johns River Water Management District and vicinity, Florida. U. S. Geological Survey Water-Resources Investigation 82-4058. Washington, D. C.

Puri, M. S. and R. O. Vernon 1964. Summary of the geology of Florida, and a guidebook to the classical exposures. Florida Geological Survey Special Publication 5. Tallahassee, Fla.

Schiner, G. R. and E. C. Hayes. 1981. Potentiometric surface of the Floridan aquifer, St. Johns River Water Management District and vicinity, Florida, May 1981. U. S. Geological Survey Open-File Report 81-1052. Tallahassee, Fla.

Shoemyen, A. H., S. S. Floyd, and A. T. Banta. 1986. Florida statistical abstract (20th Ed.). Bureau of Economic and Business Research. Gainesville, Fla: University of Florida.

Smith, S. K. and R. Bayya. 1990. Projections of Florida population by county, 1989-2020. Population Studies 23(2). Bureau of Economic and Business Research Bulletin 92. Gainesville, Fla.: University of Florida.

Steward, J. 1985. An environmental evaluation of direct water reuse in the St. Johns River Water Management District. St. Johns River Water Management District Technical Publication SJ 85-2. Palatka, Fla.

Stewart, J. W. 1980. Areas of natural recharge to the Floridan aquifer in Florida. Florida Bureau of Geology Map Series 98. Tallahassee, Fla.

Stringfield, V. T. 1934. Ground water in Seminole county, Florida. Florida Geological Survey Report of Investigations 1.

Tibbals, C. H. 1975. Recharge areas of the Floridan aquifer in Seminole County and vicinity, Florida. Florida Bureau of Geology Map Series 68.

Tibbals, C. H. 1977. Availability of ground water in Seminole County and vicinity Florida. U. S. Geological Survey Water-Resources Investigations 76-97.

Toth, D., K. P. Rohrer, and D. A. Munch. 1989. Water quality assessment of the Floridan aquifer in the Wekiva River basin of Orange, Lake, and Seminole counties. St. Johns River Water Management District Technical Report SJ 89-5. Palatka, Fla.

Unklesbay, A. G. 1944. Ground water conditions in Orlando and vicinity, Florida. Florida Geological Survey Report of Investigations 5.

White, W. A. 1970. Geomorphology of the Florida peninsula. Florida Bureau of Geology Bulletin 51. Tallahassee, Fla.

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