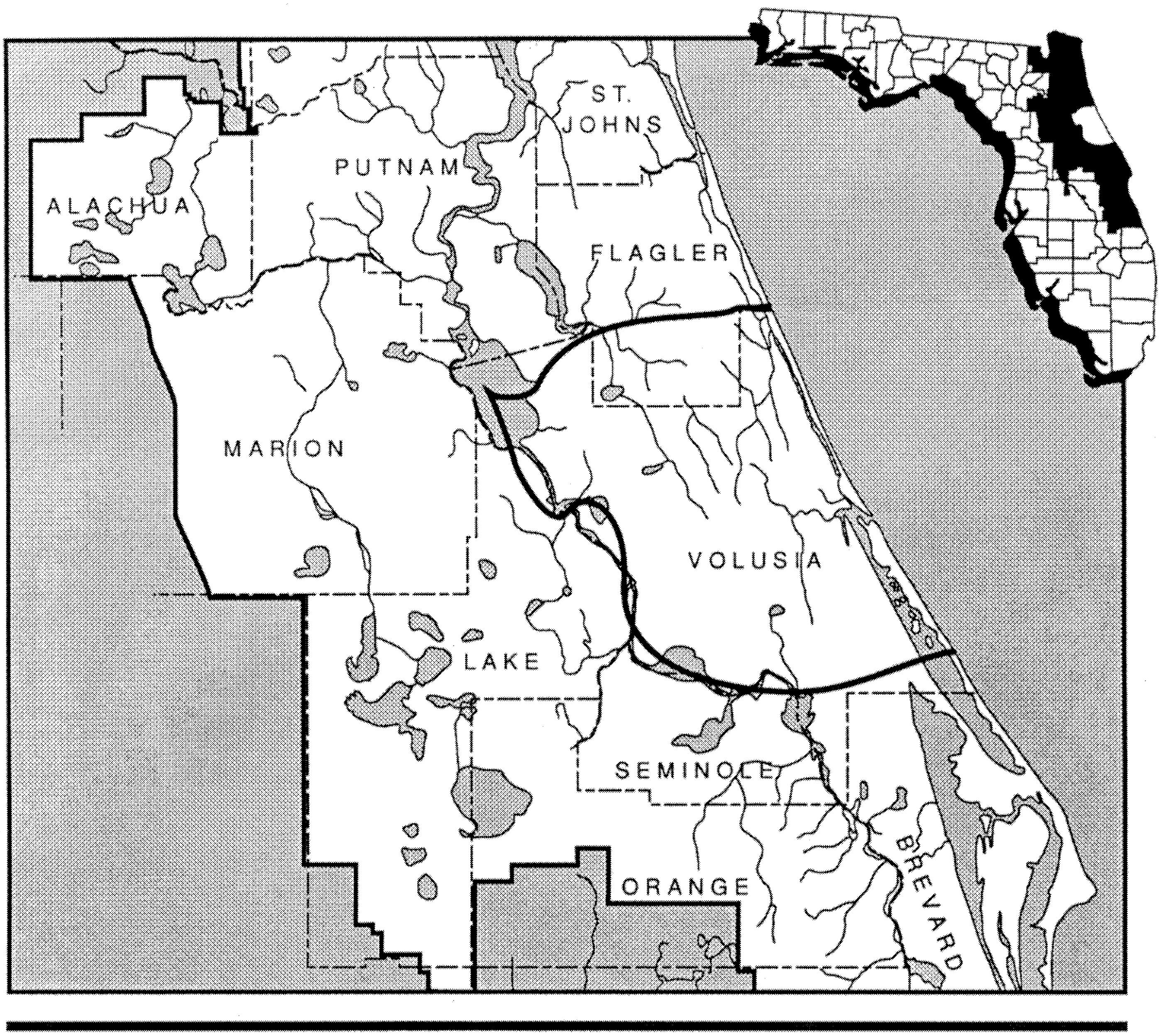
Technical Publication SJ 89-4

Volusia Ground Water Basin Resource Availability Inventory



St. Johns River Water Management District

Technical Publication SJ 89-4

VOLUSIA GROUND WATER BASIN RESOURCE AVAILABILITY INVENTORY

by

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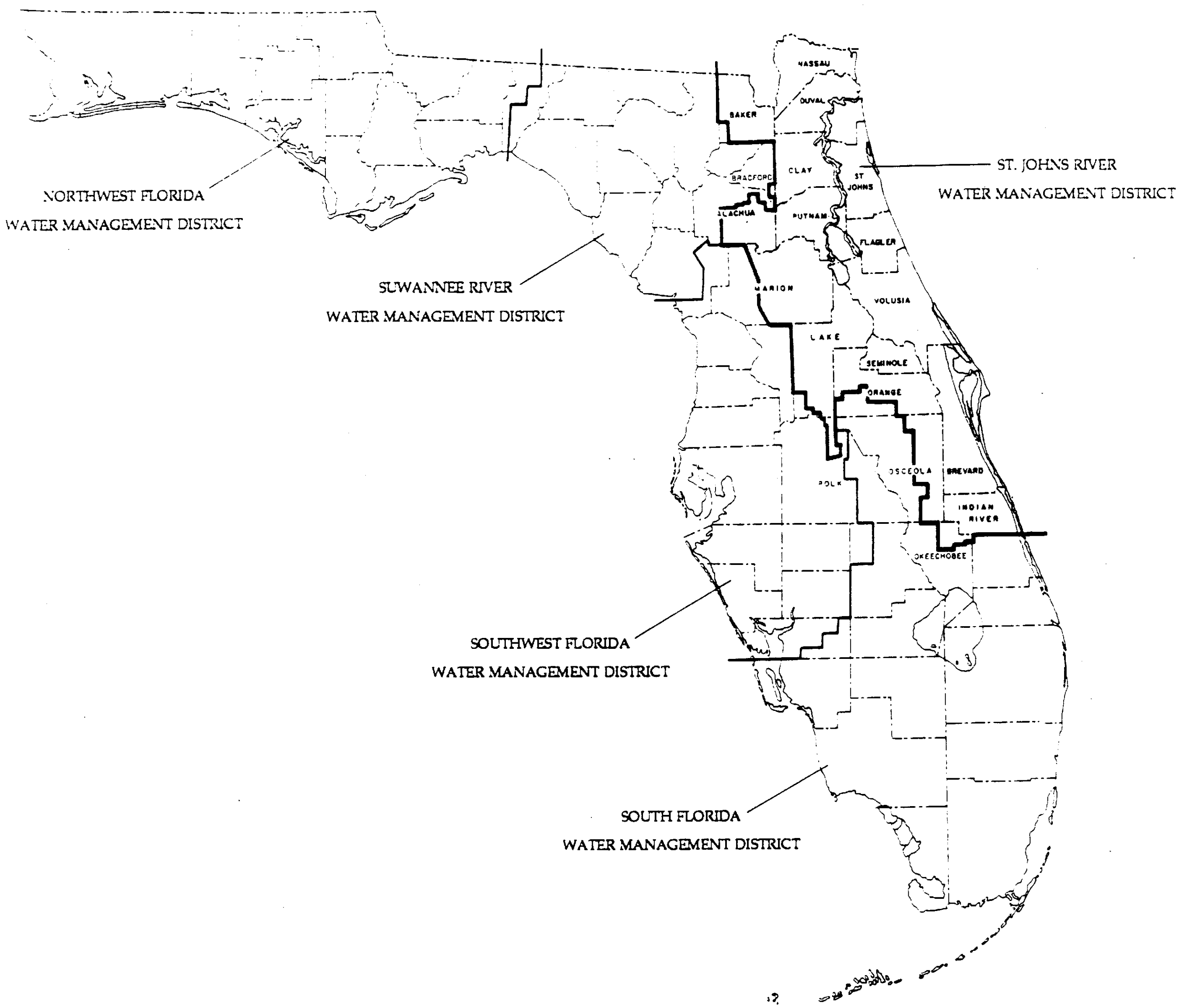
St. Johns River Water Management District
Palatka, FL

1989



THE ST. JOHNS RIVER WATER MANAGEMENT DISTRICT

The St. Johns River Water Management District (SJRWMD) was created by the Florida Legislature in1972 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.

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FIGURES

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 is conservation, addressing the conservation, use, and protection of natural resources, including water and water recharge areas (Section 163.3177, Florida Statutes).

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

This report provides a general inventory of the water resources of the Volusia ground water basin including hydrogeologic features, recharge and discharge areas, ground water quality characteristics, present and projected water use, direct water reuse, and areas suitable for future water resource development. The Volusia ground water basin is one of five ground water basins within the SJRWMD (Figure 1) and is located almost entirely within the boundaries of Volusia and the southern half of Flagler counties (Figure 2).

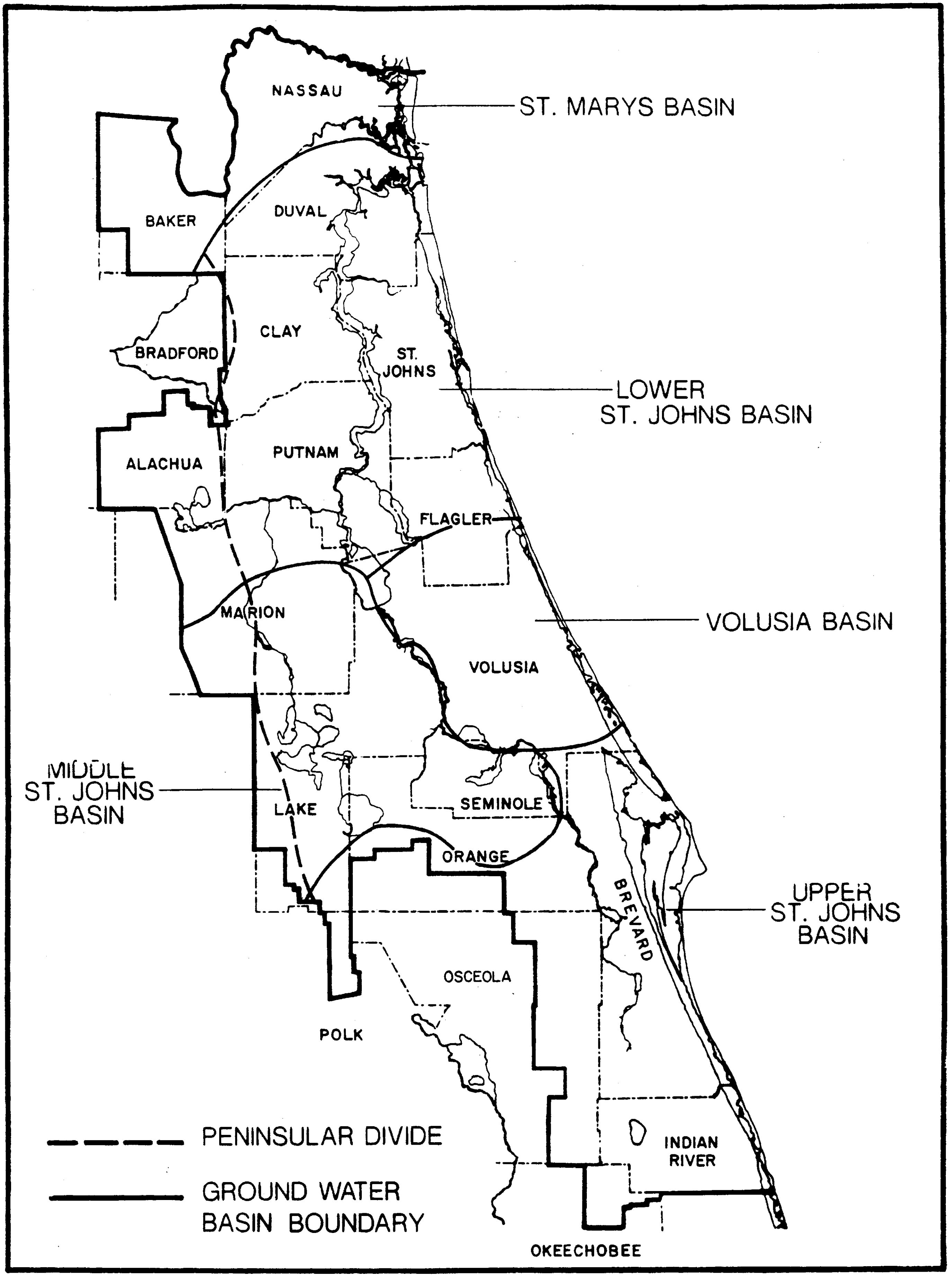


Figure 1. St. Johns River Water Management District and ground water basins

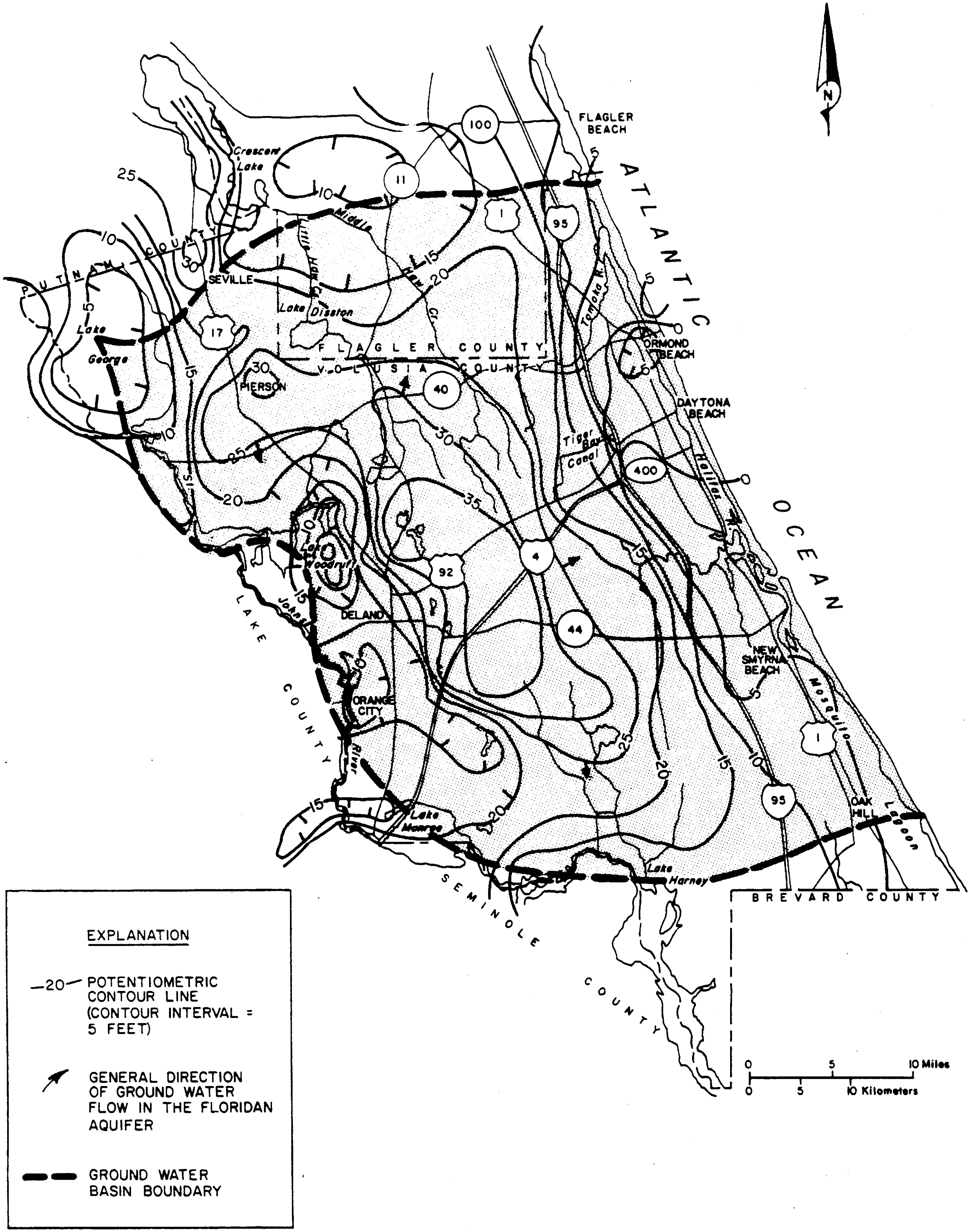


Figure 2. The Volusia ground water basin (potentiometric surface for May 1987, modified from Schiner and Hayes 1981)

PHYSIOGRAPHY

The Volusia ground water basin lies in the Coastal Lowlands physiographic province (Cooke 1945) which is characterized by karst topography, marine terraces, and shoreline ridges (Figure 3).

Karst topography is an irregular, pitted land surface formed by the dissolution of limestone. This topography, as it occurs on the Deland and Crescent City ridges, is characterized by high relief, circular lakes, sinkholes, and caves at land surface (Knochenmus and Beard 1971) (Figure 4).

The marine terraces are horizontal expanses of sand and shell deposited when sea levels stood at higher levels than present day. When the sea was higher it eroded away the sea floor, and subsequent lowering of the sea exposed these erosional surfaces as marine terraces. In the Volusia ground water basin, four terraces are present: the Penholoway, the Talbot, the Pamlico, and the Silver Bluff (Cooke 1945, Parker and Cooke 1944) (Figure 3).

Between each marine terrace is a relict shoreline represented by a sandy ridge. Formed as the seaward edges of the marine terraces, these ridges parallel the coastline. Acting as reservoirs, these ridges store surface and ground water until it is recharged into the underlying aquifers or is lost through the processes of evaporation (Knochenmus and Beard 1971). Land surface elevations range from 5 ft above mean sea level (msl) along the coast and the St. Johns River to approximately 120 ft above msl in the Deland area.

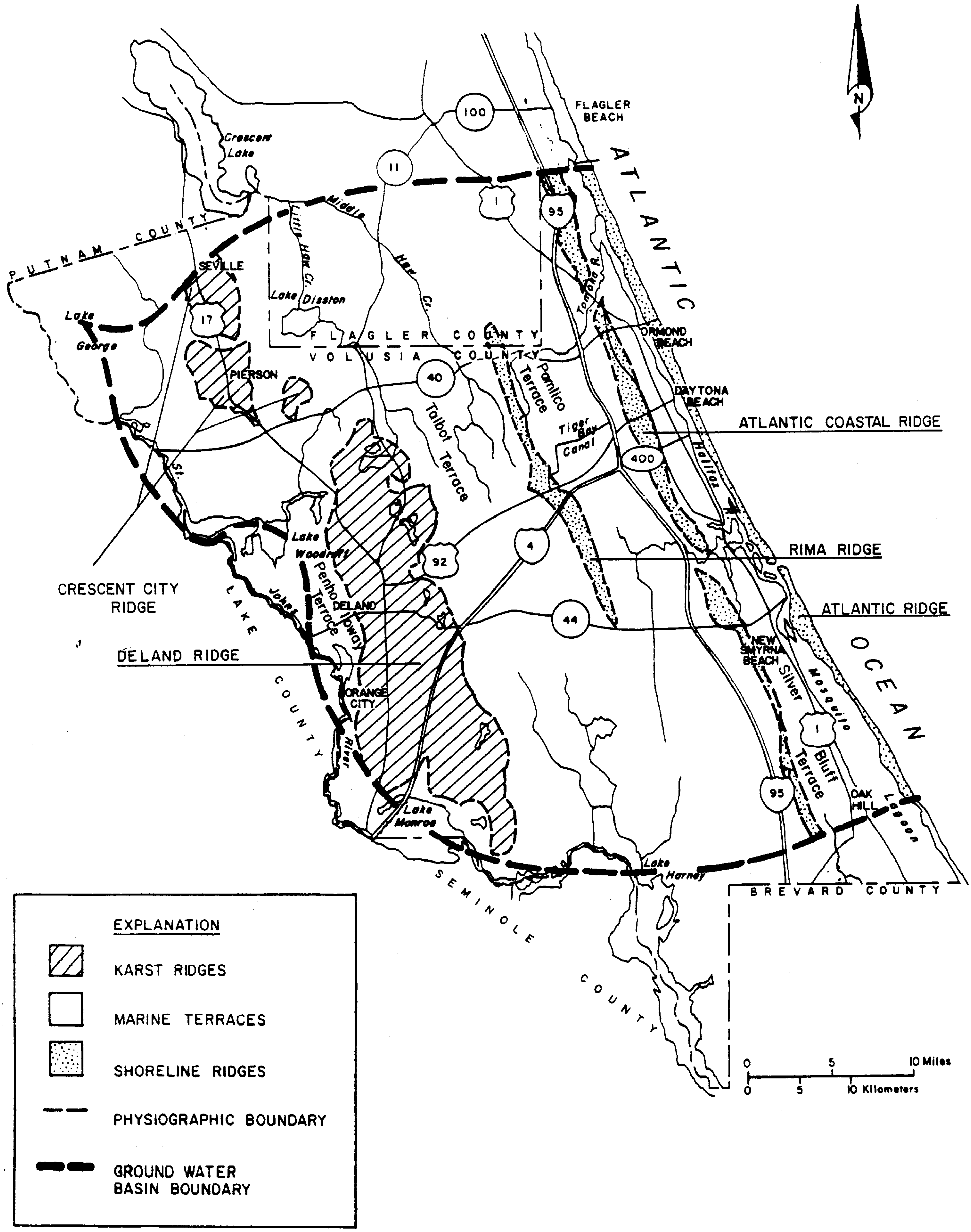
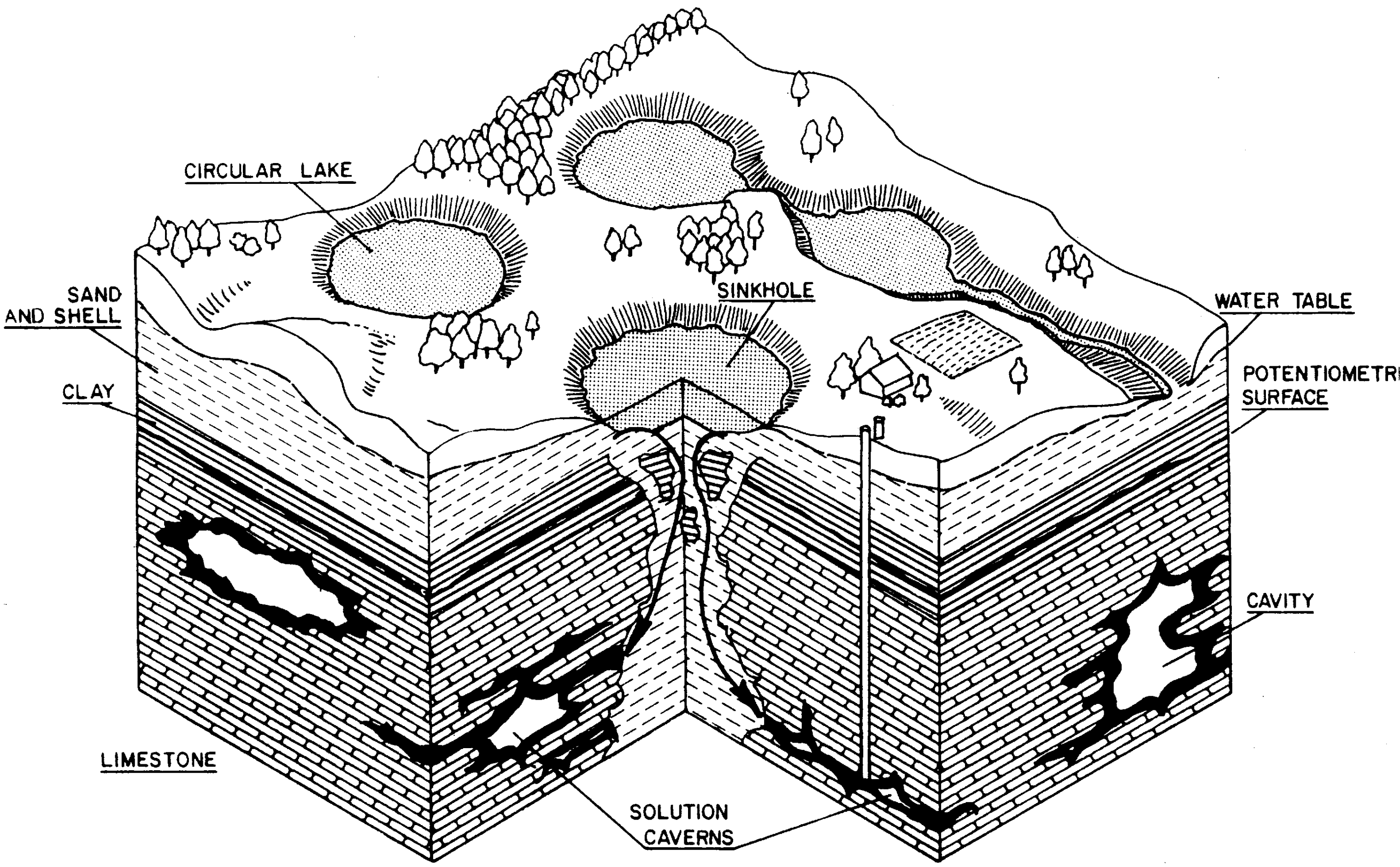


Figure 3. Physiographic features of the Volusia ground water basin, from Knochenmus and Beard (1971) and Wyrick (1960)



F'gure 4. Karst topography in the Volusia ground water basin

HYDROGEOLOGY

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

The **surficial** aquifer system is composed of sand, shell, and some clay. The aquifer ranges in thickness from 25 ft near the St. Johns River to approximately 80 ft in the central part of the basin (Wyrick 1960). 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 system usually follows the topography of the land. In the Volusia ground water basin the surficial aquifer system is a source of water for small-scale irrigation.

The **intermediate** aquifer, which also acts as a confining unit in eastern Flagler County, is composed of clays and thin, water-bearing zones of sand, shell, and limestone. This aquifer occurs at 40 to 90 ft below land surface and supplies water to some parts of eastern Flagler County (Navoy and Bradner 1987). This aquifer is an important source of potable water where the Floridan aquifer contains water of marginal quality.

The **Floridan** aquifer, the primary water-producing aquifer in the Volusia ground water basin, 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 on a map, this surface can be interpreted to show the direction of ground water flow (Figure 4). 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 in the coastal areas of the Volusia ground water basin and along the St. Johns River. Generally, in some areas east of the Rima Ridge (Figure 3), wells less than 200 ft deep contain potable water while more saline water is present in wells greater than 200 ft deep (Toth pers. com. 1989). The Floridan aquifer is an important source of public, industrial, irrigation, and rural domestic water supplies.

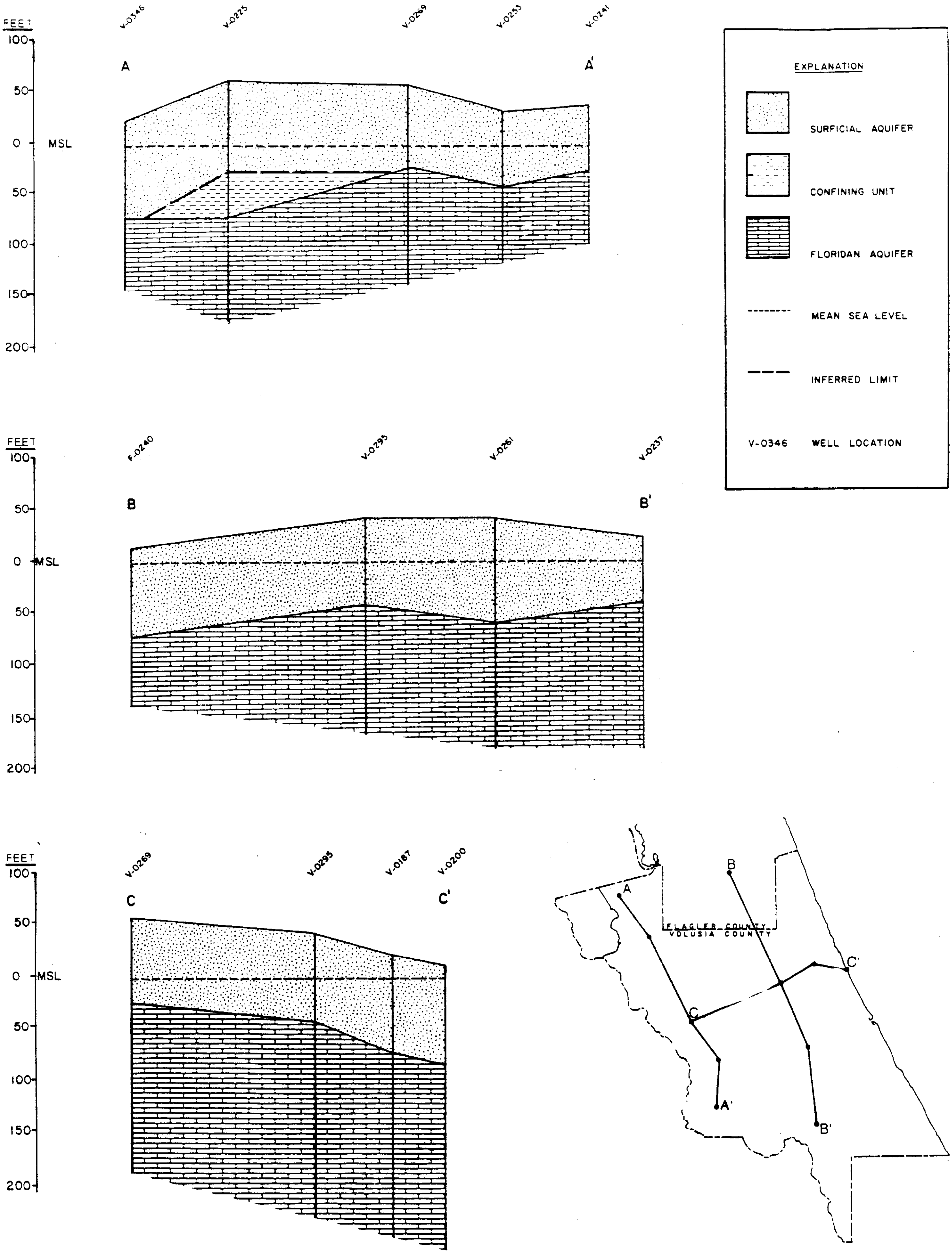


Figure 5. Hydrologic cross sections of the Volusia ground water basin

RECHARGE AND DISCHARGE

The Floridan aquifer is recharged by the surficial aquifer system in areas where the water level in the surficial aquifer system is higher than the potentiometric surface of the Floridan aquifer. Areas within the Volusia ground water basin have been classified according to the potential recharge capability from the surficial aquifer system to the Floridan aquifer (Stewart 1980, Healy 1975) in four classes ranging from zero recharge to high recharge (Figure 6). The areas of high potential recharge in the Volusia ground water basin are the Crescent City, Deland, and Rima ridge areas (Figure 3).

Discharge occurs in the Volusia ground water basin where the potentiometric levels of the Floridan aquifer are greater than the water levels in the surficial aquifer system. Features typical of discharge areas are springs and wells which flow freely at land surface.

PRIME GROUND WATER RECHARGE AREAS

Section 373.0395, F.S., provides that the GWBRAI include the designation of prime ground water recharge areas. A pilot study to delineate areas of prime recharge to the Floridan aquifer is being performed by the SJRWMD. The methodology and knowledge gained from this pilot study will be used to delineate prime recharge areas in other parts of the district. Similar work in the Volusia ground water basin is scheduled to be completed by September 30, 1990.

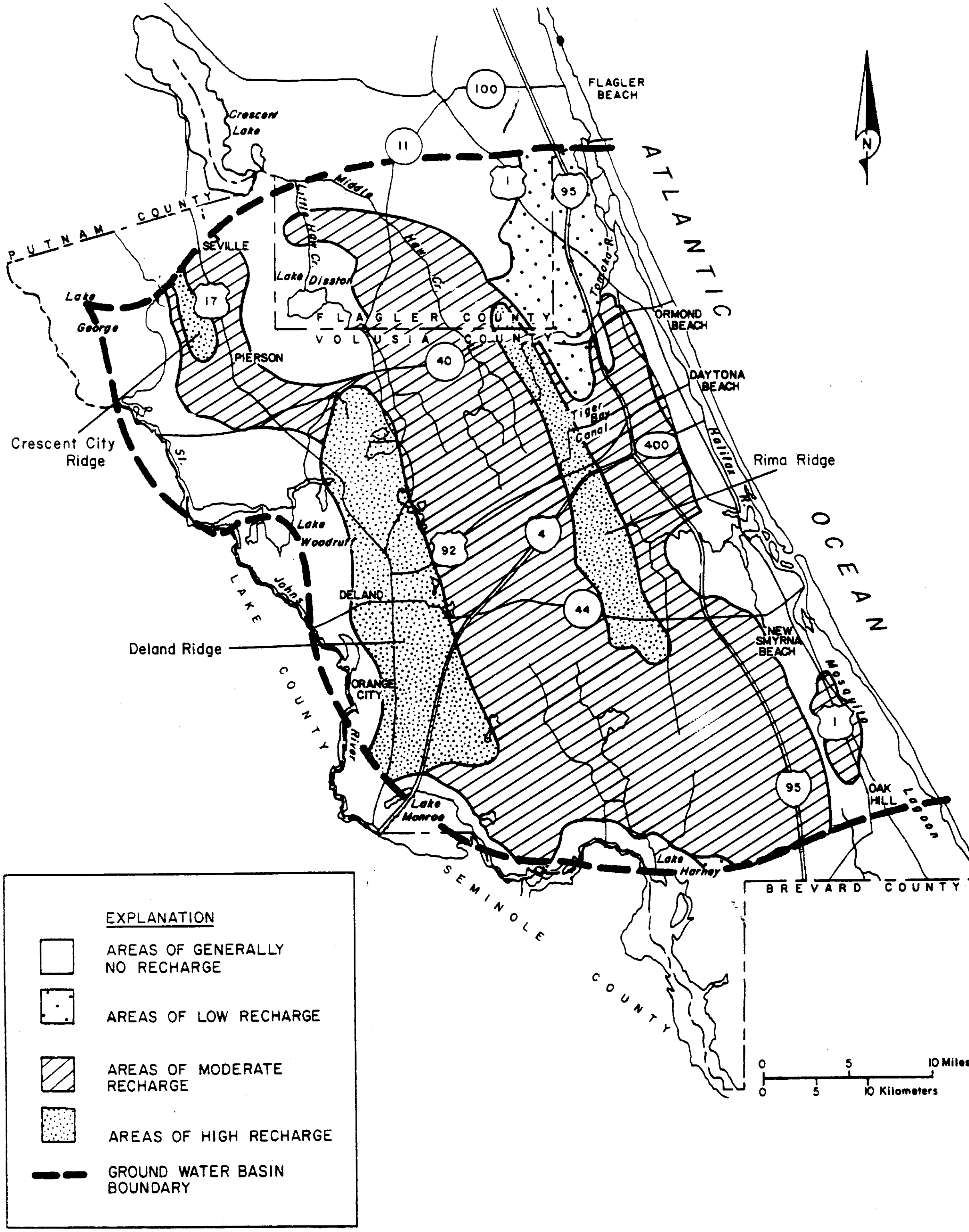


Figure 6. Approximate areas of natural recharge and discharge of the Floridan aquifer in the Volusia ground water basin (modified from Stewart 1980)

GROUND WATER QUALITY

The natural quality of ground water in the Volusia ground water basin varies greatly depending on the location and the depth from which water is obtained. A major concern is saltwater intrusion.

The quantity of potable water within the Floridan aquifer varies with fluctuations in the potentiometric surface. These fluctuations result from seasonal climatic changes and from changes in the magnitude of ground water withdrawal. The potable water within 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 7).

Saline water can be characterized as water with high salt content. The salts are reflected in a total dissolved solids (TDS) concentration in excess of 500 mg/l. In drinking water systems the salts of greatest concern are chloride and sulfate. The Environmental Protection Agency (EPA) recommended standards for public drinking water for chloride and sulfate are 250 mg/l.

In the Volusia ground water basin, chloride concentrations measured in water samples withdrawn from wells that penetrate the Floridan aquifer generally increase from west to east and increase with depth within the aquifer. These concentrations generally vary from nearly zero at depths of 300 ft below land surface in recharge areas to thousands of mg/l at equivalent depths in discharge areas along the coast and along the St. Johns River (Toth pers. com. 1989) (Figure 8).

In addition to chloride concentrations, sulfate concentrations in the Floridan aquifer vary from nearly zero at depths of 300 ft below land surface in recharge areas to greater than 250 mg/l at equivalent depths in discharge areas (Toth pers. com. 1989) (Figure 9).

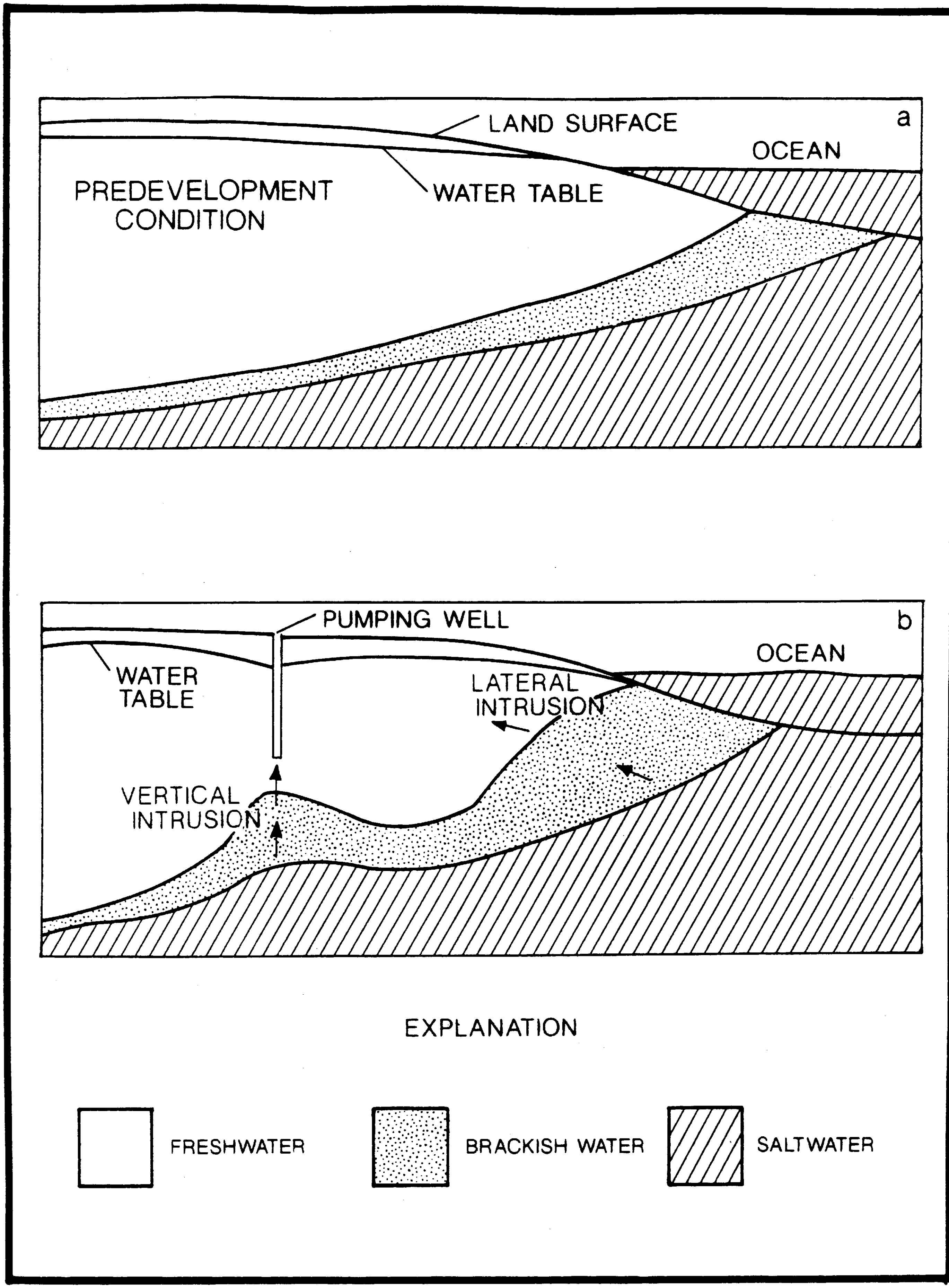


Figure 7. The movement of brackish water caused by pumping (from Rutledge 1985)

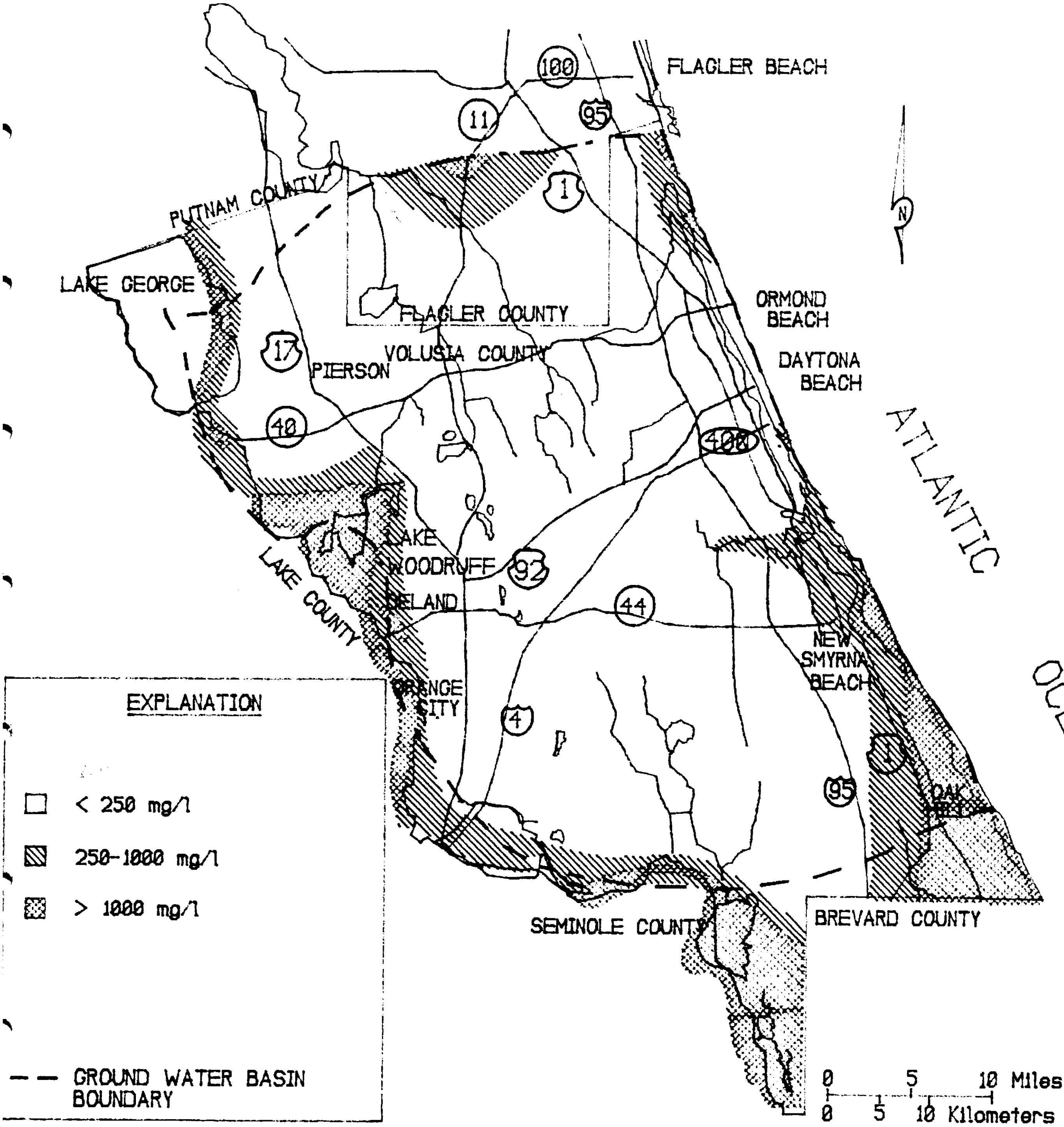


Figure 8. Chloride concentration in the Floridan aquifer in the Volusia ground water basin (Revised, modified from Rutledge, 1985).

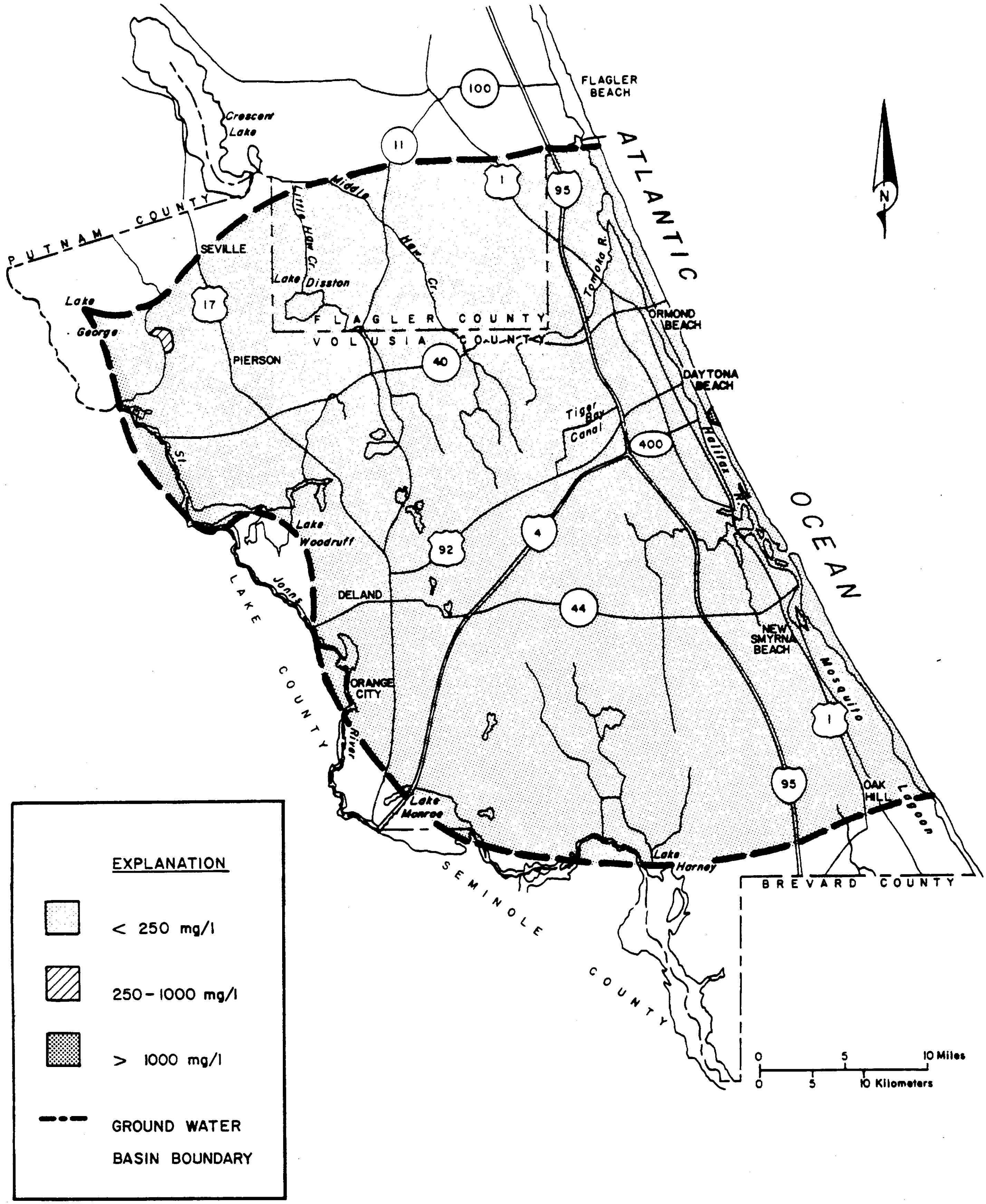


Figure 9. Sulfate concentration in the Floridan aquifer in the Volusia ground water basin

AREAS PRONE TO SALTWATER INTRUSION

The surficial aquifer system and the Floridan aquifer are prone to saltwater intrusion in the coastal areas of the Volusia ground water basin. The Floridan aquifer is also prone to saltwater intrusion in discharge areas (Figure 6) near the St. Johns River where relict seawater occurs at depth.

Vertical and lateral saltwater intrusion occurs with change in the depth to the freshwater/saltwater interface. This depth changes in response to changes in the potentiometric surface, i.e., generally as the potentiometric surface declines, the depth to the freshwater/saltwater interface decreases (Figure 10). Changes in the potentiometric surface result from changes in the magnitude of ground water withdrawals and climatic changes.

The surficial aquifer system is most prone to saltwater intrusion along the coast. The surficial aquifer system in the coastal areas depends upon rainfall to maintain its freshwater supply. Withdrawals from this aquifer in coastal areas are used primarily for lawn irrigation (Toth 1988).

Saltwater intrusion has occurred in the Floridan aquifer in the coastal areas of the Volusia ground water basin. Rutledge 1985 notes that between November 1955 and September 1982, water levels declined more than 10 ft in the areas of Ormond Beach, Daytona Beach, and Port Orange. According to Rutledge, these declines were caused by pumping deep public supply wells for long periods of time at high rates of withdrawal. Increases in chloride concentrations were observed in association with these increased withdrawals and declines in potentiometric surface. For example, chloride concentration increased 166 mg/l between 1950 and 1982 in a well at Daytona Beach (Toth 1988).

As a result, some municipal water supply wells at Daytona Beach, Ormond Beach, and Port Orange were abandoned and new wells have been installed further inland toward the center of the ground water basin where the thickness of potable water is greater (see Appendix C for map showing the thickness of potable water in the Floridan aquifer).

Another area of the Volusia ground water basin which has experienced saltwater intrusion problems is the agricultural area near Osteen. The Osteen area has experienced increased chloride concentrations as a result of the upward movement of relict seawater. This upward movement is the result of potentiometric surface declines caused by large seasonal withdrawals from agricultural irrigation.

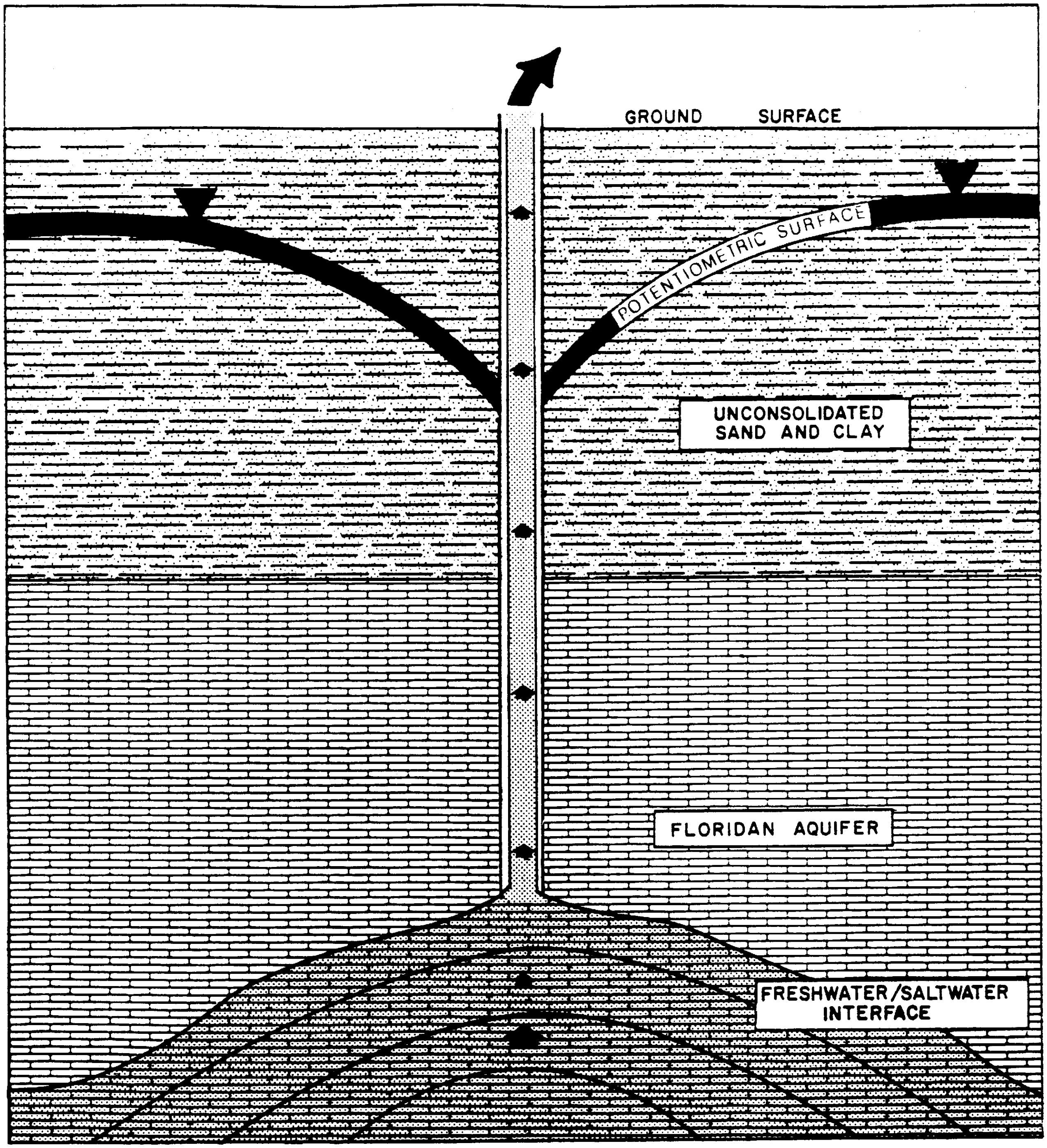


Figure 10. Generalized diagram illustrating upconing beneath a well pumping from the Floridan aquifer in the Volusia ground water basin

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 suitability for water resource development are:

1. presence of desirable water quality conditions,
2. thickness of potable water within a given aquifer,
3. presence of confining units above aquifer zones of supply to provide protection against contamination,
4. presence of unique geologic conditions which may cause sinkholes or land subsidence, and
5. 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.

MINIMUM GROUND WATER LEVELS

The state legislature has mandated that the water management districts establish minimum flows and levels for surface water and ground water (Section 373.042, F.S.). The SJRWMD is developing a technique for establishing these levels. These levels, when proposed, must be adopted through the public hearing process, which will provide the public, local governments, and regional agencies an opportunity for input. A schedule for establishing these levels has not been set.

WATER USE

The majority of the Volusia ground water basin is within the boundaries of Volusia County. A major portion of the projected population growth and increased water supply demands within the basin are also in Volusia County. The Flagler County portion of the basin is not projected to require significant additional amounts of water in the next 10 years, and for this reason withdrawal predictions will be confined to Volusia County.

For the past ten years Volusia County has experienced increased population growth and water supply demands (Figure 11). In 1975, ground water withdrawals totaled 37.29 mgd and by 1985 the withdrawals increased by 132 percent to 86.37 mgd (Marella 1988). The population increased 45 percent from 1975 (218,900) to 1985 (307,042) (Shoemyen and others 1986). Wellfield locations and pumpage values for major public suppliers in the Volusia ground water basin are shown in Appendix B.

Ground water withdrawals are expected to exceed 101.6 mgd by the year 2000 (Marella pers. com. 1989). Predictions for ground water withdrawals through the year 2000 were made by assuming the following: the population being served by public supply will remain at approximately 87 percent of the total population of the county, no major self-supplied commercial or industrial facility will move into Volusia County in the next 15 years, and withdrawals for agricultural irrigation will increase by approximately 1 mgd per year. The population is projected to surpass 440,000 by the year 2000 (Smith and Sincich 1987).

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). In areas of increasing water demands such as the coastal areas of the Volusia ground water basin, reuse could provide an important conservation measure. 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 waste water could conserve significant quantities of fresh ground water for higher priority uses.

Volusia County has the potential to implement a direct wastewater reuse program (Figure 12). In 1985, the county generated 28.4 mgd of wastewater that was available for reuse from private and public municipal wastewater treatment plants (Figure 12). Reuse in this county could reduce potable water demands, help conserve water, solve problems with wastewater 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 treatment.

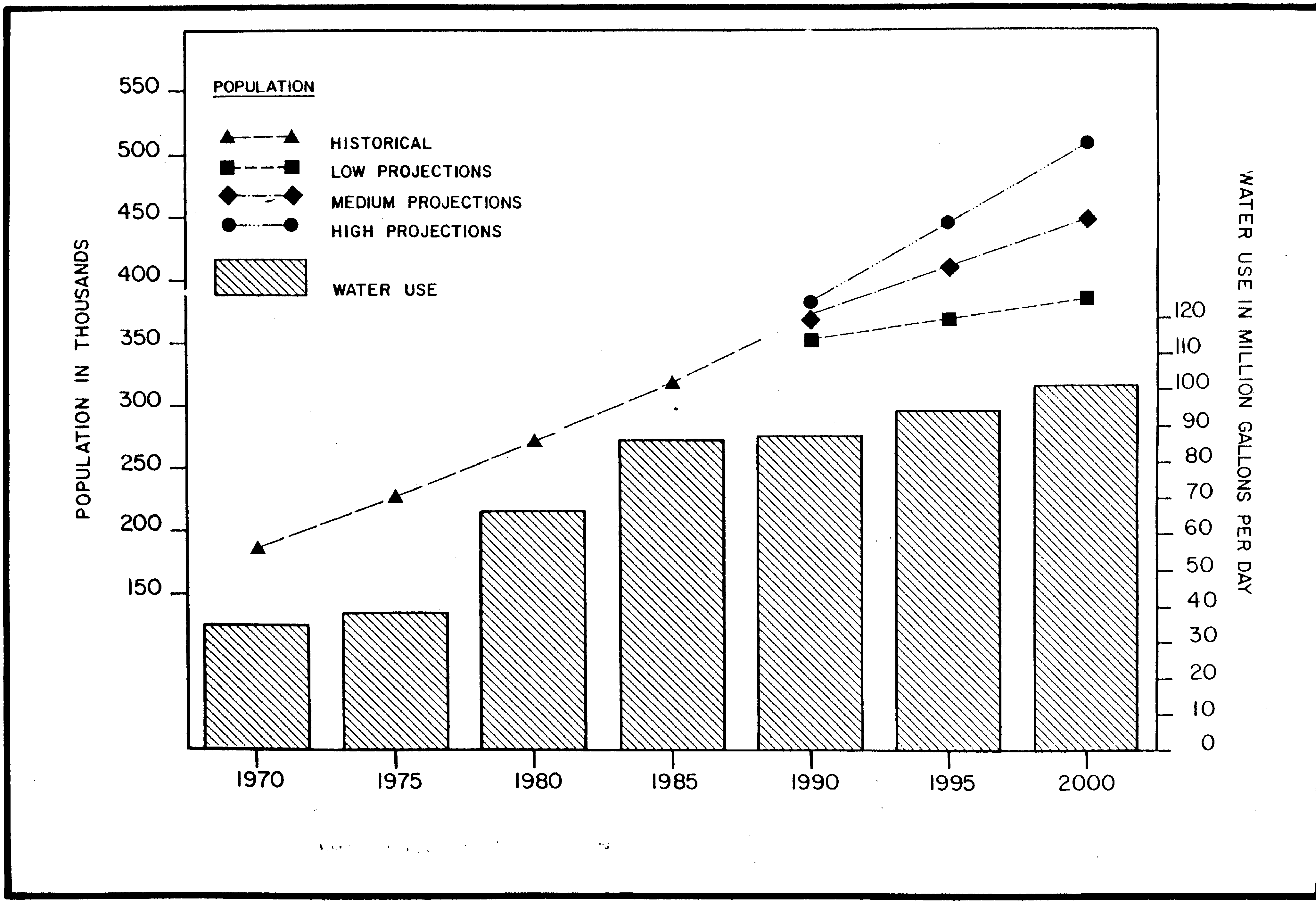


Figure 11. Past and projected population and ground water use for Volusia County

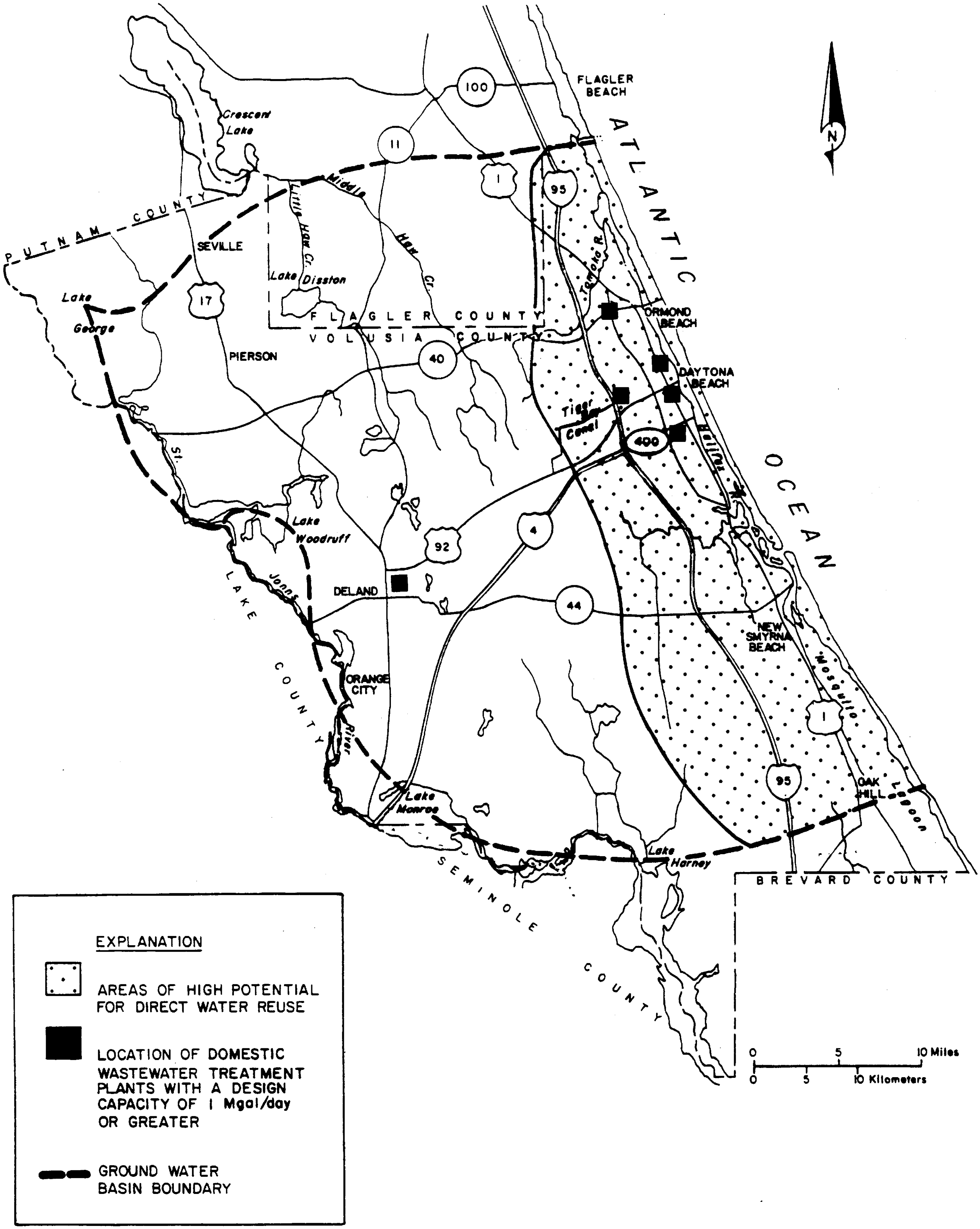


Figure 12. Areas of high potential for direct water reuse in the Volusia ground water basin (modified from Steward 1985)

Proximity to golf courses, landscaped areas, and agricultural areas are some of the important concerns which should be considered when assessing the potential for implementation of a reuse program. WWTPs must have a design capacity of 1.0 mgd for land application of waste water to be considered cost effective (Steward 1985). Environmental factors such as soil characteristics, depth to water table, and proximity of application site to surface waters also need to be considered in a reuse program.

Integration of Coastal Wellfields

Eight public supply wellfields are located in the coastal area of the Volusia ground water basin (Appendix B). A means of meeting increasing water demands for public supply is to integrate these wellfields. Wellfields could be interconnected to distribute withdrawals among wellfields to provide for more flexible water management. This could be accomplished through inter-local agreements or the creation of a regional water supply authority.

Decisions concerning integration of wellfields should be made based on hydrologic and economic considerations. Inadequate information is currently available to propose specific integration strategies.

ADDITIONAL INFORMATION

Additional information on the subjects contained in this report can be obtained by contacting the St. Johns River Water Management District. All of these references are available for review in major libraries and the SJRWMD library.

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Appendix A

LEGISLATION

Appendix A

LEGISLATION

373.0395, F.S., Ground water basin resource availability inventory.

Each water management district shall develop a ground water basin resource availability inventory covering those areas deemed appropriate by the governing board. This 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.

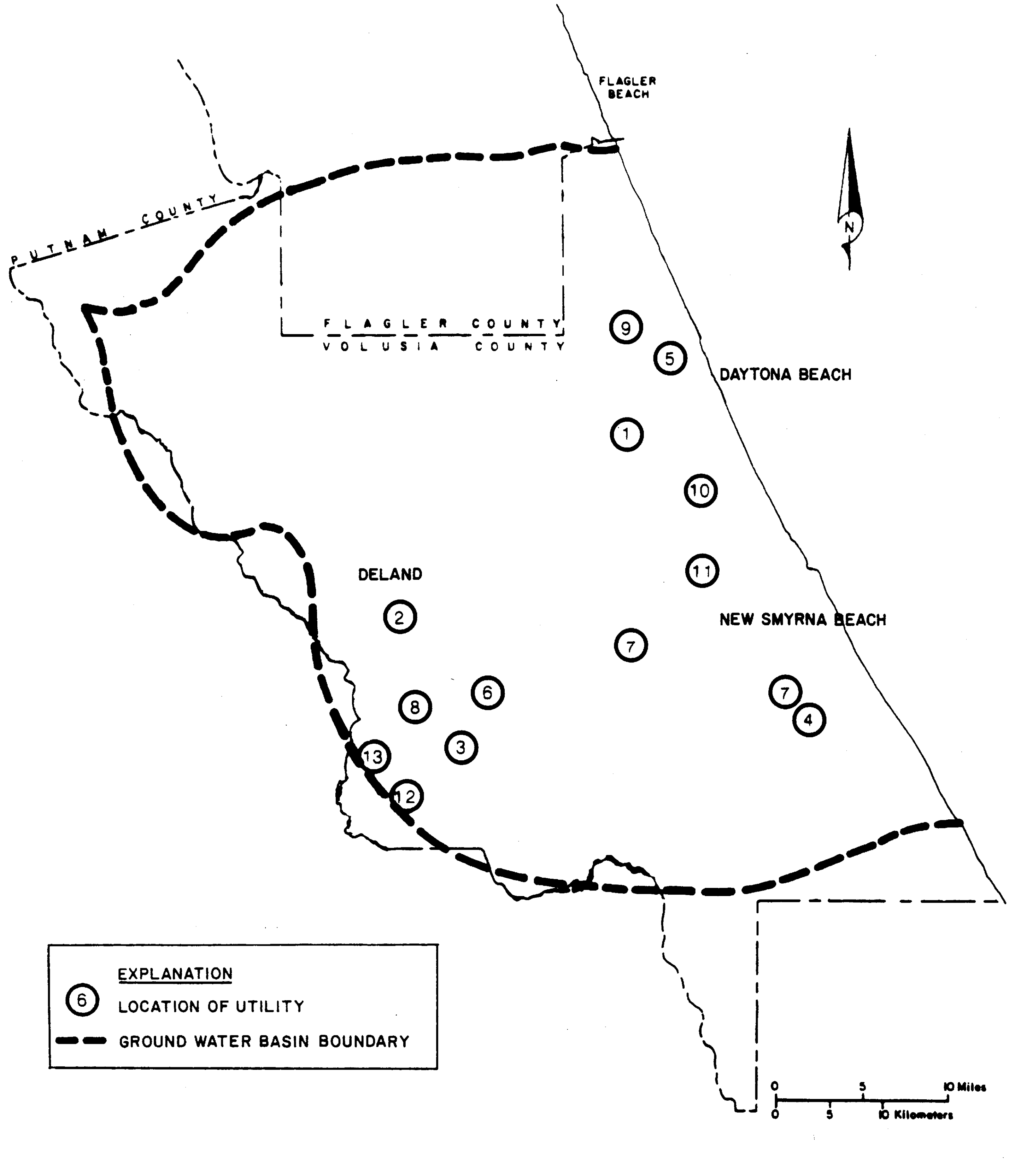
(6) Existing sources of waste water discharge suitable for reuse as well as the feasibility of integrating coastal wellfields.

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

Upon completion, a copy of the ground water basin availability inventory shall be submitted to each affected municipality, county, and regional planning agency. This inventory shall be reviewed by the affected municipalities, counties, and regional planning agencies for consistency with the local government comprehensive plan and shall be considered in future revisions of such plans. It is the intent of the legislature that future growth and development planning reflect the limitations of the available ground water or other available water supplies.

Appendix B

PUBLIC SUPPLY WITHDRAWALS BY UTILITY IN THE VOLUSIA GROUND WATER BASIN FOR 1985 AND 1987



Appendix B. Public supply withdrawals by utility in the Volusia ground water basin for 1985 and 1987

Public supply withdrawals by utility in the Volusia ground water basin for 1985 and 1987 (includes utilities or facilities that withdrew more than 0.20 mgd in 1985 or 1987)

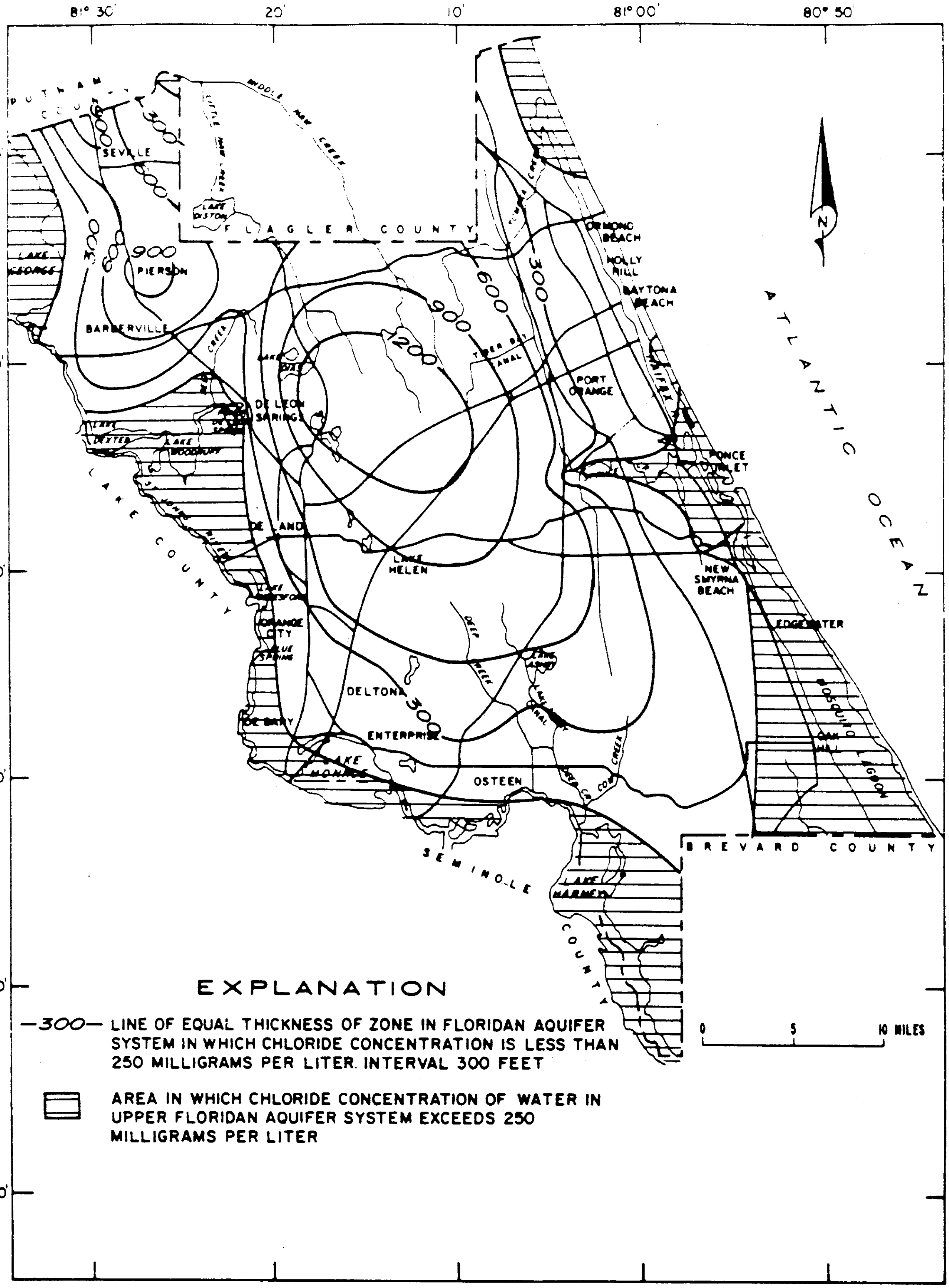
			1985		1987	
Number	Utility/Owner	Water source	mgd	population	mgd	population
1	Daytona Beach, City of	Floridan aquifer	12.35	84,812	12.08	80,436
2	Deland, City of	Floridan aquifer	4.26	25,480	5.11	31,610
3	Deltona Utilities	Floridan aquifer	4.32	29,761	5.97	34,823
4	Edgewater, City of	Floridan aquifer	1.06	9,174	1.34	11,718
5	Holly Hill, City of	Floridan aquifer	1.23	11,075	1.14	12,248
6	Lake Helen, City of	Floridan aquifer	0.26	2,400	0.22	2,407
7	New Smyrna Bch., City of	Floridan aquifer	3.00	22,747	3.60	24,705
8	Orange City, City of	Floridan aquifer	0.45	3,131	0.52	3,883
9	Ormond Beach, City of	Floridan aquifer	3.98	35,000	4.55	39,125
10	Port Orange, City of	Floridan aquifer	3.77	30,290	4.13	37,727
11	Spruce Creek Utility	Floridan aquifer	0.20	1,025	0.23	1,435
12	Volusia Co.-Breezewood	Floridan aquifer	N/A	N/A	0.22	1,200
13	Volusia Co.-Four Townes	Floridan aquifer	0.46	0	0.32	2,700
		TOTALS	35.34	254,895	39.43	284,017
		County totals (1)	36.40	267,898	40.27	290,994

(1) - indicates the totals of all the Utilities in the county as published in inn 1985 (Marella 1986) and in 1987 (Marella 1989). Refer to Appendix B for utility locations.

mgd = Million gallons per day.

Appendix C

ESTIMATED MAXIMUM THICKNESS OF ZONE IN THE FLORIDAN AQUIFER IN WHICH THE WATER IS FRESH OR SLIGHTLY BRACKISH



Appendix C. Estimated maximum thickness of zone in the Floridan aquifer in which the water is fresh or slightly brackish in the Volusia ground water basin (modified from Rutledge 1985)

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