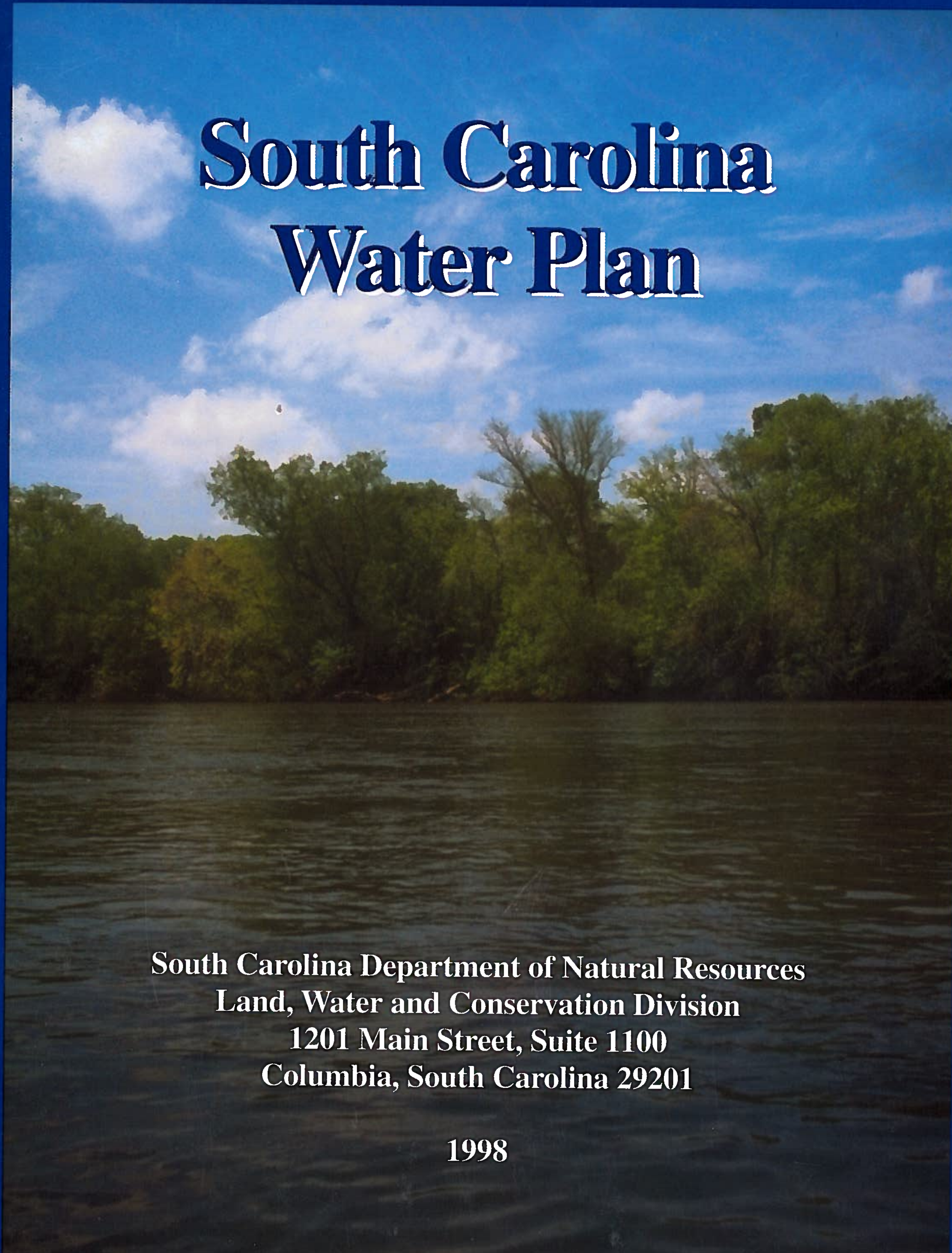
South Carolina Water Plan



South Carolina Department of Natural Resources
Land, Water and Conservation Division
1201 Main Street, Suite 1100
Columbia, South Carolina 29201

1998

SOUTH CAROLINA
WATER PLAN

Goals and Guidelines for
Management of the State's Water Resources

by

Rodney N. Cherry and A.W. Badr

with

Guidance of the Water Resources Division Advisory Committee
for the
Department of Natural Resources

Paul A. Sandifer, Director

Alfred H. Vang, Deputy Director
Land, Water and Conservation Division

1998

DNR

Effective water management is complicated by social, political and economic factors. Wise management of our water resources will require many changes and choices to reflect the reality of a limited and restricted resource.

--Linda Schroeder,
Freshwater Foundation

South Carolina Natural Resources Board

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The following letter transmitted the Water Plan to:

David M. Beasley, Governor of South Carolina
David H. Wilkins, Speaker of the South Carolina House of Representatives
Robert L. Peeler, President of the South Carolina Senate and Lieutenant Governor

The South Carolina State Water Plan is presented herewith in accordance with the provisions of the Water Resources Planning and Coordinating Act, §49-3-10, et seq., Code of Laws of South Carolina, 1976, as amended. This act states that the Department of Natural Resources "shall advise and assist the Governor and General Assembly in: (1) Formulating and establishing a comprehensive water resources policy for the State, including coordination of policies and activities among the State departments and agencies; ..." Prior to the Restructuring Act of 1993, the Water Resources Commission began development of a State Water Plan, and this work was continued by the Department of Natural Resources following the reorganization of State government.

The plan contains the Department's conclusions and recommendations on the policies that it believes the State of South Carolina should adopt at this point in our history for the efficient, equitable, and environmentally responsible science-based management of its water resources. A principal concern has been sustainability.

The Department has examined virtually the entire range of water-resources issues facing the State, including the effects of long-term water withdrawals and use. The problems of water shortage have been addressed, and guidelines and considerations for management of water 'in lakes, streams, and aquifers have been included. Each of the important purposes for which water is used has been studied, and appropriate guidelines have been drawn for insuring efficient, equitable use of these resources. While the solutions proposed may not be those that are finally adopted, they will certainly provoke further awareness and constructive thinking about the water-resource issues facing our State.

The Department has had the cooperation of and extensive review and comments from all levels of water users in South Carolina, from private individuals and organizations to the agricultural community to commercial and industrial users. For this and for the broad range of participation incident to the preparation of this report, the Department is grateful. Those persons and entities are recognized in the Water Plan.

The Department submits this State Water Plan to you with the earnest hope that it will contribute importantly to the timely and wise use of South Carolina's most precious natural resource — our water.

Respectfully submitted,

George C. Graham, D.D.S.
Chairman

South Carolina Department of Natural Resources Board

George G. Graham, Chairman
Oral and maxillofacial surgeon, in private practice in Spartanburg, S. C., since 1960. Dr. Graham graduated from the University of Tennessee College of Dentistry in 1954. He is a Diplomate of the American Board of Oral & Maxillofacial Surgery and a Fellow in the American Society of Oral & Maxillofacial Surgery. He served as a Commissioner with the South Carolina Wildlife and Marine Resources Commission from 1990 to 1994 and since then as a member of the Department of Natural Resources Board. Other affiliations: President of the Spartanburg Rotary Club 1989-1990 and a member since 1960; Board member, South Carolina Department of Health and Environmental Control 1977-1981.

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He currently serves as Chairman, Board of Trustees, The South Carolina Nature Conservancy; member of Government Affairs Committee, Forest Farmers Association; member of Board of Directors and Chairman of the Government Affairs Committee, South Carolina Forestry Association; and Chairman of the Legacy Trust Fund.

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PREFACE

The South Carolina Department of Natural Resources is the advocate for and steward of the State's natural resources. One way the Department fulfills this mission is by providing guidance in developing and managing the State's water resources through planning, research, technical assistance, and public education.

South Carolina is a land of contrasts, and its geography is a key factor in determining the availability and distribution of the State's water resources. Although the State is blessed with an abundance of water, it is unevenly distributed in both location and time.

Demands on this renewable, yet finite, resource are increasing. Water conservation is now more than just a practice to put into place during times of water shortage. Water should be conserved at all times. Even with conservation measures, water-use demands and conflicts will increase, current water supplies will be stressed, new supply sources will have to be explored and developed, and impacts on the State's natural resources during water shortages will be severe. Therefore, the Department of Natural Resources has developed this State Water Plan to provide the overall outlook for water needs throughout the State and to assess the availability of water to satisfy those needs. The Plan emphasizes the relationship between water supplies and expected changes in the agricultural, urban, instream, industrial and other uses of the resource and provides guidelines and considerations for effective management of the water resources of the State.

EXECUTIVE SUMMARY

The Water Resources Planning and Coordinating Act, §49-3-10, et seq., Code of Laws of South Carolina, 1976, as amended, states that the South Carolina Department of Natural Resources "shall advise and assist the Governor and General Assembly in: (1) Formulating and establishing a comprehensive water resources policy for the State, including coordination of policies and activities among the State departments and agencies; ..." The Water Resources Division has been working on a State water plan for several years. Phase I was completed in 1983 by its predecessor agency, the South Carolina Water Resources Commission, with the publication of the State Water Assessment, a compendium of information, by river basin, on the State's water resources. In December 1991, the Commission began preparing Phase II of the plan, which contains guidelines that maximize the availability of water from our rivers, lakes, and aquifers. This work was continued by the Department of Natural Resources following the reorganization of State government in July 1994.

The plan contains the Department's recommendations on the guidelines and considerations that it believes the State of South Carolina should adopt at this point in our history for the efficient, equitable, and environmentally responsible management of our water resources. Principal concerns are meeting present and future water demands, sustaining the natural resource, and minimizing damage to it.

The plan provides guidelines and procedures that consider:

(a) Adequate supplies of water in streams, lakes, and aquifers of suitable quality for domestic, municipal, agricultural, and industrial uses.
(b) Water-quality facilities and controls to assure water of suitable quality for all purposes.
(c) Water-navigation facilities.
(d) Hydroelectric power.
(e) Flood-damage control or prevention measures including zoning to protect people, property, and productive lands from flood losses.

(f) Land-stabilization measures.
(g)Drainage measures, including salinity control.
(h)Watershed protection and management measures.
(i) Outdoor-recreational and fish and wildlife opportunities.
(j) Any other means by which development of water and related land resources can contribute to economic growth and development, the long-term preservation of water resources, and the general well-being of all the people of the State.

The Department has examined the entire range of water issues facing South Carolina, including the effects of long-term withdrawal and use of water. The problems of water shortage have been addressed, as have the problems of integrating the management of streams, lakes, and aquifers. Each of the important purposes for which water is used has been evaluated, and guidelines have been developed for insuring efficient and equitable use of the natural resource. The solutions that are proposed may not be the approaches that are finally adopted, but these ideas are intended to provide awareness and constructive thinking about the water resource issues in South Carolina.

The plan presents general goals and objectives for sustaining the availability of water for current and future use. It also reviews the sources of our water, which are precipitation and streamflow from neighboring states; our stored water; and types of water use. Most importantly, the plan provides considerations and guidelines for how water should be managed in this State. It creates a broad framework that will conserve water supplies.

One of the plan's most critical sections addresses minimum flows for streams and minimum water levels for lakes and aquifers. The minimum streamflows should be maintained for a variety of purposes — protection of water quality, propagation of fish and wildlife, and navigation. The minimum water levels for aquifers are needed to sustain water availability and quality and to minimize the adverse effects caused by withdrawal of water. Guidelines are provided for the establishment of minimum water levels for aquifers.

All water withdrawals greater than 100,000 gallons per day should be registered. Mitigation techniques to minimize adverse effects due to withdrawal of water, such as but not limited to restricting the withdrawal, diverting water from other areas, withdrawing water from a stream rather than from an aquifer or vice versa, or taking water from water storage facilities such as lakes or reservoirs. The Department of Natural Resources would monitor, as necessary, and publish the status and trends in availability and quality of the water resources of the State.

The plan's final critical component deals with identifying and addressing water shortages. It details how to respond to a water shortage. This section is based upon the existing requirements of the South Carolina Drought Response Act of 1985.

The Department has had the cooperation of, and extensive review and comments from, all levels of water users in South Carolina, from private individuals and organizations to the agricultural community and commercial and industrial users. For this and for the broad range of participation incident to the preparation of this report, the Department is grateful. Those persons and entities are recognized in the Acknowledgments section.

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We would like to thank the following individuals, organizations, and other agencies who provided input with comments and/or reviews of the State Water Plan. Their assistance is greatly appreciated.

Mr. Ron Ahle, Department of Natural Resources
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SOUTH CAROLINA WATER PLAN

by

Rodney N. Cherry and A.W. Badr

ABSTRACT

The sources of water for South Carolina are precipitation (48 inches average per year) and streamflow from adjacent states (8 inches average per year). In addition to the annual replenishment, water is stored mostly in sand and limestone aquifers of the Coastal Plain.

The Water Plan suggests the utilization of water from streams and lakes, where feasible, in preference to using water from aquifers, because of the slow recharge to the aquifers and the high evapotranspiration losses and shorter retention times in streams and lakes.

Minimum flows for streams should be established to protect fish and wildlife, preserve water quality, and maintain navigability. Minimum water levels for aquifers should be established to sustain water availability, control land-surface subsidence, and maintain wetlands ecosystems.

All water withdrawals of 100,000 gallons or more in any day, 1 million gallons in any month, or 10 million gallons in any year should be registered.

Mitigation techniques such as but not limited to restricting withdrawal, diverting water from other areas, withdrawing water from a stream rather than from an aquifer or vice versa, or taking water from water storage facilities such as lakes or reservoirs should be considered if a stream's flow is less than the minimum flow or the static water level is below the Trigger Level in an aquifer or undesired effects are occurring because of water withdrawals.

A water shortage should be declared and administered by the State Drought Response Committee when insufficient water is available to meet all withdrawals and maintain the required minimum flow in streams or water level in aquifers.

INTRODUCTION

South Carolina is blessed with an abundance of good water. The State's water resources are replenished primarily by rainfall and by streamflow from adjacent states (Figure 1). In addition, water has been stored over geologic time in the aquifer systems, mostly in the Coastal Plain (Figure 2).

Water in South Carolina's streams and lakes generally is low in dissolved solids and well oxygenated. In the low-lying areas of the lower Coastal Plain, water in streams may contain concentrations of dissolved oxygen below 4.0 mg/L (milligrams per liter), owing mostly to the decomposition of organic materials from wetlands and the low rate of reoxygenation resulting from the slow-moving water. The concentration of dissolved solids in the water of the aquifers ranges from low (less than 100 mg/L) to high (more than 1,000 mg/L). Water in most of the aquifer systems becomes more mineralized as it approaches the coastline. In deep aquifers near the coast, where the water has been in storage for longer periods of time and is mixed with incompletely flushed connate water (water trapped in the sediments at the time of deposition), the mineralization is even higher. High fluoride concentrations (greater than 1.0 mg/L) are a concern in aquifers underlying the coastal counties and, generally, the second tier of counties inland. Water from aquifers in some areas of the upper Coastal Plain contains concentrations of iron greater than 1.0 mg/L.

Water supplies in South Carolina have been developed from aquifers, streams, and lakes. Streams have higher rates of flow than aquifers, but aquifers contain larger amounts of water in storage. Few water systems have been developed to rely on both ground water and surface water. Notable exceptions are the City of Myrtle Beach water system and the Grand Strand Water and Sewer Authority, both of which use streams as the primary source of water and aquifers as a backup. Generally, large water systems rely on streams or lakes and small systems rely on wells.

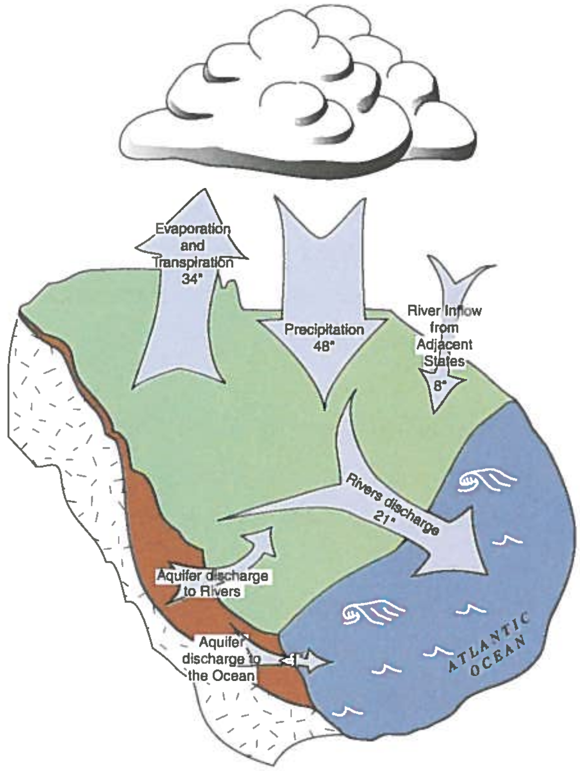

Figure 1. South Carolina Water budget, in inches, for the period 1948-1990.

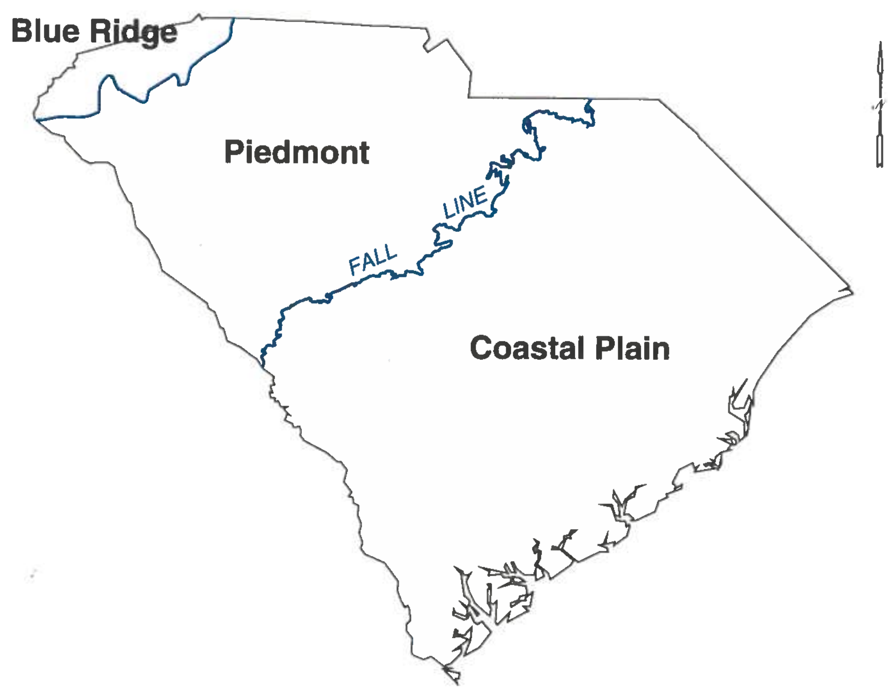

Figure 2. Location of physiographic provinces and the Fall Line in South Carolina.

The cities of Sumter and Florence have the largest systems supplied only by wells. Water systems that rely on impounded streams, such as those at Greenville and Spartanburg, generally fare well during periods of water shortage, whereas systems on streams without impoundments are more frequently faced with insufficient quantity to meet demands. The lowering of water levels in aquifers by withdrawal has caused saltwater intrusion in some coastal areas (e.g. Hilton Head Island).

Demand for water in South Carolina is increasing (Figure 3). The largest increases in recent years have been for nuclear and thermoelectric power generation.

The South Carolina Water Resources Planning and Coordination Act of 1967 assigned to the South Carolina Water Resources Commission the overall responsibility for developing a water resources plan for South Carolina. As part of government restructuring, this act was amended in 1993, and these responsibilities were placed with the South Carolina Department of Natural Resources.

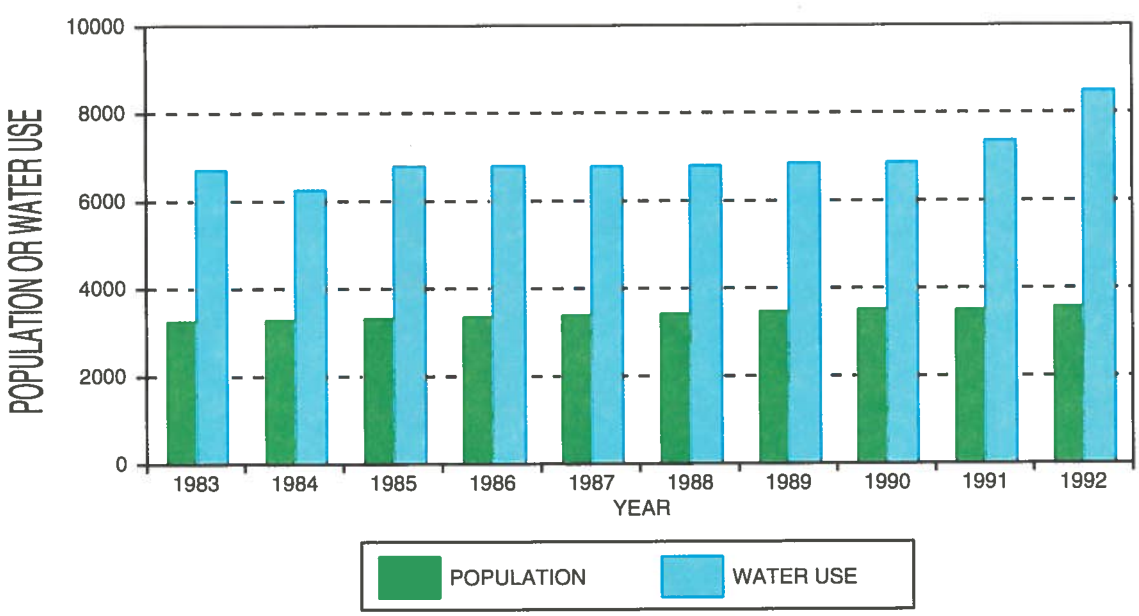

Figure 3. South Carolina population, in thousands, and reported water use, in million gallons per day, for the period 1983-1992.

The State Water Plan consists of two phases. Phase I is an assessment of the water resources of the State and was published as Water Resources Commission Report No. 140, South Carolina State Water Assessment. The Assessment describes the State's stream, lake, and aquifer systems and provides information relating to the occurrence and availability of water in South Carolina.

This document is Phase II and outlines the considerations, guidelines and procedures for managing the State's water resources.

Both parts should be updated periodically, on the basis of changes in water demand and availability and on development of new technologies.

PURPOSE

The purpose of this water plan is to establish considerations, guidelines, and procedures for the effective management of the State's water resources in order to sustain the availability of water for present and future use in South Carolina.

SCOPE

This plan recognizes that, at present, South Carolina possesses an abundance of good water. The plan outlines procedures for assuring that future water requirements of the State can be met and acknowledges that: (1) there are regional variations in the amount of available water; (2) there are temporal variations in the amount of available water; (3) there are seasonal and spatial differences in the demand for water; and (4) there are both intrastate and interstate conflicting demands for water. The plan discusses the source, availability, and demand for water. It also outlines procedures by which (1) an accurate inventory of water withdrawn, stored, and discharged will be maintained; and (2) conflicting demands for water and damage to the natural resources will be minimized, especially during periods of water shortage.

WATER RESOURCES GOALS

The following are declared to be the water resources goals of South Carolina:

1. Recognition that the waters of the State are a finite and valuable natural resource.
2. Recognition that an adequate amount of good water for domestic use, agriculture, industry, and commerce, and for fish and wildlife habitat is essential to the health, safety, and welfare of the people and environment.
3. Utilization of advanced technologies, methods, and procedures to promote efficient use of water and to meet present and future water demands.
4. Preservation of the quality of water and improvement of the water of poorer quality; restoration of the quality of degraded water.
5. Maintenance of an equitable balance between competing demands for water at a reasonable cost.
6. Development of a water-conservation ethic by providing educational opportunities and information to the citizenry.

SOURCE AND AVAILABILITY OF WATER

The sources of freshwater in South Carolina are precipitation, streamflow from adjacent states, and water stored in aquifers. Each year an average of about 48 inches of water is received as precipitation (Figure 4) and about 8 inches as streamflow (averaged over the State) from adjacent states. An estimated 1,100 inches of water are stored in aquifers in the Coastal Plain of South Carolina (Figure 5) which is equivalent to about 700 inches of water averaged over the State. Water stored in the Piedmont region is controlled by the location and size of fractures in the bedrock and the thickness of the overlying weathered portion of the bedrock. Replenishment of this water is primarily from precipitation.

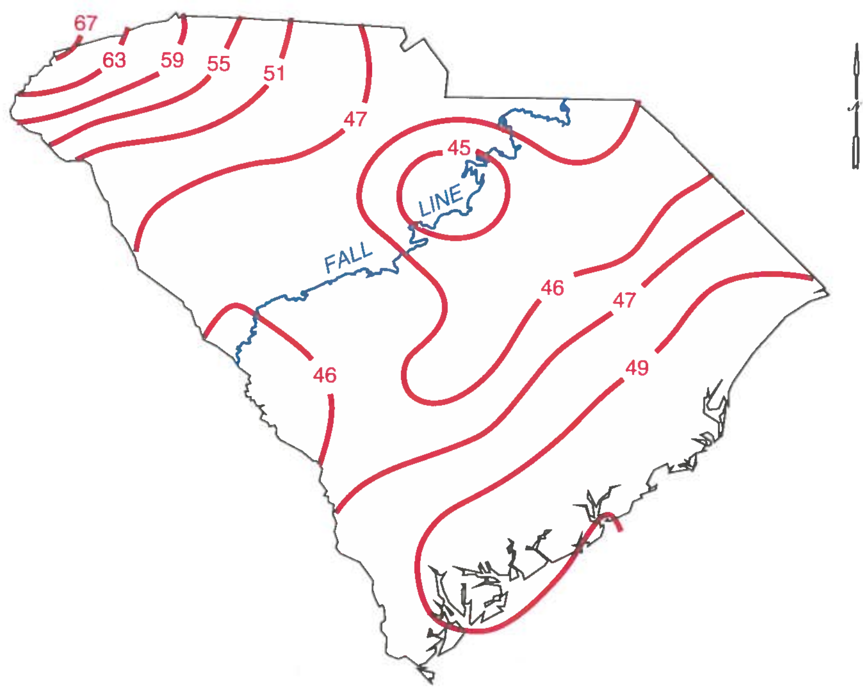

Figure 4. Average annual precipitation, in inches, for the period 1948-1990.

Outflow of water from the State occurs through evapotranspiration and discharge from streams and aquifers. In an average year, 34 inches of water are evapotranspired, 21 inches are discharged as streamflow, and less than 1 inch is discharged from aquifers (Figure 1). Therefore, most of the inflow to the State is from precipitation (48 inches) and most of the outflow is by evapotranspiration (34 inches).

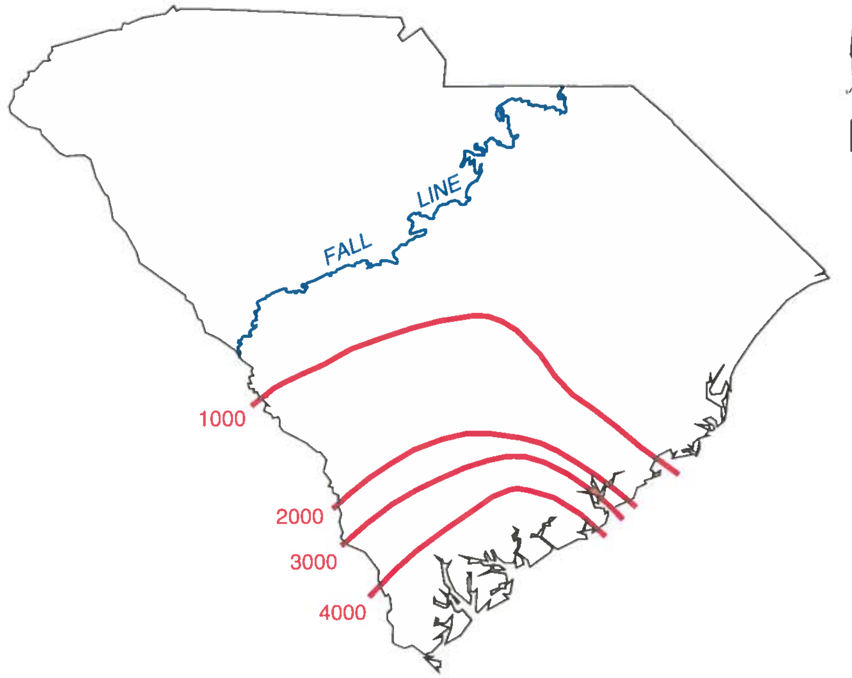

Figure 5. Estimated amount of water, in inches, stored in aquifers of the Coastal Plain.

Precipitation is distributed unevenly over the State. Figure 4 shows that for the period 1948-1990, annual precipitation ranged from 67 inches at the northwest tip of the State to 45 inches in the central part, with the coast receiving about 50 inches.

The average annual evapotranspiration in Figure 6 and the average annual temperatures in Figure 7 indicate that annual evapotranspiration is least in the cooler northern part of the State, (26-30 inches) and greatest in the warmer southern part (30-40 inches).

The annual difference between precipitation and evapotranspiration is greatest, 20-35 inches, in the northwestern part of the State and least, 10-15 inches, in the southern part (Figure 8). Also, there are seasonal and monthly variations. Precipitation is generally high during the period January-May and low during the period September-November. Evapotranspiration is generally high during the period June-October and low during the period November-May. When precipitation exceeds evapotranspiration, streamflow and aquifer

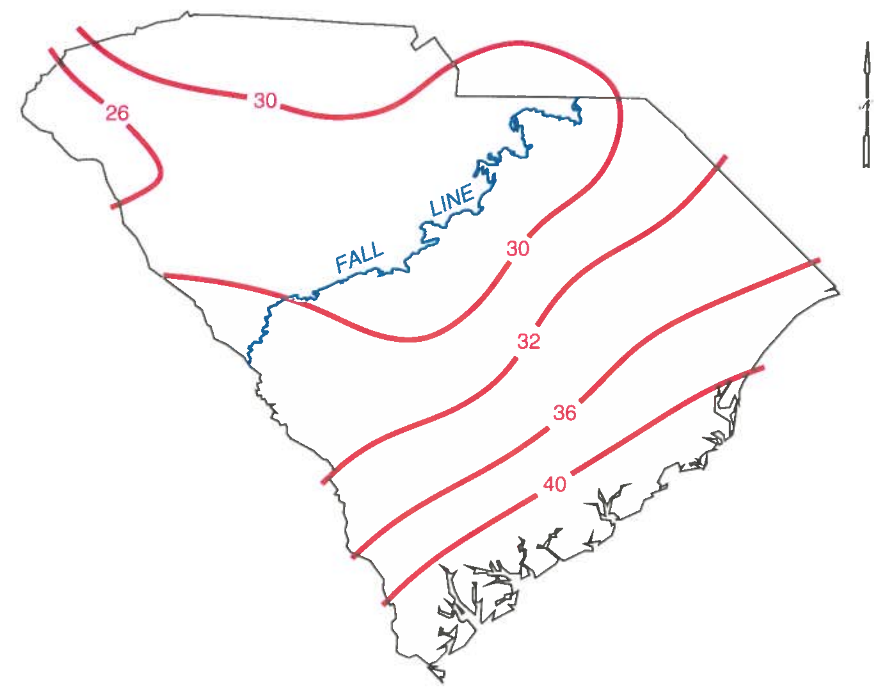

Figure 6. Average annual evapotranspiration, in inches, for the period 1948-1990.

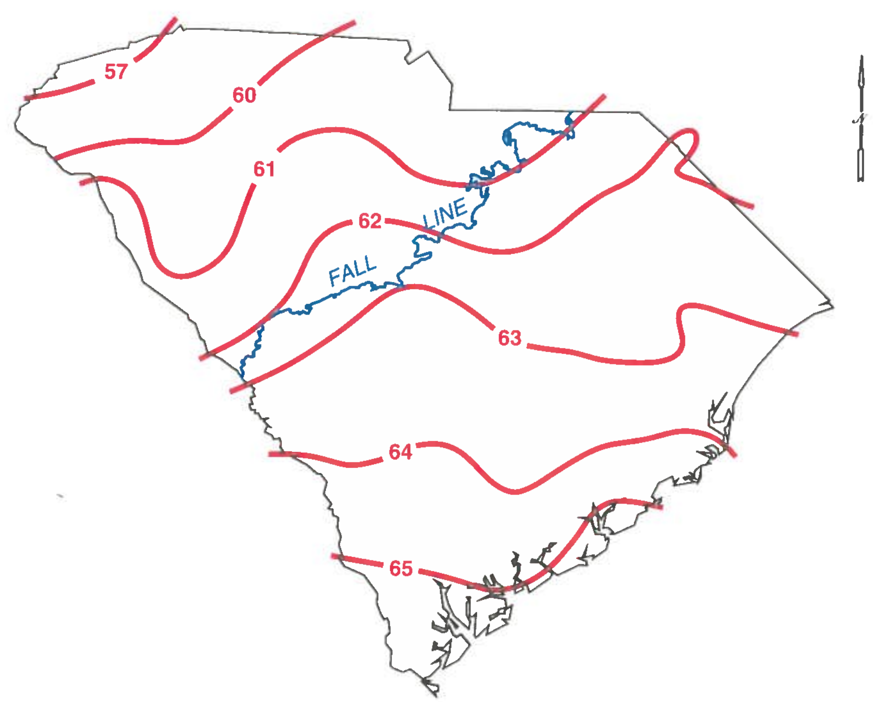

Figure 7. Average annual temperature, in degrees Fahrenheit, for the period 1948-1990.

storage increases. As a result, streamflow and water levels in aquifers tend to be highest in February and March and lowest from August through October. During dry periods, when little or no precipitation reaches the streams, streamflow is maintained by discharge from aquifers.

Only in localized areas of the Coastal Plain, such as Florence, Charleston, and the Grand Strand region, have there been significant long-term declines in water levels in the aquifer, as a result of heavy pumping. In Figure 9, long-term water level trends at selected Coastal Plain sites having relatively constant storage are compared to water levels at sites experiencing storage declines (Florence and Georgetown).

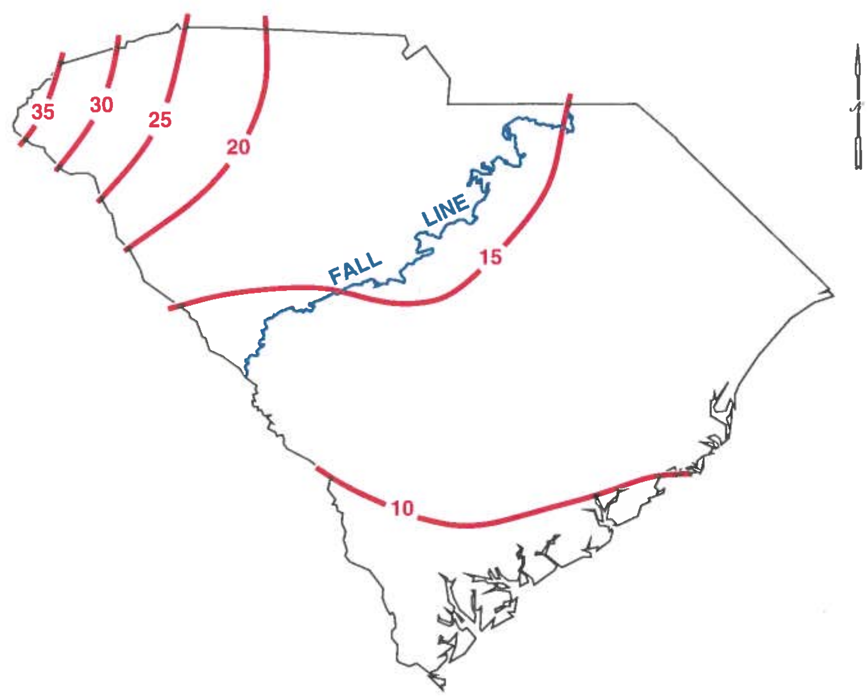

Figure 8. Average annual precipitation less evapotranspiration, in inches, for the period 1948-1990.

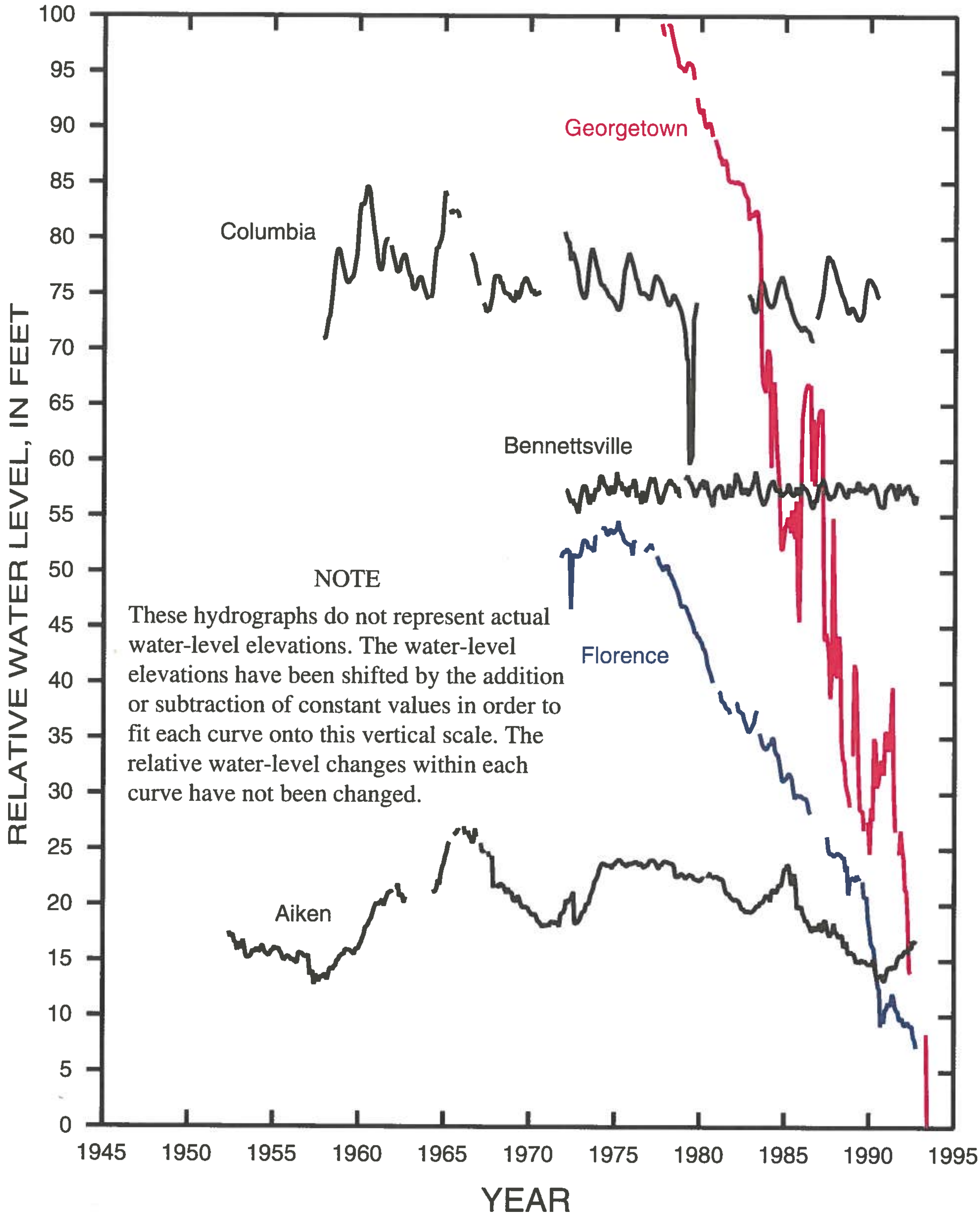

Figure 9. Water-level trends for aquifers at selected sites in the South Carolina Coastal Plain.

WATER USE

Water withdrawal data are collected as a part of the Water Use Reporting Program (South Carolina Water Use Reporting and Coordination Act), which is administered by the South Carolina Department of Health and Environmental Control (DHEC). This program requires any person and any public or private entity withdrawing 100,000 gpd (gallons per day) or more to report the use. Withdrawals or deliveries of less than 100,000 gpd and discharges to surface or ground water bodies are not included or estimated in this plan.

Water withdrawal is discussed as either offstream or instream use. Offstream water use is that which is diverted or withdrawn from either a stream, lake, or aquifer. Instream use is that which takes place without diversion or withdrawal of water from a stream. Instream use in this plan includes only hydropower generation.

In the following analysis, missing monthly water use data for each source (a user may have more than one water source) were assumed equal to the average use of that month for that source.

OFFSTREAM USE

The withdrawals of water shown in Table 1, for the period 1983-1992, are for 11 categories of offstream use: public supply (domestic), commercial, irrigation, golf course, livestock, aquaculture, industry, Savannah River Site (SRS), mining, and thermoelectric and nuclear power generation.

It can be calculated from the data in Table 1 that water withdrawn for cooling at nuclear power plants makes up 60 percent of the total offstream use and that withdrawn for cooling at thermoelectric power plants is about 20 percent. Thus, the combined use for nuclear and thermoelectric power generation represents almost 80 percent of the total water withdrawal.

The offstream water use shown in Figure 10 is for the period 1983-1992. This figure shows an average yearly increase of 2.5 percent in offstream water withdrawals for the period 1983-1991.

Table 1. Reported instream and offstream daily water use for the period 1983-1992

Offstream use	Average daily water withdrawal, in millions of gallons									
Self-supplied	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Aquaculture	0.00	0.28	0.08	0.74	0.65	0.43	0.54	2.7	2.1	4.4
Commercial	0.15	0.24	0.30	0.32	0.31	0.33	0.45	0.57	0.29	0.16
Golf course	6.1	6.54	9.4	12.6	12.1	13.0	14.4	19.5	13.1	13.8
Industry	287	367	338	412	424	460	455	464	486	496
Irrigation	31	37	39	62	54	53.1	41.9	59.8	53.6	54.3
Livestock	0.06	0.03	0.01	0.17	0.03	0.14	0.14	0.20	0.20	0.20
Mining	12	5.5	7.3	5.2	17.6	20.6	17.9	13.6	14.1	15.3
Nuclear power	3780	3400	3860	3840	3660	3780	3870	3890	4600	5960
Thermo power	1194	1346	1404	1240	1370	1578	1720	1665	1370	1190
SRS	791	753	777	780	780	390	187	170	264	211
Public supply										
Domestic	302	318	338	421	431	479	514	560	526	536
Deliveries[1]	22.3	42	43	67	58	50.4	51	51.7	48.2	51.6
Total[2]	6684	6233	6770	6780	6760	6780	6830	6850	7340	8470
Instream use Hydroelectric	48,100	60,900	45,700	40,700	52,900	39,000	60,400	60,000	57,000	57,000

[1]Deliveries for all non-domestic uses.
[2]Rounded.

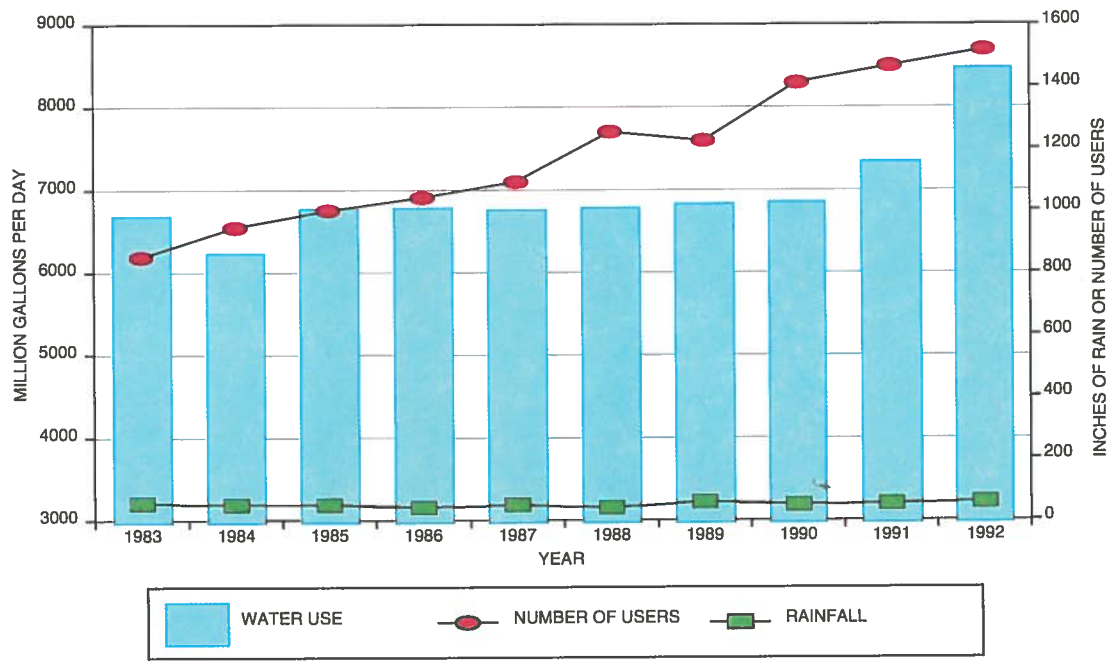

Figure 10. **Reported average daily offstream water use, number of users, and annual precipitation for the period 1983-1992.**

Public Supply

Public supply refers to water withdrawn by public and private water suppliers for domestic, commercial, industrial, irrigation, golf course, aquaculture, livestock, and thermoelectric power generation uses.

Annual water use for public supply, along with precipitation and number of users for the period 1983-1992, is shown in Figure 11. Although the number of public suppliers increased 50 percent during this period, water use increased more than 80 percent, which indicates an increasing use by the public suppliers.

Domestic water use includes water for household use, such as drinking, food preparation, bathing, cleaning, flushing toilets, and watering lawns and gardens. Domestic water use was considered to be equivalent to public supply withdrawals minus deliveries by public suppliers to all non-domestic users. Nearly 24 percent of the population is self supplied (DHEC, 1993); thus, the remaining 76 percent is assumed to be served by public suppliers.

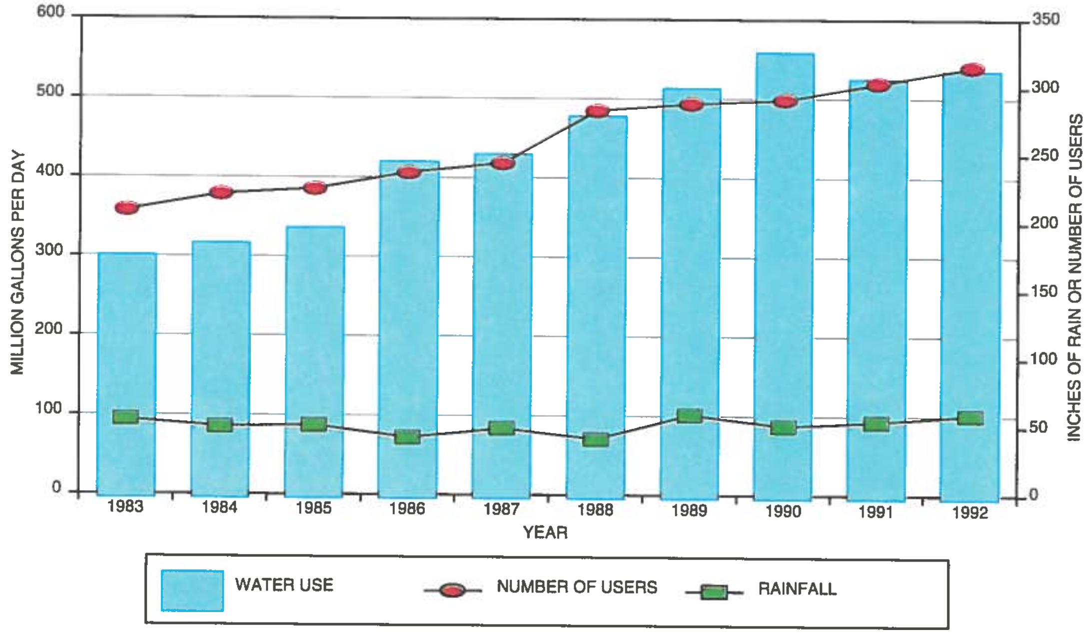

Figure 11. **Reported average daily water use by public suppliers, number of users, and annual precipitation for the period 1983-1992.**

Annual water use for domestic purposes and annual precipitation are shown in Figure 12. Domestic water users here represent only large public suppliers (100,000 gallons per day or more) and small water utilities that purchase water from those large public suppliers; self-supplied domestic use is not included. Large public suppliers serve about 65 percent of the State population, and small utilities serve 11 percent. The average per capita water use was calculated by dividing the domestic water use by 76 percent of total population for each year. Annual per capita water use is given in Figure 13 for the period 1983-1992. Water use per capita may be over-estimated, because it includes water losses in the distribution system and all deliveries less than 100,000 gallons per day. The data show an increase in the period 1983-1990.

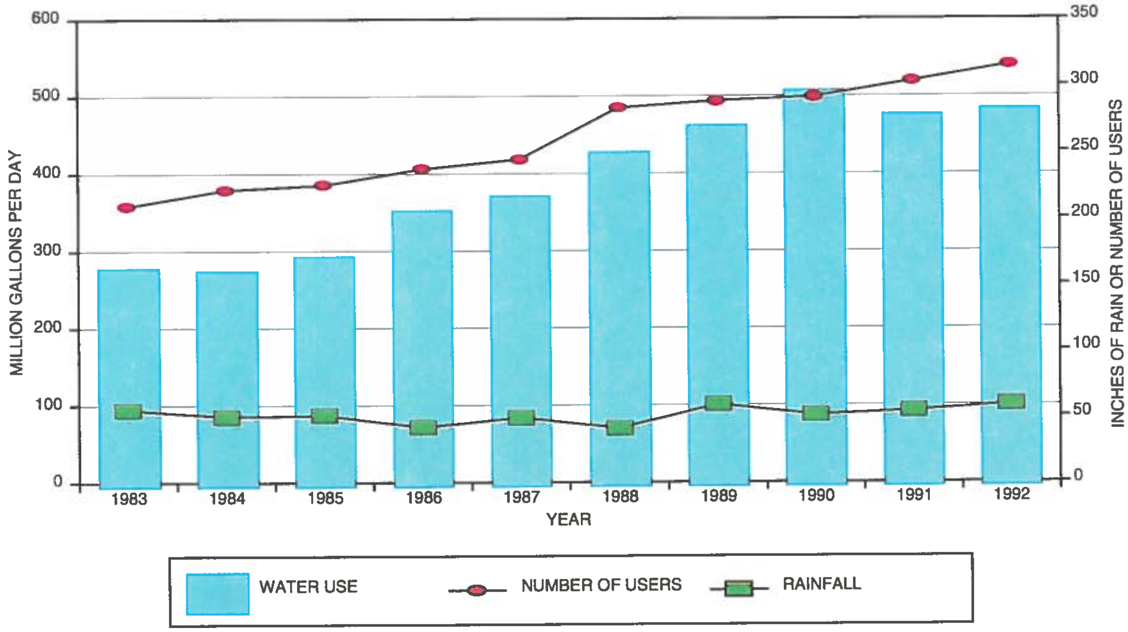

Figure 12. **Reported average daily water use from public suppliers for domestic use, number of users, and annual precipitation for the period 1983-1992.**

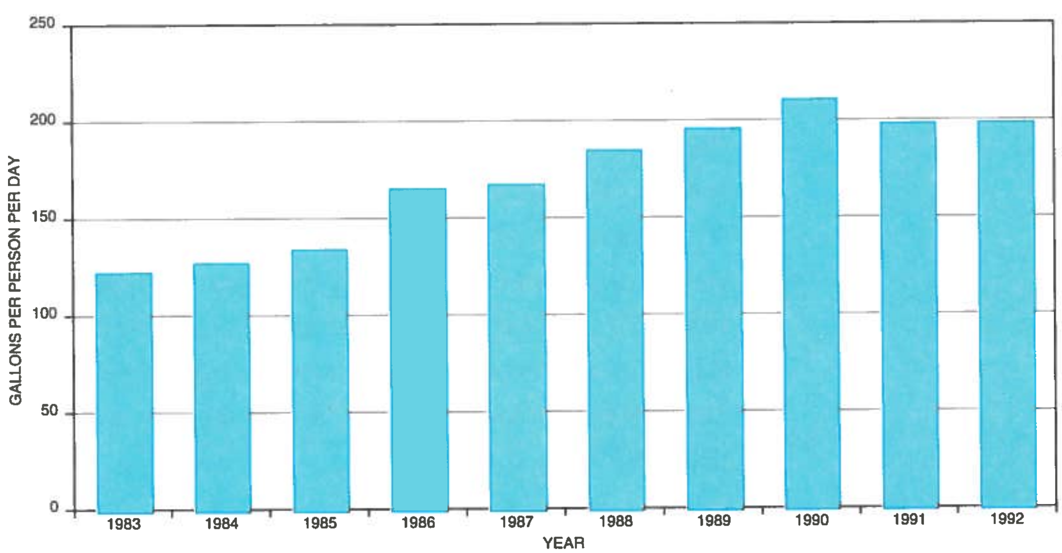

Figure 13. **Estimated average daily per capita use of water for domestic purposes, for the period 1983-1992.**

Commercial

Commercial use includes water for motels, hotels, restaurants, office buildings, civilian and military institutions, and other commercial facilities. Water use for commercial purposes includes both self supplied water and deliveries from public suppliers. Annual commercial water use, along with precipitation and the number of users for the period 1983 through 1992, is given in Figure 14.

Irrigation

Irrigation water use includes all water applied to farm and horticultural crops, but it excludes golf courses. The water is self supplied or obtained from public suppliers. Annual water use for irrigation, along with precipitation and number of users for the period 1983-1992, is shown in Figure 15. Although the number of users more than doubled during this period, their total annual water use increased by only 70 percent, which indicates a net decline in the per user rate of water for irrigation.

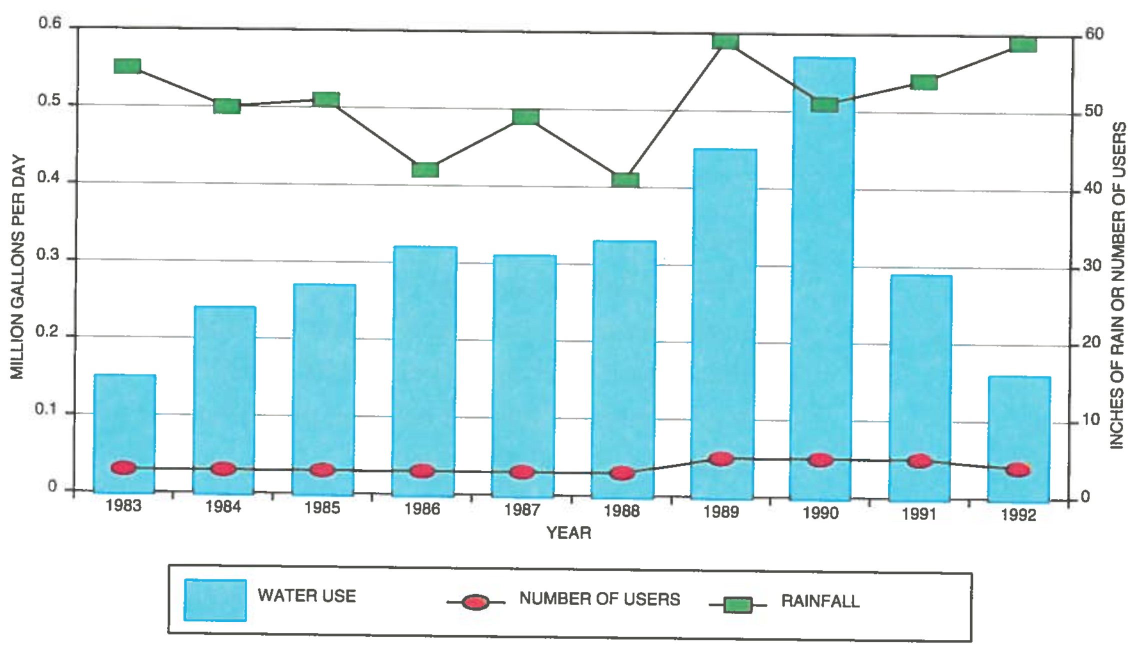

Figure 14. **Reported average daily water use for commercial purposes, number of users, and annual precipitation for the period 1983-1992.**

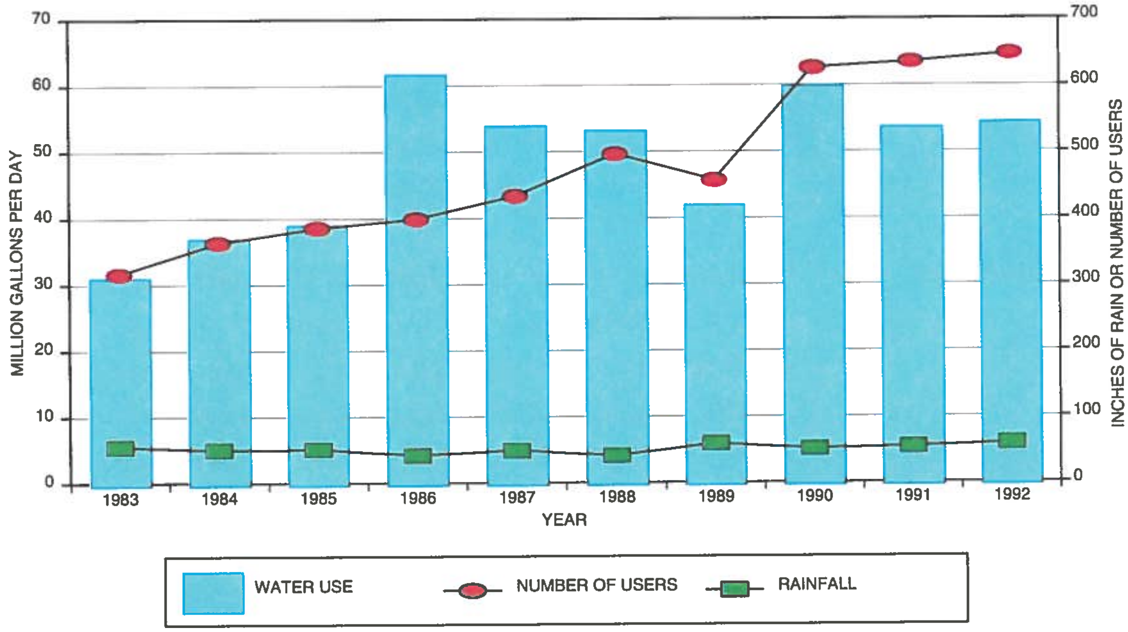

Figure 15. **Reported average daily water use for irrigation, number of users, and annual precipitation for the period 1983-1992.**

Golf Courses

Golf course water use includes all water artificially applied to golf courses. Average annual water use, along with precipitation and number of users, is given in Figure 16. The number of golf courses almost tripled during the period 1983-1992. The data in the graph do not indicate any relation between the amount of water used and the amount of annual precipitation.

Livestock

Livestock water use includes water for animals, feed lots, dairies, poultry, and animal specialties. Annual water use for livestock, along with precipitation and number of water users, is shown in Figure 17.

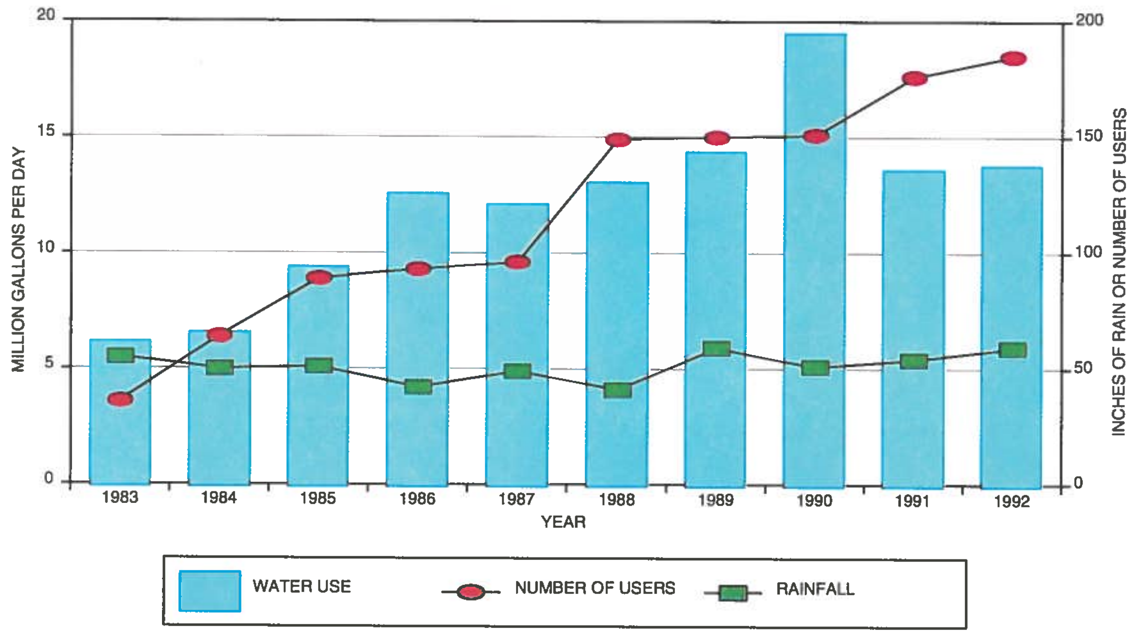

Figure 16. Reported average daily water use for golf courses, number of users, and annual precipitation for the period 1983-1992.

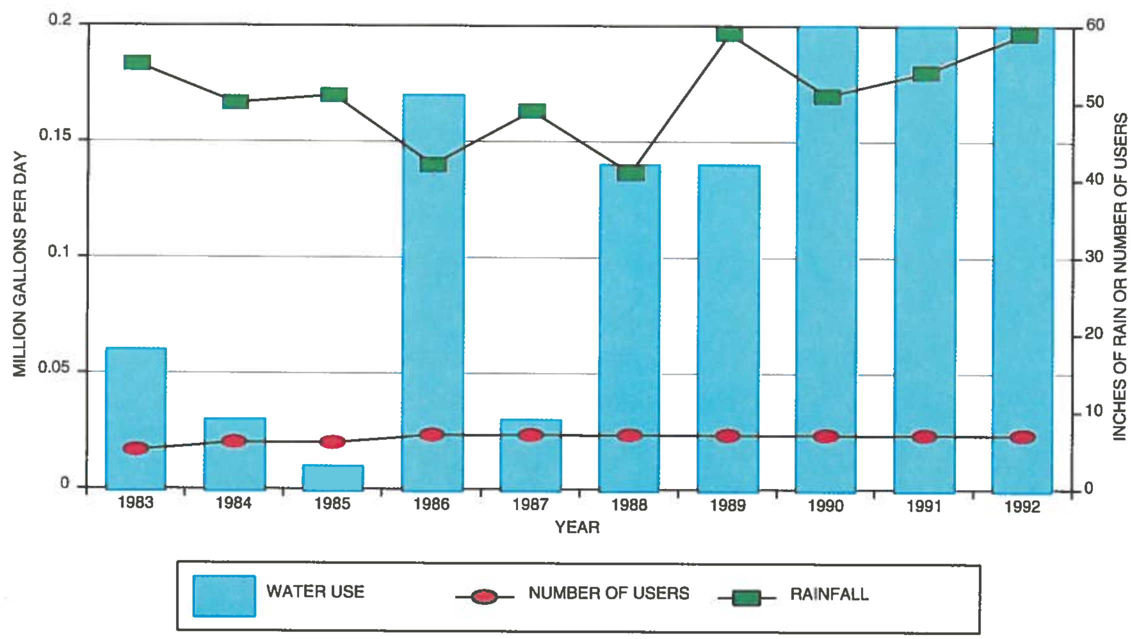

Figure 17. Reported average daily water use for livestock, number of users, and annual precipitation for the period 1983-1992.

Aquaculture

Aquaculture water use includes water for the production of fish in captivity. Annual water use for aquaculture, along with precipitation and number of users, is given in Figure 18. The data in this graph show that the number of users increased about fifteen times during the period 1983-1992.

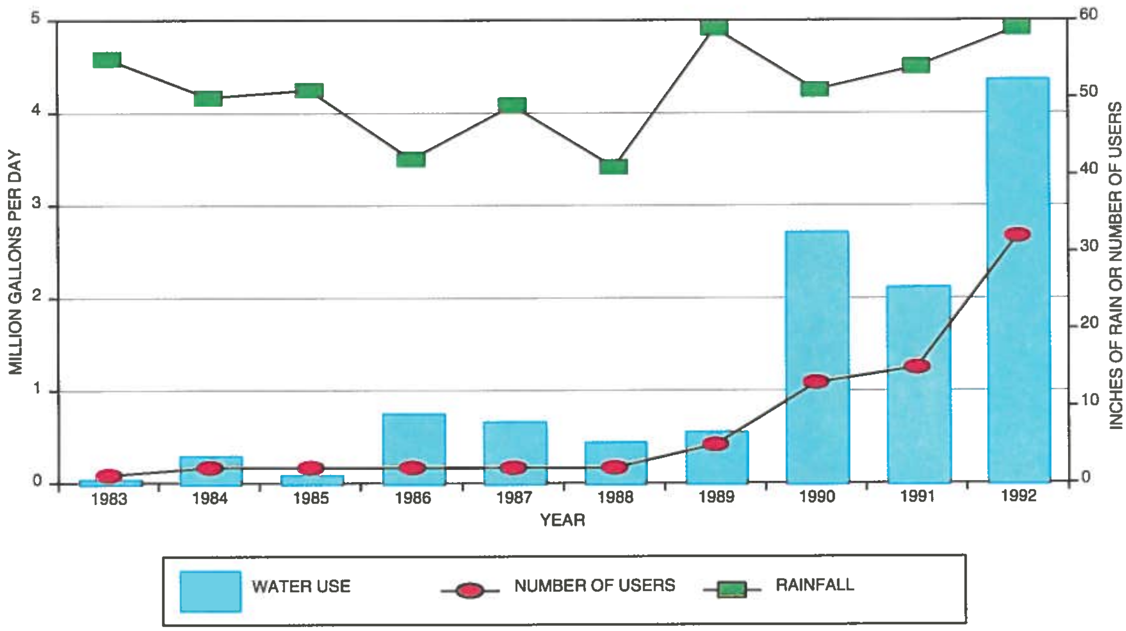

Figure 18. Reported average daily water use for aquaculture, number of users, and annual precipitation for the period 1983-1992.

Industrial

Industrial water use includes water for processing, washing, and cooling in manufacturing facilities. Major water-using industries include, but are not limited to, steel, chemical, and allied products; textiles; and paper and allied products. Annual water use for industrial purposes, precipitation, and number of users for the period 1983-1992 are shown in Figure 19. Withdrawals for industrial use increased more than 70 percent while the number of users increased only 14 percent. This is due to a higher water use in some new industries. Industrial water use shows very little correlation with precipitation.

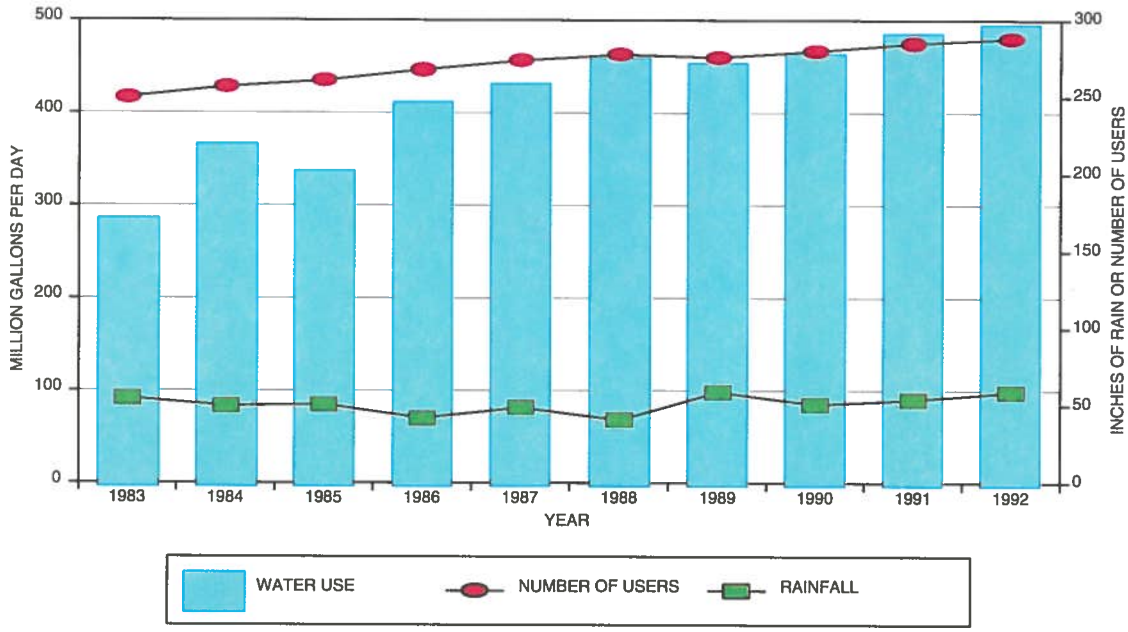

Figure 19. **Reported average daily water use for industry, number of users, and annual precipitation for the period 1983-1992.**

Savannah River Site (SRS) Water use at the Savannah River Site is primarily for cooling of the nuclear reactors. Water use at this facility depends on the number of reactors in operation. Annual water use by SRS, along with precipitation, is shown in Figure 20. The data indicate the highest water use during the period 1983-1987. At present, and for the foreseeable future, none of the reactors are in operation.

Mining Mining water use includes water for the extraction, dewatering, milling, and other preparations that are part of mining activities. Annual water use for mining, the annual precipitation, and the number of users are given in Figure 21.

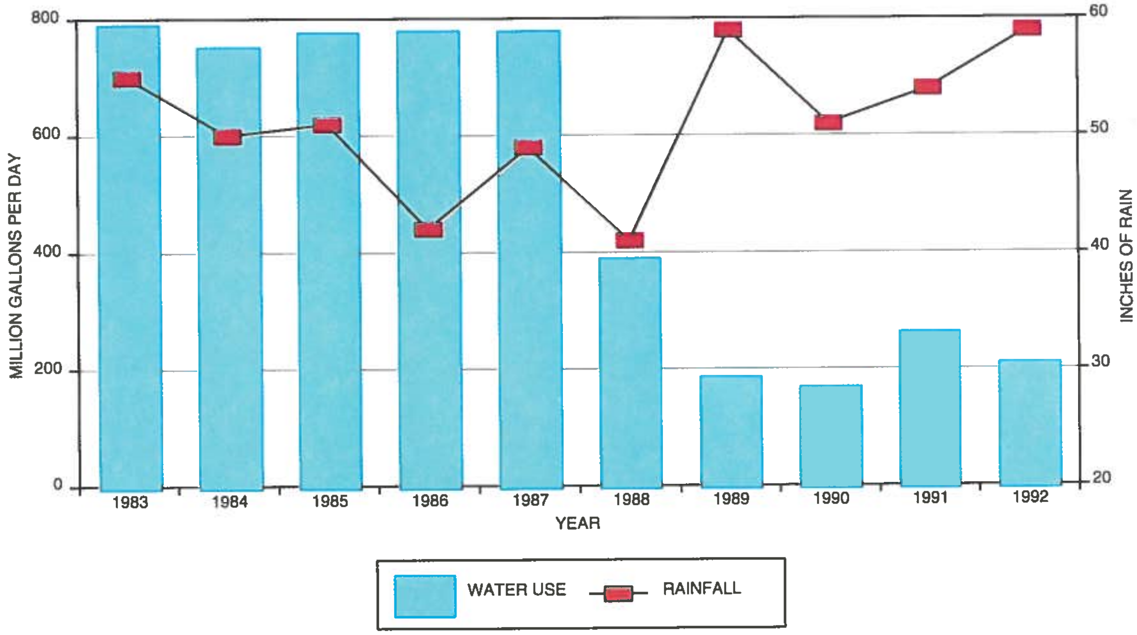

Figure 20. **Reported average daily water use by the Savannah River Site and annual precipitation for the period 1983-1992.**

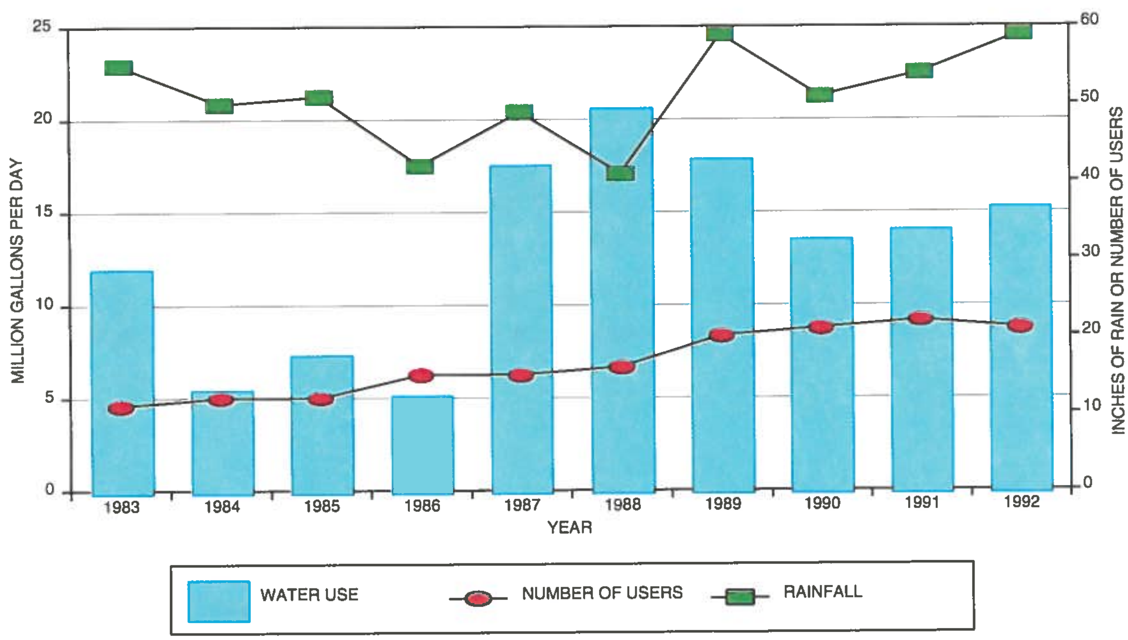

Figure 21. **Reported average daily water use for mining purposes, number of users, and annual precipitation for the period 1983-1992.**

Thermoelectric Power

Thermoelectric power includes water used in the generation of electric power with fossil fuel and excludes nuclear energy. Annual water use for thermoelectric, along with precipitation and number of users, is shown in Figure 22. The data show no significant differences in the number of water users for the period 1983-1992.

Nuclear Power

Nuclear power includes water used in the generation of electric power by nuclear fission. Annual water use for nuclear power, along with precipitation and number of users, is shown in Figure 23. These data show an increase in water use from 1983-1992, even though the use was fairly constant for the period 1984-1990.

INSTREAM USE

Hydroelectric power generation, employs falling water to drive the turbines that produce electricity. Annual water use for hydroelectric power generation, along with precipitation and number of users for the period 1983-1992, is shown in Figure 24.

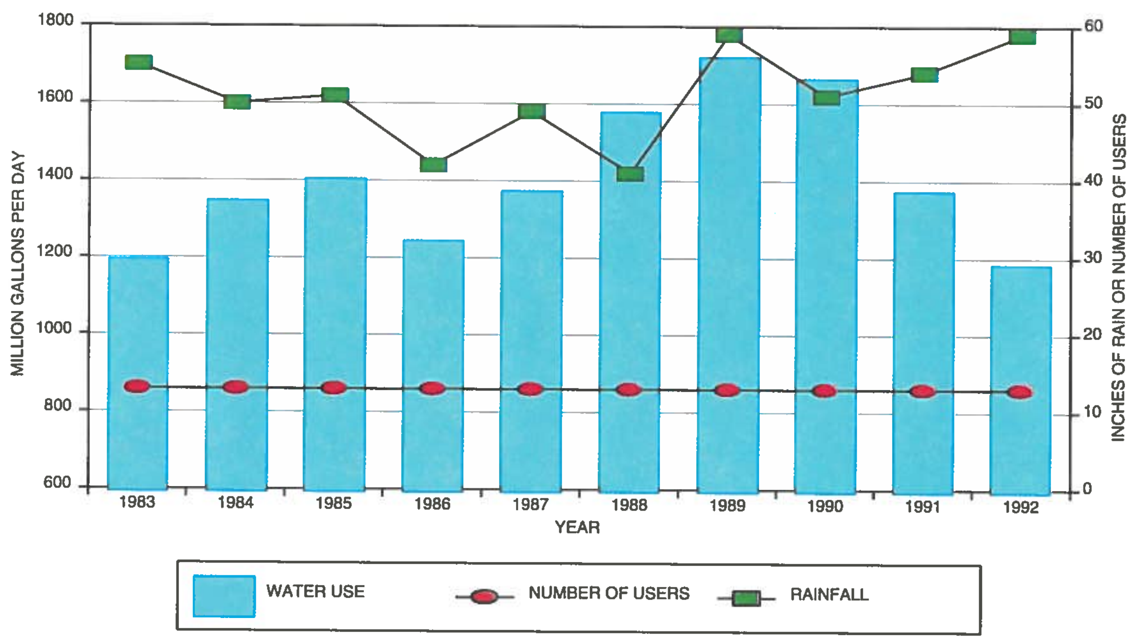

Figure 22. Reported average daily water use for thermoelectric-power generation, number of users, and annual precipitation for the period 1983-1992.

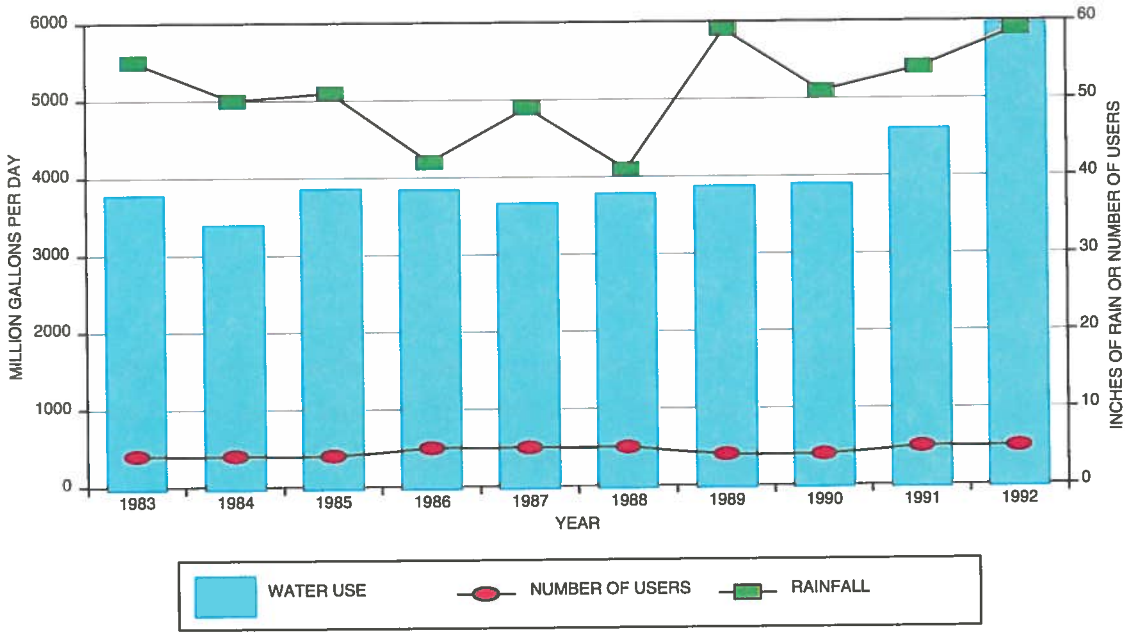

Figure 23. **Reported average daily water use for nuclear-power generation, number of users, and annual precipitation for the period 1983-1992.**

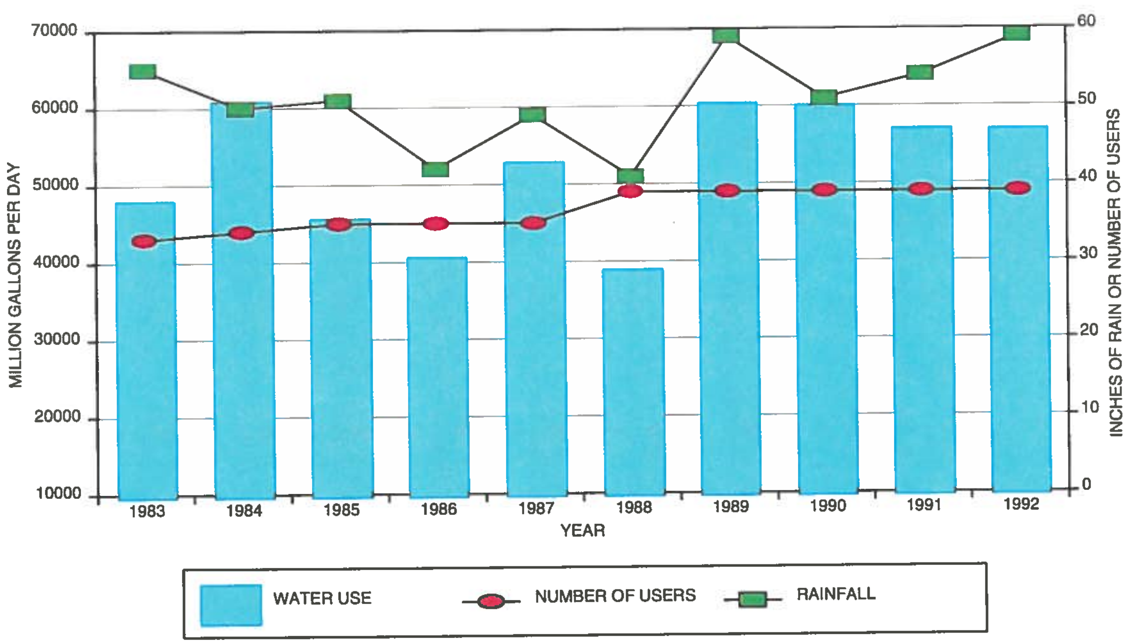

Figure 24. **Reported average daily water use for hydropower generation, number of users, and annual precipitation for the period 1983-1992.**

COLLECTION, MANAGEMENT, AND ANALYSIS OF WATER RESOURCES DATA

The South Carolina Department of Natural Resources (DNR), in its overall assessment and continuous monitoring of the status of the natural resources of the State, will coordinate with other agencies the collection, management, and analysis of water resources data. Management of data will include the dissemination of data by publication of formal reports, responses to information requests, conducting educational and information programs, and portrayal of data on web sites.

All streams, lakes, and aquifers are components of the hydrologic system which conveys water from where it falls as precipitation to the ocean. The quantity and quality of water should be monitored in all streams, lakes, and aquifers on a continuous basis (Figure 25). Streams that originate outside the State and flow through the State should be monitored (quantity and quality) at sites near the point of entry into the State, near midstate (Fall Line), and at sites just upstream of tidal waters. The quantity and quality of water should be monitored in streams where the drainage area is totally within a physiographic province of the State (Blue Ridge Mountains, Piedmont, and Coastal Plain). Quantity and quality of water should be monitored at sites representative of the upper, middle, and lower areas of the Piedmont and Coastal Plain. The flow quantity and quality of streams should be monitored upstream and downstream of facilities discharging wastes.

Withdrawal and use of water in excess of 100,000 gallons per day should be reported to DHEC.

Quantity and quality of the water resources are presently monitored either by or in cooperation with DNR, DHEC, and U.S. Geological Survey (USGS). DNR collects data related to the quantity and quality of water. DHEC collects data related primarily to the quality of water. USGS collects data related to the quantity and quality of water in cooperation with DNR, DHEC, and other interested parties. All data should be entered into a natural-resource data base maintained by DNR. DHEC and USGS should enter data into the system in a standardized format coordinated and developed jointly by the three agencies.

DNR is determining the areal extent, thickness, and water-transmitting characteristics of aquifers and will periodically publish the status of water storage in aquifers and the flow of streams in the State in cooperation with USGS. DHEC will continue to monitor the quality of water, particularly with respect to contaminants that may be introduced to the streams and aquifers. Studies of the water chemistry of the aquifers will be conducted by DNR, DHEC, and USGS.

The location of the saltwater-freshwater interface (concentrations of chloride equal to or greater than 250 mg/L) will be determined and monitored by DNR and DHEC. Monitor wells should be located or installed for all aquifers along the entire coast of the State.

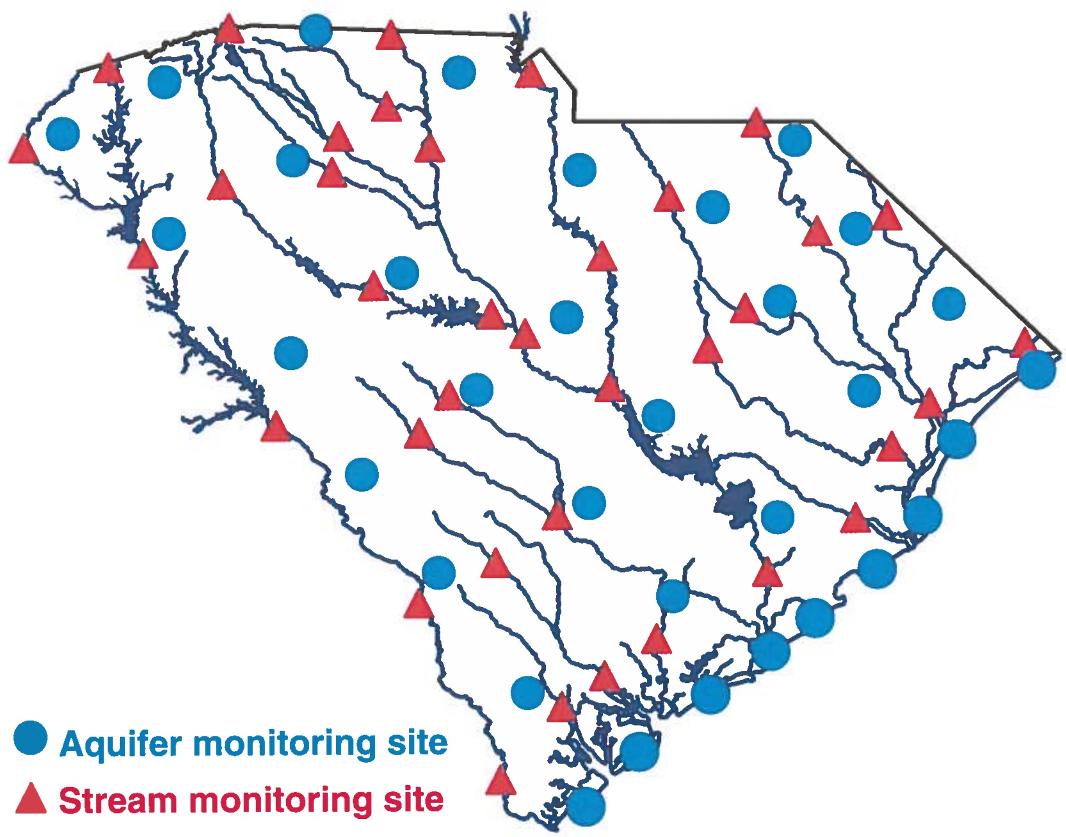

Figure 25. Basic network for monitoring quantity and quality of water in streams, lakes, and aquifers of the State.

MINIMUM FLOWS FOR STREAMS AND MINIMUM LEVELS FOR LAKES AND AQUIFERS

Minimum flows for streams are established by DNR to protect public health and safety, maintain fish and wildlife, and provide recreation while promoting aesthetic and ecological values. Minimum water levels for aquifers should be established by DNR to maintain the availability of water for supplies.

MINIMUM FLOWS FOR STREAMS

The minimum flow established for a stream is the greatest of the minimum flows required for:

1. maintenance of water quality;
2. maintenance of fish and wildlife;
3. maintenance of navigability.

In general, the highest minimum flow is required for fish and wildlife. de Kozlowski (1988) indicated that about 20 percent of the annual average flow would be the minimum required for maintenance of fish and wildlife during low-flow periods in late summer and early fall.

Minimum flow varies with the drainage area of the stream. The relationships shown in Table 2 are based on 20 percent of the average annual flows for the period 1938-1995 and the drainage areas of selected streams in South Carolina.

Maintenance of Water Quality

Streamflows should be preserved to protect human health and safety and to prevent irreversible damage to the ecosystem. Ordinarily, the minimum flow required to maintain water quality in streams is the 7Q10 flow, which is used to determine wasteload allocation for a stream. The 7Q10 flow is a statistically determined value and is defined as the lowest mean streamflow over 7 consecutive days that can be expected to occur once in a 10-year period. In any year, there is a 10-percent probability that the average flow for 7 consecutive days will be equal to or less than the 7Q10.

Maintenance of Fish and Wildlife

The minimum flow for fish and wildlife is defined as the flow required to maintain adequate habitat for most aquatic life forms. Guidance for instream flow requirements for fish and wildlife can be found in *South Carolina Instream Flow Studies: A Status Report* (Bulak and Jöbsis, 1989).

Table 2. Equations for use in estimating minimum flow, for drainage areas along South Carolina streams.

STREAM SYSTEM	EQUATION FOR MINIMUM FLOW
Black Creek (Pee Dee Basin)	$0.803\ DA^{0.755}$
Black River	$.249\ DA^{0.936}$
Broad-Congaree-Santee River	$1.21\ DA^{0.816}$
Catawba-Wateree River	$1.25\ DA^{0.811}$
Enoree River	$.827\ DA^{0.811}$
Little Pee Dee River	$.264\ DA^{0.975}$
Lynches River	$1.08\ DA^{0.761}$
Pacolet River	$.694\ DA^{0.859}$
Salkehatchie River	$1.74\ DA^{0.650}$
Saluda River	$2.12\ DA^{0.714}$
Savannah River	$3.98\ DA^{0.691}$
North, South Fork Edisto-Edisto River	$.533\ DA^{0.873}$
Tyger River	$.285\ DA^{0.999}$
Yadkin-Pee Dee River	$.487\ DA^{0.912}$
Waccamaw River	$.114\ DA^{1.089}$

***Example:** For the Pee Dee River where the DA (drainage area) is 8,830 mi*^{2} *the minimum flow =* $0.487\ (DA)^{0.912} = 0.487\ (8830)^{0.912} = 1{,}993$ *cubic feet per second.*

Navigability

Minimum flow for navigation is based on either one-way or two-way navigation for individual stream segments. Minimum flow for one-way passage by boat will provide a minimum depth of 1 foot across a channel 10 feet wide or across 10 percent of the total stream width, whichever is greater. The minimum flow for two-way passage of boats would provide a minimum depth of 2 feet across a channel 20 feet wide, or across 20 percent of the total stream width, whichever is greater.

MINIMUM WATER LEVELS FOR LAKES

Water releases downstream of a regulated lake should be equal to or greater than the minimum flow downstream from the lake unless the inflow to the lake is less than the minimum flow, then the minimum flow from the lake should be equal to the inflow to the lake. A water-shortage contingency plan should be developed for lakes and approved by DHEC in coordination with DNR. The plan should be developed and coordinated with the appropriate Federal and State agencies and local governments. The plan should include indicators that reflect the water-shortage severity levels and the associated water releases with each severity level. A public-information program should be included in the water-shortage contingency plan for each lake. DNR will act as the lead agency for public information and for recommending water-use priorities during periods of water shortage.

MINIMUM WATER LEVELS FOR CONFINED AND UNCONFINED AQUIFERS

A confined aquifer (also called an artesian aquifer) is bounded above and below by relatively impermeable layers. Water entering an unconfined aquifer in areas at higher altitude becomes subject to pressure in the aquifer when confined downgradient. In some areas, water in confined aquifers is under sufficient pressure to produce flowing wells.

The minimum static (nonpumping) water level for an aquifer is the lowest water level above which no irreversible damage to the aquifer or other natural resources would occur as a result of withdrawal of water. Saltwater intrusion into an aquifer is not considered to be irreversible, even though it may be very costly to reverse.

An unconfined aquifer (also called phreatic, shallow, or water-table aquifer) has the land surface as its upper boundary. Unconfined aquifers are directly recharged from precipitation on the ground surface above it, by leakage upward from underlying confined-aquifer systems, or from streams and lakes during periods of high stream or lake levels.

The unconfined water should be managed for its appropriate uses and to mitigate irrigation requirements during periods of water shortage. The impact of such management on wetlands, flood hazard, saltwater intrusion, and other environmental concerns should be considered in management of the aquifer.

A decline in water level may increase the stress on an aquifer system that could cause rearrangement of the particles composing the aquifer skeleton and/or dewatering of clay within the aquifer system, with subsequent subsidence of the land surface. It is of concern in South Carolina because of the large amounts of clay in the aquifer systems.

Although some lowering of land surface due to water withdrawal from the aquifer system in some areas of the State may go unnoticed or may be acceptable, it could be devastating to the resource in other areas of the State, especially near the coast.

Land-surface subsidence caused by withdrawal of water from the aquifer(s) has been reported in various parts of the world (Poland, 1984) and in South Carolina by Hockensmith (1989) and Spigner (1978).

Minimum water levels are not established at this time; however, procedures and guidelines for their establishment should include the following:

(a) The withdrawal of water from an underlying aquifer should not continuously result in the capture of shallow-aquifer water at a rate that exceeds the water yield of the area (see Fig. 8).

(b) The withdrawal of water from an aquifer should not result in saltwater intrusion. Pumping schedules should be planned such that saltwater intrusion is prevented. Withdrawals should be located at sufficiently inland locations so as not to exacerbate existing intrusion but to aid in its elimination;

(c) The withdrawal rate should be minimized so as to prevent subsidence of the land surface at all locations;

(d) The withdrawal of any water should be viewed as a withdrawal against either the reservoir's storage or as a capture of water supplying a stream system.

WATER QUALITY MANAGEMENT POLICIES

Water quality in streams, lakes, and aquifers should be maintained at, or better than, the current quality. Point-source pollutants discharged to waters in a basin should be treated as required and then dispersed in such a manner that the effluent is mixed with the receiving stream.

Water that meets established standards for all State water should be maintained. Water that does not meet standards should be improved to meet standards where possible.

Water quality of all streams and lakes should be maintained to provide for the survival and propagation of a balanced indigenous aquatic community of flora and fauna and to provide for recreation in and on the water.

Water quality in aquifers should be maintained or restored so that the water is suitable as a drinking-water source without any treatment.

Degradation of water quality will not be allowed beyond permitted levels. If localized degradation is allowed, DHEC will designate the appropriate mixing zones for each discharge and establish limits for the extent of the mixing zones. Mixing-zone areas will be based on site-specific channel and flow characteristics.

Assessment of the State's water quality and of its quality-management policies should be an ongoing process.

STATEWIDE REGISTRATION AND MITIGATION OF THE EFFECTS OF WITHDRAWALS

All withdrawals of 100,000 gallons or more in any one day, 1 million gallons in any month, or 10 million gallons in any year from a stream, lake, or aquifer should be registered with DHEC. Information should be provided to DHEC annually on the withdrawal amount and its use.

REGISTRATION

Registration should include information on location of withdrawal site, proposed withdrawal rate, proposed use of water, well construction including depth, size of well, and screen depth and length.

MITIGATION OF THE EFFECTS OF WITHDRAWALS

Withdrawal or diversion of water from a lake, stream, or aquifer may cause some undesired or adverse effect such as, but not limited to, saltwater intrusion, lowering of water levels in a lake or wetland, capturing the flow to a stream, reducing the ability of an aquifer to produce water, lowering the water level in other wells (well interference) land subsidence, or sinkhole formation.

The undesired or adverse effects of water withdrawal may be mitigated by restricting the withdrawal, diverting water from other areas, withdrawing water from a stream rather than from an aquifer or vice versa, lowering pump intakes in wells or taking water from water storage facilities such as lakes or reservoirs. In an area where the undesired or adverse effects are occurring, the process to declare the area a "Capacity Use Area" should be initiated.

In areas where the static water level in an aquifer is below the Trigger Level (defined on next page) or the flow of a stream is less than the minimum flow for extended periods, the process to declare the area a Capacity Use Area should be initiated. The process could be initiated by any local citizens group, legislator(s), or governmental agency. "Extended periods" would be four consecutive months for aquifers and four consecutive weeks for streams.

"Trigger Level" is defined as the minimum water level allowed in an aquifer before the processes to 1) declare a Capacity Use Area is automatically initiated or 2) initiate a water shortage procedure. The Trigger Level is used herein as a water level decline equal to 150 ft below the predevelopment level of an aquifer as determined by Aucott and Speiran (1985); except for the Floridan aquifer system, in which the Trigger level is a decline of 75 ft below the predevelopment level or to mean sea-level, whichever is the least decline (see Figures 26-29).

Procedures should be initiated to restrict withdrawal in the Critical Area. The Critical Area is defined by Section 48-39-10 et seq., Code of Laws of South Carolina 1976, as amended. The location of the Critical Area is shown in Figures 26-29.

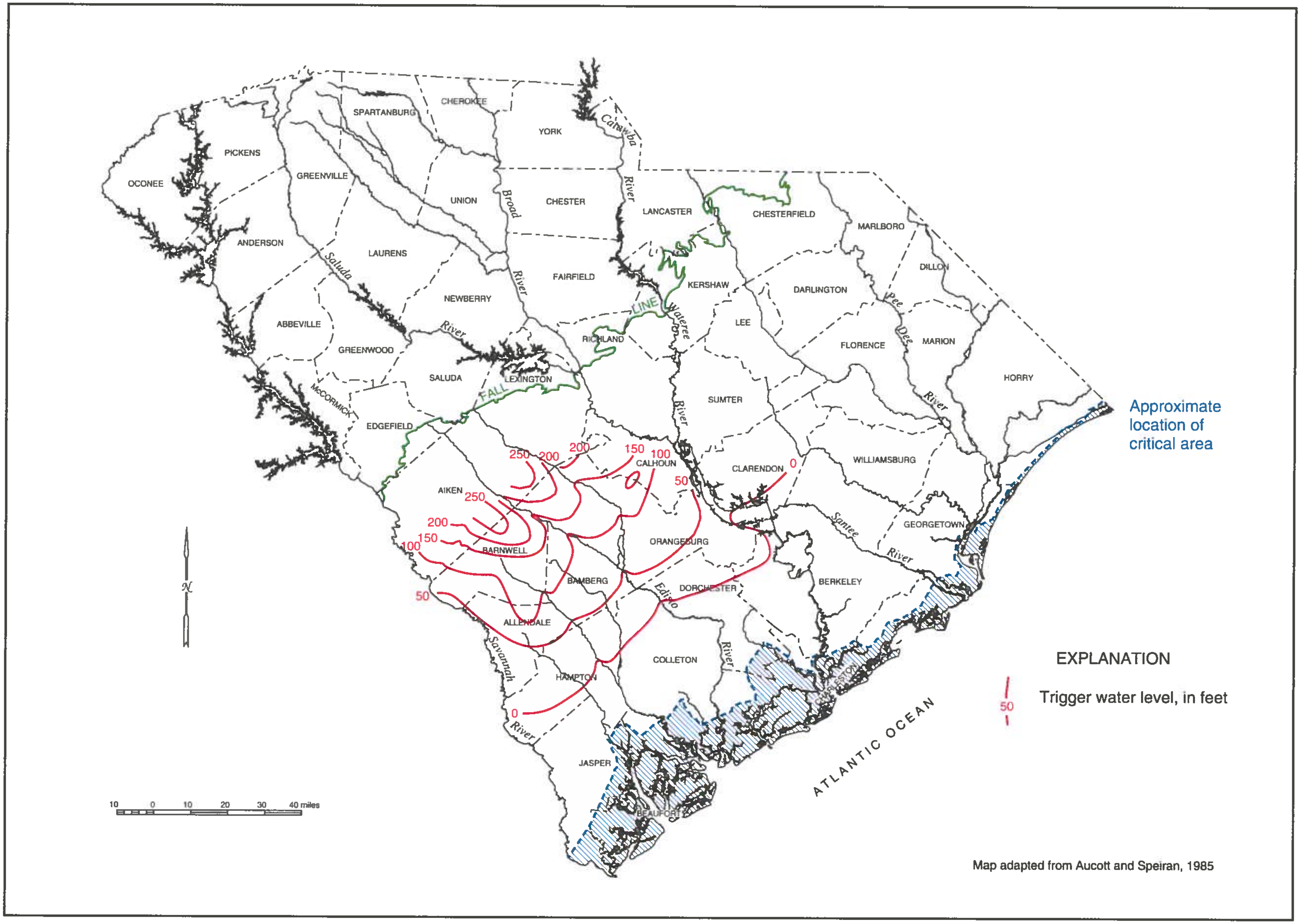

Figure 26. Trigger levels for initiating mitigation techniques for the Floridan aquifer.

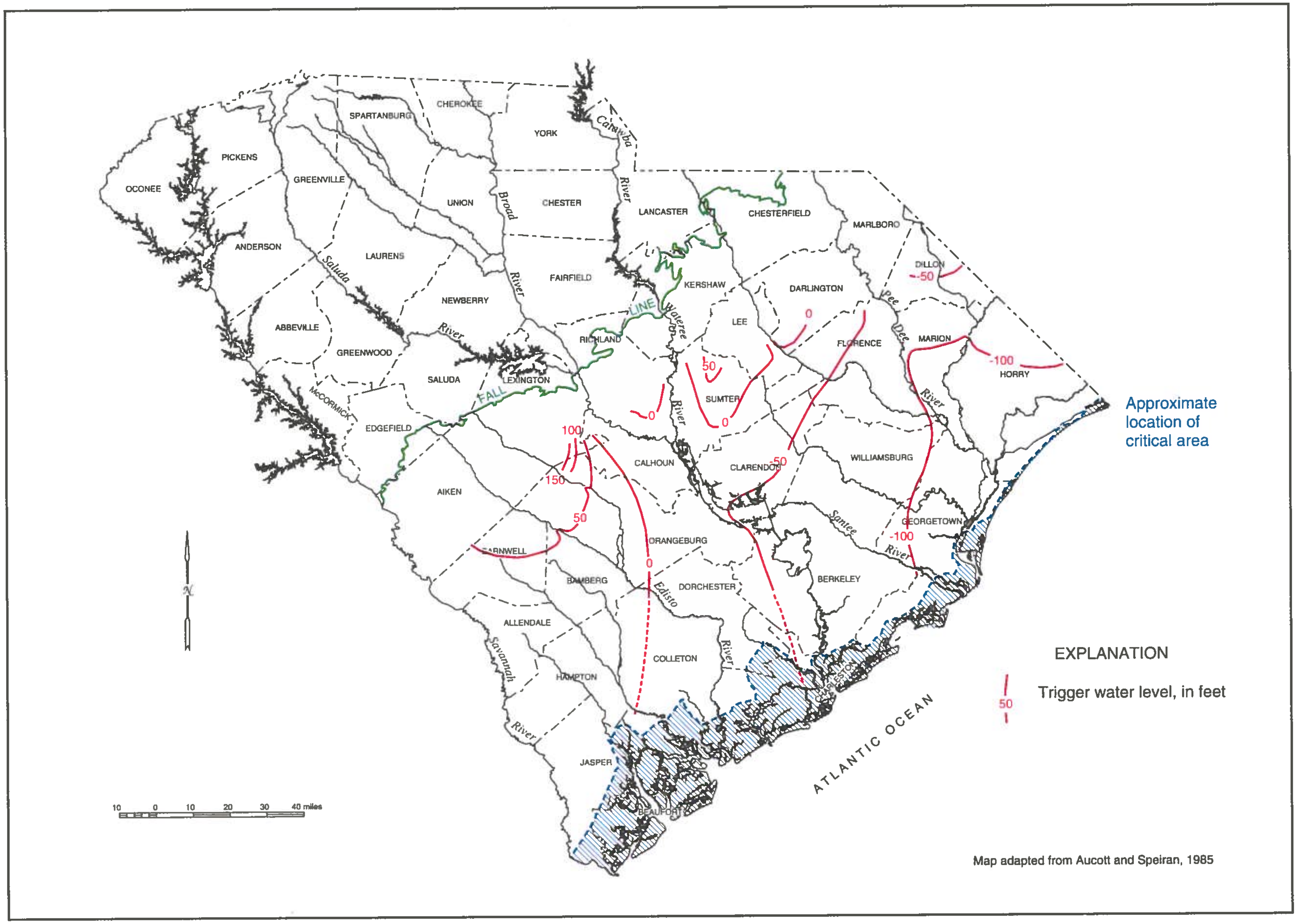

Figure 27. Trigger levels for initiating mitigation techniques for the Black Creek aquifer.

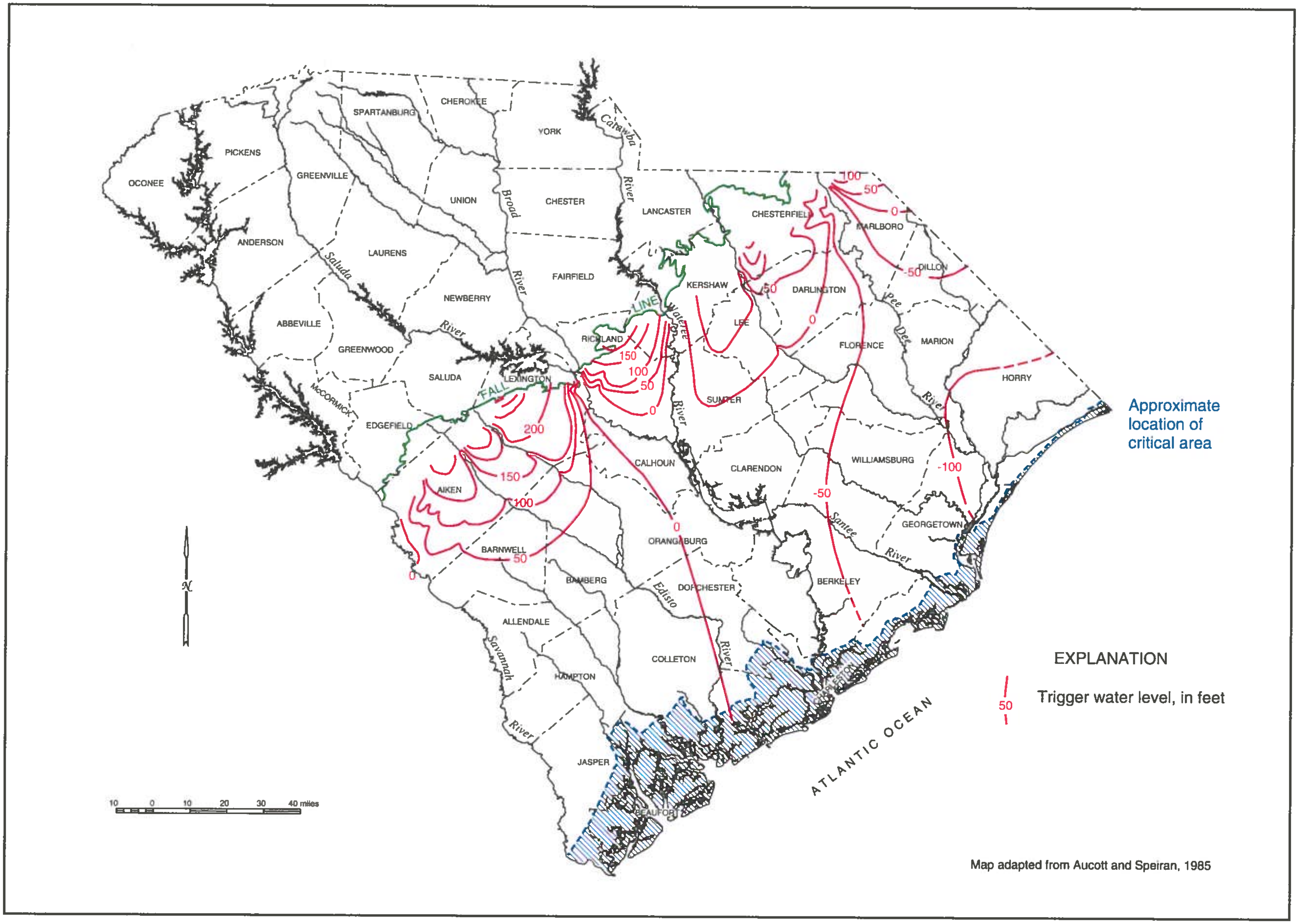

Figure 28. Trigger levels for initiating mitigation techniques for the Middendorf aquifer.

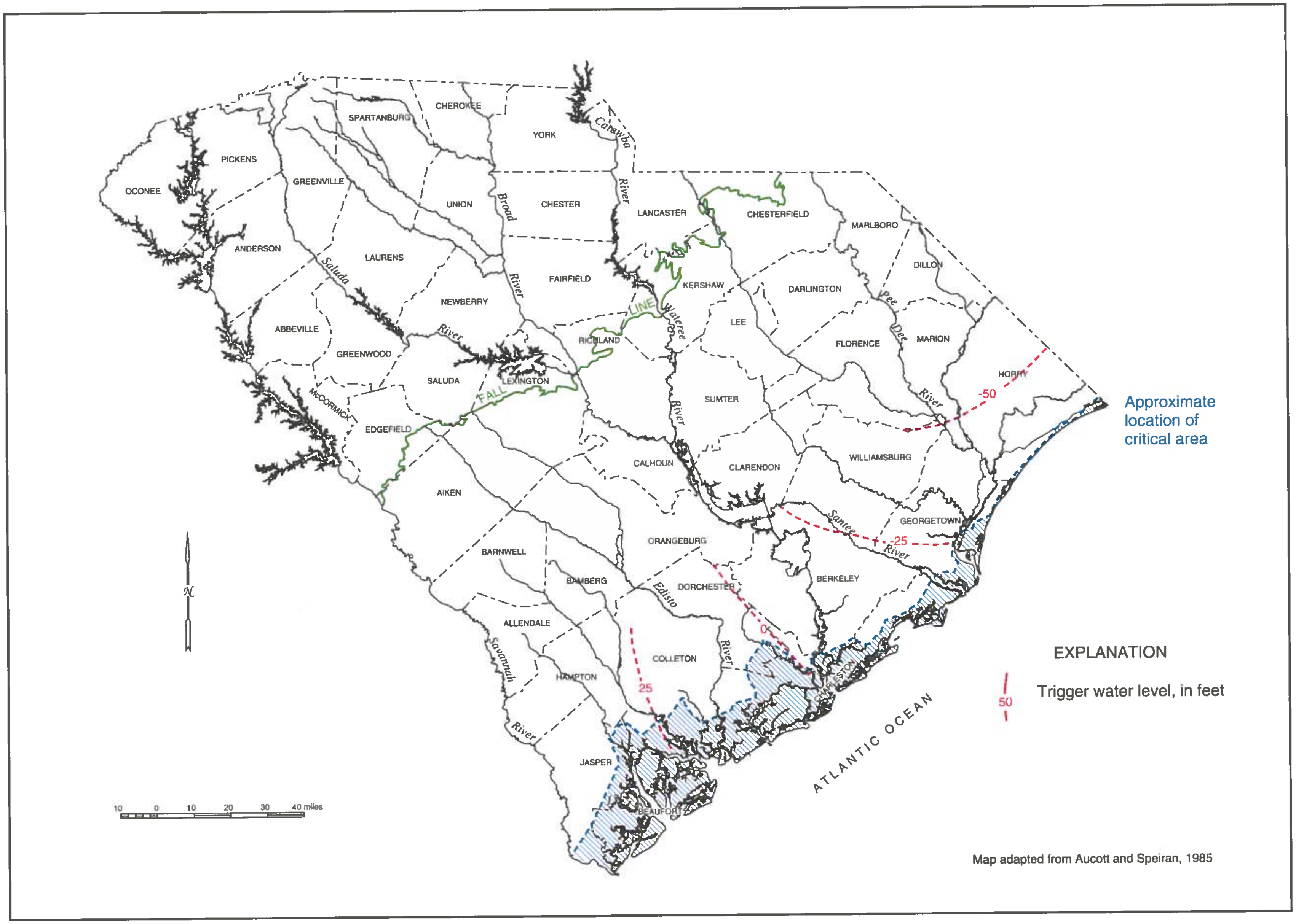

Figure 29. Trigger levels for initiating mitigation techniques for the Cape Fear aquifer.

PERIOD OF RECORD

The periods of record for hydrologic data vary in South Carolina. The period of record for some streamflow sites is more than 75 years, whereas for others it is only a few years. Since 1981, continuous water level data have been obtained from a number of wells in the state by DNR in cooperation with USGS.

Mean daily streamflow, 7Q10 flow, flow frequency, and other water related calculations should be based on the longest period of record available and adjusted to the base period of 1938-1995.

DECLARATION OF WATER SHORTAGE

Water shortage includes: 1) agricultural drought due to lack of precipitation during the growing season, as reflected by the Palmer Drought Severity Index or other accepted indices; and 2) a lack of water to meet both withdrawals and minimum streamflow or Trigger Level.

A water shortage may be declared by the State Drought Response Committee for a stream or several streams, an aquifer or combination of aquifers, or a combination of streams and aquifers. The Drought Response Committee was established by the South Carolina Drought Response Act of 1985 and includes State and local representation. A shortage may be declared for a stream when its daily average flow is 120 percent or less of the established minimum flow for a period of two consecutive weeks, and for an aquifer when its static water level is 20 feet or less above the Trigger Level for that aquifer over a period of two consecutive months.

The purpose of declaring a water shortage is to protect the minimum flows of streams and the water levels of aquifers and to assure the equitable distribution of the available water among all users, consistent with minimizing adverse economic and health-related problems.

The decision to declare a water shortage will be based on present streamflows, soil moisture, and water levels in lakes and aquifers. The levels of water shortage severity are described in Table 3.

An updated status of soil moisture, streamflows, aquifer water levels, and climate would be issued periodically for as long as the water shortage exists. Notification of water shortage severity would be provided by DNR by letter and/or public communications through such media as newspaper, radio, and television.

Restrictions of withdrawals from a stream or aquifer may be based on a composite of the relative benefits of all withdrawals and subsequent use of the water within the declared water shortage area, as may be determined by the Drought Committee.

During periods of prolonged water shortage when the availability of water is nearing exhaustion, extreme water restrictions may be imposed. Withdrawals, although at restricted rates, could be allowed even though flows downstream would be less than the minimum flow. All users, including fish, wildlife, and waste assimilators, would share in the remaining resource.

WATER SHORTAGE FOR STREAMS

A water shortage for a stream should be declared when the conditions outlined in Table 3 occur. The area included in the water shortage declaration should be the drainage area upstream of the lowest downstream location where the measured flow meets the criteria outlined in Table 3.

WATER SHORTAGE FOR AQUIFERS

A water shortage for an aquifer should be declared when conditions exist as outlined in Table 3. The water shortage may be declared for an aquifer or a combination of aquifers within an area where the water level is between 10 and 20 feet above the Trigger Level for two consecutive months.

WATER SHORTAGE FOR LAKES

Water levels and associated downstream water releases for each lake should be managed and operated according to the lake's water shortage contingency plan.

Table 3. Criteria for declaring water shortages

Severity level	Palmer index *	Streamflow	Water level in confined aquifer
I. Incipient	-0.50 to -1.49	Average daily flow is 111%-120% of the minimum flow for two consecutive weeks	Static water level is between 11 and 20 feet above the Trigger Level[1] for two consecutive months
II. Moderate	-1.50 to -2.99	Average daily flow is 101%-110% of the minimum flow for two consecutive weeks	Static water level is between 1 and 10 feet above the Trigger Level for two consecutive months
III. Severe	-3.00 to -3.99	Average daily flow is between the minimum flow and 90% of the minimum for two consecutive weeks	Static water level is between the Trigger Level and 10 feet below for two consecutive months
IV. Extreme	-4.00 or lower	Average daily flow is less than 90% of the minimum flow for two consecutive weeks	Static water level is more than 10 feet below the Trigger Level for two consecutive months

* The Drought Severity Index, developed by W.S. Palmer in 1965, is a commonly used drought index in the United States. This index, based on the supply-and-demand concept of the water balance equation, was developed as a tool for assessing the long-term meteorological drought. It is a useful index when monitoring the agricultural impacts of drought.

APPLICATION OF RESTRICTED RATES OF WITHDRAWAL AND STORAGE OF WATER

Restrictions on rates of withdrawal and storage will be based on the severity of the water shortage. Severity of the water shortage is determined by the proportion of the streamflow to the minimum flow and/or the relation of the water levels of aquifers to the Trigger Levels. The greater the deficiency of water, the greater the severity (as shown in Table 3).

The Drought Response Committee may allow individuals who withdraw or store water to reach voluntary agreements among themselves that may include distribution of water to withdrawers in exchange for cessation of withdrawal or storage of water.

The Drought Response Committee may require additional monitoring of streamflows, water levels, or water quality to ascertain the adequacy of the restrictions in the protection of the natural resource.

Any withdrawer of water seeking relief from the water restrictions may file a petition of variance with the Drought Response Committee.

Upon declaration of a water shortage, wasteful and unnecessary use of water will be prohibited. Such wasteful and unnecessary water use will include but not be limited to:

1. Allowing water to be dispersed without any practical purpose to the water user, regardless of the type of water use.
2. Allowing water to be dispersed to accomplish a purpose for which water use is unnecessary or which can be readily accomplished through alternative methods without water use.

It will be the duty of each user to stay informed as to the severity of the water shortage and the applicable restrictions for that level of severity.

Severity Level I Severity Level I, or incipient water shortage, exists when the Palmer Drought Severity Index reaches the -0.5 to -1.49 range and/or the average daily streamflow for two consecutive weeks is between 111 and 120 percent of the minimum flow and/or the static water level in an aquifer is between 11 and 20 feet above the Trigger Level for two consecutive months. Severity Level I will initiate mobilization of designated DNR staff and the Drought Response Committee. The DNR staff that monitors climatic variables, streamflow, and water level in aquifers will notify the Drought Response Committee and Federal, State, and local agencies of water shortage conditions. DNR staff will increase monitoring activities to identify changes in conditions.

Severity Level II Severity Level II, or moderate water shortage, exists when: (1) the Palmer Index reaches the -1.50 to -2.99 range; and/or (2) the average daily streamflow is between 101 and 110 percent of the minimum flow for two consecutive weeks; and/or (3) the static water level in a confined aquifer is between 1 and 10 feet above the Trigger Level for two consecutive months.

At and beyond Severity Level II, statements will be released to the news media by DNR, and appropriate agencies will increase monitoring activities.

Severity Level III Severity Level III, or severe water shortage, exists when: (1) the Palmer Index reaches the -3.00 to -3.99 range and/or (2) the average daily streamflow is between the minimum flow and 90 percent of that minimum for two consecutive weeks; and/or (3) the static water level in the confined aquifer is between the Trigger Level and 10 feet below the Trigger Level for two consecutive months. The water shortage should be verified by utilizing data from DNR and other agencies. A water shortage of this severity will require an official declaration by the State Drought Response Committee.

Severity Level IV Severity Level IV, or extreme water shortage, exists when: (1) the Palmer Drought Severity Index reaches -4.00; and/or (2) the average daily streamflow for two consecutive weeks is less than 90 percent of the minimum flow; and/or (3) the static water level in the confined aquifer is more than 10 feet below the Trigger Level for two consecutive months. Upon confirmation that Severity Level IV, or extreme water shortage, exists, the Drought Response Committee may recommend that the Governor issue a public statement that an extreme water shortage exists and that mandatory water-use restrictions are being imposed.

GUIDELINES FOR WATER USE DURING PERIODS OF WATER SHORTAGE

The following are guidelines for use by the Drought Response Committee in addressing water shortages:

DOMESTIC USE

Residential domestic use should be voluntarily reduced to achieve a per capita consumption of no more than 60 gallons per person per day. Domestic use in industrial and commercial establishments should be voluntarily reduced.

WATER UTILITY USE

The utility should institute additional voluntary conservation measures, such as reclaiming of backwash water, improving and accelerating leak-detection surveys and repair programs, and installing and calibrating water flow metering devices.

POWER PRODUCTION USE

Water used for power production should be voluntarily reduced.

COMMERCIAL AND INDUSTRIAL PROCESS USE

Water used for commercial and industrial processes should be voluntarily reduced.

Commercial car washes should voluntarily reduce the amount of water per wash to less than 75 gallons for vehicles weighing less than 10,000 pounds and to 150 gallons per wash for vehicles weighing 10,000 pounds or more.

AGRICULTURAL USE

1. All irrigation systems should be operated in a manner that will minimize the water withdrawn.
2. Portable volume-gun irrigation hours should be voluntarily reduced.
3. Low-volume irrigation hours should not be restricted.

LIVESTOCK USE

Livestock water use should be voluntarily reduced.

AQUACULTURE USE Aquacultural water use should be voluntarily reduced.

NURSERY/URBAN IRRIGATION USE

1. Withdrawals for irrigation should be voluntarily reduced.
2. Overhead irrigation should be restricted to the hours of 7:00 P.M. to 7:00 A.M. seven days per week.

LANDSCAPE IRRIGATION USE

1. Water use for landscape irrigation installations that have been in place less than 30 days and are:
   A. less than 5 acres in size should be permitted from 2:00 A.M. to 8:00 A.M. Monday through Saturday;
   B. 5 acres or more in size should be permitted from midnight to 8:00 A.M. Monday through Saturday.
2. Water use for landscape irrigation installations that have been in place for 30 days or more and are:
   A. less than 5 acres in size should be permitted from 4:00 A.M. to 8:00 A.M. three days per week;
   B. greater than 5 acres in size should be permitted from midnight to 8:00 A.M. three days per week.
3. Installations with odd-numbered addresses should be permitted to irrigate on Monday, Wednesday, and Friday.
4. Installations with even-numbered addresses or no address should be permitted to irrigate on Tuesday, Thursday, and Saturday.
5. Low-volume, hand-watering of new landscaping should be voluntarily reduced.

RECREATION AREA USE Existing and new recreation area water use should be voluntarily reduced.

WATER-BASED RECREATION USE Water-based recreation water use should be voluntarily reduced.

GOLF COURSE USE

1. Irrigation of greens and tees should be voluntarily reduced and done during non-daylight hours.
2. Irrigation of fairways, roughs, and nonplaying areas on the first nine holes of the course should be from midnight to 8:00 A.M. on Monday, Wednesday, and Saturday.
3. Irrigation of fairways, roughs and nonplaying areas on the last nine holes of the course should be from midnight to 8:00 A.M., on Tuesday, Thursday, and Sunday.

CLAY TENNIS COURT USE

1. Watering of clay tennis courts should be allowed from noon to 3:00 P.M. and will have a maximum duration of 5 minutes for each court during each allowed time period.
2. Low-volume watering techniques should be used.

COOLING AND AIR CONDITIONING USE

The use of water for cooling and air conditioning should be restricted to that amount of water necessary to maintain a temperature of 78 degrees Fahrenheit or above.

OTHER OUTSIDE USES

1. Washing or cleaning streets, driveways, sidewalks, or other impervious areas with water should be prohibited.
2. Mobile-equipment washing with water should be restricted to the hours and days prescribed for existing landscape irrigation, using only low-volume methods. Rinsing and flushing of boats after saltwater use should be limited to 5 minutes once a day for each boat.
3. Outside pressure cleaning should be restricted to only low-volume methods 7 days per week.

AESTHETIC USE

1. Outside aesthetic uses of water should be prohibited.
2. Inside aesthetic uses of water should be voluntarily reduced.

ALTERNATIVE WATER SUPPLIES DURING PERIODS OF WATER SHORTAGE

As indicated in previous sections of this report, the State receives ample water to meet present and future needs. Because of its temporal and spatial distribution, however, water is sometimes unavailable in the right place at the right time and of the right quality. This variability in the water supply is controlled to a large extent by climatic factors over which man has no influence. Water quality is determined by both natural and man-induced factors.

Methods of addressing problems of water availability in streams during periods of water shortage include:

1. Prearrangement for withdrawals or release of water from existing lakes or reservoirs.

2. Storage of water in instream reservoirs for subsequent release or withdrawal.

Instream reservoirs are built by damming streams to store water during periods of high flow. This storage of water changes the natural flow of a stream, reduces flooding, provides water for generation of hydroelectric power and other uses, and can augment the streamflow during low-flow periods. When instream reservoirs are constructed, stream ecosystems are altered in the reservoir and downstream of the dam, and flood-plain wetlands adjacent to streams are changed. The migration of some fish and other aquatic organisms across the dam decreases or ceases. There may be a gain or loss in the diversity of organisms. Vegetation in a lake is different from vegetation in streams, and terrestrial and wetland wildlife habitats are converted to open-water habitats. Instream reservoirs also serve as traps for sediment and nutrients, and nutrient concentrations may be greater in the reservoir than downstream. Because of an increase in evaporation, the overall streamflow of the system probably decreases following construction of reservoirs. Recreational opportunities for reservoirs and those for free-flowing streams are different.

3. Storage of water in offstream reservoirs for subsequent release or withdrawal.

Offstream reservoirs are built adjacent to streams to store water during periods of high flow. Use of the reservoir modifies the natural flow of a stream. Water storage lessens the effects of floods, provides water for other uses such as generation of electricity, and augments streamflow below the reservoir during periods of low streamflow. Owing to an increase in evaporation, the overall streamflow of the system probably decreases following construction of reservoirs. The ecosystem downstream of the reservoir is likely to be modified, and a different reservoir ecosystem is added. There is a gain in diversity of aquatic organisms. Terrestrial habitat is replaced by aquatic habitat. Recreational use of the stream probably is not significantly changed. Use of the reservoir is dependent upon ownership of and provision for public access to the reservoir.

In general, offstream reservoirs should be considered preferential to instream reservoirs with respect to maintenance of minimum flows for propagation of fish and wildlife.

4. Agricultural water table management.

Water table management is the operation and management of the water table in order to maintain proper soil moisture for optimum plant growth, to sustain or improve water quality, and to reduce the demand for agricultural irrigation.

FLOOD MANAGEMENT

The use of State flood-plain areas should be optimal. Construction in the area subject to the 100-year flood should not restrict floodwater; these areas may be used for parks and recreational purposes. Where people are concentrated, flood protection should be provided by construction of reservoirs, levees, and bypasses or by impoundment.

The State flood forecast program should be strengthened to accurately give flood warning to occupants of threatened areas, helping them to evacuate areas expected to be inundated.

State, Federal, and private organizations should cooperate in conducting flood-emergency programs. There is a need for better understanding by the public of the basic nature of the flood problem and programs and, in particular, the community-action plan for flash-flood areas.

Flood maps for the State should be verified to accurately represent the potential flood areas.

CONSIDERATIONS IN MEETING WATER DEMANDS AND SUSTAINING THE RESOURCE

1. **Primary source of water to the freshwater system is precipitation.**
   South Carolina receives an average of about 48 inches of water a year as precipitation. In addition, the combined flow in the Broad, Catawba, Pee Dee, and Waccamaw Rivers from North Carolina contributes the equivalent of 8 inches of water to the State.

2. **Primary outflow from the freshwater system is streamflow.**
   Streamflow is the primary outflow from the freshwater system. Of the 48 inches of precipitation, 13 inches is discharged to the ocean as streamflow. Less than 1 inch is discharged to the ocean as outflow from aquifers.

3. **Primary storage of freshwater is in aquifers and reservoirs.**
   The primary storage of water is in the aquifer system of the Coastal Plain. The estimated storage of water within the Coastal Plain aquifer system is about 1,100 inches.

4. **Greatest demand for water is evapotranspiration.**
   Evapotranspiration exerts the greatest demand on the freshwater system. The amount of evapotranspiration averages about 34 inches per year over the State. The evapotranspiration rate is highest during the warmer months.

5. **Aquifers, streams, and lakes are interrelated parts of one water system.**
   South Carolina's water originates as precipitation, some of which flows over the surface of the ground to streams and some of which enters the ground (to aquifers). Part of the water in aquifers is discharged to streams. Thus, streams may be fed by substantial amounts of water from aquifers, and aquifers are fed by surface infiltration from precipitation, streams, and lakes. Withdrawals from a stream or lake may affect the water level in an aquifer and vice versa; and such withdrawal may have an adverse effect on the water resources of the area.

6. **Water use will increase indefinitely.**
   The use of water increases about 2 percent each year. The primary offstream use of water is for nuclear and thermoelectric power generation. The primary instream water use is hydroelectric power generation.

7. **Use of water does not necessarily mean loss of water.**
   Withdrawal and use of water does not necessarily mean a loss of water if the water is returned to the freshwater system within the State. Major losses of water from the freshwater system are by evapotranspiration and by streamflow to the ocean. Water moved from one basin to another may constitute a loss of water from the donor basin but not a loss of water for the freshwater system.

8. **Withdrawal of water may cause some adverse effects.**
   a. Lowering of water levels in lakes and aquifers
   b. Dewatering of wetlands
   c. Dewatering of aquifers
   d. Reduction of flow in streams
   e. Degradation of water quality and contamination of aquifers.
   f. Land subsidence
   g. Saltwater intrusion
   h. Withdrawal interference with other users

Withdrawing water from an aquifer may reduce streamflow or lower lake levels, or it may dewater wetlands. The extent of this effect will depend on a variety of factors, such as the hydraulic characteristics of the aquifer and its confining layer and the amount of water withdrawn.

Withdrawing water lowers the water level (or pressure) in the aquifer from which the water is withdrawn. The area of lowered water level is referred to as the cone of depression. Water levels are lowered in all wells withdrawing water from the same aquifer within the cone of depression. The amount of water-level lowering depends on the amount of the withdrawal, the water-transmitting characteristics of the aquifer, and the proximity of the wells to one another.

Subsidence is the lowering of land surface and is usually caused by dewatering of the clay within or overlying an aquifer. The lower the water level, the greater the likelihood and magnitude of subsidence. Subsidence in areas of significant water-level lowering, such as Myrtle Beach and Florence, has not been observed, but it has been observed in areas where dewatering activities have occurred.

Saltwater intrusion is the displacement of freshwater with saltwater. Saltwater is heavier than freshwater; therefore saltwater will displace freshwater, assuming the altitude of the freshwater is equal to or less than the altitude of the saltwater. The contact between freshwater and saltwater is referred to as the saltwater-freshwater interface and, in the aquifers of South Carolina, is generally located several miles offshore. Because freshwater levels are much higher inland, the general direction of water movement is seaward. In areas such as Hilton Head, however, the freshwater level in aquifers has been lowered by withdrawal and the direction of the freshwater movement has reversed, allowing saltwater to move inland and displace freshwater in the aquifers. The process of reversing saltwater intrusion in aquifers is generally slow, and an aquifer may contain saltwater in areas of intrusion for many years. Tidal fluctuations cause movement of the saltwater-freshwater interface in streams and aquifers. At high tides, the interface moves inland and at low tides, seaward.

GUIDELINES FOR MEETING WATER DEMANDS AND SUSTAINING THE RESOURCE

1. Monitor the status of the State's water resources through a cooperative statewide network to continuously measure streamflow,water levels in aquifers, water quality, saltwater intrusion, subsidence and other variables that control water availability.

2. Educate the general public about the availability of water and the factors that affect that availability.
   a. Disseminate water-resources information via the media, conservation offices, computer networks, course contents for high schools and colleges, research grants, seminars, public hearings, and other means.
   b. Disseminate real-time status of the water resources to the general public.
   c. Provide periodic appraisal of the availability of water and changes or trends in water quantity and quality to the public.

3. Avoid depletion of the resource.
   Continuous lowering of the water level in aquifers depletes the resource. Withdrawing water from aquifers reduces the storage of water in the aquifer. In confined aquifers, the time needed to replace water removed from storage is approximately equal to the time required to remove the water. When water is continuously removed from an aquifer for years, an equal amount of time should be allowed to replace the water. The replacement water comes from precipitation and from other aquifers. In coastal areas, saltwater may move inland to replace the withdrawn water.

4. Avoid saltwater intrusion.
   Development of the coastal area for residential and recreational activities has been considerable. This development would have been impeded if withdrawal of water from aquifers in the coastal areas had been disallowed. Because of the water-level lowering associated with development, saltwater intrusion has become a concern. To control saltwater intrusion, withdrawal of water from aquifers in the coastal areas should be reduced or avoided. An alternative water supply could come from coastal streams or from inland sources. Where withdrawals continue, saltwater probably will continue to move inland.

5. Increase availability of water.
   The availability of water can be enhanced by increasing the retention time of water. Water in aquifers and reservoirs is retained longer within the State than water in free-flowing streams. The following techniques could be used to enhance the availability of water by increasing the retention time:
   a. Withdraw water in the following order of source preference:
      (1) streams
      (2) lakes and reservoirs
      (3) aquifers
   b. Return, when and where practical, water at or near the point of withdrawal.
   c. Reuse water when and where practical.
   d. Irrigate during cool times of the day.
   e. Store water during periods of excess availability for use during periods of shortage, utilizing techniques such as aquifer storage and retrieval.
   f. Develop conjunctive-use capabilities such as withdrawal from streams during periods of availability and from aquifers during periods of shortage.

6. Maintain at least minimum flow in streams.
   A minimum flow has been determined for streams in the State. The minimum flow will allow for propagation of fish and wildlife, navigation, protection of water quality, and waste assimilation.

7. Avoid degradation of water quality.
   a. Avoid adding any constituent to water that will cause that constituent to exceed its maximum allowable concentration or cause the concentration of another constituent to be less than its minimum allowable concentration at 7Q10 flow.
   b. Avoid storage of uncontained hazardous or potentially hazardous material in any aquifer of the State.
   c. Avoid storage of waste in areas of the State where the principal water-producing aquifers are unconfined.

d. Avoid storage of waste in areas where water is withdrawn from unconfined aquifers.
e. Avoid withdrawal of water for human consumption (drinking water) from unconfined aquifers.
f. Avoid saltwater intrusion.
g. Implement best-land-management practices to minimize degradation of water quality.

8. Minimize withdrawal by conserving water through the use of low-volume and low-flow fixtures and the use of efficient irrigation techniques.

9. Intakes of pumps should be placed significantly below the cone of depression created by withdrawals of water from the aquifer, as deep as the top of the aquifer if necessary, to fully utilize the aquifer and to minimize the undesirable effects of well interference.

10. Initiate procedures to transfer water from areas of excess to areas of shortage.

11. Collect and analyze data that better define the hydrologic system and the availability of water.

    Estimates of water availability, storage, and use should be better defined to assist in management of the resource. The movement of water into and through the aquifer system should be better quantified. Evaporation rates from all parts of the State should be better quantified.

    Reporting of water withdrawals and use of water should be required to better define the effects of present withdrawals and to provide a better forecast of future demands and effects of withdrawals.

    Collect climatic data, to determine any trends in the availability or quality of the water resource. The amount of water available is, to a large extent, controlled by climatic conditions, and a lack of availability of water may not be due solely to withdrawal and use.

The amounts of precipitation, stored water, and discharge to the ocean should be continuously monitored. The dissolved and suspended loads carried by our streams should also be monitored.

12. Determine the effectiveness of the resource management guidelines and procedures, and modify them if necessary.

SUMMARY

The purpose of the Water Plan is to encourage considerations and establish guidelines for maximizing and sustaining the availability of water in the State of South Carolina, for now and in the future.

The amount of water available in South Carolina's rivers, lakes, and aquifers varies in both time and space. Generally, replenishment of water is greater in the northwestern part of the State and less in the southeastern part. Climatic conditions usually cause water availability to be greatest in the spring and least in the fall.

Replenishment of water in the State is primarily from precipitation. Annually, South Carolina receives about 48 inches of water as precipitation and about 8 inches as streamflow from adjacent states. The greatest loss of water, about 34 inches, results from evapotranspiration. The remaining water, about 22 inches, is available for use.

Water withdrawals increased from about 6,684 mgd (million gallons per day) in 1983 to about 8,470 mgd in 1992. The largest use of water is for power generation. In 1992, 57,000 mgd of water were used for instream hydroelectric power generation, and 7,100 mgd were used for offstream power generation.

Because the current water-use reporting program does not include users of less than 100,000 gpd, and because water-use reporting is voluntary, the Water Use Reporting Act underestimates the actual water demand. A reporting mechanism should be developed and mandated to more accurately measure water withdrawals and water use.

The withdrawal of more than 100,000 gpd (or 1 million gallons per month or 10 million gallons per year) of water should be registered. Registration should include (1) information on the location, type of construction of facility, and method of withdrawal; (2) reporting the amount of withdrawal, and (3) agreement to restrict withdrawal during periods of water shortage.

Minimum flows are intended to protect the State's natural resources from damage due to (1) reduction of the habitat of fish and wildlife, (2) restriction of navigation, (3) water-quality deterioration, (4) subsidence of the land surface, and (5) intrusion of saltwater.

Trigger levels for aquifers are intended to initiate a process to mitigate the adverse effects of withdrawal of water from aquifers.

Mitigation techniques such as but not limited to, restricting withdrawal, diverting water from other areas, withdrawing water from a stream rather than from an aquifer or vice versa, or taking water from water-storage facilities such as lakes or reservoirs should be considered if a stream's flow is less than the minimum flow for four consecutive weeks or the static water level in an aquifer is below the Trigger Level for four consecutive months or undesired effects are occurring because of the water withdrawals.

When the flow of a stream is less than 120 percent of the minimum streamflow or the water level in an aquifer is lower than 20 feet above the Trigger Level, a water shortage may be declared. The water shortage relief procedures will be administered in the affected area by the Drought Response Committee. The more acute the water shortage, the greater the severity designation and, therefore, the greater will be the restriction on water use.

The combined use of streams, lakes, and aquifers for storage of water is encouraged during periods of excess availability in order to meet water demands and to sustain the availability of water.

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