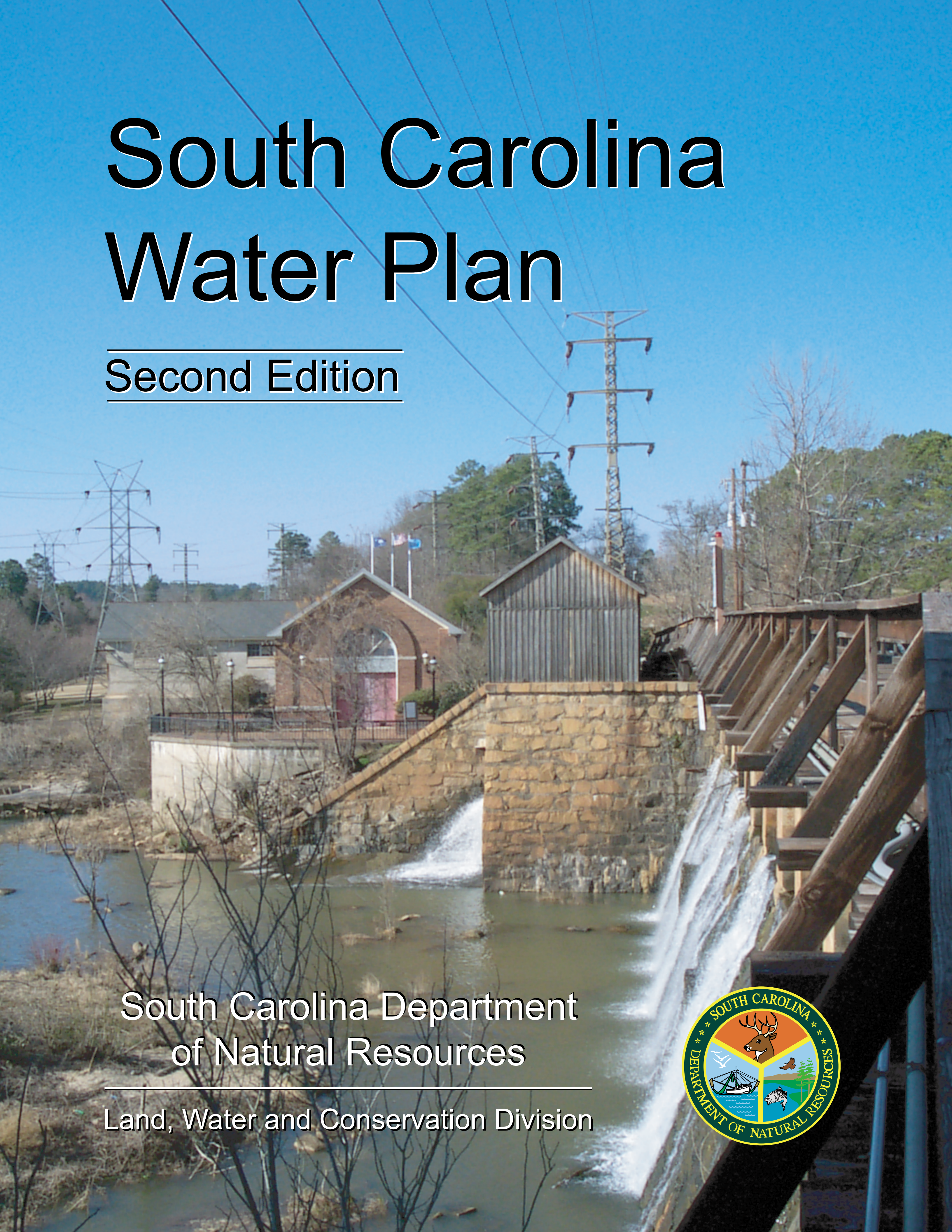
South Carolina Water Plan

Second Edition



South Carolina Department of Natural Resources

Land, Water and Conservation Division

On the cover: Water from the Columbia Canal falls over a spillway behind the old Columbia Water Works complex on the Congaree River in Columbia, South Carolina. The Columbia Canal, originally completed in 1824 to provide navigation past local rapids, was redesigned in 1891 to provide hydroelectric power to local industries. The red brick building in the center of the photograph was built in the 1890's and houses the pumps once used by the City of Columbia to supply water to its citizens. Although use of this pumping plant ended in the early 1970's, the canal still serves as a source of public-supply water and hydroelectric power for the City. Today, these buildings and the canal form part of Columbia's Riverfront Park. (Photograph by Andrew Wachob, S.C. Department of Natural Resources.)

SOUTH CAROLINA WATER PLAN

Second Edition

by

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STATE OF SOUTH CAROLINA
The Honorable Mark H. Sanford, Governor

South Carolina Department of Natural Resources

Board Members

DNR
South Carolina Natural Resources Board

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The following letter transmitted the *South Carolina Water Plan–Second Edition* to:

Mark Sanford, Governor of South Carolina
David H. Wilkins, Speaker of the South Carolina House of Representatives
André Bauer, President of the South Carolina Senate and Lieutenant Governor

The *South Carolina Water Plan–Second Edition* 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 department and agencies;…"

The Department of Natural Resources published the first State Water Plan in 1998. This second edition incorporates the experience and knowledge we gained from the severe drought of 1998-2002 and other timely water resources issues.

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 principle concern has been sustainability.

The Department has examined virtually the entire range of water-resources issues facing the State, including the effects of neighboring states on our water availability. 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. Water resources planning is a continuous process.

The Department recognizes that the effective management of the State's water resources is beyond the scope of any one agency or organization and will require cooperation and shared responsibility among federal, State, and local agencies, public and private parties.

The Department submits this *South Carolina Water Plan–Second Edition* 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.

The Department appreciates the valuable input and cooperation of the S.C. Department of Health and Environmental Control.

Respectfully submitted,

Michael McShane
Chairman

PREFACE

South Carolina experienced one of its worst multiyear droughts on record during the period from June 1998 to August 2002. Average precipitation was 10-30 percent below normal during the drought. Streamflows were at historic lows throughout the State, threatening water-supply intakes and causing saltwater intrusion in coastal areas. Lakes were being drained to perilously low levels in order to sustain water demands and downstream flows. Levels in Lake Thurmond, for example, dropped so low that the lake had only a few months of storage remaining for downstream flow requirements. Lakes in North Carolina, on the Yadkin-Pee Dee River, were being drained to meet water demands of North Carolina and of major industries in South Carolina, and to prevent saltwater intrusion from contaminating supply intakes in the Grand Strand area. Ground-water levels in shallow and deep aquifers dropped to record lows. Pumps in municipal and domestic wells had to be lowered, wells had to be deepened and, in some cases, new wells had to be drilled to keep pace with declines. Ground water levels in some areas of the State declined to the point that streams were losing water to the ground, the reverse of what normally occurs.

What if the drought had continued for another year? The thought of this had policy makers thinking about water. Suddenly, lawyers were reviewing State water laws and water-resource managers were thinking of more effective ways to manage water in the State. The drought, in fact, marked a turning point in how we viewed our water resources. The belief that only water-starved western states could run out of water was replaced by the stark realization that we could run out of water too. Water could no longer be taken for granted in South Carolina. This is the lesson that we learned from the drought.

Undoubtedly, the recent drought was one of the worst on record, but its effects were also compounded by population increases that have taken place during the past 50 years. South Carolina's population has nearly doubled during this period, growing from 2.1 million in 1950 to 4.0 million in 2000. The population will continue to grow and the demand for water will correspondingly increase, but the amount of water that is available will remain essentially the same. What steps should the State take now to ensure that adequate amounts of water will be available in the future? This revision to the *South Carolina Water Plan* addresses this question. The *Water Plan* recognizes the economic importance of water and the multitude of uses that it has, from hydropower generation and water supply, to recreation and tourism. A fair and balanced approach to managing the resource must consider all users. The goal is to wisely use the water that is available to meet growing demands without jeopardizing the health, welfare, and quality of life of future generations. The *South Carolina Water Plan* provides guidelines for achieving such a goal.

EXECUTIVE SUMMARY

In 1998, the Department of Natural Resources published the first edition of the *South Carolina Water Plan*, a guide for managing the State's surface and ground water in order to maximize the use of this resource while protecting it for future use. In the middle of that same year, South Carolina entered into one of the worst droughts in its history, lasting until late in 2002. That drought reminded us that the State's water supply is not unlimited, and that careful management is needed to ensure water availability for future generations. This second edition of the *Water Plan* incorporates the experience of that drought and the lessons learned from it into the management strategies presented in the original *Water Plan*.

One of the more important recommendations in this *Water Plan* is the proposal to regulate surface and ground water withdrawals. Presently, there are no limitations on the amount of water that can be withdrawn from a river, and ground water withdrawals are regulated only in coastal counties. In order to sustain the resource and protect the environment and the rights of all water users, this edition recommends that the State be authorized to allocate and regulate surface and ground water withdrawals. The need for such authority was evident during the recent drought, when water levels in aquifers and flow rates in streams were at record lows, causing conflicts among competing uses. Regulating withdrawals would provide a mechanism to alleviate these conflicts and would ultimately benefit all users by encouraging conservation and efficiency.

This edition of the *Water Plan* also introduces a water-sharing strategy that relates lake inflows and lake levels to downstream releases and other lake withdrawals in an effort to balance and mitigate the negative impacts that water shortages have on all surface-water users. This strategy emphasizes the need for all users to share the burden of water shortage during prolonged droughts.

Because water availability is intrinsically tied to the quality of the water, this *Water Plan* provides an overview of existing water-quality regulations and programs. These programs have been successful in improving the quality of water in our streams, lakes, estuaries, and aquifers. The leading cause of water pollution in the State is polluted runoff. Sources of this pollution are diffuse and, therefore, difficult to control. Reducing polluted runoff must be the collective responsibility of government, agriculture, industry, and all citizens and can best be achieved by using an integrated watershed-management approach that addresses all water-related activities within an entire watershed.

Monitoring of the State's water resources is critical for evaluating the severity and duration of droughts and for predicting water shortages. One of the most important components of the hydrologic system is the shallow ground water that occurs in water-table aquifers and continually discharges to streams, sustaining flows during droughts. The *Water Plan* recommends the establishment of a Statewide water-table monitoring network to improve our capability of assessing hydrologic conditions and managing droughts.

Because three of the State's four major river basins—and thus much of its surface water—are shared with neighboring states, it is important that South Carolina establish formal mechanisms with Georgia and North Carolina for the equitable apportionment of all water shared with these states. Formal agreements, such as interstate compacts, will promote interstate coordination, reduce potential disputes between the states, enhance the flow regime of many of South Carolina's rivers, and extend the availability of water in during severe droughts.

South Carolina ordinarily receives ample water to meet its needs; however, because of the State's growing population and the uncertain and varying nature of water availability, consideration must be given to resource-management policies that can help maximize water availability. This edition discusses many practical practices and technologies geared toward maximizing availability, such as water conservation, construction of new reservoirs, and aquifer storage and recovery programs.

Water planning requires continual reassessment and updating to address changing social, economic, and environmental conditions and to reflect new data, knowledge, and technologies that become available. The effective management of the State's water resources is beyond the scope of any single agency or organization and will require cooperation and shared responsibility among Federal, State, and local entities, as well as public and private parties.

The *Water Plan* concludes with a summary set of recommendations that the Department believes will help protect the State's water resources for future generations and will help mitigate the effects of future droughts and water shortages. While the recommendations proposed in this plan may not be those that are finally adopted, they will certainly provide an awareness of the water resource issues facing our State and stimulate constructive thinking about how best to manage South Carolina's most precious natural resource.

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The authors would like to thank the following individuals who provided input with comments and/or reviews of this edition of the *Water Plan*. Their assistance is greatly appreciated.

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INTRODUCTION

The South Carolina Water Resources Planning and Coordination Act of 1967 assigned the overall responsibility for developing a comprehensive water resources policy for the State, including coordination of policies and activities among State departments and agencies, to the South Carolina Water Resources Commission. As part of government restructuring, this act was amended in 1993, and these responsibilities were placed with the South Carolina Department of Natural Resources (DNR).

The water resources policy plan consists of two parts. Phase I—an overall assessment of the water resources of the State—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. Phase II outlines guidelines and procedures for managing the State's water resources, and was first published in 1998 by the Department of Natural Resources as the *South Carolina Water Plan*.

Both the *Assessment* and the *Water Plan* must be updated periodically, on the basis of changes in water demand and availability, and the development of new technologies and management strategies. The updating of the *State Water Assessment* is underway. This second edition of the *South Carolina Water Plan* includes experience and knowledge gained from the severe drought of 1998-2002.

PURPOSE

The purpose of this *Water Plan* is to establish guidelines for the effective management of the State's water resources to sustain the availability of water for present and future use, to protect public health and natural systems, and to enhance the quality of life for all citizens.

The *South Carolina Water Plan* outlines procedures for assuring that future water requirements of the State can be met and acknowledges that (1) South Carolina usually possesses an abundance of water; (2) water is a limited natural resource and is a major factor for economic development; (3) there are regional and temporal variations in the amount of available water and in the demand for water; and (4) there are both intrastate and interstate competing demands for water. The *Water Plan* describes the source, availability, and quality of the State's water, as well as the demands for that 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.

LEGAL STATUS OF WATER IN SOUTH CAROLINA

The Supreme Court of South Carolina has established that water is subject to the Public Trust Doctrine and is, therefore, too important to be owned by one person.

> "The underlying premise of the Public Trust Doctrine is that some things are considered too important to society to be owned by one person. Traditionally, these things have included natural resources such as air, water ...and land.... Under this doctrine, everyone has the right to breathe clean air; to drink safe water; ... and to land on the seashores and riverbanks." [Sierra Club v. Kiawah Resort Assoc., 318 S.C. 119, 456 S.E. 2d 397 (1995)]

South Carolina abides by the Riparian Rights Doctrine and incorporates the concept of reasonable use of water in the Riparian Rights Doctrine. The Riparian Rights Doctrine holds that it is a fundamental right of any riparian landowner to the "reasonable use" of water [White v. Whitney Mfg. Co., 60 S.C. 254, 38 S.E. 456 (1901)]. The difficulty with water management is that any limitation the State might place on riparian rights could be challenged in court as a "taking." There is legal precedent, however, that the State has authority to manage water without compensating adversely affected riparians. In Rice Hope Plantation v. South Carolina Public Service Authority [216 S.C. 500, 59 S.E.2d 132 (1950)], the court said that the waters of the State are part of the public domain and the State may authorize the diversion of such waters for any purpose it deems advantageous to the public, without providing compensation to the riparian proprietors injuriously affected. Such a diversion is not a taking of private property by eminent domain, but a disposition by the public of the public property.

WATER RESOURCES MANAGEMENT GOALS

In recognition that the State's waters are part of the public domain, and are to be managed in the best interest of the public, the following are declared to be the water resources management goals of South Carolina:

1. To ensure that water of suitable quality and quantity is available for use when and where needed.
2. To manage the quantity and quality of both surface and ground water in an integrated manner to protect, maintain, and enhance the overall resource.
3. To use the *South Carolina Water Plan* to provide guidance for regional and local water planning efforts.
4. To develop interstate agreements with North Carolina and Georgia for the protection of water quality and quantity and for equitable allocation of surface and ground water.
5. To allocate surface and ground water to ensure the long-term availability of the resource.
6. To have a drought management and mitigation plan that establishes actions and procedures for different drought levels in order to minimize drought impacts.
7. To manage water shortages so that all users would share the burden.
8. To have a flood management and mitigation plan that establishes actions and procedures to minimize flood hazards and protect life and property.
9. To protect freshwater and estuarine ecological functions and habitats.
10. To regulate interbasin water transfers in a way that reflects the variability in water availability, respects the natural systems, and protects the source basin's present and future water demands.
11. To utilize advanced technologies, procedures, and practices to promote more efficient use of water and to maximize water availability.
12. To develop a water-conservation ethic by providing educational opportunities and information to the citizenry.

Some of these goals are already being addressed with existing programs; other goals have yet to be given appropriate attention. All of these goals, however, represent important steps toward the ultimate goal of protecting the State's waters so that this vital resource will be available for the use and benefit of all future generations.

SOUTH CAROLINA'S WATER RESOURCES

Although South Carolina has an abundance of clean, fresh water, it is unevenly distributed in both location and time. Almost all of the State's water is ground water, located beneath the land surface; only about 1 percent of the State's water is surface water. Most of the ground water is located in the Coastal Plain, and most of the surface water is located in large, manmade reservoirs on the major rivers. Water is most abundant during the spring months when streamflows and ground-water levels are at their highest; less water is available during the late summer and early fall, when streamflows and ground-water levels are typically at their lowest.

Although there is much more water under the ground, surface water is the source for most of the large water supplies in the State because of its convenience and availability. Seventy percent of the State's population rely on surface water, and 30 percent rely on ground water (Bristol and Boozer, 2003).

HYDROLOGIC SETTING

The State's physiographic and climatic settings are key factors that determine the availability and distribution of the State's water resources.

South Carolina contains all or part of four major river basins (Figure 1). These major basins, defined by the topography that controls surface water drainage, can be divided into subbasins on the basis of local drainage patterns. The two largest of these basins, the Yadkin-Pee Dee and the Catawba-Santee, encompass about 25 percent and 34 percent, respectively, of South Carolina's area and are shared with North Carolina. The headwaters of most of the major rivers in these two basins are located in North Carolina. The Savannah basin encompasses about 15 percent of the State and is evenly shared with Georgia, with a small area at its northern tip located in North Carolina. The ACE (Ashepoo-Combahee-Edisto) basin, which covers about 26 percent of the State, is the only major basin located entirely within South Carolina.

In South Carolina, the four major basins are divided into 15 subbasins, and these subbasins can be further divided into smaller local watersheds. In fact, the United States Geological Survey (USGS) has delineated more than 1,000 watersheds in South Carolina (Bower and others, 1999).

South Carolina contains parts of three major physiographic provinces that encompass the southeastern United States (Figure 2). These provinces—Blue Ridge, Piedmont, and Coastal Plain—are defined on the basis of physical geography and geology. The boundary between the Blue Ridge and Piedmont is defined by a sharp change in topographic slope at an elevation of about 1,000 feet, but from a hydrologic perspective, the Piedmont and Blue Ridge provinces are essentially the same. The boundary between the Piedmont and Coastal Plain, called the Fall Line, is defined as the surface contact between the metamorphic rocks of the Piedmont and the unconsolidated sediments of the Coastal Plain.

In the Coastal Plain, which encompasses about two-thirds of the State, sediments overlie basement rock (or "bedrock"), thickening from just a few feet near the Fall Line to about 3,800 feet at the southernmost corner of the State (Figures 3 and 4). These sediments form the aquifers that hold most of the State's water. Aquifers—extensive beds of sand or permeable limestone generally bounded above and below by

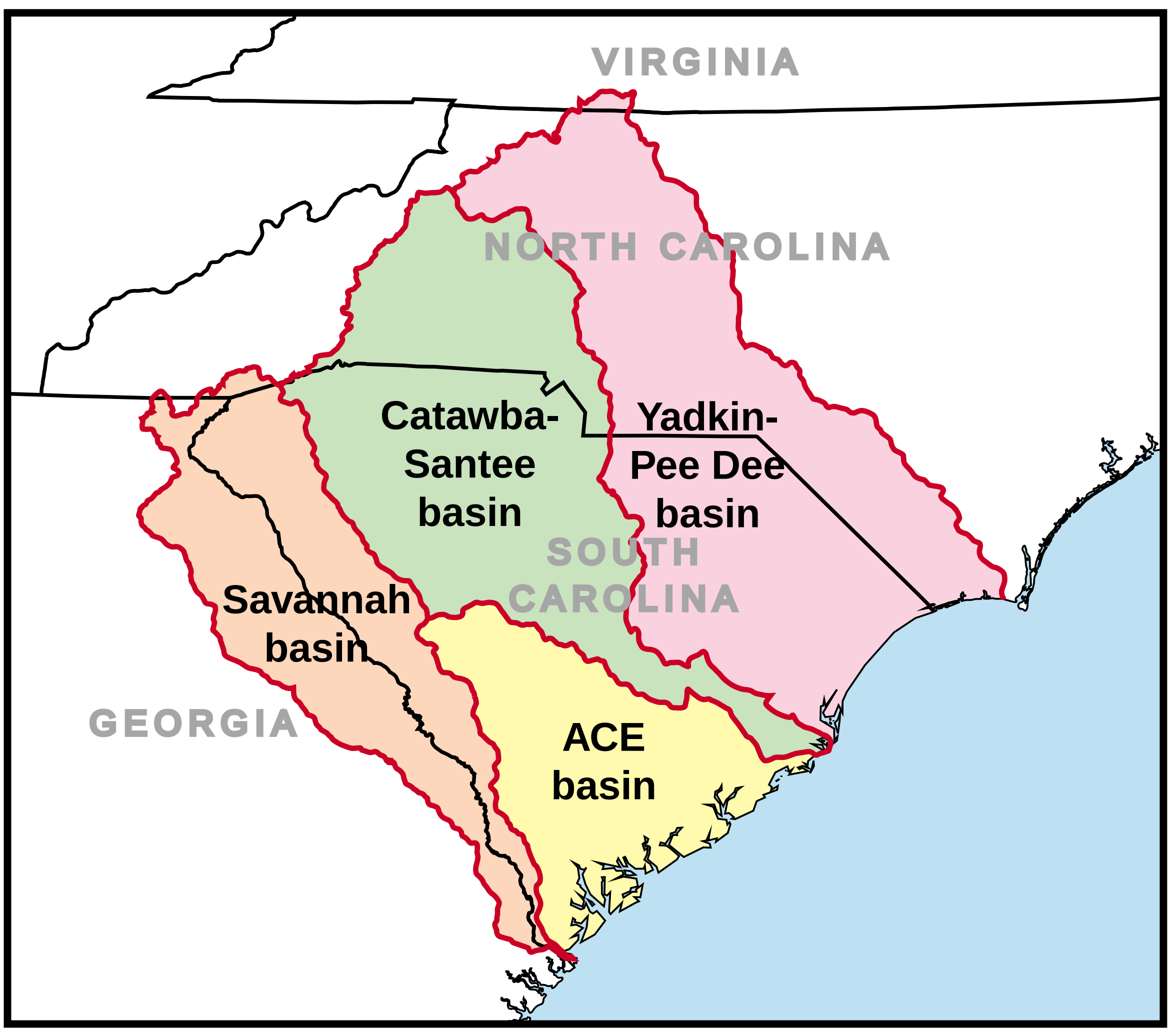


Figure 1. Major river basins in South Carolina. The ACE basin is the Ashepoo-Combahee-Edisto basin.

impermeable clay or rock—hold water in the pore spaces between sand grains or in voids within the limestone rock. Water enters an aquifer primarily in its outcrop area, where the sediments are at or very near to the surface. In this recharge area, precipitation and surface water slowly seep into the permeable sediments to replace water removed from the aquifer elsewhere. The storage capacity of these aquifers is great: probably 95 percent of the State's total volume of ground water is contained in the Coastal Plain aquifers.

In the Piedmont region, which lacks the porous sediments that form aquifers in the Coastal Plain, ground water is stored in fractures in the bedrock and in a soil-like layer of weathered rock called saprolite that rests upon the bedrock. The continuity and permeability of bedrock fractures and the thickness of saprolite control the occurrence of ground water, which is replenished primarily by precipitation seeping into the saprolite and bedrock fractures. The storage capacity of fractures and saprolite is very small compared to that of the Coastal Plain aquifers.

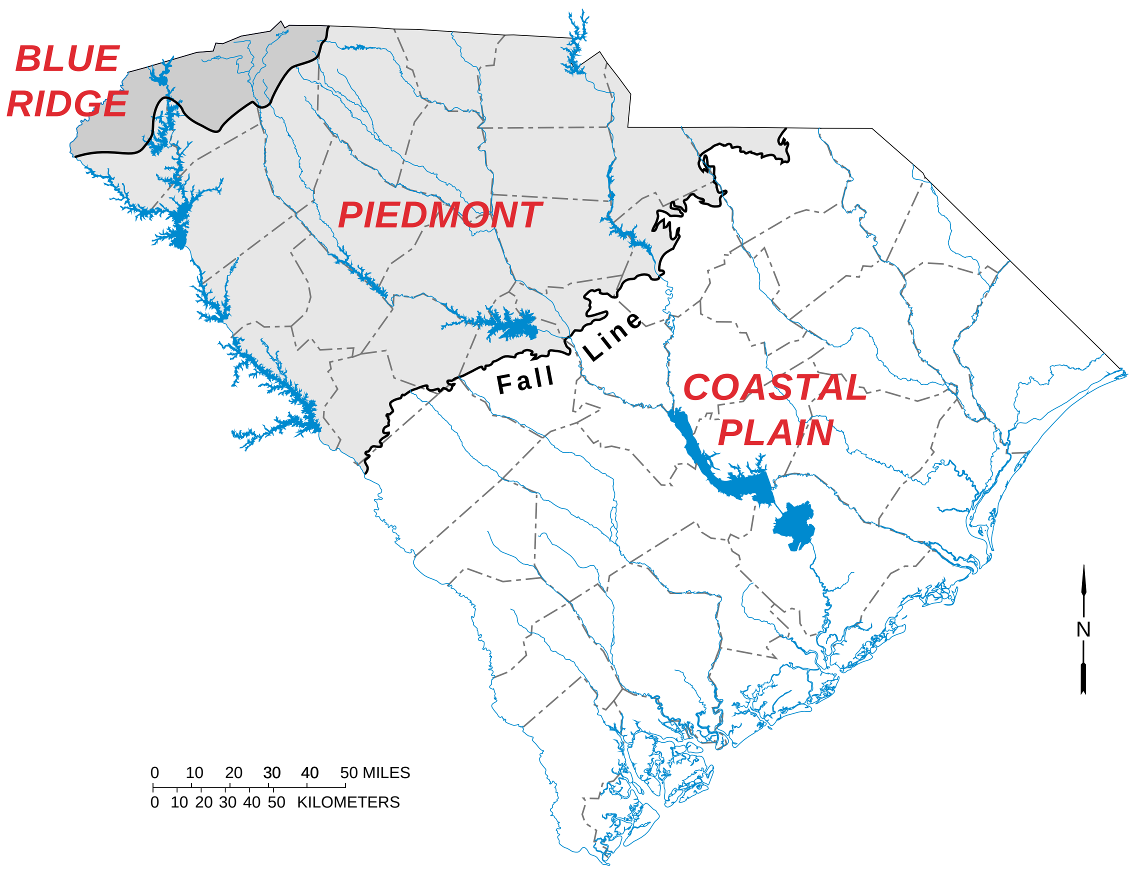


Figure 2. Location of physiographic provinces and the Fall Line in South Carolina.

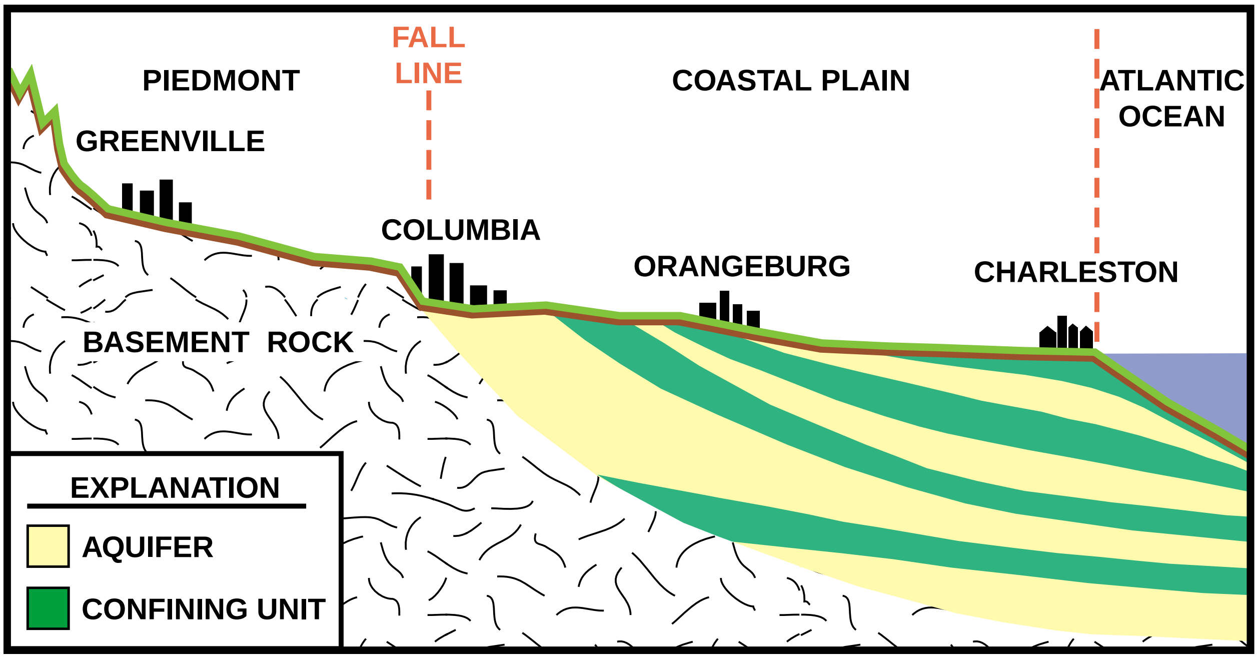


Figure 3. Simplified hydrogeologic cross section through South Carolina.

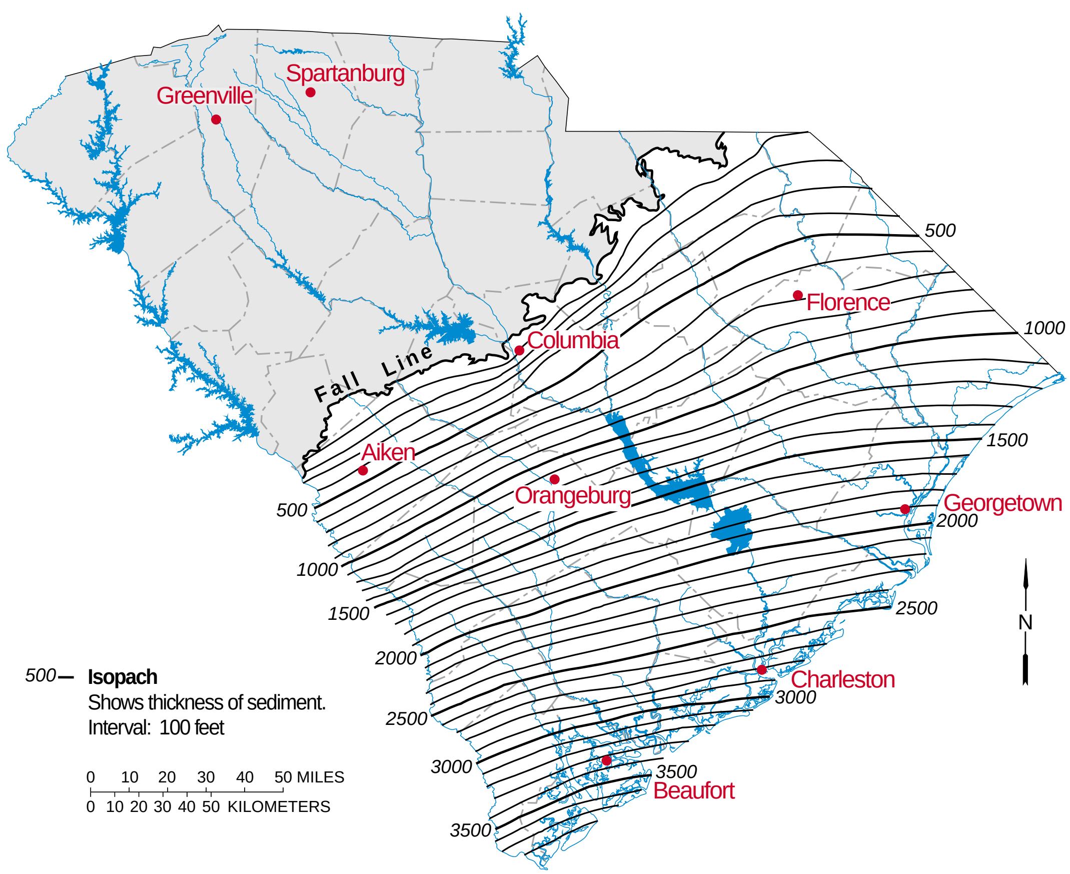


Figure 4. Thickness of Coastal Plain sediments in South Carolina, in feet.

Because watersheds are defined by surface drainage patterns, the movement of surface water and, to a large extent, ground water in shallow water-table aquifers is restricted to the individual basin. The movement of ground water in deeper aquifers, however, is not restricted to local drainage basins.

Surface water and ground water are connected hydraulically, but their interaction is often overlooked in water-resource management considerations. During dry periods, streamflows and lake levels are maintained by discharged ground water (base flow); at other times, aquifers are recharged when water seeps from lakes and streams into the ground. Because many natural processes and human actions affect this interaction, it is important for water managers to consider ground water and surface water as a single resource.

SOUTH CAROLINA'S WATER BUDGET

When water enters a watershed, it becomes part of the total water budget for that watershed, whether it flows on the surface or below it. The water budget equation

Inflow – Outflow = Change in Storage

includes all the water in the watershed.

In a typical year, about 56 inches of water (averaged over the State) comes into South Carolina from all sources. Precipitation is the source of about 48 inches, or 85 percent of the total, and streamflow from North Carolina accounts for the remaining 8 inches. Loss of water from the State occurs primarily through evapotranspiration (the conversion of liquid into vapor by the processes of evaporation and transpiration) and discharge from streams into the ocean. In an average year, 34 inches of water are evapotranspired, 21 inches are discharged into the ocean from streams, and less than 1 inch is discharged into the ocean from aquifers (Figure 5).

Precipitation is distributed unevenly over the State. The mountainous northwestern part of the State receives the most precipitation, the central part receives the least, and coastal areas tend to receive slightly more than inland areas (Figure 6).

Average annual evapotranspiration is also distributed unevenly over the State, being greatest along the coast and in the warmer southern part of the State, and lowest in the cooler Piedmont region (Figure 7).

The annual difference between precipitation and evapotranspiration is greatest in the northwestern part of the State and least in the southern part (Figure 8). When precipitation exceeds evapotranspiration, water is added to the surface- and ground-water systems, increasing streamflow and aquifer storage.

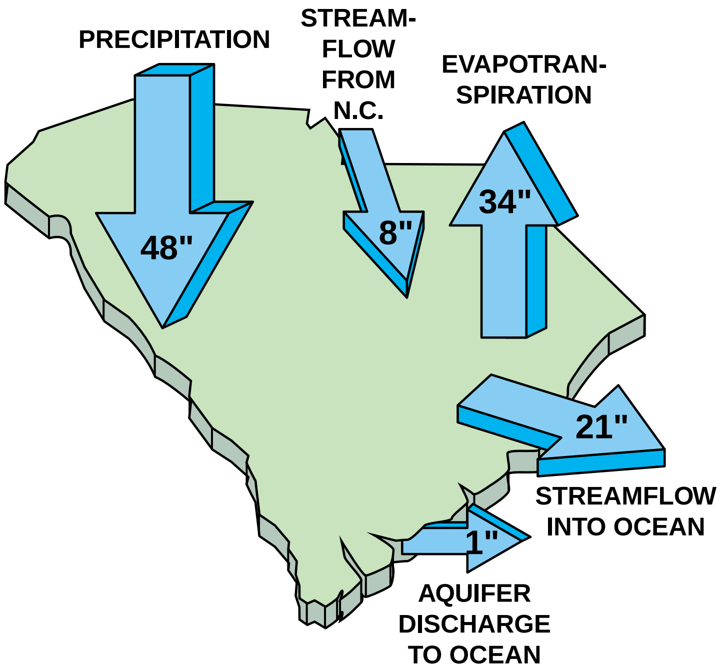


Figure 5. South Carolina's water budget.

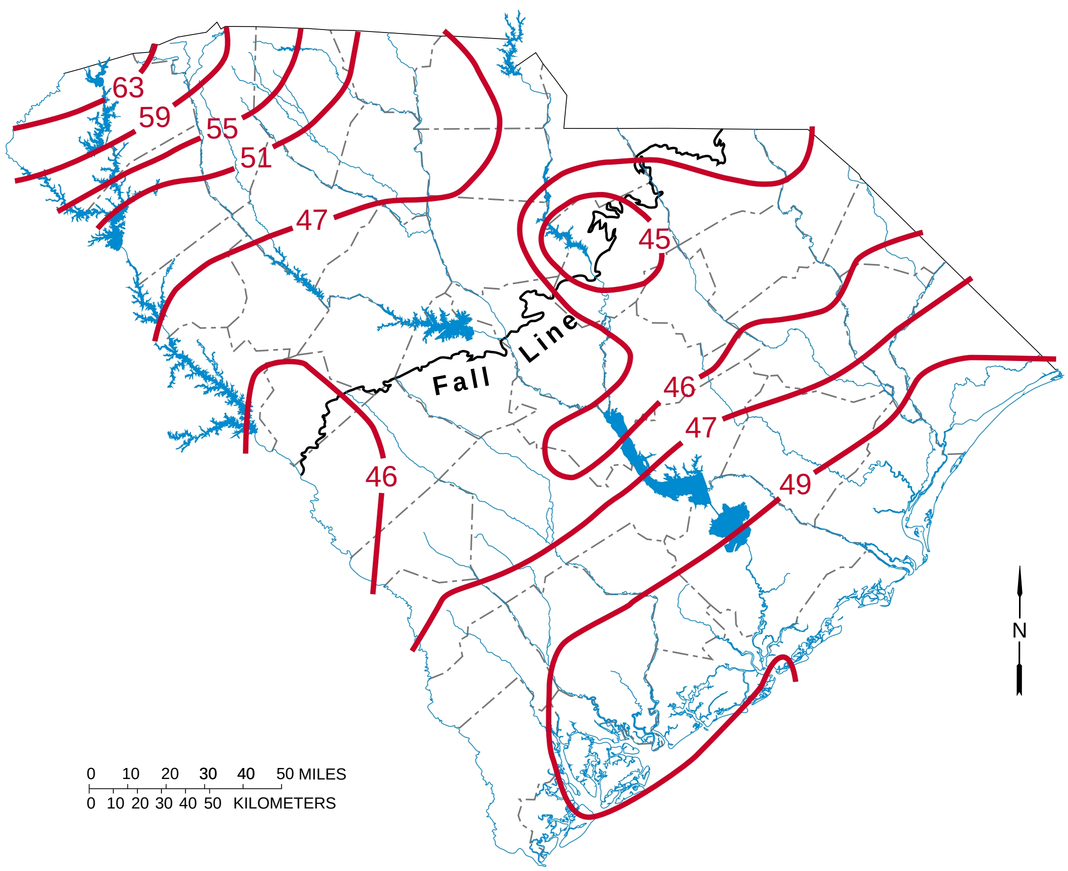


Figure 6. Average annual precipitation, in inches, for the period 1948-1990.

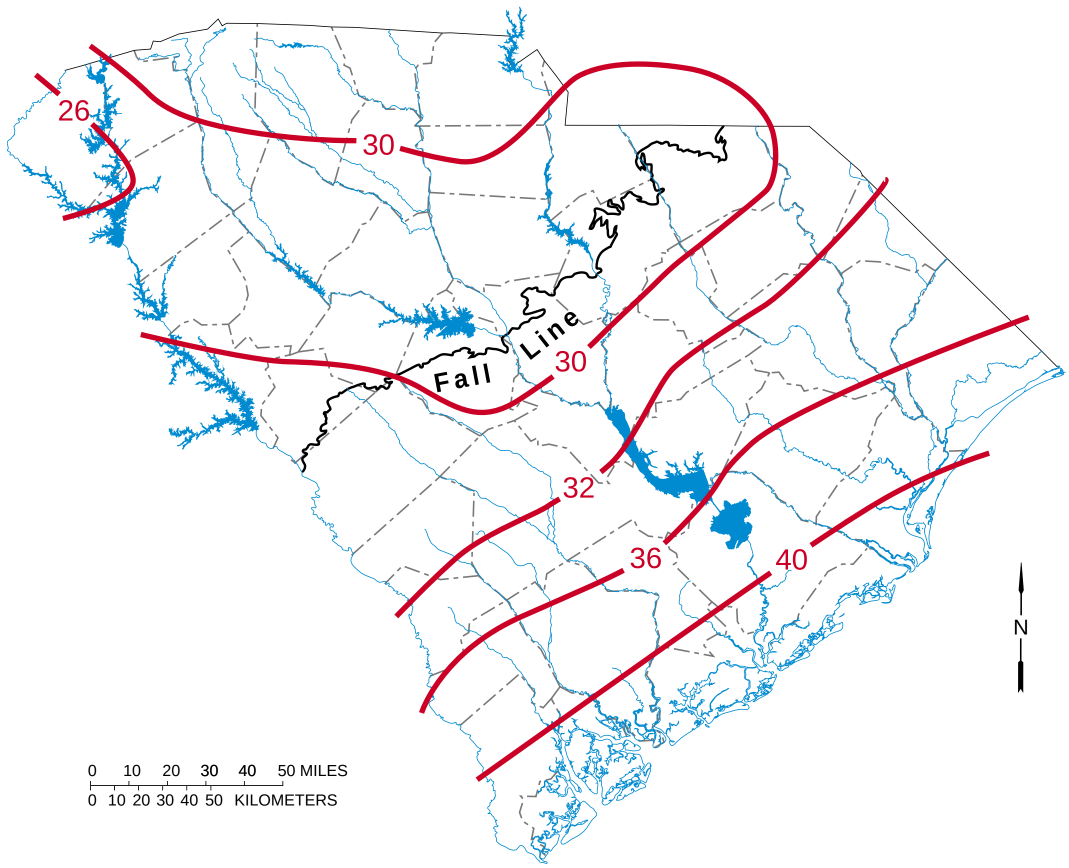


Figure 7. Average annual evapotranspiration, in inches, for the period 1948-1990.

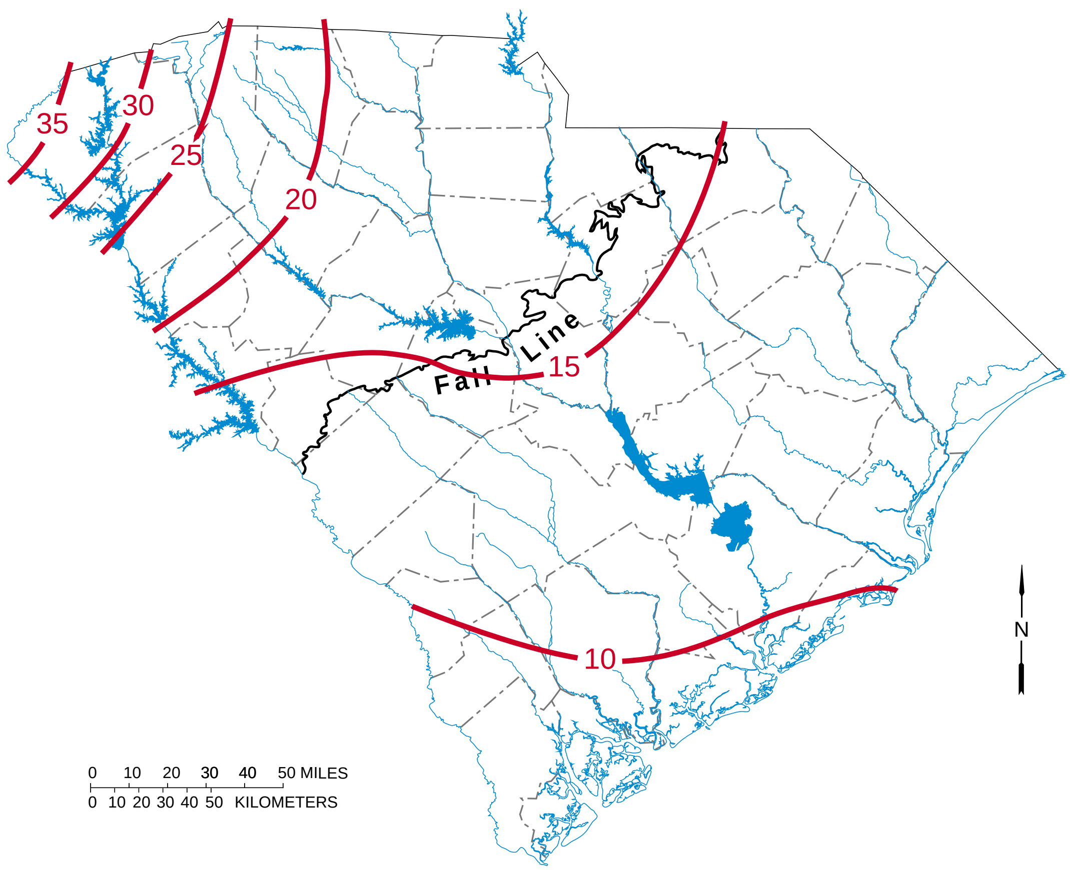


Figure 8. Average annual precipitation less evapotranspiration, in inches, for the period 1948-1990.

VARIATIONS IN WATER AVAILABILITY

The availability of water—especially surface water—is strongly influenced by seasonal variations in precipitation and evapotranspiration. Precipitation is generally high during the summer months and low during the fall months, whereas evapotranspiration is generally high during the warm summer and fall months and low during the cool winter months (Figure 9). As a result, streamflows and lake levels tend to be highest in the winter and lowest in the summer and fall (Figure 10).

Ground-water supplies are also subject to seasonal variation and decline due to prolonged drought, but usually to a lesser degree than surface-water supplies. Ground-water levels lowered during the summer and fall, the result of both increased pumping and reduced recharge, usually recover during the winter and spring, owing to increased aquifer recharge and reduced pumping (Figure 11). Multiyear droughts lower aquifer water levels by limiting the recharge that normally occurs during the wet winter and spring months (Figure 12).

In addition to seasonal variations in the water supply, long-term variations in the climate can, over time, affect the water supply. Climate changes affect precipitation, temperature, and evapotranspiration, gradually changing the "normal" values. Because the normal amount of precipitation is essentially the average annual precipitation for the last 30 years, this value will change as the climate changes. Figure 13 illustrates how the normal rainfall amounts in South Carolina have changed during the 20^{th} century. Over the past 50 years, there has been a trend toward increasing precipitation; a normal amount of rain in the 1990's, for example, would have been a greater-than-normal amount in the 1950's.

One of the biggest challenges in water resources management is satisfying the demands of all users at all times by getting the water where it is needed when it is needed. On average, there is more than enough water in South Carolina to meet the needs of all users, but water shortages can occur because of the variable nature of the surface water supply. Seasonal variations in precipitation can produce extreme variations in streamflow rates; tropical storms or long, steady rainfall events can flood rivers that, during drier months, are reduced to much lower than normal flows (see Table 1). This wide range of surface water availability is a major problem for resource managers trying to allocate and sustain surface water for all users. Compounding this problem is the fact that demand for water is usually greatest during times when the supply is lowest.

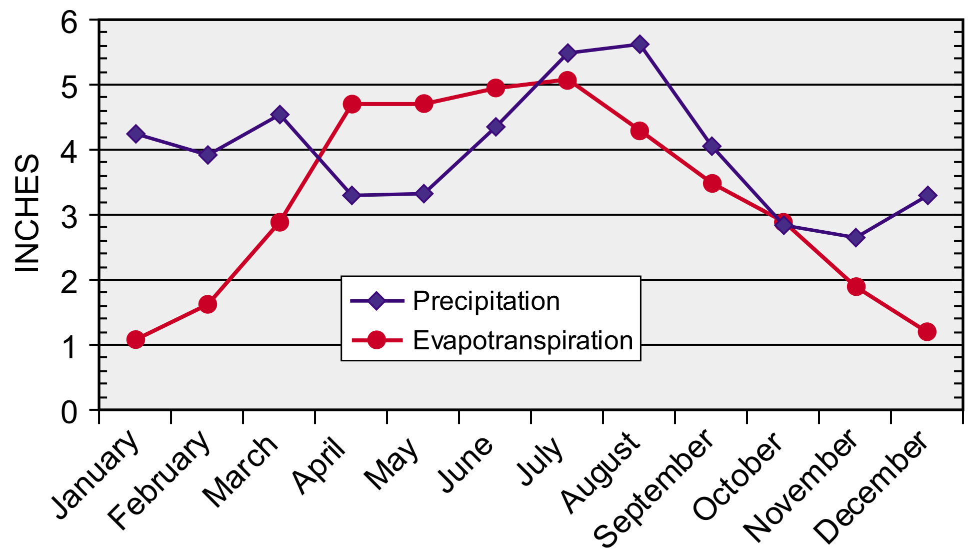


Figure 9. Average annual statewide precipitation and evapotranspiration for South Carolina, by month.

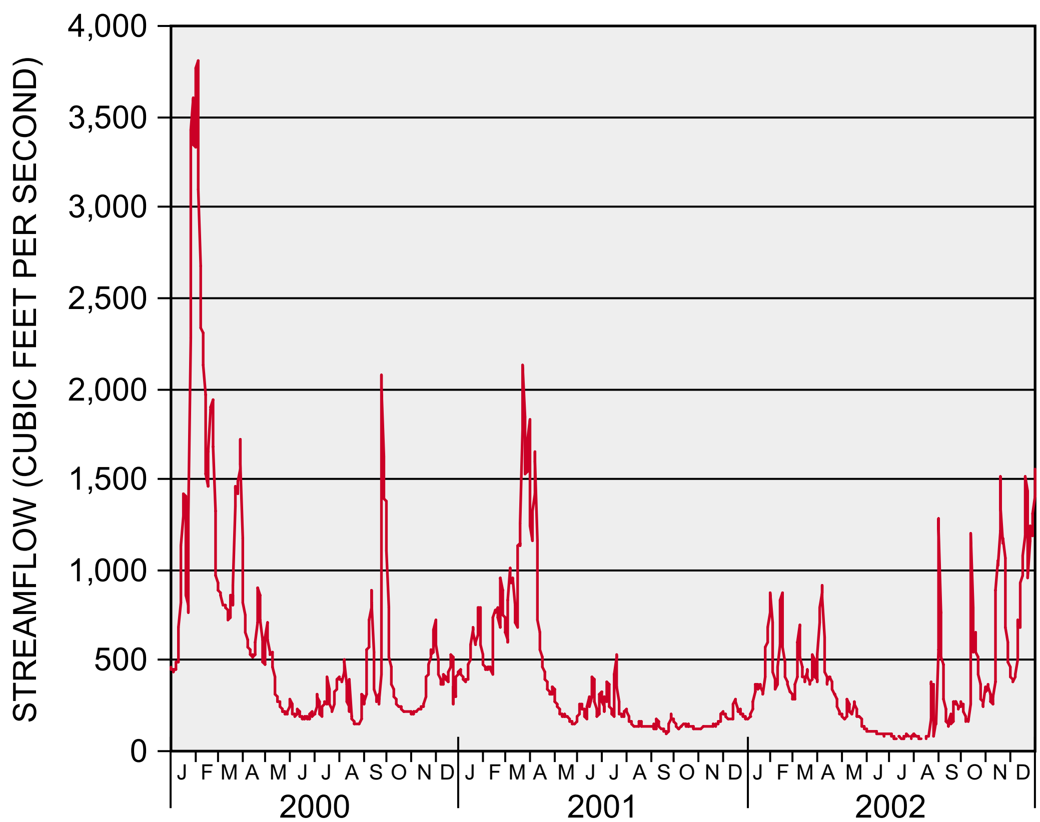


Figure 10. Streamflow in the Lynches River, showing seasonal variation in flow.

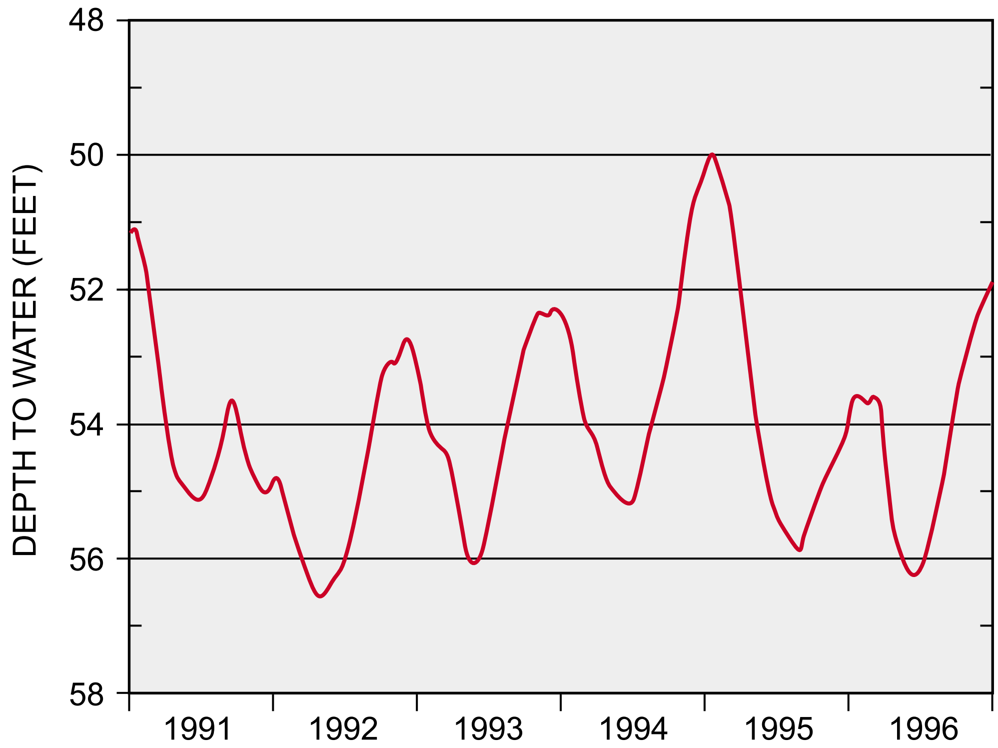


Figure 11. Hydrograph showing typical seasonal variation in ground-water level.

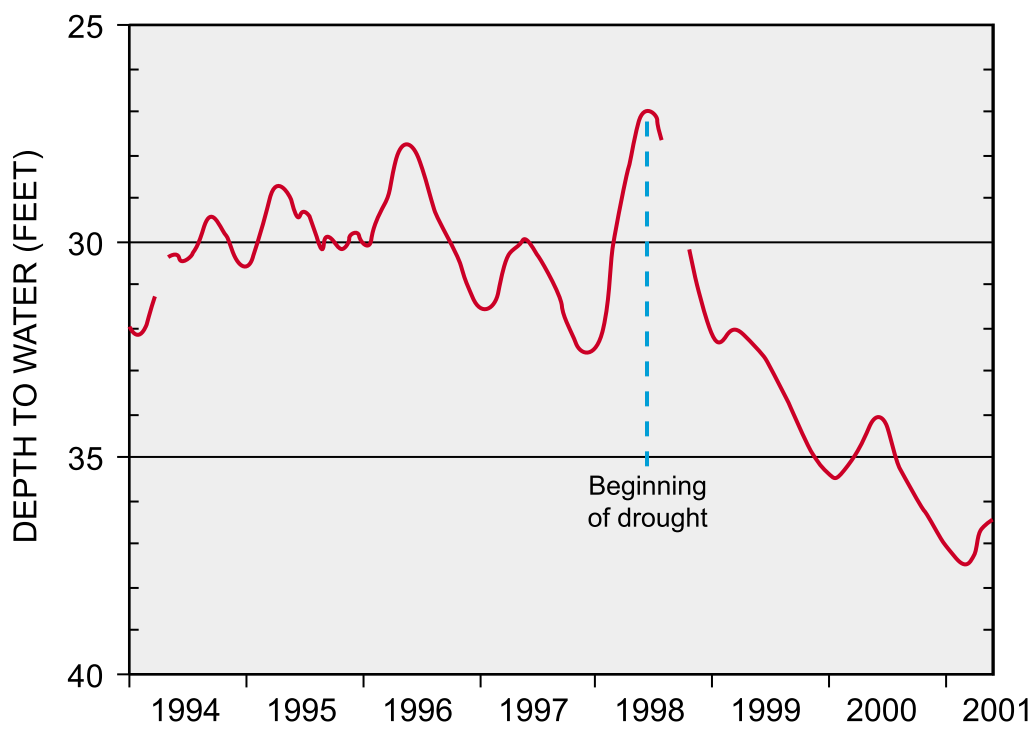


Figure 12. Hydrograph showing effect of prolonged drought on ground-water level in a Greenville County well.

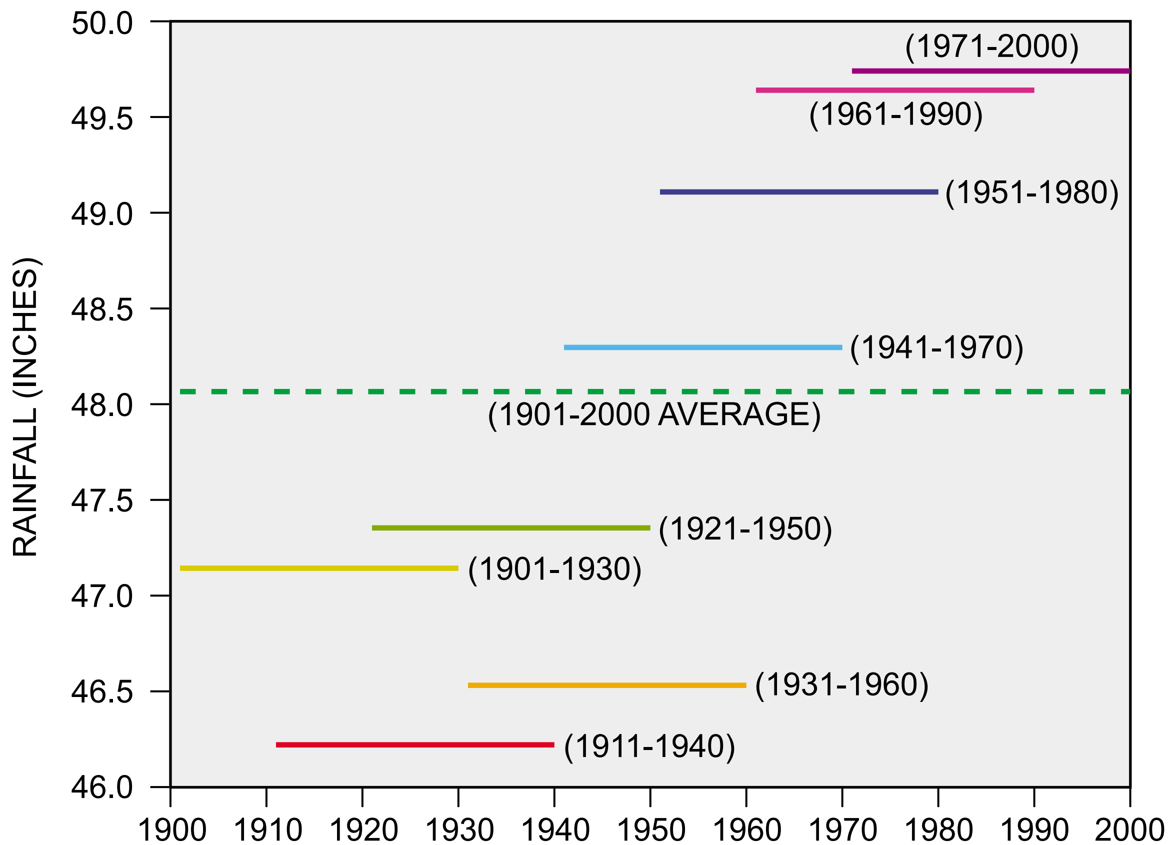


Figure 13. "Normal" precipitation values for South Carolina during the 20th century.

Table 1. Lowest and highest daily mean flows, in cubic feet per second, during a given year for several streams in South Carolina (data from United States Geological Survey)

Station name and location	Lowest daily mean flow (date)	Highest daily mean flow (date)	Annual mean flow (year)
Waccamaw River near Longs	58 (Nov. 18, 1999)	28,100 (Sep. 23, 1999)	3,556 (1999)
Congaree River at Columbia	1,360 (Sep. 16, 1998)	90,600 (Feb. 5, 1998)	11,680 (1998)
Stevens Creek near Modoc	7.1 (Sep. 1, 1998)	16,300 (Mar. 9, 1998)	544 (1998)
Coosawhatchie River near Grays	0.06 (Jul. 10, 1998)	7,030 (Feb. 6, 1998)	718 (1998)

WATER USE

Two of the most important elements in water resources management are knowing how much water is available and knowing how much water is being used. Knowing how much water is being used requires accurate and comprehensive water use reporting.

In order to effectively manage the State's water resources, and in particular to minimize the impact of droughts, comprehensive and accurate monitoring of water use is needed. Prior to the early 1980's, water use reporting in South Carolina was not required; reports were supplied voluntarily to State and Federal agencies. Water use reporting became more regular as a result of the South Carolina Water Use Reporting Act of 1982, which required reporting to the State any withdrawal of 100,000 gallons or more per day. Present regulations call for anyone withdrawing in excess of 3 million gallons in any month to register and report that use annually to the South Carolina Department of Health and Environmental Control (DHEC). Water-use reporting is now enforceable and penalties can be issued to those who fail to report. Accurate estimates of ground and surface water use are still difficult to obtain. Irrigation-use estimates are particularly poor because of inadequate reporting procedures.

INSTREAM USE

All of the uses for surface water and ground water in South Carolina can be classified as either instream use or offstream use. Instream uses are those that take place without diverting or withdrawing water from a stream. Instream uses are nonconsumptive, in that no water is lost from the stream as a result of that use. Instream water uses include maintenance of fish and wildlife habitat, recreation, navigation, wastewater assimilation, and hydroelectric power generation. Hydroelectric power generation has, by far, the greatest demand for water of all uses.

OFFSTREAM USE

Offstream uses are those that involve withdrawing or diverting the water from a stream, lake, or aquifer. The offstream-use categories presented here—including thermoelectric power generation, industrial, public supply, crop irrigation, golf course irrigation, and self-supplied domestic—are those used by DHEC in its water use reporting programs. Because offstream uses involve removing water from its source (stream, lake, or aquifer), these uses are usually consumptive, meaning that some of the water withdrawn is not returned to its source.

Thermoelectric power generating facilities—both nuclear and fossil fueled—use large quantities of water for cooling purposes. At these facilities, tens of millions of gallons per day are lost to evaporation and become unavailable to downstream users. These losses, although seemingly large, represent only 1 to 2 percent of the total volume of water withdrawn for thermoelectric use.

Industrial water use includes water used for washing, cooling, manufacturing, and processing materials, primarily chemicals and allied products. This use category represents self-supplied industries, and does not include water used for industrial purposes that was purchased from a public supply system.

Public supply includes any public or private utility that distributes water for sale to the public primarily for domestic, commercial, or industrial use. The majority of the State's large public supply systems depend on surface water, but there are some systems in the Coastal Plain—the city of Sumter being the largest—that rely entirely on ground water.

Crop irrigation represents self-supplied water used for agricultural and horticultural irrigation, except for golf course irrigation. Irrigation generally occurs during a 150-day period from late March through August. During this growing season, irrigation use can have a significant impact on the overall water supply. Crop irrigation is highly consumptive; much of the water withdrawn is lost to evapotranspiration.

Golf course irrigation represents all self-supplied water applied to golf courses. This water use is greatest in the coastal counties, which have the majority of the golf courses. Like crop irrigation, golf course irrigation is highly consumptive.

Self-supplied domestic use represents the water used by the population not served by public supply systems. Practically all of these withdrawals are from ground-water sources. This use was calculated by applying a water use rate of 75 gallons per day per person not served by a public supply system.

Other offstream use categories include **mining** (water used for the extraction, dewatering, milling, and other preparations that are part of mining activities), **aquaculture** (water used for the production of aquatic organisms in captivity), **commercial** (water used for hotels, restaurants, office buildings, and other commercial facilities), and **livestock** (water used for animals, feed lots, dairies, poultry, and animal specialties). These uses make up a very small percentage of the total offstream water use, and are therefore not included in the water use data presented in the following section.

The **interbasin transfer** of water is an offstream use not included in DHEC's water use categories. Regardless of the eventual use for the water at its destination, interbasin transfer is a 100-percent consumptive use for the source basin.

WATER USE IN THE YEAR 2000

Water use data for the year 2000 is presented to illustrate the relative magnitudes of the water uses in South Carolina. These numbers come from the forthcoming revised *South Carolina State Water Assessment*, which contains a detailed description of how these estimates were made.

Hydroelectric-power water use (instream) was estimated at 36,175 MGD (million gallons per day) for the year 2000, which is less than 75 percent of the 50-year average for this use. This very low total—the third smallest annual total since 1950—is the result of the drought that began in 1998. Reduced streamflows and lake levels limited the amount of water available to generate electricity.

Offstream water withdrawals in South Carolina during the year 2000 totaled 7,362 MGD, of which 5,840 MGD was used for thermoelectric power generation. The combined total of all other offstream uses for the year 2000 was 1,522 MGD, of which industry used 37 percent, public supply 36 percent, crop irrigation 17 percent, golf course irrigation 6 percent, and self-supplied domestic 4 percent. Streams and lakes provided nearly all of the supply for hydroelectric and thermoelectric power generation and 71 percent of the supply for all other uses. Wells and springs provided the remaining 29 percent. Table 2 lists the water use data by county in South Carolina for the year 2000, and Table 3 presents a summary of water use for each basin during that same year.

TRENDS

Water use in South Carolina is linked to many social, economic, technological, and regulatory factors. The demand for water is closely tied to the State's population; as the population grows, so too will the demand for water. Further industrial development and the ever-increasing demand for electricity will also increase the need for available water. The combined water demand for industry, public supply, crop and golf course irrigation, and domestic use is expected to increase by nearly 50 percent between the years 2000 and 2045 (Castro and Foster, 2000; Figure 14).

Table 2. Estimated water use (million gallons per day) in South Carolina, by county, for the year 2000

County	Hydro-electric	Thermo-electric	Public supply	Industry	Irrigation	Golf course	Domestic	Subtotal
Abbeville	3,273		3.41	1.67	1.08	0.30	0.73	7
Aiken		161	19.32	81.71	5.85	3.00	0.80	111
Allendale			1.20	2.95	14.94	0.10	0.27	19
Anderson	2,232	75	20.41	2.09	1.61	2.30	0.36	27
Bamberg			0.79	0.08	12.94	0.40	0.41	15
Barnwell			3.20	0.91	16.46	0.50	0.63	22
Beaufort			23.50	0.89	5.06	15.20	0.52	45
Berkeley	5,222	585	12.77	11.77	1.83	1.50	3.60	31
Calhoun			0.91	90.20	21.20	0.30	0.61	113
Charleston			53.38	39.29	8.04	6.00	2.56	109
Cherokee	1,022		12.03	2.30	1.75	0.60	0.37	17
Chester	3,105		3.52	0.79	0.31	0.60	1.45	7
Chesterfield			5.89	1.53	1.50	1.00	0.84	11
Clarendon			1.83	0.10	5.72	1.50	1.07	10
Colleton		3	2.35	0.13	3.69	0.40	1.30	8
Darlington		824	6.27	18.10	3.53	1.50	0.42	30
Dillon			4.87	2.21	1.80	0.20	0.40	9
Dorchester			7.49	3.33	0.60	1.50	1.92	15
Edgefield	2,660		3.60	0.10	7.33	0.50	0.11	12
Fairfield	4,825	803	2.29	0.10	2.46	0.20	0.50	6
Florence			14.82	37.84	5.29	1.30	2.81	62
Georgetown		12	7.43	32.03	4.79	4.20	0.43	49
Greenville	571		56.57	0.76	5.11	6.20	2.87	72
Greenwood	477		13.18	0.40	0.09	1.90	1.33	17
Hampton			1.80	1.76	5.68	0.70	0.47	10
Horry		104	30.24	3.10	3.14	19.40	1.44	57
Jasper			1.26	0.15	2.16	0.40	0.18	4
Kershaw	1,652		7.28	13.30	0.45	0.80	0.40	22
Lancaster	1,165		11.84	13.75	0.95	1.30	0.68	29
Laurens	295		5.96	0.13	3.17	0.80	0.90	11
Lee			1.58	1.93	0.77	0.20	1.25	6
Lexington	288	146	18.24	44.10	18.30	2.30	8.46	91
McCormick	3,266		1.71	0.01	1.34	0.90	0.08	4
Marion			4.71	2.43	1.90	0.30	0.59	10
Marlboro			3.10	9.66	2.92	0.40	0.81	17
Newberry			5.16	0.38	0.87	0.60	1.05	8
Oconee	32	2,596	10.12	2.33	1.44	1.50	0.53	16
Orangeburg			9.60	8.80	47.60	1.50	1.29	69
Pickens	492		13.18	1.58	0.71	1.60	1.86	19
Richland	1,222	438	57.61	29.62	1.77	4.30	1.65	95
Saluda			0.63	0.15	6.07	0.30	0.95	8
Spartanburg	46		39.80	3.82	3.13	3.30	3.53	54
Sumter			16.13	2.59	13.18	1.30	2.53	36
Union	3,047		4.46	3.65	0.76	0.40	0.25	10
Williamsburg			1.64	4.77	2.31	0.30	1.93	11
York	1,283	93	14.68	86.50	1.00	3.20	6.41	112
South Carolina	36,175	5,840	542	566	253	97	64	1,522

* Subtotals do not include hydroelectric or thermoelectric uses.

Table 3. Estimated water use (million gallons per day) in South Carolina, by basin, for the year 2000

Basin		Hydro-electric	Thermo-electric	Public supply	Industry	Irrigation	Golf course	Domestic	Subtotal
Surface water	Savannah	11,626	2,757	53	81	16	7	0	157
	ACE	2,926	588	92	53	58	20	0	223
	Santee	21,621	1,554	251	283	32	21	0	587
	Pee Dee	0	940	41	103	20	23	0	186
	Statewide	36,173	5,839	437	519	126	71	0	1,153
Ground water	Savannah	0	0	6	9	16	2	5	38
	ACE	0	4	29	15	58	9	15	127
	Santee	0	0	11	7	32	7	30	87
	Pee Dee	0	0	58	20	20	8	13	119
	Statewide	0	4	104	51	126	26	64	371
Total water	Savannah	11,626	2,757	59	90	33	9	5	195
	ACE	2,926	592	121	68	116	29	15	350
	Santee	21,621	1,554	262	290	64	28	30	675
	Pee Dee	0	940	99	123	40	31	13	305
	Statewide	36,173	5,843	541	570	253	97	64	1,525

* Subtotals do not include hydroelectric or thermoelectric uses.

** Irrigation use estimates are based on a 5-month growing season. The source of irrigation water is assumed to be half surface water and half ground water.

*** Some values do not equal those of Table 2 because of rounding errors.

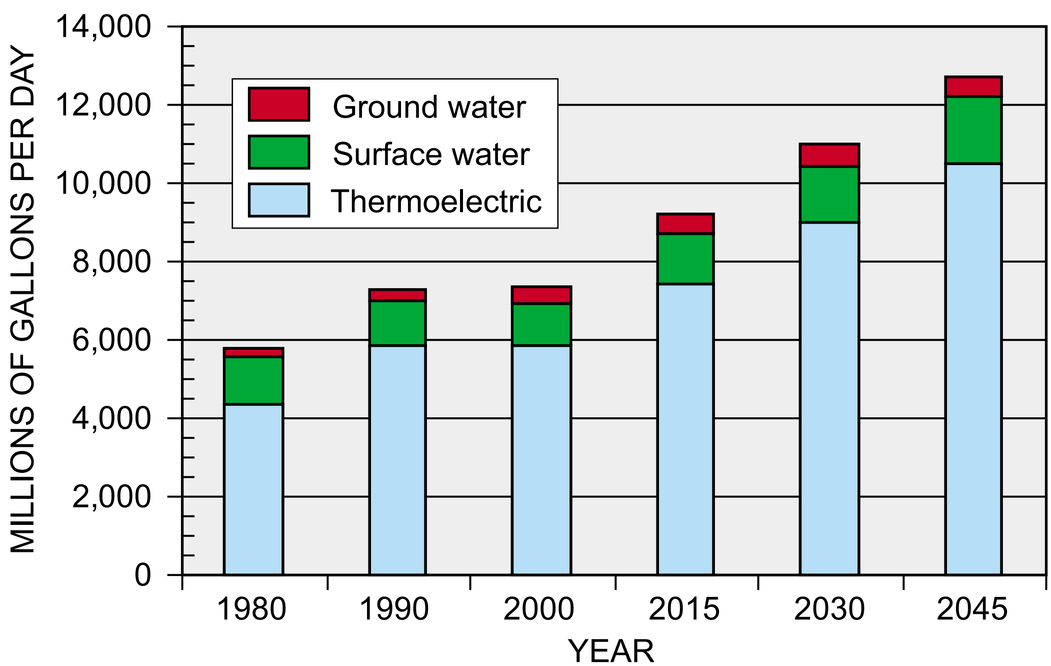


Figure 14. Past water use and projected water demand for South Carolina (Castro and Foster, 2000).

WATER RESOURCES MANAGEMENT

Early in this State's history, rivers were used for transportation, irrigation, and drinking water. Over time, rivers were harnessed to provide mechanical power for mills, and in the 20th century, water wheels gave way to hydroelectric turbines, as massive dams were built to generate electricity and provide some degree of flood control. By the end of the 20th century, most of South Carolina's larger rivers were regulated by releases from impoundments, several of which are located in North Carolina. Only in the ACE basin (see Figure 1) are any major rivers in South Carolina still unregulated and flowing naturally.

The regulation of South Carolina's rivers was by far the most important water resources management decision in the State's history. Dams and reservoirs provided many benefits, such as electricity, flood control, water supply, sustained flow during dry periods, and increased recreational and tourism opportunities. But the dams also created some problems, such as altered flow regimes, interrupted fish passage, destroyed and altered habitats, and changes in water chemistry.

In the later part of the 20th century, the water demands of an increasing population and growing industrial base, as well as greater environmental awareness, led to an increasing need for effective water resources management. The South Carolina Water Resources Commission (SCWRC) was established in 1967 to provide the State with an assessment of its water resources and to offer management guidelines for sustaining the State's water resources for future generations.

Today, water resources planners and managers are faced with many issues, such as monitoring and protecting water quality and quantity, determining and maintaining appropriate flows in rivers, protecting riverine habitats and ecosystems, regulating releases from reservoirs, allocating water during shortages, maintaining navigation, and managing flood plain development. Many of these issues stem from an increasing population making increasing demands on the finite water resources of the State.

In addition to problems caused by competing demands, the withdrawal or diversion of water from a lake, stream, or aquifer may cause undesired effects, such as saltwater intrusion, lowering of water level in a lake or wetland, diminishing the flow to a stream, reducing the ability of an aquifer to produce water, lowering the water level in nearby wells (well interference), land subsidence, or sinkhole formation. These adverse effects can be mitigated by restricting withdrawals, 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 effective management of South Carolina's water resources—finding ways to satisfy the many competing demands while still protecting the resource for future generations—is beyond the capability of any one agency or organization; it will require cooperation and shared responsibility among public and private parties.

Effective resource management requires the increased utilization of regulatory science—research directed to provide useful information for regulators facing specific choices. Research institutes and universities should be encouraged to work with State resource agencies and become integrated into the decision-making processes of the State. South Carolina needs integrated, long-term research projects to answer specific regulatory questions.

The management of South Carolina's water resources is a task made difficult by the complexity of the system and the interconnection of its components. Water quantity affects water quality; water quality affects the quantity of usable water; lakes affect rivers; ground water affects surface water; surface water affects ground water; and climatic conditions ultimately control all these components. Because of the complex interaction of all the components of the State's water resources system, management strategies must be flexible, responsive to trial, monitoring, and feedback, and should change in response to new scientific information and technical knowledge. This "adaptive management" approach provides a process for continually improving management practices and policies.

Whether dealing with surface water or ground water, there are two major issues facing water resource managers: *water quantity*—making sure there is enough water at the right place at the right time; and *water quality*—making sure the available water is suitable for use.

SURFACE WATER QUANTITY

The flow of unregulated streams is essentially controlled by climatic and geographic conditions, outside the influence of man. Quantity management programs for these rivers are therefore limited primarily to water allocation and conservation mechanisms. Regulated streams, on the other hand, are strongly controlled by man and, as such, offer a much better opportunity to manage the quantity and location of the surface water. The management of the reservoirs that control South Carolina's rivers is the key to the effective management of the State's surface water resources.

An essential element of any successful water quantity management program is knowing how much water there is, and where it is, at any given time. To that end, a good monitoring network is a requirement for an effective surface water management program.

South Carolina's Streams

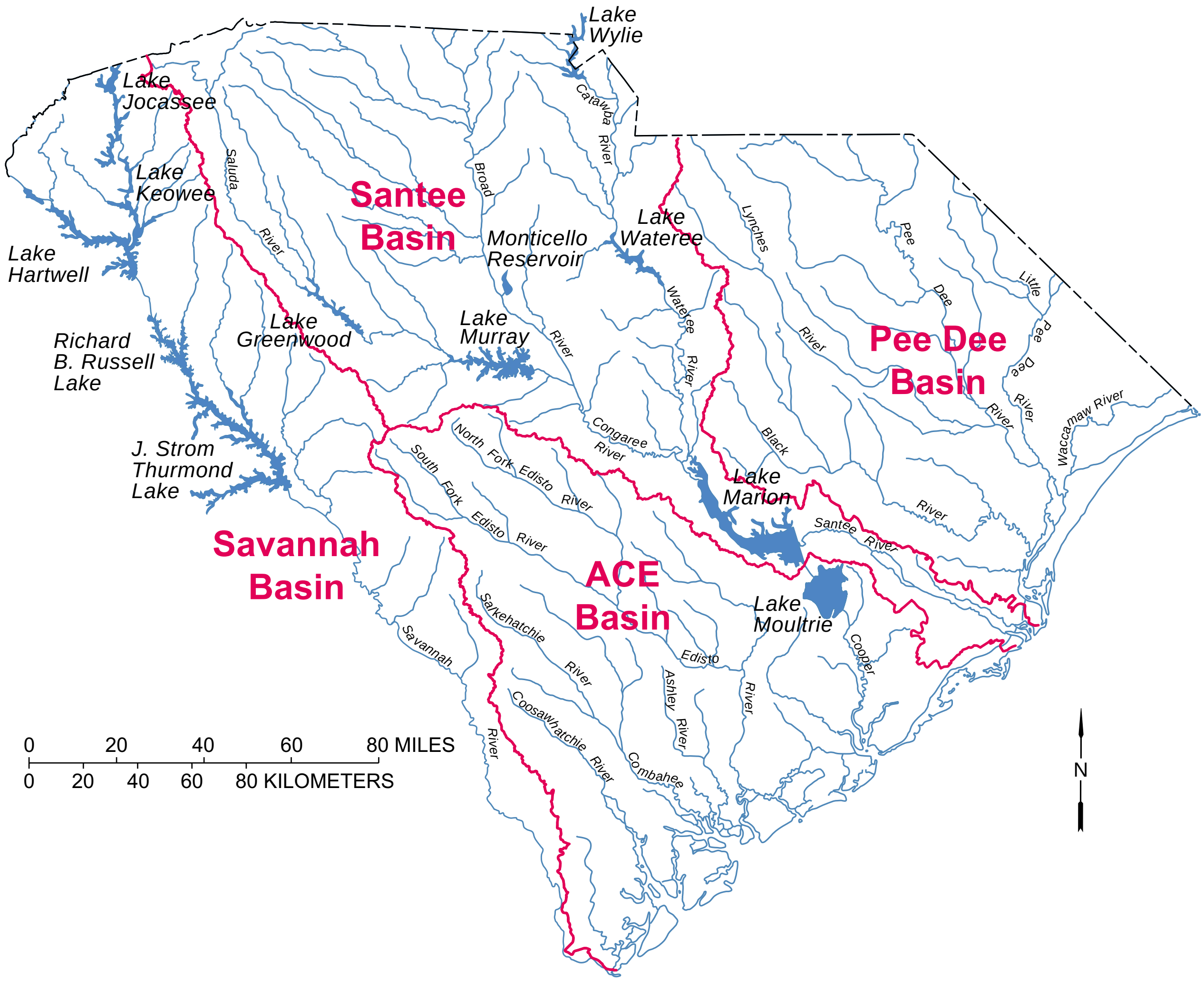
There are more than 11,000 miles of permanently flowing streams in South Carolina (Beasley and others, 1988), having an average flow of about 33 billion gallons per day (SCWRC, 1983). Four major drainage basins contain the State's streams (Figure 15), and 3 of these are shared with Georgia or North Carolina. Most of South Carolina's major rivers are highly regulated by releases from instream reservoirs.

The Savannah River, which forms the Georgia-South Carolina border, is the dominant river in the Savannah basin, and is heavily regulated by releases from Lakes Hartwell, Russell, and Thurmond.

In the Santee basin, the Saluda River and Broad River enter South Carolina from North Carolina and converge to form the Congaree River at Columbia. The Catawba River, entering South Carolina near Charlotte, N.C., becomes the Wateree River before merging with the Congaree to form the Santee River just above Lake Marion. All of these rivers are controlled by releases from reservoirs in South Carolina and North Carolina.

Most of the major rivers of the Pee Dee basin—the Pee Dee, Little Pee Dee, Lynches, and Waccamaw—originate in North Carolina and receive much of their flow from drainage in that state. The Black River is the largest river in this basin that originates within South Carolina. There are no major reservoirs in this basin in South Carolina, but the flow of the Pee Dee River is controlled by reservoir operations in North Carolina.

The ACE basin is the only major drainage basin located entirely within South Carolina, and most of its major rivers—the Ashley, Edisto, Salkehatchie, Coosawhatchie, and Combahee—are essentially unregulated. Only the Cooper River, which flows from Lake Moultrie to the Charleston Harbor, is significantly regulated.



Rank	Lake	Drainage basin	Lake operator	Surface area (acres)	Volume (acre-feet)
1	Hartwell	Savannah	Corps of Engineers	56,000	2,549,000
2	Thurmond	Savannah	Corps of Engineers	70,000	2,510,000
3	Murray	Santee	SCE&G	51,000	2,114,000
4	Marion	Santee	Santee-Cooper	110,000	1,400,000
5	Moultrie	ACE	Santee-Cooper	60,000	1,211,000
6	Jocassee	Savannah	Duke Power	7,565	1,185,000
7	Russell	Savannah	Corps of Engineers	26,650	1,026,000
8	Keowee	Savannah	Duke Power	18,372	1,000,000
9	Monticello	Santee	SCE&G	6,800	431,050
10	Wateree	Santee	Duke Power	13,710	310,000
11	Wylie	Santee	Duke Power	12,455	281,900
12	Greenwood	Santee	Duke Power	11,400	270,000

Figure 15. Major rivers and the 12 largest lakes, by volume, in South Carolina.

South Carolina's Lakes

There are more than 1,600 lakes in South Carolina that cover an area of 10 acres or more (SCWRC, 1991). They impound more than 15 million acre-feet of water, 95 percent of which is contained in the State's 12 largest reservoirs (Figure 15), and releases from these manmade lakes control the flow of many of the State's rivers.

All of these major reservoirs were constructed for the primary purpose of hydroelectric power generation, and that function is still the guiding force behind reservoir operations. The lakes also provide some flood control by reducing the severity of peak flood flows, and they help to supplement low flows during extended dry periods. Reservoirs also serve as reliable sources of water for many cities and water companies across the State.

In the years since they were constructed, South Carolina's lakes have become nationally known for their boating, fishing, and recreational opportunities. Recreational use of lakes has become an important economic asset, and this use needs to be given important consideration in any lake management program.

In the Savannah basin, Lakes Thurmond, Russell, and Hartwell dominate the upper Savannah River and effectively control the flow of the lower Savannah River. These reservoirs, operated by the U. S. Army Corps of Engineers, are located on the Georgia-South Carolina border, and are shared by the two states. Lakes Jocassee and Keowee, both located entirely within South Carolina, flow into Lake Hartwell via the Seneca River.

The Santee basin contains 6 of the 12 largest lakes in South Carolina: Lakes Murray and Greenwood on the Saluda River; Lakes Wylie and Wateree on the Catawba/Wateree River; Monticello Reservoir off the Broad River; and Lake Marion on the Santee River. (Although Lake Moultrie gets its water from the Santee River via Lake Marion, the reservoir itself is located in the ACE basin.) In addition to these South Carolina lakes, there are several more reservoirs in North Carolina that regulate flows of the Broad River and Catawba River before they enter South Carolina.

Although there are no major reservoirs on the rivers of the Pee Dee basin in South Carolina, this basin is influenced by reservoirs located in North Carolina. The Pee Dee River, for example, is controlled by 6 reservoirs in North Carolina.

Only in the ACE basin are most of the rivers undammed and in a relatively "natural" condition. But even this basin contains one major reservoir: Lake Moultrie, which gets its water from Lake Marion via a cross-basin canal. Lake Moultrie discharges some of its water into the Cooper River, enhancing natural flows into the Charleston Harbor, while the rest of its discharge is returned to the Santee River.

Lakes and Rivers are Interconnected

Lakes and rivers are inherently connected and interdependent. What happens in a river affects every lake downstream, and what happens in a lake affects the river downstream. Management of the State's surface water system requires a coordinated management of its lakes and rivers in order to balance the needs of lake users with the needs of river users. Lakes cannot be operated without regard for the needs of downstream users, with respect to both water quantity and water quality. Likewise, the needs of river users cannot necessarily outweigh the needs of lake users.

The construction of an instream reservoir has a profound impact on the river in which it is constructed. Some of the impacts are beneficial, such as sustaining streamflows during extended dry periods, whereas other impacts are detrimental, such as decreasing the downstream river's dissolved-oxygen concentrations, hindering navigation, altering habitats, and preventing fish passage past the dam. Perhaps the most significant impact a reservoir has on its river is the change in the downstream flow regime.

Management Guidelines for Streams

South Carolina's streams are one of its most important resources, and their wise use and management is clearly in the State's interest. The complexity of South Carolina's river systems, their dependence on unpredictable and uncontrollable weather patterns, and the diverse multitude of users and their demands all contribute to the complexity of managing South Carolina's streams.

Some of the major issues facing resource managers are developing appropriate release schedules for reservoirs, establishing desired and minimum allowable flows, monitoring both water quantity and water quality, protecting habitats and ecosystems, maintaining and restoring water quality, controlling point and nonpoint sources of pollution, allocating water during times of shortage, managing flood-plain development, dredging channels, controlling invasive exotic species, and maintaining navigation.

Many of these issues are being addressed, to some extent, by Federal, State, and local government agencies, as well as by private organizations, particularly the environmental issues. For example, the DNR's Scenic Rivers Program works to conserve unique ecological, cultural, recreational, and scenic resource values in South Carolina's rivers. Through a cooperative, voluntary management process involving landowners, community interests, and the DNR working together for common river-management goals, more than 250 miles along segments of eight rivers are being managed and protected as State Scenic Rivers.

Minimum Required Flows

Minimum required flows for streams need to be established to protect public health and safety, maintain fish and wildlife, and provide recreation, while promoting aesthetic and ecological values. The minimum required flow for a stream is the greatest of the minimum flows required for:

1. Protection of water quality;
2. Protection of fish and wildlife habitats;
3. Maintenance of navigability;
4. Estuary maintenance and prevention of saltwater intrusion.

Protection of water quality—Streamflows must be maintained to protect human health and safety and to prevent irreversible damage to the ecosystem.

The *assimilative capacity* of a stream refers to the amount of wastewater and other pollutants a stream can receive without causing harmful effects to aquatic life or humans who consume the water. The assimilative capacity is directly related to how much water is in the stream; higher flows can handle larger amounts of pollutants before becoming adversely affected.

Although a stream's assimilative capacity is proportional to its flow, it is usually impractical to permit all wastewater discharges as a function of streamflow. A more manageable approach is to determine a low-flow value for the stream—a flow that is almost always met or exceeded—and determine the assimilative capacity of the stream for that low flow. Permits to discharge are then issued based on the assimilative capacity for that low flow. By doing this, the assimilative capacity of the stream will almost always be greater than the permitted wasteload, so the stream's water quality standards will almost always be met without curtailing normal discharges.

DHEC, the State agency responsible for overseeing and regulating wastewater discharge, uses the "7Q10" flow as the low flow value to determine the wasteload capacity of 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. The 7Q10 flow is usually met or exceeded about 95 percent of the time. In general, DHEC allows treated waste discharges into a stream only to the extent that, under 7Q10 conditions, all water quality standards will be met.

7Q10 values are not fixed numbers, and should not be thought of as fixed values; they can vary over time as water availability changes during wet and dry periods. Because of this variability, if 7Q10 values are used for comparison of the assimilative capacity of different drainage areas, they should each be calculated from the same period of record. To maintain water quality during prolonged dry periods, when flows frequently drop below established 7Q10 values, regulatory programs should have the flexibility and authority to reduce permitted waste discharges or improve waste treatment in order to maintain water quality standards.

Protection of fish and wildlife habitats— Reduced flows decrease the amount of habitat available to aquatic biota and can restrict the movement of resident and migratory fish species. Reduced flows also intensify pollution, inflate water temperature, and exacerbate dissolved-oxygen problems, all of which can damage riverine habitats and ecosystems.

It is the responsibility of the DNR to determine the minimum flow required to protect the State's aquatic resources. The current policy for determining instream flow requirements for fishery resources can be found in *South Carolina Instream Flow Studies: A Status Report* (Bulak and Jöbsis, 1989). Work is currently underway to determine if it is more appropriate to prescribe minimum flows based on a percentage of mean monthly flows rather than mean annual flow as employed by Bulak and Jöbsis (1989). Basing minimum flows on mean monthly flows has the advantage of a closer adherence to a stream's natural flow pattern. This methodology would require a technique for estimating the natural flow pattern of regulated rivers, and it would also require an evaluation of the change in habitat at various percentages of mean monthly flow.

Maintenance of navigability—Minimum-flow requirements for navigation are based on either one-way or two-way navigation. The minimum flow for one-way passage by boat for a given stream segment 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 by boat 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 (de Kozlowski, 1988).

Prevention of saltwater intrusion—Estuaries are essential habitats for numerous marine resources, and adequate freshwater flow into estuaries is necessary to maintain the ecological functions that support recruitment of important recreational finfish and shellfish populations. Freshwater flow in coastal rivers must also be maintained to keep saltwater away from the intake structures of water supplies. Measured data of saltwater advances into rivers during different flows should be used to build and verify simulation models to enhance the management of flow regimes in rivers in order to control the saltwater wedge and maintain the ecological functions of estuaries. Minimum flows required to prevent undesirable saltwater intrusion should be determined by the DNR.

Allocation of Stream Water

South Carolina's streams usually have more than enough water to satisfy the demands of all water users. During dry summers or prolonged droughts, however, streamflows can become unusually low, and demands for water can exceed the available supply. To maximize water availability at all times and to protect human and economic needs, surface water use must be regulated. An allocation mechanism must be established to control the distribution of water so that all users have a reliable water supply. Variations in surface water availability and the location of withdrawals must play major roles in the allocation of water.

At any given withdrawal point, there is a quantifiable amount of *available water* that can be removed from a stream without adversely impacting downstream users. This available water is the difference between how much water is in a stream at the withdrawal point and how much water must be left instream for downstream use. Any withdrawals, discharges, and drainage recruitments occurring upstream from the withdrawal point are incorporated into the measured flow at the withdrawal point. The amount of water needed for downstream use is the sum of all downstream permitted withdrawals and required instream flows minus local discharges and recruitments. The amount of available water will vary with changes in streamflow or offstream use.

Many users of stream water—in particular public suppliers and industries—return much of their withdrawn water back into the stream, usually in the form of treated wastewater. This nonconsumptive use results in a net withdrawn amount (the total withdrawn amount minus the returned amount) that is often considerably less than the total withdrawn amount. For these cases in which a portion of the withdrawn water is returned to its source, both the amount of total withdrawal and net withdrawal need to be considered. Between the point of withdrawal and the point of return, the stream must be able to adequately accommodate the loss of the amount of total withdrawal. Downstream from the point of return, however, the stream must be able to accommodate the loss of only the amount of net withdrawal. In order to minimize the impact of the withdrawal on the stream between the withdrawal point and the return point, water should be returned as near to the point of withdrawal as is practical.

There will be times when the available water is less than the desired withdrawal amount. How often this is likely to occur can be determined by examining the stream's historical measured-flow data. A duration curve—a statistical analysis of how often various flows occur—can provide an estimate of how often the desired withdrawal amount will be available, and the stream's measured flow history can provide an estimate of the longest continuous period during which the streamflow will be inadequate to provide to desired withdrawal amount. The summation of flow deficit during this period represents how much additional water would be needed from other sources to supplement the natural flow in order to meet the user's demands during this dry period. This supplemental water can come from storage facilities, ground water, or other water suppliers.

During extended dry periods, reduced water availability may necessitate a reduction in offstream withdrawals, resulting in a shortage of water for some users. Economic, social, and environmental considerations must be weighed against overall fairness when imposing water restrictions.

Management Guidelines for Lakes

A properly managed reservoir can be a valuable asset to the State, providing a reliable supply of water, generating electricity, and offering numerous recreational and economic opportunities. An improperly managed reservoir, however, can become a liability, disrupting lake and downstream ecosystems, failing as a reliable source of water, and reducing the potential economic benefits a reservoir can offer. The goal of lake management is to satisfy as many demands as possible while protecting the resource for future use.

A multitude of issues face lake managers and water resources planners. Some issues, such as water quality or allocation programs, are similar to those associated with river management. Other issues, such as hydroelectric power generation, are specific to lake management. Many problems stem from competing demands for the same limited resource. Complicating the management task is the fact that many of the reservoirs that control South Carolina's surface water system are partly or entirely located in other states. Further complicating matters is the fact that the State has little direct control over the operation of these reservoirs.

Lake Levels and Rule Curves

From the point of view of a reservoir manager (and most lake users), an important operating goal is to keep the lake level at a desired elevation, usually the "full pool" level. There are many benefits to maintaining a full-pool lake level: more efficient hydroelectric power generation; consistent boating and fishing conditions; a consistent shoreline (important to lakeside property owners); and a maximized supply of water for offstream use.

Seasonal variations in the desired lake elevations are normal. Lake levels are usually lowered from full pool during the early winter in anticipation of high inflows expected during the spring. Capturing high springtime flows provides some flood protection downstream from the lake, while returning the reservoir to its full pool level. The desired, or target, lake elevation over the course of a year is known as a rule curve or guide curve. Reservoir releases are adjusted in order to keep the lake level as close to the rule curve as possible: If the lake level is too high, release more water; if it is too low, release less water.

Reservoir Release Schedules

The DNR should evaluate each regulated river in the State to determine the desired and minimum required flows just downstream from each impoundment. These flows are determined on the basis of permitted offstream withdrawals and required instream flows. During nondrought conditions, reservoirs should be operated so that releases are sufficient to ensure that desired downstream flows are always met. During droughts, the reservoir's drought contingency plan must be activated, and releases made according to the drought plan and the severity of the drought.

Most reservoirs are obligated, by permit or license, to release a minimum flow volume over some period of time, typically one week. While these releases usually average more than the minimum required downstream flow, the timing of the releases is often highly variable: most of a week's allocation of water can be released in only three or four days (because releases are made with consideration only for hydroelectric power generation), leaving very little water for release during the remaining days of the week. Although the required weekly average release is met, instantaneous flows or average daily flows can be significantly less than the minimum required flow for several days each week. Reservoir operations should be planned to ensure adequate average daily or instantaneous flows, rather than weekly releases.

Another conflict between reservoir operations and downstream flow requirements stems from a reservoir's tendency to smooth out seasonal fluctuations in flows. To reduce a reservoir's potential negative impact on aquatic populations, consideration should be given to releasing water in such a way as to mimic natural seasonal fluctuations, where appropriate.

One of the most important issues in water resources management is balancing reservoir operations with the demands of upstream and downstream uses. Although lake uses are important, consideration must also be given to the many downstream uses as well. Specific release schedules designed to meet downstream requirements must be incorporated into the Federal license, State operating permit, or Corps of Engineers operating plan that specifies release schedules.

The State should use its authority under Section 401 of the Federal Clean Water Act to ensure that any proposed releases will not result in violations of State water quality standards nor in an unacceptable degradation of water quality.

FERC Licenses—With the exception of the reservoirs operated by the U.S. Army Corps of Engineers (COE), all of the major hydropower reservoirs in South Carolina and North Carolina are licensed by FERC, the Federal Energy Regulatory Commission. FERC licenses specify operational plans, including required minimum releases. The best way to guarantee downstream flow protection is to incorporate the appropriate release conditions into the FERC licenses.

FERC licenses are usually issued for long periods of time—typically 30 to 50 years. When licenses are reissued, changes in reservoir operating plans can be made. Relicensing, therefore, offers an excellent opportunity to incorporate strategies for managing not just the reservoir, but the entire river system, into the reservoir operating plans. Although relicensing opportunities are rare, many lakes in South Carolina and North Carolina will be relicensed within the next few years, providing important opportunities to adjust release schedules for the betterment of all the lake and river users. DNR and DHEC need to be involved in the relicensing of these reservoirs so that these rare opportunities for change are not missed.

Over time, significant changes may occur in the lake and downstream river uses, perhaps because of increasing populations or changing climatic conditions. Because of the length of time between relicensing opportunities, it is important that the reservoir operating plans detailed in the FERC licenses allow for some flexibility in reservoir operations, so that resource managers can react to changes in either water availability or demands for the water.

COE Lakes—Because the U.S. Army Corps of Engineers operates the major reservoirs on the Savannah River (Lakes Thurmond, Russell, and Hartwell), these reservoirs do not fall under the jurisdiction of FERC, and are therefore not licensed by FERC. These lakes are operated according to plans developed and implemented by the COE.

Because Georgia and South Carolina share the Savannah River lakes, both states must work together to determine downstream water demands and to incorporate appropriate release schedules into the COE operational plans. The need for this cooperation has been recognized on a political level, with the proposed (but unrealized) *Savannah River Compact*, a formal agreement between Georgia, South Carolina and the Federal government to work together to manage the Savannah River. On a technical level, the *Savannah River Basin Comprehensive Water Resources Study* is an ongoing cooperative project between Georgia, South Carolina, and the Corps of Engineers, with the goal of balancing the many uses and demands for the entire Savannah River with the operation of the Corps' reservoirs.

The Southeastern Power Administration (SEPA), a division of the U. S. Department of Energy, has the responsibility to market electricity generated by the reservoirs operated by the U. S. Army Corps of Engineers in the southeastern part of the country. On average, the three reservoirs on the Savannah River—Hartwell, Russell, and Thurmond—generate more than half of the total power from SEPA's ten multipurpose reservoirs within the Mobile, Savannah, and Wilmington Districts in the Southeast.

Although the U. S. Fish and Wildlife Service (FWS), a division of the Interior Department, does not have direct authority over reservoir operations, this agency develops and enforces legislation to protect and maintain riverine ecosystems, primarily concerning minimum required flows and habitat protection. Federal environmental laws are important in ensuring that aquatic and other ecosystems are protected. Many aquatic systems in South Carolina should be restored so that important functions of those systems can be recovered and benefits can be realized and sustained. Restoring aquatic systems does not necessarily mean returning those systems to predisturbance or predevelopment conditions. State agencies should establish and maintain a strong cooperation with the Fish and Wildlife Service in order to coordinate activities relating to water resources in the State.

Water-Shortage Contingency Plans

Water-shortage contingency plans must be developed by the lake owners for all Federally-operated, FERC-licensed, or State-permitted lakes in the State. These plans should be developed and coordinated with the appropriate Federal and State agencies, local governments, and all other stakeholders, and should include water-shortage severity levels, the water releases associated with each severity level, and a public-information program. The State Drought Response Committee should approve these plans.

During water shortages, reservoir releases (outflows) should be reduced as the volume of water in the lake declines (Figure 16). As long as the water level in a regulated lake is above the first water-shortage severity level, as described in the lake's operating plan, water releases from the lake should equal or exceed the downstream desired flow requirements as defined by DNR.

If the lake level declines to less than the first water-shortage severity level because of low inflow, downstream releases and lake withdrawals should both be reduced, but downstream releases must always meet minimum flow requirements.

If the volume of usable storage in the lake is reduced so much that running out of water becomes a realistic concern—for example, if the volume of usable storage is equivalent to only 100 days of lake withdrawals—downstream releases should be set equal to the inflow into the lake. By setting outflow equal to inflow, the entire volume of water remaining in the lake's usable storage becomes available to lake users.

Evaporation from a lake can be thought of as a type of withdrawal; water is removed from the lake and does not enter the downstream system. Evaporative losses, therefore, must be included in the 100-day withdrawal-volume calculations.

If a drought persists to the extent that the water level nears the bottom of the conservation pool, and the volume of usable storage in the lake is almost exhausted—for example, equivalent to 10 days of lake withdrawals—further reductions in both lake withdrawals and downstream uses should be required. The lake's outflow should be set equal to the lake's inflow minus the newly-reduced lake withdrawals.

Uncertainty in estimates of drought severity and duration, the tolerance for water-use curtailment, and the probability of system failures all need to be considered by lake managers. Drought contingency plans need to be specific to the particular uses and conditions of each lake.

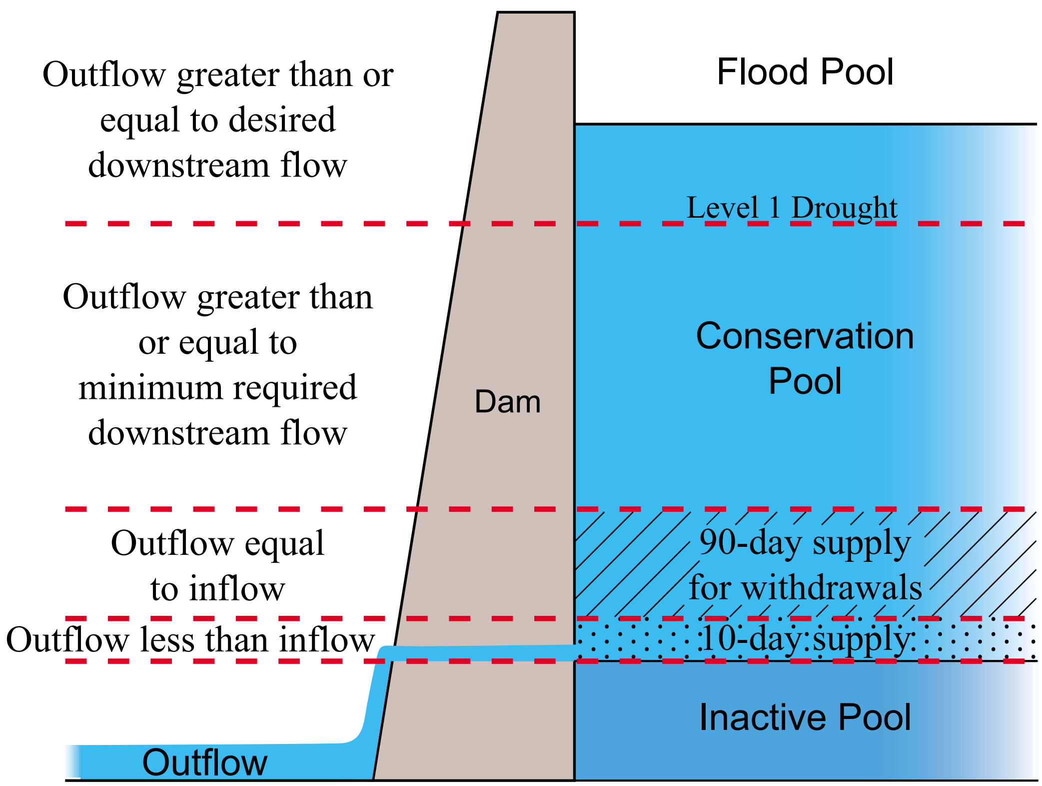


Figure 16. Illustration showing how the recommended reservoir release (outflow) is reduced as lake levels decrease due to drought.

Surface Water Quantity Monitoring Network

Perhaps the most important tool available to help manage the State's surface-water resources is a good monitoring network. Without an accurate knowledge of how much water is on the ground and where it is, no water-resources management program can be successful.

Continuous monitoring of streamflow is necessary to collect enough flow data to develop a statistically meaningful understanding of flow regimes and to determine accurate relationships between precipitation, soil-moisture conditions, and streamflows. These relationships are crucial for modeling and predicting future flows, in normal conditions as well as during droughts or floods.

Water quantity should be monitored in all the larger streams and lakes throughout the State. Streams originating outside South Carolina should be monitored at sites near the point of entry into the State, near midstate (Fall Line), and at sites just upstream of tidal waters. Streams located entirely within the State should be monitored at sites representative of the upper, middle, and lower areas of the Piedmont and Coastal Plain. Streams should also be monitored near sites of significant net withdrawal or discharge. In addition, many gages are installed at other locations for site-specific reasons, such as local hydrologic studies. For example, note the many streamflow gages located near the Savannah River Site (see Figure 17).

The current surface-water quantity-monitoring network consists of streamflow gages, stage-only gages, and crest-stage gages (Figures 17-19). Streamflow gages continuously measure river stage, from which flow volumes are calculated, and stage-only gages continuously record lake levels and river stages without making flow calculations. Crest-stage gages record only a single high-water level resulting from a significant flood event. Many of these gaging stations operate on a near-real-time basis and, as such, play an important role in the State's management of extreme-flow conditions. The gages in this surface-water network are operated and maintained by the USGS, with financial assistance from DNR, DHEC, and other government and private organizations.

Having an adequate number of properly located gages is vital to the effectiveness of this monitoring network, but it is also very important that these gages are continuously operated at the same location for a long period of time. Long-term flow records—preferably in excess of 20 years—are necessary in order to produce statistically meaningful flow histories, as well as to accurately evaluate trends in flow rates. Reduced funding has led to the elimination of several streamflow gages in each of the last few years. It is imperative that this monitoring program receives adequate funding to prevent the loss of any more gages, in particular those having been in service for many years or those installed at important locations.

Figure 17. Current network of USGS streamflow gaging stations in South Carolina.

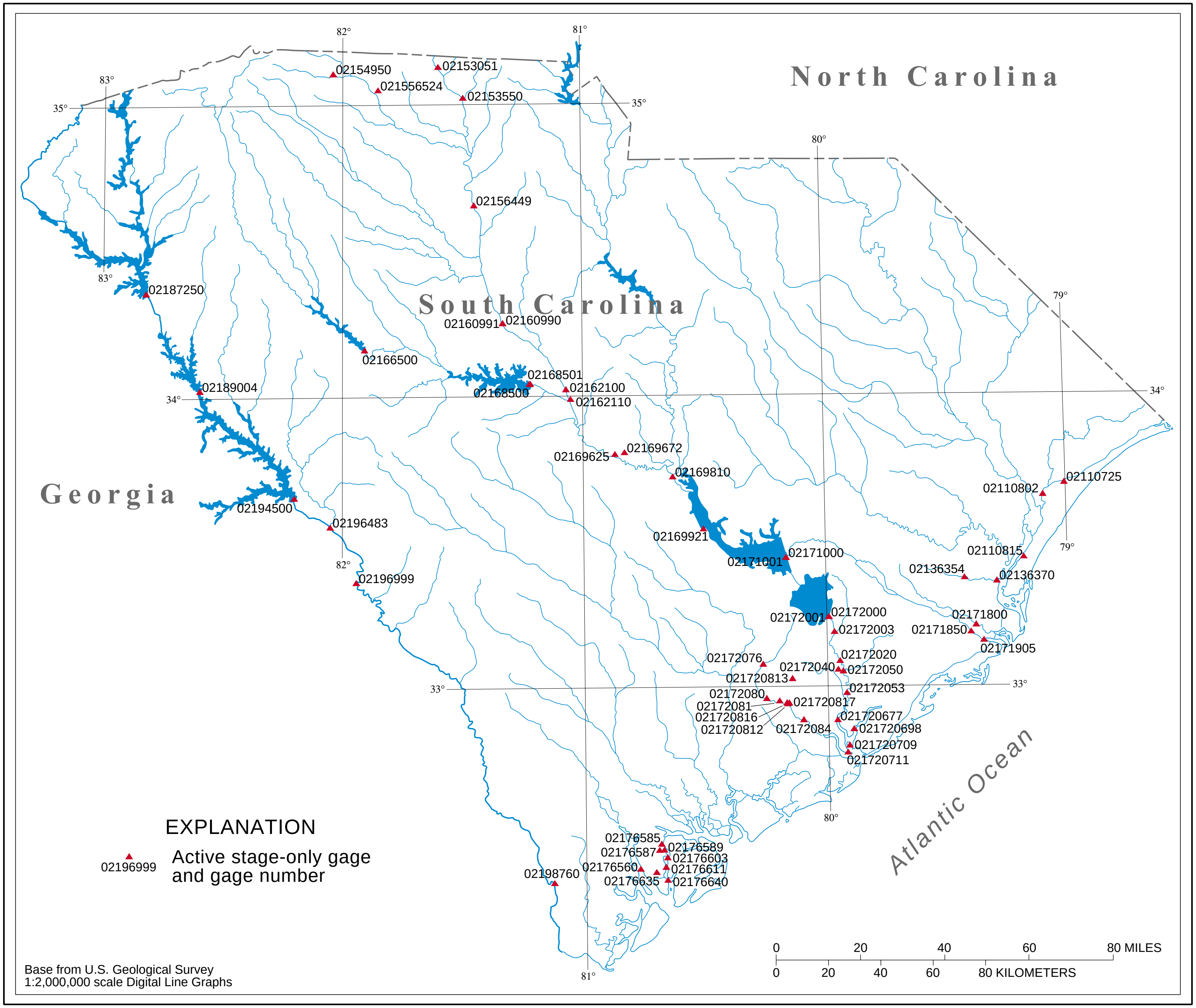


Figure 18. Current network of USGS stage-only gaging stations in South Carolina.

Figure 19. Current network of USGS crest-stage gaging stations in South Carolina.

SURFACE WATER QUALITY

"It is declared to be the public policy of the State to maintain reasonable standards of purity of the air and water resources of the State, consistent with the public health, safety and welfare of its citizens, maximum employment, the industrial development of the State, the propagation and protection of terrestrial and marine flora and fauna, and the protection of physical property and other resources." S.C. POLLUTION CONTROL ACT

From agriculture and manufacturing, to recreation and tourism, clean water is essential to the economy and to the health and welfare of the citizens of South Carolina. Over the years, Congress has promulgated, and Federal and State agencies have implemented, effective water quality management laws, such as the Clean Water Act and the Safe Drinking Water Act. These laws have significantly reduced surface water pollution and improved drinking water quality by regulating point source discharges and by establishing and enforcing strict standards for safe drinking water. As a result, the water in our lakes, streams, and estuaries is now cleaner than it was 30 years ago, and tap water is now safer to drink. These gains should not be lost, and a strong commitment to clean water must continue.

Polluted runoff, also known as nonpoint-source pollution, is now the leading cause of water pollution in the Nation and in the State. Pollutants, such as bacteria and fertilizers from farms and chemicals and oils from cities, wash into our waterways after rainstorms and adversely impact water quality. Sources of this pollution are numerous, widespread, hard to detect, and often unregulated, making them more difficult to manage than point-source discharges. Preventing and reducing polluted runoff is the collective responsibility of all levels of government, agriculture, industry, landowners, and citizens alike and is best achieved at the watershed level by enhancing stewardship, forging partnerships, and increasing public education and participation.

South Carolina Pollution Control Act

South Carolina is fortunate to have an abundance of water. Most of it is clean enough to support desired uses such as fishing and swimming. Urbanization, land development, and the extensive use of fertilizers and pesticides, coupled with increased demands for water to meet population growth and industrial and agricultural needs, place added pressures on the resource, making it increasingly difficult to meet and maintain water quality standards. Protecting, improving, and restoring water quality are goals of the State. Waters that meet State standards must be protected to ensure that quality will not be compromised in the future. Waters that do not meet standards must be restored for the intrinsic benefits that clean waters afford the citizens of the State.

The principal law governing pollution in South Carolina is the S.C. Pollution Control Act (SCPCA). In accordance with the SCPCA, DHEC abates, controls, and prevents pollution of all bodies of surface and ground water, natural or artificial, public or private, inland or coastal, fresh or salt, which are wholly or partially within or bordering South Carolina or within its jurisdiction. DHEC's goal is to maintain and improve all surface waters to a level that provides for the survival and reproduction of a balanced community of plants and animals, recreation in and on the water, and, where appropriate, drinking water after conventional treatment, shellfish harvesting, and industrial and agricultural uses. Other Federal and State agencies have interests and programs involving water quality protection, including the South Carolina Department of Natural Resources, U.S. Army Corps of Engineers, and U.S. Geological Survey, as well as county and city governments.

Federal Clean Water Act

The principal law governing pollution of the Nation's surface waters is the Federal Water Pollution Control Act Amendments of 1972, commonly known as the Federal Clean Water Act (CWA). The CWA provides for a variety of regulatory and nonregulatory programs to reduce direct pollutant discharges into waterways and to manage polluted runoff. Administered by the Environmental Protection Agency (EPA), the goal of the CWA is to restore and maintain the chemical, physical, and biological integrity of the Nation's waters so they can support the protection and propagation of fish, shellfish, and wildlife and recreation in and on the water.

DHEC has been delegated authority by the EPA to implement the Federal Clean Water Act in South Carolina. Under Section 106 of the CWA, in order to receive funding to prevent and reduce water pollution in South Carolina, DHEC must monitor, and compile and analyze data on, surface and ground water quality.

Water Quality Standards

Under the CWA and SCPCA, DHEC is required to classify South Carolina's waters and develop water quality standards. Beneficial uses are designated for each water body, and water quality standards are established that will protect the uses of the water (S.C. Regulation 61-68, *Water Classifications and Standards*; SCDHEC, 2001a). A requirement of the CWA is that State water quality standards be at least as stringent as those established by the EPA. Standards include three major components: (1) designated uses of a water body; (2) water quality criteria necessary to support those uses; and (3) antidegradation rules to maintain good water quality.

"Designated uses" are the desired uses of a water body that, at a minimum, meet the fishable/swimmable standard of the Clean Water Act. Examples of designated uses are aquatic life support, shellfish harvesting, drinking water, primary contact (swimming), and secondary contact (boating). All surface waters in South Carolina are classified on the basis of their designated uses (S.C. Regulation 61-69, *Classified Waters*; SCDHEC, 2002d), which must be approved by the South Carolina General Assembly and the EPA.

Water quality criteria describe the conditions that are necessary to support the designated uses. Numeric water quality criteria are expressed as quantitative units, such as concentration of pollutants, temperature, or pH. Narrative water quality criteria are general statements made to protect a specific designated use or set of uses.

Antidegradation policies are a set of rules that restrict or prohibit activities that could result in the degradation of high-quality waters. Under provisions of the Clean Water Act, conditions of a water body must not be allowed to deteriorate to such a degree that one or more of the designated uses can no longer be supported. Antidegradation policies apply to point-sources and nonpoint-sources of pollution (SCDHEC, 1998b and 1999c).

Water quality standards—designated uses, water quality criteria, and antidegradation policies—are the foundation of an effective water quality management program and are essential for protecting the quality of the State's surface waters. They establish water quality goals for specific water bodies and provide the regulatory basis for implementing treatment strategies to meet these goals. They are used to determine permit limits for treated wastewater discharges and any other activity that may impact water quality. Under provisions of the Clean Water Act, water quality standards are reviewed and revised every three years.

Areawide Water Quality Management Planning

The South Carolina Department of Health and Environmental Control was designated by Governor Edwards in 1976 as the State Planning Agency for water quality and, as such, is responsible for Areawide Water Quality Management Planning in South Carolina pursuant to Section 208 of the CWA. Six Councils of Government (COG) have been designated by the Governor to provide specific areawide water-quality management-planning functions in areas of the State within their jurisdictions. These COGs are Appalachian, Central Midlands, Waccamaw Regional, Lowcountry, Berkeley-Charleston-Dorchester, and Santee-Lynches Regional. DHEC provides specific areawide water-quality management-planning functions for those counties not serviced by the named COGs.

The 208 Water Quality Management Plan prepared by DHEC is updated on an as-needed basis. The process for updating or amending the plan is described in it. As the State water quality planning agency, DHEC reviews and, where applicable, certifies, approves, and submits Water Quality Management Plans and updates prepared by other areawide planning agencies to EPA for approval.

Intergovernmental and Interagency Cooperation

Enabling intergovernmental and interagency cooperation is important for several reasons. It allows for the sharing of information and expertise, helps to prevent the duplication of effort, and ensures consistency between State and Federal programs. In the case of nonpoint-source pollution that does not remain within political boundaries, intergovernmental cooperation is essential. Interagency cooperation must also occur in order to streamline regulatory activities. Achieving consistency with Federal programs involves cooperation with the U.S. Fish and Wildlife Service, Department of Defense, Federal Highway Administration, U.S. Geological Survey, and the National Resource Conservation Service, among others. Councils of Government, designated management agencies, the DNR, and the S.C. Forestry Commission are key local and State partners in water quality management.

Pollution Control Programs

DHEC is authorized to implement and enforce key pollution control programs created by the Federal Clean Water Act. Five of the most important of these programs are described below:

Section 303(d) (Total Maximum Daily Load)—Section 303(d) requires that every 2 years the State inventories waters and identifies those that do not meet water quality standards. For these impaired water bodies, a Total Maximum Daily Load (TMDL) must be developed for the pollutant(s) causing the water quality violation. States are required to identify high priority waters targeted for TMDL development over the next 2 years. TMDLs includes both nonpoint sources and point sources of pollutants in the calculations used to determine how much of the pollutant can be assimilated by the receiving body of water. The TMDL must also include a margin of safety. TMDLs are developed by DHEC's Bureau of Water, approved by EPA and then implemented by reissuing or modifying permits, and through voluntary pollution reduction measures.

Section 402 (National Pollutant Discharge Elimination System)—Section 402 of the Clean Water Act creates the National Pollutant Discharge Elimination System (NPDES). All facilities that discharge pollutants from any point source to waters of the United States must obtain a permit through the NPDES. These permits state the limits placed on discharges, as well as monitoring and reporting requirements. Any permit limit must be stringent enough to ensure that the discharge will not cause a violation of the water quality standards. NPDES permits are issued for a period of up to 5 years.

DHEC will not issue an NPDES or wastewater construction permit unless it has been certified by the applicable areawide water quality management agency that the permit will be consistent with the applicable plan. South Carolina has six separate areawide wastewater treatment plans as described in the 208 Water Quality Management Plan produced by DHEC. This document describes how agencies are authorized to administer wastewater issues. It also provides an inventory of the publicly owned wastewater treatment works in the area of the State where DHEC provides specific areawide water quality management functions.

Residual waste is the solid material, or sludge, remaining after wastewater treatment. Disposal and use of sludge is regulated by DHEC's Bureau of Water as part of the NPDES or land application permitting process.

Section 319 (Nonpoint Source Pollution Program)—Section 319 of the Clean Water Act requires the State to produce a nonpoint-source pollution (NPS) assessment report and to develop a Statewide NPS pollution management program.

NPS is the leading cause of water pollution in the nation and in the South Carolina. The State's NPS Assessment Report describes existing and potential NPS problems for more than 300 water bodies in the State. To address this growing problem, the S.C. NPS Management Program was developed by DHEC, approved by the EPA in 1990, and was updated in 1999. The NPS Management Program provides a framework for managing NPS pollution and for restoring water bodies impacted by it. It relies on regulatory and nonregulatory programs and on the implementation of Best Management Practices (BMP).

Water pollution caused by atmospheric (wind-borne) deposition is a growing problem in the Nation. The National Air Deposition Program monitors mercury, nitrogen compounds, phosphate, sulfur oxides, and acid rain at more than 200 stations Nationwide, 5 of which are located in South Carolina. Mercury is a naturally occurring element that is commonly found in coal. When coal is burned at power plants, mercury is emitted with the smoke and is directly deposited in water bodies or washed into streams or lakes by runoff. Microorganisms convert elemental mercury to methylmercury, a highly toxic form that accumulates in fish tissue. Samples collected from blackwater streams in the Santee basin by the USGS indicate the greatest ratio of methylmercury to total mercury in the Nation (Hughes and others, 2000). This suggests that conditions in the Santee basin are conducive to converting a relatively small amount of elemental mercury into high concentrations of methylmercury. Additional studies should be made to address the high levels of methylmercury concentrations found in fish-tissue samples in the State.

Section 401 (Water quality certification)—Section 401(a) of the Clean Water Act requires that an applicant must receive approval from the State certifying that the proposed activity will not violate water quality standards before it can receive a Federal license.

This section provides protection around and downstream from Federally permitted projects, such as hydroelectric generation. Applications for wetland alterations can be denied under provisions of this section. Certification issued by the State is contingent upon meeting water quality standards. S.C. Regulation 61-101 (*Water Quality Certification*; SCDHEC, 1995) establishes procedures and policies for implementing certification.

Section 404 (Placement of dredged materials into waters)—Under Section 404 of the Clean Water Act, a Federal permit is required to discharge dredged or fill material into waters of the United States, including wetlands. This program is administered jointly by EPA and the U.S. Army Corps of Engineers, but the Federal permit cannot be issued if the State (DHEC) denies 401 water quality certification.

Activities that are regulated under this program include fills for development, water resource projects (such as dams and levees), infrastructure development (such as highways and airports), and conversion of wetlands to uplands for farming and forestry. No discharge of dredged or fill material is permitted if a practical alternative exists that is less damaging to the environment or if the State's waters would be significantly degraded.

Wetlands contribute to the health and safety of the public by controlling floods and by intercepting and storing polluted stormwater runoff before it reaches other waterways. They also serve as important habitats for plants and animals. Small, isolated freshwater wetlands in the State continue to be lost to development by being either filled or ditched. At the present time, the State has no authority to prevent this from occurring. The State must remain committed to the protection and restoration of its wetlands and to the concept of no-net-loss of wetlands.

Watershed-based Water Quality Management

A watershed-protection approach focuses all water-quality management activities—such as monitoring, assessment, NPDES permitting, and TMDL restoration studies—in a single watershed. Such an approach recognizes that water pollution in a watershed is a function of land-use activities that are occurring in the watershed.

In 1991, DHEC implemented the State's Watershed Water Quality Management Strategy to increase the efficiency and effectiveness of programs that protect and improve the quality of South Carolina's surface and ground water resources. The strategy recognizes the interdependence of water quality and all the activities that occur in the associated watershed. Water quality monitoring, assessment, modeling, planning, permitting, and other DHEC initiatives are coordinated within the framework of a watershed management approach. Such an approach fosters stewardship and volunteerism by allowing stakeholders to participate in decisions and actions that will protect and restore the watershed in which they work and live.

Watershed Water Quality Assessment reports are prepared for all of the major river basins on a 5-year rotating basis. These comprehensive reports include information about a watershed's water chemistry, biological monitoring, physical characteristics, natural resources, growth potential, potential nonpoint-source contributions, ground water concerns, and point-source discharges.

Water Quality Planning

Section 303(e) of the CWA requires that each state establish and maintain a continuing planning process (CPP) consistent with the Act. The CPP explains South Carolina's approach to implementing Federal and State laws and regulations on water quality. It describes processes for developing and updating water quality management programs and their implementation and public participation requirements. DHEC is responsible for routinely updating South Carolina's CPP.

Programs of the U.S. Geological Survey

As the primary Federal science agency for water-resources information, the U.S. Geological Survey (USGS) monitors the quantity and quality of water in the Nation's rivers and aquifers. The Cooperative Water Program has been a successful cost-sharing partnership between the USGS and water-resources agencies at the State and local levels. Most work in the Cooperative Water Program is directed toward potential and emerging long-term problems, such as water supply, waste disposal, ground-water quality, effect of agricultural chemicals, floods, droughts, and environmental protection.

The National Water Quality Assessment Program (NAWQA) is a USGS program that collects and assesses information on water chemistry, hydrology, land use, stream habitat, and aquatic life from more than 50 major river basins and aquifers across the Nation. This information supports the development and evaluation of management, regulatory, and monitoring decisions by other Federal, State, and local agencies, and assesses water quality conditions Nationwide.

The USGS Toxic Substances Hydrology Program was initiated in 1982, with the goal of providing scientific information on the behavior of toxic substances in the Nation's hydrologic environments. Investigations occur over a wide range of scales; from point sources such as leaks or discharges from industrial facilities, to multiple, closely-spaced releases such as domestic septic systems, to relatively uniform releases that occur over broad areas such as agricultural and residential land uses.

Drinking Water

The Federal Safe Drinking Water Act (SDWA) of 1974 authorizes the EPA to set National health-based standards for drinking water to control the levels of naturally occurring and manmade contaminants in the Nation's drinking-water supply. These standards are a key component of the EPA's comprehensive approach to drinking water protection, which includes assessing and protecting drinking-water sources, protecting wells and collection systems, making sure water is treated by qualified operators, ensuring the integrity of distribution systems, and making information available to the general public about the quality of their drinking water. Under provisions of the Federal Safe Drinking Water Act, EPA authorized DHEC to implement and enforce programs of the SDWA to ensure that the public water systems in the State provide safe drinking water.

Amendments to the SDWA in 1996 place a priority on prevention activities as an approach to improving drinking water supplies. The amendments require the State to provide Source Water Assessments for each Federally defined public water supply system. These assessments include the *Source Water Protection Area (SWPA)*—a description of the drinking-water source and the land area that contributes water to that source; a *Potential Contaminant Source Inventor*y—a listing of the land uses and activities within the SWPA that could potentially release contaminants to the source water; and a *Susceptibility Analysis*—an evaluation of the contaminant inventory to determine the likelihood that a potential contaminant source will affect a nearby drinking-water source. These assessments should be used by public water systems to determine what preventive actions are needed to protect drinking-water sources from contamination.

The "Capacity Development" initiative requires states to develop and implement (1) a strategy to ensure that all public water systems have the technical, managerial, and financial capability to reliably deliver safe water to the public and (2) a plan to identify and assist those water systems that need improvements. South Carolina had already initiated such an effort in 1993 and received early approval from the EPA. Components of the program include construction-permitting requirements for new water systems or for modifications or expansions of existing systems; sanitary surveys that evaluate a system's technical, managerial, and financial capacity to comply with the State Safe Drinking Water Act; and an operating permit program requiring systems that fail sanitary surveys to prepare and submit a business plan to DHEC. To strengthen drinking-water safety, DHEC has the legal authority to deny business plans or construction permits to any public water system that is unable to demonstrate the capacity to comply with State drinking water standards.

States are required to submit an annual report on public water system violations to EPA. These reports must address violations of drinking water standards with respect to maximum contaminant levels, treatment techniques, monitoring requirements, and variances and exemptions. As of 1999, all community water systems are required to prepare and distribute an annual "Consumer Confidence Report" documenting the quality of water delivered by the system. The report includes information about the type of contaminants that were detected and the health risks associated with those contaminants. Public water systems must also notify their customers when they violate EPA or State drinking water standards. Any violation of a standard "that has the potential to have serious adverse effects on human health as a result of short-term exposure" must be reported within 24 hours.

Surface Water Quality Monitoring Networks

The Clean Water Act of 1972 gives states the primary responsibility for implementing programs to protect and restore water quality, including monitoring. Under the provisions of both the South Carolina Pollution Control Act and the Clean Water Act, DHEC is the State agency delegated responsibility for monitoring the quality of water in the State's streams, lakes, and estuaries. Monitoring is done in order to determine water quality status and trends, identify emerging water-quality problems, identify water bodies that are not supporting designated uses, determine if remediation and management programs are effective, issue permits for effluent discharge and determine if dischargers are in compliance with pollution regulations, and evaluate the impacts of environmental emergencies such as spills.

The primary monitoring network in the State is the Ambient Surface Water Quality Monitoring Network (DHEC, 2003b). This network, operated by DHEC, is used to assess the overall physical, chemical, and biological integrity of the State's streams, lakes, and estuaries. The core of this statewide network consists of Integrator Sites, which are 314 permanent, fixed-location monitoring sites that are sampled monthly (Figure 20). Sites are targeted for the farthest downstream access of each of the Natural Resource Conservation Service 11-digit watershed units, as well as the major lakes, reservoirs, and estuarine areas in each watershed unit.

Special Purpose Sites of the ambient network are also permanent, fixed-location sites, but they do not meet the location criteria of the Integrator Sites (Figure 20). These sites represent locations that are of special interest to the State, such as areas used to track the progress of specific remediation activities, or

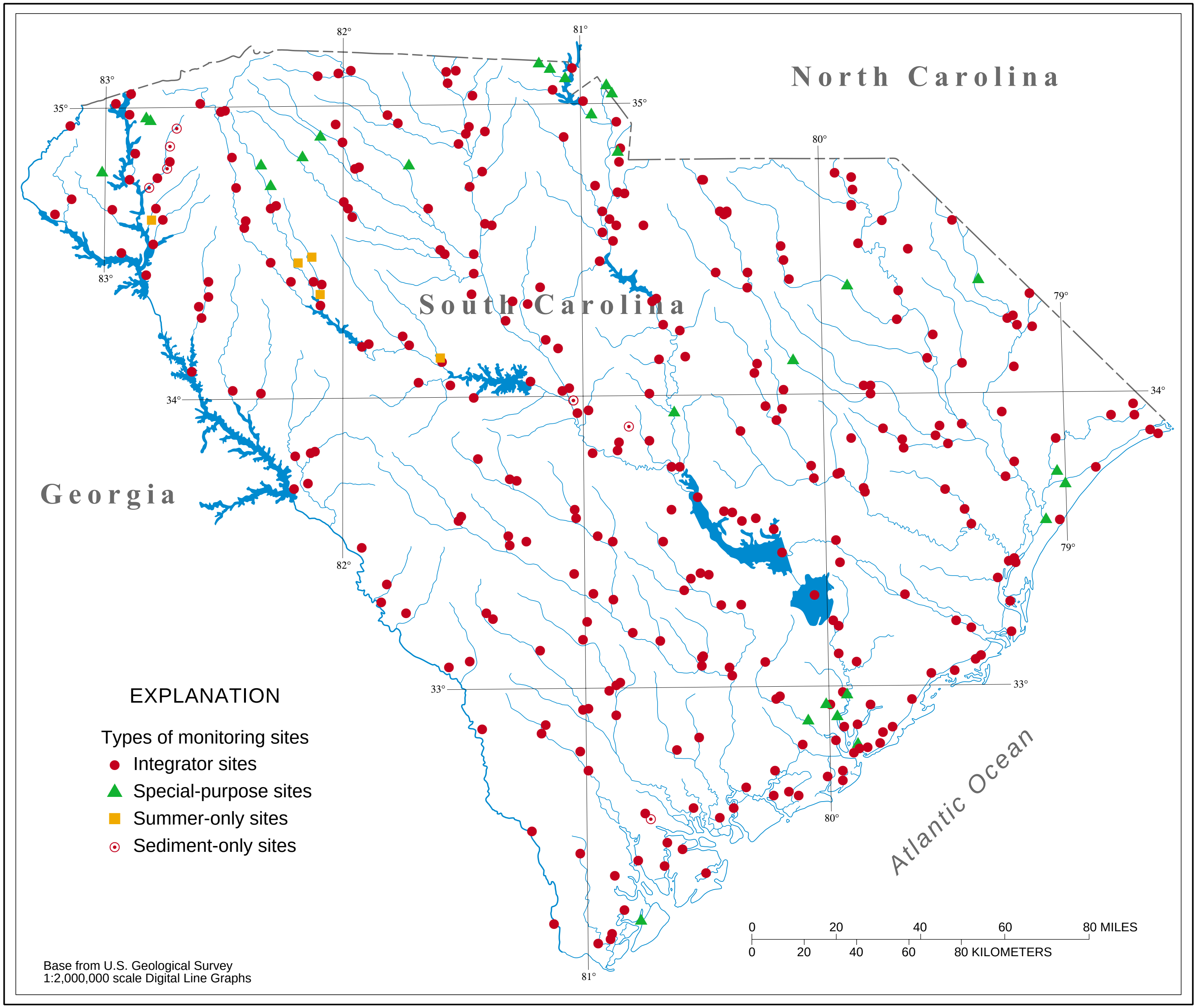


Figure 20. DHEC's Ambient Surface Water Quality Monitoring Network (modified from SCDHEC, 2003b).

where additional data are needed in large watersheds. Currently, there are 28 Special Purpose Sites, sampled monthly. In addition, there are 5 Summer-Only Sites that are sampled monthly from May through October to measure specific reservoir eutrophication conditions.

Watershed Water Quality Management Sites constitute a monitoring network that supplements the Integrator and Special Purpose stations on a 5-year rotating schedule (Figure 21). Each major watershed is sampled once every 5 years to provide additional information for various programs and to assess results of remediation activities. There are 80 to 100 monitoring sites within a given watershed, sampled monthly for a year.

A statewide random sampling of streams, lakes, and estuaries is done each year as part of the Ambient Surface Water Quality program. These samples are collected in order to make statistically valid statements about the water quality of large areas on the basis of a relatively small subset of sampling points. Each year, approximately 30 randomly selected sites are sampled in streams, and about 30 sites are sampled in lakes or reservoirs. Each of these sites is sampled monthly for 1 year.

The South Carolina Estuarine and Coastal Assessment Program was developed by DHEC, DNR, and the Marine Resources Research Institute (MRRI) to assess water quality of coastal estuaries. Water samples at 30 Core Sites in tidal creeks and open-water environments are sampled monthly by DHEC as part of the Ambient Surface Water Quality Monitoring Network. Sediment samples at the Core Sites are collected annually by DNR and MRRI for sediment chemistry and toxicity analyses. Sediment and water samples are also collected from 30 Supplemental Sites on a yearly basis.

Pollutants that are discharged at low concentrations or during storm runoff events may be undetectable or absent during normal sampling intervals. These pollutants bind to organic matter in the water column and settle to the bottom where they become part of the sediments composing the streambed. Sediment samples are collected at each randomly selected site, as described above, and at 87 permanent, fixed-location sites and analyzed for the presence of pollutants.

In the course of a complete 5-year Watershed cycle, data are collected at more than 1,250 monitoring locations across the State through the Ambient Surface Water Quality Monitoring Network.

The Ocean Water Monitoring Program is administered by DHEC and is designed to protect the health of beachgoers. Water samples are collected from 112 sites along the coast on a monthly basis from April through October and on a biweekly basis from May through September. Samples are also collected after rain, sewage spills, or excessively high tides. Swimming advisories are issued if samples are found to contain elevated counts of bacteria.

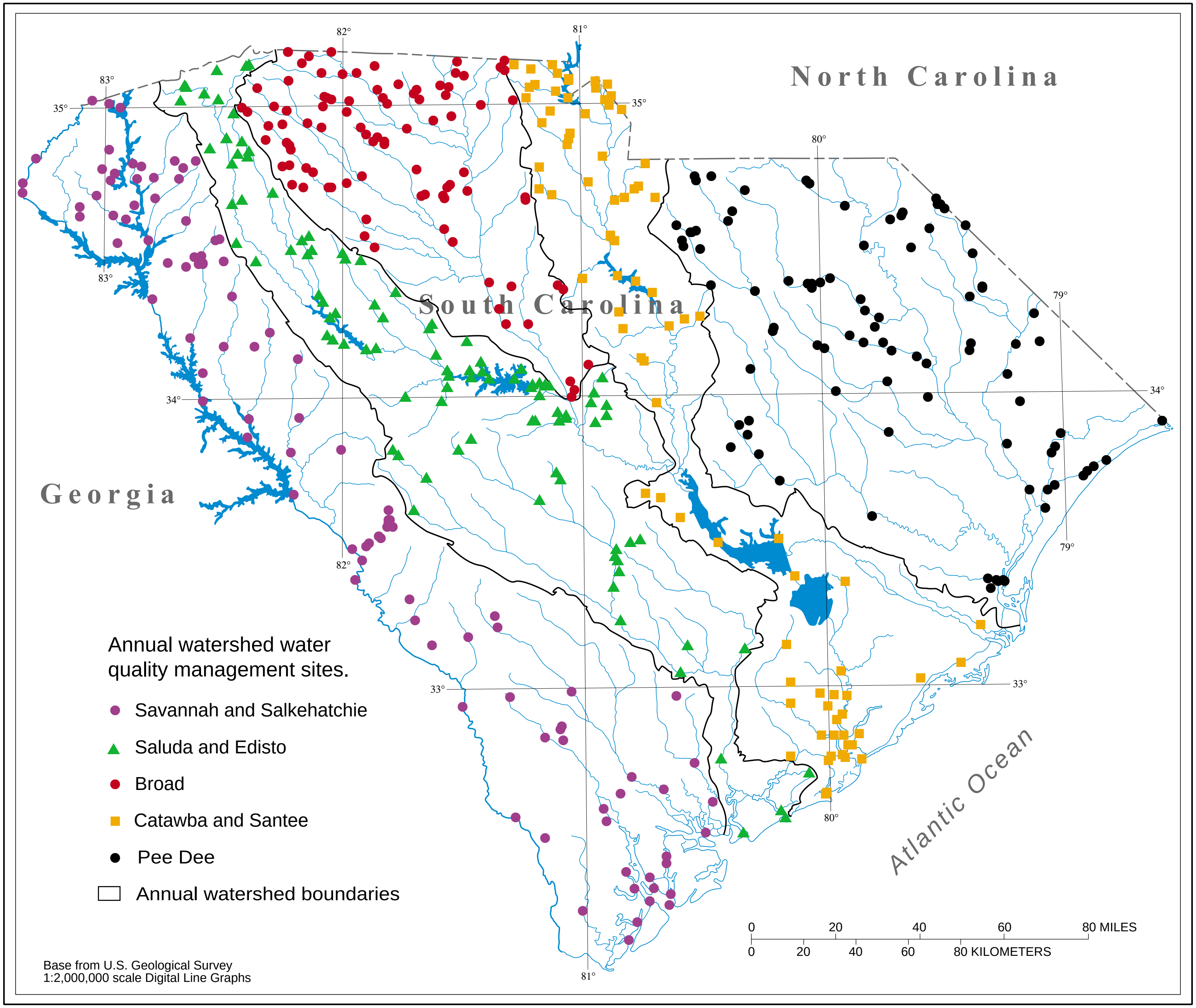


Figure 21. DHEC's Watershed Water Quality Monitoring Network (modified from SCDHEC, 2003b).

The U.S. Geological Survey maintains a network of water quality stations near several of their stream gages (Figure 22). Continuous-record stations at fixed locations monitor water quality on a regularly scheduled basis, where the frequency of sampling can be one or more times daily, weekly, monthly, or quarterly. Partial-record stations are maintained at fixed locations for a period of years but record limited water-quality data at a sampling interval that is usually less than quarterly. Other stations collect random samples from locations other than the continuous- and partial-record sites. Properties and constituents measured at these stations generally include water temperature, specific conductance, dissolved oxygen, pH, and turbidity.

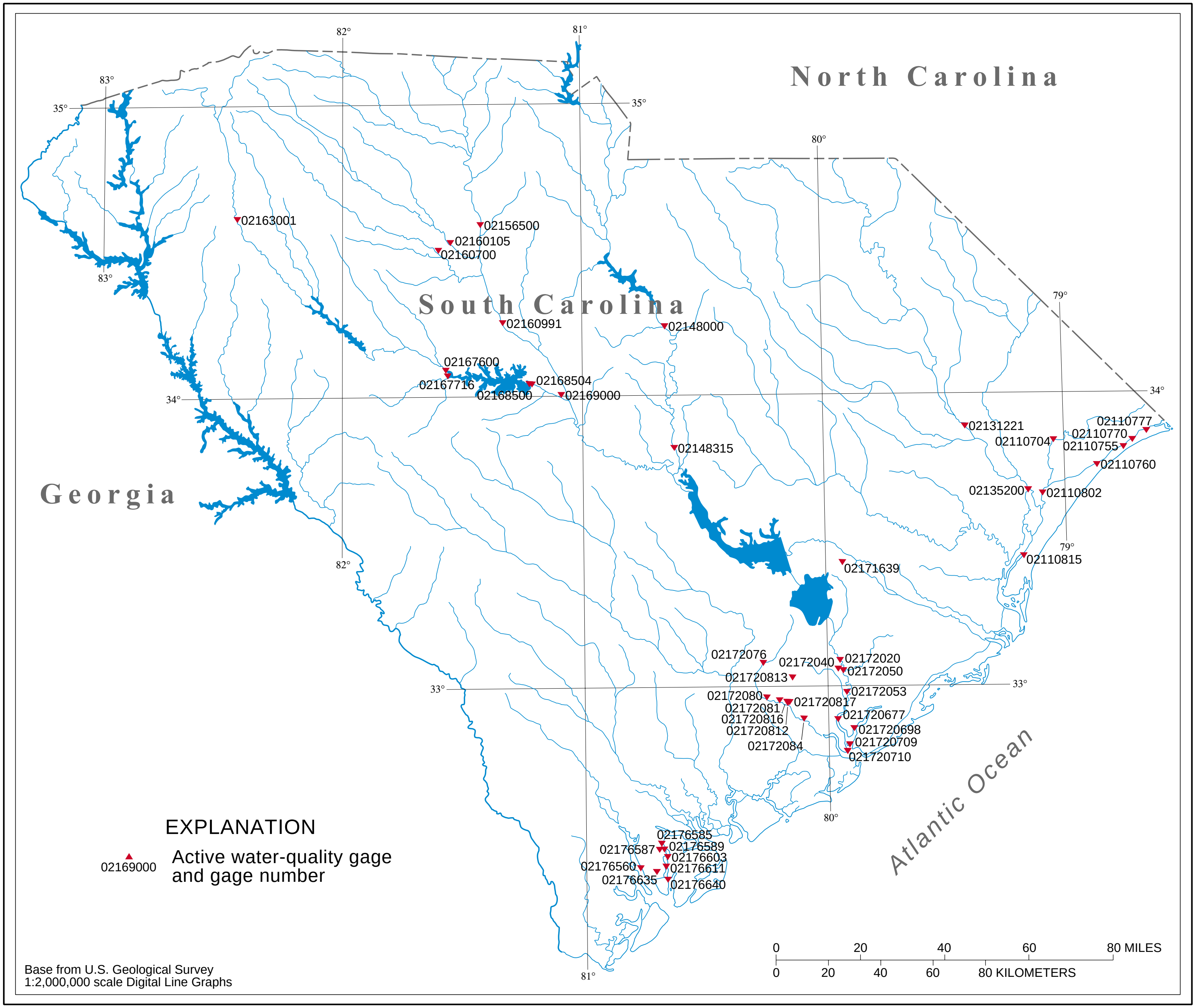


Figure 22. Current network of USGS surface water quality stations in South Carolina.

GROUND WATER QUANTITY

Ground water is a significant source of drinking water in the State, supplying about 40 percent of the population, including virtually all of the rural population. It is also an important source of water for manufacturing, irrigation, and power generation and is vital for maintaining aquatic ecosystems by recharging streams, lakes, and wetlands and for sustaining surface water supplies during droughts. It is estimated that about 60 percent of the water in South Carolina's streams originates as ground water (Winter and others, 1998).

Aquifers of South Carolina

Ground water occurs everywhere in the State but is most abundant in the Coastal Plain province. The Coastal Plain contains a wedge of unconsolidated sand, clay, and limestone that thickens from zero at the Fall Line to about 3,800 feet near Hilton Head Island. The sand and limestone beds are permeable and constitute the aquifers of the Coastal Plain; clay layers are relatively impermeable and constitute the confining units. Wells in the Coastal Plain aquifers can produce as much as 3,000 gpm (gallons per minute).

Aquifers that are bounded above and below by clay or rock, and which contain water under pressure, are called "confined aquifers." Wells constructed in such aquifers are termed "artesian wells" because the water level in the wells rises above the top of the aquifer. The wells may or may not flow at the land surface; wells that do flow are referred to as "flowing artesian wells." Some confined aquifers of the Coastal Plain can be mapped for tens, and even hundreds, of square miles.

Aquifers that lack confinement are called "unconfined" or "water-table aquifers," and wells tapping such aquifers are referred to as "water-table wells." Water in unconfined aquifers is under only atmospheric pressure and stands at the top of the saturated zone, or "water table." Water-table aquifers occur throughout the Coastal Plain, but they locally discharge to streams and other surface-water bodies, thereby limiting their lateral continuity and size. Where the water table coincides with the land surface, a swamp results.

The Piedmont and Blue Ridge provinces consist of hard, metamorphic and igneous rock overlain by a layer of sand and clay called saprolite. Saprolite is the weathered by-product of Piedmont rocks and serves as a storage reservoir for ground water. Although relatively impermeable, compared to Coastal Plain deposits, saprolite slowly transmits water downward wherever the hard rock is fractured.

Water in the saprolite is generally under atmospheric pressure; as such, wells constructed in saprolite are similar to water-table wells of the Coastal Plain. For the purposes of this discussion, both the unconfined aquifers of the Coastal Plain and the saprolitic layer of the Piedmont and Blue Ridge are considered to be the water-table aquifers of the State.

Water that occurs in fractured bedrock can either be under atmospheric pressure or artesian pressure. Unlike confined aquifers of the Coastal Plain, however, fracture zones are typically connected only over short distances. As such, there is little hydraulic continuity to the aquifers of the Piedmont province. Wells constructed in the fractured bedrock are referred to as rock wells, and the aquifers they tap are collectively called “bedrock aquifers.” Wells in bedrock aquifers typically yield only between 5 and 15 gpm.

Groundwater Use and Reporting Act

The principal law governing the management of ground water quantity in the State is the Groundwater Use and Reporting Act, which states that “the general welfare and public interest require that the groundwater resources of the State be put to beneficial use to the fullest extent to which they are capable, subject to reasonable regulation, in order to conserve and protect these resources, prevent waste, and to provide and maintain conditions which are conducive to the development and use of water resources.”

The act also establishes conditions for the designation of Capacity Use Areas: “In the State where excessive groundwater withdrawal presents potential adverse effects to the natural resources or poses a threat to public health, safety, or economic welfare or where conditions pose a significant threat to the long-term integrity of a groundwater source, including salt water intrusion, the board, after notice and public hearing, in accordance with the Administrative Procedures Act, shall designate a capacity use area.”

In Capacity Use Areas, permits are required for large-scale (3 million gallons or more in any month) ground water withdrawals. Each permit must comply with the construction, operation, and special conditions as set forth in the regulations. DHEC has the authority to modify, revoke, or deny permits and can set limits on pumping rates and on the number of wells withdrawing from an aquifer.

Ground Water Programs

The occurrence and movement of ground water are not completely understood. Water wells offer the primary means of studying ground water. Tens of thousands of wells have been drilled in the State, and they have provided much information on the resource, but much more is needed in the form of geophysical logs, surface geophysics, water-level data, hydraulics tests, cores, and water-quality analyses.

The USGS, DNR, and DHEC all play key roles in the collection, management, and analysis of ground water data. Advancing our understanding of this resource must continue with routine data collection, county and statewide ground water investigations, and with programs like DNR’s surface geophysics and borehole geophysical logging programs. New test holes, core holes, and well clusters should be drilled in areas that are deficient in subsurface data. State colleges and universities should play a larger role in addressing State ground water issues.

A key to understanding the ground water resources is having accurate information about the location, thickness, and continuity of aquifers and confining units. The DNR, in cooperation with the USGS and DHEC, should reevaluate the State's existing hydrogeologic framework and revise it where necessary. Aquifers and confining units should be delineated, mapped, and characterized with respect to their hydraulic properties. Recharge areas should also be delineated and mapped. New water wells and test holes should be added on an ongoing basis to continually improve the accuracy of the framework.

Geophysical logs are an important source of subsurface data and are used for delineating aquifer boundaries, assessing water salinity, and determining well-screen locations to optimize ground water development. Efforts should be coordinated between DHEC and DNR to ensure that geophysical logs are obtained from all new public-supply wells.

Ground water flow models are important management tools for allocating and optimizing ground water withdrawals, for evaluating conjunctive use strategies and interactions between ground water and surface water, for predicting the effect of future pumping scenarios, and for determining optimal well spacings. The USGS, DNR, and DHEC should develop a comprehensive ground water flow model of the Coastal Plain. The model should incorporate the best scientific data available and should be revised periodically as new data or modeling techniques warrant.

Accurate water use data are important when developing a ground water management plan and for evaluating water use trends. Historically, only large ground water users in Capacity Use Areas were required to report their water use. The Groundwater Use and Reporting Act was amended in 2000 to require anyone in the State who withdraws 3 million gallons or more in any single month to register and annually report their water use to DHEC. This applies to ground water users in Capacity Use Areas and those outside Capacity Use Areas. This program should be strictly enforced to ensure compliance with metering requirements and reporting requirements. Unscheduled field checks should be made to ensure compliance.

Because the State does not have the financial resources to drill the number of deep wells that are needed to implement and maintain the potentiometric mapping program and other ground water investigations, existing municipal, irrigation, industrial, and other deep wells are used in these programs. These non-State-owned wells are sometimes abandoned by their owners when the wells are no longer needed or used, resulting in the permanent loss of the wells and of any future information they might provide. To prevent such losses, the DNR and USGS should be given 60 days advance notice of any well that is being considered for abandonment. If deemed important to the State's ground water monitoring programs, a variance should be granted to keep wells from being permanently plugged. In all other cases, wells should be abandoned in accordance with the law as described in the *State Primary Drinking Water Regulation* (S.C. Regulation 61-58; SCDHEC, 2003c) and in the *Well Standards* (S.C. Regulation 61-71; SCDHEC, 2002e).

Managing Ground Water Withdrawals

Although ground water is a renewable resource, pumping water from wells at rates that exceed natural replenishment will deplete the resource and cause ground water levels to decline. Consequences of overpumping include reductions in well yield, increased pumping costs, reduced flow rates in streams, altered ground water flow patterns, water-level declines in lakes and wetlands, land subsidence, sinkholes, and saltwater intrusion.

"Cones of depression" develop where aquifers are stressed by pumping. When water is pumped from a well, it is replaced with water from the aquifer. As pumping continues, water levels in the aquifer continue to decline and take on the shape of an inverted cone, the apex of which is centered at the well. Water levels are at their deepest near the well and gradually become shallower away from the well. Deep and areally extensive cones of depression often develop where excessive, long-term pumping occurs.

Identifying and mapping the extent of these cones is critical for evaluating ground water conditions. Potentiometric maps are used to detect changes in aquifer storage by evaluating the expansion or contraction of cones, and to assess the effectiveness of ground water management practices. Potentiometric maps of each major aquifer in the State should be constructed at least every 5 years to identify those areas where overpumping is occurring and to determine how conditions are changing with time.

Overpumping has caused significant regional water-level declines in nearly half (13) of the counties in the Coastal Plain. Declines have been documented in Beaufort, Berkeley, Charleston, Colleton, Darlington, Dorchester, Florence, Georgetown, Horry, Jasper, Marion, Sumter, and Williamsburg Counties. Cones of depression can impact large areas, affect hundreds of well owners, and can take decades to recover. For example, separate cones of depression in Georgetown and eastern Williamsburg Counties have coalesced to form a large cone that covers an area of about 700 square miles; water levels in that area have declined more than 200 feet from predevelopment levels (Hockensmith, 2003).

Although cones of depression are reversible—reduced pumping will result in a return to higher water levels—significant overpumping of an aquifer can also cause permanent damage to the aquifer or the overlying land. The water level in a confined aquifer can decline to a point at which the increased stress on the aquifer system causes a rearrangement of the grains that form the aquifer skeleton, resulting in an irreversible reduction in the aquifer's water-storing capacity. Excessive pumping can also lead to the dewatering of clay layers within the aquifer system, which can cause land subsidence. This is of particular concern in South Carolina because of the large number of clay beds in the Coastal Plain aquifer systems. A study should be made by DNR and the South Carolina Geodetic Survey to determine if, and to what extent, subsidence has occurred in the Coastal Plain.

In addition to a gradual and regional subsidence of land surface, overpumping in areas of the State that are underlain by limestone aquifers can also cause a sudden and localized collapse of land surface, resulting in sinkholes. Sinkholes have been documented throughout much of the lower Coastal Plain, particularly in Orangeburg and Berkeley Counties (Spigner, 1978; Hockensmith, 1989). A study should be made to identify existing sinkholes and areas susceptible to sinkhole development.

To protect aquifer systems from permanent damage due to overpumping and to ensure the long-term usefulness of the ground water resources, ground water withdrawals exceeding 3 million gallons per month should be regulated throughout the Coastal Plain. Currently, only the coastal counties and a small portion of southern Marion County are regulated as Capacity Use Areas. The Capacity Use Area should be expanded to include all Coastal Plain counties.

One of the challenges of ground water management is determining when withdrawals should be restricted. The 1998 Water Plan (Cherry and Badr, 1998) called for a water-level trigger mechanism for each aquifer in the State; when the water level in an aquifer drops below the trigger level, restrictions would be activated. In the 1998 Water Plan, water-level declines of 150 feet for the Black Creek and Middendorf aquifers and 75 feet for the Floridan aquifer were the trigger levels. The large areal extent of these aquifers and their wide range of hydrologic and physical properties may limit the application of such generalized triggers. Withdrawal-restriction criteria that are effective for an aquifer in one location may be inappropriate for that same aquifer in another location. Further studies are needed to refine this water-level index and establish additional indices for initiating withdrawal restrictions; until that is done, water levels should be maintained at least above the 1998 trigger levels. Resource managers should also consider policies—such as mandatory well spacing, or the reservation of certain aquifers for a given use or uses—to minimize the need for restricted withdrawals.

Ground water withdrawals should be managed to address the following goals:

1. Withdrawals should be managed so as to minimize their impacts on other users of the aquifer. Large-capacity wells, for example, should be placed suitably far from existing wells, and they should not be screened or gravel-packed in aquifers used primarily for domestic supply.

2. Withdrawals during droughts should be managed to protect drinking-water supplies.

3. Withdrawals should be managed to prevent land subsidence and sinkholes.

4. Withdrawals from water-table aquifers should be managed to minimize their impact on wetlands, surface water, and confined aquifers.

5. Withdrawals should not cause saltwater intrusion.

6. Withdrawals should not cause a degradation of an aquifer's water quality, which can occur when pumping-related changes in water pressure between two aquifers causes water from an adjacent aquifer with lower-quality water to move into the pumping aquifer.

An effective ground water management plan that involves the regulation of withdrawals should incorporate elements of adaptive management. Programs that restrict withdrawals should be monitored, evaluated, and adjusted as needed. This approach allows for the continual improvement of practices by learning from the outcome of operational programs.

Ground Water Quantity Monitoring Networks

Ground-water levels should be monitored throughout the State to determine the effects that withdrawals and droughts have on the State's ground-water resources. Water-level data indicate seasonal and long-term changes in ground water storage and can be evaluated to determine the general conditions of the State's ground-water resources.

Seven confined aquifers can be delineated and mapped across the Coastal Plain. In each county, water levels in a minimum of two wells per aquifer should be monitored with automatic data loggers. In those counties where water-level declines have been documented, or where a single aquifer is heavily utilized, a minimum of three wells should be monitored per aquifer. Monitor wells should have screens set adjacent only to the aquifer that is being monitored; wells with screens set adjacent to two or more aquifers should not be included in the monitoring network. Figure 23 shows the current ground-water monitoring network for the confined aquifers of the Coastal Plain, and Table 4 lists the number of additional wells required to complete the network.

In addition to the confined aquifers of the Coastal Plain, water levels in at least one well per county should be monitored in the bedrock aquifers of the Piedmont and Blue Ridge, using automatic data loggers. The current ground-water monitoring network for the State's bedrock aquifers is shown on Figure 23, and Table 4 lists the number of additional wells required to complete this network.

Owing to their shallow depths and low yields, water-table aquifers typically are not used as a source for water-supply systems; however, they are important because they contribute significantly to base flow and evapotranspiration; they are in direct contact with other surface-water bodies such as wetlands, springs, streams, ponds, and lakes; and they recharge the deeper, confined aquifers. A rise in the water table generally results in an increase in soil moisture content, but it also results in a reduction in storage capacity, rendering the area more susceptible to flooding. On the other hand, a drop in the water table leads to an increase in storage capacity, but generally causes a reduction in soil moisture content, rendering the area more susceptible to drought. As such, the water level in the water-table aquifer serves as an index for evaluating the severity of both droughts and floods.

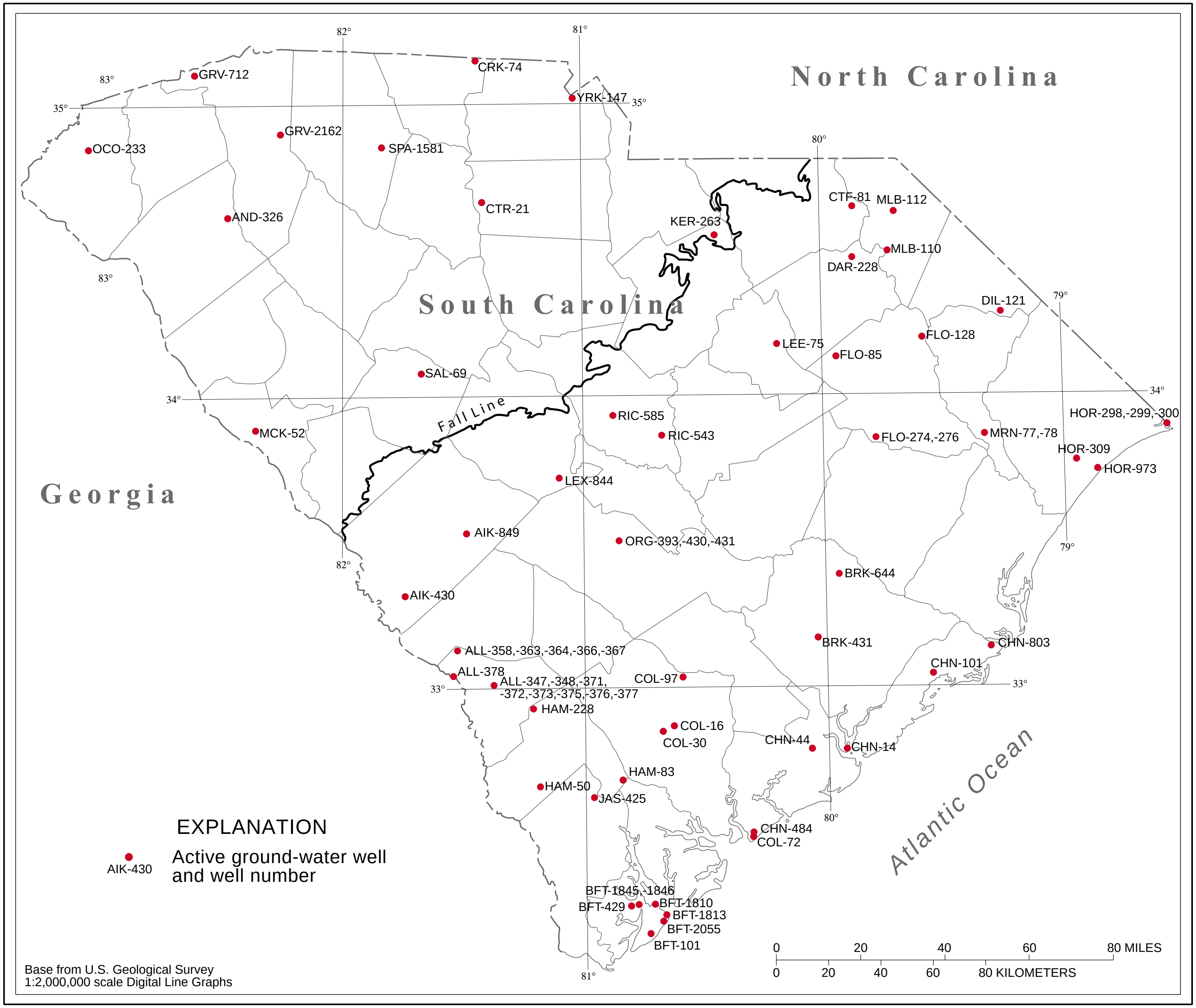


Figure 23. Current network of ground-water monitor wells in South Carolina.

Table 4. Number of required and existing monitor wells for confined aquifers of the Coastal Plain and bedrock aquifers of the Piedmont and Blue Ridge

County	Number of aquifers	Number of monitor wells required	Number of existing monitor wells	Number of additional monitor wells required
Abbeville	1	1	0	1
Aiken	3	6	2	4
Allendale[1]	5	10	14	0
Anderson	1	1	1	0
Bamberg	5	10	0	10
Barnwell	4	8	0	8
Beaufort[2,4]	4	8	7	4
Berkeley[4]	5	10	2	8
Calhoun	4	8	0	8
Charleston[2]	4	8	5	5
Cherokee	1	1	1	0
Chester	1	1	1	0
Chesterfield[3]	3	5	1	4
Clarendon	4	8	0	8
Colleton[4]	6	12	4	8
Darlington[4]	2	4	1	3
Dillon	3	6	1	5
Dorchester[4]	5	10	0	10
Edgefield[3]	2	3	0	3
Fairfield	1	1	0	1
Florence[4]	3	6	4	2
Georgetown[4]	4	8	0	8
Greenville	1	1	2	0
Greenwood	1	1	0	1
Hampton	5	10	3	7
Horry[4]	3	6	5	1
Jasper[4]	5	10	1	9
Kershaw[3]	3	5	1	4
Lancaster	1	1	0	1
Laurens	1	1	0	1
Lee	3	6	1	5
Lexington[3]	4	7	1	6
McCormick	1	1	1	0
Marion[4]	3	6	2	4
Marlboro	2	4	2	2
Newberry	1	1	0	1
Oconee	1	1	1	0
Orangeburg	5	10	3	7
Pickens	1	1	0	1
Richland[3]	4	7	2	5
Saluda	1	1	1	0
Spartanburg	1	1	1	0
Sumter[4]	3	6	0	6
Union	1	1	0	1
Williamsburg[4]	5	10	0	10
York	1	1	1	0
Total		**234**	**72**	**172**

[1] Allendale County currently has more monitor wells than required.
[2] County with more than 2 existing monitor wells in some aquifers.
[3] County is in both the Coastal Plain and Piedmont provinces. Only 1 well required for bedrock aquifer.
[4] County has documented water-level declines in 1 or more aquifers and may require additional monitor wells.

Because the movement of water in water-table aquifers is strongly influenced by topography, the location and number of water-table monitor wells should be based on the location and size of drainage subbasins within the State. Water-table monitor wells should be sited near surface drainage divides rather than near streams for two reasons: (1) the water table near a drainage divide changes gradually compared to the water table near a stream; and (2) the overall range of water levels near a divide will be greater than that near a stream. As such, the water table measured near a divide provides a better measure of the volume of water available for base flow and evapotranspiration, and it provides a better indication of the rate and direction of water movement between the water table aquifer and the underlying confined aquifer. No wells are currently available for continuously monitoring the water-table aquifers of the State. Figure 24 shows proposed locations of monitoring stations for these aquifers.

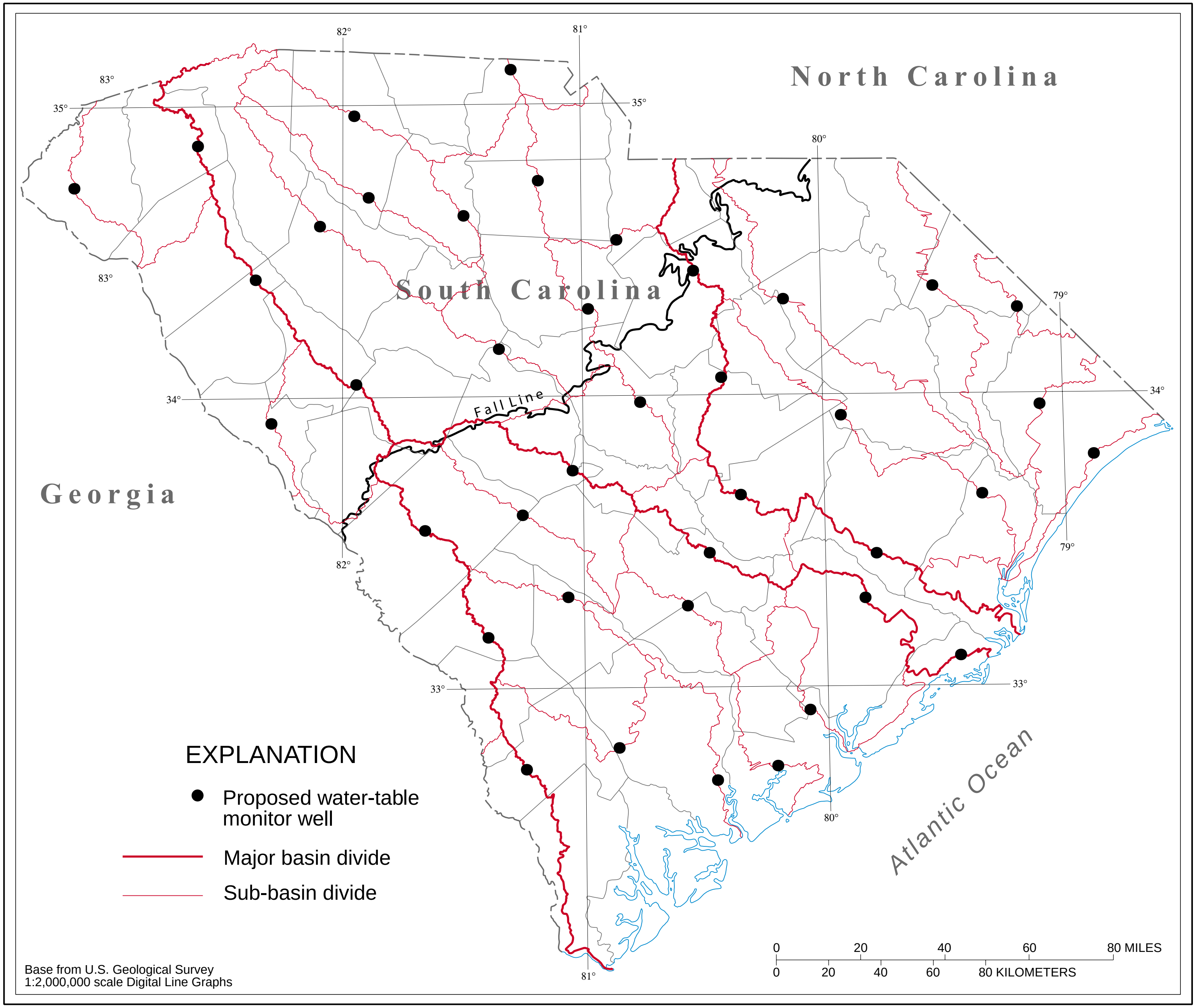


Figure 24. Proposed network of water-table monitor wells in South Carolina.

GROUND WATER QUALITY

Like surface water, ground water is vulnerable to contamination and must be protected. Contrary to popular belief, sand and soil do not completely "filter out" all pollutants; even pathogens such as bacteria and viruses are found in ground water. This contamination occurs mainly from improper fuel storage and waste disposal and from agricultural and industrial practices. Natural processes, however, can also degrade water quality. Elevated metal concentrations can result when metals, such as iron, are leached into ground water from minerals present in the earth. Naturally-occurring radionuclides (uranium and radium) have also been detected in ground water in some areas of the State.

Pollutants are numerous, but they commonly consist of nitrates, pathogens, petroleum products, metals, volatile organic compounds, fertilizers, pesticides, and radionuclides. In general, water-table aquifers are more susceptible to surface contamination than are confined aquifers, and therefore should not be used as potable sources without appropriate water-quality monitoring, analysis, and treatment. Because shallow ground water and surface water are hydraulically connected, contaminated ground water that is discharging into surface waters can also degrade the water in streams, lakes, and wetlands.

Contamination can originate from point sources and form well-defined, localized plumes beneath leaking tanks or industrial spills, or it can occur over wide areas from diffuse, nonpoint sources such as from the improper application of fertilizers and pesticides or from urban runoff. Remediation of ground water is costly, time consuming, and often ineffective at restoring water to its original condition. Consequently, efforts must be focused on preventing ground water contamination rather than on treating contamination after it occurs.

Water Quality Standards

Water quality standards promulgated in S.C. Regulation 61-68 (*Water Classification and Standards*; SCDHEC, 2001a) are applicable for both surface water and ground water. Because most of the ground water in the State "is presently suitable for drinking water without treatment … all South Carolina ground water is classified Class GB effective June 28, 1985," unless otherwise classified (SCDHEC, 2001a). Class GB is ground water that is suitable for drinking and meets safe-drinking-water standards set forth in S.C. Regulation 61-58 (S*tate Primary Drinking Water Regulation*; SCDHEC, 2003c).

The State recognizes that Class GB may not be suitable for some ground water. Ground water can also be classified as Class GA, which is exceptionally valuable ground water that is vulnerable to contamination due to hydrological characteristics, or Class GC, which is ground water not suitable for drinking. The State has the right to require that an owner or operator of a contaminated site restore the ground water quality to a level that maintains and supports the classified use.

Pollution Control Programs

Federal, State, and local government agencies are responsible for enacting laws and regulations that protect ground water resources, but it is the responsibility of each citizen to do his part. The State's goal is "to maintain or restore ground water quality so it is suitable as a drinking water source without any treatment" (SCDHEC, 2001a). DHEC administers most of the programs involving ground water quality, including the Clean Water Act and the Safe Drinking Water Act (SDWA). Section 102 of the Clean Water Act authorizes states to "develop comprehensive programs for preventing, reducing, or eliminating the pollution of navigable waters and ground waters and improving the sanitary condition of surface and underground waters." Under this authority, South Carolina is currently developing a Comprehensive State Ground Water Protection Program that will provide a framework for protecting the ground water resources.

The SDWA of 1974 protects public health by regulating public drinking water supplies. One of the most effective ways to ensure safe drinking water is to protect the source of the water. Source water protection is achieved through four programs provided under the SDWA: (1) the Wellhead Protection Program; (2) the Sole Source Aquifer Program; (3) the Underground Injection Control Program; and (4) the Source Water Assessment Program.

The Wellhead Protection Program is voluntary and allows for increased protection of source areas that supply water to public supply wells. Potential sources of contamination that threaten the wells are identified and the water system's susceptibility to each source of contamination is quantified. Amendments to the SDWA in 1996 essentially expanded this program to include surface-water supply systems as well as ground water systems.

Under provisions of the Sole Source Aquifer Program, communities or individuals can petition the EPA for an added degree of protection for an aquifer that is the "sole or principal" source of drinking water for the community. A region is eligible to participate in this program if 50 percent or more of the population in the defined area relies on the designated aquifer as a source of drinking water. If the sole source aquifer is threatened by a project that is financed by the Federal government, the EPA can modify the project to reduce the potential for contamination.

The Underground Injection Control Program regulates injection wells to ensure that they do not contaminate aquifers. Injection wells used to inject municipal and industrial wastes and to dispose of hazardous or radioactive waste are prohibited in the State. The majority of injection wells permitted in the State are used for aquifer remediation.

The Federal Resource Conservation and Recovery Act regulates monitoring, investigation, and remediation activities at currently operating hazardous treatment, storage, and disposal facilities. Underground storage tanks are regulated under this act. Storage tanks that leak gasoline are the leading cause of ground water pollution in the State.

The Federal Comprehensive Environmental Response, Compensation, and Liability Act provides a "Superfund" to clean up soil and ground water contaminated by uncontrolled and abandoned hazardous-waste sites or by accidents, spills, and emergency releases of contaminants into the ground. Sites typically include industrial and municipal landfills and dump sites at military installations and manufacturing plants.

The Federal Insecticide, Fungicide, and Rodenticide Act protects human health and the environment by requiring the testing and registration of all chemicals used as active ingredients of pesticides and pesticide products.

Saltwater contamination of ground water is a concern in coastal counties of South Carolina. Overpumping can induce saltwater into freshwater aquifers, contaminating the aquifers for years or even decades. The Groundwater Use and Reporting Act allows for areas threatened by overpumping to be designated as Capacity Use Areas. In these areas, ground water withdrawals are regulated by the State, either by limiting the amount of water that can be pumped from a well or by limiting the number of wells that can be drilled into a specific aquifer. This act allows the State to minimize damages caused by saltwater contamination. Currently, all coastal counties in the State are designated as Capacity Use Areas.

Ground Water Quality Monitoring Networks

The State's ambient ground-water-quality monitoring network, operated by DHEC, consists of 115 wells located throughout the State (Figure 25). The objectives of this monitoring program are to determine the baseline values of ground water quality, to determine geographic and temporal variations in ground water quality, and to provide ground water quality data for specific aquifers, especially those that are in the initial phases of contamination studies.

Public-supply wells constitute the majority of the wells in this network; however, in rural areas where public-supply wells do not exist, privately owned wells are used. Wells are sampled in one or two of the major river basins each year and then are resampled on a 5-year rotating cycle. This sampling schedule corresponds to the watershed water-quality management schedule for surface water sampling. As such, both surface and ground water are sampled from the same watershed in the same year.

Other State and Federal agencies, such as DNR and the USGS, measure ground water quality for investigations related to specific study areas or to specific aquifers.

Some wells in coastal counties are already being continuously checked for specific conductance (a measure of salinity) to monitor saltwater intrusion, but saltwater intrusion should be monitored in aquifers along the entire coast with automated recording devices. Well-cluster sites in six coastal zones should be constructed, each consisting of three or four wells (one per aquifer) that monitor specific conductance and water chemistry for saltwater contamination. Changes in conductance or chemistry within any well should be examined as an indication of possible saltwater intrusion. In areas where saltwater problems are known to exist, more monitor wells may be needed. Existing wells in the saltwater contamination monitoring network and proposed cluster sites are shown on Figure 26.

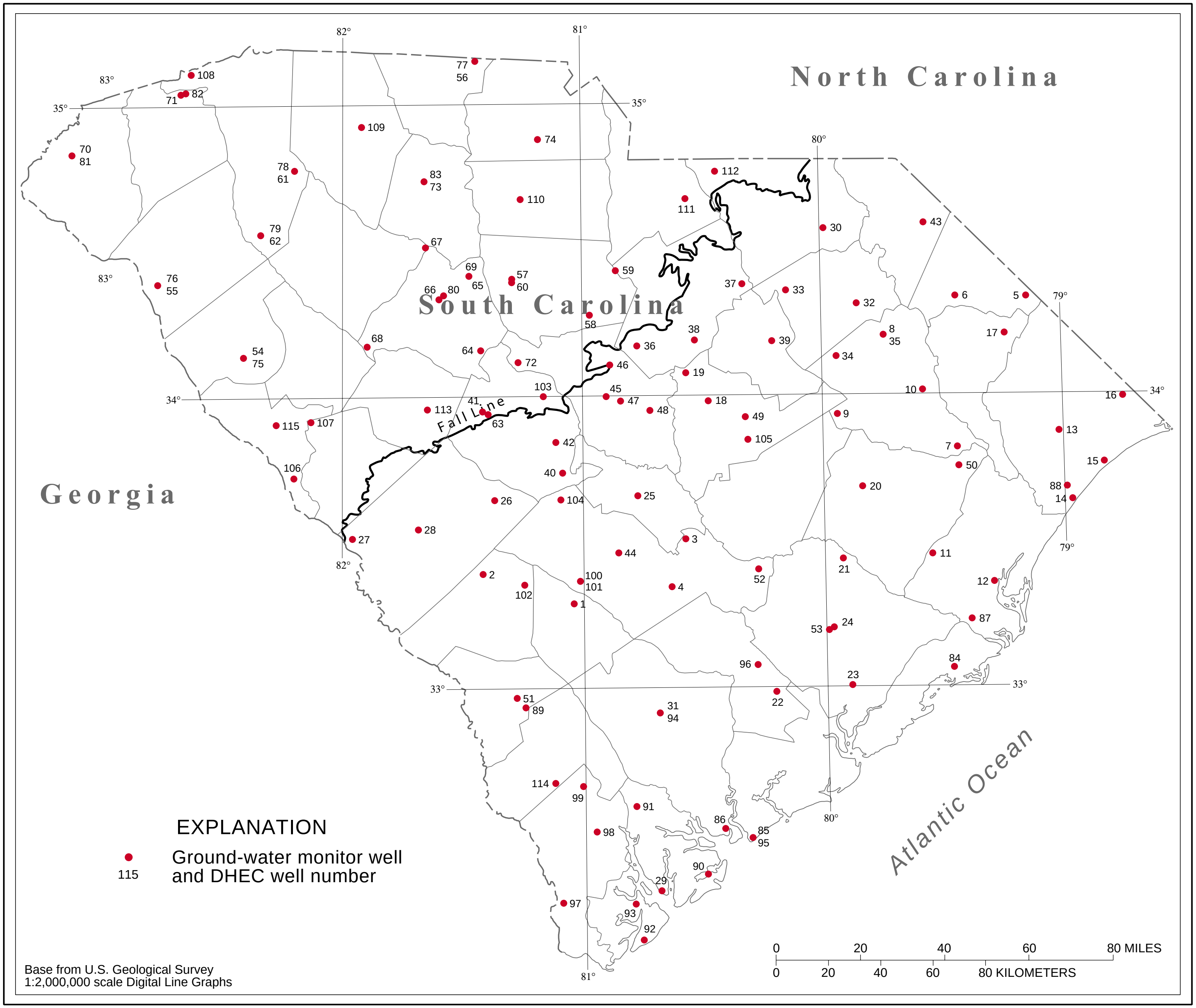


Figure 25. Location of wells in DHEC's Ambient Ground Water Quality Monitoring Network (modified from Reihm, 2002).

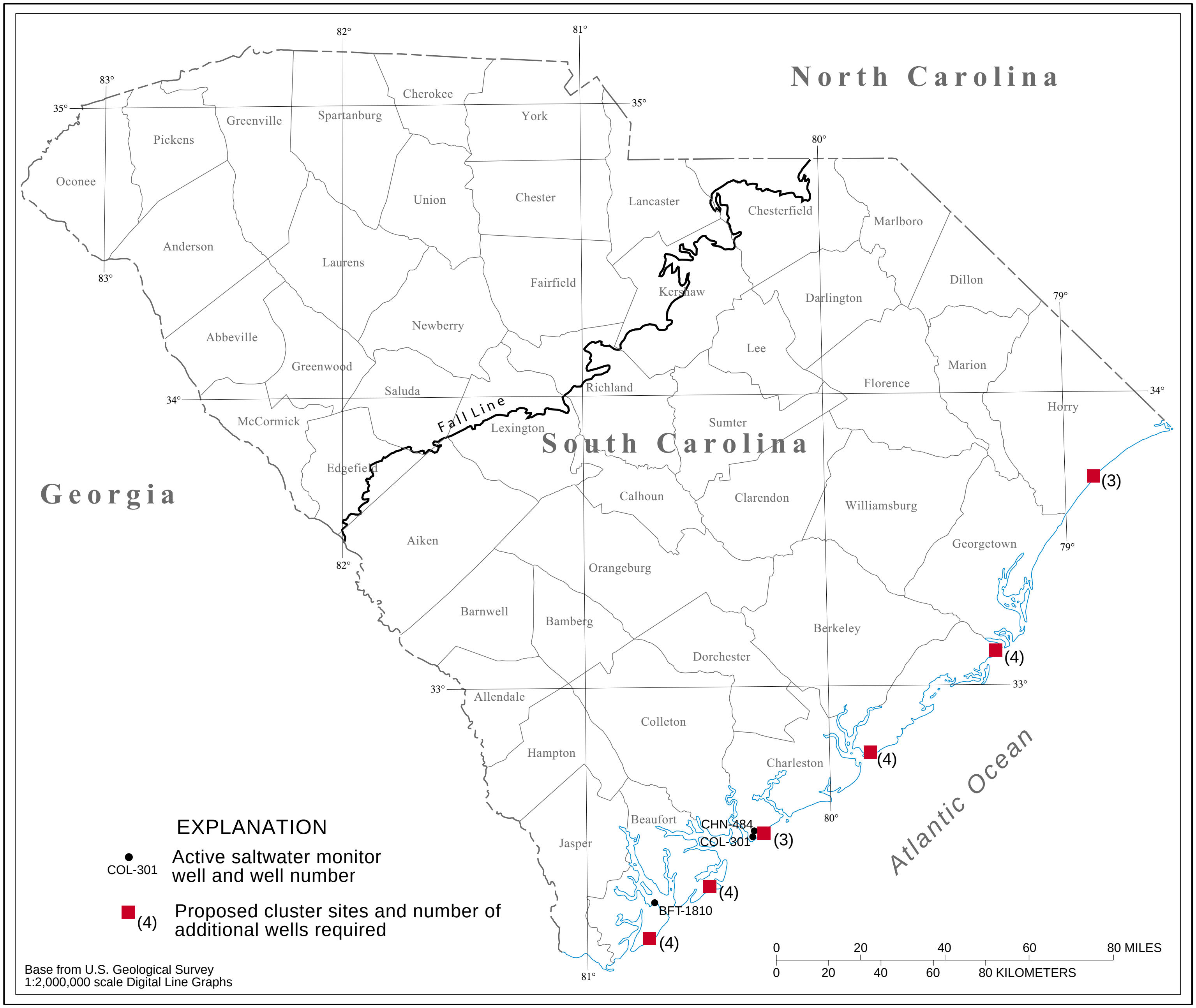


Figure 26. Location of saltwater intrusion monitor wells.

DROUGHT MANAGEMENT AND MITIGATION

Deficient precipitation for extended periods can cause an agricultural drought during the growing season and a lack of water to meet other demands. The State should have a statewide drought management and mitigation plan to help sustain all water uses in the State during water shortage periods. The available water during dry periods should be allocated among all uses in such a way as to minimize adverse economic and health-related problems, but all users within the drought-affected area should share the burden.

The Drought Response Committee was established by the South Carolina Drought Response Act of 1985 and includes State and local representation. The Committee has the authority to declare a drought based on climatic conditions, soil moisture, streamflows, and water levels in lakes and aquifers. The specific drought indices used in declaring a drought, and the corresponding drought levels, are the responsibility of the Drought Response Committee. Drought declarations should not be made prematurely or so frequently that the public becomes unresponsive. The Committee may request that State and Federal water resource agencies provide additional monitoring of streamflows, water levels, and water quality to ascertain the adequacy of drought mitigation practices. The DNR serves as the primary agency to monitor drought conditions throughout the State and coordinate the State's response.

An updated status of soil moisture, streamflows, aquifer water levels, lake levels, and overall climate must be issued periodically for as long as the drought exists. Notification of water-shortage conditions is to be provided by the DNR by letter and/or public communication through such media as newspaper, radio, television, and the Internet. The Drought Response Committee can recommend that the Governor issue a public statement imposing mandatory water-use restrictions. Economic, social, and environmental considerations should be used to help prioritize water use in order to enhance the recommendations of the Drought Response Committee and the Governor's Office.

A proactive approach to drought management is required to lessen the economic, social, and environmental impacts of drought. Federal and State funds should be used for drought mitigation, and cooperation among Federal, State, and local agencies, as well as private interests, is essential for sustaining all uses during dry periods. An assessment is needed of how droughts impact the State and of how vulnerability to droughts can be reduced. The following recommendations should be considered for inclusion into a drought mitigation plan:

- DHEC and DNR should develop allocation mechanisms for surface and ground water to ensure water availability and minimize conflicts during water shortages.

- DHEC and DNR should establish and enforce minimum required flows and water levels to protect water quality for the designated uses of surface water.

- Resource agencies should promote measures to increase water availability, as described in the "Maximizing Water Availability" section later in this report.

- Farmers should invest, with Federal and State support, in efficient irrigation systems where adequate surface or ground water supplies are available.

- Farmers, especially those not using irrigation systems, should select varieties of crops that have a high tolerance for dry weather.

- Federal and State resource agencies should improve research programs to increase the accuracy of drought predictions. Earlier warnings will enhance drought management and mitigation.

- A Statewide shallow-ground-water monitoring network should be developed to monitor the effects of drought on water-table aquifers.

- Statistical analyses of water-level data should be made from long-term surface- and ground-water records to determine the relative severity and recurrence interval of droughts.

- All water suppliers should prepare drought response plans, specifying water reduction schedules, alternate supply sources, and backup systems.

- Victims of drought should seek relief from the nearly 50 federal programs that have some element of drought relief, primarily for agricultural droughts. Federal and State agencies should improve programs that assist businesses that suffer drought-related losses. Also, the Emergency Board of each county in the State should help alleviate the impacts of extreme droughts on farmers, ranchers, local businesses, and communities.

- During the 1998-2002 drought, many owners of private wells had to deepen their wells or lower their pumps in reaction to water-level declines caused by the drought. No State or Federal assistance was available to help these citizens maintain their water supply. A program should be developed to provide financial assistance to low-income households in order to help them maintain their wells during prolonged or severe droughts.

FLOOD PLAIN MANAGEMENT AND MITIGATION

The ancient Egyptians built their agriculture and social system around periodic flooding. Although floods are natural events necessary for healthy ecosystems, modern man tends to regard floods as natural disasters to be prevented if at all possible. Since the 1930's, the approach to flood control has been to build reservoirs capable of holding large volumes of water, while also building levees to prevent high streamflows from escaping the river channel. While this structural approach has been successful in reducing some flooding and flood damage, it has become very expensive, and it does not guarantee protection: levees and floodwalls can fail or be overwhelmed by storms that exceed the design limits of the protective structures.

Because flood plains and wetlands provide important ecological and hydrological functions, an important goal of a flood plain management program should be to preserve natural flood plains and wetlands, not only by limiting development in those areas but also by allowing flooding to occur. The goal of flood plain management is not necessarily to reduce or eliminate flooding, but to reduce or eliminate the dangers and damages associated with floods. Flood plain management is most effective at the local level, but it requires the cooperation of all levels of government, as well as those at risk from flooding.

Flood damage can be reduced by minimizing the potential for damage. Highly vulnerable structures and critical facilities, as well as large population groups, should be relocated out of potential flood areas. Levees and floodwalls can protect heavily developed areas, but these structures are expensive and provide a false sense of security. Because all developments have the potential to increase flood damage by increasing flood stage, flood flow, and flood velocity, or by altering erosion rates, new developments can increase the flood risk for existing structures previously thought to be adequately protected. It is important that new developments are designed to minimize any flood impact they may have on existing structures.

With the goal of protecting the public and minimizing flood damages, DNR developed the *South Carolina Flood Mitigation Plan* (SCDNR, 1999). Both State and Federal governments should encourage and provide incentives for communities that participate in flood management planning while discouraging behavior likely to result in future loss of property and life. The State should also oversee flood plain and floodway delineation, and verify the hydrologic and hydraulic analyses used to make those delineations. Because DNR administers the National Flood Insurance Program, the Flood Mitigation Program, and the Federal Emergency Management Agency (FEMA) Map Modernization Program for South Carolina, it should be the State agency spearheading the implementation of these management and mitigation practices.

BASINWIDE MANAGEMENT AND INTERSTATE COOPERATION

Conflicting jurisdictions, authorities, and program objectives of the various government agencies and private organizations that have interests in the water resources of a basin greatly compound the complexity of effective water resources management. The State should work to establish a river basin advisory committee for each of its four major basins. Each committee, made up of representatives from Federal, State, and local agencies and stakeholders, would develop a basinwide comprehensive water resources plan to optimize water use throughout that basin.

The water in three of the four major basins in South Carolina is shared with either Georgia or North Carolina. To promote interstate coordination and reduce potential disputes among these States, formal mechanisms meant to provide equitable water apportionment, such as interstate compacts or memoranda of agreement, should be developed among these States. These mechanisms also provide the means for active programs for basinwide water conservation, flood protection, improved water quality, dependable navigation, and protection of fish and wildlife habitats.

DNR, DHEC, other State resource agencies, the State Legislature, and the Governor must work together with their counterparts in Georgia and North Carolina to develop these formal mechanisms. The United States government, including the Corps of Engineers and FERC, should also be involved in developing these mechanisms whenever appropriate.

MAXIMIZING WATER AVAILABILITY

South Carolina ordinarily receives ample water to meet its present and future needs, but because of its temporal and spatial distribution, 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 shortages, droughts, and increasing populations are driving nations, states, and municipalities to investigate better ways of conserving water and to find new and alternative water supply technologies. South Carolina needs to join this quest for a sustainable water supply.

The amount of time required for surface water to travel through the hydrologic cycle before being discharged to the ocean is significantly less than that needed for ground water. If water in a stream is not utilized before reaching the ocean, it is no longer available as a supply source. As such, water availability can be enhanced by withdrawing water in the following order of source preference: (1) streams; (2) lakes; and (3) aquifers.

Consideration must be given to resource management policies that can help maximize water availability. DNR, in cooperation with other government and private agencies, should investigate the economic feasibility and overall practicality of the following practices and encourage their implementation where appropriate:

1. Water conservation
2. Optimization of water use in reservoirs
3. Construction of new reservoirs
4. Agricultural water-table management
5. Aquifer storage and recovery
6. Interbasin transfer of water
7. Conjunctive water use
8. Desalination
9. Gray water
10. Recycled wastewater

Water Conservation

Water conservation and improved efficiency of use can have many benefits and should be the first approach for extending or augmenting available supplies. Conservation has a limited impact on the overall water supply, however, unless consumptive use is reduced. Conservation can significantly extend water supply availability and can also reduce costs to municipal facilities.

Water conservation must become an integral component of effective water resource management. Water should be conserved at all times rather than only as a last resort during times of crisis. Initiatives to manage water resources effectively can be achieved only through cooperation and collaboration among all water users—individuals, businesses, industries, farmers, and government. Individuals must conserve water at home and at work. Businesses and industries across the State must find more efficient ways to use water and eliminate waste. Farmers must help find solutions that reduce their irrigation needs while protecting their crops. And all water supply systems must develop interconnections with neighboring systems, increase storage capacity when possible, and establish aggressive conservation programs.

Water conservation can be achieved through more efficient operation of storage and delivery facilities (to increase supply) and more efficient use by users (to reduce demand). Implementation of many conservation measures will present new challenges in securing authorizing legislation and funding, developing integrated policies, setting an appropriate balance of government and the private sector, and integrating research and education for technology transfer.

The key to making water conservation work is education. Significant water use reductions can be achieved when people understand the reasons to conserve. South Carolina needs a multifaceted water conservation campaign with voluntary, incentive, and regulatory mechanisms to address both supply-side and demand-side conservation.

Optimization of Water Use in Reservoirs

The State should play a major role in managing existing lakes to maximize the mix of benefits from the lake water and to minimize conflicts among all upstream, downstream, and lake uses. Lake management should give equal consideration to all uses, including but not limited to, water supplies, hydroelectric power, fish and wildlife, water quality, recreation, flood control, and real estate. During water shortages, all users should share the burden based upon economic, social, and environmental impacts.

Each reservoir should have a drought contingency plan that associates reservoir water levels, drought conditions, and natural inflows with the allocation of water for all uses, including downstream releases. These plans should be developed in coordination with State resource agencies, Federal agencies, stakeholders, and all interested parties in the basin. The drought contingency plan should minimize the likelihood of a reservoir's conservation pool becoming so depleted that no more water is available for withdrawal for public supplies. State resource agencies should take an active role in developing and enforcing these plans to maximize water supplies for all uses.

Construction of New Reservoirs

Although there is usually more than enough water in South Carolina to satisfy all the demands for it, shortages can occur when water availability is low. One method for improving water availability is to capture excess water during wet periods and store it in reservoirs for use during dry periods. Water stored in reservoirs in South Carolina and its neighboring states played a major role in alleviating the drought of 1998-2002; very low natural flows in the streams were supplemented by releases of water stored in those reservoirs.

Instream Reservoirs

An instream reservoir is built by damming a stream to store water. The reservoir changes the natural flow of a stream, reduces flooding, provides water for generation of hydroelectric power and other uses, and can augment the streamflow below the dam during low-flow periods. When instream reservoirs are constructed, stream and wetland ecosystems are altered in the reservoir area, upstream from the reservoir, and downstream from the dam. Because instream reservoirs tend to reduce downstream flooding, flood-plain wetlands adjacent to streams receive less water and often undergo significant ecosystem changes. The migration of fish and other aquatic organisms across dams decreases or ceases, altering ecosystems both above and below the dam. 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 while nutrient concentrations may be greater in the reservoir than downstream, dissolved-oxygen levels are often much lower in reservoirs than in flowing streams. Recreational opportunities for reservoirs and those for free-flowing streams are different, and use of the reservoir is dependent upon ownership and provision for public access to the reservoir.

Offstream Reservoirs

An offstream reservoir is an artificial lake positioned adjacent to a stream rather than in the stream channel, made without damming the stream or altering the watercourse. An offstream reservoir can still modify the natural flow of a stream, however; water diversion and storage can reduce downstream flows and lessen flooding when streamflows are high, and reservoir releases can augment naturally low streamflows during extended dry periods. An offstream reservoir has considerably less impact on riverine ecosystems than does an instream reservoir, and because the stream remains unimpeded, navigational and recreational uses of the stream are generally not significantly changed. Some terrestrial habitat will be replaced by aquatic habitat, increasing the diversity of aquatic organisms.

The diversion of water from a stream into an offstream reservoir should be treated like any other offstream withdrawal; permitted and subject to curtailment during extended periods of low streamflow. Because offstream reservoirs do not control streamflow as do instream reservoirs, releases from offstream reservoirs should not be determined by minimum downstream flow requirements.

Agricultural Water-Table Management

Agricultural water-table management is the management, control, and regulation of soil-water conditions in the profile of agricultural soils: excess and deficit soil-water conditions can be managed to provide better plant growth conditions, with the benefit of more efficient water use. Agricultural water-table management also provides an added level of protection to farmers from drought conditions by artificially maintaining the water content in the soil and reducing water loss through drainage. The key elements of effective water-table management are controlled subsurface drainage and subirrigation.

The addition of properly designed and constructed water-control structures to a subsurface drainage system allows the drainage outlet to be artificially set at any level between the ground surface and the drain depth. Raising the outlet after planting helps keep water available for plant use longer than does uncontrolled subsurface drainage. This practice also can be used to recharge the water table between growing seasons by capturing water that would normally drain into local streams.

With subirrigation, water is supplied through the subsurface drainage system by using control structures to regulate the water table in the field. Irrigation water is applied below the ground surface, thus raising and maintaining a water table at an appropriate depth in the crop root zone. The pumping system and water control structure can be managed to create a constant or fluctuating water table. If the system is properly designed for the site and soil conditions, loss of water through deep seepage is negligible, and runoff of irrigation water rarely occurs. Water is always applied where the crop needs it most. A water supply such as a deep well, farm pond, or stream can be used to supply adequate supplemental water when needed for subirrigation.

Together with the U.S. Department of Agriculture's South Carolina Natural Resources Conservation Service and other agricultural research institutes, the DNR should promote these techniques and provide design and operational guidance and, if possible, financial incentives to farmers implementing these practices.

Aquifer Storage and Recovery

Underground water storage involves the injection or infiltration of water into an aquifer for future use. In effect, it makes use of an underground reservoir to store water in much the same way that surface water reservoirs are used. This technique has advantages over storage in surface water reservoirs because water stored underground is not subject to evaporation and is less easily contaminated. Artificial aquifer recharge holds significant potential for the storage of surplus, good-quality water for future use.

Aquifer storage and recovery (ASR) projects take advantage of a water supplier's unused treatment capacity during times of low water demand (usually in the winter) to treat surface water and then pump it into an aquifer for storage until later recovery during times of peak demand or low flow (typically a few days during the summer). ASR helps water suppliers meet peak summer demands by providing pretreated water to augment surface supplies without the need for increased treatment capacity.

ASR programs are already in use throughout the United States. In South Carolina, ASR programs are operating in Horry, Charleston, Beaufort, and Jasper Counties. An ASR program is being considered in Orangeburg County, and the South Carolina DNR is currently studying the feasibility of using ASR techniques in the Piedmont province.

Interbasin Transfer of Water

In some areas, the demand for water may exceed the natural availability, resulting in a water shortage. One solution to this problem is to transfer water from an area that has an excess of water into the area that has the deficit. The interbasin transfer of water involves moving water from one hydrologic basin (the origin basin) into another basin (the receiving basin), where it is used and discharged. The significant feature of interbasin transfer is that the water is completely removed from the origin basin, preventing its use by anyone downstream of the withdrawal point.

The Interbasin Transfer Act of 1985 gave DHEC the authority to regulate and permit interbasin transfers in South Carolina. Permit conditions should reflect a scientific understanding of the water availability, and protect both basins of origin and receipt. Interbasin transfer permit conditions should also consider the flow frequency and magnitude of the source stream, as well as the volume of stored water needed to supplement natural low flows in the origin basin.

Normally, there will be adequate excess water in the origin basin, so that transferring water to another basin will not result in detrimental water shortages in the origin basin. If the origin basin is experiencing a water shortage, however, there may not be enough water available for transfer without aggravating the water shortage in the origin basin. A trigger mechanism should be designed into special-permit conditions to make transferable volumes proportional to the available water volume in the origin basin: the less water available, the less water transferred. In that way, both the origin and receiving basins share the burden during water shortages.

Conjunctive Water Use

Conjunctive water use is the combined use of ground- and surface-water resources in order to optimize the water availability, increase the reliability of the water supply, or to offset the negative impacts of using a single source. Water planners should consider the implementation of conjunctive strategies—that is, using both surface water and ground water—for the following conditions:

- If withdrawals from a single source are limited or are unreliable;
- If heavy withdrawals from aquifers are substantially altering horizontal or vertical flow patterns or are causing land subsidence or irreversible damage to the aquifers;
- If withdrawals from aquifers are negatively impacting domestic ground-water users;
- If withdrawals from streams are destructive to aquatic ecosystems;
- If water quality from a single source is inconsistent or undesirable.

The combined use of ground water and surface water should be optimized to reduce the effects that withdrawals have on either source and on the environment.

Desalination

Desalination is the process in which dissolved minerals—primarily salt—are removed from seawater or brackish water, making the saltwater or brackish water suitable for use in public supply systems. Desalination plants are becoming increasingly common, primarily in high-growth coastal areas of Florida and California. While only Florida is currently desalting seawater for drinking-water use, more than 20 states employ technologies such as reverse osmosis to desalt brackish water. South Carolina is one of those states: in 1991, Mount Pleasant Waterworks became the first municipal water system in South Carolina to provide drinking water treated with reverse-osmosis technology.

The most common objection to using desalted water to help meet municipal water needs is that the process is expensive; however, developments in technology and improvements in desalting processes have dramatically reduced the cost of desalination over the past 30 years. When considering new sources for public supplies near the coast, State and local governments, as well as private water companies, should consider the feasibility of desalination by making cost comparisons to other sources of suitable water, such as surface water impoundments, remote well fields, and long-distance pipelines.

Gray Water

Gray water is water that can be used twice; it includes the discharge from kitchen sinks and dishwashers (*not* garbage disposals); bathtubs, showers and lavatories (*not* toilets); and household laundry (*not* diaper water). Using gray water can almost double home water-use efficiency and provide a water source for landscape irrigation. Although properly treated and continuously monitored gray water can be a valuable and safe resource for landscape irrigation, poor maintenance or system neglect can lead to human health problems and maintenance difficulties. Currently, South Carolina's health codes do not allow the use of gray water because of possible health risks.

Recycled Wastewater

Treated municipal wastewater can be recycled for irrigation, industry, and fire-control purposes. The use of reclaimed water is less expensive, optimizes the resource, provides nutrients to crops, reduces surface-water pollution, and conserves freshwater. Because effluent can contain pathogens and harmful chemicals, however, it must be carefully applied and monitored in order to prevent direct human contact and contamination of ground-water resources. Only effluent that has passed through a secondary treatment phase and that has been approved by public health officials should be recycled. A separate delivery system must be constructed to prevent contamination to the public water system. If effluent is used for irrigation, monitor wells should be constructed to evaluate the long-term effects on ground-water quality. Effluent irrigation should not be used on row crops or crops that are eaten raw, such as fruits and nuts, but can be used on grasslands such as turf farms, pastures, golf courses, parks, athletic fields, and cemeteries. The State encourages the use of recycled water as long as it is adequately treated to ensure water quality appropriate for the use.

RECOMMENDATIONS

WATER RESOURCES MANAGEMENT

The effective management of South Carolina's water resources is beyond the scope of any one agency or organization and will require cooperation and shared responsibility among Federal, State, and local agencies, as well as public and private parties.

Management strategies must be flexible, responsive to trial, monitoring, and feedback, and should change in response to new scientific information and technical knowledge. This "adaptive management" approach provides a process for continually improving management practices and policies.

Effective resource management requires the increased utilization of regulatory science. Research institutes and universities should be encouraged to work with State resource agencies to advance regulatory science and become integrated into the decision-making processes of the State.

The State should work to establish a river basin advisory committee for each of its four major basins. Each committee, made up of representatives from Federal, State, and local agencies and stakeholders, would provide a basinwide comprehensive water resources plan to optimize water use throughout that basin. These plans should be approved and adopted by the appropriate Federal, State, and local agencies.

Formal mechanisms such as interstate compacts, memoranda of agreement, or protocols should be developed with Georgia and North Carolina to provide equitable water apportionment.

Consideration must be given to resource management policies that can help maximize water availability. The State, in cooperation with other government and private agencies, should investigate the economic feasibility and overall practicality of these policies.

Water availability can be enhanced by withdrawing water in the following order of source preference: (1) streams; (2) lakes; and (3) aquifers.

In order to effectively manage the State's water resources, comprehensive and accurate monitoring of water use is needed.

Preventing and reducing water pollution is the collective responsibility of all levels of government, agriculture, industry, landowners, and citizens alike, and it is best achieved at the watershed level, by enhancing stewardship, forging partnerships, and increasing public education and participation.

Source Water Assessments should be used by public water systems to determine what preventive actions are needed to protect drinking-water sources from contamination.

The State must remain committed to the protection and restoration of its wetlands and to the concept of no-net-loss of wetlands. Legislation should be enacted to establish a Statewide wetlands protection program.

Water conservation and improved efficiency of use can have many benefits and should be the first approach for extending or augmenting available supplies. Water should be conserved at all times rather than only as a last resort during times of crisis. South Carolina needs a multifaceted water-conservation campaign with voluntary, incentive, and regulatory mechanisms to address both supply-side and demand-side conservation.

Water planners should consider the implementation of conjunctive strategies—that is, using both surface water and ground water. The combined use of ground water and surface water should be optimized to reduce the effects that withdrawals have on either source and on the environment.

All water supply systems should develop interconnections with neighboring systems, increase storage capacity when needed, and establish aggressive conservation programs.

The State should promote efficient irrigation and agricultural water table management techniques and provide design and operational guidance and, if possible, financial incentives to farmers implementing these practices.

Interbasin-transfer permits should allow for restrictions on the volume of transferable water during water shortages in the origin basin.

Water suppliers near the coast should consider the technical and economic feasibility, as well as the ecological impact, of desalination as a source of water.

Treated municipal wastewater should be recycled for irrigation use on grasslands such as turf farms, pastures, parks, athletic fields, and golf courses.

SURFACE WATER

The effective management of the State's surface water system requires a coordinated management of its lakes and rivers in order to balance the needs of lake users with the needs of river users.

To maximize water availability at all times and to protect human and economic needs, surface water use must be regulated. An allocation mechanism must be established to control the distribution of water so that all users have a reliable water supply. Variations in surface water availability and the location of demands must play major roles in the water allocation.

Desired flows and minimum required flows for streams should be established to protect public health and safety, maintain fish and wildlife, and provide recreation and navigation while promoting aesthetic and ecological values. It is the responsibility of the DNR to determine the minimum flow required to protect the State's aquatic resources.

The DNR should evaluate each regulated river in the State to determine the desired flows and minimum required flows just downstream from each reservoir.

The State should determine the minimum streamflow needed to maintain ecological functions of estuaries and to prevent saltwater contamination of water-supply intakes.

Permitted discharges should be adjusted as needed to reflect variability in the assimilative capacity of a river, which will change over time due to the cyclic nature of wet and dry periods.

When water is being discharged back into a stream, it should be returned as near to the point of withdrawal as is practical in order to minimize the impact of the withdrawal on the stream between the withdrawal point and the return point.

Reservoir operations should be planned to ensure adequate instantaneous or average daily flows, rather than average weekly flows.

Releases from reservoirs should be conducted in such a way as to mimic natural seasonal fluctuations in streamflow, where appropriate.

During nondrought conditions, reservoirs should be operated so that releases are sufficient to ensure that desired downstream flows are always met. During droughts, the reservoir's drought contingency plan must be enforced.

Downstream minimum required flows can be achieved by incorporating the appropriate releases into the FERC license, State operating permit, or Corps of Engineers operating plan.

The State needs to be involved in the issuing and reissuing of FERC reservoir operating licenses, which offer excellent opportunities to incorporate strategies for managing the entire river system into the reservoir operating plans.

It is important that reservoir operating plans detailed in FERC licenses allow for some flexibility in reservoir operations so that resource managers can react to changes in either water availability or demands for water without having to wait for the next relicensing opportunity.

The State should continue to use its authority under Section 401 of the Federal Clean Water Act to ensure that any proposed releases will not result in violations of State water quality standards, nor result in an unacceptable degradation of water quality. The 401 Certification can also be used to require minimum flow releases.

Because Georgia and South Carolina share the Savannah River and its lakes, these States must work together to incorporate appropriate release schedules into the Corps of Engineers operating plans for these lakes.

State Legislatures should authorize the development of a formal agreement between Georgia and South Carolina to work together to manage the Savannah River basin.

South Carolina and Georgia should continue to support the *Savannah River Basin Comprehensive Water Resources Study*, an ongoing cooperative technical project of Georgia, South Carolina, and the Corps of Engineers.

State agencies should work with relevant Federal agencies in order to coordinate activities relating to the water resources of the State.

When reservoir water levels are above the first water-shortage severity level, releases from the reservoir should equal or exceed the downstream desired-flow requirements.

When lake levels decline to less than the first water-shortage severity level because of low inflow, downstream releases and lake withdrawals should both be reduced, but downstream releases must always meet minimum flow requirements.

If the volume of usable storage in a lake is reduced so much because of drought that running out of water becomes a realistic concern—for example, if the volume of usable storage is equivalent to only 100 days of lake withdrawals—downstream releases should be set equal to the inflow into the lake. All regulated lakes must be studied to determine if this 100-day level is an appropriate trigger for this action.

If a drought persists to the extent that the water level nears the bottom of the conservation pool, and the volume of usable storage in the lake is almost exhausted—for example, equivalent to 10 days of lake withdrawals—further reductions in both lake withdrawals and downstream uses should be required. The lake's outflow should be set equal to the lake's inflow minus the newly-reduced lake withdrawals.

Having an adequate number of properly located gages is vital to the effectiveness of the surface-water monitoring network. The State should provide adequate funding to support this monitoring program and to prevent the loss of existing gages.

Protecting, improving, and restoring water quality are goals of the State. The State should continue to develop and improve water-quality standards that will meet the goals of South Carolina and the Clean Water Act. Waters that do not meet standards must be restored.

The State should continue to revise and refine water-quality monitoring programs to address additional potential impacts on water quality from increasing population and development. It should increase analytical capabilities to measure the presence of chemicals at very low concentrations, strengthen monitoring programs that assess biological integrity of water bodies, and improve lake-quality monitoring programs.

The State should continue to develop and implement Total Maximum Daily Loads for all waters on the 303(d) list. This includes waters impaired solely or primarily by nonpoint-source pollution.

The State should continue efforts to reduce point-source pollution by issuing water-quality based National Pollutant Discharge Elimination System permits.

The State should continue to seek additional resources and technology to identify and reduce nonpoint sources of pollution.

The State should investigate the elevated mercury levels found in fish tissue samples.

The State should continue to conduct water-quality assessment and protection at the watershed level. It should continue to increase watershed partnerships among government, the private sector, and stakeholders and encourage resource stewardship through education and outreach.

GROUND WATER

Advancing our knowledge of the State's ground water resources must continue with routine data collection, county, regional, and Statewide ground water investigations, and with programs like the surface geophysics and borehole geophysical logging programs.

To protect aquifer systems and to ensure the long-term sustainability of the ground water resources, the entire Coastal Plain province should be designated a Capacity Use Area.

Efforts should be coordinated between DHEC and DNR to ensure that geophysical logs are obtained from all new public-supply wells.

The State, in cooperation with the USGS, should reevaluate the existing hydrogeologic framework and improve it where necessary. New test holes should be drilled in areas that lack substantial subsurface data.

A comprehensive ground-water flow model of the Coastal Plain should be developed and used to predict the effect of future pumping and to determine optimal well spacings.

Potentiometric maps of each major aquifer in the State should be constructed at least every 5 years to identify those areas where overpumping is occurring and to determine how ground water levels are changing with time.

The DNR and USGS should be given 60 days advance notice of any well that is being considered for abandonment. If deemed important to the State's ground-water monitoring programs, a variance should be granted to keep a well from being permanently plugged.

A study should be made by the State to determine if, and to what extent, subsidence has occurred in the Coastal Plain. Withdrawal rates should be managed so as to prevent land subsidence and sinkholes.

In areas where water-level declines are or may become troublesome, withdrawals should be restricted in order to minimize further declines and allow ground-water levels to recover.

Ground-water levels in the Coastal Plain aquifers should be kept above the trigger levels described in the 1998 *South Carolina Water Plan*. More studies are needed to refine this water-level index and to establish additional indices for initiating withdrawal restrictions.

Resource managers should develop ground water policies—such as mandatory well spacing, or the reservation of certain aquifers for specific uses—to minimize the need for restricting ground-water withdrawals. Withdrawals should be managed so as to minimize their impacts on other users of the aquifer.

Withdrawals should be managed so as to prevent degradation of aquifer water quality. Efforts must focus on preventing ground-water contamination as well as treating it.

The State should continue to investigate elevated levels of uranium and radium found in some aquifers.

Withdrawals from an aquifer should not result in saltwater intrusion.

Withdrawals from water-table aquifers should be managed with consideration for the impact these aquifers have on wetlands, surface water, and confined aquifers.

Withdrawals should be managed to protect drinking-water supplies obtained from public-supply wells or private domestic wells.

Ground-water quantity should be monitored throughout South Carolina to determine the effects that withdrawals and droughts have on the State's ground-water resources.

In each county, water levels in a minimum of two wells per aquifer should be monitored with automatic data loggers. In those counties where water-level declines are or may become troublesome, or where a single aquifer is heavily utilized, a minimum of three wells per aquifer should be monitored.

Water levels in a minimum of one well per county should be monitored in the bedrock aquifers of the Piedmont province.

A Statewide water-table monitoring network should be established. Each monitor well should be sited near a drainage divide.

Saltwater intrusion should be monitored in aquifers along the entire coast; each major aquifer should have at least two monitor wells.

DROUGHT MANAGEMENT AND MITIGATION

The State should have a drought management and mitigation plan to enhance current drought-related legislation and to help sustain all water uses in the State during water shortages.

Water available during dry periods should be allocated among all uses in such a way as to minimize adverse economic, environmental, and health-related problems, but all users within the drought-affected area should share the burden. Economic, social, and environmental impacts should be considered when prioritizing water use.

Drought-contingency plans must be developed by lake owners for all Federally operated, FERC-licensed, or State-permitted lakes.

All water suppliers and industries should prepare drought response plans, specifying system-specific triggers or indicators, predrought planning efforts, water reduction schedules, alternate supply sources, and backup systems. These plans should be filed with and approved by the State Drought Response Committee.

Federal and State agencies should improve research programs to increase the accuracy of drought predictions and should improve programs to assist businesses that suffer drought-related losses.

Farmers should invest in efficient irrigation systems if adequate surface- or ground-water supplies are available, and they should select varieties of crops that have a high tolerance for dry weather.

During the 1998-2002 drought, many owners of private wells had to deepen their wells or lower their pumps in reaction to water-level declines caused by the drought. No State or Federal assistance was available to help these citizens maintain their water supply. A program should be developed to provide financial assistance to low-income households.

FLOOD PLAIN MANAGEMENT AND MITIGATION

An important goal of a flood-plain management program should be to preserve natural flood plains, not only by limiting development in those areas but also by allowing flooding to occur.

Highly vulnerable structures and critical facilities, as well as large population groups, should be relocated out of flood-hazard areas.

New developments should be designed to minimize any flood impact they may have on existing structures.

State and Federal governments should encourage and provide incentives for communities that participate in flood-management planning while discouraging behavior likely to result in future loss of property and life.

The State should oversee flood-plain and floodway delineation and verify the hydrologic and hydraulic analyses used to make those delineations.

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GLOSSARY

Abandoned well—A well whose use has been permanently discontinued or which is in a state of such disrepair that it cannot be used for its intended purpose. Generally, abandoned wells will be filled with cement to protect ground water from waste and contamination.

Adaptive management—A process for implementing policy decisions as an ongoing activity that requires monitoring and adjustment. Adaptive management applies scientific principals and methods to improve resource management incrementally as managers learn from experience and as new scientific findings and social changes demand.

Agricultural water-table management—Modification and management of the water table to maintain the water level at a depth favorable for optimum crop growth. Also referred to as controlled drainage.

Antidegradation policy—Rules or guidelines that are required of each state by Federal regulations implementing the Clean Water Act, stating that existing water quality be maintained even if the current water quality in an area is higher than the minimum permitted as defined by Federal ambient water quality standards.

Aquatic life—All forms of living things found in water, ranging from bacteria to fish and rooted plants. Insect larvae and zooplankton are also included.

Aquifer—(1) A geologic formation, a group of formations, or a part of a formation that is water bearing. (2) A geological formation or structure that stores or transmits water, or both, such as to wells and springs. (3) A layer of sediments or rock that is sufficiently permeable to conduct ground water and to yield significant quantities of water to wells and springs. Aquifers can lie close to the surface or at great depths, and can occur over areas of hundreds of square miles.

Aquifer storage and recovery—The process of pumping and storing treated water in an aquifer for recovery and use at a later time. During periods of low demand, treated water is pumped into an aquifer; water is then recovered during periods of high demand. In coastal counties, for example, treated water can be pumped into an aquifer during the winter and recovered during the summer months when demand is greatest.

Aquifer test—See *Pumping test*.

Artesian aquifer—See *Confined aquifer*.

Artesian well—A well drilled into an artesian aquifer that has enough hydraulic pressure for water to rise above the top of the aquifer.

Assimilative capacity—The capacity of a natural body of water to receive wastewaters or toxic materials without deleterious effects and without damage to aquatic life or humans who consume the water.

Base flow—(1) The flow in a channel that is sustained by ground-water discharge in the absence of direct runoff. (2) The flow that a perennial stream reduces to during the dry season. (3) That part of stream discharge derived from ground water seeping into the stream.

Basement—See *Bedrock*.

Basin—A geographic area drained by a single major river; consists of a drainage system comprised of streams and often natural or man-made lakes. There are four major basins in South Carolina: Ashepoo-Edisto-Combahee (ACE), Catawba-Santee, Savannah, and Yadkin-Pee Dee.

Basin of origin—See *Origin basin*.

Bedrock—A general term for solid rock that lies beneath soil, loose sediments, or other unconsolidated material. In the Piedmont and Blue Ridge provinces of South Carolina, bedrock occurs below the saprolite layer, about 0 to 100 feet below land surface. In the Coastal Plain region of the State, bedrock occurs below layers of sediments, from 0 to 3,800 feet below land surface.

Bedrock aquifer—An aquifer composed of solid rock, in which most water flows through cracks and fractures in the rock instead of through pore spaces between sand grains.

Beneficial use (of water)—A use of water resulting in an appreciable gain or benefit to the user, consistent with State law. Most states recognize the following as beneficial uses: domestic, municipal, industrial, irrigation, mining, hydroelectric power, navigation, recreation, stock raising, public parks, wildlife, and game preserves.

Best management practice (BMP)—Methods that have been determined to be the most effective and practical means of preventing or reducing nonpoint-source pollution.

Blue Ridge province—A mountainous area in the northwest corner of South Carolina with elevations generally greater than 1,000 feet. Blue Ridge refers to a mountain range in the United States, extending from northern Georgia across western North Carolina and into West Virginia. It is the easternmost range of the Appalachian Mountains and consists mainly of igneous and high-grade metamorphic rocks.

Borehole—A hole bored or drilled into the earth for exploratory purposes or to obtain water.

Brackish—Water containing 1,000 to 3,000 parts per million total dissolved solids. Brackish water, a mixture of seawater and freshwater, is generally unsuitable for municipal, domestic, and irrigation uses and has a salty taste.

Capacity use area—An area in the State where ground water withdrawals are regulated. Overpumping of aquifers in some areas has depleted the ground water resources or has caused saltwater intrusion. In such areas, water wells are permitted and ground water withdrawals are regulated by the State. Currently, all the coastal counties and a small part of Marion County are designated as Capacity Use Areas.

CFS—Cubic feet per second. The common unit for measuring streamflow. One cfs is equivalent to about 448 gallons per minute.

Chlorides—Negative chlorine ions found naturally in surface and ground water and in high concentrations in seawater. Elevated levels of chlorides in ground water near coastlines may indicate saltwater intrusion.

Clay—A fine-grained earth material with grains smaller than 0.2 millimeters in diameter. Beds of clay form confining units in the Coastal Plain.

Clean Water Act (CWA)—A pollution-control program administered by the EPA that regulates the discharge of pollutants from point- and nonpoint-sources into waters of the United States. Originally established in 1972 under the name Federal Water Pollution Control Act Amendments.

Coastal Plain province—An area of the State which extends from the Fall Line to the coast that is characterized by a low, broad plain consisting of layers of sand, clay, and limestone. The Coastal Plain thickens from zero feet at the Fall Line to about 3,800 feet at Hilton Head Island.

Commercial water use—Water used for motels, hotels, restaurants, office buildings, and other commercial facilities and institutions.

COE—The United States Army Corps of Engineers. Provides engineering services to the Nation, including planning, designing, building, and operating water resources projects.

Compact—See *Interstate water compact*.

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)—Provides the EPA with authority for emergency response and cleanup of hazardous substances that been spilled, improperly disposed of, or released into the environment. Also referred to as the Superfund Law.

Cone of depression—A depression in the water table or potentiometric surface of a body of ground water that has the shape of an inverted cone and that develops in the vicinity of a well by withdrawal of water. The surface area included in the cone is known as the area of influence of the well.

Confined aquifer—An aquifer bounded above and below by impermeable beds, such as clay or rock, and which contains water that is under pressure. Also referred to as an artesian aquifer.

Confined ground water—Water in an artesian or confined aquifer.

Conjunctive water use—The combined use of surface and ground water systems and sources to optimize the resource and to prevent or minimize adverse effects of using a single source.

Conservation storage—The portion of water stored in a reservoir that can be released for all useful purposes, such as municipal water supply, power, irrigation, recreation, and fish and wildlife demands. Conservation storage is the volume of water stored between the inactive pool elevation and flood-control stage. Also referred to as active conservation storage, conservation pool, and usable storage.

Consumptive water use—(1) A use of water that lessons the amount of water available for another use (e.g., water that is consumed by humans or animals). (2) A portion of water withdrawn from a surface or ground water source that is consumed and does not return to its original source or to another body of water. This includes water that is evaporated, transpired by plants, incorporated into products or crops, consumed by humans or livestock, or otherwise removed from the immediate water environment.

Contaminant—Any physical, chemical, biological, or radiological substance or material that has an adverse effect on air, water, or soil.

Contamination—The introduction of microorganisms, chemicals, toxic substances, or wastes into water in a concentration that makes the water unfit for its next intended use.

Core drilling—Cylindrical samples of earth materials obtained by drilling into the earth. The resulting samples (cores) are circular sections of each layer of sediment or rock. Cores are used to delineate and characterize aquifers and confining units and to identify and map geologic formations.

Crest-stage gage—An instrument used to obtain a record of flood crests (peak height).

Dam—(1) A structure of earth, rock, or concrete designed to form a basin and hold water back to make a pond, lake, or reservoir. (2) A barrier built for impounding or diverting the flow of water.

Datum—An elevation to which gage-height readings are referenced.

Dead storage—See *Inactive Pool*.

Depletion—The progressive withdrawal of water from reservoirs or aquifers at a rate greater than that of replenishment.

Desalination—Removal of dissolved salts from saltwater or brackish water to make it usable.

Designated uses—Those water uses identified in State water quality standards that must be achieved and maintained as required under the Clean Water Act. Such uses may include primary contact (swimming), secondary contact (boating), drinking water, shellfish harvesting, and aquatic life support.

Desired flow—A streamflow, greater than the minimum required streamflow, that enhances all instream water-uses.

DHEC—The South Carolina Department of Health and Environmental Control. The State agency responsible for implementing and enforcing State and Federal pollution control programs. http://www.scdhec.net/

Discharge—(1) The flow of surface water in a stream or the flow of ground water from a spring or well. (2) The volume of water that passes a given point in a given period of time.

Discharge point—A location at which effluent is released into a receiving stream or body of water.

Dissolved oxygen (DO)—The concentration of free (not chemically combined) oxygen dissolved in water and readily available to fish and other aquatic organisms. Adequate concentrations of dissolved oxygen are necessary for the life of fish and other aquatic organisms. Usually expressed in milligrams per liter or parts per million.

Dissolved solids—Minerals and organic matter dissolved in water, including salt. Excessive amounts make water unfit to drink or use in industrial processes.

Distribution system—Any combination of pipes, tanks, pumps, and so forth that delivers water from water sources or treatment facilities to the consumer.

Divide—See *Drainage divide*.

DNR—The South Carolina Department of Natural Resources. The State agency responsible for preserving, protecting, and enhancing the natural resources of the State. http://water.dnr.state.sc.us/

Domestic water use—Water used normally for residential purposes, including household use, personal hygiene, drinking, washing clothes, flushing toilets, washing cars, and for lawns, gardens, trees and shrubs. Also referred to as residential water use.

Domestic well—A water well used solely for domestic use.

Drainage area—(1) An area enclosed by a drainage divide from which direct surface runoff from precipitation normally drains by gravity into a common stream. (2) An area having a common outlet for its surface runoff.

Drainage basin—(1) The land area drained by a river. (2) Part of the Earth's surface that is occupied by a drainage system with a common outlet for its surface runoff. The term is used synonymously with *watershed*, *river basin*, and catchment.

Drainage divide—The line of highest elevations that separates adjoining drainage basins.

Drawdown—(1) The act or process of the lowering of the water surface level due to release of water from a reservoir. (2) The magnitude of the lowering of a water surface or a potentiometric surface. (3) The decline of water below the static level during pumping from a well.

Dredging—The process of digging up and removing material from wetlands or from the bottoms of waterways to clear them or make them deeper or wider.

Drought—A period of diminished precipitation that results in negative impacts upon the hydrology, agriculture, biota, energy, and economy of the State. The following are three broad categories of drought:

> ***Meteorological drought*** – such a drought is considered to occur when rainfall is less than the long-term average rainfall over a given time interval.
>
> ***Agricultural drought*** – this type of drought occurs when soil moisture availability to agricultural crops is reduced to a level causing adverse effects on the agricultural production of a region.
>
> ***Hydrological drought*** – the onset of such a drought is signified by the occurrence and/or persistence of meteorological drought causing a shortage of surface water in streams, lakes, and/or ground-water supplies.

Drought contingency plan—A document setting out an organized, planned, and coordinated course of action to be followed in case of a drought.

Drought index—An indicator of drought, or below-normal precipitation conditions. Drought indices are most typically represented as numeric values and are useful for planning. Indices used by the State include sustained decline in water levels of natural flowing streams and other natural bodies of water, decline in water tables, forest fire indices, sustained decline in potable drinking water supplies, agricultural stress, low soil moisture, and low precipitation.

Duration curve—A cumulative frequency curve that shows the percentage of time during which a specified value of a measurable property (e.g., streamflow, discharge, or power) was equaled or exceeded in a given period. Commonly referred to as flow duration curve.

Ecological impact—The effect that a human or natural activity has on living organisms and their environment.

Ecosystem—The interacting system of a biological community and its environmental surroundings.

Effluent—Treated or untreated wastewater that flows out of a treatment plant, sewer, or industrial outfall. Generally, refers to wastes discharged into surface waters.

Elevation—The variation in the height of the earth's surface as measured by the vertical distance from a known datum plane, typically mean sea level (MSL).

EPA—The United States Environmental Protection Agency. Responsible for implementing Federal laws designed to protect the environment. http://www.epa.gov/

Estuary—A region of interaction between rivers and near-shore ocean waters, where tidal action and river flow mix freshwater and saltwater. Such areas include bays, mouths of rivers, salt marshes, and lagoons. These brackish water ecosystems shelter and feed marine life, birds, and wildlife.

Evaporation—The process by which liquid water is converted into water vapor.

Evaporation rate—The quantity of water that is evaporated from a given surface per unit of time. It is usually expressed in inches or depth per day, month, or year.

Evapotranspiration—The loss of water to the atmosphere from water bodies or soil by evaporation and by transpiration from the plants.

Fall Line—An line marking the boundary between igneous and metamorphic rocks of the Piedmont province and sediments of the Coastal Plain province.

FEMA—The Federal Emergency Management Agency. FEMA is responsible for reducing the loss of life and property and protecting our Nation's critical infrastructure from all types of hazards. http://www.fema.gov/

FERC—The Federal Energy Regulatory Commission. FERC regulates and oversees energy industries in the economic and environmental interest of the American public. http://www.ferc.gov/

Flood—Temporary inundation of a normally dry area caused by high flow or overflow of water in an established watercourse, such as a river or stream.

Flood control storage—The control of floodwaters by the construction of flood storage reservoirs, floodwater retaining structures, channel improvements, levees, bypass channels, or other engineering works.

Flood crest—The maximum height of a flood at a particular location.

Flood plain—The flat or nearly flat land along a river or stream or in a tidal area that is covered by water during a flood.

Flood plain management—The operation of an overall program of corrective and preventive measures for reducing flood damage, including flood control projects, flood-plain land-use regulations, flood-proofing of buildings, and emergency preparedness plans.

Flood prevention—Measures that are taken in order to keep flood problems from getting worse. Planning, land acquisition, river channel maintenance, wetlands protection, and other regulations all help modify development on flood plains and watersheds to reduce their susceptibility to flood damage.

Flood stage—A gage height at which a watercourse overtops its banks and begins to cause damage to any portion of the defined reach.

Floodway—(1) The channel and that portion of the adjacent land area that is required through regulations to pass flood flows without increasing the water surface elevation more than a designated height. (2) Defined by FEMA as the stream channel plus that portion of the overbanks that must be kept free from encroachment in order to discharge the 1-percent annual chance of flood without increasing flood levels by more than 1 foot.

Flowing well—A well drilled into a confined aquifer that has enough hydraulic pressure for the water to flow to the surface without pumping. Also called a flowing artesian well.

Fracture—A break in a rock formation due to structural stresses.

Freshwater—Water that generally contains less than 1,000 milligrams per liter of dissolved solids.

Full pool—Maximum water surface elevation of a reservoir under normal operating conditions.

FWS—The United States Fish and Wildlife Service. An agency of the U.S. Department of Interior that is responsible for acquiring, protecting, and managing unique ecosystems necessary to sustain fish and wildlife, operating fish hatcheries, conducting research on fish and wildlife, developing recovery plans for endangered and threatened species, and other responsibilities related to fish and wildlife ecosystems. http://www.fws.gov/

Gaging station—A site on a stream, canal, lake, or reservoir where systematic observations of stage, discharge, or other hydrologic data are obtained. The USGS maintains most of the gaging stations in South Carolina.

Geophysical log—A record of the structure and composition of the earth obtained by lowering probes into a well or test hole.

Gray water—Domestic wastewater composed of wash water from washing machines, showers, bathtubs, and laundry sinks.

Ground water—Water within the earth that seeps downward and saturates the soil or rock, supplying wells and springs.

Ground water flow model—A computer model that uses numerical methods to estimate ground water flow directions and rates.

Ground water level—The elevation of the water table or potentiometric surface at a particular location.

Hazardous waste—Solid, liquid, or gaseous substances that are classified under State or Federal law as potentially dangerous and are subject to special handling, shipping, and disposal requirements.

Headwaters—The source and upper reaches of a stream or reservoir.

Hydraulic head—(1) The height of the surface of a water body above a given point. (2) The difference in water level at two given points.

Hydraulics test—See *Pumping test*.

Hydroelectric plant—Electric power plant in which the energy of falling water is used to spin a turbine generator to produce electricity.

Hydroelectric power—Electricity produced using falling water as a source of energy.

Hydrograph—(1) A graphical representation or plot of changes in the flow of water or in the elevation of water level plotted against time. (2) A graph showing stage, flow, velocity or other hydraulic properties of water with respect to time.

Hydrologic cycle—Movement or exchange of water between the atmosphere and earth.

Igneous rock—A rock formed by the solidification of molten rock.

Impermeable—Unable to transmit water; not easily penetrated. The property of a material or soil that does not allow, or allows only with great difficulty, the movement or passage of water.

Impoundment—A body of water, such as a pond, confined by a dam, dike, floodgate, or other barrier. It is used to collect and store water for future use.

Inactive pool—(1) The volume of water in a reservoir stored below the lowest outlet or operating level. (2) Storage in a reservoir that cannot be released by the dam. Also referred to as dead pool or dead storage.

Industrial water use—Water used for industrial purposes such as fabricating, manufacturing, processing, washing, and cooling, and includes industries as steel, chemical, paper, mining, and petroleum refining.

Infiltration—(1) That portion of rainfall that moves downward into the subsurface rock and soil. (2) The process by which water moves from the surface into the soil.

Inflow—(1) The act or process of flowing in or into, such as water flowing into a reservoir. (2) The volume of water flowing into a reservoir, including precipitation falling onto the surface of the reservoir.

Injection well—A well constructed for the purpose of injecting treated water into the ground.

Instantaneous discharge—The discharge rate at a particular instant of time.

Instream flow—(1) The amount of water remaining in a stream that is required to satisfy a particular water use. (2) Nonconsumptive water in a stream.

Instream reservoir—A lake that is created by impounding a stream channel for use in collecting and storing water for future use. Unlike offstream reservoirs, instream reservoirs dam the stream and interrupt fish and boat passage along the stream.

Instream use—(1) Nonconsumptive uses of water in a stream. (2) Water use that takes place within a stream channel (e.g., hydroelectric power generation, navigation, water quality improvement, fish propagation, and recreation).

Interbasin transfer—The physical transfer of water from one watershed to another.

Interstate water compact—(1) Broadly, an agreement between two or more states regarding competing demands for water resources that are beyond the legal authority of one state alone to solve. (2) An agreement negotiated between states, adopted by their state legislatures, and approved by Congress.

Irrigation—The controlled application of water to soil when rainfall is insufficient to maintain desirable soil moisture for plant growth.

Land application—The discharge of treated effluent onto the ground for reuse, typically for irrigation.

Landfill—(1) Sanitary landfills are disposal sites for non-hazardous solid wastes spread in layers, compacted to the smallest practical volume, and covered by material applied at the end of each operating day. (2) Secure chemical landfills are disposal sites for hazardous waste, selected and designed to minimize the chance of release of hazardous substances into the environment.

Limestone—A sedimentary rock composed of calcium carbonate, and sometimes containing shells and other hard parts of prehistoric water animals and plants.

Maximum Contaminant Level (MCL)—Legally enforceable standards regulating the maximum allowed amount of certain chemicals in drinking water. The MCL is the greatest amount of a contaminant that can be present in drinking water without causing a risk to human health. MCLs are set for certain inorganic and organic chemicals, turbidity, coliform bacteria, and certain radioactive materials.

Mercury—A heavy metal that can accumulate in the environment and is highly toxic if inhaled or ingested.

Metamorphic rock—A sedimentary or igneous rock that has been changed by pressure, heat, or chemical action. For example, limestone, a sedimentary rock, is converted to marble, a metamorphic rock.

Methylmercury—An organic compound formed by the action of certain bacteria on available supplies of inorganic mercury in stream-bottom sediments containing low concentrations of dissolved oxygen. Has known neurological toxicity effects in humans.

Minimum required streamflow—The minimum amount of water required in a stream to protect fish and wildlife, protect water quality, meet navigation needs, and to prevent saltwater intrusion. Also referred to as minimum instream flow.

Mitigation—Actions designed to lessen or reduce adverse impacts.

Monitor well—(1) A well used to obtain water quality samples or measure ground water levels. (2) A well drilled at a landfill or hazardous waste management facility to collect ground-water samples for the purpose of physical, chemical, or biological analysis to determine the amounts, types, and distribution of contaminants in the ground water beneath the site.

Municipal water use—Water supplied for municipal uses through a distribution system.

National Flood Insurance Program (NFIP)—A federal program enabling property owners in participating communities to purchase insurance for the protection against losses from flooding.

National Pollutant Discharge Elimination System (NPDES)—A program established by the Clean Water Act that requires all point sources of pollution discharging into any "waters of the United States" to obtain a permit from the EPA or the State. The permit lists permissible discharges and/or the level of cleanup technology required for wastewater.

Navigable—Waters which are now navigable, or have been navigable at any time, or are capable of being rendered navigable by the removal of accidental obstructions, by small pleasure or sport fishing boats or by rafts of lumber or timber.

Nitrates—Nitrates are chemical compounds used as fertilizers to supply a source of nitrogen for plant growth. Nitrates washed into surface waters can lead to excessive growth of aquatic plants and can cause dissolved-oxygen levels to decrease.

Nonconsumptive water use—Water use in which the water is not consumed or lost from the system. Examples include hydropower generation, boating, and fishing.

Nonpoint-source (NPS) pollution—(1) Pollution discharged over a wide land area, not from a specific location. (2) Water pollution caused by diffuse sources with no discernable distinct point of source, often referred to as runoff or polluted runoff from agriculture, urban areas, mining, construction sites, and other sites. The pollutants are generally carried off the land by storm water.

NRCS—The Natural Resources Conservation Service. An agency of the U.S. Department of Agriculture, the Natural Resources Conservation Service works in soil and water conservation, resource inventories, and rural community development. Formerly known as the Soil Conservation Service.
http://www.nrcs.usda.gov/

Nutrient pollution—Contamination of water resources by excessive inputs of nutrients, usually nitrogen and phosphorus. In surface waters, excess algal production is a major concern of nutrient pollution.

Offstream reservoir—A reservoir built adjacent to a stream in which water is diverted from the stream and stored in the reservoir for later use. Unlike instream reservoirs, offstream reservoirs do not dam the stream and interrupt fish and boat passage along the stream.

Offstream use—Water withdrawn or diverted from surface or ground water sources for use at another place. Examples of offstream use include public-water supply, industry, irrigation, thermoelectric power generation, and other uses.

Origin basin—The basin from which water is removed during an interbasin transfer.

Outcrop—(1) Subsurface formations that become exposed at the surface. (2) An area where subsurface formations are exposed at the surface.

Outflow— (1) The act or process of flowing out, such as water being released from a reservoir. (2) The volume of water leaving a hydrologic system, such as a reservoir, including evaporation and seepage.

Overpumping—Pumping a well at a rate that causes a significant decline in the potentiometric surface, subsidence of the land surface, or a degradation of water quality.

Partial-record station—A gaging station at which discrete measurements of one or more hydrologic parameters are obtained over time without continuous data being recorded. A common example is a crest-stage gage, at which only peak stages are recorded.

Pathogens—Microorganisms (e.g., bacteria, viruses, or parasites) that can cause disease in humans, animals, and plants.

Period of record—The period of time during which hydrological measurements have been collected at a given location; such as the period of time that a streamflow gage has been in operation at a specific site.

Permeability—(1) The capacity of soil, sediment, or porous rock to transmit water. (2) For a rock or earth material, the ability to transmit fluids or the rate at which fluids pass through soil. Hydraulic conductivity and permeability are typically used synonymously in water-related studies.

Physiographic province—A region of which all parts are similar in geologic structure and climate and which has consequently had a unified geomorphic history; a region whose pattern of relief features or landforms differs significantly from that of adjacent regions.

Piedmont province—An area of the State northwest of the Fall Line that is characterized by rolling hills and elevations which range from about 500 to 1,000 feet. Piedmont refers to an area or plain at the base of a mountain. In the United States, the Piedmont province is a plateau extending from New Jersey to Alabama and lying east of the Appalachian Mountains.

Plume—A relatively concentrated mass of chemical contaminants spreading in the environment that were released from a point source into either a surface water body or an aquifer.

Point-source—A stationary location or fixed facility from which pollutants are discharged; any single identifiable source of pollution, such as a pipe, ditch, ship, pit, or factory smokestack.

Point-source pollution—Pollution originating from any discrete source, such as a pipe, ditch, or sewer.

Pollutant—Generally, any substance introduced into the environment that adversely affects the usefulness of a resource or the health of humans, animals, or ecosystems.

Pollution—Generally, the presence of a substance in the environment that because of its chemical composition or quantity prevents the functioning of natural processes and produces undesirable environmental and health effects. Under the Clean Water Act, for example, the term has been defined as the man-made or man-induced alteration of the physical, biological, chemical, and radiological integrity of water.

Potable water—Water that is safe for drinking and cooking.

Potentiometric surface—A surface that represents the static head of ground water in tightly cased wells that tap a confined aquifer. The potentiometric surface is defined by the levels to which water will rise in these wells.

Predevelopment—Refers to the potentiometric-surface or water-table elevation of an aquifer before ground water was withdrawn from the aquifer. Predevelopment water levels are estimated with computer modeling programs.

Primary drinking water regulation—A regulation applying to public water systems that specifies a contaminant level that, in the judgment of the EPA, will not adversely affect human health.

Primary drinking water standards—Enforceable regulations applying to public water systems and specifying the maximum contamination levels that, in the judgment of the EPA, are required to protect the public welfare.

Public supply water—Water withdrawn by public and private water suppliers and delivered to users who do not supply their own water.

Public Trust Doctrine—A judicial doctrine under which the State holds its navigable waters and underlying beds in trust for the public and is required or authorized to protect the public interest in such waters.

Public water system—A system that provides piped water for human consumption to at least 15 service connections or regularly serves 25 individuals for at least 60 days per year.

Pumping test—A test involving the withdrawal of a fixed quantity of water from a well to determine the hydraulic properties of an aquifer. Also referred to as an aquifer test or hydraulics test.

Radionuclide—Radioactive chemicals that usually occur naturally and are found in drinking water supplies. Radium and uranium are examples of radionuclides found South Carolina.

Receiving basin—The basin that receives water from another basin (origin basin) during an interbasin transfer.

Recharge—The downward movement of water through soil to ground water. There are three types of recharge:

> ***Natural recharge*** – precipitation or other natural surface flows making their way into ground water supplies.
> ***Artificial or induced recharge*** – actions by man specifically designed to increase supplies in an aquifer through various methods, such as water spreading (flooding), ditching, or pumping.
> ***Incidental recharge*** – actions such as irrigation and water diversion that add to ground water supplies but are intended for other purposes.

Recharge area—The land area over which precipitation infiltrates into soil and percolates downward to replenish an aquifer. Also referred to as recharge zone.

Recharge rate—The quantity of water per unit of time that replenishes or refills an aquifer.

Recorder—A mechanical apparatus that records measured hydrologic parameters, such as streamflow rates or aquifer water levels.

Recurrence interval—A statistical expression of the average time between floods or other hydrologic events that equal or exceed a given magnitude. For example, a flood that would be equaled or exceeded on the average of once in 100 years would have a recurrence interval of 100 years, or a 1-percent chance of occurring in any year. The actual times between occurrences vary randomly. Also referred to as the return period.

Recycled water—Water that is used more than one time before it passes back into the natural hydrologic system. Also referred to as recirculated water.

Recycled wastewater—Wastewater that becomes suitable for a specific beneficial use (such as irrigation) as a result of treatment. Also referred to as reclaimed wastewater.

Regulated stream—A stream whose flow has been manipulated either by a dam or by diversion.

Release schedule—A schedule of when and how much water will be released from a reservoir.

Relicensing—The process of renewing a license previously issued by the Federal government (commonly involving the Federal Energy Regulatory Commission) to operate a hydroelectric power plant.

Renewable resource—A natural resource that can be continuously replenished in the course of natural events and within the limits of human time. Water is an example of a renewable resource.

Resource Conservation and Recovery Act (RCRA)—Federal legislation requiring that hazardous wastes be tracked from generation to disposal.

Reservoir—(1) Any natural or artificial holding area used to store, regulate, or control water. (2) An artificially created lake in which water is collected and stored for future use.

Reverse osmosis—The process of removing salts from water using a membrane.

Riparian—Pertaining to the banks of a river, stream, waterway, or other typically flowing body of water. Also commonly used in reference to other water bodies such as ponds and lakes.

Riparian Rights Doctrine—The system for allocating water used in England and the eastern United States, in which owners of land along the banks of a stream or water body have the right to reasonable use of the waters and a correlative right protecting against unreasonable use by others that substantially diminishes the quantity or quality of water.

Riparian owner—One who owns land on the bank of a river or on other water bodies.

River basin—(1) A term used to designate the area drained by a river and its tributaries. (2) The area from which water drains to a single point. Also referred to as a watershed.

River stage—The elevation of a stream's water surface at a specified location. Usually referenced to an arbitrary zero datum or to mean sea level.

Rule curve—A graphical representation of the desired operating water level of a reservoir throughout a year. Also known as a guide curve.

Runoff—(1) That portion of precipitation that moves over the land into surface water bodies. (2) That portion of precipitation not intercepted by vegetation, absorbed by the land surface, or evaporated, and thus flows overland into a stream, lake, pond, or ocean.

Safe Drinking Water Act (SDWA)—A water-related program administered by the EPA that protects public health by ensuring that the source of drinking water as well as the system storage distribution and service lines are free and protected from contamination. Establishes uniform drinking water standards for the Nation.

Saltwater—Water that contains a relatively high percentage of dissolved solids. Generally, there are four categories, based on the dissolved solids concentration in parts per million (ppm):

Brackish water – 1,000 to 3,000 ppm
Moderately saline water – 3,000 to 10,000 ppm
Very saline water – 10,000 to 35,000 ppm
Brine – more than 35,000 ppm. Seawater has a concentration of 33,000 to 36,000 ppm.

Saltwater intrusion—The invasion of a body of freshwater by a body of saltwater. It can occur either in surface-water bodies or in aquifers. The term is applied to the flooding of freshwater marshes by seawater, the migration of seawater up rivers and navigation channels, and the movement of seawater into freshwater aquifers in coastal areas.

Sanitary survey—An onsite review of the water resources, facilities, equipment, operation, and maintenance of a public water system.

Saprolite—A soft, clay-rich, thoroughly decomposed rock formed in place by chemical weathering of igneous or metamorphic rock. Forms in humid, tropical, or subtropical climates.

Scenic Rivers Program—Created by the South Carolina Scenic Rivers Act of 1989, this program has the purpose of protecting "unique or outstanding scenic, recreational, geologic, botanical, fish, wildlife, historic or cultural values" of selected rivers or river segments in the state. The goal of the program is the conservation of South Carolina's river heritage through the proper management of the natural and cultural character of the State's river corridors.

Sediment—Soil particles that have been transported from their original location by wind or water action. Most particles originate from disintegrated rocks, such as sand and clay, but some are derived from chemical or biochemical precipitates, such as limestone, and some from decomposed organic material, such as humus.

Seepage—(1) The passage of water or other fluid through a porous medium. (2) The slow movement of water through small cracks, pores, or interstices of a material into or out of a body of surface or subsurface water. (3) The interstitial movement of water that may take place through a dam, its foundation, or abutments.

Self-supplied water—Water withdrawn from a surface or ground water source by a user rather than being obtained from a public water-supply system.

Southeastern Power Administration (SEPA)—Federal power administration that markets electricity (mainly hydroelectric power generated from dams and reservoirs operated by the U.S. Corps of Engineers) to utilities companies in West Virginia, Virginia, North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, Tennessee, Kentucky, and southern Illinois.

7Q10—Seven-day, 10-year low flow of a stream. The minimum flow averaged over 7 consecutive days that is expected to occur, on average, once in any 10-year period. The 7Q10 has a 10-percent chance of occurring in any given year.

Sewage sludge—Settled sewage solids combined with varying amounts of water and dissolved materials that are removed by screening, sedimentation, chemical precipitation, or bacterial digestion. The disposal of sewage sludge is regulated under the Clean Water Act. Also referred to as biosolids or sludge.

Sinkhole—A depression in the earth's surface caused by dissolving of underlying limestone, salt, or gypsum.

Soil Conservation Service—The former name of a branch of the United States Department of Agriculture, renamed the Natural Resources Conservation Service (NRCS). See *NRCS*.

Sole-source aquifer—An aquifer that is the sole or principal source (50-percent or more) of drinking water for a geographic area, as established by the Safe Drinking Water Act.

Source Water Assessment Program (SWAP)—A requirement established under the 1996 amendments to the Safe Drinking Water Act that requires each state to develop and implement a program to identify ground and surface waters that supply drinking water for public water systems. Once a source area is identified or delineated, a state must then locate contaminants within the delineated area that could potentially degrade source water.

Source Water Protection Area (SWPA)—A description of the drinking-water source and the land area that contributes water to that source.

Specific conductance—A measure of the ability to conduct an electrical current. It is commonly used as a field method of estimating the dissolved solids content water. Specific conductance is measured in wells along the coast to detect saltwater intrusion.

Spillway—A channel or passageway around or over a dam through which excess water or flood flows are discharged. If gates control the flow, it is a controlled spillway; if the elevation of the spillway crest is the only control, it is an uncontrolled spillway.

Spring—A place where ground water flows naturally from a rock or the soil onto the land surface or into a body of water.

Stage—The level of the water surface above a given datum at a given location. Generally refers to the level of water in a stream.

Stage-only gage—An instrument used to measure the stage (height) of the water in a stream, canal, lake, or reservoir. The USGS maintains most of the stage-only gages in South Carolina.

Stakeholders—Individuals and organizations with an interest in a particular area, issue, or project. Stakeholders may include public agencies at all levels, non-profit organizations, private landowners, and industries.

State Drought Response Committee—A committee authorized by the South Carolina Drought Response Act that analyzes drought conditions and makes recommendations as to the severity of droughts. It consists of representatives from the S.C. Department of Natural Resources, S.C. Emergency Preparedness Division of the Office of the Adjutant General, S.C. Department of Health and Environmental Control, S.C. Department of Agriculture, and S.C. Forestry Commission.

Storage—(1) Water artificially impounded in surface or underground reservoirs for future use. (2) Water naturally detained in a drainage basin, such as ground water, channel storage, and depression storage.

Static level—The level of water in a non-pumping or non-flowing well.

Storage capacity—The total volume of a reservoir, exclusive of surcharge.

Streamflow—(1) Water flowing in the stream channel. (2) The discharge that occurs in a natural channel. (3) The amount of water that moves past a fixed point during a given period of time.

Streamflow gage—An instrument used to measure the volume of water flowing in a stream or canal. The USGS maintains most of the streamflow gages in South Carolina.

Sub-basin—A portion of a basin drained by a single stream or group of minor streams.

Subirrigation—(1) Irrigation below the land surface (as by periodic rise in water table). (2) Irrigation from the water table that is supplied by seepage from overlying canals, reservoirs, or irrigated fields.

Subsidence—The sinking or settling of land due to a number of factors, one of which is the pumping of ground water.

Surface water—(1) All water naturally open to the atmosphere (rivers, lakes, reservoirs, ponds, streams, impoundments, seas, estuaries, etc.). (2) Water that remains on the earth's surface. (3) A source of drinking water that originates in rivers, lakes, and reservoirs.

Thermoelectric power—Electrical power generated using fossil fuels (coal, oil, or natural gas), geothermal heat, or nuclear energy.

Total Maximum Daily Load (TMDL)—The maximum quantity of a particular water pollutant that can be discharged into a body of water without violating a water quality standard.

Transmissivity—(1) The rate at which water is transmitted through a unit width of an aquifer under a unit hydraulic gradient. (2) The ability of an aquifer to transmit water.

Transpiration—(1) The movement of water from the soil or ground water to the atmosphere via plant cells. (2) The process by which water vapor escapes from a living plant, principally through the leaves, and enters the atmosphere. Transpiration, combined with evaporation, is referred to as evapotranspiration.

Unconfined aquifer—An aquifer containing water that is under atmospheric pressure. The water level in a well that penetrates an unconfined aquifer is the same as the water table outside the well.

Underground Injection Control Program (UIC)—A program required in each state by a provision of the Safe Drinking Water Act for the regulation of injection wells, including a permit system.

Unregulated stream—A stream that has not been dammed or diverted.

Unsaturated zone—The ground above the water table in which soil pores are not fully saturated, although some water may be present.

USGS—The United States Geological Survey. An agency of the U.S. Department of the Interior, responsible for extensive earth-science studies of the Nation's land, water, and mineral resources. http://www.usgs.gov/

Volatile Organic Compounds (VOC)—Organic compounds, most of which are man-made, that are used and produced in the manufacture of paints, adhesives, petroleum products, pharmaceuticals, and refrigerants. They are often compounds of fuels, solvents, hydraulic fluids, paint thinners, and dry cleaning agents. VOC contamination of drinking-water supplies is a human health concern because many are toxic and are known or suspected human carcinogens.

Wastewater—A combination of liquid and water-carried pollutants from homes, businesses, industries, or farms; the spent or used water that contains dissolved or suspended solids.

Wastewater treatment plant—A water effluent treatment facility containing a series of tanks, screens, filters, and other mechanical, biological, and chemical processes by which pollutants are removed from water.

Water budget—An accounting of the inflows to, the outflows from, and the storage changes of water in a hydrologic system.

Water demand—The water requirements for a particular purpose, such as irrigation, power production, municipal supply, or storage.

Water level—(1) A measurement of the height of the surface of still water. (2) The water-surface elevation or stage of the free surface of a body of water above or below any datum, or the surface of water standing in a well, which is usually indicative of the position of the water table or potentiometric surface.

Water-quality criteria—A specific level or range of levels of water quality necessary for the protection of a water use. Criteria are based on specific levels of pollutants that would make the water harmful if used for drinking, swimming, farming, fish production, or industrial processes.

Water-quality standards—State-adopted and EPA-approved ambient standards for water bodies. The standards prescribe the use of the water body and establish the water-quality criteria that must be met to protect designated uses.

Watershed—(1) An area that, because of topographic slope, contributes water to a specified surface-water drainage system, such as a stream or river. The watershed for a major river may encompass a number of smaller watersheds that ultimately combine at a common point. (2) An area confined by topographic divides that drains a given stream or river. Also referred to as a *drainage basin*.

Watershed Protection Approach (WPA)—A type of pollution management program supported by the EPA as being the most effective mechanism for achieving clean water. The WPA is an approach that integrates water quality management activities within hydrologically-defined drainage basins, or watersheds, as opposed to conventional, politically-defined boundaries. Public participation is emphasized and stakeholders can tailor management activities to local concerns within the watershed.

Water supply system—The infrastructure used for the collection, treatment, storage, and distribution of potable water from source to consumer.

Water table—(1) The water level in an unconfined aquifer at which the pressure is atmospheric. It is found at the level at which water stands in wells that penetrate the aquifer just far enough to hold standing water. (2) The upper surface of the saturated zone in an unconfined aquifer.

Water-table aquifer—An unconfined aquifer within which the water table occurs.

Water well—An excavation drilled, dug, bored, driven, or jetted into the ground where the intended use is for the location, acquisition, development, or artificial recharge of ground water.

Wellhead—(1) The source of a well or stream. (2) The physical structure, facility, or device at the land surface from or through which ground water flows or is pumped.

Wellhead protection area—A protected surface and subsurface zone surrounding a well or well field supplying a public water system to prevent contaminants from reaching the well water.

Wellhead Protection Program—A program intended to protect and preserve the quality of ground water that is used as a source of drinking water.

Wetland—An area that is periodically inundated or saturated by surface or ground water on an annual or seasonal basis, that displays hydric soils, and that typically supports or is capable of supporting hydrophytic vegetation. Other common names for wetlands are sloughs, ponds, swamps, bogs, and marshes. All definitions of wetlands generally require that at least one of the following attributes be met:

> ***Wetland hydrology*** – at some time in the growing season, the substrate is periodically or permanently saturated with or covered by water.
>
> ***Hydrophytic vegetation*** – at least periodically, the land supports predominantly water-loving plants such as cattails, rushes, or sedges.
>
> ***Hydric soils*** – the area contains undrained, wet soil that is anaerobic, or lacks oxygen in its upper levels.

This glossary was compiled from numerous sources including the *Glossary of Geology* (Bates and Jackson, 1987) and online glossaries provided by the Nevada Division of Water Resources, U.S. Environmental Protection Agency, National Weather Service, and United States Geological Survey.

Nevada Division of Water Resources:
http://water.nv.gov/Water%20planning/dict-1/ww-index.htm

U.S. Environmental Protection Agency:
http://www.epa.gov/OCEPAterms/

National Weather Service:
http://www.srh.noaa.gov/wgrfc/resources/glossary/a.html

United States Geological Survey:
http://search.usgs.gov/query.html?qt=glossary

ABBREVIATIONS and ACRONYMS

ACE	Ashepoo-Combahee-Edisto river basin
ASR	Aquifer Storage and Recovery
BMP	Best Management Practice
CFS	Cubic feet per second
COE	United States Army Corps of Engineers
COG	Council of Governments
CPP	Continuing Planning Process
CWA	Federal Clean Water Act
DHEC	South Carolina Department of Health and Environmental Control
DNR	South Carolina Department of Natural Resources
EPA	United States Environmental Protection Agency
FEMA	Federal Emergency Management Agency
FERC	Federal Energy Regulatory Commission
FWS	United States Fish and Wildlife Service
GPM	Gallons per minute
MGD	Million gallons per day
MRRI	Marine Resources Research Institute
NAWQA	National Water Quality Assessment Program
NFIP	National Flood Insurance Program
NPDES	National Pollutant Discharge Elimination System
NPS	Nonpoint-Source Pollution
NRCS	Natural Resources Conservation Service
SCE&G	South Carolina Electric and Gas
SCPCA	South Carolina Pollution Control Act
SCWRC	South Carolina Water Resources Commission
SDWA	Safe Drinking Water Act
SEPA	Southeastern Power Administration
SWAP	Source Water Assessment Program
SWPA	Source Water Protection Area
TMDL	Total Maximum Daily Load
UIC	Underground Injection Control Program
USGS	United States Geological Survey
7Q10	Seven-day, 10-year low flow