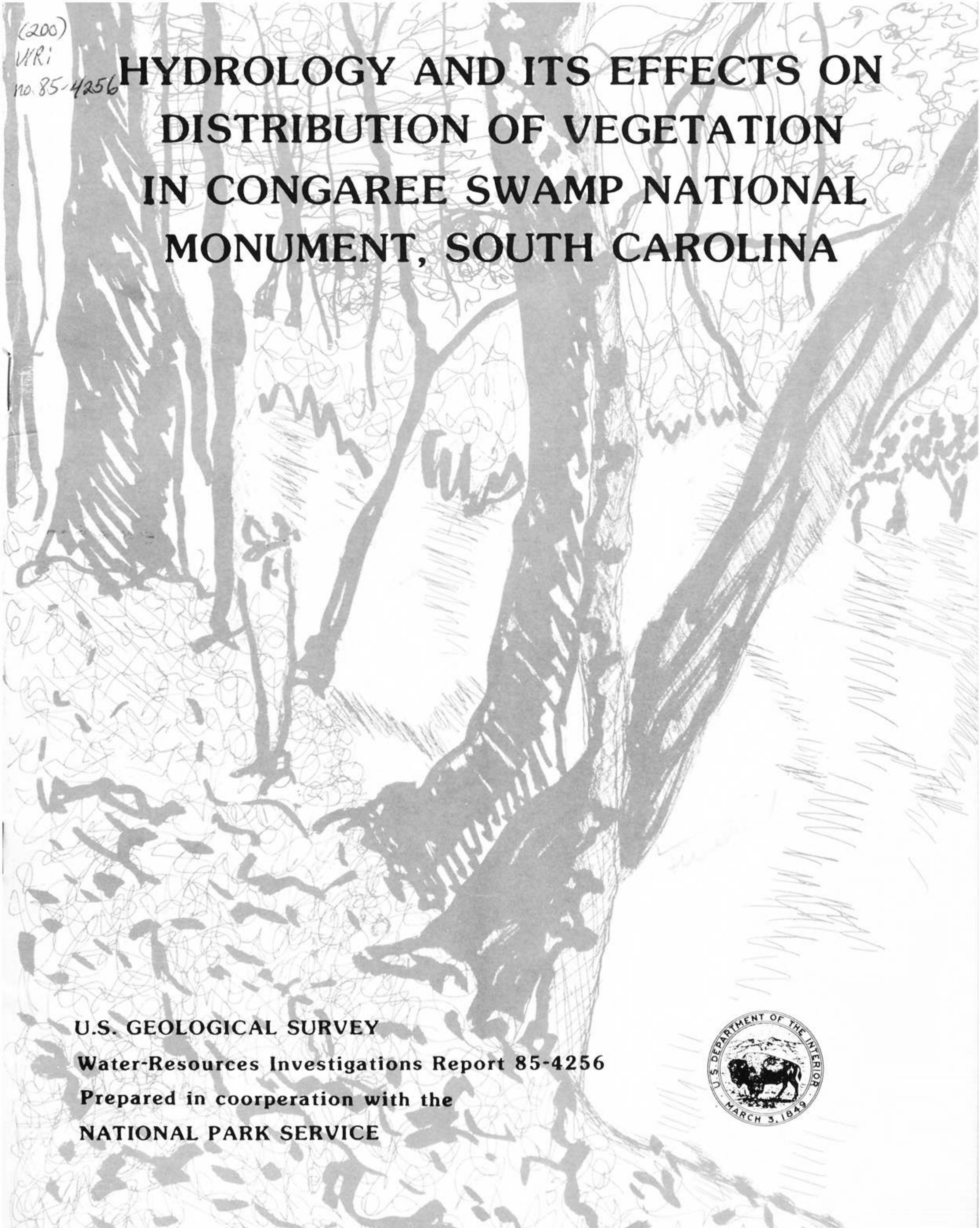
(200)
WRi
no. 85-4256



HYDROLOGY AND ITS EFFECTS ON DISTRIBUTION OF VEGETATION IN CONGAREE SWAMP NATIONAL MONUMENT, SOUTH CAROLINA

U.S. GEOLOGICAL SURVEY

Water-Resources Investigations Report 85-4256

Prepared in coorperation with the

NATIONAL PARK SERVICE

U.S. DEPARTMENT OF THE INTERIOR
MARCH 3, 1849

HYDROLOGY AND ITS EFFECTS ON DISTRIBUTION OF VEGETATION IN CONGAREE SWAMP NATIONAL MONUMENT, SOUTH CAROLINA

by Glenn G. Patterson, Gary K. Speiran, and Benjamin H. Whetstone

---

U.S. GEOLOGICAL SURVEY

Water-Resources Investigations Report 85-4256

U. S. GEOLOGICAL SURVEY
RESTON, VA.
JUN 3 1987
LIBRARY

Prepared in cooperation with the

NATIONAL PARK SERVICE

Columbia, South Carolina

1985

UNITED STATES DEPARTMENT OF THE INTERIOR

DONALD PAUL HODEL, Secretary

GEOLOGICAL SURVEY

Dallas L. Peck, Director

For additional information
write to:

District Chief
U.S. Geological Survey, WRD
1835 Assembly Street, Suite 658
Columbia, South Carolina 29201

Copies of this report can be
purchased from:

Open-File Services Section
U.S. Geological Survey
Federal Center, Box 25425
Denver, Colorado 80225
(Telephone: 303/236-7476)

CONTENTS

ILLUSTRATIONS

TABLES

CONVERSION FACTORS AND ABBREVIATIONS OF UNITS

The following factors may be used to convert the inch-pound units published herein to the International System of units (SI).

Multiply inch-pound units	by	To obtain SI units
inch (in.)	25.40	millimeter (mm)
foot (ft)	0.3048	meter (m)
square foot (ft^2)	0.09294	square meter (m^2)
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
cubic foot per second per square mile [$(ft^3/s)/mi^2$]	0.01093	cubic meter per second per square kilometer [$(m^3/s)/km^2$]
mile (mi)	1.609	kilometer (km)
square mile (mi^2)	2.590	square kilometer (km^2)
acre	4,047.	square meter (m^2)

Temperature in degrees Fahrenheit (°F) can be converted to degrees Celsius (°C) as follows: $°C = \frac{5}{9} (°F - 32)$

HYDROLOGY AND ITS EFFECTS ON DISTRIBUTION OF VEGETATION IN CONGAREE SWAMP NATIONAL MONUMENT, SOUTH CAROLINA

by Glenn G. Patterson, Gary K. Speiran, and Benjamin H. Whetstone

ABSTRACT

Congaree Swamp National Monument preserves a large stand of old-growth southern bottomland hardwood forest on the flood plain of the Congaree River. The distribution of vegetation types in the Monument is controlled by duration of saturated soil conditions during the growing season, which is related to duration of inundation by the flooding river. During dry periods upland streams fed by seepage from shallow and deep aquifers supply water to the flood plain, and the potentiometric gradient in the flood plain slopes toward the river. During floods river water flows into the flood plain through breaches in the natural levee, inundating as much as 90 percent of the Monument an average of once per year. During floods the potentiometric gradient briefly slopes away from the river. The frequency of large floods has decreased slightly since completion of Lake Murray Dam in 1929.

INTRODUCTION

Congaree Swamp is in the forested flood plain of the Congaree River in central South Carolina. It is similar to bottomland hardwood swamps that originally existed on flood plains throughout the southeastern United States. A large stand of virgin bottomland hardwoods is one of the exceptional characteristics of the Swamp. A 15,135 acre part of Congaree Swamp was designated as Congaree Swamp National Monument in 1978 to preserve this natural swamp ecosystem for research and enjoyment, and for education of visitors.

The swamp ecosystem is maintained by periodic flooding and a shallow water table (Wharton and others, 1982, p. 16). The relation between vegetation and hydrology in swamps is sufficiently distinct to permit estimation of flood characteristics by evaluating the distribution of tree species (Bedinger, 1981, p. 173; Leitman and others, 1982, p. A41). Because of the influence of water on the ecosystem and on management considerations for the Monument, the National Park Service and the U.S. Geological Survey cooperated in a study of the hydrology of Congaree Swamp National Monument. The objectives of the study were to:

1. Delineate the network of surface channels within the Monument;

2. Delineate areas of inundation at different stages of the Congaree River;

3. Compare water levels in the Congaree River, Cedar Creek, and the shallow ground-water system;

4. Describe the interrelations of ground water and surface water within the Monument; and

5. Describe the influence of hydrology on the distribution of plant communities within the Monument.

DESCRIPTION OF STUDY AREA

Congaree Swamp National Monument is located about 20 miles southeast of Columbia, South Carolina (fig. 1). The Monument lies almost entirely within the flood plain on the northern side of the Congaree River in the Coastal Plain Physiographic Province. It is about 3 miles wide and 12 miles long, and has an area of 15,135 acres.

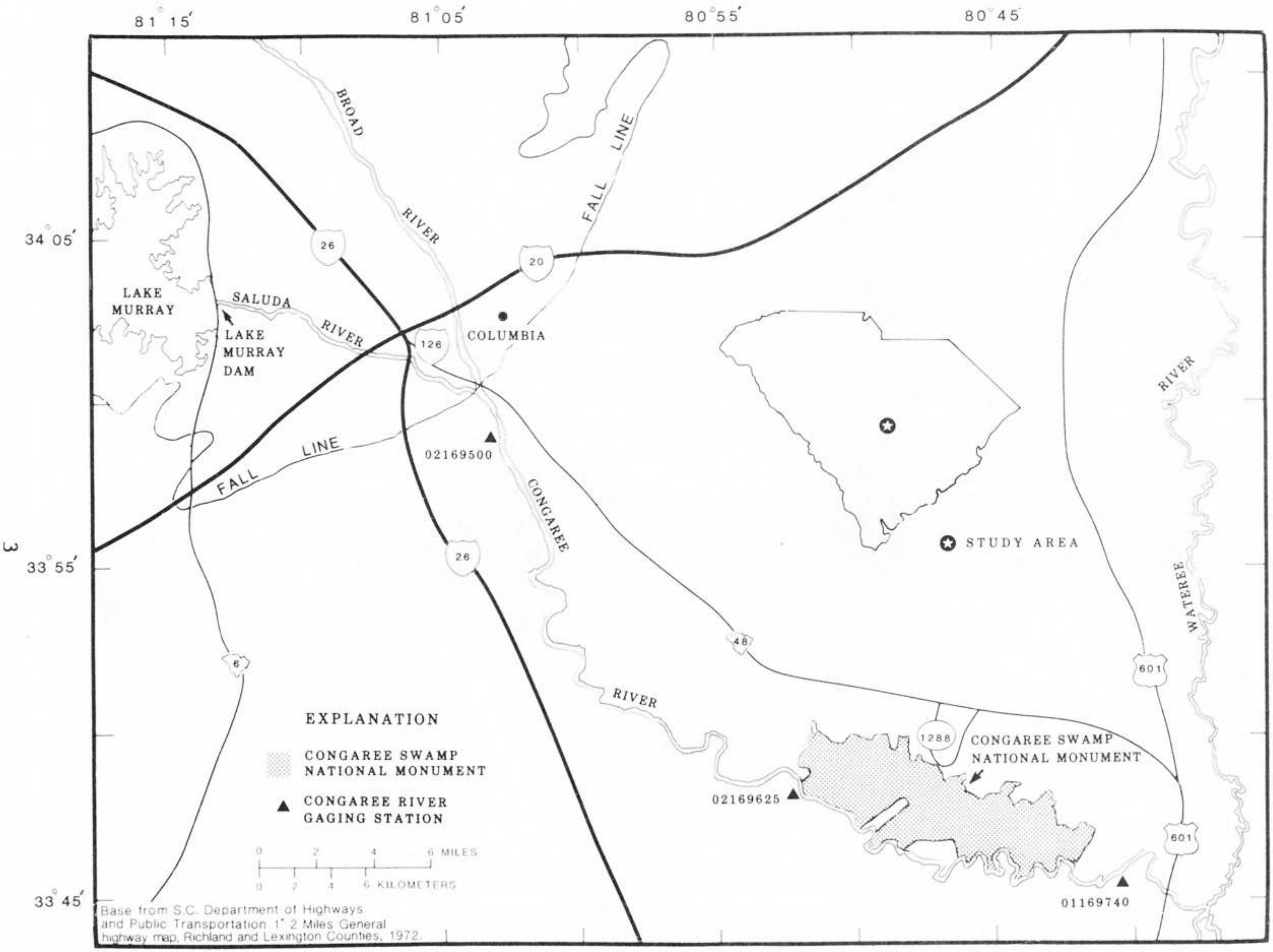


Figure 1.--Location of Congaree Swamp National Monument and streamflow gaging stations on the Congaree River

Topography

Land surface altitudes within the Monument range from about 80 feet to about 120 feet above sea level. Altitudes within the flood plain of the Monument range from about 80 feet to about 100 feet above sea level. The present Congaree River channel is near the southern edge of the flood plain where steep bluffs of the Congaree Sand Hills rise to altitudes of about 300 feet above sea level within 1,200 feet of the flood plain. North of the flood plain, the land surface rises in a series of low scarps and terraces. These terraces are the Wicomico (125 feet above sea level), Okefenokee (150 feet above sea level), Sunderland (180 feet above sea level), Coharie (220 feet above sea level) and Hazelhurst (270 feet above sea level) (Colquhoun, 1965).

The topography of the Monument is dominated by two parallel features that slope southeastward, the channel of the Congaree River and the flood plain. The deep, narrow channel of the Congaree River has banks generally 8 to 10 feet high at normal stages of the river. The flood plain is a wide, nearly flat plain separated from the river channel by a low natural levee on the northern bank of the Congaree River. This type of levee is a common feature along aggrading rivers that deposit sediment on broad flood plains. (Bedinger, 1981 p. 163). The levee is breached in several places by small channels that connect the river and the flood plain. Except for brief periods following large floods, flow through most of the breaches in the natural levee is from the Congaree River toward Cedar Creek. The major exception is the mouth of Cedar Creek, a tributary that meanders through the flood plain before discharging into the river (fig. 2). Most of the discharge from the flood plain is to the Wateree River which joins the Congaree River a few miles below the Monument.

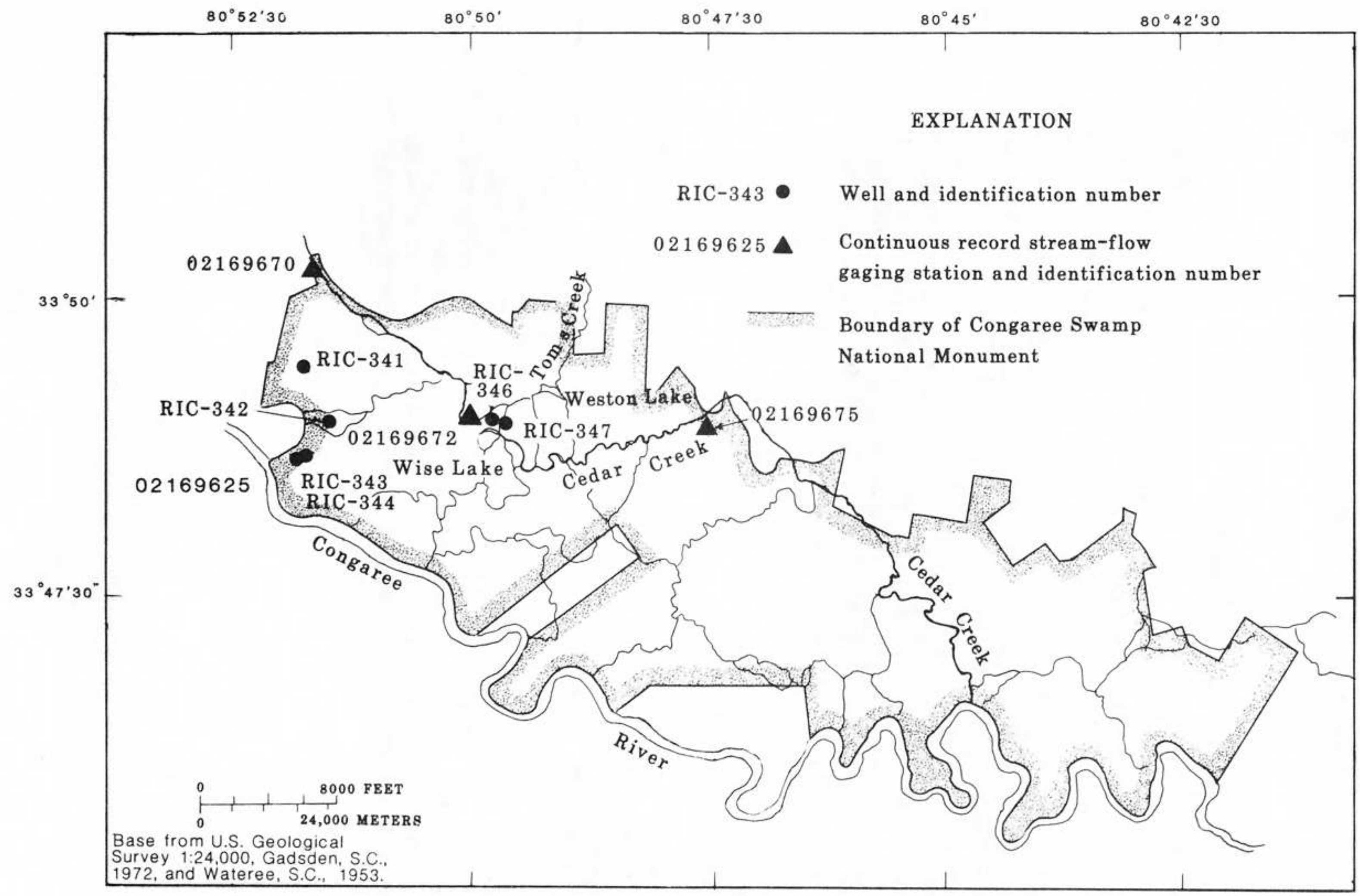


Figure 2.--Location of Congaree Swamp National Monument, streamflow gaging stations, and observation wells

The flood plain contains innumerable sloughs and channels. Periodically, the Congaree River has changed its course, bypassing sharp bends and leaving oxbow lakes such as Weston Lake and Wise Lake, in the western part of the Monument.

Geology

The geologic formations underlying Congaree Swamp National Monument consist of a pre-Cretaceous basement complex of igneous and metamorphic crystalline rock overlain by approximately 500 feet of unconsolidated interbedded sand and clay of Late Cretaceous and younger ages. The Middendorf Formation, formerly known as part of the Tuscaloosa Formation (Cooke, 1936), and, possibly, older formations are between a depth of 350 feet and basement. Cretaceous sediments above a depth of about 350 feet include the stratigraphic equivalent of the Black Creek Formation.

Holocene deposits occur from land surface to a depth of at least 55 feet within the flood plain and consist of an alluvial fining-upward sequence of gravel, sand, silt, and clay. In three wells (RIC-341, RIC-344, and RIC-346) (fig. 2) drilled in the flood plain in the western part of the Monument, the deeper deposits were mostly gravel, sand, and clayey sand whereas the shallower materials were mostly fine-grained sand, silt and clay (table 1). The sediments are more uniform with depth in well RIC-345, located just outside of the flood plain and consist primarily of medium-to fine-grained quartz sand with some silt and clay (table 1).

Thin layers of sediment are added periodically to the Holocene deposits within the Monument during each inundation of the flood plain. The rate of sediment accumulation varies greatly from place to place within the flood plain, but is greatest near the banks of the Congaree River. The sediments deposited near the banks are usually coarser-grained than those deposited farther from the river in the flood plain. The rate of sediment transport and, presumably, deposition increased greatly following settlement of the basin by European immigrants during the 19th century. During the last two decades the rate of sediment transport has begun to decrease again, in response to abandonment of farms and implementation of soil convservation practices during the early part of the 20th century (Patterson and Cooney, 1986).

Table 1. -- Lithologic logs of RIC-341, RIC-344, and RIC-345, and RIC-346

Depth	Description of material
	RIC-341, total depth 24 feet
0-5	Brown, silty, clayey fine sand; 50 percent fine quartz sand, 25 percent silt, 25 percent clay
5-8	Mottled gray and yellow-orange plastic clay; 10 percent fine-quartz sand, 10 percent silt, 80 percent clay
8-10	Gray to off-white clayey find sand; 50 percent fine quartz sand, 50 percent clay
10-22	Gray to off-white clayey medium sand; 40 percent medium quartz sand, 30 percent fine quartz sand, 30 percent clay
22-24	Light tan coarse sand; 40 percent coarse quartz sand, 40 percent medium quartz sand, 20 percent fine quartz sand
	Well RIC-344, total depth 29 feet
0-11	Brown, silty, clayey sand; 40 percent fine quartz sand, 30 percent clay; slightly micaceous
11-19	Brown silty sand and clay; 40 percent fine quartz sand, 20 percent silt, 40 percent clay
19-28	Brown slightly clayey medium sand; 60 percent medium quartz sand, 20 percent fine quartz sand, 20 percent clay
28-29	Brown medium sand; 10 percent coarse quartz and feldspar sand, 80 percent medium quartz and feldspar sand, 10 percent fine quartz and felspar sand

Table 1. -- Lithologic logs of wells RIC-341, RIC-344, RIC-345, and RIC-346 (Continued)

Depth	Description of material
	RIC-345, total depth 49 feet
0-3	Light tan medium sand; 60 percent medium quartz sand, 20 percent fine quartz sand, 10 percent silt, 10 percent clay
3-8	Light tan to off-white clayey sand; 40 percent medium quartz sand, 10 percent fine quartz sand, 10 percent silt, 40 percent clay; slightly micaceous
8-12	Light tan slightly clayey sand; 30 percent medium quartz sand, 40 percent fine quartz sand, 10 percent silt, 20 percent clay
12-17	Light gray slightly clayey medium sand; 60 percent medium quartz sand, 30 percent fine quartz sand, 10 percent clay
17-49	Light gray to cream white sand; 50 percent medium quartz sand, 30 percent fine quartz sand, 20 percent clay; gravel at 24, 27, 37-39, 42-44, and 46-49 feet

Table 1. -- Lithologic logs of wells RIC-341, RIC-344, RIC-345, and RIC-346 (Continued)

Depth	Description of material
	RIC-346, total depth 64 feet
0-11	Brown, silty clay; 5 percent fine quartz sand, 40 percent silt, 55 percent clay
11-22	Moderately plastic, mottled light-gray to orange silty clay; 10 percent fine quartz sand, 40 percent silty, 50 percent clay
22-24	Light grayish-brown clayey sand; 60 percent medium quartz sand, 10 percent fine quartz sand, 30 percent clay
24-28	Light grayish-brown clayey sand; 20 percent medium quartz sand, 60 percent fine quartz sand, 20 percent clay
28-34	Light grayish-brown clayey sand; 5 percent coarse quartz sand, 10 percent medium quartz sand, 60 percent fine quartz sand, 25 percent clay; some gravel at 28 to 29 feet
34-42	Light brown slightly clayey sand; 25 percent coarse quartz sand, 25 percent medium quartz sand, 30 percent fine quartz sand, 10 percent silt, 10 percent clay
42-50	Light brown slightly clayey sand; 40 percent coarse quartz sand, 30 percent medium quartz sand, 20 percent fine quartz sand, 10 percent clay
50-55	Light brown to gray gravel; 70 percent gravel, 10 percent coarse sand, 20 percent medium sand
55-64	Dark gray clay; 10 percent silt, 90 percent clay

The lithologic log for well RIC-346 (table 1), located in the flood plain near Wise Lake, identifies dark gray clay below a depth of 55 feet. This may be the lower limit of Holocene alluvial deposits at this site, however, samples from deeper than 64 feet are not available. The grain size of the sediment gradually grades from gravel at about 55 feet to silty clay above a depth of 22 feet. This fining-upward trend is typical of sediments deposited in an alluvial environment with the ever-changing erosional and depositional patterns of such an environment. After the river cuts into existing sediment, gravel and coarse-grained sand are first deposited in the inside of bends in the river. As sediment accumulates and the channel moves laterally, finer-grained sediment is deposited. As the river gradually changes course the old channel area becomes part of the flood plain where additional silt and clay are deposited during flooding (Bedinger, 1981, p. 163).

Because of this depositional sequence and the continuous meandering of the river channel, the lithology of the sediment column in the Monument changes over short distances. Less silt and clay are found near the surface in the vicinity of the Congaree River (well RIC-344), the more recent channels of Congaree River, (well RIC-341), and outside of the plain (well RIC-345) than in other parts of the flood plain (well RIC-346). The coarse-grained sand and gravel that were deposited in older channels of the river have been covered with finer-grained materials in most areas. The channels of Cedar Creek and other small streams do not cut deeply enough to fully breach the old deposits of silt and clay.

Terraces outside of the flood plain consist of marine deposits of Pleistocene age. These deposits are primarily gravel and sand with some clay and probably have been completely eroded within the Congaree River flood plain.

Climate

The Monument has a warm, humid climate. Based on 97 years of record at the University of South Carolina in Columbia, long-term mean monthly temperatures range from 46 to 81^{0}F. Average annual rainfall is about 47 inches and ranges from 34 to 53 inches. Average monthly rainfall varies seasonally with a low in the fall and a high in the spring and summer. Average monthly rainfall ranges from about 2 1/2 inches in November to about 5 1/2 inches in August. Evapotranspiration also varies seasonally, reaching a low in the winter, increasing to a high in the late spring and summer, then decreasing through the fall to the low in the winter.

Vegetation

Most of Congaree Swamp National Monument is covered with a mature bottomland hardwood forest dominated by sweet gum (Liquidambar styraciflua L.), hackberry (Celtis laevigata Willd.), oak (Quercus spp.), hickory (Carya spp.), black gum (Nyssa sylvatica Marshall), and sycamore (Platanus occidentalis L.). In lower areas baldcypress (Taxodium distichum L.) and tupelo (Nyssa aquatica L.) are dominant, while on slightly higher sites loblolly pine (Pinus taeda L.) is dominant.

About 700 acres of forest were clearcut and another 2,000 acres were selectively cut before the Monument was established (U.S. Department of the Interior, 1979, p. 20). The approximately 12,000 uncut acres constitute one of the last major remnants of mature, bottomland hardwood forest in the Southeast.

The large number of record or near record trees is one of the outstanding features of the Monument (table 2). At least 19 State record trees and 6 national record trees have been found in or near Congaree Swamp National Monument (U.S. Department of the Interior, 1979, p. 20). One of the Monument's largest national record trees was a laurel oak (Quercus laurifolia Michaux), 20 feet 9 inches in circumference and 148 feet in height. This tree and three other record trees have died since they were identified as record trees. Some loblolly pines, which usually do not live more than 100 years, probably are more than 300 years old (U.S. Department of the Interior, 1979, p.20). The flood plain's fertile soil, abundant water, infrequent fires, and limited disturbances by man have allowed such trees to survive.

Table 2.--Selected Record trees identified in Congaree Swamp National Monument and vicinity

Common name	Scientific name	Measurements Circumference (feet inches)		Height (feet)	Spread (feet)
National					
Possumhaw	Ilex decidus	1	8	33 in.	30
Swamp tupelo	Nyssa sylvatica var. biflora	13	1	112	52
*Laurel oak	Quercus laurifolia Michaux	20	9	148	76
Overcup oak	Quercus lyrata	22	0	123	48
State					
American hornbeam	Caroubys caroliniana	4	7	60	49
Green ash	Fraxinus pennsylvanica	15	2	118	74
Honeylocust	Gleditsia triacanthos	8	3	122	36
*American holly	Ilex opaca	8	2	99	40
Water tupelo	Nyssa aquatica	20	11	124	62
Loblolly pine	Pinus taeda	15	1	140	46
Willow oak	Quercus phellos	17	8	158	73
Shumard oak	Quercus shumardii	15	4	149	64
American elm	Ulmus americana	16	6	144	72

* Trees that have died since being identified as record trees.

HYDROLOGY

Surface Water

The Congaree River has played a major role in the formation of Congaree Swamp (Wharton and others, 1982, p. 4). It is formed by the confluence of the Saluda and Broad Rivers at Columbia. Flow from the Saluda River (drainage area = 2,520 mi^2) is regulated by Lake Murray Dam. Flow from the Broad River (drainage area = 5,320 mi^2) is regulated to a minor degree by small dams. The Congaree River crosses the Fall Line at Columbia, South Carolina, about 15 miles upstream from the Monument (fig. 1). Here the river passes from the moderately sloping clay and consolidated igneous and metamorphic rock of the Piedmont to the gently sloping sediments of the Coastal Plain. The decrease in velocity of flow caused by this transition to a more gentle channel gradient results in deposition of sand, silt, and clay, especially during floods when the sediment load is great. The sand, silt, and clay are reworked into gradually shifting meanders on a broad flood plain as the river seeks to balance its energy and its sediment load.

Numerous tributary streams, including Cedar Creek and Toms Creek, flow through Congaree Swamp National Monument into the Congaree and Wateree Rivers. The largest of these tributaries, Cedar Creek, enters the Monument at the northwestern corner and meanders southeasterly through several channels to the Congaree River. Cedar Creek, the Congaree River, and numerous old channels, some containing oxbow lakes, are interconnected by a complex network of intermittent channels.

To delineate the channel network and areas of inundation and to determine the frequency and duration of inundation, the topography of the Monument was compared with water level records. The topographic information was derived from a detailed map of the Monument prepared in conjunction with this study. The water-level records included observations of water levels at various locations in the Monument and continous water-level records from 6 gaging stations (figures 1, 2). The gaging stations involved were:

		Period of Record
02169500	Congaree River at Columbia	1891 to current year
02169625	Congaree River west of Wise Lake near Gadsden	1981 to 1983
02169670	Cedar Creek below Myers Creek near Hopkins	1981 to 1983
02169672	Cedar Creek at Wise Lake near Gadsden	1981 to 1983
02169675	Cedar Creek at County Road 1288 near Gadsden	1981 to 1983
02169740	Congaree River at Southern Railroad bridge near Fort Motte	1981 to 1983

The flow of the Congaree River measured near the upstream boundary of the Monument west of Wise Lake (02169625) ranged from about 1,400 ft^3/s to 55,000 ft^3/s during the period October 1, 1981, through September 30, 1982. Highest flows in the Congaree River occurred during the period December through March, and the lowest flows occurred during October and November. The flow in Cedar Creek at the point where it enters the Monument (02169670) ranged from 11 ft^3/s to about 522 ft^3/s during the period October 1, 1981, through September 30, 1982. The mean flow for the year at this station was 64 ft^3/s. Flows were highest in the spring and lowest in the fall.

Figure 3 shows hydrographs of the mean daily stage of the Congaree River at Columbia, the Congaree River west of Wise Lake, and Cedar Creek at Wise Lake. The hydrographs indicate that peak stage in the streams occurred at slightly different times. Peak stages in the Congaree River west of Wise Lake occurred about a day later than the peak stages of the Congaree at Columbia. Peak stage in Cedar Creek occurred about two days later than the peak stage at Columbia.

The water-level records were compared for a series of floods during water years 1982 and 1983. The relations of the peak stages at Cedar Creek and the Congaree River west of Wise Lake to the peak stage in the Congaree River at Columbia are shown in figure 4. The slopes of the curves decrease at high stages because a given increase in discharge causes a greater increase in stage at Columbia, where the flood plain is narrow, than in the Monument, where the flood plain is wide.

The relation of stages in the Monument to stage at Columbia are useful because they can be used to predict stages in the Monument, and because the longer period of record from the Columbia station permits analysis of frequency and duration of flooding. This was done for 5 stages (table 3) by counting the total number of days per year, and the number of times per year, that each stage was equaled or exceeded at Columbia during the 10-year period 1973 to 1982, and by performing a log Pearson type III flood frequency analysis.

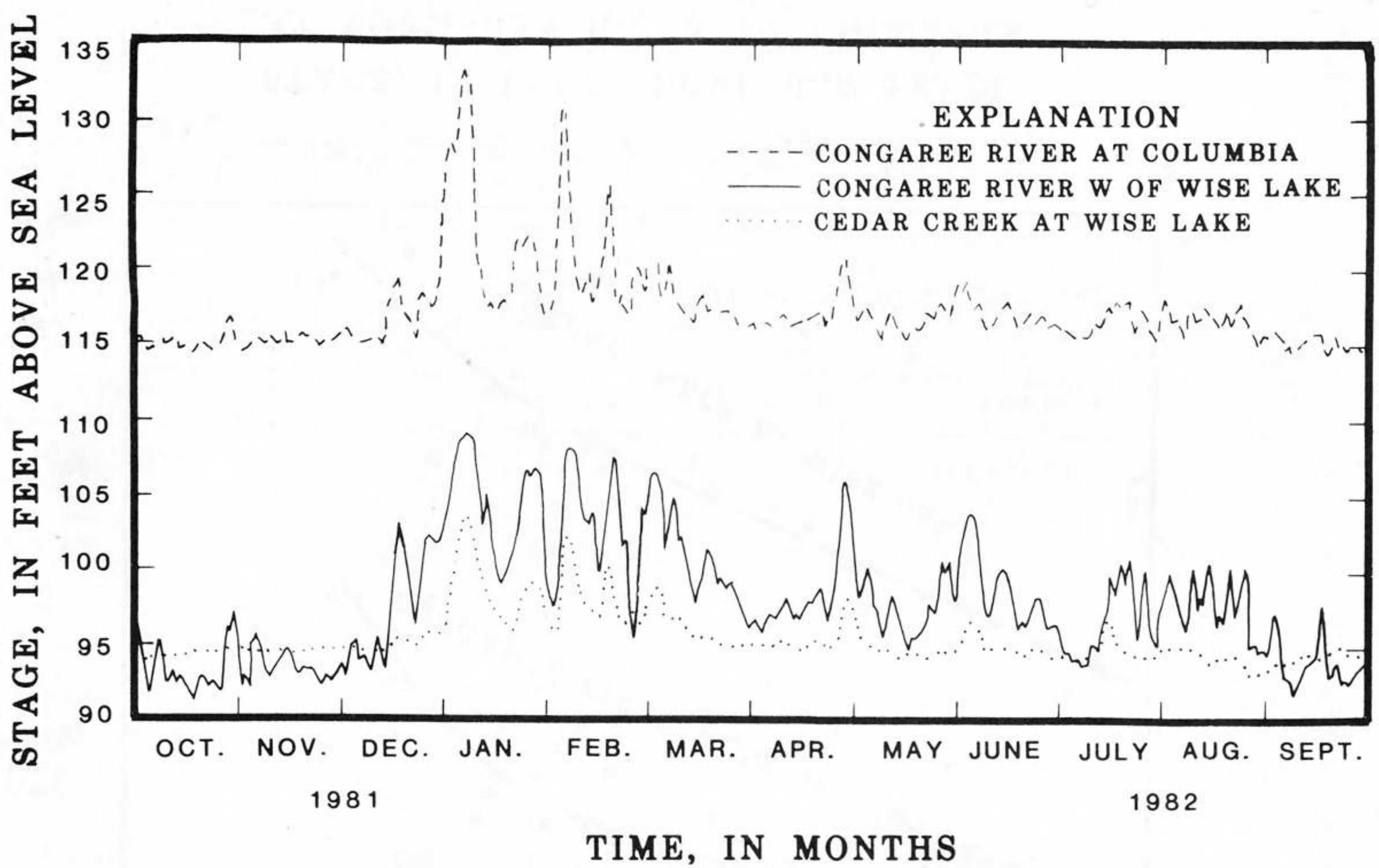


Figure 3.--Congaree River at Columbia, Congaree River west of Wise Lake, and Cedar Creek at Wise Lake

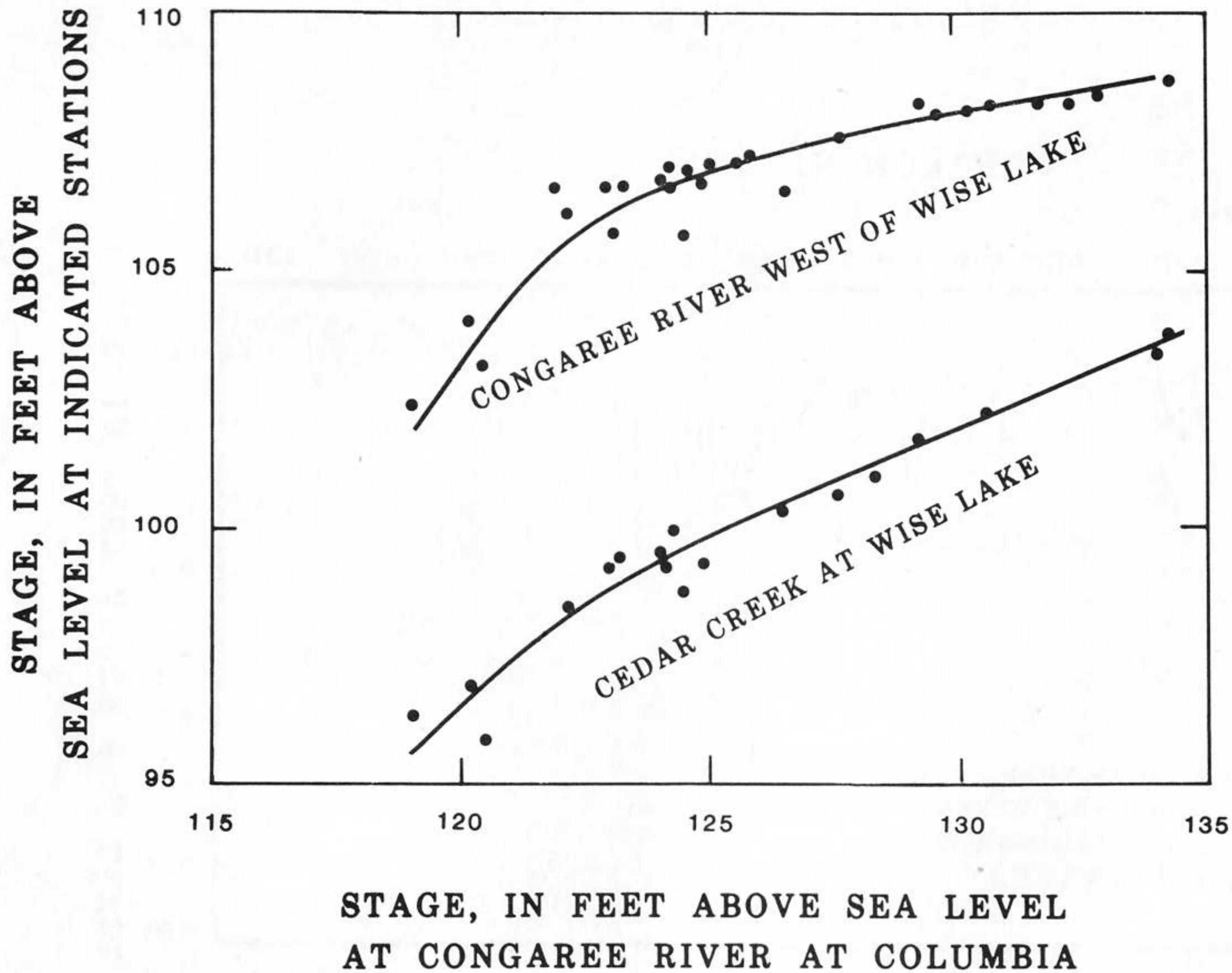


Figure 4.--Relation of water levels of Cedar Creek at Wise Lake and the Congaree River west of Wise Lake to the Congaree River at Columbia, South Carolina

Table 3. -- Flooding effects, percent of time equaled or exceeded, and average number of times per year water levels are equaled or exceeded in Congaree Swamp National Monument at selected stages of the Congaree River at Columbia, South Carolina

Flooding effects in Congaree Swamp National Monument	Percent of time equaled or exceeded 1973-82	Average number of times per year equaled or exceeded 1973-82	Exceedance probability for any given year	02169500 Congaree River at Columbia			02169625 Congaree River west of Wise Lake near Gadsden		02169672 Cedar Creek at Wise Lake	
				Gage height, feet (datum is 113.02 feet sea level)	Water-surface elevation feet, sea level	Discharge (cubic) feet per second)	Gage height, feet (datum is 90.88 feet sea level)	Water-surface elevation feet, sea level	Gage height feet (datum is 93.33 sea level)	Water surface elevation feet, sea level
River water enters flood plain channels	23.7	11	>0.99	6.1	119.1	11,800	11.1	102.0	2.4	95.7
Guts overflow into low spots in the flood plain; road to Wise Lake impassable	9.3	6	>0.99	8.4	121.4	19,900	14.3	105.2	4.5	97.8
Bankfull flow at station 02169625	5.8	5	0.99	10.0	123.0	25,500	15.5	106.4	5.1	98.9
Water covers ground at Wise Lake; most of swamp flooded	3.0	4	0.95	12.7	125.7	34,300	16.4	107.3	6.8	100.1
Entire swamp flooded	0.3	1	0.42	21.2	134.2	76,600	18.0	108.9	10.5	103.8

Records from the six gaging stations and observations from elsewhere in the Monument show that the water surface of the inundated flood plain slopes both downstream and away from the Congaree River. Water surfaces representing three levels of inundation were defined by plotting the sloping surfaces on the topographic map of the Monument (fig. 5). The lowest of of the three levels represents water that is confined within the banks of channels and lakes on the flood plain. At this height the water in the flood plain is effectively separated from the Congaree River, and flood-plain water levels are controlled by flow in tributaries such as Cedar Creek. According to duration statistics for Cedar Creek stations 02169670 and 02169672 for water years 1981 to 1983, this level of inundation is equalled or exceeded about 75% of the time.

The second level of inundation occurs when water from the Congaree River swells flood-plain channels and spills over into low-lying areas on the flood plain. At this and higher heights the water level in the flood plain is controlled by flow in the Congaree River. The Congaree River West of Wise Lake (02169625) attains this level (105.1 ft above sea level) following flow at Columbia (02169500) that reaches a corresponding height of 121.3 ft above sea level. Duration statistics for the Congaree River at Columbia for water years 1970 to 1982 show that this level is equalled or exceeded 25% of the time.

The highest level of inundation shown in figure 5 represents flooding of all but the highest land in the Monument. The Congaree River West of Wise Lake (02169625) attains this level (108.1 ft above sea level) following flow at Columbia (02169500) that reaches a corresponding height of 130.2 ft above sea level. This level is equalled or exceeded 1% of the time, according to duration statistics for the Congaree River at Columbia for water years 1970 to 1982.

The probability that a water level will be exceeded in a given year, the exceedence probability, was computed for three flooding stages (table 3). Almost the entire swamp is flooded, on the average, once per year. The probability of that flood stage being equaled or exceeded in any given year is 0.42, because it is exceeded more than once in some years and not at all in other years.

Data from a series of discharge measurements of the Congaree River west of Wise Lake were plotted to determine the relation between discharge in the main river channel and discharge in the floodplain as stage increases (fig. 6). The discharge in the floodplain, represented by the shaded area between the two curves, accounts for an increasing proportion of the total river flow as stage increases. All of the flow of the Congaree River west of Wise Lake is within the channel at stages below 102 feet (14,000 ft^3/s). At stages above 102 feet, water starts to flow through the small channels in the natural levee onto the flood plain. At stages above 106 feet (26,000 ft^3/s), water overtops the natural levee along the river channel, adding to the inundation and flow on the flood plain. At a stage of about 109 feet, the discharge is 56,000 ft^3/s, of which 21,000 ft^3/s is through the flood plain.

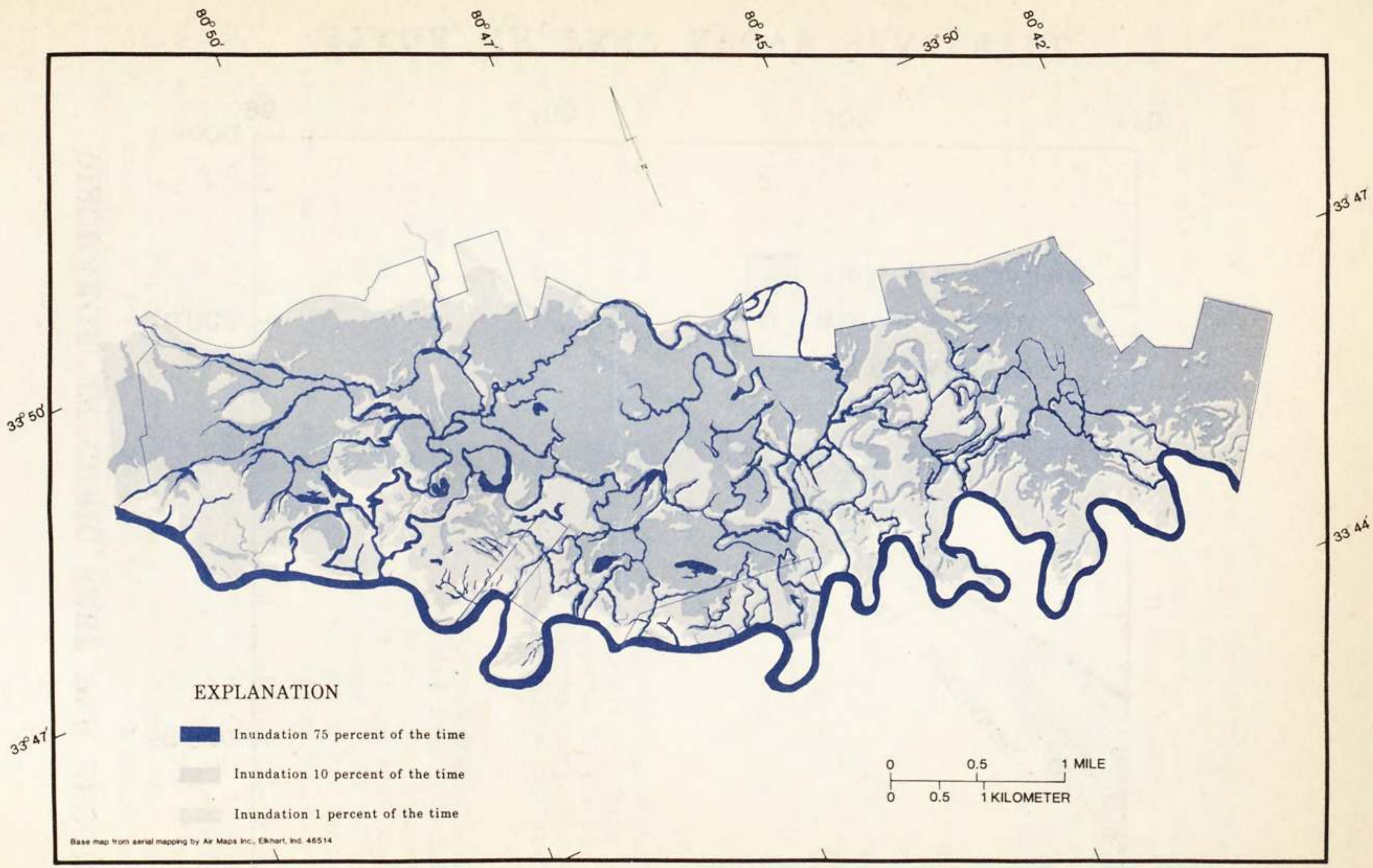


Figure 5.--Areas of Congaree Swamp National Monument inundated 75, 10, and 1 percent of the time, October 1973 through September 1982

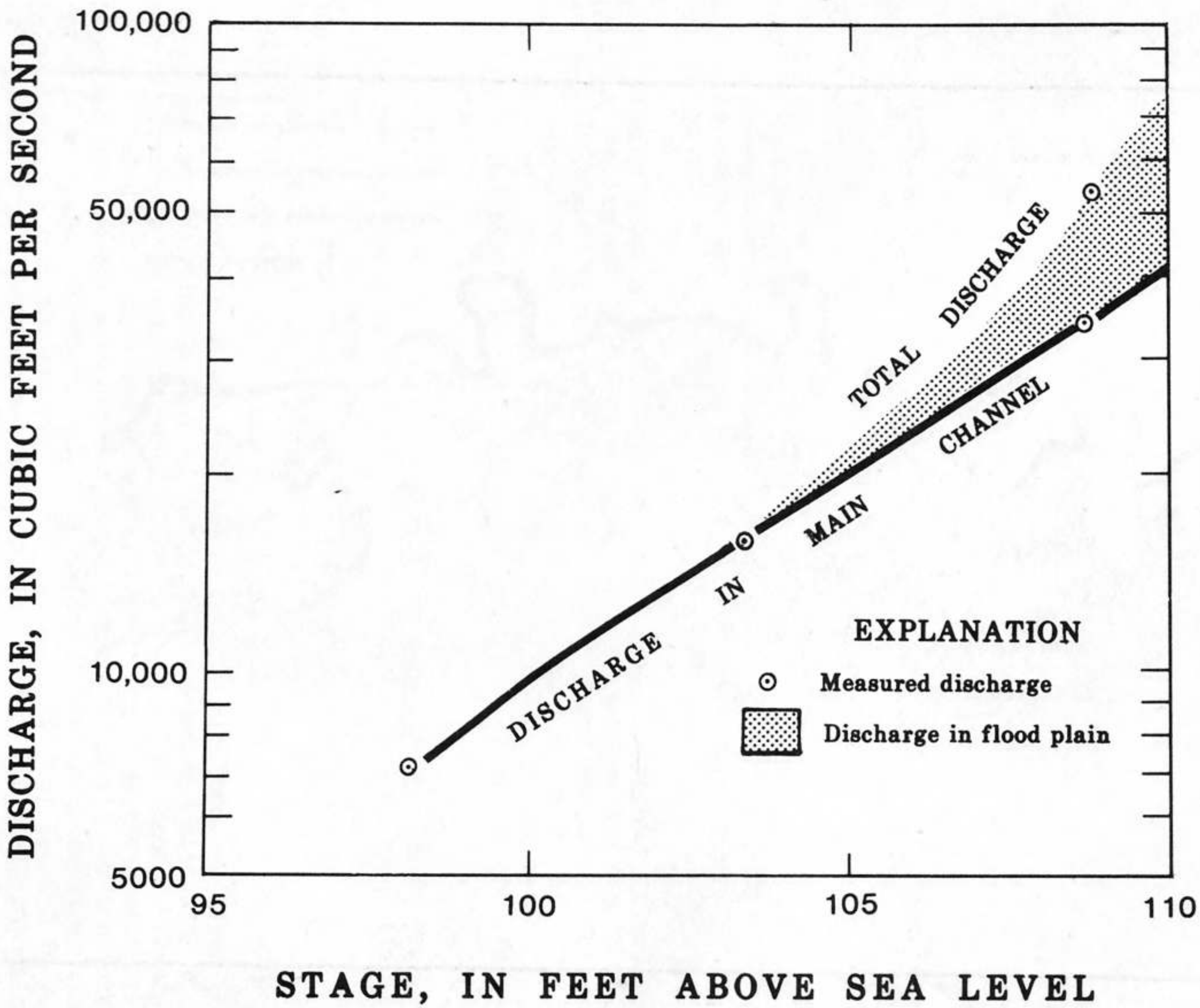


Figure 6.--Relation of water levels in the Congaree River west of Wise to total discharge in the main channel, and discharge in the flood plain

The construction of Lake Murray Dam on the Saluda River in 1929 created a large reservoir that regulates floods on the Congaree River. Operation of the reservoir has had no discernable effect on the 1-year exceedence probabilities for stage listed in table 3. However, operation of the reservoir has affected the recurrence intervals, and thus the exceedence probabilities, for floods with recurrence intervals of 2 years or more (fig. 7) (Whetstone, 1982, p. 27). A discharge that had a 2-year recurrence interval before 1929 had a 4.5-year recurrence interval after 1929. A flood that had a 5-year recurrence interval before 1929 had a 25-year recurrence interval after 1929.

Ground Water

Congaree Swamp National Monument is underlain by a shallow aquifer and a deep aquifer separated by a clay or sandy clay confining bed approximately 70 feet thick (fig. 8). Although the deep aquifer is underlain by a deeper aquifer, it is not discussed in this report because of its minor effect on the hydrology of the Monument.

Deep Aquifer

The deep aquifer that underlies Congaree Swamp National Monument consists predominantly of sand with thin clayey layers at depths of 125 to 360 feet. Recharge to the deep aquifer is by rainfall in the aquifer outcrop in the interstream areas between the Congaree River, the Wateree River, and the Fall Line and by leakage from the shallow aquifer through less permeable confining beds in upland areas.

The potentiometric surface slopes from the outcrop areas toward the Congaree and Wateree River (fig. 9). This indicates that ground-water flow in the aquifer is from the recharge areas toward the Congaree and Wateree Rivers. The potentiometric surface is depressed more near the confluence of the Wateree and Congaree Rivers because of the effects of discharge to both rivers. The potentiometric surface of the deep aquifer in Congaree Swamp National Monument is about 125 feet above sea level.

Discharge from the deep aquifer occurs as upward leakage, through overlying confining beds or breaches in the confining beds, to the flood plain part of the shallow aquifer and the Congaree River. In December 1981 the water level in well RIC-347 which is screened in the top of the deep aquifer was 10.9 feet higher than the water level in companion well RIC-346 which is screened in the shallow aquifer, indicating the potential for leakage from the deep aquifer to the shallow aquifer.

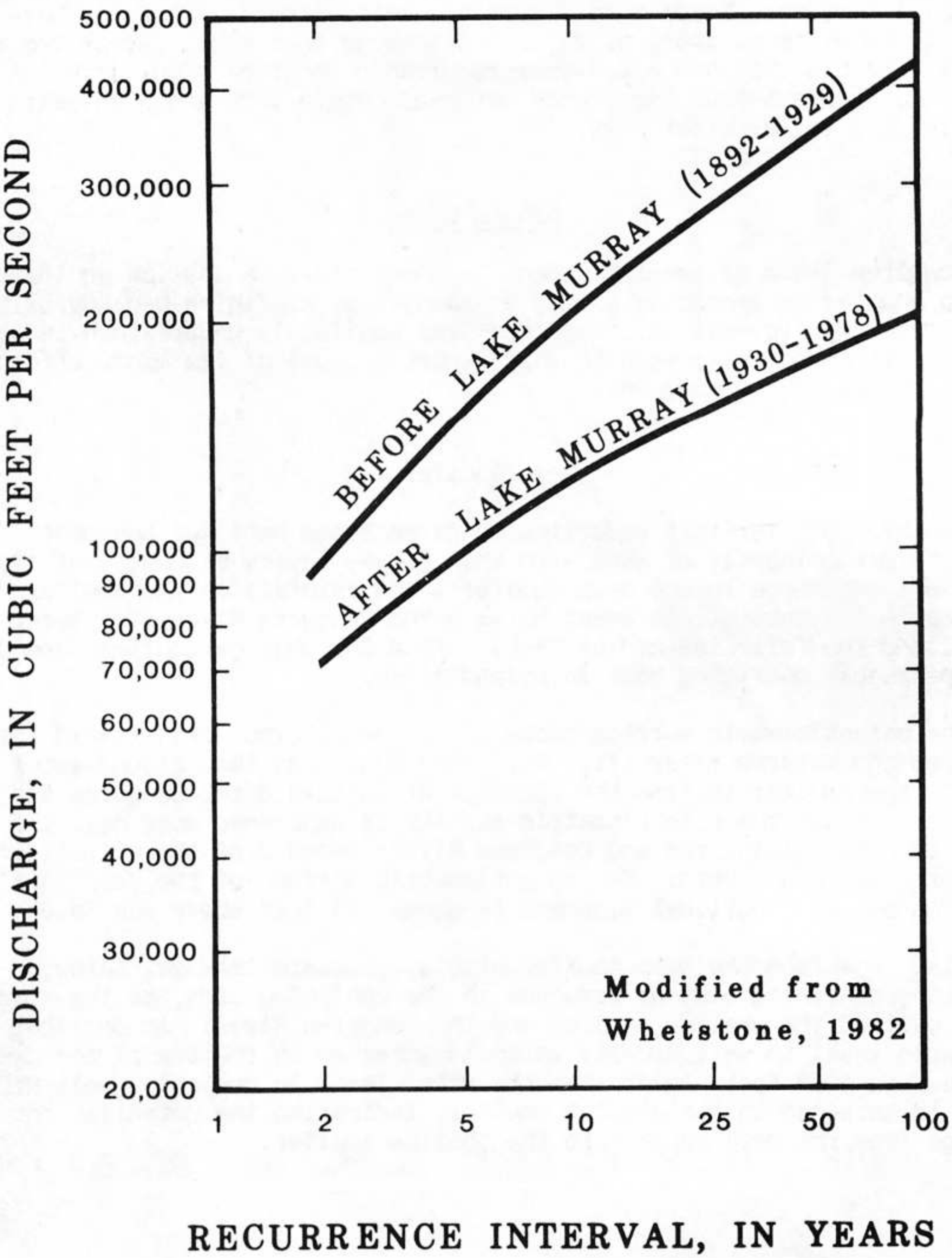


Figure 7.--Flood frequency for Congaree River at Columbia, South Carolina

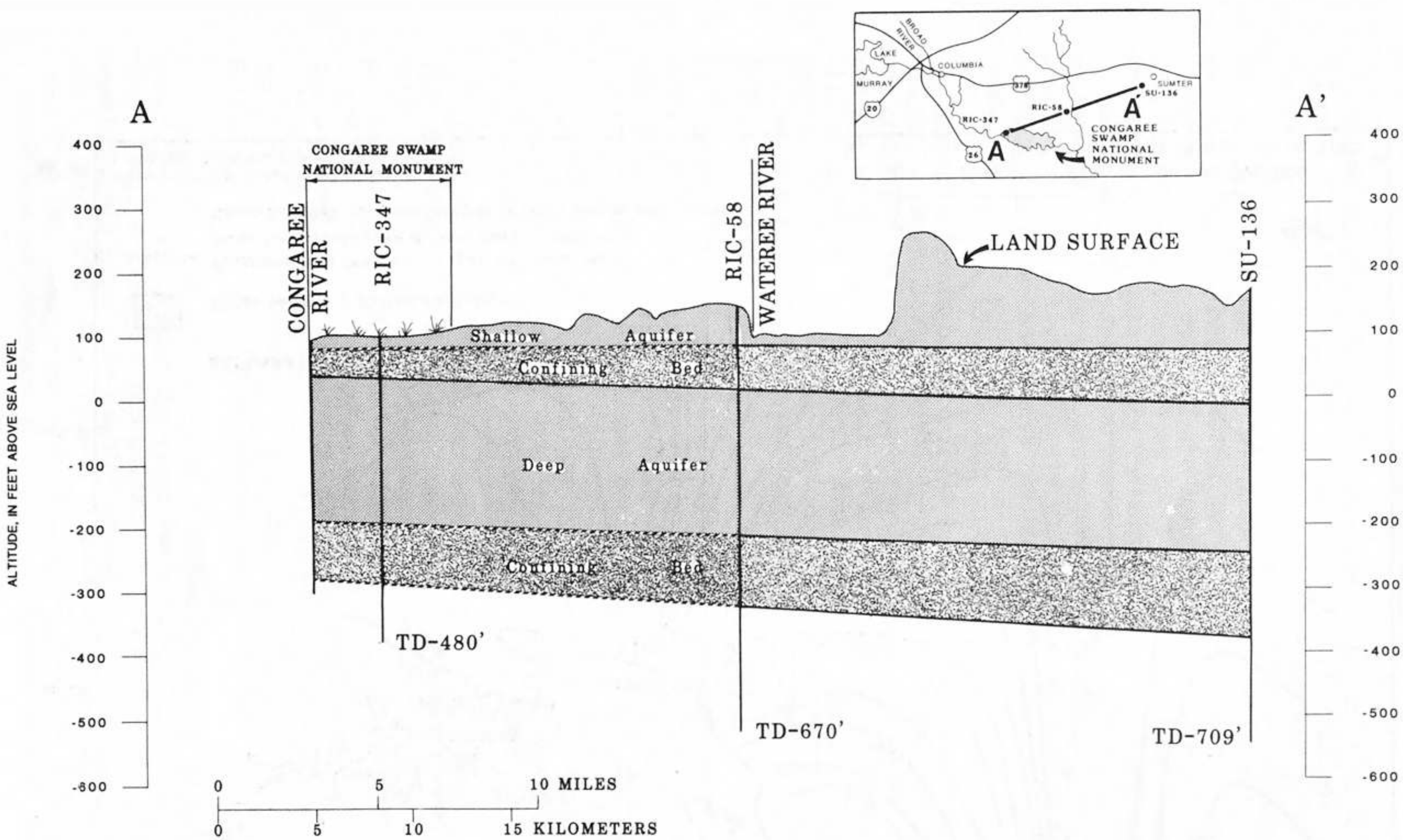


Figure 8.--Geohydrologic section from well SU-136 through Congaree Swamp National Monument

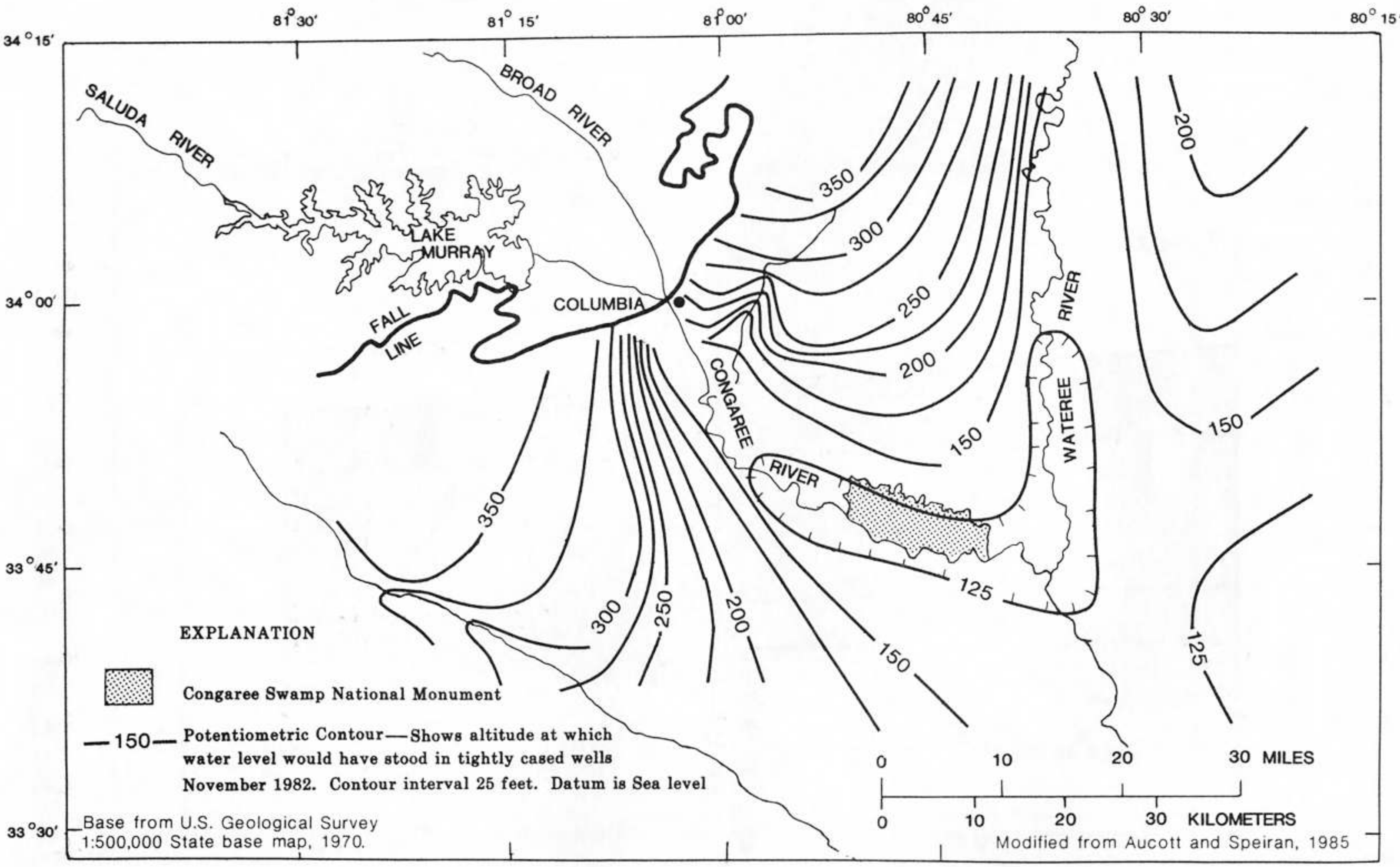


Figure 9.--Potentiometric surface in the deep aquifer in the vicinity of Congaree Swamp National Monument

Shallow Aquifer

In the flood plain, the shallow aquifer consists of heterogeneous Holocene flood-plain deposits extending from the land surface to a depth of at least 55 feet in some areas. The shallow aquifer outside of the flood plain consists of Pleistocene terrace deposits that probably have a sand-to-sand contact with the flood plain deposits in many areas. The depth and thickness of the shallow aquifer vary throughout the Monument because of differences in the depth of the lower confining unit and differences in the thickness of the silty clay at the surface. The water-bearing capacity of the sediments is also highly variable because of differences in aquifer thickness and permeabilty of the sediments. The materials near the land surface in the flood plain are generally silt and clay except along the present or recent river channels where the surface materials are coarser grained. In areas outside of the flood plain the materials are mostly sand.

Ground water is both confined and unconfined in the flood plain of the Monument. Where low permeability silt and clay occur at the surface and are underlain by more permeable sand and gravel, the ground water is confined and the water level in a well screened in the more permeable material will rise above the top of the more permeable layer. Where the surface material is permeable sand, the ground water is unconfined, and a depression in the land surface that extends below the water table will form a pond or lake.

Recharge to the shallow aquifer occurs by local rainfall primarily where surface sediments have a high permeability and by leakage from the deep aquifer. Ground water flows from areas of higher elevation outside of the flood plain toward streams outside of the flood plain and toward the flood plain. Discharge outside of the flood plain is to streams and through seeps along the bluff at the edge of the flood plain. Discharge in the flood plain is to the Congaree River, to evapotranspiration, and to the tributaries where the low-permeability surface sediments are breached.

Hydrographs from wells screened in the shallow aquifer were compared with the stage hydrograph for Congaree River west of Wise Lake (fig. 10). Water levels in wells in the shallow aquifer within the flood plain are controlled by the stage of the Congaree River because the river is a discharge sink with a fluctuating level. Water levels in wells in the shallow aquifer outside the flood plain are not significantly influenced by river stage, but are controlled by recharge from local rainfall and by discharge. The water-level gradient is toward the river during low flows, but briefly reverses during high river stage.

The effect of the river on ground-water levels in the flood plain is generally greatest near the river (well RIC-343) and least away from the river (well RIC-341). This pattern is similar to that observed in the Appalachicola River flood plain (Leitman, Sohm, and Franklin, 1983, p. A28). Water-level fluctuations in well RIC-343, a well located about 200 feet from the Congaree River, are similar to but of less magnitude than the fluctuations in the stage of the Congaree River west of Wise Lake (fig. 10).

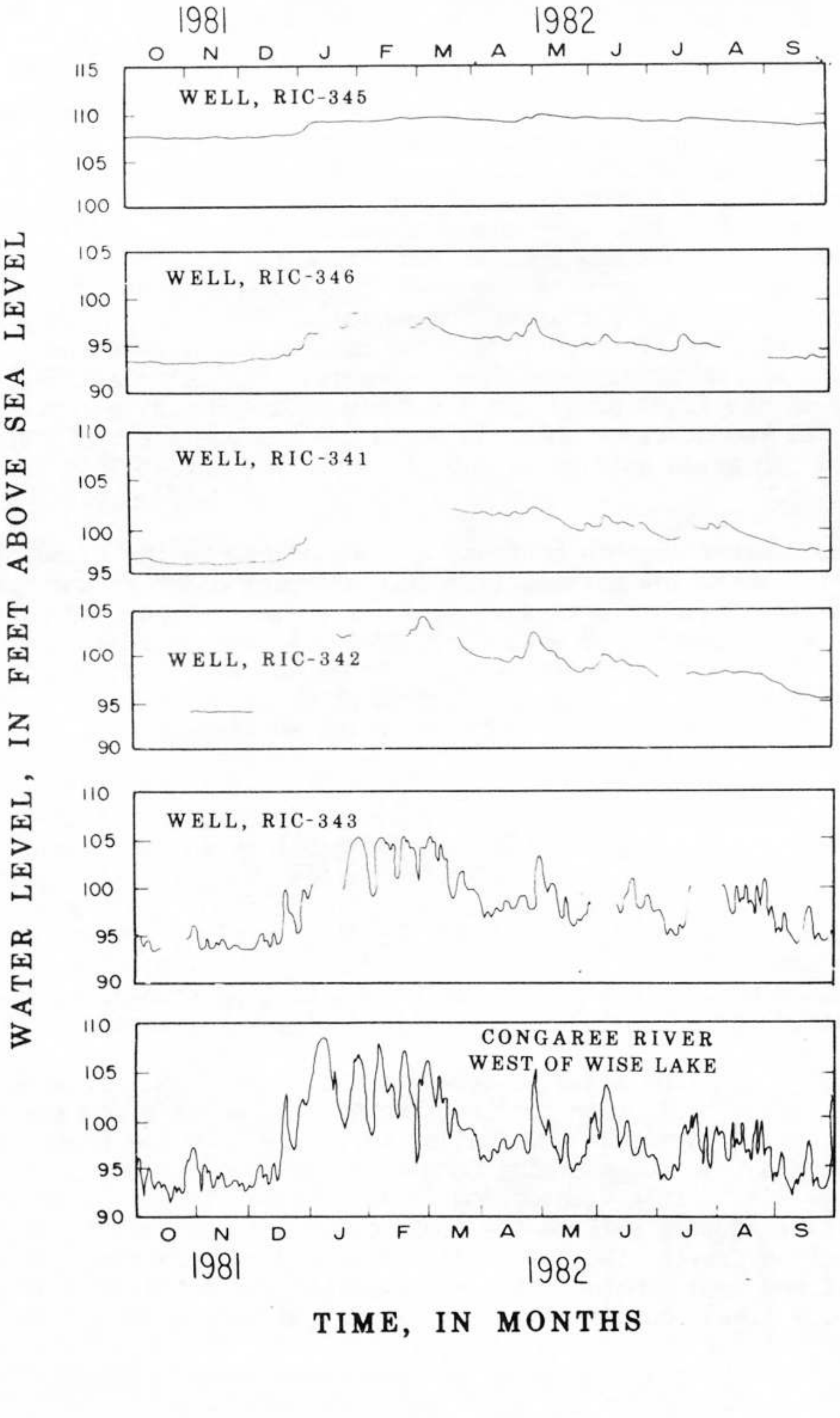


Figure 10.--Water levels in wells RIC-345, RIC-346, RIC-341, RIC-342, and RIC-342, and the Congaree River west of Wise Lake near Gadsden, South Carolina

From top to bottom in figure 10 the graphs reflect decreasing distance from the river. Water levels in well RIC-345, which is located outside of the flood plain, shows little, if any effect from fluctuation in the stage of the Congaree River. The sharp fluctuations in water level of well RIC-341 may be partially due to a better hydraulic connection to the river, provided by a buried river channel.

Interrelation of Ground Water and Surface Water

Ground water and surface water are more closely interrelated in swamps than in most environments. Exchanges of surface water, soil moisture, and shallow ground water are limited primarily by the permeability of the sediments separating them. In the vicinity of Congaree Swamp National Monument the permeable sand of the uplands facilitates exchange of ground water and surface water while the silt and clay of the flood plain limit exchange.

In the upland areas adjacent to the flood plain ground water sustains the flow of tributaries during periods of low flow. Some small streams receive flow only from the shallow aquifer and have poorly sustained low flows. These streams are not incised into the deep aquifer or are located where the combined effects of ground-water discharges to the Congaree and Wateree Rivers depress the potentiometric surface. The more deeply incised streams that receive flow from the deep aquifer as well as from the shallow aquifers have better sustained low flows and are important to the swamp because they provide water and help to maintain surface water when other sources are reduced. Annual minimum 7-day, 10-year low flows of small streams not recharged by the deep aquifer include 0 $(ft^3/s)/mi^2$ for Griffins Creek and Dry Branch and 0.05 $(ft^3/s)/mi^2$ for Tom's Creek (Bloxham, 1976). Annual minimum 7-day, 10-year flows of streams recharged by the deep aquifer include 0.19 $(ft^3/s)/mi^2$ for Mill Creek and 0.25 $(ft^3/s)/mi^2$ for Cedar Creek.

Seepage of ground water from the shallow aquifer along the bluffs at the edge of the flood plain maintains swampy conditions in areas along the northeast boundary of the Monument. This upwelling of ground water creates small areas of "quicksand" by keeping the sand grains in suspension. In this area wet conditions enable hydrophilic (water-loving) vegetation to survive even extended drought periods and to repopulate other areas of the swamp when normal wet conditions return.

Within the flood plain the interaction of ground water and surface water is limited by the low permeability of the surface sediments. The major interaction is that between the shallow aquifer and the Congaree River. This interaction causes the fluctuation in ground-water levels with river stage as the river recharges the aquifer along the river banks during rising stages and the aquifer discharges into the river during falling stages. The discharge of ground water to the Congaree River also results in a depression in the potentiometric surface of the deep aquifer near the Congaree River. There is probably little interaction between the shallow ground water and the tributary streams because they seldom cut through the low permeability surface sediments.

EFFECTS OF HYDROLOGY ON VEGETATION

The flood-plain environment of Congaree Swamp National Monument favors the growth and survival of many kinds of trees, especially those adapted to a moist environment. Periodic flooding brings fertile soil to the flood plain, keeps insect populations in check, and puts limits on human activity. The moist environment also reduces the risk of fire.

Although a shallow water table may be an important source of water for vegetation in some areas, the low permeability of the shallow sediments probably limits the importance of ground water in determining the distribution and maintaining the growth of vegetation in the Monument. Flooding by the Congaree River is probably more important in this respect.

One hazard that is increased in the flood plain is that of trees falling. Because of the importance of flooding as a source of water in the low permeability sediments, most trees in the Monument have shallow unstable root systems. Several trees have fallen even on calm days (F. Pametta, National Park Service, oral communication, 1985).

Slight variations in topography affect soil moisture and flood frequency, and hence, the distribution of plant species. Trees that tolerate anaerobic soil conditions caused by standing water or frequent flooding, such as baldcypress and tupelo, are found in the lowest areas. Those adapted to a drier habitat, such as loblolly pine, grow on the higher sites.

The completion of Lake Murray Dam on the Saluda River in 1929 has reduced the frequency of large floods but probably has increased the duration of inundation along the Congaree River. It is likely that the distribution of plants in the Monument may be shifting in response to this change in hydrology.

Ground-water pumpage at current rates has had little if any effect on water levels, and hence, vegetation, in the Monument. Major withdrawals are from the deep aquifer, which is largely isolated from the shallow aquifer and the root zone by the confining bed. Recharge by upward leakage from the deep aquifer is probably small in comparison to other sources of recharge. Therefore, only a major increase in pumpage near the Monument would be likely to affect water levels in the shallow aquifer.

SUGGESTIONS FOR FURTHER STUDY

The bottomland hardwood forest preserved in Congaree Swamp National Monument provides ideal opportunities for further research on the relations between hydrology and vegetation in a flood plain. One possible topic is the effect of long-term changes in frequency and duration of flooding on growth of trees. Studies of tree rings and tree distribution in relation to the 1929 completion of Lake Murray Dam could help to elucidate this relation. A second possible topic is determination of nutrient and sediment balances for the flood plain. Other similar flood plains vary in their roles as sources or sinks for nutrients and sediment (Elder and Cairns, 1982). It would be useful to determine how the Congaree Swamp compares.

The ground water of the Monument also merits further study. A more comprehensive water-level monitoring program involving observation wells at more locations and tensiometers at different depths would help to further refine our knowledge of potentiometric gradients and exchange of water in the hydrologic system.

SUMMARY

Congaree Swamp National Monument was established in 1978 to preserve one of the largest stands of old-growth southern bottomland hardwoods in the southeastern United States. The trees grow on the flood plain of the Congaree River in the upper Coastal Plain of South Carolina. The flood plain is underlain by approximately 500 feet of unconsolidated Upper Cretaceous sediments. Within the flood plain shallow sediments have been reworked by the meandering river. The topography of the flood plain is nearly flat, with a complex network of channels and a natural level along the river.

On the average, the Congaree River floods several times per year. Such flooding causes river water to flow through breaks in the natural levee, into flood plain channels, and onto parts of the flood plain. Water that enters the flood plain re-enters the Congaree River downstream through Cedar Creek or flows into the Wateree River near its confluence with the Congaree. Slight variations in topography result in variations in duration and frequency of inundation, influencing the distribution of plant species. The frequency of large floods in the Monument has decreased slightly since the construction of Lake Murray Dam in 1929.

During periods of low flow, upland streams fed by ground-water seepage supply water to the flood plain. Large streams with deeply incised channels receiving water from the deep aquifer have better sustained base flows than do small streams that have shallow channels.

The potentiometric gradient in the shallow aquifer in the flood plain is generally toward the river. However, during floods the gradient is briefly reversed when the high river stage raises ground-water levels near the river. Ground water in the deep aquifer discharges to the shallow aquifer and to the Congaree River.

REFERENCES

Aucott, W. R., and Speiran, G. K., 1985, Potentiometric surfaces of the Coastal Plain aquifers of South Carolina prior to development: U.S. Geological Survey Water-Resources Investigations Report 84-4208, 5 sheets.

Bedinger, M. S., 1981, Hydrology of bottomland hardwood forests of the Mississippi Embayment, in Clark, J. R. and Benforado, J., editors, Wetlands of bottomland hardwood forests, proceedings of a workshop on bottomland hardwood forest welands of the southeastern United States, Lake Lanier, Georgia, 1980: Amsterdam, Elsevier Scientific Publishing Company, 401 p.

Bloxham, W. M., 1976, Low-flow characteristics of streams in the inner Coastal Plain of South Carolina: South Carolina Water Resources Commission Report No. 5, 28 p.

Colquhoun, D. J., 1965, Terrace sediment complexes in central South Carolina: Atlantic Coastal Plain Field Conference 1965, University of South Carolina, 62 p.

Cooke, C. W., 1936, Geology of the Coastal Plain of South Carolina: U.S. Geological Survey Bulletin 867, 196 p.

Elder, J. R., and Cairns, D. J., 1982, Production and decomposition of forest litter fall on the Appalachicola River flood plain, Florida, U.S.G.S. Water-Supply Paper 2196B, 42 p.

Leitman, H. M., Sohm, J. E., and Franklin, M. A., 1983, Wetland Hydrology and tree distribution of the Apalachicola River flood plain, Florida: U.S. Geological Survey Water-Supply Paper 2196, 52 p.

Overstreet, W. C., and Bell, Henry III, 1965, Geologic map of the crystalline rocks of South Carolina: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-413, scale 1:250,000.

Patterson, G. G., and Cooney, T. W., 1986, Sediment transport and deposition in Lakes Marion and Moultrie: Third International Symposium on River Sedimentation, Wang, Shen, and Ding, editors, University of Mississippi, pp. 1336-1345.

U.S. Department of the Interior, 1979, Assessment of alternatives for proposed general management plan and wilderness suitability analysis, Congaree Swamp National Monument, South Carolina: Denver Service Center, National Park Service, 163 p.

Wharton, C. H., Kitchens, W. M., Pendleton, E. C., and Sipe, T.W., 1982, The ecology of bottomland hardwood swamps of the southeast: A community profile: U.S. Fish and Wildlife Service Biological Services Program Publication FWS/OBS-81/37, 133 p.

Whetstone, B. H., 1982, Techniques for estimating magnitude and frequency of floods in South Carolina: U.S. Geological Survey Water-Resources Investigations 82-1, 78 p.

USGS LIBRARY - RESTON
3 1818 00098442 5