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WATER RESOURCES MANAGEMENT PLAN

CONGAREE SWAMP NATIONAL MONUMENT

NATIONAL PARK SERVICE
U.S. DEPARTMENT OF THE INTERIOR

Water Resources Management Plan

Congaree Swamp National Monument

May 1996

under cooperative agreement number
CA-5240-3-9002/1

Project Coordinators:

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EXECUTIVE SUMMARY

The Congaree Swamp National Monument is located in a complex floodplain that contains an array of aquatic ecosystems and wetlands occupied by old growth forest. The National Monument was established in 1976. This designation was due primarily to its unique biodiversity which represents one of the few remaining vestiges of old-growth forest in the southeast and to the large size and age of the trees, some of which are national and state champions. Most of the 22,200 acres is occupied by wetlands and seasonally inundated bottomland hardwood and swamp forests. Hydrology is the master variable that controls the delivery of sediments, nutrients, and contaminants to the floodplain ecosystem. Flooding also limits species composition to those tolerant of saturated soils. Both water quantity and water quality are concerns that must be addressed to meet the objectives of protecting, managing, and administering the National Monument in a way that conserves and protects it for the public. This Water Resources Management Plan describes the water resources, points out past and potential issues and problems, and charts a course for the management of water resources in the future.

The water resources of the National Monument include all surface water and groundwater within the National Monument but also extends to sources such as precipitation, groundwater discharge, overbank flow from the Congaree River, and the inflow from several tributaries from the north. Overbank flow from the Congaree River potentially exposes the National Monument to activities that occur within its 5.2 million acre watershed. The flood pulse normally occurs during late winter and early spring. At other times of the year, aquatic resources are more dependent on smaller tributaries flowing from the north, groundwater discharge, and precipitation. These sources maintain aquatic habitat in such diverse features as ephemeral ponds or depressions, oxbow lakes and sloughs, and perennial and intermittant streams. The aquatic resources have been affected by dams upstream and possible contamination from wastewater discharges, spills, and non-point sources.

The water resources issues identified as most pressing include the following: (1) improving the understanding of fluvial processes and hydrodynamics of the Congaree River floodplain; (2) assessing and understanding the status of surface water and groundwater contamination; (3) detecting the effects of changing discharges on the aquatic resources of the National Monument; (4) participating in river corridor planning; (5) tracking land use within watersheds large and small; (6) ensuring the safety and enjoyment of visitors; and, (7) augmenting public awareness and environmental education.

Management recommendations have been developed to address water resources issues, and are presented as preferred alternatives to management . The most important of these are developed as 14 project statements that specify actions to be taken over the next decade. Several of these have a one-to-one correspondence with the issues listed above. Others include plans to: (1) adopt a collaborative approach to monitoring water quality; (2) adopt a flood prediction system and implement a flood warning system; (3) upgrade stream classification of tributary creeks; (4) assess contaminant sources and pathways; (5) conduct an inventory of wetlands and other biotic resources dependent on aquatic habitats; (6) assess the impact of man-made structures; and, (7) promote the recognition of the National Monument as an important ecological and recreational resource.

INTRODUCTION

Congaree Swamp National Monument was established in 1976, initially consisting of 15,135 acres (6,125 hectares), and expanded by an act of Congress in October, 1988 to 22,200 acres (8,984 hectares), its present size (Figure 1). It is located near the geographic center of South Carolina, on the inner coastal plain, adjacent to the Piedmont (Figure 2). The National Monument is a large, complex floodplain extending roughly 10 miles (15 km) along the length of the north bank of the Congaree River, and varying 1.8 to 3.5 miles (2.5 to 5 km) in width. It is located in Richland County, approximately 26 river miles (42 km) downstream from the confluence of the Broad and Saluda Rivers in Columbia, South Carolina (Figure 3).

The water resources of the National Monument include all sources of water to the site, including precipitation, groundwater discharge, overbank flow from the Congaree River, and the inflow from several tributaries from the north (Table 1). Water resources also include water and its movement within the National Monument . This includes such standard components as flowing and ponded surface water and surficial groundwater, as well as less commonly recognized atmospheric water vapor that derives principally from transpiration by plants and evaporation from surfaces.

The National Monument is surrounded by land used for agriculture, silviculture, low-density residential development, and military bases. Each type of land use has the potential to alter water quality of the streams flowing in from the north. Water is also transported to the swamp surface by overbank flow from the Congaree River. The Congaree River upstream from the National Monument has a large watershed containing 5,238,988 acres (2,121,790 ha) (Figure 4). At the river reach adjacent to the National Monument, the Congaree River is a high order stream (stream order > 6), based on an ordering system in which headwater streams have an order of 1, with stream order increasing at the confluence of same order tributaries. In the region surrounding the National Monument, high order streams typically drain areas having a mixture of land use categories, including forest, farmland, and cities. The Congaree River itself flows through the large urban area of Columbia, South Carolina, approximately 25 miles (40 km) upstream from the National Monument. The 1990 population within the Congaree River watershed was approximately 1.3 million (U.S. Department of Commerce 1994).

The National Monument contains some of the last vestiges of old growth forest in the southeastern United States. A recent study by Jones (1996) indicates that the National Monument is among the tallest temperate deciduous forests in the world. The forest ranges from cypress-tupelo swamps growing in nearly permanently saturated conditions to oak-sweetgum ridges that are infrequently flooded. These differences in hydroperiod (depth, duration, frequency, and seasonality of inundation) are largely a result of differences in elevation. Elevation differences are caused by remnants of geomorphic processes resulting from the action of a stream with a dynamic fluvial regimen. This massive wetland complex is reminiscent of the extensive bottomland forests that once bordered major streams in the southeastern United States.

Purpose of the Water Resources Management Plan

Enabling legislation for the National Monument calls for the National Park Service to protect, manage, and administer the National Monument in a way that conserves and protects both its scenery and its natural, geologic, historic, and archaeological resources (P.L. 94-545).

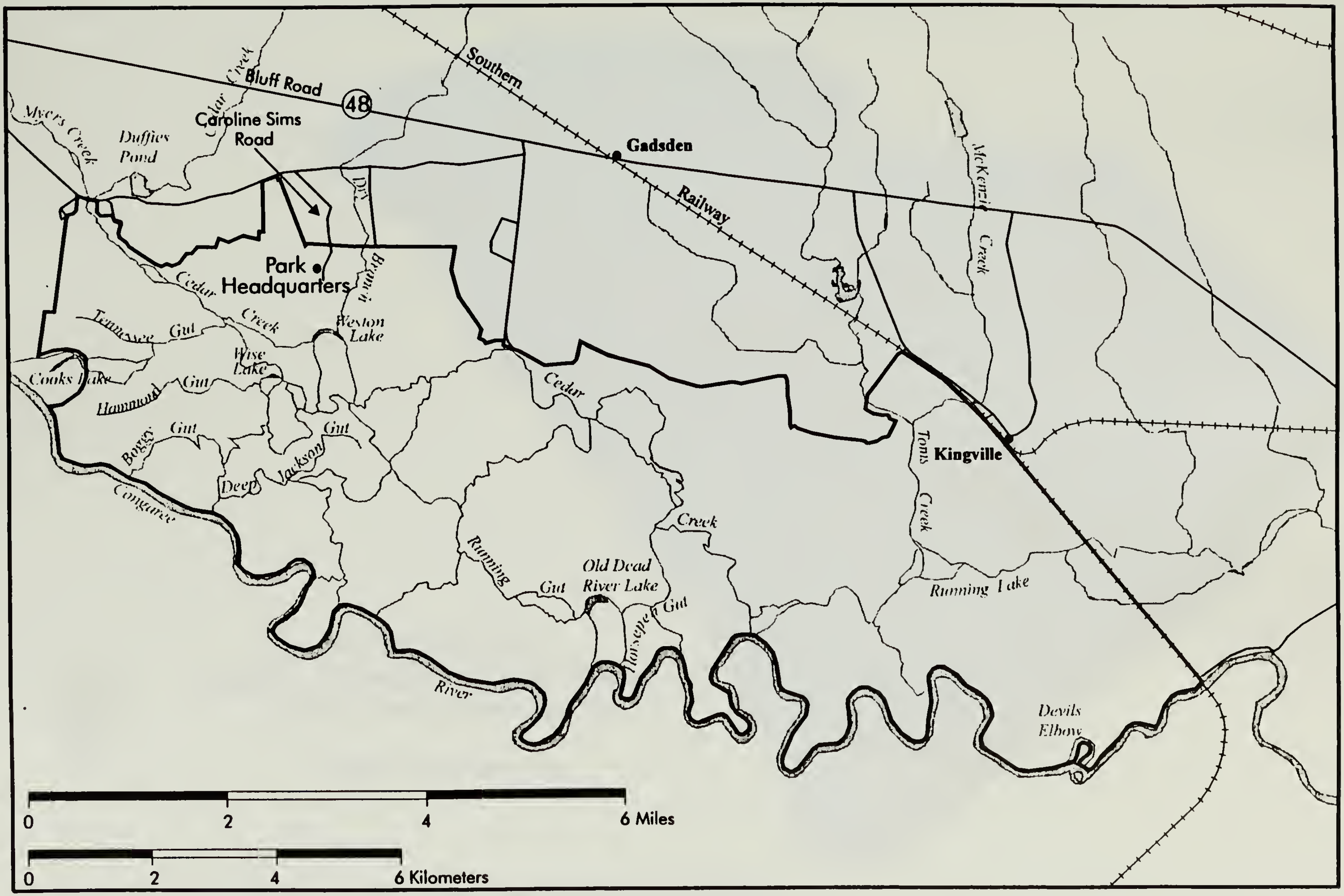
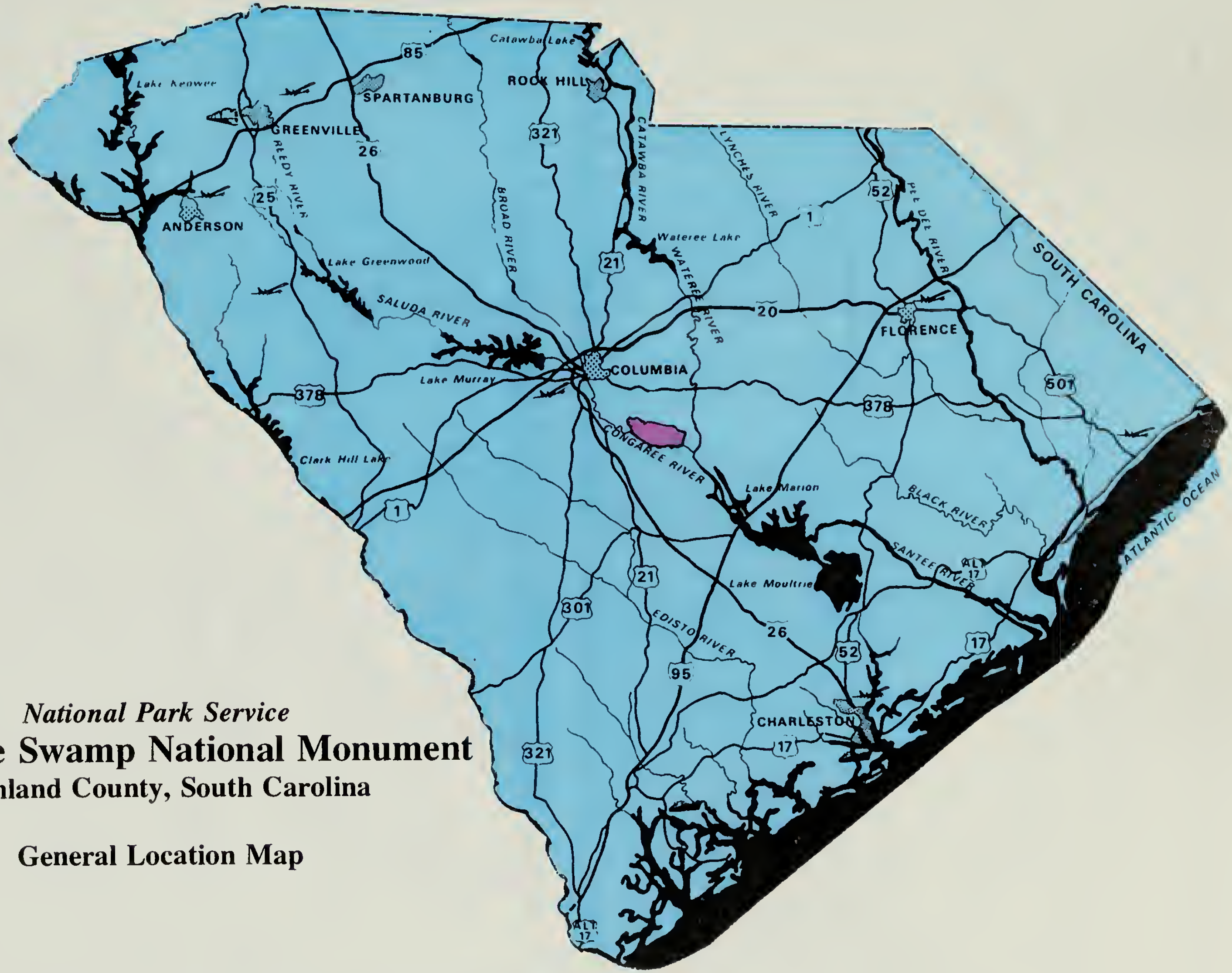


Figure 1. The Congaree Swamp National Monument showing aquatic features.



National Park Service

Congaree Swamp National Monument

Richland County, South Carolina

General Location Map

Figure 2. General location map of Congaree Swamp National Monument.

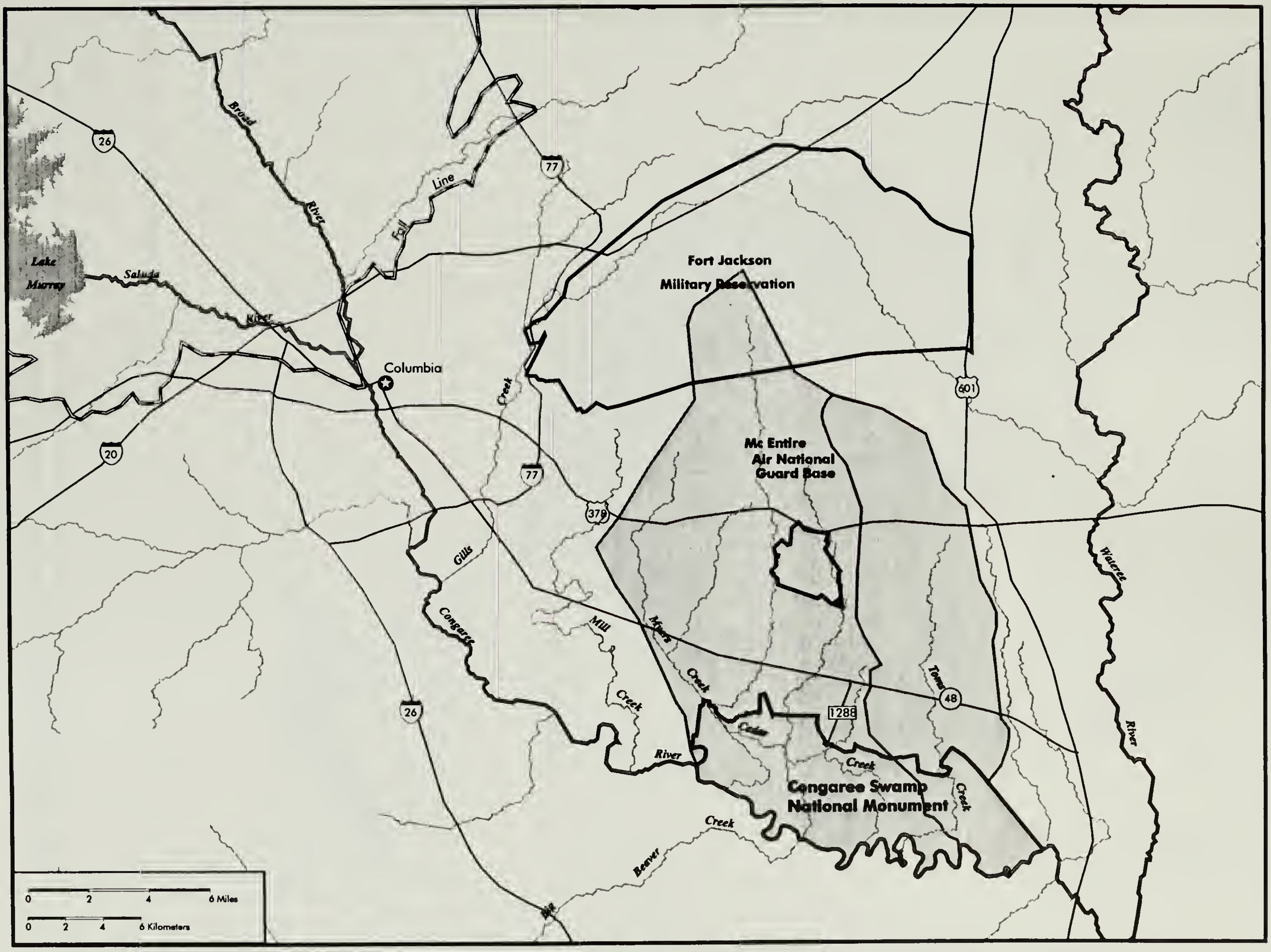


Figure 3. The Congaree Swamp National Monument and vicinity showing the location of Lake Murray, the watersheds of the tributaries to the north of the site, the city of Columbia, and highway and river identification.

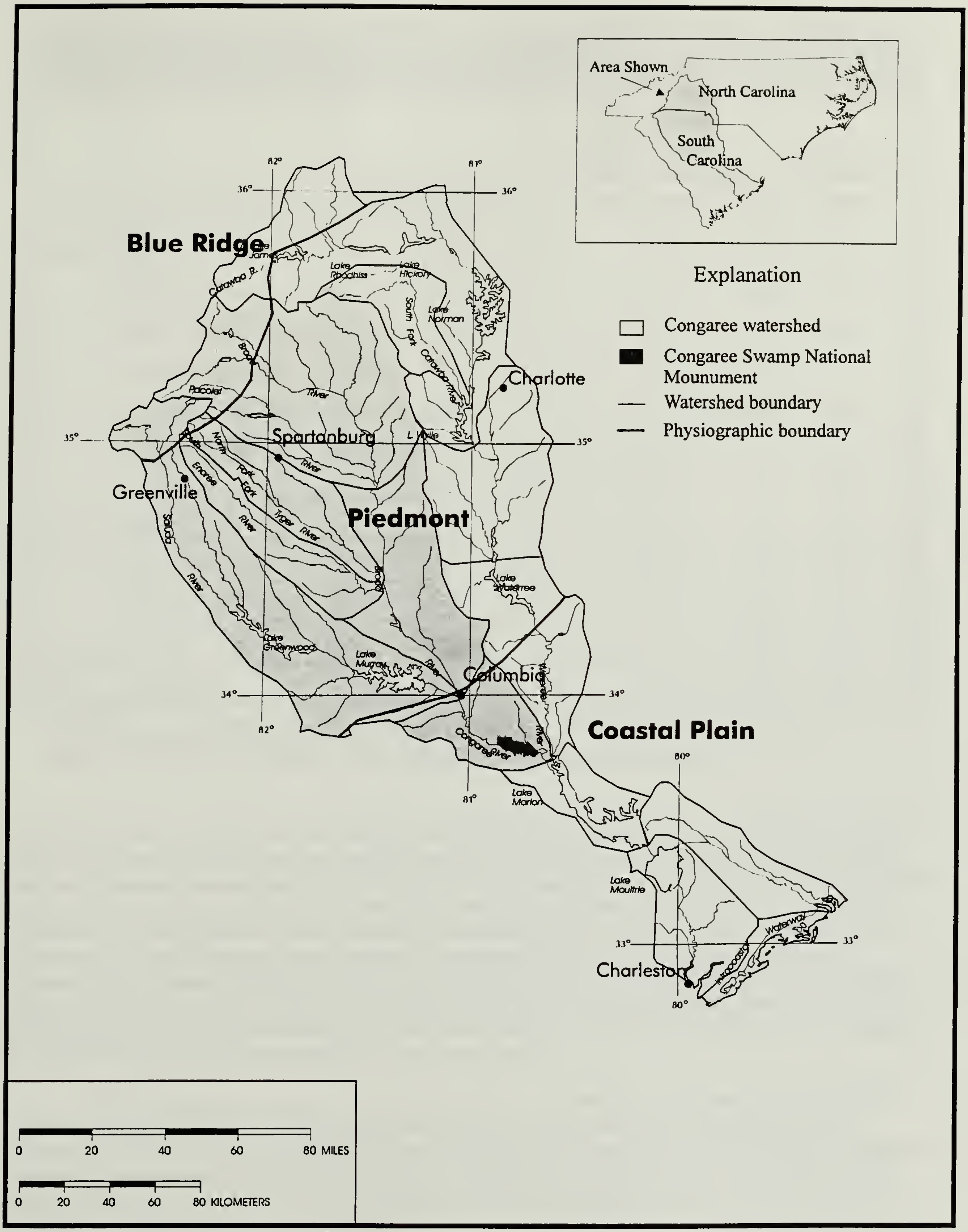


Figure 4. Map of the Santee River basin with the Congaree River watershed highlighted.

Table 1. Named streams and tributaries flowing through the Congaree Swamp National Monument. Tributaries are indented below streams of higher order.			
Streams and Tributaries	**Approximate Length (miles)**	**Approximate length (miles) within National Monument**	**Maximum Stream Order**
Cedar Creek	25.8	14.0	5
Myers Creek	6.3	0	2
Cabin Branch	5.8	0	3
Horsepen Branch	0.9	0	3
Goose Branch	0.9	0	2
Reeves Branch	3.6	0	4
Dry Branch	13.5	0.4	3
Toms Creek	13.5	1.8	4
McKenzie Creek	5.4	0.6	3
Ray Branch	2.7	0	2
Griffins Creek*	13.5	0	3
Singleton Creek*	4.5	0	2

*Griffins Creek and Singleton Creek enter the floodplain to the east of the Southern Railway and thus are outside the boundaries of the National Monument.

At the same time, NPS must also facilitate use by the public, both now and indefinitely into the future. This was accomplished primarily through the Statement for Management (NPS 1994a) and the Resource Management Plan (RMP) for the Congaree Swamp National Monument (NPS 1993a). The purpose of this Water Resources Management Plan (WRMP) is to give specific guidance on water related issues. Because the National Monument is largely a hydrological phenomenon, water related issues naturally dominate the site. For this reason, land use adjacent to the property and anywhere in the watershed, connected by groundwater or surface water, has the potential to impact the National Monument. The focus of this plan is to provide information on potential threats to the water resources of the National Monument, and guidance on action that can prevent degradation of water resources.

Planning typically occurs in the following steps: (1) identify water resources and water dependent environments; (2) formulate water resources management objectives; and, (3) develop a plan of action that protects the water resources according to the objectives. However, planning is necessarily a continuous process, particularly when it is used in conjunction with adaptive management (Holling 1978), because neither the natural resource nor the public is static over time. During the early part of this century, poor farming practices in the Piedmont resulted in mass wasting and the filling of floodplains with topsoil eroded from the uplands (Trimble 1970). The reddish soils that occupy much of the National Monument are suggestive of this Piedmont source, causing one to question the wisdom of considering the soil a stable resource. More recently, Hurricane Hugo (September 1989) provided a reminder of the dynamics of the vegetation as 49% of the trees of the mixed bottomland forest were seriously damaged (Putz and Sharitz 1991). The dynamics of the vegetation are only exceeded by the dynamics of stream flow, which ranges over 3 orders of magnitude for the Congaree River (Patterson et al. 1985). As the public becomes more aware of the National Monument and begins to place more demands on its use, a Water Resources Management Plan is a useful guide for management as well as a foundation on which to build future management objectives.

Distinctive Features of the National Monument

The National Park Service Organic Act of 1916 (P.L. 39-535) states that the National Park Service shall "....promote and regulate the use . . . by such means and measures as to conform to the fundamental purpose of said parks . . . which purpose is to conserve the scenery and the natural and the historic objects and the wildlife therein and to provide for the enjoyment in such manner and by such means as will leave them unimpaired for the enjoyment of future generations." The enabling legislation establishing the Congaree Swamp National Monument (P.L. 94-545) specifically states the purpose of the National Monument is "...to preserve and protect for the education, inspiration, and enjoyment of present and future generations an outstanding example of a near-virgin southern hardwood forest situated in the Congaree River floodplain in Richland County, South Carolina."

Most of the area of the National Monument is an alluvial floodplain occupied by hardwood forest consisting of tree species ranging from upland pines to wetland cypress and tupelo gum. Because of the expansive stands of old growth timber, the National Monument was designated a National Natural Landmark in 1974. After being established as a unit of the National Park Service in 1976, the National Monument received international recognition in 1983 by being included in the United Nations Educational, Scientific and Cultural Organization's (UNESCO) International Network of Biosphere Reserves. The National Monument is now a part of the UNESCO's South Atlantic Coastal Plain Biosphere Reserve.

Other distinctions associated with the National Monument are its prospective nomination as a World Heritage Site and Wetlands of International Importance. The area also serves as a benchmark for the measurement of long-term environmental changes via its inclusion in the Gulf Coast Biogeographic Area of the National Park Service's Global Change Research Program. In short, the National Monument is widely recognized as a representative ecological area and serves as a focus for research and education.

Overview of Present Resource Status

A 1988 Statewide Rivers Assessment found the Congaree River to be one of only seven rivers in South Carolina to have statewide or greater than statewide significance in seven resource categories. The State Scenic Rivers Program lists the Congaree River as a proposed Class II Pastoral River. The Congaree River was also listed in the 1982 Nationwide Rivers Inventory as possessing scenic, recreational, geologic, fish, wildlife, historic, cultural and other outstanding characteristics. Likewise, the 14-mile segment of Cedar Creek which flows through the National Monument has many similar attributes. Both the Congaree River and Cedar Creek appear to meet eligibility criteria for inclusion in the National Wild and Scenic Rivers System (NPS 1993b).

The hardwood forest which covers the majority of the National Monument represents the primary biological resource. This unique and diverse plant community contains many record or near record trees measuring at least 80% of the national and state record size for their species. Included are vast stands of magnificent tupelo (*Nyssa* spp.) and bald cypress (*Taxodium distichum*), oak (*Quercus* spp.), and sweetgum (*Liquidambar styraciflua*). Numerous loblolly pines (*Pinus taeda*) over 150 feet (45 m) tall are interspersed among the hardwoods. In 1989 Hurricane Hugo ravaged the forest. As a result, the national champion Shumard oak (*Quercus shumardii*) and a former national champion overcup oak (*Quercus lyrata*) were toppled. An assessment after the hurricane indicated that significant percentages of canopy trees in the National Monument suffered severe damage (25% of crown lost and trunks snapped or uprooted). Nineteen percent of the trees in the cypress-tupelo sloughs suffered serious damage, while 49% of the trees in the bottomland hardwood forest were similarly affected. The overall effect has culminated in a forest floor littered with downed trees and limbs (Putz and Sharitz 1991). These storms combined with others since the inception of the National Monument have left the area with only four remaining verifiable National record trees: one co-champion possumhaw (*Ilex decidua*), two co-champion persimmon (*Diospiros virginiana*), and one champion water hickory (*Carya aquatica*). The total number of state champions stands at 30 individuals (25 species) (Jones 1996).

Cypress timber was extracted by the Santee River Cypress Lumber Company soon after it began purchasing land in 1895. A few of the cypress trees escaped cutting and these large specimens may be found in the eastern-most portion of the National Monument. According to William Milliken, Milliken Forestry Company, Inc., Columbia, South Carolina (Consulting Forester for the Beidler family), only the large cypresses were cut in the early 1900s. Since then, the smaller trees have grown to become sizable trees.

Prior to the inclusion of the National Monument into the NPS system in 1976, approximately 700 acres (283 ha) were clear-cut and 2,000 acres (809 ha) selectively cut. Of the additional 7,000 acres (2,833 ha) being acquired as part of the boundary expansion, approximately 3,300 acres (1,336 ha) have been clear-cut and 900 acres (364 ha) selectively cut. Combined, 24% of the National Monument has been clear-cut and 13% selectively cut, with the remainder being virgin or near-virgin timber.

The major source of information on the hydrology of the National Monument is the U.S. Geological Survey study by Patterson et al. (1985). Several gauging stations operative during this study were subsequently discontinued and then later reactivated (Table 2). Stations that are now active include: Congaree River west of Wise Lake near Gadsden and three Cedar Creek stations; below Myers Creek near Hopkins; Wise Lake near Gadsden; and, at County Road 1288 near Gadsden.

The Patterson et al. (1985) study identified major sources of water to the National Monument. The Congaree River is a major source during flood events when the overbank flow breaches the natural levee. On average, flood events occur ten times per year. As much as 90% of the National Monument is flooded annually by this source, normally in late winter and early spring. During floods that cover the entire swamp, nearly 40% of the discharge of the Congaree River is estimated to occur within the floodplain.

Table 2. Gauging stations on streams and tributaries that discharge into the Congaree Swamp National Monument. Several stations active during the Patterson et al. (1985) study have been reactivated as shown by the period of record.

Station No.	Location	Period of record
#02169500	Congaree River at Columbia	*1891 to current
#02169625	Congaree River west of Wise Lake near Gadsden	*1981-1983; 1992 to current
#02169740	Congaree River at Southern Railway bridge near Fort Motte	1981-1983
#02169670	Cedar Creek below Myers Creek near Hopkins	**1981-1983; 1994 to current
#02169672	Cedar Creek at Wise Lake near Gadsden	*1981-1983; 1994 to current
#02169675	Cedar Creek at county road 1288 near Gadsden	**1981-1983; 1994 to current

*Real time stations.
**Continuous stations.

Much attention has been given to the potential effects of the Saluda Dam on flooding frequency of the National Monument. The dam controls flow in the Saluda River, one of two major tributaries that form the Congaree River just above Columbia. Since its operation was initiated in 1930, the dam has reduced significantly the frequency of flows that contribute to flooding (Patterson et al. 1985). No conclusions have been reached on whether altered flooding frequencies may affect the species composition of the forest.

During the growing season, tributaries draining watersheds north of the National Monument maintain aquatic conditions in stream channels as they flow through the floodplain of the Congaree River. Cedar Creek is the major tributary, entering the National Monument at the northwestern boundary and continuing its flow across and down the floodplain where it discharges into the Congaree River well into the eastern portion of the National Monument. These inflows are supplemented by groundwater discharge which contributes to base flow as Cedar Creek and other streams flow across the floodplain.

Based upon site requirements and regional distribution, several plants listed on the national threatened and endangered list and some considered to be of South Carolina significance may potentially occur in the National Monument. As an exhaustive and comprehensive survey has yet to be conducted, there currently are no verifiable plant species known to occur in the National Monument that are endangered or threatened, as defined by the Endangered Species Act of 1973, as amended.

The nationally threatened bald eagle (*Haliaeetus leucocephalus*) is occasionally seen flying over the National Monument, but is not known to be nesting there at present. Amphibians are plentiful because of the wet environment. Reptiles are also common. Other aquatic fauna in the National Monument include swamp crayfish (*Procambarus clarki*), chimney crayfish (*Cambarus diogenes*), Asiatic clams (*Corbicula manilensis*), and several species of snails. Based upon natural resources baseline inventories conducted in the early 1980s, the aquatic fauna and macroinvertebrates on which they are dependent are in good condition. However, recent and dramatic declines in amphibian populations have occurred elsewhere in the southeastern United States, but it remains equivocal whether or not these fluctuations are natural (Pechmann and Wilbur 1994; Sarkar 1996). Regardless, updated inventories are warranted to determine whether population fluctuations in the National Monument are in synchrony with those elsewhere in the Southeast.

Bobcats (*Lynx rufus*) and river otters (*Lutra canadensis*) are seen occasionally. Several other animals considered significant by local naturalists are found in the National Monument [e.g., Swainson's warbler (*Limnothlypis swainsonii*), American swallow-tailed kite (*Elanoides forficatus*), Mississippi kite (*Ictinia mississippiensis*), spotted turtle (*Clemmys marmorata*), marsh rabbit (*Sylvilagus palustris*), and fox squirrel (*Scirus niger*)].

The Congaree River is the primary fishery of the area. On the floodplain, fishing is limited to accessible reaches of Cedar Creek and Toms Creek and to some of the oxbow lakes. Recreationally important fishes of the National Monument include largemouth bass (*Micropterus salmoides*), sunfish (*Lepomis* spp.), black crappie (*Pomoxis nigromaculatus*), yellow perch (*Perca flavescens*), and catfish (*Ictalurus* sp. and *Ameiurus* sp.). Other fishes include gar (*Lepisosteus osseus*), bowfin (*Amia calva*), darters (*Etheostoma spp.*) and shiners (*Notropis* spp.). Striped bass (*Morone saxatilis*) are found in the Congaree River.

Other biological inventory and monitoring programs which have received considerable documentation in the past, or are currently receiving some degree of attention, include the areas of ornithology, herpetology, small mammals and macrofungi. These are documented in the Resources Management Plan (NPS 1993a).

Water Resources Management Objectives

Water resources are a critical component of any ecosystem, and especially for the water-dominated floodplain and forest that constitute the National Monument. It is the policy of the NPS to seek to maintain, rehabilitate, and perpetuate the inherent natural integrity of water resources and water-dependent environments occurring within units of the NPS System (NPS 1991). As a focal point of this management plan, the following objectives have been developed to guide actions related to priority water resources issues within the National Monument and to minimize potential threats to the National Monument from external sources.

1. To maintain surface and groundwater flows, hydroperiods, and natural patterns of flooding within the National Monument in order to support the natural functioning of the wetland ecosystem.

2. To understand, maintain, and/or enhance surface and groundwater quality both through internal resource management initiatives and through

cooperative water quality protection activities involving local, state, and federal regulatory and/or planning agencies.

3. To provide public awareness of the water resources and water-dependent environments of the National Monument and an understanding of existing or potential human impacts upon these resources.

4. To encourage and participate in local land use planning activities in watersheds adjacent to the National Monument (especially Cedar Creek, Myers Creek, Toms Creek, and Griffins Creek) in order to assure that future land use change and development activities do not degrade water-related resource values within the National Monument.

5. To promote the role and value of the National Monument as an International Biosphere Reserve and as a significant site for the study of the aquatic component of a representative old growth bottomland hardwood forest.

6. To maintain an environment conducive to visitor enjoyment, education, and safety.

Legislative, Planning, and Regulatory Relationships

There are a variety of federal, state and local regulatory programs which pertain to the protection and management of water-related resources in and adjacent to the National Monument. The principal federal programs are established under the Clean Water Act and the National Environmental Policy Act. The state of South Carolina also has regulatory programs aimed at protecting water resources. These programs, created through enabling state legislation, may provide state level regulations and oversight. Many of the state programs are administered at the local government level. None of these regulatory programs appears to establish any conflicts with National Monument management objectives. However, given the nature of the hydrologic resources of the National Monument and the importance of activities outside its boundaries on water resource quality within the National Monument, full knowledge of and coordination with these programs and their implementing agencies are crucial.

The following state and federal statutes, regulations, and executive orders have regulatory significance regarding water resources management at the National Monument. A description of the applicable provisions of each statute is provided.

<u>Federal Legislation and Authorities</u>

<u>NPS Organic Act/Congaree Swamp National Monument Enabling Legislation</u>.--The National Park Service Organic Act (1916) specifies that the NPS is responsible for the preservation and conservation of natural resources in all parklands under its jurisdiction. This act was reinforced by Congress in 1970 with legislation stating that all parklands are united by a common preservation purpose, regardless of title or designation. Hence, all water resources in the National Park System are protected equally by federal law, and it is the fundamental duty of the NPS to protect those resources unless otherwise indicated by Congress.

Of particular significance to the water resources of the National Monument, Public Law 94-945 has special provisions related to fishing. Fishing is to be permitted in the park in accordance with applicable state and federal laws. Zones and periods of time may be designated in which no fishing may be permitted for reasons of public safety. Except in emergencies, any regulations that prescribe such no-fishing zones or times shall be enacted only after consultation with the appropriate state agency.

Federal Water Pollution Control Act.--The Federal Water Pollution Control Act (P.L. 92-500 and amendments), more commonly known as the Clean Water Act, was first promulgated in 1972 and amended in 1977, 1987, and 1990. This law was designed to restore and maintain the chemical, physical, and biological integrity of the nation's waters. Goals set by the act were to maintain or upgrade waters to swimmable and fishable conditions by 1983 and to eliminate discharges of pollutants into the nation's waterways by 1985. As part of the act, Congress recognized the primary role of the states in managing and regulating the nation's water quality within the general framework developed by Congress. All federal agencies must comply with the requirements of state law for water quality management, regardless of other jurisdictional status or land ownership. States act to protect water quality under the authority granted by the Clean Water Act by establishing water quality standards and issuing point source discharge permits. In addition, best management practices, which are defined by the Environmental Protection Agency as methods, measures, or practices to prevent or reduce pollution in "waters of the United States," may be required by an agency to meet its nonpoint pollution control needs. These practices include, but are not limited to, structural and non-structural controls, operational procedures, and maintenance procedures. They can be applied before, during, and after pollution-producing activities to reduce or eliminate the introduction of pollutants into receiving waters. Water quality standards are composed of the designated use or uses made of a water body or segment, water quality criteria necessary to protect those uses, and an anti-degradation provision to protect the existing water quality.

Section 404 of the Clean Water Act further requires that a permit be issued for the discharge of dredged or fill materials in waters of the United States, including wetlands. The Army Corps of Engineers administers the Section 404 permit program, with oversight and veto powers held by the EPA. Federal legislation and regulations are generally implemented by the states, with the EPA serving in an oversight role. A triennial review of a state's water quality regulatory program is conducted by each state's water quality agency to determine if its standards are adequate to meet federal requirements. These standards are then forwarded to the EPA for approval.

The National Environmental Policy Act.--The National Environmental Policy Act (NEPA) (P.L. 91-190) was passed by Congress in 1969. NEPA established a general federal policy for the responsibility of each generation as trustee of the environment for succeeding generations. Specifically, NEPA requires that an environmental impact statement (EIS) be prepared by federal government agencies as part of the review and approval process of major actions which significantly affect the quality of human life. The primary purpose of an EIS is to serve as an action-forcing device to ensure evaluation of the impacts of proposed projects and facilitate public review.

An environmental assessment may be prepared prior to initiating an EIS. The assessment is used to make a determination if the preparation of an EIS is required. An EIS is not prepared when the review of an environmental assessment results in the "Finding of No Significant Impact (FONSI)." Implementing regulations requires the cooperation of federal agencies in the NEPA process. The regulations also encourage the reduction of duplication through cooperation with state and local agencies.

Executive Order 11988.--Because the National Monument is predominately a floodplain environment, Executive Order 11988 entitled "Floodplain Management" has special significance. It requires all federal agencies to "reduce the risk of flood loss, . . . minimize the impacts of floods on human safety, health and welfare, and . . . restore and preserve the natural and beneficial values served by floodplains" (Goldfarb 1988). Federal agencies are therefore required to implement floodplain planning and consider all feasible alternatives which minimize impacts prior to construction of facilities or structures. Construction of such facilities must be consistent with federal flood insurance and floodplain management programs. West (1990) suggests that National Park Service managers ensure that where park resources fall within flood hazard areas, these areas be properly marked to increase public awareness of potential flood dangers at the site. To the extent possible, park facilities such as campgrounds and rest areas should be located outside these areas. National Park Service guidance pertaining to Executive Order 11988 can be found in Floodplain Management Guidelines (NPS 1993b).

Executive Order 11990.--Executive Order 11990, entitled "Protection of Wetlands," requires all federal agencies to "minimize the destruction, loss or degradation of wetlands, and preserve and enhance the natural and beneficial values of wetlands" (Goldfarb 1988). Unless no practical alternatives exist, federal agencies must avoid activities in wetlands which have the potential for adversely affecting the integrity of the ecosystem. National Park Service guidance for compliance with Executive Order 11990 can be found in Floodplain Management and Wetland Protection Guidelines, published in the *Federal Register* (45 CFR 35916, Section 9). The publication, Wetland Regulatory Compliance: A Guidance Manual for the National Park Service Mid-Atlantic Region (NPS 1989), should also be consulted for issues pertaining to wetlands. This document is being updated (Joel Wagner, NPS Water Resources Division, personal communication, December 1995).

Other Federal Legislation.--Three additional acts are noteworthy. One is the Water Quality Improvement Act (1970) which requires federally regulated activities to have state certification that they will not violate water quality standards. The Safe Drinking Water Act (1974) and Amendments (1986) set national minimum water quality standards and requires regular testing of drinking water for developed public drinking water supplies. Finally, the Federal Energy Regulatory Commission (FERC) licenses several hydroelectric facilities on tributaries to the Congaree River.

State Legislation and Authorities Affecting Water Quantity and Water Quality

No permitting programs exist in South Carolina which provide general regulation of the withdrawal and use of surface waters by riparian or non-riparian users. Use of surface water in South Carolina, with a few exceptions, is governed only by the common law doctrine of riparian rights. Most notably, these exceptions include the Interbasin Transfer Act (Act No. 90 of 1985) which regulates the transfer of water between 15 major river basins within the state. Groundwater use is not regulated except during drought and emergency situations.

Public Water Supply Withdrawals.--The State Primary Drinking Water Regulations, R. 61-58 (Statute: South Carolina Safe Drinking Water Act, Title 44, Chapter 55), require that both construction and operating permits be obtained from the South Carolina Department of Health and Environmental Control (SCDHEC) for any public water supply. In selecting the source of water to be developed, the quantity of water at the source shall be adequate to meet the projected peak day demand (1.5 times average) of the service area as shown by calculations based on the extreme drought of record (R. 61-58.2 B.,(1),(a)). Therefore, consideration is given to the availability of water for the proposed withdrawal, and in part, to other users potentially impacted. This does not necessarily mean that a permit would be denied if other users are impacted.

R. 61-58.8,D., provides specific authority to restrict water withdrawals, but only during drought and other emergency situations. R. 61-58.8, D.,(1), states that when drought reduces the amount of surface or groundwater available for domestic, industrial, agricultural, and commercial use, "SCDHEC may regulate surface water and groundwater withdrawals in an equitable manner to reduce the impact to the public well being and health." Further, R. 61-58.8, D., (1), states that "no person shall withdraw water from a surface or groundwater source at such a rate and daily volume as to infringe on the use of said water source by a public water supply." Although authorized, these provisions have never been exercised by SCDHEC.

Construction in State Navigable Waters.--The reach of the Congaree River that flows past the National Monument is designated as State Navigable Waters. Cedar Creek within the National Monument is also designated as State Navigable Waters. The state of South Carolina regulates construction activities in state navigable waters. Regulated activities include the construction of surface water intakes on streams and reservoirs. Regulation of construction activities in state navigable waters is administered by SCDHEC. R. 19-450 requires that a permit be issued by SCDHEC for: *any* "dredging, filling or construction or alteration activity in, on, or over a navigable water; in or on the bed under navigable waters; or, in or on lands or waters subject to a public navigational servitude under Article 14 Section 4 of the South Carolina Constitution and Section 49-1-10 of the 1976 S.C. Code of Laws including submerged lands under the navigable waters of the state, or for any activity significantly affecting the flow of a navigable water." Any permits issued must not endanger public health, or cause a violation of R. 61-68, Water Classification and Standards, also administered by SCDHEC. However, the state has not been delegated authority from the U.S. to administer 404 "dredge and fill" activities under the section 404 program of the Federal Water Pollution Control Act.

A number of important factors must be considered during application review, including the utilization and protection of important state resources. Specifically, R. 19-450.9., (A), states the review is to consider the benefits and detriments of the proposed activity including its "impact on conservation, economics, aesthetics, general environmental concerns, cultural values, fish and wildlife, navigation, erosion and accretion, recreation, water quality, supply and conservation, and determine whether the proposed project is consistent with the needs and welfare of the public." Although not explicitly regulating surface water withdrawals, R. 19-450 has been used to impose permit requirements, restricting the construction of reservoirs and water intakes. R. 19-450 mandates minimum flow requirements associated with offstream withdrawals. These permit requirements protect navigability, fisheries, and general environmental concerns.

R. 19-450 was revised and amended in 1995 by the State Budget and Control Board and ratified by the South Carolina General Assembly. Older versions of the regulations are no longer applicable.

Protection of Minimum Flows.--South Carolina does not have specific legislation which authorizes the implementation of minimum water levels or flows, except under the authority of the regulations mentioned above and the Interbasin Transfer Act. In 1983, the South Carolina General Assembly passed a joint resolution recognizing the importance of instream uses and the need for their protection and directed the South Carolina Water Resources Commission to identify streams in need of minimum flow protection. The Saluda River below Lake Murray was cited as being in need of protection due to hydrologic regulation of the Saluda River for peak hydroelectric power generation. While the Saluda River flows into the Broad River near Columbia to form the Congaree River, the Congaree River was not cited as being in need of minimum flow protection (South Carolina Water Resources Commission 1988). South Carolina has determined that instream flows are essential uses to be protected during drought conditions.

Specific guidance on the determination of minimum instream flow standards to protect navigability and fisheries is contained in South Carolina Water Resources Commission Report No. 163 (SC Water Resources Commission 1988). Prior to 1994, this guidance was used by the Commission to determine instream flow needs concerning Interbasin Transfer Permits, Permits for Construction Activities in State Navigable Waters, and comments on Federal Energy Regulatory Commission (FERC) licenses. Since restructuring of environmental permitting agencies in South Carolina on July 1, 1994, SCDHEC has not used Commission Report No. 163 to determine permit conditions. The Water Resources Division of the South Carolina Department of Natural Resources continues to use this guidance to comment on federal and state permits regarding water resources activities.

Interbasin Transfer Act.--In 1985, the South Carolina General Assembly enacted Act No. 90 (Statute: Interbasin Transfer of Water Act, Title 49, Chapter 21), which regulates the transfer of surface water among 15 river basins within the State. The purpose of the act and R. 121-12.1 is to protect the water quality of the losing river basin. In particular, these provisions are designed to safeguard present and projected surface water uses in the losing river basin including, but not limited to, agricultural, municipal, industrial, instream uses, and assimilative needs. A permit is required for any entity to withdraw, divert, pump, or cause directly the transfer of either 5% of the seven-day, ten-year low flow (7Q10), or one million gallons or more of water per day, whichever is less, from one river basin and to use or discharge all or any part of the water in a different river basin. Fifteen river basins are delineated in the permit program, including the Congaree River basin. The Interbasin Transfer Act does not regulate interbasin transfers of groundwater.

The Interbasin Transfer Act is the only state law which has specific authority to limit the use of surface water in order to provide protection to offstream and instream uses, especially during low flow periods. Interbasin transfer permits may require the establishment of bypass requirements for diversions from rivers or streams to maintain minimum flows during low flow periods. For withdrawals from rivers or streams, the withdrawal must cease during these adverse conditions so as not to directly cause the remaining flow to be below the specified instantaneous minimum flow. By statute, the 7Q10 is the lowest minimum allowed. Other higher minimums may also be specified in order to protect downstream withdrawals, protect water quality and important fisheries resources, or to insure an adequate water supply for the state. Permits may be issued for a period of one to 40 years.

In determining whether or not to issue a permit, SCDHEC must :

1) insure the protection of present stream uses and consider projected stream uses in the losing river basin including offstream uses, instream uses, and assimilative needs;

2) protect the present and permitted assimilative needs, and insure the protection of water quality and the health of the losing river basin (Water Quality Certification);

3) consider future water demand, efficiency, and conservation of the water used;

4) consider the engineering and economic feasibility of alternatives to the proposed interbasin transfer; and,

5) consider impacts on the state, local subdivisions of government, and interstate water use.

Water Quality.--The majority of programs concerned with water quality in South Carolina are administered by the Bureau of Water Pollution Control of SCDHEC. The Bureau is responsible for a variety of permits, approvals, and certifications associated with water pollution control. The authority for these programs originates from multiple federal statutes, including the Federal Water Pollution Control Act (P.L. 92-500) as amended by the Clean Water Act of 1977 (P.L. 95-217), as amended by the Water Quality Act of 1987 (P.L. 100-4). The South Carolina Pollution Control Act (SC Code of Laws, Title 49, Chapter 21), and R. 61-9 provide statutory authority to implement and enforce general pollution control programs within the State.

The SCDHEC is responsible for several other environmental permitting programs that could have relevance to the National Monument. These include Storm Water permitting, Dam and Reservoir Safety permitting, Underground Storage Tank permitting, Solid Waste Landfill permitting, and Mining and Reclamation permitting. Specific reference to statutory authority, regulations, and a description of these and all environmental permitting is found in a General Guide to Permitting in South Carolina (SCDHEC 1994a).

Classification and Standards--The South Carolina "Water Classifications and Standards" establishes classified uses for the state's waters and provides specific guidance on criteria to protect those uses. The purpose of these standards is also to protect the public health and welfare, and maintain and enhance water quality. The "Water Classifications and Standards" and "Classified Waters" are found in R. 61-68 and 61-69, respectively (Statute: Section 48-1-10). These standards serve as a guide for decisions regarding the issuance of National Pollutant Discharge Elimination System (NPDES) permit limits for discharges to the state's waters.

In an effort to monitor the effectiveness of the state's programs concerning water quality, SCDHEC develops and implements an annual monitoring strategy. Technical Report No. 002-95 (SCDHEC 1995a) provides an overview of the state's monitoring strategy for 1996. SCDHEC monitors numerous water quality parameters on a monthly basis at 271 primary stations across South Carolina. Samples are taken six times per year at 286 secondary stations. A listing of these stations and the monitored constituents can be found in Technical Report No. 002-95.

In an effort to develop a coordinated approach to planning, monitoring, and permitting, SCDHEC initiated a watershed approach to water pollution control. Five major watersheds, encompassing 15 minor watersheds, were included in the program of the Watershed Water Quality Management Strategy (SCDHEC 1995b). Each watershed is examined on a five year rotating schedule. The National Monument is located in the Saluda-Edisto Basin, and in 1995, the first report was issued for the basin (SCDHEC 1995c).

Fisheries and Wildlife.--The responsibilities for management of fish and wildlife resources at the National Monument are concurrently administered by the National Park Service and the South

Carolina Department of Natural Resources, Division of Wildlife and Freshwater Fisheries. In addition to provisions of the NPS Organic Act (16 USC 1, March 1, 1916), the enabling legislation for the Congaree Swamp National Monument [90 Stat.2517, Sec 3(b)] specifically states regarding the fishery resource that,

> "The Secretary shall permit sport fishing on lands and waters under his jurisdiction within the monument in accordance with applicable Federal and State Laws, except that he may designate zones where and establish periods when no fishing shall be permitted for reasons of public safety, administration, fish and wildlife management, or public use and enjoyment. Except in emergencies, any regulations promulgated under this subsection shall be placed in effect only after consultation with the appropriate fish and game agency of the State of South Carolina."

National Park Service fishing regulations, applicable to the National Monument, are found in 36 CFR, Section 2.3.

South Carolina Code (Section 50-1-10) provides specific legislative authority for the management of fish and wildlife resources within the state. Specific regulations pertaining to freshwater and anadromous fisheries are found throughout the South Carolina Code. Changes and modifications of these fishing regulations require approval by the State Legislature.

These concurrent authorities for the protection and management of aquatic and fishery resources within the National Monument will require ongoing collaboration and cooperation between the National Park Service and the state of South Carolina.

Water Rights in South Carolina

Like most states in the eastern third of the United States, South Carolina has accepted the riparian doctrine in allocating rights to use water from surface water bodies. The doctrine of riparian rights applies to all natural watercourses (Spitz 1991). The riparian doctrine is a court-derived system of rules used to allocate rights to use water from surface water bodies such as rivers, streams, and lakes. A riparian right arises from the ownership of land either bounded or crossed by a natural watercourse. The United States enjoys the same rights as any other riparian landowner.

The fundamental riparian right in South Carolina is the right to reasonable use of water. That is, a riparian user is entitled to make a reasonable use of a portion of the flow of a water course that arises by virtue of ownership of land that adjoins, is overflowed by, or overlays a water resource. The use is subject both to the availability of water and to the reasonable use by other landowners similarly situated (Tarlock 1988). The reasonable use basis of the riparian right does not allow for quantification of existing water uses since the basis of the riparian right is not the quantity of water used, but the way in which the water is used.

Typically, riparian rights are asserted for water diverted out of a stream. Riparian rights could be asserted downstream from existing diversions to maintain flow levels (assuming these flow levels could be reasonably maintained, given hydrologic conditions in the stream) for beneficial and reasonable uses of water.

South Carolina has also adopted permit programs to govern some surface and groundwater uses. The Interbasin Transfer Act, as stated above, requires a permit to transfer surface water to another basin for use or discharge. The Ground Water Use Act (SC Code of Laws, 1969, Chapter 5 of Title 49, Section 49-5-10 et seq. Of the 1976 Code as amended) regulates the use of groundwater withdrawals, in excess of 100,000 gallons per day, in declared groundwater control areas. These areas, called "capacity use areas," have been designated for coastal counties, and do not include the National Monument. Statewide, groundwater withdrawals that exceed 100,000 gallons per day require periodic groundwater use reports. Nothing in these statutes changes the relative rights of riparian landowners.

Water Resources Issues

The floodplain ecosystem of the National Monument is a dynamic system responding to intrinsic and extrinsic influences which affect its development and maintenance. While many of the influences are natural occurrences, such as the disturbance and succession initiated by Hurricane Hugo, anthropogenic influences are now very much a part of the system. Because of its position in a strongly human-influenced landscape, which includes numerous point sources of pollution, the National Monument may be subjected to influences which diminish its ecological, scientific, recreational, and aesthetic value. This Water Resources Management Plan identifies seven central issues that must be addressed if the water resources of the National Monument are to be maintained and improved in a way that is consistent with goals established by the National Park Service. These issues, treated in detail in the Issues and Management section of this document, should be addressed by:

1. achieving an enhanced understanding of floodplain function and hydrologic processes and using this knowledge for the long-term preservation and management of the floodplain forest of the National Monument;

2. determining the current status of surface water and groundwater quality and investigating regulatory options that will result in the maintenance or improvement of water quality;

3. evaluating the influence/impacts of water management (water supply and hydroelectric production) in the upper Congaree River watershed upon resource conditions in the National Monument;

4. recognizing the relationship between land use and water quality, and recommending long-term monitoring of land use changes that may affect water quality in the National Monument;

5. encouraging riparian corridor and tributary planning for the Congaree River and tributaries to the north of the National Monument in order to protect resource values;

6. ensuring that NPS operations, visitor use, and safety are compatible with the maintenance of the ecological integrity of the National Monument; and,

7. promoting public awareness and education for broader recognition of the National Monument as a nationally and internationally important ecological and recreational resource.

HYDROLOGIC ENVIRONMENT AND AQUATIC FEATURES

The primary goals established by the National Park Service for Congaree Swamp National Monument, as stated in the Resources Management Plan (NPS 1993a), are the long-term maintenance of the ecological integrity of the National Monument and its use for public enjoyment and education. To achieve these goals, it is necessary to identify pertinent management issues and take action on them. Many of the resource issues can be justified for inclusion in a Water Resources Management Plan because the site is dominated by a floodplain wetland where aquatic ecosystems are prevalent. The National Monument's floodplain ecosystem may be at risk as a consequence of its location at the lower end of the Congaree River watershed, one of South Carolina's largest and most human-impacted regions. Although the floodplain of National Monument has received only minor or moderate alterations compared to similar floodplains elsewhere in the Southeast, the potential for water quality degradation and water withdrawal for urban and industrial development is a primary concern.

Wetland and aquatic ecosystems are dominant natural features of the National Monument. These ecosystems are controlled largely by flooding and water flow and secondarily by the quality of the water received. These controls are essential to the maintenance of the properties that led originally to the designation of the site as having national significance.

As with other National Parks, the features and resources for which the National Monument is managed and protected are strongly dependent on natural forces external to its boundaries. These resources include the quantity and timing of surface water flows, and the quality of subsurface and surface water. This section of the WRMP emphasizes the hydrologic and geomorphic features of the watershed that are responsible for the development of the geomorphic setting of the floodplain and for the continued support of the uniquel biotic resources of the National Monument.

Hydrologic Regime

The hydrologic regime is dominated by two principal sources of surface water; the larger Congaree River watershed and the smaller watersheds of tributary streams north of the National Monument. The Congaree River watershed provides by far the deepest flooding and largest pulse of water through large overbank flood events. These floods are most common in late winter and early spring after a period of low evapotranspiration has allowed soil water and shallow groundwater storage to reach a maximum in the watershed. With little storage capacity remaining, much of the precipitation finds its way to streams through groundwater flow paths and overland flow.

The smaller watersheds to the north of the National Monument are the second major source of surface water, but they are incapable of producing large floods like the Congaree River. In fact, their flows are roughly synchronized with the Congaree River because they are driven by similar weather patterns. As such, flood peaks in tributaries are a lower order of magnitude compared with overbank flows from the Congaree River. During the summer and fall, however, when flooding from overbank flow is least likely, the smaller tributaries entering from the north become proportionately more important to floodplain hydrology. It is during these drier times of the year that perennial flows from several of the tributaries sustain base flows and maintain the aquatic habitat of the floodplain and localized flooding.

Base flows of the smaller streams in the floodplain are maintained by groundwater discharges (Patterson et al. 1985). These groundwater contributions maintain shallow water tables and saturated soil conditions. Ground water not only enhances base flow of the smaller channels in the floodplain (Patterson et al. 1985), but also maintains shallow water tables which contribute to the overall wetness of the site. As with surface flows, groundwater sources originate almost entirely outside of the boundaries of the National Monument.

Climate

The climate of the eastern United States is moist enough to support forest vegetation on well-drained upland sites. Precipitation and temperature interact to produce a water balance that has a seasonal and inter-year source of variation. The warm season, when vegetation requires the greatest amount of water for transpiration, coincides with the season of greatest precipitation (Figure 5). In fact, average monthly precipitation increases from April to August, the period when demand for water is greatest. Precipitation decreases later in the warm season during September and October, those months when vegetation is most likely to experience soil moisture deficits. Moisture deficits are further compounded in riverine swamps like the Congaree River because this is the time of year that supplementary water sources from overbank flow and groundwater discharge are in lowest supply.

For most deciduous trees, such as the oaks, sweetgum, and red maple, leaf fall occurs by mid-November. Water demand by these species becomes negligible at this time, and evaporation rates are minimal due to low temperatures. This lower water demand by evapotranspiration more than compensates for the lower mean monthly precipitation at that time of the year. Consequently, a typical year consists of a growing season that continually becomes drier, and a dormant season that becomes progressively wetter.

Water Sources

Supplemental water sources to the Congaree Swamp are provided by overbank flow, tributary supply, and groundwater discharge. These sources have profound effects on the biota of the swamp, either by eliminating potential competitors that cannot tolerate soil saturation and flooding, or by providing aquatic habitat to those that require submergence.

Streamflow.--Flows of the Congaree River vary greatly within each year and between years. Within a year, daily flows typically range over 2 orders of magnitude (Figure 6). For example, in 1977, which had a maximum daily flow of 150,000 cubic feet per second (cfs), the lowest daily flow was 1,240 cfs. Maximum daily flows for any year vary more than the average or minimum flows (Figure 6). For example, the maximum daily flow for 1988 (22,300 cfs) was only one order of magnitude higher than the minimum daily flow (1,240 cfs). The short term nature of maximum flows is evident from the extent to which average flows for the year are skewed toward the minimum flows.

Flows within a given year show seasonal pulses of one to several peaks of average monthly discharge (Figure 7). For large rivers in the Southeast like the Congaree, this is indicative of the seasonal balance of precipitation and evapotranspiration over the larger watershed. Flooding usually occurs late in the dormant season after low evapotranspiration

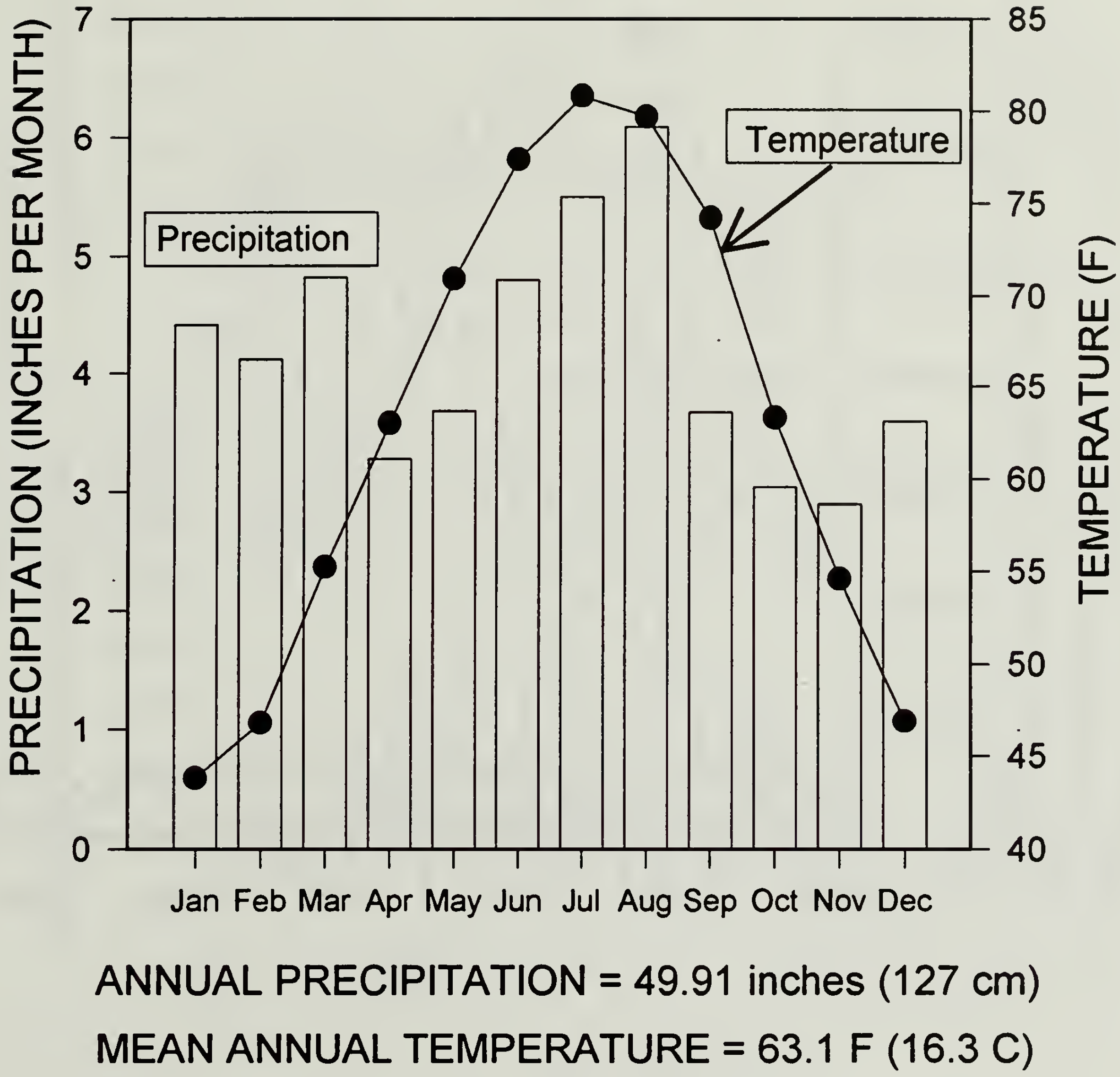


Figure 5. Mean monthly temperature and mean monthly precipitation at Columbia, South Carolina. Data based on standard 30-year period, 1961 through 1990. From U.S. Department of Commerce (1994).

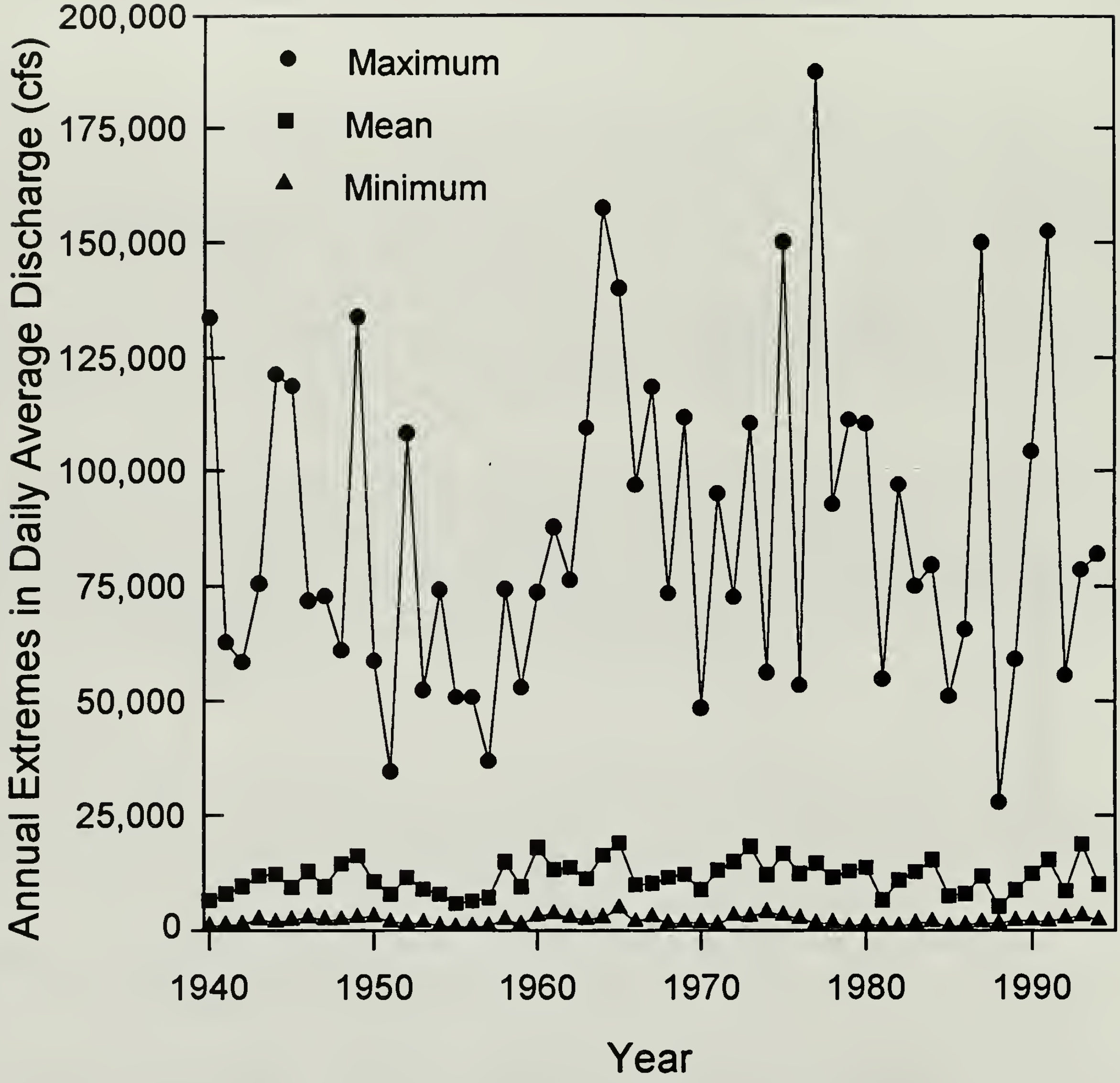


Figure 6. Annual extremes in daily average discharge of the Congaree River at Columbia (#02169500), the location of the gauge with the longest period of record (1939 - 1994). Maximum, minimum, and mean annual discharges for daily averages each year demonstrate the extremes that occur in any one year and the high variation in maxima among years. Water years begin on October 1 of the year previous to that listed. Source: USGS South Carolina District Office.

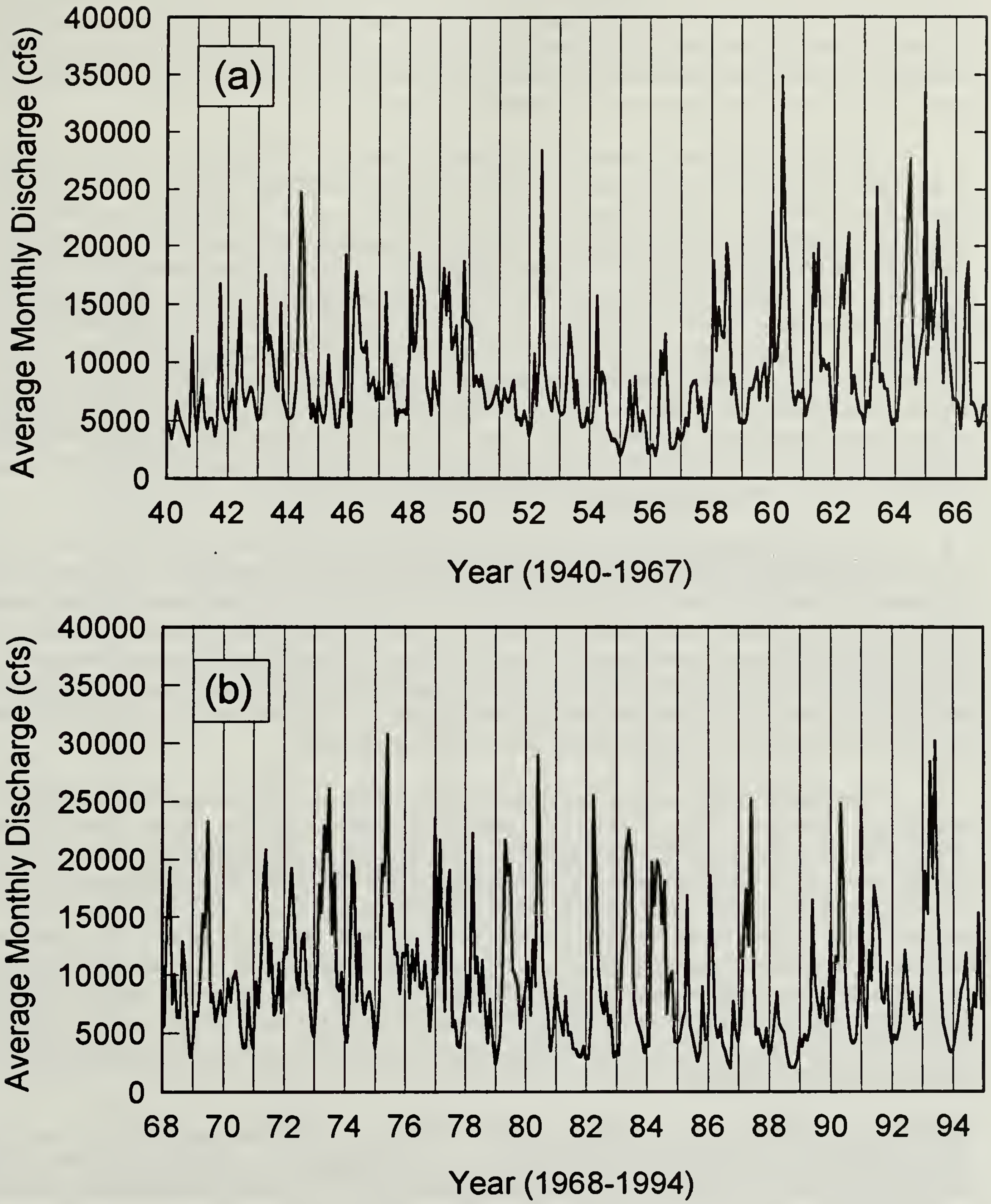


Figure 7. Mean monthly discharge for the period 1939 - 1994 at the Columbia gauge (#02169500) on the Congaree River. Water years begin on October 1 of the year previous to that listed. Source: USGS South Carolina District Office.

reduces the capacity for infiltration and storage of precipitation in soils of the watershed, thus contributing to stream discharge. Typically, monthly averages are highest during the first half of the water year. [Water years, by convention, begin in October, thus making March and April the midpoints (months six and seven).] While the pattern of flows appears relatively repeatable from year to year, the magnitudes can vary greatly (Figure 7).

Discharge-duration curves can be used to estimate the proportion of time a particular flow is exceeded for the period of record. The curve for the Congaree River at Columbia (Figure 8) has superimposed on it the estimates given by Patterson et al. (1985) for flood status in the floodplain of the National Monument. For example, surface water begins to enter floodplain channels at a discharge (at the Columbia gauge) of 11,800 cfs. Presumably the source of water is shallow groundwater discharge provided by the hydrostatic head of high stages in the river channel. Breaks or “guts” in the natural levee begin to carry overflow into low elevations of the floodplain at a discharge of 19,900 cfs. This makes most of the length of the road to Wise Lake impassable. Most of the swamp is flooded at 34,000 cfs discharge. The percentage of time that these three stages were either matched or exceeded during 1973-1982 was 23.7% (surface water enters floodplain channels), 9.3% (road to Wise Lake impassable), and 3.0% (most of swamp flooded). Stages corresponding to these percentages are also given in Patterson et al. (1985) for the Congaree River west of Wise Lake.

During extreme floods, the floodplain itself carries a significant portion of the total flow. At a discharge of 56,000 cfs near the Wise Lake station, approximately 38% of the flow occurs outside the channel, in the sloping floodplain itself. Storage of surface water in the floodplain reduces the magnitude and retards the rate of travel of the peak flow relative to what it would be if the floodplain were not available for storage. Even so, flood peaks generally require approximately 1 day to travel from Columbia to the Southern Railroad Bridge crossing at the eastern boundary of the National Monument (Figure 9). Flood warning procedures for visitors in the National Monument must take this short time into account.

Tributaries to the north of Congaree Swamp show a similar seasonal distribution of discharge, although no analysis has yet been conducted to establish a more specific pattern (Figure 10). For the smaller drainages, flows rise and fall more rapidly than they do for the larger tributaries such as Cedar Creek. Other tributaries to the east of Cedar Creek are Dry Branch, Toms (and McKenzie) Creek, Griffins Creek, and Singleton Creek. The latter two are not presently within the boundaries of the National Monument, but are located in the polygon between the eastern boundary (Southern Railroad) and Highway 601. In the eastern portion of the National Monument, Running Lake and Running Creek are confined to the floodplain. Other permanent open water bodies within the floodplain are Wise Lake, Weston Lake, Big Lake, Old Dead River, Blue Hole, Little Lake, and Big Lake. The last three of these are located in the polygon mentioned above.

<u>Occurrence and Movement of Groundwater</u>.--Contribution of ground water to the swamp by the deep aquifer has not been estimated with accuracy (Patterson et al. 1985). The deep aquifer, which underlies a 70 ft (21 m) thick confining bed (Figure 11), has a potentiometric surface that was shown to be 10.9 ft (5.5 m) higher than the level of the shallow aquifer above the confining bed. The flow from the deep to the shallow aquifer has been estimated roughly at 60 cfs (Aucott et al. 1987). The channel of the Congaree River itself is probably a discharge point for the deep aquifer. Total groundwater contribution (deep plus shallow aquifers) is estimated to be 500 cfs. This is calculated from the average total base flow of 0.9 cfs per square mile for six small

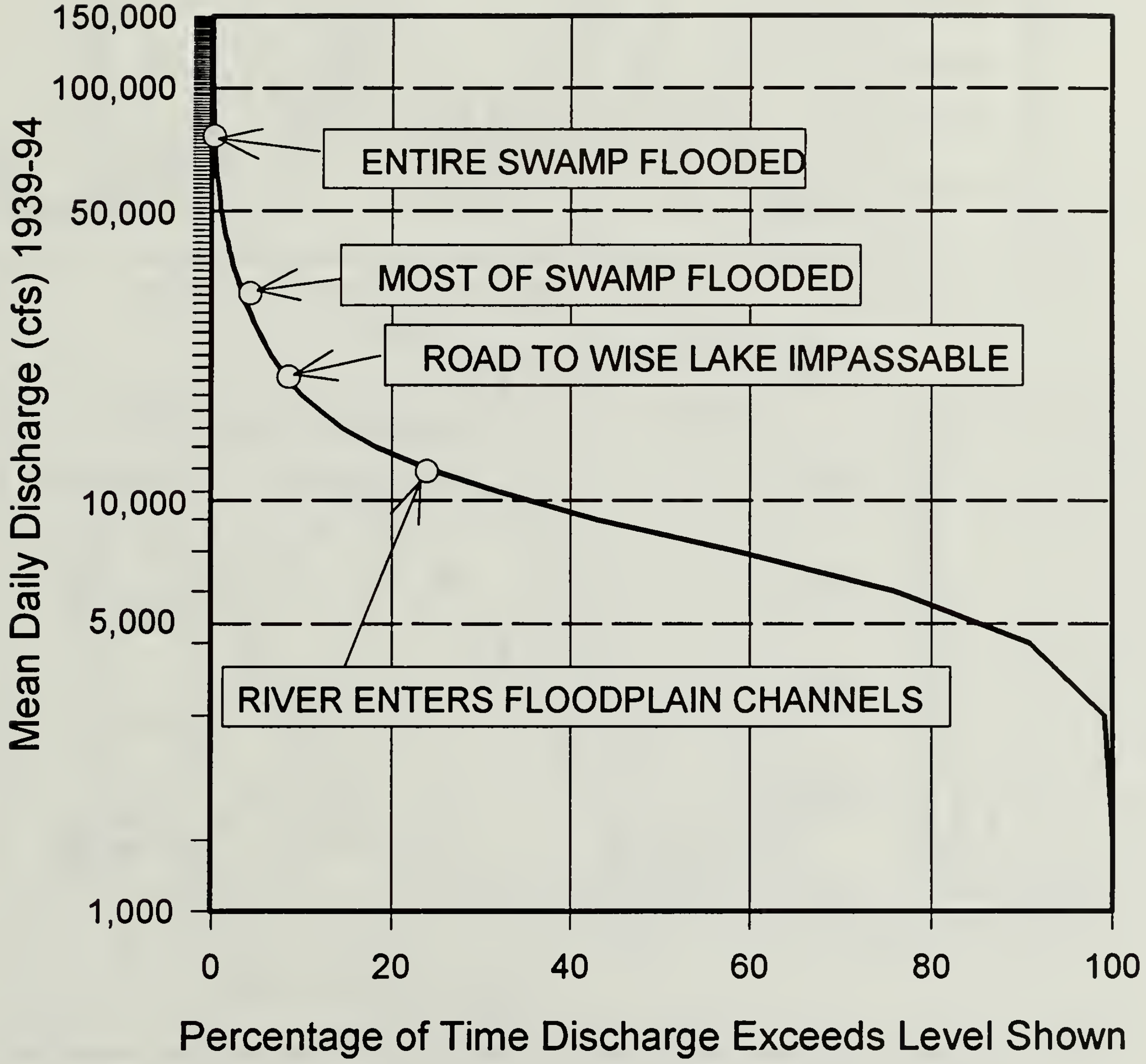


Figure 8. Discharge-duration curve showing discharge at which various parts of the swamp are flooded. Data are from the Columbia gauge (#2169500), 1939-1994. Source: USGS South Carolina District Office and Patterson et al. 1985.

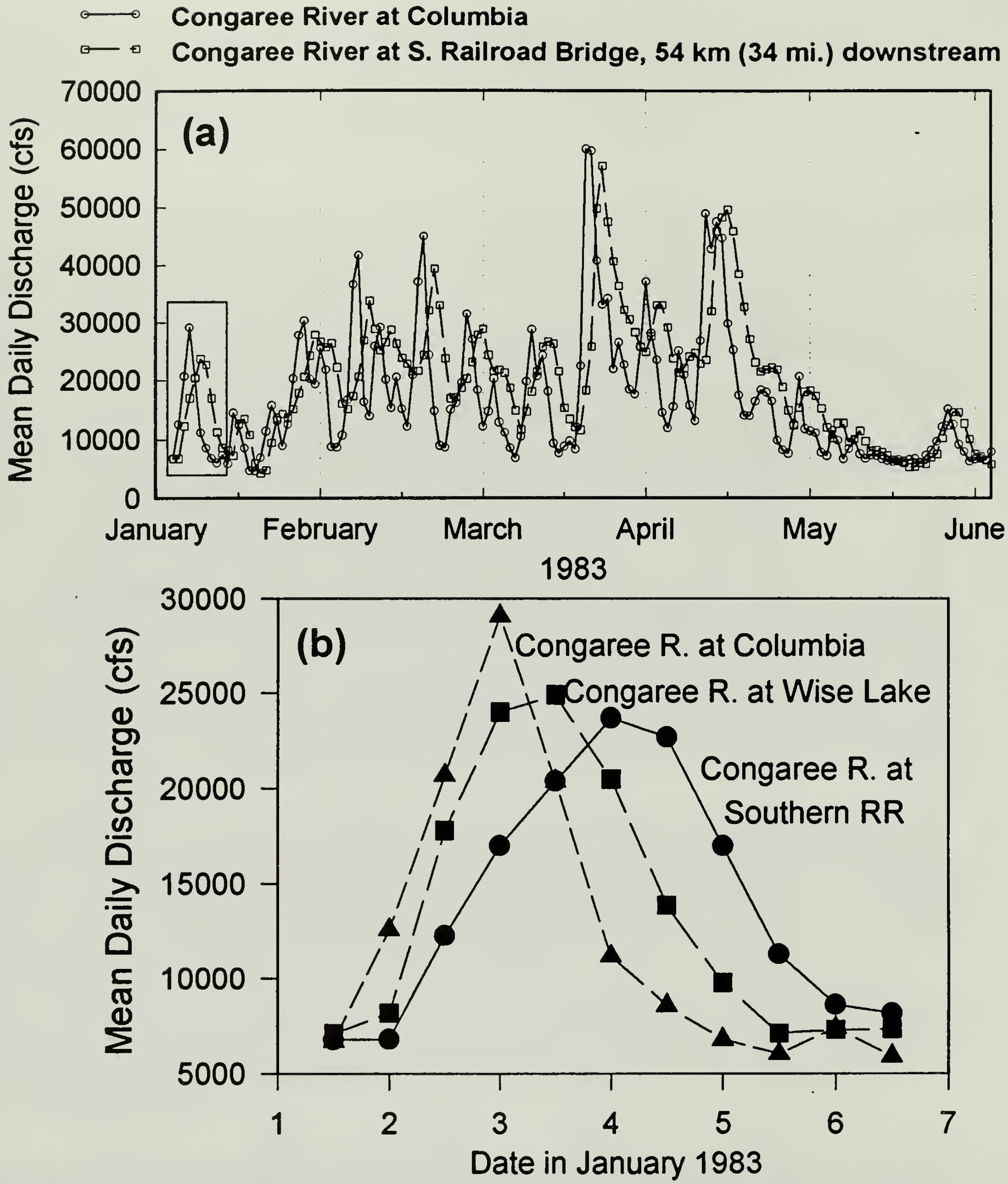
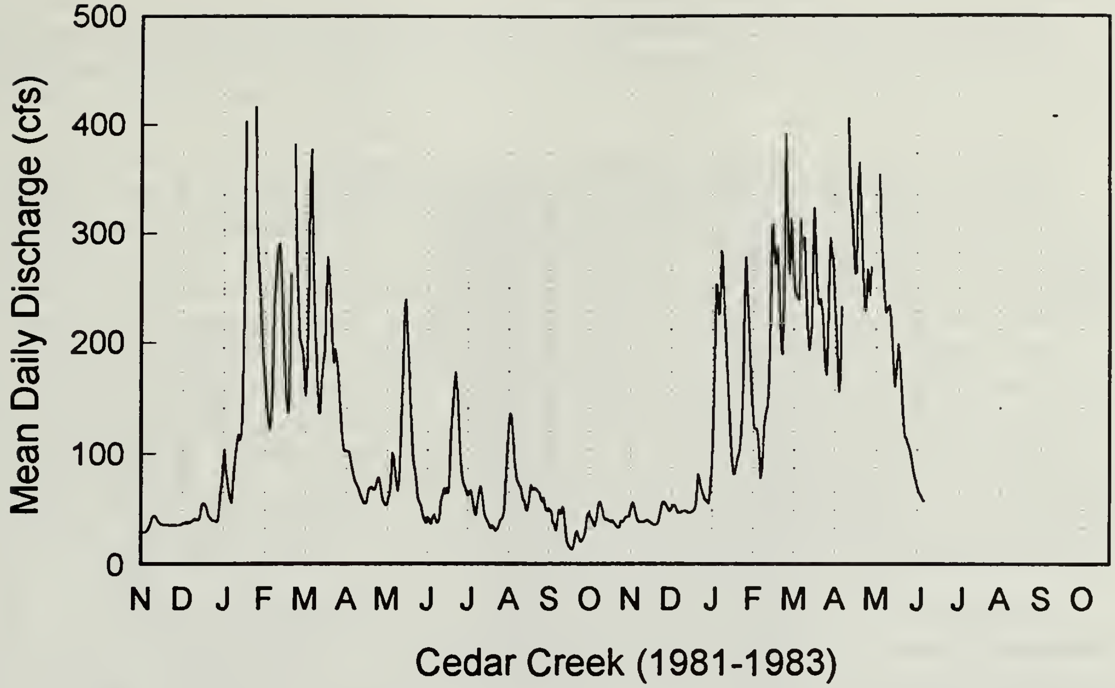


Figure 9. An example of mean daily discharge for the Congaree River between January and June 1983 showing: (a) the time lag in peak flow between gauges at Columbia (#02169500) and the Southern Railway Bridge (#02169740), 54 km downstream, and (b) a single pulse in early January with peaks at Columbia, Wise Lake (#02169625) (near the western boundary of the National Monument and approximately 34 km downstream from Columbia, and the Southern Railway bridge. Source: USGS South Carolina District Office.



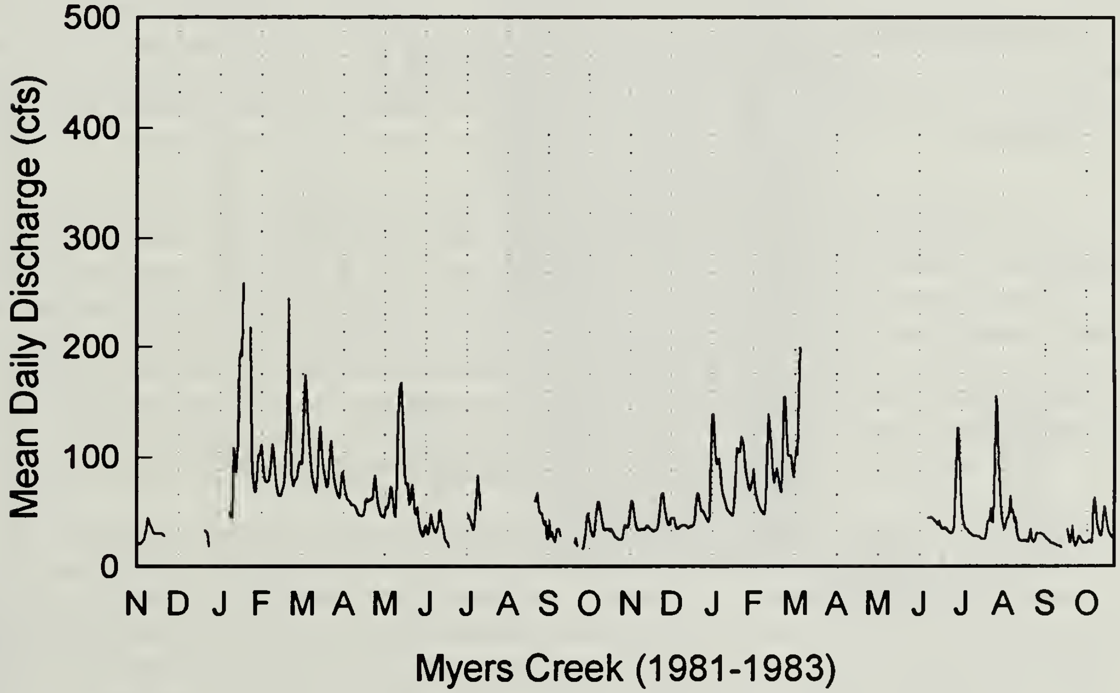


Figure 10. Discharge of Cedar Creek at County Road 1288 (#02169675) and its tributary Myers Creek (#02169670) between 1981 and 1983. Cedar Creek enters the northwestern boundary of the National Monument. Source: USGS South Carolina District Office.

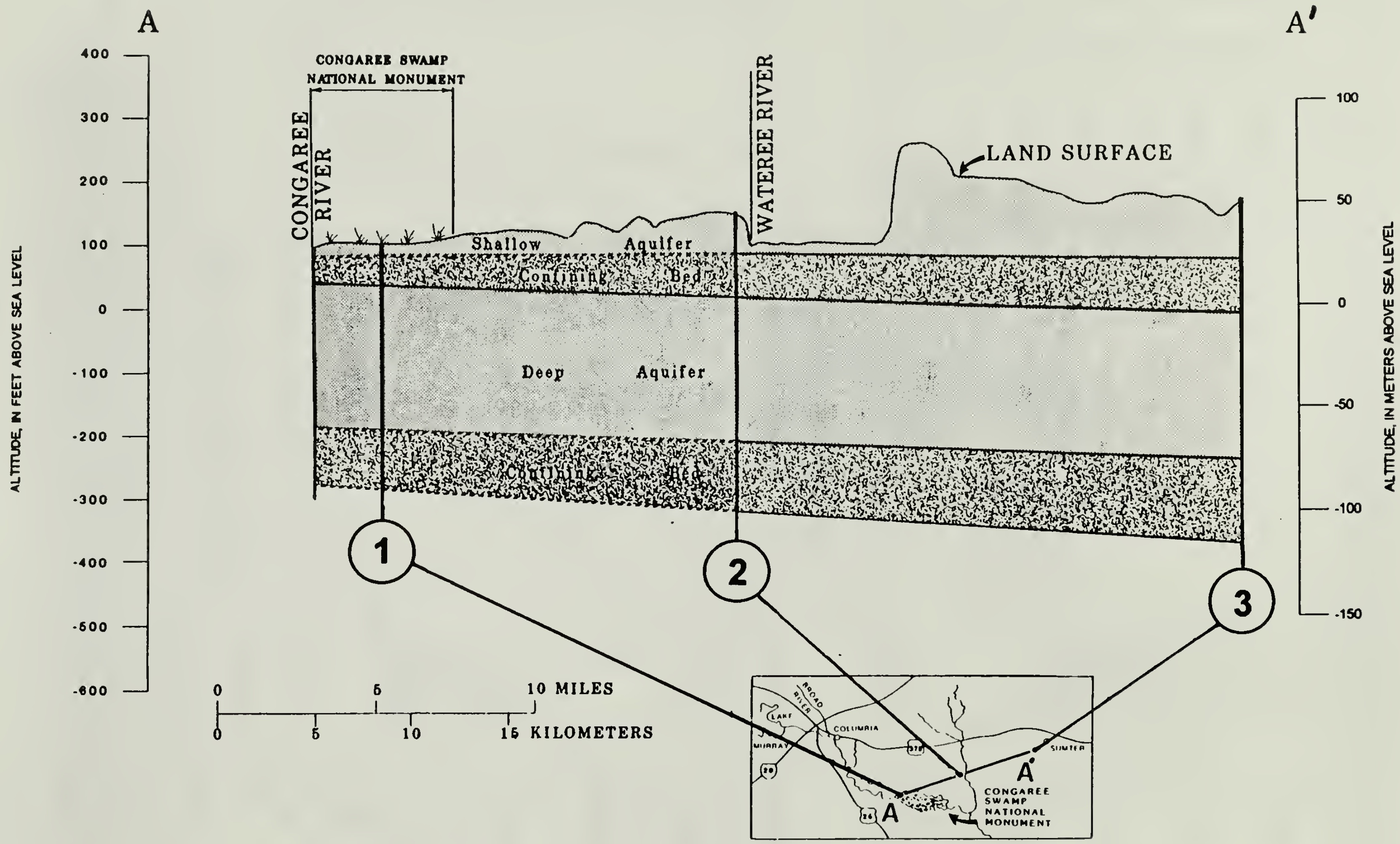


Figure 11. Cross section of the deep and shallow aquifers underlying the National Monument and surrounding regions. Adapted from Patterson et al. (1985).

streams in the South Carolina coastal plain (Stricker 1983) and multiplying by the 560 square miles of coastal plain that contribute ground water to the National Monument (Aucott 1988). The 500 cfs per square mile could be in error by 50% (G. G. Patterson, U.S. Geological Survey, personal communication, March 1996).

The thickness of the shallow aquifer of the floodplain is 55 ft (17 m) in some places. Ground water occurs in both confined and unconfined conditions, depending in part on the permeability of floodplain deposits. Where the sediments are sandy and highly permeable, ground water is unconfined, and will be expressed as ponds and lakes where the water table is intersected by depressions. Where the surface sediments are silt and clay of low permeability, ground water may become confined. Stream channels in the floodplain (e.g., Cedar Creek) may incise below this layer so that ground water of the floodplain provides base flow during non-flooding conditions of the Congaree River. Larger tributaries sustain flows for longer periods because they are more deeply incised into the aquifer. The annual minimum 7-day, 10-year low flows are 0 $(ft^3/s)/mi^2$ for Griffins Creek and Dry Branch, and 0.05 $(ft^3/s)/mi^2$ for Toms Creek. Cedar Creek and Mill Creek (just west of National Monument boundary) receive some flow from the deep aquifer, with annual minimum 7-day, 10-year flows of 0.25 $(ft^3/s)/mi^2$ and 0.19 $(ft^3/s)/mi^2$, respectively. (The units, $(ft^3/s)/mi^2$, may be converted to $m^3 s^{-1} km^{-2}$ by multiplying by 0.0109.)

All of the flows mentioned above were measured or estimated prior to entering the National Monument. Once within the floodplain of the Congaree River, the deeper groundwater sources contribute to tributary flow as described by Birch (1981). He measured flow at three stations along Cedar Creek. The first was at the boundary of the National Monument, the second 2.9 miles (4.7 km) downstream on the southern fork, and a third 3.4 miles (5.5 km) below the second station where Cedar Creek passes near the bluff line along the northern boundary. Mean monthly discharge increased in a downstream gradient from the first through the third stations even during the summer when considerable groundwater is intercepted by evapotranspiration.

During the summer, discharge at base flow (when flow is derived primarily from groundwater sources well after rainfall events) increased with distance downstream due to groundwater discharge. During the larger wintertime increases in downstream flow, the source of water was not only base flow augmentation from ground water, but also overflow from the Congaree River, through side channels connected to the Congaree River at flood stage. Birch (1981) subtracted discharge at the third station from the first station in order to estimate how much water was contributed by groundwater and overland flow before reaching the last station. In February, 47% originated from Cedar Creek as it flowed into the park, while the other 53% was derived from a combination of Congaree River overflow and groundwater discharge.

For shallow groundwater near the channel of the Congaree River, lateral flow occurs in two directions. When river stage is below that of the water table in the floodplain, the groundwater discharges to the river and contributes to base flow. During higher river stages, the gradient becomes reversed, and the river serves as a source of water for the ground water in the floodplain until breaks in the levee are breached and surface flows obliterate gradients. Figure 12 shows groundwater fluctuations in the floodplain at sites several hundred meters from the river (Patterson et al. 1985). This appears to be a common phenomenon in large river floodplains such as the lower Missouri River (Grannemann and Sharp 1979).

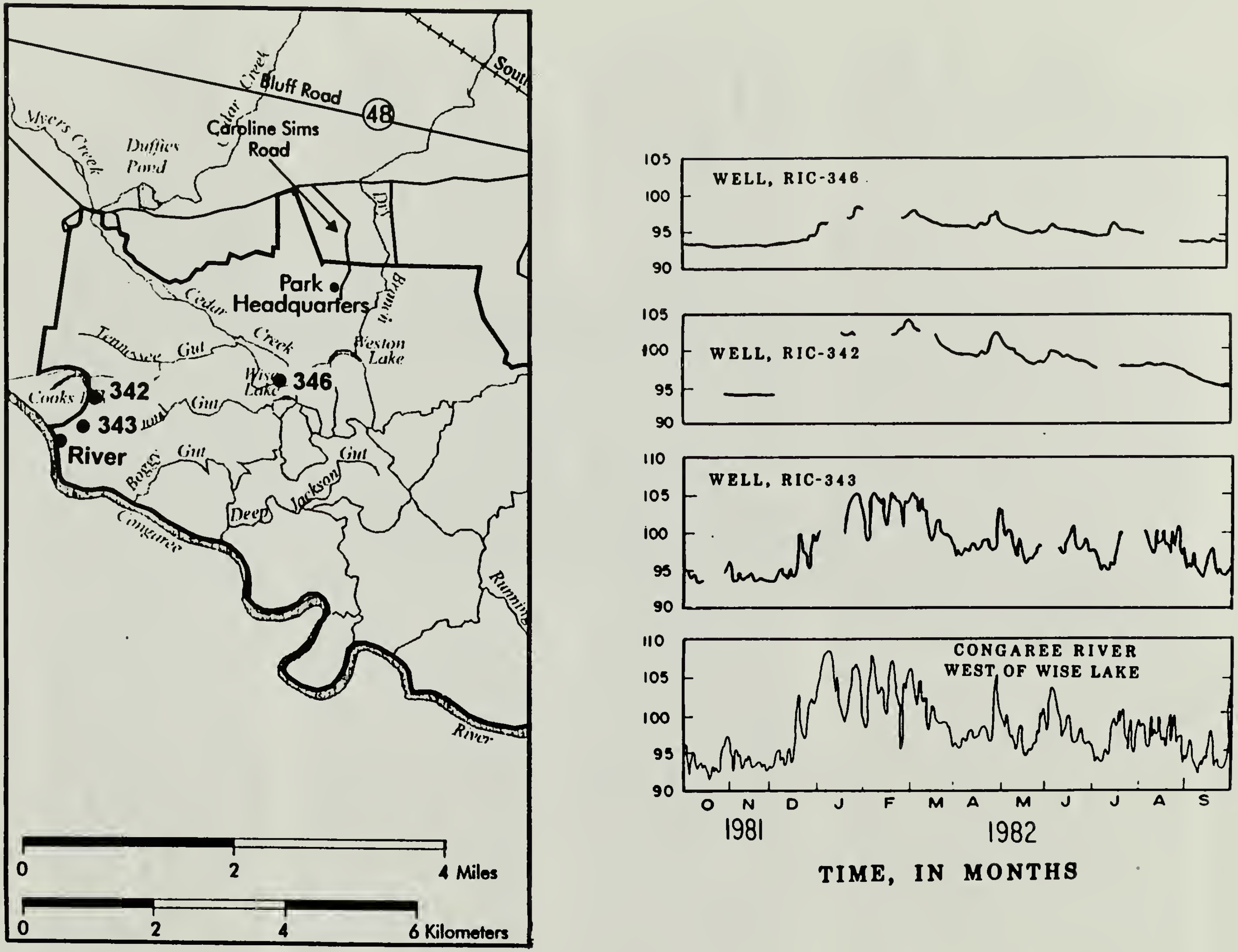


Figure 12. Hydrograph of the Congaree River and water table fluctuations of ground water in wells located at increasing distances from the river's channel. Except for the river, most of the fluctuations occur below the surface. Land elevation at the wells is 98 to 103 feet. Adapted from Patterson et al. (1985).

Flow paths of the regional aquifer (Figure 13) can be inferred from the Patterson et al. (1985) study. Flow path directions are perpendicular to the contours of the potentiometric surface. Discharge occurs in the Congaree River itself and Cedar Creek and Toms Creek. In contrast, shallow groundwater movement is controlled principally by precipitation and flood events.

These principal sources of water have significance not only because they provide moisture and aquatic habitat, but also because they serve as the medium for transporting nutrients and sediments. Alteration in the supply of water, nutrients, and sediments occurs both by alteration of flows and alteration of concentrations of the constituents that the water carries. A network of crest gauges and continuous and real-time gauging stations provide the capacity to monitor surface water sources (Figure 14).

Water Budget

Typical hydrologic studies of ecosystems produce summaries of annual or monthly inflows, outflows, and volumetric changes in the storage (i.e., surpluses and deficits) of water. Such results would be of limited utility for understanding a floodplain ecosystem like that of the National Monument. This is because water depth and duration of flooding is more useful in understanding wetland functions than volumetric water storage itself. Even if an annual or monthly volumetric water budget were accurately determined, its usefulness would be limited unless the values could be converted to water depth or soil moisture content. Further, a volumetric budget would not be relevant to most ecosystem functions because much of the volume during major floods passes through quickly.

Annual average flows do not convey information on the periodicity of flow and its importance. During high flow periods, for example, the floodplain conveys over one-third of the total flow of the river, thus making other critical flows seem trivial when compared on a volume basis. It is during these events that much of the geomorphic work is done, such as sediment conveyance and deposition, and the erosion of cut banks. Relative measures of flow velocities in various parts of the floodplain would provide more insight into floodplain hydrodynamics than flows averaged over long periods of time.

Other flows of much lesser magnitude on an annual basis (precipitation, groundwater discharge, tributary inflow) are not trivial from an ecological perspective, however. Flows lower than average, while not capable of contributing to geomorphic structure, meet critical needs of biota by providing surface water as feeding habitat and by providing conduits for movement of aquatic organisms from one part of the floodplain to another.

Historic Changes of Hydrology in the Congaree River Watershed

Changes in the Congaree River watershed have resulted from recent activities within a longer history of geologic evolution. The geologic history of the Congaree River floodplain is partly revealed by the complex fluvial features (oxbows, meander scrolls) and the large size of the floodplain. These features are virtually all derived from lateral erosion and deposition as water currents cause the stream to meander to the south and downslope.

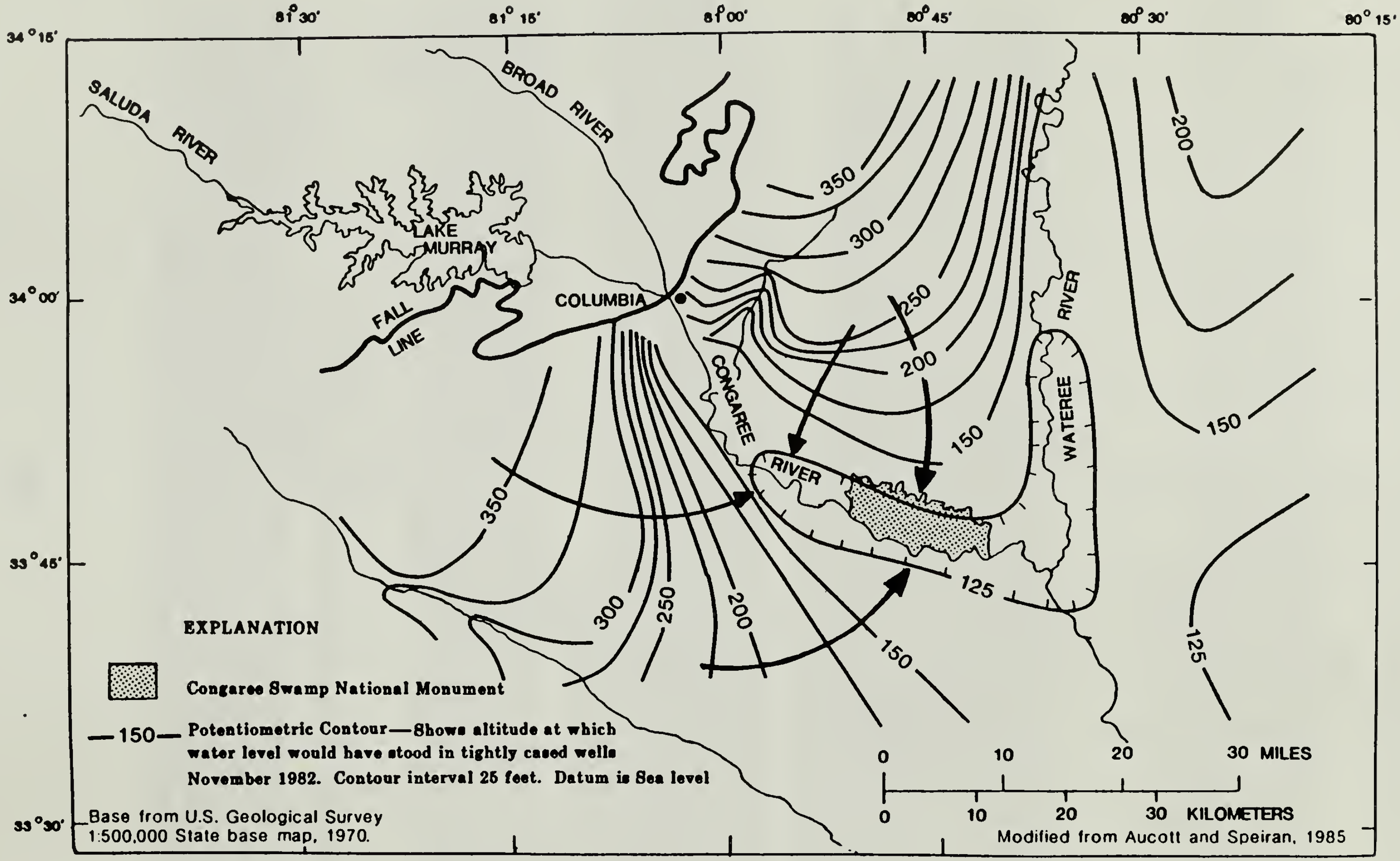


Figure 13. Potentiometric surface of the deep aquifer in the region of the National Monument.

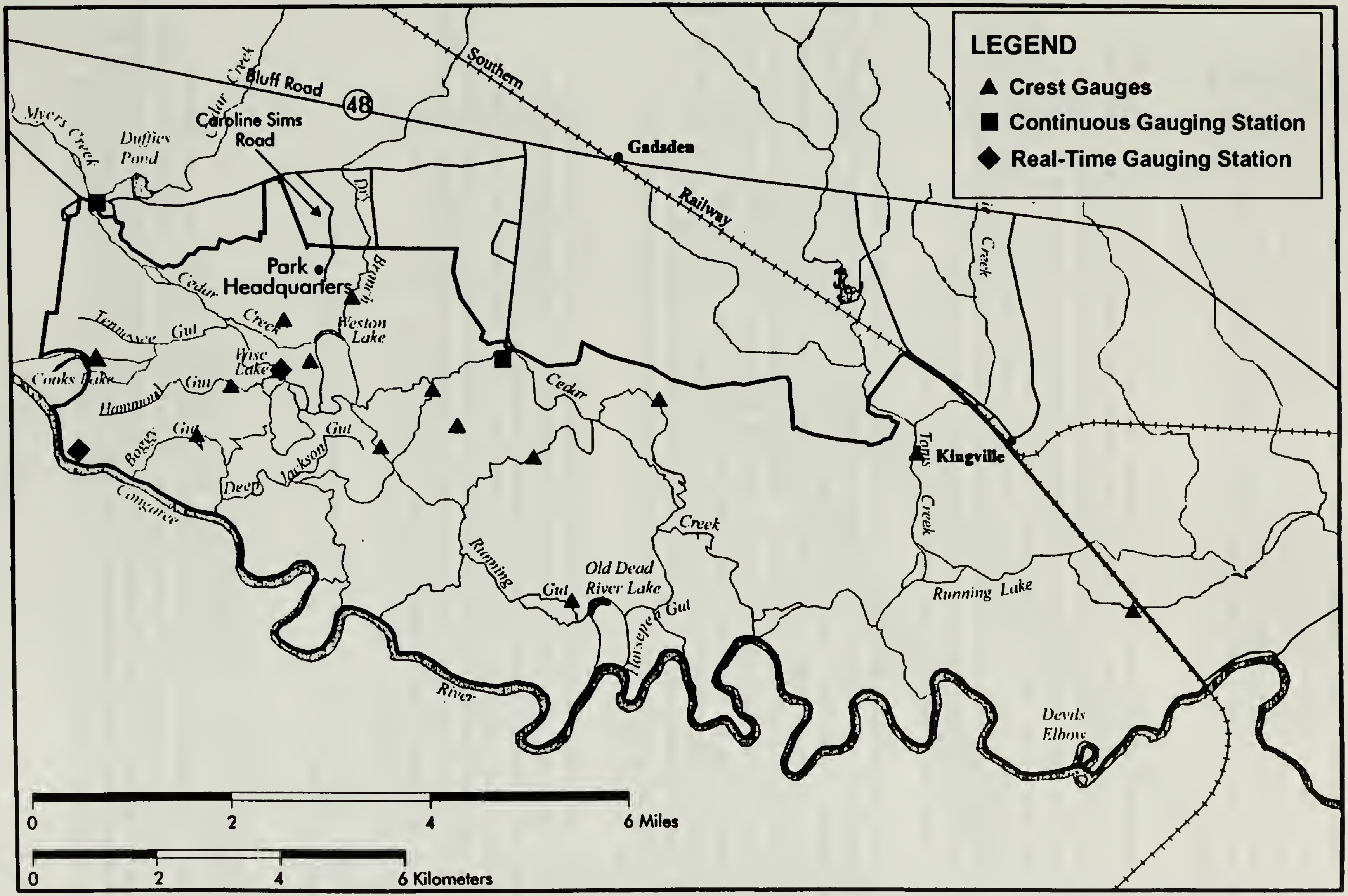


Figure 14. Location map of crest gauging stations and continuous and real-time gauging stations within the Congaree Swamp National Monument.

Historical activity during the past 200 years has had profound effects on flow. The conversion of forest to agriculture in the Piedmont was virtually complete by the Civil War. At that time forests of the region probably covered only a small fraction of what they do today. The land was highly erodible, and there is evidence of mass wasting of uplands and the filling of floodplains and river corridors with sediment (Trimble 1970). This erosion was likely due to increased exposure of soil to direct rainfall, which resulted in higher rates of runoff and less infiltration.

Re-establishment of forest cover on uplands has had the effect of reducing runoff from overland flow and increasing the proportion of precipitation that infiltrates. As a result, more of the water budget is allocated to evapotranspiration and groundwater recharge due to the stabilizing effect of forest cover. The net effect of reallocation of components of the water budget is less water yield from the watersheds through stream flow. Trimble and Weirich (1987) estimate that between 1919 and 1967 annual runoff decreased in the range of 3 and 10 cm per year. The Saluda River above Columbia, in particular, showed a decrease in annual yield of 6.6 cm, or 16.1%. Greatest reductions occurred during dry years, explained in part by the fact that trees have greater access to moisture deeper in the soil than do crops.

The Saluda Hydroelectric Project began operation in 1930 on the Saluda River, one of the major tributaries to the Congaree River. The dam is only 11 miles (18 km) above the confluence of the Saluda and Broad Rivers that forms the Congaree River. The dam captures about 96% of the Saluda River drainage basin, or 2,420 mi^2 (6,268 km^2). This is about half the drainage area of the Broad River, or 5,320 mi^2 (13,779 km^2). While the Broad River drainage only contains minor dams, the Saluda Dam controls roughly one-third of the total flow to the Congaree River above Columbia. This led Patterson et al. (1985) to conclude that "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." Thus, recurrence intervals greater than the annual flood have been substantially altered by the impoundment (Figure 15).

There are at least two potential effects of the Saluda Dam on fluvial geomorphic processes. One is the reduction in frequency of large floods. These are floods that occur infrequently but have the greatest capability to drive geomorphic processes such as major cutbank erosion, building levees, and creating meander cutoffs. Second is the reduction in sediment supply from the Saluda River that is trapped behind the dam. This potential effect must be analyzed in concert with the confounding effects of changing sediment supplies during historic alterations of land use in the Piedmont (Trimble 1970). The effects of both of these are addressed in project statements COSW-N-058 and COSW-N-059.

Geomorphic Regime

Macrotopographic Features Driven by Hydrology

The Congaree Swamp National Monument has well developed geomorphic features derived from fluvial processes of the river channel. The most prevalent are oxbow lakes, ridge-and-swale topography, high flow channels (guts and sloughs), point bars, and stream-side levees with gaps that allow exchange of water with the river channel. All of these can be related to the dynamics of stream meandering and are developed in the process of lateral movement of the

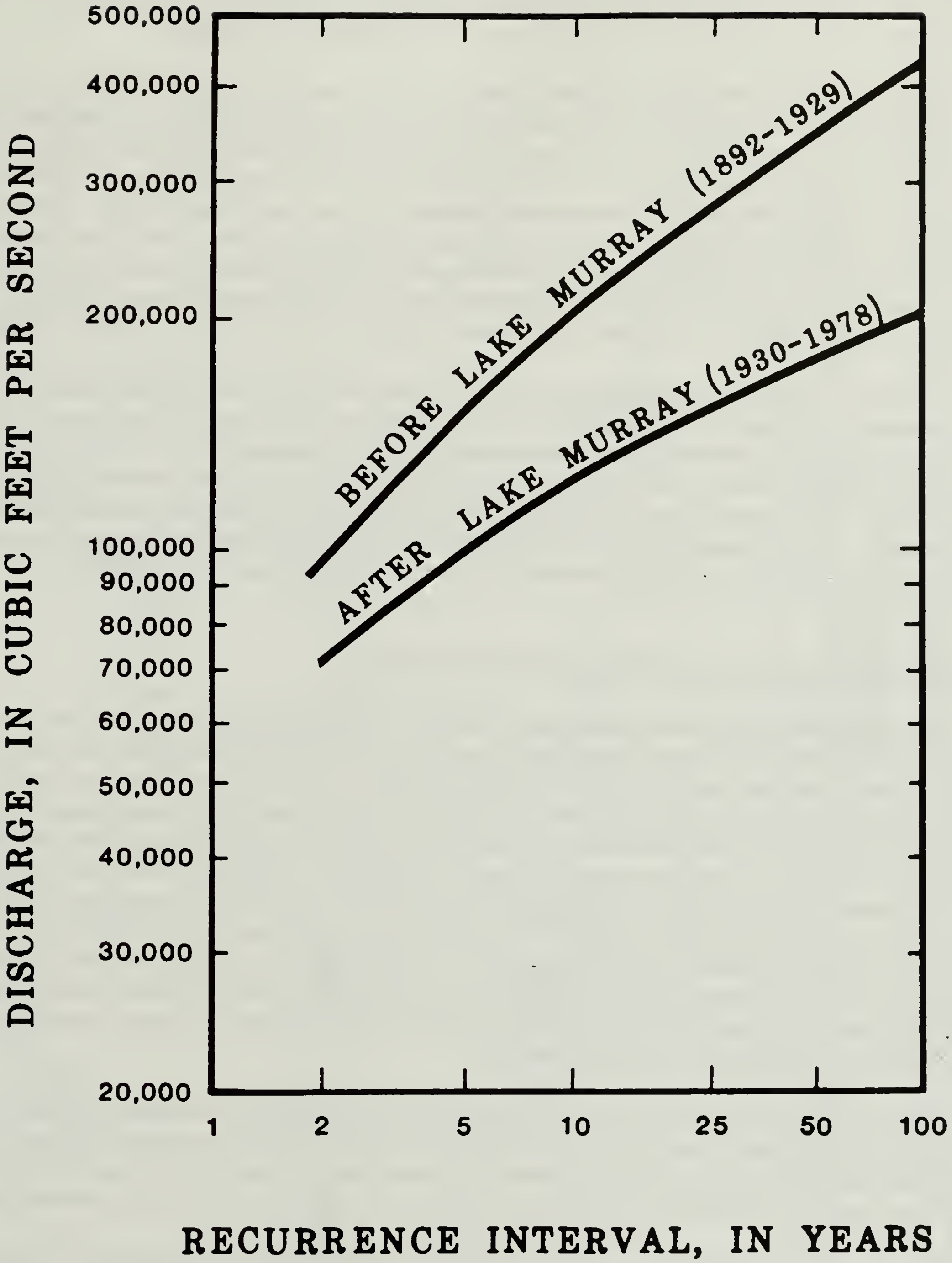


Figure 15. Recurrence intervals of discharge of the Congaree River at Columbia before and after construction of the Saluda dam. Data from Whetstone (1982) as reported in Patterson et al. (1985).

channel (Leopold et al. 1964). Vertical accretion of sediment, the result of accumulation of sediment on the floodplain surface, has not been measured. Natural levees are evidence of vertical accretion, but the occurrence of active levees is limited to a very narrow margin of the swamp. These topographic features create a juxtaposition of aquatic and terrestrial environments that is important to the life history of amphibians and reptiles.

Cross-sectional profiles of the floodplain show the relationship of topographic features to each other and the changes that occur both perpendicular to and parallel with the floodplain slope (Figure 16). Cross-section A-A' shows a pronounced natural levee next to the stream channel. In contrast, cross-section B-B' terminates in one of the several gaps in the levee. Cross-section C-C' illustrates the downstream gradient of the floodplain which is roughly 1.54 feet per mile (slope of 2.9×10^{-4}). Each of these cross sections would show even greater variation in elevation if the bottoms of oxbow lakes and stream channels had been included in the surveying. [The contour map was prepared by the U.S. Geological Survey during the Patterson et al. (1985) study. Copies of the map are kept at National Monument headquarters.]

Floodplain patterns are maintained in part by an overlay of stream channels entering the swamp laterally from the north and meandering through the floodplain. These streams supply water to the National Monument during periods when the Congaree River is least likely to overflow its banks and when months of warm temperatures have caused water tables to drop. Except for the deep oxbow lakes, the creeks become the only habitats for organisms requiring surface water. The perennial flow of Cedar Creek is especially important because it provides a flowing, free water surface through the length of the National Monument's floodplain.

Potential Influence of the "Mass Wasting" of the Piedmont

The Congaree River watershed has undergone dramatic changes during the past two centuries. Although the swamp is technically on the inner Coastal Plain, it is so close to the fall line that it likely received sediment loading similar to that in the Piedmont. In the Georgia Piedmont where land uses similar to the South Carolina Piedmont likely occurred, small scale subsistence farming was replaced by an overwhelming dominance of cotton after the invention of the cotton gin in 1793. Massive erosion followed, resulting in the loss of nearly all topsoil from 47% of the uplands, and gullying on 44% of the land (Brender 1974). Floodplains in the Piedmont became filled with silt and clay from the eroding uplands, thus removing them from their former use as productive crop and pasture. Trimble (1970) reports that rapid aggradation filled many of the river valleys up to 18 feet (5.5 m) in depth, not only burying the original floodplain surface, but also causing the wholesale burying of bridges. Stream gradients were reduced, further affecting flooding regimes.

Abandonment of farmland and regrowth of forest in uplands reversed the sediment budget of floodplains and streams. Many of these streams have since incised, and in the process have exported sediment downstream. These areas still are not in equilibrium in many parts of the Piedmont, although many have incised to the bedrock which halts downcutting.

The position of the Congaree Swamp just below the fall line suggests that it may have been the recipient of considerable quantities of sediment during both the mass wasting that occurred in the late 1800s, and more recently when Piedmont streams continued to export alluvium during their subsequent incision. Current sediment loads in the Congaree River are

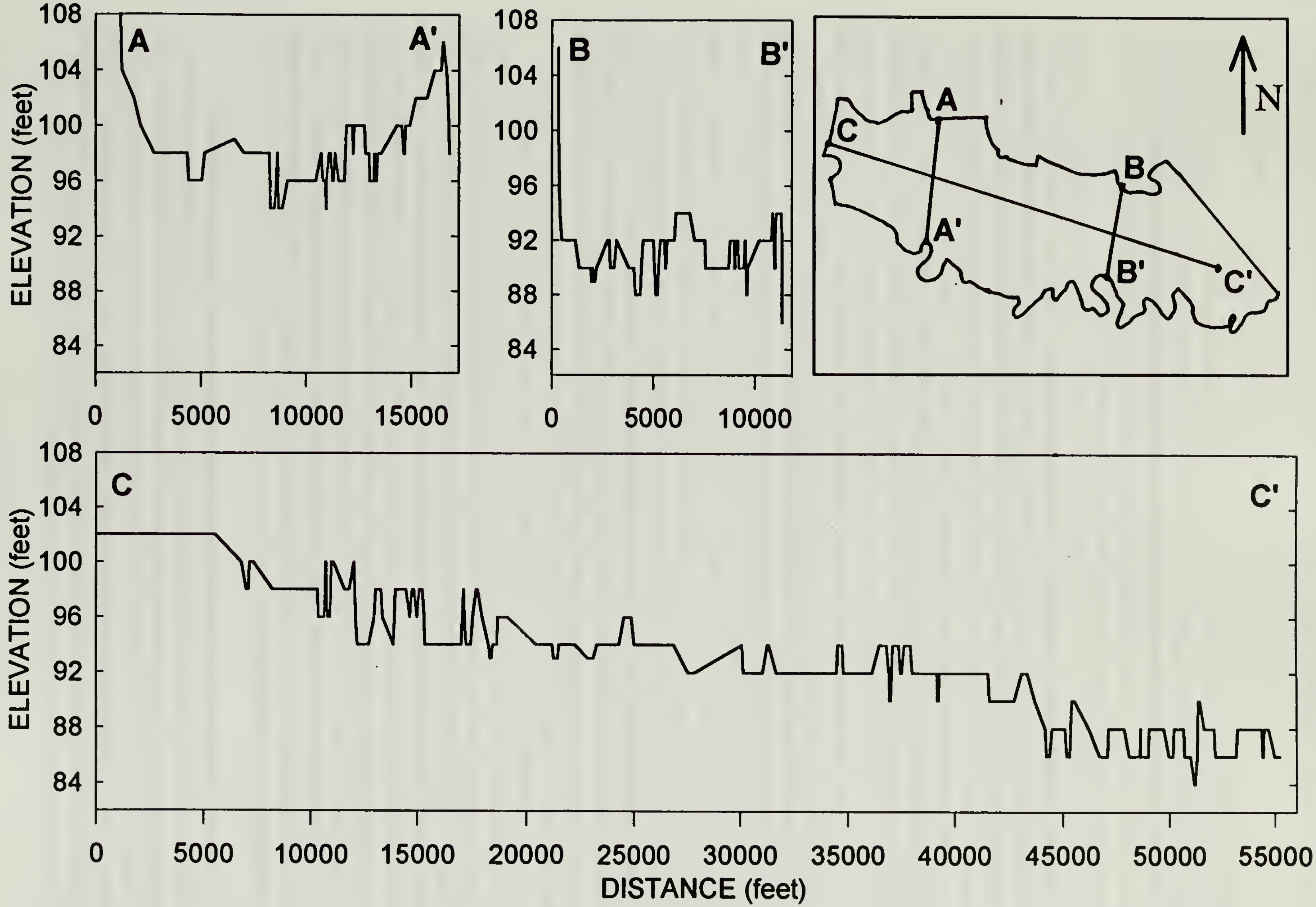


Figure 16. Three cross sections showing variations in elevation of the floodplain within the Congaree Swamp National Monument. Elevations were taken from a 2-foot interval contour map. Transect locations (A-A', etc.) are shown in the inset. Vertical scale is greatly exaggerated.

being measured, and can be attributed to both continuing channel erosion and urbanization (John C. Hayes, Clemson University, May 1996).

Characterization of Soils

Soils are important to the water resources of the National Monument because: (1) their distribution occurs within a complex geomorphic setting that is reflective of the history of floodplain formations; and, (2) soils become the sediments of the aquatic ecosystem whenever the Congaree River inundates the floodplain and creates a water column.

The National Monument is underlain by marine sediments which were deposited during Pleistocene sea invasions (USDA-SCS 1978). Periods of inundation by shallow seas, followed by exposure during periods of lower sea levels, produced erosional terraces along the Congaree River (Colquhoun et al. 1991). Since the last inundation event, the ancient river valley has filled with alluvial sediments derived from the Congaree River's Piedmont watershed. This is an on-going geologic process, although sedimentation rates during the 19th and early 20th centuries were probably at a maximum.

Many soil types exist within the greater Congaree River watershed. In general these soils are Ultisols, products of weathered shale, schists, and granite of the Piedmont and Mountain provinces of South Carolina and North Carolina. The floodplain of the Congaree River has silty and clayey alluvial sediments apparently derived from eroded upland soils in the Piedmont and Mountains.

Soils of the Cedar Creek and Toms Creek watersheds are of a different origin and composition than those of the greater Congaree River watershed. These two watersheds lie within the upper Coastal Plain province, immediately below the Piedmont plateau fall line. The upper portions of these watersheds lie within the sand hills region which is underlain by sandy marine deposits. Soils of this region are well drained sands to moderately well drained loams and comprise the soil series Lakeland, Vaucluse/Ailey/Pelion, and Fuquay/Troup/Vaucluse (USDA-SCS 1978).

The lower portions of the Cedar Creek-Myers Creek and Toms Creek watersheds lie within the National Monument. These soils grade into nearly level coastal plain soils and eventually floodplain soils adjacent to the Congaree River. The Persanti soil series occupies the northern portions of the National Monument (USDA-SCS 1978). These are moderately well drained soils with a fine sand surface underlain by a deep sandy clay loam. The clayey subsoil results in low permeability and thus has limited potential for urban development and agricultural production. Persanti soils are more suitable for upland pine forest and hardwood forest production. These soils are situated on a terrace above the Congaree River floodplain and are not subject to flooding by overbank flow.

The dominant soil series within the National Monument is the Congaree-Tawcaw-Chastain series. The area occupied by these soils often floods between November and April, although flooding can occur at any time of the year. Seasonal flooding by overbank flow transports clays, silts, and fine sands that may be deposited on the forest floor. Generally, the larger sand size fractions become less abundant in the floodplain soils with increasing distance from the higher velocities of the waters of the Congaree River. Silts and clays are more easily transported into the interior of the National Monument and thus predominate there. Due to a combination of soil texture and hydrologic regime, the levee soils differ from those toward the floodplain interior.

Prevalent soil series of the National Monument are:

Congaree Loam - The natural levees adjacent to the channel of the Congaree River range between 1,000 - 4,000 ft (330 m and 1,300 m) in width. They are dominated by well drained to moderately well drained Congaree loams. Congaree loams are capable of supporting loblolly pine and a number of bottomland hardwood tree species.

Tawcaw - Extensive areas of Tawcaw soils with numerous small Chastain inclusions lie between the Congaree soils and the Persanti soil terrace. Further from the Congaree River channel, Tawcaw soils are composed of silty clays and have less fine sands than Congaree soils. Tawcaw soils are poorly drained but are very productive soils for bottomland hardwood tree species.

Chastain - The size of the Chastain soil inclusions ranges from 10 - 400 acres (4 to 160 ha). Chastain soils occur in depressional sloughs and thus are subjected to prolonged flooding throughout the year. Several hardwood species are well adapted to these poorly drained, silty clay loams.

Dorvan Muck - Dorvan muck is found at several locations at the upland edge of the floodplain. This is a histosol (peat), reddish brown at the surface where decomposed leaves and twigs occur, but quickly changing to a black muck. The soil is very poorly drained, with the water table within 6 inches (15 cm) of the surface most of the year. Swamp tupelo (*Nyssa sylvatica* var. *biflora*) is the canopy dominant.

Toccoa Loam - This soil is deep, well drained, and nearly level. The organic matter content is medium, permeability is rapid, and available water is low to medium. Large areas of this soil are found throughout the floodplain, but interior to the natural levees.

Rikard (1988) reports on soil samples from the plots of his vegetation study in the National Monument. The sandiest soils were nearest the river, thus corresponding to the general pattern that coarsest soils are found in proximity to the channel where overbank flow loses velocity and deposits sediment. Within each zone, there was a tendency for the finest textures to be found at the most frequently flooded sites. These low elevation sites are most likely to experience the lowest velocities and thus act as sediment traps during floods that are incapable of transporting coarse sediments. Depth to mottling followed the predictable pattern of being shallowest at the lowest elevation plots within each zone. Shallow mottling occurs where water tables are closest to the surface. (Mottling is a soil color phenomenon usually associated with alternating oxidizing and reducing conditions, as might be caused by water table fluctuations. Mottles may consist of rust colored microfeatures within a background of duller soil colors.)

The highest concentrations of phosphorus were associated with the lowest elevations for two reasons. First, phosphorus tends to be attached to clay particles, and clays accumulate in greatest abundance in floodplain depressions. Second, the lowest elevations experience the most frequent water table fluctuations which results in alternating saturation and desaturation of water. Phosphorus tends to accumulate within this zone as it is mobilized from deeper, more anoxic and more continuously saturated conditions below. Potassium, calcium, and magnesium did not show strong patterns, although the lowest concentrations of calcium and magnesium were associated with the sandiest soils and, likely, the least fertile conditions.

Controls on Microtopography

Most major topographic features of the floodplain can be attributed to fluvial processes by the Congaree River when it occupied what are now interior positions in the floodplain. After the initial setup of topographic features due to point bar and cutbank activity by the channel, other factors worked on shorter time scales to maintain varied microtopography within the larger macrotopographic setting. The prevalent microtopographic features are the hummocks and depressions caused by soil redistribution during windthrow of trees. Sediment deposition originating from overbank flows from the Congaree River has likely contributed to vertical accretion of the floodplain surface. Sediment deposition tends to smooth the surface in the swamp interior. On the natural levee, differentially greater sediment accumulation would serve to further accentuate this macrotopographic feature. Additional sources of sediment redistribution occur on smaller scales, including burrowing by earthworms and crayfish, rooting by feral hogs, and conveyance by water.

Soil redistribution by windthrow of trees deserves particular attention in the swamp, not because of its absence in other alluvial floodplains, but because of the likelihood that these features are proportionally greater in size and frequency in an old-growth condition. One of the biotic consequences is a greater proportion of shallow aquatic pools than might occur on floodplains dominated by younger forests and smaller trees.

Microtopographic relief caused by windthrow of trees and the accompanying redistribution of soil is commonly referred to by the term "tip-up mounds." Unfortunately, this term calls greater attention to the mound than to the depression. These features occur also in upland forests, and have profound effects on colonization by forest floor plants (Beatty 1984). The elevation differences in upland forests are important to the distribution of recruitment of forest tree seedlings and establishment of ground cover. In wetlands, where subtle topographic features partition environmental conditions to greater extremes than in uplands (Sharitz et al. 1990), tip-up mounds may be even more important in determining survival and recruitment of plants, in providing microscale habitat for animals (especially herpetofauna), and in establishing heterogeneous soil conditions for biogeochemical cycling of elements.

The spatial distribution of tip-up mound features is not known, nor is it known how frequently such mounds are created or how long it takes them to return to background levels. However, general observations indicate that their formation is punctuated by wind storms, as illustrated by the abundance of new tip-up mounds after Hurricane Hugo in 1989 (Putz and Sharitz 1991). It is also apparent that the mound features persist beyond the lifetime of decaying logs and the root wad that forms the mound. Decay rates of logs in more northerly climates are on the order of several decades (McFee and Stone 1966). This raises the point that logs also create microtopographic relief, and are themselves potentially important microsites for germination and establishment of plants in an otherwise flat terrain.

Circular depressions that lack mound features are less prevalent (personal observations, 1994). These are most likely caused by tree death and decay in the absence of windthrow. The contribution of these depressions to aquatic habitat is not known. Even so, they create microsites on the forest floor that otherwise would not be present.

Both the larger geomorphic features and the microtopographic variation are worthy of study not only to determine their origin and maintenance, but also to relate them to surface hydrologic patterns and habitat conditions for plants and animals. These topics are addressed in project statements COSW-N-058 and COSW-N-059.

Biogeochemical Regime

The cycling of nutrients and other elements has particular relevance for the National Monument and this Water Resources Management Plan because of the influence that riverine wetlands have on water quality. It is also significant that water flow from outside the boundaries of the National Monument is the principal pathway by which contaminants can enter the site. Moreover, the cycling of certain elements in wetlands deviates from the normal pattern in upland forests because of the prevalence of anoxic conditions in the soil when saturated or inundated. For these reasons, it is important to understand how floodplain wetlands transport, cycle, and store elements.

Transport, Distribution, and Activity of Elements

Wetlands have access to nutrients transported laterally by surface flows and groundwater, pathways that are virtually absent in uplands where infiltration creates mostly vertical flows. Access to nutrients in groundwater and surface water supplied to a site makes it less likely that plant growth in wetlands would be limited by nutrients as compared to upland forests. Flooding and associated anoxia (lack of oxygen) also support special chemical reactions and bacteria that mediate unique chemical transformations. For example, in water-saturated soils there is higher availability and mobility of phosphorus and higher accumulation of organic matter. The phosphorus improves fertility while the organic matter enhances water holding capacity during periods of drydown. Anoxia also supports denitrification, a major mechanism for maintaining water quality through the reduction of potentially high levels of nitrate.

Where anoxia develops in freshwater wetlands, methanogenesis (i.e., methane production by anaerobically metabolizing microbes) is usually active (Harriss and Sebacher 1981). Wetlands worldwide are major contributors to atmospheric methane, a major greenhouse gas with significance for global warming and global change (Matthews and Fung 1987). Because old growth forested wetlands are now virtually absent from the Southeast, methane production in the National Monument's wetlands may provide an important frame of reference in reconstructing methane budgets of the past.

In general, riverine wetlands can be considered phosphorus sinks (i.e., they accumulate more phosphorus than they release) (Brinson 1990). While much of this phosphorus is unavailable for plant uptake when deposited, anoxic conditions that form in saturated soils facilitate the reduction of iron to Fe^{+2}. This causes a concomitant release of phosphorus in a form that is readily available for plant uptake. Thus the swamp serves not only as a phosphorus trap, but the phosphorus is made more readily available for plant nutrition because of the prevalence of soil saturation. From this, one could speculate that phosphorus, a common limiting factor in plant growth in many agricultural soils, is an unlikely candidate for plant growth limitation in the floodplain of the National Monument.

Nitrate removal, most likely by denitrification, was demonstrated in the Santee River floodplain downstream from the National Monument (Kitchens et al. 1975). While this is significant for maintaining water quality, there is an additional effect. Denitrification converts nitrate (NO_3) to nitrogen gas (N_2) and nitrous oxide (N_2O). This production of N_2 is of little practical concern because the atmosphere is already 80 % N_2. However, N_2O, an intermediate product of incomplete denitrification, is a greenhouse gas similar to methane in its potential effect on atmospheric warming. Wetland and aquatic sediments are "hot spots" for denitrification.

How Large River Floodplains Contribute to Water Quality

Riverine wetlands are considered to be nutrient and sediment traps, and thus function to improve water quality of surface waters. Wetlands bordering small streams receive most of their water by-groundwater discharge and occasional episodes of overland flow from uplands. Thus they are perceived as "buffers" to nutrients and sediments derived from uplands (Lowrance et al. 1984, Peterjohn and Correll 1984, Cooper and Gilliam 1987, Cooper et al. 1987). These processes are likely important in maintaining the quality of stream water in the drainages of Cedar and Toms Creeks.

In contrast, the National Monument's large river floodplain receives most of its external water from big flood events when overbank flow delivers water from the Congaree River to the wetland surface. Instead of being buffers like small streams, which receive water more directly from upland runoff, large floodplains interact with large flows from upstream. As overbank flow continues downstream, but within the floodplain, the residence time of the water increases and thereby establishes greater contact with microbial-rich surfaces such as sediment, woody debris, leaf litter, and other forms of detritus and living plants. In fact, some of the water derived from overbank flow never leaves the floodplain, but is held for longer periods of time within depressions and as groundwater. This water may eventually leave by evapotranspiration, and, thus, never actually contribute to downstream loading of nutrients, other elements and compounds, or sediments.

Biota of Aquatic and Wetland Environments

The dynamic flood regime and diversity of aquatic and wetland environments in the National Monument severely restrict the ability of some species to colonize, yet provide critical habitat for others that depend on this variation for their very existence. Because of this interdependence, it is useful to consider what is known about the relationship between the biota and the hydrologic environment to which they are exposed.

Vegetation Adapted to Flooding

Individual plant species vary in their tolerance to soil saturation and inundation. Species that tolerate flooding for long periods of time, known as hydrophytes, possess adaptive characteristics that allow roots to metabolize anaerobically or that facilitate transport of oxygen to roots. When one considers entire, natural plant assemblages of the National Monument, it is convenient to simplify the approach by identifying discrete plant community types or categories. One way of depicting these categories is to arrange them along a continuum of hydroperiod (flooding frequency, duration, and depth). Such generalizations have been developed from literature on bottomland hardwood forests and related ecosystems developed within the last 20 years (Clark and Benforado 1981, Gosselink et al. 1990, Wharton 1978, Wharton et al. 1982).

The relationship between hydroperiod and species composition of plant communities would lead one to predict that changes due to alteration of flooding patterns, such as those caused by the Saluda Dam, would cause shifts in species composition. The relatively long life of the trees makes them poor indicators of potential changes in downstream flooding. Trees are most sensitive to flooding and dry conditions during seedling establishment, but are more resistant after they have reached a mature stage.

One of the difficulties in trying to find correlations between hydroperiod and the species composition of wetland forests is that the hydrology can change much more rapidly than individual trees can replace one another. This is due in part to the long life history of tree species and in part to the capacity of mature individuals to withstand greater ranges of flooding than seedlings. There are several well documented cases in which floodplains with altered flows have undergone changes in vegetation [the Missouri River in North Dakota (Johnson et al. 1976), the Hassayampa River in Arizona (Stromberg et al. 1991), and the Black Canyon of the Gunnison River National Monument in Colorado (Auble et al. 1994)]. Consequently, the concern exists that continued alteration of flows upstream of the National Monument may change the current species composition of the forest. Beaver impoundments could cause rapid local shifts to wetter conditions within the National Monument. This often results in the death of trees not adapted to the longer hydroperiod of beaver ponds. As described earlier, there is not yet convincing evidence that the establishment of Saluda Dam, and subsequent changes in flooding return intervals for a given flow, have yet changed species composition in the swamp (Rikard 1991).

The first vegetation maps of the area were developed by Gaddy et al. (1975) in preparation for the designation of the Beidler tract as a National Monument. This effort and more recent works recognized 11 community types (Table 3). Appendix A provides a list of the plants in the National Monument. Wetland indicator status is provided for those that appear in Reed (1988). Indicator status is used as one of the criteria to delineate wetlands for regulatory purposes. Project Statement COSW-N-005 identifies a wetland inventory and mapping effort underway.

Vegetation of the National Monument shares many of the features of the Francis Beidler Forest in Four Holes Swamp, Berkeley and Dorchester Counties, South Carolina (administered by the Audubon Society and The Nature Conservancy). A survey of the vascular flora of Four Holes Swamp (Porcher 1981) provides an annotated checklist of the mixed mesophytic hardwood forest (an upland community) and four wetland plant communities: seepage bog, swamp forest, hardwood bottom, and ridge bottom. The ridge bottom would not likely meet the criteria for jurisdictional wetland, but is nevertheless highly integrated into the larger floodplain ecosystem.

Seedling establishment and subsequent mortality ultimately determine species composition of the forest. Work by R. R. Sharitz at the Savannah River Ecology Laboratory, University of Georgia, is in progress to examine regeneration and recovery of vegetation. The approach for regeneration is to determine if seedlings and saplings, which will eventually replace canopy individuals over time, match the species composition of the canopy. If they do not, one might hypothesize that changes in hydrology to wetter or drier conditions is the cause. Hurricane Hugo in 1989 caused significant reductions in tree canopy cover, thus providing an opportunity for suppressed individuals in the understory to become dominant (Putz and Sharitz 1991). Flooding and the recruitment process for seedlings needs more work and can be accomplished only through long-term observations such as that occurring on permanent plots as described by Sharitz et al. (1993). Hurricanes likely play a major role in structure over the long term.

Table 3. Plant community types of the Congaree Swamp National Monument.*

Community Type	Canopy Dominant	Understory Dominant	Shrub Dominant
Pine-mixed hardwoods	Loblolly pine	American holly	Pawpaw
Cypress-tupelo	Bald cypress	Water elm and Carolina ash	Virginia willow
Overcup oak	Overcup oak	Red maple	Switch (giant) cane
Sweetgum-mixed hardwoods	Sweetgum	American holly and ironwood	Switch cane
Cherrybark oak-sweetgum-swamp chestnut oak	Cherrybark oak or swamp chestnut oak	Ironwood and American holly	Pawpaw
Tupelo-cypress	Water tupelo	Water elm and Carolina ash	Virginia willow
Pine-swamp tupelo	Swamp tupelo	Laurel oak	Fetterbush (Leucothoe)
Swamp tupelo	Swamp tupelo	Sweet bay	Leucothoe
Riverbank hardwoods	Sugarberry	Box elder	Switch cane
Laurel oak-sweetgum	Laurel oak	Ironwood & possumhaw	Switch cane & dwarf palmetto
Ash-red maple	Green ash	Water elm	--

*Assembled from the works of Gaddy et al. (1975), Smathers and Gaddy (1980), and personal communication with R. R. Sharitz (Savannah River Ecology Laboratory, University of Georgia, March 1996) and M. Kinzer (March 1996).

The Fire Management Plan (NPS 1995) for the National Monument recommends that further consideration be given to implementing a prescribed natural fire management program. Under the auspices of this program, wildland fire due to natural causes, such as lightning, is allowed to run its natural course provided predetermined conditions are met (resource availability, weather parameters, etc.) that are favorable to the management of the fire. Further information on fire is provided in the Fire Management Plan. Regardless, most of the floodplain wetlands of the National Monument represent a strong barrier to fires and may prevent fires in upland forests from carrying from one side of the Congaree River to the other.

Besides the continuing work by Sharitz, two other efforts attempted to shed some light on the effects of decreased frequency of flooding:

1. Rikard (1988) found some evidence that sugarberry and water oak were occupying lower elevation sites in the floodplain. This was inferred from the smaller diameter classes of those species at the lower elevations. However, Rikard pointed out that information on ages and growth rates of individual trees would be necessary to more convincingly link apparent changes with hydrologic alterations of the Saluda Dam. This is because tree size is not perfectly correlated with age because of varying growth rates.

2. The surveys of champion trees made by Jones (1996) suggest that individual trees reach champion size rapidly because of the rich alluvial soils. Consequently, senescence and death may be more rapid than earlier perceived. This relatively rapid turnover (in contrast to upland forests) may allow the forest community to respond more rapidly to hydrologic changes. Whether the hydrologic changes are great enough to induce a response large enough to be detected is still unresolved.

Fish and Other Vertebrates Dependent on Aquatic Regime

The large size and unfragmented nature of vegetative cover within the National Monument make this area particularly important for fish, birds, and other vertebrates dependent on aquatic ecosystems. A number of the fish species are permanent residents of the shallow stagnant habitats. Examples are bowfin, redfin pickerel, yellow bullhead, and mosquitofish. Impoundments downstream from the National Monument (Lake Marion and Lake Moultrie, Figure 4) began storage in 1941 (Cooney 1988). As a result, anadromous fish are much less abundant now than they were before the reservoirs were created. Now only remnant populations of rock fish (striped bass) are able to survive landlocked conditions, while others have been completely cut off from their migratory routes (various species of shad, herring, and sturgeon). Aquatic reptile species abound and many are aquatic obligates, such as the aquatic turtles (snapping turtle, mud turtle and river cooter) and eastern cottonmouth snake. Examples of mammals include river otter and marsh rabbit.

From a broader perspective of biodiversity, the alternation of flooding and drydown cycles in the Congaree Swamp has special significance because of the capacity to support different groups of animals both in time and space. This places the floodplain and wetland nature of this site in a category of high species richness and high habitat heterogeneity to support this species richness. Highly motile species such as birds preferentially use corridors in eastern deciduous biomes (Brinson et al. 1981). This includes not only waterfowl and many waders, which tend to limit their activities to open-water sites, but also smaller species, such as the prothonatary warbler, which prefers to nest in small cavity trees over open water.

Ecological versus Regulatory Wetlands

Wetlands have received a great deal of public attention nationally (National Research Council 1995). Because the National Monument consists largely of wetlands, resource managers should be aware of two perspectives on wetlands: ecological and regulatory. From an ecological perspective, the National Monument is a large, complex landscape of oxbow lakes, stream channels, seasonally flooded bottomland hardwood forests, cypress-tupelo swamps, and upland inclusions. During seasonal flooding, the floodplain behaves as an integrated unit, albeit poorly understood in terms of specific surface flow pathways, groundwater discharge, and origin of geomorphic features. The net effects of the multiple functions of the Congaree floodplain are improved water quality, better habitat for fish and other water-dependent species, and reduced downstream flood peaks. Descriptions of the floodplain for interpretive purposes and proposals for studies to gain further insight into floodplain functioning need not be influenced by how much and which parts of the floodplain are wetlands from a regulatory perspective.

In contrast, the manager must be acutely aware of any activities that may disturb sediment or alter the flow of water in a "jurisdictional" wetland. Sediment may be disturbed by road building and maintenance, timber extraction, and other activities. Flow may be altered by culvert placement, clearing fallen snags from channels, ditch maintenance, and dam placement or removal. These and other activities may require permits from different agencies, in addition to being governed by NPS policies, depending on how the land is classified in terms of regulatory wetland status.

From the regulatory standpoint, it is essential to identify which portions of the ecological wetland are "jurisdictional" wetland and which are not. The 1987 manual for delineation of wetlands currently in force (Environmental Laboratory 1987) requires a combination of hydrologic, vegetation, and soil conditions to be met in order for a site to qualify as a regulated wetland. The issue of wetland jurisdiction is relevant to this Water Resources Management Plan because wetlands are considered "waters of the United States" under section 404 or the Clean Water Act. Consequently, a permit must be issued by the U.S. Army Corps of Engineers before a water dependent activity is initiated.

NPS staff need not be skilled in determining whether a site is wetland or not. Such determinations require specific training and specialized skills. The Charleston District Regulatory Branch of the U.S. Army Corps of Engineers should be contacted if activities in a wetland are planned in order to know the procedure for permit application and if there are any peculiarities in applying the criteria for wetland status to the local environmental conditions.

If a project requiring any of the activities mentioned above is planned on land that is not obviously an upland site, a professional wetland delineator should be enlisted to make wetland determinations. While the resource manager does not need to know the details of delineation, it is prudent to know the general approach for wetland determination and potential problems that may exist with the soils and vegetation of the National Monument.

Three criteria are used in determining wetland status: hydrology, soils, and vegetation. In a general sense, the period of inundation or saturation to the surface is one of the most difficult to measure. The threshold to be exceeded is continuous inundation or saturation to the surface for 5% to 12.5% of the growing season during one-half of the years (e.g., 50 of 100 years). Hydrologic monitoring in the National Monument (Patterson et al. 1985) is more extensive than it is for most wetland sites. However, further data analysis would be necessary to determine if existing hydrographs are close enough to the site in question to be useful. Thus, soil and vegetation parameters must be invoked to make the determination.

For a soil to meet the wetland criterion, it must be hydric, a condition that develops when either organic or mineral soils are inundated for long periods of time. Such soils generally appear dark, a feature that can be determined by comparison with the "chroma" from a Munsell Color Chart. One must rely exclusively on soils to determine wetland status if neither vegetation nor hydrologic information is available.

Many of the soils of the National Monument are typically too bright (high chroma as determined by a Munsell Color Chart) to qualify as "hydric." The soils are bright because they originated from the red clays in the Piedmont. Soils exposed to the longest periods of flooding and anoxia, such as the cypress-tupelo sloughs, develop low enough chromas that they do not pose a problem for the hydric soils criterion. Therefore, caution should be exercised to verify whether the soils in question are classified as hydric by referring to the Hydric Soils List (U.S. Department of Agriculture 1991), rather than relying solely on field indicators that may be masked by the reddish colors.

As most of the National Monument has relatively undisturbed vegetation and soils, determinations would appear to be straightforward. For vegetation, however, a problem may occur where sweetgum (*Liquidambar styraciflua*) is dominant. In seasonally flooded portions of the National Monument, sweetgum is only a marginally useful species for indicating wetlands because of its "facultative" status (i.e., it is equally likely to be found in uplands as wetlands). [Actually, *L. styraciflua* is FAC+, slightly more hydrophytic than facultative, but not FACW (facultative wet).] In spite of this, there are usually many other species in the canopy, subcanopy, and herbaceous layer that can be used. Therefore, the problem is not insurmountable; it simply requires recognition that sites with sweetgum dominance be given a closer examination for hydrophytic vegetation.

Finally, in addition to the 404 permit process discussed above, the NPS has an agency wide guideline for wetlands protection and management. This guideline, which implements Executive Order 11990 (Protection of Wetlands), was published in 1980 as the "NPS Floodplain Management and Wetlands Protection Guidelines" (45 FR 35916, minor revisions in 47 FR 36718). The procedures direct NPS managers to avoid actions with the potential for adversely impacting wetlands when there is a practicable alternative and to minimize degradation of wetlands when no such alternatives exist. If avoidance is not practicable and a project will adversely impact wetlands, a "Statement of Findings" must be attached to the FONSI (Finding of No Significant Impact) or final EIS for the project. This document: (1) describes the affected wetlands and the predicted impacts on wetland functions and values; (2) explains why there are no practicable alternatives to the proposed action with less impact on wetlands; and, (3) describes wetland restoration activities that will be completed to compensate for wetland degradation or loss (minimum of 1:1 compensation required). The guideline is currently being revised, but the aspects discussed here are expected to remain.

There are many similarities between NPS wetland compliance requirements and the Section 404 permit program, and typically the wetland delineation and impact analysis required for one set of requirements may be used for the other. However, there are some key differences between the two:

1) The NPS guidelines are broader than the 404 requirements with respect to types of regulated activities. While 404 regulation is restricted to discharge of dredged or fill material into wetlands and other "waters of the U.S.," the NPS guidelines cover any activity which may adversely impact wetlands. For example, drainage ditches or groundwater pumps located entirely on upland sites would not be regulated under Section 404 even if they drain nearby wetlands, but such activities would be subject to NPS guideline requirements.

2) The definitions of "wetlands" under the two programs are very similar, but do not entirely overlap. The Executive Order 11990 definition used in the NPS guidelines includes all of the wetlands regulated under the 404 program, but adds unvegetated wetlands such as many shorelines, playas, tidal flats, riverbeds, and so on. To bridge this difference for compliance purposes, it may generally be assumed that wetlands falling under the NPS guideline are vegetated wetlands as identified under the 1987 Corps of Engineers manual plus any other unvegetated habitats identified as wetlands under the Cowardin classification system (Cowardin et al. 1979).

Again, a professional wetland delineator should be enlisted to survey a site in question unless it is obviously upland and no off-site wetland impacts are anticipated.

WATERSHED CHARACTERISTICS AND WATER QUALITY

Drainages of all major waterways that flow through the National Monument originate outside of its boundaries (Figure 3). Land use activities within the Congaree River watershed and the watersheds of all tributaries flowing through the National Monument may impact the hydrologic regime and water quality within the National Monument. Although more extensively forested or in perennial cover today, this region has historically experienced intensive cultivation and widespread deforestation. Subsequent soil erosion has severely reduced topsoil depths and increased sediment loading in stream and river beds (Phillips 1993). In the Piedmont region of South Carolina and other southeastern states, the loss of topsoil, reduced soil fertility, and soil degradation necessitated a cultural shift from agricultural to silvicultural production in recent decades (Odum 1989, Turner 1987).

As cropland declines, the remaining cropland is often intensively cultivated, requiring large inputs of fertilizers and pesticides to maintain or increase crop yields. If the fertilizers contain nutrients that are limiting to plant growth in adjacent aquatic ecosystems, eutrophication may result. Eutrophication is the response of nutrient enrichment which stimulates the growth of aquatic algae and higher plants. The eventual decomposition of this plant biomass consumes oxygen. Dissolved oxygen levels may decrease to levels incapable of supporting aerobic organisms. The standing waters of the National Monument's Weston Lake and Wise Lake are at greatest risk from eutrophication because they lack flow and flushing that would displace accumulated nutrients. Pesticides also may have deleterious acute and chronic effects on aquatic food webs. Entire taxa of pesticide-sensitive organisms may be eliminated. At higher trophic levels of the food chain, pesticides bioaccumulate in animal tissues and can cause growth abnormalities, lack of reproductive success, and reduced resistance to disease.

Probably the greatest water-related environmental problem facing the National Monument and the Congaree River watershed is a decline in water quality resulting from change in land use that occurs as urban and industrial areas expand into rural areas. South Carolina's major urban centers of Greenville, Spartanburg, and Columbia are located within the Congaree River watershed and are sources of stormwater runoff which may transport pollutants into waterways. As is the case with many rapidly developing areas of the Southeast, these urban and industrial centers are often ill-planned, with inadequate siting restrictions and zoning ordinances, as well as poorly-enforced pollution control measures. Land use patterns within the Congaree River watershed will be examined separately from land use patterns within the local watersheds of Cedar and Toms Creeks. Strategies to protect the water resources for the National Monument will differ for these two drainages.

Land Use and Watershed Development

Land Use in the Congaree River Watershed

Within the state of South Carolina, the Congaree River watershed encompasses 7,020 square miles (18,182 km^2) and extends from the North Carolina-South Carolina border to the river's confluence with the Wateree River in Calhoun and Sumter Counties to form the Santee River (Figure 4). The South Carolina Department of Natural Resources, Land Resources and Conservation Districts has developed land use coverage data for the Congaree River watershed from satellite imagery. A 1,166 square miles (3,020 km^2) portion of the Congaree River watershed lies within North Carolina (R. Lacy, South Carolina Department of Natural Resouces, Land Resources and Conservation Districts, unpublished data). This region comprises less than 17% of the Congaree River watershed but includes the headwaters of the Broad River, a major tributary to the Congaree River. Land use coverage data for the North Carolina portion of the watershed region are not available from satellite imagery. However, satellite imagery for this region was scheduled for analysis beginning in 1994 (M. Rink, Center for Geographic Information and Analysis, Raleigh, North Carolina, personal communication, October 1994). Estimates of land use coverage for the three North Carolina Counties (Cleveland, Rutherfordton, and Polk Counties) within the watershed have been provided by county offices of the Natural Resources Conservation Service.

The most prevalent coverage type for the Congaree River watershed is mixed hardwood and pine forest, occupying 39.7% of the watershed (Table 4). Evergreen forest, primarily managed pine plantations, occupies 16.3% and deciduous forest occupies 7.9%, respectively. The total watershed coverage in forest, either in permanent or in long-term vegetative cover (including the shrub/scrub and saturated bottomland forest land use categories) is approximately 72%. In the Congaree River watershed, as in much of the Piedmont region of the Southeast, there has been a trend toward increasing forest coverage. The economic hardship brought on by the Great Depression of the 1930s, coupled with a history of soil degradation and erosion, initiated an abandonment of once cultivated lands, thus allowing forest succession to proceed (Odum and Turner 1990). Additionally, forest lands became less fragmented since fewer small fields were maintained; consequently, remaining cropland fields are larger in size.

While forested lands contribute low levels of nutrient loading, intensively managed pine plantations are potentially larger sources for nutrients and sediments (Stanley 1988). However, croplands are much larger contributors of sediments, nutrients (Lowrance et al. 1985, Stanley 1988), and pesticides into Piedmont and Coastal Plain watersheds. Urban and residential landscapes contribute sediments, pesticides, and an array of pollutants from stormwater runoff in much higher quantities per unit area than any of the above land uses (Stanley 1988).

Nonforested coverage is primarily agricultural land and pasturage (15.8% of total), or urban coverage (9.1%) (Table 4). Cropland remaining in cultivation is generally confined to sites suitable for large-scale agricultural production. Although less land is in cultivation today, increased crop yields per unit area have resulted, in part, from increased fertilizer and pesticide usage. Determining the fate of these nutrients and pesticides is often problematic. The removal of nutrients (especially nitrogen compounds and phosphorus) by harvesting crops accounts for the largest nutrient output from agricultural systems; however, denitrification, seepage into groundwater, and runoff into surface waters may account for additional nutrient losses (Thomas and Gilliam 1978). In agriculture-dominated watersheds of the Georgia Coastal Plain, nutrient loading of streams as a result of cultivation has been demonstrated (Lowrance et al. 1985). Phosphorus loading in streams is often associated with increased sedimentation rates because phosphate binds to soil particles.

Changes in agricultural policy (e.g., loss of agricultural subsidies), technologies, and economics (e.g., the establishment of large slaughterhouses in the region) may result in rapid and widespread changes in agricultural land use. For example, changes in the tobacco industry in North Carolina and elsewhere in the South has, in part, been responsible for a shift in land use toward cotton production (which requires large acreages and increased pesticide use) and toward concentrated livestock production (swine and poultry production with the potential for substantial degradation of surface and groundwater quality). Such land use changes in the

Congaree River watershed and especially in the northern tributary watersheds may have profound effects on environmental quality in the National Monument.

Table 4. Land use in the Congaree River watershed above and including Congaree Swamp National Monument. (Data provided by the South Carolina Department of Natural Resources, Land Resources and Conservation Districts, September, 1994, and North Carolina Cooperative Extension Service, November 1994.)

Land Use Category	Acres	Hectares	Percent
Evergreen Forest	851,422	344,826	16.3
Deciduous Forest	415,857	168,422	7.9
Mixed Forest	2,080,497	842,601	39.7
Shrub/Scrub	379,624	153,748	7.2
Saturated Bottomland Forest	56,632	22,936	1.1
Nonforested Wetland/Marsh	587	238	<0.1
Agriculture/Grassland	829,034	335,759	15.8
Barren Disturbed Land	28,988	11,740	0.6
Urban Built-Up Land	476,110	192,825	9.1
Water	120,236	48,696	2.3
TOTALS	5,238,988	2,121,790	100.0

Surface Water Development in the Congaree River Watershed

One of the consequences of increasing urban and industrial development in the Congaree River watershed is the potential for increased development of water for hydroelectric and water supply uses. The Saluda Hydroelectric Plant on Lake Murray is owned by the South Carolina Electric and Gas Company (SCE&G) and located on the Saluda River approximately 11 miles (18 km) upstream from the confluence of the Saluda and Broad Rivers at Columbia and 38 miles (60 km) above the National Monument. This facility has been in operation since 1930. Daily flows in the Congaree River are affected by releases from the Saluda Hydroelectric Plant. Under daily peaking operation, instantaneous flows in the Saluda River can vary from approximately 200 cfs to up to 18,000 cfs. Under the existing Federal Energy Regulatory Commission (FERC) license (which expires in 2007), there is no requirement to release water for maintaining minimum flows in the Saluda River. There are no new large-scale hydroelectric projects scheduled for the Congaree watershed.

There are numerous sites on tributaries to the Congaree River in the Piedmont and Mountains that may be developed for small-scale, lowhead hydroelectric power production. Five small hydroelectric facilities on the Broad River (Gaston Shoals, 99 Islands, Lockhart, Neal Shoals, and Columbia Hydro) are currently undergoing relicensing with FERC. Three facilities on the Saluda River (Saluda Station, Holidays Bridge, and Buzzards Roost) have received new FERC licenses. With the exception of Buzzards Roost, these facilities are modified run-of-river facilities and their continued operation would not affect mean daily flows in the Congaree River. Individually, these small-scale facilities should not affect the water regime at the National Monument; however, the cumulative effect of numerous facilities of this type is not known. If extensive hydroelectric development throughout the Congaree River watershed is undertaken, management personnel at the National Monument should investigate its effects.

A construction permit for a moderately sized water supply reservoir and dam is under review by the South Carolina Department of Health and Environmental Control (SCDHEC), Water Pollution Control/Dam Safety Section (G.D. Ballentine, SCDHEC, personal communication, December 1994). This reservoir will be a 137 acre (55 ha) lake on the North Tyger River (a tributary to the Broad River) in Spartanburg County. The dam will be a run-of-river dam with a minimum flow requirement designed to maintain a near normal flow regime in the river. Permit applications for several smaller farm ponds have been received; the consequence of their construction on the hydrology of the watershed is likely to be minimal.

Two large interbasin transfers are located upstream from the National Monument. The City of Columbia is registered to transfer a maximum of 100 million gallons of water per day (mgd) from the Columbia Canal (Broad River basin) and 100 mgd from Lake Murray (Saluda River basin). Water is transferred to the Saluda, Broad, Congaree, and Wateree River basins. No restrictions on use, other than the maximum amount, are placed on the City of Columbia's transfer since Columbia had existing facilities in place to transfer water when the Interbasin Transfer Act was passed (discussed earlier in the Planning Relationships section of this document) . In accordance with the Act, Columbia was grandfathered or registered. This registration expires in 2007 at which time a permit will be required for the transfer. This is an unusual transfer in that it occurs at the confluence of the Saluda and Broad Rivers to form the Congaree River. Currently, very little water is actively transferred to the Wateree River basin.

The second transfer is held by the City of West Columbia and Lexington County. The entities jointly have an Interbasin Transfer Permit for 48 mgd to transfer water from Lake Murray (Saluda River basin) to the Congaree River basin. West Columbia and Lexington County have certain permit conditions including water audit and leak detection requirements on their permit. The permit also contains a minimum flow requirement that the withdrawal can not directly cause the flow from Lake Murray to be less than the 7Q10 flow. Flows less than the 7Q10 flow are observed regularly from Lake Murray, but result from SCE&G's operation, and not from the interbasin transfer. Because of the water distribution and wastewater collection systems of Columbia and West Columbia, a majority of the water withdrawn and transferred is returned as wastewater to the Congaree River above the National Monument. However, insufficient water is returned to maintain 7Q10 flows above the National Monument.

Land Use Within the Cedar Creek and Toms Creek Watershed Subunits

Two watershed subunits terminate within the National Monument boundaries: the Cedar Creek watershed, in the western and central portions of the National Monument and Toms Creek in the eastern portion of the National Monument (Figure 3). Both of these watersheds originate outside of the National Monument boundaries and are susceptible to changes in land use that may degrade water quality. Thus, land use activities beyond the National Monument boundaries may be inconsistent with management goals of the National Monument.

The Cedar Creek-Myers Creek watershed encompasses 66,648 acres (26,992 ha) and the Toms Creek watershed occupies 48,982 acres (19,838 ha) (Table 5). Collectively, these watersheds are forest-dominated, with evergreen forests (pine silviculture) covering 38% of the total area and mixed pine-hardwood forests covering 26%. Less than 15% of the combined watershed area is agricultural and less than 2% is urban. Since a substantial portion of the Cedar Creek-Myers Creek watershed lies within the National Monument, a relatively high percentage of its coverage (20%) is designated as saturated bottomland forest (Table 5).

Two military bases are located within the Cedar Creek watershed. The headwaters of Cedar Creek are Westons Pond and associated drainages which lie within the south-central portion of US-Army, Fort Jackson. Further downstream on Cedar Creek, McEntire Air National Guard (ANG) Base is situated between Cedar Creek and Dry Branch. Dry Branch joins Cedar Creek at Weston Lake in the National Monument (Figure 3).

The portion of Ft. Jackson within the Cedar Creek watershed is largely undeveloped training ground with few buildings or paved roads. This area is occupied by sand hills with a pine and shrub-scrub vegetative cover. A 1994 listing of South Carolina groundwater contamination sites by SCDHEC indicated that six groundwater contamination sites resulting from underground storage tanks were located at Ft. Jackson. None of these sites are within the Cedar Creek watershed (L. Estaba, hydrogeologist, Environmental and Natural Resources Division, US-Army, Ft. Jackson, written statement, 24 February 1995). A recreation area, used principally by military personnel, is located at Westons Pond. A restroom facility at the recreation area has an associated sewage treatment system and has been issued an NPDES permit (#SC0003786); however, discharge to the pond is negligible to non-existent (L. Estaba, Ft. Jackson Environmental Branch, personal communication, May 1996) .

The McEntire ANG Base is located entirely within the Cedar Creek and Dry Branch watersheds and presents a risk to the surface waters of the National Monument. The ANG Base operates a 20,000 gallon per day wastewater treatment plant that discharges into Cedar Creek; presently, there are no planned expansions to the plant (McEntire ANG Memorandum 14 December 1994). An NPDES permit (#SC000701) was issued for the wastewater plant. The plant is in compliance with NPDES standards except for failure to submit copies of a required Discharge Monitoring Report (DMR) for August 1993. Twelve soil or groundwater contamination sites have been identified on Base property; remediation is in progress through an Installation Restoration Plan. All contamination site remediation is scheduled for completion by the year 2000. Stormwater runoff from runways and impervious surfaces drains into ditches which connect to oil/water separators before entering the wastewater treatment plant. Some drainage ditches on Base property connect directly to Cedar Creek or Dry Branch but no industrial wastes enter these ditches. A stormwater management and best management practices study has been conducted for the Base and is presently in review (McEntire ANG Memorandum 14 December 1994).

Table 5. Land use in the Cedar/Myers Creek and Toms Creek watershed subunits. (Data provided by the South Carolina Land Resources and Conservation Districts, September, 1994.)

Land Use Category	Cedar Creek and Myers Creek			Toms Creek		
	Acres	Hectares	Percent	Acres	Hectares	Percent
Evergreen Forest	18,144	7,348	27.2	25,616	10,374	52.3
Deciduous Forest	0	0	0.0	0	0	0.0
Mixed Forest	19,416	7,863	29.1	10,519	4,260	21.5
Shrub/ Scrub	1,603	649	2.4	1,779	720	3.6
Saturated Bottomland Forest	13,436	5,442	20.1	4,424	1,792	9.0
Nonforested Wetland/ Marsh	0	0	0.0	0	0	0.0
Agriculture/ Grassland	11,369	4,604	17.1	5,226	2,117	10.7
Barren Disturbed Land	226	92	3.4	492	199	[illegible].0
Urban Built-Up Land	1,642	665	2.4	248	100	0.5
Water	812	329	1.2	678	275	1.4
TOTALS	66,648	26,992	100.0	48,982	19,838	100.0

Water Classification and Standards for Waters of the National Monument

The Congaree River and all tributary streams or ponds in the National Monument are classified as "Freshwaters" (FW) by SCDHEC in Regulations 61-68 and 61-69 of the South Carolina Water Pollution Control Act, 48-1-10, et seq, S.C. Code of Laws, 1976. This designation is the most common category for lower watershed streams throughout the state. Water quality standards for Class "Freshwaters" are provided in Tables 6a and 6b. A higher stream classification is Class "Outstanding Resource Waters" (ORW) (Tables 7a and 7b). This designation may be appropriate for waters of high ecological or recreational value, such as the waters of the National Monument.

Table 6a. South Carolina water quality standards for Class "Freshwaters." The Congaree River, Cedar Creek, Toms Creek, and all other tributaries flowing through the National Monument are classified as Freshwaters (Reg. 61-68, South Carolina Water Pollution Control Act, 48-1-10, et seq, S.C. Code of Laws, 1976).

Parameter	Freshwater Standards
(a) Garbage, cinders, ashes, sludge, refuse.	None allowed
(b) Treated wastes, toxic wastes, deleterious substances, colored or other waste substances except those given above.	None alone or in combination with other substances or wastes in sufficient amounts to make the waters unsafe or unsuitable for primary contact recreation or to impair the waters for any other best usage as determined for the specific waters which are assigned to this class.
(c) Toxic pollutants listed in S 307 of the Federal Clean Water Act and for which EPA has developed national criteria; including ammonia, chlorine, metals, and PCBs.	As prescribed in E(7) and E(8)of Regulation 61-68. See 40 CFR Parts 100-149 (Table 6b).
(d) Dissolved Oxygen.	Daily average not less than 5.0 mg/L with a low of 4.0 mg/L.
(e) Fecal coliform.	Not to exceed a geometric mean of 200/100 ml, based on five consecutive samples during any 30 day period; nor shall more than 10% of the total samples during any 30 day period exceed 400/100 ml.
(f) pH.	Between 6.0 and 8.5
(g) Temperature.	No increases of more than 2.8°C (5°F) above natural conditions or to exceed 32.2°C (90°F) as a result of discharges, or otherwise prescribed in E.(6) of Regulation 61-68.

Table 6b. National water quality criteria that have been adopted by SCDHEC to protect aquatic life in waters of South Carolina (40 CFR Parts 100-149).

Pollutant	EPA Criteria to Protect Aquatic Life	
Metals[3]	Acute[1]	Chronic[2]
Arsenic	360 ug/L	190 ug/L
Cadmium	3.9+ ug/L	1.1+ ug/L
Chromium +3 & +6	1700 & (16 ug/L)	210+/11 ug/L
Copper	18+ ug/L	12+ ug/L

Table 6b. Continued.

Pollutant	EPA Criteria to Protect Aquatic Life	
Metals[3]	**Acute[1]**	**Chronic[2]**
Lead	82+ ug/L	3.2+ ug/L
Mercury	2.4 ug/L	0.012 ug/L
Nickel	1400+ ug/L	160+ ug/L
Selenium +4	20 ug/L	5 ug/L
Silver	4.1+ ug/L	(0.12 ug/L)
Zinc	120+ ug/L	110 ug/L
Pesticides and PCBs		
A-Endosulfan	0.22 ug/L	0.056 ug/L
Aldrin	3.0 ug/L	—
Dieldrin	2.5 ug/L	0.0019 ug/L
DDT	1.1 ug/L	0.001 ug/L
Endrin	0.18 ug/L	0.0023 ug/L
Heptachlor	0.52 ug/L	0.0038 ug/L
Chlordane	2.4 ug/L	0.0043 ug/L
Toxaphene	0.73 ug/L	0.0002 ug/L
Aroclors (PCBs)	2.5 ug/L	0.014 ug/L
Others		
Pentachlorophenol	20 ug/L	13 ug/L
Cyanide	22 ug/L	5.2 ug/L
Chlorine	19 ug/L	11 ug/L
Ammonia	pH/temp. dependent	—

[1] "The not to be exceeded value for national criteria published in 1980 or the one-hour average value for national criteria published in 1985 or later shall be used as an acute toxicity number for calculating effluent limitations" (Reg. 61-68, South Carolina Water Pollution Control Act, 48-1-10, et seq, S.C. Code of Laws, 1976).

[2] "The 24-hour average for national criteria published in 1980 or the four-day average for national criteria published in 1985 or later shall be used as a chronic toxicity number for calculating effluent limitations" (Reg. 61-68, South Carolina Water Pollution Control Act, 48-1-10, et seq, S.C. Code of Laws, 1976).

[3] "If metals concentrations for national criteria are hardness-dependent, the chronic and acute concentrations shall be based on 50 mg/l hardness if the ambient hardness is less than 50 mg/l. Concentrations shall be based on the actual mixed stream hardness if it is greater than 50 mg/l." (Reg. 61-68, South Carolina Water Pollution Control Act, 48-1-10, et seq, S.C. Code of Laws, 1976). Hardness values in the Congaree River, Cedar Creek, and Toms Creek are usually less than 50 mg/l (EPA, STORET System database for the USGS catalog unit encompassing the Congaree Swamp National Monument, 1995).

Table 7a. South Carolina water quality standards for Class "Outstanding Resource Waters." (Reg. 61-68, South Carolina Water Pollution Control Act, 48-1-10, et seq, S.C. Code of Laws, 1976).

Parameter	Outstanding Resource Waters Standards
(a) Dissolved oxygen, fecal coliform, pH, temperature, turbidity, or other parameters.	Water quality conditions will be maintained and protected as feasible, within SCDHEC statutory authority.
(b) Discharge from domestic, industrial, or agricultural waste treatment facilities; open water dredged spoil disposal.	None allowed.
(c) Stormwater and other nonpoint source runoff including that from agricultural uses or permitted discharge from aquaculture facilities.	Allowed if water quality necessary for existing and classified uses will be maintained and protected consistent with Antidegradation Rules.
(d) Dumping or disposal of garbage, cinders, ashes, oils, sludge, or other refuse.	None allowed.
(e) Activities or discharges from waste water treatment facilities in waters upstream or tributary to ORW waters.	Allowed if water quality necessary for existing and classified uses will be maintained and protected consistent with Antidegradation Rules (Table 7b).

Table 7b. South Carolina Antidegradation Rules applicable to Classes "Freshwaters" and "Outstanding Resource Waters." (Reg. 61-68, South Carolina Water Pollution Control Act, 48-1-10, et seq, S.C. Code of Laws, 1976).

(1) Existing water uses and the level of water quality necessary to protect these existing uses shall be maintained and protected regardless of the water quality classification and consistent with policies below. (a) Existing uses and water quality necessary to protect these uses are presently affected or may be affected by instream modifications or water withdrawals. The streamflows necessary to protect classified and existing uses and the water quality supporting these uses shall be maintained consistent with riparian rights to reasonable use of water. (b) Existing or classified groundwater uses and the conditions necessary to maintain those uses shall be maintained and protected.
(2) Where surface water quality exceeds levels necessary to support propagation of fish, shellfish, and wildlife, and recreation in and on the water, that quality shall be maintained and protected unless the SCDHEC finds, after intergovernmental coordination and public participation, that allowing lower water quality is necessary to important economic and social development in the areas where the waters are located. In allowing such lower water quality, water quality adequate to protect existing uses shall be maintained. The highest statutory and regulatory requirements for all new and existing point sources shall be achieved and all cost-effective and reasonable best management practices for nonpoint source control shall be achieved within the State's statutory authority and otherwise encouraged.
(3) The water quality of outstanding resource surface waters designated as Class ORW shall be maintained and protected through application of standards for Class ORW. The SCDHEC may determine, through the classification process, that some ORW waters are nationally significant. Upon such determination, all activities described in Table 7a shall be prohibited.
(4) Under certain conditions, the quality of some free flowing surface waters and lakes, including water in adjacent wetlands, does not meet numeric standards for dissolved oxygen due to natural conditions, even though classified uses in these waters are achieved. Under these conditions, the quality of the free flowing surface waters or lakes, but excluding water in the adjacent wetlands, shall not be cumulatively lowered more than 0.10 mg/L for dissolved oxygen from impacts by point sources and other activities, unless a site-specific standard is established.

Class "Freshwaters" are defined by SCDHEC as: "freshwaters suitable for primary (e.g., swimming) and secondary (e.g., fishing and wading) contact recreation and as a source for drinking water supply after conventional treatment in accordance with the requirements of the Department. Suitable for fishing and survival and propagation of a balanced indigenous aquatic community of fauna and flora. Suitable also for industrial and agricultural uses" (Reg. 61-68, South Carolina Water Pollution Control Act, 48-1-10, et seq, S.C. Code of Laws, 1976).

Class "Outstanding Resource Waters" are defined by SCDHEC as: "freshwaters or saltwaters which constitute an outstanding recreational or ecological resource or those freshwaters suitable as a source for drinking supply with treatment levels specified by the Department" (Reg. 61-68, South Carolina Water Pollution Control Act, 48-1-10, et seq, S.C. Code of Laws, 1976).

Water Quality Status for Surface Waters Affecting the National Monument

Studies of water quality in the National Monument have been of two types: (1) intensive, short-term studies of chemical and nutrient constituents in surface waters, sediments, and biological tissue; and, (2) long-term collection and analysis of surface water samples for physical and chemical parameters. A summary of these studies follows.

Evaluation of Water Quality Data from Intensive Studies

Four intensive studies of water/sediment chemistry have been conducted within or in the vicinity of the National Monument. Birch (1981) examined water quality in upstream and downstream segments of Cedar Creek during periods of normal flow and flood flow. Birch reported occasional low dissolved oxygen concentrations but normal concentrations were seldom limiting to most aquatic organisms. Nitrate and phosphate concentrations were within normal levels for inner coastal plain streams. During normal flows, Cedar Creek was low in suspended particles and high in dissolved materials; during flood flows when back-flooding from the Congaree River mixed with the waters of lower Cedar Creek, the reverse condition prevailed: samples contained relatively higher concentrations of suspended particles and lower concentrations of dissolved materials. Trace metals analysis indicated that manganese frequently exceeded EPA Drinking Water Standards and that iron and lead occasionally occurred at levels that warrant monitoring.

Cooney (1990) analyzed bed-sediments and surface water for trace metals in Cedar Creek and Toms Creek upstream from and within the National Monument. Samples taken in 1985-1986 indicated widely ranging concentrations of barium, iron, magnesium, and manganese in bed-sediments, with highest concentration in Myers Creek (a tributary to Cedar Creek) and Cedar Creek upstream from the National Monument. Surface water samples taken within the National Monument on Cedar Creek near Wise Lake indicated maximum concentrations of cadmium and manganese in excess of EPA Drinking Water Standards. Copper, zinc, and lead were also found in slightly elevated concentrations but maximum concentrations were below EPA Drinking Water Standards. Relatively high concentrations of trace metals in floodplain sediments indicated that the floodplain of the National Monument is a sink for these trace metals.

Pickett (1992) examined trace metals in the tissue of the Asiatic clam, *Corbicula fluminea*, and in bed-sediments of the lower Congaree River (at the US 601 bridge) and the lower Wateree

River during 1989-1991. Cadmium, copper, and zinc were found to bioaccumulate in clam tissue at higher concentrations than could be found in bed-sediments. Concentrations of trace metals were generally higher in tissue collected in the Wateree River than in the Congaree River even though the Congaree River had higher sediment and solute trace metal concentrations. Pickett proposed that cooler ambient water temperature and higher total suspended solids and organic content in the waters of the Congaree River tended to reduce the bioavailability of trace metals.

No previous studies have attempted to comprehensively survey the distribution of aquatic invertebrates and vertebrates, or to determine potential levels of contamination in the major waterways of the National Monument. An approach to surveying the aquatic macroinvertebrates is described in Project Statement COSW-N-018. In a related study (COSW-N-067), fish and aquatic herpetofauna are proposed as indicators of water quality and habitat condition. This latter study will also examine the physical and chemical controls on aquatic metabolism, nutrient exchange, and sediment dynamics.

An intensive study of chemical/nutrient status was conducted by Rikard (1991) on three tributaries (Myers, Reeves, and Toms Creeks) that enter the northern boundary of the swamp. He analyzed 20 chemical constituents on water samples collected at intervals of approximately two weeks from February 6, 1989 to June 23, 1990. Field measurements were taken of temperature, pH, conductivity, and dissolved oxygen. Water temperatures fell below 10°C only twice during the sampling period. Conductivity was quite low, with most values falling in the 20 to 30 umhos/cm range, suggesting that the groundwater was not in contact with soils or other deposits for long enough periods to supply abundant ions. Waters with such low conductivities would be expected to be poorly buffered to changes in pH. While low pHs would be expected in such poorly buffered waters, most values were in the neutral and slightly alkaline range. Surface water pH may have been high due to depletion of carbon dioxide from photosynthesis of algae at the time samples were collected. This interpretation needs to be confirmed, however. Regardless, dissolved oxygen concentrations well above saturation in several instances are indicative of high rates of photosynthesis.

Samples were analyzed using an ICAP/plasma emission spectrometer, and a number of elements were present at concentrations "negligible or below the detectable range" of the analysis (e.g.,barium, boron, cadmium, chromium, cobalt, copper, lead, molybdenum, nickel, strontium, and zinc) (Rikard 1991). The metal of greatest concern was aluminum. High concentrations of aluminum were found in Myers, Reeves, and Toms Creeks. Aluminum toxicity is pH dependent with increased toxicity in streams of low pH such as is characteristic of many southeastern coastal plain streams. Aluminum and iron, both components of local soils, tended to occur in low concentrations during the cool season. The presence of the highest concentrations of iron during the warm seasons is consistent with lower flows and the possible development of anoxia, which would facilitate reduction of iron to the reduced, more mobile form. Aluminum also shows this pattern. Manganese showed no obvious pattern except for a number of unexplainable high concentrations in Myers Creek. There were no trends of interest for phosphorus or potassium.

Calcium is often a dominant cation in fresh waters, yet concentrations in streams sampled for this report were mostly below 1 mg/L, indicative of the poorly buffered nature of these streams. Sodium concentrations have a consistent pattern, with concentrations in Myers Creek exceeding those in Toms Creek, which in turn exceeded concentrations in Reeves Creek. Silica has strong seasonality, presumably inversely proportional to flows, with highest concentrations in the warm periods and lowest when evapotranspiration is low and flows would be greatest.

Of the three streams sampled (Myers, Toms, and Reeves Creeks), a general trend emerged. Myers Creek normally had the highest concentrations of all elements sampled while Reeves Creek had the lowest concentrations, and Toms Creek was intermediate. The reason for this pattern is not known; however, it should be noted that the Myers Creek watershed contains more residential and minor industrial development than the other watersheds. Additional field sampling of conductivity and dissolved organic carbon would be useful in characterizing changes in water chemistry as these tributaries enter the swamp. The results of the study by Birch (1981) should be consulted for insight into flow patterns before a sampling design is developed.

In general, the waters of the northern tributaries are very poorly buffered and nutrient poor. The dilute nature of the tributary waters may make them particularly susceptible to enrichment in potentially growth-limiting plant nutrients such as nitrogen and phosphorus. Such enrichment, without equivalent increases in buffering capacity, may increase rates of photosynthesis of algae, which depresses even further the buffering capacity, and has the collateral effect of further increasing pH. More research on nutrient dynamics in surface waters is warranted in order to better understand which nutrients are likely to occur in concentrations that may be limiting to plant growth in the floodplain ecosystem. Synoptic sampling of surface and ground water for content of major ions (calcium, sodium, chloride, and carbonate), pH and buffering capacity, and dissolved organic carbon may allow a better understanding of the sources and mixing regimes of the water. Such background data and information on probable water sources would not only assist in the interpretation of the natural water quality functioning of the swamp, but would also provide a baseline for comparison of samples in the future. Streams that flow intermittently (Dry Branch, Griffin Creek) should not be neglected in synoptic sampling because they can convey contaminants at high flows.

A sufficient understanding of the biogeochemical status of the surface waters and groundwaters of the swamp is lacking. Developing a better understanding of biogeochemical cycling in the watersheds of the National Monument could contribute to an appreciation of the wetland and aquatic ecosystems, and provides a basis for anticipating and interpreting the consequences of water quality alteration due to inevitable changes outside the National Monument's boundaries. The study on hydrodynamics, outlined in Project Statement COSW-N-059, is a natural precursor to an effort that focuses on biogeochemical processes.

Evaluation of Water Quality Data Maintained in the EPA-STORET Database

Water quality in the Congaree River, Cedar Creek, and Toms Creek is monitored by SCDHEC at Primary or Secondary Water Quality Monitoring Stations. Two Primary Stations (sampled monthly on a year-round basis) are located on the Congaree River at Columbia, two Secondary Stations (sampled monthly from May-October) are located on Cedar Creek, and one Secondary Station is located on Toms Creek (Figure 17). Data from these water sampling efforts are maintained in the EPA-STORET database. Partial inventory summaries for these sampling stations are provided in Table 8. Only two sampling stations in the immediate vicinity of the National Monument have sufficient sample sizes to allow reasonable estimations of the status of water quality: Station C-069 (Cedar Creek at SC 66) and Station C-007 (Congaree River at US 601 Bridge). A limited number of samples have been obtained and parameters measured at the Cedar Creek station. Measurements were obtained for basic physical parameters (i.e,

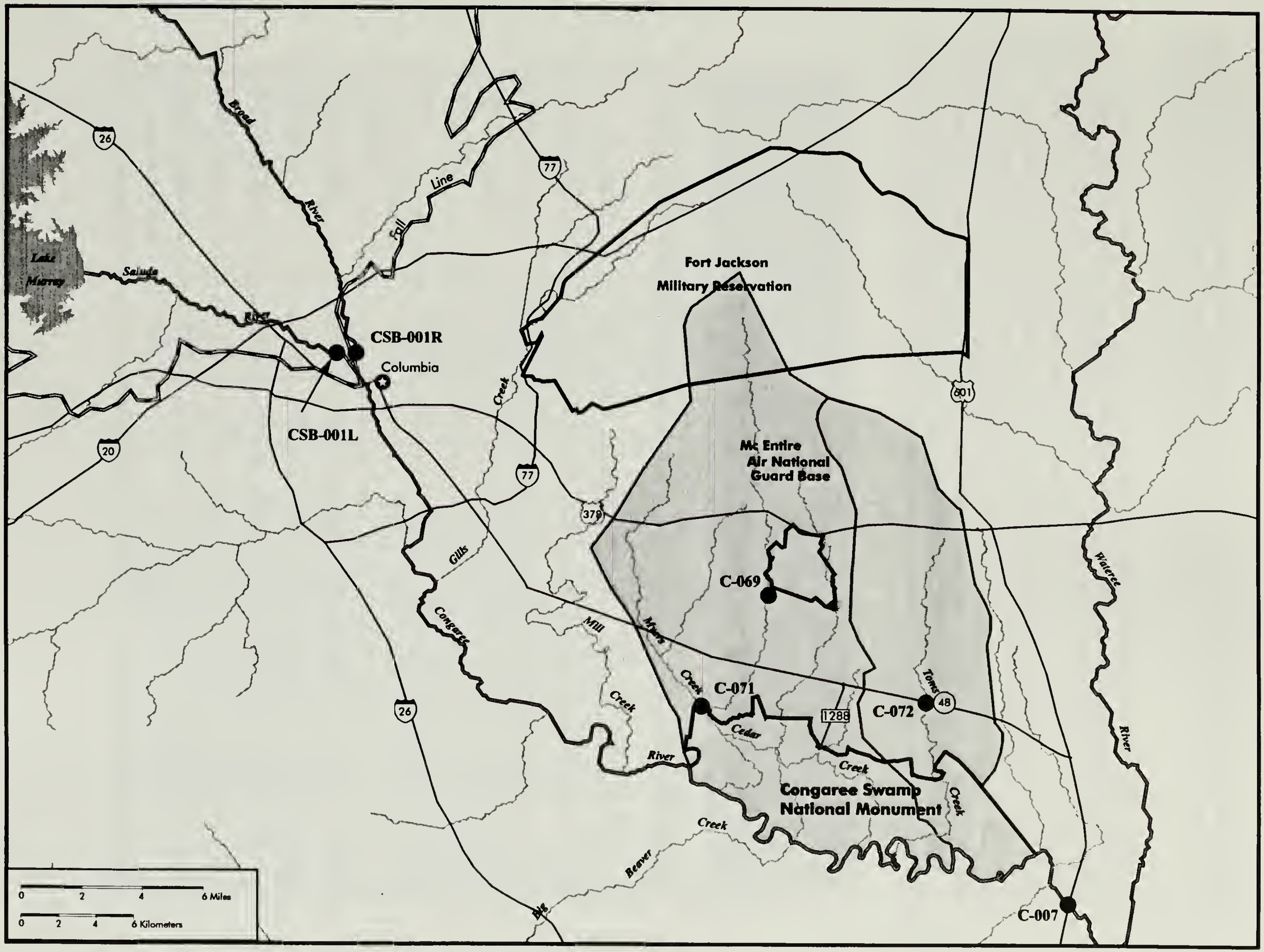


Figure 17. SCDHEC water quality sampling station locations.

temperature, turbidity, dissolved oxygen, biological oxygen demand, specific conductance, and pH), nutrient concentrations (ammonia/ammonium, nitrite/nitrate, total Kjeldahl nitrogen, and total phosphorus, organic carbon), and fecal coliform concentration.

Monthly samples (May-October only) taken from 1985-1995 at Station C-069 on Cedar Creek indicated that median values for the basic physical and biological parameters for Station C-069 and listed in Table 8 were within standards established by SCDHEC for "Freshwaters" (Reg. 61-68, South Carolina Water Pollution Control Act, 48-1-10, et seq, S.C. Code of Laws, 1976). However, maximum values for fecal coliform concentration were reported in excess of standards during this period. The minimum value for pH was below "Freshwaters" standards during the period but this is not uncharacteristic for low order streams in this region. Similarly, monthly samples (year-round) taken from 1985-1995 at Station C-007 on the Congaree River were within "Freshwaters" standards for basic physical and biological parameters, but fecal coliform and dissolved oxygen concentrations that were not within standards have been reported.

Table 8. Selected water quality parameters measured monthly at six SCDHEC water quality monitoring stations on the Congaree River and its tributaries in the National Monument. Summary data are provided for a period of record 1985-1995 except where noted. Arithmetic means are reported for all parameters except fecal coliform which is a geometric mean (GM) value.

Congaree River at Columbia (CSB-001L) (Saluda River side) 1985-1995 (12 mos.)

Parameter	STORET No.	n	Median	Mean	Std. dev.	Max.	Min.
Temperature °C	00010	121	16.5	16.3	5.6	30.5	6.5
Turbidity NTU	00076	123	7.0	9.3	6.9	40.0	1.8
Dissolved O_2 mg/L	00300	121	9.0	9.1	1.5	13.2	5.9
BOD 5-day	00310	121	1.5	1.7	1.1	7.1	0.1
pH	00400	121	7.2	7.2	0.5	8.4	6.2
Specific conductance umhos/cm	00402	110	70.0	79.0	27.1	175.0	40.0
NH_3+NH_4 mg/L	00610	122	0.05	0.07	0.05	0.31	0.05
TKN mg/L	00625	123	0.44	0.50	0.28	2.0	0.1
NO_2+NO_3 mg/L	00630	123	0.32	0.32	0.13	0.95	0.04
Total P mg/L	00665	123	0.06	0.07	0.05	0.34	0.02
Total OC mg/L	00680	119	4.4	5.8	11.0	123.0	1.2
Fecal coliform/100ml	31616	121	94.0	96.4 (GM)	n/a	12000	8

Congaree River at Columbia (CSB-001R) (Broad River side) 1985-1995 (12 mos.)							
Parameter	STORET No.	n	Median	Mean	Std. dev.	Max.	Min.
Temperature °C	00010	118	16.5	16.9	6.6	32.5	5.5
Turbidity NTU	00076	123	10.0	16.5	17.3	110.0	1.0
Dissolved O_2 mg/L	00300	118	8.8	9.0	1.7	15.5	6.0
BOD 5-day	00310	122	1.5	1.8	1.3	7.7	0.4
pH	00400	118	7.2	7.2	0.4	8.8	6.2
Specific conductance umhos/cm	00402	109	80.0	84.0	28.0	250.0	40.0
NH_3-NH_4 mg/L	00610	123	0.05	0.07	0.07	0.68	0.05
TKN mg/L	00625	123	0.42	0.48	0.30	2.43	0.10
NO_2+NO_3 mg/L	00630	124	0.32	0.32	0.11	1.09	0.07
Total P mg/L	00665	124	0.05	0.07	0.05	0.30	0.02
Total OC mg/L	00680	120	4.2	4.8	2.8	19.0	1.0
Fecal coliform/100ml	31616	119	110	119 (GM)	n/a	8000	9

Congaree River at U.S. 601 Bridge (C-007) 1985-1995 (12 mos.)							
Parameter	STORET No.	n	Median	Mean	Std. dev.	Max.	Min.
Temperature °C	00010	126	17.0	17.6	6.8	30.0	5.0
Turbidity NTU	00076	119	12.0	16.0	13.2	80.0	1.5
Dissolved O_2 mg/L	00300	126	8.1	8.3	1.7	13.2	2.9
BOD 5-day	00310	120	0.9	1.0	0.6	5.9	0.1
pH	00400	126	6.8	6.8	0.4	8.5	6.0
Specific conductance umhos/cm	00402	120	80.0	76.8	18.0	155.0	5.00
NH_3-NH_4 mg/L	00610	121	0.05	0.07	0.05	0.44	0.05
TKN mg/L	00625	120	0.36	0.38	0.18	1.87	0.10
NO_2+NO_3 mg/L	00630	121	0.35	0.78	4.70	52.00	0.03
Total P mg/L	00665	122	0.08	0.09	0.03	0.20	0.02
Total OC mg/L	00680	114	4.0	4.3	2.0	10.0	1.0
Fecal coliform /100ml	31616	110	67	71 (GM)	n/a	1700	4

Cedar Creek at S-40-66 (C-069) May-October 1985-1995							
Parameter	STORET No.	n	Median	Mean	Std. dev.	Max.	Min.
Temperature °C	00010	59	21.0	20.8	3.0	28.0	13.0
Turbidity NTU	00076	59	4.6	5.0	3.7	24.0	1.0
Dissolved O_2 mg/L	00300	59	7.7	7.7	0.8	9.6	5.2
BOD 5-day	00310	60	1.2	1.3	0.6	3.0	0.1
pH	00400	59	5.7	5.9	0.7	7.8	4.7
Specific conductance umhos/cm	00402	n/a	n/a	n/a	n/a	n/a	n/a
NH_3-NH_4 mg/L	00610	2	0.05	0.05	0.01	0.06	0.05
TKN mg/L	00625	2	0.29	0.29	0.14	0.39	0.19
NO_2+NO_3 mg/L	00630	59	0.32	0.31	0.10	0.67	0.02
Total P mg/L	00665	61	0.04	0.04	0.01	0.08	0.02
Total OC mg/L	00680	n/a	n/a	n/a	n/a	n/a	n/a
Fecal coliform /100ml	31616	59	140	160 (GM)	n/a	3500	20

Cedar Creek at SC-40 (C-071) May-October 1992							
Parameter	STORET No.	n	Median	Mean	Std. dev.	Max.	Min.
Temperature °C	00010	6	23.0	22.7	4.2	28.0	17.5
Turbidity NTU	00076	6	4.0	4.4	2.4	8.3	2.0
Dissolved O_2 mg/L	00300	6	7.5	7.8	1.1	9.5	6.3
BOD 5-day	00310	6	1.5	1.5	0.8	2.9	0.7
pH	00400	6	5.9	6.0	0.5	6.9	5.6
Specific conductance umhos/cm	00402	n/a	n/a	n/a	n/a	n/a	n/a
NH_3-NH_4 mg/L	00610	6	0.05	0.05	<.01	0.05	0.05
TKN mg/L	00625	6	0.32	0.4	0.34	1.06	0.11
NO_2+NO_3 mg/L	00630	6	0.03	0.05	0.04	0.13	0.02
Total P mg/L	00665	6	0.03	0.03	0.02	0.06	0.02
Total OC mg/L	00680	2	5.3	5.3	0.3	5.6	5.1
Fecal coliform /100ml	31616	6	24	31	n/a	120	14

Toms Creek at SC-48 (C-072) May-October 1992							
Parameter	STORET No.	n	Median	Mean	Std. dev.	Max.	Min.
Temperature °C	00010	6	22.2	20.7	3.7	24.0	14.0
Turbidity NTU	00076	6	4.8	5.1	3.1	11.0	2.5
Dissolved O_2 mg/L	00300	6	7.4	7.5	0.6	8.4	6.8
BOD 5-day	00310	6	1.0	1.1	0.4	1.7	0.6
pH	00400	6	5.9	5.9	0.1	6.1	5.7
Specific conductance umhos/cm	00402	n/a	n/a	n/a	n/a	n/a	n/a
NH_3-NH_4 mg/L	00610	5	0.05	0.05	<.01	0.05	0.05
TKN mg/L	00625	6	0.34	0.37	0.18	0.62	0.10
NO_2+NO_3 mg/L	00630	6	0.28	0.28	0.09	0.37	0.15
Total P mg/L	00665	6	0.03	0.03	0.01	0.05	0.02
Total OC mg/L	00680	2	4.9	4.9	1.4	5.9	3.9
Fecal coliform /100ml	31616	6	245	223 (GM)	n/a	490	100

The STORET database also contains an array of organic and inorganic chemical concentrations and heavy metal concentration measured in samples obtained at SCDHEC water quality monitoring stations. Analysis of these contaminants is complicated by the frequency of sampling, ambient water conditions, and contaminant detection limitations. Currently, SCDHEC sampling at the Congaree River sites (C-007, CSB-001L, CSB-001R) and one site on Cedar Creek (C-069) is on a quarterly basis which is insufficient to determine if concentrations are within chronic toxicity criteria (Table 6b) (SCDHEC 1995c). Heavy metal toxicity is dependent, in part, on water hardness. Formulas have been developed by USEPA to ascertain heavy metal toxicity levels; however, these formulas are not valid for waters with hardness values of less than 50 mg/L. South Carolina waters are typically less, approximating 20 mg/L statewide (SCDHEC 1995c). Lastly, several important heavy metals (i.e., cadmium, copper, lead, and mercury) cannot be adequately measured at SCDHEC sampling stations because the analytical methods used are not sufficient to detect either acute or chronic concentrations (D. Chestnut, SCDHEC, Water Quality Monitoring Section, draft WRMP review comments, March 1995).

An in-depth analysis of STORET water quality data is beyond the scope of the Water Resources Management Plan; however, the NPS's Inventory and Monitoring Program, in conjunction with the NPS Water Resources Division and the Horizon Systems Corporation, is currently compiling and interpreting STORET water quality data for 250 units of the National Park system, including the Congaree Swamp National Monument. The report for the Congaree Swamp National Monument will provide a comprehensive analysis of an array of physical and chemical water quality conditions, including heavy metal (the toxicity of which is problematic to ascertain and is dependent upon water hardness) and pesticide concentrations, taken at

SCDHEC water quality monitoring stations on the Congaree River, Cedar Creek, and Toms Creek. The Congaree Swamp National Monument report is scheduled for completion in 1996 (B. Long, NPS Water Resources Division, Ft. Collins, CO, personal communication, 1996).

Evaluation of Water Quality Data Prepared by SCDHEC for WWQMS Reporting

The SCDHEC, Bureau of Water Pollution Control, Watershed Water Quality Strategy: Saluda-Edisto Basin (WWQMS) program published the results of a watershed water quality study based on data obtained in part from SCDHEC primary and secondary water quality monitoring stations in the Congaree River basin (Watershed Management Unit 0202) (SCDHEC 1995c). A summary of water quality data obtained for the Congaree River at SCDHEC monitoring sites CSB-001L and CSB-001R in Columbia, and C-007E and C-007H at the US 601 bridge downstream from the National Monument was provided in the report. Waters at all stations were reported to be capable of fully supporting aquatic life and recreational uses; however, some water quality conditions or contaminants were found to be problematic on one or more occasions. At the Columbia sites, these problematic parameters included a declining trend in dissolved oxygen concentrations and excursions from "freshwaters" standards for fecal coliform bacteria concentrations, although a declining trend in bacteria concentrations indicate improving conditions. The US 601 bridge sites also reported excursions of fecal coliform concentration beyond "freshwaters" standards. In sediment and surface water samples obtained between 1988 and 1992, several toxic organic chemicals were reported in samples taken from either of the Columbia sites. Most were found in single samples and only once during the sampling period: these toxins included: di-n-butylphthalate (1990 sediment); toluene (1988 water); chlordane (1988 sediment); several polycyclic aromatic hydrocarbons (PAHs); and, PCB 1254 (1990, 1992 sediment). A high concentration of zinc was found in a 1988 sediment sample from a Columbia station.

The WWQMS summary data for Cedar Creek was based on samples obtained from SCDHEC monitoring stations C-069 and C-71 (SCDHEC 1995c). Waters at both stations were fully capable of supporting aquatic life. Recreational uses were fully supported at the downstream site (C-071) but could be only partially supported at the upstream site (C-069) because of increased turbidity and excursions of fecal coliform bacteria from water quality standards. Surface water pH experienced excursions below "freshwaters" standards at both stations, but this was probably a consequence of the natural acidity of these swamp-influenced waters rather than anthropogenic contaminants (SCDHEC 1995c). Waters at the Toms Creek station (C-072) fully support aquatic life and recreational uses, even though fecal coliform concentrations experienced excursions beyond standards. As with Cedar Creek, pH was below standards in some samples.

Water Quality Contaminant Risks

Contamination of surface waters and groundwater entering the National Monument may originate from nonpoint sources and point sources. Nonpoint sources of contamination usually associated with land use practices are discussed in the Land Use and Watershed Development section of this document. Point sources of contamination are more easily identified, monitored, and regulated. Consequently, state and federal programs monitor most of the known sites of point source contamination within the Congaree River watershed. The contaminant pathways discussed in this document are water-borne contaminant pathways. One pathway that is not discussed is the atmospheric pathway, which may be significant for mercury contamination.

Industrial and Municipal Wastewater Discharges

Wastewater dischargers to the Congaree River and its tributaries are required to obtain effluent discharge permits through the National Pollutant Discharge Elimination System (NPDES). SCDHEC has been delegated authority to administer this program with federal EPA oversight. The program establishes physical and chemical standards for effluent and monitors effluent discharge into waterways. Effluent standards are monitored by SCDHEC through: (1) NPDES Self-Monitoring (data recorded by dischargers and reported in Discharge Monitoring Reports (DMRs)); (2) Compliance Evaluation Inspections (CEI) (a records review and visual inspection of permittee's facilities, effluent, and receiving waters); (3) Compliance Sampling Inspections (CSIs) (inspection of a facility's operations through sampling of effluent and review of the self monitoring program); (4) Operation and Maintenance Inspections (visual inspection of wastewater treatment facilities and limited physical and chemical tests of effluent; (5) Performance Audit Inspections (PAI); (6) Diagnostic Evaluations (DE); and, (7) Pretreatment Program Audit/Inspection.

Within the SCDHEC watershed unit #03050110, which includes portions of Lexington, Richland, and Calhoun counties (including Columbia and the National Monument), 63 NPDES permits have been issued (unpublished document from Glen Trofatter, SCDHEC, December 1994). The approximate location of key wastewater dischargers is provided in Figure 18. Selected wastewater dischargers to the Congaree River from this watershed unit are listed in Table 9. Wastewater discharges in the Cedar Creek watershed subunit (#03050110-050) are of special concern and are listed separately in Table 10. No NPDES permits have been issued in the Toms Creek watershed subunit (#03050110-060).

Wastewater Dischargers in the Vicinity of the National Monument

Numerous industries with the potential to adversely impact the waters of the Congaree River are located in Columbia. Three firms are of special concern due to their relatively close proximity to the National Monument and a recent history of toxic releases: Westinghouse Electric Corporation, Carolina Eastman Company, and Teepak Industries. Two of these firms, Carolina Eastman Division and Teepak Industries were included on a list of the top ten releasers of toxic materials in South Carolina for 1990 and 1991 (Chappell 1993a). Inclusion on the list is based on combined air and water releases.

The Nuclear Fuels Division of Westinghouse Electric Corporation is located approximately 4 miles (7 km) overland and northwest of the National Monument in Richland County. The plant was included on the August 1994, State Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Site Inventory (SCDHEC 1994b) and on the South Carolina Groundwater Contamination Inventory for 1995 (SCDHEC 1995d). A contaminant plume containing nitrate and volatile organic compounds (VOCs) was determined to be discharging into Sunset Lake, unnamed streams, and wetlands on or adjacent to plant property. These waters and wetlands connect to Mill Creek which flows into the Congaree River approximately 6.2 miles (10 km) from the plant and approximately 5 miles (8 km) upstream from the western-most boundary of the National Monument.

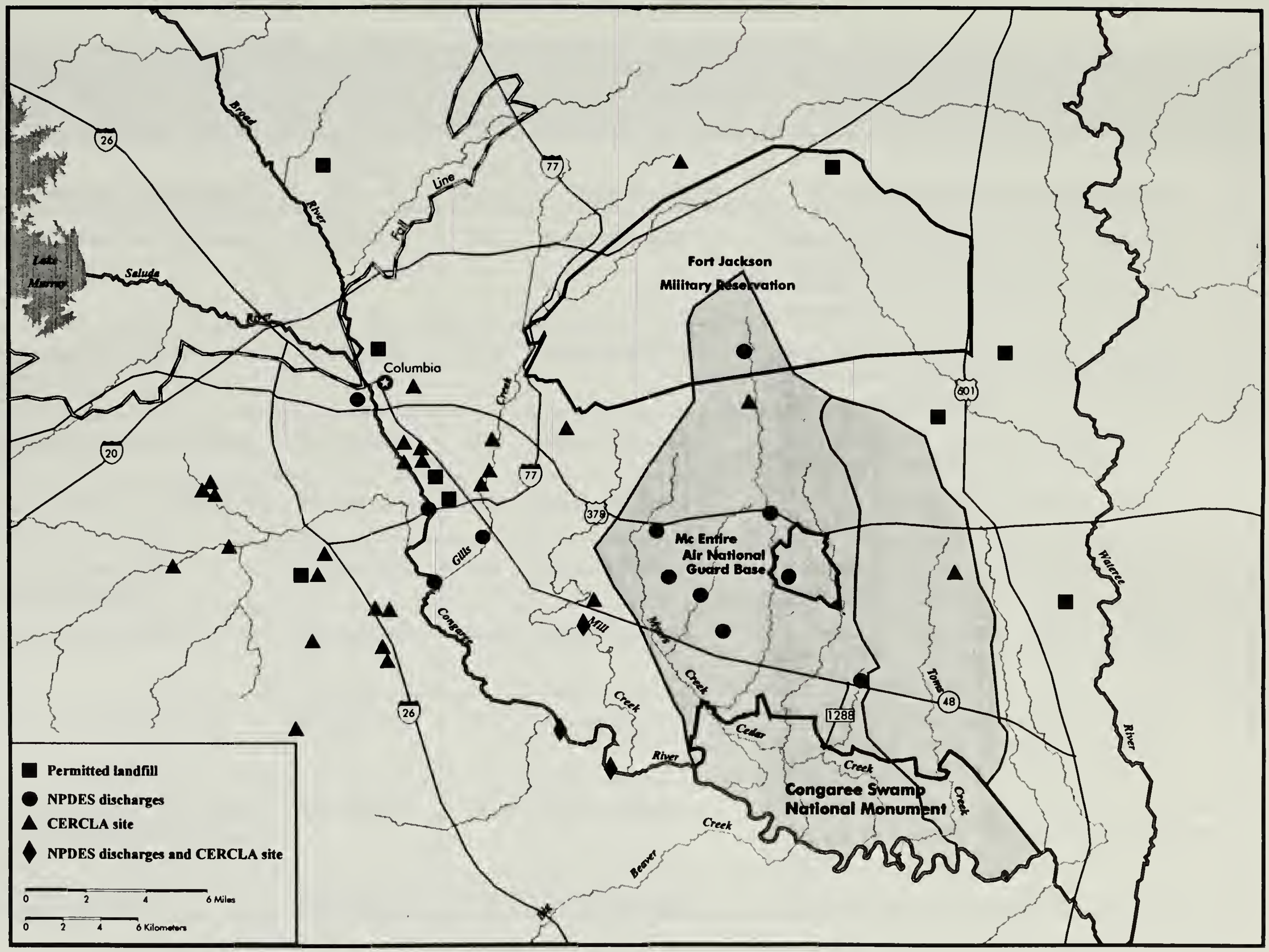


Figure 18. Point sources of pollution in relation to the Congaree Swamp National Monument as of December 1994.

Table 9. Selected NPDES permitees on the Congaree River in the vicinity of the Congaree Swamp National Monument (Watersheds 03050110-010 and -020) (SCDHEC-Bureau of Water Pollution Control NPDES compliance database 1994 and G. Trofatter, SCDHEC, WRMP draft review comments, March 1996).

Wastewater Discharger	NPDES Permit	Flow (MGD)	Type of Facility	Water Quality Parameters of Concern
Carolina Eastman Company	SC0001333	75.0	Major Industrial	Suspended solids, grease and oil, pH, flow, temperature, BOD, DO, ammonia, fluoride, fecal coliform, TRC, acute toxicity, (annually: toxic organics)
Westinghouse Electric Corporation	SC0001848	0.13	Major Industrial	Suspended solids, grease and oil, pH, flow, temperature, BOD, DO, ammonia, fluoride, fecal coliform, acute toxicity
Teepak, Inc./Coria Division	SC0033367	N/A	Minor Industrial	Flow, BOD, DO, TSS, TRC, nitrate-N, aluminum, ammonia, fecal coliform
City of West Columbia/Water Plant	SCG641005	N/A	Minor Industrial	pH, TSS, total phosphate, total aluminum, flow, TRC
City of Cayce/Water Treatment Plant	SC0046825	N/A	Minor Industrial	Suspended solids, residual chlorine, pH, flow, aluminum, phosphate
City of Columbia/Metro Plant	SC0020940	40.00	Major Municipal	Suspended solids, fecal coliform, cadmium, copper, lead, zinc, acute toxicity, flow, BOD, DO, TSS, ammonia, pH
City of Cayce/Main Plant	SC0024147	8.00	Major Municipal	Residual chlorine, fecal coliform, cadmium, copper, lead, acute toxicity, flow, BOD, DO, TSS, ammonia, pH
East Richland County Public Service District/Gills Creek Plant	SC0038865	10.50	Major Municipal	Fecal coliform, flow, BOD, DO, TSS, ammonia, TRC, pH, cadmium, copper, zinc, lead, acute toxicity
Columbia Airport	SC0044342	N/A	Minor Industrial	Oil and grease, TOC, BOD, pH

Table 10. NPDES permitees on Cedar Creek (Watershed 03050110-050) (SCDHEC-Bureau of Water Pollution Control NPDES compliance database, 1994 and G. Trofatter, SCDHEC, draft comments, March 1996).

Wastewater Discharger	NPDES Permit	Flow (MGD)	Type of Facility	Water Quality Parameters of Concern
South Carolina Air National Guard/ McEntire Base	SC0000701	0.02	Minor Industrial	Flow, oil and grease, suspended solids, BOD, DO, TRC, pH, fecal coliform
U.S. Army/ Ft. Jackson	SC0003786	0.05	Minor Industrial	n/a
Square-D Company	SC0004286	#1-0.007 #2-0.02 #3-0.004	Major Industrial	For #1: suspended solids, pH, flow, BOD, DO, TSS, toluene, nickel, copper, silver, ammonia, oil and grease, cadmium, chromium, lead, acute toxicity; for #2: suspended solids, pH, flow, TRC, fecal coliform, TSS, BOD; for #3: suspended solids, pH, temperature, flow, BOD, TSS
Cedar Creek Mobile Home Park	SC0032018	0.1575	Minor Community	Suspended solids, BOD, DO, flow, fecal coliform, TRC, pH
Piney Grove Utilities/Franklin Park Subdivision	SC0031399	0.04	Minor Community	Suspended solids, BOD, DO, flow, fecal coliform, TRC, pH
Richland County School District #1/ Gadsden Elementary School	SC0031526	0.01	Minor Community	Suspended solids, BOD, DO, flow, ammonia, fecal coliform, TRC, DO, pH, (annually: cadmium, copper, lead, zinc)
Richland County School District #1/Hopkins Junior High School	SC0031500	0.03	Minor Community	Suspended solids, BOD, DO, flow, ammonia, fecal coliform, TRC, pH
Richland County School District #1/Hopkins Elementary School	SC0031496	0.012	Minor Community	Suspended solids, BOD, flow, ammonia, fecal coliform, TRC, pH

Teepak Industries manufactures edible meat casings and is located in Calhoun County. The plant was listed on the 1993 Groundwater Contamination Inventory (SCDHEC 1993). The major water contaminant is nitrate which was discharged to the Congaree River and groundwater from an on-site wastewater treatment facility located approximately 3 miles (5 km) upstream from the National Monument. Recent upgrades to the plant and wastewater treatment facility should reduce the amount of nitrate discharged (Chappell 1993b).

Carolina Eastman Division, Eastman Chemical Company, is located adjacent to the Congaree River approximately 11 miles (17.5 km) upstream from the National Monument, in Calhoun County. Carolina Eastman produces plastic resin used for the manufacture of plastic packaging. The plant was listed on the 1994 State CERCLA Site Inventory (SCDHEC 1994b) and the 1993 Groundwater Contamination Inventory (SCDHEC 1993). Most of the toxic releases were air emissions. However, nitrate discharges into groundwater and surface water occurred from spray irrigation and from pits, ponds, or lagoons. A wastewater plume discharges into the Congaree River; the firm has applied for a permit to allow for a wastewater mixing zone specific to groundwater contained on-site. The mixing zone allows discharged wastewater to disperse until uniform concentrations are achieved and subsequent discharge to surface waters does not contravene SCDHEC water quality standards. Waste reduction and recovery technologies have been implemented to reduce emissions and discharges.

The Columbia Metro municipal wastewater treatment facility is located on the Congaree River approximately 12.5 miles (20 km) upstream from the southwest boundary of the National Monument. A 48"-diameter pipe discharges treated wastewater into the river near I-77. The facility is operated by the City of Columbia. Columbia Metro is an activated sludge-type facility currently permitted to discharge 40 mgd. Eventually, the facility may be upgraded to 100 mgd, as development within the Columbia area necessitates. In 1991 and 1992, the facility received a rating of "good" (highest rating) in an independent assessment of environmental records of South Carolina industrial and municipal facilities (Chappell 1993b). Infrequent effluent violations for Total Suspended Solids (TSS) have been reported, primarily during heavy rainfall events while the plant was undergoing construction or maintenance (Chappell 1993b). The July 1995 upgrade should alleviate these problems. In 1989, excessive rainfall and flooding due to Hurricane Hugo resulted in discharge of untreated wastewater into the river (D. Fincher, Columbia Metro, personal communication, June 1995).

Southland Fisheries, Inc. is an aquaculture operation adjacent to Cedar Creek. The operation has 35 separate ponds in the vicinity of the Old Bluff Road (County Road 734) crossing of Cedar Creek. The total ponded area is approximately 80 acres. Cedar Creek and groundwater wells are the water sources for the ponds. Fingerling freshwater gamefish species, mainly *Lepomis macrochirus* (bluegill), *L. microlophus* (red-ear sunfish), and *Micropterus salmoides* (largemouth bass) are reared for fish stocking projects. Although many thousands of fish are produced, the total annual harvest of these fingerlings is only 10,000 to 15,000 lbs. Since annual fish production at the operation is less than 100,000 lbs., wastewater may be discharged to Cedar Creek without an NPDES permit. Fingerling production generates relatively little wastewater compared to aquaculture facilities that produce fish for human consumption. Ponds are maintained with 2-3 ft of freeboard, and thus are decoupled from Cedar Creek except during overflow events. The hydrological and ecological implications of surface water and groundwater withdrawals to maintain water levels in 80 acres of ponded surface are not known.

Aquaculture operations are subject to regulation by the Richland County Zoning Board. To operate "concentrated agricultural livestock enterprises," which includes aquaculture operations, proposed projects must be reviewed by the Richland County Zoning Board of Adjustment and operators must provide public notice (6-1.4 Richland County Zoning Codes, amendment 93-016TA). Since Southland Fisheries, Inc. began operation in 1981 (prior to the adoption of this amendment), the existing operation and future expansions have been given a "Special Exemption" status. Thus, they are not subject to review by the Board of Adjustment, provided that the facility complies with related SCDHEC regulations.

Road Runoff and Inadvertent Hazardous Waste Spills

De-icing of roads and bridges with salt may cause abnormally high salinities in freshwater streams, thus adversely affecting local aquatic biota. This is especially problematic in regions with severe winter weather that necessitates de-icing procedures. It occurs infrequently in Richland County (R. Wertz, S.C. Department of Transportation, personal communication, December 1994). The application of salt to roads and bridges is required only once or twice each winter. When applied, a 3:1 salt to sand ratio is used at a rate of 333 lbs. per 2-lane mile.

There are seven bridge or culvert locations on roads immediately north of the National Monument boundary that may require periodic de-icing. If the salt/sand mixture is applied at the standard rate, approximately 6 lbs. of the mixture would be applied to each bridge. However, spot application of the mixture on bridges is probably heavier.

Accidental leakage or spillage of hazardous materials outside of the National Monument boundaries presents a potential risk to the waters and ecosystem of the National Monument and to the safety of visitors and NPS staff. The risk is derived from accidents involving commercial trucking on Bluff Road (SC 48) north of the National Monument and railroad freight lines at the eastern perimeter. The greatest potential risk is at locations where bridges cross streams that flow into the National Monument. Spillage of hazardous materials into the Congaree River upstream from the National Monument would presumably be diluted prior to reaching the National Monument. Further, surface water from the Congaree River would be isolated from the National Monument except during floods. The nearest railroad crossing upstream on the Congaree River is near Cayce/Columbia.

Response to hazardous material spills is through the Hazardous Materials Division, Richland County Fire Marshall Office, and SCDHEC. The initial respondents to a reported spill in the vicinity of the National Monument would be the Gadsden or Eastover Volunteer Fire Stations. Fire fighters have been trained and provided with equipment to initiate spill containment actions. The costs of spill cleanup and remediation will be borne by the party responsible for the spill, if identified. Otherwise, state and federal funds may be provided through the Comprehensive Environmental Response Compensation and Liability Act (CERCLA). Should damage to natural resources within the National Monument occur, compensation may be sought by the National Park Service through Natural Resources Damage Assessment procedures. To date, there has not been a major spill posing an immediate threat to the National Monument.

Groundwater Contamination from CERCLA Sites

The Bureau of Solid and Hazardous Waste Management of SCDHEC administers the assessment and remediation of toxic and hazardous waste sites that have resulted from uncontrolled land disposal of waste material (SCDHEC Superfund Fact Sheet #017033, May

1992). As mandated by state law, voluntary cleanup is required by the parties or firms responsible for the waste site, thus reducing state expenses (South Carolina Hazardous Waste Management Act, Title 44, Chapter 56, SC Code of Laws, 1976) as amended). However, the responsible parties may not be identifiable or they may be unable to pay the cost of site assessment and remediation. In such circumstances, state and/or federal funds may be appropriated. Funds for site assessment and remediation are provided, in part, through the State Hazardous Waste Contingency Fund of the S.C. Hazardous Waste Management Act (State CERCLA or "Superfund") (SC Code of Laws, Title 44, Section 44-56-160) which is financed by disposal fees at the GSX, Inc. hazardous and non-hazardous waste facility at Pinewood, South Carolina. Matching federal funds may be provided to the state program through the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) (42 U.S.C. 9601). Federal funds may be provided for sites that have qualified through the federal Hazardous Ranking System and have been included on the National Priority List (NPL).

In August 1994, there were 514 State CERCLA sites listed on the South Carolina CERCLA Site Inventory (SCDHEC 1994b). Twenty-nine State CERCLA sites are located within tributary watersheds of the Congaree River in Richland, Lexington, and Calhoun Counties (Figure 18 and Table 11). Most are located in the immediate vicinity of Columbia and present little direct threat to the National Monument (G. Stewart, SCDHEC-Bureau of Solid and Hazardous Wastes, personal communication, February 1995). Statewide, there are approximately 25 contamination sites included on the EPA-National Priority List (NPL). Six of the EPA-NPL sites are located in the vicinity of Columbia and are within drainages to the Congaree River (Table 11).

The site with the greatest potential threat to the National Monument is an EPA-NPL site located on the north side of Bluff Road (opposite the main entrance to the Westinghouse facility) approximately 4 miles from the northwest boundary of the National Monument. This site is an abandoned chemical and petroleum recycling and disposal facility formerly operated by South Carolina Recycling and Disposal, Inc. (SCR&D). A groundwater contaminant plume has been identified between the disposal site and Myers Creek approximately 1,000 ft downslope. Myers Creek adjoins Cedar Creek near the northwest boundary of the National Monument. From the late 1970s to 1982, an assortment of containerized toxic and hazardous materials were stored or disposed of above-ground on the site. Soil and groundwater contamination were discovered and the containers were removed. However, the contaminated soil and water remained. Subsequent site assessment revealed soil contamination by a variety of volatile organic compounds including chlorinated solvents, chiefly dichloroethane (B. Britton, SCDHEC Bureau of Solid and Hazardous Waste, personal communication, October 1995). A two-component site remediation plan was developed. The first component was soil remediation at the contamination site (<0.5 acre) by installing a soil vapor extractor and carbon absorption system to treat contaminant vapors removed from 5-6 extraction wells. Soil remediation began in 1995. The second component of site remediation is being developed to treat contaminated groundwater in a contaminant plume that has migrated off-site, towards Myers Creek, at approximately 100 feet per year. Depending on adjacent landowner cooperation, the groundwater cleanup component is tentatively scheduled for implementation in 1996. No EPA-NPL sites or South Carolina CERCLA sites are located within the Toms Creek watershed.

Table 11. SCDHEC and NPL CERCLA sites in the vicinity of the Congaree Swamp National Monument and Columbia (SCDHEC 1995b). US-EPA National Priority List (NPL) sites are denoted with an asterisk.

CERCLA Site Name	SCDHEC-CERCLA Site Number	Contaminant Source[1]	Monitoring Agency[2]	Principal Contaminant[3]	Status[4]
Anchor Continental, Inc.	SCD003344843	UKN	WPC	VOC	Monitoring and assessment
Cardinal Chemical, Co.	SCD003339447	S/L	WPC	VOC	Assessment; CERCLA inspection in progress; possible discharge to Gills Creek
Carolina Chemicals, Inc.	SCD003339991	LF	SHW	P/H	Assessment
Carolina Eastman Co.	SCD069326007	SI, PPL	WPC	NO_3, Other	Monitoring
Columbia Metropolitan Airport	SCD073707168	S/L	SHW	P/H	Remediation and monitoring
Columbia Organic Chemical Co.	SCD003343571	UPD	SHW	VOC, BNA	Monitoring
*Homelite Textron (Townsend Sawchain)	NA	PPL	SHW	SHW	Remedial action in progress; discharge into tributary; US-EPA NPL site
*Lexington County Landfill	SCAD	LF	SHW	VOC, Metals	Monitoring
Lindau Chemical	SCAD	S/L	WPC	VOC	Assessment
*Palmetto Wood Preserving, Inc.	SCAD	UPD, S/L	SHW	Cu, Cr, As	Assessment; remediation design; US-EPA NPL site
*Palmetto Recycling	NA	S/L	NA	Metals	Remedial action
*S.C. Recycling and Disposal (Bluff Road Site)	SCD000622787	S/L	SHW	VOC	Assessment and remediation; US-EPA NPL site
*S.C. Recycling and Disposal (Dixiana)	SCD980711394	S/L	SHW	Metals, VOC	Remediation system being modified; US-EPA NPL site
U.S. Army Ft. Jackson	SC3210020449	UPD	SHW	VOC, Petro	Assessment; RCRA site
Weeks Liquid Fertilizer	SCD987580933	S/L	SHW	VOC, P/H	Assessment
Westinghouse Electric	SCD047559331	S/L, SPL	WPC	NO_3, VOC	Assessment and monitoring; plume discharging to Sunset Lake, streams, wetlands

[1] S/L = Spills and leaks; PPL = Pits, ponds, and lagoons; UNK = Unknown; LF = Landfills; UPD = Unpermitted disposal; SPL = Single-event spills.

[2] SHW = SCDHEC, Division of Hydrology, Bureau of Solid and Hazardous Waste; WPC = SCDHEC, Division of Water Quality, Bureau of Water Pollution Control; NA = information is not available.

[3] Petro = Petroleum products; VOC = Volatile Organics; NO_3 = Nitrates; P/H = Pesticides and Herbicides; BNA = Base, Neutral, and Acid Extractables; NA = information is not available.

[4] Assessment status refers to site at which the vertical and horizontal extend of the contamination is being assessed; monitoring status refers to sites at which the contamination extend has been assess and is currently being monitored for biological degradation; and remediation status refers to sites at which active clean-up is underway (A. Collier, SCDHEC-Groundwater Protection Division, personal communication, July 1995).

Groundwater Contamination from Underground Storage Tanks

The South Carolina Groundwater Contaminant Inventory for 1993 lists 2,207 contaminant sites statewide (SCDHEC 1993). Of these, 813 or 37% are in counties partially or entirely within the Congaree River watershed. Leaking Underground Storage Tanks (USTs) were the sources of contamination in 547 (67%) of these sites. The main contaminant was identified as petroleum product, and was found at 80% of the sites; volatile organic compounds (VOCs) and metals were the main contaminants at 10% and 5% of the sites, respectively.

Within Richland County, 153 contaminant sites were listed for 1993 and 172 for 1994. In 1993, 112 (73%) of the sources of contamination were UST sites. The majority of these sites are in Columbia and adjacent areas. Two UST sites are in Eastover, South Carolina and may be on the border of the Toms Creek watershed, thus presenting the possibility of water contamination reaching the National Monument. Petroleum is the main contaminant at both of these sites.

Groundwater Contamination from Landfills

There are eleven permitted solid waste landfills in Richland County (Table 12). The majority of the solid waste disposed of in most of the landfills is generated in Richland County. Landfills operated by Container Corporation of Carolina, Chambers Development Corporation, and Carolina Grading, Inc. accept most of their solid waste from out-of-county sources. The Carolina Grading, Inc. and Union Camp landfills are located within 2 km of the headwaters of Toms Creek and Griffins Creek, respectively (Figure 18). Both landfills are in tributary watersheds of the Wateree River, presumably having a hydraulic gradient flowing away from the National Monument (Figure 3). The risk of landfill leachate contaminating groundwater entering the Cedar Creek or Toms Creek watersheds is probably minimal due to groundwater flow direction. In addition, the clay-dominated subsoils of the region, which tend to have a very low hydraulic conductivity, further limit the extent to which leachate may affect the National Monument. All other landfills, except for the Container Corporation of Carolina landfill, are located within the tributary watersheds of the Congaree River. Discharge of leachate from these landfills may contribute to the overall reduction of water quality in the Congaree River but will be isolated from the National Monument except during overbank flood events.

The Richland County Landfill and the Columbia Landfill are listed on the South Carolina CERCLA Site Inventory for August 1994 (SCDHEC 1993). The Chambers Development Corporation Landfill was included on the 1993 South Carolina Ground-water Contamination Inventory (SCDHEC 1993). The contamination was classified as volatile organic compounds (VOC). In 1993 the site was in an assessment phase. Another public landfill in Columbia was used prior to 1973 but is now closed. Additional information pertaining to abandoned landfills in Richland County is incomplete or unobtainable (S. Hall, Richland County, Dept. of Solid Waste, personal communication, February 1995).

There are two landfills in Lexington County which may discharge leachate into groundwater systems of the Congaree River or its tributaries (Table 12). Pesticide/herbicide dumping occurred at the Carolina Chemicals landfill between 1958 and 1962 (SCDHEC 1993). In 1993, the site was in an assessment phase. The Lexington County Landfill is listed on the US-EPA National Priority List. Multiple leachate plumes containing VOCs and metals have been documented. In 1993, a remedial investigation and feasibility study was in progress. No landfills in Calhoun County have been identified upstream of the National Monument.

Table 12. Permitted landfills of Richland County and portions of Lexington County, South Carolina.

Landfill	Major Waste Category	Approximate Annual Tonnage	Watershed
Richland County Public Landfill*	Residential and Commercial	167,119***	Broad River, Congaree River
Richland County Construction and Demolition Landfill	Construction and Demolition	58,346***	Broad River, Congaree River
Columbia Landfill*	Residential and Commercial	NA	Gill's Creek, Congaree River
Container Corporation of Carolina, Northeast Sanitary Landfill	Industrial and Commercial	154,008	Wateree River
Chambers Development Corporation, Screaming Eagle Road Landfill**	Commercial	115,000	Sloan Branch, Wateree River
Carolina Grading, Inc. Landfill	Inert Industrial Waste	21,562	Colonels Creek, Wateree River
Columbia Inert Landfill	Residential and Commercial	NA	Gill's Creek, Congaree River
Anchor Continental Landfill	Paper	7,300	Gill's Creek, Congaree River
Richtex Landfill	Mining and Industrial	100	Broad River, Congaree River
Union Camp Landfill	Wastewater and Industrial Sludge	276,000 yd^3	Wateree River
Ft. Jackson Landfill	Residential	Now Closed	Mill Creek, Congaree River
Carolina Chemicals* **	Industrial	NA	Six Mile Creek, Congaree River
Lexington County Landfills* **	Residential and Commercial	NA	Congaree Creek, Congaree River

* Listed on the South Carolina CERCLA Inventory (SCDHEC 1994b).
** Listed on the Ground-water Contamination Inventory (SCDHEC 1993).
*** For fiscal year 1994.

Within the National Monument's boundaries, five abandoned trash dumps have been identified (R. Clark, Congaree Swamp National Monument, memorandum, March 1996). Four sites contain household and farm trash and garbage probably placed at the site by local residents prior to the designation of the area as a National Monument. These sites include: (a) two dumps on the Georgia Pacific tract near Kingville, (b) the Garrick tract dump, and (c) the Dawson cabin dump. Additionally, Cedar Creek near Wise Lake has been used as a dump for fill material in an apparent attempt to partially dam the stream. Cinder blocks, bricks, and construction debris were used as fill material. The extent to which these dumps affect groundwater or surface water is unknown. All five sites are presently in an assessment phase to determine if they present a substantial and immediate risk to the National Monument's resources (R. Clark, Congaree Swamp National Monument, personal communication, April 1996).

WATER RELATED ASPECTS OF NATIONAL MONUMENT OPERATIONS AND MANAGEMENT

Park Operations, Visitor Use, and Safety

The ecological integrity of the National Monument may be compromised by human activities within the National Monument boundaries as well as beyond the boundaries. Internal threats to surface water and groundwater may arise from water withdrawal wells, septic tanks, and fuel tanks in the vicinity of the ranger/visitor contact station. Presently, the potential for adverse effects on water resources is probably minor and very localized. However, in the eventuality of increased visitor usage and the expansion of visitor facilities, these water resources issues may become more substantial.

To better respond to visitor inquires, provide for visitor safety, and facilitate operations, Clemson University hydrologists, John C. Hayes and Dale E. Linvill have been engaged by the NPS to prepare a decision support system for predicting floods in the National Monument. Their work began in the fall of 1994 and includes a determination of statistical relationships to predict lag time and flood elevations at specified gauges within the National Monument. This will allow National Monument personnel to make decisions about park utilization during potential flood events.

Well Water Withdrawals and Septic Systems

Currently, there is one water withdrawal well at the ranger/visitor contact station and one well at the "Dawson" cabin near County Road 1288. The cabin is used infrequently by researchers and NPS staff (R. Clark, Congaree Swamp National Monument, written communication, February 1995). The well at the contact station has a depth of approximately 25 ft (into the surficial aquifer) and has a discharge capacity of 720 gallons per day; the water is treated by a chlorination system. The well discharge at the cabin is minimal and the water is untreated. The National Monument's General Management Plan (NPS 1988) proposes an expansion of the visitor center and a new water well system; well specifications have not been detailed.

Due to the relatively low numbers of daily visitors and fewer overnight campers, water consumption is unlikely to exceed well production. Back-country campers may use surface waters for dish washing, bathing, and drinking (if properly treated). Back-country usage is light and campers are provided with information concerning appropriate water usage and camping etiquette.

Wastewater from the contact station is currently treated by a 1,000-gal septic tank with an associated drain field. The proposed new visitor center will include an expanded septic system capable of serving an expected increased number of visitors in excess of the current 70,000 visitors per year. There are no backcountry toilet facilities in the National Monument. Proposed improved parking sites at key access points to the National Monument may include toilet facilities. The Dawson cabin has a septic tank but specifications are unknown. No apparent groundwater contamination has occurred from any of the septic systems within the National Monument.

Solid Waste Management

A solid waste reduction and recycling program is in place at the National Monument (Integrated Solid Waste Alternative Program, Congaree Swamp National Monument, internal document, 19 October 1994). Reusable, recyclable, or biodegradable containers are used whenever feasible at the ranger/visitor contact station. Recyclable glass, aluminum, plastic, paper, lumber, oil, and batteries are collected and recycled. All non-recyclable and non-hazardous waste generated at the National Monument is collected through a licensed commercial contractor. Occasionally, solid waste is illegally dumped by the public along roads adjacent to the National Monument. These sites are promptly cleaned up by National Monument staff. There are five small abandoned dump sites within the National Monument (discussed earlier in the Water Quality Contaminants Risks section). These contain household and farm trash including bottles, glass, tires, and used appliances.

Hazardous Materials Management

A chemical spill (oil and hazardous materials) response plan has been developed for the National Monument as described in NPS Memorandum A7615 (SER-OR) from the Acting Regional Director, Operations, Southeast Region on 12 August 1994. This plan requires the immediate notification of appropriate NPS personnel at the NPS Washington Office, the Southeast Field Area Office, the US Coast Guard National Response Center, and SCDHEC. A NPS On Scene Coordinator will be dispatched to the spill site to ensure that proper clean-up and human safety procedures are followed.

There are no known underground storage tanks (USTs) within the National Monument. All fuel tanks used for the operation of the National Monument are above-ground, EPA-approved storage tanks (R. Clark, Congaree Swamp National Monument, personal communication, February 1995). A 1,000-gal fuel tank is confined within a concrete basin and, a 250-gal waste oil tank is confined within a high-grade impermeable plastic containment basin; both are located in a maintenance compound. Spills have occurred, but were very minor and infrequent, consisting primarily of coolant, oil, or fuel leakage during vehicle maintenance and within the maintenance area.

Flood Prediction, Flood Alert, and Contingency Planning

In 1994, visitation at the National Monument was 67,756. The 5-year and 10-year projected increase in visitation will result in approximately 123,500 visitors in 1999 and 179,100 in 2004 (R. Clark, Congaree Swamp National Monument, personal communication, April 1995). With these expected increases, visitor safety becomes more crucial. The development of flood prediction capabilities is imperative to control visitor access to the National Monument trail system during flood events and to ensure the safety of back country visitors (Project Statement COSW-N-003.001).

Most of the National Monument is part of the floodplain of the Congaree River. The site is located where the floodplain broadens as the river flows from the Piedmont to the Coastal Plain. Long-term records (since 1939) of stage height and discharge at Columbia, South Carolina, provide an adequate data set upon which to predict discharge from precipitation events in the Piedmont. The gauging station at Columbia provides a site for continuous monitoring of stage height, and is located sufficiently far upstream that a lag time of approximately 1 day is required for a flood peak to travel from the gauging station in Columbia to the western boundary of the National Monument. Not predictable at this time is the rate at which flood waters would rise at different locations in the floodplain (e.g., riverbank environments, deep oxbow sloughs, floodplain interior), the duration of a given flood event, and the flooding status of major trails and visitation sites during such flood events. These matters are currently being addressed by Hayes and Linvill in the 5-year flood prediction study which began in 1994.

Saluda Dam Failure Alert and Contingency Planning

Historically, floods along the Congaree River have resulted in catastrophic loss of life and property. Since the construction of the Saluda Dam on the Saluda River in 1930 for hydroelectric power generation, flood peaks due to rainfall events have been dampened (Patterson et al. 1985). However, the presence of the Saluda Dam at Lake Murray presented another safety threat, the possibility of severe flooding from dam failure. It is imperative for the safety of NPS personnel, researchers, and backcountry visitors to the National Monument that an emergency warning and evacuation system be implemented (K. Massey, SCE&G, draft review comments, February 1996).

The owner and operator of the dam, South Carolina Electric and Gas (SCE&G), a subsidiary of SCANA Corporation, filed a required revision to the Saluda Hydroelectric Project Emergency Action Plan (EAP) with the Federal Energy Regulatory Commission (FERC) in 1993 (SCE&G 1993). The EAP is on file at the National Monument. SCE&G was notified by FERC in 1994 that the previous dam failure analysis needed to be revised, in part because the analysis and inundation maps did not extend far enough downstream to include the National Monument (K. Massey, SCE&G, draft review comments, February 1996). The 1993 EAP included a flood prediction time table no further downstream than a site 6 miles upstream from the National Monument (Table 13). A revised dam failure analysis was submitted to FERC in August of 1994, including flood prediction for the Congaree River at the National Monument. This revision is currently under review by FERC. (As of May 1996, the 1994 EAP was still in the process of being reviewed by FERC. Therefore, an updated flood prediction time table that was inclusive of the National Monument was not available for publication in the WRMP.) Revisions and periodic updates of the emergency action plan are routinely forwarded to the National Monument. Upon approval by FERC, management intends to use the newly calculated flood travel times to revise and update evacuation procedures identified in the 1994 Emergency Action Plan for the National Monument.

The effect of catastrophic dam failure on the National Monument could be severe. The Saluda Dam is an earthen dam. Earthen dams tend to fail gradually due to erosion of the material composing the dams, rather than sudden or abrupt collapse. If a seepage or movement problem becomes apparent, a Class II emergency warning ("potentially hazardous situation is developing") will be issued to state and county emergency preparedness officials. Evacuation notices will be issued via the Emergency Broadcast System on radio and television stations. Thus, the National Monument will not be notified directly by SCE&G. The National Monument is located approximately 35 river miles downstream from the Saluda Dam. Predicted effects at the Mill Creek confluence site 6 miles upstream from the National Monument include an 8 hour delay until floodwaters are observed (Table 13). A gradual increase in floodwater levels will occur until levels peak 15 hours after dam failure. Maximum flood levels at the Mill Creek site may reach 131.5 ft above mean sea level or approximately 31 ft above the surface of the National Monument (assuming a 100 foot elevation). The minimum

8 hour delay before flood waters begin to impact the National Monument coupled with a flood warning system within the National Monument should provide sufficient opportunity to evacuate visitors and personnel from frontcountry areas. To afford backcountry users with the same opportunity to evacuate, consideration should be given to installing an automated early warning notification system. A second large hydroelectric facility, the Fairfield Pumped Storage Facility, is located off the Broad River near Jenkinsville, South Carolina. Because of the relatively small storage capacity of the Monticello Reservoir, formed by the Fairfield Facility dams, there would be much less impact on the National Monument (i.e., water levels only slightly higher than a 25-year flood) in the unlikely event of a dam failure (K. Massey, SCE&G, draft review comments, February 1996).

Table 13. Probable maximum flood levels of the Congaree River approximately 6 miles upstream from the National Monument's southwestern boundary at the Mill Creek confluence. Times and elevation are provided for dam failure on a sunny day and during periods of probable maximum precipitation (PMP) (SCE&G 1993).

Description	Sunny day	PMP
Flood wave front travel time (hrs)	8.3	5.4
Time to reach peak elevation (hrs)	15.4	13.1
Peak elevation (ft-msl)	131.5	140.3
Approximate elevation of National Monument floodplain surface	100.0	100.0

Non-consumptive Water Uses within the National Monument

Non-consumptive water uses are primarily non-contact recreational activities. Hook-and-line bank fishing is a frequent activity at easily accessible locations on Wise Lake and Cedar Creek. Fishing at these locations is a traditional activity for local residents and was probably on-going prior to the inclusion of the National Monument into the NPS system. Fishing provides an important means of recreation for the area as well as an important supplementary food source for persons with low income. Non-threatened resident fish species constitute the majority of the catch, primarily Centrarchidae [sunfish (*Lepomis* spp.), crappie (*Pomoxis* spp.), and largemouth bass (*Micropterus salmoides*)] and Ictaluridae [catfish (*Ictalurus* spp.)]. Fishermen are required to adhere to inland fishing regulations and license requirements of the State of South Carolina. The sufficiency of state creel and size limits in protecting the National Monument fisheries is addressed in Project Statement COSW-N-017.

Cedar Creek is used by canoeists during periods of adequate water flow. Canoe trips may be single day outings or extended trips with overnight camping within the National Monument. The most frequently used waterway is a segment of Cedar Creek from the intersection of Cedar Creek with Old Bluff Road to a take-out east of Wise Lake near SC 1288. More extended canoe trips continue downstream on Cedar Creek to the Congaree River to a take-out at the US 601 bridge landing. Maintenance of canoe trails may require periodic removal of obstructing fallen snags and limbs. This woody debris provides important substrate for aquatic invertebrates, serves as cover for fish, contributes to streambed and channel morphology. Maintenance of canoe trails should minimize removal of this material and limit clearing of the debris to provide adequate passage of single canoes only.

Man-made Structures Potentially Affecting Hydrology

Man-made structures that may affect the hydrologic regime within the National Monument consist of shelters for water level recorders, roadbeds, and bridges for hiking trails and vehicular traffic. Most of these structures have been in existence for many years and are probably of minimal impact to the hydrologic regime of the National Monument.

Four water level gauging stations have been established by the USGS within the National Monument. The stations are located on Cedar Creek below Myers Creek near Hopkins, Cedar Creek near Wise Lake near Gadsden, Cedar Creek at county road 1288 near Gadsden, and adjacent to the Congaree River west of Wise Lake near Gadsden (Table 2). At each station there is a 1-ft. diameter metal pipe seated vertically in the streambed and a small shelter elevated above the adjacent bank on support pilings. During low flow conditions, these structures do not obstruct or constrict water movement. However, during flood conditions woody debris may accumulate on the pipes or pilings which may alter water flow to a small degree and alter the distribution of detritus. A system of flood crest gauges that have been established along small watercourses (Figure 14) do not interfere with water movement.

Several unpaved roadbeds exist within the National Monument, primarily in the western sections. Though originally constructed prior to the establishment of the National Monument, two roads are maintained for use by NPS staff, researchers, and visitors. The most frequently used road extends from the National Monument headquarters to Wise Lake, while the second road follows the National Monument's western boundary to the Congaree River. Culverts have been placed in roadbeds where the roads intersect watercourses. Several other roads within the National Monument have been abandoned and they may temporarily restrict water movement. In addition to possible influences of roads on surface water flow, near-surface groundwater flow may have been altered by the accumulated fill material used to create roadbeds.

Along hiking trails, several wooden bridges have been constructed across permanent streams and watercourses. During floods, woody debris may accumulate at the support pilings resulting in damage to the bridge and interfering with canoe access. NPS staff regularly maintains these bridges and removes accumulated debris.

A small relic dam is located on Cedar Creek near Wise Lake. Although the dam has been broken for many years, brick, concrete, and stone blocks in the streambed tend to constrict water flow and create unnatural turbulence. This condition has minimal adverse impacts on the stream ecosystem but may present problems for unsuspecting or inexperienced canoeists. Recommendations for man-made structures are made in Project Statement COSW-N-064.

PLANNING RELATIONSHIPS

Since the National Monument is not an isolated ecosystem, land use beyond National Monument boundaries will largely determine water quality of surface water entering the National Monument. As urban centers within the Congaree River watershed continue to expand, increased storm water runoff and contamination seems inevitable. The presence of the National Monument downstream from urban and industrial centers necessitates stringent compliance to regulations stipulated in the federal Clean Water Act and amendments. Beyond these measures, federal, state, and municipal agencies should encourage watershed protection through the establishment of set-back regulations, greenway and river corridors, appropriate land use zoning regulations, and more environmentally sound agriculture and silviculture. Protection of water quality and the biological integrity of the National Monument could be used as a focal point for environmental education which emphasizes land use and watershed protection.

In the local watersheds of the Cedar Creek and Toms Creek watershed, similar compliance with water quality regulations is needed. The NPS may actively promote watershed protection on lands adjacent to waterways flowing onto the National Monument. Thus, a buffer zone may be established to reduce sediment, nutrient, and pesticide loading in these waterways. The interests of the National Monument should be represented at local land use planning sessions and zoning hearings. Presently, urban and industrial development in lower Richland County is limited, in part, by the lack of a centralized sewage system. New industrial or residential developers would be required to design and implement private sewage systems which, if not properly constructed and maintained, could adversely affect water quality in the National Monument (Project Statements COSW-N-023 and COSW-N-061).

Lower Richland County Land Use Plan

The Central Midlands Regional Planning Council publishes a land use planning guide, the Richland County Comprehensive Land Use Plan Update: Lower Richland, every 5 years which establishes development objectives for unincorporated subareas (Central Midlands Regional Planning Council 1992). The 1992 Land Use Plan Update encompasses the National Monument and the drainages of all tributary streams passing through the National Monument. Several proposed land use and development projects have the potential to affect the National Monument. In response to projected population and development increases in lower Richland County, the plan proposes expanding transportation routes, industrial development, and public water and sewer services.

Highway lane improvements (widening) and/or intersection improvements are anticipated for Leesburg Road (SC 262), Air Base Road, and Zeigler Road South, each of which cross watersheds of streams flowing into the National Monument. However, these improvements are long-range and not currently scheduled for construction (D. Godfrey, Richland County Planning Department, draft WRMP review comments, April 1996). The impact of these road improvements will probably be minimal since the roads cross at least 3-6 miles north of the National Monument boundary. Improvements to Bluff Road (SC 48) may be necessary from Columbia to the Westinghouse plant, which lies approximately 4 miles west of the National Monument. East of the Westinghouse plant, vehicular traffic is expected to remain relatively low (approximately 2,000 vehicles per day) and road improvements should not be necessary.

The land use plan identifies sites that hold potential for industrial development. Industrial development sites were proposed based on infrastructure support, soil and topographic characteristics, lot size, and compatibility within the landscape. Five sites with the potential for industrial development were identified within the Myers Creek-Cabin Branch watershed, three sites within the Cedar Creek watershed, and one site in the Toms Creek watershed. The Toms Creek watershed site is located within 2 miles of the National Monument boundary at the junction of Bluff Road (SC 48) and Congaree Road (SC 769), and should be of special concern to the NPS.

A special land use plan has been proposed for the area surrounding McEntire ANG Base (Central Midlands Regional Planning Council 1992). In order to limit public exposure to noise and to reduce the possibility of public endangerment due to accidents involving military aircraft, yet promote appropriate land use in areas adjacent to military aircraft installations, the U.S. Air Force has developed the Air Installation Compatible Use Zone (AICUZ) concept. This concept establishes concentric zones around aircraft installations in which appropriate types and intensities of development are permitted. The AICUZ for McEntire ANG Base is located entirely within the watersheds of Cedar Creek and Toms Creek. Frequent low-level flyovers by military aircraft have generated complaints from National Monument visitors and are in conflict with wilderness values (R. Clark, Congaree Swamp National Monument, personal communication, January 1996). This issue and attempts to reduce the number of flyovers and noise abatement are being addressed by National Monument management in cooperation with McEntire ANG command.

Water and sewer development are primary factors limiting industrial and residential development in rural areas. The lack of these services limits the water available and wastewater disposal capabilities of industry and high-density residential development. In lower Richland County, most industrial and residential development is located within outlying areas of Columbia which are on public water and sewer lines. Presently, there is minimal residential development (using individual water supply wells and septic tanks) and no industrial development immediately adjacent to the boundaries of the National Monument. The water resources of the National Monument are probably not greatly affected by this low-density development. McEntire ANG Base has separate water and wastewater treatment facilities.

The Richland County Comprehensive Land Use Plan Update: Lower Richland (Central Midlands Regional Planning Council 1992) includes a proposed network of sewer line extensions and wastewater treatment plants in the watersheds of Cedar Creek, Cabin Branch, and Myers Creek. The extension of public water and sewer lines into central and eastern portions of lower Richland County may reduce haphazard and improperly sited private water and wastewater facilities, but may encourage higher density development within tributary watersheds of the National Monument. These extensions may necessitate the construction of an interim wastewater treatment facility on Cedar Creek upstream from the northwest boundary of the National Monument near the bridge at Old Bluff Road until the treatment capacity of a wastewater treatment facility in Columbia can be upgraded. The actual construction of this interim plant on Cedar Creek is unlikely due to the current lack of development pressure in the area and the improbability of obtaining a wastewater discharge permit in such close proximity to the National Monument (P. Slayter, Central Midlands Planning Council, personal communication, June 1995).

Economic Development and Conservation Organizations

A non-profit, economic development organization, the Sunrise Foundation is promoting a comprehensive development plan for the 360 square miles (932 km^2) lower Richland County area. The plan includes the development of an industrial park adjacent to the Wateree River. The Foundation views the National Monument as an asset to residential and recreational development in the area and is interested in upgrading support facilities for National Monument visitors (K. Newman, Sunrise Foundation, personal communication, February 1995). The recently formed River Alliance, the Columbia-based Friends of the Congaree, and the Palmetto Foundation also recognize the natural attributes of the National Monument as a means to promote ecotourism and the quality of life in the Columbia area (including lower Richland County). Local chapters of the Sierra Club and Audubon Society are active in the Columbia area. These groups may be valuable liaisons between private landowners and the National Monument in discussions of streamside protection options on lands adjacent to streams flowing into the National Monument.

River Corridor Planning

In order to maintain and protect the ecological, recreational, and aesthetic values of the National Monument, it is imperative that the water resources upstream from the National Monument are also provided some protection. This becomes increasingly important as residential, industrial, and agricultural land uses within the watershed become more intensively developed. It is generally accepted that vegetated buffers between intensively used lands and waterways are necessary to ensure basic protection of the water resources. Two programs, the National Wild and Scenic Rivers program and the South Carolina Scenic Rivers program, provide a mechanism by which river corridors are provided some protection by limiting certain activities that degrade environmental quality within the river corridor. These programs should be considered when developing a river corridor plan for the Congaree River and its tributaries.

Rivers or river segments that are designated as National Wild and Scenic Rivers are provided with instream and streamside protection designed to maintain their free flowing character and their outstanding natural, cultural, scenic, or recreational attributes. National Wild and Scenic Rivers are often designated within federal land holdings; this circumvents the necessity of acquiring property or easements from the multiple private landowners along river courses on non-governmental properties. The National Wild and Scenic Rivers Act (P.L. 90-542 as amended; 16 U.S.C. 1271-1287) establishes two basic criteria for designation. Firstly, rivers or river segments must be free flowing; generally, this precludes the existence or construction of dams or impoundments, alteration of the river channel, or other major water development projects that impede the natural flow of the river. However, upstream or downstream dams or projects do not unconditionally prevent designation. Secondly, the river or river segments and their immediate environments must contain one or more of seven outstandingly remarkable features; scenic, recreational, geologic, fish and wildlife, historical, cultural, or other similar values.

There are three classes of designations in the National Wild and Scenic Rivers program; wild, scenic, or recreational rivers. The classes of designation depends largely upon the existing condition and character of the river or river segment and its uses. As defined by the National Wild and Scenic Rivers Act (P.L. 90-542 as amended; 16 U.S.C. 1271-1287), wild river designation may be afforded to unimpounded rivers that have little access except by trail, as well as essentially undeveloped shorelines and unpolluted waters. Scenic rivers designations may be applied to rivers with minimal shoreline development but accessible in places by road. Recreational rivers are readily accessible with some shoreline development and may have undergone some impoundment or diversion prior to designation.

The South Carolina Scenic Rivers Act (SC Code of Laws, 1989, Title 49, Chapter 29) also provides protection of the "unique or outstanding scenic, recreational, geological, botanical, fish, wildlife, historic, or cultural values" of designated rivers and streams. River corridor protection through the South Carolina Scenic Rivers Program entails the cooperative and voluntary agreement among landowners, community interests, and the South Carolina Department of Natural Resources to develop long-term management strategies which will preserve traditional uses of the river as well as the scenic character the river corridor (South Carolina Water Resources Commission 1991). Project Statement COSW-N-023 advocates the need for multilateral cooperation among agencies in river corridor planning.

ISSUES AND MANAGEMENT ALTERNATIVES

This section provides a brief description of water resources issues affecting the Congaree Swamp National Monument (Table 14) and recommended management alternatives for addressing these issues. While much of the background information concerning the issues was presented in previous sections, this section more directly addresses management needs. Resource managers at the National Monument are provided with a choice of management alternatives that recommend either specific action by resources managers or, if sufficient need exists, the development of project statements (Appendix A) outlining resource protection, inventory, monitoring, research, and/or mitigation activities that will require additional funding support. These water related project statements are provided in a format compatible with the current NPS Resource Management Plan Guideline (NPS 1994b). These project statements will also be incorporated into the National Monument's Resource Management Plan.

Table 14. Water resources issues for the Congaree Swamp National Monument and suggested actions to address the issues.
1. FLOODPLAIN FUNCTION AND HYDROLOGIC PROCESSES a) Improve the understanding of fluvial processes and hydrogeomorphic dynamics of the Congaree River floodplain. b) Improve the understanding of the hydrodynamics of the Congaree River floodplain. c) Evaluate the applicability of technical advances in the understanding of floodplain dynamics and hydrologic processes toward the management of the National Monument. d) Evaluate and assess regulatory and policy developments related to wetland and river corridor resources.
2. ASSESSING THE STATUS OF SURFACE WATER AND GROUND WATER QUALITY AND CONTAMINATION a) Assess the current status of water quality and compliance with South Carolina water quality standards. b) Evaluate the adequacy of the SCDHEC water quality monitoring and stream classification for Cedar Creek and Toms Creek; advocate reclassification to "Outstanding Resource Waters." c) Assess the compliance of National Pollutant Discharge Elimination System (NPDES) permitees in the vicinity of the National Monument. d) Evaluate the potential for surface water contamination in Cedar Creek and Toms Creek from military bases, roads and railroads, and an aquaculture facility within the watersheds of these streams. e) Evaluate the potential for groundwater or surface water contamination in the National Monument from landfills, CERCLA sites, industries, and fuel storage tanks in the vicinity of the National Monument. f) Pursue the inclusion of National Monument waters in the USGS National Water Quality Assessment Program (NAWQA).

Table 14. Continued.
3. WATER MANAGEMENT IN THE UPPER CONGAREE RIVER BASIN AFFECTING RIVER DISCHARGE a) Determine the effect of water management at the Saluda Hydroelectric Project on the water resources of the National Monument. b) Evaluate the adequacy of the Emergency Action Plan of the Saluda Hydroelectric Project for flood alert. c) Review proposals for hydroelectric and water supply development within the watershed of the Congaree River. d) Review proposals for dredging and channel alteration of the Congaree River, Cedar Creek, or Toms Creek.
4. LAND USE WITHIN THE GREATER CONGAREE RIVER WATERSHED AND THE CEDAR CREEK AND TOMS CREEK WATERSHEDS a) Monitor the effect of changing land use patterns within the greater Congaree River watershed and the Cedar Creek and Toms Creek watersheds on the water resources of the National Monument. b) Participate in local economic development and planning.
5. CONGAREE RIVER AND TRIBUTARY CORRIDOR PLANNING a) Pursue the designation of the portion of the Congaree River adjacent to or upstream from the National Monument as National Wild, Scenic, or Recreational River or South Carolina Scenic River. b) Pursue the establishment of watershed and streamside protection zones for Cedar Creek and Toms Creek.
6. NATIONAL MONUMENT OPERATIONS, VISITOR USE, AND SAFETY a) Implement a flood warning system for the National Monument. b) Evaluate the development and maintenance of water and wastewater facilities for National Monument visitors and NPS staff. c) Evaluate the potential for groundwater contamination from aboveground fuel storage tanks within the National Monument. d) Assess the impact of existing man-made structures within the National Monument on water flow regime.
7. PUBLIC AWARENESS AND ENVIRONMENTAL EDUCATION a) Promote national and international recognition of the National Monument as an important ecological and recreational resource.

Understanding Floodplain Function and Hydrologic Processes in the National Monument

Statement of the Issue

To best maintain the natural integrity of the National Monument, resource management at the National Monument should have a basic understanding of the ecological and geological functions of this floodplain ecosystem. As technical advances are made in understanding floodplain ecosystems, National Monument managers need to become informed. Legislative and policy developments related to wetland and river corridor resources may affect management decisions; National Monument managers need to be advised of these policy developments.

There is apparently no definitive information on the potential influence of human activities on the current geomorphic setting of the modern National Monument. Although the hydrology of the National Monument is being studied for the purpose of developing a flood warning prediction system (Project Statement COSW-N-003.001), there is a need for a more fundamental approach for understanding the interaction of hydrology and ecological functions of the wetlands. While these interactions are largely physical issues dealing with land form and water flow, they are directly responsible for the biotic characteristics for which the National Monument is so highly valued.

A firm grasp of environmental and legal policies that offer protection of the National Monument's natural attributes can be a powerful tool if applied in a timely and effective fashion. On the other hand, environmental regulations, National Park Service policy, and other legal factors may constrain the manner in which management is carried out. Natural resource managers should be skilled in assimilating new technical developments and merging this information with current policies in a way that allows them to achieve goals developed for the resource they are managing.

Management Alternatives

- Improve the understanding of fluvial processes and hydrogeomorphic dynamics of the Congaree River floodplain.

Many Piedmont floodplains owe their present elevation and sediment balance to massive rates of erosion during the late 1800s when land in cultivation was at a maximum. Much of this sediment was deposited in floodplains, as much as 10 feet (3 m) in thickness in some places (Trimble 1970), thus creating an entirely new topographic surface. With reforestation of uplands, sediment sources from uplands have diminished, and many Piedmont streams are incising back to former bedrock control. We do not know the extent to which the fluvial geomorphology of the National Monument was influenced by these events during the past century. The old growth nature of the forest might lead to the tacit assumption that little change has occurred. If this is true, the National Monument would appear to be highly resilient. If it is not true, the dynamic nature of a sediment budget needs to be quantified and any trends need to be identified (Project Statement COSW-N-058). In spite of obvious floodplain features that testify to the fact that river meandering has created many present-day floodplain features, we are unable to place the current geomorphic environment into a temporal perspective until this recent history is better documented. Techniques are available to measure sedimentation rates (both current and historic) and to estimate ages of development of floodplain features (such as point bars) by radiocarbon-dating buried woody materials.

Another alteration that confounds the understanding of the sediment dynamics of the National Monument is the construction of a dam as part of the Saluda Hydroelectric Project. The facility began operation in 1930 on the Saluda River, a major tributary to the Congaree River. The dam is only 11 miles above the confluence with the Broad River that forms the Congaree River, in effect capturing the entire drainage basin of the Saluda River, or 2,420 mi^2 (6,268 km^2). This is about half of the Broad River's drainage area of 5,320 mi^2 (13,779 km^2). While the Broad River drainage contains only minor dams, the dam at the Saluda Hydroelectric Project controls roughly one-third of the total flow to the Congaree River above Columbia. The storage capacity of Lake Murray, which is formed by the dam, reduces the frequency of virtually all floods. Several studies have explored whether altered flows could cause the species composition of the old-growth forest to change because of changes in flooding depth and frequency, as well as altered rates of sedimentation. Studies that have explored potential effects on vegetation include those of Rikard (1988), Sharitz et al. (1993), and Jones (1996). In addition, the Saluda Hydroelectric Project potentially has had a two-fold effect. One is the reduction in frequency of floods with long return interval, the ones most capable of inducing geomorphic alterations such as major cutbank erosion, levee building, and meander cutoffs. Second is the reduction in sediment supply from the Saluda River as a result of sediment loads being trapped behind the dam. The potential effects of these two must be analyzed in concert with the confounding effects of changing sediment supplies during historic alterations of land use in the Piedmont.

Alternative A: Conduct a literature review and synthesis that assesses information available from other large floodplain systems and applies the information to the National Monument using best professional judgement without further data collection.

Alternative B (preferred alternative): Study the fluvial geomorphology prior to further studies of hydrologic flow paths. The following types of information will contribute to the understanding of the fluvial geomorphology and will provide background upon which further studies in surface water hydrology can take place:

1. Map, classify, and interpret major geomorphic features of the 100-year floodplain of the Congaree River within the National Monument's authorized boundary. The degree of additional mapping that may be required should be determined after the present 2-foot contour map is examined. The portion of the floodplain mapped, and the scale and contour intervals should be at sufficient detail to meet the objectives of the study on floodplain dynamics explained in project statement COSW-N-059.

2. Develop a map of the surface geomorphic features and provide interpretation of the probable origin and evolution of the geomorphic features based on best professional judgement.

3. Determine current, recent historic, and geologic rates of sedimentation on the floodplain through monitoring of sedimentation events on floodplain surfaces. Estimates would include instantaneous rates of deposition as well as measuring the rate of recent, decades-scale sediment accretion rates using modern geochemical techniques. These approaches would allow an estimation of whether the potential effects of the Saluda Hydroelectric Project on sediment supply could possibly influence responses in vegetation, and predict potential effects of additional impoundments in the watershed on vegetation and fluvial geomorphology.

Project statement COSW-N-058 (Improve Understanding of Fluvial Geomorphic Processes of the Congaree River Floodplain) provides information on these geomorphic processes. This information will contribute to the general understanding of large rivers and their floodplains (Gore and Shields 1995). Moreover, descriptions of relatively unaltered sites like the Congaree Swamp National Monument may serve as templates for restoration of highly altered river systems.

- Improve understanding of the hydrodynamics of the Congaree River floodplain.

The hydrologic complexity of the floodplain is not well understood, especially with respect to the relative importance of inflows from the northern tributaries (several small streams) and overbank flow from the Congaree River (one large Piedmont-draining stream). This lack of understanding prevents the development of management strategies based on specific sources of water, their seasonal delivery to the floodplain, and the vulnerability of aquatic ecosystems within the National Monument to external sources of water-borne contamination and eutrophication. The National Park Service must currently make management decisions pertaining to activities inside the boundaries of the National Monument with little confidence as to whether they will be effective in maintaining the sustainability of its aquatic ecosystems.

A basic understanding of water flow pathways is needed because:

1. A practical knowledge of surface hydrology is fundamental to understanding the potential sources and fates of contaminants that may enter the National Monument with stream flow. Once water is inside the park, the flow pathways are largely under control by geomorphic features of the floodplain. Flows within the National Monument will control the distribution and ultimate fate of any water-borne contaminants. Because so little is known about the flows under different flood stages, it is impossible to predict the movement of contaminants within and through the floodplain. In addition, little is known about the potential effects of flow paths and velocities on sediment transport and organic matter redistribution.

2. Ecosystem dynamics may depend on the frequency and duration at which otherwise relatively isolated aquatic environments such as oxbow lakes and smaller sloughs potentially become "reset" during flood events. These events displace a limnetic (lake-like) with a lotic (stream-like) environment. Such events serve to displace water that may have accumulated organic matter, high concentrations of nutrients, and reduced compounds (such as hydrogen sulfide) during the limnetic phase. Flood events also create opportunities for exchanges of fish and other aquatic organisms between the rivers and the lakes. The flows of the streams entering the National Monument from the north, such as Cedar Creek, apparently become dominated by overbank flow and downstream surface water flow when the Congaree River reaches flood stage.

The fluvial geomorphic study (Project Statement COSW-N-058) will provide critical background for this study, for the management of aquatic resources of the National Monument, and for further interpretation and understanding of the natural history of the site.

Alternative A: Conduct a literature review and synthesis on floodplain hydrology that assesses information available from other large floodplain systems and applies the information to the National Monument using best professional judgement.

Alternative B (preferred alternative): After a study of the fluvial geomorphology (Project Statement COSW-N-058), a study is recommended that would produce the following types of information:

1. Determine base flow associated with tributaries entering the National Monument from the north. This will provide an estimate of the importance of groundwater sources to maintaining perennial or intermittent flow. From this information, the relative importance of channel inflow from outside the National Monument and groundwater discharge to the stream channels inside the National Monument can be determined. This will allow better predictions of the effects of proposed flow alterations of the tributaries on aquatic environments within the National Monument.

2. Determine surface flow vectors at the annual flood stage, and at the 5 and 25 year return intervals. Flow pathways established from flow vectors provide insight into how potential contaminants would be transported through and within the floodplain, how aquatic organisms are exchanged between channel and floodplain, how woody debris and floating seeds are dispersed, and at what stages of overbank flow the Congaree River influences flows and water quality of Cedar Creek and other tributaries. Flow vectors can be estimated from the contour maps provided in project statement COSW-N-058 as well as from the asynchrony in hydrographs measured at strategic locations within the floodplain. Such data may allow estimates of the degree of connection between sites within the floodplain and the larger river system. Sites for potential sediment deposition and detritus transport may also be identified.

3. Estimate velocities at several flood return intervals. Velocities affect sediment transport, fine and coarse woody debris movement, and residence time of the surface water in the swamp.

4. Use the predictions of flood return interval and duration from the flood warning study (John C. Hayes and Dave E. Linvill at Clemson University, in progress) to evaluate possible biotic influences, especially on the aquatic ecosystems of the National Monument.

5. Provide a narrative description of water flow pathways, ecological and environmental significance of the flows, and the environmental consequences of their alterations.

Project Statement COSW-N-059 (Improve Understanding of Hydrodynamics of the Congaree River Floodplain) provides information on these hydrodynamic processes, which are critical to the general understanding of flow dynamics within the floodplain.

- Evaluate the applicability of policy developments and technical advances in the understanding of floodplain dynamics and hydrologic processes toward the management of the National Monument.

The National Monument has served and will continue to serve as a valuable research site for studies of floodplain ecosystems. Since the National Monument is a unit of the National Park System, it is afforded greater environmental protection than most other public and private land holdings. However, the National Monument is not an isolated ecosystem; it is largely influenced by activities in the surrounding landscape. Changes in federal, state, and local policies regarding wetlands and river corridors in the surrounding landscape may have significant consequences within the National Monument. National Monument management needs to be familiarized with the results of past studies and kept informed of on-going research activities and insights. It is vital that an open dialogue with researchers is maintained and that researchers provide National Monument management with up-to-date developments in their research.

The best informed management decisions concerning the maintenance of the National Monument ecosystem require an understanding of the most current theoretical and applied ecological concepts pertaining to floodplain ecosystems that are available. Much of this information may be obtained by examining the primary literature published in professional journals such as the journal *Wetlands* published by the Society of Wetland Scientists, *Ecological Applications* published by the Ecological Society of America, and *Limnology and Oceanography* published by the American Society for Limnology and Oceanography.

In addition to the primary literature sources, specialized review articles and symposia often provide a synopsis of information pertinent to the informed management of floodplain resources.

Alternative A: No new action. The knowledge-base and conduit for technical information gathering of National Monument managers is sufficient to meet present needs.

Alternative B: Develop a library of primary literature, symposia proceedings, textbooks, and other documents pertaining to the ecology of riverine floodplains of the Southeast and other relevant sites. Subscribe to professional journals and attend conferences which are pertinent to gaining a better understanding of the National Monument ecosystem and management strategies. Additionally, changes in environmental policy related to the National Monument should be examined by subscribing to professional society newsletters and obtaining public documents.

Alternative C: Develop a streamlined reference library that is limited to focused symposium proceedings, review articles, and management discussions of large floodplain ecosystems and water quality issues that pertain to floodplains.

Alternative D: Develop staff expertise through training and contacts with wetland ecologists and floodplain specialists.

The preferred alternative is a combination of actions provided in alternatives C and D. Staff should be strongly encouraged to develop expertise and improve communications with wetland specialists through the maintenance of a resource library focusing upon wetland and floodplain management as well as attendance at applicable training courses and academic symposia focusing upon these issues.

Assessing the Status of Surface Water and Groundwater Quality and Contaminant Risks

Statement of the Issue

A major concern for preserving the National Monument's ecosystems and ensuring the safety of visitors is maintenance and improvement of water quality. The headwaters of all streams that enter the National Monument are on public and private lands beyond the jurisdictional boundary of the National Monument. Surface waters enter the National Monument in two ways, (1) overbank flow from the Congaree River and (2) channel flow and overbank flow of local streams, principally Cedar Creek and Toms Creek. Portions of the groundwater aquifers of the National Monument are also beyond National Monument boundaries and may be at risk. Wastewater discharges, urban and agricultural runoff, and groundwater contamination occur within the Congaree River and Cedar Creek and Toms Creek watersheds, upstream from the National Monument. These point sources and nonpoint sources of water contamination have the potential to degrade water quality and present a threat to biota of the National Monument. While contaminant sources within the vicinity of the National Monument are the greatest risk, the cumulative impact of multiple contaminant sources far upstream from the National Monument are also of concern. It is imperative to the ecological integrity of the National Monument that water quality is routinely monitored, that water quality trends are assessed, and that management action is taken when deemed necessary.

Management Alternatives

- Assess current status of water quality and compliance with South Carolina water quality standards.

Water quality test results from water samples obtained for the Fixed Monitoring Network program by the SCDHEC-Office of Environmental Quality Control, Bureau of Water Pollution Control can be used to track water quality at monitoring stations on Cedar Creek, Toms Creek, and the Congaree River (Table 15). The test results are available upon request from the SCDHEC Office of Environmental Quality Control. These data are also maintained by the US Environmental Protection Agency in a national database, the STORET database.

In order to meet goals established in section 208 of the Federal Water Pollution Control Act of 1972 (P.L. 92-500, and amendments), which requires States to prepare areawide water quality monitoring plans, SCDHEC, Bureau of Water Pollution Control developed the Watershed Water Quality Monitoring Strategy (WWQMS) (SCDHEC 1995b). After an extended delay, the WWQMS was re-initiated in 1994. The state has been divided into 5 major watershed units, with the Congaree River and the National Monument being included in the Saluda-Edisto Basin WWQMS watershed unit (Unit II). The Broad River, which along with the Saluda River combine to form the Congaree River, is a separate WWQMS watershed unit, the Broad River Basin (Unit V). The WWQMS uses water quality data collected by SCDHEC to develop watershed management plans and implement strategies for water quality protection. Strategies include: "monitoring, assessment, problem identification and prioritization, wasteload allocation monitoring, planning, permitting and other agency activities" (SCDHEC 1995c). By incorporating water quality data from SCDHEC's Fixed Monitoring Stations, Biological Monitoring Stations, and Watershed Water Quality Monitoring Stations within major watershed units, watershed management plans specific to each watershed unit can be developed.

The NPS's Inventory and Monitoring Program, in conjunction with the NPS Water Resources Division and the Horizon Systems Corporation, is currently compiling and interpreting STORET water quality data for 250 units of the National Park system, including the Congaree Swamp National Monument. The report for the National Monument will provide a comprehensive analysis of an array of physical and chemical water quality conditions, including heavy metal and pesticide concentrations. The Congaree Swamp National Monument report is schedule for completion in 1996 (B. Long, NPS Water Resources Division, personal communication, August 1995).

Table 15. Pertinent SCDHEC water quality monitoring stations in the vicinity of the Congaree Swamp National Monument.

STORET Name	Latitude / Longitude	SCDHEC Station Number
Congaree River at Blossom St Left - Saluda River	33° 59' 20.0" / 081° 002' 40.0"	CSB-001L
Congaree River at Blossom St Right - Broad River	33° 59' 20.0" / 081° 002' 40.0"	CSB-001L
Congaree River at US 601	33° 45' 00.0" / 080° 38' 40.0"	C-007
Cedar Creek at S-40-66	33° 53' 49.0" / 080° 49' 09.0"	C-069
Cedar Creek at S-40-734	33° 50' 26.0" / 080° 51' 36.0"	C-071
Toms Creek at SC 48	33° 50' 30.0" / 080° 43' 54.0"	C-072

Alternative A: No new action. Rely on the SCDHEC water quality sampling programs to detect and mitigate water quality problems affecting the National Monument.

Alternative B (preferred alternative): Request on an annual basis water quality results from the SCDHEC Fixed Network Monitoring for the sampling stations listed on Table 15 and compliance monitoring reports from NPDES permitted dischargers in the vicinity of the National Monument. Request copies of the WWQMS Saluda-Edisto Basin reports upon publication every five years. The water quality information so obtained should then be reviewed by National Monument managers annually. These data and reports should be analyzed by a consulting water quality specialist to determine contaminant trends affecting the National Monument no less than once in a three year cycle. In addition, the National Monument should continue its ongoing monthly monitoring program which measures four physical/chemical constituents, including temperature, dissolved oxygen, specific conductance, and turbidity. Recommended actions for this alternative are further developed in Project Statement COSW-N-060.

- Evaluate the adequacy of SCDHEC water quality monitoring and stream classification for Cedar Creek and Toms Creek; advocate reclassification to "Outstanding Resource Waters."

The Water Quality Monitoring Section of SCDHEC, Central Midlands District Office, obtains surface water samples for analysis from the Congaree River at Columbia and at the US-601 (station C-007) bridge at monthly intervals. Samples are obtained from Cedar Creek at SC-66 (C-069) at monthly intervals for 6 months per year (May through October). The year-round sampling stations on the Congaree River are classified as Primary Stations; the 6-month station on Cedar Creek is a Secondary Station. One-time sampling was conducted in 1992 at Cedar Creek at SC 734 (Old Bluff Road) (C-071) and Toms Creek at SC 48 (Bluff Road) (C-072).

The Congaree River, Cedar Creek, Toms Creek, and other streams in or near the National Monument are subject to standards established by SCDHEC (S.C. Water Pollution Control Act, 48-1-10, et seq, S.C. Code of Laws, 1976). The Congaree River and the local streams are designated "Freshwater" (FW) streams in the SCDHEC Water Classifications and Standards. Because the National Monument is an ecologically unique system with valuable recreational and ecological attributes, a stream classification upgrade from "Freshwaters" to "Outstanding Resource Waters" (ORW) may be justified for Cedar Creek and Toms Creek. "Outstanding Resource Waters" are designated as waters of exceptional recreational value or ecological importance. In contrast to the Congaree River, these local streams flow through the National Monument year-round and may have the greatest impact on localized portions of the National Monument. The Congaree River, however, is a high order river situated downstream from one of the states' major urban regions. As with most other similar sized, high order rivers of the region, the waters of the Congaree River are not pristine. For this and related reasons, the "Freshwaters" classification is appropriate.

Classification upgrade for Cedar Creek to ORW may be complicated by the existence of eight permitted wastewater dischargers and an aquaculture facility on the waterway. New discharges of wastewater into ORW streams are not allowed. However, if the stream segment containing the wastewater facilities and the aquaculture facility were to retain FW classification, discharges may be allowed and possibly increased as long as the dischargers are operating in accordance with SCDHEC Antidegradation regulations. In this eventuality, the stream segment of Cedar Creek within the National Monument could be upgraded to ORW. Since no wastewater dischargers are located on the tributary streams of Cedar Creek (Reeves Creek, Myers Creek, and Goose Creek), consideration should be given to upgrading the classification of these waters to ORW where appropriate.

Since Toms Creek and its tributaries (Dry Branch and McKenzie Creek) do not receive discharges from existing domestic, industrial, or agricultural wastewater treatment facilities, an upgrade to ORW should be less problematic. Stormwater runoff from McEntire ANG Base and nonpoint source runoff from agricultural lands would have to be in compliance with ORW standards and consistent with Antidegradation regulations established by SCDHEC (S.C. Water Pollution Control Act, 48-1-10, et seq, S.C. Code of Laws, 1976).

Alternative A: No new action. This assumes that the Secondary Station status and FW classification are sufficient to protect National Monument values and that water quality is within state standards for FW. The current sampling regime is adequate to assess water quality trends in the Congaree River, Cedar Creek, and Toms Creek.

Alternative A would not require additional management actions since the NPS would defer to SCDHEC to monitor compliance with FW standards. However, FW standards may not be sufficient to maintain the ecological quality of the National Monument. Additional discharge permits may be issued on upstream tributaries flowing through the National Monument if FW classification is maintained.

Alternative B (preferred alternative): Pursue sampling station and stream classification upgrades for Cedar Creek and/or Toms Creek. Water quality sampling station status should be upgraded from Secondary Station status to Primary Station status and stream classification should be upgraded from FW to ORW. These upgrades would provide additional protection for upstream portions of streams flowing into the National Monument, thus helping to ensure the maintenance of water quality before it enters the National Monument. The recommended action is further developed in Project Statement COSW-N-061.

- Assess compliance of National Pollutant Discharge Elimination System (NPDES) permitees in the vicinity of the National Monument.

NPDES permits are required for all major wastewater dischargers. Wastewater samples are routinely tested for compliance with NPDES regulations. As of 1995, 63 NPDES permits had been issued in the Congaree River watershed between Columbia and the National Monument. Eight NPDES permits had been issued to wastewater dischargers on Cedar Creek.

Alternative A: No new action. Rely on SCDHEC and EPA to monitor compliance of NPDES permitees.

Alternative B (preferred alternative): Request that the SCDHEC-Bureau of Water Pollution Control provide National Monument managers with an annual listing of the compliance record for the NPDES permitees listed in Tables 9 and 10. Additionally, request notification of new NPDES permit applications for discharges into Cedar Creek, Toms Creek or their tributaries. Contract on no less than a triennial basis with a water quality specialist to evaluate NPDES compliance data, and work within SCDHEC and EPA frameworks to assure full compliance. Seek resolution of compliance problems based on recommendation from the water quality specialist. This recommended activity is further developed in Project Statement COSW-N-062.

- Evaluate the potential for surface water contamination in Cedar Creek and Toms Creek from military bases, roads and railroads, and aquaculture and agriculture facilities within the watersheds of these streams.

Two military bases are located to the north of the National Monument and within the watersheds of Cedar Creek and Toms Creek. A portion of US-Army, Ft. Jackson at Westons Pond is located in the Cedar Creek watershed (another pond with the same name is located on Dry Branch). McEntire ANG Base is located entirely within the watersheds of Cedar Creek and Dry Branch, a tributary of Toms Creek.

The risk of surface water contamination in Cedar Creek from Ft. Jackson is probably minimal since the site is used for training maneuvers only and is the location of a small recreation area. The risk of surface water and groundwater contamination from McEntire ANG Base is considerably higher. McEntire ANG Base has a permitted wastewater treatment facility which discharges into Cedar Creek, as well as stormwater drainages which discharge into Cedar Creek and Dry Branch. Typically, an array of solvents, petrochemicals, and metals may be found in wastewater and runoff from aircraft maintenance facilities such as those at McEntire ANG Base.

The risk of contamination from road and bridge salting and de-icing or other highway maintenance activities is minimal. Conditions favorable for ice formation on bridges and necessitating de-icing procedures occur only intermittently during the winter months. This usually coincides with high stream discharge and minimal biological activity. However, since the bridges on Old Bluff Road (SC 734) at Cedar Creek and Dry Branch, and on Griffins Creek Road at McKenzie Creek, are in close proximity to the National Monument boundaries, the NPS may request that the Richland County Department of Transportation use reduced salt formulations or mechanical means instead of salting to de-ice these bridges.

The risk of an accidental spill of hazardous materials is greater on roads with a high percentage of commercial traffic compared to roads used primarily for local traffic. If spills occur at bridges over streams flowing into the National Monument, the biota and water quality of the National Monument may be jeopardized. The most heavily used roadway for commercial traffic in the vicinity of the National Monument is Bluff Road (S.C. 48). The secondary roads, Old Bluff Road, Cedar Creek Road (S.C. 1288), and Griffins Creek Road, are closer to the National Monument but are used primarily for local traffic. Each of these roadways crosses streams flowing into the National Monument. Another potential site for accidental spills is along the Southern Railway line which forms the eastern boundary of the National Monument. This is a trunk line which transports general cargo and coal between Charleston and Columbia, South Carolina.- The section of track and railway trestle over the Congaree River adjacent to the National Monument was retimbered in 1994 (G. Eckley, Safety Commission, S.C. Public Service Commission, personal communication, May 1995). The rail line adjacent to the National Monument is inspected two to three times per year. In 1995, this section of track was considered in good condition (G. Eckley, Safety Commission, S.C. Public Service Commission, personal communication, May 1995).

Southland Fisheries is an aquaculture facility located on Cedar Creek less than 1 km from the entrance of Cedar Creek into the National Monument. The facility produces fingerling freshwater fish for restocking projects. The facility produces less than 100,000 lbs. of fingerlings annually. Thus, it is not required to obtain an NPDES wastewater discharge permit.

Presently, there are few concentrated livestock operations in the watersheds of Cedar Creek and Toms Creek. However, the abundance of low-cost land and limited economic development options in lower Richland County may encourage this type of agricultural development in the future. In many cases, the current state of animal waste disposal technologies at concentrated livestock operations does not adequately protect surface water and groundwater resources. Concentrated livestock operations, such as swine and poultry production units, upstream from the National Monument could present a significant risk to water quality and the ecological integrity of the National Monument.

Alternative A: No new action. Rely on existing SCDHEC water quality monitoring and enforcement programs for environmental protection. Rely on the Richland County Department of Transportation and the South Carolina Public Service Commission to conduct road and railroad inspections.

Alternative B (preferred alternative): Investigate the feasibility of a Special Water Quality Study conducted by SCDHEC-Bureau of Water Pollution Control. The purpose of a Special Water Quality Study is to investigate a specific environmental problem, such as the effect of effluent from US-Army, Ft. Jackson and McEntire ANG Base on water quality in Cedar Creek and Toms Creek, or the effect of Southland Fisheries on water quality in Cedar Creek (SCDHEC 1995a). These studies are appropriate for waters of high public water use value or where trend monitoring has indicated a deterioration in environmental quality. Requests for Special Water Quality Studies usually originate within SCDHEC, but may be requested through SCDHEC by the National Park Service. A request for the study must be presented to the SCDHEC-Bureau of Water Pollution Control for review. The study will be designed and conducted by SCDHEC according to the Standard Operating and Quality Control Procedures for Ambient Water Quality and Wastewater Facility Monitoring (SCDHEC 1994c) and the Procedures Manual for Stream and Wastewater Facility Flow Measurement (SCDHEC 1981).

NPS management should review, update, and practice contingency plans of the Richland County Emergency Services Department for the containment and removal of hazardous materials spills in the vicinity of the National Monument. These recommended alternatives are further developed in Project Statement COSW-N-062.

- Evaluate the potential for groundwater and surface water contamination within the National Monument from CERCLA sites, landfills, underground fuel storage tanks, and nearby industries outside of the National Monument boundaries.

Thirty-one state and/or federal CERCLA (Comprehensive Environmental Response, Compensation, and Liability Act program) sites have been identified in the vicinity of the Congaree River between Columbia and the National Monument. Most of these sites are several miles from the National Monument and do not present a direct threat to the surficial aquifer of the National Monument. The possible exceptions are the abandoned South Carolina Recycling and Disposal site on Bluff Road and a site at the Westinghouse Electric Corporation facility northwest of the National Monument. The contamination risk from these sites is primarily via groundwater discharge into the surface waters of Myers Creek and the Congaree River floodplain. No known landfills or underground fuel storage tanks are in the immediate vicinity of the National Monument boundaries.

The three major industrial dischargers in the vicinity the National Monument, Westinghouse Electric Corporation, Carolina Eastman Company, and Teepak, Inc., each have been granted NPDES wastewater discharge permits. Additionally, all three industries were listed in the 1995 Ground-Water Contamination Inventory (SCDHEC 1995d).

Carolina Eastman Corporation and Teepak, Inc. are located on the opposite (south) side of the Congaree River from the National Monument. Thus there is probably little risk to the surficial aquifer of the National Monument. Contaminants from these sites would have to be first discharged into the surface waters of the Congaree River prior to impacting the National Monument.

The industry that is the greatest potential threat to water quality of the National Monument is Westinghouse Electric Corporation. The facility is located on a bluff above the Congaree River floodplain approximately 4 miles (7 km) from the National Monument's northwestern boundary. The floodplain below the facility is contiguous and connected to the floodplain of the National Monument. Discharges of nitrate and volatile organic compounds (VOC's) have been reported in surface waters and wetlands near the facility. It is unlikely that the surficial aquifer of the National Monument will be at risk directly, but discharges of contaminants into surface waters of the floodplain may enter the National Monument during flood events.

Alternative A: No new action. Rely on SCDHEC, Groundwater Division to monitor and remediate groundwater contamination sites in the vicinity of the National Monument.

Alternative B (preferred alternative): Request a periodic review and threat evaluation of CERCLA sites, leaking underground storage tanks (USTs), and landfills by the appropriate sections or divisions SCDHEC. CERCLA sites are supervised by the SCDHEC, Environmental Quality Control, Solid and Hazardous Waste, Hydrogeology Division. USTs are supervised by the

SCDHEC, Environmental Quality Control, Solid and Hazardous Waste, Drinking Water Protection Division. Landfills in Richland County are supervised by the Richland County Department of Solid Waste Management. If contaminated groundwater discharges into surface waters occur, the SCDHEC, Environmental Quality Control, Bureau of Water Pollution Control is authorized to investigate the problem. National Monument management should request that the project manager for the South Carolina Recycling and Disposal site at Bluff Road provide an annual review of the status of the contaminant plume and remediation efforts until the site has been successfully remediated.

National Monument management should also request NPDES compliance records for Westinghouse Electric Corporation, Carolina Eastman Company, and Teepak, Inc. on an annual basis. In addition, the management should contact SCDHEC, Bureau of Water Pollution to obtain compliance records for these dischargers. To determine the extent of contamination from the Westinghouse facility on floodplain wetlands, a request should be made that a Special Water Quality Study be conducted by SCDHEC-Bureau of Water Pollution Control. A consulting water quality specialist should be contracted to evaluate the threat to the National Monument. The recommended alternative is further developed in Project Statement COSW-N-062.

- Pursue inclusion of National Monument waters in the U.S. Geological Survey's National Water Quality Assessment (NAWQA) Program .

The U.S. Geological Survey administers the National Water Quality Assessment (NAWQA) Program. The purpose of this nationwide program is to determine water quality conditions using standardized sampling and analytical techniques in the major watershed units of the United States and to periodically monitor water quality to determine trends. The Congaree River and the National Monument are included in NAWQA's Santee Basin and Coastal Drainage, North Carolina and South Carolina watershed unit. Water quality, streambed sediment, and biological tissue samples are collected from selected and representative sampling sites throughout each watershed unit, and then analyzed and reported according to NAWQA protocols. One of the criteria used in the selection of USGS-NAWQA study units was the "consideration of water-quality concerns and programs of other Federal and State agencies" (Leahy et al. 1990). The NAWQA program recognizes that considerable water quality data have been collected by federal and state agencies and that these data may be incorporated into water quality synthesis reports developed by NAWQA (Hirsch et al. 1988).

Alternative A: No new action. Sites within the National Monument will not be used as NAWQA water quality sampling stations. However, because the National Monument is located within the Santee Basin and Coastal Drainage NAWQA study unit, water quality trends for the Congaree River watershed may be useful to National Monument managers.

Alternative B (preferred alternative): Within the NAWQA program framework, conduct a synoptic study to assess the status of water and soil contamination within the National Monument. The study should be a collaborative effort between the National Park Service, USGS-NAWQA, and other federal and state agencies. The initial synoptic study will establish baseline conditions; future studies should be conducted within the NAWQA program rotation (6-7 years). This recommended action is further developed in Project Statements COSW-N-063 and COSW-N-067

Water Management in the Upper Congaree River Watershed Affecting Discharge

Statement of the Issue

The maintenance of the ecological integrity of the National Monument depends not only upon water quality but also on water quantity. The National Monument depends on periodic inundation by floodwaters of the Congaree River, Cedar Creek, and Toms Creek for the maintenance of biogeochemical cycling and sedimentation characteristic of floodplain ecosystems. Instream flow modification, such as the existing the Saluda Hydroelectric Project on the Saluda River or future impoundments on tributaries to the Congaree River system, as well as channel modification to Cedar Creek upstream from the National Monument, may result in alteration of the flow regime and the temporal and spatial distribution of flood peaks.

An additional concern to the NPS is the safety of visitors to the National Monument. The possibility of sudden, controlled or uncontrolled release of water from the Saluda Hydroelectric Project presents a risk to National Monument visitors and staff.

Management Alternatives

- Determine the effect of water management at the Saluda Hydroelectric Project on the water resources of the National Monument.

The construction of the dam at the Saluda Hydroelectric Project and the creation of Lake Murray on the Saluda River in Lexington County, South Carolina was completed in 1930. This hydroelectric facility is operated by the South Carolina Electric and Gas Company (SCE&G). Since the completion of the impoundment, the flow regime of the Congaree River has been modified such that flood height on the Congaree River at Columbia as been reduced (Patterson et al. 1985). The long-term ecological ramifications of the flow modification on the National Monument floodplain are not fully understood. Since flood peaks have been dampened, there may have been changes in sedimentation and organic debris transport, and seedling establishment in the upper portions of the floodplain.

Alternative A: No new action. The National Monument floodplain ecosystem has assumed a new ecological and geomorphological equilibrium in the absence of the pre-dam flood regime.

Alternative B (preferred alternative): Conduct a study to assess the impact of the Saluda Hydroelectric Project on the flood regime and ecology of the National Monument. Evaluate the operation plans of the facility to determine the feasibility of altering the water release pattern to more closely mimic the natural flood regime. Alternative B is further developed in Project Statement COSW-N-059.

- Evaluate the adequacy of the Emergency Action Plan of the Saluda Hydroelectric Project for flood alert.

The Federal Energy Regulatory Commission (FERC) requires that the Saluda Hydrologic Project have an Emergency Action Plan (EAP) in the eventuality of a catastrophic dam failure (SCE&G 1993). In 1994, SCE&G, which operates the Saluda Hydroelectric Project, was required to perform a new dam failure analysis, which is an integral part of the EAP. This revision included extending the flood inundation study to include the portion of the Congaree River at the National Monument, indicating flood elevations and travel times for both sunny day failure and failure during a probable maximum flood. The revised dam failure analysis was submitted to FERC in August, 1994 and is presently under review by FERC (K. Massey, SCE&G, personal communication, May 1995).

In the most recent revision of the Saluda Hydroelectric Project EAP, National Monument personnel are not notified directly by SCE&G in the event of a Class I (dam failure is imminent dam) or Class II (hazardous situation is developing) emergency. SCE&G's primary notifications are made to county Emergency Preparedness offices, which are the agencies responsible for directing evacuation efforts in their counties.

A flood warning system is being developed and will be implemented at the National Monument. This flood warning system uses USGS gauging station data from sites on the Congaree River upstream from the National Monument to predict flood water levels and timing at the National Monument (see Project Statement COSW-N-003.001). This flood warning system will be especially useful in predicting and warning of floods arising from natural, rainfall events. The early warning system also plays a role in alerting visitors to floodwaters that may arise from dam failure at the Saluda Hydroelectric Project. The Emergency Action Plan (EAP) for the Saluda Hydroelectric Project and the National Monument's EAP should be consulted for specific procedures to follow to evacuate visitors in the event of rising floodwaters.

Alternative A: No new action. The present emergency warning system is adequate to protect National Monument visitors and NPS personnel.

Alternative B (preferred alternative): Periodic revisions and updates to the Saluda Hydroelectric Project EAP are delivered to the National Monument by SCE&G. Revisions and updates are made at least annually. Any time there is a change in National Monument management personnel or their telephone numbers, National Monument personnel, the Saluda Hydroelectric Project EAP Coordinator and the Richland County Emergency Preparedness officials should be notified and the EAP should be updated. National Monument management should prepare and distribute a listing of alternative National Monument personnel to be contacted in the event of an emergency. The Saluda Hydroelectric Project EAP coordinators, Richland County EPD, and National Monument personnel should develop and practice evacuation procedures from the National Monument in preparation for Class I and II emergencies and carry out a drill employing the National Monument flood warning system.

- Review proposals for hydroelectric and water supply development within the watersheds of the Congaree River.

A proposed 137-acre water supply reservoir on the North Tyger River is the only impoundment presently scheduled in the greater Congaree River watershed. The consequences of this impoundment on the volume and timing of water reaching the National Monument is not known. As development within the Congaree River watershed continues, there will be an increasing demand on water supplies; this may necessitate the construction of additional water supplies and hydroelectric impoundments.

Alternative A: No new action. No action assumes that relatively small water impoundments will have little impact on the water regime at the National Monument.

Alternative B (preferred alternative): Conduct an investigation to determine the potential for water supply and hydroelectric development within the Congaree River watershed. This investigation should address the potential influence of future impoundments on water flow at the National Monument. Request that SCDHEC Water Pollution Control/Dam Safety Section and the FERC advise National Monument management of proposals for future water supply and hydroelectric impoundments. Be prepared to comment on the operating plans of proposed impoundments to better ensure that new impoundments will have a minimal impact on the National Monument.

In November 1995, the U.S. Army Corps of Engineers, Charleston District initiated the Santee/Cooper/Congaree General Investigations Study. Aspects of this program include conducting reconnaissance and feasibility studies of water related issues such as the downstream effects of hydroelectric and water supply development, and provide technical assistance to address these issues (US Army Corps of Engineers 1994). Upon the completion of this study, National Monument management should review its findings and consult with Corps of Engineers officials on matters of consequence to the National Monument.

- Review proposals for dredging and channel alteration of the Congaree River, Cedar Creek, or Toms Creek.

Channel alteration of the Congaree River, Cedar Creek, or Toms Creek as well as of their tributaries upstream from the National Monument, will affect the long-term water regime and short-term water quality of the river and floodplain. Widening, deepening, or channelizing these waterways either upstream or downstream of the National Monument or removing snags and obstructions from the Cedar Creek and Toms Creek will increase water conveyance and alter normal flood peaks on the National Monument floodplain.

Alternative A: No new action. Dredging and channel alteration are not imminent concerns.

Alternative B (preferred alternative): Request that the U.S. Army Corps of Engineers advise management personnel at the National Monument of proposed dredging or channel alteration activities on Cedar Creek, Toms Creek, and their tributaries, and on the Congaree River between Columbia and its confluence with the Wateree River. In addition, because the U.S. Fish and wildlife Service and the South Carolina Wildlife and Marine Resources Department are routinely notified prior to dredging operations, local offices of these agencies should be requested to notify National Monument personnel of proposed dredging activities as a means of back-up notification. Review proposals to determine the extent of the threat to the National Monument and, if deemed necessary, request that the Corps of Engineers conduct further assessments concerning the potential impacts to the National Monument.

Land Use Within the Congaree River Watershed and the Cedar Creek and Toms Creek Watersheds.

<u>Statement of the Issue</u>

Within the past half-century, the Congaree River watershed has changed from an agriculture-dominated landscape to an increasingly urbanized, industrial, and residential landscape. Although much of the former farmland has reverted to second-growth forest, the major urban centers of Columbia, Greenville, and Spartanburg continue to expand. Soil erosion and stream sedimentation rates are probably less now than when agriculture was more prevalent. However, stormwater runoff from urban, industrial, and residential areas, as well as wastewater discharges associated with these land uses present, an on-going threat to the waters of the Congaree River, its tributaries, and the National Monument.

Changes in watershed-scale land use can be best monitored using remotely sensed data (high altitude aerial photography and satellite imagery) and geographic information system (GIS) database technologies. The South Carolina Department of Natural Resources, Land Resources and Conservation Districts Division (formerly the South Carolina Land Resources Conservation Commission) was contracted by the NPS to prepare a characterization of wetland resources in the National Monument using these technologies. The product of this project is the "Wetland Resource Characterization of the Congaree Swamp National Monument, South Carolina: Database Preparation Based on Remotely Sensed Data for Use in Geographic Information Systems" (Lacy and Somers 1995). In preparation of this document, overflight photographic imageries, including hard copy photos and transparencies, were obtained in 1992 from the National Aerial Photograph Program (NAPP) image data base for South Carolina (dates 1989-91). Scale corrected color infrared aerial photographs were received for post-Hurricane Hugo NAPP at scales of 1:24,000 (1" = 2000') and 1:4,800 (1" = 400'). Color infrared transparencies at a scale of 1:40,000 (1" = 3,333') were obtained for both pre- and post- Hugo NAPP. These NAPP images are the basis for completing all current land base maps and more precisely identifying surficial features.

The color infrared transparencies for pre- and post-Hurricane Hugo NAPP imagery were scanned and stored on laser discs and magnetic tape. A total of 16 transparencies were scanned. The resolution of the scanned imagery is approximately 2 meters. Ninety-one ground control points (GCP) were collected using Trimble Pathfinder Basic-plus global positioning systems (GPS). Using the rectification procedures contained within the Earth Resources Data Analysis System's (ERDAS) software package, each scanned NAPP image has been geometrically corrected and edge-matched to develop a photo mosaic of the National Monument region. The Congaree River floodplain was extracted from this data set and used to georeference the contour data for the National Monument.

Contour data for the National Monument has also been digitized, transformed, and rectified to the image-based NAPP photo composite. The National Wetlands Inventory (NWI) maps for the Gadsden and Wateree 7.5' topographic quadrangles have been digitized and converted to the Universal Transmercator (UTM) coordinate system. Additionally, the 1980 Gaddy/Smathers vegetation map has been digitized and rectified to the NAPP image-based mosaic of the National Monument. Also as part of the wetlands inventory and GIS project, the SPOT satellite image of the National Monument and surrounding area has been classified and completed.

The final report prepared by Lacy and Somers (1995) provides coarse-resolution maps of vegetation coverage type, soil types, and hydrographic contours which may be of value as management tools within the National Monument. However, since the watersheds of Cedar Creek, Toms Creek and the Congaree River are largely outside the National Monument boundaries and since land use activities in the watershed may significantly impact the water resources and ecology of the National Monument, remote sensing and GIS technologies should be used to monitor and analyze watershed-scale land use changes.

The University of South Carolina, Department of Geography, Hazards Research Lab is utilizing GIS technologies to analyze environmental hazards in South Carolina and Georgia. The Lab develops and utilizes GIS databases to assess community risks, improve flood forecast and dam failure risks, and identify potential sources of contaminants. This information is available upon request and should be consulted by National Monument managers on a regular basis to detect changes in land use that may affect the National Monument.

Management Alternatives

- Monitor the effect of changing land use patterns within the Congaree River watershed and the Cedar Creek and Toms Creek watersheds on the water resources and ecology of the National Monument.

Ten land use coverage categories were assigned to the Congaree River watershed in 1992, within the state of South Carolina. These data were prepared by the South Carolina Land Resources and Conservation Districts Division from the National Aerial Photograph Program (NAPP) image data base for South Carolina. Seventeen percent of the Congaree River watershed lies within the state of North Carolina; this section of the watershed has not been analyzed using remote sensing techniques.

Alternative A: No new action. Land use information based on analysis of remote sensing data is available from the National Wetland Inventory and the South Carolina Land Resources and Conservation Districts Division. These existing databases can be used for management decisions at the National Monument.

Alternative B: Develop a Project Statement to be included in the Resources Management Plan for the Congaree Swamp National Monument to continue the collaborative effort between the NPS and the South Carolina Land Resources and Conservation Districts Division to further develop a GIS database to monitor and analyze land use changes in the greater Congaree River watershed. Collaborate with the University of South Carolina, Hazards Research Lab to conduct an environmental hazards risk study for the National Monument.

Alternative C: Review land use plans that have been developed by the Central Midlands Regional Planning Council, Planning Councils for Richland, Lexington, and Calhoun Counties, and the City of Columbia Zoning Division. Actively participate and coordinate with these planning offices to promote environmentally appropriate development and land use in areas that may directly impact the National Monument. Be prepared to comment on any proposed livestock slaughterhouses or other intensive agricultural operations that may precipitate major land use changes to agricultural lands in the region.

The recommended preferred alternative is implementation of both Alternatives B and C.

- Interact with local economic development and planning agencies.

Since the National Monument is located at the lower end of a largely agricultural, industrial, and urbanized watershed, there is a significant risk to its ecosystems due to water quality degradation and/or water withdrawals within the watershed. Understandably, the National Monument cannot influence development activities in the Congaree River watershed, but the National Monument may be able to influence development immediately upstream from its boundaries on the Congaree River and in the local watersheds of Cedar Creek and Toms Creek.

Alternative A: No new action. The National Monument is provided with the Richland County Comprehensive Land Use Plan Update: Lower Richland which is prepared by the Central Midlands Regional Planning Council on a 3-5 year interval.

Alternative B (preferred alternative): Representatives of the National Monument should attend local government meetings and meeting of citizens groups (such as the Sunrise Development Corporation) when issues pertaining to land use are discussed. In lieu of attending planning commission and other pertinent meetings, the National Monument should be provided with minutes of the meeting and permitted the opportunity to comment. Additionally, U.S. Army, Fort Jackson and McEntire ANG Base should notify the National Monument of planned development and changes in land uses on military installation properties lying within the watersheds of Cedar Creek and Toms Creeks.

Congaree River and Tributary Corridor Planning

Statement of the Issue

The establishment of instream protective zones and buffer zones along streams adjacent to or flowing into the National Monument is an important step toward the maintenance or improvement of water quality in the National Monument. To preserve the ecological quality of the National Monument, protection of water resources must begin beyond the designated boundaries of the National Monument. State and federal programs should be considered which limit certain types of instream and streamside development that are not compatible with the protection of stream water quality. The National Wild and Scenic River System and the South Carolina Scenic Rivers Program should be given due consideration as potential means to further protect the integrity of the Congaree River corridor. The South Carolina Scenic Rivers Program is less restrictive and thus may be more acceptable to streamside landowners. However, neither program should be dismissed outright and should provide a framework for any serious cooperative river corridor planning effort.

The Santee/Cooper/Congaree General Investigations Study sponsored by the U.S. Army Corps of Engineers, Charleston District recognizes the need for riparian and tributary planning for the Congaree River and its tributaries (J. Preacher, Acting Chief, Planning Branch, US Army Corps of Engineers, Charleston District, draft WRMP review comments, March 1995). Concomitant with this interest, the Corps of Engineers and the National Park Service may collaborate on initiatives designed to protect riparian corridors.

Management Alternatives

- Pursue the designation of portions of the Congaree River and Cedar Creek adjacent to or upstream from the National Monument as National Wild and Scenic Rivers or South Carolina Scenic Rivers.

The inclusion of segments of the Congaree River and Cedar Creek in federal and/or state designation programs would provide these waterways with limited instream and/or riparian corridor protection. Stream segments within the National Monument may be appropriate for federal designation in the National Wild and Scenic Rivers program. The intent of such designation is to preserve the "outstandingly remarkable features" of the river or streams; in so doing, downstream and adjacent riparian habitats should benefit ecologically. "Outstandingly remarkable features" refers to appraisal of riverine attributes based on best professional judgement of federal agency personnel conducting Wild and Scenic River studies (Coyle 1988). An additional benefit of federal designation would be national recognition of the recreational and aesthetic value of the resource. The riparian land use restrictions imposed with this designation may be problematic in the human-dominated landscape outside of the National Monument boundaries. Rivers and streams of any size, either for their entire length or for specific segments, may be considered for designation in the federal program (P.L. 90-542, as amended, the Wild and Scenic Rivers Act). There are three designation categories: "wild," "scenic," and "recreational." Designation depends upon the status of existing water quality, the presence of impoundments or other modifications to the natural flow regime, and land uses on adjacent lands. Since two small impoundments (Duffies Pond and Clarkson Pond) are located on the segment of Cedar Creek upstream from the National Monument, this segment may be considered for "recreational" status only. The segment of Cedar Creek within the National Monument may qualify as "wild" or "scenic" since access is limited, the shoreline is undeveloped, and the old-growth forest through which it flows represent "vestiges of primitive America." One potential problem that may influence "wild" river designation for the National Monument segment of Cedar Creek is a relic dam near Wise Lake. Site remediation may be required if "wild" river designation is pursued.

Another alternative for river and stream protection outside the boundaries of the National Monument would be through the South Carolina Scenic River Program. The South Carolina Scenic Rivers Act (SC Code of Laws, 1989, Title 49, Chapter 29) provides protection of the "unique or outstanding scenic, recreational, geological, botanical, fish, wildlife, historic, or cultural values" of designated rivers and streams. River corridor protection through the South Carolina Scenic Rivers Program entails the cooperative and voluntary agreement among landowners, community interests, and the South Carolina Department of Natural Resources to develop long-term management strategies which will preserve traditional uses of the river as well as the scenic character of the river corridor (SC Water Resources Commission 1991). Landowners may voluntarily participate in the program to conserve and manage the river corridor through land registration, management agreement, conservation easement, and land donation within a scenic river management plan. The plan consists of: (1) an inventory of existing land uses; an assessment of the scenic, recreational, geological, botanical, fish, wildlife, historic, or cultural attributes of the river corridor; (2) an overview of problems in the river corridor and possible solutions; and, (3) a scenic river management plan written by a Scenic River Advisory Council made up of landowners along the river and interested members of the public (paraphrased from the Fact Sheet of the South Carolina Department of Natural Resources, Water Resources Division, Columbia, South Carolina Scenic Rivers Program).

The Congaree River was one of only seven rivers in the state determined to have statewide or greater than statewide significance in seven resource categories (i.e., scenic, recreational, geologic, fish, wildlife, historic and cultural, and other remarkable characteristics) (National Rivers Inventory of 1982). This, coupled with the State Scenic Rivers program listing of the Congaree River as a Class II Pastoral River in 1988, should help qualify the Congaree River as a candidate for higher level South Carolina Scenic River status. Cedar Creek and Toms Creek may also be eligible for designation in either the federal or state programs. Toms Creek is considerably smaller in size and is not suitable for canoeing; however, designation is not necessarily dependent upon these criteria.

Alternative A: No new action. The 24-mile segment of the Congaree River adjacent to the National Monument is recognized as eligible for designation as a South Carolina Scenic River by the 1988 Statewide Rivers Assessment. This provides no protection or preservation of the scenic, aesthetic, historic, and wildlife qualities of the river.

Alternative B: Pursue inclusion of the segment of the Congaree River adjacent to the National Monument and/or the segment of Cedar Creek and Toms Creek within the National Monument into the National Wild and Scenic Rivers System. Federal designation is possible either by congressional enabling legislation or, in the case of state administered components, by the Secretary of the Interior. A state administered component seems to be the most sensible approach for the Congaree River, while NPS administration would be appropriate for designated segments of Cedar Creek and Toms Creek within National Monument boundaries (P.L. 90-542 as amended; 16 U.S.C. 1271-1287).

In the event that Alternative B is not practicable, initiate the inclusion of segments of the Congaree River and Cedar Creek in the South Carolina Scenic Rivers program. Inclusion of these waterways in the state program requires that an eligibility study be conducted by the South Carolina Department of Natural Resources. Criteria that are considered include: stream water quality, extent of development on riparian lands, cultural and historical features, and wildlife habitat (B. Beasley, South Carolina Department of Natural Resources, South Carolina Scenic Rivers program, personal communication, April 1995). Upon recommendations of the SCDNR, the South Carolina General Assembly determines if the stream segments will be included in the South Carolina Scenic Rivers program. Inclusion of segments of the Congaree River and Cedar and Toms Creeks into the National Wild and Scenic Rivers System and/or the South Carolina Scenic Rivers Program is discussed in Project Statement COSW-N-023

- Pursue the establishment of watershed and streamside protection zones for Cedar Creek and Toms Creek.

The water quality of Cedar Creek, Toms Creek, and other tributary streams that originate outside of, and then flow through the National Monument may be degraded due to land use practices within their watersheds that are environmentally unsound. Most of these streams are bordered by forested riparian wetlands which tend to trap some sediments, nutrients, and pollutants, and provide surface water storage which diminishes downstream flooding. However, logging of these forested wetlands and intensive agricultural and residential development in the surrounding uplands may compromise the buffering ability of the riparian zone. Landowners adjacent to the streams and within their watersheds may participate in any of several state and federal programs designed to promote sound land stewardship and protect water quality. Many of these programs provide cost-share, tax reduction, or direct payment incentives.

Alternative A (preferred alternative): In cooperation with the Richland County office of the U.S. Department of Agriculture, Natural Resources Conservation Service, the National Monument management should encourage landowners in the watersheds of Cedar Creek, Toms Creek, and other tributaries in the area to voluntarily enroll in appropriate conservation and best management practices (BMPs) programs. Landowners should be advised of the economic and environmental benefits of these programs, the limitations placed on land use, and enrollment requirements. A partial listing of pertinent conservation programs is included in Table 16.

Table 16. State and federal conservation programs that are available to private landowners and that establish streamside protection or improve watershed water quality.

Conservation Programs	Agency*	Principal Goal
Conservation Reserve Program	NRCS	Conversion of highly erodible land or flood-prone land to conservation usage
Forestry Incentive Program	NRCS	Establishment of permanent forest coverage
Forestry Stewardship Program	SCFC	Prevention of soil erosion and water quality improvement
South Carolina Agricultural Conservation Program	FSA	Prevention of soil erosion, establishment of permanent coverage, and reduced crop tillage and pesticide use
Water Quality Incentive Program	FSA, NRCS	Construction of sediment retention ponds
Wetland Reserve Program	NRCS, USFWS	Wetland restoration and preservation

* NCRS = Natural Resources Conservation Service, U.S. Department of Agriculture
SCFC = South Carolina Forestry Commission
FSA = Farm Service Agency (formerly Agricultural Stabilization and Conservation Service (ASCS), U.S. Department of Agriculture
USFWS = U.S. Fish and Wildlife Service, U.S. Department of the Interior

National Monument Operations, Visitor Use, and Safety

Statement of the Issue

In 1994, visitation at the National Monument was 67,756. Based upon current trends, the five year and ten year projected increase in visitation will result in approximately 123,500 visitors in 1999 and 179,100 in 2004 (R. Clark, Congaree Swamp National Monument, personal communication, April, 1995). With these expected increases, visitor safety becomes more problematic. Flood prediction capabilities are needed to predict when visitors can safely use the National Monument trail system and to provide warning for the safety of backcountry visitors. Water supplies and wastewater disposal systems may be inadequate to meet demands of increased visitation. Additional recreational usage of trails and backcountry may impact trailside and floodplain vegetation, as well as water quality.

Management Alternatives

- Implement a flood warning system for the National Monument.

Most of the National Monument is part of the floodplain of the Congaree River. The site is located where the floodplain broadens as the river flows from the Piedmont to the Coastal Plain. Long-term records (since 1934) of stage height and discharge at Columbia, South Carolina, provide an adequate data set upon which to predict discharge from precipitation events in the Piedmont. The gauging station at Columbia provides a site for continuous monitoring of stage height, and is located sufficiently far upstream that a lag time of approximately 1 day is required for a flood peak to travel from the station to the National Monument. Not predicable at this time is the rate at which flood waters would rise at different locations in the floodplain (e.g., riverbank environments, deep oxbow sloughs, floodplain interior), the duration of a given flood event, and the flooding status of major trails and visitation sites during such flood events.

The NPS has the responsibility to forecast flood events for potential visitors and to predict flood dynamics for current visitors in the National Monument. It is anticipated that a one to two day prediction should be adequate to ensure visitor safety.

Alternative A: No new action. Existing relationships between river stage at Columbia and extent of flooding after the lag period are adequate for forecasting floods for potential visitors and flood depths for visitors in the National Monument.

Alternative B (preferred alternative): To develop flood prediction capabilities that can forecast for potential visitors the timing, depth, and duration of wetland flooding and a warning system to notify visitors of flooding status at particular sites in the swamp floodplain. The current one to two day prediction is not adequate for visitor safety. [This project is being conducted by John C. Hayes and Dave E. Linvill at Clemson University (COSW-N-003.001).] Recommendations on what type of warning system, if any, is expected to be made as part of this study.

- Evaluate the development and maintenance of water and wastewater facilities for NPS staff and visitors within the National Monument.

Drinking water supplies in the National Monument must meet criteria established by the South Carolina Safe Drinking Water Act (Title 44, Chapter 55, S.C. Code of Laws 1976, as amended); additionally, the National Monument must meet NPS criteria established for units of the National Park System (NPS 1991). Upgrades and inspections to the well water supply system must be approved by SCDHEC (Environmental Quality Control, Drinking Water Protection); upgrades and inspections to the wastewater disposal system must be approved by SCDHEC (Office Environmental Health, On-site Wastewater Management).

Backcountry users are not advised to drink surface water that has not been treated with an effective portable treatment apparatus (i.e., filter apparatus or chemical treatment) that eliminates biological pathogens. Such water treatment systems are commercially available and are typically used by campers and hikers to obtain potable water from surface waters.

Alternative A: No new action. Presently, the water supply wells at the National Monument are inspected on a 2-3 year basis.

Alternative B (preferred alternative): Request annual inspections of the National Monument's existing water supply wells and wastewater disposal systems by SCDHEC. Submit future water supply and wastewater disposal system designs to the appropriate SCDHEC agencies (Environmental Quality Control and Environmental Health) and to the Richland County, Health Department, Office of Environmental Health.

- Evaluate the potential for groundwater contamination from aboveground fuel storage tanks within the National Monument.

The environmental consequences of a major fuel spill in the National Monument may be severe due to the close proximity of aboveground fuel storage tanks to the waters of the National Monument. However, the limited fuel storage capacity of the tanks would restrict the extent of contamination. The potential for an accidental spill is probably minimal if the fuel storage tanks are properly maintained, inspected, and surrounded with appropriate containment structures. Generally, containment structures should be capable of retaining 200% of the fuel storage tank capacity.

Alternative A (preferred alternative): No new action. The aboveground storage tanks at the National Monument are adequate to contain accidental leaks or spills. The Richland County Emergency Services Department, Fire Marshal Division will routinely conduct inspections of present and future fuel storage facilities in the National Monument. National Monument management may request more frequent inspections if the aboveground tanks show signs of deterioration.

- Assess the impact of existing man-made structures within the National Monument on water flow regime.

Man-made structures that may affect the hydrologic regime within the National Monument consist of shelters for water level recorders, roadbeds, and bridges for hiking trails and vehicular traffic. Most of these structures have been in existence for many years and are probably of minimal impact to the hydrologic regime of floodplain.

Four water level gauging stations have been established by the USGS within the National Monument. Stations are located on Cedar Creek near Old Bluff Road, Cedar Creek near the Dawson cabin, Cedar Creek near Wise Lake, and adjacent to the Congaree River on the River Trail. At each station there is a 1-ft. diameter metal pipe seated vertically in the streambed and a small shelter elevated above the adjacent bank on support pilings. During low flow conditions, these structures do not obstruct or constrict water movement. However, during flood conditions woody debris may accumulate on the pipes or pilings which may alter water flow to a small degree and alter the distribution of detritus. A system of flood crest gauges that have been established along small watercourses does not interfere with water movement.

Six groundwater observation wells were established as part of the Patterson et al. (1985) study. These wells were capped at the completion of the study and are currently inactive. Unless the recharge area for the National Monument undergoes a significant increase in groundwater withdrawals, information from the Patterson et al. (1985) appears to be sufficient for water resource management decisions. Future groundwater monitoring would be warranted if the recharge area for groundwater in the National Monument experiences increased withdrawals for agricultural irrigation, residential development, or industry. If such withdrawals occur, the inactive wells should be evaluated for their contribution to a larger network of groundwater monitoring stations.

Several unpaved roadbeds exist within the National Monument, primarily in its western section. Though originally constructed prior to the establishment of the National Monument, two roads are maintained for use by NPS staff, researchers, and visitors. The most frequently used road extends from the National Monument contact station to Wise Lake, while the second road follows the National Monument's western boundary to the Congaree River. Culverts have been placed in the roadbed where the road intersects watercourses. Several other roads within the National Monument have been abandoned and may temporarily restrict water movement. In addition to possible influences of roads on surface water flow, near-surface groundwater flow may have been altered by the accumulated fill material used to create roadbeds.

Along hiking trails, several wooden bridges across permanent streams and watercourses have been constructed by the NPS. During floods, woody debris may accumulate at the support pilings resulting in damage to the bridge and interfering with canoe access. NPS staff regularly maintains these bridges and removes accumulated debris.

A small relic dam is located on Cedar Creek near Wise Lake. Although the dam has been broken for many years, brick, concrete, and stone blocks in the streambed tend to constrict water flow and create unnatural turbulence. This condition has minimal adverse impacts on the stream ecosystem but may present problems for unsuspecting or inexperienced canoeists. Since "wild" river designation in the National Wild and Scenic Rivers Program is contingent upon an unaltered flow regime, the existence of structures which alter flow regime may impede designation of the segment of Cedar Creek within the National Monument as a "wild" river.

Alternative A: No new action. Man-made structures within the National Monument have a negligible impact on water regime.

Alternative B (preferred alternative): Roads, culverts, buildings, the relic dam on Cedar Creek, and other man-made features have an unnatural effect (albeit minimal) on flow regime. An assessment of the impact of man-made structures on flow regime is addressed in Project Statement COSW-N-064.

Public Awareness and Environmental Education

Statement of the Issue

One of the principal goals of the National Park Service is to inform and educate. To better accomplish this goal, there is a need to increase public awareness of the existence and value of the National Monument locally, regionally, nationally, and internationally. The value of the National Monument ecosystem is often underestimated by the general public, possibly as a consequence of a lack of understanding and misunderstanding of bottomland hardwood swamps and other wetlands or forests.

Management Alternatives

- Promote public recognition of the National Monument as an important ecological and recreational resource.

Visitors to the National Monument may develop a better understanding of the floodplain ecosystem if the appropriate printed information is available to them. Presently, a brochure (GPO: 1992-312-248/60007) is available to visitors which provides basic information about the National Monument's ecosystems, with emphasis on the biological resources and record trees of the National Monument. Although reprinted in 1992 and 1995, the brochure does not include information about Hurricane Hugo (1989) and its effects on forest structure in the National Monument.

International recognition has been afforded the National Monument by its inclusion in the United Nations Educational, Scientific, and Cultural Organization's (UNESCO) Biosphere Reserve Program. The Biosphere Reserve Program is an integral part of UNESCO's Man and the Biosphere Program (MAB) which provides a knowledge-base to facilitate a better understanding of the interrelationships of humans and their environment. In 1983, the National Monument was designated a part of the South Atlantic Coastal Plain Biosphere Reserve; the Pinelands National Reserve in the New Jersey Pine Barrens is the National Monument's partner reserve. Biosphere Reserves are designated because they are minimally disturbed and are valuable in monitoring global change and for promoting ecological research. Considerable ecological research has already been conducted in the National Monument. This research can be used to provide baseline ecological information.

Alternative A: No new action. The existing brochures and printed information available to visitors and visiting researchers provide a general overview of the National Monument and its resources. However, the visitor is not provided with sufficient information to develop an understanding of bottomland hardwood forest and swamp forest ecology, or of the importance of these ecosystems in the watershed and landscape.

Alternative B (preferred alternative): Coordinate with private partner organizations such as the National Park Foundation to upgrade the visitor brochure and printed information available to visitors. The upgrade will entail a synthesis of information on floodplain hydrology and the ecological functions and values of the National Monument's ecosystems in the local, regional, and international landscape.

In addition, promote the fact that the National Monument is a Biosphere Reserve. As a Biosphere Reserve, the National Monument may serve as a reference site to monitor future environmental changes in the National Monument and to compare environmental impacts in similar ecosystems within the region. Encourage the use of the National Monument as a host site for small conferences or meetings (if facilities are adequate) and for field excursions for conferences held in the Columbia area. Provide local and regional universities and ecological research institutions with a semiannual listing of research opportunities and needs in the National Monument. This alternative is further developed in Project Statement COSW-N-065.

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APPENDIX A

Project statements described on the following pages. These project statements will also be incorporated into the Congaree Swamp's Resources Management Plan with priorities being the same as indicated. Priorities assigned '0' are funded projects.

<u>Number</u>	<u>Title (priority no.)</u>
COSW-N-003.001	Develop a flood prediction system and implement a flood warning system for the Congaree Swamp National Monument . . . . (0)
COSW-N-005	Wetlands inventory and vegetation mapping . . . . (0)
COSW-N-017	Fish ecology and gamefish management study . . . . (16)
COSW-N-018	Aquatic macroinvertebrate community surveys of major waterways . . (11)
COSW-N-023	Participate in the development of a river corridor plan for the Congaree River and tributaries . . . . (9)
COSW-N-058	Improve understanding of fluvial geomorphic processes of the Congaree River floodplain . . . . (4)
COSW-N-059	Improve understanding of hydrodynamics of the Congaree River floodplain . . . . (5)
COSW-N-060	Assess the current status of water quality and compliance with South Carolina water quality standards . . . . (6)
COSW-N-061	Upgrade stream classification of Cedar Creek to Outstanding Resource Waters . . . . (8)
COSW-N-062	Assess contaminant sources and pathways affecting the Congaree Swamp National Monument . . . . (7)
COSW-N-063	Adopt an interagency collaborative approach to monitoring water quality in the Congaree Swamp National Monument . . . . (0)
COSW-N-064	Assess the impact of existing man-made structures within the National Monument on water flow regime . . . . (17)
COSW-N-065	Promote national and international recognition of the National Monument as an important ecological and recreational resource . . . . (23)
COSW-N-067	Ecological processes and profiles of major waterways in the Congaree Swamp National Monument . . . . (0)

PROJECT STATEMENT

PROJECT NUMBER: COSW-N-003.001

Last Update: 01-15-96 Priority: 0
Initial Proposal: 1993

Title: DEVELOP A FLOOD PREDICTION SYSTEM AND IMPLEMENT A FLOOD WARNING SYSTEM FOR THE CONGAREE SWAMP NATIONAL MONUMENT.

Funding Status: Funded: 50.00 Unfunded: 0.00

SERVICE WIDE ISSUE CODES: N12 (WATER FLOW)
N20 (BASELINE DATA)

PROBLEM STATEMENT:

The Congaree Swamp National Monument contains one of the few remaining old-growth forests in the eastern United States. Most of its 22,200 acres is in the floodplain of the Congaree River, a major drainage within the Santee River basin that discharges to the Atlantic Ocean. The National Monument is located just east of the Fall Line between the Piedmont and Coastal Plain in South Carolina. Most of the site floods annually. This feature, in addition to the numerous oxbow lakes and perennial streams, is critical to the maintenance of the old-growth forest and concurrently makes the site rich in a variety of aquatic ecosystems. The relatively undisturbed condition of the National Monument, and especially the stature of its old-growth forests, makes the site attractive for tourists, hikers, and researchers.

In 1994, visitation at the National Monument was 67,756. The 5-year and 10-year projected increase in visitation will result in approximately 123,500 visitors in 1999 and 179,100 in 2004 (R. Clark, Congaree Swamp National Monument, personal communication, April, 1995). With these expected increases, visitor safety becomes more crucial. The development of flood prediction capabilities is imperative to control visitor access to the National Monument trail system during flood events and to ensure the safety of backcountry visitors.

Most of the National Monument is part of the floodplain of the Congaree River. The site is located where the floodplain broadens as the river flows from the Piedmont to the Coastal Plain. Long-term records (since 1939) of stage height and discharge at Columbia, South Carolina, provide an adequate data set upon which to predict discharge from precipitation events in the Piedmont. The gauging station at Columbia provides a site for continuous monitoring of stage height, and is located sufficiently far upstream that a lag time of approximately 1 day is required for a flood peak to travel from the gauging station in Columbia to the eastern boundary of the National Monument. Not predicable at this time is the rate at which flood waters would rise at different locations in the floodplain (e.g., riverbank environments, deep oxbow sloughs, floodplain interior), the duration of a given flood event, and the flooding status of major trails and visitation sites during such flood events.

The NPS has the responsibility to forecast flood events for potential visitors and to predict flood dynamics for current visitors in the National Monument. It is anticipated that a one to two day prediction should be adequate to ensure visitor safety for those within the National Monument and those planning to visit the same or the next day. Longer predictions would be for the planning convenience of longer-distance travelers. Real-time information should be available on what parts of the National Monument are flooded. This is highly site specific because ground elevations differ by as much as 2-3 meters within the floodplain.

Flooding due to failure of the Saluda Dam, and the flood warning system in force for such an event, is addressed in the Issues and Management Alternatives section of the Congaree Swamp National Monument Water Resources Management Plan.

DESCRIPTION OF RECOMMENDED ACTION OR ACTIVITY:

It is recommended that flood prediction capabilities be developed. Most urgent is a warning system to notify current visitors within the National Monument, both campers and day hikers, that they are in danger of becoming trapped, or, in some cases, may become exposed to life-threatening conditions. Secondly, day visitors must be made aware when passing by the contact station of predictions that forecast the timing, depth, duration, and location of flooding for the day of the visit. Finally, 7 day predictions are needed for potential visitors that inquire by phone on the flooding status at particular sites as it may affect their plans for National Monument use. The current one to two day prediction is not adequate for those traveling longer distances to visit the National Monument .

Status:

This project is being conducted by John C. Hayes and Dave E. Linvill at Clemson University. The 5-year project is scheduled to conclude in 1999. The warning system should meet established standards of appropriate agencies.

Budget and FTEs:

-----FUNDED-----

	Source	Activity	Fund Type	Budget ($1000s)	FTEs
FY94:	NPS	RES	ONE-TIME	25.00	0.1
FY95:	NPS	RES	ONE-TIME	25.00	0.1
			Total:	50.00	0.2

Compliance Codes: EXCL

Explanation: 516 DM2 APP. 2, 1.6

PROJECT STATEMENT

PROJECT NUMBER: COSW-N-005

Last Update: 01-15-96 Priority: 0
Initial Proposal: 1991

Title: WETLANDS INVENTORY AND VEGETATION MAPPING

Funding Status: Funded: 97.00 Unfunded: 96.30

SERVICE WIDE ISSUES: N17 (BIODIVERSITY)
N20 (BASELINE DATA)

PROBLEM STATEMENT:

The Congaree Swamp National Monument is a 22,200-acre old growth forest in the Congaree River floodplain on the South Carolina Coastal Plain. The National Monument contains a complex and varied pattern of wetland plant communities that results from changes in river meanders and variations in the frequency and duration of flooding. The Resource Management Plan (NPS 1993) for the National Monument recognizes the need to better understand how the floodplain ecosystem functions. Critical to this understanding is an accurate baseline map of the wetland plant communities supported by up-to-date quantitative data regarding the composition and structure of these communities. The map must be meaningful to a variety of users, including resource managers, researchers, planners, interpretive staff, operations personnel, and the general public. Until an accurate baseline map is established, attempts to detect and quantify wetland vegetation change, whether from natural or human caused disturbance or from natural ecological successional processes, will not be successful. Such a wetlands vegetation map will become a part of the geographic information system (GIS) of the National Monument and will be referenced to soils, hydrologic data, and other information such as National Wetlands Inventory maps.

A detailed vegetation map of the Congaree Swamp National Monument was prepared by Smathers (1980). This map was based on extensive but largely qualitative field sampling (performed in 1975) followed by subjective interpretation of aerial photography. As a result, the map is not repeatable and thus cannot serve as a baseline for change detection. Furthermore, the map does not reflect the impact of Hurricane Hugo, which significantly affected the forests of the National Monument in September of 1989.

The newly developed GIS for the National Monument (Lacy and Somers 1995) includes a vegetation map based on remotely sensed data (aerial photography and satellite imagery). This GIS will prove valuable to managers at the National Monument. However, the vegetation/wetlands component is not sufficiently detailed to permit detection of changes due to natural or human influences. Such changes are most likely to be subtle and gradual rather than catastrophic. This component delineates only a few easily recognizable vegetation types because it is based on remotely sensed data acquired in winter of 1989 (before Hurricane Hugo). These vegetation types have not been verified by up-to-date ground truthing through field sampling.

The two maps currently representing the complex vegetation of the National Monument thus have both advantages and shortcomings. The Smathers (1980) map is detailed but subjective and dated; the new map is repeatable (because it is based on computer classification of imagery) but is insufficiently detailed and also does not reflect recent hurricane effects. Comparisons of the maps are confounded by these differences. There is a clear need to delineate vegetative communities in sufficient detail and with repeatable methods to allow detection of changes attributable to natural or human influences. Remotely sensed data must be corroborated by extensive, updated field sampling, and the results must be integrated within the existing GIS.

DESCRIPTION OF RECOMMENDED ACTION OR ACTIVITY:

The major goal is to develop and execute a program of standardized data acquisition and analysis that allows detection of observable change in the wetlands vegetation of the National Monument attributable to natural or human causes. The expected outcomes of this research include a field verified, repeatable baseline map of vegetation cover types, quantitative descriptions of the forest vegetation in the cover types, and a protocol for data acquisition (both field and remotely sensed data) and analysis, classification, and interpretation.

Specific goals, and the methods to be used to attain those goals are:

(1) Acquisition of satellite imagery

Satellite imagery (e.g., Systeme Probatoire d'Observation du Terrain [SPOT] or Landsat Thematic Mapper [TM] imagery) would be preferable for vegetation classification in the National Monument. The resolution (20 meters for SPOT, 30 meters for TM) integrates vegetation characteristics of species associations that may be repeated across a landscape (e.g., tupelo/bald cypress forest). In contrast, the resolution of aerial photography is often too high to generalize to the level of species associations. Also, available satellite imagery does not require corrections for many of the distortions characteristic of aerial photographs (e.g., variations in aircraft altitude and attitude) that require the existence of numerous identifiable ground points of fixed and known locations. Very few such points exist within the interior of the National Monument.

Recent (over the last 23 years) satellite imagery available for two different seasons (late spring and mid-fall) will be obtained in computer ready format at modest cost. These images are best suited to providing maximum differentiation of tree species, a critical step in recognizing species associations. Every effort will be made to ensure that the images represent comparable water levels, as hydrologic conditions can significantly affect the appearance of vegetation features on the National Monument. Water levels can be estimated from available Congaree River flow rate data from a station upstream at Columbia, South Carolina.

(2) Location of examples of the expected vegetation classes

The Smathers (1980) map delineates 29 vegetation cover categories; such detail implies the existence of numerous, highly discrete plant associations. Because these categories were identified in a subjective manner and were not discriminated mathematically, they may not be recognized by others. At the other extreme, the Lacy and Somers (1995) map recognizes only 7 vegetation categories; such generality does not adequately reflect the vegetation structure relevant to most management, research, and interpretive concerns.

Locations of many of the vegetation associations are known from existing maps, photographs, and ground reconnaissance. Some of these associations are easily recognized both on the ground and on remote sensing images (e.g., tupelo/bald cypress and pine dominated forest). Other associations are much less obvious in remotely sensed data, particularly the complex mixtures of hardwoods (e.g., sweetgum, holly, oak, ash, elm, and sugarberry) that comprise much of the high diversity on the National Monument.

Based on the work of Lacy and Somers (1995), vegetation categories likely to be easily detected from satellite imagery include:

water tupelo-bald cypress
loblolly pine-hardwoods
swamp tupelo-hardwoods
bottomland hardwoods
scrub/shrub/disturbed (includes cut areas)
agricultural vegetation (surrounding the National Monument)

Other categories that are distinct on the ground but may not be initially differentiated on satellite imagery include:

upland pines
upland hardwoods
riverbank (riparian) hardwoods

These may be distinguished by correlation with topographic position data both available in the existing GIS and obtainable in the field.

Among these categories, the most complex and most extensive is the bottomland hardwoods category. Included here are at least 30 tree species that are likely to be detectable in remotely sensed data. In this case, it is difficult to develop prior expectations of distinct and repeated species associations. Once the bottomland hardwoods category is identified on satellite imagery, systematic, quantitative field data will be obtained to resolve this category into finer subdivisions.

(3) Quantification of forest community structure

Ground truthing is needed to verify vegetation composition determined from remote data. This project will focus more on ground truthing and field sampling to quantify vegetation structure than was possible in the development of the existing GIS (Lacy and Somers 1995). To augment previous information on wetland vegetation types, and to determine the major vegetation classes in the National Monument, transects will be placed across the floodplain at randomly chosen locations and forest vegetation will be quantitatively sampled. These transects will not only include the previously identified vegetation types but also will be used to determine the hydrologic and geomorphologic variability that exists in the National Monument. Locations of the transects will be established with Global Positioning System (GPS) technology. In addition, quantitative data on tree species composition already exist for ten one hectare plots established after Hurricane Hugo (and resampled in 1994), and the precise locations of these plots are known (Sharitz et al. 1993). These will be used to recognize known species associations that can be detected with satellite imagery. The quantitative data on forest composition (e.g., species densities, size classes, canopy structure) will be subjected to a hierarchical clustering technique to discriminate the major categories of forest types. This approach removes the subjectivity of vegetation class discrimination inherent in previous mapping efforts. This process is also repeatable, mathematically rigorous, and scientifically defensible.

(4) Generation of a preliminary vegetation map with a supervised classification of the imagery

The locations of the major vegetation types discriminated in the previous analysis will be determined from the transect sampling. Thus, areas of known forest composition can be used as training sites in a supervised classification of the satellite imagery. In this way, a preliminary map of the wetlands vegetation of the National Monument will be developed. This map will be produced in both digital and printed form and will be accompanied by detailed textual descriptions.

(5) Field verification of image classification

A sample of stands of each vegetation category assigned by the supervised classification procedure will be selected for field verification. Each stand will be located using GPS technology and quantitatively sampled as before. Statistical comparisons will be made between these stands and those used to generate the supervised classification scheme. Agreement between the supervised classification and actual species composition can be estimated at this point.

(6) Revision of image classification

Corrections to the wetlands vegetation map will be made as necessary based on the field verification. Additional sites sampled during the field check may be used as necessary as additional training fields to fine-tune the map. Field verification and additional image classification will be repeated as necessary until a map meeting the National Biological Service Inventory and Monitoring (I& M) standards of classification accuracy is achieved.

(7) Generation of final map and documentation and integration into existing geographic information system

The final map will be generated as described above. As specified in the I & M mapping protocols, classification accuracy of the interpretation will be at least 80% for each vegetation class. Thorough documentation of the classification protocol and the vegetation sampling and analysis procedures will be provided. Personnel of the South Carolina Department of Natural Resources (SC DNR) Southeastern Remote Sensing Center (which maintains the current GIS of the National Monument) will provide consultation, technical support, and administrative support as necessary in order to access the National Monument GIS and integrate the new map into the GIS.

Alternatives:

There are two possible approaches to describe and analyze the vegetative communities of the National Monument. The first approach would be to use aerial photography to prepare a wetlands inventory map that would focus on wetland classifications as used in the National Wetlands Inventory (NWI). This map would essentially be a more detailed version of the NWI data that already exist for the National Monument. However, NWI maps have low resolution; their wetland classes are mostly physiognomic (i.e., structurally descriptive, such as palustrine forest) and may not be useful for detecting the subtle species-level changes resulting from successional processes or hydrologic shifts within a system dominated by long lived trees. This approach will not provide sufficient detail for resource management decisions.

The second, and more appropriate, approach will be to produce a vegetation map in accordance with I & M protocols. These protocols stipulate that "all parks must be mapped at the same level of classification detail (i.e., plant association/cover type)...." Plant associations and cover types are normally described in terms of their dominant species (e.g., water tupelo-baldcypress forest). In addition to being that used by the I & M effort, the second approach is preferable in that a detailed map of vegetation cover types will be a more sensitive indicator of changes in the wetland system of the National Monument. The data will be at a species level, and significant changes in wetland structure or function will be expressed first in the dynamics of particular indicator species. Furthermore, this map will be integrated into the existing GIS of the National Monument and can serve as a baseline for change detection in future I & M efforts.

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Budget and FTEs:

FUNDED

	Activity	Fund Type	Budget ($1000s)	FTEs
1992:	PKBASE-NR ADM	ONE-TIME	10.00	0.20
	WATER-RES RES	ONE-TIME	35.00	0.00
	WATER-RES RES	ONE-TIME	5.00	0.00
	ST-LOCAL RES	ONE-TIME	32.00	0.00
		Subtotal:	82.00	0.20
1993:	PKBASE-NR ADM	ONE-TIME	5.00	0.10
1994:	PKBASE-NR ADM	ONE-TIME	5.00	0.10
1995:	PKBASE-NR ADM	ONE-TIME	5.00	0.10
		Total:	97.00	0.50

UNFUNDED

	Activity	Fund Type	Budget ($1000s)	FTEs
Year 2:	RES	ONE-TIME	18.00	0.00
	RES	ONE-TIME	18.70	0.00
	RES	ONE-TIME	8.20	0.00
	ADM	ONE-TIME	3.25	0.10
		Subtotal:	48.15	0.10
Year 3:	RES	ONE-TIME	18.00	0.00
	RES	ONE-TIME	18.70	0.00
	RES	ONE-TIME	8.20	0.00
	ADM	ONE-TIME	3.25	0.10
		Subtotal:	48.15	0.10
		Total:	96.30	0.20

Compliance Codes: DOC (Covered by another DOC)

Explanation: 516 DM2 APP. 2, 1.6

PROJECT STATEMENT

PROJECT NUMBER: COSW-N-017

Last Update: 01-15-96 Priority: 16
Initial Proposal: 1993

Title: FISH ECOLOGY AND GAMEFISH MANAGEMENT STUDY

Funding Status: Funded: 0.00 Unfunded: 105.00

SERVICE WIDE ISSUES: N00 (BASELINE DATA)
N00 (FISHERIES)

PROBLEM STATEMENT:

Recreational fishing within the National Monument is managed and regulated in accordance with state law. A survey to determine the overall effects of fishing activities on the fishery resources and fish populations of the National Monument has yet to be conducted. A study is needed to document fishing pressure and harvest, to assess the impacts of this visitor use on the fishery resources and fish populations of the National Monument, and to evaluate the appropriateness of existing state fishing regulations.

A monitoring program will be developed as part of this study that tracks relative abundance, species composition, and diversity, and also provides distribution patterns for all species within the National Monument. Data on the size structure (or age structure) of key species should be conducted annually. Key species could include recreationally important species, forage species, and/or dominant native species that are indicative of the health of the system. Biological information derived from these populations can be used to assess the impacts of fishing activities and to evaluate the appropriateness of state fishing regulations.

Given the length of the state fishing season and allowed creel limits, there may be an adverse affect on the National Monument's fishery resource. A study of the National Monument's fish ecology is needed in order to document annual recreational fishing activity, the number of fish harvested, the impact of harvest on fishery resources, and the number of game fish available in relation to the number of non-game species. The study will serve as a basis for any recommendations to the state to regulate fishing within the National Monument.

DESCRIPTION OF RECOMMENDED ACTION OR ACTIVITY:

To make educated decisions concerning fishery resources within the National Monument, an extensive and exhaustive study will be required to bridge current data gaps. In particular, the following issues will need to be addressed: (1) determine baseline fish population inhabiting all sloughs, creeks and lakes and the Congaree River; (2) determine historical and current species composition; (3) develop a program to monitor fish population dynamics, including density and biomass change annually; and, (4) determine current harvest and catch rates, size and age composition of the population of each species being harvested.

Other objectives of this study are to determine: (1) the effects of fishing pressures on the fish population; (2) the degree to which frequent flooding naturally stocks game fish within the National Monument; and, (3) how many, what type, and where game fish are located. Accepted fisheries methodology will be employed. Fish population monitoring, including creel surveys, will be performed regularly during study period and indefinitely thereafter when the monitoring program is fully developed and implemented.

Budget and FTEs:

UNFUNDED

	Source	Activity	Fund Type	Budget ($1000s)	FTEs
Year 1:		RES	ONE-TIME	90.00	1.50
Year 2:		MON	RECURRING	2.00	0.00
		ADM	RECURRING	3.00	0.10
			Subtotal:	5.00	0.10
Year 3:		ADM	RECURRING	3.00	0.10
		MON	RECURRING	2.00	0.00
			Subtotal:	5.00	0.10
Year 4:		ADM	RECURRING	3.00	0.10
		MON	RECURRING	2.00	0.00
			Subtotal:	5.00	0.10
			Total:	105.00	1.80

Compliance codes: EXCL

Explanation: 516 DM6 APP. 7.4 E

PROJECT STATEMENT

PROJECT NUMBER: COSW-N-018
Last Update: 05-03-96 Priority: 11
Initial Proposal: 1993

Title: AQUATIC MACROINVERTEBRATE COMMUNITY SURVEY OF MAJOR WATERWAYS

Funding Status: Funded: 0.00 Unfunded: 81.50

SERVICE WIDE ISSUES: N17 (Biodiversity)
N20 (Baseline Data)

PROBLEM STATEMENT:

It is recognized that changes in macroinvertebrate densities and shifts in species composition and diversity in the aquatic community can readily be related to changes in environmental conditions. There are four major types of aquatic habitats within the National Monument: (1) riverine (Congaree River); (2) floodplain streams; (3) lakes, bogs and sloughs; and, (4) floodplain areas temporarily inundated during high water. Of these, the floodplain streams are especially important because they are a major source of water to the National Monument. Cedar Creek and Toms Creek are particularly important given their stream order and topographic position within the floodplain.

Flooding occurs an average of 10 times per year. These waters inundate the floodplain with sediment and nutrients which support the wetland ecosystems. However, the nature of the floodplain makes it very open to the import and export of waterborne substances (Birch 1981). This characteristic, coupled with the location of the National Monument downstream in a largely agricultural, urban, and industrialized watershed, makes the quality of water flowing into the National Monument a critical component to the continued maintenance of the National Monument's relatively unspoiled ecosystems.

Prompted by concern that waterborne contaminants could enter the floodplain and detrimentally affect the plant and animal life, several water quality studies have been (Birch 1981, Cooney 1990, Rikard 1991) or are currently being performed on the National Monument's waterways. The results from these physio-chemical studies are important as a resource management tool. However, the effects of the many different types of environmental stress on the biological components of the floodplain ecosystems are virtually unknown. Lenat et al. (1980) noted that biological monitoring programs have, in several instances, revealed problems undetected by using chemical or physical analyses. Therefore, a biological monitoring program used in conjunction with current and future water quality studies would be a useful tool in assessing the health of the ecosystems of the National Monument.

The aquatic ecosystem is a major component of the National Monument's natural resources and can be utilized in assessing impacts, such as the effects of encroachment on the boundaries, airborne pollutants and timber harvesting. The use of aquatic macroinvertebrates for environmental assessments has become widespread in recent years. Macroinvertebrates are typically defined as organisms which live at least part of their life cycles in an aquatic system and are large enough to be seen by the naked eye (worms, crayfish, dragonfly nymphs, etc.) and retained by a Standard U.S. #30 sieve (Weber 1973). They are an integral part of the trophic structure in aquatic ecosystems as well as primary processors of organic mater.

Due to their long, aquatic-dependent life cycles, benthic macroinvertebrate communities exhibit organismal and community responses to environmental degradation. Such effects are well documented (Lenat et al. 1980). Aquatic macroinvertebrates are thus recognized indicator organisms for assessing water quality.

Only one aquatic macroinvertebrate study has been conducted at the National Monument to date (Smock and Gilinsky 1982). Cedar Creek communities were examined quantitatively in order to establish a species composition over a one-year period, determine spatial distribution and seasonal patterns of the macroinvertebrates, and estimate macroinvertebrate densities and standing crops. Additionally, the study provided information on the water quality of Cedar Creek.

The study found that Cedar Creek supported high densities and standing crops of macroinvertebrates and that the water quality of the creek was excellent at all stations sampled. They also recommended that similar studies be repeated and conducted on Toms Creek and the Congaree River in order to have a complete data base for the National Monument and that quarterly sampling of the study streams be conducted every two to three years in order to aid resource managers in identifying possible changes in the National Monument's water quality. To date, no follow-up studies have been conducted.

DESCRIPTION OF RECOMMENDED ACTION OR ACTIVITY:

The objectives of this project are to provide information that will serve three primary functions: 1) provide baseline data on the structure of the macroinvertebrate communities in the major waterways of the National Monument; 2) provide resource managers with continuous data that can be used to assess the condition of the water flowing into and through the swamp ecosystem; and, 3) provide the first complete taxonomic listing of aquatic macroinvertebrates present at the National Monument. The fulfillment of these functions will possibly result in the added benefits of increased interest in the National Monument from academic institutions and a greater knowledge about the insect and other invertebrate communities which park naturalists and interpreters can pass on to visitors.

The study will entail three components:

I. Faunal Survey

Component I, the faunal survey, will consist of the deployment of light traps at various locations throughout the National Monument. Light traps attract adult flying insects into bottles containing preservative. These will provide the majority of specimens necessary to compile the taxonomic list. Immature forms of many aquatic invertebrates are problematic to positively identify to species level; however, an attempt should be made to sample and identify immature forms to at least family, suborder, or order. To supplement these collections, field personnel will use various collection tools such as dip nets, dredges and corers. This will ensure that the macroinvertebrates with entirely aquatic life cycles, such as crayfish, worms and beetles, are identified in the taxonomic list.

II. Quarterly Sampling

Component II will consist of quarterly instream sampling for one year to provide the background data necessary for the third component. Collections need to be made quarterly because the macroinvertebrate community structure naturally changes over the course of the year due to the metamorphosis of many of the insects in the community.

III. Periodic Sampling

Component III will consist of quarterly sampling over an annual period and repeated every two years. This will allow for water quality assessments to be made by comparing the data to baseline and previous data sets. Once firmly established, instream assessments are anticipated to become an indefinitely recurring part of the National Monument's ongoing water quality monitoring program. During all phases of the project, macroinvertebrate specimens will be added to and maintained as voucher specimens in a reference collection to be housed at the - Natural Monument contact station and headquarters. The reference collection will be comprised of identified and verified specimens in excellent condition, preserved and documented in such a way that they will serve as indispensable aids to taxonomists for comparison during laboratory analysis.

LITERATURE CITED:

Birch, J. 1981. Water Quality of the Congaree Swamp National Monument. Project Completion report. Institute of Ecology, University of Georgia, Athens, Georgia. 101 pp.

Cooney, T.W. 1990. Concentrations of Trace Metals in Bed Material in the Area of Congaree Swamp National Monument and in Water in Cedar Creek, Richland County, South Carolina, US Geological Survey. Open-File Report 90-370. 18 pp.

Lenat, D.R., L.A. Smock, and D.L. Penrose 1980. Use of benthic macroinvertebrates as indicators of water quality. In D.L. Worf (ed.). Biological Monitoring for Environmental Effects. Lexington Books.

Rikard, M. 1991. A Water Quality Study at the Congaree Swamp National Monument of Myers Creek, Reeves Creek, and Toms Creek. Unpublished manuscript. National Park Service, Cape Lookout National Seashore, Morehead City, NC, November 1991. 22pp.

Smock, L.A. and E. Gilinsky. 1982. Benthic Macroinvertebrate Communities of a Floodplain Creek in the Congaree Swamp National Monument. Unpublished manuscript. National Park Service. Department of Biology, Virginia Commonwealth University, Richmond, Virginia. February 1982. 82 pp.

Weber, C.I. 1973. Biological field and laboratory methods for measuring the quality of surface waters and effluents. Environmental Monitoring Series, US Environmental Protection Agency. EPA-670/4-73-001.

Budget and FTEs:

			Budget ($1000s)	FTEs
	UNFUNDED			
	Activity	Fund Type	Budget ($1000s)	FTEs
Yr 1:	RES	One-time	60.00	2.00
	ADM	One-time	6.50	0.00
		Subtotal	66.50	2.00
Yr 3:	MON	One-time	15.00	0.50
		Total	81.50	2.50

Compliance Codes: EXCL

Explanation: 516 DM2 APP. 2, 1.6

PROJECT STATEMENT

PROJECT NUMBER: COSW-N-023

Last Update: 01-15-96 Priority: 9
Initial Proposal: 1993

Title: PARTICIPATE IN THE DEVELOPMENT OF A RIVER CORRIDOR PLAN FOR CONGAREE RIVER AND TRIBUTARIES

Funding Status: Funded: 0.00 Unfunded: 90.00

SERVICE WIDE ISSUES: N06 (LAND USE PRAC)
N16 (NEAR-PARK DEV)

PROBLEM STATEMENT:

The Congaree River is formed in Richland County by the confluence of the Saluda and Broad Rivers at Columbia, South Carolina. Approximately 26 miles downstream from the confluence, and then continuing for another 24 miles, the Congaree River forms the southern boundary of the Congaree Swamp National Monument. From its origin in Columbia to its confluence with the Wateree River to form the Santee River, the Congaree River is approximately 60 river miles in length. The Congaree River meanders through and is bounded by an extensive floodplain ecosystem throughout its length. The floodplain ecosystem is strongly dependent upon the river's pattern of seasonal flooding for the maintenance of ecosystem structure and functions. The Congaree Swamp National Monument is located almost entirely within this floodplain ecosystem and thus is also strongly dependent upon the river.

Initially, the bluffs on the south side of the Congaree River, opposite of what is now the National Monument, were proposed for protection and management by the National Park Service. Opposition from landowners resulted in the south side of the Congaree River being withdrawn from consideration. National Monument managers should be aware that the perception of government intervention and the apparent loss of private property rights are a sensitive issues among landowners in the vicinity of the National Monument.

Other sources of surface water flowing into the National Monument are tributaries originating to the north and then flowing through the of the National Monument before joining the Congaree River. The two principal tributaries are Cedar Creek and Toms Creek. Though much smaller in discharge volume than the Congaree River, these tributaries maintain permanent, year-round flows through the National Monument and thus are integral components of the floodplain ecosystem.

In order for the integrity of the National Monument to be preserved to the greatest extent possible, it is imperative that the Congaree River corridor and the Cedar Creek and Toms Creek corridors are protected. As Columbia and the lower Richland County region develops economically, greater ecological pressures on the floodplain ecosystem will be incurred from industrial, residential, and possibly agricultural sectors. In recognition of these potential threats, a plan should be initiated to facilitate corridor protection.

The Congaree River was identified in the 1982 Nationwide Rivers Inventory as possessing outstanding remarkable characteristics and would appear to be eligible as a candidate for inclusion in the National Wild and Scenic Rivers System. Similarly, a 1988 Statewide Rivers Assessment conducted by the State of South Carolina, in conjunction with the National Park Service and other interest groups, found the Congaree River to be one of only seven rivers to have statewide or greater than statewide significance in seven resource categories. The report concluded that these rivers can be considered among the state's most valuable because of the large number of superior resource values that they possess. The superior resource values noted for the Congaree River include historic and cultural, industrial, inland fisheries, natural features, recreational fishing, timber management, and lack of unsightly development. In spite of the recognition, little progress has been made and the corridor is virtually unprotected.

Although a portion of the Congaree River corridor is protected by virtue of its inclusion in the Congaree Swamp National Monument, the majority of the river and its floodplain is unprotected (except through federal and state wetland floodway regulations) and subject to development pressures typical of a river system located in close proximity to a major urban area (e.g., impoundment or shoreline development of non-wetland areas). In order to develop an appropriate protection strategy, a coalition of local interests and governmental representatives coordinated by a unbiased constituency group needs to prepare a river corridor protection plan.

Either of two river corridor protection programs should be considered: the National Wild and Scenic Rivers System and the South Carolina Scenic Rivers program. The federal National Wild and Scenic Rivers Act (P.L. 90-542 as amended; U.S.C. 1271-1287) program is designed to provide river and river corridor protection to rivers or river segments of "outstandingly remarkable features." Dependent upon exiting water quality, scenic quality, impoundments, shoreline development, and access rivers may be designated as "wild," "scenic," or "recreational;" with "wild" river designation reserved for the most natural condition. Rivers may be designated by Congress or through a recommendation by the Governor of South Carolina to the Secretary of the Interior of the United States .

The South Carolina Scenic Rivers Act (SC Code of Laws, 1989, Title 49, Chapter 29) program entails the cooperative and voluntary agreement among landowners adjacent to the river, community interests, and the South Carolina Department of Natural Resources to develop long-term management strategies which will preserve the traditional uses of the river or stream, as well as the scenic character of the river corridor (S.C. Water Resources Commission 1991). Landowners may voluntarily participate in the program to conserve and manage the river corridor through land registration, management agreement, conservation easement, and land donation. The framework for management is a scenic river management plan written by a Scenic River Advisory Council made up of landowners and interested members of the public. State and federal conservation programs that are available to private landowners and that establish streamside protection or improve watershed water quality are identified in Table 16 in the "Issues and Management" section of the COSW WRMP. Examples of conservation programs available include the Conservation Reserve Program administered by the USDA National Resources Conservation Service (NRCS) and the Wetland Reserve Program administered jointly by NRCS and the USDI Fish and Wildlife Service.

DESCRIPTION OF RECOMMENDED ACTION OR ACTIVITY:

In cooperation with a coalition of local interests and governmental representatives, develop a Corridor Conservation Plan for the Congaree River and its tributaries. It is recommended that work be coordinated with neighboring communities and other entities with a vested interest in the Congaree River, Cedar Creek, and Toms Creek to find the best way to develop and implement plans to conserve the corridor. Corridor protection within the framework of the National Wild and Scenic River program and/or the South Carolina Scenic Rivers program should be considered. Resources, issues, goals, alternatives, and actions must be identified through a process which emphasizes citizen participation and constituency building. The plan should fulfill the community's objective for conserving the river and stream systems. Consideration should be given toward expanding the biosphere reserve concept into local land use and zoning.

Project Statement COSW-N-061 of the COSW WRMP address additional protective measures for the Cedar Creek and Toms Creek watersheds wherein an upgrade from "Freshwaters" class to "Outstanding Resource Waters" class is recommended for consideration.

Literature Cited:

S.C. Water Resources Commission. 1991. South Carolina Scenic Rivers Program Handbook, South Carolina Water Resources Commission, Report No. 172, Columbia, South Carolina.

Budget and FTEs:

----------UNFUNDED----------

	Activity	Fund Type	Budget ($1000s)	FTEs
Yr 1:	PRO	ONE-TIME	30.00	0.5
Yr 2:	PRO	ONE-TIME	30.00	0.5
Yr 3:	PRO	ONE-TIME	30.00	0.5
		Total:	90.00	1.5

Compliance Codes: EXCL

Explanation: 516 DM6 APP. 7.4 B (4)

PROJECT STATEMENT

PROJECT NUMBER: COSW-N-058
Last Update: 01-15-96 Priority: 4
Initial Proposal: 1996

Title: IMPROVE UNDERSTANDING OF FLUVIAL GEOMORPHIC PROCESSES OF THE CONGAREE RIVER FLOODPLAIN.

Funding Status: Funded: 0.00 Unfunded: 300.00

SERVICE WIDE ISSUES: N12 (WATER FLOW)
N20 (BASELINE DATA)

PROBLEM STATEMENT:

The Congaree Swamp National Monument contains one of the few remaining old-growth forests in the eastern United States. Most of its 22,200 acres is in the floodplain of the Congaree River, a major drainage within the Santee River basin that discharges to the Atlantic Ocean. The National Monument is located just east of the Fall Line between the Piedmont and coastal plain in South Carolina. Most of the site floods annually. This feature, in addition to the numerous oxbow lakes and perennial streams, is critical to the maintenance of the old-growth forest and concurrently makes the site rich in a variety of aquatic ecosystems. During flood stage, the floodplain potentially receives contaminants from anywhere in the watershed including smaller watersheds of the tributaries that flow directly into the floodplain from the north. This vulnerability justifies surveillance of water-related factors and activities that may interfere with preserving the natural attributes of the National Monument.

Geomorphic features of the floodplain surface control surface flow paths during flood events and govern water storage after overbank flow has ceased. Oxbow lakes, meander scrolls, point bars, high flow channels (sloughs), and other macro- and micro-topographic features result in a very complex geomorphic setting. The juxtaposition of these features creates an interspersion of plant community types and a diversity of habitats for aquatic organisms and water-dependent terrestrial organisms. The relative abundance of these features likely changes from the Congaree River channel to the floodplain-upland interior in a way that reflects the history of river meandering. This distribution may have landscape-level influences on water storage and inundation patterns as well as on the dispersal of organisms .

There is apparently no definitive information on the potential influence of human activities on the current geomorphic setting of the National Monument. Because of its proximity to the Piedmont province, the floodplain of the National Monument shares some features, such as brightly colored soils, with floodplains of the Piedmont. Sediment eroded from the Piedmont has been deposited in characteristic point bars, deltas, natural levees, and floodplain deposits along the meandering and gradually shifting course of the river. Many Piedmont floodplains owe their present elevation and sediment balance to massive rates of erosion during the time when cotton was cultivated. Much of this sediment was deposited in floodplains, as much as 3 m in thickness in some places (Trimble 1970), thus creating an entirely new topographic surface. With reforestation of uplands, sediment sources from uplands have diminished, and many Piedmont streams are incising back to former bedrock control.

We do not know the extent to which the fluvial geomorphology of the National Monument was influenced by these events during the past century. The old growth nature of the forest might lead to the assumption that little change has occurred. If this is true, the National Monument would appear to be highly resilient. If it is not true, the dynamic nature of the National Monument's sediment budget needs to be quantified and any trends need to be identified. In spite of obvious floodplain features that testify to the fact that river meandering has created many present-day floodplain features, we are unable to place the current geomorphic environment into a temporal perspective until this recent history is better documented. Techniques are available to measure sedimentation rates (both current and historic) and to estimate ages of development of floodplain features (such as point bars) by radiocarbon-dating buried woody materials. Such methods can be used to better understand factors responsible for the origin of geomorphic features and their continued maintenance.

Another alteration that confounds the understanding of the sediment dynamics of the National Monument is the construction of the Saluda Dam. The dam began operation in 1929 on the Saluda River, a major tributary to the Congaree River. The dam is only 11 miles above the confluence with the Broad River that forms the Congaree River, in effect capturing the entire drainage basin of the Saluda River, or 2,520 mi^2 (6,527 km^2). This is about half the Broad River's drainage area of 5,320 mi^2 (13,779 km^2). While the Broad River drainage contains only minor dams, the Saluda Dam controls roughly one-third of the total flow to the Congaree River above Columbia. This led Patterson et al. (1985) to conclude that "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."

The storage capacity of the Saluda Dam reduces the frequency of virtually all floods. Several studies have investigated whether altered flows would cause the species composition of the old-growth forest to change because of changes in flooding depth and frequency, as well as altered rates of sedimentation. Studies have explored potential effects on vegetation and are summarized as follows: (1) Rikard (1988) found some evidence that sugarberry and water oak were advancing to lower elevations sites in the floodplain. However, he pointed out that ages and growth rates of individual trees would be necessary to provide a more convincing link between the apparent changes and the hydrologic alterations caused by the Saluda Dam. (2) Sharitz et al. (1993) reported wide variation in recruitment of seedlings following the effects of Hurricane Hugo in 1989. The lack of correspondence between species composition of woody seedlings and canopy species makes it difficult to project species composition of future stands. More shade intolerant species may be expected in the wake of Hurricane Hugo, but no major compositional shifts are indicated from hydrologic changes that may have taken place based on analysis of flood tolerances of the various strata. (3) The surveys of champion trees made by Jones (1996) suggest that individual trees reach champion size rapidly because of the rich alluvial soils. Consequently, senescence and death may be more rapid than earlier perceived. This relatively rapid turnover (in contrast to upland forests) may allow the forest community to respond more rapidly to hydrologic changes. Whether the hydrologic changes are great enough to induce a response large enough to be detected is still unresolved. (4) The Saluda Dam potentially has had a two-fold effect. One is the reduction in frequency of floods with long return interval (i.e., the ones most capable of inducing geomorphic alterations such as major cutbank erosion, levees build-up, and meander cutoffs). Second is the reduction in sediment supply from the Saluda River as a result of sediment loads being trapped behind the dam. The consequences of these two phenomena must be analyzed in concert with the confounding effects of changing sediment supplies during historic alterations of land use in the Piedmont.

The relic dam near Wise Lake, should be examined as to its influence on the connection between Wise Lake and Cedar Creek. Both excavation and damming apparently were conducted by members of a hunting club, and need to be evaluated to determine if restoration to the original landscape is warranted. The other man-made structure is the network of roads and culverts that impede the flow of water down the gradient in the floodplain. Both of these items are treated more fully in project statement COSW-N-059 concerning floodplain hydrodynamics.

Information on this and the surface hydrologic study (COSW-N-059) will contribute to the general understanding of large rivers and their floodplains (Gore and Shields 1995). Moreover, descriptions of relatively unaltered sites like the Congaree Swamp National Monument may serve as templates for restoration of highly altered river systems.

DESCRIPTION OF RECOMMENDED ACTION OR ACTIVITY:

It is recommended that a study of fluvial geomorphology precede further studies of hydrologic flow paths. The following types of information will contribute to the understanding of the fluvial geomorphology and will provide background information upon which further studies in surface water hydrology can be based.

Map, classify, and interpret major geomorphic features of the 100-year floodplain of the Congaree River within the National Monument's authorized boundary:

- The degree of additional mapping that may be required should be determined after the present 2-foot contour map is examined. The portion of the floodplain mapped, and the scale and contour intervals should be at sufficient detail to provide the information necessary to initiate the study on floodplain dynamics explained in project statement COSW-N-059.

- Classify the surface geomorphic features from the map and from field work to produce a more accurate map illustrating the locations of these features.

- Describe the probable origin and evolution of the geomorphic features based on best professional judgement.

- Evaluate whether the relic dike near Wise Lake and the network of roads and culverts are having adverse impacts on the flow and circulation of water in the floodplain.

Determine current, recent historic, and geologic rates of sedimentation:

- Monitor two sedimentation events on floodplain surfaces to estimate instantaneous rates of deposition for the lower elevation sites (at annual flood stage and below). This will provide a better understanding of sediment sinks in the National Monument.

- Measure the rate of recent, decades-scale sediment accretion rates using modern geochemical techniques. Potential techniques include the amount of accretion since the cesium-137 peak in fallout, rates derived from lead-210 profiles, and accretion determined from carbon-14 dating. Other, more novel, approaches may be appropriate for the floodplain. This will provide insight into whether landscape disturbance in the Piedmont contributed to the geomorphic condition of the National Monument.

- Determine the age of geomorphic features through sediment dating (carbon-14 dating) to provide better temporal resolution of the evolution of floodplain structure.

- Estimate whether the potential effects of the Saluda Dam on sediment supply could possibly influence responses in vegetation, and predict potential effects of additional impoundments in the watershed on vegetation and fluvial geomorphology.

LITERATURE CITED:

Gore, J.A. and F. D. Shields, Jr. 1995. Can large rivers be restored? BioScience 45:142-152.

Jones, R.H. 1996. Location and ecology of champion trees in Congaree Swamp National Monument: Draft Final Report. Virginia Polytechnic Institute and State University, Blacksburg, Virginia.

Rikard, M. 1988. Hydrologic and vegetative relationships of the Congaree Swamp National Monument. Ph.D. dissertation, School of Forestry, Clemson University, Clemson, South Carolina and Report No. 33 of Technical Report Series of the USDI National Park Service.

Sharitz, R.R., M.R. Vaitkus, and A.E. Cook. 1993. Hurricane damage to an old-growth floodplain forest in the Southeast. Pages 203-210 *in* J.C. Brissette, editor. Proceedings of the Seventh Southern Silvicultural Research Conference. U.S. Forest Service General Technical Report 50-93. USDA Forest Service, Washington, D.C.

Trimble, S.W. 1970. The Alcovy River swamps: The result of culturally accelerated sedimentation. Bulletin of the Georgia Academy of Science 28:131-144.

Budget and FTEs:

--UNFUNDED--

	Activity	Fund Type	Budget ($1000s)	FTEs
Yr 1:	RES	ONE-TIME	100.00	0.10
Yr 2:	RES	ONE-TIME	100.00	0.10
Yr 3:	RES	ONE-TIME	100.00	0.10
		Total:	300.00	0.30

Compliance Codes: EXCL

Explanation: 516 DM2 APP. 2, 1.6

PROJECT STATEMENT

PROJECT NUMBER: COSW-N-059

Last Update: 1-15-96 Priority: 5
Initial Proposal: 1996

Title: IMPROVE UNDERSTANDING OF HYDRODYNAMICS OF THE CONGAREE RIVER FLOODPLAIN.

Funding Status: Funded: 0.00 Unfunded: 150.00

SERVICE WIDE ISSUE CODES: N12 (WATER FLOW)
N20 (BASELINE DATA)

PROBLEM STATEMENT:

The Congaree Swamp National Monument contains one of the few remaining old-growth forests in the eastern United States. Most of its 22,200 acres is in the floodplain of the Congaree River, a major drainage within the Santee River basin that discharges to the Atlantic Ocean. The National Monument is located just east of the Fall Line between the Piedmont and coastal plain in South Carolina. Most of the site floods annually. This feature, in addition to the numerous oxbow lakes and perennial streams, is critical to the maintenance of the old-growth forest and concurrently makes the site rich in a variety of aquatic ecosystems. During flood stage, the floodplain potentially receives contaminants from anywhere in the watershed including smaller watersheds of the tributaries that flow directly into the floodplain from the north. This vulnerability to present and past discharges and land uses justifies a high level of surveillance of water-related factors that may be incompatible with preserving the natural attributes of the National Monument.

The hydrologic complexity of the floodplain is not well understood in terms of the relative importance of inflows from the northern tributaries (several small streams including Cedar Creek and Toms Creek) and overbank flow from the main channel (one large Piedmont-draining stream, the Congaree River). This lack of understanding prevents the development of management strategies based on specific sources of water, their seasonal delivery to the floodplain, and the vulnerability of aquatic ecosystems within the National Monument to external sources of water-borne contamination and eutrophication. The National Park Service must currently make management decisions inside the boundaries of the National Monument and undertake initiatives outside the National Monument with little confidence in the consequences that these actions will have on the sustainability of the National Monument's aquatic ecosystems.

A basic understanding of water flow pathways is needed because:

1. A practical knowledge of surface hydrology is needed to understand the potential sources and fates of contaminants that may enter the National Monument with stream flow. Once water is inside the boundaries of the National Monument, the flow pathways are largely under control by geomorphic features of the floodplain. Flows within the boundaries will control the distribution and ultimate fate of any water-borne contaminants. Because so little is known about the flows under different flood stages, it is impossible to predict the movement of contaminants within and

through the floodplain. In addition, little is known about the potential effects of flow paths and velocities on sediment transport and organic matter redistribution.

2. The ecosystem dynamics of relatively isolated aquatic environments, such as oxbow lakes and smaller sloughs, may depend on the frequency and duration of flood events that "reset" the ecosystems by displacing a limnetic (lake-like) with a lotic (stream-like) environment. Such events serve to displace water that may have accumulated organic matter, high concentrations of nutrients, and reduced compounds (such as hydrogen sulfide) during the limnetic phase. Flood events also create opportunities for exchanges of fish and other aquatic organisms between the rivers and the lakes. The streams entering the National Monument from the north, such as Cedar Creek, apparently become dominated by overbank flow when the Congaree River reaches flood stage.

The fluvial geomorphic study (COSW-N-058) will provide critical background for this study, for the management of aquatic resources of the National Monument, and for further interpretation and understanding of the natural history of the site.

DESCRIPTION OF RECOMMENDED ACTION OR ACTIVITY:

Continued efforts to expand the knowledge base of the National Monument are needed, especially with regard to poorly understood aspects of water flow pathways during flooding events. It is recommend that the hydrodynamics of the floodplain be further studied, but only after the fluvial geomorphology has been better defined (Project Statement COSW-N-058). The following types of information are needed:

- Determine and map of base flow associated with tributaries. The extent to which the discharge of the tributaries from the north increases in a downstream direction within the National Monument will provide an estimate of the importance of groundwater sources to maintaining perennial or intermittent flow. From this information, the relative importance of channel inflow from outside the National Monument and groundwater discharge to the stream channels inside the National Monument can be determined. This will allow better predictions of the effects of proposed flow alterations of the tributaries on aquatic environments within the National Monument.

- Determine surface flow vectors at the annual flood stage, and at the 5 and 25 year return intervals. Flow pathways established from flow vectors provide insight into how potential contaminants would be transported through and within the floodplain, how aquatic organisms are exchanged between channel and floodplain, how woody debris and floating seeds are dispersed, and at what stages of overbank flow the Congaree River influences flows and water quality of Cedar Creek and other tributaries. Flow vectors can be estimated from the contour maps provided in COSW-N-058 as well as from the asynchrony in hydrographs measured at strategic locations within the floodplain. Such data may allow estimates of the degree of connection between sites within the floodplain and the larger river system. Sites for potential sediment deposition and detritus transport may also be identified.

- Estimate velocities at the return intervals of the flood return times indicated above. Velocities affect sediment transport, fine and coarse woody debris movement, and residence time of the surface water in the swamp.

- Use the predictions of flood return interval and duration in the flood warning study (John C. Hayes and Dave E. Linvill at Clemson University, in progress) to evaluate biotic influences, especially on the aquatic ecosystems of the National Monument.

- Provide a narrative description of water flow pathways, ecological and environmental significance of the flows, and the environmental consequences of their alterations.

Budget and FTEs:

--UNFUNDED--

	Activity	Fund Type	Budget ($1000s)	FTEs
Yr 1:	RES	ONE-TIME	50.00	0.10
Yr 2:	RES	ONE-TIME	50.00	0.10
Yr 3:	RES	ONE-TIME	50.00	0.10
		Total:	150.00	0.30

Compliance Codes: EXCL

Explanation: 516 DM2 APP. 2, 1.6

PROJECT STATEMENT

PROJECT STATEMENT NUMBER: COSW-N-060

Last Update: 1-15-96 Priority: 6
Initial Proposal: 1996

TITLE: ASSESS THE CURRENT STATUS OF WATER QUALITY AND COMPLIANCE WITH SOUTH CAROLINA WATER QUALITY STANDARDS

Funding Status: Funded: 0.00 Unfunded: 8.00

SERVICE WIDE ISSUE CODES: N11 (WATER QUAL-EXT)

PROBLEM STATEMENT:

The Congaree Swamp National Monument is adjacent to the Congaree River in South Carolina at a location approximately 26 miles downstream from the city of Columbia. The National Monument has been designated an International Biosphere Reserve due primarily to the old-growth bottomland hardwood forest and to the national and state champion trees contained within the National Monument. The National Monument is situated in the lower end of a 5.2 million acre watershed that contains several of the major urban and industrial centers of the state and has a variety of land uses, including agriculture, silviculture, residential, and military, as well as urban and industrial. Point source wastewater discharges and nonpoint source contaminated runoff associated with these land use activities have the capacity to degrade water quality in the Congaree River and its tributaries. During periods of flooding in the Congaree River, the floodplain of the National Monument may become inundated for several days or weeks, thus exposing the biota and sediments to these contaminants.

Floodwaters usually enter the National Monument from the Congaree River during winter and spring flood events. However, waters from two Congaree River tributaries, Cedar Creek and Toms Creek, flow through the National Monument all year. Land use within these tributary watersheds is largely silvicultural and agricultural, with light industrial, municipal, and residential development. Of special concern in these watersheds is McEntire Air National Guard Base, which may contribute surface water contaminants to Cedar Creek and Toms Creek via wastewater discharge and surface runoff.

A determination of the current status of contaminants in the water, sediment, and biota of the National Monument would serve as a benchmark for future comparison and would help to identify problem contaminants for possible remedial action. Water quality standards have been developed by state and federal agencies in order to help maintain or improve water quality in natural waters. At a minimum, waters entering the National Monument from Cedar Creek and Toms Creek should be in compliance with these standards. Floodwaters from the Congaree River should be within established water quality standards also; this is more problematic, however, since the Congaree River watershed is much larger, with a complex array of point source and nonpoint sources of contamination.

The South Carolina Department of Health and Environmental Control-Office of Environmental Quality Control, Bureau of Water Pollution Control has developed a water quality monitoring program to monitor the chemical, physical, geological, biological, and other environmental parameters in natural waters and wastewater discharge (SCDHEC 1995). The regulatory purpose of the monitoring program is to achieve the goals of the South Carolina Pollution Control Act (S.C. Code of Laws, 1976, as amended, Title 48, Chapter 1), the Federal Water Pollution Control Act of 1972 (Pub. L. 92-500), the federal EPA Environmental Monitoring Policy, and other applicable State and Federal regulations. Regulatory monitoring involves the collection of ambient data for assessing and enforcing compliance with wastewater discharge permits, and for evaluating environmental quality.

The waters entering or within the National Monument are subject to these regulations and are monitored by SCDHEC. Reporting water quality test results and compliance of these waters with State standards is available through the SCDHEC's Saluda-Edisto Watershed Water Quality Monitoring Startegies (WWQMS) program. WWQMS reports should facilitate water quality-related management decisions by the National Park Service and provide a framework to encourage state and federal agencies to seek remediation action at sources of contamination.

The National Monument contains some of the largest remaining stands of old-growth bottomland hardwood forest in the southeastern United States; the maintenance of high water quality in waterways flowing into and occurring within the National Monument is necessary to preserve its ecological integrity and recreational values.

Current Water Quality Compliance Monitoring

Water quality standards for natural waters have been established by SCDHEC. These standards are applicable for a given stream segment depending on the stream's classification. The Congaree River, Cedar Creek, and Toms Creek and all other waters of the National Monument are classified as "Freshwaters" by SCDHEC (Reg. 61-68, South Carolina Water Pollution Control Act, 48-1-10, et seq, S.C. Code of Laws, 1976). This designation is the most common category for lower watershed streams throughout the state. "Freshwaters" are defined by SCDHEC as: "freshwaters suitable for primary (e.g., swimming) and secondary (e.g., fishing and wading) contact recreation and as a source for drinking water supply after conventional treatment in accordance with the requirements of the Department. Suitable for fishing and survival and propagation of a balanced indigenous aquatic community of fauna and flora. Suitable also for industrial and agricultural uses" (Reg. 61-68, South Carolina Water Pollution Control Act, 48-1-10, et seq, S.C. Code of Laws, 1976).

In order to measure water quality and monitor compliance with state standards in the Congaree River, Cedar Creek, and Toms Creek, water samples are collected by the SCDHEC-Office of Environmental Quality Control, Bureau of Water Pollution Control at Primary or Secondary Water Quality Monitoring Stations. Two Primary Stations (sampled monthly on a year-round basis) are located on the Congaree River at Columbia, two Secondary Stations (sampled monthly from May-October) are located on Cedar Creek, and one Secondary Station is located on Toms Creek. These stations are part of the SCDHEC Fixed Monitoring Network program.

The data obtained from SCDHEC water quality analyses are available from the SCDHEC. These data are also maintained by the U.S. Environmental Protection Agency in a national database, the STORET database. Although the data are compiled by these state and federal agencies, there is no mechanism for systematic review and analysis of the data specifically applicable to the National Monument.

In recognition of this problem, the National Park Service, Inventory and Monitoring Program, in conjunction with the NPS Water Resources Division and the Horizon Systems Corporation, is compiling and interpreting STORET water quality data for the Congaree Swamp National Monument, as well as 250 other units of the National Park system. The report for the Congaree Swamp National Monument will provide a comprehensive analysis of an array of physical and chemical water quality conditions, including heavy metal and pesticide concentrations current to 1995. The Congaree Swamp National Monument report is scheduled for completion in 1996 (B. Long, NPS Water Resources Division, personal communication, 1996).

DESCRIPTION OF RECOMMENDED ACTION OR ACTIVITY:

The synthesis of STORET water quality data in preparation by Water Resources Division and the Horizons Systems Corporation will provide National Monument managers with a summary of water quality conditions. The interpretation of this information will require review by a water quality specialist familiar with EPA and South Carolina water quality standards. Due to fiscal constraints, the review process may be shared among other NPS entities with significant water resources that are within the same NPS cluster as the Congaree Swamp National Monument.

The following actions may be necessary to utilize water quality data in the management of the National Monument:

- Contract a water quality specialist to review a water quality report in preparation for the National Monument by the NPS's Inventory and Monitoring Program, NPS Water Resources Division, and the Horizon Systems Corporation, based on the EPA's STORET water quality database. This report will provide a synthesis of water quality conditions, prior to 1996, in streams affecting the National Monument (Cedar Creek, Toms Creek, and the Congaree River). The review should determine if the pertinent streams are in compliance with EPA and SCDHEC water quality standards. Additionally, the water quality specialist should determine if the SCDHEC water quality sampling program and the standards established for these streams are sufficient to protect the ecological integrity of the National Monument.

- Since a periodic synthesis of the STORET water quality database for the National Monument is not expected after 1996, the water quality specialist should be contracted triennially to review water quality databases. The review will be useful in establishing water quality trends, highlighting problem contaminants, and determining if a course of action should be implemented by the NPS to remediate water quality problems.

LITERATURE CITED:

SCDHEC. 1995. State of South Carolina Monitoring Strategy for Fiscal Year 1996, Technical Report No. 002-95, SC Department of Health and Environmental Control, Bureau of Water Pollution Control, Columbia, South Carolina.

Budget and FTEs:

	-----UNFUNDED-----			
	Activity	Fund Type	Budget ($1000s)	FTEs
Yr 1:	RES	ONE-TIME	8	0.1

Compliance Codes: EXCL
Explanation: 516 DM6 APP. 7.4 B(10)

PROJECT STATEMENT

PROJECT STATEMENT NUMBER: COSW-N-061

Last Update: 1-15-96 Priority: 8
Initial Proposal: 1996

TITLE: UPGRADE STREAM CLASSIFICATION OF CEDAR CREEK AND TOMS CREEK TO OUTSTANDING RESOURCE WATERS

Funding Status: Funded: 0.00 Unfunded: 20.00

SERVICE WIDE ISSUE CODES: N11 (WATER QUAL-EXT)

PROBLEM STATEMENT:

The Congaree Swamp National Monument is a 22,200 acre tract along the Congaree River in central South Carolina consisting primarily of old-growth bottomland hardwood forest. The National Monument is a highly water-dependent ecosystem that experiences periodic flooding from the Congaree River, and, to a lesser extent, tributaries of the Congaree River (Cedar Creek and Toms Creeks) that arise north of the National Monument's boundaries and then flow through the National Monument. The maintenance of the National Monument's relatively unaltered ecosystem is largely dependent upon the quantity and the quality of waters entering the National Monument.

The South Carolina Department of Health and Environmental Control, Office of Environmental Quality Control, has developed a system of surface water classifications and standards designed to protect the natural waters of the state by establishing numeric water quality criteria for waters and specific uses for these waters. The most common designation for Piedmont streams in the vicinity of the Congaree River is the "Freshwaters" (FW) designation. Another classification which is appropriate for high quality streams or streams of special ecological or recreational value is the "Outstanding Resource Waters" (ORW) designation. This designation provides additional protection of surface waters by limiting wastewater discharge on ORW streams, stream segments, and their tributaries.

Presently, Cedar Creek, Toms Creek, and their tributaries are classified as "Freshwaters" by SCDHEC in Regulations 61-68 and 61-69 of the South Carolina Water Pollution Control Act (48-1-10, et seq, S.C. Code of Laws, 1976). "Freshwaters" are defined by SCDHEC as: "freshwaters suitable for primary (e.g., swimming) and secondary (e.g., fishing and wading) contact recreation and as a source for drinking water supply after conventional treatment in accordance with the requirements of the Department. Suitable for fishing and survival and propagation of a balanced indigenous aquatic community of fauna and flora. Suitable also for industrial and agricultural uses" (Reg. 61-68, South Carolina Water Pollution Control Act, 48-1-10, et seq, S.C. Code of Laws, 1976).

"Outstanding Resource Waters" are defined by SCDHEC as: "freshwaters or saltwaters which constitute an outstanding recreational or ecological resource or those freshwaters suitable as a source for drinking supply with treatment levels specified by the Department" (Reg. 61-68, South Carolina Water Pollution Control Act, 48-1-10, et seq, S.C. Code of Laws, 1976). On streams or stream segments designated as ORW, discharges from domestic, industrial, or agricultural waste treatment facilities are not allowed; additionally, SCDHEC "Antidegradation Rules" restrict activities or wastewater discharges in waters upstream or tributary to ORW waters such that the activities or discharges may not degrade the ORW waters. Because the National Monument is designated as an International Biosphere Reserve as a result of its ecological importance, and because it is an important recreational site, an upgrade in stream classification from "Freshwaters" to "Outstanding Resource Waters" should be justified.

DESCRIPTION OF RECOMMENDED ACTION OR ACTIVITY:

Redesignation of Cedar Creek and Toms Creek as Outstanding Resource Waters will require the following actions:

- A contracted water quality specialist (COSW-060) should review existing water quality conditions in Cedar Creek and Toms Creek and discharge permits issued for Cedar Creek to determine if an upgrade from "Freshwaters" to "Outstanding Resource Waters" is appropriate.

- If Cedar Creek and Toms Creek are determined appropriate for classification upgrades, the National Monument and the National Park Service should pursue the redesignation of Cedar Creek and Toms Creek as ORW waters. At a minimum, the stream segments of these waters and their tributaries that flow through the National Monument should be upgraded. On Cedar Creek and its principal tributary, Myers Creek, stream classification upgrade to ORW may not be appropriate since approximately 9 permitted wastewater dischargers already exist. ORW designation of the segment of Cedar Creek within the National Monument would ensure that existing discharges are consistent with SCDHEC Antidegradation Rules and would prevent the issuance of new discharge permits upstream. At present, Toms Creek and its tributaries do not have wastewater discharges; designation of the entire reach of Toms Creek as ORW may be possible.

- Coordinate with local environmental advocacy groups (Sunrise Foundation, River Alliance, Sierra Club, Audubon Society) that are concerned with preserving and improving the ecological quality of the National Monument. The NPS and SCDHEC should make a presentation to these groups and to landowners in the vicinity of the National Monument addressing the rationale for an ORW upgrade. The presentation should explain the ecological and economic benefits, and land use and discharge restrictions associated with upgrading. Demonstrated support by local citizens for an ORW upgrade may be an effective strategy to achieve cooperation from landowners in the Cedar Creek and Toms Creek watersheds.

- Prepare a request from the NPS and other interested parties asking SCDHEC to upgrade the stream classification of Cedar Creek and Toms Creek from "Freshwaters" to "Outstanding Resource Waters." Upon review by SCDHEC, recommendations for the upgrades will require approval by the South Carolina legislature.

Budget and FTEs:

	Activity	Fund Type	Budget ($1000s)	FTEs
		UNFUNDED		
Yr 1:	PRO	ONE-TIME	10.00	0.2
Yr 2:	PRO	ONE-TIME	10.00	0.2
		Total:	20.00	0.4

Compliance Codes: EXCL

Explanation: 516 DM6 APP. 7.4 B(10)

PROJECT STATEMENT

PROJECT STATEMENT NUMBER: COSW-N-062

Last Update: 1-15-96
Initial Proposal: 1996

Priority: 7

TITLE: ASSESS CONTAMINANT SOURCES AND PATHWAYS AFFECTING THE CONGAREE SWAMP NATIONAL MONUMENT

Funding Status:	Funded: 0.00	Unfunded:	Year 1:	10.00
			Years 2 and 3:	50.00

SERVICE WIDE ISSUE CODES: N11 (WATER QUAL-EXT)
N20 (BASELINE DATA)

PROBLEM STATEMENT:

The 22,200 acre Congaree Swamp National Monument is located almost entirely in the floodplain ecosystem of the Congaree River in central South Carolina. The position of the National Monument at the lower end of a 5.2 million acre watershed exposes the National Monument ecosystem to water-borne contamination originating upstream from multiple land uses including, urban, industrial, agricultural, and silvicultural uses. Floodwaters from the Congaree River, which may contain contaminants inundate the National Monument during late winter and early spring flood events; inundation is less frequent during summer and fall flood events. When the river stage is below flood levels, the National Monument is isolated from the river by a natural levee.

Surface waters also enter the National Monument from Cedar Creek and Toms Creek and their tributaries; both streams flow through the National Monument before discharging to the Congaree River. These perennially flowing streams contact a small area of the National Monument but they represent a disproportionately critical habitat for organisms that require flowing water. They also may be the pathway for water and sediment contamination. The watersheds of Cedar Creek and Toms Creek are primarily silvicultural and agricultural, but they contain several potential point sources of contamination, including five community, one industrial, and one military airbase wastewater treatment plants.

An important value of floodplain forests in watersheds is the accumulation and sequestering of contaminants (Mitsch and Gosselink 1986). The uptake of excessive nutrients and other contaminants by floodplain trees and the sequestering of these contaminants in floodplain sediments may temporarily remove contaminants that would otherwise enter aquatic food webs. However, acute or long-term exposure of biota in the floodplain forest to contaminants may disrupt nutrient cycling within the ecosystem and impede forest productivity and regeneration.

Because the National Monument is still a relatively unaltered ecosystem that contains some of the last remnant stands of old-growth bottomland hardwood forest in the Southeast, measures should be undertaken to protect the National Monument ecosystem from acute exposure and to excessive long-term chronic exposure to contaminants.

Potential Sources of Contamination Via the Congaree River:

- The city of Columbia, South Carolina is located at the confluence of the Broad and Saluda Rivers, which form the Congaree River 26 river miles upstream from the western boundary of the National Monument. Stormwater runoff from impervious surfaces in urban areas (roadways, parking lots, and rooftops) is diverted through storm drainage systems directly into the Congaree River without the benefit of treatment. Urban runoff typically contains an array of contaminants, such as petroleum products, heavy metals, solvents, nutrients from fertilizer, fecal coliform and associated bacteria, suspended sediments, and litter. In Columbia, Gills Creek has been identified by the South Carolina Department of Health and Environmental Control as a highly contaminated stream due to urban and industrial pollutants. The cities of Greenville, South Carolina and Spartansburg, South Carolina and several smaller municipalities are also within the Congaree River watershed and may be contributing to contaminant problems in the Congaree River.

- Between the confluence of the Broad and Saluda Rivers, at least 69 wastewater discharge permits have been issued through the National Pollutant Discharge and Elimination System (NPDES) program. Major NPDES dischargers are listed below:

  - Carolina Eastman Company, which discharges approximately 100 MGD (million gallons per day) of wastewater 3 miles upstream from the National Monument's western boundary. In 1994 wastewater discharge from the plant was reported to be excess of NPDES standards for suspended solids, grease and oils, and pH.

  - Westinghouse Electric Corporation, which discharges 0.13 MGD of wastewater into a tributary that enters the Congaree River approximately 6 miles upstream from the National Monument's western boundary. In 1994, Westinghouse wastewater discharge exceeded NPDES standards for dissolved oxygen, 5-day biological oxygen demand, suspended solids, ammonia-nitrogen, and fluoride.

  - Teepak, Incorporated, which discharges on land surfaces adjacent to the Congaree River near Columbia. In 1994, Teepak, Inc. wastewater discharge exceeded standards for ammonia-nitrogen and fecal coliform.

  - City of Columbia Metro Plant, a municipal wastewater treatment plant 12 miles upstream from the National Monument, which discharges 60.0 MGD into the Congaree River. In 1994, the plant exceeded NPDES standard for suspended solids and fecal coliforms.

  - City of Cayce Main Plant is a municipal wastewater treatment plant which discharges 8.0 MGD. In 1994, wastewater discharge exceeded NPDES standards for residual chlorine and fecal coliform.

  - East Richland County Public Schools, Gills Creek Plant, is a wastewater treatment plant which discharges 10.5 MGD. In 1994, the wastewater discharge from the plant exceeded NPDES standards for fecal coliform.

- Twenty-nine hazardous waste sites have been identified in the Congaree River watershed between Columbia and the National Monument. The risk of contaminant problems affecting the National Monument as a result of uncontrolled discharges from these sites depends on: (a) the proximity of these sites to surface waters and groundwater that discharge into streams; (b) the direction and rate of contaminant plume migration; and, (c) the status of site remediation. A contaminant plume at the Westinghouse Electric facility containing nitrate and volatile organic compounds (VOC) was determined to be discharging into Sunset Lake, unnamed streams, and wetlands on or adjacent to plant property. These waters and wetlands connect to Mill Creek which flows into the Congaree River approximately 6 miles from the plant and approximately 5 miles upstream from the western boundary of the National Monument. The site was included on the State Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Site Inventory for 1994 (SCDHEC 1994) and on the South Carolina Groundwater Contamination Inventory for 1995 (SCDHEC 1995).

- Other nonpoint sources of pollution are runoff from areas used for agricultural and silvicultural production. Such pollutants include excess nutrients from fertilizer applied to farm fields; animal waste products which may contain pathogenic organisms, as well as nutrients; pesticides (insecticides and herbicides); and eroded sediments from farm fields, logging operations, and other intensive land uses. These contaminants often enter river and stream systems via drainage ditches which connect agricultural and silvicultural land far from the river corridor.

Potential Sources of Contamination Via Cedar Creek and Toms Creek:

- The watersheds of Cedar Creek and Toms Creek are dominated by silvicultural and agricultural land uses with limited light industrial, municipal, and residential development. One other significant component of the landscape in these watersheds, however, is the presence of two military bases, U.S. Army, Fort Jackson and McEntire Air National Guard Base. The portion of Fort Jackson within the Cedar Creek watershed is used for maneuvers only and does not contain sources of contamination. McEntire ANG Base is located entirely within the watersheds of Cedar Creek and Toms Creek. A permitted wastewater treatment facility (0.02 MGD) on the Base discharges into Cedar Creek. In 1994, this facility exceeded NPDES standards for suspended solids, biological oxygen demand, pH, and fecal coliform. In addition to this point source discharge, runoff from the airbase tarmac may enter into drainageways that flow into Cedar Creek and Toms Creek.

- Square-D Company in the Cedar Creek watershed discharges 0.027 MGD and was in excess of NPDES standards for suspended solids and pH during 1994.

- Small wastewater treatment facilities at 2 residential developments and 3 public schools discharge a total of 0.126 MGD within the Cedar Creek watershed. Each discharge facility was in excess of NPDES standards for suspended solids and biological oxygen demand during 1994.

- A hazardous waste site is located on the north side of Bluff Road (opposite of the main entrance to the Westinghouse facility) approximately 3 miles from the northwest boundary of the National Monument. This site is an abandoned chemical and petroleum recycling and disposal facility formerly operated by South Carolina Recycling and Disposal, Inc. (SCR&D). A groundwater contaminant plume has been identified between the disposal site and Myers Creek. Myers Creek adjoins Cedar Creek near the northwest boundary of the National Monument. During the 1980s, an assortment of containerized toxic and hazardous materials were stored or disposed of on the site. Soil and groundwater contamination were discovered and the containers were removed. However, the contaminated soil and water remained. Soil remediation at the site was initiated in 1995. Groundwater remediation is scheduled to begin in 1996. The site is included on the Environmental Protection Agency National Priority List within the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) program.

- An aquaculture facility, Southland Fisheries, Inc., is located adjacent to Cedar Creek. This facility produces fingerling gamefish in several impoundments that are isolated from the stream. The facility does not require a discharge permit and its impact on water quality is probably minimal.

- Nonpoint sources of pollution as described above.

DESCRIPTION OF RECOMMENDED ACTION OR ACTIVITY:

- Enter into a cooperative agreement with the National Biological Service (NBS) to conduct a preliminary study of existing and potential contaminant problems in the National Monument. The NBS, Biomonitoring of Environmental Status and Trends (BEST) program was designed to identify potential contaminant problems through a two phased process. The first phase entails compiling pertinent contaminant source, pathway, and fate data from existing reports and databases following a standardized format detailed in the NBS, *Contaminants Problem Identification Manual.* If contaminant problems are perceived, a sampling plan is developed to confirm the extent of the contaminant threat to the National Monument (NBS 1994). The second phase entails implementing the sampling plan, analyzing the data, and preparing a summary report which may be used by managers at the National Monument to study the problem further or develop remedial action plans designed to reduce the contaminant threat.

- Monitor compliance with NPDES discharges. Contract a water quality analyst to conduct an annual review of NPDES compliance reports for major wastewater dischargers on the Congaree River and Cedar Creek.

- Request that the South Carolina Department of Health and Environmental Control-Bureau of Water Pollution Control conduct a Special Water Quality Study at Cedar Creek and Toms Creek to determine the effect of McEntire Air National Guard Base on water quality in these streams.

- Review remediation status of the SCR&D-Bluff Road and the Westinghouse Electric Corporation CERCLA sites. Request that the Project Managers for these sites submit annual reports detailing the status of contaminant migration and remediation efforts.

- Advocate the implementation of Best Management Practices (BMPs), zoning regulations, and voluntary community efforts that would reduce contamination resulting from urban runoff in Columbia and other major municipalities in the watershed.

- Advocate land use practices which reduce the amount of runoff from agricultural and silvicultural lands, and provide buffers between these lands and river and stream corridors. Descriptions of state and federal programs aimed at river corridor protection are provided in Project Statement COSW-N-023 and in the Issues and Management Alternatives section (see Table 16) of the Water Resources Management Plan for the Congaree Swamp National Monument.

- Coordinate with the University of South Carolina, Department of Geography, Hazards Research Lab to develop a relative risk profile for the National Monument. This program may be useful in assessing the potential risk of contamination from hazardous waste sites and water of degraded quality on the National Monument using geographic information processing techniques. This program may also be used to address issues of environmental responsibility and causality related to land use, development, and population demographics.

LITERATURE CITED:

Mitsch, W.J. and J.G. Gosselink. 1986. Wetlands. Van Nostrand Reinhold Company. New York. 539 pp.

NBS (National Biological Service). 1994. Contaminants Problem Identification Manual. Biomonitoring of Environmental Status and Trends Program. (Unpublished document) Washington, D.C.

SCDHEC. 1994. State C.E.R.C.L.A. Site Inventory. South Carolina Department of Health and Environmental Control, Bureau of Solid and Hazardous Waste, Columbia, South Carolina. 43 pp.

SCDHEC. 1995. South Carolina Ground-Water Contamination Inventory. Bureau of Drinking Water Protection, Ground-Water Protection Division, Columbia, South Carolina. 132 pp.

Budget and FTE's:

----------UNFUNDED----------

	Activity	Fund Type	Budget ($1000s)	FTEs
Yr 1:	PRO	ONE-TIME	10.00	0.10
Yr 2:	PRO	ONE-TIME	25.00	0.10
Yr 3:	PRO	ONE-TIME	25.00	0.10
		Total:	60.00	0.30

Compliance Codes: EXCL

Explanation: 516 DM2 APP. 2, 1.6

PROJECT STATEMENT

PROJECT STATEMENT NUMBER: COSW-N-063

Last Update: 01-15-96 Priority: 0
Initial Proposal: 1996

TITLE: ADOPT AN INTERAGENCY COLLABORATIVE APPROACH TO MONITORING WATER QUALITY IN THE CONGAREE SWAMP NATIONAL MONUMENT

Funding Status: Funded: 112.10 Unfunded: 0.00

SERVICE WIDE ISSUE CODES: N11 (WATER QUAL-EXT)

PROBLEM STATEMENT:

The unique forests and relatively unaltered ecological conditions of the Congaree Swamp National Monument, South Carolina are dependent upon the maintenance of high water quality and natural season flow regimes in the streams and floodwaters that enter the National Monument. The National Monument is located on the Congaree River at the lower end of a 5.2 million acre watershed which encompasses a variety of land uses, some with the potential to degrade water quality. In order to adequately assess the existing water quality conditions, determine water quality trends, and evaluate the potential impact of contaminants on the National Monument ecosystem, intensive and specific sampling and analysis is needed. Evidence of declining water quality trends may necessitate remedial action to restore water quality. The South Carolina Department of Health and Environmental Control (SCDHEC) has established water quality monitoring stations on waterways in the vicinity of the National Monument. Water samples are taken infrequently and a limited set of ecological and chemical parameters are analyzed in waters flowing into the National Monument. The fate of potential contaminants, except for a year of biweekly sampling for metals and nutrients in Cedar Creek, Toms Creek, and Reeves Creek by NPS personnel (Rikard 1991), has not been addressed and warrants further study.

Previous studies are based on short-term sampling efforts of surface water and bed sediment. Cooney (1990) detected elevated levels of cadmium and manganese and Birch (1981) detected elevated levels of iron and manganese in the waters and sediments of the National Monument. Each of these levels exceeded EPA drinking water standards. Longer-term and standardized contaminant studies are needed to better monitor contaminant problems in the National Monument.

Overview of the USGS National Water Quality Assessment Program

A long-term and in-depth federal water quality monitoring program, the U.S. Geological Survey's (USGS) National Water Quality Assessment (NAWQA), has been initiated, nationwide, to assess and track water quality conditions (USGS 1994). This program includes assessment and tracking of water quality trends in the Santee River watershed in which the Congaree Swamp National Monument lies. The basic strategy of this program establishes surface water and groundwater quality monitoring fixed-stations in 60 watershed study units nationwide (USGS 1994). For each NAWQA fixed-station within a study unit, physical habitat, ecological communities, water and sediment chemistry, and chemical contaminants in biological tissue are recorded and analyzed. To best utilize personnel, analytical facilities, and program funding, sampling and analysis in study units are conducted on a rotational basis. Intensive sampling and analysis is conducted for 3 to 4 years in 20 of the NAWQA study units followed by a 6 to 7 year period of less intensive study while the other 40 study units are investigated. The NAWQA program also conducts Synoptic Studies which are designed to examine specific water quality parameters.

Objectives of the NAWQA Program at the Congaree Swamp National Monument

NAWQA personnel for the Santee River Basin watershed subunit conducted a feasibility study at the National Monument to determine the suitability of sites within or adjacent to the National Monument as NAWQA fixed-station sampling sites. At the conclusion of this investigation, NAWQA personnel determined that appropriate sites for fixed-stations were not available at the National Monument. However, the National Monument was determined to be a viable site to conduct a Synoptic Study.

A Synoptic Study at the National Monument would address the relationships between land use in the Cedar Creek and Toms Creek watersheds and water quality downstream in the National Monument. Further, the study will examine the relationship between water quality and the accumulation of contaminants in streambed sediment, as well as the effects of contaminants on the National Monument ecosystem (B. Hughes, USGS-NAWQA, Santee River Basin and Coastal Drainages Study Unit, memorandum, October 1995).

For reasons of efficiency and mutual benefit from the data collected and analyzed, NAWQA studies are often conducted in collaboration with other federal agencies and state or local agencies within the study unit. A Synoptic Study at the National Monument should involve efforts from the U.S. Geological Survey-NAWQA and the National Park Service. The information obtained in the study would benefit the NAWQA by helping to establish correlations between land use in small watersheds (Cedar Creek and Toms Creek) within the Santee River Basin and benefit the National Monument by providing data that would identify water quality problems in the National Monument and facilitate management decisions related to water quality.

The USGS will provide read-only access to water quality (QWDATA) and ecological (BDAS) databases. All data collected as part of this interagency project will be provided to the NPS in digital form. An open-file report and possibly a journal article will be prepared on water quality and ecological community structure in the National Monument. Copies of these reports will be provided to the NPS (B. Hughes, USGS-NAWQA Chief for Santee River Basin Study, Columbia, South Carolina, memorandum, January 1996).

DESCRIPTION OF RECOMMENDED ACTION OR ACTIVITY:

In August, 1995, an interagency meeting was held in Columbia, South Carolina to discuss a USGS-NPS collaborative effort to assess water quality in the Congaree Swamp National Monument. In October, 1995, a draft Proposed Scope of Work was presented to the NPS by the USGS-NAWQA study group for the Santee River Basin and Coastal Drainages Study Unit (B. Hughes, USGS-NAWQA, Santee River Basin and Coastal Drainages study unit, memorandum, October 1995). In order to address questions related to land use, water quality, and ecological communities in the Cedar Creek and Toms Creek watersheds, the NAWQA study group proposed the following approaches:

- Collection of streambed sediment and biological tissue samples at 5 locations within and near the National Monument during fiscal year 1996. Sample sites include: Myers Creek (a tributary to Cedar Creek), Cedar Creek at SC 734 (Old Bluff Road), a point near Wise Lake in the National Monument, Toms Creek, and the Congaree River at the US 601 bridge. Bed samples and tissue samples will be analyzed for trace elements and hydrophobic organic chemicals including pesticides. The principal targets for tissue analysis will be freshwater Asiatic clams, *Corbicula fluminea*, which has been demonstrated as a suitable bio-indicator species for heavy metals in ambient water in the Congaree River basin (Pickett 1992), and fish species.

- Collection of quarterly surface water samples for 3 years (FY96, FY97, FY98) for water quality analysis using NAWQA protocols at 4 locations: Cedar Creek at SC 48 and near Wise Lake, Myers Creek, and Toms Creek. Samples will be analyzed for major ions, nutrients, and pesticides at the USGS Central Laboratory, Arvada, Colorado. Stream discharge will be measured when samples are collected to enable calculation of stream contaminant loads.

- Completion of an ecological assessment at each of the 4 water quality sampling sites during FY97. The ecological assessment entails a habitat assessment and collection of algae, macroinvertebrates, and fish. This information will be used to establish the relationship between ecological community structure and water quality.

STATUS:

A study plan for the proposed synoptic study has been developed by the USGS NAWQA Santee River Basin Study Team. NPS cooperative funding is expected to be made available in FY96.

LITERATURE CITED:

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Budget and FTEs:

	Source	Activity	Fund Type	Budget ($1000s)	FTEs
		FUNDED			
FY96:	USGS	MON	R	20.15	0.00
	NPS			20.15	0.10
FY97:	USGS	MON	R	17.95	0.00
	NPS			17.95	0.10
FY98:	USGS	MON	R	17.95	0.00
	NPS			17.95	0.10
			Total:	112.10	0.30

Compliance Codes: EXCL

Explanation: 516 DM2 APP. 2, 1.6

PROJECT STATEMENT

PROJECT NUMBER: COSW-N-064

Last Update: 01-15-96 Priority: 17
Initial Proposal: 1996

TITLE: ASSESS THE IMPACT OF EXISTING MAN-MADE STRUCTURES WITHIN THE NATIONAL MONUMENT ON WATER FLOW REGIME

Funding Status: Funded: 0.00 Unfunded: 20.00

SERVICE WIDE ISSUE CODES: N12 (WATER FLOW)

PROBLEM STATEMENT:

The Congaree Swamp National Monument contains one of the few remaining old-growth forests in the eastern United States. Most of its 22,200 acres is in the floodplain of the Congaree River, a major drainage within the Santee River basin that discharges to the Atlantic Ocean. The National Monument is located just east of the Fall Line between the Piedmont and coastal plain in South Carolina. Most of the site floods annually. This feature, in addition to the numerous oxbow lakes and perennial streams, is critical to the maintenance of the old-growth forest and concurrently makes the site rich in a variety of aquatic ecosystems.

Man-made structures that alter the flow and circulation of water in the National Monument may adversely affect the natural attributes of the National Monument. Some of these structures have a minor effect on water circulation. These include culverts and associated gravel from washouts of former roads, and classified cultural structures (6 cattle mounts, 3 dikes, and 1 bridge). Two others are of greater concern: the relic dam located on Cedar Creek near Wise Lake and roads in various parts of the floodplain within the annual flood zone.

The relic dam near Wise Lake should be examined to determine its influence on the connection between Wise Lake and Cedar Creek. Both excavation and damming were apparently conducted by members of a hunting club that once used the area. The results of this activity need to be evaluated to determine if restoration to the original landscape is warranted. As water passes through the broken dam, the drop is steep enough to cause riffles in the channel, an aquatic habitat that is very uncharacteristic of coastal plain streams. One can infer that the dam also has reduced the channel gradient upstream. The higher water table caused by this change in gradient likely has made land adjacent to the stream wetter than normal. Reestablishment of the stream channel to its previous gradient is a possible restoration option. The manner in which this is done needs to be approached with caution. If the dam is simply removed, the stream channel may erode headward, thus transporting sediment downstream and effectively draining adjacent land where wetland plant communities are established. Another possible consequence is lateral erosion. This would occur as the stream dissipates energy in meandering to achieve a slope that is in equilibrium with its morphology before the dam was built.

Any proposals to restore the stream to its former natural course should take into account pre-impoundment conditions. The proximity to Wise Lake suggests that the two were hydrologically connected in the past. The nature of this relationship, if it existed, should be determined and understood before restoration plans are decided upon. While engineering solutions may make it possible to stabilize the stream after dam removal, this is inconsistent with NPS policy on restoration, and may not be an improvement over the present condition. On the other hand, actions that produce an unstable stream channel that may interfere with the current condition of Wise Lake is also undesirable. Therefore, it is recommended that restoration options receive the review of fluvial geomorphologists who are specialists in small stream restoration.

Other man-made structures include the network of roads, culverts, and groundwater observation wells. The roads represent fill above the floodplain surface that impedes the flow of water down the gradient in the floodplain and causes ponding on the upslope side. The culverts mitigate the effects of the road by allowing water to pass under roads. The extent to which shallow flows are impeded by roads and the frequency of size and spacing of culverts that reduce potential ponding should be examined and assessed. If excessive ponding is occurring, actions can be taken to mitigate these effects.

DESCRIPTION OF RECOMMENDED ACTION OR ACTIVITY:

In most cases the effects of structures are not widespread enough to have significant influences on flow patterns of surface water. There may be aesthetic reasons to remove some structures. In other cases they are considered attributes and designated as classified structures of cultural significance. Where structures have no cultural significance and appear to be impeding flow and circulation of water, steps should be taken to evaluate their influence and implement habitat restoration if deemed desirable.

Recommended actions include:

- The broken dam on Cedar Creek creates a riffle area on the stream that is uncharacteristic of the natural stream's gradient. However, steepness of the stream in that area probably does not create impediments to aquatic organism use. In contrast, the lowering of the stream's gradient upstream from the dam has increased water tables to which existing vegetation has apparently adapted. A habitat restoration plan should be developed that will attempt to re-establish as closely as possible the natural flow patterns of the area.

- Where roads are essential to the maintenance of the National Monument, the roads should be inspected to determine if they cause ponding up-gradient during moderate flow events that do not overtop the roads within the floodplain. If ponding occurs, additional culverts should be installed.

- An assessment should be completed as to the status of the inactive groundwater observation wells, and a recommendation made regarding the long-term maintenance of these potentially important reference sites.

Budget and FTEs:

---------------------------UNFUNDED---------------------------				
	Activity	Fund Type	Budget ($1000s)	FTEs
			==========================	
Yr.:	MIT	ONE-TIME	20	0.2

Compliance Codes:

Compliance codes: EXCL

Explanation: 516 DM6 APP. 7.4 B (10)

PROJECT STATEMENT

PROJECT STATEMENT NUMBER: COSW-N-065

Last Update: 01-15-96 Priority: 0
Initial Proposal: 1996

TITLE: PROMOTE NATIONAL AND INTERNATIONAL RECOGNITION OF THE NATIONAL MONUMENT AS AN IMPORTANT ECOLOGICAL AND RECREATIONAL RESOURCE

Funding Status: Funded: 45.00 Unfunded: 0.00

SERVICE WIDE ISSUE CODES: N24 (OTHER (NATURAL))

PROBLEM STATEMENT:

The Congaree Swamp National Monument was established in 1976. The 22,200 acre National Monument protects one of the last remnants of old-growth bottomland hardwood forest in the Southeast. Several national and state champion trees were originally located within the National Monument. In 1989, Hurricane Hugo toppled several of these record trees. A 1995 survey established that four national champion and several state champion trees remained (Jones 1996).

International recognition has been afforded the National Monument by inclusion in the United Nations Educational, Scientific, and Cultural Organization's (UNESCO) Biosphere Reserve Program. The Biosphere Reserve Program is an integral part of UNESCO's Man and the Biosphere Program (MAB) which provides a knowledge-base to facilitate a better understanding of the interrelationships of humans and their environment. In 1983, the National Monument was designated a part of the South Atlantic Coastal Plain Biosphere Reserve; the Pinelands National Reserve in the New Jersey Pine Barrens is its partner reserve. Biosphere Reserves are designated because they are minimally disturbed and are valuable in monitoring global change and promoting ecological research.

Considerable ecological research has already been conducted in the National Monument by researchers from regional universities and research institutions. However, numerous research opportunities remain. The National Monument has support facilities for researchers including three USGS gauging stations, crest gauge stations located near areas accessible by vehicle, an air quality and acid deposition station maintained by the South Carolina Department of Health and Environmental Control, a fire/weather station, published and unpublished surveys and research reports on file at the NPS headquarters in the National Monument, and a small cabin for overnight use.

As a recreational resource, the National Monument is probably under-appreciated. Visitation in 1994 was 67,756 and is expected to double within 5 to 10 years. Still, visitation in the National Monument falls far short of other National Park Service units in the region. Increased visitation and public support would better ensure funding support from the National Park Service and justify upgrading visitor and NPS personnel facilities at the National Monument.

DESCRIPTION OF RECOMMENDED ACTION OR ACTIVITY:

The enhancement of the Congaree Swamp National Monument as a research site and for use by the visiting public will require the improvement of facilities available to researchers and visitors. To achieve these goals, the following recommendations may be made:

Research Use of the National Monument:

- Coordinate research activities with local and regional universities and research institutions. Promote the establishment or continuance of cooperative agreements with these public and private institutions. Local and regional institutions with a strong interest in forest and wetland ecology include: the University of South Carolina (Columbia, South Carolina), Clemson University (Clemson, South Carolina), University of Georgia (Athens, Georgia), North Carolina State University (Raleigh, North Carolina), East Carolina University (Greenville, North Carolina), and the Savannah River Ecology Laboratory (Aiken, South Carolina).

- Provide local and regional universities and ecological research institutions with a semiannual listing of research opportunities and needs in the National Monument.

- Maintain the USGS gauging stations, crest gauges, the air quality station, and the weather station and make the data available to researchers.

- Encourage researcher use of back-country sites where sample plots and equipment could be established in a manner that would not be obtrusive to the visiting public and would be minimally exposed to vandalism. Post summaries of on-going research projects for public viewing at the National Monument headquarters.

- Encourage the use of the National Monument as host site for small conferences or meetings (if facilities are adequate) and for field excursions for conferences held in the Columbia area. As a Biosphere Reserve, the National Monument may serve as a reference site to monitor future environmental changes in the National Monument and to compare environmental impacts in similar ecosystems within the region.

Visitor Use of the National Monument:

- Visitors to the National Monument may develop a better understanding of the National Monument ecosystem if the appropriate printed information is available to them. Presently, a brochure (GPO: 1992-312-248/60007) is available to visitors which provides basic information about the National Monument ecosystem with emphasis on the biological resources and record trees of the National Monument. Although reprinted in 1992 and 1995, the brochure does not include information about Hurricane Hugo (1989) and its effects on forest structure in the National Monument. A new brochure should include a discussion of the post-Hurricane Hugo structure of the forest and a new listing of record trees. The new brochure should provide the visitor with a synthesis of floodplain hydrology and ecological functions and values of the National Monument ecosystem. Such a synthesis would allow visitors to develop a better understanding of bottomland hardwood forest and swamp forest ecology, as well as the importance of these ecosystems in the local watershed and in the regional and international landscape.

- Coordination with private partner organizations, such as the National Park Foundation, to upgrade the visitor brochure and printed information available to visitors.

LITERATURE CITED:

Jones, R.H. 1996. Location and ecology of champion trees in Congaree Swamp National Monument. Virginia Polytechnic Institute and State University, Blacksburg, VA (Cooperative Agreement with School of Forestry, Auburn University)

Budget and FTEs:

-----FUNDED-----

	Source	Activity	Fund Type	Budget ($1000s)	FTEs
FY96:	SVC-OTHER	INT	ONE-TIME	15.00	0.00
	PKBASE-NR	INT	RECURRING	5.00	0.10
	PKBASE-NR	ADM	RECURRING	5.00	0.10
			Subtotal:	25.00	0.20
FY97:	SVC-OTHER	INT	RECURRING	5.00	0.10
	PKBASE-NR	INT	RECURRING	5.00	0.10
			Subtotal:	10.00	0.20
FY96:	PKBASE-NR	INT	RECURRING	5.00	0.10
	PKBASE-NR	INT	RECURRING	5.00	0.10
			Subtotal:	10.00	0.20
			Total:	45.00	0.60

Compliance Codes: EXCL

Explanation: 516 DM2 APP. 2, 1.6

PROJECT STATEMENT

PROJECT NUMBER: COSW-N-067
Last Update: 05-03-96 Priority: 0
Initial Proposal: 1995

Title: ECOLOGICAL PROCESSES AND PROFILES ON MAJOR WATERWAYS

Funding Status: Funded: 734.10 Unfunded: 0.00

SERVICE WIDE ISSUES: N11 (WATER QUAL-EXT)
N20 (BASELINE DATA)

PROBLEM STATEMENT:

The Congaree River drains a watershed greater than 8,000 square miles in the southeastern United States and is responsive to land use changes in that area. The Congaree River does not have the volume of flow to dilute or buffer regional changes like the largest U.S. rivers, nor the flashiness and high variability of very small rivers that vacillate between near stagnation and extreme flooding. The Congaree River flows adjacent to Congaree Swamp National Monument and provides an excellent study area for several reasons.

From a regional perspective, it is centrally located and representative of a group of eastern rivers that flows off the interior highlands and onto the coastal plain. Findings here will be relevant to other eastern rivers of similar size. From a more localized perspective, the Congaree River and associated bottomland hardwood ecosystem in the Congaree Swamp National Monument are ecologically closer to pristine condition than most other river swamps. Although the upper and middle reaches of the Congaree River flow through and region that has recently undergone substantial urban and industrial development, the lower reach of the river (from Columbia to the National Monument, approximately 28 miles) is relatively unaltered. Finally, from an applied perspective, the river interacts with its basin throughout the length of the park. The river plays important ecological roles in creating and maintaining the riparian habitats, bottomland landscape forms, productivity, biota, biodiversity, detrital energy charge, plant occurrence and animal dispersal. The river is a crucially important landscape component.

Much of the National Park Service's mission is to preserve the environmental and ecological conditions and maintain the integrity of important natural or semi-natural ecosystems through land management. Continued development is expected in the watershed and the river may change as a result. The only way to quantify the change is to have pre-development baseline data. Specifically, scientific information in the areas of aquatic metabolism, water quality monitoring, and sediment dynamics and hydrology is needed in-hand before social, economic or political activities potentially conflict with the ecological principles (conservation, sustainability, biodiversity and ecosystem integrity) that are central to the National Monument's very survival.

DESCRIPTION OF RECOMMENDED ACTION OR ACTIVITY:

Hydrology is a strong determinant of the character and integrity of the aquatic and wetland habitats of the National Monument. Managers must understand the inherent variability in water quality and quantity in these systems and the mechanisms of ecosystem responses to this variability to predict the vulnerability of these systems to changes in the water regime or water quality. Because these aquatic habitats are at the lower end of the protected area/ecosystem gradient, the vertebrates which will serve as indicators are the fish and aquatic herpetofauna. Only cursory information is currently available and data sets are disjunct and difficult to relate to each other.

In 1995 a 5-year National Resources Protection Program (NRPP) study was undertaken by the National Park Service in cooperation with the National Biological Service, Southern Science Center in Lafayette, Louisiana. This study will provide a coordinated, multi-area program of research on the key variables of aquatic metabolism, water quality monitoring, and sediment dynamics and hydrology. This detailed and repeatable picture of the aquatic and wetland resources will serve as a benchmark from which to detect future changes.

<u>Aquatic Metabolism</u>

With the exception of the deep-ocean vents, photosynthesis (plant primary production) forms the basis of life in all ecosystems. This fundamental process thus influences numerous other ecosystem properties including biomass production, biodiversity, ecosystem resilience and stability, and type and extent of nutrient cycling. Primary production is itself controlled in a cyclic fashion by the interaction of nutrient regeneration processes and environmental factors such as light and temperature. Either process (nutrient regeneration or environmental factors) may dominate in a given ecosystem or at a given time.

Aquatic ecosystems may be highly autotrophic (plant production>consumption), balanced (plant production equals consumption), or heterotrophic (plant production is less than consumption). The aquatic ecosystems of Congaree Swamp comprise large rivers, small streams, deep and shallow oxbow lakes, and ephemeral sloughs. Depending on changes related to seasons and hydrology, these ecosystems probably exhibit the full range of ecosystem trophic states. Measurements of aquatic metabolism and water quality parameters in conjunction with the studies on hydrology and sediment dynamics will provide baseline data on the nutrient cycling and trophic states of the aquatic ecosystems in the National Monument.

Measurements of the community metabolism and associated nutrient fluxes of the water and sediment communities of the aquatic ecosystems of the National Monument will provide an assessment of the trophic state of these resources and characterize the nutrient dynamics occurring in these systems, over a multi-year, seasonal basis. The measurements of oxygen and dissolved carbon production and consumption can be used in conjunction with data on light and temperature to determine the trophic state of the aquatic communities in the National Monument ecosystem (below). Measurements of sediment dynamics and deposition rates will give an indication of the magnitude of organic inputs to the aquatic communities of the National Monument, indicating the degree to which inputs from outside the National Monument may affect the metabolism of the aquatic communities within the National Monument.

Similarly, the rates of nutrient cycling by the aquatic communities within the National Monument may be compared to inputs from outside the National Monument. The current patterns of metabolism and nutrient cycling within the swamp ecosystems can be upset by land use changes within the watershed. Water quality measurements such as light, pH, temperature, discharge, sediment organic matter content, and nutrient concentrations can be related to the processes of community metabolism and nutrient cycling to assess the relative importance of these environmental factors on the aquatic communities of the park. Water quality monitoring can then be used to predict the effects of changes on the functioning of the National Monument's aquatic ecosystems.

Water Quality Monitoring

A water quality monitoring program will be designed to provide baseline information on the water quality variables most likely to influence the metabolism and nutrient cycling characteristics of the park's aquatic ecosystems. The variables which are typically most important to metabolic processes in aquatic ecosystems are dissolved oxygen, dissolved inorganic carbon, pH, dissolved nutrients (aluminum, nitrate, phosphate), temperature and light (as photosynthetically active radiation, or PAR), chlorophyll a, in-sediment communities, and organic matter content. The basic ecological reasons for inclusion of these variables is presented below. The significance of organic matter content was noted above. Chlorophyll a is used as a surrogate for plant biomass for microscopic algae. The amount of plant material in a system is important in determining rates of primary production.

Dissolved oxygen is critical to the survival of aquatic organisms. Many organisms become stressed at levels below about 5 mg/L (5 parts per million), and begin to die or emigrate at levels much below 2 mg/L (2 parts per million). The situation is most critical in summer when the ability of water to hold oxygen becomes minimal due to seasonally high temperatures. Low dissolved oxygen is often indicative of ecosystems in which heterotrophic metabolism has increased because of anthropogenic inputs of organic matter, e.g., sewage, pulp mill waste, feedlot wastes, etc. Such large inputs of organic matter may also result from collapse of dense algal blooms caused by cultural eutrophication.

Eutrophication results in unacceptably large increases in algal production caused by high levels of anthropogenic nutrient inputs. Dissolved nitrogen and phosphorus are the nutrients most commonly responsible for eutrophication. Nitrogen can be input as either ammonium, preferred by algae, or nitrate. Both can result in nuisance algal growth. Algal biomass builds up until it begins to die as growth finally becomes limited by exhaustion of some nutrient or by self-shading. This large die-off of algal biomass spurs the growth of decomposer organisms like bacteria that deplete dissolved oxygen, often resulting in fish kills. In addition to the magnitude of nutrient inputs, the ratios of the various nutrients are important in determining ecosystem metabolism. The water quality monitoring program being developed as part of this project will provide information on both aspects.

The buffering of dissolved carbonate in an ecosystem is important both as a potential limit to plant production (from insufficient dissolved carbon dioxide or bicarbonate) and as a regulator of system pH, which has direct effects on system nutrient cycling and the health of aquatic organisms. Measurements of pH can also indicate potential problems resulting from acidification within the watershed.

Light and temperature are both very important controls on metabolism and nutrient cycling. Plants typically will sharply increase photosynthesis as light increases, until further increases in light produce no further increase in photosynthesis. The initial plant response is primarily controlled by light availability, while the maximum level of response is controlled by both the light climate and temperature. The response of the autotrophic communities of the swamp ecosystems to light can be used in conjunction with light monitoring data to determine the rates of primary production in the ecosystems of the National Monument, and to characterize their state of adaptation to light and temperature. Thus, various light and temperature monitoring applications can be used to predict the relative trophic state of the National Monument's ecosystems over time.

Sediment Dynamics and Hydrology

The movement of suspended sediment by the Congaree River is an important determinant of the character of both the river and the floodplain within the National Monument. Suspended sediment is an indicator of the erosional status of the watershed. The Congaree River fluctuates between within-channel flow and overbank flow in normal years with an average of 10 overbank floods per year and a total inundation of the floodplain once each year. Changes to the soils in the floodplain that occur during these floods are important. Soil water, nutrient, and mineral recharge likely occur during flood and inundation events.

A field experiment will be designed to test the ability of the National Monument to act as a forested basin where floodwater attenuation and sediment trapping occur. The National Monument will be divided into three levels: (1) riverside, (2) backswamp, and (3) upland transition zone. Each level will then be divided into three strata: (a) upstream, (b) midstream, and (c) downstream. Sediment traps in each of the nine level/strata combinations will then be used to determine to what degree sediment deposition is related to degree of inundation. If the two are related, the greatest sediment deposition would be expected to occur in the cells that are closest to the river and the most upstream.

Sediment movement dynamics will also be assessed to determine whether sediment transport is occurring during initial overbank flooding or at some "active" level when the water levels are falling and current speeds increase sufficiently to entertain sediments. Recognizable powdered tracer techniques will also be used in the Congaree River and major tributaries to measure residence times for sediment transport. Additionally, sediment accumulations will be measured by using a sediment erosion table.

Therefore, the studies of hydrology and sediment dynamics can be linked to the studies of community metabolism and water quality to provide a comprehensive picture of the factors affecting the current status of the National Monuments's various aquatic ecosystems.

Budget and FTEs:

--FUNDED--

	Activity	Fund Type	Budget ($1000s)	FTEs
Yr 1 (95):	FED-OTHER RES	One-time	87.50	0.00
	PKBASE-NR ADM	One-time	5.00	0.05
		Subtotal	92.50	0.05
Yr 2 (96):	FED-OTHER RES	One-time	182.10	0.00
	PKBASE-NR ADM	One-time	10.00	0.10
		Subtotal	192.10	0.10
Yr 3 (97):	FED-OTHER RES	One-time	185.80	0.00
	PKBASE-NR ADM	One-time	10.00	0.10
		Subtotal	195.80	0.10
Yr 4 (98):	FED-OTHER RES	One-time	149.00	0.00
	PKBASE-NR ADM	One-time	10.00	0.10
		Subtotal	159.00	0.10
Yr 5 (99):	FED-OTHER RES	One-time	84.70	0.00
	PKBASE-NR ADM	One-time	10.00	0.10
		Subtotal	94.70	0.10
		Total	734.110	0.00

Compliance Codes: EXCL

Explanation: 516 DM2 APP. 2, 1.6

APPENDIX B

Wetland indicator status of vascular flora of the Congaree Swamp National Monument. Plant list is from the files of the National Monument. Wetland indicator status is from Reed (1988) for the Southeast (Region 2). Plants without indicator status are generally considered to be upland species.

Family / *Species*	Common Name	Wetland Indicator Status*
Selaginellaceae		
Selaginella apoda	Meadow Spike-moss	FACW+
Phioglossaceae		
Botrychium virginianum	Rattlesnake Fern	FACU
Botrychium dissectum	Cutleaf grapefern	FAC
Osmundaceae		
Osmunda regalis var. spectabilis	Royal Fern	OBL
Osmunda cinnamomea	Cinnamon Fern	FACW+
Schizaeaceae		
Lygodium japonicum	Japanese Climbing Fern	FAC
Pteridaceae		
Adiantum pedatum	Northern Maiden-Hair Fern	FACU
Pteridium aquilinum	Bracken Fern	FACU
Aspidiaceae		
Athyrium asplenoides	Southern Lady Fern	
Dryopteris ludoviciana	Southern Shield-Fern	FACW
Polystichum acrostichoides	Christmas Fern	FAC
Thelypteris hexagonoptera	Broad Beech Fern	FACU+
Thelypteris palustris	Marsh Fern	
Onoclea sensibilis	Sensitive Fern	FACW
Blechnaceae		
Woodwardia areolata	Netted Chainfern	OBL
Polypodiaceae		
Polypodium polypodioides	Resurrection Fern	
Pinaceae		
Pinus taeda	Loblolly Pine	FAC
Pinus palustris	Long-Leaf Pine	FACU+
Taxodiaceae		
Taxodium distichum	Bald Cypress	OBL
Typhaceae		
Typha latifolia	Broad-Leaf or Common Cattail	OBL
Poaceae		
Tridens flavus var. flavus	Purple-Top Tridens	FACU
Uniola sessiliflora		
Uniloa latifolia	Upland Sea Oats	
Bromus catharticus	Brome Grass	
Hordeum pusillum	Little Barley	FACU
Avena satiua	Oats	
Aristida stricta	Pineland Three-Awn Grass	FAC-
Sporobolus poiretii	Smut Grass	
Leersia oryzoides	Rice Cutgrass	OBL
Zea mays	Corn	
Arundinaria gigantea	Giant Cane	FACW
Eragrostis refracta	Meadow Love Grass	FACW
Poa autumnalis	Autumn Bluegrass	FACW-
Glyceria striata	Fowl Manna Grass	OBL

*Indicator status is OBL (obligate wetland, almost always found in wetlands); FACW (facultative wetland, usually found in wetlands); FAC (facultative, equally likely to be found in wetlands and nonwetlands); FACU (facultative upland, usually occur in nonwetlands); UPL (obligate upland, almost always in nonwetlands). See Reed (1988) for details.

Family / *Species*	Common Name	Wetland Indicator Status
Poaceae		
Festuca elatior	Fescue	
Elymus virginicus	Virginia Wild-Rye Grass	FAC
Alopecurus caroliniana	Foxtail Grass	
(*carolinianus*)	Tufted Foxtail	FACW
Agrostis hyemalis	Winter Bentgrass	FAC
Phalaris caroliniana	Carolina Canary Grass	FACW
Leersia lenticular	Cut Grass	
(*lenticularis*)	Catchfly Cutgrass	OBL
Leersia hexandra	Club-head Cutgrass	OBL
Leersia virginica	Whitegrass	FACW
Setaria geniculata	Knotroot Bristle Grass	FAC
Echinochloa colonum	Jungle-Rice	FACW
(colona)		
Echinochloa crusgalli	Barnyard Grass	FACW-
Oplismenus setarius		
Digitaria sanguinalis	Hairy Crabgrass	FAC-
Sacciolepis striata	American Cupscale	OBL
Panicum verrucosum	Warty Panic Grass	FACW
Panicum anceps	Beaked Panic Grass	FAC-
Panicum dichotomum	Panic Grass	
Panicum scoparuim	Panic Grass	
Panicum agrostoides	Panic Grass	
Panicum dichotomiflorum	Fall Panic Grass	FACW
Panicum gymnocarpon	Panic Grass	
Panicum hemitomon	Maiden-Cane	OBL
Panicum boscii	Panic Grass	
Microstegium vimineum		
Arthraxon hispidus	Joint-Head Arthraxon	FACU+
var. cryptatherus		
Erianthus strictus	Narrow, Plumegrass	OBL
Erianthus giganteus	Sugar Cane Plumegrass	FACW
Andropogon virginicus	Broom-Sedge	FAC-
Cyperaceae		
Dulichium arundinaceum	Three-Way Sedge	OBL
Eleocharis tortilis	Twisted spikerush	FACW
Scleria minor	Slender Nutrush	FACW
Carex howei	Howe Sedge	OBL
Carex typhina	Cat-Tail Sedge	OBL
Cyperus erythrorhizos	Red-Root Flatsedge	OBL
Cyperus polystachyos	Many-Spike Flatsedge	FACW
Cyperus odoratus	Rosty Flatsedge	FACW
Cyperus strigosus	Straw-Color Flatsedge	FACW
Cyperus pseudovegetus	Marsh Flatsedge	FACW
Scirpus cyperinus	Wool-Grass	OBL
Scirpus atrovirens	Green Bulrush	OBL
Eleocharis obtusa	Blunt Spikerush	OBL
Fimbristylis autumnalis	Slender Fimbry	OBL
Rynchospora corniculata	Short Bristle Beak Rush	OBL
Rynchospora pallida	Pale Beak Rush	OBL
Rynchospora glomerata	Clustered Beak Rush	OBL
Rynchospora globularis	Globe Beak Rush	FACW
Carex turgescens	Pinebarren Sedge	OBL
Carex frankii	Frank's Sedge	OBL
Carex baileyi	Bailey's Sedge	FACW
Carex grayi	Asa Gray's Sedge	FACW
Carex louisianica	Louisiana Sedge	OBL

Family *Species*	Common Name	Wetland Indicator Status
Arecaceae		
Sabal minor	Dwarf Palmetto	FACW
Araceae		
Peltandra virginica	Arrow Arum	OBL
Arisaema triphyllum	Swamp Jack-in-the-Pulpit	FACW-
Arisaema dracontium	Green Dragon	FACW
Lemnaceae		
Lemna valdiviana	Pale Duckweed	OBL
Xyridaceae		
Xyris caroliniana	Carolina Yellow-Eyed-Grass	FACW+
Bromeliacea		
Tillandsia usneoides	Spanish Moss	
Commelinaceae		
Aneilema keisak		
Commelina virginica	Virginia Dayflower	FACW
Commelina communis	Asiatic Dayflower	FAC
Juncaceae		
Juncus effusus	Soft Rush	FACW+
Juncus coriaceus	Leathery Rush	FACW
Juncus dichotomus	Forked Rush	FACW
Juncus biflorus	Turnflower Rush	FACW
Juncus acuminatus	Taper-Tip Rush	OBL
Lilaceae		
Trillium catesbaei	Trillium	
Smilacina racemosa	Feather False-Solomon's-Seal	FACU
Uvularia sessilifolia	Sessile-Leaf Bellwort	FAC+
Smilax rotundifolia	Greenbrier Common	FAC
Smilax bona-nox	Saw Greenbrier	FAC
Smilax glauca	Cat Greenbrier	FAC
Smilax laurifolia	Laurel-Leaf Greenbrier	FACW+
Smilax walteri	Coaral Greenbrier	OBL
Allium ampeloprasum	Wild Leek	
Dioscoreaceae		
Dioscorea villosa var. villosa	Yellow Yam	FAC
Dioscorea batatas	Cinnamon Vine	
Amaryllidaceae		
Hypoxis hirsuta var. leptocarpa	Eastern Yellow Stargrass	FAC
Agave virginica		
Orchidaceae		
Halenaria clavellata	Greewood Orchard	
Spiranthes cernua var. odorata	Nodding Ladies'-Tresses	FACW
Malaxis unifolia	Green Adder's-Mouth	FAC+
Tipularia discolor	Cranefly Orchid	FACU
Aplectrum hyemale	Puttyroot	FAC+
Habenaria flava	Southern Rein Orchid	
Spiranthes praecox	Grass-Leaved Ladies' Tresses	FACW
Saururaceae		
Saururus cernuus	Lizard's Tail	OBL
Salicaceae		
Salix nigra	Black Willow	OBL
Populus heterophylla	Swamp Cottonwood	OBL
Populus deltoides	Eastern Cottonwood	FAC+
Myricaceae		
Myrica cerifera	Southern Bayberry	FAC+
Juglandaceae		
Juglans nigra	Black Walnut	FACU
Carya glabra	Sweet Pignut Hickory	FACU

Family / *Species*	Common Name	Wetland Indicator Status
Juglandaceae		
Carya cordiformis	Bitter-Nut Hickory	FAC
Carya aquatica	Water Hickory	OBL
Carya ovata	Shagbark Hickory	FACU
Carya tomentosa	White Heart Hickory	
Betulaceae		
Betula nigra	River Birch	FACW
Ostrya virginiana	Eastern Hophornbeam	FACU-
Alnus serrulata	Brrok-Side Alder	FACW+
Carpinus caroliniana	American Hornbeam	FAC
Fagaceae		
Quercus shurmardii	Shumard Oak	FACW-
Quercus lyrata	Overcup Oak	OBL
Quercus michauxii	Swamp Chestnut Oak	FACW-
Quercus velutina	Black Oak	
Quercus laurifolia	Laurel Oak	FACW
Quercus falcata var. pagodaefolia	Cherry-Bark Oak	FAC+
Quercus nigra	Water Oak	FAC
Quercus phellos	Willow Oak	FACW-
Fagus grandifolia	American Beech	FACU
Ulmaceae		
Celtis occidentalis var. occidentailis	Common Hackberry	FACU
Ulmus rubra	Slippery Elm	FAC
Ulmus americana	American Elm	FACW
Ulmus alata	Winged Elm	FACU+
Planera aquatica	Planer-Tree	OBL
Celtis laevigata	Sugar Berry	FACW
Moraceae		
Morus rubra	Red Mulberry	FAC
Urticaceae		
Laportea canadensis	Canada Wood Nettle	FACW
Urtica chamaedryoides	Heart-Leaf Nettle	FAC
Boehmeria cylindrica	Small-Spike False Nettle	FACW+
Pilea pumila	Canada Clearweed	FACW
Loranthaceae		
Phoradendron serotinum	Mistletoe	
Aristolochiaceae		
Aristolochia serpentaria	Virginia Snakeroot	FACU
Asarum canadense	Northern Wild Ginger	
Hexastylis arifolia	Wild Ginger	
Polygonaceae		
Rumex acetosella	Sheep Sorrel	FACU+
Tovara virginiana	Jumpseed	
Polygonum aviculare	Prostrate Knotweed	FAC-
Polygonum setaceum	Swamp Smartweed	FACW
Polygonum hydropiperoides	Swamp Smartweed	OBL
Polygonum cespitosum var. longisetum	Cespitose Knotweed	FACW-
Polygonum puctatum	Dotted Smartweed	FACW+
Chenopodiaceae		
Chenopodium album	White Goosefoot	FAC-
Phytolaccaceae		
Phytolacca americana	Common Pokeweed	FACU+
Caryphyllaceae		
Stellaria media	Common Chick-Weed	FACU
Stellaria pubera	Giant Chick Weed	
Silene virginica	Fire Pink	

Family	Species	Common Name	Wetland Indicator Status
Ranunculaceae			-
	Clematis crispa	Swamp Virgin's-Bower	FACW+
	Clematis viorna	Leather Flower	
	Clematis virginiana	Virginia Virgin's-Bower	FAC+
	Thalictrum thalictroides	Rue Anemone	
	Ranunculus abortivus	Subalpine Buttercup	FAC
	Hepatica americana	Liverleaf	
Berberidaceae			
	Podophyllum peltatum	May-Apple	FACU
Menispermiceae			
	Cocculus carolinus	Carolina Coralbeads	FAC
Magnoliaceae			
	Liriodendron tulipifera	Tulip Tree	FAC
	Magnolia virginiana	Magnolia Sweetbay	FACW+
Annonaceae			
	Asimina triloba	Common Pawpaw	FAC
Calycanthaceae			
	Calycanthus floridus	Eastern Sweetshrub	FACU+
Lauraceae			
	Sassafras albidum	Sassafras	FACU
	Persea borbonia	Red Bay	FACW
	Lindera benzoin	Northern Spicebush	FACW
Fumariaceae			
	Corydalis flavula	Yellow Corydalis	FACU
Brassicaceae			
	Lepidium virginicum	Poor-Man's Pepper-Grass	FACU
	Cardamine bulbosa	Bulbous Bitter-Cress	OBL
Crassulaceae			
	Cardamine pensylvanica	Pennsylvania Bitter-Cress	FACW+
	Penthorum sedoides	Ditch-Stonecrop	OBL
Saxifragaceae			
	Decumaria barbara	Southeast Decumaria	FACW
	Hydrangea arborescens	Wild Hygrangea	FACU
	Heuchera americana	American Alum-Root	FACU
	Itea virginica	Virginia Willow	FACW+
Hamamelidaceae			
	Hamamelis virginiana	American Witch-Hazel	FACU
	Liquidambar styraciflua	Sweet Gum	FAC+
Platanaceae			
	Platanus occidentialis	American Sycamore	FACW-
Rosaceae			
	Malus augustifolius	Crab Apple	
	Rubus cuneifolius	Sand Blackberry	FACU
	Rubus betulifolius	Blackberry	FAC
	Ceum canadense	Avens	
	Crataegus crus-galli	Cockspur Hawthorn	FAC-
	Prunus angustifolia	Chickasaw Plum	
	Prunus umbellata	Flatwoods Plum	
	Rubus hispidus	Bristly Blackberry	FACW
	Crataegus viridis	Green Hawthorn	FACW
	Crataegus marshallii	Parsley Hawthorn	FAC
	Prunus serotina var. serotina	Black Cherry	FACU
	Geum laciniatum	Rouge Avens	FACW
	Geum virginiana	Avens	
	(virginianum)	Pale Avens	FACW-
	Duchesnea indica	Indian Mock-Strawberry	
	Potentilla canadensis	Five Fingers	

Family / *Species*	Common Name	Wetland Indicator Status
Fabaceae		
Cercis canadensis	Eastern Redbud	FACU
Cassia fasciculata	Partridge Pea	FACU
Gleditsia triacanthos	Honey Locust	FAC-
Crotalaria spectabilis	Rattlebox	
Lespedeza striata	Japanese Clover	FACU
Glottidium vesicarium		
Wisteria frutescens	American Wisteria	FACW
Apios americana	American Potato-Bean	FACW
Desmodium rotundifolium	Beggar's Ticks	
Robinia nana	Locust	
Phaseolus polystachios		
Glycine max	Soybean	
Amorpha fruticosa	False Indigo-Bush	FACW
Melia azedarach	Chinaberry	
Albizia julibrissin	Mimosa	
Linaceae		
Linum striatum	Ridged Yellow Flax	FACW-
Oxlidaceae		
Oxalis stricta	Wood Sorrel	
Geraniaceae		
Geranium carolinianum	Carolina Geranium	
Anacardiaceae		
Rhus copallinum	Winged Sumac	
Rhus (Toxicodendron) vernix	Poison Sumac	OBL
Rhus (Toxicodendron) glabra	Smooth Sumac	
Rhus (Toxicodendron) radicans	Poison Ivy	FAC
Cyrillaceae		
Cyrilla racemiflora	Swamp Cyrilla (Ti-Ti)	FACW
Aquifoliaceae		
Ilex opaca	American Holly	FAC-
Ilex decidua var. decidua	Deciduous Holly	FACW-
Ilex amelanchier	Sarvis Holly (Serviceberry)	OBL
Ilex verticillata	Common Winterberry	FACW
Ilex glabra	Ink-Berry	FACW
Ilex vomitoria	Yaupon	FAC
Celastraceae		
Euonymus americanus	American Strawberry-Bush	FAC-
Aceraceae		
Acer negundo	Box-Elder	FACW
Acer rubrum	Red Maple	FAC
Acer rubrum	Trident Red Maple	OBL
Acer rubrum	Drummond Red Maple	OBL
Acer saccharinum	Silver Maple	FACW
Hippocatanaceae		
Aesculus pavia	Red Buckeye	FAC
Aesculus sylvatica	Painted Buckeye	FAC
Balsaminaceae		
Impatiens capensis	Spotted Touch-Me-Not	FACW
Vitaceae		
Vitis cinerea var. floridana	Pigeon Grape	FAC+
Vitis rotundifolia	Muscadine Grape	FAC
Vitis aestivalis var. aestivalis	Summer Grape	FAC-
Ampelopsis arborea	Pepper-Vine	FAC+
Ampelopsis cordata	Heart-Leaf Pepper-Vine	FAC+
Tiliaceae		
Tilia heterophylla	Basswood	

Family *Species*	Common Name	Wetland Indicator Status
Malvaceae		
Hibiscus moscheutos	Swamp Rosemallow	OBL
Hypericaceae		
Hypericum hypericides	St. John's Cross	
Hypericum mutilum	Slender St. John's-Wort	FACW
Hypericum walteri	St. John's Wort	
Hypericum virginicum	St. John's Wort	
Hypericum gentianoides	Orange-Grass	FACU
Cistaceae		
Lechea villosa	Pin-weed	
Violaceae		
Viola affinis	Leconte's Violet	FACW
Viola papilionacea	Common Blue Violet	FAC
Viola primulifolia	Primrose-Leaf Violet	FACW
Passifloraceae		
Passiflora lutea	Passion Flower	
Lythraceae		
Cuphea carthagensis	Columbia Waxweed	FACW
Melastomataceae		
Rhexia mariana var. mariana	Maryland Meadow-Beauty	FACW+
Onagraceae		
Oenothera biennis	Common Evening-Primrose	FACU
Ludwigia glandulosa	Cylindric-Fruit Seedbox	OBL
Ludwigia leptocarpa	River Seedbox	OBL
Ludwigia palustris	Marsh Seedbox	OBL
Ludwigia uraguayensis	Uraguary Seedbox	OBL
Ludwigia alternifolia	Bushy Seedbox	OBL
Haloragaceae		
Prosperpinaca palustris	Marsh Mermaid-Weed	OBL
Prosperpinaca pectinata	Comb-Leaf Mermaid-Weed	OBL
Araliaceae		
Aralia spinosa	Hercules Club	FAC
Apiaceae		
Hydrocotyle umbellata	Many-Flower Penny-Wort	OBL
Hydrocotyle verticillata var. verticillata	Worled Penny-Wort	OBL
Centella asiatica	Asian Coinleaf	FACW
Sanicula canadensis	Canadian Black-Snakeroot	FACU
Osmorhiza claytonii	Hairy Sweetcicely	FAC-
Osmorhiza longislylis	Smoother Sweetcicely	FAC
Zizia aurea	Golden Alexanders	FAC+
Angelica triquinata	Filmy Angelica	FAC
Cryptotaeania canadensis	Canada Honewart	FAC+
Apium leptophyllum	Marsh Parsley	
Nyssaceae		
Nyssa sylvatica var. sylvatica	Black Gum	FAC
Nyssa sylvatica var. biflora	Swamp Tupelo, Swamp Black Gum	OBL
Nyssa aquatica	Water-Tupelo	OBL
Cornaceae		
Cornus florida	Flowering Dogwood	FACU
Cornus stricta	Swamp Dogwood	
Clethraceae		
Clethra alnifolia var. tomentosa	Coast Pepper-bush	FACW
Ericaceae		
Chimaphila maculata	Pipsissewa	
Monotropa uniflora	Indian-Pipe	FACU-
Rhododendron canescens	Hoary Azalea	FACW-
Kalmia latifolia	Mountain Laurel	FACU
Oxydendrum arboreum	Sourwood	

Family *Species*	Common Name	Wetland Indicator Status
Ericaceae		
Gaylussacia dumosa	Dwarf Huckleberry	FAC
Vaccinium stamineum var. stamineum	Deerberry	FACU
Vaccinium corymbosum	Highbush blueberry	FACW
Vaccinium arboreum	Sparkleberry	FACU
Vaccinium elliottii	Elliott Blueberry	FAC+
Leucothoe axillaris	Coastal Dog-Hobble	FACW
Lyonia lucida	Fetter-Bush	FACW
Primulaceae		
Samolus parviflorus	Water Pimpernel	OBL
Sapotaceae		
Bumelia lycioides	Buckthorn Bumelia	FACW
Ebenaceae		
Diospyros virginiana	Common Persimmon	FAC
Symplocaceae		
Symplocos tinctoria	Horse-Sugar	FAC
Styracaceae		
Styrax americana	American Snowbell	FACW
Oleaceae		
Fraxinus caroliniana	Carolina Ash	OBL
Fraxinus pennsylvanica var. subintegerrima	Green Ash	FACW
Fraxinus americana	White Ash	FACU
Chionanthus virginius	White Fringe Tree	FACU
Forestiera acuminata	Swamp Privet	OBL
Ligustrum sinense	Chinese Privet	FAC
Loganiaceae		
Cynoctonum mitreola	Lax Hornpod	FACW+
Gelsemium sempervirens	Yellow Jessamine	FAC
Spigelia marilandica	Indian Pink	
Apocynaceae		
Trachelospermum difforme	Climbing-Dogbane	FACW
Asclepiadaceae		
Asclepias perennis	Aquatic Milkweed	OBL
Matelea carolinensis		
Convolvulaceae		
Cuscuta compacta	Compact Dodder	
Ipomoea lacunosa	Small-Flower White Morning-Glory	FAC+
Dichondra carolinensis	Carolina Pony-Foot	FACW-
Jacquemontia tamnifolia	Hairy Cluster-Vine	FACU-
Polemoniaceae		
Phlox carolina	Thick-Leaf Phlox	FACU
Boraginaceae		
Heliotropium indicum	Indian Heliotrope	FAC+
Verbenaceae		
Callicarpa americana	American Beauty-Berry	FACU-
Verbena urticifolia	White Vervain	FAC+
Verbena bonariensis	South American Vervain	FAC+
Lamiaceae		
Scutellaria lateriflora	Blue Skullcap	FACW+
Lycopus virginicus	Virginia Bugleweed	OBL
Macbridea caroliniana	Carolina Birds-In-A-Nest	OBL
Satureja georgiana		
Perilla frutescens	Beef-Steak Plant	FAC
Solanaceae		
Physalis virgininana var. virginiana	Ground Cherry	
Solanum pseudocapsicum	Jerusalem Cherry	

Family *Species*	Common Name	Wetland Indicator Status
Solanaceae		
Solanum americanum	Black Nightshade	FACU+
Scrophulariaceae		
Gratiola virginiana	Round-Fruit Hedgehyssop	OBL
Lindernia dubia	Yellow-Seed False-Pimpernel	OBL
Linaria canadensis	Toadflax	
Mimulus alatus	Sharp-Wing Monkey-Flower	OBL
Bacopa monnieri	Coastal Water-Hyssop	OBL
Veronica peregrina	Purslane Seedwell	FAC+
Mecardonia acuminata	Purple Mecardonia	FACW
Bignoniaceae		
Anisostichus (Bignonia) capreolata	Cross Vine	FAC
Catalpa bignonioides	Southern Catalpa	FAC-
Orobanchaceae		
Epifagus virginiana	Beech Drops	
Lentibulariaceae		
Utricularia subulata	Zigzag Bladderwort	OBL
Acanthaceae		
Ruellia carolinensis	Rhuellia	
Dicliptera brachiata	Wild Mudwort	FACW
Justicia ovata	Loose-Flower Water-Willow	OBL
Dyschoriste humistrata	Swamp Dyschoriste	FACW
Plantaginaceae		
Plantago rugelii	Black-Seed Plaintain	FAC
Rubiaceae		
Richardia scabria		
Houstonia caerulea	Innocence	FAC
Galium obtusum var. obtusum	Blunt-Leaf Bedstraw	FACW-
Galium triflorum	Small Bedstraw	
Galium circaezans	Wild Licorice	FACU-
Galium tinctorium	Stiff Marsh Bedstraw	FACW
Cephalanthus occidentalis	Common buttonbush	OBL
Diodia virginiana	Virginia Button-Weed	FACW
Mitchella repens	Partridge-berry	FACU+
Caprifoliaceae		
Lonicera japonica	Jananese Honeysuckle	FAC-
Lonicera sempervirens	Trumpet Honeysuckle	FAC
Virbumum nudum	Possum-Haw Viburnum	FACW+
Virburnum cassinoides	Withe-Rod	FACW
Virbumum prunifolium	Black-Haw	FACU
Virbumum dentatum var. dentatum	Arrow-Wood	FAC
Virbumum rufidulum	Rusty Blue-Haw	FACU
Sambucus canadensis	American Elder	FACW-
Cucurbitaceae		
Cayaponia boykinii		
Campanulaceae		
Lobelia cardinalis	Cardinal Flower	FACW+
Lobelia puberula	Downy Lobellia	FACW-
Lobelia elongata	Elongated Lobellia	OBL
Asteraceae		
Prenanthes serpentaria		
Taraxacum officinale	Common Dandelion	FACU
Erigeiron canadensis	Horseweed	
Aster lateriflorus	Calico Aster	FAC
Haplopappus divaricatus		

Family Species	Common Name	Wetland Indicator Status
Asteraceae		-
Silphium compositum var. compositum	Rosinweed	
Helianthus augustifolius	Swamp Sunflower	FAC+
Bidens bipinnata	Spanish Needles	
Ambrosia artemisiifolia	Annual Ragweed	FACU
Xanthium spinosum	Spiny Cockle-bur	FACU
Aster pilosus	White Heath Aster	FAC-
Aster vimineus	Small White Aster	FAC
Aster dumosus	Bush Aster	FAC
Aster simplex	Panicled Aster	FACW
Pyrrhopappus carolinianus		
Senecio glabellus	Grass-Leaf Groundsel	FACW+
Senecio smallii		
Erechtites hiercifolia	American Burn	FAC-
Vernonia angustifolia	Narrow-Leaf Ironweed	FACU-
Vernonia noveboracensis	New York Ironweed	FAC+
Vernonia glauca	Ironweed	
Elephantopus carolinianus	Carolina Elephant's Foot	FAC
Eupatorium capillifolium var. capillifolium	Thorough-Wort, Small Dog Fennel	FACU
Eupatorium coelestinum	Mist Flower	
Eupatorium serotinum	Thorough-Wort, Late-Flowering	FAC
Mikania scandens	Climbing Hempweed	FACW+
Pluchea camphorata	Salt Marsh Camphor-Weed	FACW
Pluchea rosea	Rosy Camphor-Weed	FACW
Gnaphalium obtusifolium	Rabbit Tobacco	
Baccharis halimifolia	Eastern False-Willow	FAC
Erigeron canadensis	Horse Weed	
Boltonia caroliniana	Carolina Boltonia	FACW
Solidago odora	Goldenrod	
Solidago altissima	Tall Golden-Rod	FACU+
Solidago gigantea	Giant Golden-Rod	FACW
Solidago microcephala		
Heterotheca subaxillaris	Camphor-Weed	FACU-
Eclipta alba	Yerba de Tajo	FACW-
Bidens frondosa	Devil's Beggar-Ticks	FACW
Heleninum autumnale	Common Sneezeweed	FACW

APPENDIX C

Environmental Compliance

The Congaree Swamp National Monument Water Resources Management Plan is categorically excluded from the National Environmental Policy Act (NEPA). This determination is based on the guidelines provided in the United States Departmental Manual:

> 516 DM6, Appendix 7.4 B(4) - This plan would only involve nondestructive data collection, inventory, study, research, and monitoring activities.

Any activities involving disturbance to park lands will involve appropriate environmental and cultural review and compliance.

Copies of this plan have been provided to those agencies, organizations, and individuals listed under the section entitled "Peer and Public Review Comments." Their review and comments on the draft report were considered in the preparation of this final Water Resources Management Plan.

Peer and Public Review Comments

Draft reports of the Congaree Swamp National Monument Water Resources Management Plan were provided to a peer review group including key individuals in federal, state, and local governmental agencies, as well as individuals in the private sector. Draft copies were available for review by the general public at the Columbia Library Main Branch, the Eastover Library, and at the Congaree Swamp National Monument contact station. Copies were mailed on 2 February 1996 and review comments were accepted through 19 March 1996. On 19 March 1996, an open public meeting and workshop was held in Columbia, South Carolina (the meeting was announced in a regional newspaper). The principal authors presented a synopsis of the WRMP and entertained questions and comments from meeting attendees. Approximately 50 individuals representing public and private entities were in attendance.

The following individuals received draft copies for review:

Barry Long, Water Quality Specialist, Water Resources Div., NPS
Dan McGlothlin, Water Rights Specialist, Water Resources Div., NPS
Glenn Patterson, District Chief, Columbia Field Office, USGS
Brian Hughes, National Water Quality Assessment Program, USGS
William Rizzo, Southern Science Center, NBS
Larry Gamble, Biomonitoring Coordinator, NBS
Kermet Scott, Environmental Protection, McEntire ANGB
David Chestnut, Water Quality Monitoring Section, SCDHEC
Edward Youngener, Water Quality Monitoring Section, SCDHEC
Glen Trofatter, Bureau of Water Pollution Control, SCDHEC
Gary Stewart, Division of Site Assessment, SCDHEC
Barry Beasley, Water Resources Division, SCDNR
Phillip Slayter, Central Midlands Regional Planning Council

Kristina Massey, SCE&G, Saluda Hydroelectric Project
John M. Dean, University of South Carolina
Rebecca Sharitz, University of Georgia-SREL
Robert Jones, Virginia Polytechnic Institute and State University
John C. Hayes, Clemson University
Robert S. McDaniel, Superintendent Emeritus, Congaree Swamp National Monument
Mark W. Kinzer, Friends of the Congaree
Dick Watkins, Friends of the Congaree

Additionally, letters of invitation to the public meeting and workshop were mailed to key individuals in federal, state, and local governmental agencies and conservation groups.

Summary of Written Review Comments

Federal Agencies

Barry Long, NPS, Water Resources Division, Fort Collins, Colorado: Provided commentary on the reporting of STORET water quality data and water quality standards.

Dan McGlothlin, NPS, Water Rights Branch, Denver, Colorado: Provided commentary on document organization and clarification of pertinent federal, state, and local water quality and water quantity legislation and water rights issues, water supply and hydroelectric development, and floodplain functions.

Glenn Patterson, USGS, Columbia, South Carolina: Provided commentary concerning estimates of groundwater discharge to the Congaree River and the geographic position of the Congaree Swamp in the watershed.

James Preacher, US-Army Corps of Engineers, Charleston District, Planning Branch, Charleston, South Carolina: Overview of the Santee/Cooper/Congaree District General Investigations Study and shared interest with the Congaree Swamp National Monument.

Frank Panek, NPS, Water Resources Division, Fisheries Management Assistance Office, Arlington, Virginia: Provided commentary on the fisheries and aquatic management issues in the National Monument.

Martha Bogle, NPS, Congaree Swamp National Monument, Supervisor: Provided commentary on operations and management at the National Monument.

Robert McDaniel, NPS, Congaree Swamp National Monument, Retired Supervisor: Provided commentary on operations and management at the National Monument, and local issues.

State Agencies

David Chestnut, SCDHEC, Bureau of Water Pollution Control, Water Quality Monitoring Section, Columbia, South Carolina: Extensive review of Watershed Characteristics Section of the WRMP.

Glenn Trofatter, SCDHEC, Division of Water Quality, Assessment and Enforcement, Columbia, South Carolina: A Review of NPDES permitting procedure and status of key NPDES permits in the vicinity of the National Monument.

Local

Kristina Massey, EAP Coordinator, South Carolina Electric and Gas (SCE&G), Columbia, South Carolina: Provided clarification of operations at the Saluda Hydroelectric Project, status of FERC Emergency Action Plans, and hydroelectric development in the watershed.

Donna Godfrey, Richland County Planning: Clarifications concerning the title, scope, and status of county zoning plans.

Researchers and Citizens Groups Active in the National Monument

Rebecca Sharitz, Savannah River Ecology Laboratory, Aiken, South Carolina: Provided commentary on document organization and vegetation of the National Monument.

Robert Jones, Virginia Polytechnic Institute and State University, Department of Biology, Blacksburg, VA: Updated information on state/national champion trees within the National Monument.

John C. Hayes, Clemson University, Agricultural and Biological Engineering Department, Clemson, South Carolina: Clarification of technical issues regarding hydrology and geomorphology.

Mark Kinzer, Friends of the Congaree: Extensive and much valued editorial comments and practical information concerning specific features of the Natural Monument resulting from an extensive familiarity with its history and setting.

Agencies and Contact Persons

AGENCIES AND ADDRESSES	CONTACT PERSON	TELEPHONE NUMBER
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Water Quality Assessment and Enforcement (NPDES)	Glen Trofatter	(803) 734-5300
Water Pollution Control (WWQMS Program)	Cynthia M. Lacy	(803) 734-5300
Water Pollution Division (Groundwater Contamination Study)	Addie Collier	(803) 734-4666
Water Pollution Control (Dam Safety)	George Ballentine	(803) 734-5216
S.C. DEPARTMENT OF NATURAL RESOURCES		
Land Resources and Conservation Districts SE Remote Sensing Center 221 Devine St. Columbia, SC 29205	Richard Lacy	(803) 734-9114
Water Resources Division, South Carolina Scenic Rivers Program 1201 Main St., Suite 110 Columbia, SC 29201	Barry Beasley	(803) 737-0800
LOCAL AGENCIES AND UNIVERSITIES		
Richland County South Carolina Planning Department PO Box 192, Hampton St Columbia, SC 29202	Gael V. Cayton Donna Godfrey Terry Brown	(803) 929-6097 (803) 929-6097 (803) 256-0862
Central Midlands Regional Planning Council 236 Stoneridge Dr. Columbia, SC 29210	Phillip Slayter	(803) 771-0887
Richland County Dept. of Solid Waste Management	Sharon Hall	(803) 735-7033
Public Service Commission/Safety Dept. (railroads)	Gordon Eckley	(803) 737-5193
Center for Environmental Policy Carolina Plaza, University of South Carolina Columbia, SC 29208	John Dean	(803) 777-4568
Dept. of Agricultural Engineering, McAdams Hall College of Agricultural Sciences, Clemson University Clemson, SC 29634-0357	John C. Hayes Dale E. Linvill	(803) 656-0338 (803) 656-0338
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Southland Fisheries, Inc. Hopkins, SC 29061	Jesse Chappell	(803) 776-4923
NON-GOVERNMENTAL ORGANIZATIONS		
Sunrise Foundation of Lower Richland County 2711 Middleburg Dr., Suite 213 Columbia, SC 29204	Kathy Newman	(803) 765-0307
Columbia Audubon Society 5000 Thurman Mall Columbia, SC 29201	NA	(803) 748-9066
Congaree Land Trust PO Box 448 Columbia, SC 29202	James E. Smith	(803) 790-8129
The Nature Conservancy-South Carolina Office 2231 Devine St. Columbia, SC 29250	NA	(803) 254-9049
Palmetto Conservation Foundation 1314 Lincoln St. Suite 213 Columbia, SC 29201-3154	NA	(803) 771-0870
River Alliance 2711 Stoneridge Dr. Columbia, SC 29210	Mike Dawson	(803) 771-0887
Sierra Club, Columbia Chapter 1314 Lincoln St. Columbia, SC 29201	NA	(803) 256-8487
Friends of the Congaree 1230 Peachtree St., NE, Suite 3100 Atlanta, GA 30309-3592	Mark Kinzer	(404) 815-3591
Friends of the Congaree PO Box 1467 Camden, SC 29020	Richard Watkins	(803) 432-4253

NATIONAL PARK SERVICE

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