Charleston Harbor

Special Area Management Plan

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Prepared by
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The Table of Contents

Foreword

As with any major planning effort, this management plan represents the work of a great many people. What sets the Charleston Harbor Project (CHP) Special Area Management Plan apart, at least in the realm of federally funded projects, is that the impetus and the direction came from the local community. NOAA is to be commended for allowing the local resource managers, local researchers, and local citizens to set the tone and make the decisions on the direction this project should take.

Critical to focusing state and local efforts and seeking assistance from the appropriate federal programs, were Senator Fritz Hollings and his staff. Senator Hollings, well known for his support of vital coastal zone management programs and environmental protection, provided guidance and introduction to the federal programs with mandates to support management of estuarine resources. Along with other members of Congress, his past support of the Sea Grant program and other water resources programs that build significant local research teams in South Carolina universities and elsewhere, and his support of NOAA and other agencies to pursue special area management plans and estuarine studies provided the vital expertise and funding to undertake the Charleston Harbor Project.

Seeing that these vital federal and state resources were effectively and efficiently directed was a strong suit of the Charleston Harbor Project. Heyward Robinson, who shepherded the Project nearly from inception to the final stages, did so with vision and exceptional leadership. We were fortunate to have someone with the hands-on regulatory background necessary to understand the management needs and the technical background to be able to direct the research. This is a unique blend, and Heyward consistently showed his mastery of the issues and used his unusual vantage point to bring a complicated project to successful conclusion.

The CHP was complicated because a new locally led approach was necessary, the magnitude of the problem was extensive, and interdisciplinary investigative teams were needed to efficiently focus the funds available onto common objectives. We appreciate the adaptation that local, state, and federal agencies underwent to support the local vision for investigating Charleston Harbor. Resource degradation of estuaries has rarely been addressed early enough because mandates for air, water, and land protection and preservation are constitutionally and legislatively split between different levels of government and many different agencies. The dominance of urban land uses in the local contributing watersheds affects almost each drop of water flowing through the Harbor. The only effective means to understanding the degradation of Charleston Harbor and relate the degradation to the causes was to employ nationally recognized teams of interdisciplinary experts to evaluate the resources and trends in water quality.

Earlier attempts to protect the environment have been successful. Because of the Clean Water Act, Charleston Harbor is cleaner than thirty years ago. The Clean Air Act has had the same effect on air quality. But the sheer volume of the changes that are occurring begin to overwhelm these single-issue regulatory programs. The Coastal Zone Management Act is largely designed to weave these various programs together for the overall protection of coastal resources. Unfortunately, this approach has seldom been used because it is difficult to develop a system to address the cumulative impacts of hundreds of decisions that affect the environment.

The lack of information about how the ecosystem works is the main stumbling block to developing protective measures. Recognizing this, the CHP assembled a number of experts and gave them the tasks of finding and filling gaps in our knowledge of resource status and protection. The process of watching very competent people uncover relevant questions and explore possible answers was an inspiration. They performed their tasks admirably. Unfortunately, they cannot all be listed in this report, but a brief summary of all their research is given in the appendix.

All of us who worked on the CHP are proud to have been a part of this effort. The problem has been laid out and a plan designed. It is now up to each of us to insure our natural and cultural heritage is protected.

Referenced Sites Within the
Charleston Harbor Project Study Area

Origin and Purpose

The Charleston Harbor Project (CHP) evolved from a grass-roots effort to plan for the rapid urban growth projected for Charleston, Berkeley, and Dorchester counties. With the completion of the Mark Clark Expressway, large tracts of previously inaccessible land became available for development. Knowing that unplanned industrial and urban development could rapidly overwhelm a region's watershed resources, local leaders realized patterns of growth in other coastal communities could provide lessons for Charleston. These communities, similar in character to Charleston, had developed too quickly without an appreciation of the environmental consequences, resulting in the degradation of their watersheds and deterioration of their overall quality of life. In 1989, a volunteer citizens group, the Charleston Harbor Estuary Committee, united in an effort to encourage planning to manage the projected growth. Their objective: *to protect the unique, high quality of life in the Charleston area from the inadvertent resource degradation experienced by many urban coastal communities.* With help from The South Carolina Sea Grant Consortium, a series of educational seminars were held and position papers were designed to obtain federal funding for the preparation of a comprehensive management plan. As a result of these efforts, Department of Health and Environmental Control (DHEC) and Environmental Protection Agency (EPA) worked to have Charleston Harbor designated a part of the National Estuary Program. In 1991 it was finally decided the best way to proceed was for the Office of Ocean and Coastal Resource Management of the National Oceanic and Atmospheric Administration (NOAA) to provide funding for a Special Area Management Plan (SAMP) through the CHP. The objective of the SAMP is to provide guidelines for growth that will protect the natural and cultural resources of the area, strengthen the area's diverse economic resources, and provide managers and leaders with the information necessary to manage and direct this growth. The ultimate goal is *to sustain the rich economic, cultural, and natural resources of the Charleston Harbor Estuary.*

The objective of the SAMP is to provide guidelines for growth that will protect the natural and cultural resources, and provide managers and leaders with the information necessary to manage and direct this growth.

An initial grant in 1991 allowed for preliminary planning and a review of available information pertinent to the Charleston Harbor Estuary. These actions revealed that no serious ecological or water quality problems were present in the estuary and that toxic pollutants were not a widespread problem. Based on these findings, NOAA set the mission of the Charleston Harbor Project: *to conduct resource management oriented research and develop policies that would protect the balance between economic, cultural, and natural resources of the area for the next twenty years.* To accomplish this, funding of $5,642,500 for the next five years was provided to develop the management plan.

The CHP is administered through the Office of Ocean and Coastal Resource Management (OCRM) of DHEC. Section IV (F) of the South Carolina Coastal Zone Management Plan provides for the development of Special Area Management Plans when conflicts of uses are widespread and these conflicts threaten coastal resources. The "Goals and Objectives" of the CHP were developed by twelve topical task forces consisting of representatives of federal, state, and local governments, industry, the private sector, and interested citizens. These were adopted during the first year of the program and are in effect today:

(1) To maintain and enhance the quality of the environment in the Charleston Harbor estuarine system.

(2) To maintain the range of uses of waters and natural resources of the system.

(3) To anticipate and address potential problems before adverse impacts occur.

Rapid urbanization of the watershed with the consequent nutrient enrichment of the estuary is seen as the most probable cause of future degradation of the Charleston Harbor Estuary.

As these objectives indicate, preservation of the natural resources and maintenance of the quality of the environment for the Charleston Harbor region are supported by an approach to anticipate and address potential problems before they occur.

Rapid urbanization of the watershed with the consequent nutrient enrichment of the estuary is seen as the most probable cause of future degradation of the Charleston Harbor Estuary. Because land use is a vital issue in the future degradation of Charleston Harbor, this Project finds that a local, state, and federal government partnership with industry and the public must continue and focus on gaps between single purpose regulatory programs. Comprehensive coastal zone management requires that minimum requirements of air, water, solid waste, and land use laws be continually examined and upgraded where necessary to protect the unique cultural, natural, and economic resources of the Charleston area.

To achieve the objectives of the CHP the following six vital topics were investigated: (1) stormwater and point and nonpoint source inputs; (2) biological resources; (3) dredged material disposal; (4) land use and population growth; (5) public access and its utilization; and (6) data management and retrieval. Within this framework, sixty-two applied research studies were planned and conducted over a five-year period. These studies were designed to fill the gaps in the current state of knowledge and, thus, effectively complete the overview of Charleston Harbor resources. This body of research establishes a framework of information sufficient for long-term planning and the management of the Charleston Harbor Estuary at the watershed level. It also provides a basis for the methodical management of the estuary in an ecologically meaningful way. Managers can readily focus their activities where they are most needed by identifying areas for protection, research, restoration, and mitigation. Management of the Charleston Harbor Estuary at the watershed level enables managers to make individual decisions in the context of all of the region's resources. This large-scale view will make the permitting process more predictable and flexible for the business community, while providing the public with better resource management and protection.

The Counties of South Carolina and the Boundary of the Charleston Harbor Project

CHP Organization

The CHP was organized into four levels: task forces, focus groups, the Management Committee, and the Administrative Board. The Policy Steering Committee and the Oversight Committee were also created to assist in the implementation of the CHP. The South Carolina Board of Health and Environmental Control has oversight over all actions of OCRM and the CHP. The purpose of each group is described below.

Task Forces

In order to involve as many different viewpoints as possible and have public participation in the Charleston Harbor Project, twelve task forces were organized. Over 200 individuals participated on the task forces, representing the private sector, concerned citizens, and federal, state, and local jurisdictions. They identified research needs and developed investigative proposals within their focus areas. The twelve task forces were organized around the following resource management topics:

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Biological Resources	Marina
Cultural Resources	Point Source
Data & GIS	Public Involvement
Dredge/Spoil Disposal	Recreation
Economic	Storm Water
Land Use	Water Quality Modeling

Each research project was associated with one of the task force groups. However, this division was too narrow in scope to efficiently formulate a comprehensive plan. Therefore, all Charleston Harbor Project research was grouped into three larger categories: water, biological resources, and urban growth. Water Resources Management, Biological Resources Management, and Growth Management were the corresponding focus groups established to analyze data and make management recommendations.

Focus Groups

The focus groups were composed of researchers, task force members, and local, state, and federal experts in each field. Each group formed its own recommendations, based on completed research, which were then synthesized into one set of recommendations by the focus group leaders, policy makers, managers, and other officials. This set of recommendations was presented to the Charleston Harbor Project Management Committee for refinement and approval.

Policy Steering Committee

The Policy Steering Committee was formed to develop initial policy recommendations for the Charleston Harbor Project management plan for the watershed. The Policy Steering Committee was composed of representative stakeholders in the project, from federal, state, county, and municipal governments to industrial and urban development interests in the private sector. The group worked closely throughout the 1997 summer with the CHP focus group leaders and CHP researchers to review research findings and develop policy recommendations, with the ultimate goal of submitting the proposed policy recommendations to the task forces and the Management Committee for review.

Management Committee

The Management Committee is composed of the chair and vice chair of each task force, the CHP Director, and representatives of DHEC/OCRM, the National Marine Fisheries Service (NMFS), and Sea Grant. The Management Committee reviewed the proposals developed by the task forces and recommended projects for funding based on the projects' priority to the overall goals of the CHP. The Management Committee also reviewed the recommendations of the focus groups, decided which would be in the final management plan, and reviewed the drafts of the management plan prior to final plan approval.

Administrative Board

The Administrative Board is composed of a NOAA/OCRM representative, two DHEC/OCRM representatives, and the CHP Director. The Administrative Board reviewed CHP funding proposals and other activities to insure that NOAA mandates were met.

Oversight Committee

The DHEC/OCRM Oversight Committee was composed of the South Carolina Coastal Council Chair and Vice Chair, members of the council whose congressional districts are within the CHP area, and members representing the three counties in the CHP area. However, as a result of the restructuring of South Carolina state government in July 1994, the Oversight Committee was disbanded.

DHEC Board

Like all state agencies in South Carolina, DHEC has an administrative board that is responsible for the overall direction of the agency. The DHEC Board was kept informed of the work of the CHP and approved the management plan.

Organizational Structure of The Charleston Harbor Project

Description of the Project Area and the State of the Harbor Resources

The Human Setting:

The greater Charleston area is better known as the Trident Region and is comprised of portions of Berkeley, Charleston, and Dorchester counties. The area includes twenty-five incorporated communities ranging in size from Jamestown in Berkeley County, with a population of approximately 84, to the City of Charleston with about 104,000 residents. The total population of the three counties doubled between 1960 and 1990 and is expected to increase to 619,500 by the year 2015. Administratively, the counties are served by their respective county councils and the combined Berkeley-Charleston-Dorchester Council of Governments (COG). Charleston County is the state's most urban county with 88% of its residents living in an urban setting (as defined by the U. S. Census). Similarly, Berkeley and Dorchester counties are significantly more urban than rural, with respectively 65.1% and 67.4% of their populations classified as urban.

The total population of the three counties doubled between 1960 and 1990 and is expected to increase to 619,500 by the year 2015.

The economy is heavily influenced by tourism, the Port of Charleston, health care, and several large industrial employers. Charleston Harbor's port facilities, composed of an extensive network of modern shore side facilities, represent the largest economic resource associated with the Charleston Harbor Estuary. Most of the $10.7 billion in 1997 sales revenues attributed to South Carolina's ports came through Charleston. During the State Ports Authority's 1999 fiscal year, which ended in June, 13.3 million tons of cargo moved through the port aboard 2,457 ships and barges. The Port of Charleston is the number one container port on the southeast and gulf coasts and is second only to the combined ports of New York and New Jersey on the entire eastern seaboard. Until 1994, the U.S. Navy maintained its third largest home port on the Cooper and Wando rivers. These facilities consisted of a naval shipyard and weapons station and served more than 70 surface vessels and submarines. Charleston International Airport provides commercial and military air service for the region and currently serves over 1.5 million passengers annually. Six private airports located throughout the region can accommodate both corporate and private aircraft. Approximately 100 motor carriers and three railroads serve the Trident Region and, along with Interstates I-26, I-95, and I-526, provide access to residential, private, government, and commercial concerns. Six colleges and universities are located within the region with a combined annual enrollment of almost 27,000 students.

The Tri-County Area, Berkeley, Charleston, & Dorchester Counties with the CHP boundary

Although there are no major industries located on the harbor, the basin is surrounded by urban development and receives secondarily treated effluent from two sewage treatment facilities on Plum Island and in Mount Pleasant. The number of permitted point sources of pollution in the Charleston Harbor estuary decreased from 115 in 1969 to 67 in 1996. The volume of these discharges decreased from 328 to 205 cubic feet per second (9.3 to 5.8 m3/s) during the same time period. Other sources of pollution affecting the harbor include nonpoint source runoff from the city and other urban areas, marina facilities near the mouth of the Ashley River, and runoff and discharges from forested and agricultural lands. Several diked, dredged material disposal areas are located in the harbor area, with the largest being Drum Island. The water quality of the harbor's tidal saltwater is rated as suitable for fishing and boating, but not for swimming, and the harvesting of oysters, mussels and

clams is prohibited. However, reviews of data collected by DHEC reveal that the water quality within the basin often meets higher standards for dissolved oxygen and fecal coliform than the ratings indicate.

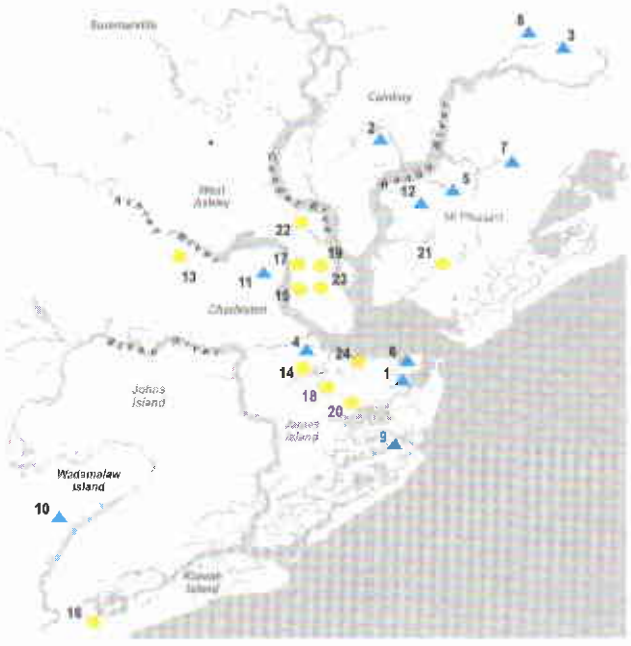
Creeks in Tidal Creek Study

▲ Reference Creeks

1 Battery Simkin Creek
2 Beresford Creek
3 Deep Creek
4 Dill Creek
5 Foster Creek
6 Grice Cove Creek
7 Horlbeck Creek
8 Lachicotte Creek
9 Lighthouse Inlet Creek
10 Long Creek
11 Orange Grove Creek
12 Rathall Creek

● Developed Creeks

13 Bull Creek
14 Cross Creek
15 Diesel Creek
16 Kiawah Creek
17 Koppers Creek
18 Metcalf's Creek
19 New Market Creek
20 Parrot Creek
21 Shem Creek
22 Shipyard Creek
23 Vardell Creek
24 Yacht Club Creek



Among the three river systems that form the Charleston Harbor Estuary, the Cooper River has the greatest number and density of industrial and port facilities. The majority of these are located on the western shore and include the former U. S. Navy port facilities, commercial facilities associated with the State Ports Authority, and numerous private companies. To accommodate shipping traffic, a 40 feet (12.2 m) deep navigation channel is maintained in the lower Cooper River and extends 20 miles (32 km) upstream from the mouth of the river. The eastern shore of the Cooper River is relatively undeveloped, although there are several diked dredged material disposal sites along the length of the maintained channel.

In 1954, Bushy Park Industrial Area was established along the east bank of the Back River and the west bank of the Cooper River. To provide freshwater to the industrial complex, the Back River was dammed near its confluence with the Cooper River and the 11-km Durham Canal was constructed as a freshwater supply from the upper Cooper River. Downstream of Flag Creek, industries dominate the eastern bank of the river and the west bank serves as a dredged-material disposal area. There are 22 industrial and municipal permitted point dischargers into the Cooper River with a combined flow of 127 ft3/s (3.6 m3/s). The water quality rating of the lower basin is rated as suitable for fishing and crabbing, but not for swimming or the harvesting of clams, oysters or mussels. Water quality often meets higher standards than the rating for oxygen and fecal coliform.

The Ashley River has the second largest number of industrial and commercial facilities, most of them located along the eastern shoreline. There are seven permitted municipal dischargers in the basin with a combined discharge of about 53 million gallons per day. Much of the remaining upland area on both sides of the river supports residential developments. Water quality in the Ashley River is suitable for fishing and boating, but not for the harvest of clams or for swimming.
The Wando River presently has the least upland development compared to the other two river systems, except in its lower reaches. In that area on the eastern shore, the State Ports Authority maintains the Wando Terminal facility. There are also several residential communities present and/or being developed on this shore-

line. Large dredged material disposal areas are located on Daniel Island, which forms the western shoreline of the Wando River. The only major industrial facility on this river is the Detyens Shipyard across from Cainhoy. Water quality above the Wando Terminal is suitable for harvesting clams, mussels, and oysters for human consumption. Water quality in the lower Wando River is similar to that of the Ashley River.

The CHP area contains some of the most significant historic and archeological sites in the United States.

The CHP area also contains some of the most significant historic and archeological sites in the United States. Cultural resources include historic buildings, structures and sites, unique commercial and residential areas, unique natural and scenic resources, archeological sites, and educational, religious, and entertainment areas or institutions. In some areas preservation programs are effective in maintaining these resources. In other areas these resources are being lost or neglected primarily because of our limited knowledge. There is a continuing need for surveys to identify the cultural resources, their locations and significance. This knowledge must be made available to local officials and interest groups to gain greater support of preservation programs and other cultural activities.

The Natural Setting:

The Charleston Harbor Watershed

The wide variety of habitats present in the estuary support a diverse array of flora and fauna, including more than 80 species of plants, over 250 species of birds, 67 species of mammals, over 570 species of invertebrates and fin fish, and at least 580 species of plankton.

The Charleston Harbor Watershed lies entirely within the South Carolina Coastal Plain and consists of sedimentary deposits of sand, gravel, clay, marl, and limestone resting on metamorphic and igneous rocks. Overlying these deposits are marine and riverine sediments and a thin veneer of sand, clay, and shell comprising Pleistocene and Recent formations. The watershed is composed of 63% uplands, 19% open water, 11% freshwater wetlands, 6.5% estuarine marsh, and less than 0.5% estuarine tidal creeks. Upland land use patterns within the watershed are 61.6% forested, 11% urban, 9.3% forested wetlands, 7.7% non-forested wetlands, 6.3% scrub/shrub/disturbed, 3.8% agricultural and grasslands, and 0.3% barren. Federal, state, county, and municipal governments own 302,122 acres (122,267 hectares) of the forested watershed lands. Farmers, corporations, and private individuals own the remaining 638,820 acres (258,527 hectares) or 68% of the total forested lands within the watershed. The forests are composed of approximately 45% loblolly, slash, and short- and long-leaf pines, and 20% oak/hickory hardwoods. Annual precipitation is 49 inches per year (124.9 cm). The wide variety of habitats present in the estuary support a diverse array of flora and fauna, including more than 80 species of plants, over 250 species of birds, 67 species of mammals, over 570 species of invertebrates and fin fish, and at least 580 species of plankton.

Within the watershed is the Charleston Harbor Estuary, located in the central portion of South Carolina's coastline and formed by the confluence of the Ashley, Cooper, and Wando rivers. An estuary is a mixing zone where the land and the sea meet, providing habitat for salt water and freshwater organisms and those that live in between. Highly dynamic, estuaries are influenced by the salinity gradient that extends from pure seawater to freshwater upriver, and the tide that provides the energy that mixes the fresh and saltwater.

The average depth of the estuary basin is 12 feet (3.7 m) at mean low water (MLW), but navigation channels have been deepened to 40 feet (12.2 m) MLW. The mean tidal range is 5.2 feet (1.6 m), and spring tides average 6.2 feet (1.9 m). Water temperatures range from 38E to 87EF (3.5° to 30.7°C), and average 67EF (19.4° C). Salinities range from 0 to 35.6 parts per thousand within the estuary. Similarly, dissolved oxygen levels range from 0 to 17.1 miligrams per liter, averaging 7.3 mg/l over the entire estuary.

The diversion of the Santee River into the Cooper occurred in 1941 when the Works Progress Administration (WPA) completed the Santee-Cooper Hydroelectric Project. This environmental modification effectively increased the drainage area of the Charleston Harbor Estuary over eleven times to a watershed of approximately 15,800 square miles (41,000 km^2). The increase was primarily due to the inclusion of the Santee River drainage basin, one of the largest river basins on the east coast of the United States. The Cooper River was thus transformed from a tidal slough with an average monthly flow of 417 cubic feet per second (11.8 m^3/s) to a riverine system with a flow of 5,339 cubic feet per second (496 m^3/s). This diversion transformed Charleston Harbor from a well-mixed to a partially-mixed estuary and created an efficient sediment trap. After diversion, average salinities in the harbor dropped from 31 to 16 per cent.

Prior to the construction of the hydroelectric project, shoaling in Charleston Harbor was minor and required the annual removal of 180,000 cubic yards (137,620 m^3) of sand and silt. Following the project's completion, shoaling in the harbor increased to the point where the annual removal of 7,600,000 cubic yards (5,800,000 m^3) was required to maintain the authorized navigation channels. To alleviate the shoaling problems, an 11 mile (18-km) rediversion canal from Lake Moultrie to the Santee River was constructed. Completed in 1985, the Cooper River Rediversion Project diverted approximately 70% of the Santee drainage water back into the Santee River through the canal located near St. Stephens, South Carolina. The rediversion canal reduced the Santee flow into the Cooper River at Pinopolis Dam to approximately 4,520 cubic feet per second (128 m^3/s).

The Cooper River

The Cooper River watershed is extremely complex due to the Santee-Cooper Hydroelectric Project and the subsequent rediversion in 1985. The lower component of the basin, which is the portion located within the CHP management area, extends 50 miles (81 km) from the Pinopolis Dam to the mouth of the Cooper River on the north side of the Charleston peninsula where it flows into Charleston Harbor. This section of the river drains almost 1400 square miles (3,625 km^2) of midlands and lowlands, including fresh and brackish wetlands. The West Branch Cooper River is 17 miles (26.5 km) long and flows from the Tail Race Canal at Moncks Corner to its junction with the East Branch. This reach is a meandering natural channel bordered by extensive tidal marshes, old rice fields, and levees in varying states of disrepair. The area contains volumes of poorly defined overbank storage and immeasurable flows because of broken levees between the channel and old rice fields. The East Branch Cooper River is 7.6 miles (12.3 km) long and flows from its headwaters in Hell Hole Bay to its junction with the West Branch, commonly referred to as the "Tee." The East Branch is a tidal slough throughout its 7.5 miles (12 km) length. The river then flows 17.7 miles (28.5 km) to its junction with the Charleston Harbor basin on the north side of the Charleston peninsula.

The long-term effects of rediversion on the marsh vegetation of the estuary are still unknown.

The long-term effects of rediversion on the marsh vegetation of the estuary are still unknown. A redistribution of plant species may occur along the estuarine gradient, and some plant communities on the upper Cooper River may be influenced by changes in water level due to the lower flow rates. The estuary does not support extensive subtidal seagrass beds or benthic algae communities, except in the upper Cooper River where the freshwater algae (*Egeria densa*) is abundant. This lack of benthic plants is related to the low transparency of the estuarine waters combined with a lack of suitable substrate. A few species of coastal/estuarine algae (*Porphyra sp.* and *Ulva sp.*) are found in the intertidal areas of the lower harbor basin.

The Ashley River

The Ashley River was not affected by rediversion above its juncture with the harbor basin because it is not connected to the Cooper River at any point. The river flows approximately 31 miles (50 km) from its headwaters in Cypress Swamp in Berkeley County to its junction with the Intracoastal Waterway on the south side of the Charleston City Peninsula, where it empties into the lower harbor basin. The river basin drains a 216-square-mile (900 km^2) area of marsh and lowlands, spread out over Dorchester, Berkeley, and Charleston counties. Depths of the natural channel in the river range from 5.9 to 36 feet (1.8 to 11.0 m) and are influenced by tidal action throughout the river's entire length. Essentially a tidal slough, the tidal ranges of the Ashley River amplify progressively upstream. The extent of saltwater intrusion on the river varies greatly with the hydrologic condition of the basin. During extremely dry periods, with little freshwater draining from Cypress Swamp, saltwater extends throughout most of the Ashley River. During periods of heavy precipitation, saltwater can be limited to the lower part of the river below Drayton Hall. The banks of the river are dominated by *Spartina* marshes.

The Wando River

The Wando River is a tidal river that flows approximately 24 miles (38 km) from its headwaters in I'on Swamp in Charleston County to its junction with the Cooper River on the north side of the Charleston City Peninsula. The river drains 120 square miles (310 km^2) of marsh and lowlands, and its depth ranges from 5 feet to 42 feet (1.5 to 12.8 m). The Wando is influenced by tidal action throughout its entire length, and estuarine waters extend into the creeks that form its upper limits. Like the Ashley River, the tide ranges are amplified as they progress upstream. The Wando River has the best water quality of the three rivers. Above the Wando Terminal the water quality is suitable for harvesting clams, mussels, and oysters for human consumption. The banks of the River are dominated by extensive *Spartina* and *Juncus* marshes.

Estuarine Habitats

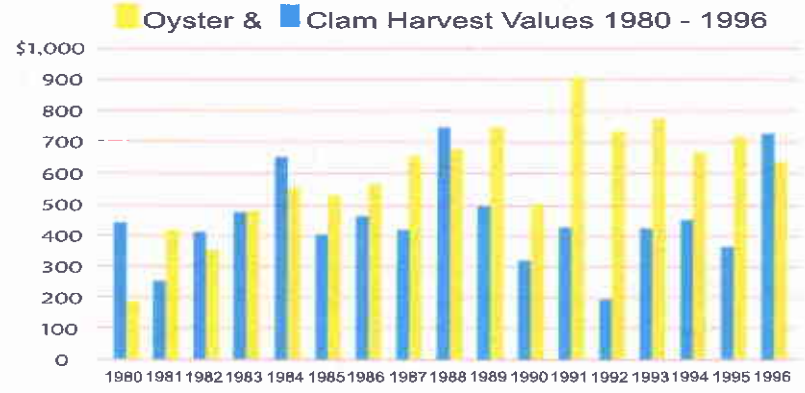
The rise and fall of the tide and the ebb and flood of the tidal currents provide a highly diverse habitat for the plants and animals common to the Charleston Harbor Estuary. Marsh vegetation is extensive in the estuary due to the gently sloping coastal plain and the tidal range. The estimated acreage of the marshes in this area exceeds 52,000 acres (21,000 ha) of which 28,500 acres (11,500 ha) consist of brackish and salt marsh, 18,500 acres (7,500 ha) consist of freshwater marsh, and approximately 5,000 acres (2,000 ha) lie within impoundments. A diverse assemblage of plant species typically found throughout the Southeast is found within the estuary with the distribution determined by salinity and the duration of inundation. The tidal marshes of the Ashley and Wando rivers reflect a strong marine influence, with salt and brackish water marshes existing throughout almost all of their length. The Cooper River marshes exhibit a wide range of vegetation, changing markedly from salt to brackish to freshwater species. The flow rate and salinity of the Cooper has been significantly altered by the diversion of the Santee into the Cooper and the 1985 rediversion project.

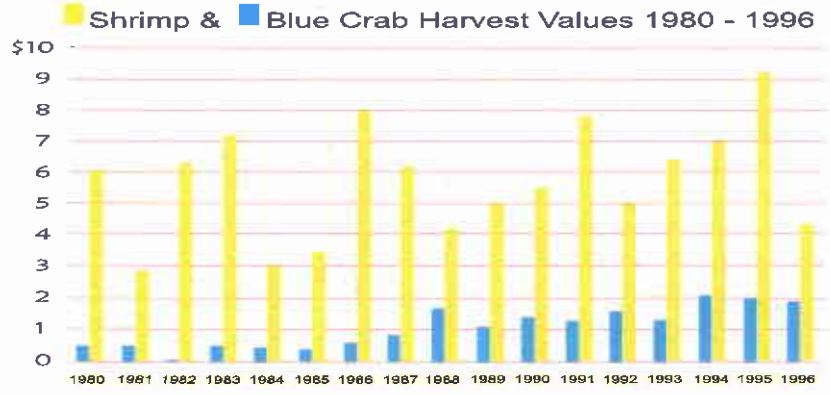
The shallow-water marsh serves as a refuge by providing a diversity of habitat and by excluding predators from the upper reaches of the estuary.

The shallow marsh habitats of the Charleston Harbor Estuary provide seasonal year-round habitats for a diverse assemblage of adult and juvenile finfish and crustaceans. Our understanding of why shallow estuarine habitats are important to the early life histories of many species of finfish, crustaceans, and clams is incomplete, yet much is known. The highly productive marshes provide abundant food resources for early life history stages. The shallow-water marsh also serves as a ref-

uge by providing a diversity of habitat and by excluding predators from the upper reaches of the estuary. These advantages may result in reduced competition, lower mortality, and faster growth rates. Many of these species are either commercially or recreationally valuable. The estuary contributes approximately 20% and 8% of the state's shrimp and crab landings, respectively. Spot, Atlantic croaker, red drum, spotted seatrout, flounder, and catfish inhabit the estuary and are recreationally important. The estuary also supports numerous ecologically important species such as bay anchovy and grass shrimps, which serve as food for economically and recreationally important species. Young of several species of finfish that are spawned in the lower estuary or ocean enter the shallows of the estuary as juveniles and stay until they reach larger sizes or until lowering winter temperatures drive them seaward.

The spatial distribution of the species living in the bottom of the Charleston Harbor Estuary is similar to that of other estuaries along the mid-Atlantic, southeast and gulf coasts of the United States. Studies suggest that there is little difference between pre- and post-rediversion assemblages, at least at this time. Several dominant species appear to be decreasing in abundance in certain reaches of the estuary. Numerically dominant species include mollusks, polychaetes, oligochaetes, nematodes, and amphipods. Within the harbor basin, several sites show evidence of reduced benthic diversity, low faunal abundance, or small-scale differences in community composition. This is perhaps related to either dredging activities or the Plum Island sewage outfall. Such changes are probably permanent, especially if dredging is the causal agent, as dredging communities become dependent on dredging for their maintenance. Among the three river systems, average diversity values are lower in the Cooper River than in the Ashley and Wando rivers. The lower diversity in the Cooper River may reflect adverse effects from the greater number of industrial and port facilities in this system as compared to the other two river systems.





Studies show that many of the changes experienced within the estuary are atypical of an estuarine system whose freshwater inflow has been reduced. In a typical estuary, the mixing zone is an important nursery area for new recruits. Many species utilize the shallows of these areas independent of salinity. Many species also use the tidal stream transport to initially colonize the upper estuary. Increased flow rates displace the freshwater line seaward, compress the freshwater boundary horizontally and vertically, and prevent flood-tide displacement into the recruitment areas. Hence, a decrease in flowrate, as occurred in the rediversion, should enhance the recruitment process. There are suggestions that reductions of flowrates by diversions result in a reduction in the overall size of the estuarine nursery habitat and in disruption of spawning and nursery cycles. Evidence suggests that a reduction of flow by as little as 30-40% can destroy the dynamic equilibrium of an estuary within three to seven years and may increase the impacts of pollutants by four to twelve times. In many ways the Charleston Harbor Estuary is a typical estuary in its role in recruitment and as a nursery. Yet, rather than the losses and destruction reported in other estuaries, there has been an increase in the use of this estuary by many more species as a nursery area, especially in the main channels of the rivers. It is possible that coincidental environmental conditions (drought or cold winters) may have caused any negative effects of rediversion to be eliminated, masked, or postponed. It may be that the continued regulation of the flow, as opposed to absolute elimination, has contributed to an improved end result. However, another possibility is that changes are occurring on a longer time scale and the current results represent a transitional phase in this process. It is also possible that the estuary is returning to its former, pre-1942 hydrographic/biologic character.

Evidence suggests that a reduction of flow by as little as 30-40% can destroy the dynamic equilibrium of an estuary and may increase the impacts of pollutants by four to twelve times.

Growth Management:

The Charleston Harbor Watershed is a complex of places and people who require goods, services, employment, shelter, and recreation. Its character is unique, having evolved out of centuries of human responses to numerous interrelated physical, economic, and social situations. The impacts of a growing population and its associated demands are causing managers to question the sustainability of the region's resources. Throughout the nation, estuaries and coastal waterways are experiencing environmental decline due to the pressure of increasing urbanization. Fortunately, by learning from their experiences and through the use of applied research and informed decision-making, local resource managers can prevent the degradation that other communities have experienced. This can be accomplished while at the same time sustaining the growth needed to ensure a strong economy and a growing population.

Charleston's location, climate, and natural resources are attractive to industrial and commercial investment, as well as to growing tourism and retirement markets. As a result, growth and change in the CHP area are expected to be significant over the next twenty years and will affect all those living in the CHP watershed. Local planning programs must play a major role in providing direction to this future growth and development. Between 1990 and the year 2015 the population is expected to increase by approximately 113,000 persons. Associated with this population growth is a projected increase of approximately 44,500 housing units, 55,600 additional jobs, 61,400 more motor vehicles, 25,500 more individuals enrolled in educational institutions, and the generation of an additional 13,651,000 gallons per day of wastewater. Opportunities for employment should increase and provide significantly more jobs. These increased numbers will generate challenging problems along with benefits. Large rural areas will be converted to urban uses, impacting biological communities and water quality. Associated with these changes is the public's interest in the type, location, quality, scale, rate, and sequence or

timing of land development and resource use activities. With proper management, these changes can reflect local needs and objectives that will improve the quality of life and, at the same time, protect the natural environment.

Planning agencies face the challenge of providing for necessary infrastructure, community services, and economic opportunities to support growth while protecting valuable and vulnerable cultural and natural resources.

Planning agencies are faced with the major challenge of providing for the necessary infrastructure, community services, and economic opportunities to support anticipated growth while at the same time protecting valuable and vulnerable cultural and natural resources. Programs should be proactive to ensure available planning tools are used to shape the future of the CHP area in a manner that is sensitive to the natural and cultural environment rather than responding simply to market trends. Such tools need to be closely tied to comprehensive development plans that define the desirable future character of the area. While some growth is anticipated in all thirty-one drainage sub-basins within the CHP area, most of this growth is expected to occur within seven of these basins. All of these basins include water bodies that have limited or no capacities to assimilate significant increases in pollutant loadings from either point or nonpoint sources.

Water Quality

Large water bodies, such as rivers and bays, have been important sites not only for commercial and recreational fishery production but also for economic development. Traditionally, industries have located along rivers to access clean water for industrial processes and to discharge effluents into receiving waters. The dilution capacity provided by river flow and tidal flushing in coastal areas naturally subsidizes the treatment of a community's domestic and industrial wastewater discharges. However, the dilution and assimilation capacity (biological uptake of nutrients) of receiving streams is not unlimited. Overloading steams with discharges can destroy biological resources.

Until the 1970s very little treatment of domestic and industrial wastewater was required. As a result of widespread water quality problems in rivers and bays across the nation, the CWA was enacted and included the creation of the EPA to manage the nation's waters. The initial objective of the EPA was to improve water quality by requiring treatment of point source discharges through permit requirements. However, point source discharges account for only a portion of the pollutants discharged into streams. As a result of the success of the point source management programs, other sources of pollution are becoming more of a factor, i.e. nonpoint source runoff and airborne sources.

The water quality in Charleston Harbor is generally considered good, but problems do exist. For example, water quality problems have been identified in the Ashley River basin. These problems have resulted from both point and nonpoint source runoff. Portions of the Ashley River have high turbidities, low dissolved oxygen, and elevated nutrients. Fertilizer production, municipal discharges, and urban nonpoint source runoff into the Ashley River have been suggested causes.

The COG found that the assimilative capacity of certain parts of the Cooper and Ashley rivers already might have been allocated to waste discharges. Support exists within the COG for the creation of a growth reserve and the development of contingency plans for responding to water quality problems caused by continued growth, drought, and other factors. Some areas of the estuary may have sufficient unallocated capacity to accept foreseeable new growth. Guidelines for the reallocation of permitted loads to accommodate new growth have been developed.

Long-term trends in water quality and recent research in the Charleston Harbor estuary suggest that wasteload assimilation, nonpoint source runoff impacts, and toxic pollutants are problems. Ninety-five per cent of the total loads in the Cooper River are point source, and thus of human origin. With recent trends of decreasing dissolved oxygen and increasing levels of turbidity and coliform bacteria, some important areas of the Charleston Harbor Estuary only partially support

aquatic life and recreational uses. Trends of decreasing nutrient concentrations suggest some improvements in water quality, although some estuarine zones in tributary sub-basins still exhibit high nutrient concentrations and hyper-eutrophic conditions. The estuary also contains several "hot spots" where heavy metals and organic compounds exceed the low range for toxic effects on estuarine organisms.

The estuary also contains several "hot spots" where heavy metals and organic compounds exceed the low range for toxic effects on estuarine organisms.

As is typical of estuaries in the southeast U.S., the Charleston Harbor estuary has a high ratio of intertidal marsh to water surface area ($\geq$ 3:1) and a large, consistent tidal range. These conditions, in combination with high rates of primary production and nutrient cycling in the wetlands, contribute significantly to the role of intertidal marshes in affecting estuarine water quality. As indicated in the literature and as demonstrated in the Goose Creek basin, intertidal marshes tend to remove inorganic nitrogen (as nitrate) and export organic matter and perhaps ammonia. These factors directly influence estuarine water quality in terms of biochemical oxygen demand (BOD) and oxygen dynamics, as well as eutrophication. A more detailed understanding of marsh nutrient exchanges in urbanized estuaries is of particular concern in water quality management and wastewater allocations. Typical applications of waste load allocation models focus largely on instream water column processes, with little regard to the potential influence of tidal wetlands. Organic matter and ammonia export from marshes are directly related to carbonaceous and nitrogenous BOD dynamics in the system and may limit the overall BOD assimilative capacity of estuarine waters. On the other hand, nitrate uptake by marshes may tend to mitigate nutrient loading and eutrophication from urban sources.

The Charleston Harbor Estuary is managed as a single homogeneous unit by current water quality (Clean Water Act) and coastal resource management standards (Coastal Zone Management Policies). These standards, while appropriate for the main rivers, are not as appropriate for primary and smaller tidal creeks and tributaries of the rivers. The CHP area is made up of sub-units that require more specific management standards. Management of the main stems of rivers is driven by point source and nonpoint source issues, and current management criteria and practices are adequate. However, main stem management issues are related to estuarine habitats through the impacts that discharges have on dissolved oxygen (DO) levels in smaller tributaries.

The CHP area is made up of sub-units that require more specific coastal resource management standards.

Cultural Resources

Preservation efforts have been relatively successful for cultural resources. Bluff and Medway Plantations and the Hunley are notable examples. This success is due in part to the preservation societies, land trusts, and to the citizens of Charleston. Unfortunately, understaffed agencies charged with regulating and permitting functions have found it frequently necessary to react to development proposals. These regulatory programs need access to modern technology (such as GIS capabilities) to increase their ability to obtain and act on background information. It is critical that they be proactive and involved in pre-permitting activities, especially those associated with prime industrial sites in high growth areas. Finally, these agencies need to be leaders in the development of local academic and scientific research projects and local educational and recreational programs.

Through archival research and land surveys, the geographic locations of 114 Federal and Confederate Civil War sites in the CHP area have been identified. A description of the military action that took place at each site, the current (as of 1994) condition and integrity of each site, and both short- and long-term threats to each site are documented. Predictive models were developed that would allow government agencies, planners, and private developers to predict where archeological sites will most likely occur within the CHP area. These models make possible the rapid identification of the probable impacts to unknown archeological sites

upon which planned or future construction is being considered. This approach allows any developer or government agency to assign site archeological probability ratings for any particular tract of land under development consideration.

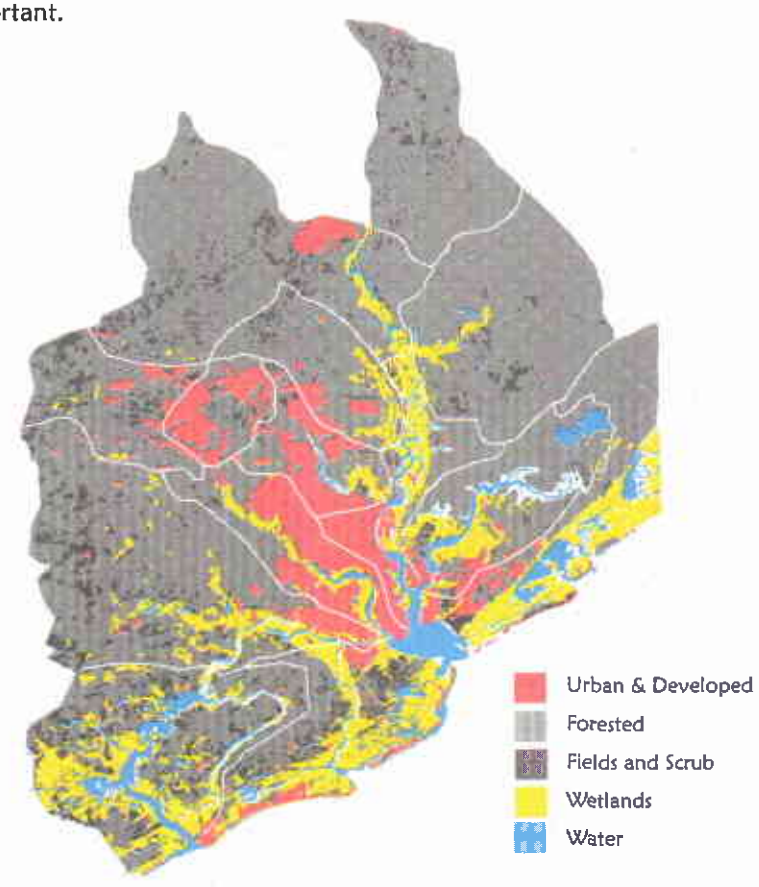
The submerged cultural resources of the Charleston Harbor area provide an important physical record of the city's development. Properly preserved and recorded, the remains of sunken ships, inundation sites, and maritime related structures provide insight into the past that is otherwise unavailable in the historical record. CHP researchers created sensitivity zones by overlaying the various historic, dredging, and remote sensing survey coverages. This allows planners and decision-makers to examine the relationship between areas of historic significance and the potential for disturbance of archeological resources.

Conclusion

Land use decisions, such as zoning and the location of new infrastructure, have a direct impact on water quality and biological and cultural resources.

Research conducted during the CHP helped to define the complex relationships between human actions and their effects on the environment. Two significant conclusions have been reached. First, tidal creeks are the most critical habitat in the watershed because they serve as important nurseries for estuarine-dependent plants and animals. These same creeks, due to their size and location, are greatly affected by stormwater runoff and adjacent land use decisions. Secondly, local governments, through their land use decisions, play a crucial role in maintaining the health of these habitats. Land use decisions, such as zoning and the location of new infrastructure, have a direct impact on water quality and biological and cultural resources. Deciding what changes in land use will occur, as well as where and when they will occur, is the key to providing for the proper maintenance of the watershed. This will allow the development and refinement of the necessary policies to ensure a balance between uses of the watershed's resources and sustainable growth well into the next century. An open dialogue and attentive relationship between managers, investigators, and decision-makers at all levels of government will become increasingly important.

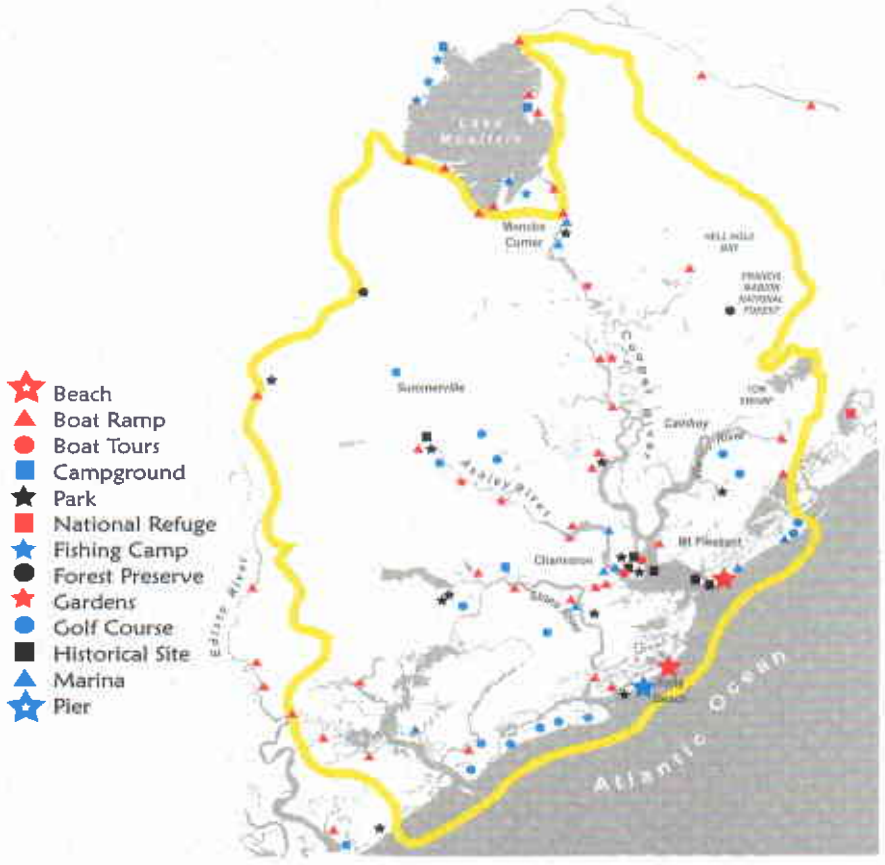
CHP Study Area
1988-90 LandUse/
Land Cover
as extracted from
SPOT imagery



Citizen Attitudes:

In order to determine the level of citizen support for environmental protection, the CHP conducted an assessment of citizen perceptions and attitudes toward environmental resource and growth issues, with emphasis on the aquatic resources and habitats. The results are based only on respondents in the Tri-County area who were willing to participate in the survey. Of those included in this study, a majority overwhelmingly supports protection of the environment. Residents think that environmental resources are very important, and they have serious concerns about specific natural resources. Consequently, they are strongly in favor of the development of a regional management plan that will protect these resources while allowing needed growth and development. In each instance the respondents are in favor of protecting the resources regardless of the "opportunity cost" associated with that protection. Only 23% of the respondents agree that the benefits of development and growth outweigh the negative consequences to the environment. Over 95% of respondents think that fish and shellfish and historical and archeological resources are important to the local area and should be protected through ecologically acceptable development and regional resource management and planning. A majority of residents are in favor of protecting both wetlands and the habitat of shoreline nesting birds, even if it would incur a cost to themselves in terms of less access to these areas.They are in favor of development restrictions when necessary to protect wetlands and local fisheries and think that historical and archeological sites are also important and should be protected.They are supportive of community boat docks that would lessen the impact of multiple private docks on the environ-

The fact that the majority overwhelmingly supports the protection of important resources bodes well for the future.



CHP Study Area
Recreation Sites

ment. Most residents support tourism but only when there is no negative consequence to wetlands, water quality, and safe edible fisheries. They find scenic vistas of the harbor, marshes, wetlands, forests, streams, and byways to be very important and feel that the creation of natural vegetation buffer zones would help to protect these visual resources.

These findings are significant because they demonstrate sophistication concerning growth and environmental protection on the part of the local citizenry. People are knowledgeable of the issues. The fact that the majority overwhelmingly supports the protection of important resources bodes well for the future.

RECOMMENDED ACTIONS TO PRESERVE & PROTECT CHARLESTON HARBOR

Over several months, twelve task forces, totaling more than 200 individuals, met and discussed issues of importance to the well being of the Charleston Harbor Estuary. From these discussions, they identified central issues and designed and allocated funding for research to address specific concerns. Focus groups of researchers and selected task force and Management Committee members then synthesized the information from the research into discrete recommendations for action. The Management Committee further refined these into the following recommendations. These recommendations represent much work by many individuals, both in and out of government, and form the basis for action to protect the natural and cultural resources of the Charleston Harbor Estuary.

Not all of these recommendations are of equal importance, but they are all important. No attempt has been made to prioritize them. A funding plan is being prepared, separate from this document, but this will not preclude following through on recommendations whenever possible.

Each recommendation details the action needed to accomplish a specific task and gives the background or reasoning behind a particular action item. Each recommendation also includes measurable goals, which both outline steps to be followed in accomplishing the action and can be used to measure success. The agencies or organizations that will play a central role in accomplishing the tasks are also identified. Staff members of DHEC/OCRM will be assigned oversight of each of the action items and made responsible for seeing that they move forward. Costs are based on estimated one-time start-up costs, staff time [person months (pm)], annual costs, and projected contractual costs for the first five-year cycle.

STATE OF THE HARBOR PROGRAM

SH-1 Establish a State of the Harbor Program

ACTION

Establish a State of the Harbor Program to ensure that the process of assessing, monitoring, and implementing environmental protection techniques within the Charleston Harbor watershed is an ongoing process.

BACKGROUND

The Charleston Harbor Project was initiated to better manage watershed resources and to minimize resource degradation caused by population growth. It was recognized that one of the main hindrances to achieving this goal was the lack of coordination in overall resource protection. Existing regulatory programs were not established or equipped to deal with problems caused by growth. Resource protection was fragmented among a variety of agencies, with local governments not being aware of their role through their control of land use. As has happened in other areas, the result was a piecemeal degradation of resources, with no mechanism to deal with cumulative impacts.

The CHP has identified the threats to the resources of the watershed and has conducted research to identify solutions to the threats. There is now the need for an organization to oversee and coordinate the various activities and recommendations which have come from this effort. A State of the Harbor Report to the community will serve to focus attention on a broad agenda of concerted action. Since local government officials play a crucial role in watershed management decisions, the State of the Harbor Report will examine issues and developments from the standpoint of cities, counties, and districts, as well as the long-established purview of state and federal agencies. The State of the Harbor Program will provide administrative support for long-term cooperative watershed planning, periodic special reports, and the publication of the full State of the Harbor Report every five years.

MEASURABLE GOALS

- Develop a five-year plan with specific measurable goals.
  2pm/$8,000/once every 5 years.
- Develop ways to measure the effectiveness of resource management policies.
  3pm/$12,000/5 years
- Establish the Management Committee of the CHP as the manager of the State of the Harbor Program.
  Meeting costs ~ $1,000 per year/annual
- Produce a yearly report on progress.
  1pm/$4,000
- Develop an applied research program, in coordination with existing efforts, supported by computer mapping, archiving, and database man agement, to determine the impacts of urbanization on water quality. As part of this it will be necessary to:
  a) Identify and catalog existing research programs and projects.
  1pm/$4,000/every 5 years
  b) Establish a task force to evaluate and make recommendations on the appropriate mechanisms to conduct the applied research program. Members should include SC Sea Grant Consortium, DHEC, SC Department of Natural Resources, the state's colleges, the United States Geological Survey, NOAA-National Ocean

Service (NOS) and representatives from private groups and local governments.
2pm/$8,000 + meeting and printing costs ~$5,000/annual
c) Develop a list of specific research needs related to the water and sediment quality impacts of urbanization.
Covered in b above-no additional costs
d) Identify funding sources for implementation of the recommendations and goals of the task force and develop a grant proposal to begin such an effort.
Covered in b above-no additional costs
e) Conduct a literature review of research on the impacts of urbanization on water and sediment quality.
Covered in b above-no additional costs

- Evaluate current and encourage new research on the impacts of pollutants associated with runoff, contaminated sediments, and the physical effects of water flow on marine fauna.
  Partially covered in b above-encouragement of new research will possibly entail help with funding.

COSTS

One-time costs	$ 0
Annual cost (times 5 years)	90,000
Every 5 years cost	24,000
Total cost for first 5-year cycle	$114,000

IMPLEMENTATION

DHEC, Sea Grant

SH-2 Cooperate with other agencies' planning cycles

ACTION

Cooperate with other agencies in the context of parallel planning cycles to insure that maximum coordination can take place.

BACKGROUND

Existing resource protection is fragmented among a variety of federal and state agencies and local governments, all of which have some sort of planning process to achieve their goals. For example, both DHEC and the SC Department of Natural Resources develop strategic plans for environmental protection every five years, and the Berkeley-Charleston-Dorchester Council of Governments is required by law to update tri-county transportation and wastewater facilities plans at five-year intervals. Many of the key factors for watershed management are contained in these planning programs. Currently there is little coordination among these various governmental entities in developing planning goals, writing plans, or scheduling projects. By synchronizing the planning cycles, related public policies can be reviewed and renewed as parts of a connected whole. Cooperation among the various groups would greatly improve efficiency and avoid duplication and even instances of government entities working at cross purposes. The proposed State of the Harbor Program would be in a unique position to help to coordinate this endeavor.

SH-2

MEASURABLE GOALS

- Identify other agencies' relevant plans, their associated schedules, and their key contacts and establish a coordination process as a component part of the five-year plan.
  1pm/$4,000/annual

COSTS

One-time costs	$ 0
Annual cost (times 5 years)	4,000
Every 5 year cost	0
Total cost for first 5-year cycle	$ 20,000

IMPLEMENTATION

DHEC

SH-3 Provide technical assistance to local governments & government agencies

ACTION

Provide local governments and government agencies with research findings and expert advice for the application of science-based management techniques in the development of policies affecting Charleston Harbor resources and water quality.

BACKGROUND

Often, governments are faced with resource management issues with which they have no in-house technical expertise. It should be the role of the coastal zone management agency, along with Sea Grant and DNR, to coordinate research on questions of resource management and distribute the technical data and provide expertise to those agencies that need it. Local governments in particular are in need of this service. Traditionally they have not recognized their role in resource protection, believing it to be the role of federal and state agencies. In truth, they make the land use decisions that fundamentally affect the development patterns for the coastal zone. However, they are not staffed or otherwise equipped to deal with resource management issues and must have technical help if they are to make wise land use decisions that incorporate resource protection techniques.

MEASURABLE GOALS

- Identify effective land use policies for protecting area waterways and wetlands.
  2pm/$8,000/every 5 years
- Provide assistance in producing appropriate elements of the comprehen sive plans of five local communities each year.
  2pm/$8,000/annual
- Develop a framework for other public agencies to provide expertise and technical advice to local governments.
  .5pm/$2,000/annual
- Establish a clearinghouse to facilitate information exchange.
  $50,000 one time start up + 12pm/$48,000/annual

SH-3

SH-3

- Develop and maintain a web page to disseminate information to the public.

  2pm/$8.000/annual

- Convert technical information into layman's terms that are easily com prehended by the public and readily accessible.

  3pm/$12.000-this also takes into account publishing the informa tion/annual

COSTS

One-time costs	$ 50,000
Annual cost (times 5 years)	390,000
Every 5 year cost	8,000
Total cost for first 5-year cycle	$448,000

IMPLEMENTATION:

DHEC, Sea Grant

PUBLIC OUTREACH

PO-1 Conduct educational campaigns

ACTION

Conduct educational campaigns on the importance of the Charleston Harbor Watershed

BACKGROUND

Citizen involvement is important to any effort to protect the resources of Charleston Harbor. In order to maximize citizen input, it is necessary to educate the public about the existing resources, their value and sensitivity. The more people understand about the harbor's environment, the more support there will be for its protection. This understanding is particularly important for the more than 100,000 students in the study area because these students will become the decision-makers of tomorrow.

MEASURABLE GOALS

- Develop and implement an educational campaign that would include:
  - Use of the shellfish resources of the Charleston Harbor Watershed
    .5pm/$2,000/every 5 years
  - A brochure on cull-in-place harvesting methods for oysters and recommended harvesting methods for clams.
    2pm/$8,000+layout and printing costs $10,000/ every 5 years
  - Guidelines and a brochure on best development practices for distribution to stakeholders that include information detailing the impacts associated with human development of the landscape.
    2pm/$8,000+layout and printing costs $10,000/ every 5 years
- Identify and develop a steering committee.
  .5pm/$2,000/annual
- Make the education campaign a component of the OCRM web page.
  Included in costs of development of web page.
- Develop a campaign to educate the public on the use of the fishery resources of the Charleston Harbor Watershed.
  1pm/$4,000+possible costs associated with distribution of information/annual
- Design and conduct one workshop a year to educate engineers, developers, advocacy groups, and municipal officials on new development models and techniques that minimize the impacts of growth on watershed resources.
  1pm/$4,000+$10,000 for speakers, mailouts, handouts, and other meeting costs/annual
- Use recreational facilities and programs to educate the public to the benefits and values of natural ecological systems, and to direct the public from over-used facilities to under-used sites. Existing kiosks at boat ramps are one method to do this. The goal should be to decrease use at over-utilized facilities by 20%, and increase use at under-utilized facilities by 25%.
  1pm/$4,000+ educational materials $5,000/annnual

PO-1

- Encourage activities in particular areas based on the best uses of a waterbody, such as for fishing, canoeing, water skiing, etc.
  Covered in the preceding costs
- Develop education materials on the importance of green space to foster public discussion on green space issues.
  1pm/$4,000 + printing $4,000/every 5 years

COSTS

One-time costs	$ 0
Annual cost (times 5 years)	145,000
Every 5 year cost	46,000
Total cost for first 5-year cycle	$191,000

IMPLEMENTATION

DHEC, SC Sea Grant Consortium, SC Department of Natural Resources, Charleston County Public Works, National Estuarine Research Reserves, College of Charleston Science Hub, Charleston Aquarium

PO-2 Create interpretative program for historic sites

ACTION

Create interpretative and educational programs for identified historic properties, including significant submerged and archeological sites, buildings, districts, landscapes, and vistas.

BACKGROUND

The CHP area contains some of the most significant historic and archeological sites in the United States. The area's economy is heavily influenced by its cultural resources, and their preservation and interpretation are important factors in the overall "quality of life" of the regional community. While scenic views and beach and ocean recreation are important attractions, historic resources differentiate Charleston from other coastal cities. In the CHP area, programs to study, preserve, and interpret historic resources therefore have a necessary sense of urgency. The CHP area has a large number of institutions and organizations that contribute to the preservation and interpretation of cultural resources. Support for cultural resource protection comes from an informed citizen base. As development threatens these resources, management decisions become increasingly complex and important. Education of the general public will lead to more informed and better decisions regarding cultural resources by managers and political leaders.

MEASURABLE GOALS

- Work with local governments, the State Historic Preservation Office, local historic societies, the Charleston County Parks & Recreation Com mission, developers, and interested parties to coordinate appropriate programs for sites.
  1pm/$4,000/annual
- Conduct workshops to pull participants together.
  1pm/$4,000+$2,000 for additional workshop costs/annual

COSTS

One-time costs	$ 0
Annual cost (times 5 years)	50,000
Every 5 year cost	0
Total cost for first 5-year cycle	$50,000

IMPLEMENTATION

State Historic Preservation Office, SC Parks, Recreation & Tourism, Charleston County Parks & Recreation Commission, DHEC, Local Historic Societies, Heritage Trust, Charleston Downtown Group, Local School Districts

PO-2

BIOLOGICAL RESOURCES

BR-1 Characterize small tidal creeks

ACTION

Categorize small tidal creeks according to physical and biological characteristics of the creek to ensure proper management.

BACKGROUND

Coastal marshes are among the most productive ecosystems in the world, in part because salt marshes are major producers of detritus (broken down plant material) which supports productivity in adjacent estuaries as much or more than phytoplankton-based production. *Meandering shallow tidal creeks* that branch from larger creeks and rivers in the Charleston Harbor estuary are vital to the ecology of the estuary because they provide nursery habitat for numerous species of fish, crab, and shrimp.

The assumption that main channel dissolved oxygen (DO) levels are representative of small creek DO is inaccurate. Small tidal creeks (less than 3 ft MLW) are a special category of estuarine habitat. Primary and smaller creeks off the main stem of rivers exhibit water quality dynamics that differ from larger rivers (different flushing rates, depths, and relative amounts of stormwater loading). Due to lower flush rates, smaller tidal creeks are more susceptible than main rivers to human induced changes in water quality, including more frequent extreme fluctuations in salinity, changes in bottom sediments, and alterations in dissolved oxygen dynamics.

Since small tidal creeks are more susceptible to eutrophication than adjacent rivers, they require more specific management criteria. These creeks are the primary nursery areas in the estuary. It has been theorized that the highly variable physical conditions (salinity, temperature, and dissolved oxygen) in these creeks cannot be tolerated by predators but can be tolerated by small juvenile organisms. *However*, even these creatures approach their physiological limit in these highly productive habitats under pristine conditions. Additional stresses to these habitats from nutrients and contaminants in stormwater runoff from upland development can move conditions in the water beyond the tolerance of the juvenile organisms and degrade nursery functions. Impacts are due, in large part, to changes in hydrology related to increases in impervious surfaces in the adjacent upland. These hydrologic changes are reflected in increased runoff entering the headwaters and are largely irreversible, although even the most heavily developed industrial creeks studied by CHP researchers provided some nursery function.

MEASURABLE GOALS

- Establish a Tidal Creek task force which would:
  - Develop a tidal creek characterization method.
    - *3pm/$12,000+$12,000 graduate student/one time*
  - Develop an inventory of small tidal creeks.
    - *$12,000 graduate student/one time*
  - Define management criteria specific to small tidal creeks.
    - *3pm/$12,000/one time*
      1) establish nutrient criteria
      2) identify chlorophyll action levels
      3) identify eutrophication potential

BR-1

COSTS

One-time costs	$48,000
Annual cost (times 5 years)	0
Every 5 year cost	0
Total cost for first 5-year cycle	$48,000

IMPLEMENTATION

DHEC, DNR

BR-2 Develop a rice field succession plan for upper Cooper River

ACTION

Develop a basin-level plan to address rice field succession in the upper Cooper River.

BACKGROUND

The upper Cooper River has been greatly altered over the last 300 years. The tidally influenced, freshwater marshes and swamps were modified in the 18th and 19th centuries for the cultivation of rice, with dikes and ditches controlling water levels. It is generally believed this rice cultivation technology and skills were brought to the Lowcountry from the Gold Coast of Africa. Africans had been growing rice under similar conditions for more than a thousand years. As slaves, they modified the landscapes and cultivated the rice, often in the absence of the white plantation owner. This productive labor supply was lost with the Civil War. Storms and lower costs production methods elsewhere contributed to the end of the rice cultivation in the Lowcountry in the 1920s. The rice fields were largely abandoned and breaches in the dikes allowed renewed tidal flow that initiated aquatic succession.

In 1941, further manmade alterations came to this system when the works Progress Administration completed the Santee-Cooper Hydroelectric Project. This diverted the flow of the Santee River into the Cooper, transforming the Cooper from a tidal slough with an average monthly flow of 417 cubic feet per second to a riverine system with a flow of 17,513 cubic feet per second. This project, more than any other human-related or natural change, has had the greatest long-term effect on the Charleston Harbor Estuary.

When it was found that the Santee-Cooper Project significantly increased siltation in Charleston Harbor, approximately 70% of the Santee-Cooper drainage water was directed back into the Santee. This was called the Cooper River Rediversion Project, and was completed in 1985. Water flow into the Cooper was reduced to approximately 4518 cubic feet per second, and caused a drop in water levels of about 5.9 inches in the upper Cooper River, relative to post-1941 elevations.

All of these changes have had a significant effect on the wetlands bordering the Cooper River. As a result of differences in cultivation history, management practices, time since abandonment, water depth and duration of inundation, salinity, and potentially other factors, the old rice fields are now in a variety of successional states. Research, some funded by the CHP, found that lowering of the water levels has accelerated vegetational succession in the remnant rice fields of the upper Cooper River. Marsh and shallow open water areas are changing to a tree cover climax ecosystem, so functions and values associated with river swamp will increase while other functions associated with earlier successional stages will be lost. Lost

BR-2

functions may be critical to the health and value of the Cooper River drainage basin. Overall, succession in the rice fields may result in a loss of habitat diversity to the watershed.

BR-2

MEASURABLE GOALS

- Establish a Ricefield Committee.
  No significant costs
- Develop a basin plan to address rice field succession in the upper Cooper River.
  1pm/$4,000 + meeting costs $2,000/every 5 years

COSTS

One-time costs	$ 0
Annual cost (times 5 years)	0
Every 5 year cost	6,000
Total cost for first 5-year cycle	$6,000

IMPLEMENTATION

DHEC, Sea Grant

BR-3 Develop molluscan shellfish management plans for the CHP watershed

ACTION

Develop molluscan shellfish management plans for the CHP area to ensure that shellfish resources are restored and sustained at levels that balance maintenance of water quality, estuarine nursery functions, and human uses.

BACKGROUND

Oysters, clams and whelks are the three species of molluscan shellfish of major economic and recreational importance found in the Charleston Harbor Estuary. Since 1986, commercial oyster landings have risen steadily, peaking during the 1993/94 season, with estimated recreational harvests equaling about 43% of the commercial landings. Commercial landings of wild clams have remained relatively stable since 1986, while clam mariculture has dramatically increased. Whelk production has remained stable for the last six years, with the landings in Charleston far exceeding landings in other parts of the state.

Although shellfish are abundant throughout Charleston Harbor, an oyster survey conducted by the federal government over one hundred years ago (1890-1891) reveals that the resource was once significantly more prevalent. Being sedentary filter feeders, mollusks are more vulnerable to water pollution than other marine animals. Because of this, much of the estuary is closed to harvesting due to either high fecal coliform counts or administrative closures around activities deemed to have the potential for contamination (i.e. marinas, and wastewater and industrial discharges). Threats to the shellfish resources of the Charleston Harbor Estuary include dredging, heavy boat traffic, urban pollutants, sedimentation, overfishing, diseases, and highly variable, short-term fluctuations in salinity caused by upland stormwater runoff.

Both DHEC and the Department of Natural Resources (DNR) have responsibility for the shellfish resource, but currently there is no overall management plan. DHEC is concerned with the public health aspects of shellfish consumption and

BR-3

BR-3

marketing and, through the OCRM program, the physical disruption of shellfish beds. DNR has traditionally focused on the permitting of commercial harvesters, the regulation of recreational users, and designating between public and commercial shellfish grounds. There have also been some attempts to relocate stock from areas closed to shellfish harvesting to areas that are open, but this program has never been adequately funded. DHEC and DNR are evaluating shellfish restoration priorities, but there is no concerted effort to restore areas now closed, reduce user conflicts, or recycle used shell for cultch (bedding or substrate) material.

MEASURABLE GOALS

- Develop a protocol to determine when over-harvesting has occurred.
  .5pm/$2,000/one time
- Establish appropriate management options for over-harvesting including moratoria on harvesting, harvest-effort limitations, stock enhancement, etc.
  .5pm/$2,000/annual
- Evaluate the benefits and disadvantages of limited entry into recreational and commercial fisheries and periodic bed closures as tools for ensuring that shellfish populations are not over-harvested.
  Covered in the above
- Determine if the uses of oyster shell can and should be limited to replanting as cultch for restoration of oyster populations.
  .5pm/$2,000/one time
- Develop an incentive program to encourage the public and restaurants to recycle oyster shell.
  8pm/$32,000/annual + pilot project/$30,000/one time
- Conduct a survey to assess the public's knowledge and use of shellfish re sources of Charleston Harbor.
  1pm/$4,000+mailing costs $2,000/one time
- Develop species profiles and assessments on *Busycon* and other shellfish species that are periodically harvested or are ecologically important.
  .5pm/$2,000/one time
- Work with existing DHEC and DNR shellfish restoration committee to de velop plans and identify candidate sites for shellfish restoration.
  .5pm/$2,000/annual

COSTS

One-time costs	$ 42,000
Annual cost (times 5 years)	180,000
Every 5 year cost	0
Total cost for first 5-year cycle	$222,000

IMPLEMENTATION

DNR, DHEC

BR-4 Stabilize Cooper River waterflows

ACTION

Stabilize Cooper River flows to the highest degree possible and increase water levels as much as is reasonable, particularly during the months of January through May, and in consideration of impacts on siltation rates.

BR-4

BACKGROUND

The Cooper River serves as a spawning/nursery habitat and provides a migratory route for many important marine and aquatic fauna. Under current agreement, the water released into the Cooper River at the Pinopolis Dam must average about 4,500 cubic feet per second (cfs) for the week. Actual flow, however, on a given day may be over twice the required average (not to exceed 10,000 cfs) or near zero. Additionally, flow rates can be highly variable within a day. This irregular flow pattern creates an unnaturally high variation in water level that frequently creates a hostile environment for aquatic biota in the river.

Anadromous species such as Atlantic sturgeon and the endangered shortnose sturgeon occur in the Cooper River. Both species of sturgeon are known to spawn directly below the dam. Sturgeon begin spawning in January and continue through April with a peak appearing to occur in March. It also appears that shortnose sturgeon spawn earlier in the season than do Atlantic sturgeon. Relatively little is known about sturgeon spawning behavior and specific spawning habitat. However, it appears that clean, flowing water that is well oxygenated is very important. The eggs are demersal and adhesive, meaning they stick to structure or the bottom. Reduced flow rates soon after spawning could result in increased siltation, which could smother eggs or cause dissolved oxygen levels to fall.

American shad, hickory shad, and blueback herring are species common to the Cooper River, and by all indications, they are less abundant since water flows were reduced with rediversion. Numbers of fish, primarily herring, passing through the fish lift declined by 75% or more in the years following rediversion. A thriving commercial herring fishery in the Cooper River has disappeared and relocated in the Santee River Tailrace Canal because of decreased catch rates in the Cooper. Shad catch rates in the recreational hook and line fishery also declined substantially after flow rates were reduced, but a valuable hook and line shad fishery still thrives in the Tailrace Canal below Pinopolis Dam. Shad, like sturgeon, require clean, flowing water for optimal spawning habitat and survival of eggs, larvae and juveniles. Herring eggs are adhesive and spawning generally occurs in shallow water near plants, rocks, or other substrates. Good water quality is required for optimal survival of all growth stages of herring. Studies in the Connecticut River have shown that year class strength of both shad and herring is largely determined by survival rates of larvae and juveniles, and survival is positively correlated to stable river flows during spring and summer.

Fishes that spawn in shallow, near-shore waters are vulnerable to variable flow rates that cause drastic water level fluctuations. Mortality of eggs and fry following drawdown has been documented for many species, including several locally important sunfish species. Falling water levels result in a loss of available habitat and can cause direct mortality of eggs. Rapidly receding waters may lead to nest desertion, disrupt normal spawning behavior, strand larvae and juveniles, or sweep them downriver. Nest desertion permits predation on unprotected eggs and larvae and usually results in complete failure of the nest. Additionally, fluctuating water levels prior to spawning may cause reabsorption of eggs by the female. Optimal conditions include relatively high, stable water levels, particularly during spring, thus providing shallow habitats in old rice fields and along river banks.

Forage fish and invertebrates also thrive when the amplitude of water level fluctuations is reduced. It has been observed that important food for shad was higher in abundance and more persistent when river discharge rates were more stable. Erratic fluctuations in river flow during spring have been found to disrupt patch formation of riverine zooplankton-important food for juvenile fishes. In addition, irregular river flow can reduce water transparency, which retards phytoplankton, the primary food source for herbivorous zooplankton.

BR-4

MEASURABLE GOALS

- Establish a committee of affected parties to negotiate a new agreement regulating water flows.
  No significant costs
- Establish a new flow management regime with the next Federal Energy Regulatory Commission permit renewal.
  1pm/$4,000+meeting costs $2,000/one time
- Evaluate the need to enhance upstream and downstream passage for anadro mous species.
  .5pm/$2,000/one time
- Evaluate impacts of flow on water quality, particularly National Pollution Discharge Elimination System permits and loading models for the harbor.
  .5pm/$2,000/every 5 years

COSTS

One-time costs	$ 8,000
Annual cost (times 5 years)	0
Every 5 year cost	2,000
Total cost for first 5-year cycle	$10,000

IMPLEMENTATION

SC Department of Natural Resources, DHEC, US Army Corps of Engineers, National Marine Fisheries Service, SC State Ports Authority, Santee-Cooper

BR-5 Establish Geographic Areas of Particular Concern (GAPC) designation for sensitive fish habitats

ACTION

Identify and designate unique and sensitive estuarine fish habitats as GAPC and establish management policies to protect them.

BACKGROUND

All creeks function as nursery grounds, with finfish being the most abundant in the brackish creeks. Spot, Atlantic croaker, red drum, spotted seatrout, flounder, and catfish inhabit the estuary and are recreationally important. Declines in the populations of some commercially and recreationally important inshore and offshore finfish species may be related to habitat degradation within the estuary.

In order for sensitive fish habitats to be preserved, they must first be identified. Some work on this has been done. Research has shown that large aggregations of seatrout are seasonally found around structures exposed to high velocity currents and that "The Grillage" area near the Charleston jetties is a spawning area for red drum. Sound detection equipment has also documented concentrations of seatrout in main shipping channels within the harbor. Dredging and other types of disruptive activities could either be directed away from these areas, or restricted as to season.

MEASURABLE GOALS

- Identify and map all unique and sensitive estuarine fish habitats.
  4pm/$16,000/every 5 years

BR-5

- Designate these areas as GAPCs under the SC Coastal Zone Management program.

  .5pm/$2,000/every 5 years

- Develop appropriate management measures for protection of these habitats.

  2pm/$8,000/every five years

COSTS

One-time costs	$ 0
Annual cost (times 5 years)	0
Every 5 year cost	26,000
Total cost for first 5-year cycle	$26,000

IMPLEMENTATION

SC Department of Natural Resources, DHEC, National Marine Fisheries Service

BR-6 Develop and promote measures to protect colonial waterbirds

ACTION

Implement measures to protect colonial waterbirds

BACKGROUND

Colonial waterbirds are a conspicuous and important component of coastal wetland ecosystems. Because of their diverse foraging and nesting requirements, waterbirds serve as valuable indicators of the health of South Carolina's wetlands.

Thirteen species of wading birds, eleven species of seabirds, and four species of shorebirds have been documented nesting in the CHP area. During a statewide survey of waterbird colonies in 1994, DNR located 59 wading bird and 29 seabird colonies in Charleston and Berkeley counties, containing totals of 11,520 and 19,800 nests, respectively. Although the Charleston Harbor Estuary still supports substantial waterbird populations, recent surveys suggest that population size has been reduced from historic levels.

Seabirds and shorebirds nest primarily on the ground on offshore sandbars, barrier island beaches, man-made dredge spoil islands, and shell banks. However, least terns also nest on large flat rooftops located near foraging sites. Wading birds are more versatile, building nests in vegetation on sandbars and man-made spoil islands, as well as in emergent aquatic shrubs and trees in swamps, ponds, and man-made impoundments. In addition, great blue herons nest singly or in small groups in mature pines on small hammocks or along the marsh-upland edge.

Colonial waterbirds exhibit a large range of habitat and prey preferences. Wading birds generally forage by standing in shallow water along creek, river, and bay shorelines. By contrast, seabirds feed primarily on the wing, often diving into the water or skimming across the surface to catch their prey.

Although there are numerous threats to the health of waterbird populations, the greatest overall threat is the reduction in the quantity and quality of habitat. The reduction in nesting, roosting, and foraging habitats limits the number of waterbirds that can be sustained within the study area. Wetlands are being al-

tered or destroyed due to increasing residential, commercial, and industrial development, as well as changing forestry practices. Shrub habitat on pond or impoundment edges is often eliminated for aesthetic reasons. In addition to the direct loss of nesting sites, tree and shrub-nesting wading birds are forced to abandon nesting sites when the hydrology is altered. Beach nourishment activity has altered longshore currents and eroded an important sand island used as a rookery by pelicans, gulls, and terns. Other nesting sites on sand islands have been impacted by human trespassers into the rookery.

Avian mortality has also been documented due to power-line collisions and entanglements with gill nets, fishing line, and various forms of plastics. Wood storks and other large wading birds are particularly vulnerable to collisions at power line crossings, but when yellow aviation spheres are located on lines, fewer collisions occur.

MEASURABLE GOALS

- Promote buffers to protect colonial water bird nesting and roosting sites. A setback of 300 feet for arboreal nesting sites and 600 feet for ground nest ing sites is recommended during the nesting season.
  2pm/$8,000/every 5 years
- Maintain a buffer of 100 feet around roosting sites. Within these buffers keep the clearing of understory trees and shrubs to a minimum, and protect mature trees and dead snags.
  Covered in the above
- Do not permit putresible waste landfills within 2 miles of nesting sites to prevent the concentration of predators.
  .5pm/$2,000/every 5 years
- Minimize alterations to natural hydrologic patterns in river swamps at colony sites. Restrict timber harvesting to high elevation areas away from deepwater channels.
  Covered by work with the South Carolina Forestry Commission (SCFC) below.)
- Encourage impoundment managers, developers, and homeowner associa tions to manage for colonial water birds.
  1pm/$4,000+possible development and printing costs of brochures $10,000/one time
- Promote measures to reduce bird mortality in gill nets and from collisions with power lines.
  .5pm/$2,000/every 5 years
- Work with SCFC to add the management measures to the SC forestry best management practices manual.
  1pm/$4,000/every 5 years
- Produce and distribute a methods manual targeting impoundment manag ers to aid them in managing for colonial wading birds.
  1pm/$4,000 + $4,000 printing/every 5 years
- Hold a workshop for impoundment managers on managing for colonial water birds.
  .5pm/$2,000 + $2,000 additional costs/annual
- Publish and distribute guidelines for designing island bird habitat.
  1pm[Department of Natural Resources (DNR)]/$4,000 + layout and printing costs $10,000/every 5 years
- Develop incentives to encourage developers to construct small island habi tats.
  1pm/$4,000/every 5 years

- Develop a geographic information system data layer showing colony roosting and nesting sites with appropriate setbacks delineated, including a 2-mile radius buffer for landfills.
  1pm(DNR)/$4,000/every 5 years
- Distribute a map for each local municipality showing locations of colony roosting and nesting sites and setbacks.
  .5pm/$2,000/every 5 years
- Develop model ordinances to protect colony roosting and nesting sites.
  .5pm(DNR)/$2,000/every 5 years
- Work with local governments to implement the management measures and get the ordinances adopted.
  .25pm/$1,000/annual
- Reduce gill netting activity that results in high mortality of sea birds.
  .25pm(DNR)/$1,000/annual
- Sign a memorandum of agreement (MOA) with power companies to re duce bird mortality from power lines.
  .5pm(DNR)/$2,000/every 5 years
- Establish a citizen Bird Watch program similar to the Turtle Watch program.
  1pm(DNR)/$4,000/annual
- Map areas to be annexed by local jurisdictions so they can police impacts to bird nesting areas.
  1pm(DNR)/$4,000/every 5 years
- Sign MOAs with local governments to establish marine patrols during nest ing season.
  1pm(DNR)/$4,000/every 5 years

COSTS

One-time costs	$ 14,000
Annual cost (times 5 years)	50,000
Every 5 year cost	60,000
Total cost for first 5-year cycle	$124,000

IMPLEMENTATION

DNR, DHEC, Local Governments

BR-7 Develop measures to protect diamondback terrapins

ACTION

Develop measures to protect diamondback terrapins.

BACKGROUND

The diamondback terrapin is the only species of turtle in North America that inhabits brackish coastal habitats exclusively. Although hunting made them scarce in the early part of this century, today diamondbacks are common. They are widely found in the marshes and tidal creeks of the Charleston Harbor Estuary.

Drowning in crab traps is a common form of mortality that was first observed in the 1940s, but only acknowledged as causing an impact on terrapin populations in the late 1970s. Recent evidence suggests that recreational crabbing activities that result in abandoned or lost traps are responsible for the greatest number of drownings. Solutions for excluding terrapins from crab traps, similar to the turtle

BR-7

excluder devices used by the commercial shrimp industry, could minimize mortalities.

MEASURABLE GOALS

- Require the use of crab traps that exclude terrapins by developing and distributing a flyer and providing information to local marine educators.
  .5pm/$2,000/every 5 years

COSTS

One-time costs	$ 0
Annual cost (times 5 years)	0
Every 5 year cost	2,000
Total cost for first 5-year cycle	$2,000

IMPLEMENTATION

SC Department of Natural Resources

BR-8 Protect hydrology of key plant habitats

ACTION

Adopt policies that prohibit alterations of hydrology of key plant habitats.

BACKGROUND

A CHP research study produced an inventory of significant botanical natural areas in the tri-county area that may be affected by human activities in the Charleston Harbor Estuary. It provides one of the more important habitat descriptions of the region's natural areas and identifies eighty significant botanical natural area sites. Significance was based on the following criteria:

Plants listed as endangered by the U. S. Fish and Wildlife Service(USFWS) - Two plants listed as endangered species are known to occur in the study area - *Schwalbea americana L* (American chaffseed) and *Lindera melissifolia (Walter) Blume* (pondberry).

Plants listed as Category 2 species - These are plants for which information now in possession of the USFWS indicates that proposing to list as endangered or threatened is possibly appropriate, but for which sufficient data on biological vulnerability or threats are not currently available to support proposed rules. There are thirteen Category 2 species in the CHP area.

Rare plant communities - Certain plant communities, such as marl forests and longleaf pine savannas, are rare in the study area and the state. This results from either natural rareness or loss of habitats due to human activities. Preservation of these rare communities is critical to preserve natural diversity.

Significant wetlands - The tri-county area harbors many wetland habitats that are important to the existence of several plant species.

Wilderness Areas - Four wilderness areas occur in the study area. All are found in the Francis Marion National Forest.

Significant sites from the rice culture era of South Carolina - Sites considered to have historical value in preserving the botanical history of the rice industry are identified.

Pristine sites of unusual natural beauty - The study area in the tri-county area is laced with sites of unusual natural beauty that should be preserved for future generations to enjoy.

MEASURABLE GOALS

- Publish the inventory of key plant habitats produced by Richard D. Porcher, Ph.D.
  layout and printing $10,000/one time

BR-8

- Develop policies to protect these habitats.
  1pm/$4,000/every 5 years
- Educate local governments about these habitats.
  1pm/$4,000/every 5 years
- Work to have Penny and Euchaw creeks designated as scenic rivers.
  1pm/$4,000/one time

COSTS

One-time costs	$14,000
Annual cost (times 5 years)	0
Every 5 year cost	13,000
Total cost for first 5-year cycle	$27,000

IMPLEMENTATION

DHEC, Department of Natural Resources, Local Governments

WATER QUALITY

WQ-1 Determine sources of bacterial contamination in area waters

ACTION

Use techniques, such as *antibiotic resistance*, developed by Harbor Project researchers to determine sources of bacterial contamination in area waters.

BACKGROUND

Several studies conducted by the Harbor Project evaluated the impact of nonpoint source pollution on water quality and aquatic resources. The human utilization of shellfish is particularly sensitive to the impacts of nonpoint source pollution. Because shellfish can be eaten raw, they can only be harvested from waters that meet the most stringent water quality standards. Levels of bacteria contained in urban runoff are orders of magnitude greater than what can be allowed in shellfish harvesting waters. Unfortunately, current technologies and best management practices for treating runoff are relatively ineffective at reducing bacteria loads to an acceptable level. It is, therefore, critically important that sources of bacterial contamination be identified and eliminated, or substantially reduced, because this is the only reliable means of treatment. Bacteria in runoff can come from humans, domestic animals or wildlife. Only by determining what the primary source is can appropriate management actions can be taken.

Local scientists with NOAA-National Ocean Service have evaluated several different ways to determine the sources of bacteria in runoff. Currently, the most promising and practical method is one called Multiple Antibiotic Resistance. Bacteria from runoff are exposed to ten different antibiotics. Generally, bacteria from humans are very resistant to most of the antibiotics. Domestic animals' bacteria are resistant to a few of the antibiotics that are commonly prescribed by veterinarians. Wildlife, however, are rarely exposed to antibiotics and, therefore, bacteria from that source are very sensitive. More work is required before this method can be widely used, but it should give managers a much-needed tool for determining where to focus limited resources and management actions.

MEASURABLE GOALS

- Evaluate the need for future research to make this technology useable by DHEC laboratories.
  1pm/$4,000/every 5 years
- Develop a project proposal to conduct any necessary research.
  1pm/$4,000/every 5 years
- Evaluate the feasibility of transferring technology to DHEC labs.
  1pm/$4,000/every 5 years
- Develop and implement a protocol for using the technology in non-point source impaired waters.
  1pm/$4,000/every 5 years

COSTS

One-time costs	$ 0
Annual cost (times 5 years)	0
Every 5 year cost	16,000
Total cost for first 5-year cycle	$16,000

IMPLEMENTATION
DHEC, NOAA-NOS

WQ-2 Adopt sediment contaminant criteria

ACTION
Adopt sediment contaminant criteria.

BACKGROUND
The estuary contains several "hot spots" where heavy metals and organic compounds in the sediments exceed the low range for toxic effects on estuarine organisms. Many of the chemical contaminants that occur in potentially toxic concentrations in the CHP area are "contaminants of antiquity," such as DDT, polychlorinated biphels (PCBs) and alpha chlordane, which have been present for decades. These chemicals were once used quite heavily, and although they are now banned or highly regulated, concentrations from past usage still can be found at area sites. The primary chemical contaminants from industrial pollution include chromium, copper, lead, and nickel. The most pervasive contemporary source of industrial pollution in the Charleston Harbor Project area appears to be centered in the Shipyard Creek watershed, with sediment concentrations of chromium representing some of the highest concentrations reported anywhere in the world. Other highly impacted sites include Diesel, Brickyard, and Shem creeks, as well as areas adjacent to large roadways and high-density urban developments. Chemical contaminants from suburban sources appear to be primarily polycyclic aromatic hydrocarbons (PAHs), chlordane, PCBs, and copper.

Spatial comparisons between small tidal creeks, rivers and lower/upper reaches of the Charleston Harbor Watershed indicate that the locations of the greatest chemical contamination are the small tidal creek regions, which are also nursery grounds for finfish, crustaceans, and shellfish. Analyses of spatial distribution of contaminant concentrations indicate migration of some chemical contaminants from land-based sources to the mouths of tidal creeks and eventually into larger water channels.

Toxicological analyses of sediments in the CHP area found that almost 22% of harbor sites tested and 16% of sites in upper reaches of the smaller tidal creeks reached levels of contamination which would be considered degraded. Additional toxicity tests found significant reductions in reproductive success of copepods, although no significant adult mortality from industrial or municipal outfall sites was observed. These findings suggest that most toxicity associated with sediment contamination in Charleston Harbor appears to cause chronic problems affecting reproduction. This effect on reproductive success can have serious consequences for the overall abundance and health of the fauna of the CHP ecosystem.

The scientific literature includes numerous different criteria for establishing sediment pollutant standards, and EPA has established sediment criteria for only a few pollutants. Currently, there is no method for addressing this problem when contaminated sediments are found. Although there are established criteria for water pollution, with numerical limits dictating when water is considered safe for certain uses, there are only a few for sediment contamination. In the absence of limits for most contaminants, regulators have no tools for requiring cleanup or effectively and consistently regulating the manipulation of existing sediments. Currently regulators must rely on guidelines that are not universally accepted, and have questionable legal status.

WQ-2

MEASURABLE GOALS

- Conduct a literature review of other states' approaches to sediment contaminant criteria: produce a state of the knowledge report on sediment criteria; and apply these findings to Charleston Harbor.
  2pm/$8,000/one time
- Establish a committee and schedule for developing a state criterion.
  1pm/$4,000/one time
- Recommend adoption of criteria.
  Covered in the above

COSTS

One-time costs	$12,000
Annual cost (times 5 years)	0
Every 5 year cost	0
Total cost for first 5-year cycle	$12,000

IMPLEMENTATION

DHEC, DNR, NOS

— WQ MONITORING —

WQ-3 Revise water quality and habitat monitoring programs

ACTION

Maintain and coordinate a coastal water quality and habitat monitoring program with increased emphasis on smaller streams and creeks.

BACKGROUND

Existing monitoring efforts for the Cooper River and open areas of Charleston Harbor appear to be adequate to document spatial patterns and long-term trends. However, main tributaries and sub-basins, such as the Ashley River and Goose Creek, are characterized by lower rates of estuarine flushing, complex inputs of point sources and nonpoint runoff, and periodic or episodic contraventions of water quality standards. More intensive monitoring is necessary in these systems, especially during the summer months.

A large fraction of the total surface area of the Charleston Harbor Estuary is composed of smaller tidal creeks and inter-tidal wetlands. These areas represent an important habitat for estuarine organisms. Considering the sensitivity of smaller tributaries and tidal creeks to eutrophication and oxygen depletion, these areas require more intensive monitoring, especially during the warm months when freshwater discharge is limited and flushing is reduced. There is an assumption that main channel dissolved oxygen (DO) levels are representative of small creek DO which is inaccurate. Lower flushing rates make the smaller tidal creeks more susceptible to human induced changes in water quality, including more frequent extreme fluctuations in salinity, changes in bottom sediments, and alterations in DO dynamics. The changes in DO levels are of particular concern because the vast majority of the creeks studied by CHP researchers failed to meet 1996 state DO standards (4mg/l). Creeks draining relatively developed watersheds showed significantly more frequent violations of existing DO standards and appeared to have the greatest exposure to low DO conditions.

WQ-3

Increases in duration and severity of exposure to low DO can result in adverse ecological changes ranging from direct mortalities to shifts in the kinds and abundance of organisms present in the ecosystem. However, existing DO standards for aquatic environments do not appear to be meaningful for small tidal creek habitats, since even undisturbed tidal creeks often are in violation of these standards. It is possible that moderately low DO levels in tidal creeks may serve as a barrier that protects the low DO tolerant juvenile fish and shrimp from their predators. Further research is needed to verify this hypothesis.

Current regulatory processes used to establish biological and chemical oxygen demand limits for point and nonpoint source dischargers do not include estimates of the DO needed to preserve and maintain the ecological services provided by tidal creeks and associated salt marshes. It is unknown if the observed alterations in DO dynamics in developed tidal creeks are associated with increased loading of oxygen-consuming material, increased loadings of nutrients (nitrogen and phosphorous) that stimulate excessive growth of primary producers, and/or some other unidentified causes, or whether they are, to a large extent, natural.

MEASURABLE GOALS

- Amend DHEC's monitoring program. (already completed)
- Amend the Department of Natural Resource's monitoring program. (already completed)
- Monitor small tidal creeks. (underway)
- Develop a voluntary program to get local governments, private industry, nonprofits and homeowner's associations to 'adopt-a-creek' and fund ad ditional tidal creek monitoring sites.
  1pm/$4,000 + $2,000 printing/one time; 1pm/$4,000/annual
- Expand the state's small tidal creek monitoring program by 5 stations every year until 2004.
  $12,500/annual
- Establish a 'State of the Creek' section in the State of the Harbor Report to publish findings.
  1pm/$4,000/annual
- Identify outside funding sources to set up monitoring stations.
  1pm/$4,000/every 5 years
- Research and develop a DO budget for tidal creeks.
  Research/$50,000/one time
- Identify the factors contributing to extremely low DO levels in developed tidal creeks.
  Research/$30,000/one time

COSTS

One-time costs	$ 86,000
Annual cost (times 5 years)	102,500
Every 5 year cost	4,000
Total cost for first 5-year cycle	$192,500

IMPLEMENTATION

DHEC, DNR, Local Governments

WQ-3

WQ-4 Monitor for chlorophyll-a

ACTION

Implement a regular monitoring network for chlorophyll-a throughout the Charleston Harbor Estuary.

BACKGROUND

Eutrophication, or overenrichment of nutrients in estuarine waters, is becoming a serious problem nationwide. Nutrients are chemicals essential for plant growth, but during the eutrophication process the fertilizing effect of nutrients in waters causes an overabundance of plant growth. The plants reproduce and grow rapidly, producing very high levels of oxygen during daylight. During darkness, or periods of reduced light due to cloud cover, the profusion of plants consume more oxygen than they produce, and their respiration, along with that of the animals, drives dissolved oxygen (DO) levels lower than normal. Eutrophication fundamentally changes the aquatic environment, which can result in nuisance algae blooms, fish kills, and a variety of other detrimental changes in biological community structure. As human populations impact adjacent waters through nutrient inputs from sewage discharges, nonpoint source runoff, and air pollution, natural nutrient levels are altered.

High algae biomass (chlorophyll-a concentrations) represents an obvious consequence of excessive nutrient loading in sensitive areas. DHEC already uses chlorophyll-a concentrations to monitor trophic conditions in lakes but additional chlorophyll-a monitoring is needed in the estuarine and coastal areas. A chlorophyll-a standard to indicate nutrient loading is also needed.

MEASURABLE GOALS

- Implement DHEC's updated monitoring plan that includes chlorophyll-a sampling in the estuaries.
  $3,400/annual
- Identify a funding source to implement the plan.
  .5pm/$2,000/one time
- Apply findings to better management of water quality issues in Charleston Harbor.
  .5pm/$2,000/annual

COSTS

One-time costs	$ 2,000
Annual cost (times 5 years)	7,000
Every 5 year cost	0
Total cost for first 5-year cycle	$29,000

IMPLEMENTATION

DHEC

WQ-5 Require organic nitrogen monitoring on National Pollution Discharge Elimination (NPDES) permits

ACTION

Require organic nitrogen monitoring on NPDES permits to allow managers to develop estimates of oxygen demand for organic nitrogen.

BACKGROUND

Point source discharges, permitted under the NPDES, are monitored by the discharger. Monthly water quality data are provided to the DHEC. DHEC reviews these monitoring data to determine compliance with NPDES permitted limits and applies enforcement policies as needed. The NPDES permitting system is designed to control overall pollutant loadings to prevent adverse effects to human health and the environment.

Organic nitrogen is nitrogen that is bound to carbon atoms and is the product of biological activity. Plants and animals bind nitrogen and carbon into large complex molecules. These molecules are typically less reactive, and the nitrogen is less biologically available than the inorganic forms of nitrogen. Therefore, organic nitrogen may not be a major contributor to biochemical oxygen demand, but more information on the form of organic nitrogen in the system is needed. Water quality modeling efforts for wasteload allocations assume that a certain percentage of organic nitrogen is directly converted to ammonia. More specific data on organic nitrogen forms in the system would help improve modeling accuracy. Although organic nitrogen sources arise from point and nonpoint source discharges, the high level of organic nitrogen in the Cooper River is thought to be from the large wetlands and erodible soils.

Some contribution of organic nitrogen is attributable to sewage discharges, but dischargers do not monitor organic nitrogen and, consequently, the proportions can not be determined. In order to develop an overall harbor nutrient budget, point source data on organic nitrogen is needed.

MEASURABLE GOALS

- Revise permitting or certification requirements for NPDES permits in coastal zone to require monitoring of various forms of organic nitrogen.
  2pm/$8,000/one time
- Begin modeling organic nitrogen with accumulated data.
  2pm/$8,000/annual

COSTS

One-time costs	$ 8,000
Annual cost (times 5 years)	40,000
Every 5 year cost	0
Total cost for first 5-year cycle	$48,000

IMPLEMENTATION

DHEC, Universities

WQ-6 Establish a National Atmospheric Deposition Pollution (napd) sampling site(s)

WQ-6

ACTION

Seek funding to establish and maintain a NADP sampling site(s) in Charleston to collect wet and dry inputs of pollutants from atmospheric sources.

BACKGROUND

The emphasis of nonpoint source pollution is usually ground-based. Often ignored in this discussion is the contribution of atmospheric deposition, despite the fact that tons of pollutants are released into the air everyday around the Charleston Harbor Watershed by industry, automobiles, and other sources. Atmospheric aerosols and particulates absorb trace metals and nutrients that then act as cloud condensation nuclei. These nuclei continue to grow and eventually fall to the earth as rain, carrying the contaminants earthward.

The CHP conducted basic research on the impact of atmospheric deposition, but the contribution of air pollutants to surface water pollution is still not clearly understood. Additional monitoring is necessary to document the significance of atmospheric pollution on surface waters.

MEASURABLE GOALS

- Research available literature on atmospheric deposition sampling.
  1pm/$4,000/one time
- Establish a committee to design a limited sampling program to determine whether atmospheric deposition is a significant contributor of pollutant loads to the harbor.
  1pm/$4,000 + $2,000 in meeting costs/one time
- Identify potential funding sources and conduct the sampling program.
  $10,000/one time + $7,000/annual
- Evaluate the sampling results and make recommendations regarding the need for long-term monitoring.
  1pm/$4,000/annual
- Install and maintain NADP sites to evaluate:
  1. Nitrogen series
  ~$10,000 per installation + $5,000 to monitor/ annual
  2. Mercury
  ~$20,000 per installation + $8,000 to monitor/annual

COSTS

One-time costs	$ 20,000
Annual cost (times 5 years)	55,000
Every 5 year cost	0
Total cost for first 5-year cycle	$75,000

IMPLEMENTATION

DHEC, Environmental Protection Agency

WQ-7 Increase monitoring in waters classified for swimming

WQ-7

ACTION

Seek funding for increased monitoring in estuarine waters that are classified for primary contact recreation (swimming) to ensure public health is protected.

BACKGROUND

As the region grows, appropriate local and state agencies should monitor the degradation of water resources and share the information with those agencies responsible for providing recreational services and facilities. Demand is increasing for outdoor recreation, but recreational sites are limited. Degradation of the resource from pollution will diminish recreational opportunities. It is important to monitor water quality at these sites to insure problems are discovered promptly.

MEASURABLE GOALS

- Identify the most heavily used swimming waters in the area.
  .5pm/$2,000/one time
- Develop a proposal and budget for monitoring these areas as required to evaluate the water quality standards for swimming.
  .5pm/$2,000/one time
- Secure the funding and monitor the identified areas.
  4pm/$16,000/annual
- Evaluate public notification process and information needs of the public.
  .5pm/$2,000/every 5 years
- Produce a map showing swimming areas.
  1pm/$4,000/every 5 years

COSTS

One-time costs	$ 4,000
Annual cost (times 5 years)	80,000
Every 5 year cost	6,000
Total cost for first 5-year cycle	$90,000

IMPLEMENTATION

DHEC, Local Governments

— WQ NONPOINT SOURCE —

WQ-8 Quantify nonpoint source loads

ACTION

Quantify and project nonpoint source (NPS) loads for inclusion in wasteload allocation models and total maximum daily loads (TMDLs) development.

BACKGROUND

Stormwater runoff from agricultural and urban areas is often characterized by high concentrations of biochemical oxygen demand (BOD), fecal coliform bacteria, nutrients, and toxic substances. As part of CHP research, two simulation models were developed to predict NPS inputs of water and nutrients based on drainage area and land-use patterns. These studies found that the degree of nonpoint source runoff from urban areas is a result of both the extent and type of urban land use and the watershed soils, highlighting the fact that care should be taken in making predictions based only on land use changes.

Current wasteload allocation models distinguish between the "background" load of pollutants and the load associated with permitted point source discharges. The background load, therefore, includes contributions from natural, nonpoint and

WQ-8

air sources. With a growing population, both the air and nonpoint loads will likely increase. These increases need to be figured into wasteload allocation models to insure water quality standards are met in the future.

MEASURABLE GOALS

- Conduct a literature review and gather existing manuals and information from other states on quantification of nonpoint source loads to receiving waters.

  1pm/$4,000/one time

- Use NPS models to extrapolate the effects of future land use changes on the total loading of nutrients and BOD to the Charleston Harbor system.

  4pm/$16,000/every 5 years

COSTS

One-time costs	$ 4,000
Annual cost (times 5 years)	0
Every 5 year cost	16,000
Total cost for first 5-year cycle	$20,000

IMPLEMENTATION

DHEC

WQ-9 Improve stormwater best management practice (BMP) design

ACTION

Develop a stormwater BMP manual that quantifies the pollution reduction capabilities of various BMPs and provides design guidance for meeting pollutant reduction goals.

BACKGROUND

Current state regulations and stormwater management system design guidance focus on removal of sediment. As various CHP studies have shown, other pollutants such as nutrients and fecal coliform bacteria are contained in urban runoff and contribute to water quality problems. It is possible to estimate the efficiency of certain BMPs at removing specific pollutants. These methods rely on data gathered from regional monitoring studies, which document the pollutant loads exiting specific types of BMPs. A region's rainfall and soils characteristics also impact removal efficiencies. Design manuals have been produced that include engineering aids that simplify the calculations necessary to determine if a particular BMP or set of BMPs will meet specific pollutant load goals.

MEASURABLE GOALS

- Develop a BMP manual that quantifies NPS pollutant load reductions associated with specific BMPs and provides how-to guidance for design engineers.

  $30,000/one time

- Conduct three workshops on the use of the manual and the pollutant load reduction design methodology.

  3pm/$12,000 + $6000 additional costs/every five years

WQ-9

- Require the use of the pollutant-load-reduction design methodology where necessary to meet water quality standards.
  2pm/$8,000/one time

COSTS

One-time costs	$38,000
Annual cost (times 5 years)	0
Every 5 year cost	18,000
Total cost for first 5-year cycle	$56,000

IMPLEMENTATION

DHEC, Local Governments

WQ-10 Reduce pulses of stormwater into tidal creeks

ACTION

Establish stormwater management plans for new development and for retrofitting of old developments that minimize "pulses" of stormwater flow into tidal creeks and rivers.

BACKGROUND

The shallow tidal creeks of South Carolina's estuaries provide nursery habitat for numerous species of economically important fish, crab, and shrimp but also serve as conduits through which pollutants enter the estuary, while creek sediments serve as repositories for these potentially toxic materials. There is a growing body of evidence that the process of urbanization dramatically increases the transfer rate of terrestrial materials to coastal estuaries.

Research indicates that small tidal creeks are important nursery areas, at least in part, because of the naturally occurring environmental stresses they provide. The highly variable physical conditions (salinity, temperature, and dissolved oxygen) cannot be tolerated by large aquatic predators, but can be tolerated by juvenile organisms. Even juveniles reach the limit of their tolerance at times under natural conditions. When the natural forested watershed of pristine creeks is changed by upland development, the nutrients and contaminants in the runoff from impervious surfaces can increase the stress levels of natural nursery areas beyond the tolerance of juvenile organisms.

Research conducted by CHP researchers found that salinity fluctuated over greater ranges and was generally more variable in developed creeks than in undeveloped reference creeks. Sediments in developed creeks were composed of more sand and had larger site-to-site variation in physical characteristics than reference creeks. Dissolved oxygen is always a limiting factor in small tidal creeks, but research found that organisms inhabiting developed creeks are exposed to low dissolved oxygen events more frequently than those in reference creeks. Trace metal concentrations, pesticides, polychlorinated biphels, and polycyclic aromatic hydrocarbons were found to be higher in developed creeks than in pristine creeks. All of these factors show the importance of reducing pulses of stormwater into tidal creeks.

WQ-10

MEASURABLE GOALS

- Research available engineering, design, and regulatory options to implement this recommendation.
  2pm/$8,000/one time
- Research/inventory needs for Charleston Harbor and seek funding for retrofits.
  $30,000/one time
- Identify areas for possible demonstration project.
  Covered by the above
- Set goal for pulse reduction.
  1pm/$4,000/one time
- Develop a design manual for engineers. Incorporate into best management practices manual for previous recommendation.

COSTS

One-time costs	$42,000
Annual cost (times 5 years)	0
Every 5 year cost	0
Total cost for first 5-year cycle	$42,000

IMPLEMENTATION

DHEC, Local Governments

WQ-11 Ensure compliance with stormwater management plans

ACTION

Compliance with stormwater management plans should be enforced.

BACKGROUND

The development of stormwater management plans is a complex process involving site level engineering. In order for the resultant plan to be effective, it must be followed from the beginning of construction and provisions must be made to maintain the stormwater system. Too often there is a breakdown in communication between the engineer and the construction personnel during the actual construction phase, resulting in unnecessary releases of sediments into the surrounding wetlands. Better communications need to be established with the construction industry, and more stormwater inspection personnel need to be employed.

MEASURABLE GOALS

- Evaluate and report on the current inspection capability of DHEC for both
- National Pollution Discharge Elimination System permits and the state stormwater permits.
  1pm/$4,000/one time
- Evaluate enforcement options available to DHEC and layout procedures for noncompliance with management plans.
  .5pm/$2,000/one time

WQ-11

- Evaluate delegation of inspections for stormwater management and sedi

ment reduction permits to local governments.

.5pm/$2,000/one time

- Develop and submit a budget proposal to adequately fund an inspection program.

1pm/$4,000/one time

COSTS

One-time costs	$12,000
Annual cost (times 5 years)	0
Every 5 year cost	0
Total cost for first 5-year cycle	$12,000

IMPLEMENTATION

DHEC

— WQ ONSITE WASTEWATER DISPOSAL SYSTEMS —

WQ-12 Develop an inspection and maintenance program for Onsite Wastewater Disposal Systems (OSDS)

ACTION

Develop an inspection program for OSDS to prevent the discharge of pollutants to the surface and groundwater. Inspect OSDS at a frequency adequate to ascertain whether they are failing. In addition, for all OSDS permits issued in the coastal zone include a recommended pump-out schedule, conduct periodic surveys of OSDS permit holders, and send reminders regarding routine maintenance.

BACKGROUND

OSDS, also known as septic tank systems, are commonly used in the CHP area. Recent data indicate that approximately 35% of the homes in Charleston County are currently using OSDS for wastewater disposal. Records for the eight county coastal zone show that between 1986 and 1999 a total of 43,918 OSDS were installed.

DHEC is the lead agency that administers the OSDS program for the state and provides the coordination and support to the county health departments (Health Authority) that are responsible for program implementation, including site investigations, system installation inspections, permitting, and enforcement. The DHEC Division of Onsite Wastewater Management periodically conducts quality control surveys as a follow up to field activities and permitting.

Poorly designed or improperly operating systems can cause surface ponding of partially treated sewage that can reach surface waters through runoff. In addition to containing oxygen-demanding organics and nutrients, these sources contain bacteria and viruses that present potential human health hazards. Routine maintenance of existing OSDS plays a key role in protecting coastal waters from this source of nonpoint pollution. Most OSDS tanks need to be pumped out every three to five years to remove the accumulated layers of sludge and scum. Routine maintenance inspections are not required by state regulations. Inspections are generally conducted as a follow-up to citizen complaints regarding individual OSDS or when homeowners request assistance.

Just as inspections and maintenance of OSDS are integral to protecting coastal waters, the repair, modification, or replacement of failing OSDS is also a key component. The Health Authority is authorized to require a permit for the repair, extension, or alteration of an OSDS, as deemed necessary, and may authorize the best possible method of repair to improve system operation, regardless of site conditions.

MEASURABLE GOALS

- Develop a system failure analysis protocol to define procedures applicable to the inspection, analysis, and repair of failing systems.
  1pm/$4,000/one time
- Identify potential resources, technical and financial, which may be devel oped to establish programs for routine maintenance and repairs of onsite systems.
  .5pm/$2,000/one time
- Provide training programs in failure analysis and repair for DHEC staff and contractors.
  $20,000/one time+.5pm/$2,000/annual+$2,000 workshop costs/annual
- Institutionalize the inspection program within DHEC by writing regulations governing its procedures.
  1pm/$4,000/one time
- Educate the public on the importance of maintaining OSDS.
  1pm/$4,000/annual
- Develop a prototype inspection program for local governments to adopt.
  ongoing
- Request that the onsite program include a pump-out recommendation in all new permits.
  .5pm/$2,000/one time
- Determine the costs associated with establishing a database and mailing reminders to permit holders.
  .5pm/$2,000/one time
- Refine maintenance recommendations to reflect varying coastal uses.
  .5pm/$2,000/every 5 years
- Determine availability of federal grants and other assistance for homeowners for OSDS problems, particularly in low income and minority communities.
  .5pm/$2,000/every 5 years

COSTS

One-time costs	$34,000
Annual cost (times 5 years)	40,000
Every 5 year cost	4,000
Total cost for first 5-year cycle	$78,000

IMPLEMENTATION

DHEC, Local Governments

WQ-12

WQ-13 Encourage connection to sewer service where available

ACTION

Encourage homeowners to connect to a centralized treatment system where sewer service is available and where septic systems are shown to contribute to groundwater and surface water pollution.

BACKGROUND

Although a recent survey of septic systems in South Carolina showed that the state has a lower failure rate (as defined by effluent surfacing on the ground or backing up in the home) than other states, it is estimated that onsight wastewater disposal systems (OSDS) are responsible for between 23 and 39% of all shellfish closures in the southern United States. Approximately 32% of shellfishing waters in South Carolina are closed to harvesting, even though some only after heavy rainfalls, due to NPS runoff. Over 10% of the permanent closures are administrative: therefore approximately 22% are closed at some time due to water quality problems. Some of these closures are near areas served by OSDS. While groundwater contamination from toxic substances is more often life threatening, the majority of groundwater-related health complaints are associated with pathogens from OSDS. In addition, a 1980 DHEC study on the hydro-geology of the shallow aquifers of the lower coastal plain of South Carolina and the impacts of land disposal sites on the shallow groundwater found that the highest degree of ground water contamination was found near tile field systems located in very permeable sediments with shallow water tables. The greatest volume of contaminants entering groundwater is from tile field effluent contributed by subdivisions and trailer parks. It is important to note that the potential for groundwater contamination is greater on those sites where OSDS were installed prior to current standards and under conditions that today would be considered unacceptable. South Carolina residents who consume groundwater from shallow aquifers that are associated with an OSDS, especially from wells that are less than 50 feet from a septic tank, and/or swim in estuarine waters in areas drained by septic tanks are at increased risk of contracting bacterial enteritis.

MEASURABLE GOALS

- Determine availability of geographic information system data on location of OSDS and examine correlations with water quality data.
  1pm/$4,000/one time
- Determine feasibility of developing a data base for such information.
  .5pm/$2,000/one time
- Based on above findings, present information to local governments and encourage adoption of ordinances requiring connection to central sewer service for areas with failing OSDS.
  1pm/$4,000/annual
- Inventory areas where people use septic tanks and have sewer available.
  1pm/$4,000/one time
- Work to resolve state and county conflicts over septic tanks/sewer requirements and regulations.
  1pm/$4,000/one time
- Identify incentives to encourage homeowners to connect to existing sewer service systems.
  .5pm/$2,000/one time

WQ-13

COSTS

One-time costs	$16,000
Annual cost (times 5 years)	20,000
Every 5 year cost	0
Total cost for first 5-year cycle	$36,000

IMPLEMENTATION

DHEC, Berkeley-Charleston-Dorchester Council of Governments, Local Governments

WQ-14 Change septic tank standards adjacent to estuarine waters

ACTION

Encourage more stringent state and local regulations for septic tank systems adjacent to estuarine waters, including requiring systems to be designed or modified to reduce total nitrogen loadings in the effluent.

BACKGROUND

Although the state no longer uses minimum lot size guidelines, some counties and municipalities have adopted the state's former guidelines. The state does stipulate minimum setback distances that, in effect, establish the minimum lot size for OSDS installed statewide. The setbacks require that no part of the system be within 50 feet of the mean high water elevation in tidal waters or ordinary high water elevation of an impounded or natural body of water, including streams and canals; within 10 feet of an upslope or 25 feet of a downslope interceptor drain; within 25 feet of a drainage ditch; or within 15 feet of the top of the slope of embankments or cuts of 2 feet or more vertical height when the soil absorption trench is to be placed higher in elevation than the invert of a cut, ditch, or gully. Additional setbacks are also required for experimental and ultra-shallow placement systems, many of which must have a minimum setback of 150 feet from environmentally sensitive waters (waters classified as outstanding resource and shellfish harvesting areas).

The current regulations are the same for all areas of the state, and do not recognize unique and sensitive areas of the coastal zone. The coastal zone has different characteristics, such as soil types, amount of surface waters, greater eutrophication potential, and slopes, from the rest of the state. For instance, since mean high water is often in the marsh and not at the edge of high ground, technically it is possible to place a system below the critical area line. A system is unlikely to be permitted in this area because of subsurface drainage problems associated with placing a system in wetlands, but represents an inconsistency in the regulations that should be clarified. Also, porous Lowcountry soils often do not allow sufficient residence time before releasing effluent into groundwater and, subsequently, surrounding waterbodies. This can result in contamination of ground and surface waters and closure of shellfish grounds. These different conditions warrant more stringent OSDS requirements.

MEASURABLE GOALS

- Participate in the rule-making process as a stakeholder for proposed rule changes to individual onsite systems.
  2pm/$8,000/one time

WQ-14

- Revise standard operating procedures for certification of large-scale onsite systems and subdivisions in close proximity to nitrogen-sensitive surface waters. Coordinate with the DHEC Health Services/Environmental Health Division in light of new evaluation procedures in subdivision regulations.

  1pm/$4,000/one time

WQ-14

COSTS

One-time costs	$12,000
Annual cost (times 5 years)	0
Every 5 year cost	0
Total cost for first 5-year cycle	$12,000

IMPLEMENTATION

DHEC, Local Governments

WQ-15 Work with Berkeley-Charleston-Dorchester Council of Governments (COG) technical advisory committee (TAC)

ACTION

Work with the BCD COG Technical Advisory Committee (TAC) to evaluate land use, industrial expansion plans, and new growth forecasts to appropriately evaluate water quality.

Establish procedures for early notification of the TAC regarding inquiries or negotiations for new industrial facilities or major facility expansions.

Ensure recommendations from the TAC are considered as proposed amendments to the 208 Water Quality Management Plan and subject to public review and comment.

BACKGROUND

In cooperation with the CHP and the Institute of Public Affairs and Policy Studies at the University of Charleston, the COG held a series of workshops in 1995 to obtain input from dischargers and other users of the Ashley and Cooper rivers regarding discharge permit policies and procedures. Dischargers and other interested parties that participated in the workshops expressed a strong interest in taking a more active role in water quality planning and management for the Cooper and Ashley rivers. They expressed support for the establishment of a technical advisory committee that would assist the COG in determining the allocation of total maximum daily loads developed by DHEC Bureau of Water and provide input on other aspects of water quality planning. The COG's board of directors approved this recommendation and formed a TAC for water quality planning.

Two policy options that received support at the workshops were the creation of an assimilative capacity growth reserve and the development of contingency plans for responding to water quality problems caused by continued growth, drought or other factors. There is some indication that sections of the upper Cooper River still have sufficient unallocated capacity to accept new growth. Even in those sections of the Cooper, Wando or Ashley rivers where the total permissible loads have been fully allocated, several options may exist to allow continued growth. However, the consensus of participants was that significant additional planning and detailed, site-specific information is needed before establishing an appropriate growth

WQ-15

reserve, creating a contingency plan, or otherwise reallocating existing permitted loads in the Cooper and Ashley river basins.

MEASURABLE GOALS

- Compare assimilative capacities, actual loads, and current projected per mitted loads along the length of the Cooper, Wando, and Ashley rivers.
  3pm/$12,000/every 5 years
- Provide a menu of policy and technical options, along with a recommended action, for accommodating new growth that addresses ecological and eco nomic conditions at different points along each river.
  6pm/$24,000/every 5 years

  Where the total permissible loads have been fully allocated, options should include;

  1) Requiring new industrial dischargers to connect to public sewer systems where excess capacity exists.
  2) Directing certain types of industries to river stretches with unallocated biochemical oxygen demand (BOD) capacity.
  3) Wasteload reallocation to include allowing new discharg ers to develop discharger specific contingency plans or re allocation policies for those river stretches that cannot eas ily accommodate new growth. General guidelines for the reallocation of permitted loads should include consider ation of the following:

  a. The relevant contributions of specific dischargers to excess loadings in any river segment.
  b. Pollution control options available to the discharger re questing the new or expanded permit, including more ad vanced wastewater treatment.
  c. Availability of unused permitted loads of existing discharg ers in the affected area.
  d. An evaluation of past pollution control efforts by the af fected dischargers.
  e. An evaluation of the costs of further load reductions to each discharger.
  f. The degree to which these costs can or would be passed on to consumers or local residents.
- Using the available modeling tools, run modeling scenarios for the Cooper, Ashley, and Wando rivers. Completed as part of previous two tasks.
- Develop policy guidance for accommodating new growth.
  1pm/$4,000/every 5 years
- Develop a map showing areas that can be feasibly served by public sewer systems with excess capacity.
  1pm/$4,000 + design and printing $10,000/every 5 years
- Evaluate whether requiring new industrial dischargers to connect to the systems with excess capacity is feasible.
  Completed as part of second task
- Develop a map showing river stretches with unallocated BOD capacity.
  .25pm/$1,000/every 5 years
- Develop an incentive package to direct industries to preferred locations.
  1pm/$4,000 + distribution of information/$10,000/every 5 years
- Make zoning changes as necessary, in cooperation with local governments, to encourage industries to locate in the identified river stretches.
  1pm/$4,000/every 5 years

WQ-15

- Evaluate the feasibility of establishing a BOD 'trading' program for each of the three rivers.
  1pm/$4,000/one time
- If feasible, develop guidance for operating a BOD trading program.
  1pm/$4,000/one time
- Map river stretches that cannot easily accommodate new growth.
  Covered by the map of unallocated BOD above
- Develop rules for formally adopting TAC recommendations and providing mechanisms for public review and comment.
  .5pm/$2,000/one time

COSTS

One-time costs	$10,000
Annual cost (times 5 years)	0
Every 5 year cost	81,000
Total cost for first 5-year cycle	$91,000

IMPLEMENTATION

COG, DHEC

WQ-16 Revise management decisions to include impacts to small tidal creeks

ACTION

Include an analysis of how permitted wasteloads affect small tidal creek eutrophication, BOD, and DO levels when deciding permit limits.

BACKGROUND

The assumption that main channel dissolved oxygen (DO) levels are representative of small creek DO is inaccurate. Small tidal creeks (creeks less than three feet at mean low water) are a special category of estuarine habitat. Primary and smaller creeks off the main stem of rivers exhibit water quality dynamics that differ from larger rivers (different flushing rates, depths, and relative amounts of stormwater loading). Due to lower volumes of freshwater discharge and flushing, smaller tidal creeks are more susceptible than main rivers to human induced changes in water quality, including more frequent extreme fluctuations in salinity, changes in bottom sediments, and alterations in DO dynamics. Creeks studied by CHP researchers that drain relatively developed watersheds appeared to have the greatest exposure to low DO conditions. Since small tidal creeks are more susceptible to eutrophication than adjacent rivers, they require more specific management criteria.

Water quality managers currently focus on worst case scenarios when allocating waste disposal permits into surface waters. This worst case is early morning during late summer when DOs are at their lowest. The rationale is that if DO conditions meet the 4-5 parts per million threshold in the main channel of the harbor during these critical times, water quality managers can safely assume that waters are being protected for living organisms at all times. This approach has worked to protect water quality in the main channel, but does not take into account the much lower DO situation in small tidal creeks.

WQ-16

MEASURABLE GOALS

- Develop or obtain a modeling algorithm that can be linked to wasteload allocation models to provide analysis of impacts to small tidal creeks from various wasteload allocation scenarios.
  4pm/$16,000 + Research/$20,000/one time

COSTS

One-time costs	$36,000
Annual cost (times 5 years)	0
Every 5 year cost	0
Total cost for first 5-year cycle	$36,000

IMPLEMENTATION

DHEC

WQ-17 Refine estimates of CHP nitrogen budget

ACTION

Refine the estimates of the CHP watershed nitrogen budget and incorporate them into ongoing regulatory actions.

BACKGROUND

Water quality in urbanized estuaries is affected by a variety of inputs from human development including municipal and industrial wastewater discharges, as well as nonpoint source urban runoff. These factors interact with a complex set of natural estuarine processes including freshwater runoff, tidal movements, ecological functions in the water, sediments, and wetlands. The combination of these influences must be understood for effective, long-term water quality management.

A study conducted by CHP researchers showed that the effects of wastewater discharge and stormwater runoff into the Goose Creek estuary were mitigated by extensive tidal wetlands which removed and transformed nutrients during tidal inundation. There were consistent trends of nitrogen uptake by tidal marshes which removed 20-34% of the nitrate flowing across the marsh during each tidal cycle. Therefore, the removal of dissolved inorganic nitrogen by the tidal marshes needs to be included in nutrient loading considerations and wasteload allocations.

MEASURABLE GOALS

- Prepare a summary paper describing the CHP watershed nitrogen budget estimates and the information necessary to refine those estimates.
  1pm/$4,000/one time
- Develop a strategic plan for refining the nitrogen budget.
  .5pm/$2,000/one time
- Develop a strategy for funding the development of the nitrogen budget.
  Covered by the above
- Fund and implement the plan.
  Research/$75,000/one time
- Incorporate the findings into the total maximum daily loads developed for the rivers of the Charleston Harbor system.
  2pm/$8,000/one time

WQ-17

COSTS

One-time costs	$89,000
Annual cost (times 5 years)	0
Every 5 year cost	0
Total cost for first 5-year cycle	$89,000

IMPLEMENTATION

DHEC, Department of Natural Resources, University of South Carolina

— WQ MODELING —

WQ-18 Improve wasteload allocation model

ACTION

Continue to refine and improve the computer simulation model that is used to determine wasteload allocations. Impacts to small tidal creeks should be taken into account during the modeling process, as well as longer modeling runs to consider eutrophication in coastal waters. Nonpoint source loading and wetland nutrient exchange rates, or percentage of loads in the nutrient budget, should be input directly into simulation models to develop total maximum daily loads (TMDLs).

BACKGROUND

One of the focal points of the Charleston Harbor Project has been the development of a wasteload allocation water quality model for the Charleston Harbor Watershed. The models that were developed, one for the Cooper and Wando rivers and one for the Ashley River, are significant improvements over previously available models. These models simulate the water level, streamflow, mass transport, and water quality of the river systems.

Key management questions, such as maximum daily loads that can be assimilated and the most appropriate location for new discharges if assimilative capacity is still available, can be addressed with models. Models can also provide guidance for the development of policies and growth management strategies that allow for continued economic development while still ensuring that water quality standards are maintained.

The interaction of total nutrient loads from point source discharges in the river sloshing up into smaller creeks, coupled with the impacts of nonpoint source nutrients running off the upland and down into the harbor, must be understood by managers charged with protecting water quality and fishery resources. An improved model is necessary to gain this understanding.

MEASURABLE GOALS

- Develop a strategic plan for improving the modeling capability of DHEC.
  1pm/$4,000/one time
- Determine costs and identify the funding needed to implement the plan.
  covered by the above
- Implement the plan.
  12pm/$48,000 + training/$5,000 + hardware/software /$7,000/annual
- Establish a State Modeling Advisory Committee.
  .5pm/$2,000 + meeting costs/$6,000/annual

WQ-18

- Develop methods to evaluate longer-term effects of nutrient enrichment.
  2pm/$8,000/annual
- Adopt procedures to directly account for nonpoint source loading in TMDL analyses.
  1pm/$4,000/one time
- Adopt procedures to directly account for wetland nutrient exchange in TMDL analyses.
  2pm/$8,000 + research/$12,000/one time
- Identify potential funding sources.
  .5pm/$2,000/one time
- Develop the model and evaluate.
  $200,000/every 5 years + 8pm/$32,000/every 5 years

Model runs should be conducted to evaluate water quality with actual as well as permitted point source discharges. The analysis of dissolved oxygen levels should be conducted for both hourly and 24-hour averages. Water quality scenarios should be developed that can help identify the effects of growth on water resources and which include projections of municipal and industrial loads through 2015. The modeling effort should also address the following questions:

What are the predicted patterns of water quality distribution and where are the critical zones of oxygen depletion given current and projected future loads? Are projected increases in population and economic growth compatible with current limitations on the assimilative capacity of the Charleston Harbor system?How much more wasteload can be assimilated (TMDL) and where are the most feasible regions for discharge? Will there need to be more advanced wastewater treatment to accommodate future growth? The model should also test the sensitivity of water quality distributions to the major point source dischargers and to variable freshwater flows from Pinopolis Dam on Lake Moultrie.

COSTS

One-time costs	$ 28,000
Annual cost (times 5 years)	380,000
Every 5 year cost	232,000
Total cost for first 5-year cycle	$640,000

IMPLEMENTATION

DHEC, SC Sea Grant Consortium, Berkeley-Charleston-Dorchester Council of Governments

WQ-19 Use Nonpoint Source (NPS) model to determine effects of development on water quality

ACTION

The NPS model should be used to extrapolate the effects of proposed future land use changes on the total loading of nutrients and resulting biological oxygen demand (BOD) on the Charleston Harbor system.

WQ-19

BACKGROUND

Urban and suburban land uses contribute significantly to the estimated loadings of nitrogen (N). The higher percentage of impervious surfaces in urbanized areas reduces infiltration and subsurface transport of precipitation. However, NPS models indicate that the degree of nonpoint source runoff from urban areas is a result of the extent and type of urban land use *and* the watershed soil composition. In other words, it is expected as urbanization increases within the watersheds, the importance of nonpoint source runoff will increase, but the rate of increase will vary depending on the soils within a given watershed. Therefore, caution should be taken in making predictions based only on land use changes.

Two models were developed to predict NPS inputs of water and nutrients to Charleston Harbor based on drainage and land-use patterns. According to these models, 28% of the total N input into Charleston Harbor comes from precipitation, and the NPS input is approximately 15% of the total annual N load to the estuary, with the remaining 85% contained in municipal and industrial point source discharges. The relative importance of point source and nonpoint source varies in each sub-basin. In the Wando River basin, there are very few point sources of dissolved inorganic nitrogen (DIN), with *non*point sources accounting for virtually all of the total input. In the Ashley River, DIN from nonpoint sources is approximately 19%, with point sources accounting for 81%. In the Cooper River watershed, point source loads are approximately 89% of total nitrogen loads, with nonpoint sources accounting for 11%.

MEASURABLE GOALS

- As part of the Technical Advisory Committee efforts, ensure future land use changes are included in the evaluation of biochemical oxygen demand and nutrient capacity in the harbor system.

  Covered by previous recommendation.
- Insure future land use changes are evaluated as part of the development of the watershed nitrogen budget.

  Covered by previous recommendations.

COSTS $0

IMPLEMENTATION

DHEC

WQ-20 Adopt a nutrient standard for estuarine waters

ACTION

Adopt a nutrient standard for estuarine waters.

BACKGROUND

As noted in previous recommendations, the level of nutrients significantly impacts overall water quality. Nutrient elements such as nitrogen (N) and phosphorus (P) are considered major limiting factors for the production of aquatic plants. High concentrations of these nutrients can result from municipal and industrial wastewater discharge or nonpoint runoff from urban or agricultural areas. Excessive concentrations can cause nuisance blooms of algae, which may degrade water quality, deplete oxygen, and cause fish kills. Managing nutrients, therefore, is necessary to insure the multiple uses of area waters are maintained.

One key management tool is water quality standards. These standards set levels for various water quality parameters necessary to ensure water uses are protected. The standards in combination with waterbody specific hydrologic information are then used to determine assimilative capacity and wasteload allocations. There are no specific water quality standards for N and P in South Carolina. However, the presence of nutrients affects more than the level of dissolved oxygen as has been discussed in previous recommendations. The Environmental Protection Agency (EPA) is currently supporting an effort to identify appropriate nutrient standards for estuarine waters. By establishing nutrient standards, managers will have a direct mechanism for monitoring nutrient levels and requiring management actions.

MEASURABLE GOALS

- Actively participate in EPA development of regional nutrient standards.
  1pm/$4,000.one time
- Once EPA standards are established, incorporate them into the state standards.
  2pm/$8,000/one time
- Evaluate the need for identifying criteria for "Nutrient Sensitive Waters".
  .5pm/$2,000/one time
- Work to speed EPA schedule for development of regional nutrient criteria.
  1pm/$4,000/one time
- Identify "Nutrient Sensitive Waters" as a specific classification for water quality management.
  1pm/$4,000/one time

COSTS

One-time costs	$22,000
Annual cost (times 5 years)	0
Every 5 year cost	0
Total cost for first 5-year cycle	$22,000

IMPLEMENTATION

DHEC

WQ-20

GROWTH MANAGEMENT

GM-1 Integrate ecosystem-level planning for wetlands

ACTION

Integrate ecosystem-level planning into the current wetland-management policy structure.

BACKGROUND

Wetlands constitute only about 5% of the land area in the United States, yet approximately 50% of the animal species listed in the United States as threatened or endangered are dependent on wetlands. Wetlands comprise a major portion of the total area of the CHP region. Until the 1970s, wetlands were poorly understood and, therefore, undervalued. It has since been proven that wetlands regulate water quantity and water quality, reduce flood damage, and store excess water.

South Carolina has been relatively successful in protecting its wetland resources, and has retained approximately 73% of historic levels. Although tidal wetlands have been relatively well protected, significant losses have occurred in freshwater non-tidal areas. The US Army Corps of Engineers, through the Clean Water Act, has direct authority over all US waters and their adjacent wetlands. DHEC-OCRM, through the state's Coastal Zone Management Act, is responsible for managing wetlands in the coastal zone, and the DHEC Bureau of Water, through section 401 of the Clean Water Act has certification authority over all federal permitting decisions relating to wetlands. Additionally, other state and federal agencies, such as the Department of Natural Resources and the US Fish and Wildlife Service, have management roles regarding wetland resources. Upland areas adjacent to wetlands are directly subject to local land use regulations. Existing regulations are designed to protect water quality functions, wetland habitats and associated wildlife. However, the current practice of parcel-level review does not provide managers with the opportunity for large-scale and long-term ecosystem management. State and federal regulations set certain parameters for environmental protection, but local decisions regarding land use, zoning, and infrastructure ultimately determine an area's future environmental condition. A more comprehensive ecosystem approach, including representation from all levels of government, is needed to ensure proper management is done in the most effective and efficient manner.

MEASURABLE GOALS

- Revise wetland permitting and mitigation review to incorporate ecosystem considerations using the method developed for the Broad and New river watershed, including whole system evaluation of socio-ecological characteristics such as water quality functions, hydrologic integrity, and anthropogenic impacts on freshwater wetlands.

  1.5pm/$6,000/startup one time + 2pm/$8,000 annual

COSTS

One-time cost	$ 6,000
Annual cost (times 5 years)	40,000
Once every 5 year cost	0
Total cost for first five year cycle	$46,000

GM-1

GM-1

IMPLEMENTATION

DHEC, US Army Corps of Engineers, Environmental Protection Agency, US Fish & Wildlife Service, SC Department of Natural Resources, National Marine Fisheries Service, NOAA/National Ocean Service, Local Governments

GM-2 Refine the wetland master planning process

ACTION

Refine the wetland master planning process to address management of wetlands smaller than one acre.

BACKGROUND

In the CHP area many small isolated wetlands, especially cypress ponds, swamp tupelo ponds, and borrow pits, are less than one acre in size. These small wetlands are particularly prone to loss or modification. Current policy allows wetlands of one acre or less to be filled for development, while requiring mitigation in larger wetland systems. This policy protects many highly valued wetland dependent resources, but it diminishes protection for some rare habitats that provide unique conditions not found in larger wetlands. CHP researchers found that at least ten frog species and five salamander species of the southeastern Coastal Plain of South Carolina are exclusively or primarily dependent on small, isolated wetlands as breeding sites, while six other amphibians and two reptiles also use small isolated wetlands in addition to other aquatic habitats. These small wetlands protect these species by excluding aquatic predators. Small isolated wetlands were found to make up approximately 15% of the freshwater wetlands of the watershed.

These small wetlands are not adequately protected under current policies. As their habitats are lost, rare species become endangered species, and federal law requires protective measures. Unfortunately, these measures are considered a serious obstacle to economic development in a community. Refining the wetland master planning process can enhance management of rare species by keeping them off the endangered species list and reducing the need for more restrictive regulations which could effect economic recruitment.

MEASURABLE GOALS

- Adopt revised wetland master planning guidance.
  1pm/$4,000/one time
- Develop and maintain inventory of wetlands within the watershed.
  .5pm/$2,000/annual
- Investigate and propose wetland land banks that would include small isolated wetlands.
  .5pm/$2,000/annual

COSTS

One-time cost	$ 4,000
Annual cost (times 5 years)	20,000
Once every 5 year cost	0
Total cost for first five year cycle	$24,000

IMPLEMENTATION

DHEC, Mitigation Banking Review Team

GM-2

GM-3 Work with local governments to protect water quality

ACTION

Make local planning commissions aware of the impacts of zoning decisions on stream use, habitat, and water quality and develop guidelines for using desired water quality characteristics to influence zoning decisions.

BACKGROUND

Tidal creeks are conduits for upland runoff from adjacent land uses. Their ecological integrity is directly dependent on the type and amount of land uses in the drainage basin. Being nearer the source, creeks accumulate sediment contaminants at a higher rate than other portions of estuary. Urbanization, agriculture, and deforestation dramatically increase the rates of transfer of sediment pollutants to coastal estuaries. Runoff enters the urbanized estuary more rapidly resulting in sharp changes in salinity, pH, and dissolved oxygen. Smaller tidal creeks are more susceptible than main rivers to human induced changes in water quality, including more frequent extreme fluctuations in salinity, changes in bottom sediments, and alterations in dissolved oxygen dynamics.

Local governments have direct control over land use through land use planning, zoning, and infrastructure decisions. Environmental protection has been largely seen as a state and federal concern, but, in fact, the decisions made at the local level will dictate the area's future environmental condition. The 1994 Comprehensive Planning Enabling Act requires local governments to consider natural and cultural resources as elements of their plans. The state has an obligation to provide data and technical assistance to local governments in order to develop a process for effective resource management.

MEASURABLE GOALS

- Work with the Berkeley-Charleston-Dorchester Council of Governments (BCD COG) to implement land use workshops for municipal officials.
  .5pm/$2,000/annual
- Evaluate [Nonpoint Source Education for Municipal Officials (NEMO)] pro gram to implement continuing nonpoint source education in this area.
  .25pm/$1,000/one time
- If NEMO is not appropriate, develop another outreach program to educate local planning commissions.
  .25pm/$1,000/one time
- Implement the chosen outreach program.
  .5pm/$2,000/annual
- Develop guidelines for using desired water quality and biological character istics to make zoning decisions.
  1pm/$4,000/annual
- Develop a presentation for civic clubs and city/county councils.
  .5pm/$2,000/annual+$5,000 for presentation software needs/ onetime

COSTS

One-time cost	$ 7,000
Annual cost (times 5 years)	50,000
Once every 5 year cost	0
Total cost for first five year cycle	$57,000

GM-3

GM-3

IMPLEMENTATION

DHEC, Department of Natural Resources, BCD COG, SC Sea Grant Consortium

GM-4 Encourage land acquisition policies

ACTION

Encourage governments to develop mechanisms to allow collection of funds to acquire areas for public recreation and resource conservation.

BACKGROUND

Increasing urbanization is placing greater demands on our resources to meet water-based recreation and resource management objectives. Acquiring uplands adjacent to water bodies can help achieve these objectives by providing habitat for songbirds, who depend on scrub areas for roost-site habitats. Scrub/shrub areas currently have no regulatory protection from encroachment. A 100-foot buffer around a site, protecting mature trees and dead snags while minimizing the clearing of understory trees and shrubs, can protect this biologically important habitat. Acquisition of land around water bodies can also provide water-based and passive recreation opportunities to the public, such as canoe and kayak throw-in areas and small community parks. Acquisition of prime habitat and park areas, combined with clustering development to protect open space and habitats while allowing for development, can meet multiple demands while allowing needed development to take place. The establishment of local, regional, and state programs for the identification, creation, and protection of greenways can help maximize the benefits of open space protection.

Interest in the establishment of greenways has risen during the past decade. Greenways serve multiple recreation and habitat protection purposes, including jogging, biking, and bird watching. Some actions have been taken to establish greenways in several areas within the watershed; however, there has been no coordination of a greenway system. Coordination would ensure a system that would maximize the benefits and uses of greenways.

MEASURABLE GOALS

- Work with local governments to develop mechanisms to allow collection of funds to acquire areas for public recreation and resource conservation.
  1pm/$4,000/annual
- Acquire and preserve scrub habitats for nearctic migrants.
  .5pm/$2,000 + $25,000 match money/annually
- Develop a map showing prime habitat for nearctic migrants and make this information available to affected local governments, Charleston County Parks & Recreation Commission (CCPRC) and local conservation organizations.
  .5pm/$2,000/annual
- Use acquisition programs to meet the need for more publicly accessible docks and fishing piers by placing a high priority on acquiring waterfront properties.
  .5pm/$2,000/annual
- Research and develop technical assistance materials for local governments on mechanisms to finance acquisition programs.
  1pm/$4,000/annual

GM-4

- Provide technical assistance to local governments interested in developing acquisition programs.
  1pm/$4,000/annual
- Conduct surveys to assess need and public opinion on the issues.
  $15,000/one time
- Draft state legislation to encourage development of local and regional ac quisition programs by providing tax credits and other incentives.
  1pm/$4,000/one time
- Investigate development of green "infrastructure" from Palmetto Conser vation Foundation reports, SC Department of Parks, Recreation & Tourism (SC PRT) trails, utility right of way, railroad right of way, etc.
  .5pm/$2,000/annual
- Inventory and map potential sites-should attempt to form practical link ages between greenways and focus on the benefits of recreation and re source protection.
  .5pm/$2,000/annual

GM-4

COSTS

One-time cost	$ 19,000
Annual cost (times 5 years)	235,000
Once every 5 year cost	0
Total cost for first five year cycle	$254,000

IMPLEMENTATION

DHEC, SC PRT, Lowcountry Open Land Trust, SC Coastal Conservation League, CCPRC, Local Governments, Utilities

– DEVELOPMENT COORDINATION –

GM-5 Establish an economic development liaison

ACTION

Work with local, regional, and state economic development agencies to create an economic development liaison office for environmental and natural resource issues to expedite communication between developers and permitting agencies prior to the permitting process.

BACKGROUND

There is a great amount of pressure on local governments to accept most types of economic investment that will create jobs for the community without full realization of their impact upon natural systems. The region's economy depends greatly on its surrounding biological and water resources, not only for wastewater assimilation but also for recreational and quality of life purposes. If the critical balance in shallow tidal creeks, with their oyster reefs and mud flats, is disturbed, it will impact the recreational harvest of such species as spotted sea trout, red drum, and white shrimp. In addition, commercial fishermen will see impacts on brown shrimp, white shrimp, blue crab and other species. Economic development agencies should target industries that are environmentally compatible with the area and have a past record of environmental regulatory compliance. The ultimate costs of dealing with industries that generate large volumes of air and water pollution, or create significant infrastructure problems, may not be worth the short-term benefits to the area.

GM-5

Infrastructure capacity in the greater Charleston region is adequate, although the assimilative capacity of the rivers and estuary may be a concern to large water users who wish to perform their own treatment. The availability of both CSX and Norfolk Southern railroad systems to service the region lowers costs to local industries. Of considerable note is the short-line rail owned by the SC Rail Commission. The ability of the state to recruit rail-dependent firms by providing an economic rate structure is a strength that is unique to the region. The Port of Charleston, considered one of the best ports on the East Coast, enhances these services.

State economic development agencies play an important role in industrial recruitment with over two-thirds of industrial prospects contacting the state first. Usually, the state has been asked to respond promptly to an inquiry, and the relative success of any one community will rest on its ability to respond quickly and thoroughly to the requests. For this reason, it is critical to maintain close working relationships with the state economic development authorities, the Charleston Regional Development Alliance, and local government economic development offices.

Coordination and communication between the regulatory and the business communities is critical to an effective and efficient process for attracting economic development. Including an environmental permitting liaison for new or existing industries requiring applications, approvals, modeling, etc., could expedite communication between developers and permitting agencies. A liaison could identify options that benefit the community and natural resources while improving and streamlining the permitting process.

MEASURABLE GOALS

- Identify an environmental issues liaison with the proper business entity or state agency.
  1pm/$4,000/one time
- Identify contacts in each of the environmental and natural resource agencies.
  .5pm/$2,000/one time
- Educate this liaison on environmental and cultural resources permitting issues.
  1pm/$4,000/annual

COSTS

One-time cost	$ 6,000
Annual cost (times 5 years)	20,000
Once every 5 year cost	0
Total cost for first five year cycle	$26,000

IMPLEMENTATION

Charleston Regional Development Alliance, DHEC, US Fish & Wildlife Service, SC Department of Natural Resources, US Army Corps of Engineers, State Historic Preservation Office

GM-5

GM-6 Establish an advanced coordination program for development sites

ACTION

Work with local economic development offices to evaluate the suitability of their prime sites for future development and establish a pre-development coordination program.

BACKGROUND

Open communication between the economic development and the regulatory community can keep uncertainty to a minimum. Currently, DHEC has a liaison that consults with the industrial development community during the permitting process. There is also an informal interagency review committee, comprised of DHEC, the Department of Natural Resources, the US Army Corps of Engineers (USA COE), US Fish and Wildlife Service, and others, that meets with potential applicants to discuss concerns that are likely to arise during the permitting process. This kind of communication should be expanded to include developers of all types of properties and representatives from all permitting authorities, including the municipal and county governments within the watershed.

In recent years attention has been focused on streamlining the permitting process. While some steps, such as the consolidation of state agencies, have moved toward a one-stop application process, each section, within these larger consolidated agencies, still has the same regulatory procedures to follow during the permitting process. A more proactive approach to permitting could make the process more efficient. Identifying wetland locations and critical habitats is important for making the permitting process more efficient. Combining this information with cultural resource data could reduce the uncertainty for developers and assist resource managers in properly managing watershed resources. The continued maintenance of prime industrial sites in the CHP area can facilitate the economic development process. Development could be focused toward areas more conducive to those activities while resource-sensitive areas could be avoided.

MEASURABLE GOALS

- Work with the Berkeley-Charleston-Dorchester Council of Governments (BCD COG), local governments, the SC Department of Commerce using INSITE program to identify sites appropriate for different types of develop ment. This should be coordinated by the environmental issues liaison.
  1pm/$4,000/annual
- Make a top ten list of developable sites available.
  1pm/$4,000/annual

COSTS

One-time cost	$ 0
Annual cost (times 4 years)	40,000
Once every 5 year cost	0
Total cost for first five year cycle	$40,000

IMPLEMENTATION

DHEC, BCD COG, Local Governments, Charleston Regional Development Alliance, State Historic Preservation Office, USA COE

GM-7

GM-7 Develop user-friendly format for data on resources

ACTION

Provide data regarding natural and cultural resources (wetlands, habitats, and historic and archaeological sites) in an accessible, user-friendly format to decision-makers at all levels of government.

BACKGROUND

The Charleston Harbor Watershed contains a multitude of biological resources and some of the nation's most important historic resources. Many of these resources have been mapped by researchers and resource managers through the years. However, the data exist in various formats and is not always available to decision makers at various levels of government. In order to promote effective and efficient resource management, this group of data and the expertise that developed it should be available to decision makers at an appropriate planning scale. Land use decisions could be made to ensure that uses are compatible with resource protection. This process could apply to transportation networks, industrial recruitment, and residential/commercial development.

MEASURABLE GOALS

- Establish an interagency task force to determine what data will be collected, who will collect the data, who will maintain the data, and the scale and format in which the data will be presented.

  1pm/$4,000/annual

COSTS

One-time cost	$ 0
Annual cost (times 5 years	20,000
Once every 5 year cost	0
Total cost for first five year cycle	$20,000

IMPLEMENTATION

Department of Natural Resources, DHEC, State Historic Preservation Office, SC Institute of Archaeology and Anthropology

GM-8 Establish local wetland mitigation banks

ACTION

Establish local wetland mitigation banks to facilitate economic development while protecting water quality and biological habitats.

BACKGROUND

A wetland mitigation bank is a site where wetlands are restored, created, or preserved expressly for the purpose of providing compensatory mitigation for the unavoidable destruction of other wetlands, thereby maintaining environmental quality while allowing development to proceed. Under the Clean Water Act, anyone wishing to fill a wetland must first demonstrate that the impact is unavoidable or that the result of the filling would be minimal. If so, mitigation is required for this unavoidable impact by replacing the filled wetland with the same or similar type of wetland, either at the impacted site or within the same watershed as the impacted

GM-8

site. A developer who needs to compensate for authorized impacts to wetlands has two options: restore or create new wetlands at the impacted site, or purchase "wetland mitigation credits" from an established mitigation bank located in or near the same watershed. Mitigation banking also allows many isolated or fragmented mitigation projects to be consolidated into larger tracts, where more benefits can be realized.

By establishing a mitigation bank, local governments would benefit by having an inventory of the region's wetlands, which would provide assistance when choosing lands to purchase for mitigation purposes. They would be able to protect valuable resources while improving the economic recruitment process by having credits readily available for potential businesses within their jurisdiction. Local jurisdictions would have economic growth placed in appropriate areas, while protecting resources in areas where development would not be appropriate. Citizens would reap the benefits of local resource protection as opposed to buying mitigation credits in a bank located somewhere outside the watershed. Protecting resources locally helps to preserve open space and may provide passive recreation opportunities.

MEASURABLE GOALS

- Develop and distribute educational material for municipal officials and local developers on local mitigation banks.
  1pm/$4,000/annual+$7,000/educational printing/one time
- Establish a local mitigation bank to serve as an example.
  1pm/$4,000/annual

COSTS

One-time cost	$ 7,000
Annual cost (times 5 years)	40,000
Once every 5 year cost	0
Total cost for first five year cycle	$47,000

IMPLEMENTATION

DHEC, Local Governments, Mitigation Banking Review Team

GM-9 Encourage reuse of existing developments

ACTION

Develop and propose incentives to encourage the improvement and reuse of older, under-utilized, or abandoned developments.

BACKGROUND

Redevelopment is becoming an increasingly important issue as the region experiences the effects of increasing urbanization. Many benefits can be realized by redeveloping areas within the urban core. Roads, water, and sewer service are already in place, thereby reducing the cost for additional infrastructure. Additional impervious surface coverage and consequent stormwater impacts on coastal resources are minimized within the watershed because areas to be redeveloped are also generally closer to the existing urban area and do not require as many new roadways. Redevelopment of areas within the urban core can simultaneously address the problems of urban decay and urban sprawl. More land on the fringe of the urban area would also be left in its natural state, protecting habitats and lessening development impacts on natural and cultural resources.

GM-9

This is consistent with the Environmental Protection Agency and DHEC brownfields initiatives. Brownfields are defined as "abandoned, idled, or underutilized industrial and commercial facilities where expansion or redevelopment is complicated by real or perceived environmental contamination."

MEASURABLE GOALS

- Develop draft ordinances and tax advantages to encourage reuse of existing developments.

  1pm/$4,000/annual

COSTS

One-time cost	$ 0
Annual cost (times 5 years)	20,000
Once every 5 year cost	0
Total cost for first five year cycle	$20,000

IMPLEMENTATION

DHEC, SC Coastal Conservation League, Local Governments, SC Department of Revenue

GM-10 Develop a cultural resources management plan (CRMP)

ACTION

Develop a CRMP based on similar plans designed and in place for military bases and other federal lands

BACKGROUND

The Charleston Harbor region's rich history dates back to the Paleoindian, Archaic, Woodland, and Mississippian periods of Native Americans, continues through Spanish exploration in the 1500s, to the English settlement of Charles Towne in 1670. In colonial times Charleston quickly grew to become the largest city of the southern colonies. Numerous cultural resources representing this rich history are present in Charleston, in the surrounding cities, and in rural areas of the watershed. Charleston's cultural resources are attractive to tourists and contribute to the immigration of residents into the area. While scenic views and beach and ocean recreation are very important attractions, historic resources differentiate Charleston from other coastal cities.

In some areas preservation programs are effective in maintaining these resources. In other areas these resources are being lost or neglected primarily due to limited knowledge about them. Due in part to the preservation societies, land trusts, and enlightened local governments, preservation efforts have been relatively successful for both land and underwater archeological sites. Bluff and Medway Plantations and the Hunley submarine are notable examples.

There is concern that the region's wealth of cultural resources may impede industrial recruitment to the area. Federal, state, and local laws and regulations require consideration of historic and cultural resources before permits for development or zoning changes may be approved. New industries looking to locate here and existing industries planning to expand must apply for and receive various permits that include consideration of cultural resources. A CRMP for the Charleston Harbor Watershed would make decision-makers aware of cultural resource con-

GM-10

cerns in the area, enhancing the ability of city, county, and local agency planners to participate in the preservation of cultural resources. The creation of a CRMP would improve the efficiency of the permitting process. This kind of information, along with data regarding historic sites and submerged archaeological sites, could assist in locating future industrial parks in an efficient manner while managing resources and providing the region with growth opportunities.

MEASURABLE GOALS

- Designate sensitive areas with the assistance of the Department of Archives and History and the SC Institute of Archaeology and Anthropology, and make this information available to local governments.
  1pm/$4,000/annual
- Designate these sensitive areas as geographic areas of particular concern.
  .5pm/$2,000/annual
- Develop CRMPs for each local jurisdiction as an element of their compre hensive plans.
  .5pm/$2,000/annual+$30,000 for local match/annual/then update every 5 years
- Amend zoning and adopt ordinances to implement the plans.
  1pm/$4,000/one time
- Develop and distribute a cultural resources management requirements bro chure, and include this information in OCRM's permit packages.
  1pm/$4,000/annual + $6,000 printing materials/annual
- Publicize information regarding the cultural resource management process for permit applicants in order to ensure a smoother regulatory process.
  .5pm/$2,000/annual

COSTS

One-time cost	$ 4,000
Annual cost (times 5 years)	250,000
Once every 5 year cost	0
Total cost for first five year cycle	$254,000

IMPLEMENTATION

DHEC, Berkeley-Charleston-Dorchester Council of Governments, State His toric Preservation Office, National Park Service, Local Governments

GM-11 Develop a regional water-related recreation plan

ACTION

Coordinate the development of a plan for natural water-related recreational opportunities in the region, allowing input from appropriate officials of all local governments. This plan should include:

1. Encouraging public-private partnerships to help generate the rev enues needed to acquire, develop and operate recreation-oriented facilities and programs.
2. Assessing the pollution and habitat degradation potential for recreational uses of areas.

BACKGROUND

The environment plays a major role in our region's economy through commercial and recreational fishing, sailing, swimming, and other water-related recreational opportunities. Saltwater fishing stamps have generated over $400,000 annually for resource protection. Waterfront property values have been enhanced due to the generally good water quality conditions of our streams and rivers and the wealth of recreational opportunities and aesthetic amenities they provide.

The region abounds with navigable waterways, including the Santee-Cooper lakes and the Ashley, Cooper, Edisto, Stono, and Wando rivers, which make boating possible from the Charleston Harbor into tributary creeks, tidal marshes and forested swamps. They afford passage through a spectrum of ecological settings. There are numerous boat landings in the region, primarily in Charleston and Berkeley counties, which are evenly distributed along the principal rivers and creeks. Amenities, such as picnicking facilities with shade trees, are not available at most sites.

The demands on the resources are heavy, and there are sections of coastline that are restricted and inaccessible to the public. Charleston's beaches are overburdened not only with county residents, but also with visitors from inland South Carolina and other states. Berkeley County's lakefront, which is predominantly private, has nearly 52.5 miles of waterfront along Lake Moultrie and 25 miles along Lake Marion. Private cottages, commercial fish camps, and private recreation areas are the dominant uses along the lakeside. There are also several commercial beaches near Moncks Corner, but no supervised public swimming areas.

Public access to water-related activities has often been taken for granted and assumed to be available in perpetuity. However, as the population has increased, public access has decreased as a result of the gradual change from rural to suburban land use. Thus, the opportunities for recreational use of water resources have diminished, leading to crowding at existing sites and conflict among user groups. In addition, the costs of obtaining and developing appropriate sites will also increase greatly as competing user groups vie for these sites.

MEASURABLE GOALS

- Establish a task force to develop a water-related recreation plan to include a funding analysis.
  .5pm/$2,000/annual
- Encourage recreation agencies to obtain and reserve sites for future recre ational development.
  .5pm/$2,000/annual
- Design and operate facilities and programs to provide maximum benefits from existing facilities and avoid conflicts among user groups.
  .5pm/$2,000/annual

COSTS

One-time cost	$ 0
Annual cost (times 5 years)	30,000
Once every 5 year cost	0
Total cost for first five year cycle	$30,000

IMPLEMENTATION

SC Parks, Recreation & Tourism, Charleston County Parks & Recreation Com mission, Berkeley-Charleston-Dorchester Council of Governments, Depart ment of Natural Resources, Local Governments, and appropriate interested parties *(recreation associations)*

GM-11

GM-12 Encourage utilization of identified dredge disposal sites

ACTION

To the extent practical, utilize the preferred dredge disposal sites as ranked in CHP research to meet future disposal capacity needs.

BACKGROUND

The maintenance of navigational channels in the Charleston Harbor Estuary is important to the regional economy. Activities associated with dredging, particularly the disposal of dredged material, may have substantial adverse effects upon natural resources. More than 7.5 million cubic yards of material are removed annually from the channels of the Charleston Harbor Estuary to maintain adequate water depths for Charleston's ship traffic. Construction of planned new port facilities and deepening of the harbor to support a broader range of vessels will require the initial removal of over 11 million cubic yards of dredged material.

Environmental concerns associated with dredged material disposal sites include:

- physical sediment characteristics, which are important environmental factors controlling distributions of organisms
- impacts on existing environmental quality, water quality, and critical habitat losses,
- impacts on environments adjacent to candidate sites,
- impacts on material cycles, and animal migration and movement patterns,
- impacts on groundwater resources,
- impacts on cultural resources,
- impacts on human uses.

Due to the anticipated reduced use of Daniel Island as a dredged material disposal site (construction of the Mark Clark Expressway has made this area accessible for development), a study was conducted to identify alternative sites to Daniel Island that had acceptable economic costs and environmental impacts. Researchers identified twenty potential sites in the CHP area with small cumulative environmental and cultural impacts and disposal capacities ranging from about 1,000,000 to 122,000,000 cubic yards. Collectively, these sites will provide most of the disposal capacity required for the Charleston Harbor area for the next 50 years. Six of the sites were currently in use. Five sites were projected to represent the least threat to natural and cultural resources and were the most acceptable alternatives to Daniel Island.

None of the preferred alternative sites were habitat for threatened or endangered species or blocked migrational routes for recreationally or commercially important species. Existing diked dredged material disposal facilities at Yellow House Creek, Naval Weapons Station, Drum Island, and Clouter Creek were projected to represent the least threat environmentally and were the most acceptable alternatives to Daniel Island. The most acceptable "new" site identified was Upper Thomas Island.

MEASURABLE GOALS

- Publish and distribute the preferred dredge disposal sites to affected parties.
  .5pm/$2,000/annual + $2,000/printing costs/one time
- Sign a memorandum of agreement designating the sites to be used.
  .5pm/$2,000/one time

GM-12

COSTS

One-time cost	$ 4,000
Annual cost (times 5 years)	10,000
Once every 5 year cost	0
Total cost for first five year cycle	$14,000

IMPLEMENTATION

DHEC, SC State Ports Authority, US Army Corps of Engineers

GM-13 Develop methods to mitigate problems caused by differences in zoning between jurisdictions

ACTION

Analyze environmental implications of differences in planning and zoning regulations across the region, particularly at jurisdictional boundaries, and facilitate consideration by each local government's planning commission of the plans developed by other agencies so that conflicts between jurisdictions can be avoided.

BACKGROUND

The Charleston Harbor Watershed consists of all or parts of eighteen municipalities and three counties. Differences in planning and zoning regulations and in standards for development complicate resource management; jurisdictional boundaries follow property lines and not natural features of the landscape, such as creeks, marshes and other biological habitats. When a municipality annexes a subdivision, it may be acquiring lots, roadways, ponds and drainage networks that do not meet its own standards, although they did meet the standards of the previous jurisdiction. A developer can intentionally avoid compliance (thereby reducing costs) by delaying a request for annexation until development is completed.

By working to eliminate differences in planning and zoning regulations between counties and municipalities, with the ultimate goal of developing regional planning and zoning standards, fewer differences in these regulations would result in fewer conflicts during annexation. This would lead to better resource management throughout the watershed, as well as making the development process easier by fostering consistency between local governments' planning and zoning rules.

MEASURABLE GOALS

- Develop and maintain a database of local, state, and federal plans and zoning regulations in the tri-county area.
  1pm/$4,000/annual
- Make the database available to local governments and the development community.
  .5pm/$2,000/annual
- Devise a process to evaluate the environmental implications of various zon ing regulations and plans.
  1.5pm/$6,000/annual

COSTS

One-time cost	$ 0
Annual cost (times 5 years)	60,000
Once every 5 year cost	0
Total cost for first five year cycle	$60,000

GM-13

IMPLEMENTATION

DHEC, Berkeley-Charleston-Dorchester Council of Governments, Local Governments

GM-13

– NONPOINT SOURCE –

GM-14 Develop an area-wide runoff management strategy

ACTION

Develop an area-wide stormwater runoff management strategy to guide decisions on construction permits and minimize the impacts.

Incorporate best management practices (BMPs) that meet specific pollutant load reduction.

Change local ordinances and state laws to require more comprehensive urban stormwater runoff control, including effective maintenance requirements.

BACKGROUND

Stormwater arises from precipitation that washes runoff from industrial, agricultural, construction, and household sites directly into streams or into drainage systems that flow into streams. Urbanization, agriculture, and deforestation degrade streams, rivers, lakes, and estuaries by greatly increasing the rates of transfer of terrestrial materials (runoff) to these waterbodies. Nonpoint source pollutants (pollutants derived from diffuse sources) in runoff include pesticides, heavy metals, excess nutrients, suspended solids, and fecal coliform bacteria. Urbanized, less forested lands retain less water, and buildings, paved roads, and sidewalks provide more direct flows into a receiving waterbody, which results in sharp changes in salinity, pH, and dissolved oxygen. Urban nonpoint source runoff varies with type of land use (residential, commercial, industrial), percent of impervious area, density of developments, alteration of hydrology, amount of fertilizer application, and degree of management practices used (e.g., impoundments, grass swales).

Historically, attempts to control the pollution in stormwater have focused on site-level planning for new development and, to a limited extent, redevelopment. This piecemeal approach is expensive for both the stormwater management agencies and the development community due to its inherent inefficiencies. Planning for drainage on the watershed level is more cost effective as well as being more efficient at controlling pollution.

Best Management Practices

The control of nonpoint pollution in the U.S. is based on the identification and promotion of best management practices, or BMPs, including retention ponds (contain permanent water storage), detention and extended detention ponds (dry out between storms), vegetative filter strips or buffers, and infiltration BMPs, such as infiltration trenches, medians, and swales. Two studies were conducted to investigate the management of urban/suburban nonpoint source pollution in the Charleston Harbor Watershed. One study evaluated the efficiency of detention/retention ponds in improving water quality. This work was part of the evaluation of structural and non-structural BMPs that aid in the reduction of erosion, flooding, and surface water contamination in the Charleston Harbor Estuary. CHP researchers also evaluated the effectiveness of vegetative filter strips for controlling sources of nonpoint pollution of urbanized creeks and waterways.

GM-14

GM-14

MEASURABLE GOALS

- Establish a tri-county stormwater committee that would focus on minimiz ing runoff.
  .5pm/$2,000/annual
- Develop and distribute a 'best' BMPs design manual that addresses both new development and redevelopment, and that encourages the use of natural predevelopment runoff patterns.
  1pm/$4,000/annual + $10,000/printing materials
- Revise ordinances and regulations to encourage use of 'best' BMPs.
  1pm/$4,000/annual
- Revise DHEC-OCRM stormwater management regulations to more effec tively address maintenance.
  .5pm/$2,000/annual
- Revise local ordinances to more effectively address maintenance.
  1pm/$4,000/annual

COSTS

One-time cost	$10,000
Annual cost (times 5 years)	80,000
Once every 5 year cost	0
Total cost for first five year cycle	$90,000

IMPLEMENTATION

DHEC, Tri-county Stormwater Committee, Local Governments, Berke ley-Charleston-Dorchester Council of Governments, SC Department of Transportation

GM-15 Limit the impact of impervious surfaces

ACTION

Limit the impact of impervious surfaces by slowing its rate of increase, holding subwatershed imperviousness to less than 30%, and placing the highest concentrations of impervious surfaces as far from receiving waters as possible.

BACKGROUND

Impervious surfaces, such as rooftops, parking lots, and roadways, accelerate runoff and contribute to eutrophication by funneling polluted stormwater runoff directly to receiving waterbodies without the benefit of filtration through vegetation or the ground. This is a serious problem for tidal creeks, due to their small size, proximity to uplands, and importance as biological habitats.

The CHP Tidal Creek Project and other research elsewhere in the country indicate that water quality changes begin to appear when a waterbody's surrounding area contains 10% impervious surface. When the impervious surface surrounding a waterbody reaches 30% of the total area, the body changes from impacted to degraded and significant changes in water quality and biological habitats can be expected. The critical nursery function of tidal creeks becomes impaired when impervious coverage in the basin exceeds 30%. The CHP Belle Hall Study concluded that the area of highest impervious coverage, the town commercial center, should be placed as far from the receiving waterbody as possible. Therefore, the amount and location of impervious surfaces is an important consideration in zoning and infrastructure decisions, particularly in areas near wetlands and tidal creeks.

GM-15

GM-15

MEASURABLE GOALS

- Delineate the region's subwatersheds.
  .5pm/$2,000/one time
- Calculate existing imperviousness in each subwatershed.
  .5pm/$2,000/annual
- Establish target imperviousness levels for each subwatershed.
  1pm/$4,000/annual
- Develop a package of incentives, ordinances, and other mechanisms local governments can use to meet imperviousness goals and adopt ordinances
- and other mechanisms to meet the imperviousness goals.
  1pm/$4,000/annual
  Adopt programs to place impervious surfaces as far from receiving waterbodies as possible.
- *.5pm/$2,000/annual*
  Sign a resolution to minimize rate of increase of impervious surfaces.
  1pm/$4,000/one time
- Review existing road codes and develop new model codes for road con struction to reduce the amount of impervious surface.
- *.5pm/$2,000/one time*

COSTS

One-time cost	$ 4,000
Annual cost (times 5 years)	80,000
Once every 5 year cost	0
Total cost for first five year cycle	$84,000

IMPLEMENTATION

DHEC, Tri-county Stormwater Committee, Local Governments, Berkeley-Charleston-Dorchester Council of Governments, SC Department of Trans portation, SC Sea Grant Consortium, and Clemson Extension Service.

GM-16 Require engineer certification of stormwater pond design depth and a bond for pond maintenance

ACTION

To ensure stormwater ponds are constructed to proper design depth, re-quire engineer certification prior to final plat approval

Require developers to leave enough open space around a stormwater pond for easy access for maintenance (dredging) equipment.

Require a maintenance bond from developers to be used for a one-time future pond maintenance.

BACKGROUND

In housing developments, retention ponds are often designed for six to ten feet of depth, but ongoing siltation reduces the holding capacity. Without adequate storage capacity, backups will occur, and drainage upstream will also be compro-mised. In the Shemwood I subdivision in Mount Pleasant, a marsh area was exca-vated as a pond in 1952, but the pond has gradually filled to the point of capacity failure, and now access to the site for maintenance is difficult.

GM-16

GM-16

The need for sufficient siltation capacity often dictates that a pond be designed to depths of ten to thirteen feet to accommodate silt deposits and six to ten feet of water. Unfortunately, construction engineers are often prevented from excavating deeper ponds because they have insufficient space in which to deposit removed material. Once a pond is excavated, housing units are built around it, which often prevents access of dredging equipment to the pond. Property owners also tend to fence their yards as close to the water line as possible.

An *engineer certification of proper* pond design depth would ensure the pond could perform as designed. When a subdivision is built, developers could be required to place in escrow funds to be used for one-time future pond maintenance at the point of 85% lot development. This system will ensure the homeowners have a pond system that can function as designed as opposed to one filled with sediments from construction of the subdivision. Since pond-side owners receive aesthetic and recreational benefits, subdivision fees could be made higher for these owners.

MEASURABLE GOALS

- Revise DHEC-OCRM stormwater requirements.
  1pm/$4,000/one time
- Revise local drainage system requirements.
  1pm/$4,000/one time
- Draft a model ordinance to require a maintenance bond in jurisdictions with no stormwater utility.
  .5pm/$2,000/one time
- Work to have the ordinance adopted by local governments

COSTS

One-time cost	$12,000
Annual cost (times 5 years)	0
Once every 5 year cost	0
Total cost for first five year cycle	$12,000

IMPLEMENTATION

DHEC, Local Governments

GM-17 Examine potential for stormwater retrofitting of roads and bridges

ACTION

Examine existing roads and bridges for retrofitting to reduce impacts on natural resources.

BACKGROUND

Many current stormwater and drainage problems are related to the construction, maintenance, and modification of roadways. In addition, highway runoff from bridges introduces potentially toxic metals and hydrocarbons into surrounding wetlands and uplands. There is an urgent need for a concerted effort to develop creative engineering solutions to existing problems so that voters and governments can be presented with reasonable retrofit options.

GM-17

In certain areas, roadside ditches drain directly into surface streams and are, in some cases, tidally influenced. The possibility of unregulated highway runoff, which may contain metals and organic materials, discharging right into tidal creeks,

is an environmental concern. In addition, the use of curb and gutter construction must be balanced with the need to reduce unnecessary increases in the total amounts of impervious surface area in each drainage basin.

GM-17

MEASURABLE GOALS

- Develop and prioritize an Environmental Restoration Program for existing roads and bridges.
  1pm/$4,000/one time
- Identify funding sources for implementing the program.
  .5pm/$2,000/annual
- Construct one project a year.
  .5pm/$2,000/annual

COSTS

One-time cost	$ 4,000
Annual cost (times 5 years)	20,000
Once every 5 year cost	0
Total cost for first five year cycle	$ 24,000

IMPLEMENTATION

SC Department of Transportation, DHEC, Local Governments

GM-18 Establish vegetated buffers

ACTION

Establish naturally vegetated buffers with a minimum average width of fifty feet for all development bordering tidal creeks and rivers.

BACKGROUND

Water quality concerns can be addressed, in part, by developing greenways and vegetated buffers to alleviate stormwater runoff problems.Vegetated buffers or filter strips trap sediments and a number of pollutants and are useful for protecting water quality when placed between impervious surfaces and nearby receiving waterbodies.

For best results, fifty-foot buffers are the minimum average widths necessary to prevent sedimentation in tidal creeks and wetlands. Fifty-foot buffers can reduce nonpoint source pollution greatly and do not require the constant maintenance needed for smaller buffers. Larger buffers are even better for controlling nonpoint source pollution and providing habitat and should be established, where possible. To a lesser extent than greenways, buffers can be used for passive recreation, cultural resource protection (if the resource is next to a waterbody), and to serve as a wildlife corridor. In general, buffers strips can be a relatively inexpensive means of reducing nonpoint source pollution. However, they are not as reliable and effective as retention ponds and other engineering practices for treating drainage from pavement, so these additional best management practices may also be required.

The Charleston Harbor Project developed a document of buffer guidelines, entitled *Vegetated Riparian Buffers and Buffer Ordinances,* which makes specific recommendations for buffer ordinances for local governments, explains the purpose of buffers, provides information on how to solve problems common to buffer ordinances (such as private property rights), and gives examples of existing buffer ordinances in the United States.

GM-18

GM-18

MEASURABLE GOALS

- Promote and distribute DHEC/OCRM's document *Vegetated Riparian Buffers and Buffer Ordinances.*
  1pm/$4,000/annually + $10,000/printing material
- Encourage establishment of larger buffers (50-100 feet), where possible.
  1pm/$4,000/annual
- Make buffer ordinances flexible, to address issues of private property rights.
  1pm/$4,000/annual
- Actively manage and maintain buffers after they are established.
  .5pm/$2,000/annual
- Print buffer boundaries on all development and construction plans, plats, and maps.
  .5pm/$2,000/annual
- Assist South Carolina communities to adopt buffer ordinances.
  1pm/$4,000/annual
- Evaluate the effectiveness of buffers in sensitive shellfish harvesting areas.
  1pm/$4,000/annual

COSTS

One-time cost	$ 10,000
Annual cost (times 5 years)	120,000
Once every 5 year cost	0
Total cost for first five year cycle	$130,000

IMPLEMENTATION

DHEC, Local Governments

RELATED ACTIONS

Limit the number and conditions for stream buffer crossings (roads, bridges, and utilities).

All footpaths running through a buffer to the water (perpendicular to the buffer) should be covered by non-elevated wooden boardwalks to prevent the channelization of stormwater runoff caused by dirt footpaths.

GM-19 Encourage environmentally friendly golf course practices

ACTION

Encourage compliance with the maintenance and design guidelines in the CHP report *An Environmentally Friendly Coastal Golf Course.*

Maintain non-chemically treated vegetative buffer zones of at least fifty feet adjacent to all natural watercourses to assist in filtering nutrients and pesticides in runoff and to moderate water temperatures.

BACKGROUND

Golf courses are manipulated environments that require significant energy (chemicals, pesticides and nutrients, and physical labor) to maintain their organization. The challenge to today's golf course architects, developers, superintendents, and managers is to facilitate the coexistence of these high-energy systems with sensitive ecosystems immediately adjacent to the courses. This is especially true along the coast where golf courses are literally designed into beach dunes and through

GM-19

sensitive marsh habitats. The potential environmental effects of golf courses include leaching and runoff of nutrients, soil erosion and sediment losses during construction and degradation of surface waters receiving runoff.

Charleston Harbor Project researchers produced a technical manual to serve as a guide for the design, construction, and maintenance of golf courses in the coastal southeastern United States. Recommendations include avoiding the disturbance of wetland areas and incorporating their features into the design, ensuring an adequate water supply is available for all potable and irrigation needs of the golf facility and neighboring properties, selecting plant species that are best suited to the local climate and require the minimum of inputs, considering on-site retention of stormwater runoff on soils with low infiltration rates, and making golf course managers aware of the wildlife species that frequent their courses and the risks incurred upon them by pesticide applications.

MEASURABLE GOALS

- Target a newly planned course to be built in compliance with the design elements in *An Environmentally Friendly Coastal Golf Course* at the beginning and an existing course for possible retrofit.
  .5pm/$2,000/annual + $5,000/printing material
- Award "Green Star" golf course designations for golf courses that comply or make significant improvements.
  1pm/$4,000/annual
- Distribute copies of "An Environmentally Friendly Coastal Golf Course" to developers, golf course designers, and local government zoning and permitting departments.
  .5pm/$2,000/annual

COSTS

One-time cost	$ 5,000
Annual cost (times 5 years)	40,000
Once every 5 year cost	0
Total cost for first five year cycle	$45,000

IMPLEMENTATION

DHEC, Local Governments, US Golf Association

GM-20 Encourage alternative development patterns

ACTION

Pass regulations encouraging development patterns, such as neotraditional design, which improve stormwater management, protect open space, and lower infrastructure costs.

BACKGROUND

Conventional development patterns, with large-lot subdivisions and complete separation of residential and commercial uses, contribute to urban sprawl, encourage dependency upon the automobile, and generate additional road and parking requirements. Nationwide, planners and developers are considering "neotraditional" planning, reminiscent of towns and cities designed prior to World War II, for the development of their communities. Areas such as downtown Charleston and the Old Village in Mount Pleasant are good examples of such design, blend-

ing residential and commercial uses together in a compact and pedestrian-friendly setting. This compact development protects land resources, improves water quality by reducing impervious surfaces and associated stormwater runoff, and reduces the number and length of car trips required by the average family.

Several neotraditional projects have been built, or partially built, in the United States and Canada in recent years, with most started in the 1990s. Seaside, Florida, begun in 1981, is considered the first neotraditional community. It is a fifty-four acre semicircular property on the Gulf of Mexico that contains homes built closely together, a commercial/civic center, narrow streets, parks, and mixed land uses (residential property above retail and offices). The design of the development places the needs of the pedestrian above the automobile. Seaside has been a financial success, as property values in the community have increased dramatically since the project's inception. Newpoint in Beaufort and I'on in Mount Pleasant are two examples of neotraditional developments in the Lowcountry of South Carolina.

The CHP conducted a study to evaluate the effects of neotraditional planning on stormwater runoff amounts in the watershed. Called the Belle Hall Plantation Charrette, this project examined the differences in stormwater runoff between two design scenarios, a typical "urban sprawl" development and a more traditional "town center" design. The land saved from development in the town scenario was left pristine in a large contiguous block, so elements of conservation subdivision design were demonstrated as well. Researchers determined that, if constructed, the sprawl scenario would produce 43% more runoff than the town scenario and three times greater sediment loads. Infrastructure (pavement, curb and gutter, sidewalk, sewer, and waterline) costs for a typical lot in the sprawl scenario would be double that of a typical town scenario lot. Local government services such as fire protection and garbage collections would also be less expensive in the town scenario, since less area would need to be serviced.

Another alternative design form is conservation subdivision design, conceived by Randall Arendt, which also contains small lots, but instead preserves the remaining land as large, contiguous tracts left in their pristine state. Designs for these developments follow guidelines similar to those for golf course communities, but instead of building a golf course the land is left pristine, with footpaths for hiking and nature watching. (Mr. Arendt polled residents of a golf course community and found that 40% of residents did not play golf, they just liked being near the greenspaces.)

MEASURABLE GOALS

- Revise subdivision regulations and zoning ordinances to allow and encour age more environment-friendly development patterns such as conserva tion subdivision design and neotraditional design.

  2pm/$8,000/annual

COSTS

One-time cost	$ 0
Annual cost (times 5 years)	40,000
Once every 5 year cost	0
Total cost for first five year cycle	$40,000

GW-20

IMPLEMENTATION

Local Governments

GM-21 Encourage utilization of existing wastewater capacity

ACTION

Direct residential, commercial, and industrial developments to areas with existing wastewater treatment capacity.

BACKGROUND

Guiding development to areas with existing wastewater capacity saves money and natural resources by making efficient use of existing facilities and by avoiding stretches of area rivers that cannot receive any more wastewater without negatively affecting water quality. The only other option in such overtaxed locations is to increase the level of wastewater treatment. Construction of new wastewater facilities to serve industrial development in these areas would be unnecessary if the projects were instead built where the receiving waterbody can still take extra discharges.

New development in remote areas disturbs more habitats and costs more money to establish and maintain. Either a new wastewater treatment plant must be built to serve the development or many more miles of water and sewer lines must be laid from an existing wastewater plant than would be required for a development built closer to the plant and the urban core.

MEASURABLE GOALS

- Maintain and update maps for each local municipality showing existing wastewater systems and their treatment capacity.
  .5pm/$2,000/annual
- Develop incentives to encourage growth in areas with existing capacity and discourage new service to inappropriate areas.
  1pm/$4,000/one time
- Adopt incentives.
  1pm/$4,000/annual
- Inform taxpayers, ratepayers, and local decision-makers about the economic costs of extending wastewater capacity to remote areas.
  .5pm/$2,000/annual

COSTS

One-time cost	$ 4,000
Annual cost (times 5 years)	40,000
Once every 5 year cost	0
Total cost for first five year cycle	$44,000

IMPLEMENTATION

Berkeley-Charleston-Dorchester Council of Governments, DHEC, Local Governments

GM-22

GM-22 Design waterbody restoration efforts

ACTION

Design waterbody restoration programs with local governments in the Charleston Harbor watershed, using the CHP Summerville project as the model for interagency cooperation.

BACKGROUND

In 1994, the Charleston Harbor Project initiated a wetlands restoration project at the Sawmill Branch Canal in Summerville with funding from the Environmental Protection Agency. The Army Corps of Engineers formed the canal in the 1960s to control flooding by deepening the existing creek and placing the dredge spoil between the creek and adjacent wetlands. Additionally, drainage pipes from the wetlands to the canal were placed too low, draining the wetlands instead of allowing them to retain and filter stormwater. In addition, other stormwater drain pipes from nearby developments bypassed the wetlands altogether and drained directly into the canal, resulting in sedimentation and polluted water in the canal, inadequate water supply to the wetlands, and eroded streambanks.

The restoration project, an effort by CHP, the Town of Summerville, Dorchester County, and other government agencies, solved the problem of the drainage pipes that led directly into the canal by redirecting them into the wetlands. The pipes that led from the wetlands to the canal were raised to allow the wetlands to retain more water. Now the water in the creek is cleaner because the wetlands can again filter it, and the wetlands are much healthier because they again have an adequate supply of water.

Other waterbodies exist in the CHP area, such as Filbin Creek in North Charleston, which would benefit from restoration projects similar to the one undertaken in Summerville. With adequate funding, such projects would have environmental, economic, and recreational benefits.

MEASURABLE GOALS

- Implement the Wetland Restoration Program funded by DHEC as part of the 319 program.
  2pm/$8,000/one time
- Inventory potential wetland restoration projects in the CHP watershed.
  1pm/$4,000/annual

COSTS

One-time cost	$ 8,000
Annual cost (times 5 years)	20,000
Once every 5 year cost	0
Total cost for first five year cycle	$28,000

IMPLEMENTATION

DHEC, Local Governments

GM-23 Encourage mass transit

ACTION

GM-23

Support efforts to develop and improve the mass transit system by making it more efficient and appealing to citizens.

BACKGROUND

GM-23

Until residents consider mass transportation to be a viable and convenient alternative to using private automobiles, mass transportation systems will continue to operate at less than maximum efficiency. Meanwhile, increased motor vehicle traffic requires more and larger roads (increasing impervious surfaces and rates of stormwater runoff); increases associated oil, grease, engine coolant, and tire wear pollutants; and increases sediments carried by runoff. An economically and functionally efficient mass transportation system reduces daily vehicle traffic, thus reducing needs for more and larger roadways and, ultimately, reduces associated pollution.

The existing mass transit system must be made more efficient and appealing to citizens and be redefined to fit the community by making changes such as using smaller buses on certain routes and increasing reliability with more frequent arrivals. Other strategies used by cities in recent years include:

- Giving buses their own lane at traffic lights. The light changes early for the buses to move in front of cars.
- Creating programs for employers to offer financial incen tives to their employees for using mass transit.

MEASURABLE GOALS

- Support efforts to educate the public on the benefits of mass trans portation by developing and distributing information regarding environmental issues and transportation.

  .5pm/$2,000/annual

COSTS

One-time cost	$ 0
Annual cost (times 5 years	10,000
Once every 5 year cost	0
Total cost for first five year cycle	$10,000

IMPLEMENTATION

Local Governments, Charleston Area Transportation Study, Berkeley-Charleston-Dorchester Council of Governments, Charleston Area Regional Transportation Authority.

GM-24 Encourage adoption of marina ordinance

ACTION

Adopt marina ordinances throughout the tri-county area that reflect CHP model ordinance.

BACKGROUND

There are over 1,450 marina slips and 730 dry stack storage units in the Charleston Harbor Project area. Several marinas are planning to add additional slips. Marinas are regulated by federal, state, and local guidelines. Consequently, the regulatory process is at times uncoordinated, resulting in poor siting decisions. A CHP project attempted to improve coordination among governmental agencies to enhance appropriate and environmentally consistent marina development. A general overview of constraints to marina siting included water quality classifications, water depth, bridges, streets and roads, wetlands and marshes, shellfish areas, exist-

GM-24

ing land uses, and public services and utilities. A finished report provides a model ordinance for the CHP area that would improve marina siting throughout the watershed.

A CHP researcher reviewed the general permitting criteria required for a developer to secure a permit for marina construction within the Charleston Harbor area. This review deals specifically with the implications of the need and demand terminology as they relate to the marine industry and marina development.The intent is to present OCRM, a permitting agency, with clarifying information about the need/demand controversy surrounding the permitting of marina development.

The primary issue in marina permitting is how the facility will affect water quality. The test for the effect on water quality has always been whether the facility will close shellfish beds. To protect public health, a shellfish buffer zone is established around marinas to prohibit the gathering of shellfish in potentially polluted areas. Other issues include the potential effects of marinas on navigation, the impacts of boat wakes on surrounding wetlands and upland property, dredging for construction and maintenance of a marina, and the effect of bridge openings on municipalities.

MEASURABLE GOALS

- Target Charleston County and City of Charleston to adopt measures from a CHP model marina ordinance.
  .5pm/$2,000/one time

COSTS

One-time cost	$2,000
Annual cost (times 5 years)	0
Once every 5 year cost	0
Total cost for first five-year cycle	$2,000

IMPLEMENTATION

DHEC, Local Governments, South Carolina Marine Association

APPENDICES

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Gail Phipps

April Turner

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BIOLOGICAL RESOURCES

Anderson, William. 1997. Utilization of Oyster Shell to Suppress Estuarine Shoreline Erosion.

Shorelines of numerous rivers and small tidal creeks have, in some cases, eroded more rapidly than others due to boat generated waves, other anthropogenic influences (e.g. structures, outfalls) and natural factors (e.g. wind driven and river currents). Intertidal areas and their adjacent marshes exposed to boat traffic are the most vulnerable. Shorelines with natural oyster populations and an underlying shell matrix afford protection by buffering or absorbing wave energy before it impacts the shoreline or marsh. In marsh areas devoid of hard substrate, the placement of oyster shells allows juvenile oyster settlement, and supplies the foundation for future populations. The utilization of oyster shells for erosion control provides a number of benefits: 1) shoreline and marsh protection; 2) the capacity for the growth of a complex, three-dimensional intertidal habitat; and 3) propagating shellfish restoration.

Anderson, William. 1997. Shellfish Resources. SCDNR.

Oysters, clams, and whelks are of major economic and social importance to the Charleston Harbor area. Commercial landings have risen steadily since 1986. The opening of Clark's Sound in 1991-92 after three decades of closure due to poor water quality resulted in increased harvests in state waters. Much of Charleston Harbor is closed to shellfish harvesting due to fecal coliform bacteria originating from nonpoint source runoff and marinas. Within the watershed, 17 state shellfish grounds for commercial and recreational harvesting, and nine public grounds for recreational harvests are managed by the state. Mariculture permits (there are currently 14 permits totaling 712.7 acres) are granted for bottoms that do not have naturally occurring shellfish. Prior to the Santee/Cooper diversion, a large subtidal seed oyster bed was found in the Wando River, but has not been harvested since 1976. Whelk production from off-shore trawling has averaged 22,200 bushels per year since 1991, and far exceeds landings from other areas of the state. Oyster reefs create habitat for other marine fauna and provide structure for river bank stabilization and the protection of marshes from erosion. Intertidal reefs provide a complex 3-dimensional habitat for resident and transient species such as red drum, spotted seatrout, flounder, grass and penaeid shrimps, hermit and blue crabs, and many others. South Carolina Department of Natural Resources develops, implements and supervises initiatives necessary for the management of the state's shellfish resources.

Burnett, L. E. and R. E. Cochran. 1996. Habitat Identification: Fish (Final Report on *Respiratory Responses of the Salt Marsh Animals* ...).

An evaluation of the respiratory responses of three species of fish and shrimp to varying levels of oxygen, carbon dioxide, and an organophosphate pesticide was made. The species typically occur in saltmarshes and creeks within the Charleston Harbor area.The pesticide, consisting of Azinphosmethyl, is widely used on vegetable, cotton, tobacco, and many other crops and may enter the estuarine system from terrestrial runoff. Low, fluctuating oxygen levels, and high and variable carbon dioxide levels are common with tidal creeks and saltmarshes. The study found that the three species are well adapted to their environment where periodic low oxygen and high carbon dioxide concentrations are normal. The animals are able to regulate their uptake over a wide range of oxygen pressures and relied on anaerobic metabolism only under extremely low oxygen levels. Under non-lethal concentrations of the pesticide Azinphosmethyl, oxygen uptake by the three species was not effected.

Cochran, R. E. and L. E. Burnett. 1994. Respiratory Responses of the Salt Marsh Animals, *Fundulus heteroclitis, Leiostomus xanthurus,* and *Palaemonetes pugio* to Environmental Hypoxia and Hypercapnia and to the Organophosphate Pesticide, Azinphosmethyl.

In tidal saltmarshes in South Carolina hypoxic and hypercapnic (high CO_2) conditions occur frequently. Water Po_2 was measured in the upper marshes and over a 24 hour period ranged from 9 to 170 torr and Pco_2 ranged from 0.3 to 5 torr. These conditions depend on the stage of the tide and the time of day. The respiratory responses to different levels of Po_2 and Pco_2 of *Palaemonetes pugio, Leiostomus xanthurus,* and *Fundulus heteroclitus* living and feeding in the saltmarsh were investigated. Mean oxygen uptake in *P. pugio, L. xanthurus,* and *F. heteroclitus* at normoxic Po_2 (130-150) torr and low Pco_2 (< 0.6 torr) was 17.5, 17.1, and 9.48 Fmol $g^{-1}hr^{-1}$ and 16.3, 24.5, and 10.47 Fmol $g^{-1}hr^{-1}$ at high Pco_2 (= 7 torr), respectively. The critical Po_2 for all species was 30 to 35 torr. Mean whole body lactate concentrations in *P. pugio, L. xanthurus,* and *F. heteroclitus* at Pco_2 < 0.6 torr are 3.48, 2.44, and 2.33 Fmol g^{-1} in normoxia and 12.3, 4.45, and 10.98 Fmol g^{-1} ($p<0.05$; Dunn's pairwise test) in hypoxia (Pco_2 <0.6 torr). In these saltmarsh animals there appears to be no specific effects on oxygen uptake of environmental fluctuations in CO_2 over a wide range of Po_2. The organophosphate pesticide, azinphosmethyl, appears to have no effect on the oxygen uptake of these three species at concentrations of 10 Fg L^{-1} for fish and 2 Fg L^{-1} for shrimp.

Burnett, L. E. and R. E. Cochran. 1996. Respiratory Responses of Grass Shrimp, Juvenile Spot Fish, and Mummichog to Hypoxia and High Carbon Dioxide.

In the saltmarshes of South Carolina, low oxygen and high carbon dioxide water conditions occur frequently and are related to tide-stage and time of day. During daylight hours, increasing oxygen and decreasing carbon dioxide reflect the dominance of photosynthesis over respiration in the metabolism of the biological community. Nighttime decreases in oxygen and increases in carbon dioxide are the result of net respiration. Although nighttime oxygen levels are often very low in tidal marshes and creeks, mortality among the marsh inhabitants is rare. Saltmarsh animals have behavioral and physiological mechanisms for dealing with such conditions. The most common behavioral response is simply to avoid the condition by leaving the area (mobile animals - shrimp and crabs) or sealing themselves (fixed animals - clams and oysters). Animals are also capable of tolerating and adapting to low oxygen levels. These animals are either *conformers* if their uptake varies directly with environmental conditions, or they are *regulators* if their oxygen uptake is independent of the surrounding oxygen levels. Many such animals exhibit a combination of responses. This study evaluated the environmental extremes in oxygen and carbon dioxide levels that animals encounter in the saltmarshes and evaluated how three residents respond to such conditions. These animals, the grass shrimp, juvenile spot fish, and mummichog are well adapted and are able to regulate their oxygen uptake over a wide range of oxygen levels. Elevated levels of carbon dioxide had differing effects on oxygen uptake: it increased in the spot fish, but had no effect on the grass shrimp or mummichog. All species relied little on anaerobic metabolism except under extremely low oxygen levels. Observed levels of the organophosphate pesticide, Azinphosmethyl, had no measurable effect on oxygen transport in any of the three species.

Coker, M. 1995. Shellfish Remediation.

The purpose of this project was to identify methodologies that would lead to the restoration of shellfish harvesting to areas previously restricted due to poor water quality. The study included the assessment of historic shellfish harvesting classifications, water quality trends, land use patterns and factors related to water quality, and identification of shellfish resource availability. In addition, water bodies with harvestable shellfish resources were identified and considered for selection for restorative efforts. The evaluation shows that a large portion of harvestable shellfish resources in the Charleston Harbor Estuary occur in areas requiring a water quality classification of Restricted or Prohibited. The low quality is related to a combination of low dilution, poor flushing action, low salinity related to source water, and non-point source runoff.

Dustan, P. 1996. Natural Variability of Secondary Estuarine Watershed Creeks.

The focus of this project was to better understand the coupling between land and tidal creeks by monitoring fine scale changes in the water quality of two creeks; one having a highly developed and the second, a relatively pristine watershed. Anthropogenic activities such as urbanization, agriculture, and deforestation dramatically increase the rates of transfer of terrestrial materials to coastal estuaries. The urbanized watershed is surrounded principally by residential neighborhoods. Significant runoff is added from storm drains, surface roads, and an elevated causeway. The second site is a forested watershed in the upper reaches of the Wando River. The temperature, salinity, dissolved oxygen, and pH data show that the creeks are highly variable; the urbanized creek showing the greatest variation. The data also suggest that rainwater moves through the two sites differently. Runoff enters the urbanized estuary more rapidly resulting in sharp changes in salinity, pH, and dissolved oxygen. Rainfall events in the "pristine" watershed appear to be dampened as the range and amplitude of parameter variations after the rainfall is considerably less. This is perhaps related to the forest canopy and the soil permeability which reduces the erosive effects of the rain, and increases infiltration. The urbanized, less forested lands retain less water, and buildings, paved roads, and sidewalks provide more direct flows into the estuary. Experiments demonstrated that following a rain, the respiration rate of the creek was usually higher (suggesting an increased biological/biochemical oxygen demand through microbial activity on organic particulates) and gradually recovered over the next several days. It was also found that at least 0.6cm of rainfall within a short time period was required to detect any effects on the oxygen or salinity concentrations of the estuary. The work suggests that rainfall should not be permitted unhindered access to estuarine creeks. Urban forest landscapes and buffer strips could be placed between creeks and landscapes to trap sediments transporting organic and inorganic materials by sheet flow.

Harrison, J. R. 1996. Distribution of Critical Habitats for Amphibian and Reptile Species of Special Concern Within the Charleston Harbor Project Area.

One hundred and eleven species of amphibians and reptiles have been recorded from, or are expected to occur within the Charleston Harbor Project area. Of these, 22 species are considered to be imperiled or potentially imperiled warrant further attention. The study documents efforts to determine the specific locations of sites containing critical habitat for those species of special concern. Approximately 6,736 miles of federal and state primary and secondary roads, and forest service roads were investigated. Off-road forays were also made where feasible. The Francis Marion National Forest, large privately-owned

areas, timberlands, and Middleton Gardens were evaluated. The National Forest, because of its size and habitat diversity, had a large potential for the presence of critical habitat. Species accounts includes information on distribution in South Carolina, preferred habitat based on plant community type and topography, current status or change in status, and any relevant information. Site locations, of which there are 194, were identified primarily on the basis of plant community type and topography. For each site, known occurrences of each species as documented from historic records and/or the present study are given.

Holland, A. F., *et al.* 1996. The Tidal Creek Project.

Meandering, shallow tidal creeks and saltmarshes are dominant features of South Carolina estuaries and provide nursery habitat for numerous species of economically important fish, crab, and shrimp. Creeks serve as conduits through which terrestrial derived pollutants enter the estuary while creek sediments serve as repositories for these potentially toxic materials. The tidal creek study summarizes the available information on the ecological value of tidal creeks and characterizes the summer water and sediment quality, and living marine organisms in the creeks of the Charleston Harbor Estuary. The major findings include: (1) Salinity fluctuated over greater ranges and was generally more variable in developed creeks than in reference creeks. Creeks dominated by salt marshes had the least variable salinity distributions. (2) Sediments in developed creeks were composed of more sand and had larger site-to-site variation in physical characteristics than reference creeks. The greater sand content and more variable sediment characteristics in developed creeks are probably associated with erosion and deposition of surface soils from tidal creek watersheds. (3) Dissolved oxygen in tidal creeks fluctuates with time of day and stage of tide. The lowest and most stressful dissolved oxygen concentrations occurs during the early morning and night-time low tides. In both developed and reference creeks, dissolved oxygen often did not meet state water quality standards. Biological resources inhabiting developed creeks were exposed to low dissolved oxygen events more frequently than those in reference creeks. (4) Trace metal concentrations in sediments of the upper reaches of industrialized creeks are enriched with trace metals to levels known to adversely affect living organisms. Sediment trace metals and sediment bioassays in reference creeks rarely exceeded values known to cause harm to biological resources. (5) The general distribution of pesticides, polychlorinated biphenyls, and polycyclic aromatic hydrocarbons (PAH) is similar to that for trace metals. The PAHs appear to pose the greatest threat to tidal creek nurseries. (6) After accounting for natural variations in salinity, sediment type, and location in the tidal creeks, increases and decreases in the abundances of benthic organisms in the upper-most reaches of tidal creeks could be attributed to human development of the watershed. (7) Colonization and recruitment studies showed, after accounting for natural variation in recruitment, that human alterations of tidal creek watersheds were found to adversely affect the abundance of only one abundant species. The survival of new recruits was much greater in reference creeks. These data suggest that human development of tidal creek watersheds impact the survival of living resources more than their recruitment processes.

Kelley, B. J. and R. D. Porcher. 1996. Vegetational Status of the Freshwater Tidal Marshes of the Upper Cooper River.

The tidally influenced, freshwater marshes and swamps of the upper Cooper River were modified in the 18th and 19th centuries for the culture of rice. Dikes and ditches controlled water levels. Due to the loss of labor, storms, and mechanized production elsewhere, the industry ended during the 1920's. Breaches in the dikes allowed renewed tidal flow and initiated aquatic succession. As a result of differences in cultivation history, management practices, time since abandonment, water depth and duration of inundation, salinity, and potentially other factors, today, these fields are found in a variety of successional states. The Cooper River Rediversion Project initiated in the early 1980's to reroute Cooper River freshwater to the Santee River caused a lowering of water levels in the upper Cooper River. It was found that the lowering of the water levels has accelerated vegetational succession in the remnant rice fields of the upper Cooper River. This succession is eliminating functions contributed by early stages and enhancing contributions made by later stages, but this natural course of events may have detrimental consequences for the drainage basin. To preserve system function and quality it may be necessary to intervene through the repair of dikes. Interventions have already taken place in the form of dams blocking access to breeding habitats, and runoff from suburban, urban, and industrial development.

Lerberg, S. B. 1997. Effects of Watershed Development on Macrobenthic Communities in the Tidal Creeks of the Charleston Harbor Estuary.

A study of the macrobenthic organisms of 24 shallow tidal creeks of the CHP area was undertaken to determine if differences existed between upland creeks draining watersheds with at least 15% terrestrial land cover, and salt marsh creeks that contained no upland habitat. The drainage basins of the creeks represented the range of watershed sizes, human population densities, and types of developments that exist in the Charleston Harbor Estuary. Urban and industrial drainage basins had degraded habitat with altered nursery functions due to biologically harmful levels of toxic substances in the sediments. They were characterized by low numbers of species and low abundances of individuals. Creeks draining subur-

ban and impacted salt marsh creeks still maintained adequate numbers of animals to support nursery functions but exhibited early warning signs (e.g. high dominance, few pollution sensitive species) of degradation. The relative abundance of pollution sensitive species responded to watershed development in an unambiguous and interpretable manner. These species are potentially useful as early warning indicators of human impact on tidal creek habitats.

Murphy, T. M. and M. G. Dodd. 1996. Seasonal Distribution, Abundance and Habitat Use of Foraging Wading Birds in the Charleston Harbor Estuary.

Because of concern over increasing residential and industrial development, we examined gross patterns of seasonal abundance and habitat use of foraging wading birds in the Charleston Harbor Estuary. We conducted boat surveys of 759 km of shoreline habitat from January-December 1994. We divided the estuary into 6 survey routes representing four river drainages (upper estuary), Charleston Harbor, and surrounding salt marsh habitat (lower estuary). On a finer scale (within survey route), we examined wading bird use of three brackish-marine habitats [mudflats, small creeks (<50 m width), estuarine shoreline] and four freshwater habitats [impounded wetlands, formerly impounded ricefields, riverine shoreline, small creeks (<50 m width)].

Abundances of foraging wading birds were greatest from June-September and positively associated with total fish biomass in the estuary. There was no difference in densities of foraging wading birds between survey routes. On a finer scale, wading birds utilized mudflats, formerly impounded ricefields, and small creeks (brackish-marine) at higher densities than other habitats. Human activities are a major factor in the disturbance of foraging wading birds. Potential disturbance from residential development includes increased activity from boat traffic, dock structures, and upland activities adjacent to foraging habitats. Brackish-marine small creeks, mudflats , and formerly impounded ricefields should be protected from human disturbance, and a strategy for the placement of boat ramps, dock structures, and marinas to minimize boat traffic in these habitats should be attempted. In upland sites, vegetative buffers should be considered as these serve the dual roles of reducing human intrusion and at the same time providing roosting habitat in close proximity to foraging sites.

Oswald, E.G. 1997. Cooper River Rice Fields: Landowner Attitudes and Perceptions Toward Change.

In 1985, the U.S. Army Corps of Engineers rediverted water, formerly flowing in the Cooper River, back to the Santee River system. This action lowered water levels and decreased flow rates, possibly increasing the rates of plant succession in abandoned rice fields of the Cooper River. Rice field landowners along the Cooper River were surveyed to determine attitudes toward regulatory agencies and management practices, and receptiveness of basin-wide cooperative management planning. Twenty-six landowners were identified and twenty surveyed. Landowners are dissatisfied with current management situations and are willing to work with land managers to bring more attention to the Cooper River and to develop a basin-wide management plan.

Porcher, R.D. 1995. Inventory of Botanical Natural Areas in Berkeley, Charleston and Dorchester Counties.

This study provides an inventory of significant botanical natural areas in the Tri-county area that may be affected by human activities in the Charleston Harbor estuary. It provides one of the more important habitat descriptions of natural areas in the Charleston Harbor area. Sites were identified through knowledge of the author, consultation with colleagues, the written record, and field surveys of the project area. Significance was based on the following: 1) Federally listed rare and endangered species, 2) Federally listed Category 2 species (those species for which proposal listing information is available, 3) rare plant communities, resulting from natural rareness or human activity, 4) significant wetlands based on the author's experience, 5) Wilderness areas, both federal and state, 6) Sites with artifacts from the rice culture era of South Carolina, 7) Pristine sites of unusual natural beauty. Through these criteria, eighty sites in the Charleston Harbor estuary are considered significant. The majority are in either local, state or federal control, some are in private ownership, and several are under local, state or federal jurisdiction, but are unknown to the governmental agency.

Post, W. and P. Coleman. 1995. The Foraging Habitats and Food Use of Colonial Wading Birds in the Charleston Harbor Area.

This study assessed the relative importance of nesting site availability and juvenile food resources to the overall productivity of colonial wading birds. The most common species was the Great Egret. The highest population densities for all species, occurred in brackish impoundments, followed by salt marsh, small tidal creek, bay edge, large tidal creek, and river. None of the species were uniformly distributed over all habitats. long-term survival of colony sites is influenced by human activity, either through long-term effects (filling, pollution), or short-term effects (disturbance of critical feeding areas, harassment of feeding birds, recreational boaters).

Post, W. 1996. Habitat Use by Nearctic Migrants in Autumn in the Charleston Harbor Project Area.

The primary objective of this research was to determine migratory patterns of autumn migrants moving through the Charleston Harbor area. The information will enable landowners and land managers to formulate land-use strategies for the preservation and protection of critical habitat for migrants. Four banding stations were operated during an 8-year period and included coastal scrub habitat bordering the harbor and the Stono River. Birds were captured in mist nest operated during the same time of day under similar weather conditions. Netting took place from 8 August through 8 November, during the eight-year period and included 367 days. A total of 21,345 nearctic migrants was captured. Overall, the largest numbers of migrants captured were at Hog Island. In some years, however, the inland station on James Island had higher capture rates. The Sullivan's Island site, which was expected to have the second highest capture rate, averaged lower than the inland station. In contrast to the species abundance, the species richness (measured by standardizing samples to equal numbers of individuals) was consistently highest on Folly Beach, and consistently lowest on Hog Island. The results suggest that, unlike concentration points along the northeastern Atlantic coast, Charleston Harbor has few or no staging areas critical to nearctic autumn migrant populations. However, these sites may well be important areas for northward-bound migrants during the spring. Also, because a large number of species use some coastal from scrub habitats (Folly Beach and Sullivan's Island) managers should be encouraged to preserve these sites from development.

Wenner, C.A. 1997. Seasonal Species Composition and Abundance of Larval and Juvenile Fishes in Surface and Bottom Plankton Collections.

The objective of this study was to describe the species composition and seasonal abundance of fish larvae along salinity gradients within the shallow habitats of the Charleston Harbor estuary and Ashley River. The study also examined the abundance and utilization of structured and unstructured habitats in the estuary. Declines in the populations of inshore and offshore commercially and recreationally important finfish species may be related to habitat degradation within the estuaries of South Carolina. Stresses to the estuaries result from urbanization, population growth, and industrial development and include loss of wetland habitat, pollution, and over-fishing. Adults of many estuarine-dependent finfish species move offshore in the fall to spawn. Eggs and larvae are transported to the estuaries by coastal currents and other physical processes. The Charleston Harbor Estuary was found to be important to the life histories of the bay anchovy, Atlantic croaker, Atlantic menhaden, and spot, the four most numerically abundant species found. The estuary provides spawning habitat, nurseries for up to several years, protection from predation, and general refuges. Salinity gradients are important to their distributions within the estuary. Drainage creeks, creek banks, the high marsh, oyster-shell substrates, submerged grassy habitats are among the those habitats of greatest importance to finfish in the estuary.

Wenner, C.A. 1997. Spawning Times and Locations of Spotted Sea Trout, *Cynoscion nebulosus*, in the Charleston Harbor Estuarine System from Acoustic Surveys.

Male sea trout produce sounds to attract females of the same species to form spawning aggregations. Hydrophones are used to detect and quantify the sound. In the Charleston Harbor estuary, aggregations of sea trout begin in May and continue into September. Large aggregations are found to be associated with structures exposed to high velocity currents. Specific locations include the supporting pylons of most bridges crossing major waterways such as the Ashley, Cooper, and Stono Rivers. Other locations include the mouth of Charleston Harbor, a deep hole in Dewees Inlet, the James Island Yacht Club dock, and Fort Johnson. Aggregations, but at lower densities, occur in most channels of major waterways.

Wenner, C.A. and W.A. Roumillat. 1993. Fishes of the Shallows as Determined from Stratified Random Trammel Net Sets in the SAMP Area.

Monthly collections of commercially and recreationally important finfish were made during ebb tide in the lower Charleston Harbor, lower Wando River, and Ashley and North Edisto Rivers. Hydrographically, salinity and temperature appear to be important to the timing and distribution of species. Temperature ranged from lows of 8/9/10°C to a high of 30°C during the summer. Salinity distribution in the North Edisto (20 - 28 ppt) is very stable due to the insignificant freshwater inflow. The Ashley is dominated by freshwater inflow from a large drainage basin of freshwater wetlands and swamps. Conse-

quently, the salinity is more variable and seasonal dependent. Salinities in the lower Wando and Charleston Harbor (15 - 25 ppt) are relatively stable. The study provides information on the seasonal distribution and abundances, sizes, and physical setting of the fish communities that utilize the shallow waters of the Charleston Harbor Estuary. Striped mullet is the most numerous species encountered in each river system and ranged from 23 - 86% of the total catch over the 22 month sampling period (Charleston Harbor: 23%, Ashley River: 86%). Red drum and spotted seatrout are the next most common species found in the four rivers system. Spot, southern flounder, Atlantic croaker, and hardhead catfish made up the remainder of the numerically dominant species, but were not found in all river systems

Banta, T. 1995. Civil War Fortifications Inventory.

The Charleston Harbor area contains some of the most significant historic and archeological sites in the United States. Some have been mapped, but many have not. The objective of this project was to identify significant Civil War battlefields and fortifications found in the Tri-County area. This information allows land management agencies and private developers to prevent or reduce the inadvertent loss of historical, Civil War sites. Through archival research and land surveys (Global Positioning System surveys), Federal and Confederate Civil War sites in the Charleston Harbor area were identified by tax map number, street address if appropriate, and property owner. All 114 sites played roles in the Campaign of Charleston during 1862, and in the Siege of Charleston, 1863-1865. A description of the military action that took place at each site, the current (as of 1994) condition and integrity of each site, and both short- and long-term threats to each site is also provided in the report. Some of the sites no longer exist and have been destroyed either through bank or shoreline erosion or development. Seventy-seven sites are Federal and Confederate earthwork fortifications and batteries. The remaining sites consist of rifle pits, forts, gun platforms, and batteries.

Beach, Virginia and Stuart Dawson. 1993. The Scenic Inventory of Church Creek and Bohicket Creek.

The need to monitor scenic features in the Charleston Harbor estuary led to the development of methodologies (1) to provide tools to help monitor and guide physical changes along the region's waterways, and (2) to educate the community to the unique aspects—vistas, fragile ecosystems, and the historical, natural, and recreational resources—that exist in the estuary. Church and Bohicket Creeks were chosen for the pilot project. While fishing and truck farming remain important industries along the banks of the creeks, resort and residential developments are occurring. Houses take the place of vegetation along the creek banks, trees are cut down to provide a view and a breeze, shorelines are armored with rip-rap to halt bank erosion from construction, boat traffic, and sea level rise, docks with various superstructures are built out over marshes to provide access to the water and suddenly, the landscape has a very different appearance. A manual was prepared that provides key data on each parcel for people involved in planning, development, and conservation in the area. This information, by tax map parcel number, includes ownership, acreage, waterfront footage, zoning, deed, wildlife species, and State Historic Survey data. Along with representative photographs, key features of parcels that make them attractive for conservation efforts are provided. The manual is intended to be a "working manual" that will serve as a 1993 base of existing conditions along the creeks. As changes occur, this information will give the user a definable point from which to monitor and evaluate these changes, and update the manual.

Berkeley-Charleston-Dorchester Council of Governments. 1992. Inventory of Permitted Solid Waste Landfills, Berkeley-Charleston-Dorchester Region.

This inventory of permitted solid waste landfill identified 47 sites within the Tri-County area. Of these sites, 30 are closed, three are inactive, and 14 are active disposal sites. Forty-seven landfill/ash storage sites have been permitted by the South Carolina Department of Health and Environmental Control. Berkeley County includes 10 sites, Charleston County 29 sites, and Dorchester County seven sites. One site is found in both Berkeley and Dorchester Counties. Of the thirty closed landfills, six were operated by industries disposing of inert materials, and 22 were facilities that accepted some domestic waste. These latter facilities existed in 1972, but rapidly closed after the counties implemented solid waste disposal programs. A large, but unknown number of dumps/landfills that existed in the region prior to 1972 when solid waste permits were first required by the State Board of Health is not included in the inventory.

Caban, J. 1994. Planning and Design, Belle Hall Plantation.

The concept of the "town" is being considered by planners and designers more today in the development of communities. The idea of higher densities and mixed uses is being reassessed as an alternative to the prevailing low densities and land use segregation that have typified urban expansion in recent decades. This study provides an analysis of the infrastructure (pavement, curb and gutter, sidewalk, sewer, and waterline) cost differences between sprawl and traditional styles of land development for Belle Hall Plantation. One basic subdivision scheme and one town scheme for the same site was evaluated. In addition, three residential schemes were evaluated. These explored alternatives of development using varia-

tions of common development formulae: smaller lots, narrower streets, ample connectivity, and larger amounts of open spaces. The sprawl scheme would contain 19,750 lineal feet of streets and cost an average of $7,000 per lot for utilities and improvements. The town scheme would contain only 9,850 lineal feet of streets and would cost only $3,494 for utilities and improvements. The benefits of compact development are in terms of protection of land resources, improvements in water quality, reduction in the number and length of car trips required of the average family, and generally in the creation of more humane living conditions.

Cable, J. and Reed. 1995. A Predictive Model for Archeological Site Location.

Predictive models were developed that would allow government agencies, planners, and private developers to predict where archeological sites will most likely occur within the Charleston Harbor area. These models would permit the rapid identification of the probable impacts to unknown archeological sites upon which planned or future construction was being considered. The archeological data base upon which the models were constructed consisted of 1,208 known sites from Beaufort, Berkeley, Charleston, and Colleton Counties. These sites were evaluated by archeologists within the ten-year period prior to 1994 and are the result of compliance surveys sponsored by government agencies and private developers. This data base assured a consistent methodology of site discovery and definition. The information within the data base includes both archeological (functional use, age, and site size) and environmental (soils, streams, and topography) variables. These data were used to produce descriptive statistics on the landscape associations of the archeological sites. From this body, statistical formulae consisting of multiple regressions were developed to allow site prediction from the landscape and archeological data. Validation of the formulae was provided through independent testing on a sample of 100 new sites recorded during 1994. This approach allows any developer or government agency to assign site archeological probability ratings for any particular tract of land under development consideration.

Cunningham, M.G. 1994. Needs Assessment of Outdoor Recreation for the Charleston Harbor Project Area.

With an anticipated population of over 600,000 by the year 2015, the availability of and access to outdoor recreational opportunities will become highly important to both residents and tourists in the Tri-County area. Many of the recreational opportunities in this area are based on its abundant natural resources, particularly marine, estuarine, and riverine. Water is the region's greatest natural asset, as well as its greatest potential for recreation development. Public access to these water-related areas may decrease significantly, as the pressure of population growth results in a gradual shift from rural to suburban land ownership. In this study, planning for public access included an inventory of existing public access, an outline of the public's needs and goals for access to public lands, and the development of a long-range plan to achieve the goals within the financial resources of the community.

The inventory found 197 sites for outdoor, water-based recreation in the Charleston Harbor area. It included federal, state, and local parks, fishing camps, marinas, golf courses, boat ramps, gardens and swamps, historical sites, forest preserves, campgrounds, and ocean beaches. There is a great deal of coastline that is restricted and inaccessible to public use. The Charleston County beaches are burdened not only with county residents, but with visitors from inland South Carolina and other states; demand is far greater than available facilities. Berkeley County's lakefront is predominantly private. With nearly 52.5 and 25 miles of waterfront along Lakes Moultrie and Marion, respectively, it is significant that there are no supervised public swimming areas. Demographic characteristics affect recreational participation, with age having the largest systematic effect. In general, younger people participate in more vigorous recreational activities, with participation consistently declining across older groups. With the median age projected to increase from 28 in 1980 to 36 years by the year 2000, planners must consider the ramifications of this. Further, the studies found significant differences in recreation participation between men and women, blacks and whites, and economic status. At present, the majority of residents of the Charleston Harbor area appear satisfied with the availability of water-related recreational opportunities. However, this level of satisfaction may decline under increasing population growth. Recreation development must incorporate strategies of preservation and conservation. Coupled with measures to protect the resource base, steps must be taken to evenly distribute access and utilization to all residents across various socio-economic groups.

Cunningham, M.G. 1996. Long-Range Plan for the Provision of Outdoor, Water-Related Recreational Opportunities in the Charleston Harbor Project Area.

Accompanying the region's projected population growth will be an increased demand for various outdoor, water-related recreational facilities and services. Recreation development must incorporate strategies of preservation and conservation to achieve success in managing the highly-valued water resources of the Charleston Harbor area. In combination with measures to protect the resource base, efforts must be made to evenly distribute access and utilization to all residents across all socioeconomic groups. This study emphasizes the need to develop environmentally compatible facilities and activities that support public access and utilization. Fishing piers, picnicking areas, open spaces, trails, educational programs, and special events are a few of such amenities. Opportunities for these forms of development exist in Dorchester County outside the Summerville corridor, the area of western Charleston County starting at the Edisto River and moving east, and the area of Berkeley County northeast of Interstate I-26 to the Francis Marion National Forest. Additionally, those activities which do not require resources that are located solely in Charleston County, such as the beach, should be developed away from the central Charleston area.

Cunningham, M. G., Dean Foster and SCDHEC. 1995. Charleston Harbor Project: Public Recreation Access Guide.

The purpose of the guide is to document public water-related recreation sites, parks, and activities in the Charleston harbor watershed area. It provides easy access to information about the Lowcountry's miles of pristine waterways and recreation opportunities. Eighty-four, forty, and eight water-related sites located in Charleston, Berkeley, and Dorchester Counties, respectively are identified and described. These sites include parks, gardens, golf clubs, boat landings, yacht harbors, marinas, beaches, forts, camp grounds, landings, plantations, fish camps, and coastal preserves, among many others. Once largely rural and agriculturally based, Charleston County is presently more urbanized with 75% of its citizens residing in urban settings. Tourism contributes almost one billion dollars to the economy and provides an estimated 15,000 jobs. Commercial fishing and shrimping are large parts of the local economy as are chartered fishing trips.

Ford, J. 1996. Pitt Street Bridge Park Pier Extension Project.

Located in the Old Village section of Mount Pleasant, the Pitt Street Bridge recreation area extends into the water towards Sullivans Island, a coastal barrier island. Prior to World War II, the Pitt Street Bridge served as the main access route to Sullivans Island. During the 1980's the area was converted into a public park to provide access to coastal recreational activities such as fishing, crabbing, and bird watching. This project involved constructing an extension of the fishing pier and boardwalk to improve safety and enhance public access to coastal resources. The park is located in an area of rapid growth and is accessible to all socio-economic groups and disabled citizens.

Hansen, T. 1997. Infrastructure Planning, Water Quality & the Clean Water Act.

The Federal Water Pollution Control Act Amendments of 1972 (The Clean Water Act), established a comprehensive Federal, State and Local water quality management program to prevent, reduce and eliminate water pollution. In South Carolina, the State's Pollution Control Act serves to implement the provisions of the Federal Clean Water Act. During 1991, the Bureau of Water Pollution Control of DHEC formalized a Watershed Water Quality Strategy for Water Quality Management Planning based upon the watersheds of the five major river basins in the State. Every five years the Department will either develop or revise one of the major watershed plans. The quality of natural resource based planning should be enhanced as water quality can be assessed, and programs developed, on a watershed basis where natural system boundaries are utilized to limit planning areas. The watershed strategy will provides the data needed to develop and issue NPDES permits, wasteload allocations, and TMDLs. The COG has maintained the 208 Plan for this Region to the present time and contains policies that provide long term direction to planning and day-to-day decision making. The Strategies set state water quality standards, provide an analysis of water quality conditions, establish TMDLs where needed, and provide for future planning activities (e.g. waste treatment and transmission systems over a twenty year planning). Projections are made over relatively small geographic areas (traffic zones) within the urban portion of the Region and by Census County Divisions outside the urban area. Traffic zones may be combined to designate the primary growth areas requiring special attention to protect water quality conditions.

Hansen, T. 1997. Infrastructure Planning - Transportation Planning.

Few planning programs have as great an impact upon patterns of growth then do those involving transportation systems. Transportation is essential for suburban and rural development and provides the freedom of access necessary for the enjoyment of opportunities within a metropolitan area. Access to employment, commerce, housing, recreation, and shopping among other amenities of life, requires that transportation systems be effective and efficient. Transportation networks are not independent of each other, rather they operate as a complete system where changes in one area affect the system elsewhere. This relationship makes coordination imperative when creating, or changing elements of networks. The U.S. Congress required the creation of a "Metropolitan Planning Organization" (MPO) to coordinate the plan-

ning process. The Charleston Area Transportation Study (CHATS) resulted from this legislation. The CHATS is an ongoing program that monitors and reviews the efficiency of the areas transportation system, and plans facilities and services needed to meet future needs of the CHP area. The CHATS is responsible project planning. The priority of any project is based on the following Primary Criteria: to (1) preserve and modernize key elements of the existing system; (2) mitigate or reduce the amount of congestion on the existing, or future road system; (3) improve safety of the current or future road system, and security of the system users; (4) improve mobility of people; and (5) improve mobility of freight to connecting points. Secondary Criteria are related to the natural and human environment and strive to (1) protect and improve the environment; (2) support planned economic activity; (3) promote preferred social activity; (4) support land use plans and goals; (5) be consistency with energy conservation programs; (6) have community support; and (7) provide or improve intermodal components.

Hansen, T. 1997. Municipal Solid Waste Landfills.

During Fiscal Year 1996, over 1.07 million metric tons (1.182 million tons) of solid waste were disposed of in landfills in the Berkeley-Charleston-Dorchester Region. These landfills include four active municipal landfills, eight industrial landfills, four construction, demolition and land-clearing debris sites, and one ash monofill site. Permitted capacities in the Oakridge Landfill are expected to be reached in September, 2010. The capacity of the Berkeley County Landfill may be reached by October 1998. Berkeley County has a permit for another landfill but it has not been constructed. The capacities of the two Bees Ferry Landfills in Charleston County may be reached by January 2006. The County is planning to locate a new landfill near the Bees Ferry facility when the existing capacity is reached. A major environmental concern associated with landfill operations is groundwater pollution due to leachates from older landfills. Each County in the CHP area has been required to prepare a Solid Waste Management Plan. These Plans must include an analysis of the existing capacities to dispose of solid waste and the identification of programs, facilities and finances needed to deal with anticipated waste disposal volumes over a twenty year period. Required Solid Waste Management Plans also include a description of the resource recovery or recycling programs to be implemented during the twenty year planning horizon. Specific minimum regulations for municipal solid waste landfills deal with airport safety, flood plains, wetlands, fault areas, seismic impact zones, unstable areas, hydrogeologic considerations, and buffer zones. As of this date, the only municipal landfill in this Region that meets RCRA standards is the Chambers Oakridge Landfill in Dorchester County.

Hefner, F. and H. Miley. 1997. A Policy Framework for Reconciling Economic Development and Environmental Preservation with Emphasis on the Charleston Harbor Project Area.

The goals of economic development and the preservation and conservation of natural, historical, and cultural resources are often seen as antagonistic. However, it is not necessarily the case that environmentalism and development must work at cross purposes. The purpose of this research was to investigate policies that would harmonize the two goals - environmental quality and economic development. The following four issues are addressed in this paper: 1) Environmental economics deals with the problems of externalities, both positive and negative. Externalities are either benefits received from the actions of others without paying for them or costs incurred by the actions of others. These problems are viewed as market failures since the market place cannot take into account the problems of externalities. The main focus on much of the economic analysis of environmental issues is to devise methods to make the market work. Since environmental issues are outside of the market, there is no way to establish price or value determined by the market for environmental resources. The first step in any kind of analysis is to measure the costs and benefits of environmental protection or degradation. 2) Economic development, particularly industrial recruitment, is a major policy goal of the state of South Carolina. Environmental protection needs to be placed within the context of the goals and policies of economic development. 3) Do preservation and conservation fit into an economic development strategy? This of course is the major issue that must be reconciled. 4) How do these issues apply to the Charleston Harbor Project Area? The main problem is how to interpret research and how to place the research within a policy framework that is usable. The goal of this project is to provide the framework for the research on the four issues. This framework should be understandable and usable for policy makers.

The environment is an economic good and has measurable economic value. It is suggested that an "inventory" of economic benefits of environmental protection and enhancement be made. The availability of this inventory would permit decision makers to have dollar figures for preservation. Recognizing that the environment has value, it is recommended that the CHP focus on "selling the product" and on adopting policies that make environmental protection work within a context of economic development. For example, designing methods to stream line the permitting process does not abandon environmental protection. Rather it reduces the regulatory costs and uncertainties often surrounding development and protection. Thus, it is suggested that the CHP identify the stakeholders and then sell them on the idea of protection. By taking a long term view while recognizing that elected officials and economic developers will often have much shorter horizons, the CHP can provide clear analyses. For example, conservation does not necessarily reduce a community's tax base by reducing the amount of land available for development.

On the contrary, by reducing the available land property values could grow faster and thus the dollar value of the tax base would be larger. Economic development and environmental development are compatible. Working with developers while protecting the environment is not inconsistent. CHP can serve the role of mediating between the two apparently inconsistent goals; especially by providing solid information and analysis. Environmental protection needs to be marketed. Economic development officials focus on a bottom line: dollars of income or profits and number of jobs. A line of research that would pay dividends in marketing environmental protection would be to construct a measure of the CHP's success: one that makes sense, is easy to understand, and conveys the value of the efforts.

Holland, A. F., D. E. Porter, R. F. Van Dolah, R. H. Dunlap, G. A. Steele, and S. M. Upchurch. 1993. Environmental Assessment for Alternative Dredged Material Disposal Sites in Charleston Harbor.

Depending on how and where it is accomplished, the disposal of dredged material may have substantial effects upon natural resources in the disposal area. Currently, more than 3.8 million cubic meters of material are removed annually from the channels of the estuary to maintain adequate water depths for Charleston's ship traffic. Twenty potential sites that had disposal capacities ranging from about 800,000 to 92 million cubic meters were identified. A habitat cover data base was developed for the potential sites that provided standardized data which could be used as a basis for projecting and evaluating environmental effects for each identified environmental concern. These concerns include effects on water quality, critical habitats, existing environmental quality, adjacent environments, material cycles, migration and movement patterns, groundwater, cultural resources, and human uses. The assessment allowed the identification of alternative disposal sites that had both small cumulative environmental and cultural impacts and small environmental and cultural costs per cubic meter. The existing dredged material disposal sites at Yellow House Creek, Naval Weapons Station, Drum Island, Clouter Creek, and the Ocean Dredged Material Disposal Site (for uncontaminated dredged materials) were projected to represent the least threat to natural and cultural resources and were the most acceptable alternatives to the Daniel Island Site. The sites generally have large capacities and are located in regions of the harbor where potential effects on ecological and cultural resources is low. None included preferred habitat for threatened and endangered species or blocked migrational routes for recreational and commercially important species. The combined disposal capacity of these existing sites is about 184 million cubic meters.

Martin, B., W. Hammitt, and A. Sheppard. 1997. Charleston Harbor Project: Resident Attitude Study.

This study assessed the perceptions and attitudes of residents of the Tri-County area toward environmental resource and growth issues, with emphasis on aquatic resources and habitats. A random digit dialing telephone survey was used to contact 743 residents, 350 of whom agreed to participate, resulting in a 47% response rate. Most respondents were long-term residents, averaging 21 years in the area; less than 7% owned waterfront property and less than 3% owned boat docks. The majority were college educated, actively employed, with household incomes in the $20,000 to $60,000 range. The 35 - 65 age category had the most respondents. Residents overwhelmingly agree that protection of the environment is important, and should be accomplished through development of a regional management plan. Residents are in favor of protecting both wetlands and habitat of shorebirds, even if it would incur a cost to themselves in terms of less access. Residents feel that historical and archeological sites are also important and should be protected. There is concern that the CHP's waters are not clean and safe for swimming and that they might not support a healthy fishery in the future. This is the management issue on which residents had the strongest feelings. Residents do not feel that the benefits of growth and development outweigh the negative consequences to wetlands, water quality, and fisheries; growth should only be supported if done in an ecologically acceptable manner. Residents feel that tourism has improved the economy and would like to see it continue as a major industry. Scenic and cultural vistas, and natural areas are important to residents, and were frequently rated as very important. The creation of natural vegetative buffers is important to residents for the protection of visual resources as well as fishery habitats.

Poplin, E.C. (Brockington & Assoc.) 1992. A Cultural Resources Reconnaissance of Possible Dredge Spoil Disposal Sites, Charleston Harbor, South Carolina.

This report is an assessment of the potential impacts of the construction and operation of dredged material disposal sites on known or suspected cultural resources. This assessment involved the identification of all known cultural resources within or adjacent to nineteen potential dredged material disposal sites for Charleston Harbor. Included are assessments of the kinds of effects that the proposed facilities would create, and the potential for these effects to detract from the significance of any listed, eligible, or potential National Register of Historic Places properties. A ranking of possible disposal sites was developed that was based on the sites probable effects on any cultural resources. A moderate potential for the existence of cultural resources, unknown at the present time, exists for Rodent Island, Cainhoy Road, Point Hope Island, and Town Creek. Upper and Lower Thomas Island possess a high potential for unknown resources. Parker Island contains 15 known National Register of Historic Places eligible resources and may contain additional submerged resources in adjacent streams and creeks. Fort Johnson is similar because of its proximity to Fort Sumter. Similarly, the use of the Old Landfill could

intrude upon the Magnolia Cemetery setting. Middle Shoal possess an extremely high potential to impact cultural resources based on its proximity to Castle Pinckney. Morris Island appears to have the highest potential impact on cultural resources. The site is near a National Register of Historic Places property, may include National Register eligible resources and unknown cultural resources associated with Civil War activities on the island.

Price, R.H. 1993. Model Marina Siting Ordinance Study.

This study provides an inventory of all existing (15) and proposed marina facilities, and community docking facilities in the Charleston Harbor area. All marinas are open to the public, and except for the Folly Marina that utilizes a septic system, all other marinas use public wastewater systems. Currently there are approximately 1,454 marina slips and 730 dry stack storage units in the Charleston Harbor area. Several marinas are planning to add additional slips. Marinas are regulated by Federal, state, and local. guidelines. Consequently the regulatory process is at times uncoordinated, resulting in poor siting decisions. In addition, some local governments are not compelled to feel concerned because marinas are permitted by the Department of Health and Environmental Control. Although it does permit marinas, it cannot address all issues related to marina development, specifically those related to land use and aesthetics. The purpose of this study was to ensure coordination among agencies to enhance appropriate and environmentally consistent marina development. A general overview of constraints to or elements that effect marina siting include the following: water quality classifications, water depth, bridges, streets and roads, wetlands and marshes, shellfish areas, existing land uses, and public services and utilities. The report provides a model ordinance for the Charleston Harbor Project area that would improve marina siting throughout the watershed.

Price, R.H. 1994. Economic Development Assessment for the Charleston Harbor Project. Planning Services Group, Inc. Charleston, SC.

The challenge facing the economic development of the Charleston Harbor area is twofold. First the base closures and realignments has created a vacuum that is, in the near term, difficult to fill. Due to the departure of the military presence from Charleston, over 22,000 jobs were lost with a corresponding offset of only about 6,000 jobs from NAVALEX and the military hospital. The annual economic impact in terms of lost wages is well over one billion dollars in direct and indirect wages. Additionally, the economy has traditionally relied on the military and tourism to provide jobs and general funds for the local tax base. As a result, the Tri-County economy is somewhat imbalanced and efforts should concentrate not so much on recruiting industries that will be easy to attract, but on attracting companies that can provide greater balance to the economy in the long run. Areas where significant deficiencies exist include food, paper, and fabricated metal products, printing and publishing, electronics and electrical equipment, and instruments and related products. It should be noted that fabricated metal products, instruments and electronics are all poised for significant growth in the coming years. As more and more industries are being recruited to the South, education and quality of life are becoming increasingly important and often outweigh cost considerations, in decisions to relocate. In addition, smaller communities and suburbs are becoming more competitive than their larger city counterparts due to trends in decentralization, technology, minimalist philosophies, and quality-of-life factors. Infrastructure capacity in the greater Charleston region is adequate, although the assimilative capacity of the rivers and estuary will be a concern to large water users who wish to perform their own treatment. The electric power rates in the region are some of the lowest in the United States, although natural gas rates are some of the highest. The relationship between these two energy commodities is no doubt influenced by the fact that there is single ownership, distribution rights, and control by one utility. This is a problem for the Charleston harbor area.

Price, R.H. 1995. The Charleston Harbor Project's Land Use Issues Study and Local Government Liaison Effort.

The mission of the Charleston harbor Project is to maintain the many uses of the water and natural resources, and to anticipate and act on potential problems before they harm the harbor system. Examination of how growth will affect the estuary, its resources, and adjoining lands is being conducted. The study covers most of the developed portions of Berkeley, Charleston, and Dorchester Counties. The need for local government involvement in the Project was realized immediately as critical to the implementation of the many policies that would be proposed by the different Task Forces. Local governments were involved in and relied on through every step of the Project. Their role will continue during the implementation phase . Once policy issues are defined, recommendations will be developed and taken to the municipalities and counties for adoption. The Project will look to the local governments to adopt ordinances that will carry out the various policies and plans of the final report. Important to the success of the implementation process will be the continued technical support to local governments by the Charleston Harbor Project staff.

U. S. Army Corps of Engineers. 1993. Daniel Island Alternatives for Dredge Disposal Study.

The purpose of the study was to identify the best alternatives to the continued use of the Daniel Island Disposal Area based on environmental, social, and cost factors. The 274 hectare Daniel Island disposal site at the southern tip of Daniel Island has been used for disposal of maintenance and new work dredged material since 1953. Dredged material from *Mile 5 to Mile 10* of the Cooper River channel including Town Creek, Wando River, and the Shipyard River is normally placed in the Daniel Island and Drum Island Disposal Sites. Daniel Island is owned by the Guggenheim Foundation and leased to the State Ports Authority. The current lease expires in January 1998. A total of 23 sites, both existing and potential, in the Charleston Harbor area were investigated for continued and potential disposal of dredged material. Sites were ranked in order of least cost and least adverse environmental effects. Detailed maps of each site are included in the report. The best alternative is to deposit the maintenance material in the existing Ocean Dredged Material Disposal Site. The Drum Island and Yellow House Creek Disposal Areas could then be used for any material unsuitable for offshore disposal. This plan has a unit cost estimate of $3.12 per *cubic yard* with an average annual cost of $4.6 million (1993 dollars) for the federal channel and $1.8 million (1993 dollars) for private dredging. Costing $2.1 million above the least cost plan, the additional funding would have to be provided by the non-federal sponsors and private dredging customers in the Charleston Harbor area. The alternative plan has greater adverse environmental effects, but promotes the development of the Daniel Island Disposal Area as a public park. In addition, several sites (for example Fort Johnson) would not be acceptable environmentally because of the diking and filling of salt marshes.

Watts, G. 1995. A Submerged Cultural Resource Management Document and GIS Database for the Charleston Harbor Project Study Area.

The submerged cultural resources of the CHP area preserve an important physical record of the city's development. Properly preserved and recorded, the remains of sunken ships, inundation sites, and maritime related structures can provide insight into the past that is otherwise unavailable in the historical record. This report includes a description of the development and contents of a geographical information system (GIS) based inventory of the submerged cultural resources of the study area and a management document and presents an overview of the area's history, types of archeological resources and their significance, legislation and regulations, as well as the agencies responsible for the protection and management of these resources. Initial literature and archive investigations focused on the documentation of activities such as exploration, colonization, development, agriculture, industry, trade, shipbuilding, commerce, warfare, transportation, and fishing that would have contributed to the region's submerged archeological record. Special attention was devoted to activities in the Charleston area, including the Ashley, Cooper, Wando, and Stono Rivers. Relevant manuscript sources of shipwreck data (libraries, archives, historical societies) were searched for site specific data associated with Charleston's history. Cartographic research identified a variety of maps and charts illustrating human activity along the Charleston Harbor area. These were examined for data related to historical and archeological sites, and shipwrecks. The identification of historic activity areas, such as brick yards, plantations, shipyards, ferry crossings, forts, redoubts, and landings was done to define high probability areas for submerged cultural resources. Since submerged archeological sites may be extensions of, or associated with, terrestrial sites, an examination of the historical record associated with settlement patterns, regional economics was also conducted. Sensitivity zones were created by overlaying the various historic, dredging, and remote sensing survey coverages. This allows one to examine the relationship between areas of historic significance, the level of possible site disturbance, as well as the level of archeological survey.

Welch, J.A. 1993. Examining SC's Marina Permitting Criteria: Should Regulators Evaluate Need?.

This paper discusses the general permitting criteria required for a developer to secure a permit for marina construction within the Charleston Harbor area. It deals specifically with the implications of the *need* and *demand* terminology as they relate to the marine industry and marina development. The intent is to present the South Carolina Coastal Council, a permitting agency, with clarifying information about the *need/demand* controversy surrounding the permitting of marina development. Recommendations include: 1) determine the compatibility of new marina development with community goals, 2) permit marina construction in stages, allow expansion only after demand is demonstrated, 3) define *need* as economic demand.

Artuso, A., *et al.* 1995. Proceedings of Two Point Source Permitting Workshops.

As part of the review and revision of its Water Quality Management Plan for Section 208, Federal Clean Water Act compliance, the Berkeley-Charleston-Dorchester Council of Governments found that the assimilative capacity of certain parts of the Cooper and Ashley Rivers may have already been allocated to waste discharges. The workshops were directed towards determining the allocation of total maximum daily loadings for the Charleston Harbor Estuary and other aspects of water quality planning. Policy options that received support were the creation of a growth reserve and the development of contin-

gency plans for responding to water quality problems caused by continued growth, drought, and other factors. Some areas of the estuary may already have sufficient unallocated capacity to accept any foreseeable new growth. Even in those sections where the total permissible loads have been fully allocated, several options exist:
1) requiring new industrial discharges to connect to public sewer systems where excess capacity exists; 2) directing certain types of industries to river stretches with unallocated biological oxygen demand (BOD) capacity; and 3) allowing new discharges to purchase BOD reduction credits from existing discharges in the affected river area. Recommendations for planning and policy development include the following:
1) For portions of the estuary where permitted loads have been fully allocated, but where actual loads are below permitted loads, establish policies governing industrial connection to public sewer systems with excess capacity.
2) Through coordination with local, regional, and state planners and development agencies, direct heavy industry to river stretches that are not water quality limited.
3) Examine alternative approaches to wastewater treatment including centralized treatment facilities, constructed wetlands, and land applications.

Blood, E. 1997. Watershed Land Use And Non-Point Source Runoff.

This project developed simulation models that provide non-point source inputs of water and nutrients for each estuarine segment based on drainage area and land use patterns. Two models were calibrated and validated for the non-point source simulations: Agricultural Non-point Source (AGNPS) and Simulator for Water Resources in Rural Basins - Water Quality (SWRBB). The AGNPS model is a spatially distributed surface flow model best suited for complex urban land uses because of the higher surface runoff from impervious surfaces. The model simulated the measured peak flows and total nitrogen loads with a very high degree of reliability ($R^2 = 0.99$). Peak flow was closely related to watershed size. Total nitrogen load and peak flow were a function of watershed soils and land use. The SWRBB water quality model is a drainage basin defined model and simulates hydrologic and related processes on a daily basis. The model provides excellent simulation of measured water yield and dissolved inorganic nitrogen loads. Total monthly water yields and dissolved inorganic nitrogen loads were with 3-8% of measured amounts during calibration and verification. The largest water yield comes from the Cooper River watershed and the lowest from the Ashley.
Nitrogen loads were simulated as surface dissolved inorganic nitrogen (DIN), sub-surface nitrogen (N), and sediment associated organic nitrogen (ON). Although the Ashley watershed is 63% of the Cooper River watershed, they both contributed about equal total quantities of surface DIN. The Wando River watershed contributed less than 2% of the total surface N load. The total organic N load to the harbor was 487,275 kg with the Cooper River watershed contributing 88% of the load. The Ashley River watershed organic N load was 10% and that of the Wando River watershed, 2%. The watershed is retaining or volatilizing 73-85% of the precipitation input. Nitrogen exports in surface flow from the watershed is 17% of atmospheric input. Point source discharges to the harbor are larger contributors to the total DIN than are non-point source loads. The non-point source surface DIN load is only 9% and the point source 91%. If the surface and sub-surface DIN is considered, then the non-point source contribution to the total DIN load (point source plus non-point source) to the harbor is 17% and point source 83%. The relative importance of point and non-point source loads varies with river basin. For example, in the Cooper River Watershed, point source loads were 94% when surface DIN non-point source loads are considered and 89% when the combined surface and sub-surface non-point source loads are used. Simulation results suggest that wetlands are reducing the potential non-point source loads by approximately 50%. Sub-surface transport of water and nitrogen is an important process because of the low topography (<1% slope) and porous soils. Urban land use generally contributes to higher surface flows and nitrogen load. The increased impervious surfaces also reduce sub-surface transport. The degree of non-point source runoff from urban areas was a result of both the extent and type of urban land use and watershed soils. Therefore, it is expected that as urbanization increased within the watershed, the importance of non-point source runoff will increase, but the rate of increase will vary with the soil types within the given watershed.

Calk, S. 1993. Septic Tank - Optical Brighteners as Tracers of Fecal Coliform Bacteria Contamination.

The contamination of productive shellfish harvesting grounds by fecal coliform bacteria requires their closure. The source of these bacteria is mammalian fecal material that includes, for example, dogs, birds, raccoons, and humans. The exact source of contamination is difficult to determine and is often attributed to failures of septic tank systems and/or runoff from highly developed urban areas. Thus remedial actions are difficult to identify, and in many instances no action is taken to reopen closed shellfish grounds. Optical brighteners, added to laundry detergents and found in waste systems (public and private), may be used to differentiate between human and nonhuman fecal waste. It also allows regulators to identify the sources of contamination, permitting corrective action to be initiated. Except in areas with sewage treatment plant discharges, where the concentrations of optical brighteners are extremely large, a number of "hot spots" were found that were coincidentally associated with closed shellfish sites. In addition, several areas on the public sewer system, showed positive levels in drainage ditches that suggested leaks from old sewer lines.

Carr, R. 1993. Toxicity Testing of Sediments from Charleston Harbor.

The toxicity of the surficial sediments of the Charleston Harbor Estuary was assessed using the amphipod, *Ampelisca abdita*, and the sea urchin, *Arbacia punctulata*. In the amphipod solid-phase test, no statistical difference in mortality between test and reference sediments was detected. In the sea urchin pore-water test, pore-water from 16 of the 83 sites tested resulted in significantly reduced fertilization.

Chapelle, F.H. 1996. Groundwater Transport of Bacteria and Nutrients from Septic Drainfields, John's Island and Isle Of Palms, South Carolina: Preliminary Summary of Findings.

Coliform bacteria, *E. Coli*, and nitrate are delivered to surface ground water from septic drain fields at sites on Johns Island and the Isle of Palms. At both sites concentrations of coliform bacteria, *E. Coli*, and nitrate were found to be several orders of magnitude higher at drainfield outfalls than further down gradient. At the Johns Island outfall, concentrations of coliform bacteria, and *E. Coli* bacteria ranged from 10^1 to 10^5 cells/100 ml, and 1 to 100 cells/100 ml of ground water respectively over a period of one year. The concentrations of *E. Coli* bacteria and nitrate decrease below detectable limits down gradient of the septic outfall. *The observed levels do not suggest contaminant transport from the septic* drainfields at these sites. This is concluded because background levels of coliform bacteria in shallow ground water bodies are naturally in the 10^3 to 10^5 cells /100 ml range and because concentrations of chloride and nitrate do not indicate contaminant transport down gradient.

Conrads, P. and P. Smith. 1997. Simulation of Temperature, Nutrients, Biochemical Oxygen Demand, and Dissolved Oxygen in the Ashley River Near Charleston, South Carolina, 1992-95.

Longitudinal dissolved-oxygen profiles of the Ashley river for various hydrologic and point-source loading conditions were determined using results from water-quality simulations by the Branched Lagrangian Transport Model. *The study area included the Ashley River from S.C. Highway 165 at Bacon* Bridge to S.C. Highway 17 near the confluence with the Charleston Harbor. Hydraulic data for the Branched Lagrangian Transport Model were simulated using the U.S. Geological Survey BRANCH one-dimensional unsteady-flow model. Data used to apply and calibrate the BRANCH model included timeseries of water-level data at three locations and measured tidal-cycle streamflows at four locations. Data used to apply and calibrate the Branched Lagrangian Transport Model included timeseries of salinity concentrations at three locations, high- and low-slack tide longitudinal salinity profiles from six sampling locations, nutrient and biochemical oxygen demand concentrations collected over a tidal cycle during two sampling surveys for six locations, nutrient and biochemical oxygen demand concentrations collected over five slack tides over two and three days during two sampling surveys for three locations, and continuous water temperature data and dissolved oxygen concentrations at three locations.

A sensitivity analysis of the simulated dissolved-oxygen concentrations to model coefficients and data inputs indicated the simulated dissolved-oxygen concentrations were most sensitive to equilibrium temperatures due to the effect of temperature on reaction rate kinetics. Of the model coefficients, the simulated dissolved-oxygen concentrations were most sensitive to sediment oxygen demand.

Scenario simulations were used to evaluate four point-source loading conditions to the system by comparing simulated dissolved-oxygen concentrations with a condition where there is no point-source discharge into the system (no-load) condition. Setting all the point-source loadings to advanced secondary treatment (10 milligrams per liter of ammonia-nitrogen [mg/L] and 20 mg/L of 5-day biochemical oxygen demand) decreased the total ultimate oxygen demand loading to the system by 28 percent and decreased the one-day mean dissolved-oxygen concentrations from the no-load condition by 29.9 percent or less. Setting all the point-source loading to advanced treatment (2 mg/L of ammonia-nitrogen and 10 mg/L of 5-day biochemical oxygen demand) decreased the total ultimate oxygen demand loading to the system by 78 percent and decreased the one-day mean dissolved-oxygen concentrations from the no-load condition by 8.1 percent or less. Setting all the point-source loadings to reclaimed-use treatment (0.5 mg/L of ammonia-nitrogen and 5 mg/L of 5-day biochemical oxygen demand) decreased the total ultimate oxygen demand loading to the system by 91 percent and decreased the one-day mean dissolved-oxygen concentrations from the no-load condition by 5.2 percent or less.

Conrads, P. and P. Smith. 1996. Simulation of Water Level, Streamflow, and Mass Transport for the Cooper and Wando Rivers Near Charleston, South Carolina, 1992-95.

This report presents the results of the calibration and validation of hydraulic and mass-transport models for simulating the movement of a conservative constituent (salinity) in the Cooper-Wando River system. These models simulate the water-level, streamflow, and mass transport of the rivers. The one-dimensional, unsteady-flow model BRANCH, and the Branched Lagrangian Transport Model (BLTM) were calibrated and validated for the Cooper and Wando Rivers. The simulated salinity concentrations were most sensitive to changes in the downstream gage datum. A decrease of 0.5 ft increased the simulated 3-day mean salinity concentration by 107 % (12.7 to 26.3 parts per thousand [ppt]). The range of the salinity concentration went from a tidal oscillation with a standard deviation of 3.9 ppt to a nearly constant concentration with a standard deviation of 0.0 ppt. An increase in the downstream gage datum decreased the simulated 3-day mean salinity concentration by 47% (12.7 to 6.7 ppt) and decreased the standard deviation from 3.9 to 3.4 ppt.

Conrads, P., T. Cooney and B. Long. 1995. Hydrologic and Water Quality Data from Selected Sites in the Charleston Harbor Estuary and Tributary Rivers, South Carolina, Water Years - 1992-95.

To support the Charleston Harbor Project water-quality model development, hydrologic and water-quality data were collected from 45 stations from October 1991 through September 1995 in the estuary and its tributary rivers. Hydrologic data include continuous stage data recorded at 15-minute intervals from 22 gauging stations, and tidal-flow measurements made at nine streamflow stations. Water-quality data include continuous 15-minute temperature, dissolved oxygen, specific conductance, salinity (calculated from temperature and conductance), and pH from 20 monitoring stations. Nutrient, biochemical oxygen demand, and suspended-sediment concentrations recorded at 15-minute intervals at 35 sampling stations.

Conrads, P. and P. Smith. 1997. Simulation of Temperature, Nutrients, Biochemical Oxygen Demand, and Dissolved Oxygen in the Cooper and Wando Rivers Near Charleston, South Carolina, 1992-95.

Longitudinal dissolved-oxygen profiles of the Cooper River for various hydrologic and point-source loading conditions were determined by using results from water-quality simulations by the Branched Lagrangian Transport Model (BLTM). Hydrodynamic data for the BLTM were simulated using the BRANCH one-dimensional unsteady-flow model, and included: nutrient and biochemical oxygen demand (BOD) concentrations at nine and five sites on the Cooper and Wando Rivers, respectively; continuous water temperature at two locations on each river, and continuous dissolved oxygen (DO) concentrations at three locations on the Cooper and two locations on the Wando. A sensitivity analysis of the simulated DO concentrations to model coefficients and data inputs was conducted. Of the model coefficients, the simulated DO concentrations were most sensitive to reaeration rates. Of the data, the simulated DO concentrations were most sensitive to the equilibrium temperature. A variety of water-resource management scenarios were simulated with the model. The time of travel of the system was simulated by injecting a conservative tracer at the upstream boundary of the Cooper River. The leading edge of the tracer reached the downstream boundary of the model 10 days after the beginning, and the peak concentration reached the boundary in 18 days. Flows from the Jeffries Hydroelectric Plant at Pinopolis Dam were increased and decreased by 50% to evaluate the effect on the DO concentrations of the Cooper river. Decreasing flows by 50% (from a 30-day average of 4,032 to 2,016 ft^3s^{-1}) decreased the 24-hour mean DO concentrations by 8.0% or less at 10 fixed sites on the Cooper River, as compared to the 24-hour mean DO concentrations using the actual flows from the dam. Increasing the flows by 50% (from a 30-day average of 4,032 to 6,048 ft^3s^{-1}) increased the 24-hour mean DO concentrations by 4.0% or less at eight of the 10 sites and decreased by 4.6% or less at the lower two sites. The decrease in the 24-hour mean DO concentrations with the increase in the flows from Pinopolis Dam is due to the moving of the DO profile (DO sag) downstream. Various point-source loading conditions were simulated and evaluated. Setting all the point-source loadings to the fully permitted levels decreased the 24-hour mean DO from the no-effluent condition by 35% or less. Setting all the point-source loadings to minimum wastewater treatment concentrations of secondary treatment (20 ppt of ammonia, and 30 ppt of BOD) decreased the total loading to the system by 65% and decreased the 24-hour mean DO from the no-effluent loading condition by 16% or less. Projected point-source loadings for the years 2000, 2005, 2010, and 2015 were input into the water-quality model. Decreases over the 1997 fully permitted levels are projected for years 2000, 2005, 2010, and 2015 with decreases of total loading to the system of 43, 40, 32, and 30%, respectively. The projected decrease in the 24-hour DO for the loading condition of the year 2015 over the no-effluent loading condition is 32% or less as compared to 35% for the fully permitted 1997 condition.

Douglas, A. P. 1995. Spatial and Temporal Patterns of Inorganic Nitrogen and Phosphorous Distributions in the Goose Creek Estuary: Cooper River/Charleston Harbor Estuary System.

Eutrophication or enrichment of inorganic nutrients of coastal and estuarine waters is becoming a serious problem, nationwide and can cause increased plant production, decreased dissolved oxygen, and changes in species composition. Reduced water quality as seen in an estimated 55% of estuaries has been traced to elevated nutrient concentrations. In estuaries the nutrients, phosphorous and nitrogen exist in particulate and dissolved forms. To better understand the spatial and temporal distributions of nutrients and their roles in determining the water quality in the Charleston Harbor Estuary, the Goose Creek subbasin of the Cooper River was selected for study. In this study, the inorganic nutrients ammonium, nitrate, and orthophosphate were monitored along the salinity gradient of Goose Creek from June 1992 through November 1993. Ammonium ranged from 1 to 138 ug-at/l. Elevated concentrations occurred during the summer and may have been caused by interacting point source wastewater discharges, tributary inputs, and remineralization. Nitrate concentrations ranged from 1 to 49.5 ug-at/l and displayed a distinct seasonal pattern with concentrations in the fall significantly higher than in the winter. Remineralization, nitrification, and municipal point source input contributed to elevated summer levels with concentrations being higher in the upper than in the lower reaches of Goose Creek. Municipal wastewater discharges contributed to elevated nitrate concentrations in the upper reaches, and this peak was displaced downwater

stream resulting in higher concentrations in the middle region than in the lower reaches of the creek. The mean nitrate concentration in the discharge (569.7 ± 110 ug-at/l) was significantly higher than in waters from urban and forested tributaries. As with ammonium, nitrate concentrations in urban tributaries were significantly higher than in forested tributaries.

Einsmann, M.R. 1994. Interfacing One-Dimensional Hydraulic and Water Quality Models for Application to the Charleston Harbor.

To evaluate the water quality of the tributary rivers of the Charleston Harbor estuary an hydraulic flow model (BRANCH) was coupled with a water quality model (WASP). This approach permitted a simulation of the movement and fate of various constituents (salt and fresh water, pollutants) within the rivers, canals, and creeks of the estuary. The relative importance of the tributary creeks to main channel water quality was determined. Tested with water quality data from the Cooper river and its tidal creeks, it was found that the flows into and out of the creeks were significant in comparison to those within the river itself. However, these flows were not important to the mixing of brackish and fresh waters since there is limited freshwater input through the creeks. The coupled models were calibrated and validated with salinity data from the Cooper River. Average salinity values were reasonably predicted. The model predicted, with far less certainty, the salinity values as these changed with changing tidal conditions. Improved flow data would permit a better calibration of the WASP water quality model. This would provide better predictions of constituent distributions.

Hayter, E. 1996. Water Quality Management Using Restored Wetlands in the Sawmill Branch Watershed.

Sawmill Branch is a large, channelized tributary of the Ashley River. The channelization permits the rapid movement downstream of poor quality stormwater. The lack of holding and assimilative capacities of the creek is degrading water quality and biological communities in the lower Ashley River and Charleston Harbor. An abandoned wetland, originally designed in the late 1980's to hold stormwater runoff from residential developments was restored in a potentially cost-effective and energy-efficient means of improving the quality of waste and stormwater runoff prior to its entering the Sawmill Branch Tributary.

Hockensmith, B. L. 1996. Effects of Irrigation from Ponds on the Shallow Aquifers of Wadmalaw Island, South Carolina.

A flow model was constructed to simulate the ground-water system on Wadmalaw Island, near Charleston, South Carolina, in order to assess the potential for well interference and saltwater encroachment as a result of pumping from irrigation ponds. Hydrologic data were collected from 5 domestic wells, 25 observation wells, and 4 pond staff gages for 21 months. The shallow, unconfined aquifer in the study area is a well-sorted, fine-grained sand. In this aquifer, for the period of record, water levels were lowest during October 1993 and highest during March 1994. Seasonal variations in water level as great as 7 feet have been noted in the aquifer. During irrigation season, pond levels declined only slightly more than the maximum seasonal fluctuation of the water table.
Well interference and saltwater intrusion induced by pond pumping were found to be minimal because of the aquifer's low hydraulic conductivity. Cones of depression centered on irrigation ponds were steep but of small areal extent. Ground-water flow patterns were such that domestic-well contamination from farming practices was minimal.

Kelly, D. M. 1993. Review of Nonpoint Source Pollution and Best Management Practices (BMPs) Along the South Carolina Coast.

Nonpoint source pollution derives from poorly defined or diffuse sources. Pesticides, heavy metals, nutrients, suspended solids, and fecal coliform bacteria are often found in lakes, rivers, streams, and estuaries. These nonpoint source pollutants are primarily the result of human activities within the watershed of the affected water body. And unlike point source discharges such as municipal sewerage treatment effluent, the identification of the sources of these pollutants is exceedingly difficult to isolate. In a survey of nonpoint source water pollution by South Carolina management agencies found that 336 water bodies were affected. Of these, 43% were influenced by storm water runoff, and 14% by construction activities. The remaining 43% were affected by practices associated with agriculture, industry, forestry, mining, land fills, and urban development. In the state, it was determined that the control of nonpoint sources of pollution could best be accomplished through education and the implementation of best management practices. Prevention of nonpoint source pollution from reaching water bodies is much less expensive than the treatment of compromised bodies. Best management practices for the control of nonpoint source pollution in the Charleston Harbor area are divided into seven categories and include: 1) agricultural activities, 2) forest activities, 3) construction activities, 4) mining activities, 5) solid waste disposal, 6) urban storm water runoff, and 7) hydrologic/wetlands modifications. Storm water best management practices include structural and non-structural measures. A structural best management practice is the construction of detention or retention ponds to control the quality and quantity of storm water runoff. Structural measures include: detention and retention ponds, infiltration basins and trenches, porous pavement, vegetative systems (grassed swales, filter strips, urban forest, basin landscaping, constructed wetland), and

quality inlets for the removal of oil and grease. A nonstructural best management practice for the control of water quality is a regulation/guideline for the disposal of used motor oil.

Kjerfve, B. 1995. Historic Water Quality Data Base.

The purpose of this project was to collect and edit into a common format existing hydrological and water quality data for the Charleston Harbor basin, and to incorporate this data into a searchable database. The database consists of data obtained from the National Ocean Service, the National Climatic Data Center, the United States Geological Survey, the Santee-Cooper Power Authority, and the University of South Carolina. The data include water level, temperature, conductance, conductivity, salinity, discharge, rainfall, wind speed and direction, dissolved oxygen, turbidity, ammonium, nitrate-nitrite, and ortho-phosphate concentrations. Some of the data bases extend back to 1922 and continue through 31 December 1994, when data collection terminated. The bulk of the data exists in an hourly format.

Klaine, S.J. and P. Rogers. 1994. Characterization of the Water and Sediment in Brickyard Creek, Charleston, SC.

Brickyard Creek is a first order stream that drains a subdivision, and industrial park prior to entering the Ashley River. This study quantified non-point source pollutants entering the Creek. Water samples were collected during the storm and surficial sediment samples collected 10 days prior to the event. Both water and sediment samples were analyzed for the full suite of anions, including fluoride, chloride, bromide, nitrate, nitrite, orthophosphate, and sulfate, as well as the metals cadmium, nickel, chromium, lead, and zinc. Fluoride was below detection limits. Chloride increased rapidly at Site 7, probably due to the influence of saltwater from the Ashley River. Nitrite was very low, but nitrate was measured up to 7 mg/l and probably entered the system early in the urban areas. Orthophosphate was very low and increased downstream to a high at Site 7. The data suggest that Sites 1 and 7 export nitrate. This is obvious from the increase in nitrate concentrations at these sites as the storm progressed. Nitrate levels at the other sites remained static or decreased during the storm. Site 1 is immediately downstream from homes with lawns that appear to be fertilized. Site 7 drains an undeveloped wetland. Sulfate concentrations were highest near the mouth of the Creek and are related to the proximity of saltwater. Sulfate concentrations dropped below 20 mg/l at all sites by the end of the event suggesting either dilution or flushing from the system. Instantaneous sulfate flux dropped at all sites throughout the storm indicting no significant sources of sulfate entering the Creek from the watershed. Zinc concentration profiles were similar to those of sulfate. All metals were detected, at low levels in the sediments even considering the industrial nature of the lower Creek. Chromium did increase to a high of 24 mg/kg. No significant levels of metals were measured in the runoff.

Klaine, S.J. 1994. Non-point Source Monitoring at the Ardmore site - Stormwater Retrofit.

Storm event monitoring was conducted to characterize pollutant loadings associated with runoff from parking lots. The runoff was analyzed for chlorides, nutrients, petroleum hydrocarbons, and lead. Analyses of storm events indicate a first flush phenomenon for chloride and sulfate with the majority of the load coming within the first hour. No lead, nitrite, bromide, or petroleum hydrocarbons were detected. Nitrate and orthophosphate were not detected until the second hour of the storm event.

Klaine, S.J. 1995. The Environmentally Friendly Coastal Golf Course: An Architect and Superintendent's Manual.

A technical manual to serve as a guide for the design, construction and maintenance of golf courses in the coastal southeastern United States. Golf courses are manipulated environments that require significant energy (chemicals - pesticides and nutrients, physical labor) to maintain their organization. The challenge today is to facilitate the coexistence of this high-energy system with sensitive ecosystems adjacent to the courses. This is especially true along the coast where golf courses are designed into beach dunes and through sensitive marsh habitat. The potential environmental effects of golf courses include, leaching and runoff of nutrients, soil erosion and sediment losses during construction, degradation of surface waters receiving runoff, the exposure of nontarget organisms to pesticides and elevated nutrient levels, the overuse of chemicals resulting in the development or resurgence of resistant insects and turfgrass diseases, the excessive use of water resources, and the disturbance of wildlife and their habitats during construction.

Lackey, K. A. 1994. Development of Nutrient Flux Values to Simulate Wetland Exchanges.

Two components of non-point source pollution were added to the two-dimensional WASP (Water Quality Analysis Simulation Program) water quality model of Charleston Harbor: watershed runoff and wetland exchange processes. To include the wetland exchange processes, net nutrient fluxes were used to increase or decrease water column concentrations during each tidal cycle. Many factors such as pH, temperature, salinity, vegetation, extent of inundation, etc. are important in determining the overall flux of a marsh. Nutrient fluxes vary significantly from marsh to marsh making it necessary to base all flux

values on site specific data from Charleston Harbor. A complete set of flux values for all nutrients simulated by WASP was developed from data collected from Brown Pond and Dill Creek in the Charleston Harbor Estuary. These include: ammonia, nitrate, organic nitrogen, organic phosphorous, orthophosphate, and dissolved organic carbon. The net flux values were seasonally averaged due to limitations in the field data.

Lackey, K., Black and Veatch, S. C. McCutcheon, and J. Ramsden. 1996. Wetland Fluxes and Watershed Nonpoint Source Contributions to the Total Maximum Daily Load of Organic Material and Nitrogen.

The water quality of Charleston Harbor is in fair to good condition, or better than most estuarine waters near a major metropolitan area. However, the waste assimilative capacity of the lower Cooper River was over permitted as of 1992. Any further loading beyond the permit levels in place in 1992 is expected to cause even lower dissolved oxygen concentrations than the standard of 4 mg/l. The critical area along the lower Cooper includes Daniel Island where intensive residential development is expected soon. In areas of the Wando River dominated by wetlands, typical dissolved oxygen levels are already below 4 mg/l, probably due to natural conditions. The elevated nutrient concentrations in the Ashley River indicate the onset of eutrophy. Both the Wando and Ashley rivers have a much lower waste assimilative capacity because of the much lower freshwater flows. This project: 1) estimated the estuary-wide flux of ammonia, nitrate, organic carbon, phytoplankton, orthophosphate, and organic phosphorus from measurements available, 2) compared those estimates with fluxes obtained from other estuaries of similar characteristics, and 3) linked loads from the watershed model and wetlands to the water quality model. A preliminary calibration and sensitivity analysis shows that the dissolved oxygen and nitrogen balances are influenced by wetland fluxes. During the summer, ammonia is imported into adjoining wetlands, and exported during less critical seasons. Phosphorus is exported but does not affect the dissolved oxygen balance. The effect of phytoplankton and organic carbon export during the critical summer periods is limited.

Lindner, B.L., *et al.* 1996. Studies of Air Deposition of Pollutants in the Charleston Harbor Watershed.

South Carolina is one of the few states that currently meets all National Ambient Air Quality Standards. There are only eight such states in the United States, and of these, three are coastal. The tri-county area enjoys some of the best air quality in the state that is probably related to the area's Class 1 Area air quality classification. This U.S. Congress designation is to preserve the relative pristine nature of the area due to its proximity to the Cape Romain National Wildlife Refuge. New facilities with sulfur dioxide emissions are difficult to locate near Charleston because more than 94% of the allowable Class 1 level for sulfur dioxide has been used. The contribution of atmospheric deposition to pollution levels within the Charleston Harbor area was evaluated at ten watershed sites over a five month period from July through December 1995. The rainwater samples collected from the Charleston Harbor Watershed were analyzed for fluoride, chloride, phosphate, nitrate, sulfate, and pH. Phosphate was not detected and sulfate concentrations showed no trends or patterns between sampling sites. Inland sites had higher concentrations of nitrate, perhaps related to anthropogenic sources and continental dust aerosols. Chloride and fluoride concentrations were higher for oceanside sites than at inland sites and is probably due to their proximity to sea spray aerosols. Developed oceanside sites had higher fluoride, chloride, and nitrate concentrations than did undeveloped oceanside sites. Whether or not this condition is due to anthropogenic sources is difficult to ascertain with the limited data. An annual cycle is evident in the pH data with a low in the summer and a high in the autumn/winter period. This may be caused by the acidic aerosols produced by pine trees during the growing season or increased summertime automobile emissions, or a combination of natural and anthropogenic sources.

McCutcheon, S.C. 1996. Evaluation of Retention Ponds and Other Best Management Practices for Controlling Non-Point Source Pollution.

Nonpoint source pollution unrelated to point sources from municipal sewage treatment and industrial plants, results from different land uses and practices. The primary land uses that degrade streams, rivers, lakes, and estuaries, include agriculture, silviculture, and urban development and activities. Urban runoff is derived from residential, commercial, and industrial land uses. Total urban contaminant loads are related to residential and commercial areas because of the extensive areas covered. The management of nonpoint sources, involves for the most part, the use of Best Management Practices (BMPs) in the United States. These practices prevent or control the levels of contaminants reaching estuaries, lakes, rivers, and streams and include: 1) constructed flow controls that remove contaminants from the runoff, and 2) nonstructural measures that limit the contamination of the runoff. This study evaluated the use of retention ponds to control the quality of urban runoff. Detention ponds that dry out between storms are less efficient in trapping contaminants and are normally employed only for flood control. Both ponds have essentially homogenous land uses throughout the watershed, one commercial and one residential. The selected ponds did not have sheet flows, although good design practice recommends that runoff be distributed over vegetation strips to remove the larger suspended solids. Gross removal efficiencies are comparable to or better than removals expected from primary treatment of wastewater. Compared to retention pond performances elsewhere, the Charleston ponds are effective in trapping contaminants. These ponds provide

limited control of coastal nonpoint source pollution. Trapping of contaminants continues between storms from settling and nutrient uptake in the permanent pond. The buildup of solids over time and their removal represent a hazardous waste management problem. Nationwide, a shift to infiltration BMPs is occurring but this may not be highly useful in coastal areas where ground water levels are near the ground surface. However, the selective use of infiltration trenches, medians, and swales should be a part of the designs considered in coastal areas, especially in large developments. The use of infiltration ponds may not be possible in low lying areas but should be considered in higher areas away from the immediate coastline or where sandy, porous soils have a high infiltration capacity. Infiltration normally captures one hundred percent of urban contaminants.

McCutcheon, S.C. 1995. Coupling of Two-Dimensional Hydrodynamic and Water Quality Models to Simulate Wetting and Drying.

The purpose of this work was to develop a means to simulate the inundation (wetting) and drainage (drying) of tidal mudflats in the water quality model for the Charleston Harbor Estuary. The work required a linkage system that averaged the flows from the hydrodynamic model (Tidal Residual Intertidal Mudflat Model) over space and time for input into the water quality model (Water Quality Analysis Simulation Program). The linkage was tested by investigating the conservation of the mass of salt, and by simulation with the WASP model to assess performance against measured values. The following were found: 1) inaccurate calculation of TRIM average depths; 2) Wetting and Drying algorithm worked in marsh segments and slightly affected adjacent wet segments; 3) conservation of mass was obeyed in wet segments but not in marsh segments; and 4) WASP correctly simulated the phase, but not the range of measured salinities.

McKellar, H., A. Douglas, A. Smith, T. Munnerlyn, and R. Rao. 1996. Nutrient Dynamics and Water Quality Interactions in the Goose Creek Sub-basin of the Charleston Harbor Estuary.

Water quality in urbanized estuaries may be affected by a variety of inputs from human development including municipal and industrial wastewater discharges, as well as nonpoint source urban runoff. These factors interact with a complex set of natural estuarine processes including freshwater runoff, tidal movements, and ecological function in the water, sediments, and wetlands. Long-term water quality management requires an understanding of the interactions and influences of these processes. As part of the Charleston Harbor Project, this study quantified dominant patterns of water quality distribution (oxygen, nutrients, algal biomass) in the Goose Creek sub-basin of the Cooper River estuary. In addition, the relationships of these patterns to freshwater runoff, wetland exchange, wastewater discharges, and nonpoint source runoff were examined.

Water quality in the Goose Creek estuary displayed distinct spatial and seasonal trends related to the location and timing of several key interacting factors. Water quality conditions were most critical during the summer when higher temperatures and lower freshwater discharge led to an accumulation of nutrients, algal blooms and oxygen depletion. Nutrients increased during the summer with ammonium concentrations exceeding 100 FM in July. In response to higher nutrients, algal biomass increased to levels indicative of eutrophic conditions with chlorophyll concentrations exceeding 40 mg/l in the upstream reaches of the estuary. Dissolved oxygen fell below water quality standards (< 4 mg/l) throughout much of the estuary. Although this general pattern was part of a natural seasonal cycle, the severity of conditions was impacted by elevated nutrient loading from wastewater discharges and localized urban runoff. Maximum nutrient concentrations in the estuary occurred in the vicinity of the wastewater discharges and urban runoff. Minimum oxygen concentrations occurred several km downstream as oxygen demand from these sources was exerted.

The effects of wastewater discharge and stormwater runoff were mitigated by extensive tidal wetlands, which removed and transformed nutrients during tidal inundation. We found consistent trends of nitrogen uptake by the tidal marshes, which removed 20-34% of the nitrate flowing across the marsh during each tidal cycle. Nitrate uptake by the wetlands exhibited a distinct seasonal pattern of daily removal ranging from 0.6-10.7 mg N/m^2 during the winter to 30-35 mg N/m^2 during summer and fall, yielding an annual uptake of 8.4 g N/m^2. Ammonium exchanges suggested a tendency for net annual export (5.7/g/m^2/yr) although values were more variable with no apparent seasonal pattern. Dissolved organic matter exchanges in the wetlands were also variable but displayed a strong tendency toward net export (57.3 g C/m^2/yr). Algal biomass (chlorophyll-a) was exported from the marsh during the winter (0.1-0.8 mg/m^2/da) and imported during the late summer and fall (1.4-1.9 mg/m^2/da) yielding an approximate annual balance. The net removal of dissolved inorganic nitrogen by the tidal marshes (21.1 metric tonnes/yr) was a significant fraction of the overall nitrogen budget for the estuary and provided a buffer to potential impacts of point-source wastewater discharges, as well as nonpoint urban runoff.

Rogers, B., D.M. Kelly, and S.C. McCutcheon. 1993. Data Collection Plans to Determine the Efficiency of Detention/Retention Ponds in Trapping Contaminants.

This reports presents the Quality Assurance/Quality Control protocols for the evaluation of the efficiency of detention/retention ponds in improving water quality. This work is part of the evaluation of structural and non-structural best management practices that aid in the reduction of erosion, flooding, and surface water contamination in the Charleston Harbor Estuary. Detention/ retention ponds are permanent stormwater management structures having the primary purpose of temporarily storing stormwater runoff and releasing it at a controlled rate. The plan consists of three sections: 1) the collection of meteorological, hydrologic, and hydraulic data, 2) sampling procedures and water collection, and 3) guide to field and laboratory procedures for the determination of the water quality parameters of interest.

Ross, P.E. 1994. 1994 Report of the Isle of Palms Connector Study for the Charleston Harbor Project.

Ross, P.E. 1995. Building a Better Bridge, a Study of the Isle of Palms Connector.

Studies suggest that highway runoff from bridges can introduce potentially toxic materials such as metals and hydrocarbons into the surrounding environment. Concern arose about such pollutants entering the wetlands during the operation of the bridge connecting the Isle of Palms with Mt. Pleasant, South Carolina. Integrated into the design of the bridge was a series of collector pans and gravel spoil areas to capture potentially toxic materials prior to the runoff reaching the wetlands surrounding the bridge. Studies have shown that sediments under bridges with drain and gutter systems have lower metal concentrations than sediments under bridges with scupper drains. Bioassays were conducted quarterly over a two year period on: the Atlantic little neck clam (growth), black-seeded Simpson lettuce (growth), and a bioluminescent bacteria (Microtox® EC_{50}). The results are at best inconclusive due to the short time frame of the study. However, if the increase in growth rates is due to the addition of trace metals and nutrients to the marsh, then one might expect to observe toxicity levels in the clams and lettuce as bridge traffic and bioaccumulation of the metals and hydrocarbons continues.

Scott, G.I. and M.H. Fulton. 1996. Contaminant Chemistry and Ecotoxicology.

This report identifies the extent of chemical contamination of bottom sediments and quantifies their potential toxicity to living marine resources. Trace metal pollution of sediments is confined to regions of the Ashley and Cooper Rivers where industrial point source discharges and shipyard activities exist. High levels of polycyclic aromatic hydrocarbons (PAHs) occur throughout the Charleston Harbor, with the highest concentrations observed in the upper reaches of small tidal creeks such as Koppers, Diesel, and Shem. High concentrations also occur adjacent to large roadways (e.g. I-26 and I-526) and high density urban developments. In the upper harbor, pyrogenic petroleum combustion products are the major source of PAHs. Polychlorinated biphenyls and persistent pesticide concentrations are elevated at several sites in the harbor and occasionally found to exceed sediment quality guidelines (e.g. Chlordane and DDT) in the upper reaches of smaller tidal creeks adjacent to industrial and urbanized areas. Toxicological analyses of the sediments found less than 22% of harbor sites degraded. These sites are adjacent to industrial and highly urbanized areas. There is a high probability that trace metal toxicity is responsible for this contamination. Only 16% of sites in the upper reaches of the smaller tidal creeks are degraded. Copepod toxicity tests found significant reductions in reproductive success, but no significant adult mortality from industrial and municipal outfall sites. These findings suggest that most toxicity associated with sediment contamination in Charleston Harbor appears to be a chronic condition and that effects on reproduction appear to be the toxicological endpoint. Adult grass shrimp abundances in Charleston Harbor are reduced by more than 90% as compared to the North Inlet reference site. In addition, alterations in reproduction (reduction in % gravid females) and growth (increased sizes at the Koppers site) were observed. The most affected sites are Shipyard, Koppers, and Diesel Creeks. Larval grass shrimp abundances are not significantly different in comparisons with those of the North Inlet site. This suggests that the survivorship from larvae to adults is greatly reduced at many Charleston Harbor sites.

Scott, G.I. et al. 1994. A Survey of Sediment Toxicity in Charleston Harbor, Winyah Bay, North Edisto River and North Inlet Estuaries of South Carolina.

During the summer of 1993 sediment surveys were conducted in the Charleston Harbor estuary as part of the National Oceanic and Atmospheric Administration's (NOAA) National Status and Trend Program. Samples for toxicological analyses were collected from 24 NOAA and 11 Charleston Harbor Project stations located in the Ashley, Cooper, and Wando Rivers, and lower Charleston Harbor. Reference (control) samples were collected from a site in the pristine North Inlet estuary. Toxicity tests included the Microtox® sediment bioassay and a copepod chronic toxicity test. Sediments consisted of predominantly silt/clay and sand sized particles. The results clearly indicate that sediments from the

Charleston Harbor estuary are potentially toxic in comparison to sediments from the North Inlet. The sediments become toxic to animals swimming in the estuarine waters when resuspended and to animals attempting to colonize the estuarine bottom. Physical examination of the Charleston Harbor estuarine sediments showed no bioturbation (presence of animals) in 61% of the stations. Additionally, 35% of the stations sampled contained sediments with visual evidence of petroleum hydrocarbon pollution (a petroleum sheen). Results from the Microtox® toxicity tests showed that 25% of the stations contained potentially toxic sediments. The most toxic sediments were found in the Ashley River near the Koppers site, Detyens shipyard, and Dolphin Cover Marina, at industrialized sites along the Cooper, Ashley, and Wando Rivers, and in mid-Charleston Harbor. Copepod toxicity tests showed no adult toxicity, but significant effects on reproduction (clutch size, copepodite and naupliar production). The most toxic sediments were found in mid- and lower-Charleston Harbor, and the Ashley River. Both trace metals and polycyclic aromatic hydrocarbons from industrial sources and urbanization are likely sources.

Szymanski, D.M. 1994. An Examination of On-Site Wastewater Disposal Policy in the Coastal Zone: Implications for the Charleston Harbor Project Area.

On-site wastewater systems (septic systems) are estimated to be responsible for between 23 and 39% of all shellfish closures in the southern United States. Efforts to implement more stringent septic regulations are difficult because of the effects such regulations are perceived to have on land use. A number of factors affect the ability of a local jurisdiction to implement septic system regulations: 1) public attitudes towards land use changes; 2) the governments' (federal, state, and local) roles in the process; 3) technical uncertainties; 4) socioeconomic factors; 5) adequacy of resources for implementation; and 6) the scientific basis of the regulations. Shellfish waters in the CHP area are in relatively poor condition compared to the remainder of the state's estuaries. Only 17% of state waters are prohibited as compared to 71% in the CHP area. Septic systems are identified by NOAA and the state shellfish sanitation agency as one of the five pollution sources responsible for the impairment of shellfish waters. The other sources are sewage treatment plants, industry, urban runoff, and boating. Septic system policy requires a six inch separation between the drain field and ground water, a fifty foot setback from water bodies, and EPA specified loading rates. There is no inspection and maintenance program, and no special provisions to protect coastal waters. Failing systems are not required to be upgraded to current state regulations; simply repaired. Implementing more effective septic system regulations involves many complex issues. The most critical factor is the attitude of the public towards the changes in land use required by more effective regulations. If a jurisdiction is indifferent to the effects that more stringent regulations will have on land use, or if it considers those effects desirable, implementing new policy will meet few political obstacles. If the public is adverse to land use controls, new regulations will be difficult to implement.

Wendt, P. H., R. F. Van Dolah, M. Y. Bobo, T. D. Mathews and M. V. Levisen. 1995. A Study of Wood Preservatives Leachates from Docks in an Estuarine Environment.

This study focused on the biological effects of metal and organic leachates from wood preservatives used to protect dock pilings, bulkheads, and other wooden structures from decay or infestation. Copper, chromium, arsenic, and polynuclear aromatic hydrocarbons (PAHs) were measured in surface sediments and naturally occurring oyster populations (*Crassostrea virginica*) from creeks with high densities (9-18 docks/km shoreline) of docks, and from nearby reference creeks having no docks. Sediments from all but one site had metal and total PAH concentrations that were below levels known to cause biological effects. Microtox® bioassays using whole sediments and rotifer bioassays using sediment pore water showed no significant differences in acute toxicity between creeks with and without docks. Oysters growing directly on dock pilings had significantly higher concentrations of copper than oysters rowing at least 10 m away. However, there were no significant differences in the physiological conditions of these oysters. Four-day field bioassays measuring percent survival of mummichogs (*Fundulus heteroclitus*), mud snails (*Ilyanassa obsoleta*), juvenile red drum (*Sciaenops ocellatus*), and juvenile white shrimp (*Penaeus setiferus*) showed no significant differences between sites near to and distant from newly constructed docks. Hatchery-reared oysters showed no significant differences between dock and reference sites in percent survival, growth, or bioaccumulation of metals after six weeks exposure. The results suggest that, in estuarine environments with a moderate tidal range (1.5-2.0 m), wood preservative leachates from dock pilings have no acutely toxic effects on four common estuarine species, nor do they affect the survival or growth of juvenile oysters over a six-week time period. In some cases, metal leachates may accumulate in sediments and oysters immediately adjacent to pilings, but do not appear to become concentrated in sediments or oysters elsewhere in the same creeks.

Williams, C.A., C.P. Weisskopf, S.C. McCutcheon, J.C.Hayes, and S.J. Klaine. 1996. Evaluation of Vegetated Filter Strips to Control Nonpoint Source Pollution into Charleston Harbor and Other Coastal Waters.

Vegetative filter strips were evaluated as a potential *best management practice* means to control sources of nonpoint pollution of urbanized creeks and waterways, and as a means of facilitating environmentally sound development in the Charleston Harbor watershed. A vegetative filter strip is simply a strip of plant life located between a source of pollution and a water body that serves to retain that pollutant. Strips may be natural or constructed and are located down gradient from the pollutant source. The strips serve to control localized soil erosion and to reduce/inhibit nutrient, sediment, organic, pathogen, and pesticide transport into receiving waters. In order for removal to occur efficiently, the flow must move slowly and uniformly through the vegetative strips to permit adequate residence times. In this study three field plots were constructed at an existing field of bahia and carpet grass. Simulated runoff was released through the strips to determine the efficiency in assimilating and trapping contaminant loads. Trapping efficiencies were higher at slower flow rates, and proportional to water infiltration. Significant removal of zinc from flows was observed, but other water quality parameters were not improved. It is suggested that strips be used with other means of control or be used under controlled conditions to limit very specific pollutant loads.

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