The Citizen's Guide to the Charleston Harbor Project

The Importance of Wetlands

Flood and Erosion Protection: Wetlands protect against flood damage by acting as natural tubs or sponges - storing water and then slowly releasing it. Wetlands act as buffers for the mainland by slowing and absorbing storm surges as well as the daily inrush of the tides, so they also prevent erosion of the coastline. The roots of wetland plants secure riverbanks against erosion.

Filtering Pollutants: Wetlands protect water bodies by removing significant amounts of sediments, nutrients, organic matter, and pollutants from runoff before these substances can enter the water. Many molecules easily adsorb, or attach, to individual sediment particles. As a result, sediments can act as chemical sinks by adsorbing pollutants. The salt-tolerant plants in the wetlands then filter out the sediments from surface runoff before it reaches the water body. In addition, filter feeders, such as oysters and clams, clean the water as they feed.

Serving as Habitat: The accumulation of nutrients from both fresh and salt water sources makes estuaries extremely productive areas, having tremendous food reserves that support vast numbers of organisms. The fluctuating temperature, salinity, and dissolved oxygen levels of small tidal creeks in wetlands make them difficult places for many organisms to survive, but these same conditions make the creeks excellent nursery grounds for the larval stages of creatures such as shrimp, oysters, and crabs. Since they have broader tolerances than the larger adult predators, the larval prey species can survive where the predators cannot. Without wetlands, these species would not survive long enough to reach adulthood.

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Preface

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COMMERCE, SCIENCE, AND
TRANSPORTATION: RANKING

APPROPRIATIONS
COMMERCE, JUSTICE, STATE AND
THE JUDICIARY: RANKING
DEFENSE
LABOR, HEALTH AND HUMAN SERVICES,
EDUCATION
ENERGY AND WATER DEVELOPMENT
INTERIOR

BUDGET

DEMOCRATIC POLICY COMMITTEE

This "Citizens Guide" summarizes six years of work that is of particular importance to those of us who make our homes along the South Carolina coast. Over twenty-five years ago, coastal populations were surging, and pristine coastal property and wetlands were being lost at an alarming rate. Concern for our nation's coastal resources prompted me to sponsor the Coastal Zone Management Act of 1972. That legislation did much to protect the natural resources that are one of the distinctive features of our quality of life in the Lowcountry. But by 1990, new problems called for new approaches.

The Charleston Harbor Project, conducted under the Coastal Zone Management Act, is such an approach. It is an example of local leadership, initiative, and concern translated into informed action. The Charleston Harbor Project began with people asking, "What does rapid growth mean to our community? How does it affect our economy, our environment , and our cultural and recreational resources?" Project scientists, local officials, and field research teams have worked for the last six years to identify policy issues and how best to address them. The Charleston Harbor Project examined pollution and stormwater runoff, subdivision design and industrial permits, tidal creeks and colonial wading birds, and much more. Using state-of-the-art methods and technology, a core group of local experts developed a series of carefully conducted investigations designed to assure that public policy is grounded in sound science and seasoned judgement.

The current population of Berkeley, Charleston, and Dorchester counties -- the region examined under the Charleston Harbor Project -- is more than twice as large as it was in 1950 and is expected to rise by another 120,000 by 2015. The cultural, recreational, and natural resources that attract both permanent residents and visitors to the area are at stake. Unless we plan now to manage our region's growth, we risk losing assets that we never can recover.

The Southeast lost 605,000 acres of wetlands between 1985 and 1995, and the effects of those losses can be seen in many large coastal communities to the north and south of Charleston such as Tampa Bay and the Chesapeake Bay. Charleston has a chance to avoid similar problems through far-sighted action. The Charleston Harbor Project lays out a timely and effective strategy for combining economic growth and sound environmental management.

Senator Ernest F. Hollings

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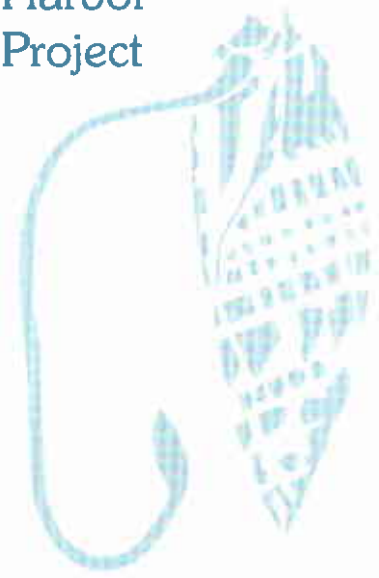
The Charleston Harbor Project



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Words and phrases that are italicized can be found in the glossary at the end of the booklet. Though, in many cases, familiar and a part of everyday usage, the words are defined with the technical meaning used by the professionals who conducted the studies and wrote about their research and findings.

The Charleston Harbor Project Study Area

The Charleston Harbor Project Study Area

The Charleston Harbor Project is a multi-year program of applied research leading to the preparation of a Special Area Management Plan (SAMP) for the Charleston, South Carolina, metropolitan area. A SAMP is a coastal management planning process that allows modifications to general coast-wide policies where local conditions or circumstances call for special measures. A Special Area Management Plan is needed in Charleston because of rapid population growth and associated land use changes. Growth increases the stress on sensitive natural systems—from egret nesting grounds to marsh vistas—that play so large a role in Lowcountry life.

Charleston, South Carolina, and its surrounding uplands and *estuary* represent a nationally significant cultural, natural, and economic resource. Charleston is a center of commerce, government, and education, and a place where historic buildings and natural beauty combine to create a favorite destination for travelers. The port is one of the largest container ship handlers in the nation, and the Harbor supports the largest commercial shrimp fishery in the state. New industries are coming to the area in record numbers. Striking a balance that will both sustain economic growth and protect the environment becomes an increasing concern.

covers more than 1,900 square miles
contains over 140 miles of rivers
is home to half a million people
and to millions of plants and animals

A Citizen Initiative

The Charleston Harbor Project came about as a result of growing citizen determination to protect the special character of the Charleston Harbor area. The experience of other places provides a glimpse of one future for Charleston, a future no one welcomes. In the aftermath of rapid growth, city after city has suffered widespread environmental damage, including pollution, blight, and problems with water supply or water quality. After-the-fact attempts at restoration are expensive and often disappointing:

It can happen here.

Boston Harbor:
An 11-year cleanup program is now underway. Cost estimates are $3.5-$4 billion.

Chesapeake Bay:
Over $2 billion has been spent on the Chesapeake Bay Restoration Project. Some S60 million is needed annually to sustain the cleanup.

Tampa Bay:
Cost to date is $2.5 billion. Continuing expenditures are over $200 million per year.

New York Harbor:
Enormous cleanup efforts are underway. A single project for correcting sewer overflows is estimated to cost as much as $5 billion for New York and $1.5 billion for New Jersey.

San Diego Bay:
Over the past five years, $16 million was spent to clean up the Bay, with a focus on commercial sites. The Navy provided over $4 million for radioactive waste cleanup work. The city is constructing a $134 million sewage outfall project to deal with sewage spill and increased discharges.

Years of growing environmental awareness, sometimes as the result of costly tragedies, have made us more conscious and conscientious about environmental issues.

Charleston citizens want to avoid a future where only strangers would think of swimming in the Harbor, or where sweetgrass and basket-makers are only memories. They seek an innovative, common-sense approach to management for the long-term protection of Charleston's water resources.

CHP Response

Background & Approach

From the outset, the Charleston Harbor Project has emphasized intergovernmental cooperation in planning and management and the continuing involvement of civic leaders and the business community. Coordinated management at the *watershed* level will enable the community to consider economic, cultural, and natural resource decisions in a common context. This approach accomplishes two purposes: it fosters new working relationships, and it supports every phase of the work by creating a broad network of knowledge. Policies that work are based on a sound understanding of conditions and processes; they evolve from rigorous research in the natural sciences, or professional review of engineering, economic or organizational issues. The Harbor Project was designed to develop responsible, well-conceived public policies and to direct attention to critical areas where too little is now known and more work is needed. For example, Harbor Project researchers were the first to identify previously unrecognized problems such as *toxic* pollution in some urbanized creeks, and to systematically investigate the *ecology* of *tidal creeks* and the key role of soils and *stormwater runoff* in overall water quality.

Primary Goals of the Harbor Project:

To maintain and enhance the quality of the environment in the Charleston Harbor estuary system,
To maintain the wide range of uses of waters and natural resources of the system,
To anticipate and address *potential* problems before adverse impacts occur.

The work involves reviewing and, where necessary, rethinking what is now being done in Charleston. What is the overall state of the Harbor as an economic resource and a natural asset? Are critical conditions improving or deteriorating? What are the measurable results of current management policies? What methods used elsewhere might be applied here? What trade-offs are involved in arriving at a recommended combination of goals and policies?

Funding & Program Support

In 1992, the National Oceanic and Atmospheric Administration provided federal funding for the six-year Charleston Harbor Project through the national Office of Ocean and Coastal Resource Management. Additional support has been provided through jointly-funded projects with state and federal agencies such as the U.S. Environmental Protection Agency, U.S. Geological Survey, U.S. Army Corps of Engineers, U.S. Department of Defense, the S.C. Department of Transportation, S.C. Department of Archives and History, Charleston County, and local utilities. The Project has been carried out by the S.C. Department of Health and Environmental Control through its Office of Ocean and Coastal Resource Management. Research projects have been conducted by specialists from public and private institutions including the S.C. Department of Health and Environmental Control, the S.C. Department of Natural Resources, the University of Charleston, The Citadel, the University of South Carolina, Clemson University, the Jones Ecological Research Center, and many others.

Twelve public *Task Forces* were established to focus on key topic areas. Participants have included representatives from federal, state, and local governments; private citizens; and community and civic organizations. Over 200 people attended workshops and briefings, evaluation sessions, and other meetings, some committing hundreds of hours.

Task Forces

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

The *Management Committee* consists of the Chairperson and Vice Chairperson from each Task Force as well as representatives of key agencies involved in the planning and management of the Harbor Project area. The findings and recommendations of each Task Force were considered by the Management Committee to add an inter-disciplinary and multi-issue perspective.

CHP Organization Structure & Community Participation

Better Management

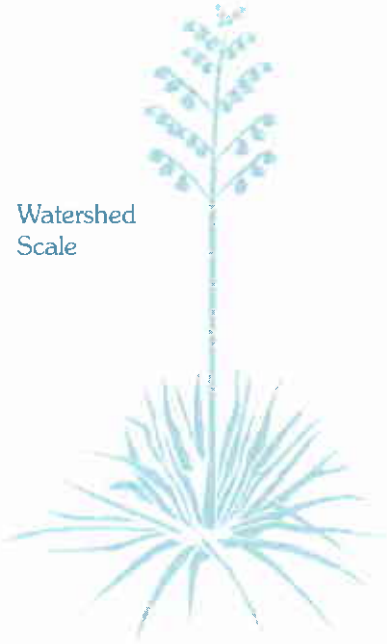
A recurring theme in the Harbor Project is matching the scale and timing of public policies to the problems they are meant to solve.

Current Best Practices

Too often, management strategies are short-sighted or based on perspectives and reasoning that have become outdated. For example, many environmental management reviews are triggered by permit requests from individual property-owners. Decisions on these permit requests are made on a parcel-by-parcel basis. Little attention is given to the combined effects of the same action on a series of nearby properties, or the cumulative effects over a span of five or ten years on an entire habitat. As another example, under the original *wetlands* regulations, small isolated wetlands often are unprotected as long as larger adjacent wetlands are buffered. These smaller wetlands have been routinely filled as properties are developed. With the passage of time there has been a noticeable decline in such species as the flatwoods salamander, for which the small wetlands are a critical habitat.

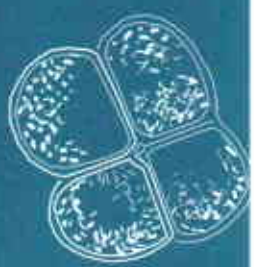
Watershed Scale

Management of the Charleston Harbor at the watershed level provides a logical alternative to the current parcel-level permit review. An area-wide watershed planning scale allows local, state, and federal managers more flexibility with permit decisions, better spatial definition of natural resources, and more predictability for economic development. Watershed-level planning can ensure that transportation corridors do not conflict with areas that should be protected as biological *habitats*. And the change in scale makes region-wide measures, such as *mitigation banks*, workable strategies for sensible solutions to localized problems. The Charleston Regional Watershed boundary adopted by the CHP is consistent with natural drainage boundaries for water quality management, the ecosystem boundary for natural resource management, and the regional community boundary for economic development.



CHP
Featured Project

Modeling the Dynamic Charleston Harbor System



Water quality management protects the living creatures of the Watershed and is essential to the commerce and enterprise that make a place prosperous. Understanding the complex interactions of river flows, tides, and rainfall is critical to effective management in the Watershed. They are dynamic processes, varying from place to place and season to season.

One of the first goals of the Harbor Project was the development of an improved *water quality model* of the Charleston Harbor system, a model which would represent the Cooper River as well as the Ashley and Wando rivers, and would directly account for the impact of stormwater runoff.

Many agencies and institutions took part in the data collection, analysis, model design, and calibration work. The CHP formed a multi-disciplinary team of experts and began to develop what was to become nationally recognized expertise in the field. The team consisted of Mr. Paul Conrads, United States Geological Survey; Dr. Earl Hayter and Dr. Steve McCutcheon, Clemson University; Dr. B.J. Kjerfve and Dr. Hank McKellar, University of South Carolina; Dr. Elizabeth Blood, Jones Ecological Research Center; and Ms. Terry Sicherman, Mr. Pauley Smith, Mr. Frank Dantzler, Mr. Jeff Wychowski, and Mr. Chester Sansbury of the S.C. Department of Health and Environmental Control.

The team delivered an operational water quality model representing the Cooper and Wando rivers. (A model representing the Ashley River has since been completed.) Computer models enable managers to develop measurable thresholds for maximum discharges and to undertake watershed scale management instead of only permit-by-permit rulings. The CHP model simulates water levels, streamflows, salinity, and concentrations of *nutrients*. It mathematically describes the natural system, and enables decision-makers to estimate the impact of change—to ask "what if?" It marks a significant improvement over earlier models.

Models developed by Dr. Blood predict the amount of pollutants that go into the Cooper and Wando rivers from different types of development. Two stormwater runoff models were created for applications in regional and local planning. A detailed spatial model was used to compare the impacts of typical *"Sprawl"* land use patterns and mixed use "Town" design in a large, unbuilt tract known as Belle Hall Plantation. A large scale model was used to develop the first *nitrogen* budget for air, land, and discharge pipe sources in Charleston Harbor. These models utilize *Geographic Information System (GIS)* technology for analysis and display, enabling planners and resource managers to visualize the relationships between patterns of urbanization and surface water quality.

CHP
Featured Project

Belle Hall Plantation Charrette

Designing for Development & Environment

Sprawl

Town

This project investigated the environmental impact of design options for developing a 583 acre tract of land in the Town of Mount Pleasant. The property, Belle Hall Plantation, is in a prime location. Design alternatives had to be feasible in terms of existing land planning regulations, standard practices, and business planning (financing and scheduling, market demand, etc.).

The urban design firm of Dover, Kohl & Partners led a three day exercise, or *charrette*, in which the participants designed two development scenarios. The Sprawl scenario was based on conventional site layout practices as currently followed in the area—large lots and wide streets, cul de sacs, and a "power center" commercial area. *Design principles* for the Town scenario were based on examples from Savannah, Downtown Charleston, and the Old Village in Mount Pleasant—conserving open space by using smaller lots with a grid street pattern and blending commercial and residential areas. Participants included planners from the Town of Mount Pleasant and Charleston County, private and public sector engineers, architects, developers, ecologists, and local officials.

The two designs were then compared using computer simulation models to forecast environmental impacts. The results showed that water flowing from the project area to the nearby creeks and marshes and the Wando River would be far less polluted under the Town scenario because it provided more open space between the development and the receiving water body. Also, in the Town scenario, the placement and the overall reduction of *impervious surfaces* (roofs, streets, sidewalks) meant that rainwater would be more likely to be absorbed into grass and soil and less likely to move quickly across pavement, etc., carrying oil, chemicals, or other pollutants into the creeks and ponds. The amount of *surface runoff from the Sprawl scenario* was 43% higher than the Town scenario. *Sediment loads* were also three times higher in the Sprawl scenario than in the Town scenario.

It should also be noted that the preservation of open space in the Town scenario provided much greater opportunities for the preservation of biological habitat and such amenities as walkways and viewscapes. Projected *infrastructure* costs were almost 50% lower in the Town scenario because there were fewer roads to pave and water/sewer lines to install. The more compact Town design was also advantageous from the standpoint of planning for such public services as police and fire protection and garbage collection.

The project was the subject of featured articles in *News-Notes*, a periodical published nationally by the Environmental Protection Agency, and in the quarterly of the National Association of Home Builders. Innovative design concepts applied in the Belle Hall Charrette are currently incorporated in high profile local development projects.

CHP
Featured Project

Tidal Creek Project

The Creeks & Estuaries

The Tidal Creek Project is the capstone of two years of coordinated CHP water quality and fishery habitat projects that identified small tidal creeks as potentially critical management points within the Charleston Harbor estuary.

Rapid population increases are projected for the Charleston Harbor Project area. This growth requires significant land use changes as forests are converted for human uses. Land use changes degrade water quality by short-circuiting natural absorption and treatment of runoff through the soils. As land use intensity increases from forest to suburban, urban, or industrial uses, runoff quantity increases and water quality declines. The Tidal Creek Project demonstrated dramatic and potentially detrimental changes in small tidal creeks.

Earlier CHP projects document the critical importance of small tidal creeks as nursery areas for highly valued fishes and crustaceans. CHP research also shows water quality conditions in small creeks to be much more extreme and stressful than conditions in large rivers. Although water quality management is designed to protect fishery habitats, policies focused on main rivers may not adequately protect critical habitats. Since the productivity of these nursery areas is dependent on adequate water quality, the Tidal Creek Project was to develop recommendations for the proper management of these important habitats.

The Tidal Creek Project designed specific objectives to protect these habitats:

- Characterize and define the ecological values and services of tidal creek systems.
- Identify pollution threats to the tidal creeks resulting from human development.
- Develop environmental quality criteria for sustaining tidal creek nursery functions.

The Tidal Creek Project was conducted by the S.C. DNR Marine Resources Division Marine Resources Research Institute (Dr. A. Frederick Holland, George Riekirk, Scott B. Lerberg, Lynn E. Zimmerman, Denise M. Sanger). The National Marine Fisheries Service Southeast Fisheries Science Center also participated (Dr. Geoffrey Scott, Dr. Michael Fulton, Brian C. Thompson, James W. Daugomah, John C. DeVane, Kevin M. Beck, and Aaron R. Diaz).

The Tidal Creek Project selected twenty-four creeks in the CHP study area with typical land use patterns: pristine, suburban, urban, and industrial. The physical, chemical, and biological characteristics of these creeks were measured and compared. The findings include:

- Pristine small tidal creeks are naturally stressful environments where fish and shrimp survive near the limits of their tolerance during extreme summer conditions.
- As nearby land is converted to residential, commercial, or industrial uses, conditions in tidal creeks intensify markedly. The creeks become less suitable as nursery grounds. Salinity levels vary erratically. There is more toxic contamination in sediments, and the health and vigor of individual animals declines.
- Small tidal creeks act as conduits for pollutants associated with uplands development, carrying them into the estuary.

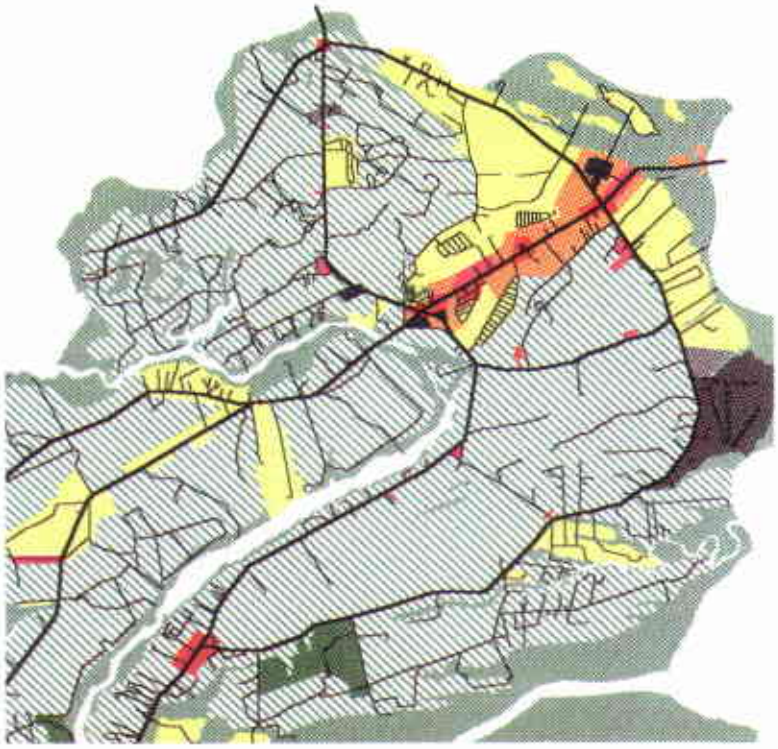
The Tidal Creek Project identified small tidal creeks as a critically important component of southeastern estuaries. The study deepens the understanding of the intimate relationship between land use and biological health in an estuarine environment. Plans are underway to continue tidal creek research, expand monitoring programs, and develop new techniques for the protection and preservation of these environments through the cooperative efforts of federal, state, and local managers.

Related work on the variability of estuarine creeks was carried out by Dr. Phillip Dustan of the University of Charleston, S.C., Dr. Hank McKellar from the University of South Carolina, and others. Their work was designed to derive a better understanding of the coupling between land and creek by monitoring fine scale changes in water quality. Creeks in developed areas were compared to creeks near pristine watersheds. They found that stormwater runoff enters the urbanized estuary quickly, causing sharp changes in water salinity and other parameters. Rainfall and runoff in the less developed watershed indicated an "ecological dampening" effect linked to the hydraulics of the two watersheds and the size of the storm. Threshold effects were observed and catalogued that were unknown prior to their research.

CHP
Featured Project

Metropolitan Charleston 1990 - 2015

Impact of Future Urban Growth



Johns Island Land Use

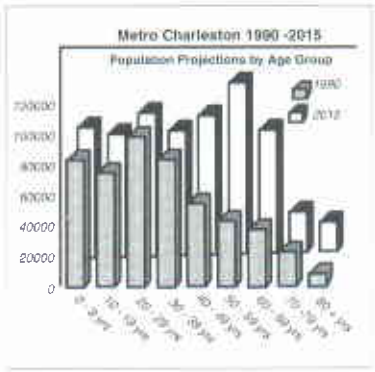
The Berkeley-Charleston-Dorchester Council of Governments was the lead agency in a study of development trends and projections in Metropolitan Charleston. The S.C. Department of Transportation and the S.C. Department of Commerce also participated. The work incorporated the collective experience and expectations of planners from three counties and eleven cities and towns, as well as officials from school systems, public utilities, and special service districts.

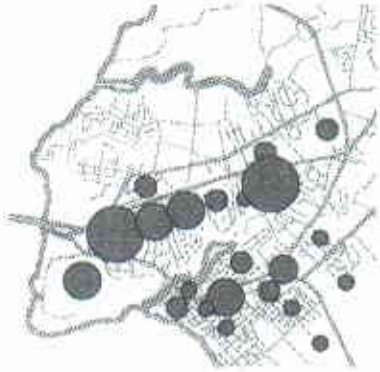
In 1990, there were more than half a million people living in the tri-county region. It was the fastest growing major metropolitan area in South Carolina between 1980 and 1990. The tri-county region accounted for one-fifth of the total population growth in the state during the eighties. *Demographers* and *economic developers* agreed that the region would continue to be a growth center into the twenty-first century. Local officials are asking, "How will all this change the Lowcountry and our communities?"

The Metro Charleston 1990-2015 project was designed to apply "fact-driven" planning approaches to the problem of understanding urban change. The work involved constructing complex computer files of subdivision plans, business locations, wetlands, vacant land, schools, demographic characteristics, and other factors. The tri-county area is vast and diverse, and regionwide planning must necessarily proceed with attention to how it will affect life in the

GIS MAPPING LAYERS

- *PLANNING ISSUES*
  - Existing or Planned Access
  - Essential Services(Utilities)
  - Zoning Districts & General Plans
  - Planned & Proposed Projects
- *DEVELOPMENT FACTORS*
  - Parcel/Tract & Ownership Patterns
  - Existing Development & Uses
  - Zoning & Permitted Uses
  - Approved Plans
- *LAND & LOCATION*
  - Flood Zones
  - Wetlands
  - Soil Types
  - Open space/Conservation Areas
  - Restricted Use Zones





neighborhoods and localities that, taken together, form the whole. Accordingly, more than 500 small areas were used as geographic "building blocks" to derive regional trends and projections. Planners used computer mapping programs to gain new understandings of the relationships between economic centers.

This was the first planning project to create a future land use model of the metro area using Geographic Information System technology. It was also the first to: develop a detailed spatial analysis of retail sales patterns; compile a full inventory of local, state, and federal employment by location; map the sites of some 13,000 business locations by type of business and number of employees; and create a regional map of more than 400 current or planned residential development and commercial/industrial sites.

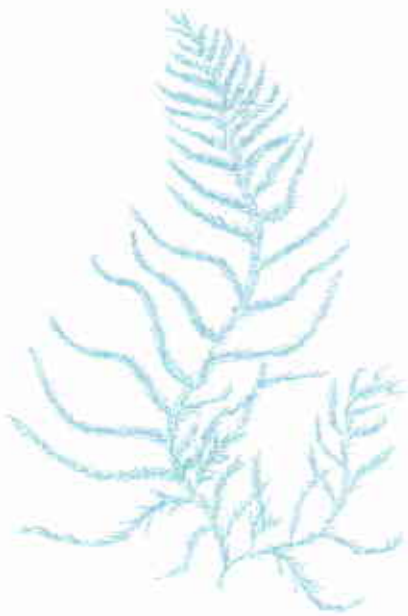
This work, combined with the detailed representation of vacant, developable parcels from aerial photography, forms the basis for location-specific watershed level planning—*mitigation* areas, *greenspaces*, *habitat* corridors, and conservation areas.

The findings of Metro Charleston 1990-2015 are used in the long-range capital improvement planning of the S.C. Department of Transportation, in the Section 208 Regional Water Quality Management Plan, and in agency planning processes carried out by local school districts and library systems.

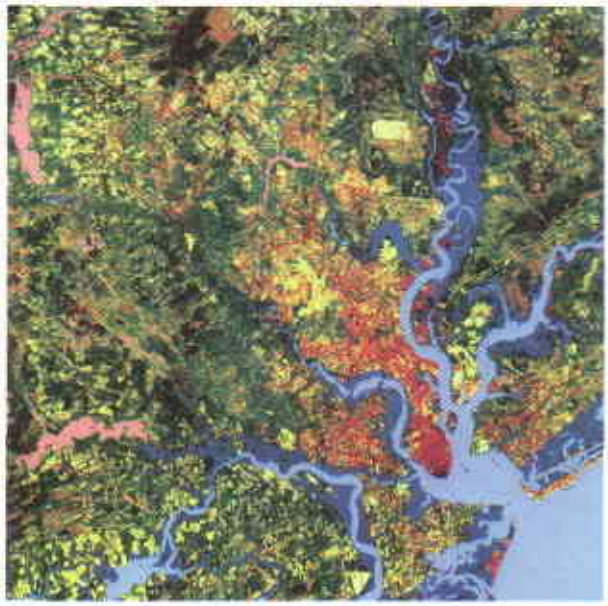
The Charleston Harbor Watershed

The Harbor Project was designed to contribute to the development of science-based resource management and planning, and to carry out this work at the area-wide, or watershed, level. A *watershed* is a single geographic unit defined by natural *topography*; its boundaries enclose the flow and absorption of surface waters and rainfall. Watersheds typically cover all or part of the jurisdictional boundaries of several towns, cities, or counties. The Charleston Harbor Project area forms the lower section of the Catawba-Santee Watershed. It extends from the outlet of Lake Moultrie to the coast, and includes the land areas that drain into the Stono, Ashley, Cooper, and Wando rivers. The Project area combines growing industrial, commercial, and residential developments with *marsh* vistas, vast wooded tracts, and *swamps*.

The boundaries of the Project area and the complex patterns of natural and man-made habitats are shown here in an image derived from a satellite image of coastal South Carolina. The Charleston Peninsula is seen at the convergence of the Cooper, Wando, and Ashley rivers. The Harbor opens into the dark blue bank of ocean waters. The color patterns reflect subtle differences in the landscape that are detectable from orbiting satellites—different colors in the satellite photographs indicate cultivated land, urban development, forested wetlands, bottomland hardwoods, etc. Computer enhanced images of this kind are used for change detection, *gap analysis*, habitat delineation, and other resource management functions.



The CHP watershed management program was designed to complement the existing environmental management framework and the information base that supports it. Special emphasis was placed on preserving the natural settings that were seen as most important to the quality of life in the Lowcountry, particularly those that were at risk from urban land transformations and water quality degradation. Over the last six years, the Charleston Harbor Project has set about to develop the information required to begin management at the watershed level through:



1991 LANDSAT TM Image
S.C. Department of Natural Resources, Southeastern Remote Sensing Center

Regional Watershed Management Requirements

- Identifying key natural resources and historic/cultural/recreational assets in the Watershed;
- Compiling inventories, assessments, and maps of these vital features and habitats;
- Conducting focused research and assembling the technical expertise to assist regulators and planners;
- Developing systems-oriented understandings of natural and social processes that drive management issues;
- Devising methods for evaluating the success of policies to improve management (i.e., monitoring and evaluating both natural resources and policy effectiveness);
- Establishing a comprehensive data storage, retrieval, and analysis system.

Baseline Information

At the outset of the Project, an assessment showed that little long-term planning information was available for the Watershed, and few record files were systematically updated or subjected to quality control review. The information base was characterized as uneven—data rich but information poor. Therefore, the CHP developed coordinated sampling protocols and created research teams composed of academic, government, and private experts from the state and region. These teams inventoried, mapped, and assessed the biological, cultural, economic, and recreational resources in the Project area. A central data repository for Geographic Information Systems products was created at the University of Charleston. Important natural and human processes associated with urbanization were examined to define "thresholds" or critical factors that would have a significant impact on the overall health of the estuary.

Natural Processes

Water chemistry, drainage, and tidal and seasonal changes affecting water quality were examined at spatial scales ranging from the 675 square mile Cooper-Wando river system down to tidal creeks less than 10 feet wide. New water quality computer models were designed and calibrated for use in permitting decisions, industrial and municipal waste load allocations, and for "what if?" simulations to estimate potential impacts on the Ashley, Cooper, and Wando rivers. Stormwater runoff models were also developed so planners could examine the likely water quality impact of projected land use changes at large and small scales.

Plant & Animal Communities

Biologists conducted a comprehensive survey of threatened and endangered species, rare plants, and their specialized habitats. Studies of tidal creeks produced new insights into how rainstorms, heat, tidal flux, and other factors make life precarious for plants and animals and how some of these same conditions provide refuge or protection when large predators will not enter the creeks to feed. Other work explored how wetlands, fish migrations, bird habitats, successional woodlands, and recreation sites were affected by the rediversion of flows from the Cooper into the Santee River.

Urban Growth

A detailed analysis of current and future population characteristics, trends, and land uses was developed in cooperation with local planners. The two-year study reviewed many aspects of urbanization, including employment patterns, building permits, highway construction programs, capital improvement programs, zoning and development plans, and vacant properties. Future growth zones were identified. Constraints on growth such as wetlands, land configuration, or lack of infrastructure were incorporated into the twenty-year projections, and later became part of other local planning projects, such as gap analysis, *greenbelt* planning, and *urban growth boundary* proposals.