GREEN GROWTH GUIDELINES

EDITION II 2014

Photo Courtesy of Richard Leo Johnson

GREEN INFRASTRUCTURE

SITE PLANNING & DESIGN

STORMWATER MANAGEMENT

STREAMBANK & SHORELINE STABILIZATION

RECREATIONAL DEVELOPMENT & MANAGEMENT

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NOAA
U.S. DEPARTMENT OF COMMERCE

GEORGIA
Coastal Management Program

DEPT. OF NATURAL RESOURCES
ENVIRONMENTAL PROTECTION DIVISION
GEORGIA

MAREX
The University of Georgia Marine Extension Service

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

Environmental Science & Technologies Inc.

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In 2006, the first edition of the Green Growth Guidelines was developed as a part of Georgia's Nonpoint Source Management Program. Over time, G3 has become a "living document", and therefore has been updated and expanded to include additional strategies that aim to prevent, reduce, or alleviate nonpoint source pollution in the coastal region of the State. The second edition of G3 was completed in Spring 2014.

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Tara R. Merrill, *Environmental Science & Technologies, Inc.*, Principal Author

Matthew R. Baker, Lead Designer

Dan Fischer, Mark Mobley, Jay Maupin, Matt Renault, Maryanna Vo, Tre Wilkins, Alec Metgzer, Patrice Cook and Adam Ragsdale, *EMC Engineering Services Inc.*, Environmental, Civil, Marine Engineering

Jess D. Henderson, Research and Development

Mark Reavis and Ben G. Whitley, Financial Analysis and Valuation

Susan Humpheries and Kathy Hart, Review Editing

Barbara and Bob Ingram, *Paramount Printing, Publishing and Printing (1st Ed.)*

Michael E. Novotney, *Baxter & Woodman, Inc.*, Contributing Authors (2nd Ed.)

Keren Giovengo and Travis Douce, *UGA-MAREX,* Contributing Authors (2nd Ed.)

Jeannie Lewis, Alice Vick, Jill Andrews, Michelle Vincent, Kelly Hill, Susan Reeves, Jan MacKinnon, Karl Burgess, Deb Barreiro, John Wynne, Bruce Foisy, Chris Faulkner, Brian Baker, Jeff Larson, Cliff Lewis, Glen Behrend, Jeff Linzer, Dale Caldwell, Jennifer Kline, Sonny Emmert, Jon Ambrose, Adam MacKinnon, Fred Hay, Collis Brown, Dale Caldwell, Harold Harbert, Julie Vann, and Teresa Shiflette, *Georgia Department of Natural Resources (GNDR) Environmental, Coastal Resource, Wildlife, and Pollution Prevention Assistance Divisions (EPD, CRD, WRD, P2AD)*

Deatre Denion, Ebony Simpson and Teresa Concannon, *Georgia Department of Community Affairs (DCA)*

Lisa Vandiver, John Kuriawa and Dr. Fred Holland (retired), *National Oceanic & Atmospheric Administration (NOAA)*

Robert Woo, Don Waye, Mary Jo Bragan, and Christine McKay, *Environmental Protection Agency (EPA)*

Angela Bray and Chris Strom, *Southern Georgia Regional Commission (SGRC)*

Ed Siegmond and Kevin Sullivan, *Coastal Regional Commission (formerly CGRDC)*

Jackie Jackson Teel, *Chatham County-Savannah Metropolitan Planning Commission (MPC)*

Gene Oliver, *Coastal Soil and Water Conservation District (formerly)*

Richard Morgan and Mark Padgett, *U.S. Army Corps of Engineers (USACE)*

Greg Hoffman, Sadie Drescher and Karen Capiella, *Center for Watershed Protection (CWP)*

Gary White and Mark McClellan, *Georgia Forestry Commission (GFC)*

David Kyler, *Center for a Sustainable Coast*

Clay Mobley, *Georgia Conservancy*

John Karrh, *Georgia Southern University*

Curtis Joyner and Debra Hernandez, *S.C. Department of Health & Environmental Control (DHEC)*

Bill Hodgins and Laura Walker, *City of Savannah*

David Hainley and Paul Andrews, *Glynn County Planning & Engineering Department*

Bill Sapp, *Southern Environmental Law Center*

Paul Wolff and Diane Otto, *City of Tybee Island*

Brian Herrmann, *Beaufort County*

Gregg Bayard and Curry Wadsworth, *Parallel Housing Inc.*

Dr. Clark Alexander, *UGA Skidaway Institute of Oceanography (UGA—SKIO)*

Dr. Timothy Carter and Katie Sheehan, UGA *River Basin Center*

Charles Hopkinson, David Bryant and Kelly Spratt, *UGA Georgia Sea Grant Program*

Janice Flory, *UGA Georgia Coastal Research Council*

Beth Gavrilles, Chuck Hopkins, E. Weatherly Jr., Ernest William Tollner, Frank Henning, Jon Calabria, JP Schmidt, Laurie Fowler, Dean Hardy, Mark Risse, Merryl Alber, Ron Carroll, and Ronald Sawhill, *University of Georgia—Athens, GA*

Courtney Reich, *Ecological Planning Group*

Tom Havens, *Coastal Civil Engineering*

Mike Browning, *JB+A Landscape Architects*

Phil Fortune and Cliff Altekruse, *Smith, Currie & Hancock LLP*

Jim Hackler, *EarthCraft House*

Brian Holland, *Southface Institute*

Chere Peterson, *Petrus UTR*

Denise Grabowski, *Lott + Barber Architects (formerly), Symbioscity*

Butch Register, *Register-Nelson Inc.*

Chuck Taylor, *Chuck Taylor Designs Inc.*

Deborah Sheppard, *Altamaha Riverkeepers*

Paul Work, *Georgia Tech Savannah*

James Collins and Honor Hutton, *Thomas & Hutton Engineering*

Ted McIntyre and Howard Pigott Jr., *CH2M Hill*

Scott Hunter, *Moffatt and Nichol Engineers*

Maureen Hoke, *O'Brien and Gere*

Ben Carswell, *Jekyll Island Authority Conservation Program*

Beth Brown, *Association County Commissioners of Georgia*

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Introduction

Georgia's coast is valued as a coveted national treasure—with its historic cities and distinctive smaller communities enhanced by natural beauty. The coastal region is set apart by its unique geographic landscape, defined by scenic rivers, creeks, forested wetlands, and the largest expanse of tidal marshlands in the southeastern United States. The beauty of Georgia's coast can be mainly attributed to its abundant natural resources—diverse and interconnected—these ecosystems are highly functional components of the landscape and, collectively, are some of the most biologically productive ecosystems on Earth.

The Coastal Georgia region encompasses six coastal counties and five inland counties, covering a land area of over 5,000 square miles [US Census]. It is home to five National Wildlife Refuge Areas, three State Parks, a State Wildlife Management Area, a National Seashore, and a National Marine Sanctuary—not to mention the nearly 100 miles of public beaches and waterways. The Georgia barrier islands are unparalleled in the continental United States as undisturbed islands in their natural state. All of Georgia's ocean beaches are on the seaward faces of barrier islands, which are separated from the mainland by a four to six mile-wide band of salt marsh, tidal creeks and estuaries. About half of the region's land area is comprised of tidal and freshwater wetlands. The Altamaha, Ogeechee, St. Mary's, Satilla and Savannah rivers are major waterways that meander through the coastal Georgia region and empty into the Atlantic Ocean. [Coastal RDC, 2010]

Ecological resources within the region offer endless social opportunities—as well as drive the local economy. These resources improve the overall quality of life, creating a highly desirable place to live, work and visit.

By 2030, over 800,000 people are expected to reside in the coastal region, an increase of 51 percent over the 2000 population [Georgia Coast 2030: Population Projections for the 10-County Coastal Region, 2006]. Most of the this growth is driven by a lower cost of living within the region, the attractiveness of the ecological resources the region offers to residents, businesses, and visitors, and the direct access to these resources. This population growth has stimulated economic prosperity in the region by producing jobs and increasing tax revenues at a pace greater than the national average; but it has also driven the development of Georgia's coast at an accelerated pace. As a result, natural lands will continue to be converted to developed areas, often at the expense of critical natural resources and ultimately the environmental, economic, and social health of our communities.

As coastal communities experience the effects of "sprawl", people are increasingly concerned about the impacts of rapid growth. For this reason, there is growing interest by the general population, developers, public officials, regulators, and environmentalists in more balanced approaches to land development. In response, the state of Georgia has supported the creation of the *Green Growth Guidelines, a Sustainable Development Strategy for Coastal Georgia.*

Coastal ecosystems provide flood and hurricane protection, food, commerce, and vital habitat for animal and plant communities. Additionally, these areas are readily accessible and offer a myriad of recreational opportunities. The use of Coastal Georgia's natural resources for recreational activities is logically dependent on the sustained health of these resources. Development without measures for protection and conservation can result in environmental impacts that are often irreversible and can result in the diminishment or loss of the very resources we are dependent upon. Development can result in poor water quality conditions caused by erosion and sedimentation, excess nutrients, pathogens, and toxic chemicals. Additionally, development can alter or even destruct vital marine and terrestrial wildlife habitats.

Outdoor recreation is an integral part of the culture of Georgia's coast. In addition to being a highly desirable place to live and work, the coast is a popular destination for tourists as well. The coast of Georgia is spectacular in its natural beauty, offering a variety of habitats: ocean, beaches, dunes, maritime forests, salt marshes, and many rivers with their own freshwater marshes and swamps [Mallory Pearce, 2012].

A sustainable environment is closely linked to the economic vitality of the coast. Property values and ecotourism-related revenue increases with proximity and accessibility to natural resources such as beaches, rivers and creeks, marshlands, and hammocks. Outdoor recreation accounts for $23.3 billion dollars annually to the local economy and supports over 16,000 local jobs [Georgia Statewide Comprehensive Outdoor Recreation Plan 2014-2016].

Preserving natural resources in the midst of population growth is imperative for coastal Georgia. Urbanization and its potential impact on a watershed are well known. While demand seems boundless, vital water resources are limited in supply. Consequently, there is a high potential for environmental impacts including:

- Degraded water quality from fertilizers, pesticides, and herbicides
- Increased impervious surfaces and stormwater runoff
- Loss of greenspace and buffers used as wildlife habitat
- Increased land erosion and sedimentation of tidal streams and creeks

- Decreased flood and hurricane protection
- Contaminated fisheries and beaches from metals, motor oil, and gasoline
- Contaminated recreation areas and drinking water from harmful bacteria caused by faulty septic systems
- Downstream channel scour and bank erosion caused by more severe peak storm flows
- Reduced shallow aquifer recharge due to stormwater conveyance bypassing the ground

Development practices that insist on locating buildings and infrastructure in close proximity to coastal beaches and wetlands pose a fundamental challenge to coastal development. Wind, water, waves, and the lack of natural buffers continually erode beaches and wetlands, and our best technical efforts to turn back these forces of nature on the intensive margin of the human-nature interface may not be ecologically sustainable. For example, creation of impervious surfaces, such as driveways and parking lots, affects the natural flow of stormwater. Instead of being absorbed into the soil naturally, in paved areas stormwater flows directly into ditches, streams, and wetlands. This runoff often includes pollutants, such as petroleum products from motor vehicles, particulates from brake-linings, fertilizers, and pesticides. According to the EPA List of Impaired Waterways, the following pollutants are mainly responsible for degraded water quality conditions in coastal Georgia:

- Toxic Pathogens
- Excess Sediments
- Fertilizers and Pesticides
- Heavy Metals
- Petroleum Hydrocarbons
- Solvents, Antifreeze, and other Harmful Chemicals
- Debris and Litter

Water pollution can potentially threaten the health of aquatic organisms and ultimately, humans using these areas. Coastal estuaries and wetlands provide spawning grounds, nurseries, shelter, and food for many species of birds, mammals, amphibians, reptiles and insects. Most recreationally and commercially important fishes, crustaceans, and shellfish spend at least part, if not all, of their lives in Georgia's estuaries and marshes. Good water conditions are vital to the health and sustainability of these important aquatic species. In addition to aquatic habitat degradation, terrestrial habitats—especially maritime forests—are often destructed for recreational uses. Wildlife depends on large, contiguous, natural areas for food, shelter, and reproduction. Habitat destruction and fragmentation is closely linked to declined species richness and biodiversity. Habitat loss is expected to persist and most likely increase in relation to continued coastal development.

When coastal barrier islands, hammocks, and wetlands are modified beyond a functional threshold, these areas lose the natural ability to protect the mainland against damaging floodwaters and winds associated with major storms and hurricanes. Cumulative aquatic ecosystem impacts coupled with rapid development of essential riparian buffers and the mainland itself can result in a significant safety risk, especially to residents and businesses located within flood-prone areas. In addition to flood protection, people depend on coastal waters for food and recreation. Some of the most sought after seafood—oysters, shrimp, crabs, clams, flounder, mackerel, shark, and mullet—are long-lived, often bottom-dwelling fish and filter feeders which are particularly susceptible to excess nutrients, chemicals, and bacteria. Chemical and bacterial contamination can also render beaches, rivers, and creeks unfit for swimming, skiing, fishing, and other water-contact activities.

In the interest of the public, the main goal is to protect and sustain the unique cultural, historical, biological, and aesthetic character of coastal natural resources. This presents an immediate need for strategies that achieve a balance between economic development and environmental conservation of natural resources. The main objective of the *Green Growth Guidelines* is to prevent, reduce, and manage nonpoint source pollution before it adversely affects coastal waters. Implementation of these guidelines can result in numerous environmental and economic benefits including:

- Better water quality
- Healthier wildlife habitat, especially for marine life
- Cleaner, safer conditions for recreational activities
- Enhanced visual appearance
- Reduced construction and maintenance costs
- More efficient operations
- Higher profit margins
- Increased property values
- Investment opportunities in sustainable businesses
- Community recognition and rewards for environmental stewardship

Executive Summary

It is the mission of the Georgia Coastal Management Program to balance economic development in Georgia's coastal zone with preservation of natural, environmental, historic, archeological, and recreational resources for the benefit of Georgia's present and future generations.

The Georgia Department of Natural Resources Coastal Resource Division's role in the GCMP is to provide funding and technical assistance for programs that prevent, reduce, and abate nonpoint source pollution in coastal waters. In support of this program objective, the ***Green Growth Guidelines (G^3)*** was developed to encourage alternative site planning and design techniques, construction practices, and management measures that protect the health and vitality of Georgia's coastal ecosystems.

The guidelines serve as a toolbox of innovative, yet practical, strategies that result in development projects that are profitable and environmentally sensitive - reaping the benefits of growth without overwhelming communities, taxpayers, and the environment in the process.

This guide strives to make the green growth process an appealing and more readily accepted model for the rapid development facing this region. Balancing inevitable development demands and natural resource protection are essential to achieving better water quality in the region. Adopting green planning and development for our coastal region achieves this balance. With creativity, determination, and support for these efforts, coastal Georgia can create and maintain healthy, vibrant communities that ensure economic vitality while retaining a healthy environment.

Made possible by the National Ocean and Atmospheric Administration, Environmental Protection Agency, and the State of Georgia, G3 is the product of a collaborative effort among a consortium of private and public stakeholders including the members of the development community, scientists and researchers, natural resource managers, local governments and private landowners. G3 is intended to evolve as a "living" document—to be updated and expanded as needed to address current and future growth patterns and natural resource issues. The Second Edition of G3 is comprised of five (5) chapters.

Chapter 1—Green Infrastructure: A Sustainable Development Approach

The first chapter includes (1) important Green Infrastructure terminology and concepts, (2) a list of technical and financial assistance tools and resources for local governments, developers and landowners interested in implementing GI strategies, and (3) a series of GI network maps that can be used for planning and design purposes.

Chapter 2—Designing with the Landform: Better Site Planning and Design

The second chapter contains (1) Site Selection Criteria, (2) Natural Resource Inventory—Site Fingerprinting Process, (3) Better Site Planning and Design Techniques, (4) Model design comparison demonstrating the economic and environmental benefits of green site development versus conventional development plans, and (5) Examples of green building case studies throughout the Southeast.

Chapter 3—Stormwater Management

The third chapter provides (1) Green Infrastructure and Low Impact Development-based Stormwater Management Practices, (2) Site Planning and Design checklists, (3) Practice Design Profiles from Georgia’s Stormwater Management Manuals—Coastal Stormwater Supplement, and (4) Regulatory Permitting Contact Information.

Chapter 4—Streambank and Shoreline Stabilization

The fourth chapter covers (1) Streambank and Shoreline Stabilization Practices, (2) Living Shorelines Local Case Study, and (3) Regulatory Requirements and Contact Information.

Chapter 5—Recreational Facilities Development and Management

The fifth chapter includes Planning, Design, Construction, and Management Guidelines for Golf Courses, Parks, Trails, Marinas, and Community Docks.

1—Green Infrastructure
A Sustainable Development Approach

Contents

1—Green Infrastructure
A Sustainable Development Approach

In This Chapter

- ***Important Terms & Concepts—Green Infrastructure, Ecosystem Services, and Natural Capital***
- ***Technical & Financial Assistance Tools and Resources for Local Governments, Developers, and Landowners***
- ***Green Infrastructure Mapping Case Study for Coastal Georgia***

Green Infrastructure

Over the past couple of decades, ***Green Infrastructure* (GI)** and other conceptual advances in environmental planning have emerged in response to increasing concerns about the negative consequences of population growth and subsequent land consumption.

Our survival and well-being, either directly or indirectly, depends heavily on our natural environment. This is exactly why we should strive to create and maintain the conditions under which humans and nature can exist in a productive union. The primary goal of sustainable development is to meet our present needs without compromising the ability of future generations to fulfill their own.

Mutually important components of a sustainable society

The term “infrastructure” commonly refers to the substructure or underlying foundation on which the continuance and growth of a community depends. Gray Infrastructure provides our built environment with necessary facilities and support services such as highways, utilities, and wastewater treatment plants.

Georgia Ports Authority, Savannah River. Source: Fitnews

Equally important is our Green Infrastructure, which serves the many needs of our communities by delivering fundamental services such as clean water, air, and soil, flood protection, diverse wildlife habitats, climate change mitigation and community resiliency.

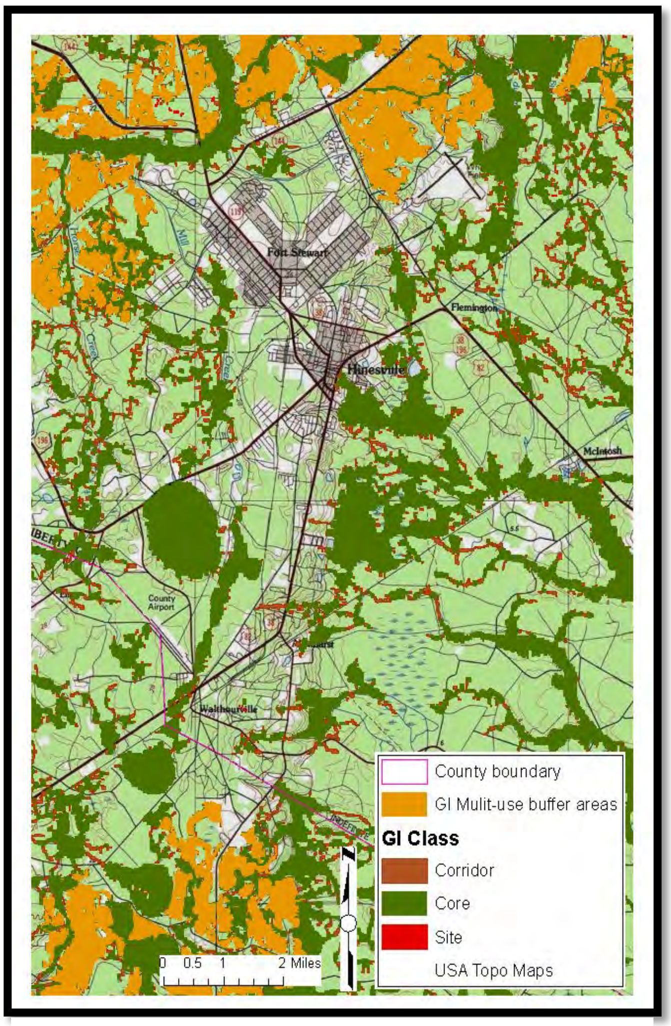
At all scales, Green Infrastructure (GI) provides ecological, economic and social benefits. The *American Society of Landscape Architects* describes GI as a conceptual framework for understanding the *"valuable services nature provides the human environment."*

At the national or regional level, interconnected networks of park systems and wildlife corridors preserve ecological functions, manage stormwater, provide wildlife habitat, and create a balance between built and natural environments. At the urban level, parks, and urban forestry are central to reducing energy usage and creating clean, temperate air. Lastly, green roofs, walls, and other techniques within or on the buildings themselves bring a range of benefits, including energy efficiency, stormwater management, and aesthetic improvement.

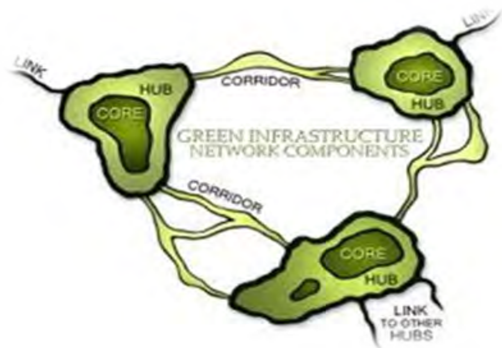

Intact Green Infrastructure: Tidal Marshlands and Maritime Forest
Source: Tara Merrill

GI focuses on two key performance objectives—**biological diversity** and **connectivity**—both of which are characteristics vital to the sustainability and maintenance of healthy human communities and functional natural ecosystems. Biological diversity—or the variation of terrestrial and aquatic organisms within a community—is heavily dependent on the degree in which habitats are physically linked or attached. An interconnected network of aquatic and terrestrial resources supports a wide range of resident and migratory organisms, maintains air and water quality, and contributes greatly to a community's natural beauty, economic prosperity, and quality of life. Like roads, utilities, and other supporting service facilities, green infrastructure must be connected to function at its fullest potential.

The GI network is comprised of three main components commonly known as **hubs**, **links** and **sites**. These components can vary in size, shape, and function.



Hubs, Links, and Ecologically-Significant Sites. Source: Coastal Habitat Mapping Project, Georgia Land Conservation Initiative



The primary building blocks of the Green Infrastructure Network are landscape **"hubs or cores"** which significantly contribute to the region's water quality, wildlife habitat, and biodiversity. These large blocks of unfragmented natural lands serve as the anchors in the network. Hubs—in the form of national and state wildlife reserves, farmlands, and community parks—provide an origin and destination for wildlife and people. **Links** or corridors connect other system components (hubs and sites) together. Links can come in many forms and sizes— linear parks and trails used for recreation, natural landscapes such as rivers, riparian corridors, and floodplains, as well as protective buffers for working and developed lands. When of sufficient width and length, these areas serve as the biological conduit of the GI network—facilitating wildlife migration, enhancing pollination, and seed dispersal and aiding in the overall retention of a variety of native plant and animal species in larger hubs or core areas.

Sites are typically smaller in scale and may or may not be attached to hubs, but despite their size or location these areas provide ecological and social values that are critical to the overall GI network. Maintaining connections between hubs, links, and ecologically significant sites strengthens the entire system by creating more resilient and biologically diverse natural communities.

*"**Green Infrastructure** can be defined as both a process and a product. Referred to as a process, the term means a systematic and collaborative conservation approach which encourages land use planning and practices that benefit nature and people. The product, or result, of this process is an interconnected system of natural areas and open space networks planned and managed for its natural resource value and for the associated benefits it confers to human populations." (Benedict and McMahon 2006)* Both uses of the term have in common a basic recognition that our built and natural environments are connected and mutually

Ecosystem Services & Natural Capital

Our natural surroundings provides direct services (e.g. air, food, water, energy) and furnishes supporting and regulating services such as water purification, carbon sequestration, and crop pollination. The benefits humans receive from ecosystem good and services are free to us and have true monetary value. When these services are impaired or lost, the community as a whole must pay to restore these systems or replace them with expensive gray infrastructure.

For example, diverse and intact wetland systems contribute to national, state, and local economies by serving as nursery grounds for commercial and recreational fisheries, filtering terrestrial runoff, protecting coastal regions from erosion and storm damage, and acting as carbon sinks which buffer against negative effects of climate change. The value of wetlands in North America has been estimated to have an annual worth of over $677 billion dollars based on the numerous functions these ecosystems perform (Worldwide Fund for Nature, 2004).

Economic Value of Wetland Functions (2000 estimates)	
Wetland Function	**Median Economic Value ($US/Acre/Year,2000)**
Flood Control	$1,146
Recreational Fishing	$924
Amenity/Recreation	$1,215
Water Filtering	$711
Biodiversity	$529
Habitat Nursery	$496
Recreational Hunting	$304
Water Supply	$111
Materials	$111
Fuel Wood	$35
Total	**$5,582**

GI seeks to identify, protect, restore, and manage the following natural ecosystem services and functions:
WATER QUALITY
Removes and reduces pollutants from water, increases groundwater recharge, and provides water quality protection for surface waters and wetlands
WATER SUPPLY & REGULATION
Stores and/or provides water within watersheds or aquifers reducing stormwater treatment needs and subsequent gray infrastructure improvement costs
AIR QUALITY & CLIMATE REGULATION
Maintains balance of atmospheric gases and sequesters greenhouse gases which regulates temperature, precipitation, and humidity through shading and evapotranspiration
POLLINATION
Enables fertilization and reproduction of important crops and other plants grown for food, beverages, fibers, spices, and medicines
PEST & DISEASE CONTROL
Provides a diverse habitat resistant to invasive pests and diseases
HAZARD MITIGATION
Reduces vulnerability to damage from flooding, storm surge, wildfire, and drought
WILDLIFE HABITAT
Provides refuge and reproduction habitats to plant and animal communities which contributes to the conservation of biological diversity and genetic evolutionary processes
EROSION & SEDIMENT CONTROL
Retains soil within an ecosystem for nutrient dispersal/cycling and prevents damage from erosion and siltation
RECREATION & ECOTOURISM
Supports ecotourism by providing an abundance of natural resources used for recreational activities (i.e. boating, fishing, kayaking, swimming, wildlife observation, and scientific education.

Valuation Tools and Resources

Listed below are a few of the more recent tools and resources that can be used by local governments and developers to identify ecosystem services and calculate the monetary value or natural capital generated from an intact and diverse Green Infrastructure Network.

- The Center for Neighborhood Technology (CNT) developed the ***Green Values © Calculator*** which can be used to quickly compare the performance, costs and benefits of green infrastructure practices to conventional stormwater practices. This free tool can be accessed @ www.greenvalues.cnt.org/national/calculator.php.
- In 2006, the U.S. Forest Service developed ***i-Tree ©***, which is a software suite that can be used to report the value of urban trees and/or forests on individual parcels, neighborhoods, cities, and regions of the state. By understanding the local, tangible ecosystem services that trees provide, i-Tree users can link urban forest management activities with environmental quality and community livability. Visit www.itreetools.org for more info.
- American Forests' ***CITYgreen ©*** is a GIS software tool that helps planners, engineers, and natural resource managers assign value to the trees found on their particular development site. It converts stormwater and energy impacts (among others) from trees and other vegetation into monetary values based on local specifications. Go to www.americanforests.org to purchase a licensed copy of this GIS analysis tool.
- The ***Low Impact Development Rapid Assessment Tool (LIDRA)*** is a model designed to compare to the life-cycle values of implementing various green infrastructure techniques used in reducing runoff versus conventional stormwater management practices. The tool pulls from a database of performance and cost values derived from national data. For more info, visit www.lidratool.org.
- The ***GreenSave ©*** **Calculator**, developed by Green Roofs for Healthy Cities and the Athena Institute, allows for the analysis of various green roof types over a set period of time in order to compare lifecycle costs. The tool is intended to help users examine future operating, maintenance, repair and replacement costs, as well energy savings benefits. This enables the users to determine whether initial costs are justified by reducing future costs. It also makes it possible to determine whether some roofs have lower initial costs that may increase over time. Visit www.greenroofs.org for additional info.

GI Implementation

Over the past decade, Green Infrastructure initiatives have been adopted, promoted, and funded at a federal and state level. In order for the results of the program to be fully actualized, *local governments* must create and enact comprehensive planning strategies, development ordinances, and zoning regulations that not only allow for, but also encourage developers and their design teams to practice GI on their projects.

> *"Green Infrastructure considers conservation values and actions in concert with land development, growth management and built infrastructure planning. Unlike other conservation approaches which are typically undertaken in isolation from, or even in opposition to, development."* (Benedict and McMahon, 2006)

As our coastal communities continue to grow, local policies and laws must also expand, diversify, and mature to meet the needs of a changing population. In this day and age, citizens are more aware and increasingly concerned with how tax revenues are generated, appropriated, and essentially spent. For this reason, City and County officials are under more pressure to implement fiscally and environmentally responsible programs and policies.

Unlike many conservation efforts preceding it, the Green Infrastructure Program seeks to balance development with conservation needs by engaging a multi-disciplinary group of partners and stakeholders. This consortium includes community leaders, landowners, developers, engineers, land planners, federal and state regulators, and natural resource managers. Local governments should host regular public forums to identify and analyze GI resources, and build a consensus on a strategic plan for the prioritization and protection of these assets for the future well-being of the community and the region as a whole.

Basic Steps in the GI Implementation Process:

1. Identify and assess existing GI assets (hubs, links and ecologically-significant sites)
2. Invite interested parties to participate in the planning and design process
3. Evaluate existing development patterns, competing land uses, and areas prone to future growth
4. Develop a strategy to balance development with conservation of green infrastructure resources
5. Integrate management of publicly owned lands with local and regional GI initiatives
6. Modify local zoning ordinances and development codes to allow for GI practices

7. Leverage state and federal funding resources to advance the protection and enhancement GI network

A potential obstacle to GI implementation in coastal Georgia is the common misperception that land conservation for the good of the public realm will infringe or encroach on private property rights. Since private lands play an essential role in the GI network, local landowners and developers must be well informed and involved throughout the decision-making process as they are ultimately the end users (beneficiaries) of the GI system. As taxpayers, they should be aware of the following values and benefits of this approach:

- Present and future natural capital assets—land conserved for ecosystem services such as stormwater treatment and flood protection means a decreased need for expensive municipal gray infrastructure systems which equates to a reduction in taxes assessed to local residents
- Properties in close proximity of natural amenities typically hold higher re-sale values
- Landowners and developers may be eligible for tax credits and deductions (see the following section for details)
- Federal and state funding is available for participating communities (see the following section for details)

Long-term conservation measures and future development activities should be viewed as mutually important factors and addressed in tandem. The GI approach is a voluntary and equitable solution to the long-term sustainability of services and goods that yields natural capital to the entire community. Increased public sector participation in the preservation of GI translates to a decreased need for costly gray infrastructure investments. With unified support for this effort, a large-scale GI network that reaches across and beyond political and jurisdictional boundaries is possible.

Local governments can ensure developers and landowners preserve and protect Green Infrastructure by requiring these practices in local regulations and policies. Another way to encourage developers to use GI practices is to offer incentives to those who go the extra mile to create environmentally-sensitive developments.

The programs and tools identified in the next section provide a collection of both regulatory and incentive-based resources available to private landowners, developers, and their design teams, as well as County officials and NGOs operating within the county or region.

Conservation Tools & Resources

The following tools, strategies, and potential funding opportunities are available for local governments, landowners, and developers interested in implementing GI practices in their communities. This following list was compiled using information from Green Infrastructure publications and websites by the Environmental Protection Agency (EPA), Natural Resource Conservation Service (NRCS), Georgia Department of Natural Resources (GDNR), Georgia Forestry Commission (GFC), Coastal Regional Commission (CRC), Department of Community Affairs (DCA), the Georgia Conservancy, Atlanta Regional Commission (ARC), and the Trust for Public Land (TPL).

Incentives for Landowners and Developers

Conservation Easements - A conservation easement is a voluntary legal agreement made by a landowner to restrict the land uses permitted on their property. It is a flexible option that can be tailored to suit the goal of the easement and the desires of the landowner. Landowners can choose to restrict one or more land uses, or to permit only particular land uses on the property, for a specified period of time.

A donation of a permanent conservation easement is eligible for significant federal and state income tax incentives. It may also reduce the landowners' property taxes by reducing the assessed value of the land. Landowners may ask for a re-assessment by their local tax assessor after completing a conservation easement. Any landowner, either private or corporate, may place an easement on their property. There is no minimum or maximum size requirement, but eligible lands must meet conservation purposes as defined by the IRS in order to qualify as a charitable gift and receive federal tax incentives. To receive the state income tax credit, the land must be certified for conservation purposes as defined by GDNR and donated to a qualified easement holder such as the *Georgia Land Trust* or the *Saint Simons Land Trust*. Check the *Land Trust Alliance* http://www.landtrustalliance.org/ and the *Georgia Land Conservation Program* (GLCP) at www.glcp.ga.gov for additional private and public entities accepting easements.

The *Georgia Conservancy*, *Association County Commissioners of Georgia* (ACCG) and the *Georgia DNR* developed the **Coastal Georgia Land Conservation Initiative**. The **CGLCI** works with coastal resource management agencies, land conservation organizations, developers, and private landowners to conserve critical lands and healthy ecosystems while promoting sustainable economic growth. Visit www.conservecoastalgeorgia.org for access to conservation easement resources as well as an interactive mapping application that shows important resources in the coastal region.

Mitigation Banking - Mitigation banking is the restoration, enhancement, or preservation of wetlands for the express purpose of providing compensation for unavoidable wetland impacts in advance of development actions. "Credits" are purchased by developers and landowners to offset damages caused by development projects. Restrictive covenants or conservation easements are placed on the property to ensure natural resources are protected in perpetuity. See http://geo.usace.army.mil/ribits/index.html for a list of mitigation banks serving your area.

Private Lands Program (PLP) – Developed by the Georgia Department of Natural Resources Wildlife Resources (WRD), this program promotes wildlife conservation on private lands. Landowners are provided with technical assistance, onsite biological consultations, management recommendations, and guidance on financial assistance programs. For more information, contact the PLP Program Office at (770)-918-6411 or (770)-761-3043.

Forest Stewardship Program (FSP) – Administered by the Georgia Forestry Commission (GFC) with help from GDNR Wildlife Resources Division (WRD), this program provides written land management plans at no cost to the landowner. Private, non-industrial forestlands of at least 25 acres are eligible for a forest stewardship plan. Based on the landowners objectives, the plan includes recommendations on managing timber, wildlife, soil and water resources, and recreational activities.

Environmental Quality Incentive Program (EQIP) – NRCS Farm Bill Program gives free technical assistance to landowners who implement management practices related to soil, water, forest, and wildlife resources on their property. Private landowners engaged in livestock, agriculture, or forestry activities are eligible for financial assistance (up to 50-70%) of the costs of implementing conservation practices. Visit the NRCS website www.ga.nrcs.usda.gov for more information.

Agriculture Conservation Easement Program (ACEP) – a Farm Bill program that recently replaced the Farm and Ranchlands Protection Program. Offers financial assistance to landowners who place a conservation easement on their property in an effort to keep productive farm and ranchlands in agricultural uses. NRCS pays 100% of the fair market value of permanent easements and between 75-100% of the restoration costs. For 30-year easements, NRCS pays 50% of the value of the easement and between 50-75% of the restoration costs. Interested parties should contact the state NRCS office at (706)-546-2272 or visit www.nrcs.gov/farmbill for more information.

Federal Income Tax Reduction – Donations of conservation easements that meet federal tax code requirements may entitle the donor to federal income tax deductions. For tax year 2014, the deduction is limited to 30% of adjusted gross income, which if not used up in 2014, may be carried forward at 30% of adjusted gross income for an additional five years or until the donation is fully expended, whichever comes first. (An enhanced federal deduction was available for the past three years, but has now expired. It could be renewed or enhanced by Congress in 2014). Contact the IRS or a tax specialist for further details.

Georgia Land Conservation Tax Credit Program - The state of Georgia provides a state income tax credit for the permanent protection of conservation lands. Approved donors can earn credits equal to 25% of the value of the donated property or easement, capped at $250,000 for individuals and an aggregate amount of $500,000 for corporations and partnerships. The credit is available for the fee-simple donation of permanently protected property or the donation of a permanent conservation easement on property made after Jan 1, 2006. Donations must be made to a qualified conservation organization (as certified by GDNR) or to a state or local governmental agency. After making a qualifying donation, the landowner must submit an application to GDNR for certification and receive a certification letter to receive the credit. For more information on the tax credit, the certification process, and a list of qualified organizations, please see www.glcp.ga.gov/taxcredit or call 770-918-6411.

General Property Exchange – Section 1031 of the IRS code allows landowners to voluntarily exchange their property for another "like-kind" property without having to pay capital gains tax on the transaction. Contact the IRS or tax specialist for further details.

Reforestation Tax Credit – This credit applies to landowners who plant and maintain timber stands on their property. Landowners who reforest their lands may be allowed to take a 10% investment tax credit for capital expenses incurred on the first $10,000 spent. Additional costs exceeding $10,000 can be amortized over a 7-year period.

Conservation Use Valuation Assessment (CUVA) – The Georgia Department of Revenue provides a reduction in property taxes through the dedication of land to a qualified use (agriculture, farming, environmentally critical, etc.). Property is assessed at 40% of its current market value. Landowners may place up to 2,000 acres in the program (restrictive covenants must be in effect a minimum of 10 years). For more info visit https://etax.dor.ga.gov/ptd/cas/cuse/index.aspx.

Energy Efficiency Tax Incentives – Property owners can get tax credit for installing qualifying energy-efficient products such as solar hot water heaters, solar electric equipment, and wind turbines. The credit is 30% of the cost of these products. There is no limit to the amount of credit you can take, and you can carry forward any unused credit to future tax years. This credit has been extended to 2016. Contact the IRS or a tax specialist for more information.

Local Government Regulatory Tools for Land Conservation

Dedications - Requests a developer donate a negotiated portion of their land as open space or as natural green space as a condition for the development approval.

Impact Fees – Fees accessed to developers to help offset infrastructure and public amenity costs necessitated by the new development. Impact fees can be applied to on-site improvements such as buildings, roads, or extending utility lines and off-site improvements such as funding for a new school or community park.

Development Incentives – Offers higher densities to landowners or developers who wish to set aside large portions of their land as open space. The purchase and/or transfer of development rights is an effective way to exchange developable land for land with high conservation value.

Development Disincentives - Discourages conventional development designs by imposing a density reduction for developers who do not incorporate Green Infrastructure protection goals.

Fee Simple Acquisition - The direct and outright purchase of a piece of property. This option can insure protection of a sensitive area—it requires landowners who are willing to sell as well as sufficient funds available for purchase.

Special Purpose Local Options Sales Tax – **SPLOST** is an optional 1% special purpose tax used to finance specific capital projects (i.e. roads, drainage improvements, municipal buildings, and civic and community-based improvements. Since program inception in 1985, Chatham County has generated more than $1.5 billion dollars from the 1 cent tax plus state-leveraged funds and interest earnings.

Local Government Zoning Tools

Local governments can use zoning designations, subdivision regulations, and building codes to control land uses and encourage green infrastructure projects.

• **Agricultural and Forest Districts** - The purpose of these districts are to help preserve blocks of agricultural and forest lands. These districts usually require that an area be kept in agricultural or forest use for the length of the agreement.

• **Planned Unit Developments (PUDs) -** Offers more flexible development practices than traditional zoning, while still meeting overall community density and land use goals. PUDs encourage open space preservation through the use of mixed use, compact or clustered development practices that result in smaller individual lot sizes. Provisions within the PUD can require developers to preserve part of the development for open space. Local governments can create a PUDs zoning district or permit a PUD in a regular zoning district on a site-by-site basis.

• **Open Space Districts** - Open space districts are created to protect natural areas and/or unique features of the site. These districts usually allow the same overall amount of development, but use clustering, density limitations, and other development restrictions to preserve open space and restrict development to a smaller area. The focus of open space districts (i.e. agriculture, forests, wetlands, parks) is flexible depending upon the desires of the local community.

• **Overlay District** - These districts are used to impose additional development restrictions in a certain area because a unique feature warrants protection. For instance, a floodplain overlay district can be used to further restrict development in the floodplain, beyond current zoning regulations.

Model Ordinances

Often, local government standards and ordinances do not allow for unconventional land development methods. In response to this challenge, the *Georgia Coastal Management Program* funded the creation of a package of companion ordinances to *Georgia's Green Growth Guidelines*. Local governments can modify these model ordinances to create development regulations and standards that are tailored to fit the individual needs of each community and the unique aspects of coastal Georgia. Templates for the following ordinances can be found at www.conservecoastalgeorgia.org.

- Stormwater Management
- Conservation Subdivisions
- Natural Resource Protection
- Riparian Buffers
- Wetlands
- Native Landscaping
- OSDS (Septic System) Maintenance and Inspection
- Preservation of Significant Lands

Additional model ordinances can be found on the *Georgia Department of Community Affairs* website@www.dca.state.ga.us/development/planningqualitygrowth/programs/modelcode.asp

- Soil Erosion & Grading
- Flood Damage Prevention
- Environmental Impact
- Alternative Development Standards
- Tree Protection
- Landscaping & Buffers
- Landuse Intensity Districts
- Scenic Corridor Overlay
- Special Growth Management
- Conservation Subdivision
- Traditional Neighborhood Design
- Low Impact Development

Funding Opportunities

A lack of funding is consistently cited as a barrier to the implementation of Green Infrastructure. Being GI projects offers so many benefits; they can compete for a variety of diverse funding services. Below is a list of several voluntary programs that offer technical and financial assistance to local governments, developers, and landowners who put GI practices into action.

EPA Clean Water Act Nonpoint Source Grants (Section 319) – 319 Grants are available for a wide variety of activities including technical and financial assistance, education, training, technology transfer, demonstration projects, and monitoring to assess the success of implemented projects. Participating landowners and developers can qualify for 60% or more cost-share assistance for implementing conservation measures on their land. Visit www.gswcc.org to obtain an application, eligibility requirements, and availability of annual program funding.

EPA Clean Water State Revolving Fund (CWSRF) – Provides funds for water quality protection projects (wastewater/stormwater treatment, watershed management, and nonpoint source pollution control). Visit http://water.epa.gov/grants_funding/home.cfm for more information on the program.

EPA Community Action for a Renewed Environment Grants (CARE) – Supports community-based partnerships to reduce pollution at a local level. For more info, visit http://www.epa.gov/care/.

EPA Office of Wetlands, Oceans and Watersheds Funding (OWOW) – Free public website offering tools, databases, and information about sources of funding for watershed protection projects. Visit http://water.epa.gov/aboutow/owow/ to access this resource.

NOAA Community Based Restoration Program – This program promotes and funds local efforts to conduct coastal habitat restoration projects in coastal Georgia. http://www.habitat.noaa.gov/restoration/programs/crp.html

DOT Transportation Enhancement Activities (TE) – Funding is provided for enhancement projects such as pedestrian/bike paths, scenic highways, landscaping, and stormwater management. Go to http://www.dot.ga.gov/localgovernment/FundingPrograms/ for more info.

Wetlands Reserve Program (WRP) - The WRP is a voluntary program that offers financial assistance to landowners who protect wetlands on their property. Usually, the landowner enters an agreement with the USDA to restore and protect the wetland, while limiting the use of the land. The program offers agreements of varying lengths, from 10 years to permanent.
http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/easements/wetlands/

National Urban and Community Forestry Program (NUCFP) – Offers cost-share grants to support community forestry projects that have national or multi-state application or impact. Visit http://www.fs.fed.us/ucf/ for further details.

Forestry Incentive Programs (FIP) - Promotes good forest management practices on privately owned, non-industrial forest lands in an effort to reduce wind and soil erosion, enhance water quality and wildlife habitat, and promote longevity of forest resources. Practices include tree planting, timber stand improvements, and natural regeneration. The FIP offers cost share assistance for participating landowners, with a limit of $10,000 per landowner and up to 65% of total costs share for implemented practices. A full list of NRCS programs can be found at www.nhq.nrcs.usda.gov/PROGRAMS/cpindex.html.

Conservation Reserve Program (CRP): A voluntary program that provides technical and financial assistance to eligible farmers and ranchers to address soil, water and related natural resource concerns on their lands. CRP offers annual rental payments and cost share assistance (usually 50%) to farmers for the term of the multi-year contract. Agreements generally last from 10 to 15 years. A full list of Farm Service Agency programs can be found at www.fsa.usda.gov/dafp/cepd/conserva.htm.

Conservation Stewardship Program (CSP) – Developed and managed by the NRCS, CSP is a Farm Bill program (formerly the Conservation Security Program) that provides financial and technical assistance to agricultural and non-industrial forestlands for the conservation and improvement of natural resources on private lands. CSP rewards participants with an annual payment for installing new conservation practices and maintaining existing activities. Contact your local NRCS office for more details or go to the website @ http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/csp/.

Georgia Land Conservation Program (GLCP) – Offers low-interest loans and competitive grants to cities, counties, state agencies, and conservation organizations to purchase land or permanent conservation easements. For more information on the GLCP and application process, visit www.glcp.ga.gov or call (404)-584-1101.

Georgia Coastal Management Program (GCMP) – Administered by the GDNR Coastal Resources Division, the GCMP offers assistance to local governments, private landowners, and industry on conservation planning, smart growth, and natural resource protection within the 11-county coastal area. Funding for conservation planning and land acquisition is available through the **Coastal Incentive Grant (CIG) Program** and the **Coastal and Estuarine Land Conservation Program (CELCP)**. Visit www.coastalgadnr.org/cm/grants/cig or www.coastalmanagement.noaa.gov/land/celcp_fundingop.html or contact GDNR - CRD at (912)-264-7218 for more details.

DOE Weatherization and Intergovernmental Program – The Department of Energy provides grants, technical assistance, and information tools to encourage the use of green infrastructure practices such green roofs, insulation, solar panels, etc. Go to http://www1.eere.energy.gov/wip/ for more info.

DOI Rivers, Trails and Conservation Assistance Program (RTCA) – The National Park Service provides assistance for community-based conservation and outdoor recreation initiatives. RCTA provides guidance to communities that conserve open space and develop trails and greenways. For more information, visit http://www.nps.gov/orgs/rtca/index.htm.

HUD Community Development Block Grant Program (CDBG) – CDBG is a flexible program that works to provide affordable housing, provide services to vulnerable communities, and create jobs through the expansion and retention of local businesses. CDBG-financed projects should include green infrastructure practices in their design and construction. http://portal.hud.gov/hudportal/HUD?src=/program_offices/comm_planning/communitydevelopment/programs

HUD Sustainable Communities Regional Planning Grants – The Department of Housing and Urban Development's Sustainable Communities Regional Planning Grant Program supports planning efforts that integrate green infrastructure practices into housing, land use, economic development, transportation, and infrastructure investments. http://portal.hud.gov/hudportal/HUD?src=/program_offices/sustainable_housing_communities/sustainable_communities_regional_planning_grants

Georgia's Green Infrastructure Network

In 2001, the University of Florida GeoPlan Center and the Environmental Protection Agency's Region IV Planning & Analysis Branch completed the Southeastern Ecological Framework (SEF) project. The GIS-based analysis produced a large-scale map showing primary ecological areas (PEAs) and significant ecological areas (SEAs).

In 2009, the Georgia Land Conservation Program (GLCP) and Georgia Department of Natural Resources conducted a joint effort to map the state's conservation values and identify regions of importance. The results of the initiative produced a statewide geographical representation of the conservation value summary (CVS) which denotes value based on the presence and abundance of specific ecological species and communities. Both the SEF and CVS decision support tools were later enhanced with new data and applied to Green Infrastructure planning efforts along the Georgia coast.

In 2011, the Coastal Georgia Land Conservation Initiative (CGLCI)—a public-private consortium comprised of the Department of Natural Resources Wildlife Resources Division (DNR), the Association of County Commissioners of Georgia, the Georgia Conservancy, and NatureServe—concluded a three-year long coastal habitat mapping project. Over 70 habitat types were assessed and mapped for each of the eleven coastal counties. In collaboration with the Wildlife Resources Division of DNR, NatureServe developed a database that includes representative ecosystem types, critical habitats supporting species of greatest concern, current land use patterns, and future land use scenarios. The analysis and inventory takes into account the presence of large, contiguous swathes of forests and wetlands, healthy streams and riparian zones, presence of rare, threatened or endangered species, existing conservation lands, prime farmland, compatible agricultural lands, pine plantations, and canopy coverage.

GI Maps

In 2012, the Georgia Forestry Commission and the Coastal Regional Commission developed the *Green Infrastructure Planning Guidelines*. The Guidelines provide conservation tools and strategies including a series of maps that illustrate the relative significance of existing conservation lands, identify areas of high conservation opportunity and vulnerability, and prioritize areas for efficient conservation action and future growth.

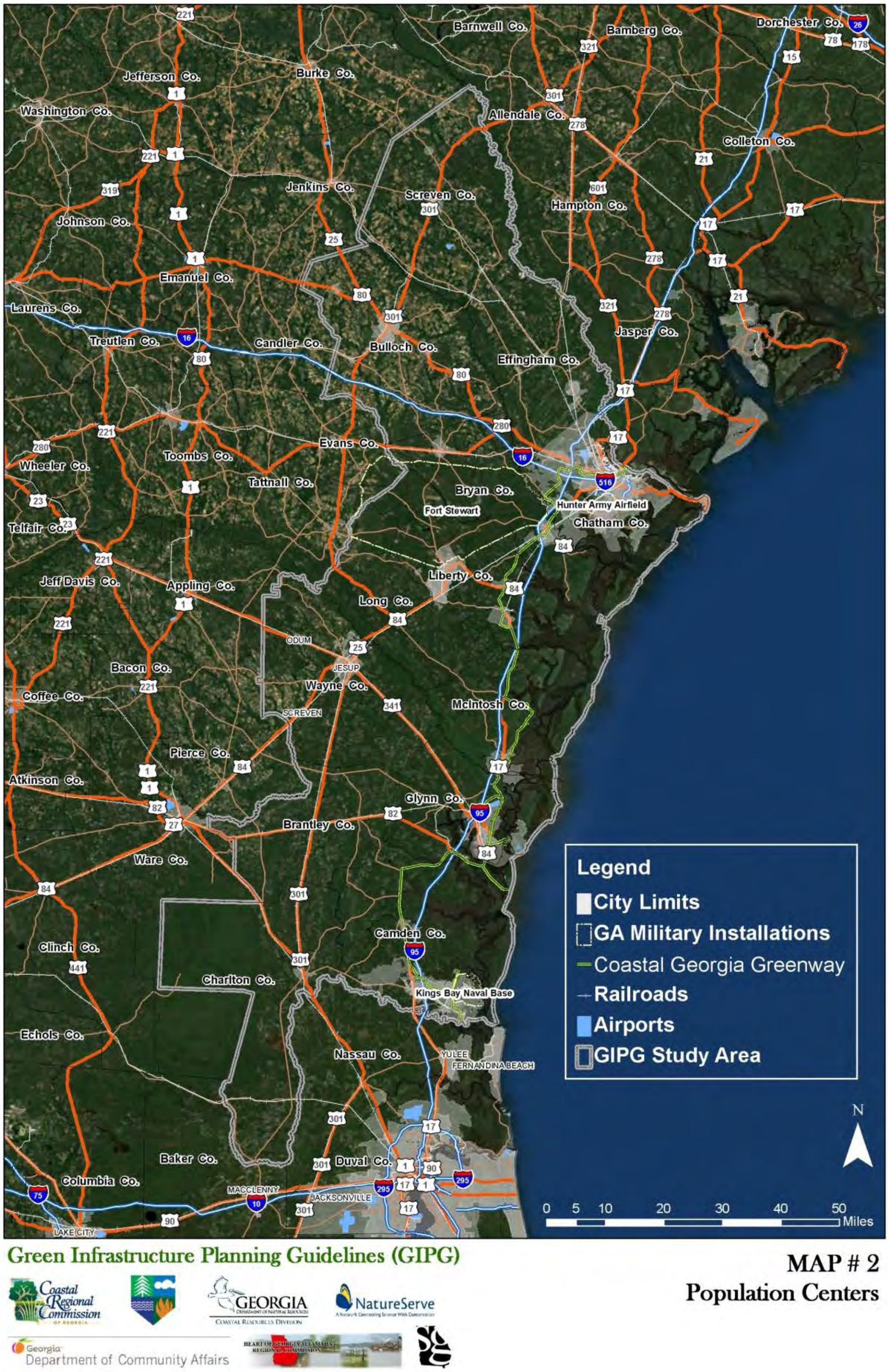
The following green infrastructure maps can be used by local governments, developers and their design teams when planning a development project in coastal Georgia. A detailed list of additional GIS Resources can be found in Appendix B.

GIPG Study Area

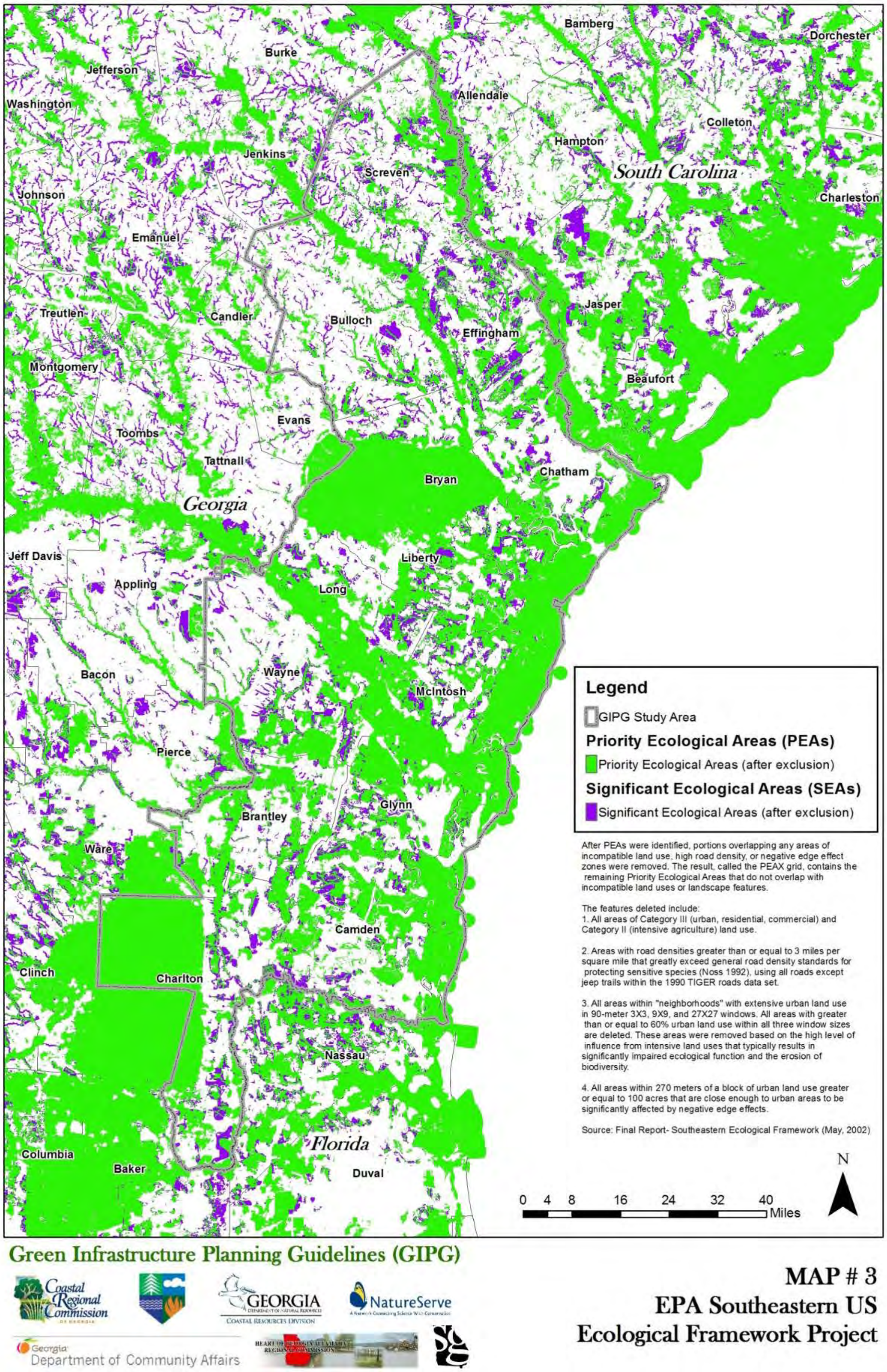
Green Infrastructure Planning Guidelines (GIPG)

MAP # 1
Study Area

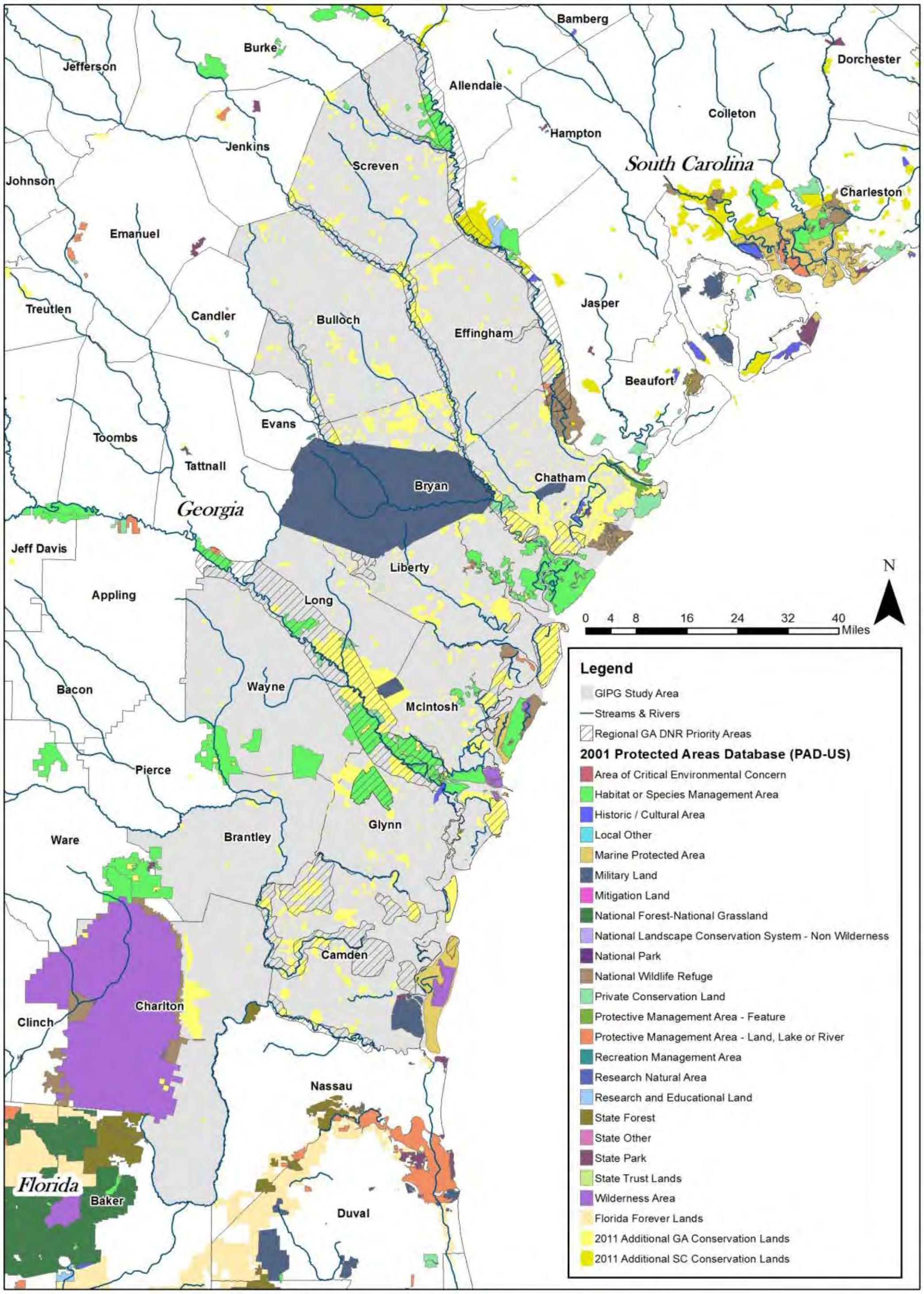
Population Centers



EPA Ecological Framework



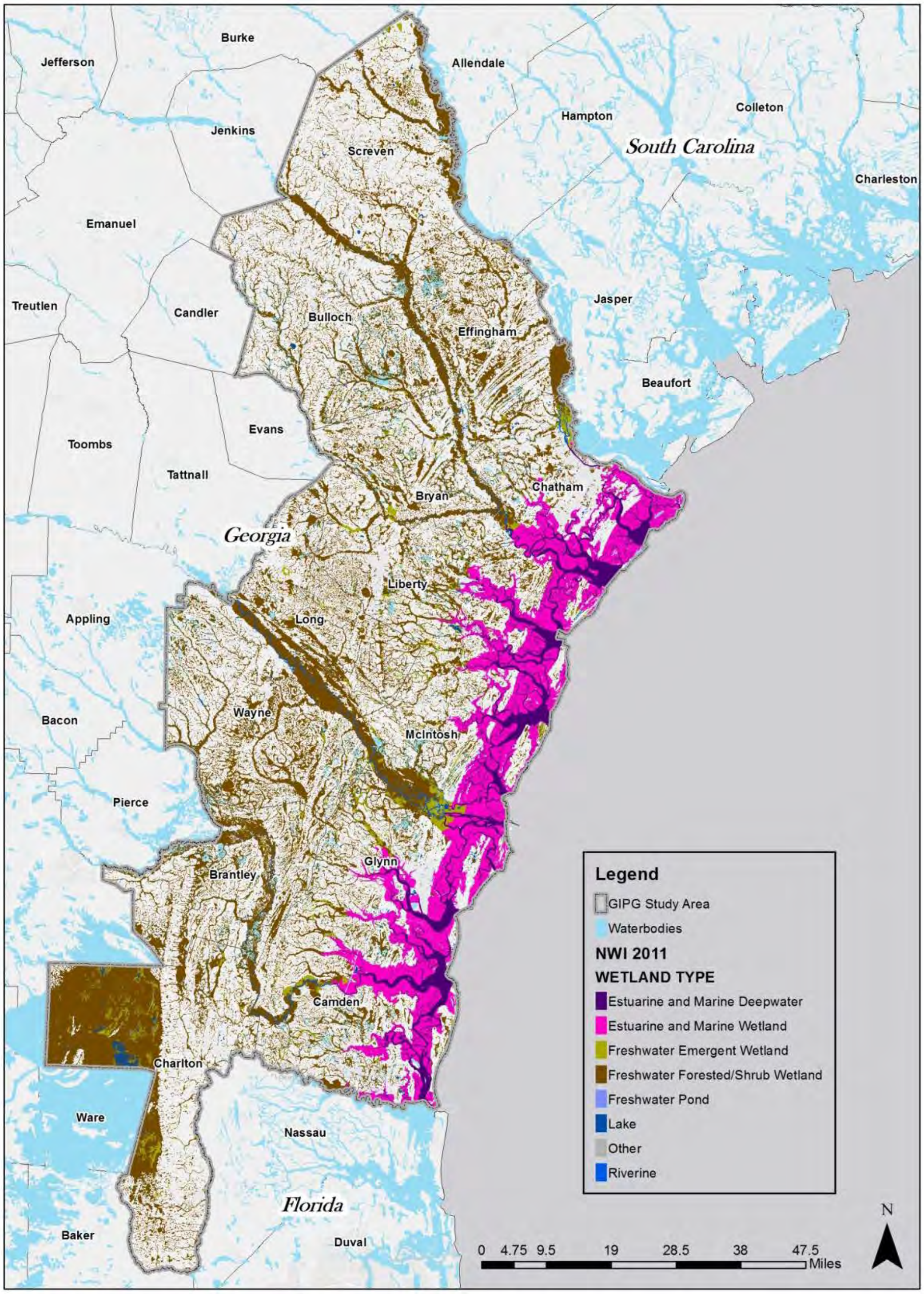
2001 Southeast GAP Analysis – Protected Areas



Green Infrastructure Planning Guidelines (GIPG)

MAP # 4
2001 Southeast GAP Analysis Project
Protected Areas Database (PAD-US)

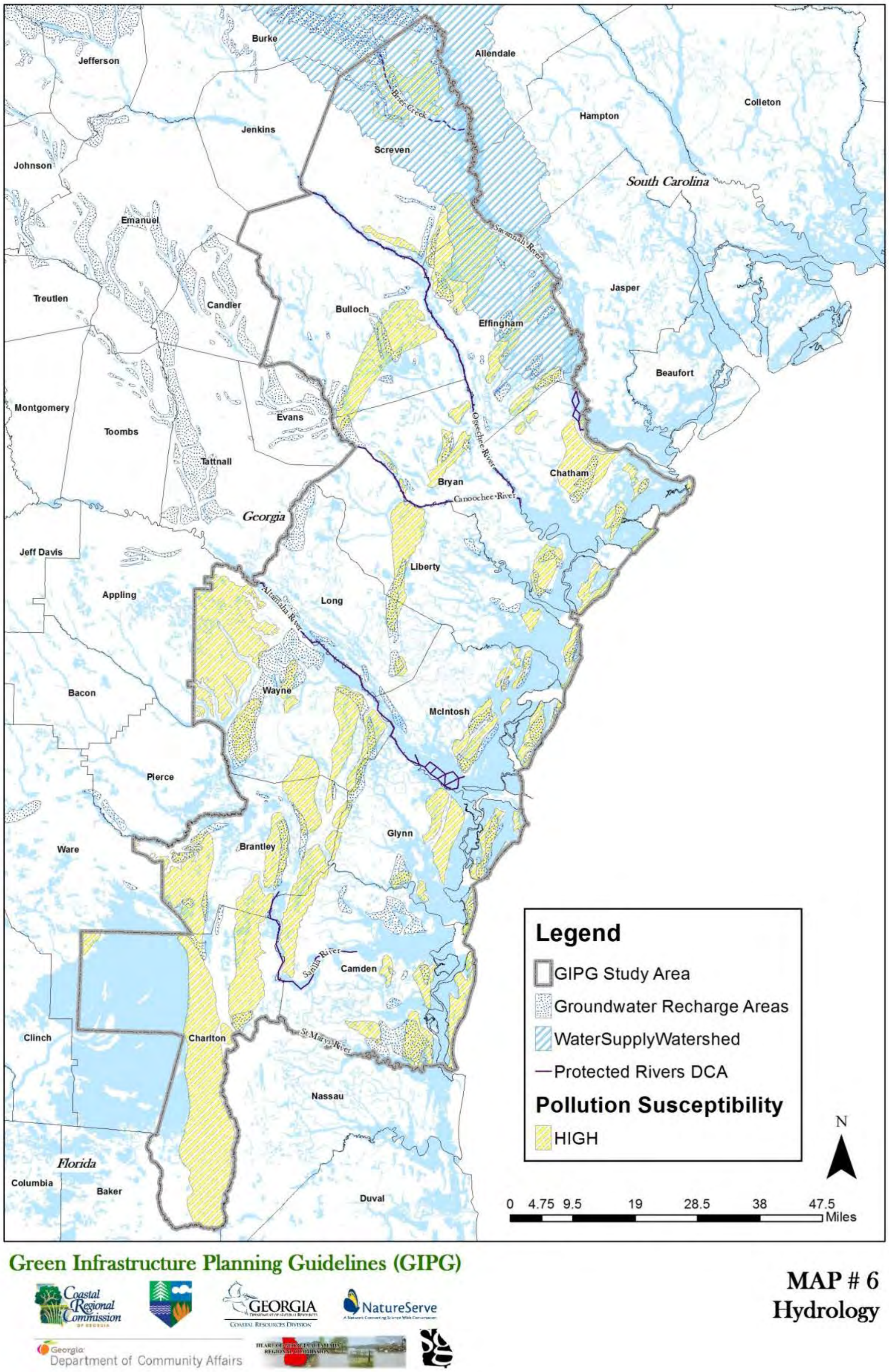
2011 National Wetland Inventory



Green Infrastructure Planning Guidelines (GIPG)

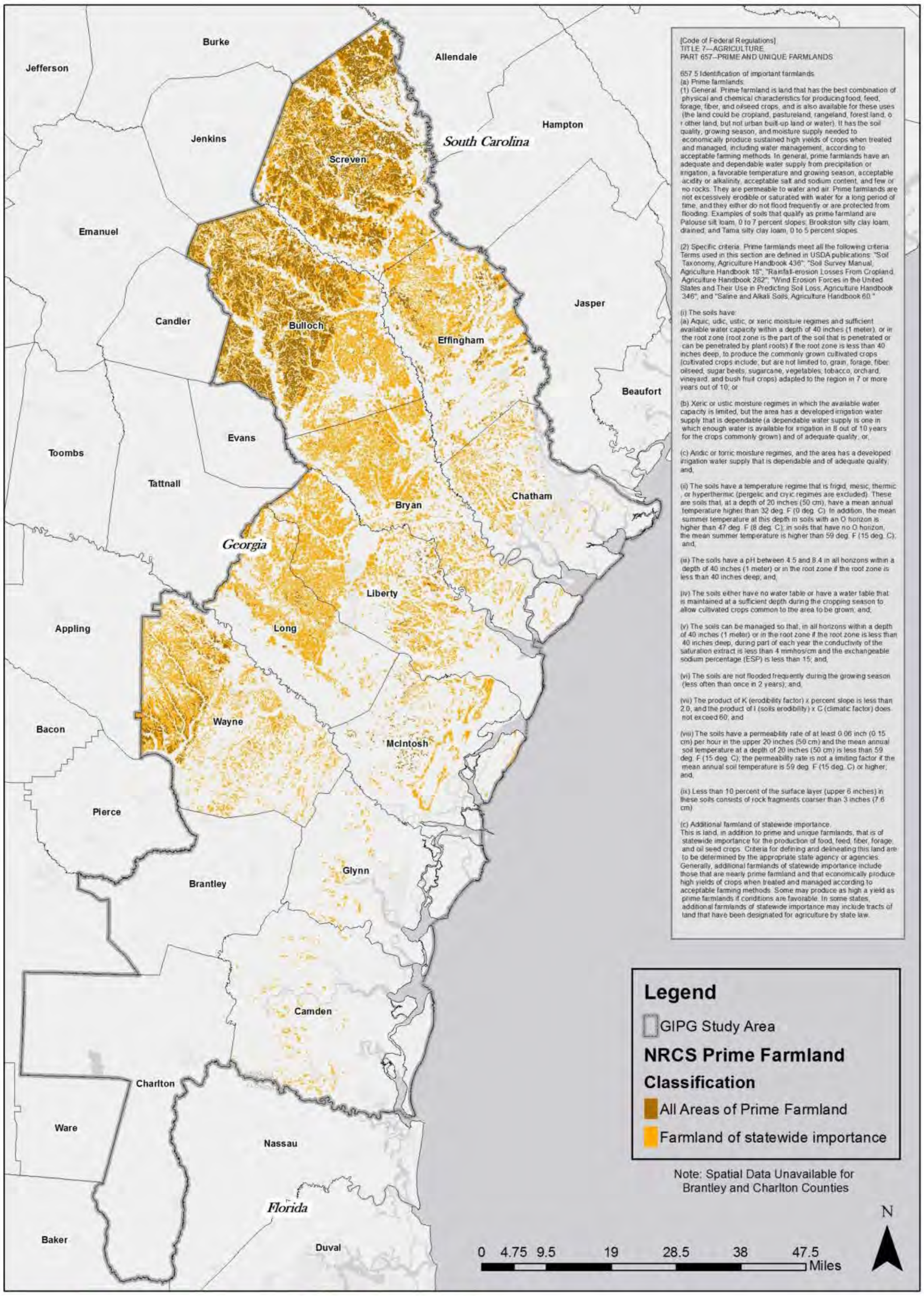
MAP # 5
2011 National Wetlands Inventory

Hydrology



MAP # 6
Hydrology

NRCS Prime Farmlands

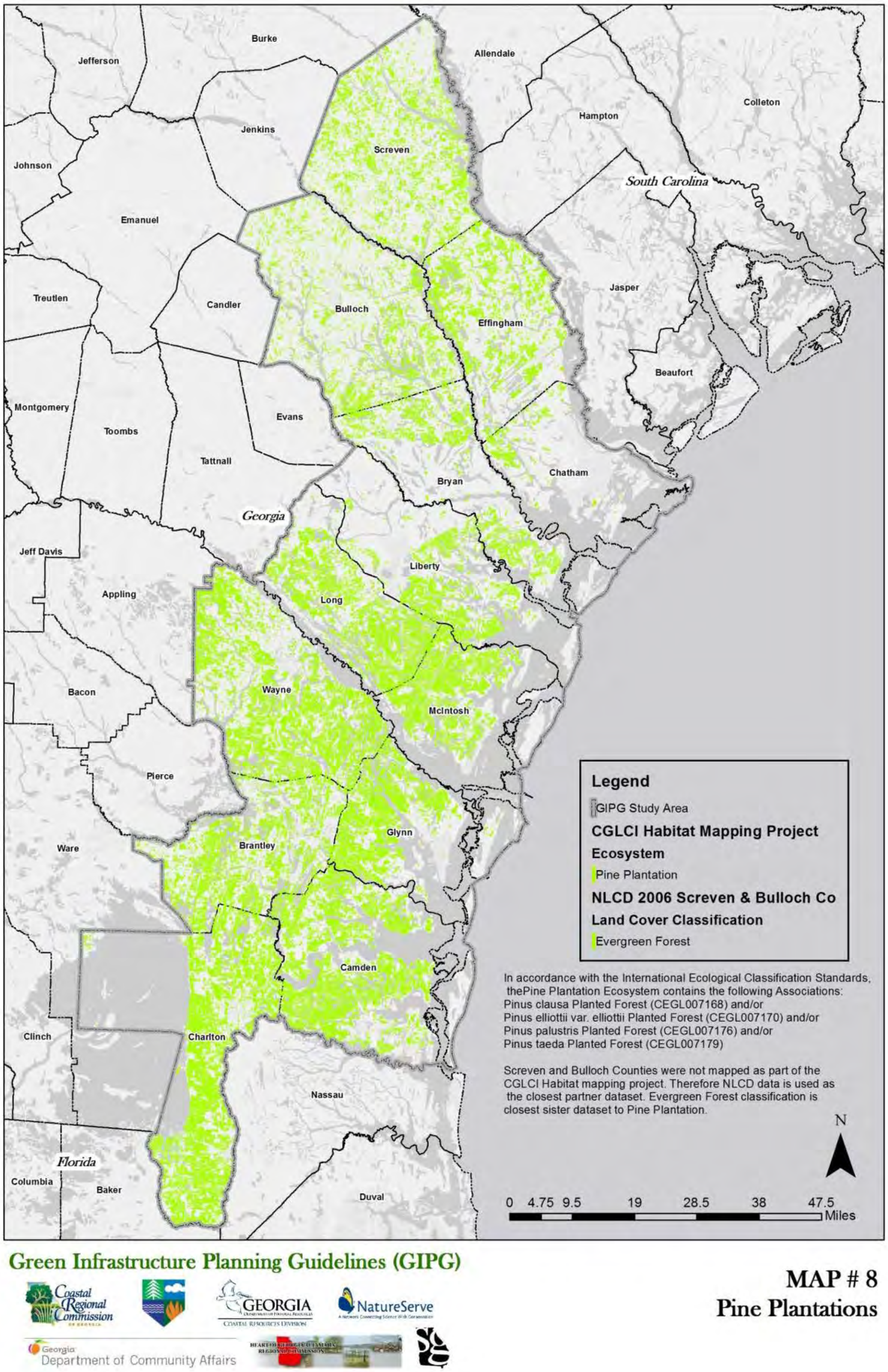


Green Infrastructure Planning Guidelines (GIPG)

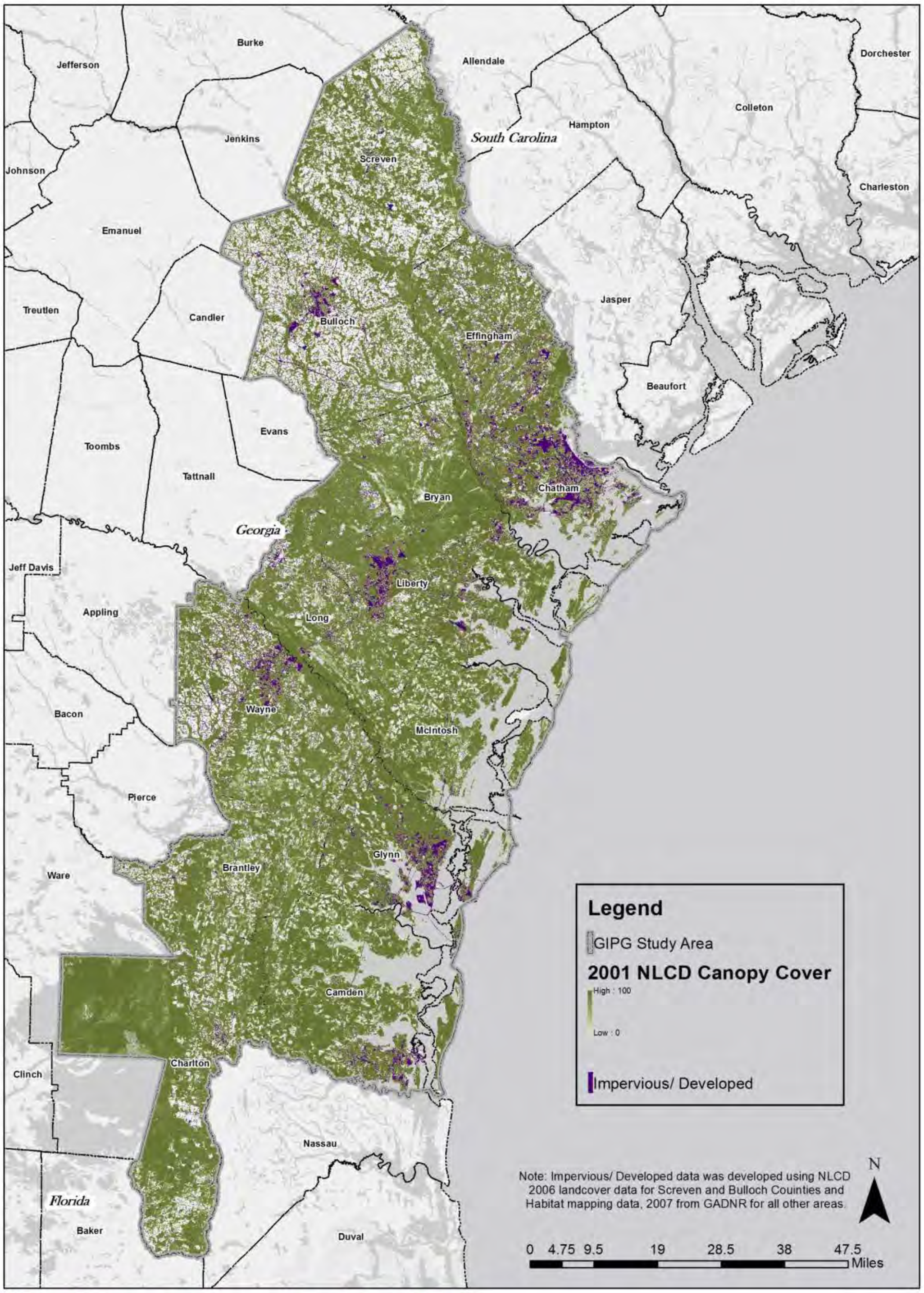
Georgia Department of Community Affairs

MAP # 7
Natural Resources Conservation Services Prime Farmlands

Pine Plantations



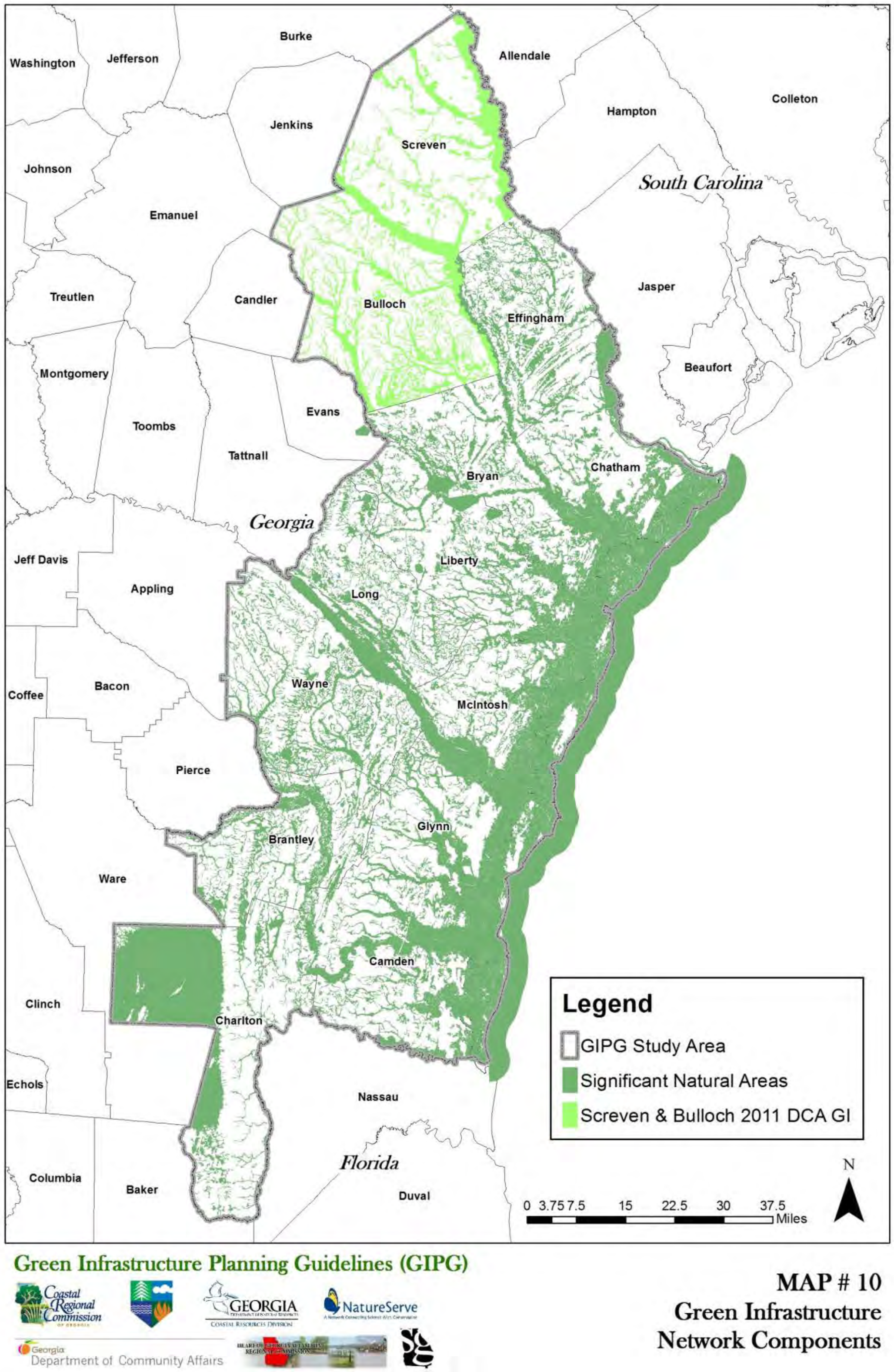
NLCD Canopy Cover



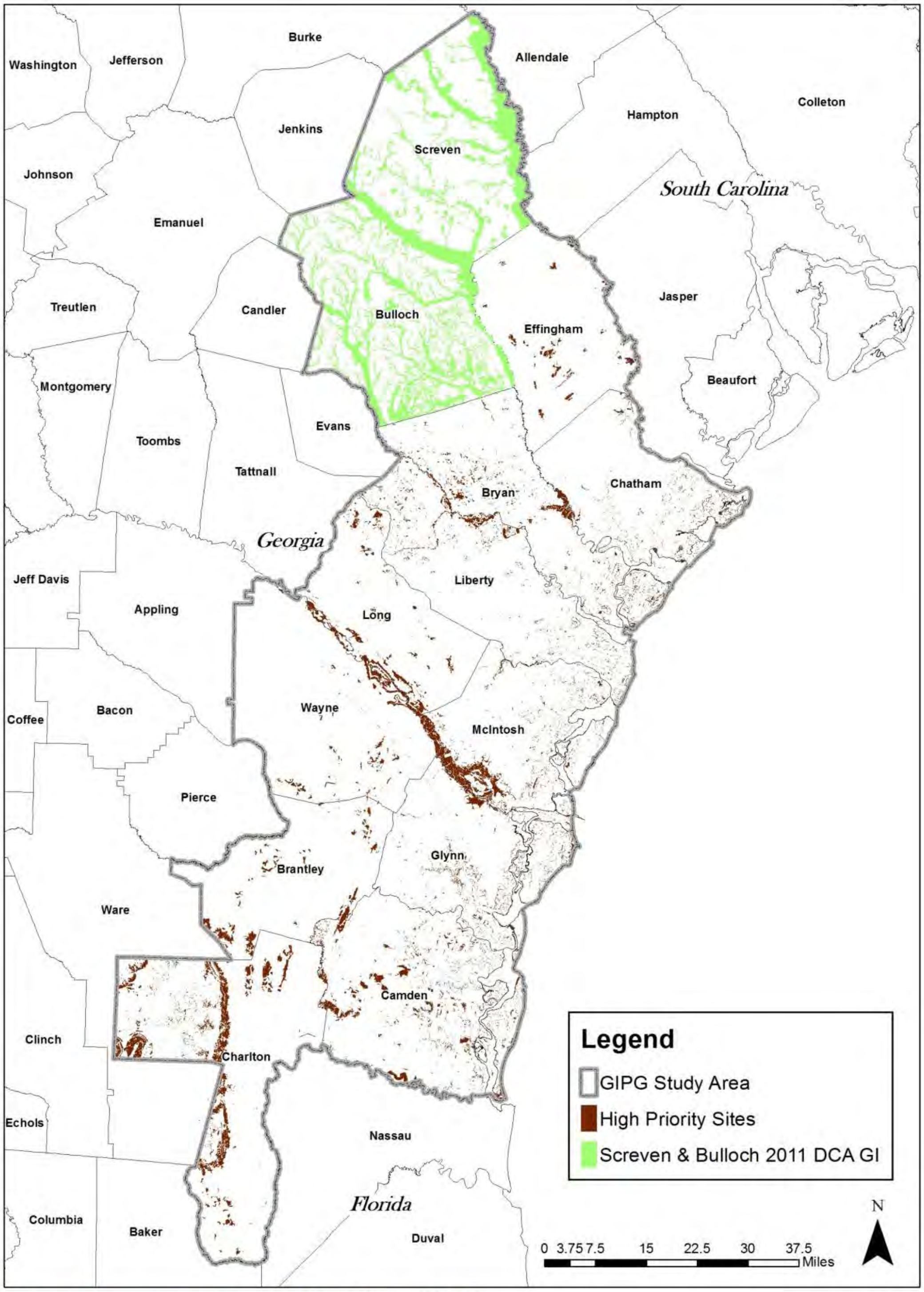
Green Infrastructure Planning Guidelines (GIPG)

MAP # 9
NLCD 2001 Canopy Cover

Significant Natural Lands



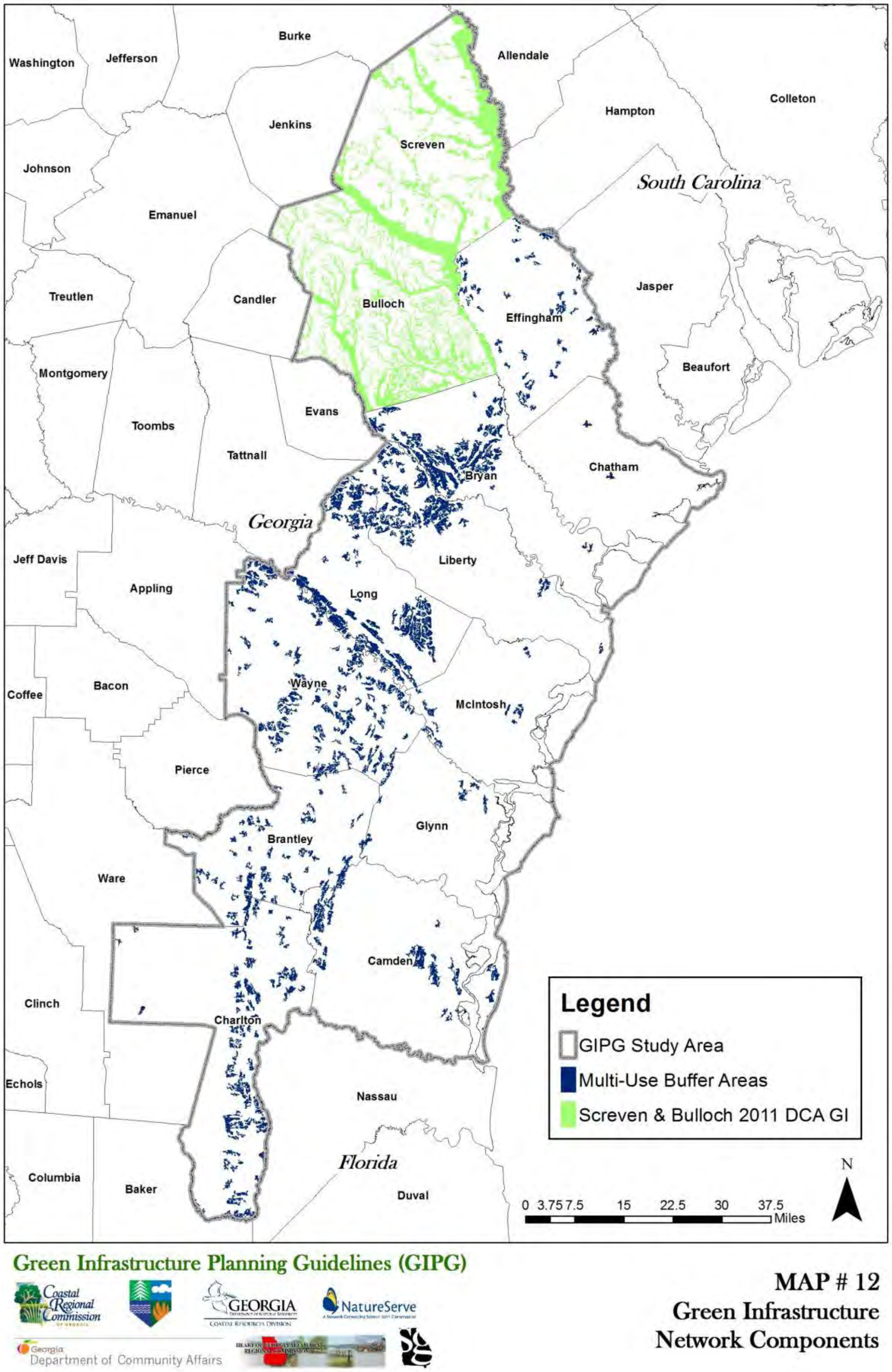
High Priority Sites



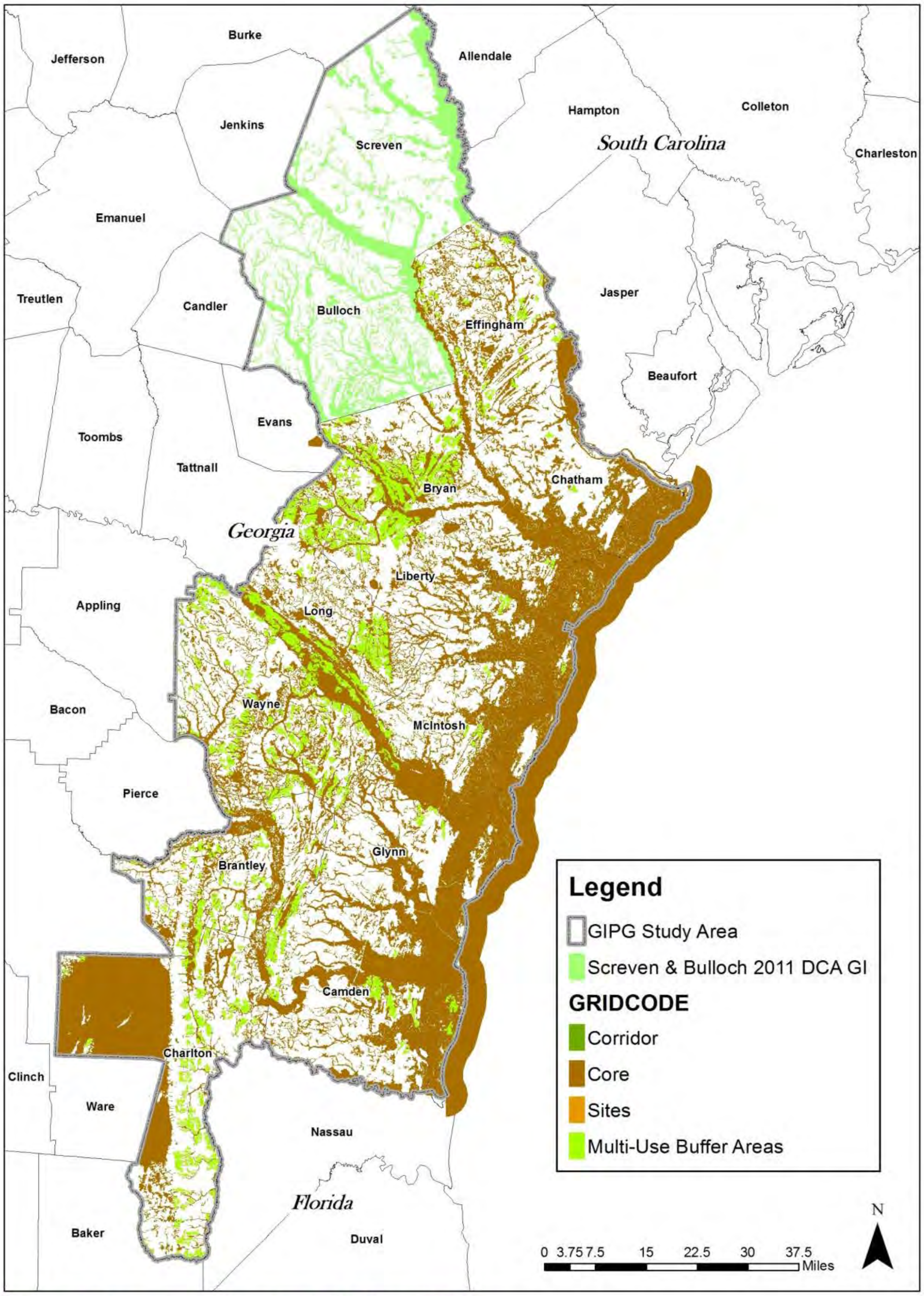
Green Infrastructure Planning Guidelines (GIPG)

MAP # 11
Green Infrastructure Network Components

Multi-Use Buffers



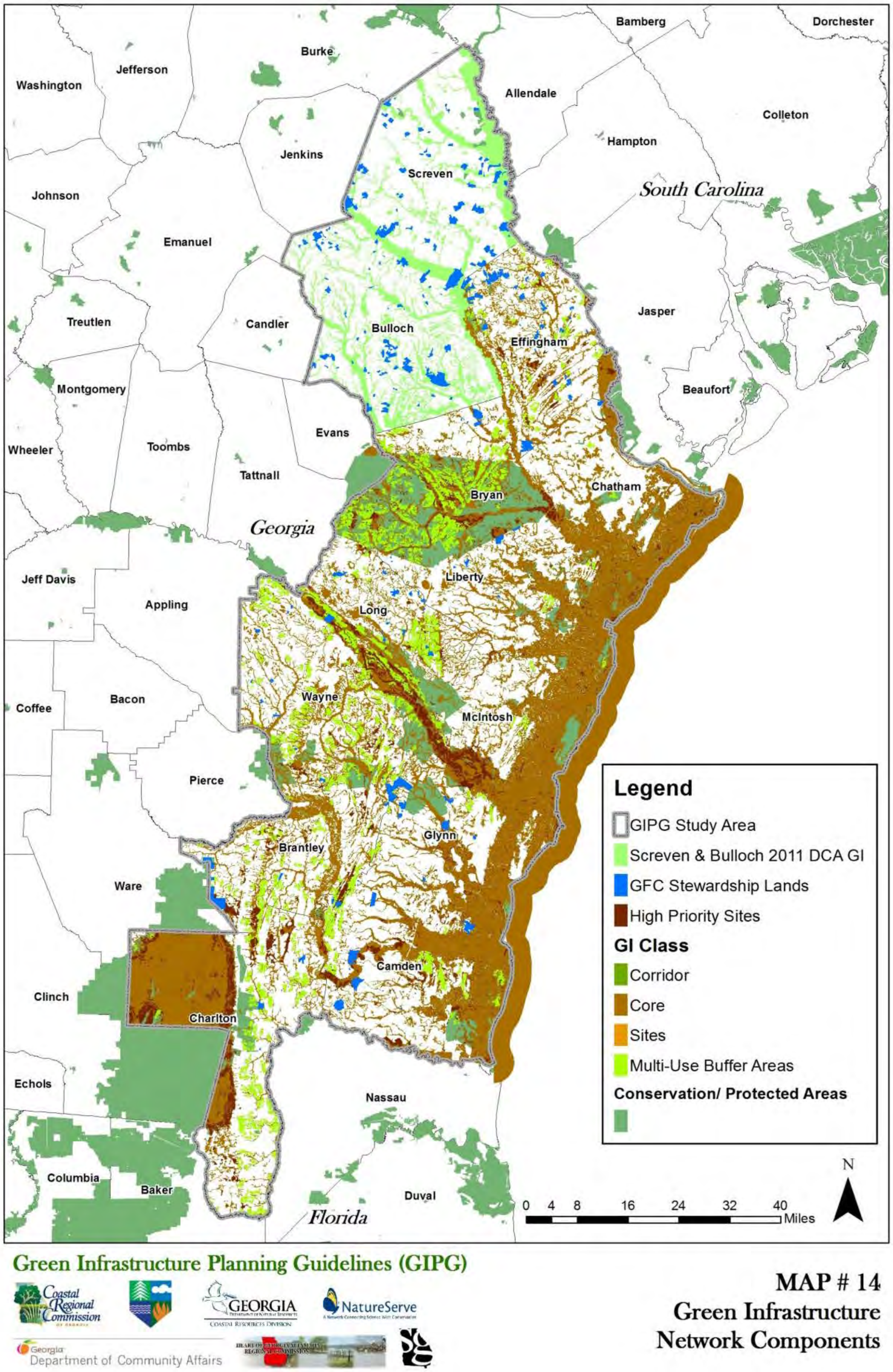
Green Infrastructure Network Components



Green Infrastructure Planning Guidelines (GIPG)

MAP # 13
Green Infrastructure
Network Components

Green Infrastructure Network Components Expanded



2–Designing with the Landform
Better Site Planning & Design

Contents

2–Designing with the Landform
Better Site Planning & Design

In This Chapter

- ***Better Site Selection Techniques***
- ***Site Planning & Design Practices***
- ***Regulatory Permitting Information & Contacts Information***
- ***Model Site Design Comparison—The Tupelo Tract***
- ***Green Building Certification Programs***
- ***Local Green Building Case Studies***

Introduction

Now that you have a better understanding of land conservation (i.e. where development should not occur), this chapter provides better site selection, planning and design guidelines (i.e. where and how development should take place).

Although this process requires coastal Georgians to reconsider many of the conventional site development practices in use today, it does so in the interest of protecting and restoring the region's valuable natural resources and the critical ecosystem services they provide.

Site Selection

While the primary subject of this chapter focuses on how development should occur, it also very important to consider where to build. Doing so helps balance land development and economic growth with the protection of coastal Georgia's important resources – before the site planning and design process even begins. Local land use planning efforts should be used to direct development away from important natural and man-made resources—such as wetlands, high priority habitats and areas of cultural/historical significance—and toward areas that are more appropriate for development. Developers can help support local land use planning efforts by using the site selection criteria provided below to select a development site. These guidelines stress the importance of locating growth – and the corresponding demand for new infrastructure (e.g. water, sewer, roadways) and municipal services (e.g. schools, police, fire) – in close proximity to existing previously developed areas (i.e. urban centers).

When selecting a site for potential development, the design team should utilize the following criteria:
Locate in close proximity to existing development to reduce land consumption and habitat fragmentation and to make use of existing infrastructure and municipal services
Provide pedestrian access to a variety of different services (e.g., commercial areas, transit routes) and to adjacent development sites
Locate near existing or planned transit, bicycle, and pedestrian routes; if possible, perform a survey of potential future site users (e.g., residents, business owners) to identify their transportation needs and preferences
Select a site that has previously been developed or that is considered to be a brownfield site; coordinate the site planning and design process with site cleanup, remediation and restoration activities, as appropriate
Select a site that has been previously developed and build on underutilized or vacant space within an existing urban center which promotes the Smart Growth infill redevelopment strategy
Select a site that is located in a priority development growth area, as designated by a local or regional land use plans
Select a site that will not require the disturbance of rivers and streams, wetlands, marsh hammocks, floodplains, groundwater recharge areas, or other important natural and man-made resources
Select a site that will avoid disturbing high priority habitat areas, as defined in the *Comprehensive Wildlife Conservation Strategy for Georgia, GDNR-WRD 2005*, or other areas providing habitat for the plant and animal species identified on federal and state threatened and endangered species lists

During the site selection process, some basic information should be used to evaluate the feasibility of conducting a development project on the prospective site. The process should consider site characteristics and constraints, applicable local, state and federal regulations, adjacent land uses, and the availability of existing infrastructure (e.g., water, sanitary sewer). Much of this information can be gathered through a joint consultation meeting and a review of the stormwater management and site planning and design requirements applicable to the site.

Early in the planning process, it is essential to have all involved parties meet, preferably on-site, to discuss the proposed development. The joint consultation meeting should involve the entire development team and representatives from applicable federal, state, and local regulatory agencies. The main objective of the pre-development meeting is to discuss the project in concept with governing authorities and identify any potential issues that may need to be considered before moving forward with the site development plan. This approach gives the design team an opportunity to analyze various alternatives and select the option that avoids or minimizes environmental impacts to the greatest extent possible.

Addressing environmental issues during the conceptual planning phase saves the developer time and money. Regulatory compliance is achieved up front which reduces the need for major design changes and plan revisions which can ultimately reduce engineering and environmental permitting costs.

Site Selection Checklist

Site Selection Checklist		
Green Growth Guidelines	√	**Comments/Notes**
Located in close proximity to existing urban core		
Will provide pedestrian access to a variety of different services (e.g., commercial areas, transit routes) and to adjacent development sites		
Located near existing or planned transit, bicycle and pedestrian routes		
Perform a survey of potential future site users (e.g., residents, business owners) to identify their transportation needs and preferences		
Select a site that has previously been developed (i.e., greyfield site) or that is considered to be a brownfield site		
Located in a priority development or priority growth area, as designated by a local or regional land use plan		
Will not require the disturbance of rivers and streams, wetlands, marsh hammocks, floodplains, groundwater recharge areas or other important natural and man-made resources		
Will not require disturbance of high priority habitat areas, as defined in the Comprehensive Wildlife Conservation Strategy for Georgia, or other areas providing habitat for the plant and animal species identified on federal and state threatened and endangered species lists		

Site Selection Checklist		
Review the local, state and federal stormwater management and site planning and design requirements that will likely apply to the development site		
Host a meeting with the local development review authority meet during the site selection process, after one or more prospective development sites have been identified		
Evaluate the feasibility of conducting a development project on the prospective development site		
Investigate opportunities and incentives for land conservation and opportunities and incentives for sustainable development projects		

Site Fingerprinting

Site fingerprinting is aplanning tool used to designcommunities where . This process enables the user to view, identify, and analyze the natural, built, economic, and social aspects of a prospective site. The basic components of this process are as follows:

Identify general site features

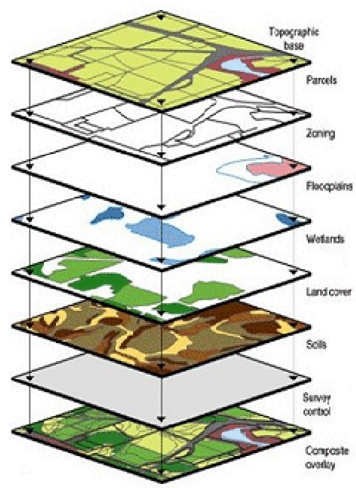
- Determine and locate primary and secondary conservation areas
- Consider other important factors adjacent land uses, accessibility, transportation and infrastructure availability
- Use collected information to derive the **actual** buildable area
- Synthesize this information into various development scenarios which incorporate the natural features of the site

Land planners, community officials, environmental scientists, engineers, and developers can natural resource using this ecology-based planning approach. Built on traditional principles, site fingerprinting uses mapping and survey technology (Geographic Information Systems “GIS” and Global Positioning Systems “GPS”) to avoid and/or minimize impacts by integrating the natural features of the site into the development concept.

The site fingerprinting process is far more efficient and accurate through the use of Geographic Information Systems (GIS) and Global Positioning Systems (GPS). These remarkably versatile mapping tools have great utility in land planning and development. GIS is a digital, geographic coordinate-based toolset used to overlay, query, and analyze information from a number of sources and inputs. GPS is a field tool used to capture geographic locations, in the form of coordinates, and record the characteristics of that location. GPS can also used to navigate to a specific location in order to verify previously gathered information or the results of GIS analysis.

The virtual desktop application of GIS and real-time, in-field application of GPS make site fingerprinting faster, cost-effective and more efficient, especially when considering the time saved in the field identifying and marking natural features already noted through GIS and GPS. While not a complete replacement for conventional methods or a legal survey, GIS and GPS improve the conventional process by delivering all site characteristics to the designer in a single picture. Furthermore, potential impacts of development scenarios can be quickly and easily measured through the use of these technologies.

A modern Geographic Information System (GIS) is a dynamic and valuable resource. To appreciate this fact, one must consider that until GIS technology was developed, maps of everything from soil types and rivers to streets and property boundaries were created by hand. The only resources for creation of these products were traditional surveys and the cartographers and field observers own interpretation of reality. To overlay any two or more of these traditional maps for any type of visual analysis posed problems. Scaling, coordinate systems, publication dates and the cartographers' own styles were all obstacles to the efficient interpretation of combined maps or data. Furthermore, the expense of photographic overlays made the overlay of multiple traditional maps even more unlikely for everyday use.



By simply adding the desired maps or layers of information to a GIS, such as parcels, residences, streets, utilities, floodplain, soils, and streams, a single digital map is produced that simultaneously displays a wealth of information. This efficient combination may produce new information such as the total acreage of wetlands on a given parcel, or the number of residences within a floodplain. What previously took weeks to research now takes a matter of hours or even minutes to complete.

GPS or Global Positioning Systems are often used in combination with GIS to field verify existing site conditions and locate physical features not yet mapped. GPS is a universal utility comprised of a radio-navigation system formed from a constellation of satellites and their ground stations. This technology uses these man-made stars as reference points to calculate one's relative position on the ground, to a level of sub-meter and sometimes centimeter accuracy. Using hand-held GPS units, real-time coordinates of certain physical features of a site can be recorded and then imported into GIS to form new layers of information from which maps and models can be produced. Like other sources of information in a GIS, the relationship between GPS and GIS is based on a common way of defining location – through real-world coordinates.

Site data can either be gathered by conventional or GPS survey methods or can be accessed by on-line databases and clearinghouses. There are many digital data sets available from national, state, and local sources that are free and/or available for purchase and can be downloaded or obtained on CD. A list of commonly used data resources are provided in Appendix B.

Natural and Man-Made Resource Inventory

Prior to the start of any land-disturbing activities, including any clearing and grading activities, acceptable site reconnaissance and surveying techniques should be used to complete a thorough assessment of the natural resources—both terrestrial and aquatic—found on a development site.

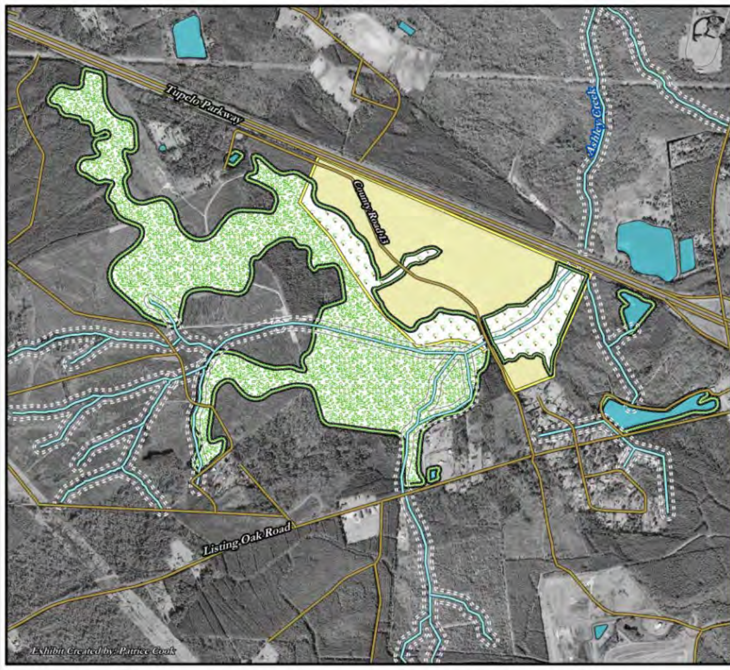
The identification, and subsequent preservation and/or restoration of these natural resources, through the use of green infrastructure practices, helps reduce the negative impacts of the land development process "by design."

The site inventory, listed in the Site Selection Checklist (contained in this chapter), should be used to identify and map the natural and man-made resources as they exist prior to the start of any land-disturbing activities.

The map that is created to illustrate the results of the natural resources inventory, (i.e. the site fingerprint) should be used to prepare a preliminary concept plan for the proposed development project.

Primary and Secondary Conservation Areas

Once a thorough analysis of existing site conditions and surrounding features is performed using GIS and GPS, the site's physical opportunities and constraints become apparent. These individual geographic, built, economical, and environmental attributes are then overlaid to form a composite map, which is used to synthesize the overall context of the site. This map shows all primary and secondary conservation areas combined, essentially defining the actual buildable area on the site.



Tupelo Tract Composite Map showing Actual Buildable Area and Primary and Secondary Conservations Areas

The overall composite becomes the base map which is used by the site designer to create a sketch level plan of the proposed development. The process of refining the land plan has historically been done using traditional survey methods. Today, we can refine the land plan using GIS and GPS technology. Instead of developing the land plan to a detailed level before site stakeout, a sketch plan can be taken into the field for adjustment (located by GPS), compared to the actual conditions on the site (mapped by GIS), and adjusted to avoid impacts before significant resources are dedicated to detailed planning, surveying, and engineering services. This process repeats until a concept plan that fits the actual character of the site is produced.

At the end of the chapter, the Site Fingerprinting process is demonstrated on a model development site—known as the **Tupelo Tract**. The demonstration includes a natural and man-made resource inventory using GIS and the preparation of a composite map showing conservation and buildable areas.

Natural & Man-Made Resource Inventory Checklist

Site Planning & Design Checklist Inventory Natural & Man-Made Resources		
Green Growth Guidelines	**√**	**Comments/Notes**
Identify and map existing contours, steep slopes (i.e., areas with slopes greater than 15%), natural drainage divides, depressional areas		
Identify and map natural drainage divides		
Identify and map natural drainage patterns and flow paths		
Identify and map natural drainage features (e.g., swales, basins, depressional areas)		
Identify and map historic, current and future (e.g., 25 to 50 years from now) mean high water (tide) lines		
Identify and map areas with perched or elevated groundwater tables		
Identify and map areas with seasonally or permanently high groundwater elevations (i.e., within 2 feet or less of the surface of the ground)		
Identify and map hydrologic soil groups and detailed soil map units, including approximate boundaries		
Identify and map unstable or unsuitable soils, such as hydric, extremely poorly drained and erodible soils		
Identify and map soils identified by the state of Georgia or the NRCS as prime farmland, unique farmland or farmland of statewide importance		
Identify and map soils disturbed by previous land development activities		
Identify and map land covers and vegetation types, indicating whether or not each zone contains the following: Note whether each zone contains the following:		
Native plants		

Site Planning & Design Checklist Inventory Natural & Man-Made Resources		
Invasive plants, as identified on federal, state and regional lists		
Native vegetative communities		
Managed vegetative communities (e.g., agricultural areas, silvicultural areas)		
Identify/map individual trees found on the site, particularly specimen, old growth, champion and monumental trees		
Identify and map the following aquatic resources, which have been identified as high priority habitat areas by the Comprehensive Wildlife Conservation Strategy for Georgia:		
Rivers and Streams		
Freshwater Wetlands, which include both jurisdictional and isolated, non-jurisdictional wetlands		
Tidal Rivers and Streams		
Sounds		
Tidal Creeks		
Coastal Marshlands, which include all of the salt marshes, intertidal areas, tidal mud flats, and tidal water bottoms found within the state's legally defined estuarine area		
Tidal Flats		
Scrub-Shrub Wetlands		
Near Coastal Waters		
Beaches		
Identify aquatic resources supporting commercial and recreational fishing and shellfishing activities including tidal marshlands, tidal creeks, estuaries, beaches, and hammocks		
Identify and map aquatic resources included on the state of Georgia's 305(b)/303(d) List		

Site Planning & Design Checklist Inventory Natural & Man-Made Resources		
Identify and map wetlands of international, national and state importance, including Outstanding National Resources Waters		
Identify and map aquatic resources that have been modified (e.g., buried, piped, drained, channelized, bulkheaded, armored)		
Identify and map the following terrestrial resources, which have been identified as high priority habitat areas by the Comprehensive Wildlife Conservation Strategy for Georgia:		
Dunes		
Maritime Forests		
Marsh Hammocks		
Evergreen Hammocks		
Canebrakes		
Bottomland Hardwood Forests		
Beech-Magnolia Forests		
Pine Flatwoods		
Longleaf Pine-Wiregrass Savannas		
Longleaf Pine-Scrub Oak Woodlands		
Identify and map high priority aquatic habitat areas, as defined in the Comprehensive Wildlife Conservation Strategy for Georgia (NOTE: there will be some overlap between this list and the aquatic resource list provided above):		
Alluvial (Brownwater) Rivers and Swamps		
Barrier Island Freshwater Wetlands and Ponds		
Bayheads and Titi Swamps		
Brackish Marsh and Salt Marsh		
Coastal Scrub-Shrub Wetlands		
Estuarine and Inshore Marine Waters		
Forested Depressional Wetlands		

Site Planning & Design Checklist Inventory Natural & Man-Made Resources		
Freshwater "Prairies"		
Intertidal/Subtidal Mud and Sand Flats		
Nonalluvial (Blackwater) Rivers and Swamps		
Offshore Marine Waters		
Natural Open-Water Ponds and Lakes		
Tidal Rivers and Freshwater Tidal Marsh		
Wet Pine Savannahs, Herb and Shrub Bogs		
Identify and map high priority terrestrial habitat areas, as defined in the Comprehensive Wildlife Conservation Strategy for Georgia (NOTE: there will be some overlap between this list and the terrestrial resource list provided above):		
Beech-Magnolia Forests		
Bottomland Hardwood Forests		
Canebrakes		
Coastal Beaches and Sand Bars		
Coastal Dunes and Bluffs		
Evergreen Hammocks and Mesic Hardwood Forests		
Hillside Seeps		
Longleaf Pine-Scrub Oak Woodlands		
Longleaf Pine-Wiregrass Savannas		
Maritime Forests and Coastal Hammocks		
Pine Flatwoods		
Identify and map other areas providing habitat, both recent and historic, for protected plant and animal species, such as those included on the federal and state threatened and endangered species lists and those protected by the Marine Mammal Protection Act, including:		
Bald eagle nesting sites and habitat protection areas; these areas are protected by the Migratory		

Site Planning & Design Checklist Inventory Natural & Man-Made Resources		
Bird Treaty Act and the Bald and Golden Eagle Protection Act		
Colonial bird (e.g., wading birds, shorebirds, etc.) nesting and roosting sites; these areas are protected by the Migratory Bird Treaty Act		
Gopher tortoise burrows; if gopher tortoise burrows are present, consult with the USFWS Ecological Services Office regarding the potential presence of the federally listed Eastern Indigo snake		
Downstream aquatic resources providing essential fish habitat including tidal marshlands, tidal creeks, estuaries, beaches, and hammocks		
Diadromous fish runs and anadromous fish spawning areas		
Wildlife corridors, including connectivity to the surrounding area		
Aquatic corridors, including connectivity to the surrounding area		
Floodplains and floodways, as determined by FEMA or GEMA or by completing a site-specific floodplain study		
Groundwater recharge areas		
Wellhead protection areas		
Other natural resources protected by setbacks, buffers, conservation easements or legal instruments (e.g., private protected lands, conservation areas)		
Identify and map existing and proposed infrastructure (e.g., utilities, roadways, railroads)		
Identify and map potential potable and non-potable water sources		
Identify nearby dams and public water supply reservoirs		
Identify and map existing and future stormwater hotspot areas and potential pollution sources		
Identify and map nearby historic landmarks and archaeological sites		

Site Planning & Design Checklist Inventory Natural & Man-Made Resources		
Identify and map nearby recreational areas (e.g., golf courses, state parks, amusement parks, campgrounds, forest preserves, marinas, public access sites, swimming and picnicking areas)		
Identify and map nearby trails and multi-use paths (e.g., riding trails, bicycle paths, hiking trails)		
Identify and map nearby open space (e.g., parks, playgrounds, school sites)		
Identify and map other interesting or unique features that help create a distinct sense of place (e.g., scenic vistas, geologic formations, specimen trees, landmarks, plazas)		

Better Site Design—Principles & Objectives

Land planning which integrates natural features (i.e. *"designing with the landform"*) into the site design is a major component of the green infrastructure approach. Site plans that accomplish this integration create livable places where natural resource conservation and wildlife management are the cornerstones for success. On a regional scale, green infrastructure strategies include the formation of compact nodes of developments connected by transportation routes and large, contiguous, green space corridors. On an individual site level, vital ecological areas are linked to the community for an improved connection to nature and to create a unique and distinctive sense of place. By understanding the context of an individual site, a site plan can be designed within the constraints of the landform, while utilizing the natural features for environmental and economic benefits. Thus, the two guiding principles which direct "*designing with the landform"* are (1) to sustain the integrity of the surrounding natural resources, and (2) to preserve and maintain cultural and natural features.

Better Site Design—Guiding Principles & Objectives
Minimize land disturbance and erosion by working with the natural topography and hydrology of the site
Locate development away from critical environmental areas such as wetlands, cultural resources, and wildlife corridors
Maintain continuous buffers and conservation areas, especially along streams and water bodies. Avoid fragmentation of buffers by roads, utilities, and trails, to the greatest extent possible
Retain a large area of green space that is preserved in a natural state and if possible, available for community recreation
Decrease the size of residential lots, streets, driveways, parking areas, and rights of way so as to increase green space acreage
Design compact development footprints that minimize impervious surface area and reduce stormwater runoff
Preserve the natural hydrology of the site and design stormwater facilities that retain runoff on-site
Preserve existing trees and vegetation and incorporate into the development, especially old growth and monumental specimens. Preserve multi-trophic layers (mixture of trees, shrubs, and herbaceous plants) that support a diverse range of wildlife species
Use native or locally adapted drought or salt-tolerant species (See marex.uga.edu/ecoscapes for local native plant lists)
Locate roads, buildings, and septic systems in areas of suitable soil, avoiding poorly drained or "hydric" soils

The Benefits of BSD

While these principles are already in use in many parts of the United States, the focus of this chapter is to adapt these principles in the coastal Georgia area. Benefits from this approach include (US EPA 2010, 2008, CWP 1988):

- Reduced and delayed stormwater runoff volumes and pollutant loads,
- Reduced sanitary and combined sewer overflow events,
- Protection of wetlands, sensitive forests, and habitats,
- Enhanced groundwater recharge,
- Reduced soil erosion during construction,
- Urban heat island mitigation,
- Reduced energy demand,
- Improved air quality,
- Increased carbon sequestration,
- Improved human health,
- Increased property values and tax revenue,
- Conservation tax incentives
- Sustainable development funding
- Reduced construction costs,
- Easier regulatory compliance,
- Creation of a sense of community within the development, and
- Improved aesthetics.

When Better Site Design (BSD) principles and Low Impact Development (LID) practices are applied in the four primary planning and design phases (namely Conservation, Streets and Parking, Lot Development, and Stormwater Management) the benefits noted above can be realized. These principles form the basis for a better site design where impervious cover is reduced, natural areas are conserved, and stormwater runoff is reduced and/or managed using Green Infrastructure and Low Impact Development practices.

The next section provides recommended practices for implementing BSD principles in each of the four primary site planning areas. The four main steps in the design process are:

1) Identification of buildable and conservation areas (Conservation Design),
2) Layout of the proposed streets and parking systems (Streets and Parking Practices),
3) Layout and configuration of the building lots (Lot Development), and
4) Layout of stormwater facilities (Stormwater Management).

A comparison of the environmental and economic benefits of these Better Site Planning and Design principles in practice on a model development site (e.g the Tupelo Tract) concludes the chapter.

Conservation Site Design

Conservation Site Design strategies seek to preserve the natural features of a site. This design type is generally achieved by compacting or condensing the actual development footprint on one portion of a site (the buildable area) while preserving significant greenspace (preferably held in its natural state) on another portion of the site (the primary and secondary conservation areas). The preservation of greenspace can result in significant economic, environmental, and social benefits, as shown throughout these Guidelines.

The first step in the design process is to identify areas within the site that should be permanently protected (i.e., non-buildable areas). This usually begins with the analysis of a composite resource map, compiled using GIS or by other conventional means.

Better site planning techniques should be used to protect the following primary conservation areas, which provide habitat for high priority plant and animal species (Appendix B and C) and are considered to be high priority habitat areas (WRD, 2005), from the direct impacts of the land development process.

Primary Conservation Areas	
Resource Group	**Resource Type**
Aquatic Resources	Rivers Perennial and Intermittent Streams Freshwater Wetlands Tidal Rivers and Streams Tidal Creeks Coastal Marshlands Tidal Flats Scrub-Shrub Wetlands Near Coastal Waters Beaches
Terrestrial Resources	Dunes Maritime Forests Marsh Hammocks Evergreen Hammocks Canebrakes Bottomland Hardwood Forests Beech-Magnolia Forests Pine Flatwoods Longleaf Pine-Wiregrass Savannas Longleaf Pine-Scrub Oak Woodlands
Other Resources	Shellfish Harvesting Areas Aquatic Buffers Other High Priority Habitat Areas

Consideration should be given to using better site planning techniques to protect the following secondary conservation areas, from the direct impacts of the land development process.

Secondary Conservation Areas	
Resource Group	**Resource Type**
General Resources	Natural Drainage Features (e.g., Swales, Basins, Depressional Areas)
	Erodible Soils
	Steep Slopes (i.e., Areas with Slopes Greater Than 15%)
	Trees and Other Existing Vegetation
Aquatic Resources	Groundwater Recharge Areas
	Wellhead Protection Areas
Other Resources	Floodplains

The following practices used during this first step in the design process are applicable to ensuring preservation of the natural features of the site with the added benefit of improved water quality.

Reduce Impervious Cover and Land Disturbance

There are strong arguments for designing more compact communities that minimize land disturbance and conserve natural areas. The first being, that the environmental benefit of a watershed is diminished when development results in land disturbance and impervious cover. Construction activities expose sediments and construction materials to rainfall events, which washes material into storm drains or directly into nearby waterways. After construction, meadows, forested areas, and other natural landscape features are replaced with compacted and fertilized lawns, impervious pavement, and rooftops. These largely impervious surfaces generate substantial quantities of surface runoff. According to U.S. Environmental Protection Agency, water quality degradation consistently occurs at relatively low levels of imperviousness, generally between 10 to 20 percent. When a watershed's topography changed and the amount of impervious cover increased, stormwater runoff was more episodic, and a larger amount of polluted water was released to receiving waterbodies. For instance, a one-acre parking lot produces 16 times the runoff as a one-acre meadow. (The Tidal Creeks Project, 1997).

The effects of urbanization on stream ecosystems are largely driven by impervious cover. There are two general ways to quantify impervious cover:

- **Total impervious area (TIA)** = all impervious area in catchment
- **Effective impervious area (EIA)** = impervious area in catchment that is directly connected to stream channels (i.e., precipitation falling on that area is effectively transported to the stream)

Many studies have found that EIA (also known as drainage connection or directly connected impervious area) is a better predictor of ecosystem alteration in urban streams. The strength of EIA relationships suggests that compact developments that retain more green space and use stormwater management practices aimed at disconnecting impervious areas from coastal waterways can improve water quality (Walsh et al. 2005).

G3 recommends the effective impervious cover be 10% or less of the total site area.

Engineers traditionally design drainage systems to move rainwater as quickly as possible by directing it towards curbs, gutters, streets, and sewers. These conventional drainage systems prevent water from flowing into the ground and filtering through soil before being released into surface and ground waters. To compound problems, traditional construction practices seek to connect all of the impervious surfaces in a development to direct water to a minimal number of drainage outlets. Even when landscaping is built into the project, the grading typically directs water away from the landscaping, thus losing any opportunity to disconnect the imperviousness for infiltration. This approach can result in increased flooding, erosion, pollution, and degraded streams.

It is important to note that some pervious surfaces, including lawns and other maintained areas, act like impervious surfaces from a water quality standpoint. However, disturbed and impervious areas vary widely in the amount, speed, and type of runoff per square foot. At one time, lawns were thought to provide open space for infiltration of water. However, development can involve wholesale grading of the site, removal of topsoil, severe erosion during construction, compaction by heavy equipment, and filling of depressions. Research now shows that even a compacted crushed rock or grassed lawn growing on severely compacted soil can act as an impervious surface.

Conservation design reduces stormwater runoff by creating compact communities that minimize land disturbance and impervious surfaces, and conserves natural areas by using smaller lots that are spaced closer together. This design practice accomplishes three major water quality goals:

1) Reduced impervious cover,
2) Reduced land disturbance due to smaller development footprint, and
3) More green space available to serve critical ecological functions (generally 20-50% of the total site area conserved).

Preserve Native Vegetation and Soils

A key principle of designing with the landform is retaining or adding significant areas of native vegetation to provide a forested canopy. Native, shrubs, and groundcover uptake excess rain water and need little or no irrigation because they are acclimated to this region's climate and rainfall. Trees also increase the value of individual lots by providing aesthetics and moderating temperatures, but they can also act as wind buffers and are one of the most effective filters for stormwater. A list of native trees, shrubs, plants, and grasses can be assessed at the University of Georgia's Marine Extension website, www.coastscapes.org.

The forest canopy can significantly reduce the volume of stormwater runoff. A healthy 100-foot-tall tree has the ability to take up 11,000 gallons of water from the soil and release it into the air again, as oxygen and water vapor, in a single growing season (Georgia Pacific, 1999). This effectiveness is achieved by a greater surface area on the leaves, branches, trunks, leaf litter and soil with which the water can interact. The whole system acts as a sponge, absorbing, treating and retaining stormwater in vast quantities.

The presence of larger trees in yards and as street trees can add from 3% to 15% to home values throughout neighborhoods. (Univ. of Washington: Green Cities: Good Health, 2010)

Measures to protect native trees and vegetation:
Locate trees before detailed planning and engineering begins
Establish tree save areas early in the planning process and protect them during construction
Keep large contiguous swathes of forested areas to maintain wildlife corridors (links) and preserve native species
Give special attention to vegetation along tidal and freshwater wetlands and streams to aid in filtering stormwater runoff before entry

In addition to native vegetation, existing soils should be considered during the planning and design phases of development. The actual performance of soils is based in great part on local conditions including:

- Severity and duration of local rainfall,
- Soil compaction,
- Velocity of runoff,
- Site contours and its neighboring grade relationship,
- Type and density of vegetation,
- Substrate type and properties,
- Distance to the water table, and
- Percolation and permeability parameters.

An analysis of all soil-related information, including percolation and stability, is essential in determining the placement of streets, lots, buildings, septic drain fields, wells and other site amenities. By knowing the location of certain soil series, planners can design the development to avoid unsuitable areas, such as hydric soils found in wetlands and poorly drained areas.

Green Infrastructure Practices for Soils
Avoid soil compaction that increases runoff. Soil compaction restricts infiltration, deep rooting, and the amount of available water, thus, inhibiting plant growth
Measures that prevent compaction include diverting traffic from areas of moist or wet soils and increasing the content of organic matter
Avoid hydric (wetland) soils for roads and building foundations
Avoid placement of septic systems in areas of poor soil – this can cause system failure and the release of contaminated effluent to groundwater aquifers
Avoid locating buildings in low areas that require the addition of fill material, especially in floodplains and wetlands, which can result in structural flooding and resource degradation
Avoid building development along unstable slopes susceptible to erosion
Retain native trees and vegetation which naturally confine soil in place
Implement proper sediment and erosion control measures during construction. Sediment barriers (silt fences, hay or straw bales) and sediment traps (forebays) are inexpensive and effective solutions. These practices are detailed in the most recent addition of the Georgia Soil & Water Conservation Commission *Field Manual for Erosion and Sediment Control*.

Protect Wetlands and Streams

When impervious cover in upstream watersheds exceeds 10%, the quality of local streams, lakes, and wetlands declines sharply, causing the following impacts often result (CWP, 1998):

- Higher peak discharge rates and greater flooding,
- Lower stream flow during dry weather (clearly evident during coastal drought periods),
- Greater stream bank erosion,
- Alteration of natural stream channels,
- Degradation of stream habitat structure,
- Increase of sediment deposition in nearby streams,
- Fragmentation of riparian forest corridor,
- Warmer stream temperatures,
- Greater loads of stormwater pollutants,
- Decline in wetland plant and animal diversity; lower diversity of aquatic insects and native fish species,
- Sewage derived bacterial levels that exceed recreational contact standards, and
- Increased number of stream crossings with greater potential to affect fish passage.

Not only is it critical for these resources to remain intact and functional for environmental reasons, it is also economically sensible to preserve these areas. Economists have calculated coastal wetlands provide valuable ecosystem services such as flood protection and recreation. For example, the Congaree Bottomland Hardwood Swamp in South Carolina removes a quantity of pollutants from the watershed equivalent to that which would be removed by a $5 million water treatment plant (USEPA 1995). In another case, scientists estimate that a 2,500 acre wetland in Georgia saves $1 million in water pollution control costs annually (OTA 1993). In 2006, hunters, anglers, bird watchers, boaters, and others who enjoy outdoor recreation spent more than $120 billion on their activities nationwide.

Coastal wetland systems are some of the most productive ecosystems in the world. Georgia's tidal wetlands account for one-third of all remaining saltwater wetlands on the east coast. Of equal importance, freshwater wetlands and streams provide essential habitat for a range of species, including some that depend on aquatic environments part or most of their life cycle. In addition, wetlands, both tidal and freshwater, provide surface and groundwater filtration and storage, flood protection, and erosion control. The water quality of these systems is essential to the overall quality of the watershed and its inhabitants. Wetlands are crucial to overall water quality as they are labyrinths of vegetation, root structures, soils, surface and submerged landforms, chemical processes, and biological activities that filter sediments and toxic substances from stormwater before discharging it into rivers and oceans. For this reason, keeping these wetland systems intact and functional is a key element of the *Designing with the Landform* process.

The following wetland protection practices are encouraged:
Avoid construction in wetlands or their buffers by building compact developments
Plan roads and utilities to cross at the narrowest point in the system
Design crossing perpendicular to the resource, diagonal crossings generally increase the area disturbed
Use permeable paving for roadways, sidewalks, driveways, parking areas, and trails
Enhance water quality by using natural wetlands for stormwater control, which puts stormwater where nature intended it
Avoid construction in contiguous and isolated wetland systems (these areas can provide natural stormwater detention for a development)
Preserve riparian buffers along wetlands and wildlife habitat
Create or construct wetlands that mimic natural hydrological processes to control nonpoint source pollutants from stormwater (see Chapter 3 - Stormwater Wetlands for a detailed description of this practice)

The quality of a receiving waterbody can be classified by the amount of impervious cover in the watershed. The amount of impervious cover is critical because it governs the amount of stormwater runoff and pollutants that flow into the stream in large quantities over short time periods. Without impervious cover, water soaks into the soil replenishing groundwater and reducing stream bank erosion among other benefits.

The primary goal of conservation design is to maintain pre-development stream quality. Healthy streams are expected to have stable channels, relatively good water quality and a diverse population of aquatic insects and fish.

Stream protection strategies include:
Reduction in the width and length of crossings to a minimum
Use existing crossings when possible
Design bridges to span the farthest distance across streams
Use bottomless culverts beneath road crossings allowing for fish passage
Preserve naturally vegetated or restored riparian buffers (a minimum of 100' in width) to improve water quality and provide sufficient habitat, (See the following sections—Riparian Buffers/Increase Buffer Effectiveness)
Implement low impact stormwater practices that control pollutants at their source before reaching the stream (Chapter 3)
Use of natural, non-invasive bank stabilization practices (Chapter 4)
Avoid alteration or obstruction to natural stream flow

Protect Wildlife Habitat and Riparian Buffers

Vegetated riparian buffers and forested areas have the capacity to reduce stormwater volumes, remove pollutants, and slow erosive flows. Taking into account their varied and considerable impact on water quality, wildlife and more, forested buffer zones are investments yielding some of the highest returns to landowners and the public in the improvement of the quality of water and life. Riparian buffers are also critical to the protection of private property from flooding and upland erosion caused by typical wet weather events as well as extreme events (e.g. hurricane-induced tidal surge).

If a wetland is nature's water filter, the riparian buffer is the pre-filter. The vegetation and soils in the buffer area perform a number of important tasks in pre-treatment of stormwater runoff before it reaches the stream. It is important that runoff flow enter the buffer zone as a sheet of water rather than concentrated flow. Techniques such as bioretention areas and grassed filter strips disperse the flow as much as possible prior to entry into a buffer zone. This process slows the water and allows the vegetation to remove harmful nonpoint source pollutants. Some of the important effects buffer zones have on protection of water quality include:

- Infiltration of water into the buffer zone slows runoff velocity (Simple friction with the surface and vegetation slows surface flows, and results in the accumulation of organic litter),
- Groundwater, a major component of stream flow, filters itself before it enters the stream via a path that passes through the soil and roots of the buffers zone, greatly expanding the effectiveness of the zone's impact on water quality,
- Nitrogen and phosphorus can be effectively removed from water flow by biochemical processes in the buffer zone (Vegetation facilitates these processes),
- Buffer zone vegetation traps sediments (The same process that slows flow velocity through the buffer also breaks up sediments into particulates that settle to the buffer floor and become part of the soil. Thus, the sediment never reaches the stream and any phosphorus becomes a nutrient for buffer zone vegetation),
- Soil in the buffer zone makes water entering the stream less acidic (The pH of water in the zone is raised by side effects of denitrification and other beneficial processes. The acidity of flow into the stream is important because highly acidic waters can have toxic effects on marine life),
- Herbicides and pesticides can be removed by biochemical activity in the buffer zones, and

- The area surrounding a stream is cooled not only by shading but by a micro-cooling process called evapotranspiration. Forested buffers are most effective in both types of cooling.

Size is an important factor in the effectiveness of buffer zones. The larger the space available for pre-treatment processes such as filtration and chemical activity, the more such activity can take place. In addition, wildlife can utilize the area as habitat. The following chart shows pollutant removal effectiveness and wildlife habitat value as a function of increased buffer width; generally the wider the buffer, the more effective.

Buffer Width (ft)	%Pollutant Removal Effectiveness	Wildlife Habitat Value
30	70	Minimal general wildlife habitat value
50	75	Wildlife travel corridor; general avian habitat
75	80	Fair to good general wildlife habitat value
100	80	Good general wildlife habitat value; may protect significant habitat
200	90	Excellent general wildlife habitat value; likely to support a diverse community
300-600	99	Excellent general wildlife habitat value; supports a diverse community; protection of significant species

Georgia has a number of laws and regulations that apply to buffer zones, so the required minimum buffer widths can vary. The Georgia Erosion and Sedimentation Control Act restricts land disturbance and trimming of vegetation within a 25’ buffer adjacent to creeks, streams, rivers, saltwater marshes, and most lakes and ponds, and within a 50’ buffer on trout streams. The Mountain and River Corridors Protection Act and the Georgia Planning Act require some local governments to adopt a 100’ buffer and restrict certain land uses along various large river corridors in the state. Water supply reservoirs, streams that flow into reservoirs, and streams above drinking water intakes may also require wider buffer zones, depending on their distance from the reservoir or intake. In 2009, the rules of the Coastal Marshlands Protection Act were amended to increase the buffer width to 50’ for the upland component of new commercial/community docks and marinas. Many local governments have adopted ordinances that specify wider buffers than the state minimum requirements (e.g. Chatham County requires a 35’ buffer in its islands overlay district). For specific information on buffer zone requirements in your area, contact your local zoning and planning department.

Being tidal waters and marshlands have been deemed an irreplaceable resource, G3 recommends a buffer of at least 100’ in width for all fresh and tidal wetlands and waterways.

Riparian buffers are of particular importance to the protection of water quality and habitat. The University of Georgia performed a literature review of over 140 articles and books in an effort to recommend scientifically sound and legally-defensible buffer width which can be found on the web at www.ecology.uga.edu/outreach. The research cites many reasons for riparian buffers, including: a) to reduce the volume and velocity of stormwater runoff in order to protect hydrological profiles; b) to reduce the sediment and pollutants going into open waters; and c) to provide upland wildlife corridors. The first two of these can be achieved with buffers ranging from 30 to 100 feet, whereas the third typically requires buffers of 300-600 feet.

Contiguous buffers are more suitable as a wildlife habitat than smaller, isolated vegetated areas scattered across the development site. When the width of the buffer as related to the size and shape of the parcel results in a situation in which it is unworkable for the physical constraints of the property, buffer averaging may be alternative solution. Buffer averaging is a method that allows for a reduction of the buffer’s width at a certain point or points just so as the average buffer width across the entire site is the required minimum width. Since runoff is often non-uniform and flow patterns are either diverging or converging due to existing topography, effective impervious cover, and other factors; buffer width should be variable by widening and narrowing the buffer as runoff loads and site conditions vary (Bentrup, 2008).

A continuous buffer provides a wildlife corridor that is of particular value in protecting amphibians and waterfowl populations, as well as coastal fish spawning and nursery areas. Such protection has an economic payoff as well, as research shows that nearly 60% of suburban residents actively engage in wildlife observation near their homes, and a majority is willing to pay a premium for homes located in a setting that attracts wildlife.

Landscaped buffer zones planted with native trees and shrubs also filter stormwater and benefit avian, terrestrial, and aquatic species dependent upon riparian habitat for survival. Rapid maturity of these buffer zones to their natural state is part of the process of increasing the effectiveness of the entire system.

Selective pruning and thinning of the existing vegetation in the buffer is permitted for the purpose of creating and maintaining a keyhole view corridor. “Keyhole” views provide sightlines extending to the marsh or open water beyond the buffer. Vegetation frames the view and can enhance privacy, aesthetics, and a sense of place while providing necessary buffer functions (Coastal Riparian Buffer Guidance, UGA River Basin Center).

Streams, wetlands, and areas where water is stored or treated even intermittently should be protected by a buffer of mixed (both woody and herbaceous) plants native to the region and suitable for local climatic conditions (Visit www.coastscapes.org for an extensive list of recommended native plantings). In some cases, the riparian buffer may need to be restored. See Ch. 4 Streambank Stabilization, Natural Vegetation Establishment (Practice 1) for further details.

Increase Buffer Effectiveness

Buffers are created by designating a vegetated corridor along a stream or wetland as an undeveloped area. Careful site design and smart planning can increase the width of these areas by using a technique known as “stacking” the buffer. Essentially, an area adjacent to the standard “required” (usually 25’) buffer area is used for a mixture of stormwater treatment practices. As an example, placing a bioretention area or filter strip outside of the state-mandated 25’ buffer could essentially increase the area preserved along streams or wetlands. Since the bioretention area itself is vegetated, a buffer zone that could well exceed 100’ in width may be created along the stream. This is substantially more effective than a more random location of these treatment practices. Since these areas are heavily wooded, buffers may be selectively pruned so that a resident’s view corridor to streams or wetland areas is not restricted.

Recommended design practices that increase buffer effectiveness include:
Combining GI & LID stormwater practices with natural undisturbed buffer areas (also known as buffer stacking) provides a stormwater treatment train to remove potential nonpoint source pollutants from overland runoff
Avoid siting roads and supporting Infrastructure within buffer zones to the greatest extent possible (If unavoidable, utilities should be bundled and run through the buffer in the least invasive manner possible)
When buffer zones and their associated streams or wetlands are crossed, they should be done so at the narrowest possible point to limit disturbance
If buffer is absent natural vegetation, reestablish native trees, shrubs and plants that require little or no irrigation and/or fertilizers

Sea Level Rise

Compact or clustered development strategies can help communities adapt to sea level rise, storm surge, and flooding of properties located along coastal wetlands and waterway. By building on a condensed footprint and determining what land to preserve and what to develop, communities can build resilience to the weather-related effects of climate change. Besides helping communities prepare for an uncertain future, these strategies can also help them deal with natural disasters, economic changes like rising fuel prices, and other challenges that could arise regardless of climate change.

Recommended design considerations for sea level rise include:
Discourage building in existing or projected flood plains or in areas that could be affected by rising sea levels and higher tides
Upgrade stormwater systems to better manage heavier storm flows and considering methods like green infrastructure to reduce the amount of runoff from paved surfaces
Coordinating land use and transportation infrastructure decisions and incorporating climate change projections into these decisions
Preserving large, contiguous areas of open space to better protect ecosystems that may be under pressure from the changing climate
Encouraging water- and energy-efficient buildings and land-use patterns so that they can continue to thrive if energy prices rise

Georgia, in particular, is vulnerable to SLR impacts due to its more than 2,300 miles of tidally influenced shoreline and growing population which now exceeds 500,000 people in the six coastal counties (Concannon et al 2010; U.S. Census 2010).

To help developers, designers, natural resource managers, and landowners, the Skidaway Institute of Oceanography developed a web-based interactive map that displays information about sea level rise, shoreline change, storm surge, FEMA flood zones, historical hurricane tracks, land use and cover, and armored shorelines. The Georgia Coastal Hazard Portal (www.gchp.skio.usg.edu) is a user-friendly decision-support aid that can be used to evaluate how sea level rise and erosion are predicted to affect properties along coastal marshlands and waterways. Other community maps and visuals are available at NOAA Coastal Services Center's website www.csc.noaa.gov/slr.

Preserve Greenspace

Community green space offers a number of benefits including:

- Reduced cost from using undevelopable land for runoff control and treatment,
- Reduced cost by eliminating the necessity for landscape maintenance for a fairly large portion of the property. Land owners can save between $270 to $640 per acre in annual mowing and maintenance costs when open lands are managed as a natural buffer area rather than turf (Wildlife Habitat Enhancement Council, 1992),
- When carefully designed, green space can promote better pedestrian movement, a stronger sense of community space and a park-like setting. Numerous studies have confirmed that developments situated near trails or parks sell for a higher price than more distant homes (North Inlet-Winyah Bay NERR Coastal Training Program, 2002).
- Enhancing development by creating a centralized and often even educational natural area for the community,
- Providing wildlife habitat for native species and nature-watching opportunities

As consumer demand for green space amenities continues to grow, the quality of streams and wetlands can be linked to improved marketability of these areas. Communities have repeatedly found that property adjacent to protected wetlands, floodplains, shorelines, and forests constitutes an excellent location for development. (U.S. EPA, 1995). A sense of place is instilled by the presence of water, forest, and natural areas and this preference is expressed in a greater willingness to pay to live near these habitats.

When managed as a "greenway," riparian buffers can expand recreational opportunities and increase the value of adjacent properties. Several studies have shown that greenway parks increase the value of homes adjacent to them. A park in Philadelphia is credited with a 33% increase to the value of nearby property – a net increase of more than $3.3 million in real estate value is attributed to the park. A greenway in Boulder, Colorado, was found to have increased aggregate property values by $5.4 million, resulting in $500,000 of additional tax revenue per year. (Chesapeake Bay Foundation, 1996.).

Street & Parking Design

The second step is the better site design process is the layout of an appropriate transportation network. *Green Growth Guidelines* encourages designs that reduce impervious surfaces and increase usable open spaces or conservation areas. Among the many practices that can achieve this goal are better road design and green parking techniques.

Given recognition of natural features and planning to accentuate and preserve these features, the appropriate street pattern will accommodate the natural contours of the site while improving interconnectivity and safety. Since streets and parking areas are impervious collectors of grease, antifreeze, oil, heavy metals, pathogens, and general debris, it is imperative to reduce impervious surfaces and nonpoint source pollutants running off of these areas.

There are several street and parking design patterns that lend themselves to reducing impervious area and increasing common open and/or preserved green space. Use of the best features of these patterns can result in numerous environmental, social, and economic benefits when compared to conventional development. Street and parking design patterns that facilitate the green infrastructure approach include (CWP, 1998):

- The grid or traditional urban pattern features short block lengths, straight streets and a systematic layout. This pattern generates greater dispersal of traffic, increased number of routes to a given destination, greater safety for pedestrians, ease of use of public transportation, and an increase in the number of homes fronting a street by using narrower lots,
- The curvilinear "modified grid" pattern is similar to a grid pattern which features longer block lengths (The curvilinear pattern allows a site designer to better follow the topography of the site to avoid sensitive environmental areas, thereby, reducing clearing, excavation, and filling activities associated with road construction),
- Hybrid street networks combine both grid and curvilinear to better accommodate the natural features of a site.

Street Width and Length

Significant reduction to impervious cover can be accomplished by minimizing street width and length. Accordingly, streets should be designed as narrow and short as possible for intended use. Careful design of streets can satisfy concerns regarding parking, safety, and traffic congestion. Conventional standards include a 32’ wide roadway composed of two 7’ parking lanes on either side of two 9’ wide moving traffic lanes. With only one 8’ wide parking lane, two 10’ wide travel lanes are standard.

Recommended design practices for roads include:
Base design on average daily traffic volume calculated by the number of actual trips per day
Provision for safe and efficient access for emergency vehicles
Design for the minimum required pavement to support traffic and parking
On-street parking lanes should serve as traffic lanes (also known as a “queuing lane”)
For urban streets with parking on both sides actual width is recommended at 32’ (The recommended actual width of a neighborhood street with parking on one side is 24’, while local street width is recommended at 18’ and a gravel alley has recommended width of 14’)

Benefits from these practices include:

- Reduction in impervious cover,
- Reduction in the speed of traffic provides greater safety for pedestrians,
- Significant savings in cost of paving, clearing and grading, infrastructure, long-term pavement maintenance and stormwater management. A savings of approximately $150 per linear foot can be achieved by shortening roads (CBP, 1993). This includes savings achieved through reduced pavement and stormwater control.

Right-of-Way Width

A street right-of-way is an area where streets, sidewalks, utilities, and sometimes stormwater features are located. Often, the entire right-of-way is cleared in preparation for grading and road construction, potentially resulting in unnecessary loss of trees and vegetation. Limiting the cleared land width reduces the amount of land disturbed. Reducing the right-of-way makes more land available for housing lots and facilitates designing a compact land plan. Conventionally, a right-of-way width of 50 to 60 feet is applicable to all residential streets.

Recommended design practices for street rights-of-way include:
Reduce cleared width to minimum required to facilitate roadway, sidewalk, and vegetated open channels
Utilities should be bundled together and located within the pavement section of the right-of-way when possible
Reduce rights-of-way by 10 to 25 feet by decreasing pavement and sidewalk width and bundling utilities within the pavement section Encourage the use of natural stormwater practices within rights-of-way such as bioretention swales and grassed filter strips that reduce the use the cleared area to treat stormwater runoff

Recommended design options for a narrower right-of-way on residential streets (CWP 1998) include:

- 36’ Road Scenario

  16’ Pavement Width – Two 8’ Wide Travel Lanes

  One 8’ Grassed Utility Easement

  One 12’ to 18’ Grass Shoulder with Parking

- 38’ Road Scenario

  20’ to 22’ Pavement Width – Two 10’ to 11’ Wide Travel Lanes

  One 8’ Grassed Utility Easement

  One 8’ to 15’ Swale

- 42’ Road Scenario

  22’ to 26’ Pavement Width – Two 8’ to 9’ Travel Lanes with One 6’ to 8’ Emergency or Parking Lane

  One 8’ Grassed Utility Easement

  One 8’ Sidewalk

Primary benefits include:

- Opportunity for on-site stormwater control and treatment,
- Reduces area to be cleared, resulting in a cost benefit, and
- More land available for development or green space.

Cul-De-Sacs & Alternative Turnarounds

A cul-de-sac is a dead-end residential street often used in conventional subdivisions. Typically, the terminal end is a large “bulb” that carries a radius of 50’ to 60’, entirely impervious and almost never fully utilized for turning purposes. There are alternative turnaround designs that serve the intended purpose while significantly reducing the area of impervious cover.

Turnaround Option	Impervious Cover (SF)
40’ Radius Cul-De-Sac	5,024
40’ Radius Cul-De-Sac with Landscaped Island	4,397
30’ Radius Cul-De-Sac	2,826
30’ Radius Cul-De-Sac with Landscaped Island	2,512
60’ by 20’ T-Shaped Turnaround	1,200

Recommended design practices for cul-de-sacs and turnarounds include:
Reduce the radius of the turnaround bulb to 40’ or less
Use interconnected streets to minimize the number of cul-de-sacs
Place a pervious island in the center of the turnaround and landscape with water-absorbing plants to facilitate storage and treatment of stormwater
Consider alternatives to circular cul-de-sacs like the T-Shaped turnaround, which can generate 75% less impervious cover than a 40’ radius circular turnaround, and the loop road, which provides multiple accesses and can carry twice the traffic volume of a cul-de-sac

Benefits include (CWP, 1998):

- Reduced impervious surface area,
- Attractive to homebuyers due to lower traffic and sense of privacy, and
- Landscaped islands can be designed as rain gardens for stormwater control.

Sidewalks and Driveways

Excessive sidewalk and driveway requirements can increase the amount of impervious area within a site, further preventing infiltration of stormwater runoff into the soil. As much as 20% of the impervious cover in a residential subdivision consists of driveways and sidewalks (CWP, 1998).

Recommended design practices for sidewalks and driveways include:
Locate sidewalks on only one side of the street
Use sidewalk widths of 6 feet in areas of high foot traffic and reduce the width to 3 or 4 feet in areas that will see less traffic
Specify narrower driveway widths
Reduce the length of driveways by relaxing street and side yard setbacks
Encourage shared driveways
Use permeable surfacing materials for sidewalk and driveway construction
Create driveways as two parallel strips with vegetation between them instead of one large expanse of concrete
Sidewalks should be graded so that they drain to the adjacent bioretention swales or rain gardens, as opposed to the street

Benefits from these practices include (CWP, 1998):

- Reduces impervious area,
- Allows for greater on-site infiltration of stormwater if bio-swales and rain gardens are used, and
- Cost savings in construction and maintenance due to reduction in amount of paving.

Parking and Parking Lots

Since parking lots, like streets and on-street parking, can be the largest impervious collectors of pollutants and debris, it is imperative to reduce these impervious surfaces and non-point source pollutants running off of these areas with common, practical, strategies referred to as "green parking".

Parking ratios are the number of parking spaces that must be provided based on land use as established by local governing bodies. They are typically based on the minimum number of spaces needed to support peak parking hour(s). Studies summarized below have shown that typically, far more spaces are built than are actually needed:

Conventional Minimum Parking Ratios

Land Use	Parking Requirement	Typical Range	Actual Average Parking Demand
Single Family Homes	2 spaces per dwelling unit	1.5 – 2.5	1.11 spaces per dwelling unit
Shopping Center	5 spaces for 1000 ft	4.0 – 6.5	3.97 per 1000 ft GFA
Convenience Store	3 spaces for 1000 ft	2.0 – 10.0	-
Industrial	3.3 spaces for 1000 ft	0.5 – 2.0	1.48 per 1000 ft GFA
Medical Office	1 space for 1000 ft	4.5 – 10.0	4.11 per 1.48 per 1000 ft GFA

*GFA = gross floor area of a building without storage or utility spaces.

Recommended design practices for parking include:
Limit the number of required parking spaces to meet actual average parking demand
Reduce the dimensions of parking stalls by 6” to 1’ off their current length and width
Create more spaces for compact cars
Pervious materials are recommended for use to pave a variety of lower usage areas including overflow parking, emergency and service lanes. A wide variety of alternative materials are available including modular pavers, gravel, crushed shell, grass pave, turf blocks, and porous concrete
Reduce the volume of stormwater runoff by requiring landscaped areas be used for stormwater management. Landscaped areas can include parking islands which can be used as bioretention areas, dry swales, or filter strips
Encourage shared parking and promote structured parking (multi-level lots). In urban areas, especially commercial areas, high parking ratios make green parking techniques, especially shared parking and structured parking, a practical approach to reducing overall impervious coverage

Primary benefits from reduction of excess parking spaces, minimization of parking stall dimension, and encouragement of shared parking and multi-level garages include:

- Decreases impervious cover and related stormwater runoff,
- Reduces construction and maintenance cost. Cost per conventional space can range from $2,000, an indication that a reduction in the required number of spaces would result in a cost savings in construction or maintenance (EPA, 2006), and
- Building a parking structure is costly but takes up no more impervious area than a single level parking lot. Therefore, in an urban setting, multi-level structures may be a financial incentive for developers.

Lot Development – The Building Footprint

The third step in the Better Site Design process involves locating individual homes sites within the buildable area of the tract. Primary consideration is given to the natural contours of the land, especially when siting building lots to minimize land-disturbing activities such as clearing and grading. In addition, the dimensions of a lot can be modified to reduce overall impervious areas and then used to accommodate stormwater management features.

Conventional subdivisions require certain distance setbacks along all sides of the lot that often restrict a site designer's ability to design compact developments and reduce impervious surfaces and related runoff problems. Relaxed building setbacks and frontages can be used to reduce roadway, driveway, and sidewalk lengths and help minimize the creation of new impervious cover on development sites. This allows the design team to use flexible lot shapes which limit site imperviousness, sometimes by as much as 40 to 60 percent. (Coastal Stormwater Supplement, CWP, MPC 2009)

Site planning and design teams are encouraged to reduce impervious cover by compacting the building footprint. This can be achieved by developing vertical versus horizontal (i.e. taller buildings with same amount of livable space). According to the Atlanta Regional Commission, a single story building can generate up to 75% more impervious cover than a four-story building with the same occupancy capacity.

Benefits of these practices include:

- Reduction in total impervious area by 40% or more when compared to conventional subdivision lot layouts, particularly if narrower streets can be utilized,
- Lower construction cost by reduced clearing, grading, and paving,
- Conserves trees and natural areas,
- Protects watershed by reducing annual stormwater runoff volume by as much as 60% and, accordingly, stormwater pollution by a corresponding amount, and
- Highly desirable green space amenity creates higher market value for lots and faster value appreciation.

Stormwater Management

Human impact can disrupt or destroy many of the processes that allow the natural landscape to perform its hydrological function of releasing cleansed water to the ocean, streams and creeks and to the local groundwater. Stormwater runoff generated from impervious cover can be a significant threat to the quality of wetlands, surface water, and groundwater. Research has shown:

- Wetlands can be adversely affected by the quality and quantity of stormwater it receives from upstream areas.
- Sole source aquifers can be contaminated if stormwater pollutants are discharged underground.
- Stormwater pollutants can be directly attributed to the closure of beaches and shellfish beds.
- Fish and wildlife habitat can be degraded by erosion and sedimentation.

Stormwater management should seek to control both the quality and quantity of stormwater runoff created from new development activity. Quantity control is achieved by use of "constructed" wetlands and ponds, which help minimize flooding and protect downstream channels from accelerated erosion. Quality control is achieved through implementation of stormwater best management practices (BMP's) like enlarged vegetated buffers, bio-retention areas, and infiltration basins that use natural processes to remove harmful nonpoint source pollutants. (CWP, 1998)

To become more effective, stormwater management must incorporate low impact development practices in its process for solving stormwater problems "*at the source*". With its focus on the reduction of impervious cover and the utilization of greenspace for stormwater treatment, LID site design practices can greatly reduce the volume of stormwater runoff leaving the site.

The following LID practices can be implemented at the site design stage:
Where feasible, parking areas, paths, sidewalks, driveways, and roadways should be surfaced using permeable paving
Parking and roadways should have grass filter strips, swales or bioretention areas to provide stormwater treatment and storage
Preserve areas with native vegetation for runoff control and buffering of environmentally-sensitive areas

While these are basic examples of how LID practices can improve stormwater management, BMPs are the primary method of stormwater control. These practices, their physical description, application, and resulting benefits, are discussed further in Chapter 3. The *Coastal Stormwater Supplement* (CSS) to the *Georgia Stormwater Management Manual* provides detailed design specifications and stormwater management credit criteria for each of these practices.

Site Planning and Design Checklist

Site Planning and Design Checklist		
Analyze Site Characteristics and Constraints—Conduct a detailed analysis of the results of the natural and man-made resources inventory to gain a thorough understanding of the site's characteristics, constraints and development opportunities		
Green Growth Guidelines	√	**Comments/Notes**
Topography		
Analyze the site's natural topography, including its existing contours and topographical features		
Avoid creating the need for excessive clearing, grading and cut and fill activities on the development site		
Preserve topography during layout of the site's transportation network		
Avoid locating buildings, roadways and other impervious surfaces in low-lying areas that require the addition of significant amounts of fill material		
Avoid locating buildings, roadways and other impervious surfaces on steep slopes (i.e., slopes of 15% or greater)		
Orient buildings so that their major axes are parallel to existing contour lines		
Natural Drainage Divides, Patterns and Features		
Analyze the site's natural drainage divides, patterns and features (e.g., swales, basins, depressional areas)		
Where feasible, ensure that natural drainage features (e.g., swales, basins, depressional areas) are preserved		
Avoid creating the need for the filling and grading of natural drainage features, depressional areas and flow paths		
Avoid locating buildings, roadways and other impervious surfaces in natural drainage features and flow paths		
Soils		
Analyze the properties of the soils found on the development site, including soil plasticity, drainage capacity, stability, permeability and shrink-swell potential		

Site Planning and Design Checklist		
Evaluate proper use and management of the soils, using guidance provided by the NRCS soil surveys		
Define the site's reference soil condition by evaluating the site's undisturbed soils for the following: organic matter content and depth, texture and bulk densities, infiltration rates, soil biological function, and soil chemical characteristics		
Evaluate the site's previously disturbed soils for the following: organic matter content and depth, texture and bulk densities, infiltration rates, soil biological function, and soil chemical characteristics		
Avoid creating the need for excessive soil compaction on the development site		
Avoid locating buildings, roadways and other impervious surfaces on hydric (i.e., wetland) and extremely poorly drained soils		
Avoid locating septic systems in areas with soils that have low permeabilities and poor percolation rates		
Avoid locating buildings, roadways and other impervious surfaces in areas that have soils with extremely high permeabilities		
Avoid locating septic systems in areas with soils that have extremely high permeabilities		
Avoid locating buildings, roadways and other impervious surfaces in areas with unstable or unsuitable soils		
<u>Trees and Other Existing Vegetation</u>		
Analyze the site's trees and other existing vegetation		
Where feasible, ensure that trees and other existing vegetation, especially old growth and specimen trees, are preserved		
Avoid creating the need to disturb trees and other existing vegetation in areas that have soils that are particularly unstable or susceptible to erosion		
Avoid creating the need to disturb trees and other existing vegetation on steep slopes (i.e., slopes of 15 percent or greater)		

Site Planning and Design Checklist		
Where feasible, maintain continuous areas of trees and other existing vegetation, especially along aquatic corridors and around streams, wetlands and other aquatic resources (i.e., aquatic buffers)		
Avoid fragmenting large, continuous areas of trees and other existing vegetation with roadways, utility crossings and trails		
Delineate tree protection areas early in the site planning and design process		
Other Site Characteristics and Constraints		
Analyze land use changes over time by reviewing historic aerial photos		
Analyze average annual and monthly precipitation patterns and temperature conditions		
Analyze site specific conditions, such as microclimate, wind direction, sun angles, slope and microtopography, that may affect site design decisions, such as building orientation and design		

Site Planning and Design Checklist		
Apply Better Site Planning Techniques—Use better site planning techniques to protect the important natural and man-made resources found on the development site		
Green Growth Guidelines	**√**	**Comments/Notes**
Preserve and protect the following primary conservation areas, which provide a number of valuable ecosystem services, including habitat for high priority and protected plant and animal species, from the land development process:		
Aquatic Resources		
Rivers and Streams		
Freshwater Wetlands		
Tidal Rivers and Streams		
Sounds		
Tidal Creeks		
Coastal Marshlands		
Tidal Flats		
Scrub-Shrub Wetlands		
Near Coastal Waters		
Beaches		
Terrestrial Resources		
Dunes		
Maritime Forests		
Marsh Hammocks		
Evergreen Hammocks		
Canebrakes		
Bottomland Hardwood Forests		
Beech-Magnolia Forests		
Pine Flatwoods		
Longleaf Pine-Wiregrass Savannas		
Longleaf Pine-Scrub Oak Woodlands		

Site Planning and Design Checklist		
High Priority Habitat Areas and Areas Providing Habitat for Protected Plant and Animal Species		
High Priority Habitat Areas		
Areas Providing Habitat for Protected Plant and Animal Species		
Other Natural Resources		
Shellfish Harvesting Areas		
Aquatic Corridors		
Man-Made Resources		
Historic Landmarks/Archeological Sites		
Preserve and protect the following secondary conservation areas, which may be considered "buildable," but have significant value if left undisturbed, from the land development process:		
Site Characteristics and Constraints		
Natural Drainage Divides		
Natural Drainage Patterns		
Natural Drainage Features (e.g., Swales, Basins, Depressional Areas)		
Erodible Soils		
Steep Slopes (i.e., Areas with Slopes Greater Than 15%)		
Trees and Other Existing Vegetation		
Other Natural Resources		
Floodplains		
Groundwater Recharge Areas		
Wellhead Protection Areas		
Man-Made Resources		
Recreational Areas		
Trails		
Open Space (e.g., Parks, Playgrounds)		
Scenic Vistas		

Site Planning and Design Checklist		
Preserve important natural and man-made resources, such as wetlands, pine flatwoods and groundwater recharge areas as large, intact tracts of land		
Preserve high priority habitat areas, as defined in the Comprehensive Wildlife Conservation Strategy for Georgia and other areas that provide habitat for protected plant and animal species as large, intact tracts of land		
Preserve areas that provide habitat for diverse groups of plant and animal species		
Preserve areas containing native trees and other existing vegetation, especially old growth and specimen trees		
Preserve existing aquatic and wildlife corridors and maintain connectivity with adjacent natural and man-made resources		
Establish a buffer along aquatic corridors around all streams, wetlands and other aquatic resources		
Unless they are being reforested or revegetated, maintain primary and secondary conservation areas in an undisturbed, natural state before, during and after construction and protect them in perpetuity through a legally enforceable conservation instrument (e.g., conservation easement, deed restriction)		

Site Planning and Design Checklist		
Establish Aquatic Buffers		
Green Growth Guidelines	**√**	**Comments/Notes**
Maintain continuous areas of trees and other existing vegetation along aquatic corridors and around streams, wetlands and other aquatic resources		
Consider the intended function of the buffer when deciding how wide an aquatic buffer should be; generally speaking, the wider an aquatic buffer, the more effective it will be		
Although state law requires the creation of 25-foot wide aquatic buffers, 50- to 75-foot wide aquatic buffers are preferred		
Do not interrupt aquatic buffers with impervious surfaces or bypass them with stormwater outfalls that discharge stormwater runoff directly into the streams, wetlands or other aquatic resources being protected by the buffers		
Reforest or revegetate aquatic corridors and buffer areas that have been significantly altered by clearing, grading and other land disturbing activities or that consist exclusively of managed turf		
Instead of clearing them completely, selectively prune aquatic buffers to create "view corridors" to nearby streams and wetlands		
Limit the length of the flow path within the contributing drainage area and use level spreaders at the upstream end of aquatic buffers used to "receive" stormwater runoff		
Unless they are being reforested or revegetated, maintain aquatic buffers in an undisturbed, natural state before, during and after construction and protect them in perpetuity through a legally enforceable conservation instrument (e.g., conservation easement, deed restriction)		

Site Planning and Design Checklist		
Apply Better Site Design Techniques—Use better site design techniques to minimize land disturbance and limit the creation of new impervious and disturbed pervious cover on the development site		
Green Growth Guidelines	**√**	**Comments/Notes**
<u>Transportation Network Design</u>		
Use the results of the natural and man-made resource inventory to design a transportation network that compliments the development site's characteristics and constraints		
Minimize the creation of ne w impervious cover during the design of the transportation network using the following better site design techniques:		
Reducing Roadway Lengths and Widths		
Reducing Right-of-Way Widths		
Using Fewer or Alternative Cul-de-Sacs		
Reducing Driveway Lengths and Widths		
Reducing Sidewalk Lengths and Widths		
Reducing Parking Lot Footprints		
Creating Parking Lot Landscaping Islands		
<u>Lot Design</u>		
Use the results of the natural and man-made resource inventory to create a lot layout that is consistent with the development site's characteristics and constraints		
Use the following better site design techniques to reduce the need for roadways, driveways, sidewalks and other impervious surfaces on the development site:		
Reducing Building Footprints		
Reducing Setbacks and Frontages		

Site Planning and Design Checklist		
Apply Stormwater Management Practices—Use stormwater management practices to manage and reduce stormwaterrunoff rates, volumes and pollutant loads on the development ****See CH. 3 For Details on SW Practices Listed Below****		
Green Growth Guidelines	√	**Comments/Notes**
Stormwater Management System Design		
Review the stormwater management requirements that apply to the development site		
Distribute the following runoff-reducing low impact development practices across the development site:		
Soil Restoration		
Site Reforestation/ Revegetation		
Green Roofs		
Permeable Pavement		
Undisturbed Pervious Areas		
Vegetated Filter Strips		
Grass Channels		
Simple Downspout Disconnection		
Rain Gardens		
Stormwater Planters		
Dry Wells		
Rainwater Harvesting		
Bioretention Areas		
Infiltration Practices		
Dry Swales		
Where feasible, use permeable pavement to construct alleys, parking stalls, walking paths and trails, driveways, sidewalks and light-duty service roads		
Provide vegetated filter strips and depressed landscaped islands in and around parking lots		

Site Planning and Design Checklist		
Use dry swales and grass channels along roadways and in roadway medians to reduce stormwater runoff rates, volumes and pollutant loads near their source		
Use primary and secondary conservation areas and aquatic buffers to "receive" stormwater runoff and buffer environmentally sensitive areas		
Check to see if the stormwater management requirements that apply to the development site have been satisfied		
If the stormwater management requirements that apply to the development site cannot be satisfied exclusively through the use of better site planning and design techniques and low impact development practices, use the following general application stormwater management practices to further manage stormwater runoff rates, volumes and pollutant loads on the development site:		
Stormwater Ponds		
Stormwater Wetlands		
Bioretention Areas		
Filtration Practices		
Infiltration Practices		
Swales		
Use the following limited application stormwater management practices only when better site planning and design techniques, low impact development and general application stormwater management practices cannot be used to satisfy the the stormwater management requirements that apply to the development site:		
Dry Detention Basins		
Dry Extended Detention Basins		
Multi-Purpose Detention Areas		
Underground Detention Systems		
Organic Filters		
Underground Filters		
Submerged Gravel Wetlands		

Site Planning and Design Checklist		
Gravity (Oil-Grit) Separators		
Alum Treatment Systems		
Proprietary Systems		
Check to see if the stormwater management requirements that apply to the development site have been satisfied		
If the stormwater management requirements have not been completely satisfied, go back to the site layout to apply additional low impact development and stormwater management practices to further reduce and manage stormwater runoff rates, volumes and pollutant loads on the development site		

Site Planning and Design Checklist		
Prepare Preliminary Plan—Use the results of the site planning and design process to prepare a preliminary plan illustrating the layout of the proposed development project and showing, in general, how stormwater runoff will be managed on the development site; Host pre-submittal meeting with local development review authority		
Green Growth Guidelines	√	**Comments/Notes**
Prepare a preliminary plan that includes the following:		
Project Narrative		
Common address of site		
Legal description of site		
Vicinity map		
Site Fingerprint		
Existing Conditions Map		
Existing roads, buildings, parking areas and other impervious surfaces		
Existing utilities and utility easements		
Existing primary and secondary conservation areas		
Existing aquatic buffers		
Existing low impact development and stormwater management practices		
Existing storm drain infrastructure		
Existing channel modifications		
Proposed Conditions Map		
Proposed topography		
Proposed drainage divides and patterns		
Proposed roads, buildings, parking areas and other impervious surfaces		
Proposed utilities and utility easements		
Proposed limits of clearing and grading		
Proposed primary and secondary conservation areas		

Site Planning and Design Checklist		
Proposed aquatic buffers		
Proposed low impact development and stormwater management practices		
Proposed storm drain infrastructure		
Proposed channel modifications		
Stormwater Management System Narrative		
List of low impact development and stormwater management practices that will be used		
Calculations showing how initial estimates of the stormwater management requirements that apply to the development project were obtained		
List of Expected Waiver Requests		
Once the preliminary plan has been created, host a pre-submittal meeting with the local development review authority to discuss the proposed development project		

THE TUPELO TRACT—A MODEL SITE DESIGN COMPARISION

In the same way a developer might conduct some research to identify a tract of land suitable for acquisition and development, the authors of the *Green Growth Guidelines* used GIS data to identify several prospective development sites within coastal Georgia (See Appendix B for List of GIS Resources). The Tupelo Tract was selected by the authors to serve as a model development site and to illustrate how sustainable development strategies outlined in previous chapters can be applied to development sites located within coastal Georgia.

Although the actual name of the site was changed and the features found on and around the site were modified, the Tupelo Tract – with its relatively flat terrain, thick vegetative cover, proximity to freshwater and tidal wetlands, and diverse population of native plant and animal species – is representative of many of the prospective development sites found within coastal Georgia. The site is zoned residential, and like many of the region's prospective development sites—is located along a main thoroughfare with access to existing infrastructure and a number of recreational and commercial amenities—making it ideal for residential development. Additionally, the site is located immediately upstream of a large system of coastal marshlands, beaches, and tidal creeks. It is an ideal site on which to demonstrate how the recommended site selection, planning and design process can be used to create more economically, environmentally, and social responsible developments in coastal Georgia.

In this section, we demonstrate how the recommended site planning and design process outlined in this chapter can be applied in coastal Georgia. It takes the reader through the process of site planning and design of a 188-acre undeveloped tract of land. Three site plans are developed for the model site; the Conventional, the Community Preserve (Conservation Subdivision), and the Village (New Urbanist/Traditional). The plans are evaluated to show the economic, environmental, and social benefits of conservation developments compared to conventional developments.

The most obvious advantage of the alternative design is the preservation of greenspace and the resultant water quality benefits. Other benefits of this approach include:

- The per lot cost of infrastructure including roads, piping, and other utilities is substantially reduced,
- Extensive surrounding green spaces gives residents a feeling of being connected to nature,
- The reduction of impervious surfaces per lot and the incorporation of alternative stormwater measures into the landscape design lessen the negative impact on the environment,

- The sizing of the community to allow for and promote walking, bicycling and other non-automotive transportation can reduce local automobile usage and consequently road maintenance and air pollution,
- Compact designs promote the interaction and proximity of residents, and large amounts of open space promote the development of the human relationships that comprise a real community, and
- Compact design considers and incorporates forested buffers and green space areas that serve as critical habitat for local wildlife.

Site Fingerprinting

The following eleven (11) exhibits demonstrate how GIS is used to identify and map natural and man-made resources found of the Tupelo Tract. The following key features were mapped during the inventory:

- Natural topography and hydrology.
- Available infrastructure including roads, rails, and utilities.
- Land use patterns and current zoning designations.
- Significant landmarks and nearby sites of interest.
- Location of wetlands, streams, and groundwater recharge areas.
- 100-year floodplain, major drainage ways, and contour elevations.
- Type and extent of tree cover.
- Soil series and approximate boundaries.
- Wildlife habitat and species of concern.
- Historic and archeological resources.
- Areas of special concern with protective setbacks and buffers.
- Downstream coastal resources bordering essential fish habitat and shellfish harvest areas including tidal marshlands, creeks, estuaries, beaches, and hammocks.

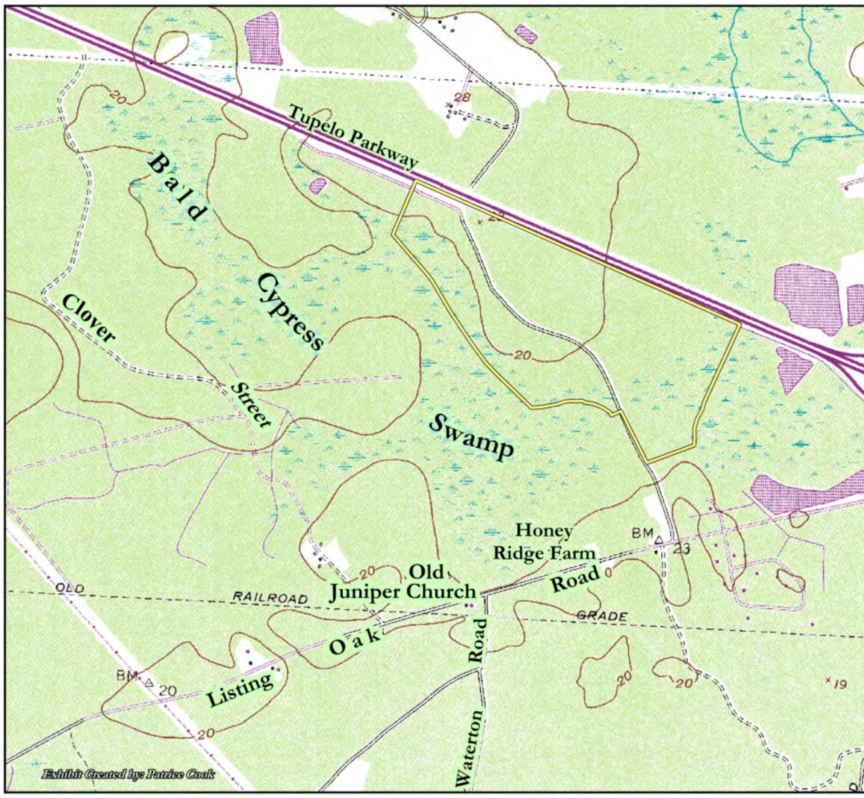


Exhibit 1: Topographic & Hydrologic Features

This exhibit displays a topographic map compiled in 1975 by the U.S. Geological Survey (USGS). This map shows the general topography and hydrology of the site and the surrounding area. Topographic maps illustrate a three-dimensional configuration of the Earth's surface (the actual ground elevation) using contour lines. Broadly spaced contours represent gentle slopes while close contour intervals indicate steep slopes. These maps show major geographic features including mountains, hills, rivers, valleys, and depressional wetlands. Also represented on the topographic are man-made features such as roads, churches, railroads, land boundaries, and buildings. Topographic maps are bounded by rectangular-shaped areas defined by latitudes and longitudes separated at 30', 15' or 7.5' intervals. These "quadrangles" are named by the most prominent geologic feature or the largest town. The 124-acre project site known as the Tupelo Tract is located on the Waterton Quadrangle.

On this map, the low-lying Bald Cypress Swamp is graphically illustrated by its defining boundary identified by the twenty-foot contour line. Also depicted is the presence of an intermittent stream flowing through the tract. This stream flows beneath the Tupelo Parkway and eventually discharges into Bald Cypress Swamp. Several borrow pits and cleared areas located around the site are instantly recognizable, as well as a dated rail bed to the south of the subject parcel. Distances and the location of significant landmarks are also ascertained from the topographic map. Approximately 4,800 linear feet of the Tupelo Tract extends east-west along the Tupelo Parkway. Bisecting the southernmost ridge defining Bald Cypress Swamp is Listing Oak Road, where Old Juniper Church and Honey Ridge Farm are located. Further east on Listing Oak Road, approximately 300 feet from Benchmark 23, is County Road 13 which runs north from Tupelo Parkway, south to Listing Oak Road through the heart of the uplands portion of the tract. This access road location, the site's proximity to main thoroughfares (Tupelo Parkway and Listing Oak Road) and the concentration of uplands as a contiguous body on the northern portion of the property make this tract ideal for residential development.

Tupelo Tract: 124 Acres

1 inch equals 1,000 feet

0 1,000 2,000 Feet

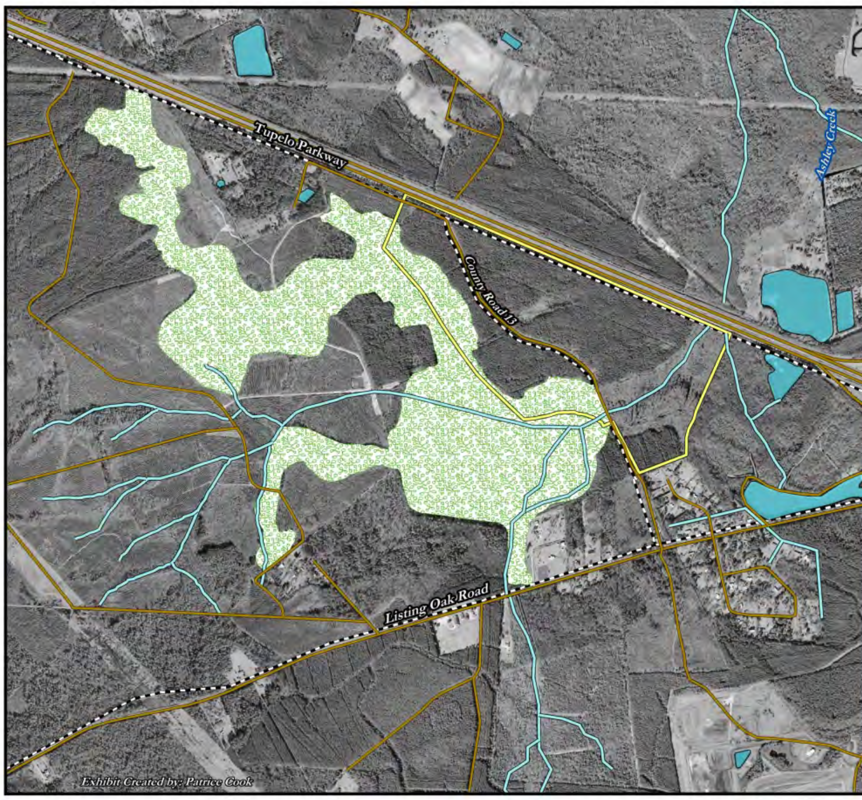


Exhibit 2: Available Infrastructure

This exhibit is derived from the layering of 2002 transportation and 2003 utility information maintained and updated by Caleb County and the Georgia Department of Transportation (GDOT) with black and white aerial photography distributed by Earthdata International, Inc. This map shows the location of roads and existing utility easements in the immediate area. This exhibit was designed to reveal the available connections of the Tupelo Tract to existing gas and power easements.

Note the existing utility easement maintained by Caleb County running alongside the Tupelo Parkway and the property access road, County Road 13 which offers connection to municipal utilities such as electricity, gas, water, sewer, and transmission lines. With this infrastructure already in place, the monetary costs associated with the project decrease dramatically, as does the disturbance required to install them. Furthermore, the existing road crossing and utility easement also reduces the need for further environmental impacts to the wetland system, benefiting both the natural area and the developer by eliminating engineering, construction, and permitting costs associated with such impacts. In addition, County Road 13 provides connection to a main thoroughfare that runs up and down the entire Georgia coast. An interchange for the Tupelo Parkway is located within a ¼ mile of the property; an indication the site is accessible yet somewhat secluded by adjacent natural areas.

Tupelo Tract — Lakes — Roads — Streams — Bald Cypress Swamp — Existing Utility Easement

1 inch equals 1,004 feet

0 500 1,000 2,000 Feet

Exhibit 3: Surrounding Land Uses

Figure 3 is a map of land uses compiled by the Caleb County Planning Commission and Waterton Building and Zoning Commission. Examining surrounding land uses is an important factor in determining the placement of future development. Land use maps offer insight to amenities available to serve residential communities such as grocery stores, shopping centers, and recreational areas. Benefits to a commercial development could be analysis of current commercial districts, proximity to competitors, and accessibility to major thoroughfares. A commercial development could benefit from an analysis of existing commercial districts, proximity to competitors, and accessibility to major thoroughfares. Understanding the surrounding land uses helps define the market conditions.

The current land use of the subject tract is predominately single-family (low to medium density) residential with clearly designated areas of wetlands, marsh, and recreational uses. The property to the north of the tract across the Tupelo Parkway is largely undeveloped. The properties along the Tupelo Parkway interchange are predominately retail, office, and commercial businesses which are conveniently located near the proposed development. In addition, adjacent public and institutional uses provide recreational opportunities. The context of the subject tract indicates an ideal location for a residential development.

Landuse Classifications

- Retail, Office & Commercial
- Single Family Residential
- Recreation
- Agriculture & Forestry
- Wetlands & Marsh
- Public & Institutional
- Recreation
- Industrial
- Mobile Homes
- Undeveloped
- Tupelo Tract
- Roads
- Lakes

1 inch equals 2,000 feet

0 0.25 0.5 1 Miles

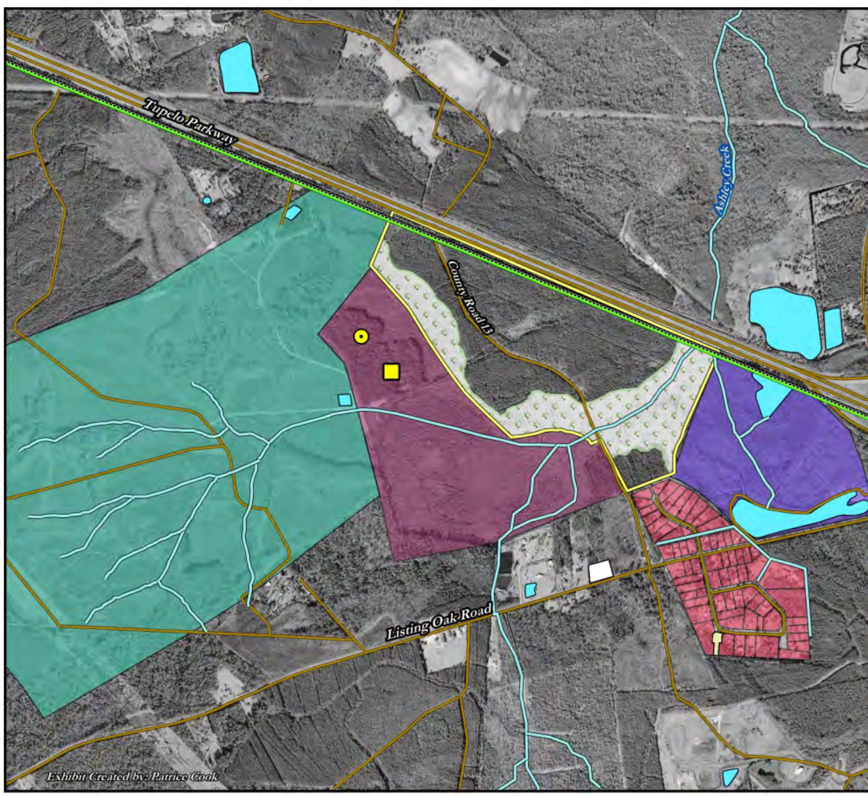


Exhibit 4: Significant Landmarks & Other Sites of Interest

Parcel information compiled by Caleb County and data from the U.S. National Park Service was utilized to build this map. This exhibit reveals some sites of interest located in close proximity to the Tupelo Tract including nearby churches, cemeteries, historic sites, recreational areas, wildlife preserves and adjacent residential developments. Most features recorded on a plat are listed within the parcel layer and are available to the viewer instantly as a particular parcel is selected. Information within the parcel database was queried to determine the value of the subject properties and adjacent tracts, the owner information, zoning designation, deeded acreage, and significant landmarks in the immediate project vicinity. Historic sites and structures were located by querying the National Register of Historic Places (NRIS) database. In addition, archeological sites were identified using report data from the Georgia Archeological Site Files (GASF) database.

This map shows the Tupelo Tract is bordered on the west by the Ashley Creek Wildlife Preserve and to the southwest by McDonough Plantation, a national historic site where a historic 18th century tabby home and rice mill are located. Juniper Crossing, a residential community is located southeast of the tract and Waterton Park, a county recreational area located east of the Tupelo Tract. This map also assisted in planning for future green space areas and trail connections.

Sites of Interest

- McDonough Plantation National Historic Site
- Tabby Home Site
- Juniper Crossing Residential Community
- Rice Mill
- Waterton Park Recreational Area
- Regional Trail System
- Ashley Creek Wildlife Preserve
- Additional Green Space Sited
- Juniper Church
- Juniper Creek Cemetery
- Lakes
- Streams
- Tupelo Tract
- Roads

1 inch equals 1,000 feet

0 500 1,000 2,000 Feet

Exhibit 5: Wetlands, Streams, & Groundwater Recharge Areas

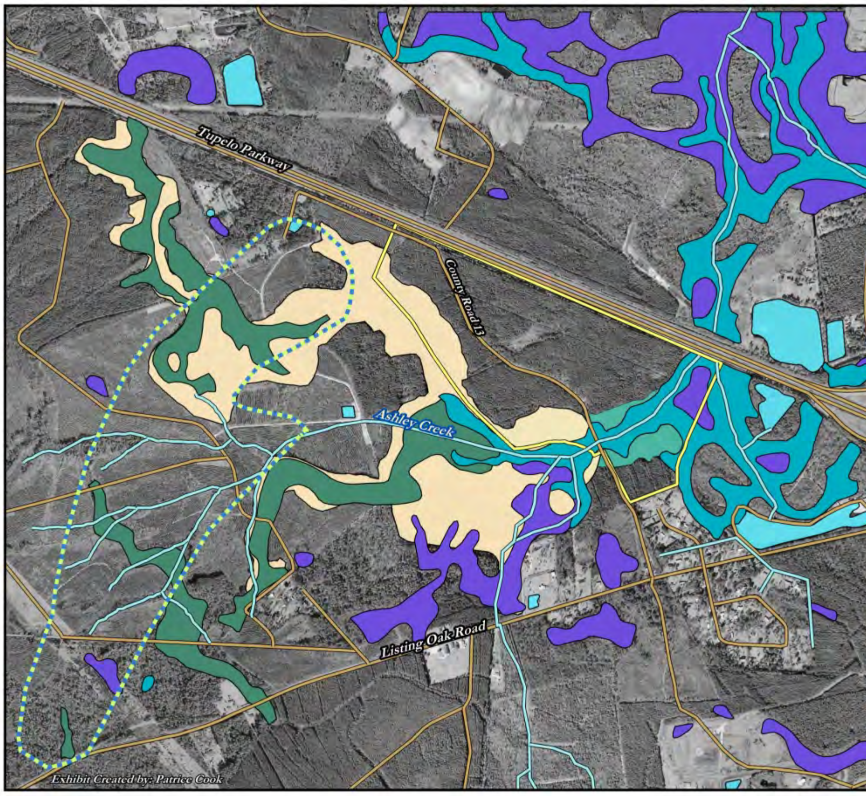


Figure 5 depicts the wetlands, marshes, ponds, lakes, streams, riparian forests, and significant groundwater recharge areas located within the tract and the immediate area. This map was used to locate the approximate wetland and stream boundaries so to avoid and minimize impacts to these areas to the greatest extent possible. These data layers were supplied by the U.S. Geological Survey (USGS) and the U.S. Fish & Wildlife Service (USFWS). In the mid 1970's, using aerial photography combined with information from NRCS soil surveys, the US FWS initiated the National Wetlands Inventory (NWI) program. The program was implemented to map the Nation's wetlands and report on their status. Each wetland is defined by type of vegetation and the areas' proclivity toward inundation (i.e. broad-leaved deciduous, seasonally flooded or needle-leaved, semi-permanently flooded). The presence and extent of the Ashley Creek and its large contiguous swath of riparian wetlands known as the Bald Cypress Swamp is apparent within the Tupelo Tract. A large portion of the Tupelo Tract is highland, while its southern, eastern and western borders are composed of deciduous semi-permanently flooded and semi-flooded wetlands.

Wetland systems are essential to flood control and provide habitat for a diverse palette of plants and animals, some of which are endangered or threatened. The NWI enables the planner to design a layout which avoids and minimizes impacts to the system. In addition, this map can be used to locate future development, specifically stormwater drainage systems and septic systems, away from major groundwater recharge areas and wetlands. Locating aquatic resources can also identify necessary buffers and conservation areas.

Exhibit 6: Floodplain and Elevations

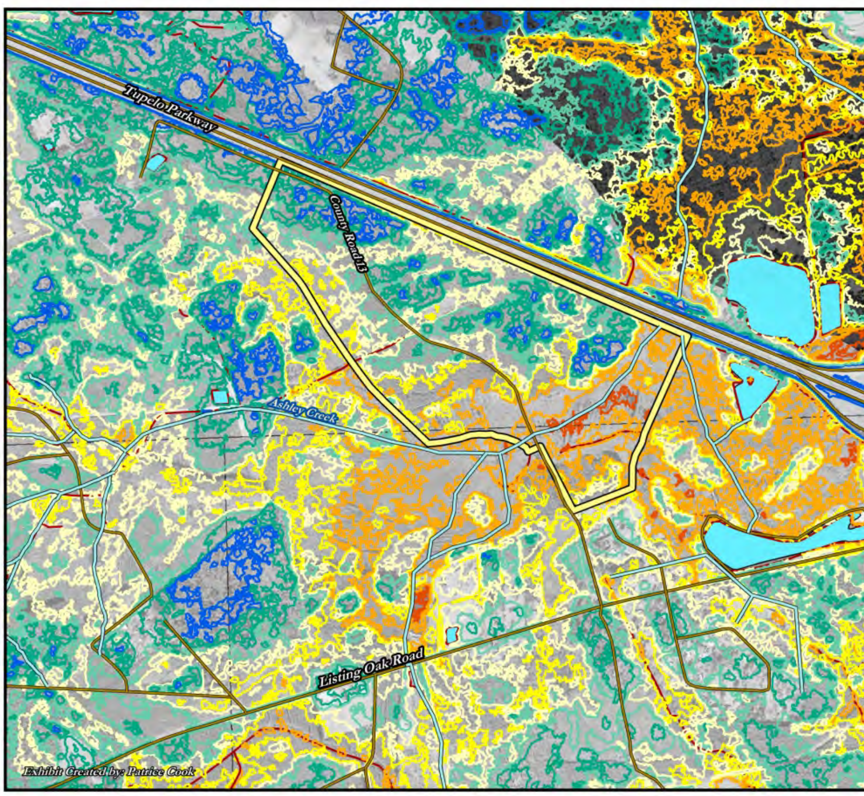


Figure 6 layers elevation contours produced from Airborne Laser Terrain Mapping (ALTM) by Earthdata International with National Flood Insurance Rate Maps (FIRM) from the Federal Emergency Management Agency (FEMA) for a more accurate depiction of elevation and proximity to the floodplain. The Federal Emergency Management Agency produces maps of flood prone areas. Because FEMA subsidizes flood insurance claims, these maps encourage development outside of the floodplain. Flood zone "A" is located within the 100-year flood boundary while zone "X" is located outside of the 100-year flood zone. This map shows the project site is located outside the 100-year floodplain, while most of the surrounding area northeast of the site is located within an area of flood concern. The map clearly indicates the area within the Tupelo Tract north of County Road 13 is 18 to 24 feet above mean sea level, while the area south, northeast and southwest of County Road 13 has a peak elevation of 20 feet and averages somewhere around 18 feet above mean sea level. These dimensions reflect natural drainage toward the lower, southern portions of the property, specifically toward the Ashley Creek. This information was utilized to determine the location of roads, stormwater treatment practices, and the general layout of the residential home sites.

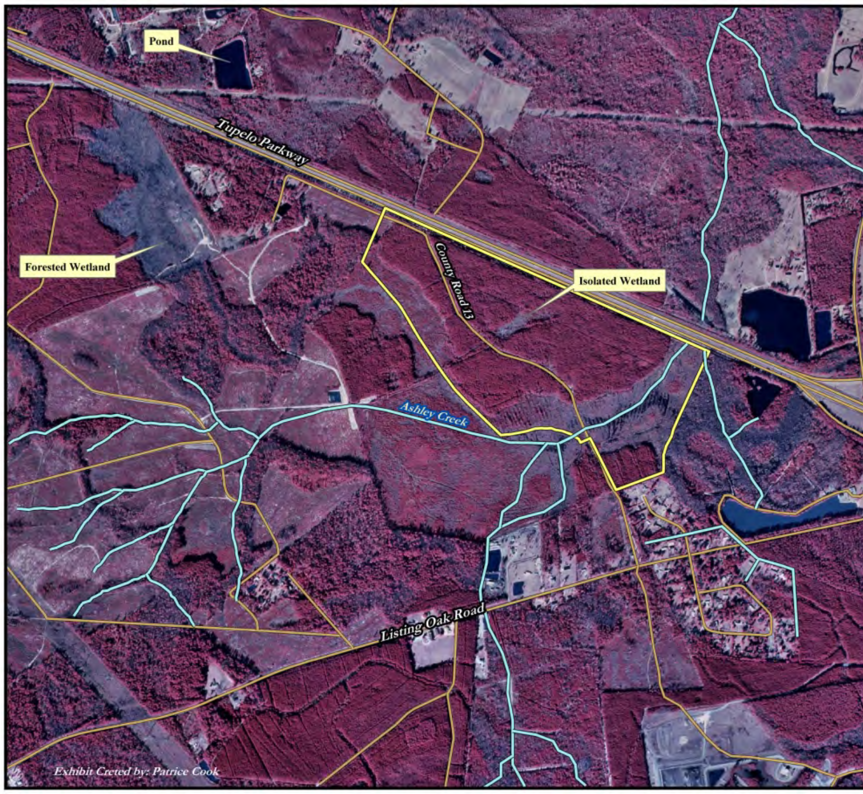


Exhibit 7: Vegetation Types & Extent of Coverage

The U.S. Geological Survey supplies Color Infrared Aerial Photography (CIR) of most of the United States. Each CIR is bound by the same coordinates as used to define the quadrangles of USGS topo graphic maps. This is the CIR of the Waterton Quadrangle taken in 1999. The aerial photograph was used to determine potentially wet areas within and adjacent to the site. This photography displays heat signatures emitted from the terrain as a range of colors from red to black. Wetlands, streams, marshes, lakes, and ponds display generally as black, indicating deep water; lighter shades of bluerepresent seasonally flooded forested wetlands; greenish blue indicates emergent wetlands and marshlands. Uplands typically show as a range of deep burgundy red to pink depending on the density of vegetation coverage. The denser the vegetation the more intense the red hue becomes. Acreage of tree cover can be quickly calculated when assessing site suitability. The type of indigenous trees and vegetation types within and around the subject tract can be identified and quantified on this coverage by recognizing its characteristic signature. The physical condition, growth pattern, and approximate age of the vegetation can also be inferred. Stressed vegetation, old growth forests, and past forestry and agricultural practices can be determined by viewing this type of imagery.

The uplands within the Tupelo Tract appear to be covered by mostly pine forest mixed with some tupelo and sweetgum. The viewer can infer from the light blue signature of this area and its proximity to the creek that it is most likely bottomland hardwood forest comprised of pines, maple, and cypress. The wetlands appear to have been timbered in the past and re-planted with pines evident by linear features (rows) and their associated bright red tones (upland species) intermingled among the deep blue hues indicative of wetlands. Also note a faint blue signature north of County Road 13 and centrally located within the uplands of the Tupelo Tract. This is a low-lying area (See Figure 6: Floodplain and Elevations), and is most likely an isolated wetland due to its proximity to the Bald Cypress Swamp and Ashley Creek. CIR photography makes these systems immediately apparent to the viewer and can be used by site designers to avoid and minimize impact to these areas during the planning phase of development. In addition, this imagery greatly aides in the planning of tree save areas timber harvest areas, buffers and hiking trails.

Tupelo Tract
Roads
Streams

1 inch equals 1,000 feet

0 500 1,000 2,000 Feet

N W E S

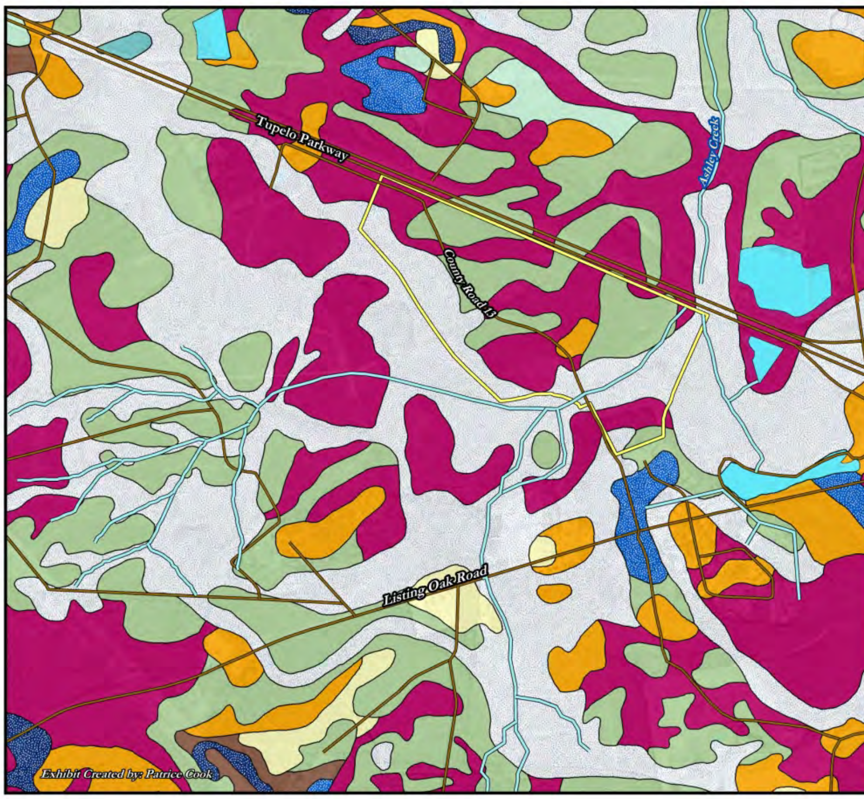


Exhibit 8: Soils Analysis

This soil map was taken from the Soil Survey of Caleb County generated in 1977 by the Natural Resources Conservation Service (NRCS). Soils are important for many reasons; they sustain plant and animal life; they regulate the flow and filtration of contaminants in runoff; and they are critical for locating septic systems and when engineering foundations for roads and buildings. A soil survey depicts soil boundaries by series with supporting tables of information on soil properties. The plasticity, drainage capacity, stability, permeability, and shrink-swell potential of each soil series are described in detail within the database. Building lots and supporting infrastructure can be located based on the suitability of certain soils and their intended use.

Most of the upland soils contained within the Tupelo Tract belong to the Lakeland, Wahee, and Ocilla Series. These series are generally sandy, well-drained soils adequate for most road and building foundations, as well as for stormwater detention facilities. The Ashley Creek and surrounding areas contain Ellabelle soils. Ellabelle is a poorly-suited wetland soil that should be avoided with structural foundations, especially sites supported by septic tanks.

Soil Types

Lakeland
Wahee
Ocilla
Olustee
Albany
Craven
Ellabelle
Mascotte
Ogeechee

Hydric Soils Shown Stippled in Blue May Indicate the Presence of Wetlands

Tupelo Tract
Streams
Lakes
Roads

1 inch equals 1,000 feet

0 500 1,000 2,000 Feet

N W E S

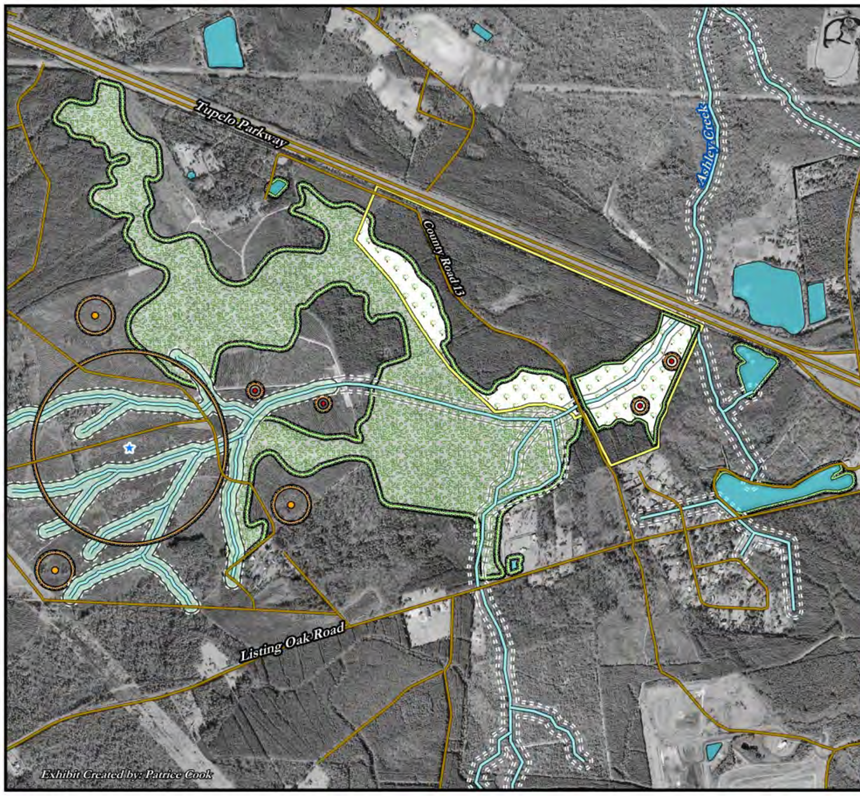


Exhibit 9: Areas of Special Concern with Setbacks and Buffers

Exhibit 9 layers U.S. Fish & Wildlife Service (USFWS) maps of critical habitat and species of concern with federal, state, and county threatened and endangered species lists as well as actual field survey information conducted by the Ashley Creek Wildlife Preserve. This map was used to determine if species of concern and their critical habitats exist on the subject tract. Since the project site is located near a freshwater stream and a large system of bottomlands, essential habitat is available for potential threatened and endangered species. A threatened and endangered species survey was conducted for Ashley Creek Preserve and the immediate areas. GPS was used to locate and map the species and their habitat in the field. This information was then imported to GIS where it was viewed and manipulated to determine the amount of space required to sustain these species once the Tupelo Tract is developed.

Buffers are applied in varying widths to essential habitat including stream and wetlands depending on the habitat requirements of certain species. The state mandates a 50' buffer for streams that support or could support trout and 25' for other streams, lakes, and marshlands. In addition to these buffers, there are species of concern that require buffers of various widths for adequate protection. The Ashley Creek was subject to a 50' buffer due to the presence of protected fish downstream; the Bald Cypress Swamp requires a 25' buffer along its boundaries. In addition, there were several species of concern in the area that require buffers, including a Bald Eagle (1/4 mile), Gopher Tortoises (100'), and Hooded Pitcher Plants (25'). These buffered areas and the resources within them are considered primary and secondary conservation areas. These areas can be beneficial to a development as they form a large continuous green space available for recreational uses such as hiking and nature-watching.

Hooded Pitcher Plants 25' Buffer
Gopher Tortoise Burroughs 100' Buffer
Essential Fish Habitat
Bald Eagle's Nest 1/4 Mile Buffer
Buffered Area 64 Acres
Protected Species Buffers
Bald Cypress Swamp
Wetland Buffer 25'
Tupelo Tract
Stream Buffer 50'
Streams
Lakes
Roads

1 inch equals 1,000 feet
0 500 1,000 2,000 Feet
N W E S

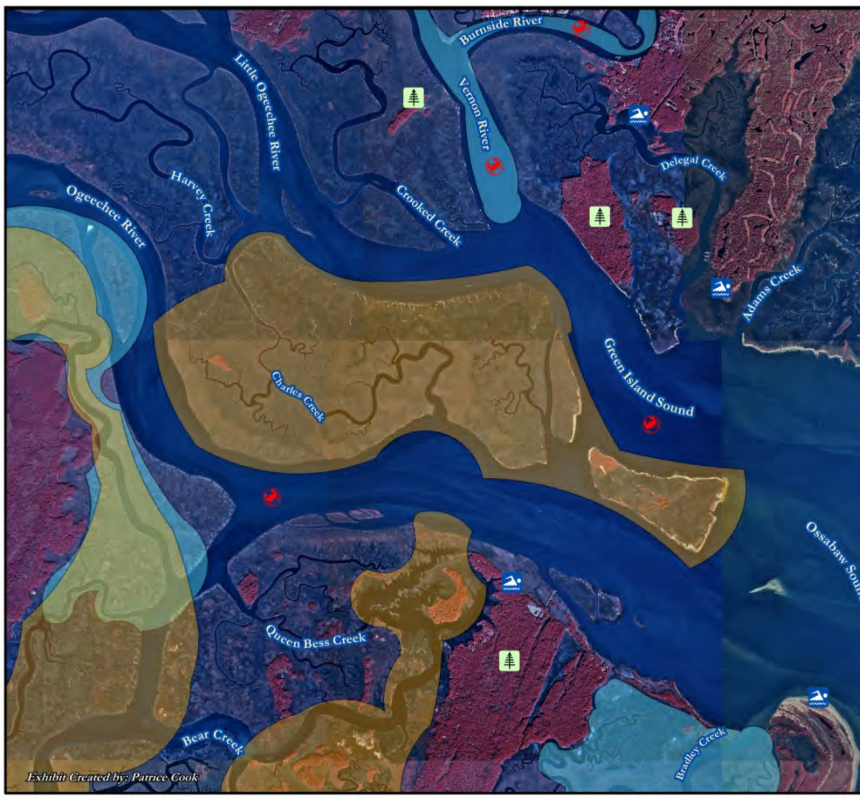


Exhibit 10: Downstream Coastal Resources of Concern

This map was assembled from USGS color infrared photography and coastal data sets compiled by the Georgia Department of Natural Resources (GDNR). Figure 10 reveals the coastal resources located within a ½ mile downstream of the Tupelo Tract. The Ashley Creek eventually discharges into the Ogeechee River, which outfalls into a system of marshlands, hammocks, and beaches all of which are areas vital to the existence of fish, crab, shellfish, and migratory birds that inhabit these areas. This information can be used to avoid impacts to the nearby marsh ecosystem by implementing measures that improve downstream water quality and protect resident and transient animal populations simultaneously. For example, upstream developments with detention ponds, bio-swales, and forested stream buffers capture and clean stormwater runoff before it enters creeks and marshes lessening the impact to these downstream species and their habitats. In addition to upstream improvements, waterfront development must give special consideration to siting septic tanks, parking lots, and turf lawns since pollutants from these areas can cause serious degradation to coastal ecosystems. Shellfish and harvest areas have strict water quality standards imposed by the U.S. Department of Agriculture (USDA) regarding nutrient loadings, turbidity, dissolved oxygen and especially fecal chloroform bacteria (most often related to septic tanks). Waterfront development setbacks must be greater near these areas to assure that septic system effluent does not reach these harvest areas via shallow groundwater. Community waste treatment systems, whether sewer or on-site systems with a common drainfield set back as far as possible from the water would be an ideal design for these areas.

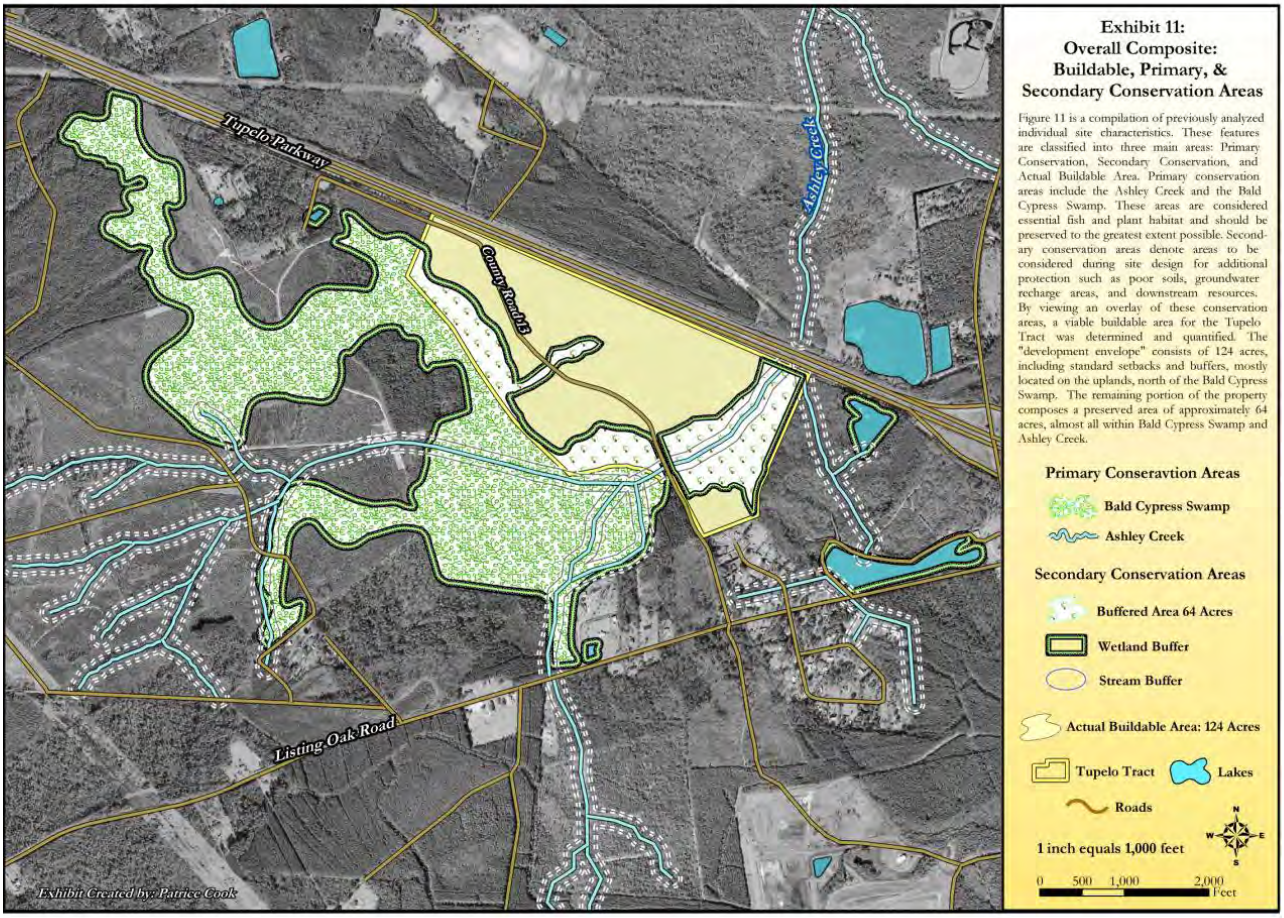
This photography can also be used for river and beach erosion studies. Accreted sand beaches and dunes as well as areas of bank scour and channel shoaling are evident from an aerial view.

Coastal estuaries, marshlands, rivers, and creeks play a vital role in the proliferation of fish, crab, and shellfish populations. For this reason, these areas deserve special planning and design measures that serve to protect these resources in perpetuity. The sustained health of these resources can provide endless commercial and recreational opportunities to residents and visitors including fishing, boating, kayaking and swimming.

Essential Fish Habitat
Shellfish Harvest Area
Crab Harvest Area
Public Beach
Coastal Hammock

1 inch equals 0.75 miles
0 0.25 0.5 1 1.5 Miles
N W E S

In subsequent steps of the site planning and design process, the results of the natural and man-made resources inventory were used to analyze the development site, delineate primary and secondary conservation areas, and define the site's buildable area. The gross area of the tract is 188.6 acres, consisting of 123.9 acres of buildable or upland area (66% of the tract) and primary and secondary conservation areas totaling 64.7 acres (or 34% of the tract).



General Descriptions of Development Types

Conventional Subdivision

Conventional development is characterized by low development densities, homogenous land uses, emphasis on the use of the automobile as the primary mode of transportation, and a lack of connectivity between adjacent developments. Generally, developments are built with separate land uses for residential, retail, office, civic, industrial, and multi-family uses. Typical site features include large buffers between areas with different land uses and development densities, roadway networks, consisting of primarily dead-end cul-de-sacs and collector roads, and few, if any functional sidewalks and bicycling lanes.

Each lot has nearly uniform road frontage, specified street standards, and minimum setbacks from roads or neighboring property owners. These restrictions generally result in equal-sized lots with homes placed in the same location on each lot regardless of the parcel's characteristics. The resulting group of homes or lots is typically termed a “subdivision”. In conventional subdivisions, individual homeowners privately own most or all of the land.

Stormwater runoff is usually managed using ditches, culverts, and storm drains that discharge directly to receiving creeks, streams, and wetlands. Little, if any, consideration is given to natural and man-made resources found on and adjacent to the site during the creation of the development plan. Increased land disturbance, conventional stormwater practices, and increased impervious areas challenge the viability of this option environmentally, and often economically as well.

Conservation Subdivision

Conservation development is a development pattern that results from the use of better site planning and design techniques. It is used to concentrate structures and impervious surfaces in a small portion of the development site, which leaves room for larger conservation areas and open spaces (e.g., parks, playgrounds) elsewhere on the site. Conservation developments are characterized by the use of smaller lots, alternative lot designs and the “clustering” of structures and other impervious surfaces within a small portion of the site.

Conservation developments provide a host of environmental benefits that are generally more difficult to achieve with conventional developments. A conservation subdivision is characterized by a compact footprint that retains significant areas of green or open space – sometimes as much as 40 to 60% – for the purpose of protecting natural resources (CWP, 1988). Reduced site imperviousness results in reduced stormwater runoff rates, volumes and pollutant loads, which help better protect both on-site and downstream aquatic resources from the negative impacts of the land development process. This design also helps to minimize the size of and need for traditional stormwater management practices and infrastructure on development sites, which can reduce overall development costs.

Due to its limited impact, this style is the recommended option for areas such as islands, hammocks, and other sensitive sites that will not support more intense development. By design, these communities reduce overall impervious area and incorporate stormwater management features such as constructed wetlands and ponds, and roadside bioretention swales.

Conservation development is a density neutral option most applicable to suburban and rural areas. By using smaller lot sizes and alternative lot designs, the site planning and design strategy provides more open space with the same number of lots as conventional developments. The main idea is to create communities that preserve and protect natural and man-made resources and maintain green infrastructure corridors.

Given that this design allows the same number of residences as a conventional development under current zoning for most municipalities, and eliminates the need to obtain approval for higher density, it is more likely to be accepted by local development review authorities and the community due to high percentage of green space conserved. With its smaller lot size, some municipalities may require a special variance for this aspect, which is usually less effort than increasing density. This makes conservation design a highly effective development solution that can be immediately implemented in coastal Georgia with little regulatory difficulty.

New Urbanist Subdivision

The New Urbanist approach, also known as Traditional Neighborhood Development, uses smaller lot sizes on one portion of the property to leave the remaining large conservation or open space areas (at least 20% or more of the total site). These areas improve the aesthetics of the property, serve as recreational areas for residents, protect natural resources and wildlife habitat, and support better stormwater management practices. Typically, road frontage and lot size is decreased to preserve ecologically sensitive areas, historical sites, or other unique characteristics of the land being subdivided.

New Urbanism is a concept derivative of the traditional development pattern. The New Urbanist approach is typically applied as an extension of an existing city or town, though it can also be applied to an area, such as a major intersection, where there is a desire to form a new node in the regional transportation network. Higher density is achieved through a grid system of streets scaled for pedestrians. It sites houses on smaller parcels of land, and the additional land that would have been allocated to individual lots is converted to common open space for residents in the form of parks or squares. It is typically mixed-use, with a combination of housing types and retail/commercial areas, and presents opportunities for residents to walk to basic services or possibly to work in the community. Road frontage, lot size, setbacks, and other traditional subdivision regulations are redefined to allow for higher density with a mix of uses, and to preserve ecologically sensitive areas, historical sites, or other unique characteristics of the land. While this may require more effort to win approval in some municipalities, the New Urbanist development pattern creates lower impervious area and associated runoff *per lot* and does the most to mitigate the negative impacts of sprawling, conventional development.

Conventional Plan

The Conventional Plan for the Tupelo Tract has many of the characteristics of other conventional development project, although a few improvements were made during the site planning and design process. Normally, one might see lots extending into the Bald Cypress Swamp area; this plan positions the lots at the edge of the wetland. The buffer to the north separating the lots from the Tupelo Parkway is 150' wide; in a typical plan, this buffer might be shown at 25' in width if any buffer were provided at all. Additionally, a 25-foot wide has been provided along the edge of the Bald Cypress Swamp. Although the buffer is part of each individual lot, it will help protect the wetland from the impacts of the development process.

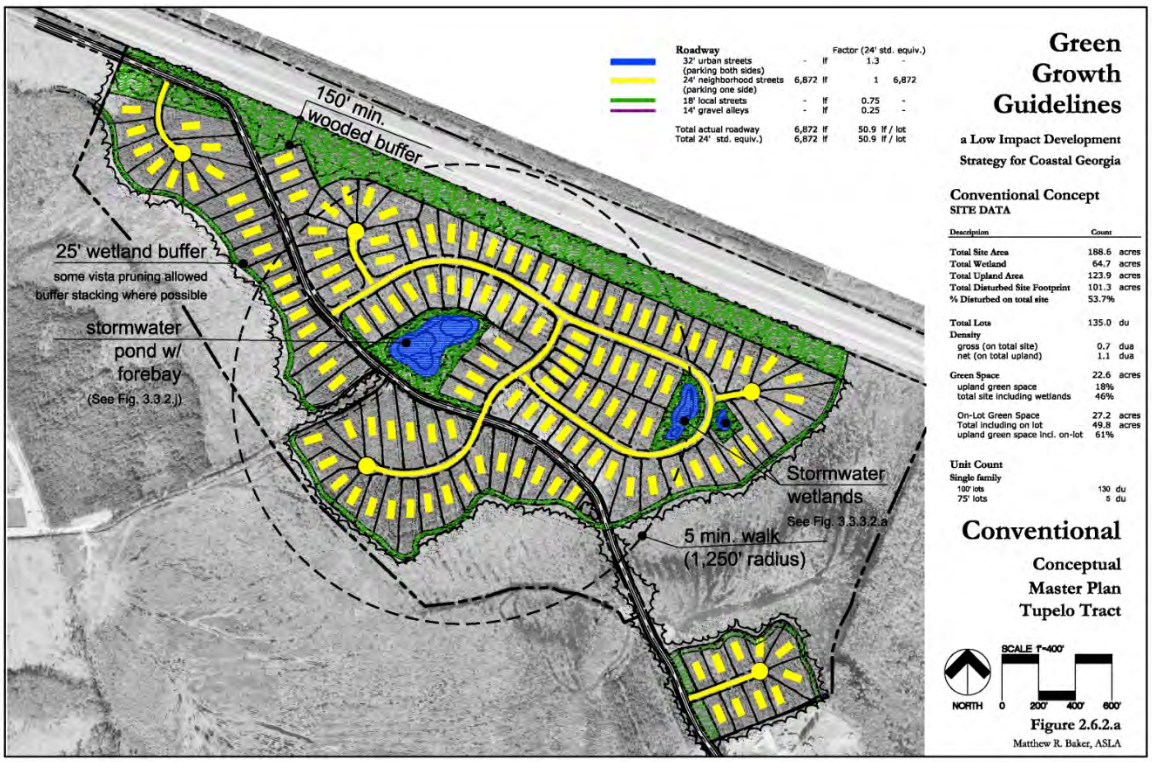


Figure 2.6.2.a
Matthew R. Baker, ASLA

A small amount of open space is included on the Conventional Plan, with only 22.6 acres of the total buildable area – 18 % – devoted to buffers and stormwater management practices. The plan maximizes the amount of space used for lot creation, with 101.3 of the 123.9 buildable acres used to create 135 lots. The gross development density is 0.7 lots per acre (i.e. 135 lots ÷ 188.6) and the net development density (i.e., density within the actual buildable area) is 1.1 lots per acre (i.e., 135 lots ÷ 123.9 buildable acres). This low density is typical of what many existing zoning regulations call for. The total disturbed site footprint is 101.3 acres, which is 53.7 % of the site.

The average lot size is 100’ by 275’, which is 27,500 square feet or approximately two-thirds of an acre. This plan and the associated calculations assume conventional practices for on-lot development. Houses are set far off the street with minimum 70’ setbacks. Driveways are 10’ wide and extend to the rear of each house, which makes them 100’ long and creates 1,000 square feet of impervious cover per driveway (i.e., 10’ x 100’). The rooftop area of each house and outbuilding was set at 2,400 square feet, creating a total of 3,400 square feet of impervious cover on each lot. Two-thirds of each lot is clear-cut, leaving only a small portion of woods along the perimeter of each lot; the rest of each lot is covered by turf grass.

The total roadway length associated with the Conventional Plan is 6,872 linear feet. This plan uses only one standard roadway cross-section, which includes a 24’ wide roadway with curb and gutter. The right-of-way for this standard cross-section is 50’ wide, which is cleared and covered with turf grass. In the descriptions of the alternative development plans, this standard cross-section is referred to as the 24-foot standard equivalent.

Because of the way the site is laid out, the Conventional Plan requires 51 linear feet of roadway per lot which totals 6,872 linear feet of roadway for the entire development. Parking is handled entirely on each lot, although overflow parking is allowed on one side of the street. Cul-de-sacs (95’ in diameter) are used frequently on the Conventional Plan, although the transportation network connects more frequently with existing roadways than a typical conventional plan would. A number of lots have frontages on County Road 13, which is an existing arterial roadway. Two other small clusters of lots at the east and west ends of the development site have a 25-foot wide buffer between them and County Road 13.

Post-development runoff from the Conventional Plan is the highest of the three plans. Using the rational method, and applying the appropriate runoff coefficient factor for woods, grass, and impervious cover, post-development runoff rates from the Conventional Plan are estimated to be 277.0 cubic feet per second (cfs). On a per lot basis, this equates to 2.1 cfs per lot. Pervious areas covered with turf grass generates the majority (46%) of this stormwater runoff (122.6 cfs). The amount of runoff from grassed areas could be reduced considerably simply by preserving more trees and other existing vegetation.

Many conventional developments use ditches, culverts, storm drains, and stormwater ponds to capture and manage stormwater runoff rates. Instead of using excavated ponds, this plan goes somewhat further by using stormwater ponds with sediment bays and aquatic benches, like those described in Chapter 3. These ponds can also be aesthetically pleasing when wetland plants are included and the shape of the pond is more refined. Therefore, the ponds in this plan are sited so they can be seen from the road, instead of being hidden in the back of the site. Ponds created with visual quality in mind can be a real asset to the community and serve as common open space.

Community Preserve Plan

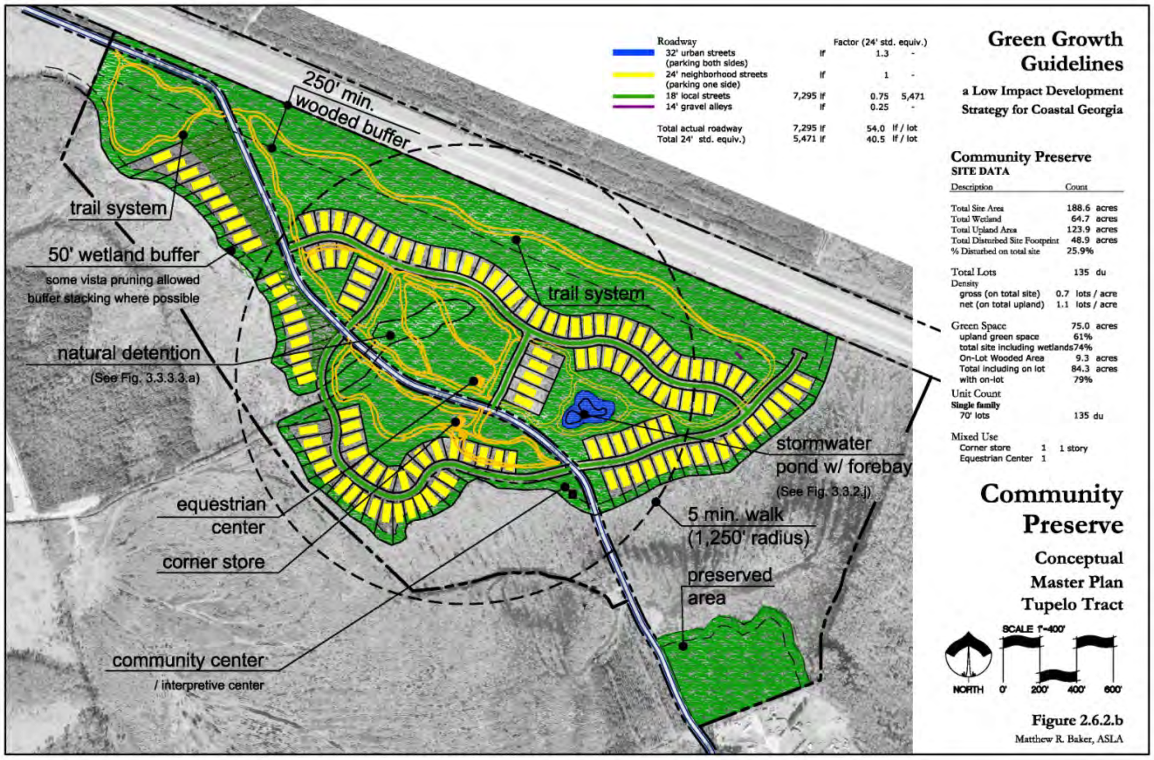


Figure 2.6.2.b

The Community Preserve Plan for the tupelo tract uses many of the better site planning and design principles described earlier in this chapter. In the plan, a considerably higher percentage of the buildable area is preserved as open space, with 75.0 acres of the buildable area – 61% – preserved as open space. By comparison, only 22.6 acres the total buildable area – 18% – is preserved as open space in the Conventional Plan. In the Community Preserve Plan, the small area in the southeast corner of the site is completely preserved. A variable width buffer of between 250 feet and 450 feet has been provided between the lots and the Tupelo Parkway. Additionally, a 50 foot wide buffer has been provided along the edge of the Bald Cypress Swamp. Since the buffer will be a part of each individual lot, some buffer pruning will be allowed to create "view corridors."

The Community Preserve Plan yields the same number of lots as the Conventional Plan (135 lots) and the gross and net densities are identical to those of the Conventional Plan at 0.7 lots per acre (i.e., 135 lots ÷ 188.6 acres) and 1.1 lots per acre (i.e., 135 lots ÷ 123.9 buildable acres) respectively. This low development density is typical of what many existing zoning regulations require. The total disturbed site footprint is 101.3 acres, which is 53.7% of the site. However, a number of existing subdivision regulations may have to be relaxed in order to allow for the smaller lot sizes, reduced setbacks and frontages, and narrower roadways used on the Community Preserve Plan.

Lots in the Community Preserve are 70' wide, but vary in depth, and therefore size. The average lot size is 70' x 125', which equates to 8,750 square feet or one-fifth of an acre. Houses are set closer to the street with 40' setbacks. Driveways are 10' wide, but extend to the front – instead of the back – of each house which makes them 60' long and creates only 600 square feet of impervious cover per driveway compared to 1,000 square feet for the Conventional Plan. The rooftop area for the house and outbuilding was set at 2,550 square feet, which creates 3,150 square feet of impervious cover on each lot – 250 square feet less than that created by the Conventional Plan.

Because so much of the total parcel is preserved and the lots are much smaller, 66% less land will be cleared, graded, and covered with turf grass under the Community Preserve Plan than under the Conventional Plan. However, the on-lot turf area provided under the Community Preserve Plan is 83% less than that provided under the Conventional Plan. (i.e., 2,600 square feet for Community Preserve and 15,100 square feet for Conventional). The Community Preserve limits the disturbed footprint by reducing lot sizes to nearly one-third of conventional subdivisions. All told, the land disturbance footprint is only 48.9 acres, which is less than half of that of the Conventional Plan.

The total roadway length associated with the Community Preserve Plan is 7,295 linear feet, which is more than that associated with the Conventional Plan (i.e., 6,872 linear feet). However, this plan uses a roadway cross-section with an 18 foot wide roadway and no curb and gutter. This allows stormwater runoff to sheet flow off of the roadways and into roadside swales, which help reduce stormwater runoff rates, volumes and pollutant loads at their source. The right-of-way for this cross-section is 40 feet wide, which is 10 feet less than that of the standard cross-section used in the Conventional Plan. A number of lots front directly onto the existing County Road 13, and those with one side facing County Road 13 have 50' or more of community area as a side buffer.

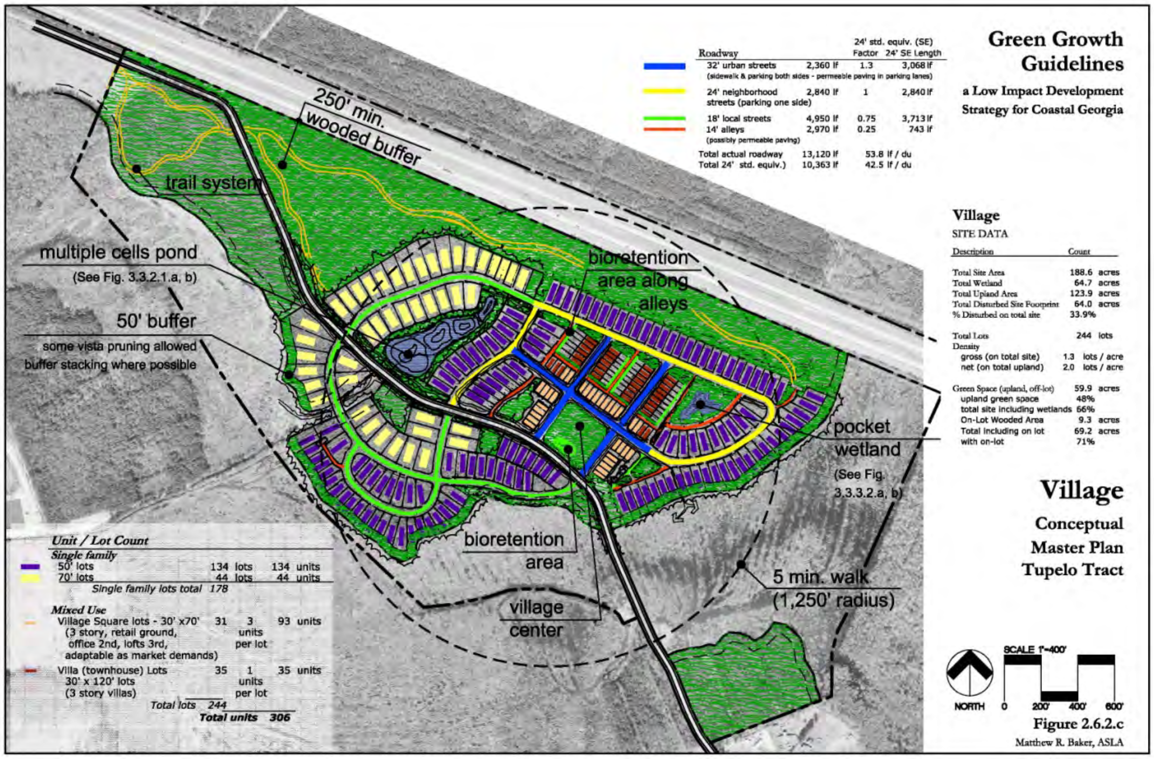
Parking is still provided on each lot, but the transportation network included on the Community Preserve Plan was laid out in a curvilinear "modified grid" pattern. It features longer block lengths and allowed the site planning and design team to follow the topography of the site and avoid sensitive environmental areas thereby reducing clearing and grading activities associated with road construction. As a result, the roads in the Community Preserve Plan are interconnected and free of dead end cul-de-sacs, with the exception of one hammerhead style turnaround used in the northeast corner of the site. However, this type of turnaround uses much less pavement that the 95-foot diameter cul-de-sacs used in the Conventional Plan.

An additional amenity that has been provided on the Community Preserve Plan is an extensive trail system that will someday connect with a larger regional trail system being planned for the area. The trail system will serve pedestrians, cyclers and horseback riders and will provide walking access to the general store that is planned for the site. Additional areas have been set aside for an equestrian center and a community shelter/interpretive center at the edge of the Bald Cypress Swamp. These passive and active recreational areas—which were lacking in the Conventional Plan—provide an opportunity for interaction between residents and help promote a sense of community and place.

Post-development stormwater runoff rates from the Community Preserve Plan are the lowest amongst any of the three preliminary development plans. Using the rational method, and applying the appropriate runoff coefficients for woods, grass, and impervious cover, post-development stormwater runoff rates are estimated to be 190.6 cubic feet per second (cfs). On a per lot basis, this equates to 1.4 cfs per lot. On-lot impervious surfaces (i.e., driveways, rooftops) generate the largest portion this stormwater runoff (70.5 cfs).

The practices used to manage stormwater runoff on the site are unique to this plan. The conservation development style affords more opportunity to manage stormwater on-site, using smaller, distributed practices that treat stormwater runoff through a variety of physical, chemical and biological processes. On the Community Preserve Plan, stormwater runoff is managed on-site using a stormwater wetland with forebay and by converting an existing natural depressional area into a natural detention area. The natural detention area is sited over an existing wooded depressional area and is designed to have trails crossing through it. The trails will be placed atop small berms that will traverse the depressional area, detaining water behind them and reducing stormwater runoff velocities so that it has a chance to infiltrate and interact with the vegetation remaining on the forest floor. The trail berms will be fitted with small culverts installed slightly above grade that will allow water to slowly pass from one "cell" to the next and will prevent the berms from overtopping in all but the largest storm events. Grass channels and dry swale located within the roadway rights-of-way and vegetated filter strips will provide pre-treatment for the natural detention area. For those lots backing up to the wetland, rain gardens and/or infiltration basins can be used on-lot and within the 50 foot wetland buffer using the buffer stacking technique discussed earlier.

Village Plan



The Village Plan for the Tupelo Tract uses New Urbanist concepts along with better site planning and design principles described earlier in this chapter. It yields more lots and significantly more dwelling units than the other two preliminary development plans. The Village Plan creates 244 lots, including 178 single-family lots, 35 townhouse (villa) lots and 31 village square lots. Land uses in the village square lots are intended for multiple uses and can vary, depending on the market, with retail or office space located on the first floor and office or residential space located on the second and third floors.

While the total yield is 244 lots, the total disturbed footprint is only 64.0 acres, which is 33.9 percent of the total site area. Comparatively, the Conventional and Community Preserve Plans disturb 53.7 percent and 25.9 percent of the total site area, respectively. This plan illustrates how higher density development can actually reduce the impacts of land development on important natural and man-made resources.

In the Village Plan, the small area in the southeast corner of the site is completely preserved. A 250-foot wide buffer has been provided between the lots and the Tupelo Parkway. Additionally, a 50-foot wide buffer has been provided along the edge of the Bald Cypress Swamp. Since the buffer will be a part of each individual lot, some buffer pruning will be allowed to create view corridors.

The Village Plan creates a hierarchy of lot sizes with varying setbacks. The largest lots are located along the perimeter of the property and lot sizes decrease as one moves toward the center of the development. The lots around the perimeter are about equal in size to those in the Community Preserve Plan, while those in the center of the development are about one-tenth of the size of the lots included on the Conventional Plan. However, market research suggests that the small lots located near the center of the development can be expected to sell for at least 80 percent of the price of the lots on the Conventional Plan.

Village Plan Lot Sizes, Setbacks and Sales Prices				
Lot Type	**Size**	**Average SF**	**Setback**	**Sales Price**
Community Preserve	70' x 125'	8,750	40'	$ 55,000
Conventional Residential	100' x 275'	27,500	70'	$ 50,000
Average Lot Residential	75' x 200'	15,000	20'	$ 47,500
Village Lot Residential	50' x 120'	6,000	15'	$ 45,000
Village Live/Work	30' x 120'	3,600	0'	$ 42,000
Village Square Lot	30' x 70'	2,100	0'	$ 40,000

In the Village Plan, houses are located closer to the street – with reduced setbacks – to allow front porches to be located near the sidewalk. Driveways are 10 feet wide but are shorter than those provided in either the Conventional or Community Preserve Plan. They are not longer than 40 feet long, which creates only 400 square feet of impervious cover per driveway (i.e., 40 feet × 10 feet). The rooftop area of each house and outbuilding is much smaller since the houses are all two stories tall. The total amount of impervious cover created on each lot is about 1,840 square feet, which is much less than that created under either the Conventional Plan (i.e., 3,150 square feet) or Community Preserve Plan (i.e., 3,400 square feet).

The transportation network associated with the Village Plan is unique in that it uses a variety of roadway cross-sections. The streets used around the Village Center are 32 feet wide and are called urban streets, since they include sidewalks and on-street parking areas on both sides of the roadway. The streets used further away from the Village Center are called neighborhood streets. They are narrower, at 24 feet wide, and have sidewalks and on-street parking on only one side of the roadway. The streets used in the areas farthest away from the Village Center are called local streets and are 18 feet wide, just like those used on the Community Preserve Plan. They have shoulders but no sidewalks or curbs and gutters. The transportation network also includes alleys, which are located between the blocks, and allow access to the rear of each lot.

The total roadway length associated with the Village Plan is 13,120 linear feet, which is more than that associated with either the Conventional Plan (i.e., 6,872 linear feet) or Community Preserve Plan (i.e., 7,295 linear feet). However, many of the roadway cross-sections used on the plan have decreased roadway widths which reduce the total amount of pavement used on the development site. The standard equivalent per lot length is 41.4 square feet per lot. Comparatively, the Conventional Plan requires 50.9 square feet of pavement per lot, while the Community Preserve Plan requires 39.9 square feet of pavement per lot.

Frequent connections between streets are provided in the Village Plan, allowing residents to use multiple routes to get to and from their destinations. Two hammerhead style turnarounds are used to provide access to two small clusters of lots at the southwest and northeast corners of the site. Hammerhead style turnarounds use much less pavement that the 95-foot diameter cul-de-sacs used in the Conventional Plan. The Village Plan, like the Community Preserve Plan, also includes an extensive trail system that will someday connect with a larger regional trail system being planned for the area.

Using the rational method, and applying the appropriate runoff coefficients for woods, grass, and impervious cover, post-development stormwater runoff rates from the site are estimated to be 237.8 cubic feet per second (cfs). On a per lot basis, this equates to 1.0 cfs per lot, which is lower than that of either the Conventional Plan or Community Preserve Plan. Although the transportation network generates a significant portion of this runoff (i.e., 51.7 cfs), on-lot impervious surfaces (i.e., driveways, rooftops) generate are the largest contributors of stormwater runoff on the site (i.e., 74.3 cfs).

Given the greater intensity of development, the stormwater management plan for the Village Plan is slightly more sophisticated than that for either of the other two preliminary development plans. A multiple cell stormwater pond, will be in the natural depressional area located just to the west of the planned village center. Located just northwest of the village center will be a pocket wetland designed to manage stormwater runoff from that portion of the site. Alleys will be surfaced with permeable pavement to reduce runoff volumes and manage stormwater runoff at its source. Along the edges of the alleys, bioretention areas and dry swales will be installed to capture and manage stormwater runoff from the backs of lots. On the southern edge of the village center, a large bioretention area will be created. It will receive runoff from the urban streets and the village green. Grass channels and dry swales installed along the local roads will provide pre-treatment for the multiple cell stormwater pond. For those lots backing up to the pocket wetland, rain gardens will be used to manage stormwater runoff on-site. They will be sited within the outer zone of the 50-foot wetland buffer.

Other low impact development practices can be used to further reduce stormwater runoff rates, volumes and pollutant loads. These are not shown on the plan, but such runoff-reducing practices include green roofs, which would best be used on top of the buildings that will be constructed around the village square. The green roofs will not only reduce runoff rates, volumes and pollutant loads, but will also help mitigate the urban heat island effect and save energy within the buildings.

Cost, Revenue, and Profit Analysis

The revenues and costs of developing the Community Preserve, the Village, and the conventional subdivisions are compared and analyzed in the following sections. The comparison indicates cost benefits for the Community Preserve because it is density-neutral and has low infrastructure costs. Likewise, the Village yields similar cost benefits compared to conventional development, but requires higher initial capital expense for infrastructure in order to produce a higher number of lots and units. The costs of acquiring and developing the subject tract under of each of these three design plans and the resulting profits from each are detailed comparatively in the following *Environmental and Economic Benefits Analysis* Tables on Pages 84-87.

Site Acquisition Cost

The cost of acquisition assumes acquisition price per acre, rounded to include anticipated closing cost such as surveying, legal fees, and title insurance and then multiplied by the number of acres in the subject site. The acquisition amount per acre was generated from Whitley, Leggett, & Associates, a local, Georgia certified, appraisal firm and based on the sales of five residential subdivision tracts in the western Chatham County, Georgia area. The comparable data indicated prices per usable acre ranged from a low of $16,519 to a high of $26,793, making the average purchase price per acre for the Tupelo Tract $20,139. The five purchases occurred over the period December 2002 to March 2004. All the parcels were fully wooded at the time of acquisition, with three of the five located partially in flood zones, one entirely in a flood zone and one entirely upland. All of the tracts were zoned to allow use as a residential subdivision, with four of the five designated Planned Urban Developments (PUD) permitting limited multi-family and commercial use. The cost of acquisition is shown as the same amount in all three cases, primarily because the intended use of the property is the same for all three cases with little influence on price due to the actual design of the planned residential subdivision.

Roadway Cost

The size, length, and width of roadways and lots, with consideration for disturbed footprints and the drainage system of each lot, were calculated and detailed in the *Environmental and Economic Benefits Analysis Tables* on Pages 84-87. The following table is a summary showing projected size, length and width for the roadway system for each site development plan facilitating comparison of the amounts found in both alternative design plans with the conventional 24' standard equivalent:

Roadways	Conventional	Preserve	Village
# of Actual LF / 24' SE	100%	75%	79%
Actual Linear Feet	6,872	7,295	13,120
24' SE / Linear Feet	6,872	5,471	10,363

The conventional plan road system is 6,872 linear feet of neighborhood streets with parking on one side. The Community Preserve roadway takes approximately 18% less 24' SE/linear foot than the conventional plan primary due to its use of narrow and curbless local streets. The Village requires approximately 30% more 24' SE/linear foot than the conventional plan, due primarily to its use of urban streets with sidewalks and parking on both sides. Based on data provided by EMC Engineering Services, Inc. in Savannah, Georgia, the Community Preserve roadway system is the least expensive to construct at approximately $30 per linear foot, nearly $20 per linear foot less than the conventional plan road system. The additional width and consequential area required for use of 2,360 linear feet of urban streets in the Village pushed the cost of this road system to approximately $60 per linear foot or $10 more per linear foot than the conventional plan. However, the Village roadway system supports 306 housing units compared to 135 in the conventional plan. Simply put, the higher cost of the Village road system is offset by higher lot and unit yield.

Site Infrastructure Cost

Site infrastructure cost represents projected expense related to constructing roadways, site grading, construction of sewer and water/drainage systems, landscaping and irrigation, and impact and design/engineering fees. These are estimated based on standards within the local area. Adding up the market cost of these resources, such as supplying sewer and water (labor, material, natural resources), are shown comparatively in the following:

Infrastructure	Conventional		Preserve		Village	
Cost Per	LF	Total	LF	Total	LF	Total
Roadways	50	$330,681	30	$164,138	60	$621,780
Excavation/Grading	10	$68,780	10	$54,713	10	$103,630
Sewer/Water/Drainage	50	$343,600	40	$218,850	50	$518,150
Landscape/Irrigation	25	$171,800	20	$109,425	35	$362,705
Engineering/Impact Fees		$472,500		$472,500		$1,009,000
Total Infrastructure Cost		$1,400,220		$1,019,625		$2,615,265
Infrastructure Cost Per Lot		$10,372		$7,553		$8,547

Grading cost for all three plans is estimated at approximately $10 per linear foot, with the Village plan requiring the greatest expenditure due to its increased area for roadway. The Community Preserve's use of less area for roadways resulted in an approximate 20% savings in grading cost compared to the conventional plan.

These same results are seen again in the cost of implementing sewer/water/drainage and landscaping/irrigation, with a downward adjustment ($50 to $40 per linear foot) made to the cost of sewer/water/drainage for the Community Preserve due to use of local streets without curbs and upward ($25 to $35 per linear foot) to the cost of landscape/irrigation in the Village due to its greater use of area.

Cost Conclusion

Overall, the cost of providing these resources in the Conventional Plan totaled $10,372 per lot compared to $7,553 per lot in the Community Preserve development plan and $8,547 per lot in the Village plan. In this example, both the Community Preserve and the Village cost less to develop than the Conventional Plan.

Revenue and Profit Analysis

Case studies throughout the country show that there is a great demand for residential lots abutting open space (especially trails and greenways), such that they are often valued higher than lots with no adjacent open space and appreciate faster in value over time than lots in a conventionally-designed subdivision. Market surveys indicate strong consumer demand (faster absorption rate) for density-neutral development alternatives like the Community Preserve plan or even higher density developments like the Village where open or green space and use of green infrastructure practices is implemented. Further, sale results of residential and non-residential lots in similar developments indicate smaller lots bordering green space appreciate faster in value than larger lots with backyard views into other homes.

Market value(s) for the improved lots for each development plan were determined from sale comparables provided by Whitley, Leggett & Associates. The sales prices of 137 improved lots sold from 1998 to the present in four subdivisions in western Chatham County, Georgia were surveyed and compared. The lots were equal in size, dimension, and accessibility to those created and used in the Tupelo Tract. Two of the comparable subdivisions were conventional, while one could be considered community preserve and one a village. In the case of the village and community preserve comparables, lots sales were as high as $120,000 per lot, while the range of lot prices within the conventional subdivisions were from $42,000 to $57,000. The model reflects a conservative estimate of value per lot based on size. For comparative purposes, lots of similar sizes have equal value regardless of where they are located within the subdivision. In reality, location of the lot plays a determining role in the price of the lot.

Once these values were determined, the tax milleage rate applicable to Chatham County, Georgia was applied to the tax assessable portion of each lot's market value. Gross market value or gross lot sales are net of any sales or marketing commissions. The following table provides a breakdown for Revenue, Profit, and Tax Value for the Tupelo Tract:

	Conventional	Preserve	Village
No. of Residential Lots	135	135	244
Gross Market Value/Sales	$6,737,500	$7,425,000	$10,822,000
Gross Profit	$2,437,280	$3,842,875	$6,071,735
Profit Margin	41.2%	51.8%	56.1%
Property Valuation (Sold Out)	6,737,500	7,425,000	10,822,000
Potential Annual Tax Revenue	281,089	309,771	451,494

Gross Revenue or Market Value is the multiplication of the amounts of various types of lots by the market value for the respective type of lot as established by the market survey. This straight-line approach ignores absorption pace and lot value appreciation over time, both factors driven by external influences (such as consumer mortgage interest rates and local unemployment trends) not necessarily vital to comparing the discounted cash flow value of the Conventional Plan to the Community Preserve or Village. Indeed, the straight-line approach in this model assumes all values remain the same over an equal sell-out or absorption period for all three models. While the horizon is key to determining the actual internal rate of return, in this case it is more important that the models are compared on an equal basis without regard for differentiation in the absorption period. In actuality, research has shown both the Village and Community Preserve are currently experiencing greater absorption due to increased consumer demand. The results indicate both the Village and Community Preserve would yield greater gross revenue over an equal period of time than the Conventional Plan. The Village generates the greater value, due to its higher number of lots and housing units.

Gross profit is the gross value of individual lot sales less the direct cost of acquisition and site infrastructure development. Marketing, fixed expense (taxes, insurance), and operational overhead are not included in this model and would be subtracted from the gross profit to determine entrepreneurial profit. The greatest gross profit margin (calculated by dividing gross profit by gross sales) was achieved in the Village, at 56.1%. Community Preserve lot sales yielded a 51.8% profit margin. Lot sales in the Conventional subdivision averaged a 41.2% profit margin, indicative of lower gross lot sales and higher infrastructure cost compared to the Community Preserve and the Village.

While there is a greater gross profit potential in the Village, there is also greater gross infrastructure cost due to the higher number of serviceable lots. The Village gross profit can be increased further if calculated by the number of sellable units rather than sellable lots, as the Village calls for 306 total housing units on 244 lots. Potential commercial development also improves the gross profit in both the Community Preserve and Village, but is not compared here, as the Conventional plan does not have space for commercial development.

Revenue and Profit Conclusion

The Community Preserve Plan is a viable alternative to conventional development yielding an equal number of lots while costing less to construct and generating better than conventional profit margins. It is also a design that can be employed in most of coastal Georgia immediately, due to its similarity to conventional design. The Village plan generates more lots/housing units and a higher profit than the Conventional Plan. Both the Village and Community Preserve plans are better site designs than the Conventional subdivision, due to the lower cost to construct and the added premium found in these forms of development – directly attributable to the ecological and social benefits of their design and consumer demand for these amenities.

Tax Considerations

When a residential development is built outside of a community, it requires roads, sewer systems and water lines to be built and brought to the development by the local governing authority. Eventually, schools and emergency services also become necessary. The cost of these is rarely returned by the collection of property taxes, in other words, most residential developments fall short of yielding sufficient tax revenue to pay for the municipal services required initially and over-time. The Village Plan development plan, however, is likely to generate tax revenue annually in an amount sufficient to pay for its annual operation and maintenance simply because of its higher density and consequential tax assessable valuation. While this may appear negative to the consumer on the surface, in reality the greater value and subsequent property tax revenue is allocated to a larger number of users in the same space, facilitating affordability.

Environmental, Economic and Social Benefits

Understanding the cost differences and profit potential among development styles is an evaluation tool for both local governments and land developers. Growing interest in sustainable development requires a comparative framework, including cost and profit considerations. This is especially true when considering historic trends and future projections for population growth, job growth, housing, family size and household income in the coastal areas of southeast Georgia.

Continuing the existing, conventional practice of site development—whether creating from existing green space or from within existing urban areas—will continuously result in expensive initial investments plus high maintenance costs almost entirely borne by the public or the developer. The best solution to the problem is the Green Infrastructure approach.

The alternative, more compact development plans discussed in this chapter provide the following economic benefits:

- ✓ Higher lot yield (Village Plan),
- ✓ Higher lot sales price (Community Preserve and Village Plans),
- ✓ Higher lot tax value (Community Preserve and Village Plans),
- ✓ Lower infrastructure cost per lot (Community Preserve and Village Plans),
- ✓ Enhanced marketability (Community Preserve and Village Plans), and
- ✓ Added amenities (Community Preserve and Village Plans).

In addition to environmental and economic benefits, the alternative, more compact development plans also provide a variety of social benefits including:

- ✓ A development with a “sense of community”,
- ✓ Convenience of a short travel to basic services,
- ✓ Recreation, both passive and active, with added green and open space,
- ✓ Communities that are more social, more connected with “nature”, and
- ✓ Greater opportunities for biking and walking.

Understanding the interaction between the physical layout and the social aspects of a place is what makes it possible to go from a mere development to a real neighborhood. Moving the buildings closer to the street provides a chance for social interaction with one’s neighbors.

The environmental benefits listed in the earlier section are also social benefits as well. Being free from a long commute both allows one to more time to spend with friends and family as well as limiting the air and water pollution generated from operating a vehicle. Having significant green space within walking distance provides an opportunity for nature walks, where wildlife can be observed, enriching the experience of living there. That same green space is helping to improve water and air quality.

ENVIRONMENTAL & ECONOMIC BENEFITS ANALYSIS
SITE SUMMARY

Development Type	**Conventional**		**Community Preserve**		**Village**	
Area Summary	Acres	% of Total	Acres	% of Total	Acres	% of Total
Total Upland Area	123.9	65.7%	123.9	65.7%	123.9	65.7%
Total Wetland Area	64.7	34.3%	64.7	34.3%	64.7	34.3%
Total Site Area	188.6	100.0%	188.6	100.0%	188.6	100.0%
Area Use Summary	Acres	% of Total	Acres	% of Total	Acres	% of Total
Gray Space						
On-Lot Impervious	10.5	5.6%	9.8	5.2%	10.3	5.5%
Roads	4.6	2.4%	3.0	1.6%	7.2	3.8%
Right-of-Ways	7.9	4.2%	8.4	4.4%	14.1	7.5%
Green Space						
On-Lot Wooded Area	27.2	14.4%	9.3	4.9%	9.3	4.9%
On-Lot Lawn	46.1	24.4%	8.1	4.3%	18.3	9.7%
Common Area	22.6	12.0%	75.0	39.8%	59.9	31.8%
Wetland Conservation Area	64.7	34.3%	64.7	34.3%	64.7	34.3%
Total Gray Area	23.0	12.2%	21.2	11.2%	31.6	16.7%
Total Wooded Area	114.5	60.7%	149.0	79.0%	133.9	71.0%
Total Disturbed Footprint	101.3	53.7%	48.9	25.9%	64.0	33.9%
Lot Yield Summary	135	Lots	135	Lots	244	Lots
Density	135	Units	135	Units	306	Units
Gross on Site	0.7	Lots / acre	0.7	Lots / acre	1.3	Lots / acre
Net of Total Upland	1.1	Lots / acre	1.1	Lots / acre	2.0	Lots / acre
Impervious Area	Acres	% of Total	Acres	% of Total	Acres	% of Total
Total Impervious Area	15.1		12.8		17.5	
% Impervious Area / Total Area	8%		7%		9%	
Total Impervious Per Lot	4,869	SF	4,125	SF	3,118	SF
Per Lot Imp. Saving compared to Conventional	-	SF	744	SF	1,751	SF
RUNOFF	Rainfall Intensity		7.6 in /hr (I) (Note 1)			
Runoff Coefficient (C)	Acres (A)	Runoff (Q)	Acres (A)	Runoff (Q)	Acres (A)	Runoff (Q)
↓ cfs = cubic feet per second						
0.12 **Predevelopment Runoff**	123.9	113.0 cfs	123.9	113.0 cfs	123.9	113.0 cfs
Gray Space						
0.95 On-Lot Impervious	10.5	75.9 cfs	9.8	70.5 cfs	10.3	74.3 cfs
0.95 Roads	4.6	33.0 cfs	3.0	21.8 cfs	7.2	51.7 cfs
Green Space	-	0.0 cfs	-	0.0 cfs	-	0.0 cfs
0.12 On-Lot Wooded Area	27.2	24.8 cfs	9.3	8.5 cfs	9.3	8.5 cfs
0.35 On-Lot Lawn	46.1	122.6 cfs	8.1	21.4 cfs	18.3	48.7 cfs
0.12 Common Area	22.6	20.6 cfs	75.0	68.4 cfs	59.9	54.6 cfs
0.35 Right-of-Way Lawn	3.3	8.8 cfs	5.4	14.2 cfs	6.9	18.4 cfs
Predevelopment Runoff (cfs)		113.0 cfs		113.0 cfs		113.0 cfs
Post-Development Runoff (cfs)		277.0 cfs		190.6 cfs		237.8 cfs
% of Conventional		100%		69%		86%
Runoff per lot (cfs)		2.1 cfs		1.4 cfs		1.0 cfs
per lot % of Conventional		100%		69%		48%
Runoff per unit (cfs)		2.1 cfs		1.4 cfs		0.8 cfs
per unit % of Conventional		100%		69%		38%

ENVIRONMENTAL & ECONOMIC BENEFITS ANALYSIS
SITE DATA

Development Type		Conventional		Community Preserve		Village	
Lot Yield	Size	No. of Lots	% of Total	No. of Lots	% of Total	No. of Lots	% of Total
Community Preserve	70' x 125'	-	0.0%	135	100.0%	-	0.0%
Conventional Residential	100' x 275'	130	96.3%	-	0.0%	-	0.0%
Average Lot Residential	75' x 200'	5	3.7%	-	0.0%	44	18.0%
Village Lot Residential	50' x 120'	-	0.0%	-	0.0%	134	54.9%
Village Live / Work	30' x 120'	-	0.0%	-	0.0%	31	12.7%
Village Square Lot	30' x 70'	-	0.0%	-	0.0%	35	14.3%
Total Lots		135	100.0%	135	100.0%	244	100.0%
		135	Units	135	Units	306	Units
Lot Size Summary	Average SF	No. of Lots	Acres	No. of Lots	Acres	No. of Lots	Acres
Community Preserve	8,750	-	-	135	27.1	-	-
Conventional Residential	27,500	130	82.1	-	-	-	-
Average Lot Residential	15,000	5	1.7	-	-	44	15.2
Village Lot Residential	6,000	-	-	-	-	134	18.5
Village Live / Work	3,600	-	-	-	-	31	2.6
Village Square Lot	2,100	-	-	-	-	35	1.7
Total Lot Size		135	83.8	135	27.1	244	37.9
On-Lot Impervious Summary	Footprint Average SF	% of Lot	Total SF	% of Lot	Total SF	% of Lot	Total SF
Community Preserve	3,150	36%	-	36%	425,250	36%	-
Conventional Residential	3,400	12%	442,000	12%	-	12%	-
Average Lot Residential	3,200	21%	16,000	21%	-	21%	140,800
Village Lot Residential	1,600	27%	-	27%	-	27%	214,400
Village Live / Work	1,600	44%	-	44%	-	44%	49,600
Village Square Lot	1,250	60%	-	60%	-	60%	43,750
Total On-Lot Impervious By SF			458,000		425,250		448,550
By Acres			10.5		9.8		10.3
On-Lot Wooded Summary	Average SF	% of Lot	Total SF	% of Lot	Total SF	% of Lot	Total SF
Community Preserve	3,000	34%	-	34%	405,000	34%	-
Conventional Residential	9,000	33%	1,170,000	33%	-	33%	-
Average Lot Residential	2,800	19%	14,000	19%	-	19%	123,200
Village Lot Residential	2,000	33%	-	33%	-	33%	268,000
Village Live / Work	400	11%	-	11%	-	11%	12,400
Village Square Lot	-	0%	-	0%	-	0%	-
Total Lot Greenspace By SF			1,184,000		405,000		403,600
By Acres			27.2		9.3		9.3
On-Lot Lawn Summary	Average SF	No. of Lots	Total SF	No. of Lots	Total SF	No. of Lots	Total SF
Community Preserve	2,600	-	-	135	351,000	-	-
Conventional Residential	15,100	130	1,963,000	-	-	-	-
Average Lot Residential	9,000	5	45,000	-	-	44	396,000
Village Lot Residential	2,400						321,600
Village Live / Work	1,600	-		-	-	31	49,600
Village Square Lot	850	-		-	-	35	29,750
Total Lot Greenspace By SF		135	2,008,000	135	351,000	110	796,950
By Acres			46.1		8.1		18.3

ENVIRONMENTAL & ECONOMIC BENEFITS ANALYSIS
INFRASTRUCTURE

Development Type		Conventional		Community Preserve		Village	
Impervious Area	Impervious		Impervious		Impervious		Impervious
Streets and Sidewalks	Width	Linear Feet	Area	Linear Feet	Area	Linear Feet	Area
Urban Street (Sidewalk & Parking Both Sides)	42.00	-	-	-	-	2,360	99,120
Neighborhood Street (Sidewalk & Parking One Side)	29.00	6,872	199,288	-	-	2,840	82,360
Local Street (Narrower, Shoulder, no curb)	18.00	-	-	7,295	131,310	4,950	89,100
Alley (Model assumes impervious, consider pervious)	14.00	-	-	-	-	2,970	41,580
Total Roadway Impervious Area		6,872	199,288	7,295	131,310	13,120	312,160
By Acres			4.6		3.0		7.2
Street Widths & Area	Width	Linear Feet	Area	Linear Feet	Area	Linear Feet	Area
Urban Street (Sidewalk & Parking Both Sides)	32.00	-	-	-	-	2,360	75,520
Neighborhood Street (Sidewalk & Parking One Side)	24.00	6,872	164,928	-	-	2,840	68,160
Local Street (Narrower, Shoulder, no curb)	18.00	-	-	7,295	131,310	4,950	89,100
Alley (Model assumes impervious, consider pervious)	14.00	-	-	-	-	2,970	41,580
Total Actual Roadway		6,872	164,928	7,295	131,310	13,120	274,360
By Acres			3.8		3.0		6.3
Right-of-Way (R/W)	R/W Width	Linear Feet	Area	Linear Feet	Area	Linear Feet	Area
Urban Street (Sidewalk & Parking Both Sides)	70.00	-	-	-	-	2,360	165,200
Neighborhood Street (Sidewalk & Parking One Side)	50.00	6,872	343,600	-	-	2,840	142,000
Local Street (Narrower, Shoulder, no curb)	50.00	-	-	7,295	364,750	4,950	247,500
Alley (Model assumes impervious, consider pervious)	20.00	-	-	-	-	2,970	59,400
Total Right-of-Way		6,872	343,600	7,295	364,750	13,120	614,100
By Acres			7.9		8.4		14.1
	SE	Actual	SE	Actual	SE	Actual	SE
Total 24' Standard Equivalent (SE)	Factor	Linear Feet	Linear Feet	Linear Feet	Linear Feet	Linear Feet	Linear Feet
Urban Street (Sidewalk & Parking Both Sides)	1.3	-	-	-	-	2,360	3,068
Neighborhood Street (Sidewalk & Parking One Side)	1	6,872	6,872	-	-	2,840	2,840
Local Street (Narrower, Shoulder, no curb)	0.75	-	-	7,295	5,471	4,950	3,713
Alley (Model assumes impervious, consider pervious)	0.25	-	-	-	-	2,970	743
Total		6,872	6,872	7,295	5,471	13,120	10,363
# of Actual LF / 24' SE		100.0%		75.0%		79.0%	
Actual Linear Feet		6,872		7,295		13,120	
Standard Equivalent Linear Feet		6,872		5,471		10,363	
per lot Actual Linear Feet		50.9		54.0		53.8	
per lot Standard Equivalent Linear Feet		50.9		40.5		42.5	
per unit Actual Linear Feet		50.9		54.0		42.9	
per unit Standard Equivalent Linear Feet		50.9		40.5		33.9	
		Cost Per Linear Foot (LF) is based on Standard Equivalent (SE)					
COST ANALYSIS		Cost Per LF	Total Cost	Cost Per LF	Total Cost	Cost Per LF	Total Cost
Hard Costs							
Roadways		$ 50.00	$ 343,600	$ 30.00	$ 164,138	$ 60.00	$ 621,780
Excavation / Grading Cost		10.00	$ 68,720	10.00	$ 54,713	10.00	$ 103,630
Sewer / Water / Drainage		50.00	$ 343,600	40.00	$ 218,850	50.00	$ 518,150
Landscaping / Irrigation		25.00	$ 171,800	20.00	$ 109,425	35.00	$ 362,705
	Subtotal hard costs	$ 135.00	$ 927,720	$ 100.00	$ 547,125	$ 155.00	$ 1,606,265
Soft Costs							
Design/ Engineering (fees by lot)		1,000.00	$ 135,000	1,000.00	$ 135,000	1,000.00	$ 244,000
Impact Fees (fees by unit)		2,500.00	$ 337,500	2,500.00	$ 337,500	2,500.00	$ 765,000
	Subtotal hard costs	$ 3,500.00	$ 472,500	$ 3,500.00	$ 472,500	$ 3,500.00	$ 1,009,000
Total Cost with Impact Fees			$ 1,400,220		$ 1,019,625		$ 2,615,265
Average Cost Per Building Lot with Impact Fees			$ 10,372.00		$ 7,552.78		$ 8,546.62
Total Cost without Impact Fees			$ 1,062,720		$ 682,125		$ 1,850,265
Average Cost Per Building Lot without Impact Fees			$ 7,872.00		$ 5,052.78		$ 6,046.62

ENVIRONMENTAL & ECONOMIC BENEFITS ANALYSIS

Projected Gross Profit & Tax Revenue

Development Type			Conventional			Community Preserve			Village		
Description	Size	Price/Cost Per SF	# of Lots	Price/Cost Per Lot	Total	# of Lots	Price/Cost Per Lot	Total	# of Lots	Price/Cost Per Lot	Total
Lot Sales											
Community Preserve	8,750	$ 6.29	-	$ 55,000	-	135	$ 55,000	7,425,000	-	$ 55,000	-
Conventional Residential	22,000	$ 2.27	130	$ 50,000	6,500,000	-	$ 50,000	-	-	$ 50,000	-
Average Lot Residential	11,250	$ 4.22	5	$ 47,500	237,500	-	$ 47,500	-	44	$ 47,500	2,090,000
Village Lot Residential	6,000	$ 7.50	-	$ 45,000	-	-	$ 45,000	-	134	$ 45,000	6,030,000
Village Live / Work	3,600	$ 11.67	-	$ 42,000	-	-	$ 42,000	-	31	$ 42,000	1,302,000
Village Square Lot	2,100	$ 19.05	-	$ 40,000	-	-	$ 40,000	-	35	$ 40,000	1,400,000
Gross Lot Sales			135	49,907	$ 6,737,500	135	55,000	$ 7,425,000	244	44,352	$ 10,822,000
Acquisition Cost				21,481	2,900,000		21,481	2,900,000		11,885	2,900,000
Site Infrastructure Cost				7,872	1,062,720		5,053	682,125		7,583	1,850,265
Total Direct A & D Expense				$ 29,353	$ 3,962,720		$ 26,534	$ 3,582,125		$ 19,468	$ 4,750,265
Impact Fees				$ 2,500	$ 337,500		$ 2,500	$ 337,500		$ 2,500	$ 765,000
Total Direct A & D Expense with Impact Fees				$ 31,853	$ 4,300,220		$ 29,034	$ 3,919,625		$ 21,968	$ 5,515,265
Gross Profit without Impact Fees				**$ 20,554**	**$ 2,774,780**		**$ 28,466**	**$ 3,842,875**		**$ 24,884**	**$ 6,071,735**
Gross Profit Margin without Impact Fees				41.2%			51.8%			56.1%	
Gross Profit with Impact Fees				**$ 18,054**	**$ 2,437,280**		**$ 25,966**	**$ 3,505,375**		**$ 22,384**	**$ 5,306,735**
Gross Profit Margin with Impact Fees				36.2%			47.2%			50.5%	
Property Valuation					$ 6,737,500			$ 7,425,000			$ 10,822,000
Assessed Value					2,695,000			2,970,000			4,328,800
Annual Tax Revenue					**$ 281,089**			**$ 309,771**			**$ 451,494**
% of Conventional					100.0%			110.2%			160.6%

Green Certification Programs

LEED-Neighborhood Development

In 2009, The U.S. Green Building Council (USGBC), the Congress for the New Urbanism (CNU), and the Natural Resources Defense Council (NRDC) developed a rating system for neighborhood planning and development based on the collective principles of Smart Growth, New Urbanism, and Green Infrastructure and Building. Through certification, LEED for Neighborhood Development recognizes development projects that successfully protect and enhance the overall health and quality of our natural environment and our communities.

The LEED-ND rating system is made up of prerequisites, which all projects must meet, and a set of credits, from which each project can choose to earn enough points for certification. The system is divided into the following credit categories: Smart Location and Linkage (SLL), Neighborhood Pattern and Design (NPD), and Green Infrastructure and Buildings (GIB). The rating system can be applied, in its entirety or in part, depending on the scale of the project.

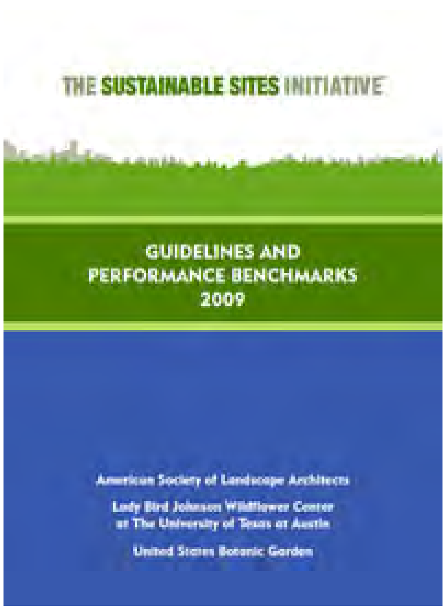
LEED ND projects vary widely in their scope and character—small infill projects qualify, as well as large master planned communities, and projects may apply early in the development process or immediately after construction is complete. As of April 2012, 106 pilot projects have been certified through the program.

For more detailed information, visit www.usgbc.org/ND. Additional information on green building practices is also available from the EPA's *Sustainable Design & Green Building Toolkit for Local Communities* at www.epa.gov/smartgrowth/partnership/tools.html.

Sustainable Sites Initiative (SITES)

The Sustainable Sites Initiative, known as SITES, is a joint effort by the American Society of Landscape Architects, Lady Bird Johnson Wildflower Center of the University of Texas at Austin, and the US Botanical Garden. This set of prerequisites and credits combines current research, technology, best practices and performance goals for the design, construction and maintenance of sustainable sites.

The Initiative developed criteria for sustainable land practices that will enable built landscapes to support natural ecological functions by protecting existing ecosystems and regenerating ecological capacity where it has been lost. This program focuses on measuring and rewarding a project that protects, restores and regenerates ecosystem services – benefits provided by natural ecosystems such as cleaning air and water, climate regulation and human health benefits.



The Guidelines and Performance Benchmarks 2009 includes a rating system for the credits that the pilot process will test for refinement before a formal release to the market place. The rating system contains 15 prerequisites and 51 credits that cover all stages of the site development process from site selection to landscape maintenance. Feedback from the pilot projects is being used to create a reference guide that will provide suggestions on how projects achieved the sustainability goals of specific credits.

The companion document titled *The Case for Sustainable Landscapes* provides a set of arguments—economic, environmental, and social—for the adoption of sustainable land practices, additional background on the science behind the performance criteria in the guidelines and performance benchmarks, the purpose and principles of the Sustainable Sites Initiative, and a sampling of some of the case studies the Initiative has followed. Both documents can be downloaded at www.sustainablesites.org.

Green Infrastructure Case Studies

As a collaborative effort, in 2012 the Southeastern Watershed Forum, University of Georgia River Basin Center, Environmental Protection Agency Region IV, Southeast Smart Growth Network, and community leaders from Georgia, Florida, North and South Carolina and Tennessee published *An Analysis of Selected Community Green Building Programs in Five Southeastern States*. The report contains green building case studies being implemented across 16 representative southeastern communities; four local examples are featured in the following section.

The full report can be found at www.southeastwaterforum.org. Additional information on green building practices is also available at the EPA's *Sustainable Design & Green Building Toolkit for Local Communities* website www.epa.gov/smartgrowth/partnership/tools.html.

Chatham County, Georgia
GREEN BUILDING PROGRAM

By Amble Johnson

Sustainable Fellwood, Green housing development in Chatham County, Georgia.

Background

Incorporated in 1777 and located at the mouth of the Savannah River, Chatham County has a land area of 426 square miles and a population of 256,128.[231] Savannah is the county's largest and most renowned municipality and the Savannah Seaport and Savannah River distinguish the character of the area. Transportation and shipping are key facets of Chatham County's history and culture.[232]

In 2007, Chatham County's Board of Commissioners passed a resolution with the goal of becoming the "Greenest County in Georgia". This resolution articulates the County's goals for natural resource and energy conservation and the building of a "high-tech, knowledge-based, and creative local economy" to create an "environmentally, economically, and socially sustainable future."[233] To promote this vision, the Board enlisted the Chatham Environmental Forum (CEF), a collaboration of business, environmental advocacy, and government stakeholders formed to promote environmental initiatives that have broad based support in Chatham County to craft a "Road Map" to becoming greener.[234]

> "This resolution articulates the County's goals for natural resource and energy conservation and the building of a 'high-tech, knowledge-based, and creative local economy' to create an 'environmentally, economically, and socially sustainable future.'"

> "New commercial buildings that achieve LEED Gold certification receive full abatement of state and county taxes for five years and partial abatement for ten years, if they demonstrably 'increase employment opportunities' and constitute expansion into 'enterprise zones'."

With Chatham Environmental Forum's Road Map as the overarching guide, the county has initiated and expanded several environmental initiatives. For example, the county is focusing on sustainable building by promoting the green construction of county and commercial buildings. All new county buildings are required to achieve LEED Silver certification or better, and this requirement also extends to renovation projects that cost $100,000 or more.[235] In addition, new commercial buildings that achieve LEED Gold certification receive full abatement of state and county taxes for five years and partial abatement for ten years, if they demonstrably "increase employment opportunities" and constitute expansion into "enterprise zones".[236]

In addition to achieving LEED certification of new buildings and large scale renovations, the county government has made numerous improvements and modifications to improve efficiency and sustainability of county facilities. As part of Chatham Environmental Forum's Road Map to streamline the government's sustainability measures, in 2007 and 2008 staff evaluated the county's carbon footprint, and used the findings to implement

231 U.S. Census Bureau State and County Quickfacts; http://quickfacts.census.gov/qfd/states/13/13051.html

232 http://georgiafacts.net/counties?countyid=13051

233 http://www.chathamcounty.org/Portals/ChathamCounty/Greenest%20County/Greenest%20County%20Resolution.pdf

234 http://www.chathamcounty.org/Home/GreenestCounty.aspx

235 http://www.chathamcounty.org/Portals/ChathamCounty/Greenest%20County/Greenest%20County%20Achievements.pdf

236 Chatham County, Ga., Code §7-1002(a)(2) (2008).

CHATHAM COUNTY, GEORGIA

> "2007 and 2008 staff evaluated the county's carbon footprint, and used the findings to implement various energy saving renovations to county facilities."

various energy saving renovations to county facilities.[237] Facility improvements at county buildings in recent years include the installation of acrylic insulating panels on Administrative Courthouse windows, the electronic ballasts and high-efficiency fluorescent light bulbs in the Judicial Courthouse, Administrative Courthouse, and Citizens Service Center buildings, the county's acquisition of the "bulb eater" to recycle fluorescent light bulbs used in county buildings, expanded recycling programs at government buildings, and the installation of an air conditioner to improve energy savings in the Administrative Courthouse.[238]

Program Inception and Development

Chatham County's goal of becoming "The Greenest County in Georgia" was articulated on October 5, 2007, in a resolution passed by the Board of Commissioners. Rather than outlining specific policies or criteria to meet its goal, the single-page resolution instead calls upon the Chatham Environmental Forum to develop a plan that identifies ways to "conserve our natural resources; conserve energy in every way possible; enhance our ability to use local labor, talent and materials; and, to make sure that our investment in new infrastructure will help us build a high-tech, knowledge-based, and creative local economy."[239] The Forum should "bring together representatives of local governments, local businesses, and local environmental groups, as well as other community-based institutions" to prepare and execute this plan.[240]

The Chatham Environmental Forum was originally established in 1989 to provide a venue to discuss local environmental issues. The Forum describes itself as a "three-legged stool" that grants equal representation to government, business, and environmental groups' interest in order to offer consensus-based analyses of environmental issues.[241]

Abercorn Common is a LEED-Certified Shopping Center.

> "Government buildings, new County-funded buildings and renovations costing $100,000 or more are required to achieve at least LEED Silver certification."

In February of 2009, the Chatham Environmental Forum released the 52-page "Road Map for Chatham County". To draft the plan, CEF members and community stakeholders met weekly in committees for over six months. The CEF members who helped in the drafting totaled 24 men and women, 8 rep-

237 http://www.chathamcounty.org/Portals/ChathamCounty/Greenest%20County/Greenest%20County%20Roadmap.pdf

238 http://www.chathamcounty.org/Portals/ChathamCounty/Greenest%20County/Greenest%20County%20Achievements.pdf

239 Chatham County Resolution "Calling for Chatham County to Become 'The Greenest County' in Georgia," passed October 5, 2007; text available at: http://www.chathamcounty.org/Portals/ChathamCounty/Greenest%20County/Greenest%20County%20Resolution.pdf.

240 http://www.chathamcounty.org/Portals/ChathamCounty/Greenest%20County/Greenest%20County%20Resolution.pdf

241 http://www.pinkchatham.com/about-cef

CHATHAM COUNTY, GEORGIA

resenting businesses, 9 representing environmental advocacy groups, and 7 representing government. Georgia Power and the Savannah Area Chamber of Commerce were among the business interests represented. The Sierra Club, US Green Building Council, and Savannah Tree Foundation were among the environmental advocacy interests. And government representation included the Georgia Ports Authority, City of Savannah, Chatham County Youth Commission and the Chatham County-Savannah Metropolitan Planning Commission. During the drafting process, one environmental advocate and one business representative held the position of CEF Chair.[242]

The document itself is divided into Green Space / Land Use, Energy, Transportation, Climate Change, Creative Infrastructure, Water Management, and Solid Waste sections, each drafted by a different CEF committee.[243] It focuses enhancement and coordination of existing conservation programs and policies to reach an environmentally sustainable Chatham County in each of the targeted sections.

In 2006, the Board of Commissioners adopted an ordinance incentivizing the achievement of LEED Gold certification for commercial buildings. For the first five years, the code grants full state and county tax abatement. This incentive then tapers off by 20% each year from year six to year ten, when it ends. To be eligible, construction projects must be new or expanding into an "enterprise zone" and must increase local employment opportunities.[244]

For government buildings, new County-funded buildings and renovations costing $100,000 or more are required to achieve at least LEED Silver certification. This mandate began as a 2010 County Commission motion; in 2011, the Board of Commissioners amended the county code to include the requirement.[245]

The county has also taken steps to enhance the sustainability of local government buildings through periodic retrofits, upgrades, and new programs. For example, the County has installed acrylic insulating panels on the windows of the Administrative Courthouse to improve the insulation of the building without compromising its historical aesthetic. Other improvements include electronic ballasts and high-efficiency fluorescent light bulbs in the Judicial Courthouse, the Administrative Courthouse, and the Citizens Service Center. In 2010, the installation of a more efficient air conditioner improved energy savings in the Administrative Courthouse.[246]

Funding

While much of the funding for Chatham County's sustainability initiatives comes directly from the county, the local government also coordinates with state and federal programs to achieve its goals. For example, a 2009 Energy Efficiency Community Block grant from Georgia Environmental Facilities Authority allocated Federal stimulus funds. The grant totaled $300,000 toward lighting and HVAC upgrades. A 25 percent energy savings will then be redirected to fund 80 total "green jobs" for a local poverty reduction initiative.[247]

Chatham County partially funded the development of the CEF plan. Additional funding was provided by contributions from the CEF and its members.[248] The joint funding effort demonstrates one of the benefits of enlisting the CEF to coordinate the county's green goals.

Results

As a result of Chatham County's sustainability efforts, the Georgia Department of Natural Resources' (DNR) Partnership for Sustainable Georgia accepted the county's 2010 application for bronze-level partnership.[249]

The Southwest Chatham Library opened in October 2009 with LEED-silver certification. Approximately 50,000 square feet in area, it is the second-largest library in the library system. It includes highly reflective roofing material, landscaping with native plants that do not require irrigation, low-flow water fixtures, and low-VOC adhesives, among other sustainable building practices.[250] Also, the library's innovative use of natural light

242 http://www.chathamcounty.org/Portals/ChathamCounty/Greenest%20County/Greenest%20County%20Roadmap.pdf

243 http://www.chathamcounty.org/Portals/ChathamCounty/Greenest%20County/Greenest%20County%20Roadmap.pdf

244 http://www.cleanair-coolplanet.org/for_communities/green_building_ordinances.php

245 http://www.chathamcounty.org/Portals/ChathamCounty/Greenest%20County/Greenest%20County%20Achievements.pdf

246 http://www.chathamcounty.org/Portals/ChathamCounty/Greenest%20County/Greenest%20County%20Achievements.pdf

247 http://savdailynews.com/main.asp?SectionID=2&SubSectionID=18&ArticleID=30721

248 http://www.chathamcounty.org/Portals/ChathamCounty/Greenest%20County/Greenest%20County%20Roadmap.pdf

249 http://www.chathamcounty.org/Portals/ChathamCounty/Greenest%20County/Greenest%20County%20Achievements.pdf

250 http://www.liveoakpl.org/upload/SWChathamFactSheet.pdf

CHATHAM COUNTY, GEORGIA

and light-sensors further contribute to energy efficiency and a smaller carbon footprint. Installation of a green roof is in future plans for the library.[251]

Lessons Learned

In its strong tax incentives for commercial green building and other initiatives, Chatham County has taken aggressive steps toward becoming greener. However, no single government department leads the way. Instead, the Board of Commissioners delegated the overarching goal to the Chatham Environmental Forum.[252] The group's make-up of business, environmental advocacy, and government actors has ensured a coherent plan. CEF's emphasis on designing consensus-approved approaches to problems has also been an asset for its goals for the county.[253] In empowering a group of informed stakeholders, Chatham County strives to establish concrete, achievable goals that will help to address the future climate and resource issues that the coastal county will face.

> **"Land conservation makes sense, therefore, as a primary goal for the county government; the Resource Protection Commission adopted a 2009 site acquisition policy with recommendations from the Environmental Forum in mind."**

Other Initiatives

In 2009, Chatham County established a "Green Team" to develop and implement energy and resource conservation strategies, and the same year appointed a Liaison to the Chatham Environmental Forum.[254] Chatham County's major sustainability steps extend to land use. The original resolution cites Chatham County's unique geographic wealth, including barrier islands, tidal marshes, the Savannah River delta, and pine and live oak forests, among other ecological treasures.[255] Land conservation makes sense, therefore, as a primary goal for the county government; the Resource Protection Commission adopted a 2009 site acquisition policy with recommendations from the Environmental Forum in mind. Granting resource protection is based on site classification, the landowner's willingness to protect the land, the price of acquisition, and the potential for funds from grants or matching funding sources to supplement Chatham County's financial investment.[256] The Resource Protection Commission also adopted an ecological systems ranking manual to guide the classification of each site. The ranking manual is 55 pages in length, and it provides a standard procedure for ranking sites for the county's Resource Protection Commission. Specifically, six ranking criteria focus on the site's environmental qualities, four deal with historical and cultural significance, three address the site's public use value, and one focuses on opportunities for collaboration with other organizations.[257]

Another example is the Lower Ogeechee River Trail program. Through a $100,000 grant from the Georgia Recreational Trail Grant Program, Chatham County has routed and will construct two miles of trails through bottomland hardwood forest in land that had been set aside as part of Chatham County's land conservation program in 2008.[258] [259]

Many of the short-term steps advocated by CEF in the Road Map have been met. For example, in 2010 twenty hybrid buses joined the Chatham Area Transit fleet. Also, the Metropolitan Planning Organization adopted "Complete Streets" guidelines, and the Public Works department opened Chatham County's fourth recycling center.[260]

Another major result of Chatham County's sustainability initiatives is completion of the Westlake / Lamarville Reforestation Project. The project connects two existing County-owned forestlands, provides flood mitigation for the County and resulted in the planting of nearly 500 new trees. It also constituted a successful partnership between Chatham County, the Georgia Forestry Commission, the Savannah Tree Foundation, and neighborhood associations.[261] In addition to the Westland/Lamarville Reforestation Project, Cha-

251 http://www.chathamcounty.org/Portals/ChathamCounty/News/Chatham%20County%20Connection/2009/April%202009.PDF

252 http://blog.thecreativecoast.org/a-road-map-for-chatham-county-for-its-journey-in-becoming-the-greenest-county-in-the-state-of-georgia/2009/03/03

253 http://www.joinchatham.org/about-cef

254 http://www.chathamcounty.org/Portals/ChathamCounty/Greenest%20County/Greenest%20County%20Achievements.pdf

255 http://www.chathamcounty.org/Portals/ChathamCounty/Greenest%20County/Greenest%20County%20Resolution.pdf

256 http://www.thempc.org/documents/CCRPC/Site%20Acquisition%20Policy.pdf

257 http://www.thempc.org/documents/CCRPC/Evaluation_Manual%201.15.09.pdf

258 http://www.n-georgia.com/new-ga-trails-press-release-2010.html

259 http://www.chathamcounty.org/Portals/ChathamCounty/Greenest%20County/Greenest%20County%20Achievements.pdf

260 http://www.chathamcounty.org/Portals/ChathamCounty/Greenest%20County/Greenest%20County%20Achievements.pdf

261 http://www.chathamcounty.org/Portals/ChathamCounty/Greenest%20County/Greenest%20County%20Achievements.pdf

CHATHAM COUNTY, GEORGIA

tham County's Conservation Land Program, overseen by the Chatham County Resource Protection Commission, expanded in 2010 to over 3,000 acres of property. Land management plans exist for the 178-acre Pennyworth Island and the 150-acre Whitemarsh Preserve.[262]

Extending Chatham County's sustainability theme of cooperation, the county has teamed with the City of Tybee Island to harvest geothermal energy. The Tybee Island Library Branch is currently connected to the geothermal system.[263] The governments are also collaborating in expansion of Tybee's geothermal energy use, requesting proposals from firms to offer services and materials to do this.[264]

As part of its publicity for the Road Map plan, the Environmental Forum launched a JoIN web site.[265] The site offers resources and mechanisms for individuals, businesses, organizations, and municipal governments to enlist in Chatham County's green initiatives. The web presence also offers a place for businesses to highlight their sustainability measures.[266]

262 http://www.chathamcounty.org/Portals/ChathamCounty/Greenest%20County/Greenest%20County%20Achievements.pdf

263 http://www.chathamcounty.org/Portals/ChathamCounty/Greenest%20County/Greenest%20County%20Achievements.pdf

264 http://www.cityoftybee.org/Assets/Files/Finance/2011/2011-621_GeothermalRFP.pdf

265 http://www.scaddistrict.com/?p=20804

266 http://www.joininchatham.com/partners-directory

Cherokee County, Georgia
GREEN BUILDING PROGRAM

By Ambie Johnson

Background

Cherokee County is just north of Atlanta off of Interstate 575. Its land area totals 424 square miles, and it has a population of 214,346, which represents a 51% increase over the County's 2000 population.[267] Cherokee County is a rapidly growing county on the suburban fringe of the Atlanta metro area. Its median age is 34.0 years, and the median household income of $64,922 is nearly $20,000 higher than Georgia as a whole.[268] Canton is the county seat, but Cherokee County also contains the cities of Ball Ground, Holly Springs, South Canton, Waleska, and Woodstock. The northern part of the county is mountainous and remains rural, while the southern and eastern parts are growing as Metro Atlanta grows.[269]

Since 1990, Cherokee County's population has increased as a result of its proximity to Atlanta, and increasing local employment opportunities accelerate this growth. Cherokee County's Community Assessment, done as part of the comprehensive planning in 2007 for the County and the Cities of Ball Ground and Waleska, anticipates the County's 2030 population to nearly double to approximately 420,000 people.[270] Many of the County's environmental concerns arise from the pressures expected from this continued rapid population growth. The Community Assessment argues for the "proactive" preservation of the county's natural resources, specifically wilderness areas and fresh water and offers some specific ideas for achieving this preservation.[271]

"Cherokee County's Community Assessment, done as part of the comprehensive planning in 2007 for the County and the Cities of Ball Ground and Waleska, anticipates the County's 2030 population to nearly double to approximately 420,000 people. Many of the County's environmental concerns arise from the pressures expected from this continued rapid population growth."

Brick Mill Falls in Cherokee County, Georgia

Program Inception and Development

Cherokee County's Green Building Program is designed to ensure new county building projects are green and encourage private development to be green as well. It is important to note that this program is only one part of a multi-pronged approach toward preserving the natural environment, which is an essential part of the community's vision. Cherokee County also has programs in place to protect and preserve greenspace through land acquisition and during the development process.

Cherokee County's construction of its LEED Silver Certified Cherokee County Administration Building in Canton is a tangible example of the County's commitment to sustainable development. The building totals 78,000 square feet. It holds the offices of department heads and other county personnel, as well as a full-service conference center with an auditorium and over 8,000 square feet of flexible meeting space.[272] The green building features account for a 20% reduction in energy

267 U.S. Census Bureau State and County Quickfacts: http://quickfacts.census.gov/qfd/states/13/13057.html

268 http://www.city-data.com/county/Cherokee_County-GA.html

269 http://www.cherokeega.com/departments/planningandzoning/uploads/File/CompPlan/Cherokee_Assessment_Vol_1_Final.PDF

270 Cherokee County Community Assessment, Vol. 1: Issues and Opportunities. Prepared by Plan Cherokee, January 2007. Available at: http://www.cherokeega.com/departments/planningandzoning/uploads/File/CompPlan/Cherokee_Assessment_Vol_1_Final.PDF

271 http://www.cherokeega.com/departments/planningandzoning/uploads/File/CompPlan/Cherokee_Assessment_Vol_1_Final.PDF

272 http://canton-ga.patch.com/listings/cherokee-county-administration-building-and-conference-center

CHEROKEE COUNTY, GEORGIA

Housing Density 1970:
Cherokee County, Georgia

Housing Density 2000:
Cherokee County, Georgia

Housing Density 2000:
Cherokee County, Georgia

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costs and 50% reduction in water usage. Through construction materials and practices, the building fosters improved indoor environmental quality and water and energy conservation.[273] 75% of the building's construction waste was recycled. Bike racks and special parking spaces for fuel-efficient and carpool vehicles encourage conservation in employees' transportation. Through low-flow fixtures and water-efficient landscaping, the building boasts 50% reduced water usage. There is also an on-site recycling program, and a white roof that reduces the building's heat island effect and, therefore, the energy usage associated with cooling. Finally, the use of building materials with low VOC content enhances the building's indoor environmental quality.[274]

The success of the new Administration Building has led county officials to set new county-wide green construction policies. All new county buildings that exceed 5,000 square feet must be LEED certified, and local government building renovations must follow LEED guidelines.[275] The County also committed to energy and water use audits to be completed for all county government facilities by 2013.[276]

To incentivize the private sector to follow the government's lead, green development in residential and commercial buildings is encouraged. Permitting reviews are expedited for new projects that achieve LEED, EnergyStar, or EarthCraft certification. Additionally, fees are reduced for such certification in

273 http://www.cherokeega.com/departments/project2_page.cfm?projectid=62

274 http://www.cherokeega.com/departments/project2_page.cfm?projectid=62

275 http://www.atlantaregional.com/File%20Library/Environment/Green%20Communities/Cherokee_Certified-Green-Community-Presentation_Dec1-2010.pdf

276 http://cherokeetribune.com/view/full_story/10643222/article-Green-is-the-way-to-go

CHEROKEE COUNTY, GEORGIA

> ***"The green building features account for a 20% reduction in energy costs and 50% reduction in water usage."***

> ***"All new county buildings that exceed 5,000 square feet must be LEED certified, and local government building renovations must follow LEED guidelines. The County also committed to energy and water use audits to be completed for all county government facilities by 2013."***

> ***"Permitting reviews are expedited for new projects that achieve LEED, EnergyStar, or EarthCraft certification. Additionally, fees are reduced for such certification in private developments."***

private developments.[277] These fee reductions generally total around 50% of the typical permitting cost, and the local government provides initial plan reviews of private green building projects within two days.[278]

As a water conservation measure, the Cherokee County Water and Sewer Authority (CCWSA) Board of Directors voted to participate in the Metropolitan North Georgia Water Planning Region Toilet Retrofit Program. This program incentivizes homeowners to replace their inefficient toilets with efficient ones. Rebates of $50 and $100 are available for houses that were built before 1992 (after 1992, low-flow requirements were added to the rules for new homebuilding).[279] After making the switch, a family of three conserves around 33 gallons every day.[280]

As early as 2001, Cherokee County outlined a "Greenspace Vision" to conserve 20 percent of the county's land within 10 years in its Planning and Land Use document. The land to be conserved includes: natural areas which have important recreational, ecological and aesthetic values, wildlife management areas and prime habitat, and prime agricultural and forest lands. To fund such efforts, the county received early funding from the Governor's Greenspace Program, instituted a Special Purpose Local Option Sales Tax and impact fees, and passed a $90 million Parks and Greenspace Bond in 2009. In 2008 Cherokee County voted to meet the Comprehensive Plan's call for more aggressive greenspace acquisition. The Parks, Recreation, and Green Space Bond set aside funds to purchase new land and improve existing parks and greenspace. Each acquisition is approved by the Board of Commissioners, and the bond constitutes a significant investment in the county's greenspace. (Citation: http://parkbond.cherokeega.com/)

Cherokee County also offers two ways to incorporate sustainability strategies into new developments. First, developers may choose to utilize the Conservation Design Community Ordinance in most residential zoning districts to reduce residential lot sizes while setting aside a minimum of 40% greenspace within a new neighborhood. This strategy, sometimes known as a Conservation Subdivision, has been successful in allowing land development while preserving sensitive natural areas. Second, Cherokee County has a Traditional Neighborhood Development (TND) zoning district that is available in the more densely developed areas. The Home Depot Foundation's Sustainable Cities Institute cited Cherokee County's Traditional TND Ordinance as a model policy. In its description, the institute cited the ordinance's emphasis on ensuring "integrated and diverse community features and uses." These uses include the presence of greenspace and the use of thoroughfares for walking and other alternative transportation (specifically, bicycles).[281]

Funding

The initial costs associated with green building is included in $22 million construction cost of the Cherokee County Administration Building.[282] With its LEED Silver certification, however, the increased construction cost should ultimately be offset with savings. Since new construction is an on-going cost for local governments anyway, building sustainable government build-

277 http://woodstock.11alive.com/content/metro-atlanta-communities-recognized-sustainability-programs

278 http://www.atlantaregional.com/File%20Library/Environment/Green%20Communities/Cherokee_Certified-Green-Community-Presentation_Dec1-2010.pdf

279 http://www.northgeorgiawater.org/html/392.htm

280 http://www.northgeorgiawater.org/files/MNGWPD_Toilet_Rebate_Program_FAQs.pdf

281 http://www.sustainablecitiesinstitute.org/view/page.basic/legislation/feature.legislation/Model_Ordinance_Cherokee_County

282 http://canton-ga.patch.com/listings/cherokee-county-administration-building-and-conference-center

CHEROKEE COUNTY, GEORGIA

> ***As early as 2001, Cherokee County outlined a "Greenspace Vision" to conserve 20 percent of the county's land within 10 years in its Planning and Land Use document. The land to be conserved includes: natural areas which have important recreational, ecological and aesthetic values, wildlife management areas and prime habitat, and prime agricultural and forest lands.***

> ***Developers may choose to utilize the Conservation Design Community Ordinance in most residential zoning districts to reduce residential lot sizes while setting aside a minimum of 40% greenspace within a new neighborhood.***

ings is an easy way for counties to encourage green building without significant added costs.[283]

Results

The Cherokee County Administration Building is a tangible success that has come out of Cherokee County's Green Building Program. The initial costs of the green features have begun to pay for themselves in reduced water and energy usage. It is an example of local government leading by example by directly demonstrating the benefits of sustainable building practices.[284] Data is still being collected and analyzed for the energy retrofit projects on existing county buildings. The incentives for new private developments have yet to be utilized due to the recent economic downturn. With sprawl a major concern in development, the Conservation Design Community and Traditional Neighborhood Development Ordinances are examples of Cherokee County's proactive approach to encouraging deliberate, thoughtful development, and this approach guides much of the county's green building strategy.

> ***With sprawl a major concern in development, the Conservation Design Community and Traditional Neighborhood Development Ordinances are examples of Cherokee County's proactive approach to encouraging deliberate, thoughtful development, and this approach guides much of the county's green building strategy.***

Lessons Learned

Cherokee County's emphasis on voluntary programs and zoning options yields a low-cost approach to fostering green building. This is reinforced by the county's reliance on outside mechanisms to fund and administer many of the green initiatives. The toilet retrofit rebate is not so much a Cherokee County initiative as the county's participation in a program of the broader Metropolitan North Georgia Water Planning Region. Cherokee County residents have access to many loans and rebates for energy improvements, but these come from the federal government or from energy providers themselves.

However, the Comprehensive Plan shows Cherokee County citizens' concerns over future growth. Because of the natural growth of the Metro Atlanta area, many pressures encourage sprawling developments. Mandating steps such as the Traditional Neighborhood Developments Ordinance and proactive zoning may be necessary to avoid this.

Other Initiatives

The Cherokee Environmental Sustainability Initiative (CESI) exists to facilitate long-term sustainability, primarily through community involvement. CESI inspires and educates Cherokee County residents to actively sustain the local environment. Specifically, it focuses on the small acts that individuals and small groups can do to contribute.[285] For example, the loss of tree cover as the county grows is a specific problem area that CESI has sought to address, through acts such as tree planting and nursery creation.

While it is not part of the Cherokee County government, the Cherokee County Chamber of Commerce also contributes to

283 http://www.cherokeega.com/departments/project2_page.cfm?projectid=62

284 http://www.cherokeega.com/departments/project2_page.cfm?projectid=62

285 http://www.crpa.net/community_cesi.php

CHEROKEE COUNTY, GEORGIA

Cherokee County's sustainability measures. It articulates the goal of "Living green, working green, thinking green." As part of this goal, it maintains a list of Going Green businesses that adhere to a list of environmentally responsible criteria. Participation is completely voluntary and is not rewarded with financial incentive, but by showcasing businesses the Chamber of Commerce contributes to a culture of proactive sustainability.

The steps necessary for businesses to qualify include basic green practices in seven categories: solid waste prevention, recycling, purchasing, energy conservation, water conservation and water quality, transportation, and stakeholder involvement in environmental practices. The Chamber provides businesses with a menu of green business practices, and based on the number of employees businesses must follow a certain amount of these practices. For small businesses with five or fewer employees, four practices must be met. For the largest companies of 100+ employees, fifteen practices must be met. These practices include the use of reusable rather than disposable materials when possible, recycle printer toner and ink jet cartridges, use low-emission building materials for remodeling, the installation of low-flow water fixtures, and other similar steps, and it reinforces the county's goal of empowering people to take steps to protect the local environment.[286]

A primary concern facing Cherokee County is the encroaching sprawl of Metro Atlanta. As a result, the Comprehensive Plan and the Zoning Ordinance convey citizens' desire to keep the county unique. Since citizens identify environmental beauty as a crucial part of that uniqueness, conservation and intelligent development are a crucial part of the county's green buildings agenda.

286 http://www.cherokeechamber.com/green.htm

Douglas County, Georgia
GREEN BUILDING PROGRAM

By Amble Johnson

Background

Named for abolitionist Fredrick Douglas, Douglas County is located 20 miles west of Atlanta. It covers 200 square miles of area. In 2010, the US Census Bureau recorded 132,403 people living in Douglas County, which marked a 43.6% growth since 2000.[287] The median per capita income in 2010 was $24,516, and 12.3% of the population lived below the poverty level.[288] The county serves as a western gateway to Atlanta, and it offers convenient access to Hartsfield-Jackson International Airport.[289]

Rapid growth is a defining characteristic of Douglas County. In a message from the Board of Commissioners available on Douglas County's web site, Chairman Tom Worthan characterizes the county as "a changing community—evolving from a rural area to suburbia and becoming the economic hub of west Georgia. However, we ensure that our growth is 'smart growth', and that the quality of life continues to be high for all our citizens."[290] This stated goal of "smart growth" seems to drive Douglas County's sustainability measures, and green building is a significant component of the County's vision of smart growth.

Program Inception and Development

Many of Douglas County's sustainability initiatives were instigated as part of the County's application for the Atlanta Regional Commission (ARC) Green Communities Program. The program encourages local governments to demonstrate "leadership on environmental sustainability in the areas of conserving energy, investing in renewable energy, conserving water, conserving fuel, reducing waste and protecting and restoring the community's natural resources." Specific measures and benchmarks are required for communities to qualify, and a majority of Douglas County's sustainability practices aim to conform to these requirements.[291]

287 U.S. Census Bureau State and County Quickfacts, http://quickfacts.census.gov/qfd/states/13/13097.html

288 *Id.*

289 http://www.celebratedouglascounty.com/about/index.html

290 http://www.celebratedouglascounty.com/about/chairman.html

291 http://www.celebratedouglascounty.com/view/departments/view_dept/&cdept=350&department=Green%20Community%20Program

The Emergency Operations Center in Douglas County collects and stores rainwater.

Douglas County's Green Community Ordinance, which the Douglas County Board of Commissioners ratified November 3, 2009, embodies the most significant sustainability measures enacted by the County. It requires New EnergyStar or EarthCraft Light Commercial certification in new construction or renovation of public buildings (subject to Board approval if meeting the certification adds costs exceeding $10,000). This document also offers expedited plan review, processing, and permitting for privately owned buildings that have LEED, EarthCraft, or EnergyStar certification. Furthermore, it requires the installation of high efficiency water fixtures such as WaterSense certified toilets and faucets in new public building installations.[292] These

292 http://www.celebratedouglascounty.com/view/global/viewdownload/

DOUGLAS COUNTY, GEORGIA

> *"Douglas County has also taken measures to make it easier for homeowners to install solar panels. The County adopted Chapter 26 of the International Residential Code, which prevents both homeowner associations and local government agencies from unnecessarily impeding installation of solar panels on residential structures."*

sustainability requirements for local government buildings ensure that Douglas County leads by example in constructing green building.

Douglas County has also taken measures to make it easier for homeowners to install solar panels. The County adopted Chapter 26 of the International Residential Code, which prevents both homeowner associations and local government agencies from unnecessarily impeding installation of solar panels on residential structures.[293]

WaterFirst Community designation is required to be one of ARC's Green Communities. Douglas County received its designation as a WaterFirst Community from the Georgia Department of Community Affairs (DCA) on February 4, 2009. DCA cited the county's recent construction of a new wastewater treatment plant, as well as strong educational programming, stormwater management, and zoning and land use regulations as qualifications.[294]

Like Green Community designation, the Livable Centers Initiative (LCI) is offered by the Atlanta Regional Commission. The LCI is a program that encourages local jurisdictions to plan and implement strategies that link transportation improvements with land use development in order to create sustainable communities. The program provides grants to plan enhancements of existing transportation centers and corridors.[295] The idea of creating sustainable, livable communities through linking transportation improvements with land use development strategies is an example of the "smart growth" that Douglas County strives for. In March of 2007 Douglas County received an LCI grant for the Highway 92 Emerging Corridor. On September 20, 2011, Douglas County applied for an LCI Transportation Project Grant for a proposed multi-use trail and raised bridge connecting Deerlick Park, Chestnut Log, and Mt. Carmel School.[296]

Funding

Much of Douglas County's sustainability program was designed to have little or no impact on the County's budget. The County employs no extra staff to work on its sustainability initiatives. Many measures are coordinated by Mark Teal, the Director of Development Services and County Engineer.[297] Incentives for private green building are not monetary; expedited permitting does not cost the County money, as they simply move qualifying projects higher up on the list.[298] Ultimately, none of Douglas County's sustainability measures cost a significant amount of revenue. This allows the County to implement the steps necessary to achieve Green Community status without straining the $77.4 million county budget.[299]

Results

As a result of its environmental sustainability initiatives, the Douglas County Courthouse received the Government Building of the Year Award for 2009-2010 from the Building Owners and Managers Association of Atlanta.[300] The courthouse, which was built by the architecture firm Cooper Carry, also earned the US EPA's Energy Star Award in 2009.[301]

Even more significantly, Douglas County met its goal of achieving Atlanta Regional Commission's Green Community status. It received the ARC's Bronze Green Community designation.

Ultimately, the Atlanta Regional Commission's Green Communities Program served as a guide for Douglas County's environmental initiatives. By tailoring its approach on the ap-

&docid=3388&file=/Green_Community_Ordinance_11-3-09.pdf

293 http://www.celebratedouglascounty.com/view/global/viewdownload/&docid=3365&file=/18_Community_Remove_Solar_Barriers.pdf

294 http://www.celebratedouglascounty.com/view/global/viewdownload/&docid=3369&file=/22_Government_DCA_WaterFirst_Community.pdf

295 http://www.celebratedouglascounty.com/view/departments/view_dept/&cdept=266&department=Livable%20Centers%20Initiative

296 http://www.celebratedouglascounty.com/view/departments/view_dept/\&cdept=266&department=Livable%20Centers%20Initiative

297 http://www.celebratedouglascounty.com/view/departments/view_dept/&cdept=282&department=Development%20Services

298 http://www.celebratedouglascounty.com/view/global/viewdownload/&docid=3388&file=/Green_Community_Ordinance_11-3-09.pdf

299 http://www.celebratedouglascounty.com/view/global/viewdownload/&docid=3837&file=/2011Budget.pdf

300 http://times-georgian.com/view/full_story/6480135/article-Courthouse-chosen-Government-Building-of-the-Year

301 http://www.coopercarry.com/awards/

DOUGLAS COUNTY, GEORGIA

> ***"Ultimately, the Atlanta Regional Commission's Green Communities Program served as a guide for Douglas County's environmental initiatives."***

> ***"Douglas County approaches sustainability with a limited scope. Their initiatives specifically limit the financial burdens; they seek to improve projects that are already required, such as purchasing Energy Star appliances or building more efficient buildings, and they do not use additional staffing to implement these changes."***

plication and relying on economically sustainable measures, Douglas County has achieved Bronze Green Community status. Its green buildings approach matches the government's overall goal of "smart growth".

Lessons Learned

Douglas County approaches sustainability with a limited scope. Their initiatives specifically limit the financial burdens; they seek to improve projects that are already required, such as purchasing Energy Star appliances or building more efficient buildings, and they do not use additional staffing to implement these changes. By taking a small, economically conservative approach to environmental sustainability, Douglas County's initiatives avoid controversy while promoting the government's vision of smart growth.

Other Initiatives

The County's Green Community Ordinance's impose a requirement of a ratio of 20 acres of greenspace per 1000 county residents. Another section of the ordinance guides the County's policy toward its vehicle fleet's size and makeup. Finally, it outlines green purchasing policies and a recycled product listing for the county government to follow.[302]

The Green Community Ordinance also guides county employees' energy efficiency policy. It requires them to turn off all lights and non-essential electronic equipment at the end of each work day, to consolidate public meetings when there are "less than four non-emergency, non-time sensitive items for vote on a regularly scheduled meeting agenda," and to install energy efficient light bulbs when bulbs are replaced in government buildings.[303]

The local government has also adopted a Bike and Pedestrian Plan to encourage alternative transportation friendly policies. The Plan was adopted as a part of the Green Community application.[304] Douglas County also offers nontraditional recycling facilities to deal with such waste as pesticides, herbicides, electronics, batteries, cell phones, and compact florescent light bulbs.[305]

Douglas County encourages mixed-use private development by offering Community Smart Growth Incentives / Bonuses. Specifically, increased density bonuses are awarded to developers for projects that incorporate mixed-use design principles as specified in Section 507, Article 5 of Douglas County's Unified Development Code.[306]

Since 2004, Douglas County has adopted shared parking requirements; a green fleet policy for all newly purchased county vehicles, and a no-idling policy for government vehicles.

A Community Water Supply/Conservation Management Plan[307] was also developed to help Douglas County's Green Communities application and their long term environmental sustainability.

http://www.celebratedouglascounty.com/view/global/viewdownload/&docid=3374&file=/37_Government_No-Idling_Policy.pdf

http://www.celebratedouglascounty.com/view/global/viewdownload/&docid=3370&file=/23_24_25_Water_Use_Reduction_and_Efficiency.pdf

302 Ibid.

303 Ibid.

304 http://www.celebratedouglascounty.com/view/global/viewdownload/&docid=3379&file=/44_Community_Bike-Pedestrian_Plan.pdf

305 http://www.celebratedouglascounty.com/view/global/viewdownload/&docid=3385&file=/51_Community_Nontraditional_Recycling_Facilities.pdf

306 http://www.celebratedouglascounty.com/view/global/viewdownload/&docid=3386&file=/56_Community_Smart_Growth_Incentives.pdf

307 http://www.celebratedouglascounty.com/view/global/viewdownload/&docid=3370&file=/23_24_25_Water_Use_Reduction_and_Efficiency.pdf

North Charleston, South Carolina

OAK TERRACE PRESERVE GREEN BUILDING PROGRAM

By Amble Johnson

Background and Description

Oak Terrace Preserve is a residential community located in the City of North Charleston, South Carolina. This development is an innovative example of a public/private partnership fostering the construction of green buildings. North Charleston's city government purchased the land with the goal of bringing environmental sustainability and economic stimulation to a blighted neighborhood.[414] Oak Terrace Preserve developers follow EarthCraft homebuilding guidelines.[415] When completed, Oak Terrace Preserve will house 374 families in single-family homes and townhouses in its 55-acre location.[416] Currently, approximately 100 homes are occupied, and under the current real estate market conditions, Oak Terrace Preserve anticipates constructing and selling the rest of the homes over the next three or four years.[417]

Adherence to environmentally sustainable practices is an important qualifier for the homebuilders that Oak Terrace Preserve uses. The City pre-qualified four home builders that property owners can select to build homes in the subdivision. The builders are Carriage Hill Associates of Charleston, Crescent Homes, Pulte Homes, and the Verdi Group. All four are based in North Charleston or Charleston. Furthermore, while the developers follow strict sustainability guidelines for each home, they used custom and standardized floor plans. Each new house is individually designed in order to encourage a more aesthetically pleasing neighborhood.[418] Also, this approach allows for private homebuilders to tailor their construction to clients' wishes while assuring the government of the ecological benefits of the project. In ensuring the environmental sustainability of Oak Terrace Preserve homes, North Charleston left much leeway to

Street scenes in Oak Terrace Preserve. Photo credits Southeast Watershed Forum.

"This development is an innovative example of a public/private partnership fostering the construction of green buildings."

"Adherence to environmentally sustainable practices is an important qualifier for the homebuilders that Oak Terrace Preserve uses. The City pre-qualified four home builders that property owners can select to build homes in the subdivision."

414 Home Depot Foundation Case Study of North Charleston, 2009; http://www.homedepotfoundation.org/assets/files/aoe_scd09_sc.pdf.

415 Oak Terrace Preserve; http://www.oakterracepreservesc.com/homes/earthcraft.html

416 An interactive map of the property is available here: http://www.oakterracepreservesc.com/location/interactive_area_map.html.

417 Interview with Keith West, Public Relations for Oak Terrace Preserve.

418 Oak Terrace Preserve; http://www.oakterracepreservesc.com/homes/our_builders.html

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"The only specific requirements builders faced were to follow EarthCraft® building standards and to preserve the site's oak trees."

"A number of manufacturers have been involved in implementing sustainable products and practices in the neighborhood, including the use of recycled materials for construction, no-VOC carpets, energy-saving lighting, and water-saving toilets."

"The use of green building standards yields some market advantages for Oak Terrace Preserve as homebuyers look to engage in environmental sustainability while not sacrificing the convenient proximity to North Charleston and Charleston."

Sustainable technologies like the pervious paving above blend with old oak trees in this green development. Photo credits Southeast Watershed Forum.

developers. In selecting builders, it searched for those with a broad commitment to sustainability. The only specific requirements builders faced were to follow EarthCraft® building standards and to preserve the site's oak trees.[419]

Another example of public-private cooperation in Oak Terrace Preserve is its partnership with private manufacturers. In the early 2000s, The Noisette Urban Alliance identified specifications for sustainable products in building sustainable homes. As the project evolved, a number of manufacturers have been involved in implementing sustainable products and practices in the neighborhood, including the use of recycled materials for construction, no-VOC carpets, energy-saving lighting, and water-saving toilets.

While the national real estate market is largely depressed, home sales in the Charleston area are rebounding, sparked by retirees from the Southeast and the burgeoning technology and aerospace prospects of Boeing. The use of green building standards yields some market advantages for Oak Terrace Preserve as homebuyers look to engage in environmental sustainability while not sacrificing the convenient proximity to North Charleston and Charleston.

Program Inception and Development

Originally, Oak Terrace Preserve was a part of a much larger project conceived in conjunction with the Noisette Company that was generally known as "Noisette". The goal of the Noisette Project was to revitalize North Charleston—its education, residences, economy, and ecology—through a large scale redevelopment of 3,000 acres centered on the redevelopment

419 Home Depot Foundation Case Study of North Charleston, 2009; http://www.homedepotfoundation.org/assets/files/aoe_scd09_sc.pdf

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of the City's abandoned naval yard. The company held community meetings and newsletter communications to gauge the needs of North Charleston residents and businesses.[420] Within this broad framework, Oak Terrace Preserve defined its mission as establishing a residential area with close proximity to businesses, schools, and recreation that nevertheless restores "the natural balance of nature that has been compromised by standard development practices."[421]

Oak Terrace Preserve comprises 55 acres of the 3,000 acres that the City, Noisette and other investors planned to redevelop. The City of North Charleston purchased the 55 acres that was originally used to house World War II-era naval shipyard workers. Cedrus Development, LLC is now the project manager responsible for the development of the Oak Terrace Preserve community.[422]

While both the Noisette Company and Cedrus Development are private entities, North Charleston's mayor's office and the City Council were both involved in development of the program and in defining its scope over the last ten years, and they continue to be involved in promoting the development.[423] The City Council deems completion and support of Oak Terrace Preserve one of the top priorities of the city's revitalization. The City of North Charleston recognizes Oak Terrace Preserve as a distinguishing feature for its community, and it strives to support the sustainable residential development as a catalyst for the revitalization of Park Circle.

Funding

Oak Terrace Preserve is a public-private project. The original master plan, incorporated into the city's Comprehensive Plan for redevelopment, initially estimated an aggregate $1 billion in public and private investment throughout the 3,000-acre area over a 15-year period. While private construction and real estate companies market Oak Terrace Preserve, the city remains the landowner, and is responsible for infrastructure costs and the purchase of the development's 55 acres.

For its community revitalization needs, the City of North Charleston has utilized South Carolina General Assembly-approved Tax Increment Financing (TIF) districts, located both on and off the former naval base, for its ongoing infrastructure needs.

Bioswales enhance water infiltration into the soil, reducing runoff. Photo credits Southeast Watershed Forum.

> **"Oak Terrace Preserve inspired the development of nearby green neighborhoods like Mixson and Hunley Waters, and the sustainable retrofitting of existing homes throughout Park Circle."**

420 Noisette Master Plan, Chapter 1: Vision; http://www.noisettesc.com/masterplan.html.

421 Oak Terrace Preserve FAQs, 1

422 See Oak Terrace Preserve Press Release dated March 8, 2010; available at: http://blog.oakterracepreservesc.com/wp-content/uploads/2010/03/OTP-NewsRelease-CedrusContract.pdf

423 http://www.postandcourier.com/news/2011/mar/22/noisette-at-10-years/

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Basically, TIF is a method to use future gains in taxes to finance current improvements, which, in theory, will create conditions for those future gains. When public projects are built, there are often gains in the value of surrounding properties, thus luring investment – consequently, the increased site value and investment generates new tax values for the municipal government of the city.

A major objective of the city's revitalization was developing new infill neighborhoods in Historic Park Circle, which had not witnessed new home construction on this scale for more than 50 years. Thus, the TIF investment in Oak Terrace Preserve is deemed a breakthrough, as young families are now moving back to Park Circle.

Before the revitalization of Park Circle, Park Circle neighborhoods did not generate enough tax revenue to support the services they received, including fire and police protection.

Current estimates indicate that Oak Terrace Preserve, upon final build out to 374 homes will generate a new tax base of $75 million in city and county collections (based on an average value of $200,000 per unit cost X 374 units) in a once heavily blighted area.

Oak Terrace Preserve inspired the development of nearby green neighborhoods like Mixson and Hunley Waters, and the sustainable retrofitting of existing homes throughout Park Circle.

The Home Depot Foundation estimated Oak Terrace Preserve's costs at $13.4 million for the first phase of the development, $4.7 million of which was made up by land costs.[424]

Results

In the early stage of the revitalization, political division surfaced in North Charleston over the role of government in community development, and there was some dissension over the city's role in residential development. After the completion of Phase One for 100-plus homes, Oak Terrace Preserve is popularly viewed as a source of pride for North Charleston residents. Recognitions for the development include honors from *Cottage Living Magazine*, *Green Builder Magazine*, and *Men's Journal*, as well as the reader-voted "Best New Development" by local *Charleston City Paper*.[425] Those involved in Oak Terrace are most proud of North Charleston's 2009 recognition by the Home Depot Foundation for the prestigious "Award of Excellence for Sustainable Community Development".[426] In its award, the Foundation cites Oak Terrace Preserve first in its section "Successful Implementation of Plan" for exemplifying intelligent planning in the areas of "Housing, Natural Resources, Land Use & Development, and other categories."[427]

> **"In its award, the Foundation cites Oak Terrace Preserve first in its section 'Successful Implementation of Plan' for exemplifying intelligent planning in the areas of 'Housing, Natural Resources, Land Use & Development, and other categories.'"**

The City was awarded the National League of Cities Award for Municipal Excellence in late 2010, which was partially attributed to the implementation of the sustainable Oak Terrace Preserve project. In 2011, Oak Terrace Preserve was named a global finalist in Project Award Category for The International Awards for Livable Communities, a United Nations-supported sustainability initiative. (See www.northcharleston.org)

Currently, about 100 of the anticipated 374 family housing units are occupied, despite the generally depressed market for new homes.[428] The average home price is $219,000. The area is a big draw for its proximity to good schools and North Charleston and Charleston resources.[429] In 2005, the North Charleston Elementary School, another component of the City's original vision, opened as the South Carolina's first LEED-certified elementary school. *Newsweek* rated the Charleston County Academic Magnet High School (which also has an environmentally sustainable campus) as one of the top **15** public high schools.[430] Some credit North Charleston's "long view" toward

424 Home Depot Foundation Case Study of North Charleston, 2009; http://www.homedepotfoundation.org/assets/files/aoe_scd09_sc.pdf.

425 http://www.oakterracepreservesc.com/news/

426 Interview with Keith West, Public Relations for Oak Terrace Preserve

427 Home Depot Foundation Case Study of North Charleston, 2009; http://www.homedepotfoundation.org/assets/files/aoe_scd09_sc.pdf

428 Interview with Keith West, Public Relations for Oak Terrace Preserve

429 Home Depot Foundation Case Study of North Charleston, 2009; http://www.homedepotfoundation.org/assets/files/aoe_scd09_sc.pdf

430 "America's Best High Schools," Newsweek, May 27, 2007.

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sustainable community development—reflected in initiatives like Oak Terrace Preserve and school improvement—with attracting developments such as the Boeing assembly plant and Clemson University Restoration Institute that have recently located in the area.[431]

Lessons Learned

While the development is broadly seen as having a positive impact on North Charleston, it has faced challenges. For example, the original residences at Century Oaks were unfit for habitation, and largely abandoned. The neighborhood faced major problems with obsolete housing and infrastructure in the former Century Oaks, dating back to World War II-era housing which had a projected ten year lifespan. In order for Oak Terrace Preserve to be built, the dilapidated housing of its predecessor, Century Oaks, had to be removed, so North Charleston provided consultation and financial help to relocating residents. In attracting new residents with improved schools, infrastructure, and housing, the city government assured that resources are available for current residents' use. City ordinances have evolved to better foster Oak Terrace Preserve's vision, and new, innovative amenities were added, like the stormwater management system. These steps include adjusting zoning requirements to allow for the setbacks that preserved Oak Terrace Preserve's oak trees.[432]

More broadly, the challenges and success of Oak Terrace Preserve and the Noisette Company offer lessons for broad urban revitalization efforts. The company's efforts were assisted by public involvement and focus on specific initiatives, but they were hampered by ambitious scope and turmoil in national financial and housing markets by 2008.

Other Initiatives

In addition to requiring homes constructed according to Earth Craft guidelines, Oak Terrace Preserve utilizes a number of other low impact development (LID) practices to minimize the environmental impact of the neighborhood. One significant practice is the inclusion of advanced environmental stormwater treatment systems such as using rain garden, bioswales, road side infiltration areas, pervious pavers, and forebays that are interconnected with perforated piping to continually promote infiltration and retention of stormwater on site, while also preventing flooding of adjacent properties.[433] Pervious walkways and on-site rainwater harvesting techniques, such as rain barrels or cisterns, are used throughout the community, but these are not connected to the piped network though they contribute to reducing the speed and volume of stormwater leaving the site.[434] Oak Terrace Preserve has been a leader in implementing stormwater best management practices, and it has been held up as a model for other communities. The development's LID stormwater practices serve as the basis for a guide published by the South Carolina Department of Natural Resources and a number of environmental organizations to instruct other home owner associations in the implementation and maintenance of LID stormwater infrastructure.[435]

Additionally, public frontage tightly follows set standards. Oak Terrace Preserve mandates the number of ornamental shrubs, canopy trees, and under story trees per 100 lineal feet of frontage, based on which of two types that the buffer area fits.[436]

Oak Terrace Preserve also allocates certain areas as "Pocket Parks" which ensure preservation of the area's trees and provide passive recreation. A "Pedestrian Green Way" ensures public access between "Public Parks". And "Community Links"

> *"Oak Terrace Preserve utilizes a number of other low impact development (LID) practices to minimize the environmental impact of the neighborhood. One significant practice is the inclusion of advanced environmental stormwater treatment systems such as using rain garden, bioswales, road side infiltration areas, pervious pavers, and forebays."*

431 Interview with Keith West, Public Relations for Oak Terrace Preserve

432 Home Depot Foundation Case Study of North Charleston, 2009, http://www.homedepotfoundation.org/assets/files/aoe_scd09_sc.pdf.

433 "Beyond Pipe and Pond: Oak Terrace Preserve Case Study." Clemson Coastal Research and Education Center; August 6, 2010; power point presentation available at: http://www.dnr.sc.gov/marine/NERR/present/pipepond/DeebHorton_OakTerracePreserve.pdf

434 "Low Impact Development: Stormwater Series," S.C. Sea Grant Consortium, available at: http://www.scseagrant.org/pdf_files/lid_final_brochure.pdf. This brochure also contains helpful descriptions and illustrations of some of the stormwater management practices implemented at Oak Terrace Preserve.

435 "Maintenance of Low Impact Development (LID) Stormwater Practices: Guidance for Homeowners Associations Based on Oak Terrace Preserve in North Charleston, SC," available at: http://www.dnr.sc.gov/marine/NERR/pdf/LIDMaintenanceBrochure.pdf

436 "Oak Terrace Preserve City of North Charleston Final Application for Planned Development District (PDD)", March 2005

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serve to connect the community as a whole. This includes greenways, bike trails, and other passages, and may follow natural or man-made corridors. All of these open space features contribute to the stormwater management, plant preservation, and natural aesthetic of Oak Terrace Preserve.[437] Stormwater management and local species preservation are major focal points of landscaping rules. Impervious pavement is limited to 10% of a lot's surface area, and non-native turf is limited to 20%. The rest of the yard should be native plants of varying species, although they may be arranged formally by the owner. Permanent irrigation is permitted, and is encouraged to link with graywater or rainwater collection systems.[438]

Oak Terrace Preserve's LID practices also focus on lighting for outdoor spaces. To reduce development impact on natural environments, and to minimize light trespass and improve night sky access, Oak Terrace Preserve's builders are encouraged to follow lighting guidelines outlined in the IESNA Recommended Practice Manual: Lighting for Exterior Environments (IESNA RP-33-99).

These LID practices support Oak Terrace Preserve's overall goal of environmentally aware housing and community design. Such a comprehensive approach to green living also distinguishes Oak Terrace Preserve to homebuyers.

> ***"Oak Terrace Preserve also allocates certain areas as "Pocket Parks" which ensure preservation of the area's trees and provide passive recreation."***

A pocket park at Oak Terrace Preserve provides a scenic stop where neighbors can meet. Photo credits Southeast Watershed Forum.

437 Ibid.

438 *Id.*

CH. 3—STORMWATER MANAGEMENT

Contents

CH. 3—STORMWATER MANAGEMENT

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- ***Stormwater Management Guidelines for Coastal Georgia***
- ***Practice Design Profiles***
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- ***Regulatory Permitting Information & Contacts Information***
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Introduction

The previous chapter presented green infrastructure-based planning and design techniques that provide better natural resource protection during the site development process. In this chapter, the GI concept is integrated into the management of *post-construction* stormwater runoff.

Stormwater has been identified as a major contributing factor to nonpoint source pollution for receiving streams and waterbodies within Georgia. With development and urbanization comes a myriad of land-altering activities which ultimately affect the way water moves through the natural hydrological cycle. The main activities affecting water quality include the addition of impervious surfaces, soil compaction and erosion, tree removal and man-made hydrological alterations (flood relief/erosion control structures).

As the natural processes of interception, evapotranspiration, and infiltration are altered and precipitation is converted to overland flow, these modifications affect not only the characteristics of the developed site but also the watershed in which the development is located. Receiving streams are significantly affected by the quantity and quality of stormwater runoff. Rainfall landing on impervious areas picks up pollutants and transports them to receiving streams and other water bodies. Runoff leaving the site at higher rates and larger amounts changes the channel profile—by scouring or filling the stream bed and eroding the banks which in turn drastically changes aquatic habitat. With an additional pollutant load, lower dissolved oxygen, and elevated water temperatures, habitat degradation is amplified. Also, since more water runs off the site sooner, there is less water percolating through the system to support base flows in the stream, creating another challenge for aquatic species.

With all of these impacts in mind, Green Infrastructure seeks to reduce runoff rates, volumes and pollutant loads through the use of a multifunctional approach—Better Site Planning, Better Site Design and Low Impact Development (LID).

In combination, this strategy takes a different approach to stormwater management as compared with conventional strategies. Conventional methods aim to convey water off-site and into the municipal storm system as quickly as possible, while GI Stormwater techniques seek to do just the opposite— either reduce the runoff or keep as much water on-site as possible for absorption and infiltration at or near the actual rainfall site. Instead of large, centralized treatment plants and water storage facilities, LID emphasizes local, distributed solutions that capitalize on the beneficial services that natural ecosystem functions provide.

Green Infrastructure stormwater practices can be both a cost-effective and an environmentally-preferable alternative to conventional hard engineering solutions. GI promotes infiltration, evapotranspiration, and re-use of stormwater rather than traditional hardscape collection, conveyance, and storage structures. It is most effective when supplemented with other decentralized storage or infiltration approaches, such as the use of permeable pavement, rain barrels, and cisterns to capture and re-use rainfall for landscape irrigation or flushing toilets. This approach reduces both the amount of stormwater entering municipal sewer systems and the amount of untreated stormwater discharging to surface waters. GI, using LID practices, facilitates or mimics natural processes that recharge groundwater, preserve baseflows, provide wildlife habitat, and protect surface water quality conditions.

The overall goal of GI is to protect the natural systems that provide us with free ecosystem goods and services. This translates into a reduction of municipal systems which means less construction and maintenance costs for the local government and its residents over time.

Stormwater Management Guidance for Coastal Georgia

High water tables, mildly-sloping to flat topography, large tidal ranges, and unique terrestrial and marine habitats present additional challenges to site development in the coastal region of Georgia. For these reasons, G3 provides stormwater management criteria and low impact development practices that have been adapted to these unique regional characteristics.

For the most part, the stormwater management criteria and practices included in this chapter are derived from the 2001 Georgia Stormwater Management Manuals (GSWMM), commonly referred to as the "Blue Books" and its Coastal Stormwater Supplement (CSS), published in 2009. With extensive public and private stakeholder input and collaboration, the technical references were developed by the Chatham County-Savannah Metropolitan Planning Commission utilizing the technical expertise of the Center for Watershed Protection and the Georgia Department of Natural Resources. Both references can be found at www.stormwater.com. Refer to the CSS directly for specific design specifications for stormwater management practices contained in this chapter.

The CSS adds to the multitude of information found in the GSMM by providing specific guidance for Georgia's coastal communities. The CSS was designed as the next generation of stormwater management, shifting the focus of coastal Georgia's post-construction stormwater management efforts to prevention, rather than mitigation of the negative impacts of the land development process. Runoff reduction strategies are detailed as an approach to manage stormwater. Coastal High Priority Plant and Animal Species and Habitat Areas are provided and integrated from the State's Comprehensive Wildlife Action Strategy. See Appendix C and D for a complete listing. Additional information includes a Rainfall Analysis, a Coastal Stormwater BMP Monitoring Protocol, a model local government ordinance for Coastal Georgia, and guidance for coastal local governments on establishing a stormwater financing mechanism. A user-friendly excel worksheet to calculate BMP credits is also provided as a tool to ensure a project's consistency with the Coastal Stormwater Supplement. The CSS provides Georgia's coastal communities with comprehensive guidance on an integrated, green infrastructure-based approach to natural resource protection, stormwater management and site design that can be used to advance protection of coastal Georgia's unique and vital natural resources as the region grows and develops.

The following stormwater management guidance, consistent with the Coastal Stormwater Supplement, has been designed to help developers comply with the requirements of various state and federal environmental policies, programs, and regulations including the National Pollution Discharge Elimination System (NPDES) Municipal Stormwater Program and Georgia's Coastal Nonpoint Source Pollution Control Program, created through the Coastal Zone Act Reauthorization Amendments (CZARA) of 1990.

Using the GI Approach, better site planning and design techniques are implemented early on in the development process which reduces post-construction stormwater runoff rates, volumes, and pollutant loads to the greatest extent possible. Then, low impact development practices are distributed across the development site. If the stormwater management criteria cannot be met solely through the use of green infrastructure practices, general stormwater management practices are applied to further manage post-construction stormwater runoff rates, volumes and pollutant loads.

Adapted from Stormwater Management Concept Plan Decision Tree. Source: Center for Watershed Protection

Stormwater Management Criteria

The Coastal Stormwater Supplement (CSS) contains stormwater management practices that have been assigned quantifiable value or "credit" that can be used to address the stormwater management criteria. The Table in Appendix E shows how each practice can meet the requirements for the following criteria:

1. **Stormwater Runoff Reduction**

   Reducing stormwater runoff volumes helps maintain pre-development site hydrology and helps to protect coastal Georgia's aquatic resources from several indirect impacts of the land development process (i.e., decreased groundwater recharge, decreased surface water baseflow and degraded water quality).

   This stormwater management (SWM) criteria can be met by reducing stormwater runoff volume generated by the 85th percentile storm event (and the "first flush" of the stormwater runoff volume generated by all larger storm events) on a development site through the use of appropriate Green Infrastructure practices. This equates to reducing the stormwater runoff volume generated by the 1.2 inch rainfall event (and the stormwater runoff generated by the first 1.2 inches of all larger rainfall events).

2. **Stormwater Quality Protection**

   Adequately treating stormwater runoff before it's discharged from a development site helps to protect coastal Georgia's aquatic resources from water quality pollution. To the greatest extent possible, apply SWM criteria #1. If any of the stormwater generated by the 1.2 inch storm event (and the first 1.2 inches of all larger rainfall events) cannot be r*educed* on a development site due to site characteristics or constraints, it should be *intercepted and treated* in one or more stormwater management practices that: (1) provides for at least an 80 percent reduction in TSS loads; and (2) reduces nitrogen and bacteria loads to the *maximum extent practical*.

3. Aquatic Resource Protection

Valuable aquatic resources can be protected from negative impacts of land development processes (e.g., complete loss or destruction, stream channel enlargement, increased salinity fluctuations) by:

- implementing better site planning techniques,
- establishing effective aquatic buffers (minimum 25-foot wide aquatic buffer, 100-foot wide aquatic buffer is preferred),
- providing 24 hours of extended detention for the stormwater runoff volume generated by the 1-year, 24-hour storm event before it is discharged from a development site, and
- providing velocity control and energy dissipation measures at all new and existing stormwater outfalls.

4. Overbank Flood Protection

This stormwater management criteria can be satisfied by controlling (attenuating) the post-development peak discharge generated by the 25-year, 24-hour storm event helps prevent an increase in the duration, frequency and magnitude of damaging overbank flooding.

5. Extreme Flood Protection

Control (attenuate) the peak discharge generated by the 100-year, 24-hour storm event to help prevent an increase in the duration, frequency and magnitude of dangerous extreme flooding. Stormwater credit can be obtained by controlling (attenuating) the peak discharge generated by the 100-year, 24-hour storm event under post-development conditions.

6. Increased Stormwater Reduction

Stormwater runoff should be reduced on development sites within ½ mile of shellfish harvesting areas to better protect these sensitive natural resources from contamination and closure.

7. Enhanced Aquatic Resource Protection

Wider aquatic buffers around all aquatic resources located within a ½ mile of shellfish harvesting areas helps better protect these sensitive natural resources from contamination and closure.

Evaluating Overall Feasibility

Site planning and design teams can evaluate the overall feasibility of applying each of the stormwater practices on a development site. The following table shows the factors to consider when selecting an appropriate stormwater practice for an individual site:

Drainage Area: Describes how large of a contributing drainage area each practice can realistically handle. It indicates the maximum size of the contributing drainage area that each practice should be designed to receive stormwater runoff.

Area Required: Indicates how much space each practice typically consumes on a development site.

Slope: Describes the influence that site slope can have on the performance of each practice. It indicates the minimum or maximum slope recommended for installation.

Minimum Head: An estimate of the minimum amount of elevation difference needed within the stormwater practice, from the inflow to the outflow, to allow for gravity operation.

Minimum Depth to Water Table: Indicates the minimum distance that should be provided between the bottom of the each practice and the top of the water table.

Soils: Describes the influence that the underlying soils (i.e., hydrologic soil groups) can have on the performance of the each practice.

Factors to Consider When Evaluating the Overall Feasibility of Green Infrastructure Practices (Source: Georgia Stormwater Management Manuals, Coastal Stormwater Supplement, CWP/MPC, 2009.)

Green Infrastructure Practice	Drainage Area	Area Required	Slope	Minimum Head	Minimum Depth to Water Table	Soils
Low Impact Development Practices						
Alternatives to Disturbed Pervious Surfaces						
Soil Restoration	N/A	No restrictions	10% maximum	N/A	1.5 FT	Restore hydrologic soil group C/D or disturbed soils

Factors to Consider When Evaluating the Overall Feasibility of Green Infrastructure Practices (Source: Georgia Stormwater Management Manuals, Coastal Stormwater Supplement, CWP/MPC, 2009.)						
Green Infrastructure Practice	**Drainage Area**	**Area Required**	**Slope**	**Minimum Head**	**Minimum Depth to Water Table**	**Soils**
Site Reforestation/ Revegetation	N/A	10,000 SF minimum to receive stormwater management "credits"	25% maximum	N/A	No restrictions	No restrictions
Alternatives to Impervious Surfaces						
Green Roofs	N/A	No restrictions	25% maximum, although 10% or less is recommended	6 to 12 inches	N/A	Use appropriate engineered growing media
Permeable Pavement	N/A	No restrictions	6%	2 to 4 feet	2 feet	Should drain within 48 hours of end of rainfall event
"Receiving" Low Impact Development Practices						
Undisturbed Pervious Areas	Length of flow path in contributing drainage area maximum 75 to 150 feet long	Length of flow path in undisturbed pervious area minimum 50 feet long	Maximum 3% in contributing drainage area; 0.5% to 6% in undisturbed pervious area	N/A	No restrictions	No restrictions

Factors to Consider When Evaluating the Overall Feasibility of Green Infrastructure Practices (Source: Georgia Stormwater Management Manuals, Coastal Stormwater Supplement, CWP/MPC, 2009.)						
Green Infrastructure Practice	**Drainage Area**	**Area Required**	**Slope**	**Minimum Head**	**Minimum Depth to Water Table**	**Soils**
Vegetated Filter Strips	Length of flow path in contributing drainage area maximum 75 to 150 feet long	Length of flow path in vegetated filter strip minimum 15 to 25 feet long	Maximum 3% in contributing drainage area; 0.5% to 6% in vegetated filter strip	N/A	No restrictions	No restrictions
Grass Channels	5 acres	Bottom of grass channel 2 to 8 feet wide; side slopes of 3:1 or flatter	0.5% to 3%, although 1% to 2% is recommended	N/A	2 feet	No restrictions
Simple Downspout Disconnection	2,500 square feet; length of flow path in contributing drainage area maximum 75 feet long	Length of flow path at least 15 feet long and equal to or greater than that of contributing drainage area	0.5% to 6%, although 1% to 5% is recommended	N/A	No restrictions	No restrictions
Rain Gardens	2,500 square feet; length of flow path in contributing drainage area maximum 75 to 150 feet long	10-20% of contributing drainage area	6%	30 to 36 inches[1]	2 feet	Should drain within 24 hours of end of rainfall event

Factors to Consider When Evaluating the Overall Feasibility of Green Infrastructure Practices (Source: Georgia Stormwater Management Manuals, Coastal Stormwater Supplement, CWP/MPC, 2009.)						
Green Infrastructure Practice	**Drainage Area**	**Area Required**	**Slope**	**Minimum Head**	**Minimum Depth to Water Table**	**Soils**
Stormwater Planters	2,500 square feet; length of flow path in contributing drainage area maximum 75 to 150 feet long	5% of contributing drainage area	6%	30 to 36 inches[1]	2 feet[1]	Should drain within 24 hours of end of rainfall event
Dry Wells	2,500 square feet; length of flow path in contributing drainage area maximum 75 to 150 feet long	5-10% of contributing drainage area	6%	2 feet[1]	2 feet	Should drain within 24 hours of end of rainfall event
Rainwater Harvesting	No restrictions	Varies according to the dimensions of the rain tank or cistern used to store the harvested rainwater	No restrictions	N/A	N/A	N/A
Bioretention Areas	5 acres	5-10% of contributing drainage area	6%	42 to 48 inches[1]	2 feet	Should drain within 48 hours of end of rainfall event

Factors to Consider When Evaluating the Overall Feasibility of Green Infrastructure Practices (Source: Georgia Stormwater Management Manuals, Coastal Stormwater Supplement, CWP/MPC, 2009.)						
Green Infrastructure Practice	**Drainage Area**	**Area Required**	**Slope**	**Minimum Head**	**Minimum Depth to Water Table**	**Soils**
Infiltration Practices	2 to 5 acres	5% of contributing drainage area	6%	42 to 48 inches[1]	2 feet	Should drain within 48 hours of end of rainfall event
Dry Swales	5 acres	5-10% of contributing drainage area	0.5% to 4%, although 1% to 2% is recommended	36 to 48 inches[1]	2 feet	Should drain within 48 hours of end of rainfall event

Site Applicability

Site planning and design teams should evaluate the applicability of each of the practices on a particular development site. The following table shows important factors to consider when evaluating the applicability of each practice:

Rural Use: Indicates whether or not the practice is suitable for use in rural areas and on low-density development sites.

Suburban Use: Indicates whether or not the practice is suitable for use in suburban areas and on medium-density development sites.

Urban Use: Identifies the practices that are suitable for use in urban and ultra-urban areas where space is at a premium.

Construction Cost: Assesses the relative construction cost of each of the practices.

Maintenance: Assesses the relative maintenance burden associated with each practice. It is important to note that nearly *all* stormwater practices require some kind of routine inspection and maintenance.

Factors to Consider When Evaluating the Applicability of Stormwater Management Practices on a Development Site (Source: Georgia Stormwater Management Manual, Coastal Stormwater Supplement, CWP/MPC, 2009.)

SW Practice	Rural Use	Suburban Use	Urban Use	Construction Cost	Maintenance
Stormwater Ponds	✓	✓		Low	Low
Stormwater Wetlands	✓	✓		Low	Medium
Bioretention Areas	✓	✓	✓	Medium	Medium
Filtration Practices	✱	✓	✓	High	High
Infiltration Practices	✓	✓	✓	Medium	High
Dry Swales	✓	✓	✱	Medium	Medium
Wet Swales	✓	✓	✱	Medium	Medium

Notes: ✓ = Suitable for use on development sites located in these areas. ✱ = Under certain situations, can be used on development sites located in these areas.

Stormwater Management Practices

Green Infrastructure (GI) and Low Impact Development (LID) comprises a set of small-scale, non-structural stormwater management practices that promote the use of natural or engineered systems for infiltration, evapotranspiration, and reuse of rainwater. These practices are designed to replicate pre-development site hydrology by integrating green space, native landscaping and natural hydrologic functions that function to reduce runoff volumes and rates, and capture and treat runoff from developed land. When installed and maintained correctly, these practices are quite adept at removing nutrients, pathogens, and metals from stormwater, as well as reducing the volume and intensity of stormwater flows.

This section contains stormwater practice profiles for GI and LID-based practices as well as general application structural controls. First, GI practices should be applied to reduce runoff volumes and rates to the greatest extent possible. Then, the remaining runoff should be captured and treated using LID practices. Finally, general application structural controls can be applied if needed. Design Profiles showing how to properly apply and design these practices on coastal development sites are provided for the following practices:

Green Infrastructure Practices

- Soil Restoration
- Site Reforestation/Revegetation
- Green Roofs
- Permeable Pavement

Low Impact Development Practices

- Undisturbed Pervious Areas
- Vegetated Filter Strips
- Grass Channels
- Simple Downspout Disconnection
- Rain Gardens
- Stormwater Planters
- Dry Wells
- Rainwater Harvesting
- Bioretention Areas
- Infiltration Practices
- Dry Swales

General Application Structural Stormwater Controls

- Stormwater Ponds
- Stomwater Wetlands
- Filtration Practices

Stormwater Management System Design Checklist

Green Growth Guidelines	√	Comments/Notes
Stormwater Management System Design		
Review the stormwater management requirements that apply to the development site		
Distribute the following runoff-reducing low impact development practices across the development site:		
• Soil Restoration		
• Site Reforestation/ Revegetation		
• Green Roofs		
• Permeable Pavement		
• Undisturbed Pervious Areas		
• Vegetated Filter Strips		
• Grass Channels		
• Simple Downspout Disconnection		
• Rain Gardens		
• Stormwater Planters		
• Dry Wells		
• Rainwater Harvesting		
• Bioretention Areas		
• Infiltration Practices		

Green Growth Guidelines	√	Comments/Notes
• Dry Swales		
Where feasible, use permeable pavement to construct alleys, parking stalls, walking paths and trails, driveways, sidewalks and light-duty service roads		
Provide vegetated filter strips and depressed landscaped islands in and around parking lots		
Use dry swales and grass channels along roadways and in roadway medians to reduce stormwater runoff rates, volumes and pollutant loads near their source		
Use primary and secondary conservation areas and aquatic buffers to "receive" stormwater runoff and buffer environmentally sensitive areas		
Check to see if the stormwater management requirements that apply to the development site have been satisfied		
If the stormwater management requirements that apply to the development site cannot be satisfied exclusively through the use of better site planning and design techniques and low impact development practices, use the following general application stormwater management practices to further manage stormwater runoff rates, volumes and pollutant loads on the development site:		
• Stormwater Ponds		
• Stormwater Wetlands		
• Bioretention Areas		
• Filtration Practices		

Green Growth Guidelines	√	Comments/Notes
• Infiltration Practices		
• Swales		
Use the following limited application stormwater management practices only when better site planning and design techniques, low impact development and general application stormwater management practices cannot be used to satisfy the the stormwater management requirements that apply to the development site:		
• Dry Detention Basins		
• Dry Extended Detention Basins		
• Multi-Purpose Detention Areas		
• Underground Detention Systems		
• Organic Filters		
• Underground Filters		
• Submerged Gravel Wetlands		
• Gravity (Oil-Grit) Separators		
• Alum Treatment Systems		
• Proprietary Systems		
Check to see if the stormwater management requirements that apply to the development site have been satisfied		

Green Growth Guidelines	√	Comments/Notes
If the stormwater management requirements have not been completely satisfied, go back to the site layout to apply additional low impact development and stormwater management practices to further reduce and manage stormwater runoff rates, volumes and pollutant loads on the development site		

Low Impact Development Local Case Study

Assessment of Stormwater Management in Coastal South Carolina: A Focus on Stormwater Ponds and Low Impact Development (LID) Practices

By Lisa Vandiver[1] and Debra Hernandez[2]
[1]University of South Carolina, Arnold School of Public Health, lisa@inlet.geol.sc.edu
[2]Hernandez & Company, LLC, debra@hernandezandcompany.com

This report addresses strengths and weaknesses of two stormwater management strategies: stormwater ponds and low impact development (LID) practices. It also addresses issues such as water quality, the permitting process, and the design, construction, and maintenance of stormwater-management projects, and measures to improve them. This report is based on 19 interviews of stormwater professionals and the input gathered from 51 workshop attendees. Stormwater professionals include:

- engineers,
- developers,
- contractors,
- landscape architects,
- regulatory staff, and
- land planners.

The workshop, Stormwater Management in Coastal S.C.: A Focus on Stormwater Ponds and Low Impact Development (LID) Practices, was held on January 22, 2009. The workshop identified informational, regulatory, and educational needs of stormwater professionals regarding both traditional and alternative stormwater-management technologies. Previous research and the responses provided by stormwater professionals were analyzed. The purpose of this report is to assist coastal communities and other stakeholders with making decisions regarding the selection and implementation of stormwater-management strategies.

Stormwater management is one way to protect our local waterbodies from the impacts of coastal development. Photo/NOAA-HML

South Carolina Stormwater Management

Southeastern coastal regions have adopted and implemented the use of Best Management Practices (BMPs) as a means of controlling stormwater quantity and quality. Generally, stormwater regulations in South Carolina require stormwater-management systems to retain the first ½ inch of runoff on site or 1 inch of runoff from the built upon area (whichever is greater), maintain pre-development discharge rates, and remove 80 percent of suspended solids during construction (SMSRA, 1991; SCDHEC, 2002; 2003; 2006). The selection and implementation of BMPs in the South Carolina coastal zone must take into consideration regional characteristics such as the flat coastal topography, shallow water tables, and minimal soil storage.

Stormwater Ponds

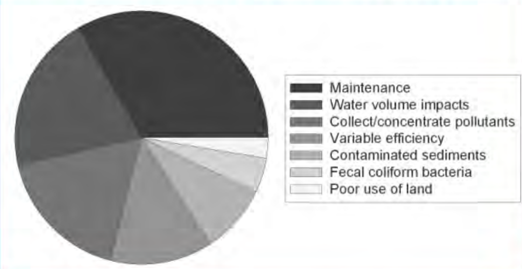
Stormwater ponds were initially designed and implemented to manage localized flooding. But as the impacts of urbanization on adjacent streams and water bodies became better understood, ponds have been required as a mechanism to treat stormwater and protect adjacent water quality (SCDHEC, 2004). Stormwater ponds can be categorized into two general types: 1) detention ponds with a permanent pool of water that is gradually discharged into adjacent water bodies through an overflow structure or 2) retention ponds with a permanent pool of water

1

that is discharged through infiltration and groundwater transport. South Carolina regulations, coupled with regional geography and hydrology, result in stormwater-detention ponds serving as the most commonly used BMP in the South Carolina coastal zone. In 1999, more than 8,000 stormwater ponds were estimated to be located within the eight coastal counties of South Carolina (Siewicki et al., 2007). Interviews with engineers of this region suggest that additional stormwater ponds will be located in the region because of ease of designing, permitting, and constructing them. Ponds also serve a critical role in providing fill material for development within topographically low-lying areas. In addition, ponds can be marketed as an amenity to a development, providing both practical management of stormwater runoff, while also serving as open space and offering recreational opportunities such as fishing, boating, and sometimes even swimming.

Although national research suggests that these ponds are effective in reducing stormwater peak flows and retaining pollutants (Table 1), recent regional research suggests that the efficiency of these ponds may be less than nationally reported (Messersmith, 2007). It is important to note that BMP efficiency is dependent upon several factors, including storm characteristics (rain volume, intensity, and frequency), pond age, pond size, and pond design (length, width, and placement of inlet and outlet) (SCDHEC-OCRM, 2007). In addition to the broad question of regional efficiency of stormwater ponds, other more specific concerns suggest a need to re-evaluate the impact of stormwater ponds on water quality. Since ponds are designed to retain stormwater, they receive high loadings of nutrients, pesticides, chemicals, and fecal coliform (SCDHEC-OCRM, 2007). As a result, the surface waters and sediments of these ponds become compromised and can lead to problems such as harmful algal blooms (HABs) or fish kills within the ponds. These conditions can be expected (given the purpose of the pond) and might not be problematic. But these ponds attract humans and wildlife, and there is often exchange between the pond and adjacent tidal creeks. These conditions can create a health hazard for those exposed to the pollutants (e.g., toxins and pathogens). In addition, these ponds are often neglected and not regularly maintained, which leads to sedimentation, reduction of the storage capacity of the ponds over time, and increased discharge of polluted water to adjacent water bodies (Messersmith, 2007).

Limitations of Stormwater Ponds



Stormwater ponds are designed to collect and concentrate pollutants and can promote algal blooms, such as these found in a pond in Berkeley County, S.C. Photo/SCDHEC-OCRM

Attendees of the workshop said that maintenance is the biggest disadvantage to relying on stormwater ponds (33%). It was noted that pond failure is often not apparent and that many ponds are maintained only for aesthetics. As a result, pond maintenance can be easily overlooked. In many cases, maintenance costs serve as a disincentive to Homeowners Associations (HOAs) to address problems. Therefore, homeowners need to be informed and educated about the importance of maintaining their ponds. Monitoring and enforcement of pond maintenance must be addressed through education and the development of guidelines for local municipalities. Additional disadvantages to relying on stormwater ponds include water-volume impacts of ponds (20%) (e.g., conveying stormwater to one location rather than promoting natural infiltration and groundwater recharge throughout a site), the collection and concentration of pollutants (18%), and variable efficiency of ponds (13%). The attendees were also concerned about sediment contamination (9%), fecal coliform bacteria (4%), and the fact that ponds are a poor solution to small sites and can be seen as a waste of developable land (3%).

The attendees indicated a need to address the concerns associated with ponds and offered solutions, such as retrofitting ponds through the use of other BMPs, tightening pond-design guidelines, or addressing maintenance educational needs. The majority of

Researchers from NOAA's Center for Coastal Environmental Health and Biomolecular Research (CCEHBR) enlisted the assistance of volunteers to plant a vegetated buffer along a stormwater pond on James Island, S.C. Photo/NOAA-CCEHBR

responses suggested that ponds should be used in concert with other BMPs (38%) to minimize the quantity and improve the quality of stormwater leaving a site. One engineer noted that a typical pond in the lowcountry is not capable of achieving the regulatory standards of discharging stormwater over 24 hours due to the low relief and shallow water tables of this area. Therefore, by incorporating ponds as a component of a stormwater management plan, one can benefit from the advantages of ponds while also improving the performance of a stormwater-treatment system of a site. Respondents said that problems related to ponds are primarily due to a lack of maintenance, which if addressed could improve the performance of ponds (27%). Specifically there is a need for better enforcement of maintenance plans and education of the homeowners. Additional options for improving the performance of ponds were suggested, including forebays (15%), better pond design (9%), flow control devices (7%), littoral shelves (3%), and improved design criteria (e.g., design storm event) of ponds (1%).

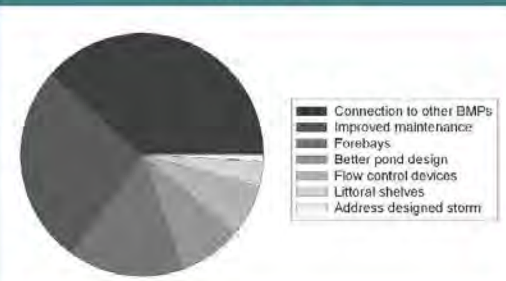
LID Practices

LID strategies integrate the use of site planning (e.g., clustering, reducing impervious cover, and preservation of open space) and alternative stormwater management strategies (e.g., bioretention swales, pervious pavement, and rainwater harvesting) to promote the infiltration and retention of stormwater runoff at the source to foster maintenance of a site's pre-development hydrologic condition (Prince George's County DER, 1999). For the purposes of this report, subsequent use of the term LID practices will refer to the stormwater-management technologies utilized to minimize the impact of development on a site.

LID practices were first implemented in Prince George's County, Maryland, in the 1990s. Since then, there have been a handful of research projects to evaluate the efficiency of these LID practices in reducing stormwater runoff and maintaining pre-development discharge rates. These projects have found that bioretention swales, pervious pavement, surface sand filters, vegetated roof tops, and gravel wetlands are effective at reducing runoff rates and removing selected pollutants (e.g., total suspended sediments [TSS], nutrients, metals, polyaromatic hydrocarbons) from stormwater runoff (EPA, 2000; Hsieh and Davis, 2005; Hunt and Lord, 2006; Roseen et al., 2006; UNH Stormwater Center, 2007; Dietz and Clausen, 2008). LID practices can generally reduce stormwater peak flows and pollutant loads to levels similar to traditional stormwater-management techniques (e.g., detention ponds), suggesting they may be a reasonable alternative to ponds (see Table 1; EPA, 2000, UNH Stormwater Center, 2007; Dietz and Clausen, 2008).

Although there have been several studies that suggest LID practices may be a useful alternative to traditional stormwater management, these studies were conducted in areas outside of

Options to Address Limitations of Stormwater Ponds



The Clemson Extension Carolina Yard constructed at the Charleston Exchange Park incorporates the use of pervious pavers, pervious walkways, a rain barrel, and a rain garden to educate the general public on the site-scale use of LID practices. Photo/USC

the Southeast coastal region and may not apply to regional soils and shallow water tables. Scientists, developers, managers, and engineers are uncertain whether LID systems will be efficient at retaining stormwater volume and pollutants along the southeastern coast where soil storage is generally minimal and rain events are flashy and often intense. The regional geographic and hydrologic limitations of the Southeast coast have also resulted in a suite of perceived and real concerns among the professional stormwater community regarding the use of LIDs. Consequently the prevalence of LID practices is limited along the Southeast coast.

When questioned about the obstacles that may inhibit the regional implementation of LID practices, workshop attendees indicated that the educational needs of stakeholders (27%) and the regulatory process (22%) were the primary obstacles. Attendees suggested that there is a need for education across all sectors including consumers, developers, engineers, and local elected and appointed municipal officials. Most notably there is a need for marketing of LID to promote their implementation. From the regulatory side, the lack of collaboration between the South Carolina Department of Health and Environmental Control (SCDHEC), local municipalities, and intra-governmental departments of those municipalities (e.g., fire, building codes, zoning, and planning) creates initial obstacles when attempting to implement something new and unfamiliar, such as LID practices. The creation of guidelines for the design, permitting, and maintenance of LID practices would assist in the intergovernmental struggles between the state and local municipalities. Attendees also suggested a need for flexibility in federal and state regulations to accommodate regional needs and provide "regulations based on science," rather than their current prescriptive basis. Additional obstacles were identified and included a need for information (e.g., standard models and guidelines) (13%), costs associated with LID (13%), maintenance concerns (12%), regional geographic and hydrologic challenges (7%), and a general resistance to change (5%).

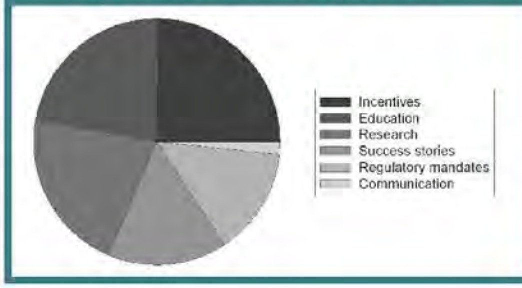
Researchers from Clemson University have recently designed, installed, and are currently studying water retention capacity and performance of bioretention cells at their new Baruch Institute facility in Georgetown, S.C. Photo/Clemson University

Of all potential stakeholders that can influence the implementation of LID practices, attendees suggested that both consumers (33%) and regulatory agencies (28%) would have the greatest impact. It is necessary for the consumers to have initial buy-in to LID practices, and then regulatory backing of those stormwater features would assist in the selection of LID over more traditional stormwater features and improve the permitting process. With support from consumer and regulatory agencies, developers and engineers would more likely select, design, and implement LID practices within their development.

Attendees suggested that the creation of incentives (e.g., bonus density, tax incentive, expedited review, flexibility in enforcement while LIDs are new, and lower impact fees) would offer opportunities to increase the prevalence of LID practices in the region (25%). Specifically, it was suggested that linking LIDs with Leadership in Energy and Environmental Design (LEED) certification

could serve as a marketing tool for LID practices among developers, engineers, and contractors/suppliers. Since the consumer must initially buy-in to LID practices, it was also suggested that there could be a need for incentives for the consumer such as reduced stormwater utility bills for treating stormwater on site. Due to the lack of knowledge and information regarding the regional use of LID practices, education (22%), research (21%), and success stories (16%) are needed to provide the information and knowledge dissemination necessary to promote the use of LID practices. This information should be disseminated across all stakeholders, including stormwater professionals and the general public through forums such as the Urban Land Institute, American Society of Civil Engineers, American Society of Landscape Architects, American Planning Association, Carolina Clear, and Lowcountry Earth Force. Attendees also felt that regulatory mandates (14%) would assist in the regional implementation of LID practices, but there is a need for regionally relevant information to support such mandates. It was also noted that the internal politics of municipalities can serve as an obstacle to implementing LIDs. Therefore, increased communication between municipal departments would assist in their implementation (2%). Until then, Planned Unit Developments (PUDs) can serve as an amendment to local zoning and a means for implementing LID practices within larger developments.

Options for Increasing LID Use



The Oak Terrace Preserve community in North Charleston, S.C., was zoned and permitted under a PUD ordinance that allowed the developers to employ LID principles in the development and preserve up to 95% of the older, healthy trees on site. Photo/City of North Charleston

Table 1

Summary of the percentage of stormwater retention and pollutant reduction of various stormwater treatment systems.							
Stormwater Treatment System	**Reference**	**Stormwater**	**TSS**	**Phosphorus**	**Nitrogen**	**Metals**	**Other**
Retention Pond				-16% (Total)	-54% (Total)	93% (Total Zn)	83% (Total HMW PAHs)
Single Detention Pond	Messersmith, 2007	7.5% (volume)	19%		-2.5% (Total)	n/a	14% (Fecal Coliform)
Series of Detention Ponds	Messersmith, 2007	-9% (volume)	88%	71% (Total)	39% (Total)	n/a	55% (Fecal Coliform)
Bioretention Swale	UNH Stormwater Center, 2007	82-85% (peak flow)	97-99%	5% (Total)	29-44% (DIN)	99% (Total Zn)	82-85% (Total HMW PAHs)
	Hunt & Lord, 2006 (tested soil media with varying P levels)	n/a	n/a	-240%-68% (Total)	33-68% (Total)	56-99% (Cu and Zn)	>90% (Fecal Coliform)
	EPA, 2000	n/a	n/a	85-89% (Total)	3-27% (Nitrate)	32-54% (Cu) & 22-100% (Zn)	n/a
	Dave, 2007; Davis, 2008	49-58% (peak flow)	47%	76% (Total)	83% (Nitrate)	57% (Cu) & 67% (Zn)	n/a
Porous Pavement	UNH Stormwater Center, 2007	68%	99%	38% (Total)	n/a	96% (Zn)	99% (Total HMW PAHs)
Cumulative use of LIDs	EPA, 2000	n/a	91%	3% (Total)	42% (Total Nitrogen)	81% (Cu) & 75% (Zn)	n/a

University of South Carolina researchers are studying the cumulative impacts of LID practices (e.g., bioretention swales, pervious pavers, pocket parks, pervious walkways) at Oak Terrace Preserve in North Charleston, S.C. Photo/City of North Charleston

The J Banks building on Hilton Head, S.C., uses pervious pavers to assist in achieving LEED Silver certification. The LEED Rating System has recently placed more emphasis on environmental factors which increase credits for LID stormwater strategies. Photo/J Banks

Conclusion

Input at the workshop from stormwater professionals and regulatory officials demonstrated agreement that ponds will continue to be a feature of future stormwater treatment systems. However, the current limitations of ponds should be addressed through homeowner education and regulatory enforcement regarding pond maintenance. In addition, ponds should be coupled with additional BMPs (e.g., created wetlands, LID practices, and grassy swales) to enhance the retention and removal of stormwater and its associated pollutants leaving a site. Overall, attendees agreed that stormwater management cannot be addressed through a "one-size-fits-all" prescriptive approach. Instead there should be more flexibility in state and local regulations to allow for site-scale management of stormwater based on the needs of a particular location (e.g., storm- water quantity or quality control) and the hydrologic conditions of the site (e.g., water table depth, soil storage capacity, soil infiltration rates, and proximity to adjacent water bodies).

Attendees agreed that LID practices could be a reasonable addition to ponds. However, LID practices should not be mandated at this time because there are still too many questions and uncertainties related to their performance, construction, and maintenance. Instead there needs to be more research, success stories, education of stakeholders, and incentives to promote the implementation of LID practices.

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Pocket Park Maintenace Needs:

Monthly	Once-a-year
• Mow grass • Remove trash and debris	• Clear vegetation around inlets and outlets to prevent clogging

Determine by Inspection:
- Reseed the pocket park to maintain dense turf.
- Remove accumulated sediment within the pocket park.


Well-established and functional pocket park


Well-established and functional forebay

Forebay Maintenace Needs:

Monthly
• Remove trash and debris

Determine by Inspection:
- Apply weed control if plant growth is choking the pond.
- Dredge the deepest portion of the forebay to maintain the permanently pooled area (suggested every 10 years).

References and Additional Resources:
- Best Management Practice (BMP) Maintenance: *www.lakecountyil.gov/Stormwater/Publications/BestManagementPractices.htm*
- LID Maintenance: *www.crwa.org/projects/greenstreets/Maintenance.pdf, www.psparchives.com/publications/our_work/stormwater/lid/D_RevisedMaintenanceofLIDFacilities.pdf*
- Pond Maintenance: *www.scdhec.gov/environment/ocrm/pubs/docs/ponds.pdf*
- Bioretention Maintenance: *www.lid-stormwater.net/bio_maintain.htm, http://www.mapc.org/search/node/bioretention%20maintenance*
- Pervious Paver Maintenance: *www.paversearch.com/permeable-pavers-maintenance.htm, www.lowimpactdevelopment.org/qapp/lid_design/permeable_pavers/permpavers_maintain.htm*
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- Carolina Clear. *www.clemson.edu/public/carolinaclear*
- Green Homes 101: *www.dnr.sc.gov/marine/NERR/traininggreenhomes.html*
- Clemson's Home and Garden Information Center. *www.clemson.edu/extension/hgic*
- Low Impact Development Center, Inc. *www.lowimpactdevelopment.org*

DNR www.dnr.sc.gov

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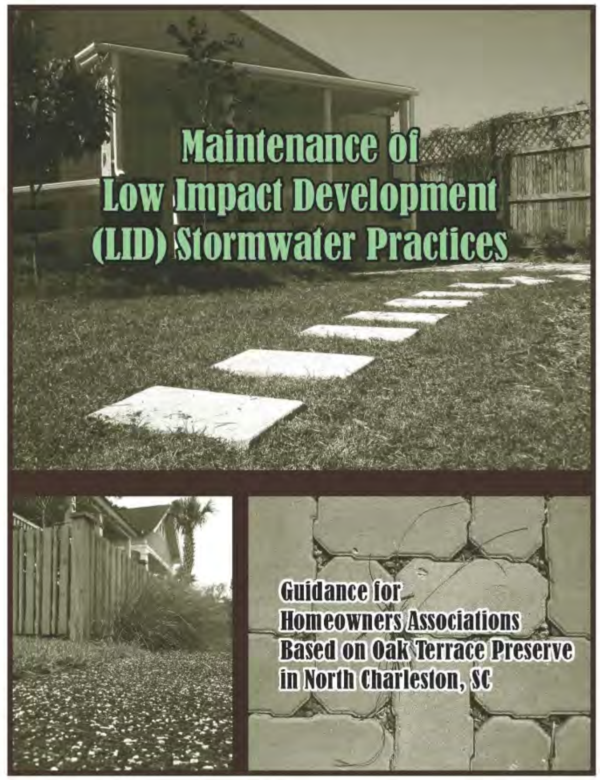


Courtesy of the City of North Charleston

Oak Terrace Preserve LID Stormwater Practices

Oak Terrace Preserve, in North Charleston, S.C., uses a network of Low Impact Development (LID) practices designed to disperse stormwater throughout the development to promote infiltration and groundwater recharge. These LID practices include bioretention swales, pervious alleys and walkways, pocket parks, and a forebay that are interconnected with perforated piping to continually promote infiltration and retention of stormwater on site, while also preventing flooding of adjacent properties.

Maintenance of LID Stormwater Practices

LID practices use natural processes (e.g., detention and infiltration of stormwater) to manage the stormwater runoff from the neighborhood, and as such, their maintenance needs are fairly minimal. However, because they are utilized as a stormwater management facility, and therefore minimize downstream pollution and flooding, routine maintenance is necessary and it is also important to continually inspect these systems to ensure that they are functioning properly. The maintenance needs of the individual LID practices vary and may require the assistance of a trained professional (e.g., landscape firm, street sweeper, and/or consultation with the supplier), which should be determined up-front to assure the appropriate maintenance of these practices. In addition, while a development is under construction, these practices should be inspected every month for maintenance needs (e.g., erosion, siltation, weeding, and watering). Following the completion and stabilization of a site, it will only need to be inspected on an annual basis.

It is important to note that this document is based on the maintenance needs of the LID practices within Oak Terrace Preserve and these guidlines have been developed based on the information provided by the documents listed in the "References and Additional Resources" section.

Bioretention Swale Maintenace Needs:

Monthly	Twice-a-year	Once-a-year
• Mow grass • Remove trash and debris	• Clean curb-cuts: remove debris from the gutter and entrance to swales • Remove and/or prune vegetation • Water plants • Weed	• Clear vegetation within one foot of inlets and outfalls

Determine by Inspection:
- Check retention of stormwater. Ponding is normal and to be expected, but should not exceed 2-3 days.
- Replace soil and/or plant material for erosion control.
- Remove sediment to maintain plant growth and water storage capabilities of the bioretention swale.
- Clean under-drains by jet-cleaning or vacuuming.
- Replace or amend soil to maintain stormwater infiltration and pollutant removal capacity of the bioretention swale. Inspections are required (visual, infiltration tests, soil tests) to check for pollutants and organic material.
- Rebuild or reinforce hard structures (e.g., drop inlets, gutters, outlets).
- Re-grade or re-contour side slopes to maintain designed slope and storage area.


Eroding bioswale


Well-established functioning bioswale


Debris removal from curb-cut needed

Pervious Alley and Walkway Maintenace Needs:

Monthly	Once-a-year
• Remove trash and debris	• Maintain vegetated or mulched buffer along periphery of pervious materials. (During construction, silt-fencing should be used and maintained adjacent to pervious materials.) • Clean permeable materials (may be necessary up to 4 times-per-year); sweep and vacuum pervious pavers and apply top-coat to aggregate material if necessary; jet-spray walkways. * *These maintenance needs are specific to previous pavers and Flexi-pave®. If using a different type of pervious material consult with the manufacturer to determine the products maintenance needs.*

Determine by Inspection:
- Maintain the integrity of the infrastructure: replace broken pervious pavers and top-coat the pervious walkway if aggregate becomes loose.
- Remove plant growth among the pavers or walkways.
- Replace the aggregate in between the pavers to maintain the permeability of the alleys.


Fully-functional pervious pavers


Fully-functional Flexi-pave®


The construction site needs to be stabilized and the pervious pavers swept and vacuumed


Sediment-laden Flexi-pave® indicating a need to jet-spray

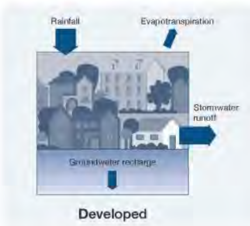

Loose aggregate that needs a top-coat applied

Stormwater Series

Distribution of rainwater

Conceptual water budgets for undeveloped and developed sites in the lowcountry. The size of the arrows is indicative of the volume of rainwater entering or leaving a site.

Undeveloped



Developed

Figure 1

Additional Resources

Polluted Stormwater Brochure
www.scseagrant.org/pdf_files/NPSbrochure.pdf

Halfacre, A.C., D.R. Hitchcock, and J.A. Schuler. 2007. *Community Associations and Stormwater Management: A Coastal South Carolina Perspective*
www.urbanestuary.org

Green Solutions to Pollution: Homeowner Practices for Managing Stormwater and Polluted Runoff
www.dnr.sc.gov/marine/NERR/traininggarden.html

Green Homes 101
www.dnr.sc.gov/marine/NERR/traininggreenhomes.html

Carolina Yards and Neighborhoods
www.clemson.edu/extension/natural_resources/water/carolina_yards

Carolina Clear
www.clemson.edu/public/carolinaclear

Clemson's Home and Garden Information Center
www.clemson.edu/extension/hgic

Low Impact Development Center, Inc.
www.lowimpactdevelopment.org

Noisette

Sea Grant S.C. Sea Grant Consortium

University of South Carolina

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SCSGC-G-09-03

Green roof on Bowen's Island photo/Charleston Green Roofs

Rain garden at James Island Charter High School photo/USC

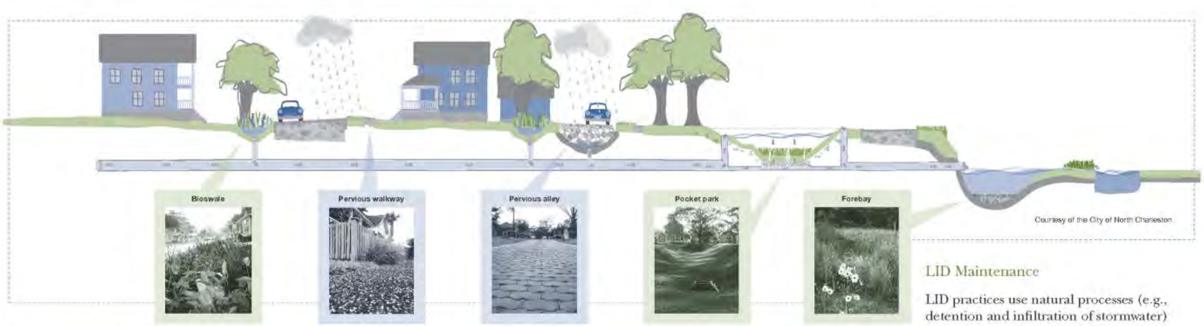
Carolina Yard at the Charleston Exchange Park photo/USC

Low Impact Development

What is low impact development?

Runoff from rainwater, often referred to as stormwater, is a primary contributor to nonpoint source (NPS) pollution of our waterways. Low Impact Development (LID) is a strategy designed to minimize the impact of development on a site by limiting the amount of stormwater and NPS pollution that is transported to our streams, rivers, lakes, and coastal waters. Typically, when it rains an undeveloped site generates less stormwater runoff because significant amounts of water seep into the ground (groundwater recharge) and moisture from soil, trees, shrubs, and grasses evaporates into the air (process of evapotranspiration). Increased development alters the landscape, removing and replacing vegetation with impervious cover, such as roads, driveways, rooftops, and sidewalks. These impervious surfaces inhibit groundwater recharge while increasing the quantity of stormwater runoff (see Figure 1). The LID approach to land development integrates the use of better site design techniques (e.g., cluster development, tree preservation) and stormwater management practices (e.g., bioswales, pervious materials, rainwater harvesting) to maintain the natural distribution of rainwater, and treat stormwater runoff on site.

Stormwater Series Low Impact Development



Courtesy of the City of North Charleston

Oak Terrace Preserve LID Stormwater Management Practices

Oak Terrace Preserve, a community in North Charleston S.C., employs a network of LID practices designed to disperse stormwater throughout the development to promote infiltration and groundwater recharge. These LID practices include bioswales, pervious alleys, pocket parks, and a forebay, and are interconnected with perforated piping to continually promote infiltration and retention of stormwater on site, while also preventing flooding of adjacent properties. In addition, a pervious walkway and on-site rainwater harvesting techniques (e.g., rain barrels) are used throughout the site but they are not connected to the piped network.

Bioswales (often referred to as bioretention swales) receive stormwater runoff from roads and the front of homes. The swales, combined with soils and plants, provide an area for temporary retention of stormwater, promote infiltration, and filtration and uptake of pollutants.

Oak Terrace Preserve is surrounded by a **pervious walkway**, Flexi-pave®, made of recycled tires and aggregate stone, which is filled with voids and installed on top of pervious stones to promote infiltration and retention of stormwater and its associated pollutants.

Pervious alleys, placed behind the homes in Oak Terrace Preserve, are designed with void spaces and underlined with pervious stones to promote infiltration and groundwater recharge.

Depressional areas, or **pocket parks**, are found throughout Oak Terrace Preserve and serve dual purposes, both functional (stormwater detention) and aesthetic (natural areas). These pocket parks are connected to the drainage network, and in the event of heavy rainfall, temporarily detain stormwater.

A terminal pond, or **forebay**, is located at the end of the network of LID practices and offers another opportunity to retain stormwater and its pollutants before flowing into the adjacent forested wetland, and ultimately, a tidal creek (Filbin Creek). This pond is designed with a deeper pooling area to promote settling of sediments and sediment-associated pollutants within the stormwater, as well as a vegetated buffer, to promote pollutant and stormwater uptake through the plants.

LID Maintenance

LID practices use natural processes (e.g., detention and infiltration of stormwater) to manage stormwater runoff from the neighborhood and maintenance needs are fairly minimal. However, the LID practices are stormwater management techniques, used to minimize downstream pollution and flooding, which require routine maintenance and inspections to ensure that they are functioning properly. Generally, LID practices require bi-annual to annual maintenance which is dependent on the type of LID practice used and is based upon routine inspections. A list of specific maintenance guidelines has been developed for the LID stormwater practices of Oak Terrace Preserve and is available online at **www.scseagrant.org/pdf_files/LID maintenance.pdf** or call S.C. Sea Grant Consortium at (843) 953-2078.

CH. 3—STORMWATER MANAGEMENT PRACTICES

Contents

****The following stormwater management practices can be found in their entirety in Georgia's Stormwater Management Manuals, Coastal Stormwater Supplement, August 2009. For the purposes of this publication, practices profile sheets have been abbreviated.**

Description

Soil restoration refers to the process of tilling and adding compost and other amendments to soils to restore them to their pre-development conditions, which improves their ability to reduce post-construction stormwater runoff rates, volumes and pollutant loads. The soil restoration process can be used to improve the hydrologic conditions of pervious areas that have been disturbed by clearing, grading and other land disturbing activities. It can also be used to increase the reduction in stormwater runoff rates, volumes and pollutant loads provided by other low impact development practices.

(Source: http://www.towncountryltd.com)

KEY CONSIDERATIONS

DESIGN CRITERIA:

- Ideal for use in pervious areas that have been disturbed by clearing, grading and other land disturbing activities
- To properly restore disturbed pervious areas, soil amendments should be added to existing soils to a depth of 18 inches until an organic matter content of 8% to 12% is obtained
- Restored pervious areas should be protected from future land disturbing activities

BENEFITS:

- Helps restore pre-development hydrology on development sites and reduces post-construction stormwater runoff rates, volumes and pollutant loads
- Promotes plant growth and improves plant health, which helps reduce stormwater runoff rates, volumes and pollutant loads

LIMITATIONS:

- Should not be used on areas that have slopes of greater than 10%
- To help prevent soil erosion, landscaping should be installed immediately after the soil restoration process is complete

SITE APPLICABILITY

☑ Rural Use	[M] Construction Cost
☑ Suburban Use	[L] Maintenance
☑ Urban Use	[L] Area Required

STORMWATER MANAGEMENT "CREDITS"

☑ Runoff Reduction
☑ Water Quality Protection
☑ Aquatic Resource Protection
☑ Overbank Flood Protection
☑ Extreme Flood Protection

☑ = practice has been assigned quantifiable stormwater management "credits" that can be used to address this SWM Criteria

STORMWATER MANAGEMENT PRACTICE PERFORMANCE

Runoff Reduction
N/A[1] - Annual Runoff Volume
N/A[1] - Runoff Reduction Volume

Pollutant Removal
N/A[1] - Total Suspended Solids
N/A[1] - Total Phosphorus
N/A[1] - Total Nitrogen
N/A[1] - Metals
N/A[1] - Pathogens

1 = helps restore pre-development hydrology, which implicitly reduces post-construction stormwater runoff rates, volumes and pollutant loads

Discussion

Soil restoration can also be used to increase the stormwater management benefits provided by other low impact development practices, such as site reforestation/revegetation (Coastal Stormwater Supplement (CSS), Section 7.8.2), vegetated filter strips (CSS, Section 7.8.6), grass channels (CSS, Section 7.8.7) and simple downspout disconnection (CSS, Section 7.8.8), on sites that have soils with low permeabilities (i.e., hydrologic soil group C or D soils). The soil restoration process can be used to help increase soil porosity and improve soil infiltration rates on these sites, which improves the ability of these and other low impact development practices to reduce post-construction stormwater runoff rates, volumes and pollutant loads.

Stormwater Management "Credits"

The Center for Watershed Protection (Hirschman et al., 2008) recently documented the ability of soil restoration to reduce stormwater runoff volumes and pollutant loads on development sites. Consequently, this green infrastructure practice has been assigned quantifiable stormwater management "credits" that can be used to help satisfy the SWM Criteria presented in the Georgia Stormwater Management Manual Coastal Stormwater Supplement (CSS). The Table in Appendix E shows how soil restoration can be used to address stormwater runoff reduction, water quality protection, aquatic resource protection, overbank flood protection, and extreme flood protection. For further details, see Section 7.8.1 of the CSS.

Overall Feasibility

Site planning and design teams should consider various factors to determine whether or not soil restoration is appropriate for use on a particular development site. The Table on Pages 3-8 through 3-12 provides design considerations for soil restoration including drainage area, area required, slope, minimum head, minimum depth to water table, and soils. For further details, refer directly to Section 7.8.1 of the CSS.

Site Applicability

Soil restoration can be used on a wide variety of development sites, including residential, commercial, industrial and institutional development sites in rural, suburban and urban areas. When compared with other low impact development practices, it has a moderate construction cost, a relatively low maintenance burden and requires no additional surface area beyond that which will undergo the soil restoration process. It is ideal for use in pervious areas that have been disturbed by clearing, grading and other land disturbing activities. (See Table on Pages 3-13 through 3-14).

Planning and Design Criteria

It is *recommended* that the soil restoration process used on a development site meet all of the planning and design criteria provided in Section 7.8.1 of the CSS to be eligible for the stormwater management "credits".

Construction Considerations

To help ensure that the soil restoration process is successfully completed on a development site, site planning and design teams should consider construction recommendations listed in Section 7.8.1 of the CSS.

Maintenance Requirements

Restored pervious areas require some maintenance during the first few months following construction, but typically require very little maintenance thereafter. Table 7.7 in the CSS provides a list of the routine maintenance activities typically associated with restored pervious areas.

Site Reforestation/Revegetation

Description

Site reforestation/revegetation refers to the process of planting trees, shrubs and other native vegetation in disturbed pervious areas to restore them to their pre-development conditions. The process can be used to help establish mature native plant communities (e.g., forests) in pervious areas that have been disturbed by clearing, grading and other land disturbing activities, which improves their ability to reduce post-construction stormwater runoff rates, volumes and pollutant loads. The process can also be used to provide restored habitat for high priority plant and animal species (Appendix C).

(Source: Center for Watershed Protection)

KEY CONSIDERATIONS

DESIGN CRITERIA:

- Ideal for use in pervious areas that have been disturbed by clearing, grading and other land disturbing activities
- Methods used for site reforestation/revegetation should achieve at least 75% vegetative cover one year after installation
- Reforested/revegetated areas should be protected in perpetuity as secondary conservation areas (Section 7.6.2)

BENEFITS:

- Helps restore pre-development hydrology on development sites and reduces post-construction stormwater runoff rates, volumes and pollutant loads
- Helps restore habitat for priority plant and animal species

LIMITATIONS:

- Should have a minimum contiguous area of 10,000 square feet
- Should be managed in a natural state and protected from future land disturbing activities

SITE APPLICABILITY

☑	Rural Use	M	Construction Cost
☑	Suburban Use	L	Maintenance
✱	Urban Use	L	Area Required

STORMWATER MANAGEMENT "CREDITS"

☑ Runoff Reduction
☑ Water Quality Protection
☑ Aquatic Resource Protection
☑ Overbank Flood Protection
☑ Extreme Flood Protection

☑ = practice has been assigned quantifiable stormwater management "credits" that can be used to address this SWM Criteria

STORMWATER MANAGEMENT PRACTICE PERFORMANCE

Runoff Reduction
N/A[1] - Annual Runoff Volume
N/A[1] - Runoff Reduction Volume

Pollutant Removal
N/A[1] - Total Suspended Solids
N/A[1] - Total Phosphorus
N/A[1] - Total Nitrogen
N/A[1] - Metals
N/A[1] - Pathogens

1 = helps restore pre-development hydrology, which implicitly reduces post-construction stormwater runoff rates, volumes and pollutant loads

Discussion

Areas that have been reforested or revegetated should be maintained in an undisturbed, natural state over time. These areas should be designated as secondary conservation areas and protected in perpetuity through a legally enforceable conservation instrument (e.g., conservation easement, deed restriction). If properly maintained over time, these areas can help improve aesthetics on development sites, provide passive recreational opportunities and create valuable habitat for high priority plant and animal species.

To help create contiguous, interconnected green infrastructure corridors on development sites, site planning and design teams should strive to connect reforested or revegetated areas with one another and with other primary and secondary conservation areas through the use of nature trails, bike trails and other "greenway" areas.

Stormwater Management "Credits"

The Center for Watershed Protection (Hirschman et al., 2008) recently documented the ability of Site reforestation/revegetation to reduce stormwater runoff volumes and pollutant loads on development sites. Consequently, this green infrastructure practice has been assigned quantifiable stormwater management "credits" that can be used to help satisfy the SWM Criteria presented in the Georgia Stormwater Management Manual Coastal Stormwater Supplement (CSS). The Table in Appendix E shows how site reforestation/revegetation can be used to address stormwater runoff reduction, water quality protection, aquatic resource protection, overbank flood protection, and extreme flood protection. For further details, see Section 7.8.2 of the CSS.

Overall Feasibility

Site planning and design teams should consider various factors to determine whether or not site reforestation/revegetation is appropriate for use on a particular development site. The Table on Pages 3-8 through 3-12 provides design considerations for site reforestation/revegetation including drainage area, area required, slope, minimum head, minimum depth to water table, and soils. For further details, refer directly to Section 7.8.2 of the CSS.

Site Applicability

Although it may be difficult to apply in urban areas, due to space constraints, site reforestation/revegetation can be used on a wide variety of development sites, including residential, commercial, industrial and institutional development sites in rural and suburban areas. When compared with other low impact development practices, it has a moderate construction cost, a relatively low maintenance burden and requires no additional surface area beyond that which will undergo the reforestation/revegetation process. It is ideal for use in pervious areas that have been disturbed by clearing, grading and other land disturbing activities. (See Table on Pages 3-13 through 3-14)

Planning and Design Criteria

It is *recommended* that the site reforestation/revegetation process meet all of the planning and design criteria provided Section 7.8.2 of the CSS to be eligible for the stormwater management "credits".

Construction Considerations

To help ensure that the soil restoration process is successfully completed on a development site, site planning and design teams should consider the construction recommendations listed in Section 7.8.2 of the CSS.

Maintenance Requirements

Reforested/revegetated areas require some maintenance during the first few months following construction, but typically require very little maintenance thereafter. Table 7.9 in the CSS provides a list of the routine maintenance activities typically associated with reforested/revegetated areas.

Green Roofs

Description

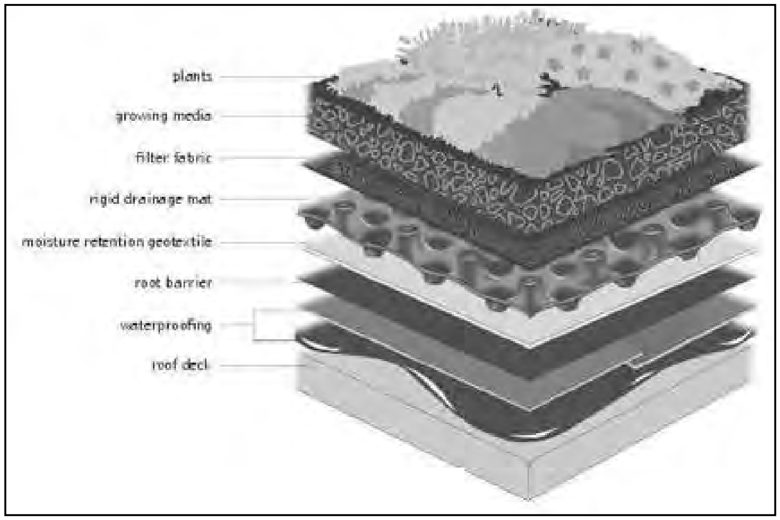
Green roofs represent an alternative to traditional impervious roof surfaces. They typically consist of underlying waterproofing and drainage materials and an overlying engineered growing media that is designed to support plant growth. Stormwater runoff is captured and temporarily stored in the engineered growing media, where it is subjected to the hydrologic processes of evaporation and transpiration before being conveyed back into the storm drain system.

(Source: http://www.greenroofs.com)

KEY CONSIDERATIONS	STORMWATER MANAGEMENT "CREDITS"
DESIGN CRITERIA: • The use of extensive green roof systems (2"-6" deep) should be considered prior to the use of more complex and expensive intensive green roof systems • Engineered growing media should be a light-weight mix and should contain less than 10% organic material • Waterproofing materials should be protected from root penetration by an impermeable root barrier BENEFITS: • Helps reduce post-construction stormwater runoff rates, volumes and pollutant loads without consuming valuable land • Particularly well suited for use on urban development and redevelopment sites LIMITATIONS: • Can be difficult to establish vegetation in the harsh growing conditions found on rooftops in coastal Georgia • Green roofs can be difficult to install on rooftops with slopes of 10% or greater	☑ Runoff Reduction ☑ Water Quality Protection ☑ Aquatic Resource Protection ☑ Overbank Flood Protection ☑ Extreme Flood Protection ☑ = practice has been assigned quantifiable stormwater management "credits" that can be used to address this SWM Criteria
SITE APPLICABILITY ✱ Rural Use — H Construction Cost ☑ Suburban Use — M Maintenance ☑ Urban Use — L Area Required	STORMWATER MANAGEMENT PRACTICE PERFORMANCE Runoff Reduction 50% - Annual Runoff Volume 60% - Runoff Reduction Volume Pollutant Removal[1] 80% - Total Suspended Solids 50% - Total Phosphorus 50% - Total Nitrogen N/A - Metals N/A - Pathogens 1 = expected annual pollutant load removal

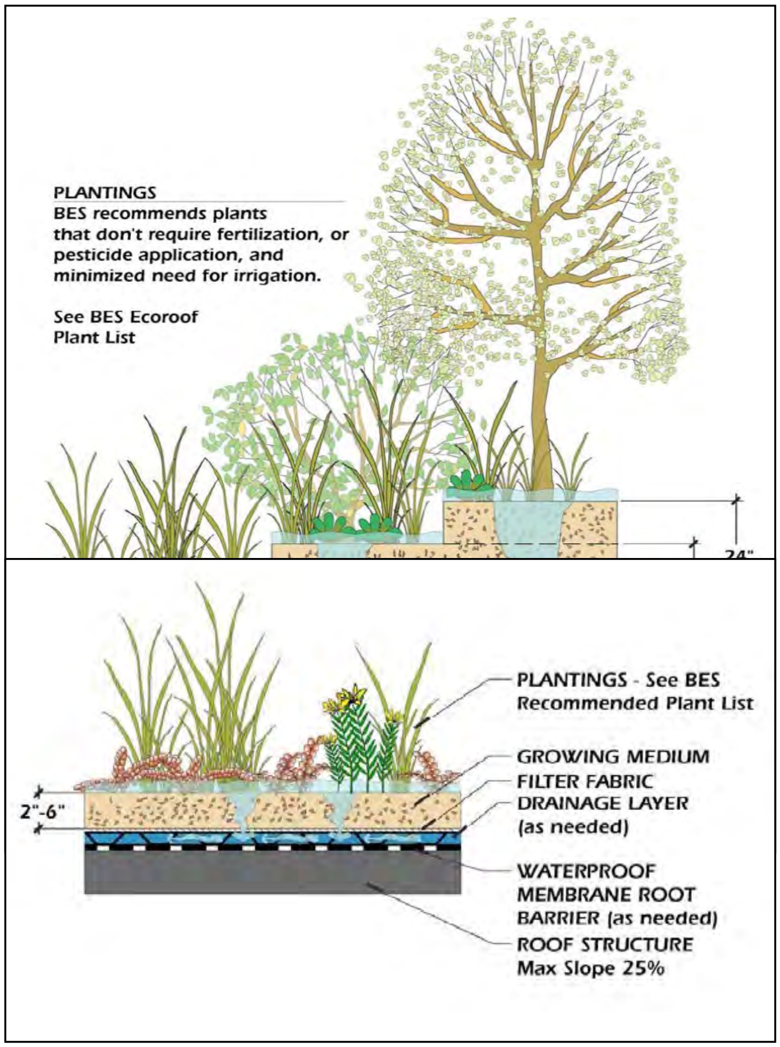
Discussion

There are two different types of green roof systems: intensive green roof systems and extensive green roof systems. Intensive green roof systems (also known as *rooftop gardens*) have a thick layer of engineered growing media (i.e., 12 to 24 inches) that supports a diverse plant community that may even include trees. Extensive green roof systems typically have a much thinner layer of engineered growing media (i.e., 2 to 6 inches) that supports a plant community that is comprised primarily of drought tolerant vegetation (e.g., sedums, succulent plants).



Components of a Green Roof System
(Source: Carter et al., 2007)

Extensive green roof systems, which can cost up to twice as much as traditional impervious roof surfaces, are much lighter and are less expensive than intensive green roof systems. Consequently, it is *recommended* that the use of extensive green roof systems be considered prior to the use of intensive green roof systems in coastal Georgia.



Extensive Green Roof System
(Source: City of Portland, OR, 2004)

Extensive green roof systems typically contain multiple layers of roofing materials, and are designed to support plant growth while preventing stormwater runoff from ponding on the roof surface. Green roof systems are designed to drain stormwater runoff vertically through the engineered growing media and then horizontally through a drainage layer towards an outlet. They are designed to require minimal long-term maintenance and, if the right plants are selected to populate the green roof, should not need supplemental irrigation or fertilization after an initial vegetation establishment period.

When designing a green roof, site planning and design teams must not only consider the stormwater storage capacity of the green roof, but also the structural capacity of the rooftop itself. To support a green roof, a rooftop must be designed to support an additional 15 to 30 pounds per square foot (psf) of load. Consequently, a structural engineer or other qualified professional should be involved with the design of a green roof to ensure that the rooftop itself has enough structural capacity sufficient to support the green roof system.

Stormwater Management “Credits”

The Center for Watershed Protection (Hirschman et al., 2008) recently documented the ability of green roofs to reduce stormwater runoff volumes and pollutant loads on development sites. Consequently, this green infrastructure practice has been assigned quantifiable stormwater management “credits” that can be used to help satisfy the SWM Criteria presented in Georgia Stormwater Management Manual Coastal Stormwater Supplement (CSS). The Table in Appendix E shows how green roofs can be used to address can be used to address stormwater runoff reduction, water quality protection, aquatic resource protection, overbank flood protection, and extreme flood protection. For further details, see Section 7.8.3 of the CSS.

Overall Feasibility

Site planning and design teams should consider various factors to determine whether or not green roofs are appropriate for use on a particular development site. The Table on Pages 3-8 thorugh 3-12 provides design considerations for green roofs including drainage area, area required, slope, minimum head, minimum depth to water table, and soils. For further details, refer directly to Section 7.8.3 of the CSS.

Site Applicability

Green roofs can be used on a wide variety of development sites in rural, suburban and urban areas. They are especially well suited for use on commercial, institutional, municipal and multi-family residential buildings on urban and suburban development and redevelopment sites. When compared with other low impact development practices, green roofs have a relatively high construction cost, a relatively low maintenance burden and require no additional surface area beyond that which will be covered by the green roof. Although they can be expensive to install, green roofs are often a component of “green buildings,” such as those that achieve certification in the Leadership in Energy and Environmental Design (LEED) Green Building Rating System. (Table ?, Appendix ?)

Planning and Design Criteria

It is *recommended* that green roofs meet all of the planning and design criteria provided in Section 7.8.3 of the CSS to be eligible for the stormwater management “credits”.

Construction Considerations

To help ensure that green roofs are properly installed on a development site, site planning and design teams should consider the construction recommendations listed in Section 7.8.3 of the CSS.

Maintenance Requirements

Maintenance is very important for green roofs, particularly in terms of ensuring that they continue to provide measurable stormwater management benefits over time. Table 7.11 in the CSS provides a list of the routine maintenance activities typically associated with green roofs.

Permeable Pavements

Description

Permeable pavements represent an alternative to traditional impervious paving surfaces. They typically consist of an underlying drainage layer and an overlying permeable surface layer. A permeable pavement system allows stormwater runoff to pass through the surface course (i.e., pavement surface) into an underlying stone reservoir, where it is temporarily stored and allowed to infiltrate into the surrounding soils or conveyed back into the storm drain system through an underdrain.

(Source: Center for Watershed Protection)

KEY CONSIDERATIONS

DESIGN CRITERIA:

- Permeable pavement systems should be designed to completely drain within 48 hours of the end of a rainfall event
- If the infiltration rate of the native soils located beneath a permeable pavement system do not meet or exceed 0.25 in/hr, an underdrain should be included in the design
- Permeable pavement systems should generally not be used to "receive" any stormwater runoff generated elsewhere on the development site

BENEFITS:

- Helps reduce post-construction stormwater runoff rates, volumes and pollutant loads without consuming valuable land
- Particularly well suited for use on urban development sites and in low traffic areas, such as overflow parking lots

LIMITATIONS:

- Relatively high construction costs, which are typically offset by savings on stormwater infrastructure (e.g., storm drain system)
- Permeable pavement systems should be installed only by experienced personnel

SITE APPLICABILITY

✱ Rural Use	H Construction Cost
☑ Suburban Use	H Maintenance
☑ Urban Use	L Area Required

STORMWATER MANAGEMENT "CREDITS"

☑ Runoff Reduction
☑ Water Quality Protection
☑ Aquatic Resource Protection
☑ Overbank Flood Protection
☑ Extreme Flood Protection

☑ = practice has been assigned quantifiable stormwater management "credits" that can be used to address this SWM Criteria

STORMWATER MANAGEMENT PRACTICE PERFORMANCE

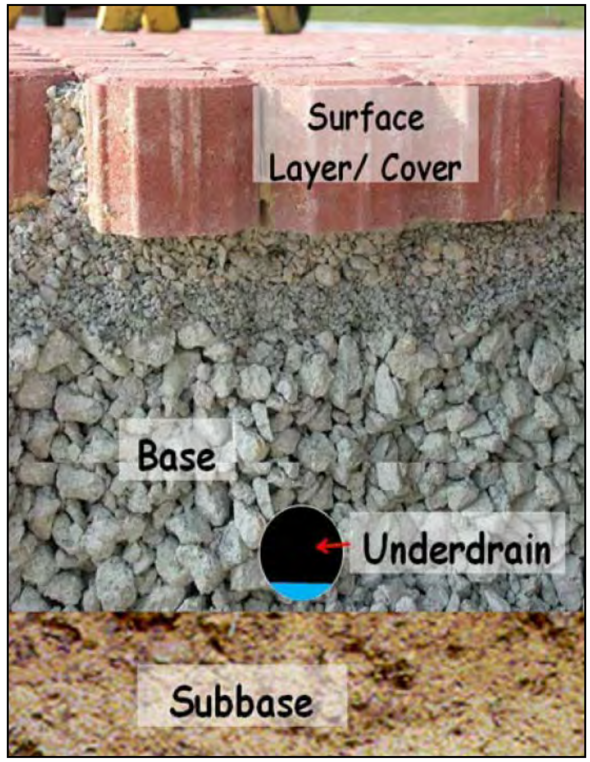
Runoff Reduction
45%-75% - Annual Runoff Volume
Varies[1] - Runoff Reduction Volume

Pollutant Removal[2]
80% - Total Suspended Solids
50% - Total Phosphorus
50% - Total Nitrogen
60% - Metals
N/A - Pathogens

1 = varies according to storage capacity of the permeable pavement system
2 = expected annual pollutant load removal

Discussion

There are a variety of permeable pavement surfaces available in the commercial marketplace, including pervious concrete, porous asphalt, permeable interlocking concrete pavers, concrete grid pavers and plastic grid pavers. Each of these permeable pavement surfaces is briefly described below:

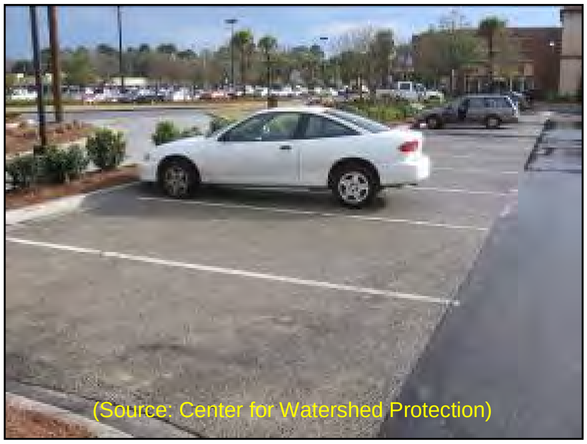


Components of a Permeable Pavement System
(Source: Hunt and Collins, 2008)

- Pervious Concrete: Pervious concrete (also known as *porous concrete*) is similar to conventional concrete in structure and form, but consists of a special open-graded surface course, typically 4 to 8 inches thick, that is bound together with portland cement. This open-graded surface course has a void ratio of 15% to 25% (conventional concrete pavement has a void ratio of between 3% and 5%), which gives it a high permeability that is often many times more than that of the underlying native soils, and allows rainwater and stormwater runoff to rapidly pass through it and into the underlying stone reservoir. Although this particular type permeable pavement surface may not require an underlying base layer to support traffic loads, site planning and design teams may wish to provide it to increase the stormwater storage capacity provided by a pervious concrete system.

- Porous Asphalt: Porous asphalt is similar to pervious concrete, and consists of a special open-graded surface course bound together by asphalt cement. The open-graded surface course in a typical porous asphalt installation is 3 to 7 inches thick and has a void ratio of between 15% and 20%. Porous asphalt is thought to have a limited ability to maintain its structure and permeability during hot summer months and, consequently, is currently *not recommended* for use in coastal Georgia. If it is used on a development site in the 24-county coastal region, it should be carefully monitored and maintained over time.

- Permeable Interlocking Concrete Pavers: Permeable interlocking concrete pavers (PICP) are solid structural units (e.g., blocks, bricks) that are installed in a way that provides regularly spaced openings through which stormwater runoff can rapidly pass through the pavement surface and into the underlying stone reservoir. The regularly spaced



Pervious Concrete

Concrete Grid Pavers

Permeable Interlocking Concrete Pavers

Plastic Grid Pavers

Various Permeable Pavement Surfaces

openings, which generally make up between 8% and 20% of the total pavement surface, are typically filled with pea gravel (i.e., ASTM D 448 Size No. 8, 3/8" to 1/8"). Typical PICP systems consist of the pavers, a 1.5 to 3 inch thick fine gravel bedding layer and an underlying stone reservoir.

- Concrete Grid Pavers: Concrete grid pavers (CGP) are precast concrete units that allow rainfall and stormwater runoff to pass through large openings that are filled with gravel, sand or topsoil and turf. CGP are typically 3.5 inches thick and have between a void ratio of between 20% and 50%, which means that the material used to fill the spaces between the grids has a large influence on the overall permeability (i.e., void space) of a CGP system. A typical CGP installation consists of the pavers, 1 to 1.5 inch sand or pea gravel bedding layer and an underlying stone reservoir.

- Plastic Grid Pavers: Plastic grid pavers (PGP) are similar to CGP. They consist of flexible, interlocking plastic units that allow rainfall and stormwater runoff to pass through large openings that are filled with gravel, sand or topsoil and turf. Since the empty plastic grids have a void ratio of between 90% and 98%, the material used to fill the spaces between the grids has a large influence on the overall permeability (i.e., void space) a PGP system.

When designing a permeable pavement system, planning and design teams must not only consider the storage capacity of the system, but also the structural capacity of the underlying soils and the underlying stone reservoir. The infiltration rate and structural capacity of the native soils found on a development site directly influence the size of the stone reservoir that is needed to provide structural support for a permeable pavement system and measurable reductions in post-construction stormwater runoff rates, volumes and pollutant loads. Site planning and design teams should strive to design permeable pavement systems that can accommodate the stormwater runoff volume generated by the target runoff reduction rainfall event (e.g., 85th percentile rainfall event). If this cannot be accomplished, due to site characteristics or constraints, site planning and design teams should consider using permeable pavement systems in combination with other runoff reducing low impact development practices.

Although permeable pavement systems have seen some use in coastal Georgia, there is still limited experience with the design and installation of this low impact development within the region. On the national scale, permeable pavement installations have had high failure rates due to poor design, poor installation, underlying soils with low infiltration rates and poor maintenance practices (ARC, 2001). Consequently, if a permeable pavement system is used on a development site, it should be carefully monitored and maintained over time.

Stormwater Management "Credits"
The Center for Watershed Protection (Hirschman et al., 2008) recently documented the ability of permeable pavement systems in the reduction of stormwater runoff volumes and pollutant loads on development sites. Consequently, this green infrastructure practice has been assigned quantifiable stormwater management "credits" that can be used to help satisfy the SWM Criteria presented in the Georgia Stormwater Management Manual Coastal Stormwater Supplement (CSS). The Table in Appendix E shows how permeable pavement systems can be used to address stormwater runoff reduction, water quality protection, aquatic resource protection, overland flood protection, and extreme flood protection. For further details, refer to Section 7.8.4 of the CSS.

Overall Feasibility
Site planning and design teams should consider various factors to determine whether or not permeable pavement is appropriate for use on a particular development site. The Table on Pages 3-8 through 3-12 provides design considerations for permeable pavement including drainage area, area required, slope, minimum head, minimum depth to water table, and soils. For further details, refer directly to Section 7.8.4 of the CSS.

Feasibility in Coastal Georgia
Several site characteristics commonly encountered in coastal Georgia may present challenges to site planning and design teams that are interested in using permeable pavement on a development site. The following table identifies these common site characteristics and describes how they influence the use of permeable pavement systems on development sites. The table also provides site planning and design teams with some ideas about how they can work around these potential constraints.

Challenges Associated with Using Permeable Pavement Systems in Coastal Georgia		
Site Characteristic	How it Influences the Use of Permeable Pavement	Potential Solutions
• *Poorly drained soils*, such as hydrologic soil group C and D soils	• Reduces the ability of permeable pavement systems to reduce stormwater runoff rates, volumes and pollutant loads.	• An underdrain should be included in permeable pavement systems that will be installed development sites that have soils with infiltration rates of less than 0.25 inches per hour (i.e., hydrologic soil group C and D soils). • Use additional low impact development practices to supplement the stormwater management benefits provided by underdrained permeable pavement systems.
• *Well drained soils*, such as hydrologic soil group A and B soils	• Enhances the ability of permeable pavement systems to reduce stormwater runoff rates, volumes and pollutant loads, but may allow stormwater pollutants to reach groundwater aquifers with greater ease.	• Avoid the use of infiltration-based low impact development practices, including non-underdrained permeable pavement systems, at stormwater hotspots and in areas known to provide groundwater recharge to water supply aquifers. • Use permeable pavement systems with liners and underdrains at stormwater hotspots and in areas known to provide groundwater recharge to water supply aquifers.
• *Flat terrain*	• Does not influence the use of permeable pavement systems. In fact, permeable pavement systems should be designed with slopes that are as close to flat as possible.	
• *Shallow water table*	• May cause stormwater runoff pond at the bottom of the permeable pavement system.	• Ensure that the distance from the bottom of the permeable pavement system to the top of the water table is at least 2 feet. • Use stormwater ponds (CSS, Section 8.6.1) and stormwater wetlands (CSS, Section 8.6.2) to

Challenges Associated with Using Permeable Pavement Systems in Coastal Georgia		
Site Characteristic	How it Influences the Use of Permeable Pavement	Potential Solutions
		intercept and treat stormwater runoff in these areas.
• *Tidally-influenced drainage system*	• May occasionally prevent stormwater runoff from being conveyed through a permeable pavement system, particularly during high tide.	• Investigate the use of other low impact development practices, such as rainwater harvesting (CSS, Section 7.8.12) to "receive" stormwater runoff in these areas.

Site Applicability

Permeable pavement systems can be used on a wide range of development sites in rural, suburban and urban areas. They are especially well suited for use on urban development and redevelopment sites to construct sidewalks, parking lots, overflow parking areas, private streets and driveways and parking lanes on public streets and roadways. When compared with other low impact development practices, permeable pavement systems have a relatively high construction cost, a relatively high maintenance burden and require no additional surface area beyond that which will be covered by the permeable pavement system. (See Table on Pages 313 through 3-14.

Planning and Design Criteria

It is *recommended* that permeable pavement systems site meet all of the planning and design criteria provided in Section 7.8.4 of the CSS to be eligible for the stormwater management "credits".

Construction Considerations

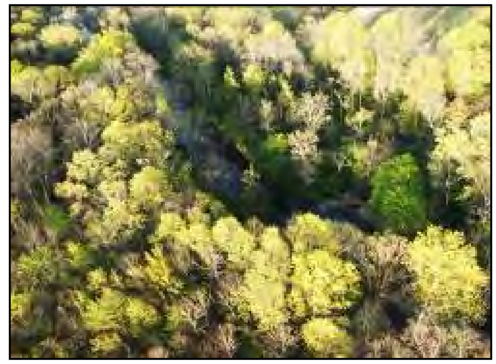
To help ensure that permeable pavement systems are properly installed on a development site, site planning and design teams should consider the construction recommendations in Section 7.8.4 in the CSS.

Maintenance Requirements

Maintenance is very important for permeable pavement systems, particularly in terms of ensuring that they continue to provide measurable stormwater management benefits over time. Table 7.14 in the CSS provides a list of the routine maintenance activities typically associated with permeable pavement systems.

Description

Undisturbed pervious areas, including primary and secondary conservation areas, can be used to "receive" the post-construction stormwater runoff generated elsewhere on a development site. If stormwater runoff can be evenly distributed over them as overland sheet flow, undisturbed pervious areas can provide significant reductions in post-construction stormwater runoff rates, volumes and pollutant loads on development sites.



(Source: Center for Watershed Protection)

KEY CONSIDERATIONS

DESIGN CRITERIA:

- Stormwater runoff should enter undisturbed pervious areas as overland sheet flow
- Length of flow path in contributing drainage areas should be 150 feet or less in pervious drainage areas and 75 feet or less in impervious drainage areas
- Length of flow path in undisturbed pervious areas used to "receive" post-construction stormwater runoff must be 50 feet or more

BENEFITS:

- Helps restore pre-development hydrology on development sites and reduces post-construction stormwater runoff rates, volumes and pollutant loads
- Helps protect valuable aquatic and terrestrial resources from the direct impacts of the land development process

LIMITATIONS:

- Should be managed in a natural state and protected from future land disturbing activities by an acceptable conservation instrument

SITE APPLICABILITY

☑ Rural Use

☑ Suburban Use

Urban Use

[L] Construction Cost

[L] Maintenance

[H] Area Required

STORMWATER MANAGEMENT "CREDITS"

☑ Runoff Reduction

☑ Water Quality Protection

☑ Aquatic Resource Protection

☑ Overbank Flood Protection

☑ Extreme Flood Protection

☑ = practice has been assigned quantifiable stormwater management "credits" that can be used to address this SWM Criteria

STORMWATER MANAGEMENT PRACTICE PERFORMANCE

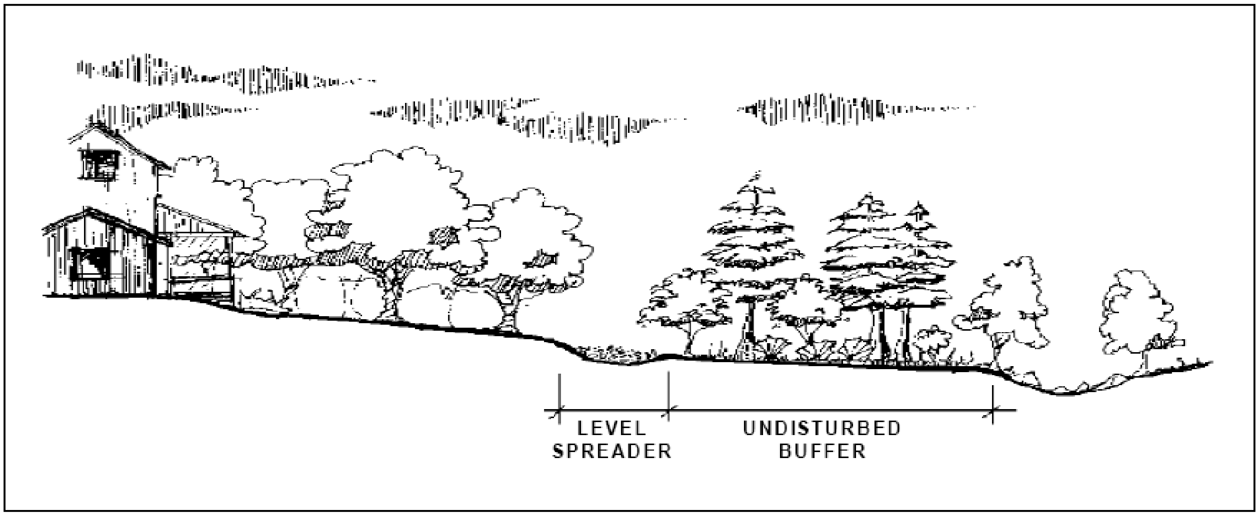
Runoff Reduction
50%-75% - Annual Runoff Volume
60%-90% - Runoff Reduction Volume

Pollutant Removal[1]
80% - Total Suspended Solids
50% - Total Phosphorus
50% - Total Nitrogen
N/A - Metals
N/A - Pathogens

1 = expected annual pollutant load removal

Discussion

If concentrated stormwater runoff is allowed to enter an undisturbed pervious area, it can cause soil erosion and can significantly reduce the stormwater management benefits that the undisturbed pervious area provides. Consequently, stormwater runoff needs to be intercepted and distributed evenly, as overland sheet flow, across an undisturbed pervious area that will be used to “receive” post-construction stormwater runoff. This can be accomplished by limiting the length of the flow path within the contributing drainage area and by using a level spreader at the upstream end of the undisturbed pervious area that will “receive” post-construction stormwater runoff.



Use of a Level Spreader Upstream of an Undisturbed Pervious Area
(Source: North Carolina Department of Environment and Natural Resources, 1998)

Since the undisturbed pervious areas that are used to “receive” stormwater runoff on a development site are typically designed to be on-line stormwater management practices, consideration should be given to the stormwater runoff rates and volumes generated by larger storm events (e.g., 25-year, 24-hour storm event) to help ensure that they do not cause significant damage within the undisturbed pervious areas.

Stormwater Management “Credits”

The Center for Watershed Protection (Hirschman et al., 2008) recently documented the ability of undisturbed pervious areas that “receive” stormwater runoff to reduce stormwater runoff volumes and pollutant loads on development sites. Consequently, this low impact development practice has been assigned quantifiable stormwater management “credits” that can be used to help satisfy the SWM Criteria presented in the Georgia Stormwater Management Manual Coastal Stormwater Supplement (CSS). The Table in Appendix E shows how undisturbed pervious areas can be used to address stormwater runoff reduction, water quality protection, aquatic resource protection, overland flood protection, and extreme flood protection. For further details, see Section 7.8.5 of the CSS.

Overall Feasibility

Site planning and design teams should consider various factors to determine whether or not undisturbed pervious areas should be used to “receive” stormwater runoff on a development site. The Table on Pages 3-8 through 3-12 provides design considerations for undisturbed pervious areas including drainage area, area required, slope, minimum head, minimum depth to water table, and soils. For further details, refer directly to Section 7.8.5 of the CSS.

Site Applicability

Although it may be difficult to use undisturbed pervious areas to “receive” stormwater runoff in urban areas, due to space constraints, undisturbed pervious areas can be used to “receive” stormwater runoff on a wide variety of development sites, including residential, commercial, industrial and institutional development sites in rural and suburban areas. When compared with other low impact development practices, undisturbed pervious areas have a relatively low construction cost, a relatively low maintenance burden and require a relatively large amount of surface area. (See Table on Pages 3-13 through 3-14)

Planning and Design Criteria

It is *recommended* that the undisturbed pervious areas used on a development site meet all of the planning and design criteria provided in Section 7.8.5 of the CSS to be eligible for the stormwater management “credits”.

Construction Considerations

To help ensure that undisturbed pervious areas are properly used to “receive” stormwater runoff on a development site, site planning and design teams should consider the construction recommendations listed in Section 7.8.5 of the CSS.

Maintenance Requirements

Undisturbed pervious areas used to “receive” post-construction stormwater runoff typically require very little long-term maintenance, but a legally binding inspection and maintenance agreement and plan should be created to help ensure that they are properly maintained after construction is complete. Table 7.16 in the CSS provides a list of the routine maintenance activities typically associated with undisturbed pervious areas.

Description

Vegetated filter strips are uniformly graded, densely vegetated areas of land designed to slow and filter stormwater runoff. They are typically installed in areas that have been disturbed by clearing, grading and other land disturbing activities and are typically vegetated with managed turf. If stormwater runoff can be evenly distributed over them as overland sheet flow, vegetated filter strips can provide significant reductions in post-construction stormwater runoff rates, volumes and pollutant loads on development sites.

(Source: Merrill et al., 2006)

KEY CONSIDERATIONS

DESIGN CRITERIA:

- Stormwater runoff should enter vegetated filter strips as overland sheet flow
- Length of flow path in contributing drainage areas should be 150 feet or less in pervious drainage areas and 75 feet or less in impervious drainage areas
- Length of flow path in vegetated filter strip should be 25 feet or more
- Vegetated filter strips should have a slope of at least 0.5% to ensure adequate drainage

BENEFITS:

- Helps restore pre-development hydrology on development sites and reduces post-construction stormwater runoff rates, volumes and pollutant loads
- Relatively low construction cost and long-term maintenance burden

LIMITATIONS:

- Can be difficult to maintain overland sheet flow within a vegetated filter strip, which needs to be provided to prevent soil erosion and ensure practice performance

SITE APPLICABILITY

☑ Rural Use	L Construction Cost
☑ Suburban Use	L Maintenance
✱ Urban Use	H Area Required

STORMWATER MANAGEMENT "CREDITS"

☑ Runoff Reduction
☑ Water Quality Protection
☑ Aquatic Resource Protection
☑ Overbank Flood Protection
☑ Extreme Flood Protection

☑ = practice has been assigned quantifiable stormwater management "credits" that can be used to address this SWM Criteria

STORMWATER MANAGEMENT PRACTICE PERFORMANCE

Runoff Reduction
25%-50% - Annual Runoff Volume
30%-60% - Runoff Reduction Volume

Pollutant Removal[1]
80% - Total Suspended Solids
25% - Total Phosphorus
25% - Total Nitrogen
40% - Metals
N/A - Pathogens

1 = expected annual pollutant load removal

Discussion

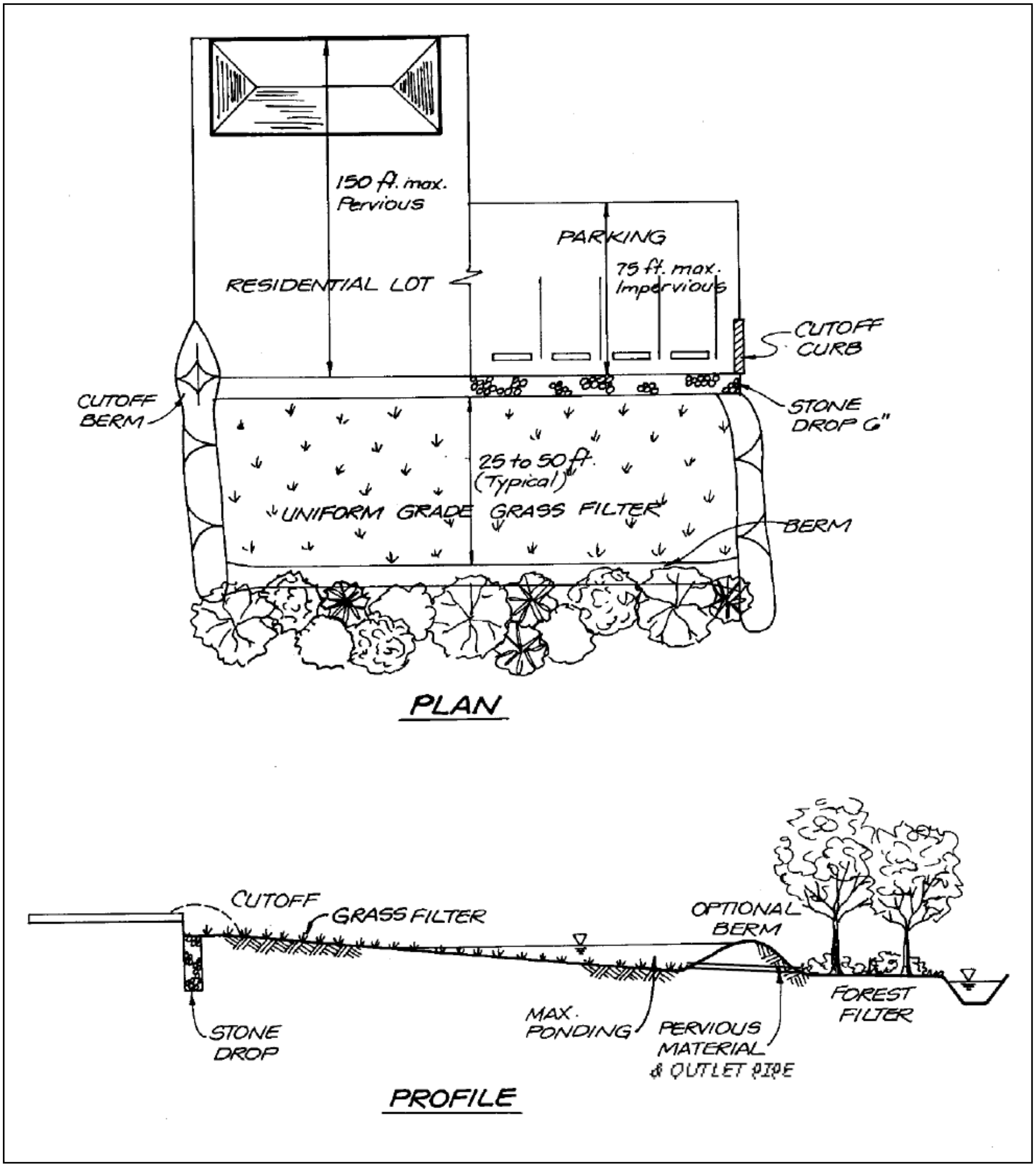
Vegetated filter strips can be attractively integrated into development sites as landscaping features and are well suited to "receive" stormwater runoff from local streets and roadways, highways, roof downspouts, small parking lots and disturbed pervious surfaces (e.g., lawns, parks, community open spaces). They are particularly well suited for use in the "outer zone" of aquatic buffers, in the landscaped areas commonly found between adjoining properties (e.g., setbacks) and incompatible land uses (e.g., residential and commercial land uses) and around the perimeter of parking lots. They can also be used to pretreat stormwater runoff before it enters other low impact development practices, such as undisturbed pervious areas (CSS, Section 7.8.5), bioretention areas (CSS, Section 7.8.13) and infiltration practices (CSS, Section 7.8.14), which increases the reductions in stormwater runoff rates, volumes and pollutant loads that these other low impact development practices provide.

Filter Strip Around the Perimeter of a Parking Lot
(Source: Atlanta Regional Commission, 2001)

If concentrated stormwater runoff is allowed to enter a vegetated filter strip, it can cause soil erosion and can significantly reduce the stormwater management benefits that the filter strip provides. Consequently, stormwater runoff needs to be intercepted and distributed evenly, as overland sheet flow, across a vegetated filter strip. This can be accomplished by limiting the length of the flow path within the contributing drainage area and by using a level spreader at the upstream end of the vegetated filter strip that will "receive" post-construction stormwater runoff.

There are two different filter strip designs that can be used on a development site. The first is a simple design, while the second is more advanced, and includes a permeable berm at the downstream end of the filter strip. The permeable berm is used to temporarily store stormwater runoff within the filter strip, which increases the residence time that it provides and reduces the required width of the filter strip.

Since the vegetated filter strips that are used to "receive" stormwater runoff on a development site are typically designed to be on-line stormwater management practices, consideration should be given to the stormwater runoff rates and volumes generated by larger storm events (e.g., 25-year, 24-hour storm event) to help ensure that they do not cause significant damage to a vegetated filter strip.



Vegetated Filter Strip

(Source: Atlanta Regional Commission, 2001)

Stormwater Management "Credits"

The Center for Watershed Protection (Hirschman et al., 2008) recently documented the ability of vegetated filter strips to reduce stormwater runoff volumes and pollutant loads on development sites. Consequently, this green infrastructure practice has been assigned quantifiable stormwater management "credits" that can be used to help satisfy the SWM Criteria presented in the Georgia Stormwater Management Manual Coastal Stormwater Supplement (CSS). The Table in Appendix E shows how filter strips can be used to address stormwater runoff reduction, water quality protection, aquatic resource protection, overland flood protection, and extreme flood protection. For further details, refer to Section 7.8.6 of the CSS.

Overall Feasibility

Site planning and design teams should consider various factors to determine whether or not is appropriate for use on a particular development site. The Table on Pages 3-8 through 3-12 provides design considerations for filter strips including drainage area, area required, slope, minimum head, minimum depth to water table, and soils. For further details, refer directly to Section 7.8.6 of the CSS.

Feasibility in Coastal Georgia

Several site characteristics commonly encountered in coastal Georgia may present challenges to site planning and design teams that are interested in using vegetated filter strips to "receive" post-construction stormwater runoff on a development site. The following Table identifies these common site characteristics and describes how they influence the use of vegetated filter strips on development sites. The table also provides site planning and design teams with some ideas about how they can work around these potential constraints.

Challenges Associated with Using Vegetated Filter Strips in Coastal Georgia		
Site Characteristic	How it Influences the Use of Vegetated Filter Strips	Potential Solutions
• *Poorly drained soils*, such as hydrologic soil group C and D soils	• Reduces the ability of vegetated filter strips to reduce stormwater runoff rates, volumes and pollutant loads.	• Use soil restoration (CSS, Section 7.8.1) to improve soil porosity and the ability of vegetated filter strips to reduce stormwater runoff rates, volumes and pollutant loads. • Place buildings and other impervious surfaces on poorly drained soils or preserve them as secondary conservation areas (CSS, Section 7.6.2). • Use additional low impact development practices to supplement the stormwater management benefits provided by vegetated filter strips.
• *Well drained soils*, such as hydrologic soil group A and B soils	• Enhances the ability of vegetated filter strips to reduce stormwater runoff rates, volumes and pollutant loads, but may allow stormwater pollutants to reach groundwater aquifers with greater ease.	• Avoid the use of infiltration-based low impact development practices, including vegetated filter strips, at stormwater hotspots and in areas known to provide groundwater recharge to water supply aquifers, unless adequate pretreatment is provided upstream of them.
• *Flat terrain*	• May be difficult to provide adequate drainage and may cause stormwater runoff to pond on the surface of a vegetated filter strip.	• Design vegetated filter strips with a slope of at least 0.5% to help ensure adequate drainage.

Challenges Associated with Using Vegetated Filter Strips in Coastal Georgia		
Site Characteristic	How it Influences the Use of Vegetated Filter Strips	Potential Solutions
		• Where soils are well drained, use non-underdrained bioretention areas (CSS, Section 7.8.13) and infiltration practices • (CSS, Section 7.8.14), to reduce stormwater runoff rates, volumes and pollutant loads and prevent ponding in these areas. • Where soils are poorly drained, use small stormwater wetlands (i.e., pocket wetlands) (CSS, Section 8.6.2) to intercept and treat stormwater runoff.
• *Shallow water table*	• May occasionally cause stormwater runoff to pond on the surface of a vegetated filter strip.	• Use small stormwater wetlands (i.e., pocket wetlands) (CSS, Section 8.6.2) or wet swales CSS, (Section 8.6.6) to intercept and treat stormwater runoff in these areas.
• *Tidally-influenced drainage system*	• May occasionally prevent stormwater runoff from being conveyed through a vegetated filter strip, particularly during high tide.	• Investigate the use of other low impact development practices, such as rainwater harvesting (CSS, Section 7.8.12) to “receive” stormwater runoff in these areas.

Site Applicability

Although it may be difficult to use them to “receive” stormwater runoff in urban areas, due to space constraints, vegetated filter strips can be used to “receive” stormwater runoff on a wide variety of development sites, including residential, commercial, industrial and institutional development sites in rural and suburban areas. When compared with other low impact development practices, vegetated filter strips have a relatively low construction cost, a relatively low maintenance burden and require a relatively large amount of surface area.
(See Table on Pages 3-13 through 3-14)

Planning and Design Criteria

It is *recommended* that vegetated filter strips used on a development site meet all of the planning and design criteria provided and Section 7.8.6 of the CSS to be eligible for the stormwater management “credits”.

Construction Considerations

To help ensure that vegetated filter strips are successfully installed on a development site, site planning and design teams should consider the construction recommendations listed in Section 7.8.6 of the CSS.

Maintenance Requirements

Maintenance is very important for vegetated filter strips, particularly in terms of ensuring that they continue to provide measurable stormwater management benefits over time. Table 7.19 in the CSS provides a list of the routine maintenance activities typically associated with vegetated filter strips. It is important to note that vegetated filter strips have maintenance requirements that are very similar to those of other vegetated low impact development practices.

Grass Channels

Description

Where site characteristics permit, grass channels, which are densely vegetated stormwater conveyance features, can be used to "receive" and convey post-construction stormwater runoff. They are typically installed in areas that have been disturbed by clearing, grading and other land disturbing activities, and are typically vegetated with managed turf. If properly designed, grass channels can provide measurable reductions in post-construction stormwater runoff rates, volumes and pollutant loads.

(Source: Center for Watershed Protection)

KEY CONSIDERATIONS	STORMWATER MANAGEMENT "CREDITS"
DESIGN CRITERIA: • Grass channels should be designed to accommodate the peak discharge generated by the target runoff reduction rainfall event (e.g., 85th percentile rainfall event) • Grass channels should be designed to able to safely convey the overbank flood protection rainfall event (e.g., 25-year, 24-hour event) • Grass channels may be designed with a slope of between 0.5% and 3%, although a slope of between 1% and 2% is recommended	☑ Runoff Reduction ☑ Water Quality Protection ☑ Aquatic Resource Protection ☑ Overbank Flood Protection ☑ Extreme Flood Protection ☑ = practice has been assigned quantifiable stormwater management "credits" that can be used to address this SWM Criteria
BENEFITS: • Helps restore pre-development hydrology on development sites and reduces post-construction stormwater runoff rates, volumes and pollutant loads • Relatively low construction cost and long-term maintenance burden LIMITATIONS: • Should not be used on development sites with slopes of less than 0.5% • Provides greater stormwater management benefits on sites with permeable soils (i.e., hydrologic soil group A and B soils)	STORMWATER MANAGEMENT PRACTICE PERFORMANCE Runoff Reduction 10%-20% - Annual Runoff Volume 12%-25% - Runoff Reduction Volume Pollutant Removal[1] 60% - Total Suspended Solids 25% - Total Phosphorus 30% - Total Nitrogen 30% - Metals

SITE APPLICABILITY	N/A - Pathogens 1 = expected annual pollutant load removal
☑ Rural Use — [L] Construction Cost ☑ Suburban Use — [M] Maintenance Urban Use — [M] Area Required	

Discussion

Conventional storm drain systems are designed to quickly and efficiently convey stormwater runoff away from buildings, roadways and other impervious surfaces and into rivers, streams and other aquatic resources. When these conventional systems are used to “receive” and convey stormwater runoff on development sites, opportunities to reduce post-construction stormwater runoff rates, volumes and pollutant loads are lost. To take better advantage of these opportunities, grass channels can be used in place of conventional storm drain systems (e.g., curb and gutter systems, storm sewers, concrete channels) to “receive” and convey stormwater runoff.

Grass channels (also known as *vegetated open channels*) are densely vegetated stormwater conveyance features designed to slow and filter stormwater runoff. They differ from the old, unvegetated roadside ditches of the past, which often suffered from erosion and standing water and occasionally worked to undermine the roadway itself. If grass channels are properly designed (e.g., sufficient channel widths, relatively flat slopes, dense vegetative cover), they can provide significant reductions in post-construction stormwater runoff rates, volumes and pollutant loads, particularly when they are located on areas with permeable soils (i.e., hydrologic soil group A and B soils).

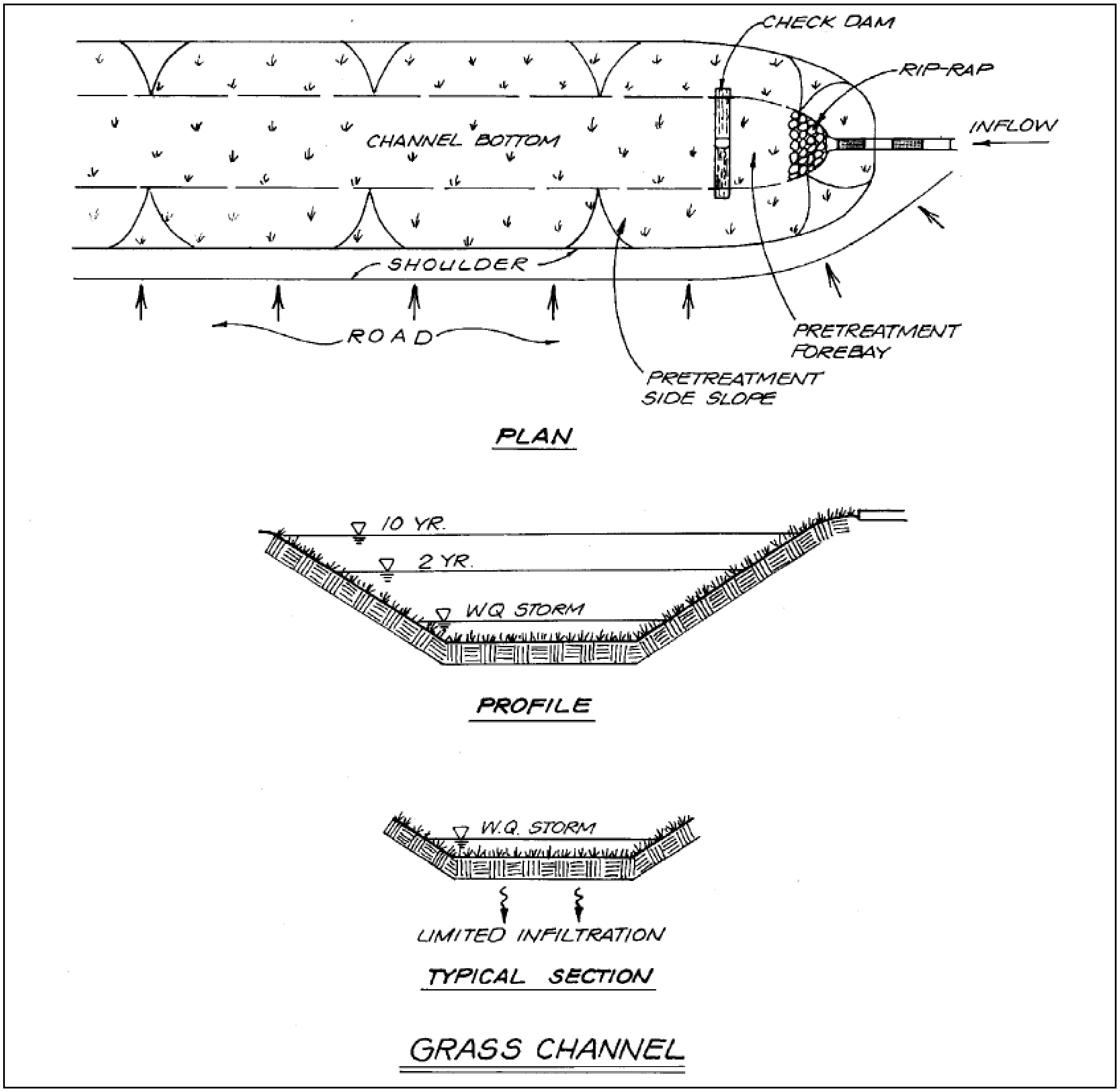
Grass Channel
Along a Local Roadway
(Source: Atlanta Regional Commission, 2001)

Grass channels can be integrated into development sites as landscaping features and are well suited to “receive” stormwater runoff from local streets and roadways, highways, small parking lots and disturbed pervious surfaces (e.g., lawns, parks, community open spaces). They are typically installed in areas that have been disturbed by clearing, grading and other land disturbing activities and are particularly well suited for use in roadway rights-of-way. Grass channels are typically less expensive to install than conventional storm drain systems and can be used to pretreat stormwater runoff before it enters other low impact development practices, such as undisturbed pervious areas (CSS, Section 7.8.5), bioretention areas (CSS, Section 7.8.13) and infiltration practices (CSS, Section 7.8.14), which increases the reductions in stormwater runoff rates, volumes and pollutant loads that these other low impact development practices provide.

Two of the primary concerns associated with grass channels are channel capacity and erosion control. In order to address these two concerns, site planning and design teams should work to ensure that the peak discharge rate generated by the target runoff reduction rainfall event (e.g., 85th percentile rainfall event) does not flow through the grass channel at a velocity greater than 1.0 foot per second (ft/s). Site planning and design teams should also work to ensure that grass channels provide at least 10 minutes of residence time for the peak discharge rate generated by the target runoff reduction rainfall event (Claytor and Schueler, 1996). Check dams can be placed across grass channels to help slow post-construction stormwater runoff and increase residence times.

Stormwater Management "Credits"

The Center for Watershed Protection (Hirschman et al., 2008) recently documented the ability of grass channels to reduce annual stormwater runoff volumes and pollutant loads on development sites. Consequently, this low impact development practice has been assigned quantifiable stormwater management "credits" that can be used to help satisfy the SWM Criteria presented in the Georgia Stormwater Management Manual Coastal Stormwater Supplement (CSS). The Table in Appendix E shows how grass channels can be used to address stormwater runoff reduction, water quality protection, aquatic resource protection, overland flood protection, and extreme flood protection. For further details, refer to Section 7.8.7 of the CSS.



Grass Channel
(Source: Atlanta Regional Commission, 2001)

Overall Feasibility
Site planning and design teams should consider various factors to determine whether or not site grass channels are appropriate for use on a particular development site. The Table on Pages 3-8 through 3-12 provides design considerations for grass channels including drainage area, area required, slope, minimum head, minimum depth to water table, and soils. For further details, refer directly to Section 7.8.7 of the CSS.

Feasibility in Coastal Georgia

Several site characteristics commonly encountered in coastal Georgia may present challenges to site planning and design teams that are interested in using grass channels to "receive" and convey post-construction stormwater runoff on a development site. The following Table identifies these common site characteristics and describes how they influence the use of grass channels on development sites. The table also provides site planning and design teams with some ideas about how they can work around these potential constraints.

Challenges Associated with Using Grass Channels in Coastal Georgia		
Site Characteristic	How it Influences the Use of Grass Channels	Potential Solutions
• *Poorly drained soils*, such as hydrologic soil group C and D soils	• Reduces the ability of grass channels to reduce stormwater runoff rates, volumes and pollutant loads.	• Use soil restoration (CSS, Section 7.8.1) to improve soil porosity and the ability of grass channels to reduce stormwater runoff rates, volumes and pollutant loads. • Use wet swales (i.e., linear wetland systems) (CSS, Section 8.6.6) to intercept, convey and treat stormwater runoff in these areas.
• *Well drained soils*, such as hydrologic soil group A and B soils	• Enhances the ability of grass channels to reduce stormwater runoff rates, volumes and pollutant loads, but may allow stormwater pollutants to reach groundwater aquifers with greater ease.	• Avoid the use of infiltration-based low impact development practices, including grass channels, at stormwater hotspots and in areas known to provide groundwater recharge to water supply aquifers, unless adequate pretreatment is provided upstream of them. • Use dry swales (CSS, Section 7.8.15) with liners and underdrains at stormwater hotspots and in areas known to provide groundwater recharge to water supply aquifers.
• *Flat terrain*	• May be difficult to provide positive drainage and may cause stormwater runoff to pond in the bottom of the grass channel.	• Design grass channels with a slope of at least 0.5% to help ensure adequate drainage. • Where soils are sufficiently permeable, use infiltration practices (CSS, Section 7.8.14) and non-underdrained bioretention areas (CSS, Section 7.8.13)and dry swales (CSS, Section 7.8.15), to reduce stormwater runoff volumes and prevent ponding in these areas. • Where soils have low permeabilities, use wet swales (CSS, Section 8.6.6) instead of grass channels to intercept, convey and treat stormwater runoff.

Challenges Associated with Using Grass Channels in Coastal Georgia		
Site Characteristic	How it Influences the Use of Grass Channels	Potential Solutions
• *Shallow water table*	• May occasionally cause stormwater runoff to pond in the bottom of the grass channel.	• Use wet swales (i.e., linear wetland systems) (CSS, Section 8.6.6) to intercept, convey and treat stormwater runoff in these areas.
• *Tidally-influenced drainage system*	• May occasionally prevent stormwater runoff from being conveyed through a grass channel, particularly during high tide.	• Investigate the use of other low impact development practices, such as rainwater harvesting (CSS, Section 7.8.12) to "receive" stormwater runoff in these areas.

Site Applicability

Although it may be difficult to use them to "receive" stormwater runoff in urban areas, due to space constraints, grass channels can be used to "receive" stormwater runoff on a wide variety of development sites, including residential, commercial, industrial and institutional development sites in rural and suburban areas. When compared with other low impact development practices, grass channels have a relatively low construction cost, a moderate maintenance burden and require only a moderate amount of surface area.

Planning and Design Criteria

It is *recommended* that the grass channels used on a development site meet all of the planning and design criteria provided Section 7.8.7 of the CSS to be eligible for the stormwater management "credits".

Construction Considerations

To help ensure that grass channels are successfully installed on a development site, site planning and design teams should consider the following construction recommendations in Section 7.8.7 in the CSS.

Maintenance Requirements

Maintenance is very important for grass channels, particularly in terms of ensuring that they continue to provide measurable stormwater management benefits over time. Table 7.22 in the CSS provides a list of the routine maintenance activities typically associated with grass channels. It is important to note that grass channels have maintenance requirements that are very similar to those of other vegetated low impact development practices.

Simple Downspout Disconnection

Description

Where site characteristics permit, simple downspout disconnections can be used to spread rooftop runoff from individual downspouts across lawns and other pervious areas, where it is slowed, filtered and allowed to infiltrate into the native soils. They are typically used in areas that have been disturbed by clearing, grading and other land disturbing activities and are typically vegetated with managed turf. If properly designed, simple downspout disconnections can provide measurable reductions in post-construction stormwater runoff rates, volumes and pollutant loads on development sites.

(Source: Center for Watershed Protection)

KEY CONSIDERATIONS

DESIGN CRITERIA:

- Length of flow path in contributing drainage areas should be 75 feet or less
- Length of flow path in pervious areas below simple downspout disconnections should be at least 15 feet long and equal to or greater than the length of the flow path in their contributing drainage areas
- Downspout disconnections should be designed to convey stormwater runoff away from buildings to prevent damage to building foundations

BENEFITS:

- Helps restore pre-development hydrology on development sites and reduces post-construction stormwater runoff rates, volumes and pollutant loads
- Relatively low construction cost and long-term maintenance burden

LIMITATIONS:

- Can only be used to "receive" runoff from small drainage areas of 2,500 square feet or less
- Provides greater stormwater management benefits on sites with permeable soils (i.e., hydrologic soil group A and B soils)

SITE APPLICABILITY

☑ Rural Use	L Construction Cost
☑ Suburban Use	L Maintenance
✱ Urban Use	M Area Required

STORMWATER MANAGEMENT "CREDITS"

☑ Runoff Reduction
☑ Water Quality Protection
☑ Aquatic Resource Protection
☑ Overbank Flood Protection
☑ Extreme Flood Protection

☑ = practice has been assigned quantifiable stormwater management "credits" that can be used to address this SWM Criteria

STORMWATER MANAGEMENT PRACTICE PERFORMANCE

Runoff Reduction
25%-50% - Annual Runoff Volume
30%-60% - Runoff Reduction Volume

Pollutant Removal[1]
80% - Total Suspended Solids
25% - Total Phosphorus
25% - Total Nitrogen
40% - Metals
N/A - Pathogens

1 = expected annual pollutant load removal

Discussion

As the name implies, a simple downspout disconnection is the most basic of all of the low impact development practices that can be used to "receive" rooftop runoff. Where site characteristics permit, they can be used to spread rooftop runoff from individual downspouts across lawns and other pervious areas, where it is slowed, filtered and allowed to infiltrate into the native soils. If properly designed, simple downspout disconnections can provide measurable reductions in post-construction stormwater runoff rates, volumes and pollutant loads on development sites and, consequently, can be used to help satisfy the SWM Criteria presented in this CSS.

Simple Downspout Disconnections to Pervious Areas
(Source: Center for Watershed Protection)

In order to use simple downspout disconnections to "receive" post-construction stormwater runoff, downspouts must be designed to discharge to a lawn or other pervious area. The pervious area located below the simple downspout disconnection should slope away from buildings and other impervious surfaces to prevent damage to building foundations and discourage rooftop runoff from "reconnecting" with the storm drain system.

The primary concern associated with a simple downspout disconnection is the length of the flow path in the lawn or other pervious area located below the disconnection point. In order to provide adequate residence time for stormwater runoff, the length of the flow path in the pervious area located below a simple downspout disconnection should be equal to or greater than the length of the flow path of the contributing drainage area. If this cannot be accomplished, due to site characteristics or constraints, site planning and design teams should consider using other low impact development practices, such as vegetated filter strips (CSS Section 7.8.6), rain gardens (CSS Section 7.8.9), dry wells (CSS Section 7.8.11) and rainwater harvesting (CSS Section 7.8.12), on the development site.

Stormwater Management "Credits"

The Center for Watershed Protection (Hirschman et al., 2008) recently documented the ability of simple downspout disconnections to reduce annual stormwater runoff volumes and pollutant loads on development sites. Consequently, this low impact development practice has been assigned quantifiable stormwater management "credits" that can be used to help satisfy the SWM Criteria presented in the Georgia Stormwater Management Manual Coastal Stormwater Supplement (CSS). The Table in Appendix E shows how simple downspout disconnections can be used to address stormwater runoff reduction, water quality protection, aquatic resource protection, overland flood protection, and extreme flood protection. For further details, refer to Section 7.8.8 of the CSS.

Overall Feasibility

Site planning and design teams should consider various factors to determine whether or not simple downspout disconnections are appropriate for use on a particular development site. The Table on Pages 3-8 through 3-12 provides design considerations for simple downspout disconnections including drainage area, area required, slope, minimum head, minimum depth to water table, and soils. For further details, refer directly to Section 7.8.8 of the CSS.

Feasibility in Coastal Georgia

Several site characteristics commonly encountered in coastal Georgia may present challenges to site planning and design teams that are interested in using simple downspout disconnections to "receive" post-construction stormwater runoff on a development site. The following Table identifies these common site characteristics and describes how they influence the use of simple downspout disconnections on development sites. The table also provides site planning and design teams with some ideas about how they can work around these potential constraints.

Challenges Associated with Using Simple Downspout Disconnections in Coastal Georgia		
Site Characteristic	How it Influences the Use of Downspout Disconnections	Potential Solutions
• *Poorly drained soils*, such as hydrologic soil group C and D soils	• Reduces the ability of simple downspout disconnections to reduce stormwater runoff rates, volumes and pollutant loads.	• Use soil restoration (CSS Section 7.8.1) to improve soil porosity and the ability of simple downspout disconnections to reduce stormwater runoff rates, volumes and pollutant loads. • Use additional downspout disconnection practices, such as rain gardens (CSS Section 7.8.9), dry wells (CSS Section 7.8.11) and rainwater harvesting (CSS Section 7.8.12) to supplement the stormwater management benefits provided by simple downspout disconnections.
• *Well drained soils*, such as hydrologic soil group A and B soils	• Enhances the ability of simple downspout disconnections to reduce stormwater runoff rates, volumes and pollutant loads, but may allow stormwater pollutants to reach groundwater aquifers with greater ease.	• Rooftop runoff is relatively clean, so this should not prevent the use of simple downspout disconnections, even at stormwater hotspots and in areas known to provide groundwater recharge to water supply aquifers. However, rooftop runoff should not be allowed to comingle with runoff from other impervious surfaces in these areas if it will be "received" by a simple downspout disconnection.

Challenges Associated with Using Simple Downspout Disconnections in Coastal Georgia		
Site Characteristic	How it Influences the Use of Downspout Disconnections	Potential Solutions
• *Flat terrain*	• May be difficult to provide adequate drainage and may cause stormwater runoff to pond in the pervious area located below a simple downspout disconnection.	• Design the pervious area located below the simple downspout disconnection with a slope of at least 0.5% to help ensure adequate drainage. • Where soils are well drained, use rain gardens (CSS Section 7.8.9), non-underdrained bioretention areas (CSS Section 7.8.13) and infiltration practices (CSS Section 7.8.14), to reduce stormwater runoff rates, volumes and pollutant loads and prevent ponding in these areas. • Where soils are poorly drained, use rainwater harvesting (CSS Section 7.8.12), small stormwater wetlands (i.e., pocket wetlands) (CSS Section 8.6.2) or wet swales (CSS Section 8.6.6), instead of simple downspout disconnection to intercept and treat stormwater runoff.
• *Shallow water table*	• May occasionally cause stormwater runoff to pond in the pervious area located below a simple downspout disconnection.	• Use rainwater harvesting (CSS Section 7.8.9), small stormwater wetlands (i.e., pocket wetlands) (CSS Section 8.6.2) or wet swales (CSS Section 8.6.6), instead of downspout disconnection to intercept and treat stormwater runoff in these areas.
• *Tidally-influenced drainage system*	• May occasionally prevent stormwater runoff from being conveyed through the pervious area located below a simple downspout disconnection, particularly during high tide.	• Investigate the use of other low impact development practices, such as rainwater harvesting (CSS Section 7.8.12) to “receive” stormwater runoff in these areas.

Site Applicability

Although it may be difficult to use them to “receive” stormwater runoff in urban areas, due to space constraints, simple downspout disconnections can be used to “receive” stormwater runoff on a wide variety of development sites, including residential, commercial, industrial and institutional development sites in rural and suburban areas. When compared with other low impact development practices, simple downspout disconnections have a relatively low construction cost, a relatively low maintenance burden and require only a moderate amount of surface area. (See Table Pages 3-8 through 3-12)

Planning and Design Criteria

It is *recommended* that simple downspout disconnections used on a development site meet all of the planning and design criteria provided in CSS Section 7.8.8 of the CSS to be eligible for the stormwater management “credits”.

Construction Considerations

To help ensure simple downspout disconnections are properly installed on a development site, site planning and design teams should consider the construction recommendations listed in CSS Section 7.8.8 of the CSS.

Maintenance Requirements

Simple downspout disconnections typically require very little long-term maintenance. Table 7.25 in the CSS provides a list of the maintenance activities typically associated with simple downspout disconnections.

Rain Gardens

Description

Rain gardens are small, landscaped depressional areas that are filled with amended native soils or an engineered soil mix and are planted with trees, shrubs and other herbaceous vegetation. They are designed to capture and temporarily store stormwater runoff so that it may be subjected to the hydrologic processes of evaporation, transpiration and infiltration. This allows rain gardens to provide measurable reductions in post-construction stormwater runoff rates, volumes and pollutant loads on development sites.

(Source: R. Bannerman)

KEY CONSIDERATIONS

DESIGN CRITERIA:

- Rain gardens should be designed to completely drain within 24 hours of the end of a rainfall event
- A maximum ponding depth of 6 inches is recommended within rain gardens to help prevent the formation of nuisance ponding conditions
- Unless a shallow water table is found on the development site, rain garden planting beds should be at least 2 feet deep

BENEFITS:

- Helps restore pre-development hydrology on development sites and reduces post-construction stormwater runoff rates, volumes and pollutant loads
- Can be integrated into development plans as attractive landscaping features

LIMITATIONS:

- Can only be used to "receive" runoff from small drainage areas of 2,500 square feet or less
- Provides greater stormwater management benefits on sites with permeable soils (i.e., hydrologic soil group A and B soils)

SITE APPLICABILITY

☑	Rural Use	L	Construction Cost
☑	Suburban Use	M	Maintenance
✱	Urban Use	M	Area Required

STORMWATER MANAGEMENT "CREDITS"

☑ Runoff Reduction

☑ Water Quality Protection

☑ Aquatic Resource Protection

☑ Overbank Flood Protection

☑ Extreme Flood Protection

☑ = practice has been assigned quantifiable stormwater management "credits" that can be used to address this SWM Criteria

STORMWATER MANAGEMENT PRACTICE PERFORMANCE

Runoff Reduction
80% - Annual Runoff Volume
Varies[1] - Runoff Reduction Volume

Pollutant Removal[2]
80% - Total Suspended Solids
80% - Total Phosphorus
80% - Total Nitrogen
N/A - Metals
80% - Pathogens

1 = varies according to storage capacity of the rain garden
2 = expected annual pollutant load removal

Discussion

The primary concern associated with the design of a rain garden is its storage capacity, which directly influences its ability to reduce stormwater runoff rates, volumes and pollutant loads. Site planning and design teams should strive to design rain gardens that can accommodate the stormwater runoff volume generated by the target runoff reduction rainfall event (e.g., 85^{th} percentile rainfall event). If this cannot be accomplished, due to site characteristics or constraints, site planning and design teams should consider using rain gardens in combination with other runoff reducing low impact development practices, such as dry wells (CSS Section 7.8.11) and rainwater harvesting (CSS Section 7.8.12), to provide more substantial reductions in stormwater runoff rates, volumes and pollutant loads.

Various Rain Gardens

Stormwater Management "Credits"

The Center for Watershed Protection (Hirschman et al., 2008) recently documented the ability of rain gardens to reduce annual stormwater runoff volumes and pollutant loads on development sites. Consequently, this low impact development practice has been assigned quantifiable stormwater management "credits" that can be used to help satisfy the SWM Criteria presented in the Georgia Stormwater Management Manual Coastal Stormwater Supplement (CSS). The Table in Appendix E shows how rain gardens can be used to address stormwater runoff reduction, water quality protection, aquatic resource protection, overland flood protection, and extreme flood protection. For further details, refer to Section 7.8.9 of the CSS.

Overall Feasibility

Site planning and design teams should consider various factors to determine whether or not rain gardens are appropriate for use on a particular development site. The Table ? on Pages 3-8 through 3-12 provides design considerations for rain gardens including drainage area, area required, slope, minimum head, minimum depth to water table, and soils. For further details, refer directly to Section 7.8.9 of the CSS.

Feasibility in Coastal Georgia

Several site characteristics commonly encountered in coastal Georgia may present challenges to site planning and design teams that are interested in using rain gardens to "receive" post-construction stormwater runoff on a development site. The following Table identifies these common site characteristics and describes how they influence the use of rain gardens on development sites. The table also provides site planning and design teams with some ideas about how they can work around these potential constraints.

Challenges Associated with Using Rain Gardens in Coastal Georgia		
Site Characteristic	How it Influences the Use of Rain Gardens	Potential Solutions
• *Poorly drained soils*, such as hydrologic soil group C and D soils	• Reduces the ability of rain gardens to reduce stormwater runoff rates, volumes and pollutant loads.	• Use an engineered soil mix instead of amended native soils to create rain garden planting beds in these areas. • Use additional downspout disconnection practices, such as rainwater harvesting (CSS Section 7.8.12) to supplement the stormwater management benefits provided by rain gardens in these areas. • Use rainwater harvesting (CSS Section 7.8.9), small stormwater wetlands (i.e., pocket wetlands) (CSS Section 8.6.2) or wet swales (CSS Section 8.6.6), instead of rain gardens to intercept and treat stormwater runoff in these areas.
• *Well drained soils*, such as hydrologic soil group A and B soils	• Enhances the ability of rain gardens to reduce stormwater runoff rates, volumes and pollutant loads, but may allow stormwater pollutants to reach groundwater aquifers with greater ease.	• Rooftop runoff is relatively clean, so this should not prevent the use of rain gardens, even at stormwater hotspots and in areas known to provide groundwater recharge to water supply aquifers. However, rooftop runoff should not be allowed to comingle with runoff from other impervious surfaces in these

Challenges Associated with Using Rain Gardens in Coastal Georgia		
Site Characteristic	How it Influences the Use of Rain Gardens	Potential Solutions
		areas if it will be "received" by a rain garden. • Use bioretention areas (CSS Section 7.8.13) and dry swales (CSS Section 7.8.15) with liners and underdrains to intercept and treat non rooftop runoff at stormwater hotspots and in areas known to provide groundwater recharge to water supply aquifers.
• *Flat terrain*	• May be difficult to provide adequate drainage and may cause stormwater runoff to pond in the rain garden for extended periods of time.	• Ensure that the underlying native soils will allow the rain garden to drain completely within 24 hours of the end of a rainfall event to prevent the formation of nuisance ponding conditions.
• *Shallow water table*	• May be difficult to provide 2 feet of clearance between the bottom of the rain garden and the top of the water table. • May occasionally cause stormwater runoff to pond in the rain garden.	• Ensure that the distance from the bottom of the rain garden to the top of the water table is at least 2 feet. • Reduce the depth of the planting bed to 18 inches. • Use rainwater harvesting (CSS Section 7.8.12), small stormwater wetlands (i.e., pocket wetlands) (CSS Section 8.6.2) or wet swales (CSS Section 8.6.6), instead of rain gardens to intercept and treat stormwater runoff in these areas.
• *Tidally-influenced drainage system*	• May occasionally prevent stormwater runoff from being conveyed through a rain garden, particularly during high tide.	• Investigate the use of other low impact development practices, such as rainwater harvesting (CSS Section 7.8.12) to "receive" stormwater runoff in these areas.

Site Applicability

Although it may be difficult to use them to "receive" stormwater runoff in urban areas, due to space constraints, rain gardens can be used to "receive" stormwater management on a wide variety of development sites, including residential, commercial and institutional development sites in rural and suburban areas. Although they are particularly well suited to "receive" rooftop runoff, they can also be used to "receive" stormwater runoff from other small drainage areas, such as local streets and roadways, driveways, small parking areas and disturbed pervious areas (e.g., lawns, parks, community open spaces). When compared with other low impact development practices, rain gardens have a relatively low construction cost, a moderate maintenance burden and require only a moderate amount of surface area. (See Table on Pages 8-13 through 3-14)

Planning and Design Criteria

It is *recommended* that the rain gardens used on a development site meet all of the planning and design criteria provided Section 7.8.9 of the CSS to be eligible for the stormwater management "credits".

Construction Considerations

To help ensure that rain gardens are successfully installed on a development site, site planning and design teams should consider the construction recommendations in Section 7.8.9 in the CSS.

Maintenance Requirements

Maintenance is very important for rain gardens, particularly in terms of ensuring that they continue to provide measurable stormwater management benefits over time. Consequently, a legally binding inspection and maintenance agreement and plan should be created to help ensure that they are properly maintained after construction is complete. Table 7.28 in the CSS provides a list of the routine maintenance activities typically associated with rain gardens. It is important to note that rain gardens have maintenance requirements that are very similar to those of other vegetated low impact development practices.

Stormwater Planters

Description

Stormwater planters are landscape planter boxes that are specially designed to “receive” post-construction stormwater runoff. They consist of planter boxes that are equipped with waterproof liners, filled with an engineered soil mix and planted with trees, shrubs and other herbaceous vegetation. Stormwater planters are designed to capture and temporarily store stormwater runoff in the engineered soil mix, where it is subjected to the hydrologic processes of evaporation and transpiration before being conveyed back into the storm drain system through an underdrain.

(Source: Center for Watershed Protection)

KEY CONSIDERATIONS

DESIGN CRITERIA:

- Stormwater planters should be designed to completely drain within 24 hours of the end of a rainfall event
- A maximum ponding depth of 6 inches is recommended within stormwater planters to help prevent the formation of nuisance ponding conditions
- Unless a shallow water table is found on the development site, stormwater planter planting beds should be at least 2 feet deep

BENEFITS:

- Helps restore pre-development hydrology on development sites and reduces post-construction stormwater runoff rates, volumes and pollutant loads
- Can be integrated into development plans as attractive landscaping features
- Particularly well suited for use on urban development sites

LIMITATIONS:

- Can only be used to “receive” runoff from small drainage areas of 2,500 square feet or less

SITE APPLICABILITY

Rural Use	H	Construction Cost
☑ Suburban Use	M	Maintenance
	L	Area Required
☑ Urban Use		

STORMWATER MANAGEMENT “CREDITS”

☑ Runoff Reduction
☑ Water Quality Protection
☑ Aquatic Resource Protection
☑ Overbank Flood Protection
☑ Extreme Flood Protection

☑ = practice has been assigned quantifiable stormwater management “credits” that can be used to address this SWM Criteria

STORMWATER MANAGEMENT PRACTICE PERFORMANCE

Runoff Reduction
40% - Annual Runoff Volume
Varies[1] - Runoff Reduction Volume

Pollutant Removal[2]
80% - Total Suspended Solids
60% - Total Phosphorus
60% - Total Nitrogen
N/A - Metals
80% - Pathogens

1 = varies according to storage capacity of the stormwater planter
2 = expected annual pollutant load removal

Discussion

The primary concern associated with the design of a stormwater planter is its storage capacity, which directly influences its ability to reduce stormwater runoff rates, volumes and pollutant loads. Site planning and design teams should strive to design stormwater planters that can accommodate the stormwater runoff volume generated by the target runoff reduction rainfall event (e.g., 85th percentile rainfall event). If this cannot be accomplished, due to site characteristics or constraints, site planning and design teams should consider using stormwater planters in combination with other runoff reducing low impact development practices, such dry wells (CSS Section 7.8.11) and rainwater harvesting (CSS Section 7.8.12), to supplement the stormwater management benefits provided by the planters.

Various Stormwater Planters

Stormwater Management "Credits"

The Center for Watershed Protection (Hirschman et al., 2008) recently documented the ability of stormwater planters to reduce annual stormwater runoff volumes and pollutant loads on development sites. Consequently, this low impact development practice has been assigned quantifiable stormwater management "credits" that can be used to help satisfy the SWM Criteria presented in the Georgia Stormwater Management Manual Coastal Stormwater Supplement (CSS). The Table in Appendix E shows how stormwater planters can be used to address stormwater runoff reduction, water quality protection, aquatic resource protection, and extreme flood protection. For further details, refer to Section 7.8.10 of the CSS.

Overall Feasibility

Site planning and design teams should consider various factors to determine whether or not stormwater planters are appropriate for use on a particular development site. The Table on Pages 3-8 through 3-12 provides design considerations for stormwater planters including drainage area, area required, slope, minimum head, minimum depth to water table, and soils. For further details, refer directly to Section 7.8.10 of the CSS.

Feasibility in Coastal Georgia

Several site characteristics commonly encountered in coastal Georgia may present challenges to site planning and design teams that are interested in using stormwater planters to "receive" post-construction stormwater runoff on a development site. The following Table identifies these common site characteristics and describes how they influence the use of stormwater planters on development sites. The table also provides site planning and design teams with some ideas about how they can work around these potential constraints.

Challenges Associated with Using Stormwater Planters in Coastal Georgia		
Site Characteristic	How it Influences the Use of Stormwater Planters	Potential Solutions
• *Poorly drained soils*, such as hydrologic soil group C and D soils	• Since they are equipped with waterproof liners and underdrains, the presence of poorly drained soils does not influence the use of stormwater planters on development sites.	
• *Well drained soils*, such as hydrologic soil group A and B soils	• Since they are equipped with waterproof liners and underdrains, the presence of poorly drained soils does not influence the use of stormwater planters on development sites.	
• *Flat terrain*	• May be difficult to provide adequate drainage and may cause stormwater runoff to pond in the stormwater planter for extended periods of time.	• Ensure that the underdrain will allow the stormwater planter to drain completely within 24 hours of the end of a rainfall event to prevent the formation of nuisance ponding conditions.
• *Shallow water table*	• May be difficult to provide 2 feet of clearance between the bottom of the stormwater planter and the top of the water table. • May cause stormwater runoff to pond in the stormwater planter.	• Reduce the depth of the planting bed to 18 inches. • Reduce the distance between the bottom of the stormwater planter and top of the water table to 12 inches and provide an adequately sized underdrain. • Use rainwater harvesting (CSS Section 7.8.12), small stormwater wetlands (i.e., pocket wetlands) (CSS Section 8.6.2) or wet swales (CSS Section 8.6.6), instead of stormwater planters to intercept and treat stormwater runoff in these areas.
• *Tidally-influenced drainage system*	• May occasionally prevent stormwater runoff from being conveyed through a stormwater planter, particularly during high tide.	• Investigate the use of other low impact development practices, such as rainwater harvesting (CSS Section 7.8.12) to “receive” stormwater runoff in these areas.

Site Applicability

Stormwater planters are typically used on commerical, institutional and industrial development sites and, because they can be constructed immediately adjacent to buildings and other structures, they are ideal for use in urban areas. Although they are well suited to "receive" rooftop runoff, they can also be used to "receive" stormwater runoff from other small impervious and pervious drainage areas, such as sidewalks, plazas and small parking lots. When compared with other low impact development practices, stormwater planters have a relatively high construction cost, a moderate maintenance burden and require a relatively small amount of surface area. (See Table on Pages 3-13 through 3-14)

Planning and Design Criteria

It is *recommended* that the stormwater planters used on a development site meet all of the planning and design criteria provided Section 7.8.10 of the CSS to be eligible for the stormwater management "credits.

Construction Considerations

To help ensure that stormwater planters are successfully installed on a development site, site planning and design teams should consider the construction recommendations listed in Section 7.8.10.

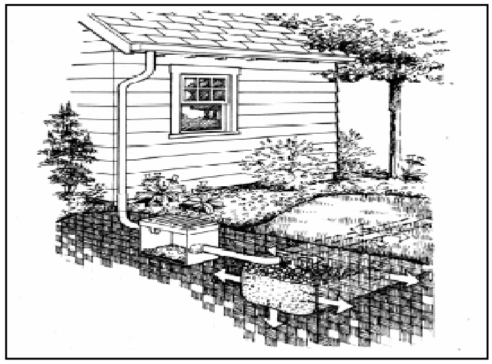
Maintenance Requirements

Maintenance is very important for stormwater planters, particularly in terms of ensuring that they continue to provide measurable stormwater management benefits over time. Table 7.31 in the CSS provides a list of the routine maintenance activities typically associated with stormwater planters. It is important to note that rain gardens have maintenance requirements that are very similar to those of other vegetated low impact development practices.

Dry Wells

Description

Dry wells are low impact development practices that are located below the surface of development sites. They consist of shallow excavations, typically filled with stone, that are designed to intercept and temporarily store post-construction stormwater runoff until it infiltrates into the underlying and surrounding soils. If properly designed, they can provide significant reductions in post-construction stormwater runoff rates, volumes and pollutant loads on development sites.



(Source: City of Portland, OR, 2008)

KEY CONSIDERATIONS

DESIGN CRITERIA:

- Dry wells should be designed to completely drain within 24 hours of the end of a rainfall event
- The distance from the bottom of a dry well to the top of the water table should be least 2 feet
- Dry wells should be designed with slopes that are as close to flat as possible to help ensure that stormwater runoff is evenly distributed throughout the stone reservoir

BENEFITS:

- Helps restore pre-development hydrology on development sites and reduces post-construction stormwater runoff rates, volumes and pollutant loads
- Particularly well suited for use on urban development sites

LIMITATIONS:

- Can only be used to “receive” runoff from small drainage areas of 2,500 square feet or less
- Should not be used on development sites that have soils with infiltration rates of less than 0.5 inches per hour

SITE APPLICABILITY

☑ Rural Use	M Construction Cost
☑ Suburban Use	M Maintenance
☑ Urban Use	L Area Required

STORMWATER MANAGEMENT “CREDITS”

☑ Runoff Reduction

☑ Water Quality Protection

☑ Aquatic Resource Protection

☑ Overbank Flood Protection

☑ Extreme Flood Protection

☑ = practice has been assigned quantifiable stormwater management “credits” that can be used to address this SWM Criteria

STORMWATER MANAGEMENT PRACTICE PERFORMANCE

Runoff Reduction

80% - Annual Runoff Volume

Varies[1] - Runoff Reduction Volume

Pollutant Removal[2]

80% - Total Suspended Solids

80% - Total Phosphorus

80% - Total Nitrogen

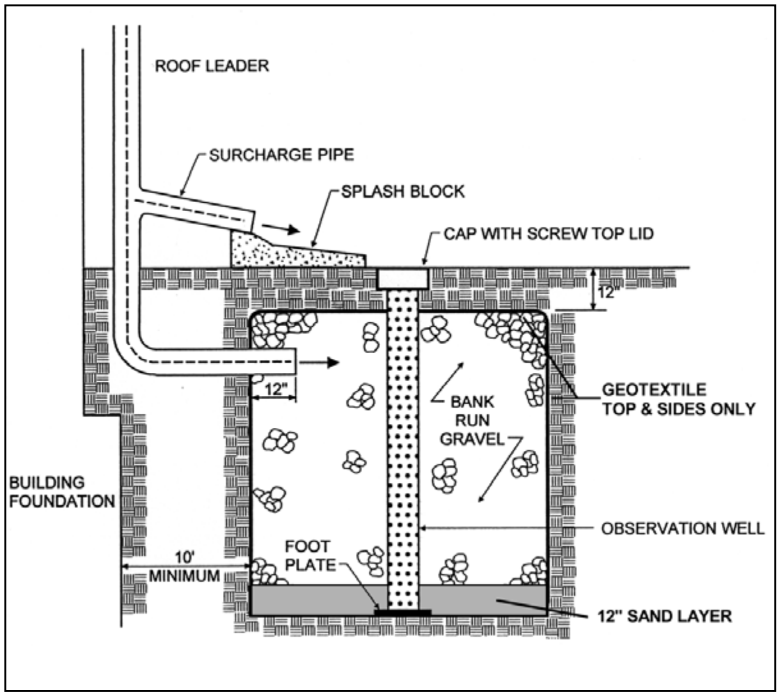
80% - Metals

80% - Pathogens

1 = varies according to storage capacity of the dry well

2 = expected annual pollutant load removal

Discussion



Dry Well
(Source: Maryland Department of the Environment, 2000)

As infiltration-based low impact development practices, dry wells are limited to use in areas where the soils are permeable enough and the water table is low enough to provide for the infiltration of stormwater runoff. They should only be considered for use on development sites where fine sediment (e.g., clay, silt) loads will be relatively low, as high sediment loads will cause them to clog and fail. In addition, dry wells should be carefully sited to avoid the potential contamination of water supply aquifers.

The primary concern associated with the design of a dry well is its storage capacity, which directly influences its ability to reduce stormwater runoff rates, volumes and pollutant loads. Site planning and design teams should strive to design dry wells that can accommodate the stormwater runoff volume generated by the target runoff reduction rainfall event (e.g., 85th percentile rainfall event). If this cannot be accomplished, due to site characteristics or constraints, site planning and design teams should consider using dry wells in combination with other runoff reducing low impact development practices, such as rain gardens (CSS Section 7.8.9) and rainwater harvesting (CSS Section 7.8.12), to supplement the stormwater management benefits provided by the dry wells.

Stormwater Management "Credits"

The Center for Watershed Protection (Hirschman et al., 2008) recently documented the ability of dry wells to reduce annual stormwater runoff volumes and pollutant loads on development sites. Consequently, this low impact practice has been assigned quantifiable stormwater management "credits" that can be used to help satisfy the SWM Criteria presented in the Georgia Stormwater Management Manual Coastal Stormwater Supplement (CSS). The Table in Appendix E shows how dry wells can be used to address stormwater runoff reduction, water quality protection, aquatic resource protection, overland flood protection, and extreme flood protection. For further details, refer to Section 7.8.11 of the CSS.

Overall Feasibility

Site planning and design teams should consider various factors to determine whether or not dry wells are appropriate for use on a particular development site. The Table on Pages 3-8 through 3-12 provides design considerations for dry wells including drainage area, area required, slope, minimum head, minimum depth to water table, and soils. For further details, refer directly to Section 7.8.11 of the CSS.

<u>Feasibility in Coastal Georgia</u>

Several site characteristics commonly encountered in coastal Georgia may present challenges to site planning and design teams that are interested in using dry wells to "receive" post-construction stormwater runoff on a development site. The Table identifies these common site characteristics and describes how they influence the use of dry wells on development sites. The table also provides site planning and design teams with some ideas about how they can work around these potential constraints.

Challenges Associated with Using Dry Wells in Coastal Georgia		
Site Characteristic	How it Influences the Use of Dry Wells	Potential Solutions
• *Poorly drained soils*, such as hydrologic soil group C and D soils	• Reduces the ability of dry wells to reduce stormwater runoff rates, volumes and pollutant loads.	• Dry wells should not be used on development sites that have soils with infiltration rates of less than 0.5 inches per hour (i.e., hydrologic soil group C and D soils). • Use other low impact development practices, such as rainwater harvesting (CSS Section 7.8.12) and underdrained bioretention areas (CSS Section 7.8.13), to "receive" stormwater runoff in these areas.
• *Well drained soils*, such as hydrologic soil group A and B soils	• Enhances the ability of dry wells to reduce stormwater runoff rates, volumes and pollutant loads, but may allow stormwater pollutants to reach groundwater aquifers with greater ease.	• Rooftop runoff is relatively clean, so this should not prevent the use of dry wells, even at stormwater hotspots and in areas known to provide groundwater recharge to water supply aquifers. However, rooftop runoff should not be allowed to comingle with runoff from other impervious surfaces in these areas if it will be "received" by a dry well. • Use bioretention areas (CSS Section 7.8.13) and dry swales (CSS Section 7.8.15) with liners and underdrains to intercept and treat non rooftop runoff at stormwater hotspots and in areas known to provide groundwater recharge to water supply aquifers.
• *Flat terrain*	• Does not influence the use of dry wells. In fact, dry wells should be designed with slopes that are as close to flat as possible.	

Challenges Associated with Using Dry Wells in Coastal Georgia		
Site Characteristic	How it Influences the Use of Dry Wells	Potential Solutions
• *Shallow water table*	• May be difficult to provide 2 feet of clearance between the bottom of the dry well and the top of the water table. • May occasionally cause stormwater runoff to pond in the bottom of the dry well.	• Ensure that the distance from the bottom of the dry well to the top of the water table is at least 2 feet. • Reduce the depth of the stone reservoir in dry wells to 18 inches. • Use rainwater harvesting (CSS Section 7.8.12), small stormwater wetlands (i.e., pocket wetlands) (CSS Section 8.6.2) or wet swales (CSS Section 8.6.6), instead of dry wells to intercept and treat stormwater runoff in these areas.
• *Tidally-influenced drainage system*	• Does not influence the use of dry wells.	

Site Applicability

Dry wells can be used to "receive" stormwater runoff on a wide variety of development sites, including residential, commercial and institutional development sites in rural, suburban and urban areas. Although they are particularly well suited to "receive" rooftop runoff, they can also be used to "receive" stormwater runoff from other small drainage areas, such as local streets and roadways, driveways, small parking areas and disturbed pervious areas (e.g., lawns, parks, community open spaces). When compared with other low impact development practices, dry wells have a moderate construction cost, a moderate maintenance burden and require only a small amount of surface area. (See Table on Pages 3-13 through 3-14)

Planning and Design Criteria

It is *recommended* that the dry wells used on a development site meet all of the planning and design criteria provided Section 7.8.11 of the CSS to be eligible for the stormwater management "credits".

Construction Considerations

To help ensure that dry wells are successfully installed on a development site, site planning and design teams should consider the construction recommendations in Section 7.8.11 in the CSS.

Maintenance Requirements

Maintenance is important for dry wells, particularly in terms of ensuring that they continue to provide measurable stormwater management benefits over time. Table 7.34 in the CSS provides a list of the routine maintenance activities typically associated with dry wells.

Rainwater Harvesting

Description

Rainwater harvesting is the ancient stormwater management practice of intercepting, diverting and storing rainfall for later use. In a typical rainwater harvesting system, rainfall is collected from a gutter and downspout system, screened and "washed," and conveyed into an above- or below-ground storage tank or cistern. Once captured in the storage tank or cistern, it may be used for non-potable indoor or outdoor uses. Rainwater harvesting also helps reduce the demand on public water supplies, which, in turn, helps protect aquatic resources, such as groundwater aquifers, from drawdown and seawater intrusion.

(Source: Jones and Hunt, 2008)

KEY CONSIDERATIONS

DESIGN CRITERIA:

- Rainwater harvesting systems should be sized based on the size of the contributing drainage area, local rainfall patterns and the projected demand for the harvested rainwater
- Pretreatment should be provided upstream of all rainwater harvesting systems to prevent leaves and other debris from clogging the system

BENEFITS:

- Helps restore pre-development hydrology on development sites and reduces post-construction stormwater runoff rates, volumes and pollutant loads
- Can be used on nearly any development site
- Reduces demand on public water supplies, which helps protect groundwater aquifers from drawdown and seawater intrusion

LIMITATIONS:

- Rain barrels may not be used except on small drainage areas of 2,500 square feet or less
- Stored rainwater should be used on a regular basis to maintain system storage capacity

SITE APPLICABILITY

☑ Rural Use	M Construction Cost
☑ Suburban Use	H Maintenance
☑ Urban Use	L Area Required

STORMWATER MANAGEMENT "CREDITS"

☑ Runoff Reduction

☑ Water Quality Protection

☑ Aquatic Resource Protection

☑ Overbank Flood Protection

☑ Extreme Flood Protection

☑ = practice has been assigned quantifiable stormwater management "credits" that can be used to address this SWM Criteria

STORMWATER MANAGEMENT PRACTICE PERFORMANCE

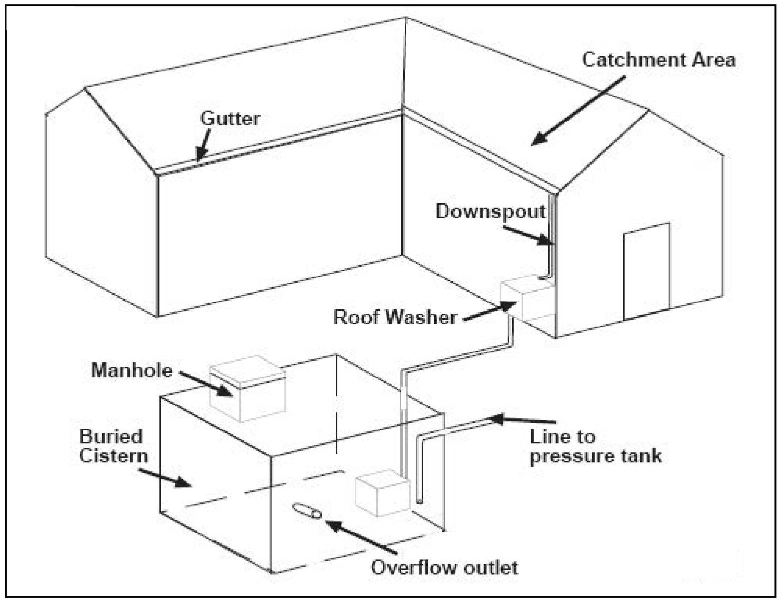
Runoff Reduction
Varies[1] - Annual Runoff Volume
Varies[1] - Runoff Reduction Volume

Pollutant Removal[2]
Varies[1] - Total Suspended Solids
Varies[1] - Total Phosphorus
Varies[1] - Total Nitrogen
Varies[1] - Metals
N/A - Pathogens

1 = varies according to storage capacity of the rainwater harvesting system
2 = expected annual pollutant load removal

Discussion

There are two basic types of rainwater harvesting systems: (1) systems that are used to supply water for non-potable outdoor uses, such as landscape irrigation, car and building washing and fire fighting; and (2) systems that are used to supply water for non-potable indoor uses, such as laundry and toilet flushing. Rainwater harvesting systems used to supply water for non-potable indoor uses are more complex and require separate plumbing, pressure tanks, pumps and backflow preventers. Additionally, the use of harvested rainwater for non-potable indoor uses may be restricted in some areas of coastal Georgia, due to existing "development rules." Developers and their site planning and design teams are encouraged to consult with the local development review authority if they are interested in using harvested rainwater for non-potable indoor uses.



Rainwater Harvesting System
(Source: Rupp, 1998)

Whether it is used to supply water for non-potable indoor or outdoor uses, a well-designed rainwater harvesting system typically consists of five major components, including the collection and conveyance system (e.g., gutter and downspout system), pretreatment devices (e.g., leaf screens, first flush diverters, roof washers), the storage tank or cistern, the overflow pipe (which allows excess stormwater runoff to bypass the storage tank or cistern) and the distribution system (which may or may not require a pump, depending on site characteristics). When designing a rainwater harvesting system, site planning and design teams should consider each of these components, as well as the size of the contributing drainage area, local rainfall patterns and the projected water demand, to determine how large the cistern or storage tank must be to provide enough water for the desired non-potable indoor or outdoor use.

Major Components of a Rainwater Harvesting System
(Source: Jones and Hunt, 2008)

Stormwater Management "Credits"

The Center for Watershed Protection (Hirschman et al., 2008) recently documented the ability of rainwater harvesting systems to reduce stormwater runoff volumes and pollutant loads on development sites. Consequently, this low impact development practice has been assigned quantifiable stormwater management "credits" that can be used to help satisfy the SWM Criteria presented in the Georgia Stormwater Management Manual Coastal Stormwater Supplement (CSS). The Table in Appendix E shows how rainwater harvesting systems can be used to address stormwater runoff reduction, water quality protection, aquatic resource protection, overland flood protection, and extreme flood protection. For further details, refer to Section 7.8.12 of the CSS.

Overall Feasibility

Site planning and design teams should consider various factors to determine whether or not rainwater harvesting systems are appropriate for use on a particular development site. The Table on Pages 3-8 through 3-12 provides design considerations for rainwater harvesting systems including drainage area, area required, slope, minimum head, minimum depth to water table, and soils. For further details, refer directly to Section 7.8.12 of the CSS.

Site Applicability

Rainwater harvesting systems can be used on a wide variety of development sites in rural, suburban and urban areas. They are especially well suited for use on commercial, institutional, municipal and multi-family residential buildings on urban and suburban development and redevelopment sites. When compared with other low impact development practices, rainwater harvesting systems have a moderate construction cost, a relatively high maintenance burden and require a relatively small amount of surface area. Although they can be expensive to install, rainwater harvesting systems are often a component of "green buildings," such as those that achieve certification in the Leadership in Energy and Environmental Design (LEED) Green Building Rating System. (See Table on Pages 3-13 through 3-14)

Planning and Design Criteria

It is *recommended* that the rainwater harvesting systems used on a development site meet all of the planning and design criteria provided Section 7.8.12 of the CSS to be eligible for the stormwater management "credits".

Construction Considerations

To help ensure that rainwater harvesting systems are successfully installed on a development site, site planning and design teams should consider the following construction recommendations listed in Section 7.8.12 of the CSS.

Maintenance Requirements

Maintenance is important for rainwater harvesting systems, particularly in terms of ensuring that they continue to provide measurable stormwater management benefits over time. Table 7.36 in the CSS provides a list of the routine maintenance activities typically associated with rainwater harvesting systems.

Bioretention Areas

Description

Bioretention areas, which may also be classified as a low impact development practice (CSS Section 7.8.13), are shallow depressional areas that are filled with an engineered soil mix and are planted with trees, shrubs and other herbaceous vegetation. They are designed to capture and temporarily store stormwater runoff in the engineered soil mix, where it is subjected to the hydrologic processes of evaporation and transpiration, before being conveyed back into the storm drain system through an underdrain or allowed to infiltrate into the surrounding soils. This allows them to provide measurable reductions in post-construction stormwater runoff rates, volumes and pollutant loads on development sites.

(Source: Center for Watershed Protection)

KEY CONSIDERATIONS

DESIGN CRITERIA:

- Bioretention areas should be designed to completely drain within 48 hours of the end of a rainfall event
- A maximum ponding depth of 9 inches is recommended within bioretention areas to help prevent the formation of nuisance ponding conditions
- Unless a shallow water table is found on the development site, bioretention area planting beds should be at least 3 feet deep

BENEFITS:

- Helps restore pre-development hydrology on development sites and reduces post-construction stormwater runoff rates, volumes and pollutant loads
- Can be integrated into development plans as attractive landscaping features

LIMITATIONS:

- Can only be used to manage runoff from relatively small drainage areas of 5 acres in size

SITE APPLICABILITY

☑ Rural Use	[M] Construction Cost
☑ Suburban Use	[M] Maintenance
☑ Urban Use	[L] Area Required

STORMWATER MANAGEMENT "CREDITS"

☑ Runoff Reduction
☑ Water Quality Protection
☑ Aquatic Resource Protection
☑ Overbank Flood Protection
☑ Extreme Flood Protection

☑ = practice has been assigned quantifiable stormwater management "credits" that can be used to address this SWM Criteria

STORMWATER MANAGEMENT PRACTICE PERFORMANCE

Runoff Reduction
40%/80% - Annual Runoff Volume
Varies[1] - Runoff Reduction Volume

Pollutant Removal[2]
80% - Total Suspended Solids
60% - Total Phosphorus
60% - Total Nitrogen
N/A - Metals
80% - Pathogens

1 = varies according to storage capacity of the bioretention area
2 = expected annual pollutant load removal

Discussion

Bioretention areas are one of the most effective stormwater management practices that can be used in coastal Georgia to reduce post-construction stormwater runoff rates, volumes and pollutant loads. They also provide a number of other benefits, including improved aesthetics, wildlife habitat, urban heat island mitigation and improved air quality. Bioretention areas differ from rain gardens (CSS Section 7.8.9), in that they are designed to receive stormwater runoff from larger drainage areas and may be equipped with an underdrain.

Various Bioretention Areas

Stormwater Management "Credits"

Bioretention areas have been assigned quantifiable stormwater management "credits" that can be used to help satisfy the SWM Criteria presented in the Georgia Stormwater Management Manual Coastal Stormwater Supplement (CSS). The Table in Appendix E shows how bioretention can be used to address stormwater runoff reduction, water quality protection, aquatic resource protection, overland flood protection, and extreme flood protection. For further details, refer to Section 8.6.3 of the CSS.

Overall Feasibility

Site planning and design teams should consider various factors to determine whether or not bioretention is appropriate for use on a particular development site. The Table on Pages 3-8 through 3-12 provides design considerations for bioretention including drainage area, area required, slope, minimum head, minimum depth to water table, and soils. For further details, refer directly to Section 8.6.3 of the CSS.

Feasibility in Coastal Georgia

Several site characteristics commonly encountered in coastal Georgia may present challenges to site planning and design teams that are interested in using bioretention areas to manage post-construction stormwater runoff on a development site. The following Table identifies these common site characteristics and describes how they influence the use of bioretention areas on development sites. The table also provides site planning and design teams with some ideas about how they can work around these potential constraints.

Challenges Associated with Using Bioretention Areas in Coastal Georgia		
Site Characteristic	How it Influences the Use of Bioretention Areas	Potential Solutions
• *Poorly drained soils*, such as hydrologic soil group C and D soils	• Reduces the ability of bioretention areas to reduce stormwater runoff rates, volumes and pollutant loads.	• Use underdrained bioretention areas to manage post-construction stormwater runoff in these areas. • Use additional low impact development and stormwater management practices to supplement the stormwater management benefits provided by bioretention areas in these areas. • Use rainwater harvesting (CSS Section 7.8.12), small stormwater wetlands (i.e., pocket wetlands) (CSS Section 8.6.2) or wet swales (CSS Section 8.6.6), instead of bioretention areas to intercept and treat stormwater runoff in these areas.

Challenges Associated with Using Bioretention Areas in Coastal Georgia		
Site Characteristic	How it Influences the Use of Bioretention Areas	Potential Solutions
• *Well drained soils*, such as hydrologic soil group A and B soils	• Enhances the ability of bioretention areas to reduce stormwater runoff rates, volumes and pollutant loads, but may allow stormwater pollutants to reach groundwater aquifers with greater ease.	• Avoid the use of infiltration-based stormwater management practices, including non-underdrained bioretention areas, at stormwater hotspots and in areas known to provide groundwater recharge to water supply aquifers, unless adequate pretreatment is provided upstream of them. • Use bioretention areas and dry swales (CSS Section 8.6.6) with liners and underdrains at stormwater hotspots and in areas known to provide groundwater recharge to water supply aquifers.
• *Flat terrain*	• May be difficult to provide adequate drainage and may cause stormwater runoff to pond in the bioretention area for extended periods of time.	• Ensure that the underlying native soils will allow the bioretention area to drain completely within 48 hours of the end of a rainfall event to prevent the formation of nuisance ponding conditions.
• *Shallow water table*	• May be difficult to provide 2 feet of clearance between the bottom of the bioretention area and the top of the water table. • May occasionally cause stormwater runoff to pond in the bioretention area.	• Ensure that the distance from the bottom of the bioretention area to the top of the water table is at least 2 feet. • Reduce the depth of the planting bed to 18 inches. • Use stormwater ponds (CSS Section 8.6.1), stormwater wetlands (CSS Section 8.6.2) and wet swales (CSS Section 8.6.6), instead of bioretention areas to intercept and treat stormwater runoff in these areas.

Adapted/abbreviated from GSWMM Coastal Stormwater Supplement, August 2009.

Challenges Associated with Using Bioretention Areas in Coastal Georgia		
Site Characteristic	How it Influences the Use of Bioretention Areas	Potential Solutions
• *Tidally-influenced drainage system*	• May occasionally prevent stormwater runoff from being conveyed through a bioretention area, particularly during high tide.	• Investigate the use of other low impact development and stormwater management practices, such as rainwater harvesting (CSS Section 7.8.12) to manage post-construction stormwater runoff in these areas.

Site Applicability

Bioretention areas can be used to manage post-construction stormwater runoff on a wide variety of development sites, including residential, commercial and institutional development sites in rural, suburban and urban areas. They are well suited to "receive" stormwater runoff from nearly all small impervious and pervious drainage areas, including local streets and roadways, highways, driveways, small parking areas and disturbed pervious areas (e.g., lawns, parks, community open spaces). When compared with other stormwater management practices, bioretention areas have a moderate construction cost, a moderate maintenance burden and require a relatively small amount of surface area. (See Table on Pages 3-13 through 3-14)

Planning and Design Criteria

It is *recommended* that the bioretention areas used on a development site meet all of the planning and design criteria provided in Section 8.6.3 of the CSS to be eligible for the stormwater management "credits".

Construction Considerations

To help ensure that bioretention areas are successfully installed on a development site, site planning and design teams should consider the construction recommendations listed in Section 8.6.3 of the CSS.

Maintenance Requirements

Maintenance is very important for bioretention areas, particularly in terms of ensuring that they continue to provide measurable stormwater management benefits over time. Table 8.12 in the CSS provides a list of the routine maintenance activities typically associated with bioretention areas.

Infiltration Practices

Description

Infiltration practices, which may also be classified as a runoff reducing low impact development practice (Section 7.8.14), are shallow excavations, typically filled with stone or an engineered soil mix, that are designed to intercept and temporarily store post-construction stormwater runoff until it infiltrates into the underlying and surrounding soils. If properly designed, they can provide significant reductions in post-construction stormwater runoff rates, volumes and pollutant loads on development sites.

(Source: Center for Watershed Protection)

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KEY CONSIDERATIONS

DESIGN CRITERIA:
- Pretreatment should be provided upstream of all infiltration practices
- Infiltration practices should be designed to completely drain within 48 hours of the end of a rainfall event
- Underlying native soils should have an infiltration rate of 0.5 in/hr or more
- The distance from the bottom of an infiltration practice to the top of the water table should be 2 feet or more

BENEFITS:
- Helps restore pre-development hydrology on development sites and reduces post-construction stormwater runoff rates, volumes and pollutant loads
- Can be integrated into development plans as attractive landscaping features

LIMITATIONS:
- Can only be used to manage runoff from relatively small drainage areas of 2-5 acres in size
- Should not be used to "receive" stormwater runoff that contains high sediment loads

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STORMWATER MANAGEMENT "CREDITS"

☑ Runoff Reduction
☑ Water Quality Protection
☑ Aquatic Resource Protection
☑ Overbank Flood Protection
☑ Extreme Flood Protection

☑ = practice has been assigned quantifiable stormwater management "credit" that can be used to address this SWM Criteria

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SITE APPLICABILITY

☑ Rural Use — [M] Construction Cost
☑ Suburban Use — [H] Maintenance
☑ Urban Use — [L] Area Required

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STORMWATER MANAGEMENT PRACTICE PERFORMANCE

Runoff Reduction
80% - Annual Runoff Volume
Varies[1] - Runoff Reduction Volume

Pollutant Removal[2]
80% - Total Suspended Solids
60% - Total Phosphorus
60% - Total Nitrogen
N/A - Metals
80% - Pathogens

1 = varies according to storage capacity of the infiltration practice
2 = expected annual pollutant load removal

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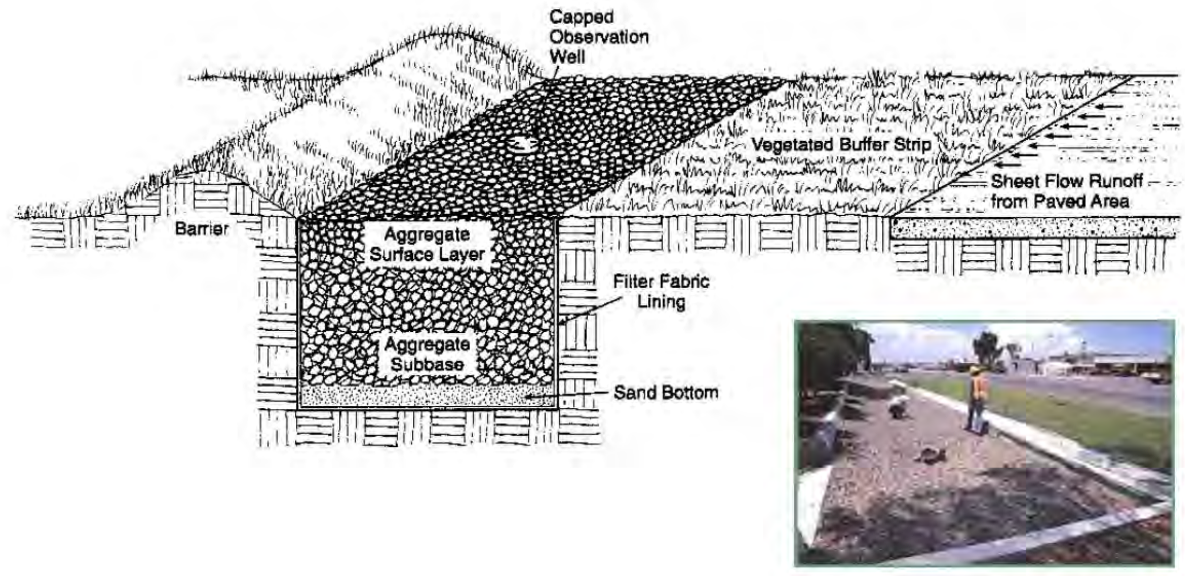
Discussion



Infiltration Trench
(Source: Center for Watershed Protection)

Although infiltration practices can provide significant reductions in post-construction stormwater runoff rates, volumes and pollutant loads, they have historically experienced high rates of failure due to clogging caused by poor design, poor construction and neglected maintenance. If infiltration practices are to be used on a development site, great care should be taken to ensure that they are adequately designed, carefully installed and properly maintained over time. They should only be applied on development sites that have permeable soils (i.e., hydrologic soil group A and B soils) and that have a water table and confining layers (e.g., bedrock, clay lenses) that are located at least 2 feet below the bottom of the trench or basin. Additionally, infiltration practices should always be designed with adequate pretreatment (e.g., vegetated filter strip, sediment forebay) to prevent sediment from reaching them and causing them to clog and fail.

There are two major variations of infiltration practices, namely infiltration trenches and infiltration basins. A brief description of each of these design variants is provided below:

- Infiltration Trenches: Infiltration trenches are excavated trenches filled with stone. Stormwater runoff is captured and temporarily stored in the stone reservoir, where it is allowed to infiltrate into the surrounding and underlying native soils. Infiltration trenches can be used to manage post-construction stormwater runoff from contributing drainage areas of up to 2 acres in size and should only be used on development sites where sediment loads can be kept relatively low.
- Infiltration Basins: Infiltration basins are shallow, landscaped excavations filled with an engineered soil mix. They are designed to capture and temporarily store stormwater runoff in the engineered soil mix, where it is subjected to the hydrologic processes of evaporation and transpiration, before being allowed to infiltrate into the surrounding soils. They are essentially non-underdrained bioretention areas (CSS Section 8.6.3), and should also only be used on development sites where sediment loads can be kept relatively low.

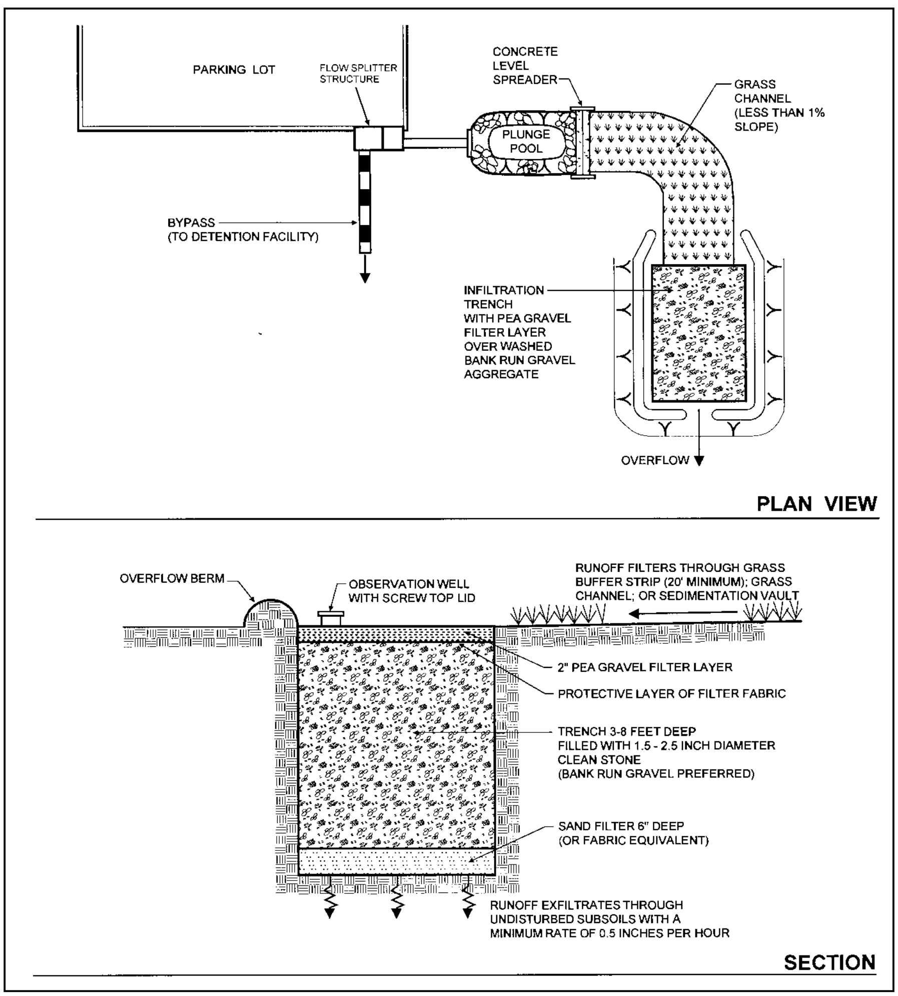
Infiltration Trench

Infiltration Basin (During Installation)

Infiltration Practices

Stormwater Management "Credits"

Infiltration practices have been assigned quantifiable stormwater management "credits" that can be used to help satisfy the SWM Criteria presented in the Georgia Stormwater Management Manual Coastal Stormwater Supplement (CSS). The Table in Appendix E shows how infiltration practices can be used to address stormwater runoff reduction, water quality protection, aquatic resource protection, and extreme flood protection. For further details, refer to Section 8.6.5 of the CSS.



Overall Feasibility

Site planning and design teams should consider various factors to determine whether or not infiltration practices is appropriate for use on a particular development site. The Table on Pages 3-8 through 3-12 provides design considerations for infiltration including drainage area, area required, slope, minimum head, minimum depth to water table, and soils. For further details, refer directly to Section 8.6.5 of the CSS.

Feasibility in Coastal Georgia

Several site characteristics commonly encountered in coastal Georgia may present challenges to site planning and design teams that are interested in using infiltration practices to manage post-construction stormwater runoff on a development site. The following Table identifies these common site characteristics and describes how they influence the use of infiltration practices on development sites. The table also provides site planning and design teams with some ideas about how they can work around these potential constraints.

Challenges Associated with Using Infiltration Practices in Coastal Georgia		
Site Characteristic	How it Influences the Use of Infiltration Practices	Potential Solutions
• *Poorly drained soils*, such as hydrologic soil group C and D soils	• Reduces the ability of infiltration practices to reduce stormwater runoff rates, volumes and pollutant loads.	• Infiltration practices should not be used on development sites that have soils with infiltration rates of less than 0.25 inches per hour (i.e., hydrologic soil group C and D soils). • Use other low impact development and stormwater management practices, such as rainwater harvesting (CSS Section 7.8.12) and underdrained bioretention areas (CSS Section 8.6.3), to manage post-construction stormwater runoff in these areas.
• *Well drained soils*, such as hydrologic soil group A and B soils	• Enhances the ability of infiltration practices to reduce stormwater runoff rates, volumes and pollutant loads, but may allow stormwater pollutants to reach groundwater aquifers with greater ease.	• Avoid the use of infiltration-based stormwater management practices, including infiltration practices, at stormwater hotspots and in areas known to provide groundwater recharge to water supply aquifers, unless adequate pretreatment is provided upstream of them. • Use bioretention areas (CSS Section 8.6.3) and dry swales (CSS Section 8.6.6) with liners and underdrains at stormwater hotspots and in areas known to provide groundwater recharge to water supply aquifers.

Challenges Associated with Using Infiltration Practices in Coastal Georgia		
Site Characteristic	How it Influences the Use of Infiltration Practices	Potential Solutions
• *Flat terrain*	• Does not influence the use of infiltration practices. In fact, infiltration practices should be designed with slopes that are as close to flat as possible.	
• *Shallow water table*	• May be difficult to provide 2 feet of clearance between the bottom of the infiltration practice and the top of the water table. • May occasionally cause stormwater runoff to pond in the bottom of the infiltration practice.	• Ensure that the distance from the bottom of the infiltration practice to the top of the water table is at least 2 feet. • Reduce the depth of the stone reservoir in infiltration trenches to 18 inches. • Reduce the depth of the planting bed in infiltration basins to 18 inches. • Use stormwater ponds (CSS Section 8.6.1), stormwater wetlands (Section 8.6.2) and wet swales (CSS Section 8.6.6), instead of infiltration practices to intercept and treat stormwater runoff in these areas.
• *Tidally-influenced drainage system*	• Does not influence the use of infiltration practices.	

Site Applicability

Infiltration practices can be used to manage post-construction stormwater runoff on development sites in rural, suburban and urban areas where the soils are permeable enough and the water table is low enough to provide for the infiltration of stormwater runoff. While infiltration trenches are particularly well-suited for use on small, medium-to-high density development sites, infiltration basins can be used on larger, lower density development sites. Infiltration practices should only be considered for use on development sites where fine sediment (e.g., clay, silt) loads will be relatively low, as high sediment loads will cause them to clog and fail. In addition, infiltration practices should be carefully sited to avoid the potential contamination of water supply aquifers. When compared with other stormwater management practices, infiltration practices have a moderate construction cost, a moderate maintenance burden and require a relatively small amount of surface area. (See Table on Pages 3-13 through 3-14)

Planning and Design Criteria

It is *recommended* that infiltration used on a development site meet all of the planning and design criteria provided in Section 8.6.5 of the CSS to be eligible for the stormwater management "credits.

Construction Considerations

To help ensure that infiltration practices are successfully installed on a development site, site planning and design teams should consider the construction recommendations listed in Section 8.6.5 of the CSS.

Maintenance Requirements

Maintenance is very important for infiltration practices, particularly in terms of ensuring that they continue to provide measurable stormwater management benefits over time. Table 8.18 in the CSS provides a list of the routine maintenance activities typically associated with infiltration practices.

Swales

Description

Swales are vegetated open channels that are designed to manage post-construction stormwater runoff within wet or dry cells formed by check dams or other control structures (e.g., culverts). They are designed with relatively mild slopes to force stormwater runoff to flow through them slowly and at relatively shallow depths, which encourages sediment and other stormwater pollutants to settle out. Swales differ from grass channels (CSS Section 7.8.7), in that they are designed with specific features that enhance their ability to manage stormwater runoff rates, volumes and pollutant loads on development sites.

(Source: Center for Watershed Protection)

KEY CONSIDERATIONS

DESIGN CRITERIA:

- Maximum contributing drainage area of 5 acres or less
- Swales should be designed to safely convey the overbank flood protection rainfall event (e.g., 25-year, 24-hour event)
- Swales may be designed with a slope of between 0.5% and 4%, although a slope of between 1% and 2% is recommended
- Swales should be designed to be between 2 and 8 feet wide to prevent channel braiding

BENEFITS:

- Provides moderate to high removal of many of the pollutants of concern typically contained in post-construction stormwater runoff
- Less expensive than traditional drainage (e.g., curb and gutter, storm drain) systems

LIMITATIONS:

- Can only be used to manage runoff from relatively small drainage areas of 5 acres in size
- Should not be used on development or redevelopment sites with slopes of less than 0.5%
- Potential for nuisance ponding to occur in wet swales

SITE APPLICABILITY

☑ Rural Use	M Construction Cost
☑ Suburban Use	M Maintenance
✱ Urban Use	M Area Required

STORMWATER MANAGEMENT "CREDITS"

☑ Runoff Reduction
☑ Water Quality Protection
☑ Aquatic Resource Protection
☑ Overbank Flood Protection
☑ Extreme Flood Protection

☑ = practice has been assigned quantifiable stormwater management "credits" that can be used to address this SWM Criteria

STORMWATER MANAGEMENT PRACTICE PERFORMANCE

Runoff Reduction
0%[1]/40%-80%[2] - Annual Runoff Volume
0%[1]/Varies[3] - Runoff Reduction Volume

Pollutant Removal[4]
80%[1]/80%[2] - Total Suspended Solids
30%[1]/50%[2] - Total Phosphorus
30%[1]/50%[2] - Total Nitrogen
20%[1]/40%[2]- Metals
N/A - Pathogens

1 = wet swale
2 = dry swale
3= varies according to storage capacity of the dry swale
4 = expected annual pollutant load removal

Discussion

There are several variations of swales that can be used to manage post-construction stormwater runoff on development sites, the most common of which include dry swales and wet swales. A brief description of each of these design variants is provided below:

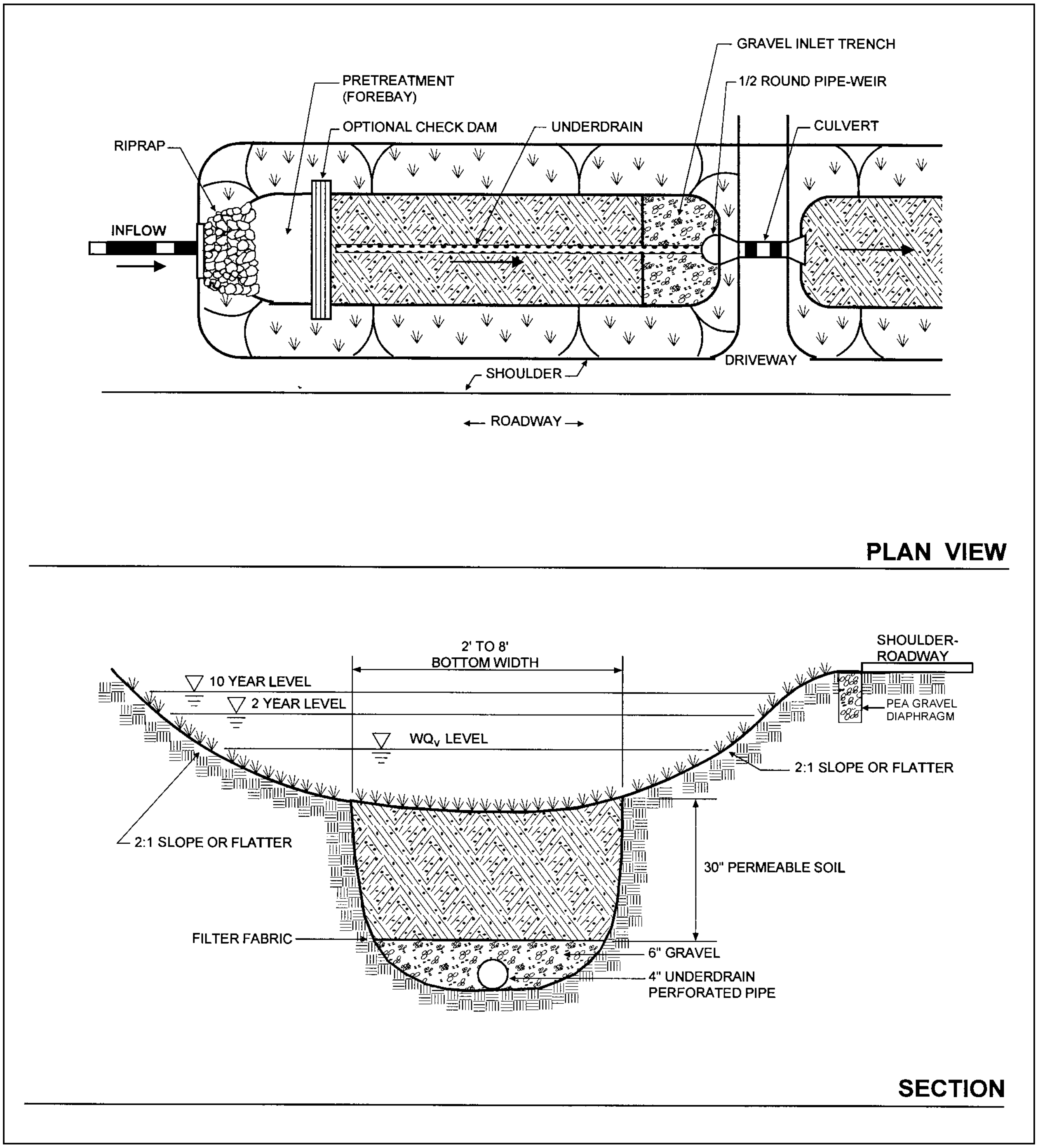
- *Dry Swales*: Dry swales (also known as *bioswales*), which may also be classified as a low impact development practice (CSS Section 7.8.15), are vegetated open channels that are filled with an engineered soil mix and are planted with trees, shrubs and other herbaceous vegetation. They are essentially linear bioretention areas (Section 8.6.3), in that they are designed to capture and temporarily store stormwater runoff in the engineered soil mix, where it is subjected to the hydrologic processes of evaporation and transpiration, before being conveyed back into the storm drain system through an underdrain or allowed to infiltrate into the surrounding soils. This allows them to provide measurable reductions in post-construction stormwater runoff rates, volumes and pollutant loads on development sites.

- *Wet Swales*: Wet swales (also known as *wetland channels* or *linear stormwater wetlands*) are vegetated channels designed to retain water and maintain hydrologic conditions that support the growth of wetland vegetation. A high water table or poorly drained soils are necessary to maintain a permanent water surface within a wet swale. The wet swale essentially acts as a linear wetland treatment system, where the stormwater runoff volume generated by the target runoff reduction rainfall event (e.g., 85th percentile rainfall event) is intercepted and treated over time.

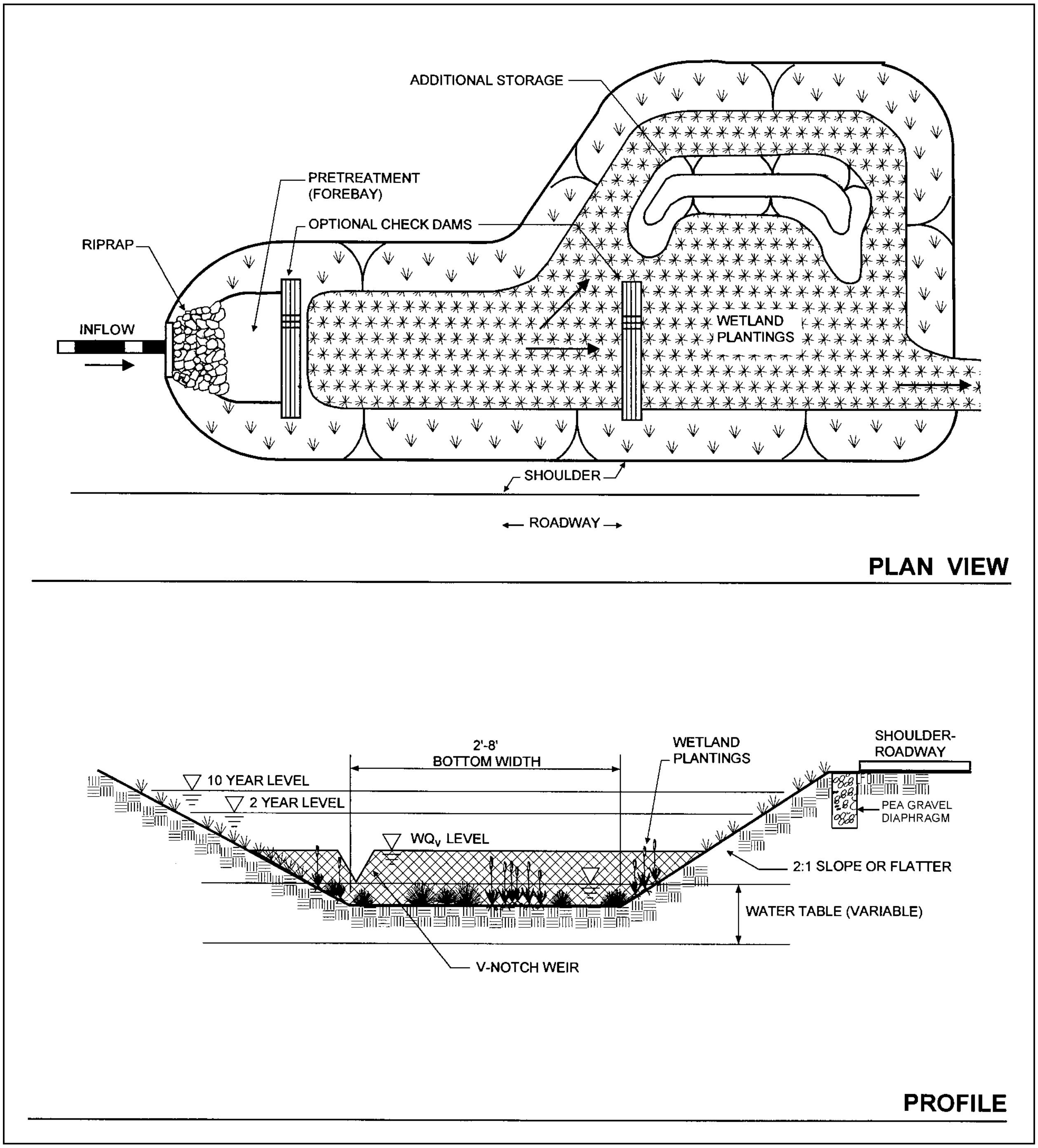
Dry Swale

Wet Swale

Various Swales



Schematic of a Typical Dry Swale
(Source: Center for Watershed Protection)



Schematic of a Typical Wet Swale
(Source: Center for Watershed Protection)

Stormwater Management "Credits"

Swales have been assigned quantifiable stormwater management "credits" that can be used to help satisfy the SWM Criteria presented in the Georgia Stormwater Management Manual Coastal Stormwater Supplement (CSS). The Table in Appendix E shows how swales can be used to address stormwater runoff reduction, water quality protection, aquatic resource protection, overland flood protection, and extreme flood protection. For further details, refer to Section 8.6.6 of the CSS.

Overall Feasibility

Site planning and design teams should consider various factors to determine whether or not swales are appropriate for use on a particular development site. The Table on Pages 3-8 through 3-12 provides design considerations for swales including drainage area, area required, slope, minimum head, minimum depth to water table, and soils. For further details, refer directly to Section 8.6.6 of the CSS.

Feasibility in Coastal Georgia

Several site characteristics commonly encountered in coastal Georgia may present challenges to site planning and design teams that are interested in using swales to manage post-construction stormwater runoff on a development site. The following Table identifies these common site characteristics and describes how they influence the use of swales on development sites. The table also provides site planning and design teams with some ideas about how they can work around these potential constraints.

Challenges Associated with Using Swales in Coastal Georgia		
Site Characteristic	How it Influences the Use of Swales	Potential Solutions
• *Poorly drained soils*, such as hydrologic soil group C and D soils	• Since they are designed to have a permanent water surface, the presence of poorly drained soils does not influence the use of wet swales on development sites. In fact, the presence of poorly drained soils may help maintain a permanent water surface within a wet swale. • Reduces the ability of dry swales to reduce stormwater runoff rates, volumes and pollutant loads.	• Use wet swales or underdrained dry swales to intercept, convey and treat post-construction stormwater runoff in these areas. • Use additional low impact development and stormwater management practices, such as rainwater harvesting (CSS Section 7.8.12) to supplement the stormwater management benefits provided by swales in these areas.
• *Well drained soils*, such as hydrologic soil group A and B soils	• May be difficult to maintain a permanent water surface within a wet swale. • Enhances the ability of dry swales to reduce stormwater runoff rates, volumes and pollutant loads. • May allow stormwater pollutants to reach groundwater aquifers with greater ease.	• Avoid the use of infiltration-based stormwater management practices, including non-underdrained dry swales, at stormwater hotspots and in areas known to provide groundwater recharge to water supply aquifers, unless adequate pretreatment is provided upstream of them. • Use dry swales and bioretention areas (CSS Section 8.6.3) with liners and underdrains at stormwater hotspots and in areas known to provide groundwater recharge to water supply aquifers.

Challenges Associated with Using Swales in Coastal Georgia		
Site Characteristic	How it Influences the Use of Swales	Potential Solutions
• *Flat terrain*	• May be difficult to provide adequate drainage and may cause stormwater runoff to pond in the swale for extended periods of time.	• Design swales with a slope of at least 0.5% to help ensure adequate drainage. • Where soils are well drained, use non-underdrained dry swales, non-underdrained bioretention areas (CSS Section 8.6.3) and infiltration practices (CSS Section 8.6.5), to reduce stormwater runoff rates, volumes and pollutant loads and prevent ponding in these areas. • Ensure that the underlying native soils or underdrain system will allow a dry swale to drain completely within 48 hours of the end of a rainfall event to prevent the formation of nuisance ponding conditions.
• *Flat terrain*	• May be difficult to provide adequate drainage and may cause stormwater runoff to pond in the swale for extended periods of time.	• Where soils are poorly drained, use wet swales and small stormwater wetlands (i.e., pocket wetlands) (CSS Section 8.6.2) to intercept and treat stormwater runoff.
• *Shallow water table*	• May be difficult to provide 2 feet of clearance between the bottom of a dry swale and the top of the water table. • May occasionally cause stormwater runoff to pond in a dry swale.	• Ensure that the distance from the bottom of a dry swale to the top of the water table is at least 2 feet. • Reduce the depth of the planting bed in a dry swale to 18 inches. • Use wet swales to intercept, convey and treat post-construction stormwater runoff in these areas.
• *Tidally-influenced drainage system*	• May occasionally prevent stormwater runoff from being conveyed through a swale, particularly during high tide.	• Investigate the use of other low impact development practices, such as rainwater harvesting (CSS Section 7.8.12) to manage post-construction stormwater runoff in these areas.

Site Applicability

Swales can be used to manage post-construction stormwater runoff on a wide variety of development sites, including residential, commercial and institutional development sites in rural, suburban and urban areas. They are well suited for use on residential and institutional development sites that have low to moderate development densities. They can be used to "receive" stormwater runoff from nearly all small impervious and pervious drainage areas, including local streets and roadways, highways, driveways, small parking areas and disturbed pervious areas (e.g., lawns, parks, community open spaces). When compared with other stormwater management practices, swales have a moderate construction cost, a moderate maintenance burden and require a moderate amount of surface area. (See Table on Pages 3-13 through 3-14)

Planning and Design Criteria

It is *recommended* that swales meet all of the planning and design criteria provided in Section 3.2.6 of Volume 2 of the *Georgia Stormwater Management Manual* (ARC, 2001) to be eligible for the stormwater management "credits" described above.

Construction Considerations

To help ensure that swales are successfully installed on a development site, site planning and design teams should consider the construction recommendations listed in Table 8.6.6 of the CSS.

Maintenance Requirements

Maintenance is very important for swales, particularly in terms of ensuring that they continue to provide measurable stormwater management benefits over time. Table 8.21 in the CSS provides a list of the routine maintenance activities typically associated with swales.

Description

Stormwater ponds are stormwater detention basins that have a permanent pool of water. Post-construction stormwater runoff is conveyed into the pool, where it is detained and treated over an extended period of time, primarily through gravitational settling and biological uptake, until it is displaced by stormwater runoff from the next rain event. Temporary storage (i.e., live storage) can be provided above the permanent pool for stormwater quantity control. This allows stormwater ponds to both *treat* stormwater runoff and *manage* the stormwater runoff rates and volumes generated by larger, less frequent rainfall events on development sites.

(Source: Atlanta Regional Commission, 2001)

KEY CONSIDERATIONS

DESIGN CRITERIA:

- Contributing drainage area of 25 acres or more typically needed for wet and wet extended detention ponds; 10 acres or more typically needed for micropool extended detention pond
- A sediment forebay (or equivalent pretreatment) should be provided upstream of all ponds
- Permanent pools should be designed to be between 3 and 8 feet deep
- Length to width ratio should be at least 1.5:1 (L:W), although a length to width ratio of 3:1 (L:W) or greater is preferred
- Side slopes should not exceed 3:1 (H:V)

BENEFITS:

- Provides moderate to high removal of many of the pollutants of concern contained in post-construction stormwater runoff
- Can be attractively integrated into a development site and designed to provide some wildlife habitat

LIMITATIONS:

- Provides minimal reduction of post-construction stormwater runoff volumes
- Stormwater pond design can be challenging in flat terrain

SITE APPLICABILITY

☑ Rural Use
☑ Suburban Use
☑ Urban Use

[L] Construction Cost
[L] Maintenance
[H] Area Required

STORMWATER MANAGEMENT "CREDITS"

Runoff Reduction
☑ Water Quality Protection
☑ Aquatic Resource Protection
☑ Overbank Flood Protection
☑ Extreme Flood Protection

☑ = practice has been assigned quantifiable stormwater management "credits" that can be used to address this SWM Criteria

STORMWATER MANAGEMENT PRACTICE PERFORMANCE

Runoff Reduction
0% - Annual Runoff Volume
0% - Runoff Reduction Volume

Pollutant Removal[1]
80% - Total Suspended Solids
50% - Total Phosphorus
30% - Total Nitrogen
50% - Metals
70% - Pathogens

1 = expected annual pollutant load removal

Adapted/abbreviated from GSWMM Coastal Stormwater Supplement, August 2009.

Discussion

Stormwater ponds (also known as *retention ponds*, *wet ponds*, or *wet extended detention ponds*) are stormwater detention basins that are designed to have a permanent pool of water (i.e., dead storage) throughout the year. Post-construction stormwater runoff is conveyed into the pool, where it is detained and treated over an extended period of time, primarily through gravitational settling and biological uptake, until it is displaced by stormwater runoff from the next rain event. The permanent pool also helps protect deposited sediments from resuspension. Above the permanent pool, temporary storage (i.e., live storage) can be provided for stormwater quantity control.

Stormwater ponds treat post-construction stormwater runoff through a combination of physical, chemical and biological processes. The primary pollutant removal mechanism at work is gravitational settling, which works to remove particulate matter, organic matter, metals and bacteria as stormwater runoff is conveyed through the permanent pool. Another primary pollutant removal mechanism at work in stormwater ponds is biological uptake of nutrients by algae and wetland vegetation. Volatilization and other chemical processes also work to break down and eliminate a number of other stormwater pollutants (e.g., hydrocarbons) in stormwater ponds.

Stormwater ponds are among the most common stormwater management practices used in coastal Georgia and the rest of the United States. They are typically created by excavating a depressional area to create "dead storage" below the water surface elevation of the receiving storm drain system, stream or other aquatic resource. A well-designed pond can be attractively integrated into a development site as a landscaping feature and, if appropriately designed, sited and landscaped, can provide some wildlife habitat. However, site planning and design teams should use caution when siting a stormwater pond. They should use the results of the natural resources inventory (CSS Section 6.3.3), to ensure that the pond will not negatively impact any existing primary conservation areas on the development site (e.g., freshwater wetlands, bottomland hardwood forests). Site planning and design teams should also consider the other potential drawbacks associated with stormwater ponds, including their potential to become a source of mosquitoes and harmful algal blooms.

There are several variations of stormwater ponds that can be used to manage post-construction stormwater runoff on development sites, the most common of which include wet ponds, wet extended detention ponds and micropool extended detention ponds. In addition, multiple stormwater ponds can be placed in series or parallel to increase storage capacity or address specific site characteristics or constraints (e.g., flat terrain). A brief description of each of these design variants is provided below:

- Wet Ponds: Wet ponds are stormwater detention basins that are designed to have a permanent pool that provides enough storage for the stormwater runoff volume generated by the target runoff reduction rainfall event (e.g., 85th percentile rainfall event). Stormwater runoff is conveyed into the pool, where it is detained and treated over an extended period of time, primarily through gravitational settling and biological uptake, until it is displaced by stormwater runoff from the next rain event. Additional temporary storage (i.e., live storage) can be provided above the permanent pool for stormwater quantity control.

- Wet Extended Detention (ED) Ponds: Wet extended detention ponds are wet ponds that are designed to have a permanent pool that provides enough storage for approximately 50% of the stormwater runoff volume generated by the target runoff reduction rainfall event (e.g., 85th percentile rainfall event). The remainder of the stormwater runoff volume generated by the target runoff reduction rainfall event is managed in an extended detention zone provided immediately above the permanent pool. During wet weather, stormwater runoff is detained in the extended detention zone and released over a 24-hour period.

Wet Pond

Wet Extended Detention Pond

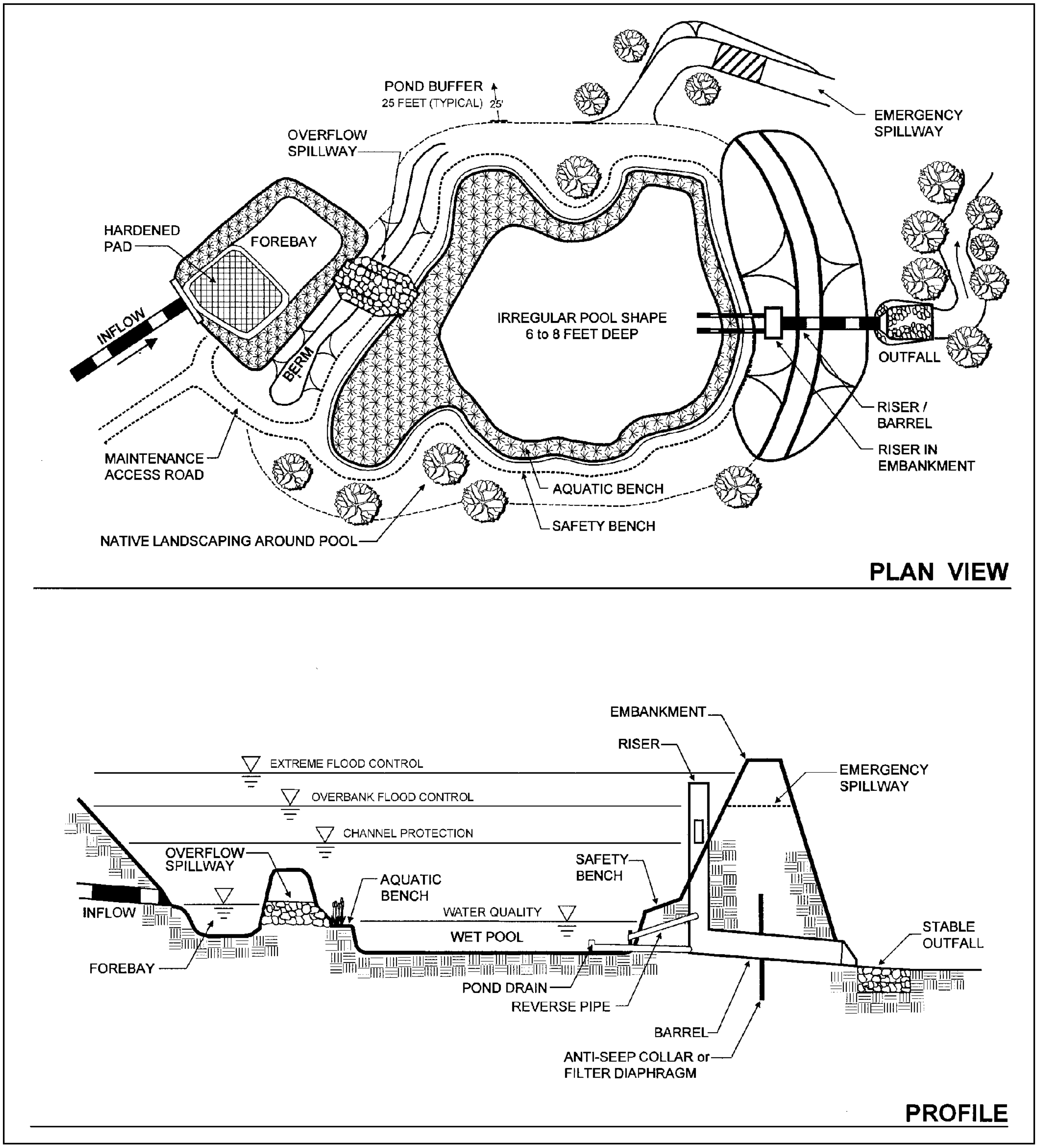
Micropool Extended Detention Pond

Wet Pond

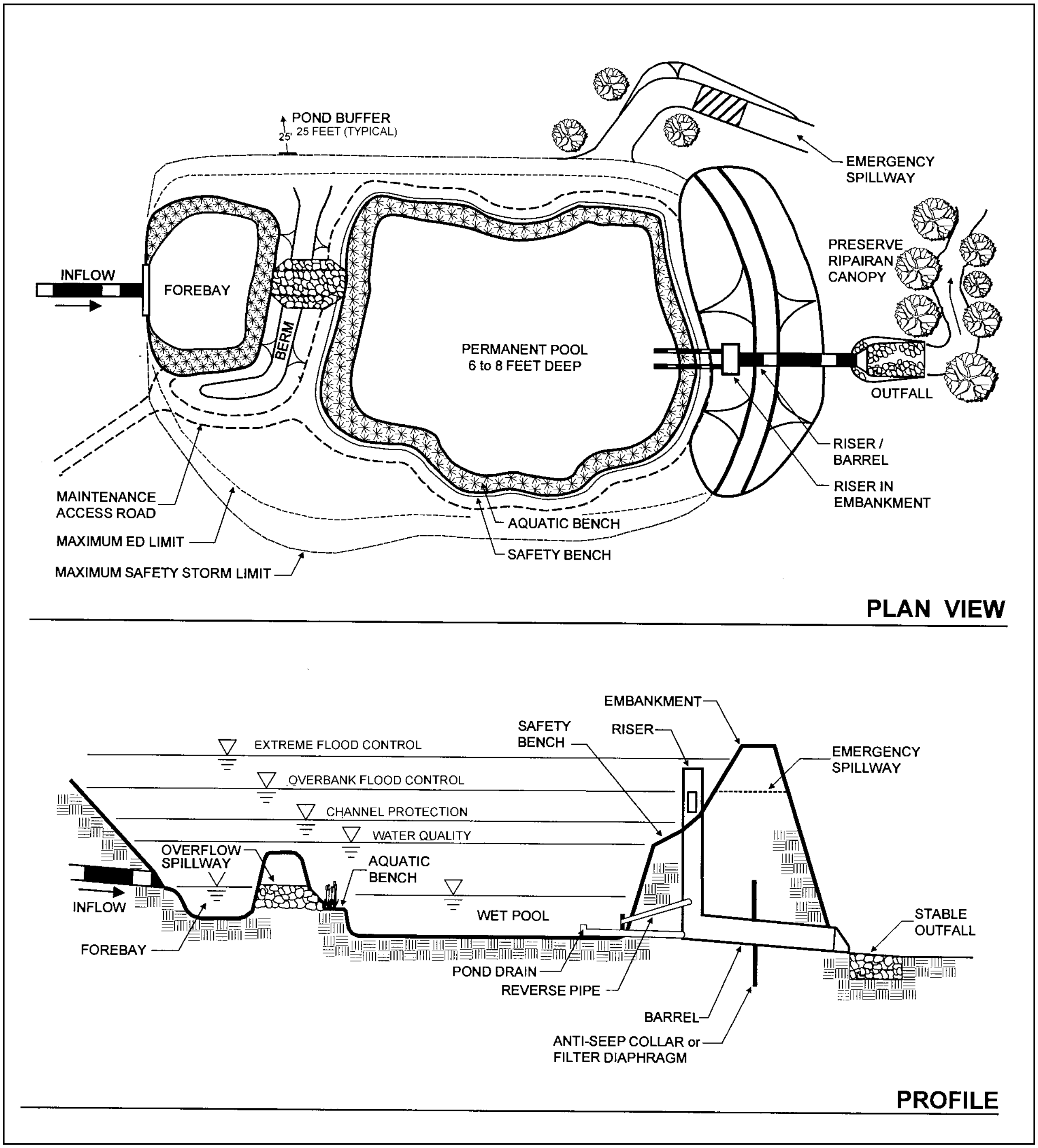
Various Stormwater Ponds

- Micropool Extended Detention (ED) Ponds: Micropool extended detention ponds are a variation of the standard wet extended detention pond that have only a small permanent pool (i.e., micropool). The "micropool" provides enough storage for approximately 10% of the stormwater runoff volume generated by the target runoff reduction rainfall event (e.g., 85th percentile rainfall event). The remainder of the stormwater runoff volume generated by the target runoff reduction rainfall event is managed in an extended detention zone provided immediately above the "micropool" and released over an extended 24-hour period.

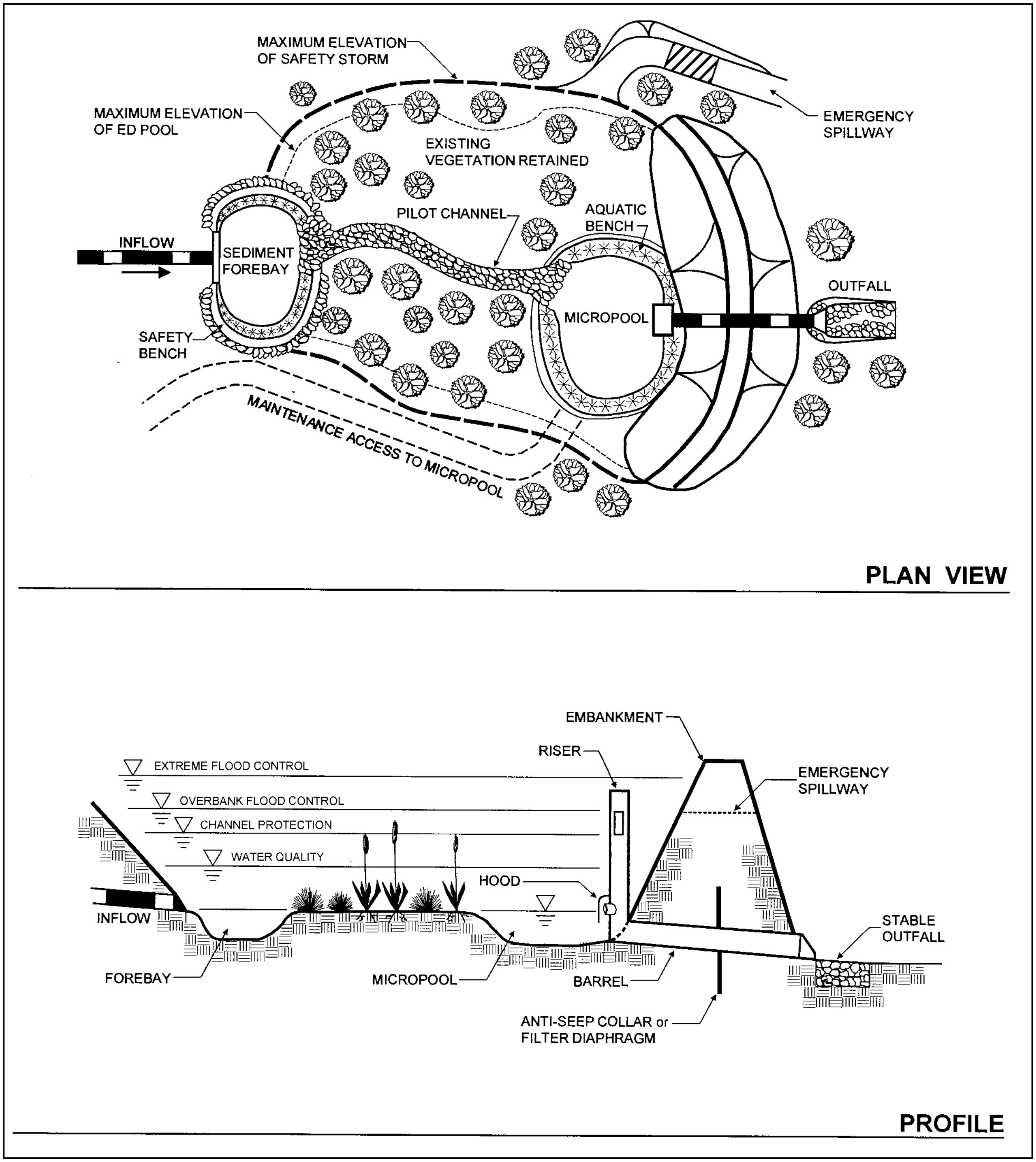
- Multiple Pond Systems: Multiple pond systems consist of a series of two or more wet ponds, wet extended detention ponds or micropool extended detention ponds. The additional cells can increase the storage capacity provided on a development or redevelopment site.



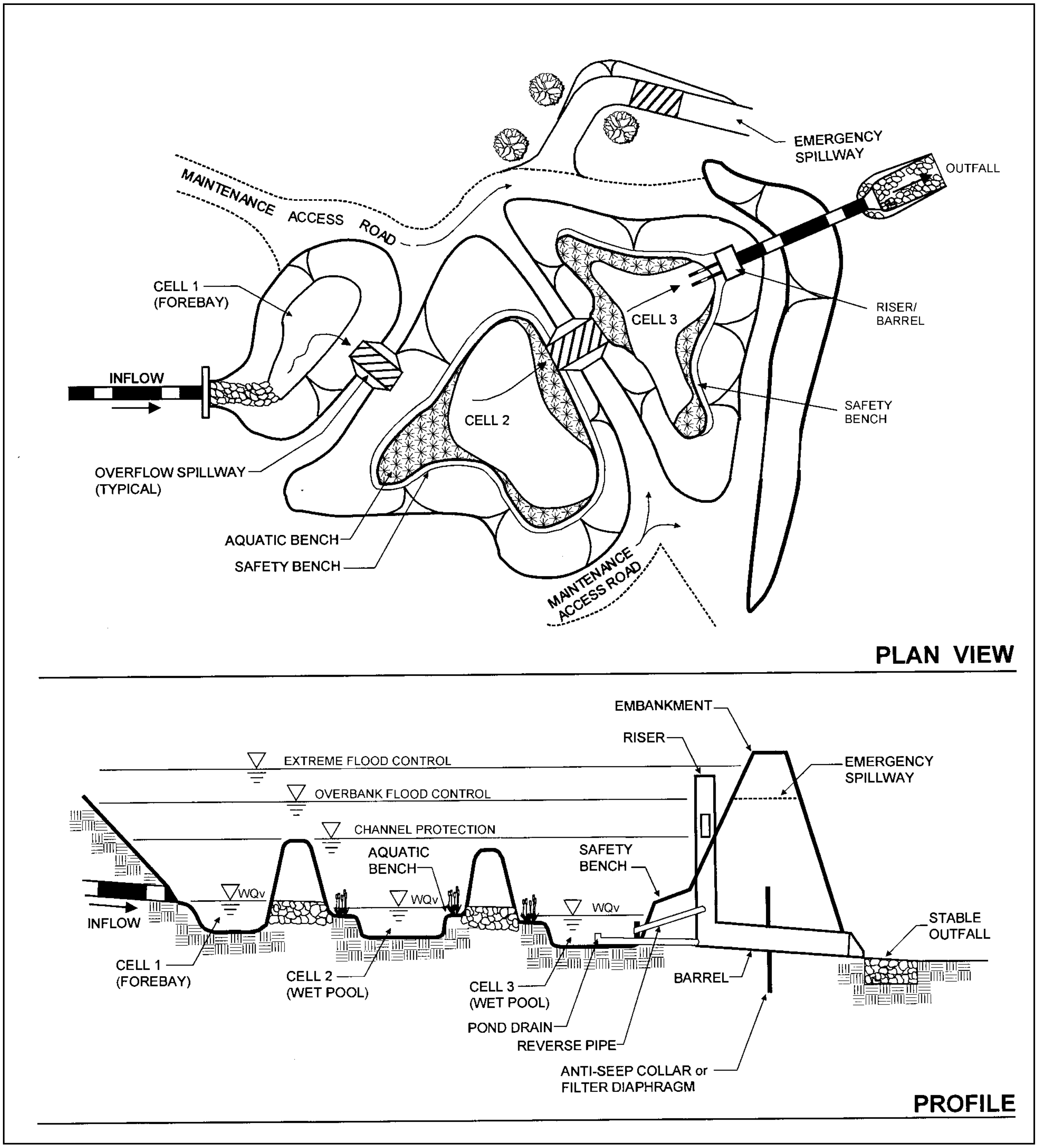
Schematic of a Typical Wet Pond
(Source: Center for Watershed Protection)



Schematic of a Typical Wet Extended Detention Pond
(Source: Center for Watershed Protection)



Schematic of a Typical Micropool Extended Detention Pond
(Source: Center for Watershed Protection)



Schematic of a Typical Multiple Pond System
(Source: Center for Watershed Protection)

Stormwater Management "Credits"
Stormwater ponds have been assigned quantifiable stormwater management "credits" that can be used to help satisfy the SWM Criteria presented in the Georgia Stormwater Management Manual Coastal Stormwater Supplement (CSS). Table ? in Appendix ? shows how stormwater ponds can be used to address stormwater runoff reduction, water quality protection, aquatic resource protection, overland flood protection, and extreme flood protection. For further details, refer to Section 8.6.1 of the CSS.

Feasibility in Coastal Georgia
Several site characteristics commonly encountered in coastal Georgia may present challenges to site planning and design teams that are interested in using stormwater ponds to manage post-construction stormwater runoff on a development site. The following Table identifies these common site characteristics and describes how they influence the use of stormwater ponds on development sites. The table also provides site planning and design teams with some ideas about how they can work around these potential constraints.

Challenges Associated with Using Stormwater Ponds in Coastal Georgia		
Site Characteristic	How it Influences the Use of Stormwater Ponds	Potential Solutions
• *Poorly drained soils*, such as hydrologic soil group C and D soils	• Since they are designed to have a permanent pool of water, the presence of poorly drained soils does not influence the use of ponds on development sites. In fact, the presence of poorly drained soils may help maintain a permanent pool of water within a stormwater pond.	
• *Well drained soils*, such as hydrologic soil group A and B soils	• May be difficult to maintain a permanent pool of water within a stormwater pond. • May allow stormwater pollutants to reach groundwater aquifers with greater ease.	• Install a pond liner to maintain a permanent pool of water. • At stormwater hotspots and in areas known to provide groundwater recharge to water supply aquifers, install a pond liner to prevent pollutants from reaching groundwater aquifers. • In areas that are not considered to be stormwater hotspots and areas that do not provide groundwater recharge to water supply aquifers, use non-underdrained bioretention areas (CSS Section 8.6.3) and infiltration practices (CSS Section 8.6.5) to significantly reduce stormwater runoff rates, volumes and pollutant loads.

Challenges Associated with Using Stormwater Ponds in Coastal Georgia		
Site Characteristic	How it Influences the Use of Stormwater Ponds	Potential Solutions
• *Flat terrain*	• Reduces the amount of storage volume that can be provided within a stormwater pond. • Makes it difficult, if not impossible, to provide a pond drain at the bottom of a stormwater pond.	• Design stormwater ponds that have shallower permanent pools, with depths of 4 feet or less (e.g., dugouts). • Eliminate the use of pond drains, if necessary. • Consider stormwater wetlands (CSS Section 8.6.2) as an alternative stormwater management practice in areas with flat terrain and a shallow water table.
• *Shallow water table*	• Makes it easier to maintain a permanent pool within a stormwater pond, but may allow stormwater pollutants to reach groundwater aquifers with greater ease.	• Excavation below the water table to create a stormwater pond is acceptable, but any storage volume found below the water table should not be counted when determining the total storage volume provided by the stormwater pond. • At stormwater hotspots and in areas known to provide groundwater recharge to water supply aquifers, install a pond liner to prevent pollutants from reaching underlying groundwater aquifers. • Use bioretention areas (CSS Section 8.6.3) and filtration practices (CSS Section 8.6.4) with liners and underdrains to intercept and treat stormwater runoff at stormwater hotspots and in areas known to provide groundwater recharge to water supply aquifers.

Challenges Associated with Using Stormwater Ponds in Coastal Georgia		
Site Characteristic	How it Influences the Use of Stormwater Ponds	Potential Solutions
• *Tidally-influenced drainage system*	• May occasionally prevent stormwater runoff from being conveyed through a stormwater pond, particularly during high tide. • May increase the amount of pollution that is transferred from stormwater ponds to adjacent estuarine resources.	• Maximize the use of low impact development practices (CSS Section 7.8) in these areas to reduce stormwater runoff rates, volumes and pollutant loads. • Provide enlarged aquatic benches (e.g., up to 30 feet wide) that have been planted with dense wetland vegetation to increase pollutant removal. • Consider the use of bubbler aeration and proper fish stocking to maintain nutrient cycling and healthy oxygen levels in stormwater ponds located in these areas. • Consider stormwater wetlands (CSS Section 8.6.2) as an alternative stormwater management practice in these areas.

Site Applicability

Although it may be difficult to use them to manage post-construction stormwater runoff in urban areas, due to space constraints, stormwater ponds can be used to manage stormwater runoff on a wide variety of development sites, including residential, commercial, industrial and institutional development sites in rural and suburban areas. When compared with other stormwater management practices, stormwater ponds have a relatively low construction cost, a relatively low maintenance burden and require a relatively large amount of surface area. (See Table 3-13 through 3-14)

Planning and Design Criteria

It is *recommended* that stormwater ponds meet all of the planning and design criteria provided in Section 3.2.1 of Volume 2 of the *Georgia Stormwater Management Manual* (ARC, 2001) to be eligible for the stormwater management "credits" described above.

Construction Considerations

To help ensure that stormwater ponds are successfully installed on a development site, site planning and design teams should consider the construction recommendations listed in Section 8.6.1 of the CSS.

Maintenance Requirements

Maintenance is very important for stormwater ponds, particularly in terms of ensuring that they continue to provide measurable stormwater management benefits over time. Table 8.6 in the CSS provides a list of the routine maintenance activities typically associated with stormwater ponds.

Description

Stormwater wetlands are constructed wetland systems built for stormwater management purposes. They typically consist of a combination of open water, shallow marsh and semi-wet areas that are located just above the permanent water surface. As stormwater runoff flows through a wetland, it is treated, primarily through gravitational settling and biological uptake. Temporary storage (i.e., live storage) can be provided above the permanent water surface for stormwater quantity control. This allows wetlands to both *treat* stormwater runoff and *manage* the stormwater runoff rates and volumes generated by larger rainfall events.

(Source: Merrill et al., 2006)

KEY CONSIDERATIONS

DESIGN CRITERIA:

- Contributing drainage area of 25 acres or more typically needed for shallow and shallow extended detention wetlands; 10 acres or more typically needed for pocket wetlands
- A sediment forebay (or equivalent pretreatment) should be provided upstream of all wetlands
- Minimum of 35% of wetland surface area should have a depth of 6 inches or less; 10% to 20% of surface area should have a depth of between 1.5 and 6 feet
- Length to width ratio should be at least 2:1 (L:W), although a length to width ratio of 3:1 (L:W) or greater is preferred
- Side slopes should not exceed 3:1 (H:V)

BENEFITS:

- Provides moderate to high removal of many of the pollutants of concern typically contained in post-construction stormwater runoff
- Ideal for use in flat terrain and in areas with high groundwater

LIMITATIONS:

- Provides minimal reduction of post-construction stormwater runoff volumes
- Requires relatively large amount of land

SITE APPLICABILITY

☑ Rural Use	[L] Construction Cost
☑ Suburban Use	[M] Maintenance
Urban Use	[H] Area Required

STORMWATER MANAGEMENT "CREDITS"

Runoff Reduction

☑ Water Quality Protection

☑ Aquatic Resource Protection

☑ Overbank Flood Protection

☑ Extreme Flood Protection

☑ = practice has been assigned quantifiable stormwater management "credits" that can be used to address this SWM Criteria

STORMWATER MANAGEMENT PRACTICE PERFORMANCE

Runoff Reduction

0% - Annual Runoff Volume

0% - Runoff Reduction Volume

Pollutant Removal[1]

80% - Total Suspended Solids

50% - Total Phosphorus

30% - Total Nitrogen

50% - Metals

70% - Pathogens

1 = expected annual pollutant load removal

Discussion

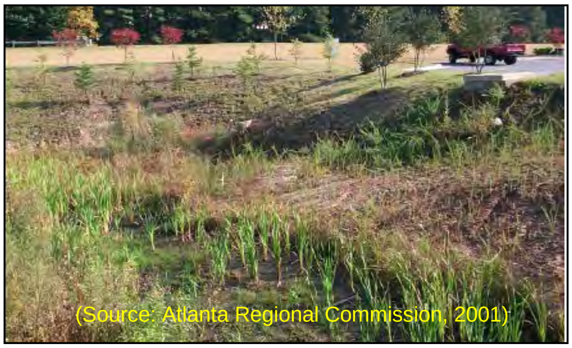
Stormwater wetlands treat post-construction stormwater runoff through a combination of physical, chemical and biological processes. The primary pollutant removal mechanisms at work in stormwater wetlands are biological uptake, physical screening and gravitational settling. Other pollutant removal mechanisms at work in stormwater wetlands include volatilization and other biological and chemical processes.

Stormwater wetlands are among the most effective stormwater management practices that can be used coastal Georgia and the rest of the United States. They are typically created by excavating a depressional area to create “dead storage” below the water surface elevation of the receiving storm drain system, stream or other aquatic resource. A well-designed stormwater wetland can be attractively integrated into a development site as a landscaping feature and, if appropriately designed, sited and landscaped, can provide valuable wildlife habitat. Stormwater wetlands differ from natural wetland systems in that they are engineered facilities designed specifically for the purpose of managing post-construction stormwater runoff. They typically have less biodiversity than natural wetlands in terms of both plant and animal life but, like natural wetlands, require continuous base flow or a high water table to maintain a permanent water surface and support the growth of aquatic vegetation.

There are several variations of stormwater wetlands that can be used to manage post-construction stormwater runoff on development sites, including shallow wetlands, shallow extended detention wetlands and pocket wetlands. In addition, stormwater wetlands can be used in combination with stormwater ponds to increase storage capacity or address specific site characteristics or constraints (e.g., flat terrain). A brief description of each of these design variants is provided below:

- Shallow Wetlands: In a shallow wetland (Figure 8.15), most of the storage volume provided by the wetland is contained in some relatively shallow high marsh and low marsh areas. The only deep water areas found within a shallow wetland are the forebay, which is located at the entrance to the wetland, and the “micropool,” which is located at the outlet. One disadvantage to the shallow wetland design is that, since most of the storage volume is provided in the relatively shallow high marsh and low marsh areas, a large amount of land may be needed to provide enough storage for the stormwater runoff volume generated by the target runoff reduction rainfall event (e.g., 85th percentile rainfall event).

- Shallow Extended Detention (ED) Wetlands: A shallow extended detention wetland (Figure 8.16) is essentially the same as a shallow wetland, except that approximately 50% of the stormwater runoff volume generated by the target runoff reduction rainfall event (e.g., 85th percentile rainfall event) is managed in an extended detention zone provided immediately above the permanent water surface. During wet weather, stormwater runoff is detained in the extended detention zone and released over a 24-hour period. Although this design variant requires less land than the shallow wetland design variant, it can be difficult to establish vegetation within the extended detention zone due to the



Shallow Wetland

Shallow Extended Detention Wetland

Shallow Wetland

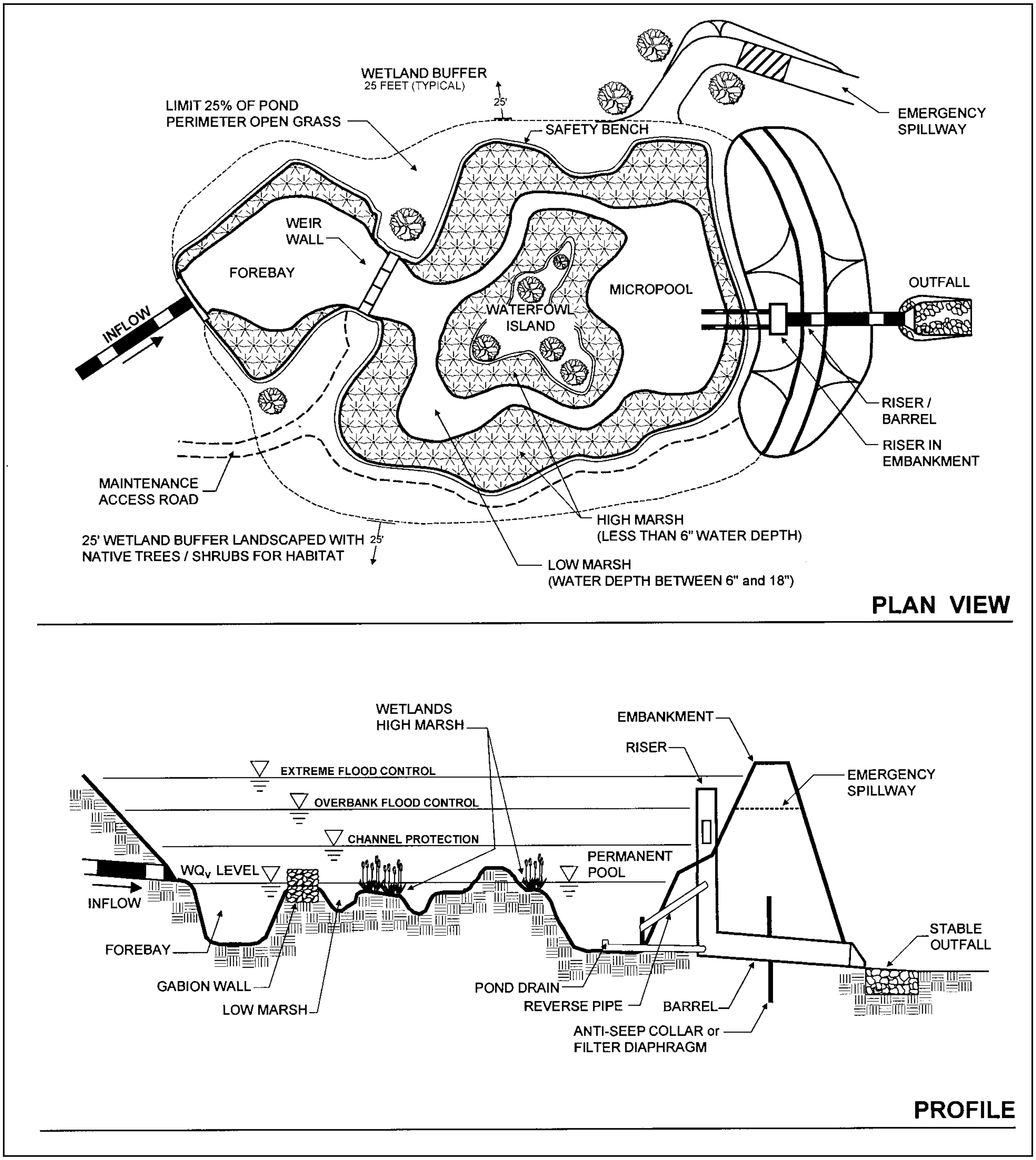
Pocket Wetland

Various Stormwater Wetlands

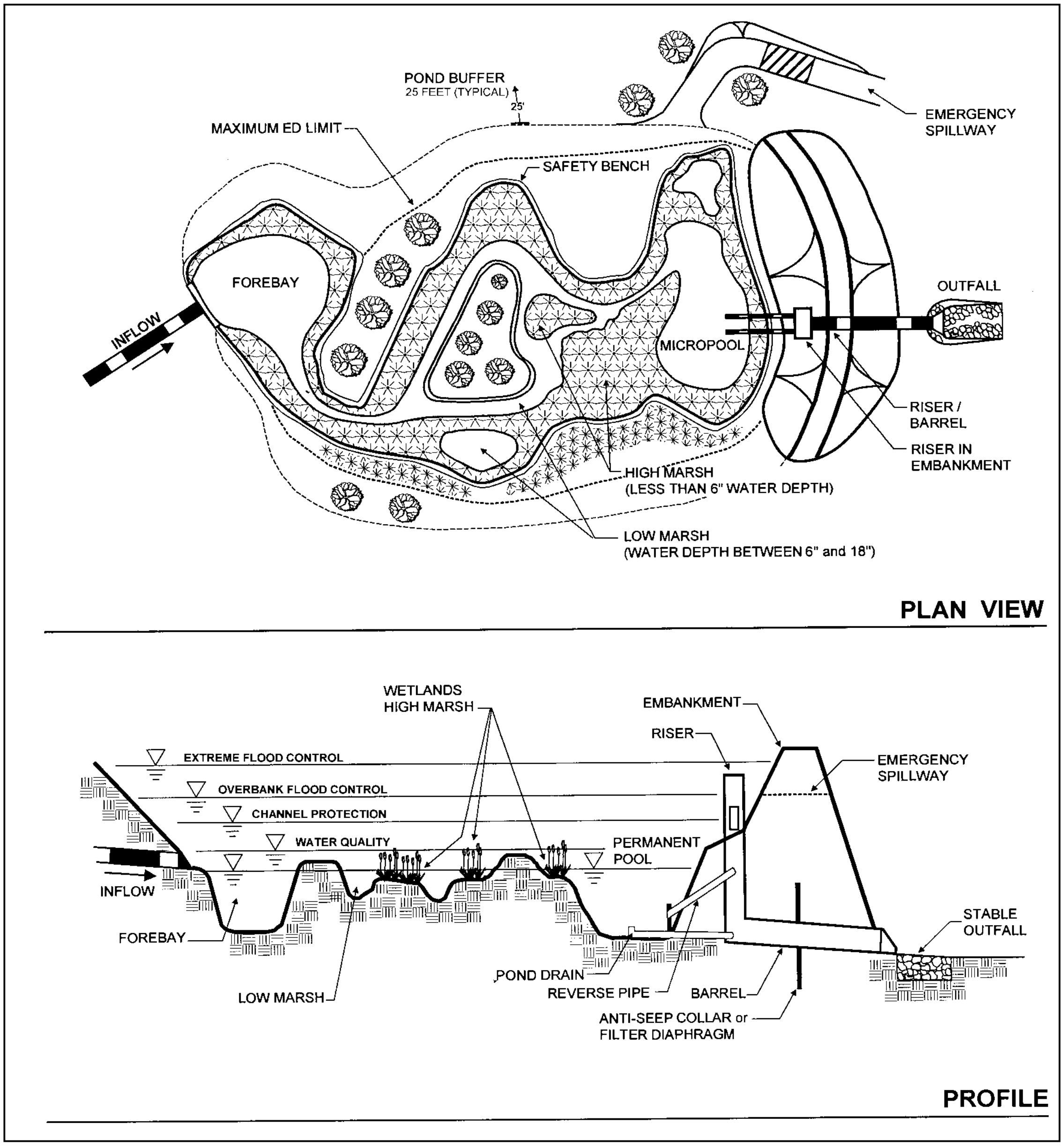
fluctuating water surface elevations found within.

- Pond/Wetland Systems: A pond/wetland system has two separate cells, one of which is a wet pond and the other of which is a shallow wetland. The wet pond cell is used to trap sediment and reduce stormwater runoff velocities upstream of the shallow wetland cell. Less land is typically required for pond/wetland systems than for shallow wetlands or shallow extended detention wetlands.

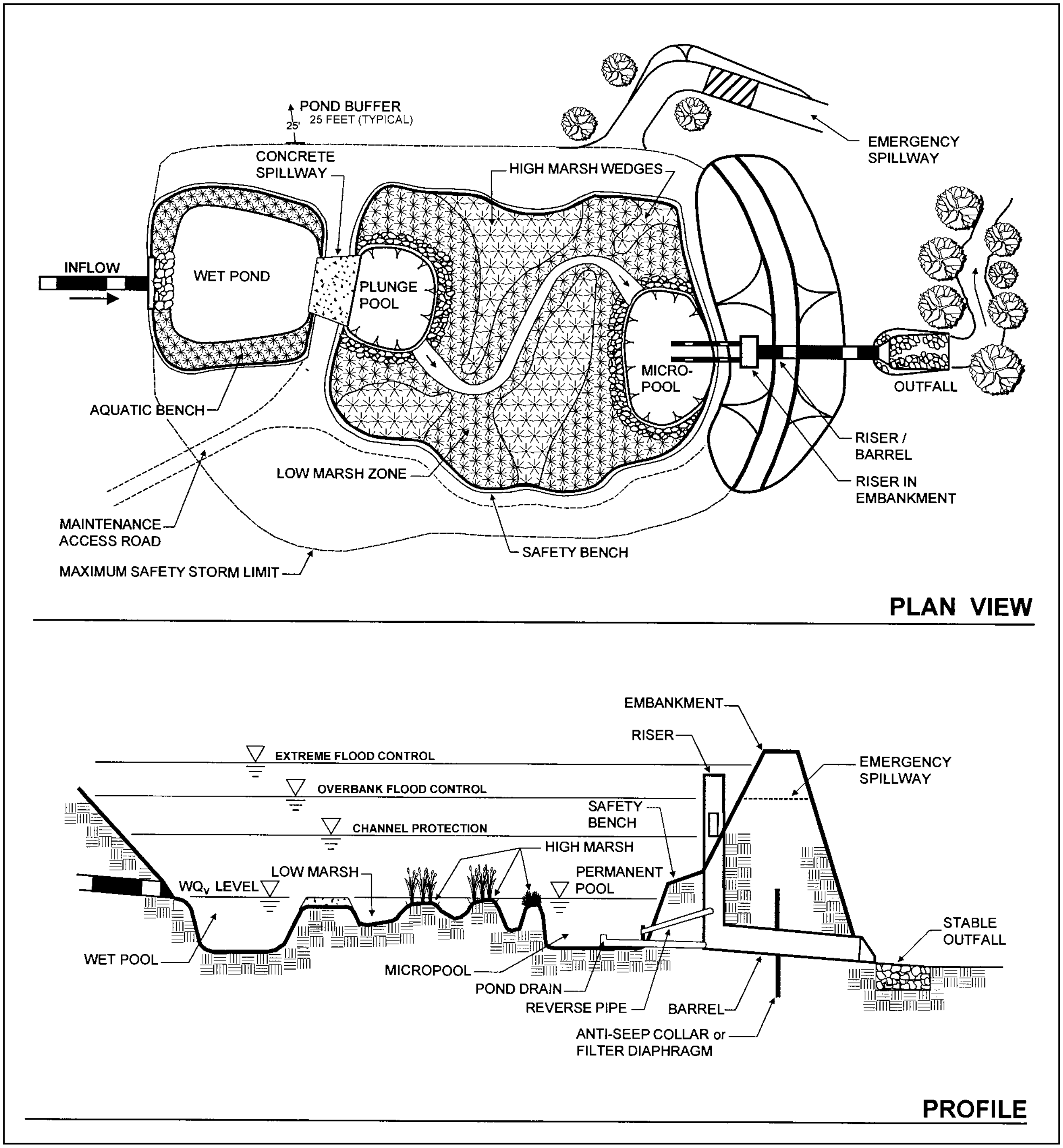
- Pocket Wetlands: Pocket wetlands can be used to intercept and manage stormwater runoff from relatively small drainage areas of up to about 10 acres in size. In order to ensure that they have a permanent water surface throughout the year, they are typically designed to interact with the groundwater table.



Schematic of a Typical Shallow Wetland
(Source: Center for Watershed Protection)



Schematic of a Typical Shallow Extended Detention Wetland
(Source: Center for Watershed Protection)

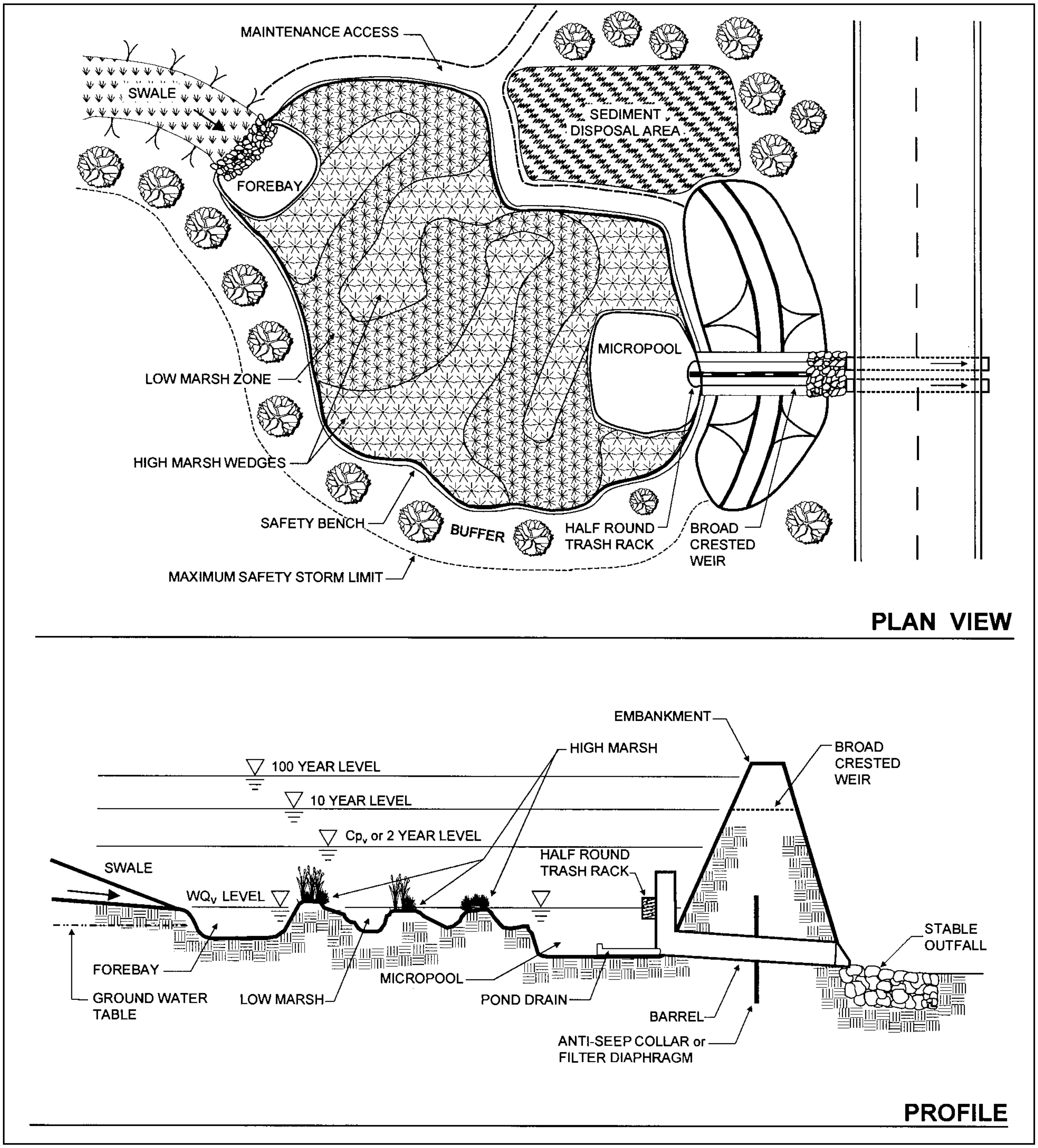


Schematic of a Typical Pond/Wetland System

(Source: Center for Watershed Protection)

Stormwater Management "Credits"

Stormwater wetlands have been assigned quantifiable stormwater management "credits" that can be used to help satisfy the SWM Criteria presented in the Georgia Stormwater Management Manual Coastal Stormwater Supplement (CSS). The Table in Appendix E shows how stormwater ponds can be used to address stormwater runoff reduction, water quality protection, aquatic resource protection, overland flood protection, and extreme flood protection. For further details, refer to Section 8.6.2 of the CSS.



Schematic of a Typical Pocket Wetland
(Source: Center for Watershed Protection)

Overall Feasibility

Site planning and design teams should consider various factors to determine whether or not stormwater wetlands are appropriate for use on a particular development site. The Table on Pages 3-8 through 3-12 provides design considerations for stormwater wetlands including drainage area, area required, slope, minimum head, minimum depth to water table, and soils. For further details, refer directly to Section 8.6.2 of the CSS.

Feasibility in Coastal Georgia

Several site characteristics commonly encountered in coastal Georgia may present challenges to site planning and design teams that are interested in using stormwater wetlands to manage post-construction stormwater runoff on a development site. The following Table identifies these common site characteristics and describes how they influence the use of stormwater wetlands on development sites. The table also provides site planning and design teams with some ideas about how they can work around these potential constraints.

Challenges Associated with Using Stormwater Wetlands in Coastal Georgia		
Site Characteristic	How it Influences the Use of Stormwater Wetlands	Potential Solutions
• *Poorly drained soils*, such as hydrologic soil group C and D soils	• Since they are designed to have a permanent water surface, the presence of poorly drained soils does not influence the use of stormwater wetlands on development sites. In fact, the presence of poorly drained soils may help maintain a permanent water surface within a stormwater wetland.	
• *Well drained soils*, such as hydrologic soil group A and B soils	• May be difficult to maintain a permanent water surface within a stormwater wetland. • May allow stormwater pollutants to reach groundwater aquifers with greater ease.	• Install a liner to maintain a permanent water surface. • At stormwater hotspots and in areas known to provide groundwater recharge to water supply aquifers, install a liner to prevent pollutants from reaching underlying groundwater aquifers. • In areas that are not considered to be stormwater hotspots and areas that do not provide groundwater recharge to water supply aquifers, use non-underdrained bioretention areas (CSS Section 8.6.3) and infiltration practices (CSS Section 8.6.5) to significantly reduce stormwater runoff volumes.

Challenges Associated with Using Stormwater Wetlands in Coastal Georgia		
Site Characteristic	How it Influences the Use of Stormwater Wetlands	Potential Solutions
• *Flat terrain*	• Makes it difficult, if not impossible, to provide a drain at the bottom of a stormwater wetland.	• Eliminate the use of drains, if necessary.
• *Shallow water table*	• Makes it easier to maintain a permanent water surface within a stormwater wetland, but may allow stormwater pollutants to reach groundwater aquifers with greater ease.	• Excavation below the water table to create a stormwater wetland is acceptable, but any storage volume found below the water table should not be counted when determining the total storage volume provided by the stormwater wetland. • At stormwater hotspots and in areas known to provide groundwater recharge to water supply aquifers, install a liner to prevent pollutants from reaching underlying groundwater aquifers. • Use bioretention areas (CSS Section 8.6.3) and filtration practices (CSS Section 8.6.4) with liners and underdrains to intercept and treat stormwater runoff at stormwater hotspots and in areas known to provide groundwater recharge to water supply aquifers.
• *Tidally-influenced drainage system*	• May occasionally prevent stormwater runoff from being conveyed through a stormwater wetland, particularly during high tide.	• Maximize the use of low impact development practices (CSS Section 7.8) in these areas to reduce stormwater runoff rates, volumes and pollutant loads. • Consider the use of bubbler aeration and proper fish stocking to maintain nutrient cycling and healthy oxygen levels in stormwater wetlands located in these areas.

Site Applicability

Although it may be difficult to use them to manage post-construction stormwater runoff in urban areas, due to space constraints, stormwater wetlands can be used to manage stormwater runoff on a wide variety of development sites, including residential, commercial, industrial and institutional development sites in rural and suburban areas. When compared with other stormwater management practices, stormwater wetlands have a relatively low construction cost, a moderate maintenance burden and require a relatively large amount of surface area. (See Table on Pages 3-13 through 3-14)

Planning and Design Criteria

It is *recommended* that stormwater wetlands meet all of the planning and design criteria provided in Section 3.2.2 of Volume 2 of the *Georgia Stormwater Management Manual* (ARC, 2001) to be eligible for the stormwater management "credits" described above.

Construction Considerations

To help ensure that stormwater wetlands are successfully installed on a development site, site planning and design teams should consider the construction recommendations listed in Section 8.6.2 of the CSS.

Maintenance Requirements

Maintenance is very important for stormwater wetlands, particularly in terms of ensuring that they continue to provide measurable stormwater management benefits over time. Table 8.9 in the CSS provides a list of the routine maintenance activities typically associated with stormwater wetlands.

Filtration Practices

Description

Filtration practices are multi-chamber structures designed to treat stormwater runoff using the physical processes of screening and filtration. After passing through the filter media (e.g., sand), stormwater runoff is typically returned to the conveyance system through an underdrain. Because they have very few site constraints beyond head requirements (i.e., vertical distance between inlet and outlet), filtration practices can often be used on development sites where other stormwater management practices, such as stormwater ponds (CSSSection 8.6.1) and infiltration practices (CSS Section 8.6.5), cannot.

(Source: Atlanta Regional Commission, 2001)

KEY CONSIDERATIONS

DESIGN CRITERIA:

- Maximum contributing drainage area of 10 acres for surface filters; maximum contributing drainage area of 2 acres for perimeter filters
- Filtration practices should be designed to completely drain within 36 hours of the end of a rainfall event
- A maximum ponding depth of 12 inches is recommended to help prevent the formation of nuisance ponding conditions
- Typically require 3 to 6 feet of head, although perimeter filters may be designed to function on development sites with as little as 2 feet of head

BENEFITS:

- Provides moderate to high removal of many of the pollutants of concern typically contained in post-construction stormwater runoff
- Ideal for intercepting and treating stormwater runoff from small, highly impervious areas, including stormwater hotspots

LIMITATIONS:

- Relatively high construction and maintenance costs
- Should not be used to “receive” stormwater runoff that contains high sediment loads

SITE APPLICABILITY

✱ Rural Use	[H] Construction Cost
☑ Suburban Use	[H] Maintenance
☑ Urban Use	[L] Area Required

STORMWATER MANAGEMENT “CREDITS”

Runoff Reduction
☑ Water Quality Protection
☑ Aquatic Resource Protection
☑ Overbank Flood Protection
☑ Extreme Flood Protection

☑ = practice has been assigned quantifiable stormwater management “credits” that can be used to address this SWM Criteria

STORMWATER MANAGEMENT PRACTICE PERFORMANCE

Runoff Reduction
0% - Annual Runoff Volume
0% - Runoff Reduction Volume

Pollutant Removal[1]
80%- Total Suspended Solids
60% - Total Phosphorus
40% - Total Nitrogen
50% - Metals
40% - Pathogens

1 = expected annual pollutant load removal

Description

Filtration practices treat stormwater runoff primarily through a combination of the physical processes of gravitational settling, physical screening, filtration, absorption and adsorption. The filtration process effectively removes suspended solids, particulate matter, heavy metals and fecal coliform bacteria and other pathogens from stormwater runoff. Surface filters that are designed with vegetative cover provide additional opportunities for biological uptake of nutrients by the vegetation and for biological decomposition of other stormwater pollutants, such as hydrocarbons.

There are several variations of filtration practices that can be used to manage post-construction stormwater runoff on development sites, the most common of which include surface sand filters and perimeter sand filters. A brief description of each of these design variants is provided below:

- Surface Sand Filters: Surface sand filters are ground-level, open air practices that consist of a pretreatment forebay and a filter bed chamber. Surface sand filters can treat stormwater runoff from contributing drainage areas as large as 10 acres in size and are typically designed as off-line stormwater management practices. Surface sand filters can be designed as excavations, with earthen side slopes, or as structural concrete or block structures.

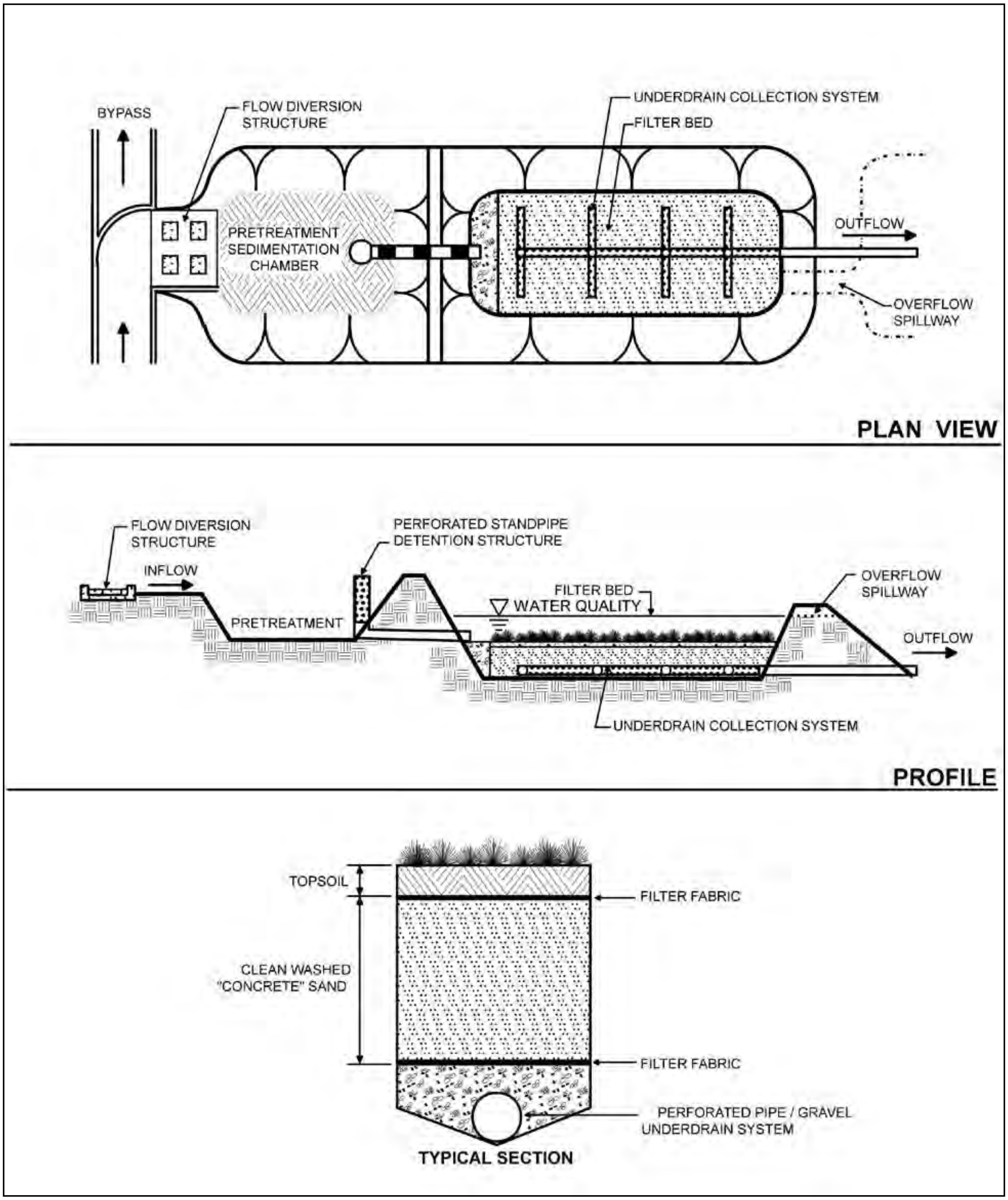
- Perimeter Sand Filters: Perimeter sand filters are enclosed stormwater management practices that are typically located just below grade in a trench along the perimeter of parking lot, driveway or other impervious surface. Perimeter sand filters consist of a pretreatment forebay and a filter bed chamber. Stormwater runoff is conveyed into a perimeter sand filter through grate inlets located directly above the system.

Other design variants, including the underground sand filter and the organic filter, are intended primarily for use on ultra-urban development sites, where space is limited, or for use at stormwater hotspots, where enhanced removal of particular stormwater pollutants (e.g., heavy metals) is desired. Additional information about these *limited application stormwater management practices* is provided in Section 8.7 of this CSS.

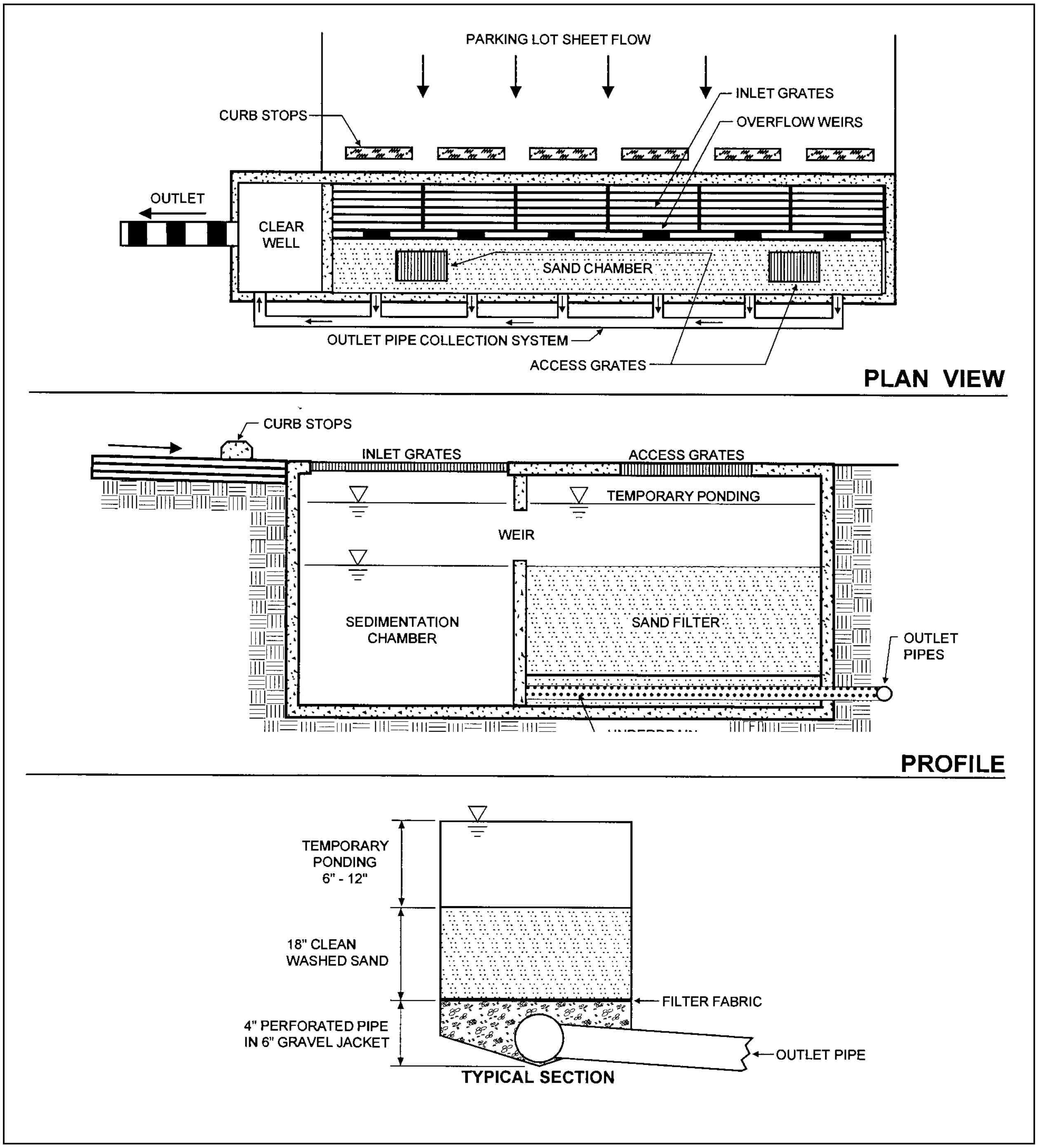
Surface Sand Filter

Perimeter Sand Filter

Various Filtration Practices



Schematic of a Typical Surface Sand Filter
(Source: Center for Watershed Protection)



Schematic of a Typical Perimeter Sand Filter
(Source: Center for Watershed Protection)

Stormwater Management "Credits"

Filtration practices have been assigned quantifiable stormwater management "credits" that can be used to help satisfy the SWM Criteria presented in the Georgia Stormwater Management Manual Coastal Stormwater Supplement (CSS). The Table in Appendix E shows how stormwater ponds can be used to address stormwater runoff reduction, water quality protection, aquatic resource protection, overland flood protection, and extreme flood protection. For further details, refer to Section 8.6.4 of the CSS.

Overall Feasibility

Site planning and design teams should consider various factors to determine whether or not filtration practices are appropriate for use on a particular development site. The Table on Pages 3-8 through 3-12 provides design considerations for filtration practices including drainage area, area required, slope, minimum head, minimum depth to water table, and soils. For further details, refer directly to Section 8.6.4 of the CSS.

<u>Feasibility in Coastal Georgia</u>

Several site characteristics commonly encountered in coastal Georgia may present challenges to site planning and design teams that are interested in using filtration practices to manage post-construction stormwater runoff on development and redevelopment sites. The following Table identifies these common site characteristics and describes how they influence the use of filtration practices. The table also provides site planning and design teams with some ideas about how they can work around these potential design constraints.

Challenges Associated with Using Filtration Practices in Coastal Georgia		
Site Characteristic	How it Influences the Use of Filtration Practices	Potential Solutions
• *Poorly drained soils*, such as hydrologic soil group C and D soils	• Since they are equipped with underdrains, the presence of poorly drained soils does not influence the use of filtration practices on development sites.	
• *Well drained soils*, such as hydrologic soil group A and B soils	• May allow stormwater pollutants to reach groundwater aquifers with greater ease.	• Use filtration practices and bioretention areas (CSS Section 8.6.3) with liners and underdrains to intercept and treat stormwater runoff at stormwater hotspots and in areas known to provide groundwater recharge to water supply aquifers. • In areas that are not considered to be stormwater hotspots and areas that do not provide groundwater recharge to water supply aquifers, use non-underdrained bioretention areas (CSS Section 8.6.3) and infiltration practices (CSS Section 8.6.5) to significantly reduce stormwater runoff rates, volumes and pollutant loads.

Challenges Associated with Using Filtration Practices in Coastal Georgia		
Site Characteristic	How it Influences the Use of Filtration Practices	Potential Solutions
• *Flat terrain*	• May be difficult to provide adequate drainage and may cause stormwater runoff to pond in the filtration practice for extended periods of time.	• Ensure that the filtration practice will drain completely within 36 hours of the end of a rainfall event to prevent the formation of nuisance ponding conditions.
• *Shallow water table*	• May be difficult to provide 2 feet of clearance between the bottom of the filtration practice and the top of the water table. • May occasionally cause stormwater runoff to pond in the filtration practice.	• Ensure that the distance from the bottom of the filtration practice to the top of the water table is at least 2 feet. • Use stormwater ponds (CSS Section 8.6.1), stormwater wetlands (CSS Section 8.6.2) and wet swales (CSS Section 8.6.6), instead of bioretention areas to intercept and treat stormwater runoff in these areas.

Site Applicability

Filtration practices can be used to manage stormwater runoff on a wide variety of development sites. They are particularly well suited for intercepting and treating stormwater runoff from small, highly impervious areas (e.g., parking lots) on development sites where space for other stormwater management practices is limited. Filtration practices should primarily be considered for use on parts of commercial, industrial and institutional development sites where fine sediment (e.g., clay, silt) loads will be relatively low, as high sediment loads will cause them to clog and fail. When compared with other stormwater management practices, filtration practices have a relatively high construction cost, a relatively high maintenance burden and require a relatively small amount of surface area. (See Table on Pages 3-13 through 3-14)

Planning and Design Criteria

It is *recommended* that filtration practices meet all of the planning and design criteria provided in Section 3.2.4 of Volume 2 of the *Georgia Stormwater Management Manual* (ARC, 2001) to be eligible for the stormwater management "credits" described above.

Construction Considerations

To help ensure that filtration practices are successfully installed on a development site, site planning and design teams should consider the construction recommendations listed in Section 8.6.4 of the CSS.

Maintenance Requirements

Maintenance is very important for filtration practices, particularly in terms of ensuring that they continue to provide measurable stormwater management benefits over time. Table 8.15 in the CSS provides a list of the routine maintenance activities typically associated with filtration practices.

CH. 4—STREAMBANK & SHORELINE STABILIZATION

Contents

CH. 4—STREAMBANK & SHORELINE STABILIZATION

In This Chapter

- ***Streambank & Shoreline Stabilization Practices***
- ***Living Shorelines Local Case Study***
- ***Regulatory Requirements & Contact Information***

Introduction

Many waterfront developments feature homes, roads and buildings constructed along rivers, streams, and wetlands that are particularly susceptible to erosion over time.

Due to the potential loss of residences, businesses, and supporting infrastructure, stabilization measures are often necessary for the long-term preservation of the upland portion of the property.

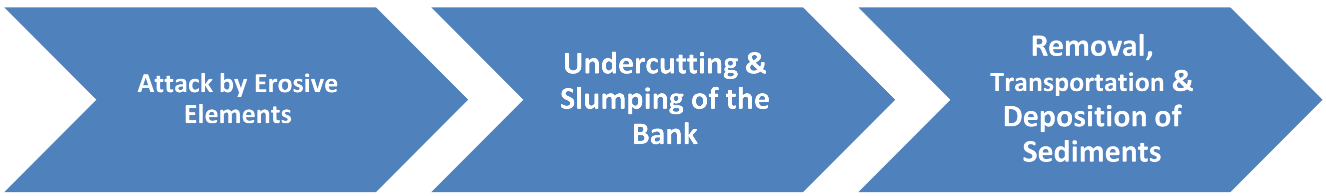
Bank Erosion on St. Catherines Island. Source: Tara Merrill

Previous chapters highlighted land development and stormwater management strategies and their effectiveness in reducing land disturbance and impervious cover - both of which significantly degrade downstream water quality. This chapter provides non-structural and structural practices that stabilize and protect streambanks and shorelines from the negative effects of land erosion. For water quality purposes—bioengineering and non-structural practices using native vegetation are preferred over conventional "hard armoring" such as riprap, seawalls, and bulkheads.

The practices contained in this chapter are most often applied to freshwater streams and wetlands. However, many of the same practices can be customized to work in to tidal waterways as well, especially the upper reaches of tidal creeks that are protected from excessive wind and wave action.

Causes of Erosion

Erosion is a natural process by which soil is removed, transported, and deposited by the forces of wind, rainfall, waves, currents, and the rise and fall of sea levels (tides).



Basic Progression of Erosion from Wave Action

The pace of natural erosion is often accelerated by human activities. Residential, commercial, and recreational developments result in the clearing of vegetation and grading of soils compromising the stability of the land-water interface. Impervious surfaces associated with the built environment also increase the amount and velocity of stormwater runoff which contributes to the erosion of streambanks and shorelines.

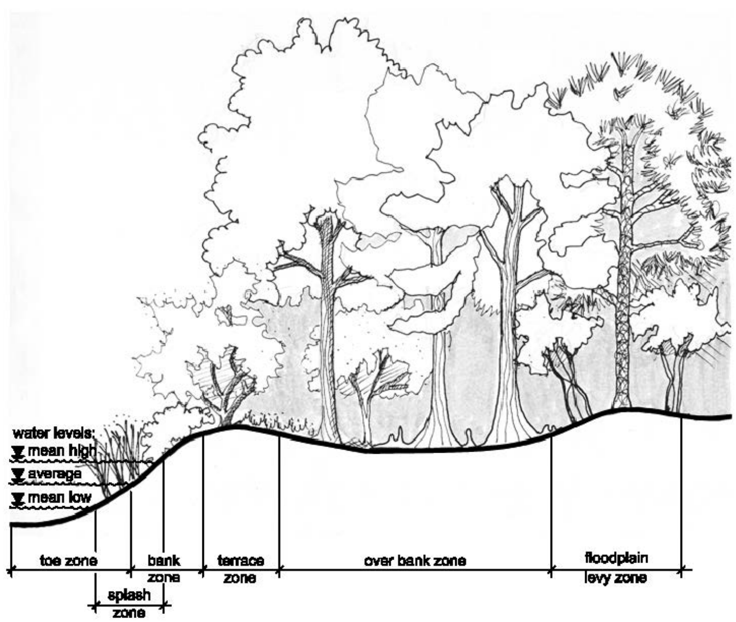
A stabilized stream bank or shoreline is dependent on the balance between soil or sand supplied from the bank or transported along the shore, and sediments lost to erosion. The movement of sediments is essential to maintaining shorelines and deterring erosion. The velocity (speed and direction) of water determines the amount of sediment moved. Larger quantities and heavier sediments (sand) can be transported by larger waves or faster moving currents along the shoreline. Fine grained sediments (silts and clays) are generally transported to the deeper waters offshore while larger grained sands are deposited along the shoreline. Stormwater runoff, wave action, and boat wakes contribute to erosion by causing the slumping of unstable shorelines.

The amount and velocity of the water, the height and slope of a bank, and the amount of vegetation determine the amount of material eroded and deposited along the shoreline.

Stream Bank Zones

It is important to understand the different zones of the stream bank is important before prescribing appropriate stabilization or protective measures against erosion. There are four principal stream bank zones:

Toe Zone—Portion of the bank between the streambed and the average normal water stage. This is a high stress area that typically has little or no aquatic vegetation. Moderate to high flow currents may erode the center and sides of the channel and undermine, or undercut, the base of the bank slope. Undercutting in the toe zone is likely to result in bank failure if appropriate preventive or corrective measures are not taken.



Bank Zones - Sketch by Matthew Baker, ASLA

Splash Zone—Portion of the bank between normal low- and normal high water levels. Located just above the toe zone, the splash zone is frequently exposed to wave wash, currents, and debris movement. This zone is typically vegetated with hardy grasses and other submergent vegetation capable of withstanding periodic inundation and possible saline conditions in tidal areas.

Bank Zone—Refers only to that portion of the bank normally above the high-water level. This area is exposed periodically to wave wash, erosive river currents, debris movement, and frequent human and animal traffic. The water table is frequently close to the soil surface due to proximity to the stream. Small trees, shrubs, and ground vegetation cover this area in optimal conditions.

Terrace Zone—Portion of the bank inland from the bank zone is called the terrace zone. It may be a sharply sloping bank or simple the level area at the crest of a high bank. Though only occasionally flooded, this zone can be easily eroded when vegetation is not present. This area is dominated by mature trees, shrubs, and herbaceous species.

Streambank and Shoreline Stabilization Practices

Since all stabilization projects are unique—each with their own specific conditions to evaluate—it is important to consult with the Georgia Department of Natural Resources (DNR) and other experienced professionals to identify the actual source and cause of the erosion problem and recommend a solution specifically adapted to local conditions.

Typical Coastal Development with Structural Stabilization Measures (Bulkheads/Rip Rap Revetment). Source: Dr. Clark Alexander

This guidance document presents methods and practices contained in the following engineering manuals and guidance documents:

- *Streambank and Shoreline Stabilization Guidance*, GDNR-EPD, July 2007
- *Streambank and Shoreline Stabilization: Techniques to Control Erosion and Protect Property*, GDNR-EPD, Georgia Soil & Water Conservation Service, April 2011
- *Hydromodification Best Management Practices Manual for Coastal Georgia*, EPA, UGA-MAREX, Ecological Solutions, September 2009
- *Federal Stream Corridor Restoration Handbook*, USDA-NRCS, Revised August 2001
- *Engineering Field Handbook: Streambank & Shoreline Protection*, USDA-NRCS, December 1996
- *A Soil Bioengineering Guide to Streambank & Lakeshore Stabilization*, USDA-Forestry Service, October 2002

While it may be necessary to use structural means to control erosion, techniques which stabilize streambanks and shorelines while protecting the natural integrity of the stream and riparian corridor are strongly encouraged. For this reason, applicable practices are divided into three categories – *preferred*, *acceptable*, and *discouraged*. Preferred and Acceptable practices promote the use of:

- Bioengineering approaches including bank shaping and sloping practices that achieve stable banks,
- Native vegetation which slows runoff and diverts flow across the land surface to allow for infiltration and treatment of potentially polluted stormwater,
- Vegetation to stabilize the soil surface which reduces erosion and promotes sediment deposition/accretion,
- Integrated practices—combination of structural and vegetative stabilization measures—which preserve the stream under normal flow conditions and withstand the impact of substantially increased flows,
- Biodegradable materials that temporarily control soil movement and eventually disintegrate into humus, a media that allows for infiltration and air exchange which promotes the growth of plants,
- Environmentally-sensitive synthetics that provide permanent stabilization with the ecological benefits
- Vegetation to shade the water, which lowers the water temperature and increases its capacity to hold oxygen needed by aquatic animals to breathe.

Stabilization Options

(In order of preference)

Minor erosion with low risk →→ Maintain and/or enhance vegetation

Minor erosion with some risk →→ Non-structural practices including bioengineering

Major erosion with risk, natural buffers present →→Hybrid (combo of vegetative & structural)

Major erosion with high risk, natural buffers absent or not feasible→→Structural controls

Many of the bioengineered and non-structural practices recommended in this chapter can be applied to coastal erosion if adapted to withstand tidal hydrology and saline conditions (See Living Shorelines Section for additional design considerations). General application and installation information are provided for the following practices:

Preferred Practices - Non-Structural & Bioengineered Practices

- Bioengineering: Shaping & Planting Banks
- Natural Vegetation Establishment
- Live Staking
- Live Fascines/Brush Mattresses
- Brush Layering/ Branch Packing
- Temporary Reinforcement: Coir Rolls/Mats
- Permanent Reinforcement: Synthetic Solutions

Acceptable Practices - Integrated Practices

- ✓ Rock Rolls/Vegetated Gabions
- ✓ Vegetated Cribwalls
- ✓ Revetments
- ✓ Joint Plantings

Discouraged Practices - Structural Practices

- Rock Riprap & Rock Gabions
- Bulkheads & Seawalls

Preferred Practices – Non-Structural & Bioengineered Practices

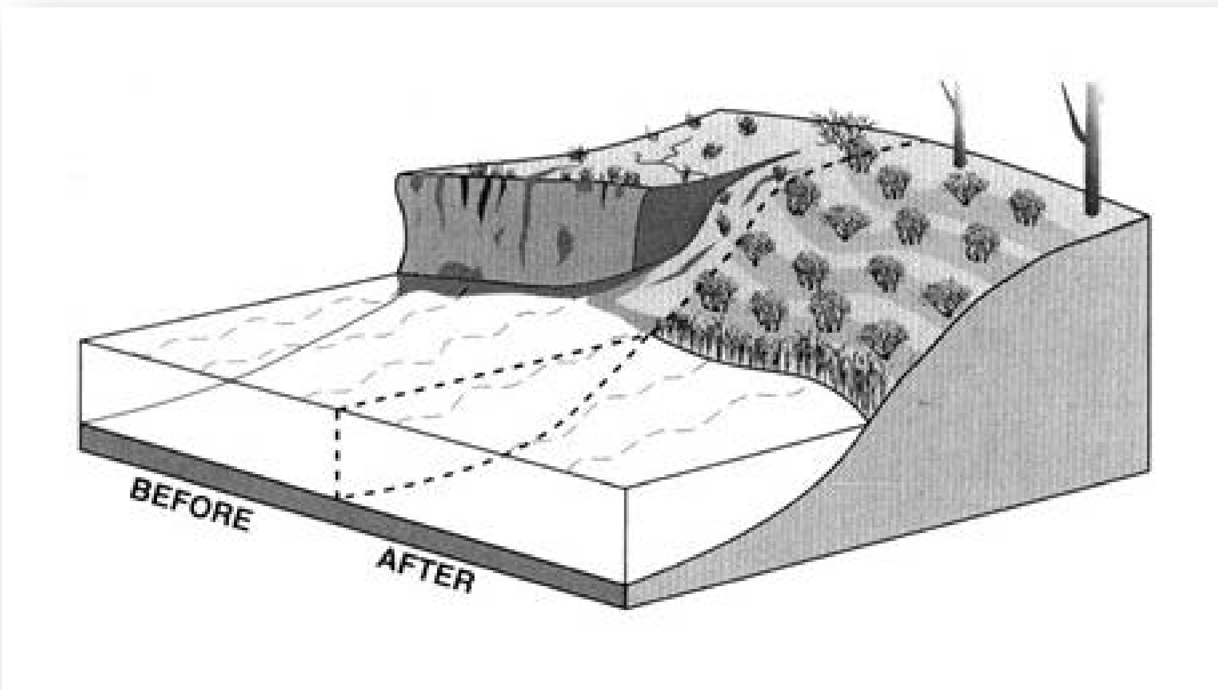
Preferred practices are non-structural techniques that employ bioengineering techniques using native vegetation. The establishment or restoration of native riparian vegetation can prevent erosion caused by rain, wind, or wave action, while preventing or treating against containments or excess nutrients. A healthy riparian corridor also provides food, shade, and cover for fish and wildlife.

Practice 1 - Bioengineering: Shaping & Planting Banks

Bioengineering refers to the process of adjusting bank slope by grading or sloping to achieve a stable shape, then establishing appropriate plant species to maintain the new bank shape. This practice essentially uses the natural strength of riparian vegetation, rather than structural measures, to provide long-term bank stability. Many factors must be considered when determining proposed slope dimensions and vegetation types including characteristics of available soils, the influence of high groundwater, and the flow velocity in the area of erosion.

There are three basic steps to this method:

1. Grade the existing banks to achieve a stable angle of the slope,
2. Install a biodegradable or synthetic fabric to hold the soil in place,
3. Plant the slope with native vegetation for added long-term stability.



Practice 2 - Natural Vegetation Establishment

Vegetation establishment is an inexpensive and effective method to minimize erosion. Native plants are particularly effective against erosion because they feature two levels of protection. The top layer of growth serves to deflect stream flows away from the banks and an extensive underground system of roots binds the soils to the slope. This practice can be applied to all four of the primary bank zones. Beyond initial earthworks and plantings, this practice is considered relatively maintenance free if left alone.

For areas of mild current and wave action with somewhat stable existing slopes, sodding and vegetating with flood tolerant plants can provide sufficient protection against erosion. For areas of moderate to high water velocities, this practice can be used in combination with structural methods to achieve the desired level of protection. For optimal protection, natural vegetation re-establishment is a recommended application for all of the practices introduced in this chapter.

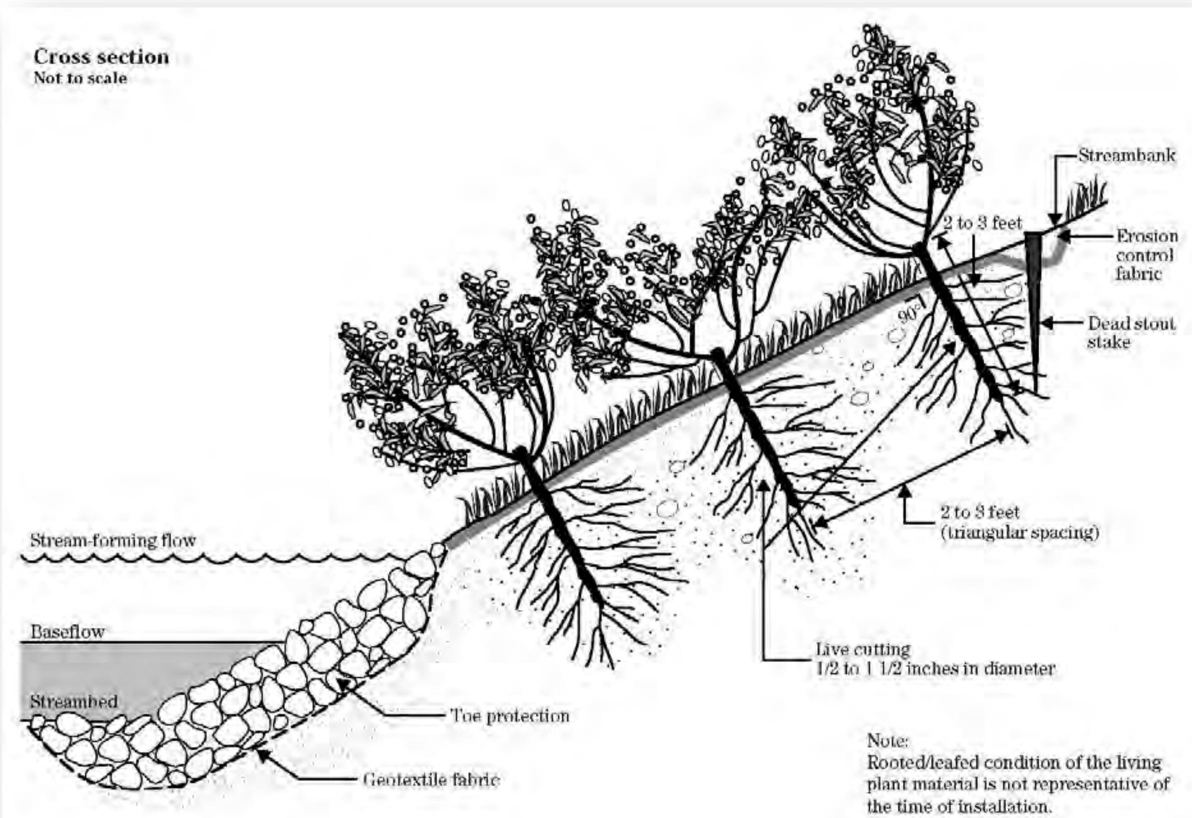
The re-establishment of vegetation can be accomplished by seeding, either by manual or mechanical application or by installing plant cuttings, rootwads, bareroot or containerized specimens. Hardy, fast-growing native species should be selected and planted close together for dense coverage once mature. The entire exposed area of the bank should be planted to promote the spreading and interweaving of fibrous root systems to hold the soil in place. The most important consideration is the ability of the plants to withstand flooded conditions all or most of the time.

It is important to avoid introduction of non-native species. These species can become invasive and out-compete existing vegetation. In addition, invasive plants are not familiar nesting or feeding habitat for fish and wildlife using these areas. A good rule of thumb is to look at the natural system and attempt to duplicate the native vegetation. A list of native trees, shrubs, plants, and grasses can be found at the University of Georgia's Marine Extension website, www.coastscapes.org. Refer to EPD's Streambank & Shoreline Stabilization Guidance for recommended planting densities.

Practice 3 - Live Staking

Live stakes are an inexpensive, easy-to-install method for re-vegetating and stabilizing bank slopes. Sometimes known as "pole plantings", these rootable cuttings can be inserted directly in the bank substrate or into a bank covering such as coir or geotextile fabric. For cuttings to be used alone in the splash zone, the toe must be hardened (rock toe rolls) and the water velocity must not exceed 5 feet per second (fps). When stream velocities are in excess of 5 fps, this method is generally used in the splash zone in combination with brush mattresses.

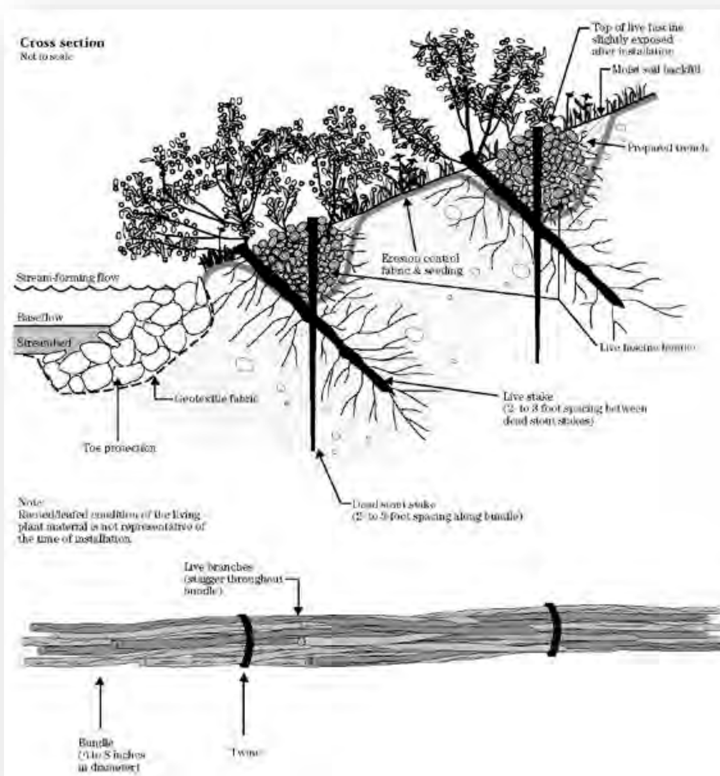
Live stakes provide habitat when used with such stabilization techniques as riprap, gabions, and log revetments. The stakes have tremendous tensile strength, which can enhance the strength and shear resistance of the soil. When incorporated into structural practices, live stakes can increase the strength and longevity of the structures. The dormant cuttings can replace wooden construction stakes for securing the matrix pad to the bank slope. Once the pad disintegrates, it serves as additional growing media facilitating root growth. The establishment of durable hardwood shrubbery with a dense fibrous matrix of roots is the desired end result.



Practice 4 – Live Fascines & Brush Mattresses

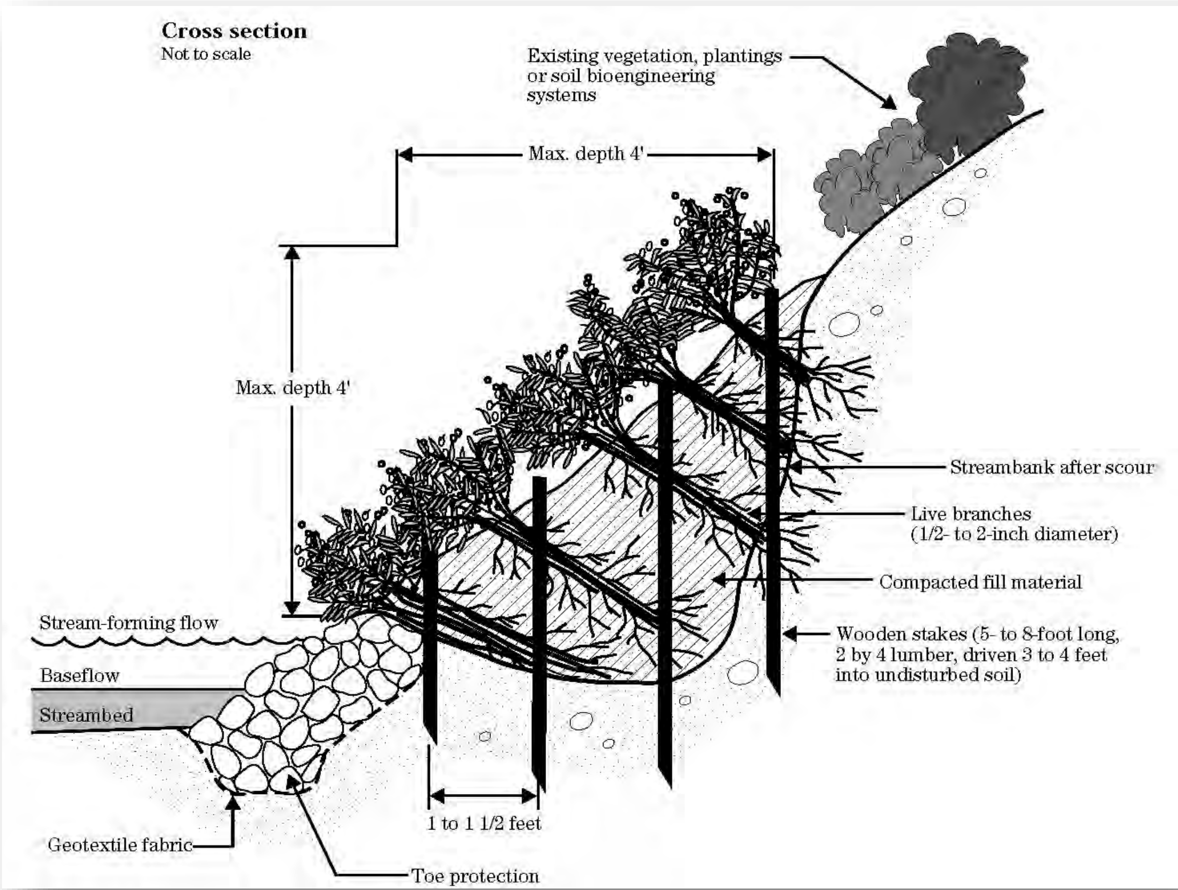
Fascines and mattresses are thick layers of live branches that serve as barriers against erosion. This practice can be applied along existing bank contours. The bundles are buried across the slope, parallel or nearly parallel to the stream and supported by stakes driven through the bundles and placed on the down slope.

The interconnected stake structure when used on slopes provides protection from erosion due to downward water flow, wind action, and trampling by livestock and humans. Live fascines and brush mattresses are also installed in combination with a coir fiber mats or rolls (see Practice 6). This holds slopes between the wattles in place without the development of rills or gulleys from overland flow. This practice is typically applied to the eroding bank and splash zones of the stream.



Practice 5 – Brush Layering & Branch Packing

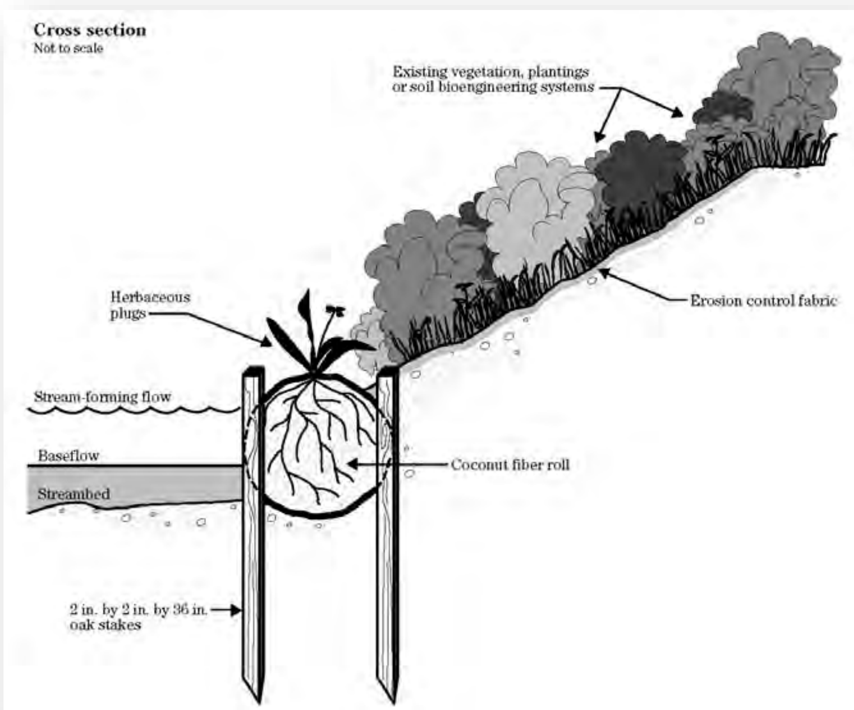
Brush Layering and Branch Packing are techniques where bundles of live tree branches are buried in parallel trenches excavated in constructed terraces or along existing contours of an eroding stream bank. When sprouted and rooted, the trees will stabilize the stream bank with a dense matrix of roots. This practice is usually applied to the splash and bank zones of a stream. For severely eroded stream banks, toe protection such as log or rock revetment (see Practice 10) may be necessary.



Practice 6 - Temporary Reinforcement: Coir Rolls & Mats

Made of rope fashioned from coconut husk fibers, coir rolls and mats are high-tensile solutions for toe and bank reinforcement. In addition to coir, several natural fabrics including jute, straw, and cotton also have high lignin content making them durable and versatile. Fibrous rolls or mats are held together by organic netting with biodegradable stitching. These materials slow and deflect water flows, hold the soils in place, and serve as growing medium for the establishment of vegetation along banks. These materials are inexpensive solutions that can be easily transported and installed at the project site. Lightweight bank coverings and vegetative establishment practices are typically applied to low flow streams or canals experiencing low to moderate effects of erosion. Because of their flexibility, they can be placed along the natural contour of the channel and banks relatively easy. Following installation, the material is seeded or planted with cuttings or root wads. Once vegetation is established, little or no maintenance is required.

Coir rolls or "bio-logs" are arranged in cylindrical bundles of fiber while mats are intertwined coir fibers held together by mesh. Both rolls and mats are available in varying thickness, width, and lengths depending on the shape and size of area to be covered. They can be ordered as pre-seeded media or planted following installation.



Practice 7 - Permanent Reinforcement: Synthetic Solutions

While biodegradable materials are preferred, several ecologically-sensitive, cost- effective alternatives can be used to retain the soils on stream banks (moderate flow conditions) that allow for drainage through the structure. These products, also known commonly as geotextiles, can be used in lieu of riprap or in combination with rock if necessary. Some toe reinforcement, rock or log revetments, or stone gabions are still required, but only up to the average annual high water line.

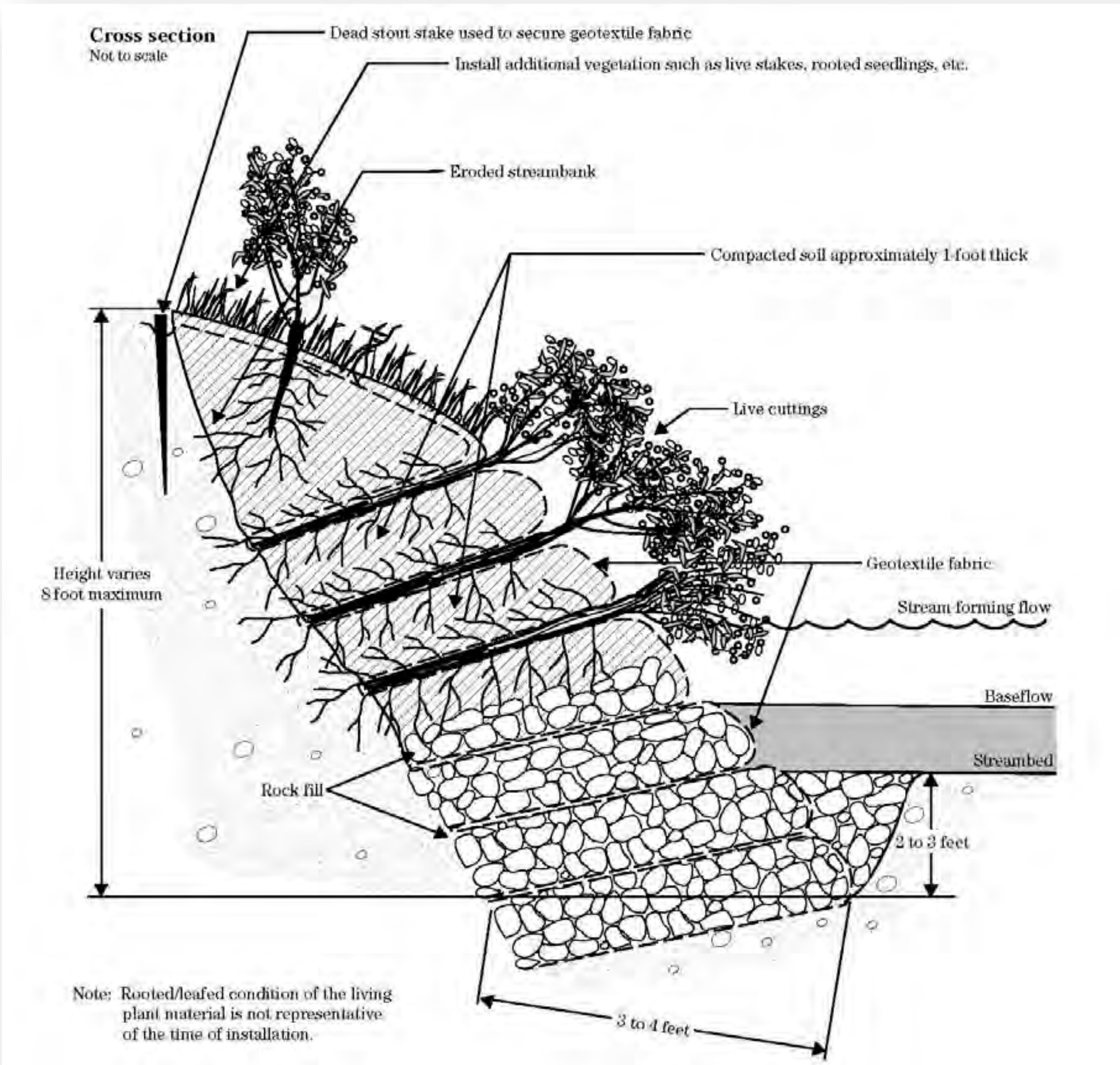
These three-dimensional, vegetated erosion reinforcement fabrics offer structural stability equivalent to a minimum of 12 inches of rock at approximately half the cost. These materials can have an effective lifespan of 4 to 50 years, depending on whether they are heavy weight and UV stabilized products. These high-density (often plastic) materials can be used to line streams, drainage swales and canals, and ponds to protect against erosion, with the added benefits of permeability, which improves wildlife habitat and increases species diversity. Most of these methods can be manually seeded or hydroseeded for rapid vegetation establishment. Geotextiles are available in various shapes, sizes, and strengths to fit almost any channel or bank configuration.

First, selected grasses are grown on a geo-membrane, which is then laid over a prepared bank. The geo-membrane holds the soils back, while the grasses penetrate through the membrane into the bank providing strength and stability.

There are three basic types of geotextiles:

1. Filter fabrics are woven, non-woven or knitted, permeable sheets used for soil reinforcement. These reinforced, high tensile strength mats are usually applied to the natural contour of the slope. They can be used alone or beneath other structures such as gabions and log revetments. The fabric is usually covered with soil and planted for optimal stability.
2. Geo-grids are tough, non-woven (webbed) synthetic sheets with large rectangular holes that can be applied to steep slopes and vegetated with grasses for additional support.

3. Geo-matrices are three-dimensional geo-grids (high density plastic webs with pockets), or sections of cells that can be filled with soil and planted to control erodible banks, especially banks that contain granular sands. Geogrids and matrices are usually rings on a flexible grid with horizontal bars connecting every few rows that increase contact time for infiltration. The flexible grid permits a good, custom fit against the natural bank contours.



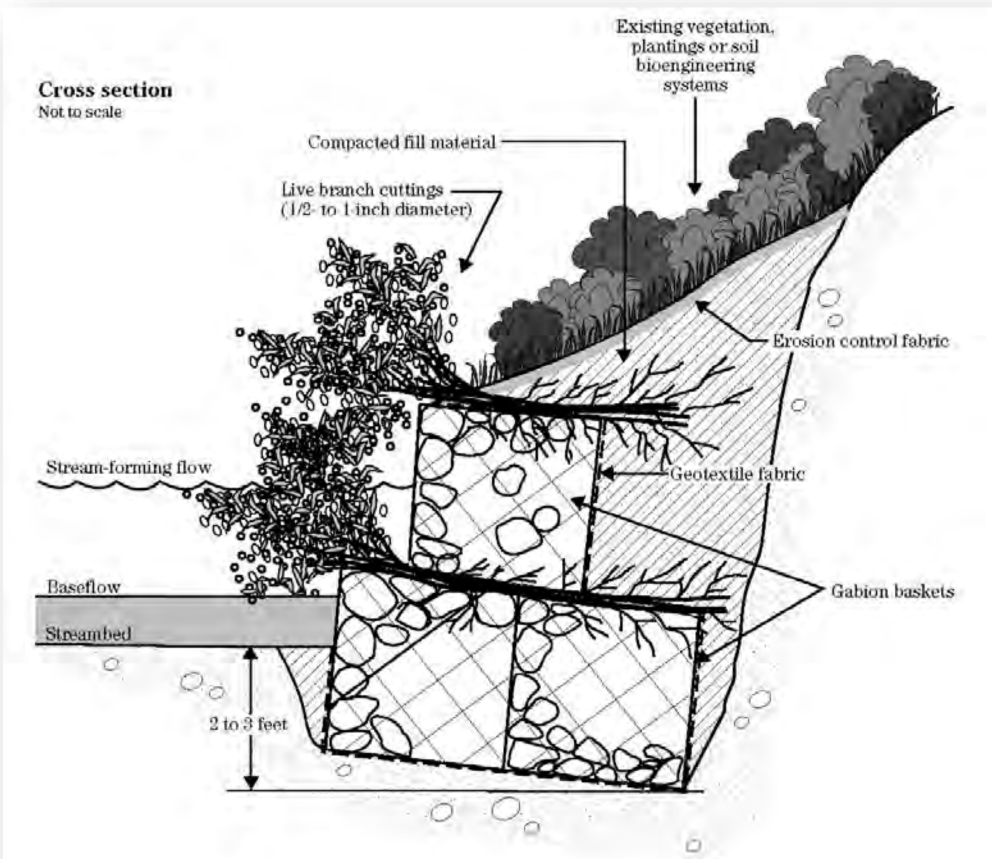
Acceptable Practices – Integrated Practices

These stabilization methods are integrated bioengineering practices combined with one or more structural component useful in areas with higher to moderate velocity flows and/or wave action. This approach is most often appropriate at the toe of the bank or shoreline to prevent additional bank slumping/failure. Structural components should be minimal and only used when necessary to ensure long-term success of stabilization efforts.

Practice 8 - Rock Rolls/Vegetated Gabions

This practice places rocks contained within wire mesh containers along the toe and splash zones to prevent bank washout and toe scour by diverting and dissipating high velocity flows. Small to medium size rocks are enclosed within rectangular or cylindrical wire-mesh baskets to form a structural toe or sidewall, which is embedded into the eroded (undercut) areas of the bank to create a stable stream profile. Live branch cuttings can be placed between each consecutive layer of baskets to consolidate the structure and bind it to the bank (see Practice 3). The baskets can be planted with native vegetation. Once mature, the vegetation will grow over the water providing a shady habitat for fish and other aquatic organisms.

This method is usually combined with bioengineering techniques (see Practice 1) such as the re-grading of the slope and re-vegetation within and above the affected area. This treatment is quite effective where the bank is steep and needs moderate structural support.

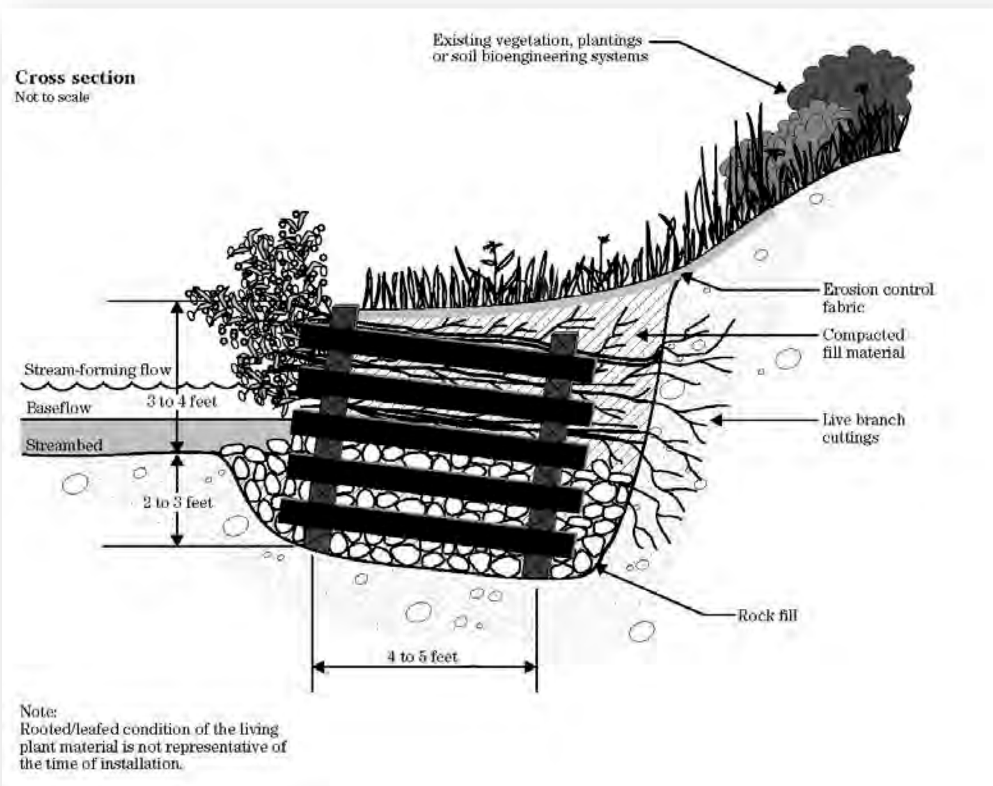


Practice 9 - Vegetated Cribwalls

Where other options would be construction-intensive, cribwalls are a useful practice in areas with near vertical banks that gives a natural appearance and effective protection. The opportunity for quick establishment of bank vegetation is another positive benefit for the use of this practice.

Made of untreated wood or timber, these hollow box-like structures are placed within eroded banks and filled with alternating layers of soil and live branch cuttings. The cuttings root and eventually replace the wood as a structural element.

The treatment is resistant to high flow velocities and is effective on the outer perimeters of bends. The cribwalls are typically applied to the toe and splash zones of the banks where a near vertical wall might be required to stabilize the toe and reduce steepness of the slope. Where stable streambeds exist, the treatment may be used above or below water level. Cribwalls can be used in conjunction with soil bioengineering methods that stabilize the upper bank and ensure a regenerative source of streambank vegetation. In moderate to high velocity conditions, a rock toe may be necessary to stabilize the crib structure.



Practice 10 - Revetments

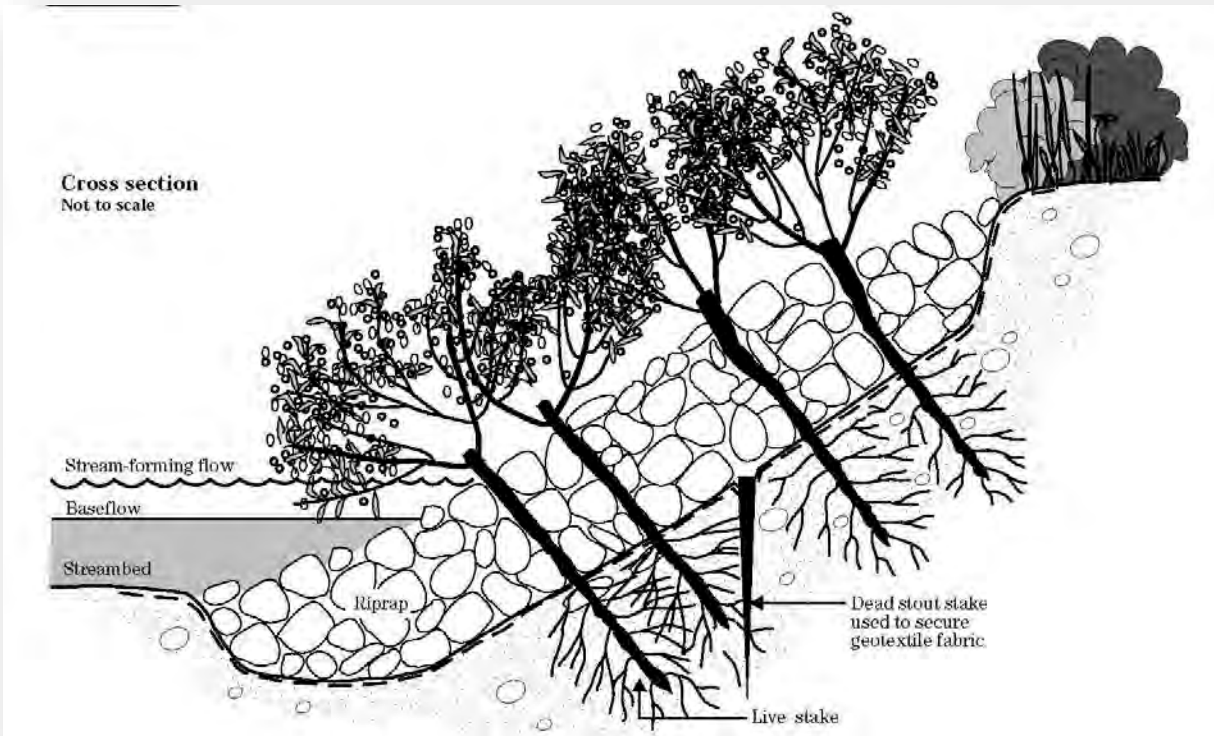
For unstable, especially steep banks, more intensive structural measures may be necessary for adequate stabilization. Similar to cribwalls, log revetments are usually placed along the bank instead of inside of it and are often used as a load-bearing solution. Better than vertical concrete bulkheads, log revetments are placed along the natural contour of the bank providing periodic level areas for vegetation establishment. Essentially, revetments reinforce granular soils by confinement via a wall or “fascia” that can be an oversteepened and still facilitate the growth of vegetation. The logs themselves provide terraces that accumulate sediment and can support vegetation in the bank and terrace zones. In addition, the vegetated terraces provide overhang essential for fish habitat. This practice is used for unstable slopes with poor soils along medium to high velocity streams.

In addition, various geo-synthetic options (high density polyethylene products) are available for supplemental use. These expandable honeycomb like structures give additional structural integrity and provide protection from future channel and bank erosion. This multi-layered technique is typically applied to steep bluffs (nearly vertical) with little or no vegetation. The sections of cells are placed in layers or terraces along the natural contours of the bank. These cells are filled with soil and planted for added stability. The web fascia is available in different colors, shapes, and sizes depending on the natural conditions of the site. These soil retention techniques are typically used on already eroded banks. In cases of limited space, backfilling may be necessary for installation.

Both of these techniques, unlike concrete, do not impede the interaction of water with the banks (water moving freely through the structure’s face). This permeability allows for crabs, insects, and fish to use these areas for breeding, feeding, and reproduction.

Practice 11 - Joint Plantings

Joint planting or vegetated rip rap involves tamping live stakes into joints or open spaces in rocks placed along the slope. Vegetation, especially deep rooting species planted above and immediately behind the rock will greatly increase the stability of the slope.



Discouraged Practices—Structural Practices

Much of the populated shorelines along the coast are modified with structures to prevent upland and developed property loss. These control structures are built to decrease or halt the erosion process in order to maintain coastal property or to aid in keeping channels or ports open and accessible. Structures are built both parallel and perpendicular to the shore. Structures parallel to the shore are bulkheads or revetments, and those perpendicular to the shore include jetties and groins. The following table shows the results of a survey conducted in 2010 by the University of Georgia Skidaway Institute of Oceanography.

Coastal Structures	Length (meters)	Number of Structures
Hardened Shoreline	212,229	3,161
Bulkhead	74,673	1,425
Revetment	118,375	1,558
Bulkhead and Revetment	7,010	122
Other	7,523	39
Undetermined	4,650	17
Causeway	137,170	494
Field Inspection Route	882,054	--

Over the past decade, there has been a movement to discourage structural practices along Georgia's coastal wetlands, waterways, and shorelines. There is a broad scientific consensus that armoring generally degrades the integrity of the marine ecosystem. Many fish and wildlife species require healthy intertidal habitats for food, migration, cover, and spawning. Structures that run parallel with the streambanks, such as bulkheads, can negatively affect the intertidal habitat by altering sediment composition and supply. Additional impacts (such as the removal of the riparian buffer or vegetation along the banks) can have negative effects on fish spawning habitats and shellfish beds. Additionally, riprap revetments, bulkheads, and seawalls often contribute to erosion in other areas by altering water flow and sediment deposition upstream and downstream of the affected area.

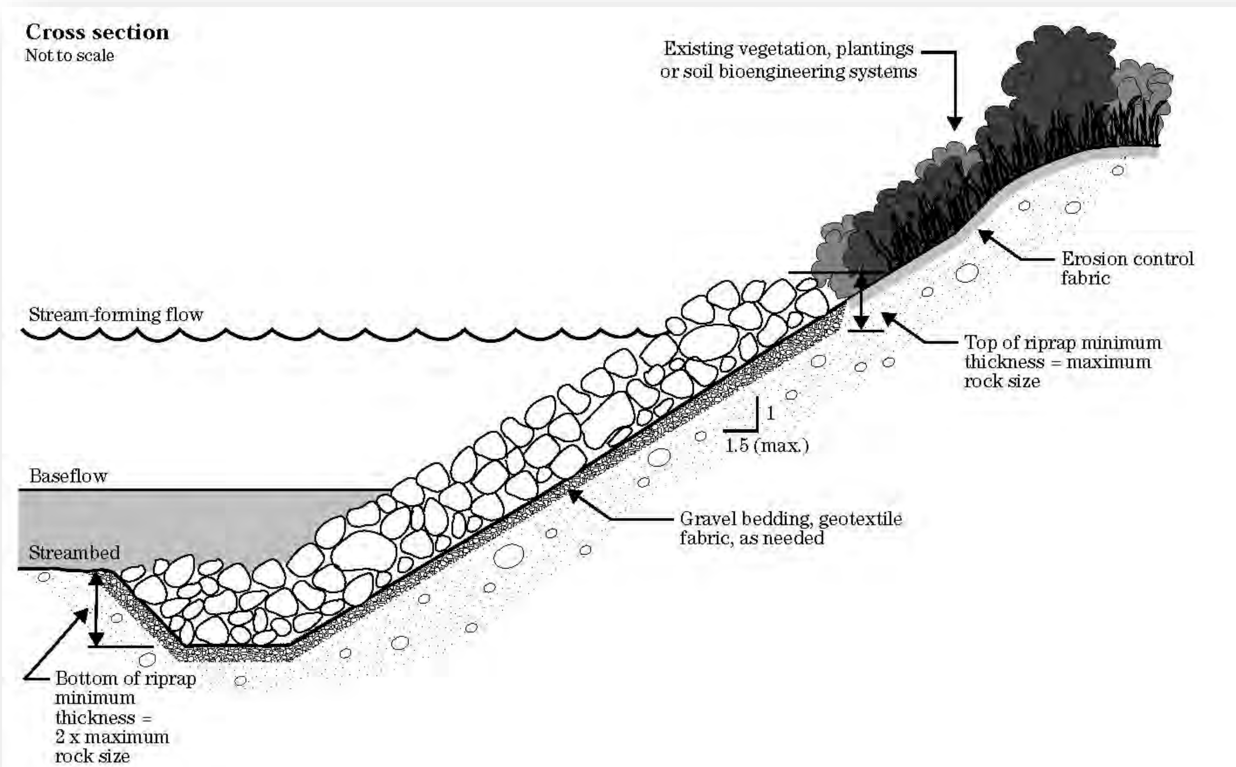
Since alternative practices are available and contractors are more familiar with alternative solutions, the use of hard armoring the streambank to control erosion should be avoided unless there are severe conditions that warrant the need for structural controls.

Practice 12 - Rock Riprap/Rock Gabions

Riprap stabilization designs should include appropriate bank slope and rock size to protect the bank from wave or current action and to prolong the life of the embankment. A final slope ratio of at least 1:2 (vertical to horizontal) is recommended, and a more stable 1:3 slope should be used when possible.

A layer of gravel, small stone, or filter cloth is placed under and/or behind the rock to prevent failure. In many cases, only the toe of the slope may need rock reinforcement; the remainder can be planted with native vegetation.

Rock gabions with vegetation are a more acceptable stabilization practice. See details for Practice 8 - Vegetated Gabions and Practice 11 for Joint Plantings.

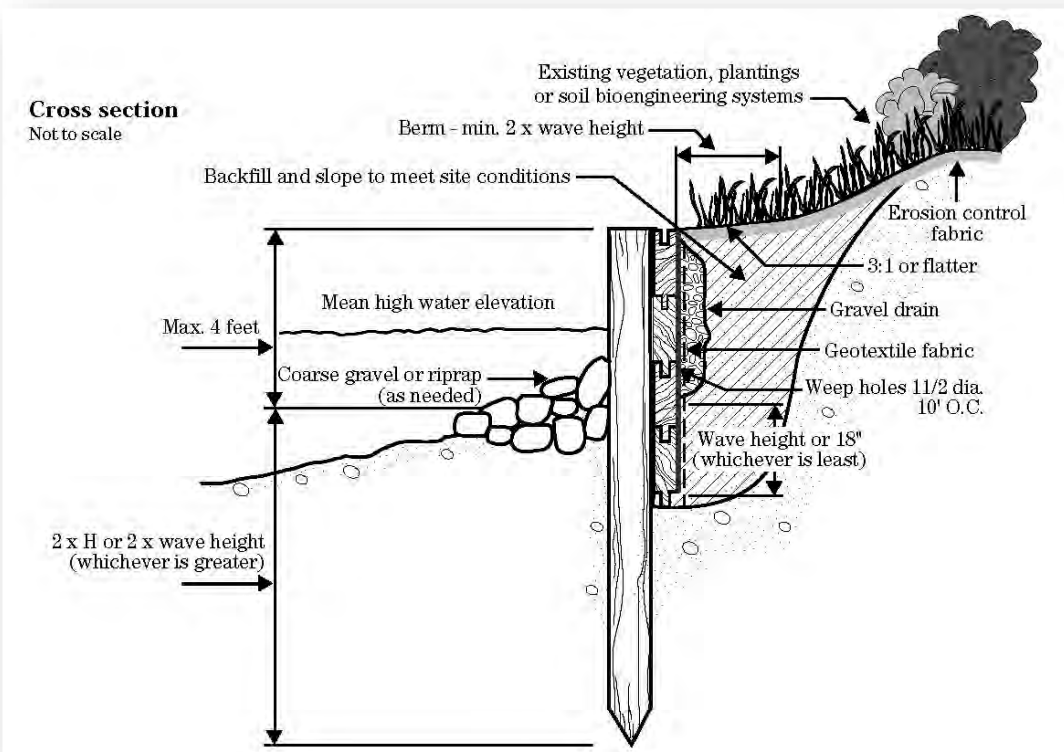


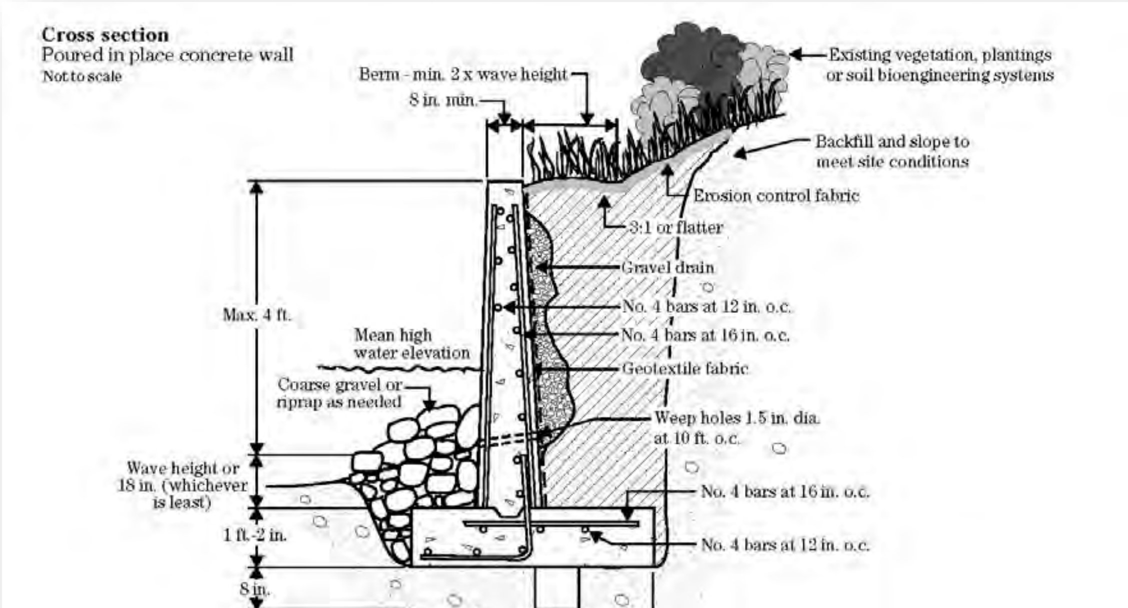
Practice 13 - Bulkheads & Seawalls

Bulkheads and seawalls are generally not encouraged. These structures (typically sheet steel, concrete, or wood) produce a sterile, vertical, flat-faced structure that is of little use to aquatic organisms and other wildlife. They also tend to reflect wave energy rather than dissipate it, usually resulting in erosion problems in front of the structure and elsewhere.

However, when erosive forces are severe and existing building foundations or structures are threatened, and other stabilization approaches would not be effective, a new or replacement retaining wall may be warranted. In these cases, rock should be placed at the toe of the structure to reduce the adverse impacted of reflected wave energy.

Typical Concrete Bulkhead Construction. Source: Dr. Clark Alexander





Typical Concrete Seawall, Source: Dr. Clark Alexander

Living Shorelines—Stabilization Practices in Tidal Waters

Many of the bioengineered and non-structural practices recommended in this chapter can be applied to coastal erosion if adapted to withstand tidal hydrology and saline conditions.

> ***Living Shorelines***
>
> A shoreline management practice that provides erosion control benefits; protects, restores, or enhances natural shoreline habitat; and maintains coastal processes through the strategic placement of plants, stone, sand fill, and other structural organic materials (e.g. coir logs, oyster reefs, etc).

When working in tidally-influenced waters and wetlands, additional factors to consider include:

- Salinity
- Full-sun exposure
- Tidal range
- Substrate type
- Elevation
- Slope
- Landscape position
- Fetch (exposure to wave action)
- Storm surge frequency

With the exception of wave action associated with seasonal storms (nor'easters) and infrequent hurricanes, the tide's twice-daily ebb and flow is by far the dominant physical process along the Georgia coast. Because of the concave shape of the shoreline and a broad, shallow continental shelf, wave energy is low with wave heights averaging from two to less than four feet at the breaking point. The average tidal range is just higher than six feet. Seasonal spring (biweekly) tides range up to ten feet and are the highest along the U.S. South Atlantic coast.

Gently sloping shorelines, beaches, and marshes are nature's best defense against erosion. A shoreline is better protected if there are shoals, tidal flats, offshore bars and/or a marsh near the shore.

Most tidally-influenced vegetation grows beneath mean tide level because the roots must be underwater at high tide but dry at low tide to survive. Source: Dr. Clark Alexander.

Wide, vegetated shorelines can withstand more wave action than narrow shores absent marsh grasses. Sandy beaches and vegetated marshlands prevent average high water from reaching upper areas of the shore. Firmly-anchored plants and stable substrates decrease the rate of erosion by breaking up waves and trapping sediment carried by currents along the shoreline. As this happens, the band of vegetation expands, pushing the mean high tide away from the toe of the bank and provides a dense band of energy-absorbing vegetation. Tidal vegetation also filters pollution from overland runoff in effect improving water quality.

Coastal marshlands serve as a transition zone between open water and land. Salt marshes and estuaries provide excellent habitat for many plant and animal species, several of which are of recreational and commercial importance.

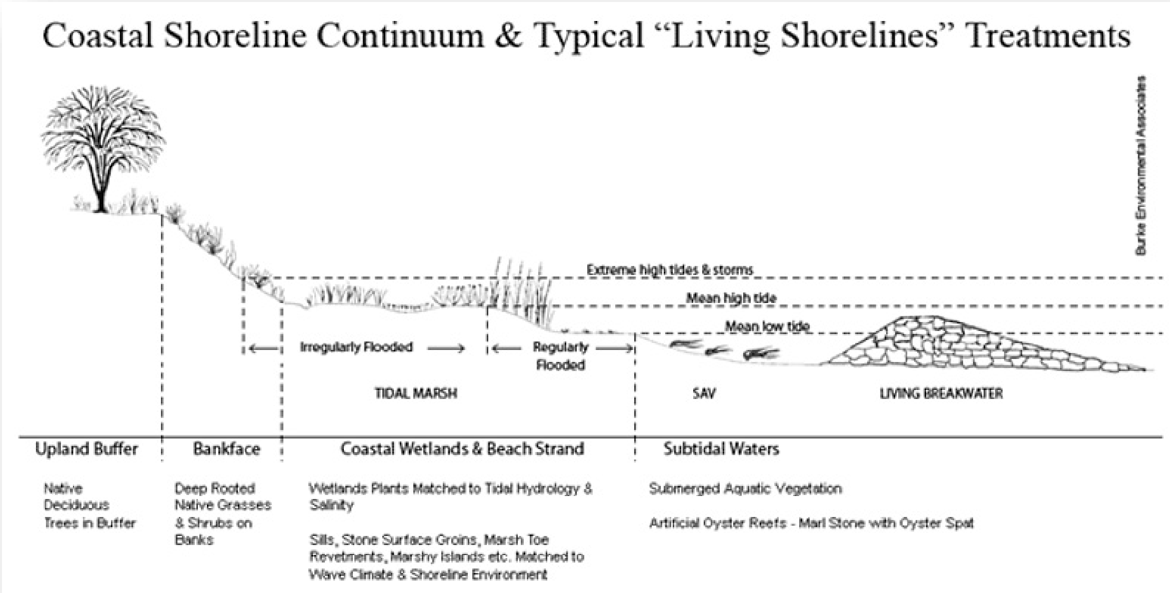
Changes in water level also have an effect on the amount and rate of erosion. Estuarine water levels are influenced by the seasons, tides, storms, droughts, floods and the rise of sea levels. Seasonal storms influence the level and movement of water, the intensity and direction of wind, and the patterns of erosion and deposition. Tidal marshlands also have the ability to protect property from hurricane damage by reducing storm intensity and resulting storm surge, which can be an added benefit for developers and homeowners.

> Living shorelines dissipate and absorb wave energy, promote the building of fringe wetlands and marsh, and provide a structure that is often rapidly colonized by a multitude of marine creatures, including oysters, barnacles, crabs, algae, shrimp, and fish. (Tidal Creek Project, 1997)

Planting a marsh along the shoreline (i.e. constructing a "Living Shoreline") can be an effective way of stabilizing the shoreline and enhancing the ecosystem. Living shorelines work best in areas with low wave action, gentle slope, and low boat traffic. Target areas include the upper reaches of tidal creeks, tidal coves, and other areas protected from excessive wind and wave action. Living shoreline projects utilize a variety of structural and organic materials, such as wetland plants, oyster shells, native substrate, and stone. Vegetative practices can be used in conjunction with bagged oyster shells or rock gabions to build marsh and protect the uplands from wind, wave, and boat actions. In an appropriate setting, this is the most economical procedure to use. Vegetative solutions are often less costly than structural measures and are an attractive way to preserve the coast of Georgia.

The following native plants will be the most successful in or around tidal waters due to their ability to withstand tidal conditions:

- False willow (Baccharis angustifolia)
- Silverling (Baccharis halomifolia)
- Saltwort (Batis maritima)
- Saltmarsh ox-eye (Borrichia frutescens)
- Saltgrass (Distichlis spicata)
- Marsh elder (Iva frutescens)
- Needle rush (Juncus roemerianus)
- Sea lavender (Limonium nashii)
- Annual glasswort (Salicornia bigelovii)
- Perennial glasswort (Salicornia virginica)
- Coastal dropseed (Sporobolus virginicus)
- Smooth marshgrass (Spartina alterniflora)
- Rough marshgrass (Spartina cynosuroides)
- Cord marshgrass (*Spartina patens*)



Living Shorelines Diagram. Source: NOAA Office of Habitat Conservation

The main objective of shoreline stabilization is to reduce the energy of waves striking the eroding bank. Non-structural design options are most suitable in very low energy settings with minor erosion, minor wave action, and good growing conditions. Areas subject to moderate to high wave energy may require a combination of vegetative and structural controls such as stone revetments and bulkheads to provide long-term protection.

Coastal wetlands function as valuable, self-maintaining "horizontal levees" for storm protection, and also provide a host of other ecosystem services that vertical structures do not. Tidal marshlands reduce the need for shoreline armoring through wave energy attenuation and shoreline stabilization that reduces flooding, erosion, and protects the shoreline. Investing in the maintenance and restoration of coastal wetlands can be a cost-effective, multi-beneficial solution to shoreline erosion.

Local Case Study—Sapelo Island, Georgia

Hardened shorelines have been identified as priority threats to marine system habitats in the St. Mary's-Satilla-Cumberland Island Estuarine Complex (DeBlieu *et al.* 2005). Likewise, banks that have been stabilized with riprap or bulkheads can, in certain instances, exacerbate erosion on adjacent properties. Extensive armoring along shorelines prevents wetlands from migrating and river morphology from shifting naturally with climatic changes such as sea level rise.

In 2010, Sapelo Island National Estuarine Research Reserve—with the help of Georgia Department of Natural Resources, University of Georgia Marine Extension, and many private citizen volunteers—applied alternative living shoreline methods along the Ashantilly and Long Tabby Creeks. The practice consisted of a combination of structural controls (bagged oyster shells and rock gabions) and bank re-vegetation (planted *Spartina* marsh grass). The goals of the project are to study the feasibility of alternative techniques and determine the level of effectiveness (shoreline protection and ecosystem function enhancement) of alternative methods.

Volunteer installing bagged oyster shells and marsh plantings. Source: Jan Mackinnon

In order to measure the success or failure of the Sapelo projects, both Ashantilly and Long Tabby sites are monitored on a semi-annual basis. The following information is collected and recorded:

- Aerial Extent of Oyster Reef Habitat
- Fixed Benthic Faunal composition: Oyster, Mussel, Barnacle Density
- Extent of Marsh Vegetation
- Vegetation Composition: # of Plants, Stem Densities/Height
- Basic Water Quality Data: Salinity, Temperature, Dissolved Oxygen

Ashantilly River - Before & After Stabilization. Source: Jan Mackinnon

To date, the alternative techniques have been effective in stabilizing the banks from erosion, filtering upland runoff, and providing marine habitat. Living benthic fauna (oysters, barnacles, and mussels) has colonized a majority of the structure as well as planted and volunteer marsh grasses and other herbaceous vegetation has re-established along the top of banks.

Sea Level Rise

Traditionally, developers, engineers and landowners have focused on practices that address past and present conditions. More recently, they are increasingly faced with planning for future circumstances—namely sea level rise. Since one of the major effects of sea level rise (SLR) is shoreline erosion, many of adaptive responses are aimed at physically protecting the land immediately inland of the tidal creek or shore with what are commonly known as *streambank/shore protection* strategies. There are currently three main categories of strategies being implemented in coastal Georgia—soft and hard engineering practices as well as strategic and/or planned coastal retreat (i.e the process of moving the built infrastructure inland to accommodate for upcoming changes).

Soft practices entail engineered solutions that reshape the landform, but largely allow for natural processes to continue unimpeded by structural controls. Soft engineering strategies include beach renourishment, dune construction, salt marsh and estuarine wetland restoration, and the establishment of living shorelines. Collectively, these strategies can range from relatively simple to extremely complex and highly engineered designs but are based on the principle that the opportunity for long-term streambank or shoreline stabilization is best accomplished through preserving, creating, or enhancing natural systems. Soft stabilization measures include the sloping and shaping of banks and vegetation establishment, both of which promote land accretion. Wetlands created as a result of this process will provide more effective protection against future sea level rise as well as flooding caused by major hurricanes and storms.

By contrast, hard engineering structures (bulkheads, seawalls, and revetments) do not allow for natural migration of streambanks and shorelines and often prohibit the natural establishment of stabilizing vegetation. Since these structures are fixed in place, there is a growing concern that on-going maintenance and future retrofits necessary to keep up with the pace of rising sea levels will render these strategies as impractical from a logistical and economical standpoint. Additionally, once these structures are installed, critical aquatic habitat is often degraded or permanently lost.

For these reasons, G3 encourages soft engineering solutions and/or planned retreat options as preferred alternatives to address long-term sea level rise impacts.

Regulatory Permitting Information

Activities in or near rivers, streams, or wetlands may require permits from local, state and/or federal agencies. A brief summary of different permit types follows; however, you should contact the appropriate agencies before beginning any stabilization activities. Some of the activities associated with stabilizing eroding banks and shorelines along streams, ponds, canals, and other waterbodies may require permitting through the United States Corps of Engineers and the Georgia Department of Natural Resources. Maintenance of existing structures may also require permitting. The following applicable laws and regulations should be considered when applying streambank/shoreline stabilization practices.

- ✓ Section 404 of the Clean Water Act (federal)
- ✓ Section 10 of the Rivers and Harbors Act (federal)
- ✓ Georgia Water Quality Control Act (state)
- ✓ Erosion and Sedimentation Act of 1975 (state)
- ✓ Coastal Marshlands Protection Act (state)
- ✓ Shore Protection Act (state)

Please note that this is not a comprehensive list, and there may be other federal, state, or local laws and regulations that may need to be reviewed prior to undertaking an activity associated with bank stabilization projects.

- Discharge of dredge or fill materials (impacts) within waters of the United States are regulated and require permit authorization by the U.S. Army Corps of Engineers (USACE) under Section 404 of Clean Water Act. Streams (intermittent and perennial), open waters (including canals), ephemeral drainages, and forested wetlands are considered "waters of the United States."
- Impacts to navigable waters of the United States require authorization under the Section 10 of the Rivers and Harbors Act. Navigable waters of the United States are defined as tidal waters and waters that have been used in the past, are now used, or are susceptible to use as a means to transport interstate or foreign commerce up to the head of navigation.
- Most waters of the State of Georgia require a 25-foot stream buffer and a variance from the Georgia EPD if the 25-foot buffer is encroached upon (unless the activity is specifically exempt). Exceptions to the buffer requirement include warm water ephemeral streams, wetlands, and stream reaches with a bulkhead or seawall. Although it is not mandated by the State, G3 recommends a 100-foot vegetated buffer for all State waters.

- A Coastal Marshlands Protection Act (CMPA) permit is required for any project which involves removing, filling, dredging, draining, or otherwise altering any coastal marshlands.
- A State Revocable License is permission from the State to use publicly owned lands lying below the ordinary high water mark. Required for permanent or temporary activities that would impact tidally influenced waters, salt marshes, intertidal areas, mud flats, or tidal waterbottoms in Effingham, Long, Wayne, Brantley, Chatham, Glynn, Camden**,** McIntosh, Bryan, Liberty, and Charlton Counties**.**
- A State Water Quality Certification is required for most USACE Clean Water Act Permits and Rivers and Harbors Act Permits. This enables the State to review federal permits to ensure the State waters quality standards are met.
- A Shore Protection Act Permit is required for any activities involving shoreline stabilization structures, piers, boardwalks, crosswalks, as well as building structures and supporting infrastructure within the Shore Protection Jurisdictional Area.
- State Buffer Variances and local permits such as Land Disturbance Permits may be required by the local municipality for land-disturbing activities in close proximity to wetlands and waterways.

Federal Regulations

In conducting maintenance/stabilization work around jurisdictional waters and dredging of canals, often the ultimate goal is to reduce erosion, improve water quality, and restore channel function. However, despite the benefit to water quality, resource managers should consider whether the proposed maintenance or enhancement to a jurisdictional area is considered an impact or regulated activity.

The following are generally not considered to be impacts:

- Activities that do not disturb bed and banks of the stream or open water feature.
- Activities that do not result in dredge or discharge of fill materials to that jurisdictional water.
- Regular maintenance of a stormwater management facility.

Regulated impacts will likely occur in the following situation:

- Construction activities that reinforce or protect stream banks with hard materials such as riprap, revetments, and structures.

- Maintenance to a stormwater management pond or facility that has not been maintained and as a result has developed a dominance of wetland vegetation and soils.

**The regulatory line along non-tidal water features (streams, canals, lakes, etc) is referred to as the ordinary high water mark (OHWM). OHWM is defined as the line corresponding to physical indicators of normal flow. Examples include shelving, break in slope, changes in soil texture or substrate size class, destruction of terrestrial vegetation, and a line of debris or wrack.

**The regulatory line (typically the mean high tide) along tidal waters and shorelines must be verified by the Georgia Department of Natural Resource (DNR) Coastal Resources Division (CRD).

The USACE has a variety of permit options to authorize impacts. The size and type of impact typically dictates the type permit that is applied:

- Nationwide Permits,
- Regional Permits,
- Individual Permits, and
- Letters of Permission.
- Minor impacts such as most impacts associated with bank stabilization activities are typically authorized under nationwide or regional permits, which applies to a number of general activities that impact jurisdictional areas. For larger, more complex projects, an Individual Permit may be required.

The Army Corps of Engineers (USACE) has jurisdiction over freshwater wetlands and waterways within all coastal counties. For more information on USACE permitting, visit http://www.sas.usace.army.mil/.

State Regulations

In addition to federal permitting through the Corps of Engineers, there may also be additional permits to obtain from the Georgia Department of Natural Resources (Environmental Protection and Coastal Resource Divisions). The EPD requires a 25-foot buffer on all waters that have wrested or removed vegetation as a result of normal stream flow or wave action resulting in a clear demarcation between the channel and adjacent vegetative growth (GAEPD 2006). Any encroachment into this protected buffer must be approved through the issuance of a Stream Buffer Variance. Preferred and acceptable stabilization methods typically have a shorter regulatory processing period whereas discouraged practices undergo additional agency review and require mitigation for impacts.

Land-disturbing activities one acre or greater are subject to the NPDES State General Permits for Storm Water Discharges associated with Construction Activities. In some counties and municipalities, the local issuing authority has jurisdiction over the issuance of this permit. For more information on EPD permit requirements, please refer to http://www.gaepd.org.

Local Regulations

In addition to the State buffer variance requirements, the local issuing authority may have buffer requirements regarding encroachment or restrictions on percent impervious cover beyond the State-mandated 25-ft buffer. Also, depending upon the County in which the project is located, the Local Issuing Authority may have additional requirements that exceed the NPDES State General Permits for Storm Water Discharges associated with Construction Activities.

Regulatory Contacts

U.S. Army Corps of Engineers Savannah District 100 W. Oglethorpe Avenue Savannah, GA 3140 (912) 652-5279/5770	U.S. Fish and Wildlife Service Southeast Region 1875 Century Blvd, Suite 400 Atlanta, GA 30345 (404) 679-4000	Georgia DNR - Coastal Resources Division One Conservation Way Brunswick, GA 31520 (912) 264-7218
Georgia DNR - Environmental Protection DivisionWatershed Protection Branch 4220 International Parkway, Suite 101 Atlanta, GA 30354 (404) 675-6240	Georgia DNR – Historic Preservation Division 254 Washington Street SW Atlanta, GA 30334 (404) 656-2840	Local Governments (City or County Building Permit/Regulatory Services)

5—RECREATIONAL FACILITIES DEVELOPMENT & MANAGEMENT

Contents

5—RECREATIONAL FACILITIES DEVELOPMENT & MANAGEMENT

In This Chapter

- ***Planning, Design, Construction & Management Guidelines for Golf Courses, Parks, Trails, Marinas, & Community Docks***

Introduction

The beauty of Georgia's coast can be mainly attributed to its unique and abundant natural resources. Diverse and interconnected, these ecosystems are highly functional components of the landscape and collectively, offer a myriad of recreational opportunities.

Recreational developments such as golf courses and marinas can be both positive and negative, offering access to natural resources but often doing so at the cost of the surrounding environment. Because these activities are carried out in or around the water itself, there is a strong potential for the degradation or even destruction of the very resources we are seeking to enjoy.

Golf courses and parks have the potential to degrade water quality by removing riparian buffers, increasing impervious surfaces, and introducing excessive nutrients and chemicals into coastal waters. Equally problematic, in-water structures, like marinas and community docks, can concentrate many boats in one area, leading to the release of petroleum hydrocarbons, sewage, anti-foulants and other harmful pollutants into wetlands and waterways. Water pollution can potentially threaten the health of aquatic organisms and ultimately, people recreating in these areas.

The continued use and accessibility of Georgia's coastal resources strongly depends on the sustained function and health of these systems. In this chapter, the Green Growth Guidelines (G3) are expanded to address the added challenges of recreational developments. G3 provides a host of conservation measures intended to protect and preserve the present and future natural capital generated by these vital ecosystem services.

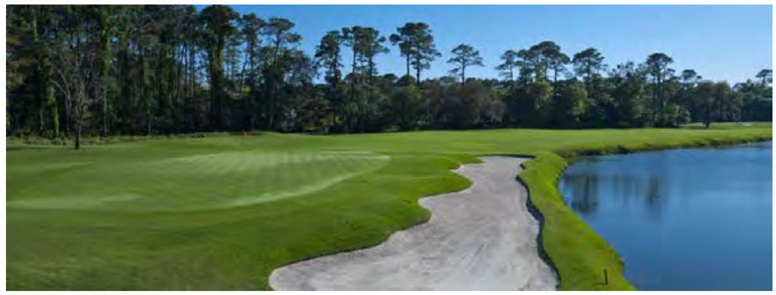
Developers, state and local governments, as well as the general public stand to benefit by implementing G3:

- Better water quality
- Healthier commercial and recreational fisheries
- Cleaner, safer conditions for recreational activities
- Increased resiliency against coastal hazards such as hurricanes and floods
- Reduced construction and maintenance costs
- More efficient operations
- Increased recreational opportunities
- Increased property values
- Enhanced visual appearance
- Better regulatory compliance

Golf Courses, Parks & Trails—Planning & Design Guidelines

Golf courses, parks, and trail systems can alter the natural features of the landscape resulting in poor water quality, loss of wildlife habitat, and land erosion. For these reasons, recreational developments should be planned, designed, and constructed with consideration for the unique conditions of the surrounding environment for which they are a part. When managed properly, these areas can serve as valuable hubs and links in the *Green Infrastructure Network*.

Incorporating natural features into the development plan protects vital ecosystem functions, reduces site development and maintenance costs, and ensures better regulatory compliance.



St. Simons Golf Club. Source: LC Lambrecht

Recommended Planning & Design Guidelines for Golf Courses, Parks and Trail Systems
Compact or condense the overall development footprint and retain large, contiguous blocks of greenspace.
 Sustain biodiversity by keeping greenspace in its natural state. Set aside as much as 50% of the total site as natural greenspace (75% or more of this area should contain native trees and vegetation).
Preserve continuous buffers and conservation areas along aquatic resources. G3 recommends 200’ from major rivers, 100’ from streams and tributaries, 50-100’ from marshlands and estuaries, and 25-50’ from forested interior wetlands.
Reduce unnecessary clearing, grading, filling, or piping of natural drainageways by tailoring the site design to fit the natural topography, hydrology, and soils found on-site (e.g. locate buildings and roadways in higher elevations and stormwater controls in lower-lying areas).
Avoid the direct discharge of concentrated stormwater runoff to natural waterbodies—instead direct runoff away from sensitive natural resources and towards areas where ponding and infiltration (pre-treatment) can occur.

Recommended Planning & Design Guidelines for Golf Courses, Parks and Trail Systems
Design green infrastructure and low impact stormwater practices which remove pollutants (phosphorus, nitrogen, fecal coliform and heavy metals) from runoff before it reaches open waters.
Design stormwater controls where post-construction runoff rates are equal to or less than pre-construction runoff rates. Check engineering specifications in the *Georgia Stormwater Management Manual—Coastal Stormwater Supplement* @ www.georgiastormwater.com
Incorporate rain harvesting practices such as underground cisterns and rain barrels to capture runoff from the rooftops of clubhouses and other supporting buildings that can be used to irrigate the greens and other surrounding landscaped areas.
For landscaped areas, plant native, non-invasive trees, shrubs and plants which require less water, fertilizers and pesticides to maintain.
Minimize effective impervious surfaces to 15% or less of the total site area. Visit www.coastalgadnr.org/pe/eic to calculate the effective impervious cover for your specific site.
Locate impervious surfaces a minimum of 50' away from rivers, creeks, marshlands and other sensitive areas. Disconnect impervious surfaces—route stormwater from rooftops and roads to grassed areas instead of concrete.
Minimize impervious surfaces by reducing the width and length of roads, right-of-ways, driveways, sidewalks and cart paths.
Use pervious materials such as porous concrete, modular pavers or geotextiles for all drivable and walkable surfaces within close proximity to coastal wetlands and waterways. Utilize grass or dirt pave, mulch or other safe recyclable surfaces for less travelled access roads, sidewalks and recreational trails.
Avoid areas of erosion when locating buildings, roads, and supporting infrastructure. If erosion is present and stabilization is necessary, apply bioengineering and non-structural practices to failing banks and unstable slopes.
Locate community sewer and private septic systems a minimum of 100' from open waters.

Construction Practices for Golf Courses, Parks & Trails

Golf courses, parks and other recreational developments near coastal waters and wetlands should implement the following construction practices:

Avoid clearing and mass grading of the site to minimize sediment erosion which can lead to turbidity of nearby waterways.

During construction, implement temporary erosion and sediment control measures such as silt curtains, hay bales and sediment traps to protect wetlands and open waters.

For detailed practices, go to www.gaswcc.georgia.gov to access the latest version of the *"Green Book"—Manual for Erosion and Sediment Control in Georgia, GA Soil & Water Conservation Commission.*

Protect native trees and vegetation during construction, especially within buffers and green space areas. If disturbance is inevitable, transplant native trees and vegetation to another area on-site.

Minimize soil compaction caused by heavy equipment to the greatest extent possible. Restore compressed soils by aerating (tilling) and amending with organic matter which improves stormwater absorption and uptake. See Ch. 3 for Soil Restoration practices.

Stabilize disturbed areas by gently sloping soils and re-establish with quick-growing, drought/ pest-resistant plants. Visit www.coastscapes.org for a list of appropriate species.

All construction equipment should be operated and stored within the limits of designated access roads and upland staging locations. Equipment maintenance and repairs should be performed off-site when possible. Any on-site maintenance should be carried out on pre-selected upland areas to reduce the risk of harmful chemicals such as motor oils, hydraulics fluids, and cleaning agents reaching nearby wetlands and waterways.

Keep construction debris piles, dumpsters and refuse containers away from open waters and wetlands.

Management Measures for Golf Courses, Parks & Trails

To ensure long-term natural resource protection goals are met, management measures should be integrated into the development's routine operation and maintenance procedures. Proper and consistent implementation of these practices is a win-win strategy—safeguard free assets (i.e. ecosystem services and the natural capital they generate) while lowering operational and maintenance costs.

The next section provides recommended practices in 4 main categories:

- Stormwater Management
- Landscape Management
- Wildlife Habitat
- Erosion Control

Stormwater Management

Basic Stormwater Maintenance Measures:
For effective pollutant removal, prune, trim and replace stressed or dead vegetation in detention, biorention and filtration areas.
When needed, aerate and amend compacted soils with organic matter for maximum stormwater infiltration.
Maintain control structures in good working order for optimal function—remove sediments and trash debris from forebays, ditches, ponds, inlets and outfalls, as well as filtration and separator devices.
To prevent clogging, routinely remove leaf debris and sediments from pervious pavers and porous concrete surfaces.

In addition to regular maintenance, a water quality monitoring plan can be established to track and maintain acceptable water quality conditions in stormwater ponds and receiving waterbodies.

Dissolved Oxygen	Total Suspended Solids	Phosphorus
Heavy Metals	Fecal Coliform	Nitrogen
Petroleum Hydrocarbons	Temperature	pH

Basic Water Quality Sampling & Testing Parameters

The U.S. Environmental Protection Agency Rapid Bio-Assessment Protocols and the Georgia Department of Natural Resources Standard Operating Procedures should be followed when performing biological assessments in coastal waters.

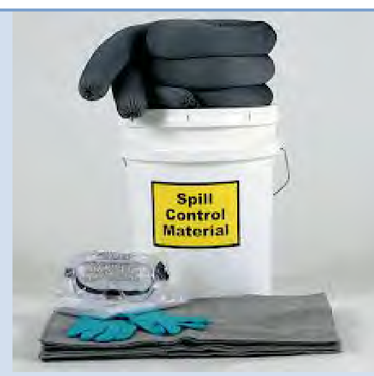
Biological assessments can also be conducted to assess macro-invertebrate and fish communities which serve as excellent indicators of water quality. Aquatic and terrestrial organisms function as continual monitors of environmental quality, capable of detecting both the effects of episodic and cumulative pollution. They inhabit these areas for most or all of their life cycles and, therefore reflect recent, as well as past, environmental conditions.

Landscape Management

Chemical Application

Recreational developments, especially maintained golf courses and parks, should prepare and implement an *Integrated Pest Management* (IPM) plan that specifically addresses the handling, storage, application and use of all on-site landscaping chemicals.

Basic Tenets of an Integrated Pest Management (IPM) Plan	
Establish "no chemical zones" in and around open waters and other environmentally sensitive areas. Chemical application (pesticides or herbicides) into open waters and tidal marshlands is strictly prohibited. Educate and train maintenance staff of the importance of this rule.	
Landscape using native trees, shrubs, and plants. See www.coastscapes.org for a list of appropriate species suited to your area.	
Use organic fertilizers such as compost, blood meal, fish meal, amino acids, humic acid, and green manure.	
Observe and record the type, severity, location, and treatment of pest problems.	
Use biological (algae-eating fish/bacteria) or physical (aeration) methods to control weeds and pests in ponds and lagoons.	
Establish and support populations of natural predators of pests—beneficial microbes, insects, birds, fish, amphibians, and mammals.	
Only use what is absolutely needed. Routinely test soils and apply fertilizers on a prescriptive basis according to site-specific needs.	
Use water-insoluble nitrogen (WIN) fertilizer which provides a slow-release of nitrogen.	
Use disease and pest-resistant turf grass varieties.	
Mow turf grass to heights that can be maintained with minimal chemical additives.	
Avoid application of fertilizers and pesticides prior to high winds or heavy rainfall.	

Basic Tenets of an Integrated Pest Management (IPM) Plan	
Follow applicable federal and state regulations for chemical storage, handling, application, and disposal. See the most current version of the *Georgia Rules for Hazardous Waste Management* for specific practices and protocols. Visit www.gaepd.org for a complete copy of the manual.	
Establish a specific pollution prevention plan that addresses all chemicals used and stored on-site.	
Consider the environmental impact of chemical application—runoff and leaching potential, toxicity to humans and wildlife, soil absorption capacity, pest resistance, and water solubility.	
Educate and train maintenance staff about the risks chemicals pose to human health and the environment. Provide staff with prevention and control measures they can use to avoid or reduce the effects of water pollution.	
	Ban the use of fertilizers, herbicides, and pesticides that are known to cause human and wildlife health problems including, but not limited to, 2,4-D, carbonyl, diazinon, dursban, diuron, malathion, triclopyr BEE, trifluralin, mancozeb, chlorothalonil, triazoles, chlordane monosodium, methane arsenate.
Keep a Material Safety Data Sheets (MSDS) for each chemical used on-site. Follow MSDS directions for specific chemicals.	
Store chemicals in a secure, well-ventilated structure located away from sensitive water resources.	
Maintain gasoline, motor oil, brake, and transmission fluid, solvents and other potentially hazardous chemicals in spill and fire-proof containers. Keep a spill containment kit readily available in the event of an emergency. Provide staff members with guidance documentation on how to use containment equipment. Post emergency contact information for reporting incidents to the appropriate authorities.	

Water Conservation & Irrigation

Golf course and park maintenance often requires large amounts of water for irrigation purposes. The biggest challenge of maintaining these recreational amenities is the constant need for hydration. Most turf grasses require quite a bit more water for their survival compared to other plants indigenous to the area. Additionally, manicured lawns consume large amounts of synthetic fertilizers, pesticides and other harsh chemicals that can contribute to nonpoint source pollution.

The following water conservation measures provide multiple benefits including reduced water use, decreased energy use (less pumping and treatment required), decreased stormwater and irrigation runoff, fewer lawn wastes, and lower maintenance costs.

Water Conservation and Irrigation Management Measures
Employ xeriscape methods—plant native trees and vegetation that can withstand local climate conditions and require little or no irrigation. Visit www.coastscapes.org for a list of native plants suitable for coastal Georgia.
Provide irrigation only on an as needed basis, especially during extended drought periods.
Harvest or collect water by cisterns, rain barrels or stormwater ponds and re-use (when possible) for landscaping irrigation.
Group plants with similar water needs to maximize irrigation.
Locate plants that require more water in lower elevations to make the most of rainwater naturally flowing to these areas.
Use bioretention areas or rain gardens which are depressed landscaped areas designed to capture stormwater. (See Ch. 3 for specific design guidelines for Bioretention Practices)
Consider evapotranspiration rates and weather conditions when scheduling irrigation. Schedule irrigation for specific early morning or evening hours to reduce water wasted due to evaporation.

Water Conservation and Irrigation Management Measures	
Use cycle and soak irrigation methods which improve infiltration, reduce runoff and achieve optimal growth by applying the right amount of water to the best location at the most favorable time.	
Use water-efficient irrigation methods such as low-precipitation sprinklers, bubbler, soaker, and drip systems that have uniform distribution patterns.	
Inspect, repair, and upgrade irrigation systems on a routine (scheduled) basis for optimal performance and efficiency.	
Equip irrigation systems with rain sensors to minimize inefficient use of water.	

RAINWATER HARVESTING

A 100-acre golf course can easily use over 100,000 gallons of water a day. Water usage can triple (300,000+ GPD) during periods of drought. Municipal water systems often place restrictions on supplies as wells can fluctuate depending on the amount of groundwater available. Usage restrictions, coupled with rising water prices, have lead golf courses to consider alternate solutions to supplement their existing irrigation systems. One logical practice is known as Rainwater Harvesting which involves simply catching the water we receive naturally from the sky. The most common way for golf courses to capture rainwater is with man-made collection ponds. Stormwater runoff captured in these ponds can then be filtered, pumped out and used for irrigating golf course greens. Rainwater can also be collected from rooftops and stored in underground cisterns or rain barrels for future uses (e.g. landscape irrigation, cart washing, etc.).

Wildlife Habitat

Golf courses, parks and trails serve as important recreational areas but also function as vital components of the Green Infrastructure system. "These connections are critical to maintaining the migration and biodiversity of wildlife populations. Links and hubs, when connected, serve as biological conduit for wildlife." (Benedict MA and McMahon ET, 2006.)

Recommended Wildlife Habitat Conservation Measures

Preserve existing native trees and vegetation in three consecutive layers: herbaceous ground cover, shrub/sapling, and tree canopy.

Maintain native trees and plants that provide food and shelter for wildlife. Trees and shrubs producing a variety of nuts and berries are preferred.

Maintain contiguous buffers for wildlife habitat—200' from major rivers, 50-100' from freshwater streams, 50'-100' from marshlands and 25-50' from interior forested wetlands.

Keep buffers in a natural state—selectively thin native trees and vegetation for scenic views and passive recreational purposes only.

Leave dead trees standing for bird-roosting habitat when they do not pose a safety hazard.

Maintain a water source for wildlife, especially shallow water with aquatic and emergent plants.

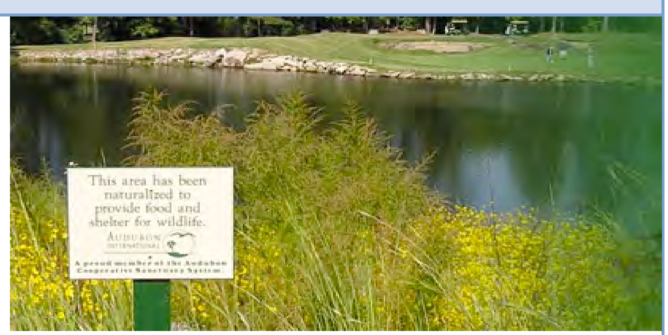
Remove trash and debris from natural areas when necessary.

Confine roads, cart paths, trails and necessary vegetation removal to the edges of existing natural areas to minimize habitat disturbance and fragmentation.

Locate and mark critical wildlife habitat on development plans.

Post signage to designate natural areas and promote wildlife awareness.

Construct wildlife structures that provide habitat (e.g. bird houses, osprey pads, eagle perches, etc.)



Erosion Control

Coastal recreational developments are often built along rivers, creeks and beaches for accessibility and scenic views of these resources. Due to location and use, these developments can accelerate natural erosion or cause land loss in areas that were previously stable.

Erosion Prevention and Control Management Measures
Maintain thick, vegetated buffers along open waterways which stabilize the banks and prevent erosion. Buffer effectiveness increases as a function of width. Generally, the wider the buffer—the greater level of protection provided.
Establish and measure reference points along banks or slopes to track the rate of erosion.
Determine the cause of erosion and make adjustments as necessary to mitigate effects.
Cease or minimize man-made activities (e.g. direct stormwater discharge, boat/jet ski wakes, removal of riparian buffer) that can worsen or accelerate erosive conditions.
Stabilize eroded areas using environmentally-sensitive methods. See Chapter 4 for specific practices.

Audubon Cooperative Sanctuary Certification Program

The *Audubon Cooperative Sanctuary Program for Golf* (ACSP) is an award winning education and certification program that helps golf courses protect the environment and preserve the natural heritage of the game. As a cooperative effort between the *United States Golf Association (USGA)* and *Audubon International*, this program promotes ecologically sound land management and natural resource conservation strategies.

Membership includes a Guide to Environmental Stewardship and a Certification Handbook that helps golf course operators to plan, organize, and document environmental efforts. Golf courses work toward certificates of recognition in six categories:

Environmental Planning—Generate a written plan outlining goals, staff, budget, and schedule. The plan is a useful tool for golf establishments to monitor their progress in meeting their goals. *Audubon International* provides one-on-one assistance for devising an appropriate environmental plan.

Wildlife and Habitat Management—Management of non-play areas is crucial to providing habitat for wildlife on the golf course. Emphasis is placed on maintaining the best possible habitat for the course considering its location, size, layout, and type of property.

Outreach and Education—Gaining the support of golfers for an environmental program is an invaluable asset. Focus is placed upon generating public awareness through education.

Chemical Use Reduction and Safety—A comprehensive and responsible program to control pests will ensure a healthy environment for both people and wildlife. Managing turf areas with environmental sensitivity requires educating workers and members about plant management, pesticide application, and use of fertilizers.

Water Conservation—Consumption of water resources remains an issue at most golf courses. Attention is directed toward irrigation systems, recapturing and reuse of water sources, maintenance practices, and turfgrass selection.

Water Quality Management—Strategies are devised to monitor the use of chemicals and the impact on the water quality of adjacent waterways and wetlands.

By implementing and documenting environmental management practices in these areas, a golf course is eligible for designation as a Certified *Audubon Cooperative Sanctuary Golf Course*. The program has the potential to improve environmental performance and community relations, reduce liability, save money, and contribute to the conservation of environmental resources. Visit www.auduboninternational.org/acspgolf for more information.

Marine Facilities—Access to Coastal Waters

Historically, Georgians relied upon tidal waters to obtain food and shelter materials, transportation, maritime commerce, and military defense. Present day, more and more people make use of these areas for boating, swimming, nature observation, and other water-dependent recreational activities. Additionally, these areas are essential to the livelihood of the local shrimping, oystering, and fishing industries.

Marine facilities are used for residential, commercial and recreational purposes by visitors, local residents, businesses, and community members. While these facilities vary in location, size and use, they all present some degree of risk to the quality of surrounding water resources.

Marinas, docks, and piers occupy coastal waterways and extend across lands where the general public has certain rights to access and usage. Therefore in the interest of the present populace and future generations, federal, state, and local governments regulate activities within these areas.

Green Growth Guidelines (G3) promotes marine development and management strategies that protect environmental health, provide for safe navigation and access, as well as preserve the visual character of the area. The following sections of this chapter provide planning and design guidelines, construction practices, and management measures for new and existing marine developments.

Promoting Community Docks & Shared Access

In order to provide deepwater access to as many users as possible, developers and their design teams are encouraged to plan and construct community docks in lieu of multiple private-use docks. Community docks can be used by many properties within the development, not just the waterfront lots. This approach grants multiple users access, but does so with substantially less impacts to adjacent riparian buffers and salt marshes. This is mainly because there is only one point of access versus many walkways, decks, and floating docks. In addition to environmental benefits, community docks often cost less to build and maintain when compared to multiple private structures.

If a community facility is not feasible for a specific project, developers and landowners should at a minimum, consider joint-use docks where the structure can be shared by two or more properties.

The following table compares the impacts of private versus community docks for a planned development that contains 10 waterfront lots. The community dock alternative provides access and comparable mooring, but the overall area covered (impacted) by the structure is decreased by 86%.

Dock Component	Private Dock Size (Ft)	10 Private Docks Impact (SF)	Community Dock Size (Ft)	Community Dock Impact (SF)	Impact Reduction (%)
Walkway	6’ x 500’	30,000	6’ x 500’	3,000	-90%
Fixed Deck	15’ x 20’	3,000	20’ x 20’	400	-86.7%
Terminal Float	8’ x 30’	2400	10’ x 200’	2000	-16.7%
Boat Hoist	16’ x 30’	4800	N/A	N/A	-100%
Total		40,200		5,400	-86.6%

Planning Marine Facilities

When planning a marine facility, benefits derived from the project should be weighed against potential negative impacts such as poor water quality, loss of wildlife habitat, and public inaccessibility. The main objective is to locate marine facilities in areas with the least impact to coastal waters and wetlands. Consideration of site conditions early in the development process will likely result in improved access, better ecological value and fewer water pollution problems. G3 focuses on wetland impact avoidance and minimization strategies which provides for better regulatory compliance and consequently, a more efficient permitting process.

The first, and perhaps the most important step in planning a marine development is the site selection process (i.e. find a site that lends itself to the project goals and objectives instead of force-fitting the development concept on the wrong site).

Site Selection

Prior to property acquisition, evaluate a proposed marine facility site based on the following criteria:
Find a site that is appropriately zoned and designated for marine structures and boating activities.
Consider previously-developed waterfront properties as opposed to natural (undisturbed) sites.
In lieu of multiple private-use docks, search for a site that can accommodate a community dock or marina which provides both neighborhood and public access. This approach maximizes user benefits, minimizes impacts to navigable waterways and tidal marshlands and in most cases, reduces construction and maintenance costs.
Check the surrounding area to see if other community docks or marinas are in close proximity to the prospective site and plan the capacity of the marine structure based on the actual need and demand for access. To avoid oversized and underutilized facilities, select a site that allows for future growth and expansion in a phased approach.

Prior to property acquisition, evaluate a proposed marine facility site based on the following criteria:
Search for, and select a site with physical characteristics compatible to the planned development requirements and objectives. The property should be suitable for the proposed marine facility, the type and size of vessels it will house, and possess adequate upland space for buildings and supporting infrastructure including necessary parking, fueling and sanitary facilities.
All marine structures serving boaters should be limited to waterways that are 20' or greater in width (measured at mean low water conditions). Avoid sites that require crossing over smaller tributaries (feeder creeks) to access deepwater.
Avoid sites that require long walkways (>500') over large expanses of vegetated marshlands to access navigable waters.
Ensure the site has adequate water depths to accommodate the proposed facility and anticipated watercraft without the need for sediment dredging. Additionally, avoid areas that are particularly susceptible to erosion and shoaling, as these conditions typically result in the need for continuous bank stabilization measures and/or maintenance dredging of waterbottoms.
Study the area to see if there are any geographical or man-made physical restrictions present (e.g. bridges, causeways, shoals, and other marine structures). If so, evaluate whether the proposed marine structure can operate at its fullest potential with these obstacles in the way.
Avoid areas where poor water quality conditions exist, especially listed degraded or impaired waterways. Check www.epa.gov or www.gaepd.org for a current list of these areas.
Do not site a marina near high-value natural resources such as oyster and clam beds. Give special consideration to FDA-regulated commercial and/or GDNR-approved recreational harvest areas (areas that meet the National Shellfish Sanitation Program criteria).

Preliminary Site Evaluation

The physical location and ecological characteristics of both the waterway itself and the nearby uplands is essential when planning a marine structure of any kind. Once a suitable site is selected, a preliminary evaluation of existing site conditions should be carried out to gain a general knowledge of the affected area.

The following basic information sources are readily available for planning purposes:
National Wetland Inventory Maps (U. S. Fish & Wildlife Service) www.fws.gov/wetlands
Topographic Maps (U.S. Geologic Survey) www.topomaps.usgs.gov/drg
Floodplain Maps (Federal Emergency Management Agency) www.msc.fema.gov
Navigational Charts (National Oceanic & Atmospheric Administration) www.nauticalcharts.noaa.gov/staff/chartspubs.html
Soil Surveys (U.S. Department of Agriculture) www.soils.usda.gov/survey
Water Quality—List of Impaired Waterways (Georgia DNR-Environmental Protection Division) www.georgiaepd.org/Documents/305b.html
Georgia Coastal Hazards Portal—Sea Level Rise, Shoreline Change, Storm Surge (NOAA Coastal Services Center, UGA Skidaway Institute of Oceanography) gchp.skio.usg.edu
Heritage Preserve Areas near Wildlife Management Areas www.georgiawildlife.org
Designated FDA Shellfish Harvest Areas www.coastaldnr.org/maps
See Appendix B for an expanded list of available site assessment resources

Assessments and Surveys

Compared to upland developments, water-dependent projects require additional consideration and evaluation due to the location of construction within environmentally-sensitive areas.

The following surveys and assessments are essential to identifying and addressing potential concerns during the initial planning phase of the development process:
Property survey showing legal boundaries (extended to show riparian access as designated and/or approved by Georgia Department of Natural Resources).
Limits of existing riparian buffers. Estimate the percent coverage of trees, shrubs and plants within buffer areas. Note old-growth specimens as well as rare, threatened or endangered species.
Bathymetry survey showing underwater relief (contour lines) and water depths (soundings). Note proximity to any known Designated FDA Shellfish Harvest Areas.
Width and depth of the waterway at mean high and low tidal stages. Note: The limit of the navigable channel is generally measured as the distance between the mean low water (MLW) lines on both sides of the waterway. Width and depth of tributaries located in the pathway of the proposed structure.
Direction and rate of water currents. If tidal, indicate ebb and flow patterns.
Spot elevations (measured in feet above mean sea level) showing extent of notable intertidal areas—mud flats, shoals, vegetated marshlands, and top and toe of bank slopes. Record location and extent of erosion, if present.
Location of adjacent docks, bridges, or other navigational obstructions or restrictions.
Survey of significant trees located on upland portion of site.
Topographic Survey—Ground elevations (height above mean sea level) of upland and wetland portions of the site. Include height of tidal vegetation in bloom.
Jurisdictional boundaries of salt marshes, freshwater wetlands and shore protection areas (as approved by the U.S. Army Corps of Engineers and/or Georgia Department of Natural Resources).
Drainage features including any tidally-influenced tributaries, ditches, ponds or lagoons.

Jurisdictional Wetland Delineations

If geographic conditions are favorable for marine development, a survey of actual site conditions should be conducted. The delineation process involves the marking and surveying of the boundary between the wetland and upland portions of the site. Wetlands are determined based on three main factors: hydric soils, native wetland vegetation and local hydrology. These conditions are different for each individual site. All wetland delineations should be performed by a qualified professional scientist and verified by the appropriate regulatory agencies. Delineations may vary by resource type (i.e. fresh vs. tidal vegetated wetlands, navigable waterways, and shorelines).

Navigable waterways and freshwater wetlands are under the regulatory jurisdiction of the U.S. Army Corps of Engineers whereas the Georgia Department of Natural Resources generally oversees activities within tidally-influenced waters, wetlands and shorelines. Proposed marine developments must be reviewed and approved by the appropriate authorities before any work can be performed in or around these protected areas.

Sea Level Rise, Storm Surge & Flooding

Georgia, in particular, is vulnerable to sea level rise impacts due to its more than 2,300 miles of tidally influenced shoreline and growing population which now exceeds 500,000 people in outermost six coastal counties (Concannon et al 2010; U.S. Census 2010).

To help developers, designers, natural resource managers, and landowners, the *Skidaway Institute of Oceanography* developed a web-based interactive map that displays information about sea level rise, shoreline change, storm surge, FEMA flood zones, historical hurricane tracks, land use/cover, and armored shorelines. The **Georgia Coastal Hazard Portal** (www.gchp.skio.usg.edu) is a user-friendly decision-support aid that can be used to evaluate how sea level rise and erosion may affect properties along coastal marshlands and waterways. Additional community maps and visuals are available at *NOAA Coastal Services Center's* website www.csc.noaa.gov/slr.

Designing Marine Facilities

By knowing and understanding the existing features of the site, the proposed marine structure can be designed within the constraints of the natural landform. Designing with nature, instead of against it, helps to protect and sustain vital ecosystems and the complimentary benefits they provide (e.g. storm surge protection, ecotourism, commercial fisheries, etc.)

The main objective during the design phase of the project is to minimize or reduce the cumulative impacts of the proposed marine structure on waterways and wetlands. Location, size, and use of the facility are major factors to consider, as well as the appropriateness of the structure given the physical and ecological characteristics of the site.

Marine Design Guidelines
Once the actual need for, and intended use of the structure is established, design the structure's capacity based on the demand for access at the time with an incremental projection for growth based on trend patterns from the surrounding area (i.e. Maximize usage and then employ a phased approach to expansion).
Position, size, and configure the structure based on the geographic features of the site, normal navigation patterns in the area, and the size of watercraft likely to use the facility.
To maximize the use of the docks, provide temporary mooring on a first-come, first-serve basis instead of permanent mooring designations. Design dry stack boat storage in a designated upland location to reduce in-water mooring.
In lieu of multiple private-use structures on smaller creeks; design public, community or joint-use docks on larger waterways, that are more amenable to recreational boating activities.
Locate the structure in the most practical and least environmentally-damaging area of the site. For example, locate the access walkway in a previously disturbed portion of the riparian buffer and over the shortest expanse of vegetated marshlands.
Reduce or compact the total size of the structure over tidal waters, especially the access walkway which typically crosses vegetated marshlands to access deepwater. Locate only water-dependent structures over jurisdictional wetlands and waterways.
Do not locate marinas or community docks in areas with degraded or impaired water quality conditions as these waters generally lack the carrying capacity to endure additional boating activities.

Marine Design Guidelines
Maintain continuous buffers along aquatic resources. G3 recommends 200’ from major rivers, 100’ from streams and tributaries, and 50-100’ from marshlands and estuaries.
Avoid direct stormwater discharge, instead provide for upland detention and treatment of potentially polluted runoff before it reaches nearby waterbodies.
As an alternative to hard-armoring the banks of the waterway, use non-invasive techniques that control erosion and provide valuable habitat for aquatic and terrestrial species. See Ch. 4 for specific Streambank & Shoreline Stabilization Practices
Locate supporting infrastructure (parking, pumpout facilities, septic systems, fuel tanks, etc.) landward of the protective wetland buffer. Vehicular access within the buffer is not allowed, unless this activity is dependent on water access.

Navigational Access

Marine structures, regardless of the type, should not alter natural water flow patterns or interfere with existing navigational access in the area.

Apply the following design guidelines for safe navigational access:
The structure should be sited in a location with navigable water depths to avoid initial and maintenance dredging activities.
The proposed facility should not extend more than one-quarter to one-third the width of the navigable channel (measured from one side of the waterway to the other side at mean low water).
All marine structures serving boaters should be limited to waterways that are a minimum of 20’ wide (at mean low tide conditions).
Locate the structure in an area with sufficient water depths to avoid floating docks and boats resting on the creek bottom, tidal flats, or marshlands during low tides.
All support piling/piers should be positioned to allow for free water movement beneath the structure. The horizontal bracing should be placed above the mean high tide line so that floating plant debris or “wracks” can easily pass below the support members of the structure.
The facility design should account for normal water currents and tidal conditions (daily ebb and flow cycles).
Avoid designing marinas with breakwater walls or enclosures as these structures interfere with natural water circulation and flow-through currents.
The proposed structure should not cross over tributaries and creeks used by small boats or non-motorized watercraft (e.g. canoes or kayaks). The alignment of the proposed facility should be adjusted as necessary to avoid blocking these waterways. If complete avoidance is impractical, the fixed walkway should span over the tributary and have a minimum clearance of 6’ at high tide to ensure future passage beneath the structure.
For ease of construction, navigation and future maintenance, a 20-25’ distance from the property line (or combined distance of 40-50’ between docks) is recommended for marinas and community docks. For smaller private recreational docks, a 10-15’ distance from the property line (combined distance of 20-30’ between docks) should be sufficient.

Riparian Buffers & Setbacks

A key element to the design of a green marine development is the incorporation of an adequate protective buffer along the water's edge. This forested/vegetated area intercepts and treats stormwater runoff from nearby uplands, protects against erosion, and offers wildlife habitat to a host of terrestrial and aquatic species. In addition, buildings and supporting infrastructure should be located a safe distance away from rivers, streams, and wetlands for added resiliency against coastal hazards such as flooding, storm surge, and sea level rise.

Georgia has a number of laws and regulations that apply to riparian buffers, thus the required minimum buffer width can vary from property to property.

- The Georgia Erosion and Sedimentation Control Act restricts land disturbance and trimming of vegetation within 25' of creeks, streams, rivers, saltwater marshes, and most lakes and ponds, and within 50' of trout streams.
- The Mountain and River Corridors Protection Act and the Georgia Planning Act require some local governments to adopt a 100' buffer and restrict certain land uses along various large river corridors in the state.
- Water supply reservoirs, streams that flow into reservoirs, and streams above drinking water intakes may also require wider protective buffers. As of 2012, the State requires all water supply watersheds provide a 100' buffer along tributaries within a 7-mile radius of a public water intake. Additionally, impervious surfaces, septic tanks and drain fields must be setback a minimum of 150'. Water supply watersheds less than 100 square miles must have a 50' riparian buffer and a 75' setback for impervious surfaces, septic tanks and drain fields.

In addition to State requirements, many local governments have adopted more stringent ordinances regulating riparian buffers and building setbacks. Contact the local planning and zoning department for specific requirements in your area.

While there is general agreement about the benefits of buffers—the specific design criteria, such as buffer width, types of vegetation, and management—are the subjects of considerable debate. Width is considered the most important variable when determining the effectiveness of buffers in reducing pollutants and protecting stream health. In the interest of water quality, flood protection, and wildlife habitat, G3 encourages developers and landowners meet or exceed regulatory standards when possible.

G3 Riparian Buffer Width Recommendations	
Buffer Type	**Preferred Width (ft)**
Major Rivers & Streams	200’
Freshwater Tributaries & Streams	50-100’
Tidal Marshes & Waters	50-100’
Forested Wetlands	25-50’

Additionally, the actual composition and makeup of the buffer has the potential to enhance normal functions. In order to support a broad range of wildlife, riparian buffers should be left in a natural state or restored with native trees, shrubs, and herbaceous plants. An overall goal is to retain at least 50% of the total site as green space (including protective buffers) and maintain a minimum of 75% of this green space as natural area with indigenous vegetation. Selectively prune or trim foliage within protective buffers only when necessary for access or scenic views.

Often, marinas and commercial docks must clear the buffer for normal water-dependent operations. In this case, utilize buffer averaging to mitigate the loss of a fully-functional, natural buffer.

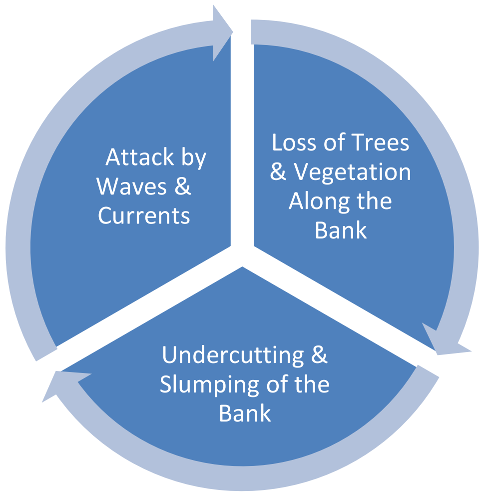
Wildlife Habitat

The Georgia coast features some of the most biologically-productive ecosystems in the world—a labyrinth of freshwater, brackish and salt-water rivers, streams and estuaries bordered by maritime forest—offering habitat to a variety of unique plant and animal communities. More than 70% of the State's most-important recreational and commercial fishes, crustaceans and shellfish depend solely on these areas for their survival.

In an effort to sustain the health and function of these essential coastal resources, marine developments should be planned and designed to coexist with terrestrial and aquatic wildlife. During the planning phase of the development, the design team is encouraged to collect important ecological information from existing data sources, field surveys, and visual observations.

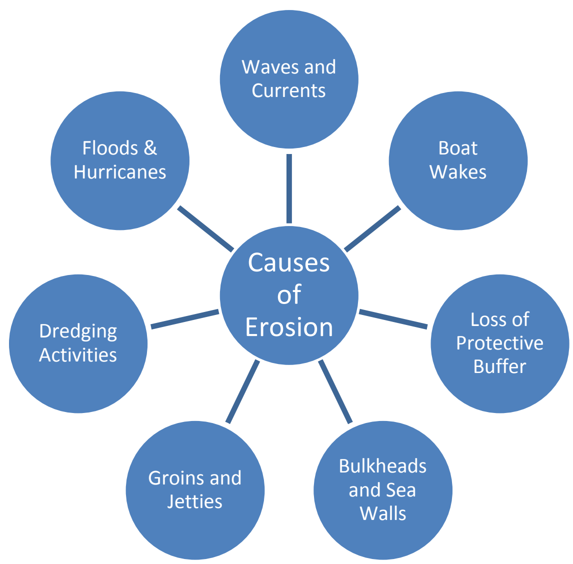
Relevant ecological information sources and recommended field observations:
Review aerial photography, maps, and previous habitat surveys of the immediate area.
Inspect federal, state, and local flora and fauna lists and maps to determine if rare, threatened or endangered species are supported by on-site habitat. If these species are present, devise a plan to preserve these critical areas.
Contact the US Fish & Wildlife Service, National Marine & Fisheries Service, Georgia Department of Natural Resources Wildlife Resources Division and the Georgia Natural Heritage Program to obtain lists, maps, and database information regarding critical habitat.
Consider the geographic location and historical uses of the area.
Identify designated wildlife management areas (WMA) in close proximity of the proposed development.
Classify substrate, vegetation types, and salinity regime to determine potential habitat suitability.
Identify and survey FDA-designated shellfish harvest areas in the project area. Maintain a minimum distance of 1000' from active harvest areas to allow natural growth and propagation.
Maintain sufficient vegetated buffers along water bodies and wetlands that can be used by a diverse population of resident and transient species.

Stream Bank & Shoreline Erosion



Erosion and sedimentation (the removal and deposition of sediments) are natural occurrences; however human activities as well as natural disasters can alter the normal balance of these processes resulting in degraded water quality, impeded navigation and ultimately, the physical loss of waterfront property.

When planning a marine facility, the site should be checked for signs of past or present erosion. If shoreline or streambank erosion is visually observed, the extent of erosion should be quantified prior to the selection of an appropriate stabilization method. An easy, relatively inexpensive way to accomplish this is to establish reference points (metal or wooden stakes installed on the uplands parallel to the eroded banks). The distance between the reference markers and the eroded streambank or shoreline can be measured over time to determine the general rate of erosion.



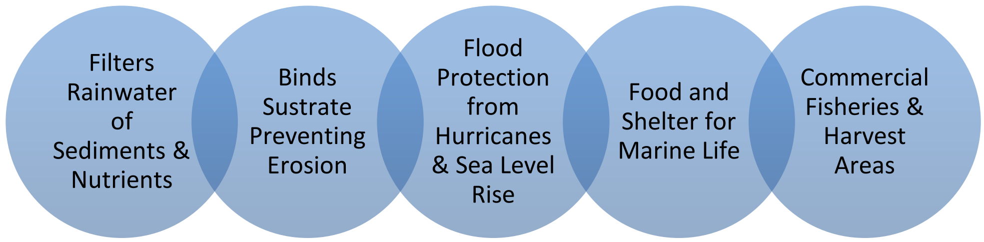
Based on the extent of erosion in the project area, the marine structure's location and configuration may need to be adjusted to prevent further erosion and possible structural failure. In addition to preventive measures, control strategies may also be warranted.

The use of hard-armored solutions—such as concrete lining or vertical bulkheads—are discouraged as these methods lack wildlife habitat value and typically alter the local hydrology and hydraulics in the area which can lead to erosion upstream or downstream of the structure. Additionally, vertical bulkheads prohibit the accretion of sediments and establishment of vegetation which provides long-term stability of the bank slope. For these reasons, G3 recommends the use of multi-functional techniques to control erosion and provide ecological benefits (See Chapter 4 for Streambank & Shoreline Stabilization Practices).

Planning & Design Guidelines for Streambank and Shoreline Erosion
Consider existing conditions when selecting the appropriate stabilization method: • slope • flow rate • water currents • tide cycle • rate of erosion • substrate properties • exposure to waves, boat wakes, flooding, and storm surge
For gently-sloping stream banks, use native vegetation to slow stormwater runoff and bind the surface together (e.g. pole plantings, brush layering, brush trenches, etc.).
For low-velocity streams, use biodegradable or synthetic materials (coir mats, filter fabrics, geo-grids/matrices) that holds soils in place and allows for the re-establishment of vegetation.
Use non-invasive structural means such as vegetated gabions or crib walls for moderate to high-velocity waters.
For tidally-influenced waters, implement “living shorelines” which is a combination of structural and organic materials (e.g. oyster shells, coir rolls, and gabions) that become naturally colonized with oysters, crabs, shrimp and fish larvae over time.

Shading Impacts

Freshwater & Tidal Vegetation



Coastal salt marshes, freshwater estuaries, swamps, and bogs provide a wide array of free ecosystem services and benefits.

Coastal marshlands are highly susceptible to impacts caused by routine access to navigable waters. Access walkways and fixed decks can prevent sunlight from reaching beneath the structure which can potentially damage or even destroy essential wetland vegetation.

Below are various strategies that can be employed to lessen the shading effects of access walkways:
Design elevated access walkways to extend the shortest distance over vegetated marshlands.
If possible, position the walkway in a north-south orientation for maximum sunlight exposure.
All floating portions of the facility, with exception of the walkway, should be positioned over open water. Observation decks and other non-water dependent structures must be located on available uplands.
The access walkway should be designed a minimum height of 3’ above native vegetation (measured in bloom stage).
Limit the width of the walkway to 6’ for community dock and marinas and 3-4’ for joint or private use structures.
Consider the use of alternative decking materials such as metal, aluminum or composite grating with holes or perforations that allow sunlight through the structure.
Space deck boards to permit light penetration beneath walkway.

Sand Dunes

Sand dunes are constantly forming and simultaneously eroding depending on wind, waves, currents, sand supply, and sea level. In addition to geologic conditions, man-made activities can also dramatically affect the sand-sharing system. Sea oats, the dominant grass on sand dunes, as well as other shrubs and plants can be shaded by elevated dune walkways (e.g. crossovers) used to gain access to the beach and ocean.

The following design recommendations will help to reduce shading impacts caused by dune access walkways:
Design a crossover structure that is elevated (supported by pilings) above the dune system. At-grade pedestrian pathways are discouraged due to the impacts caused by continuous foot traffic.
Use existing nearby public access points. If public access in unavailable, consider designing a crossover that can be used by the community, or at a minimum, several adjacent properties.
Beach crossovers must be designed for access purposes only. Viewing platforms and other non-access related structures should be located on available uplands, not over the dynamic dune system.
Crossovers should be located a minimum of 50’ away from adjacent crossovers or joint usage of the existing crossover must be explored as a viable option.
Design the crossover to span the shortest distance over the sand dunes. When possible, adjust the structure’s location so to avoid passing over the peak (or crest) of the dunes.
The structure should be at least 3’ above the existing ground elevation of the dunes/dune field, plus an additional 1’ minimum height above existing mature vegetation, if present.
The crossover should commence at the landward toe of the landward most dunes and terminate at the seaward toe of the most seaward dune.
The structure should be constructed of sturdy construction materials capable of withstanding hurricane-force winds and storm surge, but also easily modified to accommodate changes in the beach-dune system. Select construction materials that are resilient, but temporary in nature (e.g. wood and composite products as opposed to concrete and steel).

The following design recommendations will help to reduce shading impacts caused by dune access walkways:
The crossover should not encroach seaward of the ordinary high water line in the active intertidal beach. If the beach erodes in this area and the structure is seaward of the high water line, the crossover should be moved back to dry sand. Therefore, in rapidly eroding areas, the rate of erosion is necessary for proper design and maintenance.
For crossovers that do not require handicap access, decrease the width of the walkway to 3-4'.
Selectively clear no more than 6" of vegetation on either side of the crossover. If necessary, prune trees, shrubs, and plants to allow for scenic vistas (i.e. selective lines of sight through thick vegetation).

Impervious Surfaces & Stormwater Runoff

Coastal wetlands and waterways can be dramatically affected by the addition of stormwater runoff from adjacent, developed uplands. Research has shown a direct link between impervious surface cover and the water quality of nearby surface waters. The amount of impervious surface area covering the site controls the volume and rate by which stormwater reaches receiving water bodies.

Runoff from parking areas, repair yards, and access roads can carry nutrients, metals, suspended solids, hydrocarbons, and other potentially harmful pollutants into marina basins. Direct discharge to wetlands, marshes, and open waters should be avoided or minimized to the greatest extent possible by implementing low impact development practices that capture and filter stormwater using native vegetation and soils. See Chapter 3 for more information on various stormwater management practices.

The following standards should be applied to the upland component of marinas and community docks:
Reduce effective impervious cover to 15% as required by current regulations (G3 recommends 10% or less). Visit www.coastalgadnr.org/pe/eic to calculate the effective impervious cover for your particular project.
Use pervious surfaces for low traffic access roads, parking, boat storage, and sidewalks. While pervious materials often cost more during construction, these materials allow for natural infiltration of stormwater which reduces the costs of conventional stormwater controls (e.g. curb and gutter, concrete pipes, and storm drains).
Use biorention areas to collect and control stormwater. Design forebays or sediment catch basins that can be easily cleaned and maintained over time (See Ch. 3 for Stormwater Practices).
Add filters/screens, absorbents, separators, and other proprietary technologies to storm inlets or outfalls to trap and contain oils, trash, coarse sediments, and other debris.
Locate boat cleaning and maintenance stations away from open waters.
Design vegetated filter strips between impervious areas and riparian buffers for the purpose of intercepting runoff from adjacent developed uplands (i.e. overland sheet flow).

Supporting Infrastructure

In addition to the in-water portion of the project, marine facilities often include a network of supporting infrastructure located on the adjacent mainland. This area, commonly referred to as the "service area", contains accessory buildings, restrooms, roads, parking, dry boat storage, as well as fuel, sewage, water, and electrical utilities.

Supporting Infrastructure Design Guidelines
All non-water dependent structures (e.g. restrooms, fish cleaning stations, observation decks) should be located away from wetlands and waterways.
The overall disturbed footprint of necessary buildings, roads, and parking should be minimized to the greatest extent possible.
Use pervious surfaces for roads, parking, and boat storage areas.
Provide adequate parking spaces proportionate to the number of slips offered by the facility (e.g. maximum of one space for every slip as well as shared visitor parking).
Fish cleaning stations must be located on available uplands, not over marsh or open waters. Cleaning stations should be equipped with grinders capable of breaking down fish waste and connected to municipal sanitary waste systems for proper disposal.
Fuel lines, sewage pipes, and electrical lines should be bundled and secured beneath the decking of the marine structure. Utilities beneath marine structures or buried underground in adjacent uplands should be encapsulated to prevent leaks or spills into open waters or wetlands.
Locate boat fueling station in a protected area of the marina to reduce exposure to passing boat traffic, storm surge, etc.
Design fuel pump dispensing nozzles and storage tanks with an automatic closing device. Open-latch or holding clip devices are prohibited.

Sanitary Waste Disposal

Untreated or minimally-treated human waste from boats and septic systems can overload waterways and lead to local water quality problems. Excessive nutrients in waste stimulates algal growth which lowers oxygen levels in the water and often results in fish kills. Even worse, bacteria, viruses, and protozoa in contaminated water, fish, and shellfish pose a serious threat to human health if contacted or consumed.

Sanitary Waste Disposal Design Recommendations
Marinas and community docks should provide on-shore restrooms, pumpout facilities, and dump stations to prevent boaters from discharging sanitary waste into State waters.
Consider existing available services in the area (offered by nearby marine facilities) when designing the type and capacity of the pumpout/dump stations needed at your marina or community dock.
Estimate the average number, size, and type of boats to select the type of sanitary waste system that fits the needs of permanent and transient customers. If the marina will service smaller boats without holding tanks, install a portable marine toilet dump station. Larger boats with holding tanks require access to a permanent pumpout station.
Pumpouts and dump stations should be strategically located in an area that allows for safe and convenient use, as well as efficient cleanout and maintenance.
To offset the cost of installation and operation, consider allowing public access to disposal facilities for a reasonable cost.
For portable pumpout stations with above-ground storage tanks, design a concrete pad with walls to contain accidental leaks or spills.
Restrooms should be located on the upland portion of the site and connected to a municipal sewage system if possible.
Avoid the use of septic tanks and drain fields near sensitive water resources. If septic systems are the only sanitary option available, locate tanks and drain fields a minimum of 100’ away from open waters and wetlands.
Design upland fish cleaning stations to dispose of fish waste from commercial and sports fishing. Equip the station with a grinder capable of breaking down fish skeletons and connect to the municipal sanitary sewer system when possible.

Clean Vessel Act Grant Program

The *Clean Vessel Act Grant Program* provides funding for the construction, renovation, operation, and maintenance of pumpout stations and waste reception facilities for recreational boaters. Additionally, funds are used to inform boaters about the use, benefits, and availability of these facilities in the area. The grant program funds 75% of the total project cost—including new equipment, the renovation/upgrade of existing equipment, as well as necessary pumps, piping, lift stations, on-site holding tanks, pier or dock modifications, signs, permits, and other miscellaneous equipment needed for a complete and efficient station. The grant recipient is responsible for at least 25% of the installed costs (25% match can be cash, the fair market value of any labor or materials provided, or a combination thereof).

For more information on this program, please visit www.coastalgadnr.org/pumpout or contact GDNR @ (912) 280-6926.

Construction Practices for Marine Developments

Special protective measures should be taken when building in close proximity to sensitive water resources. Typical construction activities—clearing, grading, filling, and excavating on adjacent uplands—can cause soil erosion, disturb wildlife habitat, and degrade water quality. In addition, marine structures themselves can be constructed of materials treated with substances that can potentially contaminate surrounding waterways.

Recommended Marine Construction Practices
Heavy equipment used to install docks and piers should be staged on available uplands, on the completed portion of the structure, or on a floating platform or barge. If heavy equipment must go over marshlands, mud flats or the banks of the waterway, it should be done so using specially-designed construction matting to minimize substrate compaction and permanent damage to marsh vegetation. The size of the mats and duration of use should be reduced to the greatest extent possible.
Floating vessels and barges loaded with construction equipment and materials should remain floating even during low tide conditions.
For navigational safety, construction equipment on floating barges must remain landward of the terminal end of the proposed facility.
Use previously disturbed or cleared areas of vegetative buffer for construction access. If buffer is undisturbed, clear only what is necessary for safe passage of equipment.
Construct the facility in the least invasive manner possible by maintaining pre-construction topographical and hydrological conditions. Construction activities should not alter the existing elevation of the marsh or waterbottom or change the natural water patterns in the area.
Implement proper soil erosion and sedimentation control practices to prevent and manage temporary effects of land-disturbing activities on uplands adjacent to coastal waters. See Manual for Erosion & Sediment Control in Georgia (a.k.a the Green Book). Free digital copies are available @ http://gaswcc.georgia.gov/manual-erosion-and-sediment-control-georgia.
Avoid the use of potentially hazardous materials—wood preserved with copper chromate arsenic (CCA), creosote and polystyrene/styrofoam products. Alternatively, use enviro-safe materials such as pressure treated lumber, concrete or recycled plastics. There are several arsenic-free wood treatments approved for marine use including Ammoniacial Copper

Recommended Marine Construction Practices
Quaternary (ACQ) or "Kodiak Wood", Copper Azole, Copper Dimethyldithiocarbamate, Copper Citrate, Copper Boron Azole, Copper 8 Quinolinate, Borate-based Products.
Implement pile driving techniques that minimize impacts to submerged vegetation and bottom sediments (e.g. Sharpen pile ends to facilitate installation or if pile jetting technique is used, opt for less disruptive, low-pressure methods).
Take special care to avoid impacts to shellfish harvest areas and essential fish nurseries.
Implement a *Species Awareness Program* for the education and training of construction supervisors and personnel. The program should provide essential information regarding plants and animals that inhabit the area and best management practices that avoid or at least minimize the negative effects to these creatures and their habitat. This information should be posted in a highly visible area of the construction site. Contact GDNR-Wildlife Resources Division 912-264-7218 for more information.

Management Measures for Marine Developments

To effectively protect water resources over the long term, environmental management measures should be taken to control nonpoint source pollution associated with marine developments and recreational activities.

The following sections provide operations and maintenance practices for marinas and community docks that when properly implemented can result in multiple benefits including:

- Sustained wildlife habitat
- Acceptable water quality conditions
- Reduced human health risks
- More attractive to customers
- More effective work procedures and reduced operational costs
- Better employee awareness of environmental issues
- Enhanced positive image with the community and regulating authorities
- Recognition for good practices

Environmental Management Plan (EMP)

Depending on the size and uses of the facility, an *Environmental Management Plan* or EMP should be established. The EMP helps marinas meet environmental goals and keep track of management activities. It also documents key information including environmental policies, responsibilities, applicable standard operating procedures, best management practices, reports, communication, training, monitoring, and corrective actions.

EMP Development Process

To effectively develop an EMP, one must have an understanding of potential pollution sources at the marina, the physical characteristics of the site, and the specific needs of customers and their boats. The following information is necessary when developing a functional EMP for the site:

- Site Plan showing property boundary, limits of jurisdictional areas, topography, trees, and bathymetry (underwater contours of the water body).
- Facility use (boating, fishing, kayaking, wildlife observation, etc.)
- Facility capacity and services (Wet slips, dry storage, average boat size and mooring duration, total number of boaters, average vacancy, hoist capacity, fueling and pumpout amenities, community/public accessibility).

Georgia Clean Marina Program

The *Georgia Clean Marina Program* was developed by the *Georgia Department of Natural Resources* in collaboration with the *Georgia Marine Association* to recognize marinas that reduce or eliminate the sources and effects of associated water pollution. All marinas that create and properly carry out an Environmental Management Plan (EMP) may be eligible for certification through the program.

Environmental management is easier if the marine facility has a specific plan. The EMP helps implement and track environmental management activities in a more organized and streamlined manner. The *Clean Marina Program* assists marina owners with the development and implementation of an EMP customized to fit the needs of that particular marine facility.

For more information on the program visit www.uga.edu/cleanmarina/.

Water Quality Monitoring

To ensure applicable standards are met, prepare and implement a water quality monitoring program to include the following steps:
Collect and review regional and local water quality data and maps.
Observe and record existing site conditions on a frequent, routine basis. Record any unusual occurrences—strong odors, algal blooms, surface sheens or slicks, etc.
Collect representative water samples and test for basic water quality parameters—dissolved oxygen, temperature, pH, turbidity, and fecal coliform.
For calibrated results, compare samples taken within the limits of the marina to healthy reference waterways in the area.
If problems exist (visible signs of stress and/or irregular test results), increase the frequency and intensity of monitoring events in an effort to find the source of the problem. Once identified, prepare a corrective action plan to address the issue(s). Any activities found to be directly or indirectly linked to degraded water conditions should be discontinued and/or modified to rectify adverse effects.

Riparian Buffers

The following management measures are recommended for marinas and community docks:
G3 recommends wider riparian buffers to increase effectiveness. Maintain 200’ along major rivers, 100’ from rivers and streams, 50-100’ from tidal marshlands, and 25-50’ from forested interior wetlands.
Maintain a minimum of 75% of the buffer in its natural state (i.e. preserved native trees, shrubs and plants).
Restore previously disturbed buffers with indigenous trees, shrubs, and plants. Select species that require little to no irrigation, fertilizers, or pesticides.
Preserve existing native trees and vegetation in three consecutive layers (herbaceous-ground cover, shrub-sapling, and tree canopy).
Maintain trees and plants that provide food and shelter for wildlife. Visit www.coastscapes.org for a list of species suitable for your area.
Avoid clearing riparian buffers for scenic views. Viewsheds or observation corridors can be accomplished by selectively pruning and trimming vegetation in the preferred line of site. (See Ch. 2 Riparian Buffers)
Place the buffer in conservation easement or under restrictive covenants for long-term protection.
Plant native plants or grasses between impervious areas and open waters. These vegetated strips intercept and filter stormwater increasing the effectiveness of the riparian buffer.
Implement low impact stormwater practices in combination with protective buffers for enhanced water quality and overbank flood protection. (See Ch. 3 for recommended practices)

Wildlife Habitat

The following management measures should be put into place to protect wildlife habitat:
Use rapid bio-assessment techniques to monitor existing ecological conditions.
Establish a *Species Awareness Program* to educate staff members and boaters on threatened and endangered species as well as common species of concern. Make special provisions to protect these sensitive resources—prepare and disseminate brochures or post signs to increase awareness.
Establish and enforce "no wake" zones for manatees, dolphins, sea turtles and other susceptible species.
Keep area free of trash, especially fishing line and hooks which can injure marine life.
Avoid excessively bright lighting on marine structures as this can change normal behavior patterns of wildlife in the area. Limit brightness to a threshold required for safe pedestrian access and/or navigation. Reflective markers and signs can also assist with illuminating the structure.
Disallow marine users from throwing excess food, fish waste or bait near the marina as this attracts birds, fish and other animals which pose a hazard to wildlife and boaters alike.
If maintenance dredging activities (removal of waterbottom sediments) are necessary for navigation purposes, schedule event outside of active biological periods, typically March through December in coastal Georgia.

Erosion Control

Implement the following management measures to control erosion along the water's edge:
Establish a monitoring plan to establish the rate and extent of erosion.
Identify activities that contribute to or accelerate bank erosion in the immediate area and cease or minimize such activities to the greatest extent possible.
For minor to moderate erosion, apply bioengineered solutions such as sloping and grading the banks to a stable angle, adding organic topsoil and mulch, and planting with native trees, shrubs and vegetation.
Maintain natural vegetated buffers or restore areas previously disturbed.
Use bioengineered bank stabilization techniques such as fiber mats and rolls, geo-grids and matrices, cribwalls and gabions to hold the soil in place so vegetation can become re-established. (See Chapter 4 for details)
Establish and enforce "no wake" zones to control erosion caused by boat and jet ski traffic.

Fueling Operations & Storage

The following management measures can help marina operators avoid or reduce petroleum spillage and subsequent costs of cleanup and fines:
Locate boat fueling stations in a protected area of the marina to reduce exposure to passing boat traffic, storm surge, etc.
Store spill containment equipment and supplies such as booms and absorbent pads in close proximity to the fuel dock for immediate access in case of an incidental drips, spills, and overflow.
Provide emergency procedures and contact information in the event of a fire and/or explosion. Locate fire extinguishers a minimum of 100' from each pump, dispenser, and pier-mounted liquid storage tank (As per NFPA 30A, Section 10-4:7).
Install dispensing nozzles equipped with automatic-closing devices (open-latch or holding clip devices are prohibited). Additionally, fuel pumps and storage tanks should be fitted with shutoff valves that can be manually controlled in the event of an emergency.
Regularly inspect, repair, and replace leaking or damaged fuel hoses, pipes and tanks.
Full-service stations should be attended by trained employees capable of dealing with normal fueling operations as well as emergency situations. Staff should be trained in spill prevention, containment, and cleanup procedures as per HAZWOPER Protocol.
Self-service stations should have signs posted in the dispensing area that provide boaters with instructions for proper fueling procedures, spill prevention, and containment measures as well as first responder contact information in the event of an emergency.
Provide spill prevention/containment supplies such as vent line whistles, vent cups, oil absorbent collars, pillows, etc. in the marina store.
The discharge of bilge water mixed with gas and oil is strictly prohibited. Use vacuum-type systems to change oil and suction potentially contaminated water from bilge compartments.
Prohibit the use of detergent bilge cleaners. Instead, promote the use of materials that capture and digest oil in bilges. Encourage boaters to use bilge socks, pads, or pillows to absorb oil and fuel from bilge compartments.

If aboveground petroleum storage volume is greater than 1,320 gallons or underground storage is more than 42,000 gallons, a site-specific Spill Prevention, Control and Countermeasure (SPCC) Plan may be required (40 CFR 112).

Solid & Liquid Waste

Marine facilities, especially full-service marinas and community docks produce solid and liquid wastes, that if released are harmful to the surrounding environment. A customized solid/liquid waste management plan should be developed to fit the specific needs of the facility to protect against nonpoint source pollution.

Solid & Liquid Waste Management Measures
Install and maintain suitable containers for trash cans, dumpsters, and other receptacles as required by the *Act to Prevent Pollution of Ships* 33 (USCA 1901 & CFR 158).
Identify trash receptacles with signs encouraging boaters to properly discard their waste. If possible, supply trash bags as a free amenity to ensure a clean marina.
Provide trash receptacles with lids. Secure containers so wind and animals cannot cause spills.
Locate trash dumpster(s) away from open waters. Construct containment berms/barriers around dumpsters and liquid storage tanks to control potentially harmful leachate from reaching nearby waterways.
Locate hazardous liquids or solid materials away from areas subject to flooding or high winds.
Store all hazardous waste materials as per *OSHA RCRA Hazardous Waste Regulations*.
Encourage boaters and marina employees to recycle potentially hazardous substances such as antifreeze, lead batteries, kerosene, mineral spirits, gasoline, engine oil, transmission fluid, scrap metals, and some water-based paints and solvents. Provide separate, clearly labeled, containers for the disposal or recycling of liquid wastes.
Prepare a site-specific plan for proper handling, disposal, and spill procedures for hazardous substances typically found around marine developments.
Keep spill response equipment and emergency protocol on-site. Post signs to inform boaters and staff members of emergency procedures.
Hire a hazardous waste hauler to collect and dispose of the following: aerosol cans, paint cans, gasoline, glue and other liquid adhesives, oil filters, paints and varnishes, pesticides, pressure washing residue, paint chips and sanding/scraping debris, resins and bilge absorbent pads.

Sanitary Waste

Sanitary Waste Management Measures
Post signs strictly prohibiting boaters from discharging sanitary waste, bilge water, or gray water into surface waters or wetlands.
Provide pumpout service at a reasonable cost to encourage use and allow for public access to help defray the expense of operation. If pumpout facilities are open to the public, your marina may qualify for a grant that pays up to 75% of the cost of installing, operating and maintaining the facility. For more information on the *Clean Vessel Act Grant Program*, contact GDNR @ (912) 280-6926 or visit www.coastalgadnr.org/pumpout.
Clearly identify pumpout/dump station(s) with signage that instructs boaters on how to use the facility properly. Provide an emergency contact number for accidental spills or leaks.
Develop a contingency plan in the event of a sewage leak or spill. Inform staff and boat owners to report emergencies immediately. Provide a main point of contact to avoid confusion or delays in cleanup response.
Remove waste from pumpout/dump station(s) on a regular basis. Routinely examine waste disposal systems and keep a record of all inspections, maintenance and repairs.
Educate and train staff on how to properly operate and clean pumpout/dump station(s). If necessary, hire a professional waste service to inspect and maintain on-site facilities.
Promote the use of biodegradable and non-toxic holding tank deodorants. Make these products available to boaters at the marina store.
Provide and maintain in working order, restrooms for facility users (2 restrooms per 100 slips is recommended).
If restrooms use a septic system, pump tank regularly, and inspect and repair drain field as needed.

Fish Waste

In addition to noxious odor and unsightly appearance, fish refuse can attract nuisance birds, sharks and other wildlife to the docks. Most importantly, fish waste degrades water quality by lowering dissolved oxygen in surrounding waters.

Marina operators and boaters should employ the following management measures for fish waste:
Post signs promoting off-shore fish cleaning or the use of on-shore waste stations.
Provide fish cleaning stations on adjacent uplands. Cleaning stations should not be located over or discharge directly to marshlands or open waters.
Clearly identify the fish cleaning station with signs that list the rules and regulations for their use.
Equip fish cleaning station with a grinder to make chum out of fish skeletons. Freeze and sell at marina store.
Participate in the *GDNR's Sportfish Carcass Recovery Project* where saltwater anglers can donate their fish remains for scientific research and discovery. Contact GDNR @ (912) 617-1607 or visit www.coastalgadnr.org/FishCarcass.com for fish freezer locations or if your marina would like to participate in the program.
Contact local farms and gardens to see if they compost and reuse fish waste products.

Boat Cleaning, Maintenance & Storage

To protect the water quality, the following management measures should be applied to boat cleaning and other maintenance activities:
Boat cleaning and maintenance activities should be performed out of the water and away from critical resources. Boat repairs, painting, and other activities that result in the discharge of harmful pollutants is prohibited near open waters for human health and safety reasons.
Limit the amount of do-it-yourself work unless individuals follow management measures. Post signs which clearly identify designated boat maintenance areas and provide rules governing activities in these areas.
Boats should be cleaned frequently to reduce the use of harsh chemical cleaners. If using cleaners, use environmentally-safe products.
Avoid in-water hull scraping or other abrasive underwater removal methods.
Designate a suitable upland location for boat cleaning and repair activities. Maintenance areas should be swept or vacuumed on a regular basis to prevent oil, paint chips, detergents, etc. from reaching open waters.
Use spray booths or tarp enclosures when scraping, sanding, and painting in outdoor locations.
Use dustless or vacuum sanders to collect and remove paint from hulls. Place tarps or filter cloths beneath boat repairs to catch residual waste.
Provide a covered collection of containers for paint chips, scraping debris and dust from vacuum sanders.
Encourage the use of long-lasting, non-toxic, antifouling paints.
Promote the use of non-toxic products—soy or water-based paints/strippers, low volatile organic primers, reusable hull-blasting medium, etc.
If boaters store their boats on racks or trailers most of the time, recommend the use of polyurethane, bottom wax or non-metallic epoxies since antifouling paint is not necessary for boats that are not continuously moored in the water.

Boater Education & Signage

When marina operators, customers, contractors, and employees are well-informed, they tend to make better environmental choices.

Education and Awareness Management Measures
Mark shallow waters and sensitive marine resources such as manatee habitat or oyster harvest areas with advisory signage.
Restrict speed of boats and jet skis by posting "no wake" signs.
Mark stormwater drains with signs that discourage marina users from discarding harmful pollutants that lead to municipal sanitary sewer system or even worse, into adjacent surface waters.
Post warning signs prohibiting the direct discharge of sewage, wastewater, or solid refuse from boating vessels into open waters.
Provide signs that promote the reuse and recycling of liquid, solid, and hazardous wastes generated by the marina.

Maintenance Dredging

Excess sediments can settle and accumulate over time and impede navigational passage in and around marinas and community docks. In order to maintain sufficient water depths for navigational access, the dredging (or removal) of waterbottom sediments is often necessary. Trapped toxic substances can be released into the water column upon disturbing the substrate. For this reason, dredged materials should be removed, transported, and contained in a manner as to prevent the dispersal of potentially contaminated sediments into adjacent wetlands and waterways.

The following best management practices should be applied when removing, handling, and disposing of dredged sediments to minimize turbulence and potential contaminant release:
Agitation dredging is prohibited. Remove excess sediments by mechanical or hydraulic means to reduce turbidity impacts.
Lessen impacts to marine life by limiting dredge activities to times of the year when biological activity (spawning, recruitment, and migration) of sensitive aquatic species is low (December through March in coastal Georgia).
Reduce turbidity in receiving waters by filtering dredge spoil prior to disposal using enclosed buckets, turbidity curtains, monitoring devices, upland settling ponds, barges or scows.
Avoid dredging during hot summer temperatures or drought periods as the waters are often already naturally under-oxygenated and stressed.
Soil sampling and testing may be required to ensure waterbottom sediments do not contain harmful chemical contaminants that can be released in the surrounding aquatic environment during the removal process. The extent of testing varies based on the type of soils, the past uses of the property and the proposed removal method.
Locate a suitable upland location, preferably on or nearby the marine facility property, for a sediment containment area. This area is usually enclosed by earthen or concrete dikes fitted with weirs or pipes that allow for sediments to undergo the gravitational settling and dewatering process.
The upland disposal facility should be engineered to withstand the estimated volume of excess water and sediments being deposited in the containment area. If continued maintenance is required, the disposal site must be capable of holding these additional volumes as well.

The following best management practices should be applied when removing, handling, and disposing of dredged sediments to minimize turbulence and potential contaminant release:
Protective measures such as silt curtains, weirs, etc. should be properly installed prior to construction activities and maintained in working order until project completion.
Additional sediment and erosion control methods may be necessary for unstable banks of the dredged area or disposal site. Use bio-engineered techniques and other natural means to stabilize these areas. (See Ch. 4 for Recommended Bank Stabilization Practices)
If the dredged material is deemed as potentially hazardous, a plan for safe extraction, transport and disposal is required. Depending on the extent of contamination, the dredged sediments may need to be placed in a landfill approved for hazardous materials.
Consider the re-use of dredged sediments for streambank stabilization, beach nourishment, or wetland creation projects. This material can also be used as cover material for landfill closures. The physical and chemical makeup is the limiting factors for reuse options—dredged material must be an appropriate grain size, be clean of harmful toxins, and be compatible with the particular application (e.g. silts or clays taken from a river bottom would not be appropriate for a beach nourishment project).

Sediment Sampling

Representative samples should be taken from the area to be dredged as well outside the project limits for comparison purposes. In accordance with the *Georgia Environmental Protection Division Rules for Hazardous Site Response, Solid Waste Management Guidelines*, and *In-Stream Water Quality Standards*, the samples should be analyzed for the following chemical constituents:

- Aluminum
- Antimony
- Arsenic
- Beryllium
- Cadmium
- Chromium
- Copper
- Iron
- Lead
- Manganese
- Mercury
- Nickel
- Selenium
- Silver
- Thallium
- Zinc
- Ammonia
- Nitrates
- Phosphorus
- Cyanide
- Total Sulfides
- Fecal Coliform
- Polynuclear Aromatic
- Hydrocarbons
- Pesticides
- PCB congeners
- Phenols

Regulatory Requirements for Marine Structures

Marine development projects require developers and landowners obtain regulatory permits prior to construction. The *U.S. Army Corps of Engineers* has jurisdiction over U.S. waters and wetlands. The *Georgia Department of Natural Resources* manages all tidally influenced waters and marshlands. Additionally, local government approvals and permits may also be necessary.

Depending on their size, use, and location; some projects can be allowed by streamlined permits (General Programmatic Permits) while larger, more complex projects must go through a more extensive review (Individual Permits). If the project is located over State Waters, a revocable license must be obtained from the GDNR. Additionally, most marinas must execute a marina lease for the use of public lands. Consult with the appropriate federal, state and local regulatory agencies during the planning and design phase of the development to determine which permits apply to your specific project.

Regulatory Contact Information

U.S. Army Corps of Engineers Savannah District 100 W. Oglethorpe Avenue Savannah, GA 3140 (912) 652-5279/5770	U.S. Fish and Wildlife Service Southeast Region 1875 Century Blvd, Suite 400 Atlanta, GA 30345 (404) 679-4000	Georgia DNR - Coastal Resources Division One Conservation Way Brunswick, GA 31520 (912) 264-7218
Georgia DNR - Environmental Protection Division Watershed Protection Branch 4220 International Parkway, Suite 101 Atlanta, GA 30354 (404) 675-6240	Georgia DNR – Historic Preservation Division 254 Washington Street SW Atlanta, GA 30334 (404) 656-2840	Local Governments (City or County Building Permit/Regulatory Services)

Appendix A—Georgia Coastal Management Program

Activities Performed Directly by the Coastal Resources Division

Resource Management: The Coastal Resources Division manages marine resources by conducting research and surveys, monitoring saltwater fish stocks, enhancing marine access, constructing inshore artificial reefs, and educating coastal residents on fisheries issues. Research and monitoring activities focus on spotted sea trout and red drum. Enhancing marine access includes construction of fixed and floating docks at existing boat ramp sites, maintenance of existing boat ramps, and conversion of existing shoreside structures into public piers. Staff are actively involved in marine education with field demonstrations and presentations to school groups, civic groups, and conservation associations.

Ecological Monitoring: The Coastal Resources Division monitors coastal water quality and implements the National Shellfish Sanitation Program for the State of Georgia. These responsibilities include labelling areas open and/or closed to shellfishing, analyzing water quality, educating the public on shellfishing safety issues, and implementing other programs that monitor and improve coastal water quality. While the Coastal Resources Division has always administered the Georgia Shellfish Program, implementation of a federally-approved Coastal Management Program increases funding and staff dedicated to monitoring projects.

Direct Permit Authorities: The Coastal Resources Division administers several State authorities. With the approval of the Coastal Marshlands Protection Committee and the Shore Protection Committee, the Division issues Marsh Permits, Shore Permits, and the Revocable License. The Division also executes leases for State-owned water bottoms. In addition, the Division makes recommendations to the Environmental Protection Division on 401 Water Quality Certification issuance for projects that affect the coastal area. Marsh Permits and Shore Permits have always been administered at the Coastal Resources Division, while the Revocable License was previously administered by the Department of Natural Resources in Atlanta. Together, these programs give direct management authority over critical coastal habitats such as marshlands, beaches, navigable waters, and freshwater wetlands.

Technical Assistance: The Coastal Resources Division provides technical assistance for projects to minimize adverse impacts and coordinate the permitting process. The Division provides information on Best Management Practices; technical guidance on planning, construction, and design; and, information on habitat and endangered species. The Division also maintains a list of contacts in various agencies and institutions so that applicants and project designers can consult with local experts and design their projects appropriately. The Division serves as a liaison among agencies and provides forums for prospective applicants and developers to discuss potential issues and permit requirements with the appropriate agencies. The goals of this service are to promote quality development, to address resource issues, and to simplify the permit process and requirements for applicants. Implementation of a federally-approved Coastal Management Program involves significant increases in staff time and resources devoted to pre-project consultations, interagency coordination, and local government assistance.

Federal Consistency Review: With a federally-approved Coastal Management Program, the Coastal Zone Management Act gives the State of Georgia authority to review federal permits and licenses, federal projects, and federally-funded projects that affect the coastal area. The Coastal Resources Division reviews these activities to ensure that they are consistent with the Georgia Coastal Management Program. If a federal agency disagrees with the Division's consistency decision, a formal conflict resolution process may be used to settle the dispute.

Activities Implemented Through the Coastal Management Network

Local Governments: Local governments assist in long-term planning, economic development, and natural resource protection through preparation and implementation of their respective comprehensive plans, local laws and zoning regulations, as well as through their chambers of commerce and economic development authorities. Through the Georgia Coastal Management Program, the Coastal Resources Division provides technical assistance to local governments to assist in their planning efforts and address natural resource issues.

State Agencies: State agencies continue to administer their respective coastal management efforts as defined by existing Georgia State law. Memoranda of Agreement between the Coastal Resources Division and other State agencies with regulatory authority in the coastal area help ensure that all agencies act in accordance with the policies of the Georgia Coastal Management Program. The following State agencies are involved in the Georgia Coastal Management Program network.

Federal Agencies: Federal agencies continue to administer their respective programs as they are reviewed for consistency with the Georgia Coastal Management Program. On-going coordination efforts between the Coastal Resources Division and federal agencies is conducted to ensure communication and consistency.

THE FEDERAL COASTAL ZONE MANAGEMENT PROGRAM

The federal Coastal Zone Management Act of 1972 created a voluntary program for states to develop and administer coastal management programs. This Act set broad guidelines and approval criteria for states' management programs. Individual states are given the responsibility of identifying priority issues for their respective coasts, and implementing their program using State laws and regulations. General concerns such as consideration of national defense and interstate transport must be addressed to ensure that a management program does not unduly hamper these activities.

Almost all of the eligible states developed approved coastal management programs by 1990. Each state's program is unique -- the policies and administration reflect the state's individual priorities and laws. As one of the last coastal states to develop a coastal management program, Georgia has benefitted from the experiences of the other states with federally-approved management programs. The decision to submit Georgia's Coastal Management Program for federal approval is made by the Governor. Implementation and administration of the Georgia Coastal Management Program is performed by the State of Georgia and its agencies. States with federally-approved management programs have the option of withdrawing from the voluntary federal program at any time. The federal Coastal Zone Management Program provides Georgia with several significant benefits.

Federal Consistency: While federal agencies and activities are usually exempt from state laws, states with federally-approved coastal management programs gain review authority over federal activities. The Coastal Zone Management Act is the only law that provides this power to the states. This authority also gives states an equal voice with respect to interstate issues. Without a federally-approved coastal management program, Georgia forfeits its consistency review authority over federal projects, as well as its "seat at the table" of national coastal management.

Funding: Congress appropriates funds every year for approved coastal management programs under the Coastal Zone Management Act. Georgia is entitled to a portion of these funds with an approved program. If Georgia receives federal funding for coastal management, the funds will be used to sponsor monitoring, enforcement, technical assistance, public education, and research on coastal management issues.

Technical Assistance: The National Oceanic and Atmospheric Administration (NOAA), Office of Ocean and Coastal Resource Management provides assistance to state coastal programs in the form of information, technical support, and relating coastal issues to the Administration. A uniformed service of the Administration, the NOAA Corps provides research vessels, equipment, and technical staff. The NOAA Coastal Services Center in Charleston is a regional office providing technical support and other coastal services to states participating in the national coastal management program.

This section describes the mission, goals, and objectives of the Georgia Coastal Management Program. Goals and objectives of the Program are categorized as either Program Goals or Resource Goals. Program Goals were developed by the Department of Natural Resources, Coastal Resources Division with the concurrence of the Coastal Zone Advisory Committee. Resource Goals were developed by the Coastal Zone Advisory Committee.

When developing goals, the Coastal Zone Advisory Committee recognized a number of common threads in their discussions. Despite differing viewpoints on coastal issues, all committee members agreed on the following points. A coastal management program for Georgia should: provide a mechanism for conflict resolution; promote and enhance educational programs that increase the awareness and understanding of the value of our resources; promote and enhance information links to the citizenry and user groups; recognize the complexities of private property rights; improve and enhance coastal resource related tourism; address cumulative impacts; result in better enforcement and monitoring of existing regulations; and provide and enhance managed public access to the resources; and provide a simplified and efficient process for permitting, that allows for ample and early review of significant projects.

PROGRAM GOALS

Goal: Develop and implement a management program that balances sustainable economic development and natural resource conservation in coastal Georgia.

Objectives:

Encourage and assist natural and social scientific research in coastal Georgia, in order to develop a comprehensive database of the area.

Promote increased recreational opportunities in coastal areas and increased public access to tidal waters in a manner that protects coastal resource quality, public health, and public safety.

Develop and institute a comprehensive erosion policy that identifies critical erosion areas, evaluates the long-term costs and benefits of erosion control techniques, seeks to minimize the effects on natural systems (both biological and physical), and avoids damage to life and property.

Encourage new coastal development to locate in existing developed areas capable of accommodating additional growth, and in areas determined to be more environmentally and economically suitable for development.

Resolve conflicts and minimize potential conflicts among activities through improved coastal management that reflects the public's desires, the capacity of natural resources, and expected costs and benefits.

Encourage new facilities to locate in areas where adverse social, economic, and environmental impacts can be minimized, and encourage planning that prioritizes water-dependent uses along shoreline areas.

Promote the use of impact assessments which incorporate energy-saving benefits, economic effects, and social and environmental factors as the basis for decisions on development of energy facilities; and ensure that affected local governments obtain sufficient financial and technical assistance to cope with these impacts.

Support the wise commercial development of harbors, rivers, and waterways for trade and commerce in locations and using methods that maintain the environmental integrity of the coastal region.

Protect and, where possible, restore or enhance the resources of the State's coastal area for this and succeeding generations.

Develop a coastal program with flexibility for revision and improvement as knowledge and experience in managing coastal resources evolves.

Goal: Simplify the permitting system for activities in the coastal area in a manner that implements the goals and objectives of the Management Program and promotes the public interest.

Objectives:

Simplify the permitting system for activities in the coastal area in a manner that maintains the integrity and purpose of the Management Program.

Ensure that permits approved for coastal area activities are designed to minimize negative impacts on water quality, marine productivity, beach and shoreline stability, and other environmental aspects.

Give full consideration to the Rules and Regulations for permitting, with thorough and comprehensive reviews of all permit applications.

Provide guidance on environmentally suitable methods of design, construction, and development in the coastal area, and assist permit applicants to incorporate these environmentally suitable alternatives in their proposals where feasible.

Goal: Promote intergovernmental coordination and public participation in the development and implementation of the Georgia Coastal Management Program.

Objectives:

Provide full opportunity for participation by federal, State, and local government agencies, concerned organizations, and the general public in developing, implementing, and improving the Georgia Coastal Management Program.

Increase public awareness and encourage public participation during development of and decisions made pursuant to the Georgia Coastal Management Program.

Strengthen the planning and decision-making capabilities of cities and counties in the coastal area by providing financial, technical, and other assistance; and provide for coordination of local comprehensive plans and ordinances with the policies of the Georgia Coastal Management Program.

Promote coordination and use of existing State programs to minimize duplication of efforts, conflicting actions, and permit processing delays, and achieve coastal management objectives and policies.

Provide adequate representation of the interests of the State of Georgia in federal agency decisions and actions affecting the coastal area.

RESOURCE GOALS

Goal: Protect and sustain the unique character of life on the Georgia coast that is reflected in its cultural, historical, archeological, and aesthetic values by providing management of its resources.

Objectives:

Fisheries

Provide a coastal zone with finfish, crustaceans, and shellfish populations that will support commercial and sport fisheries on a sustainable basis.

Wildlife

Provide a coastal zone that maintains diverse indigenous wildlife populations at viable and sustainable levels. Provide a coastal zone in which wildlife species listed as special concern, threatened, or endangered are recovered to healthy, viable populations. Provide a coastal zone that attracts and sustains historic migratory bird populations.

Plants

Provide a coastal zone in which diverse indigenous plant populations are maintained at viable and ecologically balanced levels.

Historic and Archeological

Provide a coastal zone in which all significant archeological and historic sites and artifacts are preserved.

Cultural

Provide a coastal zone in which the unique cultural entities are recognized and protected.

Scenic Vistas

Provide a coastal zone in which marsh, river, and other natural scenic vistas, such as highway and river corridors, are free of visual obstructions and blight.

Minerals

Provide a coastal zone in which extraction and utilization of mineral resources will not detrimentally impact other coastal resources.

Surface Water

Provide a coastal zone in which surface waters of the State meet or exceed recreation-use water quality standards.

Groundwater

Provide a coastal zone in which the water supply aquifers are managed at levels needed to provide adequate, potable drinking water in perpetuity. Provide a coastal zone in which the groundwater is managed to meet demands other than drinking water on a sustainable basis, while achieving some restoration of the resource.

Tidal, Marsh, and Submerged Lands

Provide a coastal zone in which the scenic quality and biological productivity of tidal resources is maintained.

Freshwater Wetlands

Provide a coastal zone in which the area and functional integrity of wetlands that impact the coastal region of Georgia are maintained.

Barrier Islands

Provide a coastal zone in which the natural systems of barrier islands are preserved and protected.

Beaches

Provide a coastal zone in which the integrity and functioning of the sand-sharing system is maintained.

Farmlands and Woodlands

Provide a coastal zone in which the productivity of woodlands and farmlands is maintained, with management practices that preserve water quality and biodiversity.

Appendix B—Site Assessment Resources

Much of the information presented in this appendix has been reproduced from the Green Growth Guidelines, 1st Edition, and from resource lists compiled from the Center for Watershed Protection (CWP) and the Southern Georgia Regional Commission (SGRC).

GIS Resources

Although a lot of the information needed to complete an inventory of the natural and man-made resources found on a development site will need to be gathered using surveying and assessment techniques, some of it may be available, in GIS format, from online data clearinghouses or from other sources, such as local planning and zoning offices.

The following table provides an overview of GIS data layers that are typically used during the site assessment phase.

Data Types	GIS Data Layers	Sources
Topography	• Digital Line Graphs (DLGs) • Digital Raster Graphics (DRGs) • Digital Elevation Models (OEMs) • National Elevation Database (NED)	• USGS Mapping • USGS Topographic Maps • USGS Mapping • USGS Mapping
Hydrology	•National Hydrography Dataset (NHD) • Digital Line Graphs	• USGS Mapping • USGS Mapping
Wetlands	• National Wetland Inventory (NWI)	• USFWS

Data Types	GIS Data Layers	Sources
100-year floodplain	• Digital Q3 Flood Data • Digital Flood Insurance Rate Maps (DFIRM) • Coastal Barrier Resource Area (CRBA) Q3	• FEMA
Soils	• State Soil Geographic Database (STATSGO) • Soil Survey Geographic Database (SSURGO)	• NRCS STATSGO • NRCS SSURGO
Watershed/subwatershed boundaries	• Hydrologic Unit Code (HUC) boundaries	•USGS Water Resources
Parcel boundaries	Check with local GIS or planning department	
Municipal boundaries	• Topological/ Integrated Geographic Encoding and Referencing (TIGER)/Line files •Digital Line Graphs	•Census Bureau USGS Mapping
Aerial photos	• Digital Orthophoto Quadrangles (DOQs) • Ikonos imagery • National Agriculture Imagery Program (NAIP)	•USGS DOQs Space Imaging •USDA Geospatial Data Gateway
Land use/land cover	•National Land Cover data	•USGS National Land Cover Characterization

Data Types	GIS Data Layers	Sources
Municipal boundaries	•Topological/ Integrated Geographic Encoding and Referencing (TIGER)/Line files • Digital Line Graphs	•Census Bureau USGS Mapping
Aerial photos	•Digital Orthophoto Quadrangles (DOQs) • Ikonos imagery • National Agriculture Imagery Program (NAIP)	• USGS DOQs Space Imaging •USDA Geospatial Data Gateway
Land use/land cover	• National Land Cover data	• USGS National Land Cover Characterization
Zoning		• Check with local GIS or planning department
Roads	• Topological Integrated Geographic Encoding and Referencing (TIGER)/Line files • Digital Line Graphs	• Census Bureau USGS Mapping
Buildings		• Check with local GIS or planning department
Parking lots		• Check with local GIS or planning department
Driveways		• Check with local GIS or planning department

Data Types	GIS Data Layers	Sources
Sidewalks		• Check with local GIS or planning department
Turf cover		• Check with local GIS or planning department
Forest cover		• Check with local GIS or planning department
Utilities		• Check with local GIS or planning department
Sanitary sewer lines		• Check with local GIS or planning department
Storm drain network		• Check with local GIS or planning department
Storm water practices		• Check with local GIS or planning department
Storm water outfalls		• Check with local GIS or planning department
Other utilities (e.g., electric, gas, phone)		• Check with local GIS or planning department
National Pollutant Discharge Elimination System (NPDES) permit holders	• Permit Compliance System (PCS)	• EPA BASINS
Hazardous waste/materials sites (e.g., CERCLA, RCRA permit holders)	• Better Assessment Science Integrating Point and Nonpoint Sources (BASINS)	• EPA PCS

Data Types	GIS Data Layers	Sources
Erosion and sediment control (ESC) construction permits		• Check with local GIS or planning department
Sanitary or Combined Sewer Overflow Occurrences		• Check with local GIS or planning department
Other Potential Hotspots: Gas Stations & Underground Storage Tanks		• Check with local GIS or planning department
Historic Sites	• Federal and/or State Historic Sites	• National Park Service •GADNR State Parks and Historic Sites • Local GIS, planning, or historic departments
Conservation Areas	• Federal and/or State Conservation Areas	• GDNR Wildlife Resources Division • USFWS GA Ecological Services • Local GIS, planning, or environmental departments
Rare, threatened or endangered (RTE) species habitat	• Federal and/or State threatened, endangered, proposed species, and species of concern and their habitat	• USFWS GA Ecological Services • NOAA Fisheries • GADNR Wildlife Resources Division

Data Types	GIS Data Layers	Sources
Stream Condition: Monitoring stations	• 305(b) Water Quality Assessments • Storage and Retrieval (STORET)	• EPA Watershed Assessments • EPA STORET • GADNR/Environmental Protection Division
Impaired Stream Segments	• 305(b) Water Quality Assessments • Storage and Retrieval (STORET)	• EPA Watershed Assessments • EPA STORET • GADNR/Environmental Protection Division

GIS Data Clearinghouses

This section provides a list of GIS data clearinghouses. Free, downloadable resources are marked with an asterisk (*).

EPA Better Assessment Science Integrating Point and Nonpoint Sources (BASINS)*

http://www.epa.gov/waterscience/basins/b3webdwnihtm

Order software and EPA regional data including point sources, hydrology, and watershed boundaries.

EPA Permit Compliance System (PCS)*

http://www.epa.gov/enviro/html/pcs/index.html

Query and download data on NPDES permits and other industrial discharges. Data is in tabular format but contains coordinates for input into GIS.

EPA STORET (STORage and RETreival)*

http://www.epa.gov/storet

Download water quality data in tabular format from existing monitoring sites for input into GIS.

EPA Surf Your Watershed*

http://www.epa.gov/surf/locate/index.cfm

Online mapping tool used to obtain data about any specific watershed in the US.

EPA Watershed Assessments*

http://www.epa.gov/waters/data/downloads.html

Download EPA 305b assessment and 303d impaired stream layers.

ESRI*

http://www.esri.com/data/free-data/index.html

Contains a wealth of technical resources for GIS software, downloadable data layers and a downloadable GIS viewing software called ArcExplorer.

Federal Geographic Data Committee's National Geospatial Data Clearinghouse
http://fgdc.ftw.nrcs.usda.gov/gateways.html

Search hundreds of spatial data servers for data and metadata and ordering information.

Federal Emergency Management Agency (FEMA)

http://msc.fema.gov/webapp/wcs/stores/servlet/StoreCatalogDisplay?storeId=10001&catalogId=10001&langId=-1&userType=G

Flood maps available for purchase.

Georgia Department of Community Affairs, Georgia Data Base and Network*

http://www.georgiaplanning.com/dataforplanning.asp

Provides boundary maps, census maps, coastal resource maps, cultural resource maps, demographic and economic data, groundwater recharge area map, Homeland Security Infrastructure Program (HSIP), land use maps, national wetlands inventory, southeastern ecological framework, protected mountain map, protected rivers map, opportunity zone map, and aerial photography.

Georgia Department of Natural Resources, Wildlife Resources Division, Coastal Georgia Land Conservation Initiative and Coastal Mapping Project
http://www.georgiawiildlife.com/node/267

Provides green infrastructure maps showings high priority ecological resources along the Georgia coast.

Georgia GIS Data Base and Network*

http://gis.state.ga.us

Maintains current GIS layers and attributes for the state categorized by county.

GIS Data Depot*

http://data.geocomm.com/

Contains national, state, or county-level GIS data for sale at a reasonable price or for free download in some cases.

Mapmart

http://www.mapmart.com

Contains national, state, or county-level GIS data for sale at a reasonable price.

National Atlas of the United States*

http://www.nationalatlas.gov/atlasftp.html

Contains various GIS layers from the US Department of the Interior.

National Oceanic and Atmospheric Administration (NOAA), National Marine Fisheries Service, Essential Fish Habitat*

http://www.habitat.noaa.gov/protection/efh/habitatmapper.html

Contains a mapping tool and downloadable data for essential fish habitat.

Space Imaging

http://www.spaceimaging.com/products/ikons/

Vendor offering satellite imagery for sale.

Terra server*

http://www.terraserver.com

Online mapping tool used for viewing aerial photos and topographic quadrangles for locations across the US. Searchable by address, geographic coordinates and more.

US Census Bureau TIGER*

http://www.census.gov/geo/www/tiger/index.html

Download TIGER/Line files from 2010 and earlier by state. Files include municipal boundaries, roads, and other general data.

USDA Geospatial Data Gateway*

http://datagateway.nrcs.usda.gov/

Download various data including free imagery.

USDA Natural Resources Conservation Service (NRCS), State of the Land*

http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/technical/nra/nri/?&cid=nrcs143_013689

Download various ArcInfo coverages for the entire US and individual states.

USDA NRCS State Soil Geographic (STATSGO) Database*

http://soils.usda.gov/survey/geography/statsgo/

Download soil layers for U.S. states.

USDA NRCS Soil Survey Geographic (SSURGO) Database*

http://soils.usda.gov/survey/geography/ssurgo/

Download soil layers for U.S. counties.

US Fish and Wildlife Service (FWS), Georgia Ecological Services Field Offices, Threatened and Endangered Species*

http://www.fws.gov/Athens/endangered.html

Download GIS layers for the entire state or select counties.

US Fish and Wildlife Service Migratory Bird Data Center*

http://mbdcapps.fws.gov/

Provides access to bird population and habitat information relevant to population management, conservation planning, and evaluation. It includes an interactive mapping application, data query capabilities on the biological databases, and spatial data download options.

US Fish and Wildlife Service (FWS) National Wetland Inventory (NWI)*

http://www.fws.gov/wetlands/Data/DataDownload.html

Download NWI GIS layers for the entire US.

USGS Center for Spatial Analysis Technologies (CSAT)

http://csat.er.usgs.gov

Maintains database where various GIS data sets can be found.

USGS Digital Orthophoto Quadrangles (DOQs)

http://egsc.usgs.gov/isb/pubs/factsheets/fs05701.html

Fact sheet on DOQs that provides basic description and instructions for ordering.

USGS Mapping*

http://eros.usgs.gov/

Downloads and ordering information for DEMs, DLGs, NED and NHD.

USGS National Land Cover Characterization*

http://landcover.usgs.gov/landcoverdata.php

Download land cover data by state.

USGS Topographic Maps

http://topomaps.usgs.gov/drg

Download or order DRGs, also contains basic info about topographic maps and USGS map symbols.

USGS Water Resources Maps and Info

http://water.usgs.gov/maps.html

Download HUC boundaries, stream ecoregions, landuse and more for the entire US.

US Department Of Transportation TRANSTAT*

http://www.transtats.bts.gov

TRANSTAT database provides updated transportation and infrastructure layers including streets, highways, rails, pipelines, sidewalks and bike paths.

Non-GIS Resources

Some additional non-GIS resources that may be useful for completing an inventory of the natural and man-made resources found on a development site are provided below.

Coastal Georgia Regional Commission
http://crc.ga.gov/default.aspx

Information about regional land use planning efforts.

Georgia Conservancy, Coastal Georgia Land Conservation Initiative
http://www.georgiaconservancy.org/coast/cglci.html

Information about regional land conservation efforts.

Georgia Department of Natural Resources, Coastal Resources Division, Shellfish Sanitation Program

http://www.coastalgadnr.org/maps

Information about shellfish harvesting practices and protected shellfish harvesting areas.

Georgia Department of Natural Resources, Environmental Protection Division, Integrated 305(b)/303(d) List
http://www.georgiaepd.org/Documents/305b.html

Information about water quality and Georgia's degraded waterbodies.

Georgia Department of Natural Resources, State Parks and Historic Sites
http://www.gastateparks.org/historic/

Information about Georgia's state parks and historic sites.

Georgia Department of Natural Resources, Wildlife Resources Division, Nongame Conservation Section, Animals and Plants
http://www.georgiawildlife.com/conservation/georgia-animals-plants

Information about federal and state threatened, endangered and protected animal and plant species.

Georgia Department of Natural Resources, Wildlife Resources Division, Nongame Conservation Section, Coastal Georgia Land Conservation Initiative
http://www.georgiawildlife.com/node/267

Information about preserving critical lands and promoting sustainable growth and development.

Georgia Department of Natural Resources, Wildlife Resources Division, Nongame Conservation Section, State Wildlife Action Plan

http://www,georgiawildlife.com/conservation/wildlife-action-plan

Information about coastal Georgia's priority plant and animal species and habitat areas.

Georgia Exotic Pest Plant Council
http://www.gaeppc.org/

Information about non-native and invasive species in the state of Georgia.

National Oceanic and Atmospheric Administration (NOAA), National Marine Fisheries Service, Endangered Species Act

http://www.nmfs.noaa.gov/pr/laws/esa/

Information about federal and state threatened, endangered and protected animal and plant species.

National Oceanic and Atmospheric Administration (NOAA), National Marine Fisheries Service, Marine Mammal Act

http://www.nmfs.noaa.gov/pr/laws/mmpa/

Information about federal and state threatened, endangered and protected animal and plant species.

National Oceanic and Atmospheric Administration (NOAA), National Marine Fisheries Service, Magnuson-Stevens Act

http://www.nmfs.noaa.gov/msa2007/

Information about federal and state threatened, endangered and protected animal and plant species. The Magnuson-Stevens Act protects essential fish habitat.

National Park Service, Department of the Interior, National Historic Sites in Georgia

http://www.nps.gov/state/ga/index.htm?program=parks

Information about historic sites in Georgia.

Southern Georgia Regional Commission

http://www.sgrc.us/

Information about regional land use planning efforts.

US Army Corps of Engineers, Regulatory Division, Savannah District

http://www.sas.usace.army.mil/regulatory/permits.html

Information about federal regulations for wetlands and waters of the US.

US Environmental Protection Agency, Office of Wetlands, Oceans and Watersheds, Wetlands Program

http://water.epa.gov/type/wetlands/index.cfm

General information about wetlands.

US Environmental Protection Agency, Office of Wetlands, Oceans and Watersheds, Wetlands Program, Water Quality Standards

http://water.epa.gov/lawsregs/guidance/cwa/waterquality_index.cfm

Information about federal water quality regulations for wetlands.

US Fish and Wildlife Service, Bald and Golden Eagle Protection Act

http://www.fws.gov/migratorybirds/baldeagle.htm

Information about the protection of bald eagles.

US Fish and Wildlife Service, Migratory Bird Protection Act

http://www.fws.gov/migratorybirds

Information about the protection of migratory birds.

US Fish and Wildlife Service, Georgia Ecological Services Field Offices, Threatened and Endangered Species

http://www.fws.gov/Athens/endangered.html

Information about federal and state threatened, endangered and protected animal and plant species.

University of Georgia, Ecosystem Health and Invasive Species Program (Bugwood)

http://www.bugwood.org/

Information about non-native and invasive species in the state of Georgia.

University of Georgia, Marine Extension Service, CoastScapes Program

http://www.coastscapes.org

Provides an online search engine for trees and plants that are native to coastal Georgia.

APPENDIX C

High Priority Coastal Habitats

(Source: Georgia Stormwater Management Manuals, Coastal Stormwater Supplement, August 2009 and GDNR Wildlife Resources Division *Comprehensive Wildlife Strategy for Georgia*, 2005)

Table A.2: High Priority Plant Species Found in Coastal Georgia (Source: WRD, 2005)							
Scientific Name	Common Name	Global Rank	State Rank	Federal Status	State Status	Habitat in Georgia	Range in Georgia
Amorpha georgiana var. georgiana	Georgia indigo-bush	G3T2	S1			River terraces; floodplain woods; flint kaolin outcrop; mesic habitats with wiregrass,longleaf pine, mixed oaks	UCP
Amorpha herbacea var. floridana	Florida leadbush	G4T?Q	S1			River terraces along the Alapaha River	LCP, if accepted as taxonomically significant
Arabis georgiana	Georgia rockcress	G2	S1	C	T	Rocky or sandy river bluffs and banks, in circumneutral soil	PD, RV, UCP; along Coosa, Oostanaula and lower Chattahoochee Rivers
Aristida simpliciflora	Chapman three-awn grass	G3	SH			Longleaf pine-wiregrass savannas	UCP
Arnoglossum diversifolium	Variable-leaf Indian-plantain	G2	S2		T	Calcareous swamps	UCP
Arnoglossum sulcatum	Grooved-stem Indian-plantain	G2G3	S1			Bottomland forests	UCP
Asplenium heteroresiliens	Morzenti's spleenwort	G2Q	S1		T	Limestone and marl outcrops; tabby ruins	UCP, LCP
Astragalus michauxii	Sandhill milkvetch	G3	S2			Longleaf pine-wiregrass savannas; turkey oak scrub	UCP
Balduina atropurpurea	Purple honeycomb head	G2G3	S2		R	Wet savannas, pitcherplant bogs	UCP, LCP
Baptisia arachnifera	Hairy rattleweed	G1	S1	LE	E	Pine flatwoods	LCP, entire global range in parts of Brantley and Wayne Cos.
Brickellia cordifolia	Heartleaf brickellia	G2G3	S2			Mesic hardwood forests	UCP
Calamintha ashei	Ashe's wild savory	G3	S2		T	Ohoopee dunes	UCP, Tattnall and Candler Cos.
Campylopus carolinae	Sandhills awned-moss	G1G2	S2?			Fall line sandhills; Altamaha Grit outcrops in partial shade of mesic oak forests	UCP
Carex calcifugens	Lime-fleeing sedge	G2G4	SR			Said by FNA to occur in "Mesic deciduous forests, in sandy loams and sands, usually on stream bank slopes."	LCP (only?)
Carex dasycarpa	Velvet sedge	G4?	S3		R	Evergreen hammocks; mesic hardwood forests	LCP, UCP
Carex decomposita	Cypress-knee sedge	G3	S2?			Swamps and lake margins on floating logs	LCP, UCP

Table A.2: High Priority Plant Species Found in Coastal Georgia (Source: WRD, 2005)							
Scientific Name	Common Name	Global Rank	State Rank	Federal Status	State Status	Habitat in Georgia	Range in Georgia
Carex godfreyi	Godfrey's sedge	G3G4	S3?			Forested depressional wetlands.	UCP, possibly LCP?, uncertain, verification needed
Carex lupuliformis	Mock hop sedge	G5	SU			Said by FNA to occur in "Wet forests, especially in openings around forest ponds, riverine wetlands, marshes, wet thickets, 0-500 m."	LCP?, uncertain, verification needed
Coreopsis integrifolia	Tickseed	G1G2	S1S2			Floodplain forests, streambanks	UCP, LCP
Ctenium floridanum	Florida orange-grass	G2	S1			Moist pine barrens	LCP
Dicerandra radfordiana	Radford's dicerandra	G1Q	S1			Sandridges	LCP, entire global range consists of 2 small areas in McIntosh Co.
Eccremidium floridanum	Florida eccremidium moss	G1?	S1			Sandy or sometimes clay soil in open, disturbed sites, often in areas that are wet part of the year and quite dry other parts of the year, fields and roadsides, thin soil over rock outcrops, around margins of cypres	UCP
Eleocharis tenuis var. tenuis	Slender spikerush	G5T?	SU			Moist to wet sandy-peaty soils; pine flatwoods	RV, PD, where doubtfully recorded and in need of comparison with other named varieites known to be present
Elliottia racemosa	Georgia plume	G2G3	S2S3		T	Scrub forests; Altamaha Grit outcrops; open forests over ultramafic rock	PD, UCP, LCP; from Ft. Stewart to Ashburn, Turner Co.;disjunct on piedmont on Burks Mtn., Columbia Co.
Epidendrum conopseum	Green-fly orchid	G4	S3		U	Epiphytic on limbs of evergreen hardwoods; also in crevices of Altamaha Grit outcrops	UCP, LCP; widespread, sometimes locally abundant especially in bottomland forests along major rivers in Southeast Georgia
Eriochloa michauxii var. michauxii	Michaux's cupgrass	G3G4T 3T4	S1?			Coastal freshwater and brackish marshes; flatwoods	LCP; map in FNA shows records from Charlton, Glynn, Liberty and McIntosh Cos.
Eupatorium anomalum	Florida boneset	G2G3	SU			Wet, low ground	LCP, UCP; likely close to Florida pending scrutiny of closely related E. mohrii and E. rotundifolium
Evolvulus sericeus var. sericeus	Creeping morning-glory	G5T?	S1		E	Altamaha Grit outcrops; open calcareous uplands	UCP
Forestiera godfreyi	Godfrey's wild privet	G2	S1			Mesic, maritime forests over shell mounds	LCP, Camden Co.
Forestiera segregata	Florida wild privet	G4	S2			Shell mounds on barrier islands in scrub or maritime forests	Restricted to shell middens overlooking or upon barrier islands; LCP

Table A.2: High Priority Plant Species Found in Coastal Georgia (Source: WRD, 2005)							
Scientific Name	Common Name	Global Rank	State Rank	Federal Status	State Status	Habitat in Georgia	Range in Georgia
Fothergilla gardenii	Dwarf witch-alder	G3G4	S2		T	Openings in low woods and swamps; edges of seepage bogs	UCP, LCP; widely distributed from Fall Line Sandhills to more southern flatwoods
Habenaria quinqueseta var. quinqueseta	Michaux's orchid	G4G5T ?	S1			Moist shade, Altamaha Grit outcrops; open pine woods	UCP, LCP; widely scattered sites
Hartwrightia floridana	Hartwrightia	G2	S1		T	Wet savannas; ditches, sloughs and flatwood seeps	LCP, restricted to Okefenokee Basin
Hypericum sp. 3	Georgia St.-John's-wort	G2G3	S2S3			Seepage bogs; roadside ditches	UCP, LCP, upper Ogeechee and Canoochee watersheds (only?) and near Eulonia, McIntosh Co.
Justicia angusta	Narrowleaf water-willow	G3Q	SH			Roadside ditches; perhaps with Hartwrightia in shallow sloughs and wet savannas	LCP
Lachnocaulon beyrichianum	Southern bog-button	G2G3	S1			Flatwoods	UCP, LCP
Leitneria floridana	Corkwood	G3	S1			Swamps; sawgrass-cabbage palmetto marshes	UCP, LCP
Lindera melissifolia	Pondberry	G2	S1	LE	E	Margins of seasonal ponds, both sandhill and limesink with swamp blackgum (Nyssa biflora).	LCP, UCP
Litsea aestivalis	Pondspice	G3	S2		T	Cypress ponds; swamp margins	UCP, LCP; especially southeastern Georgia
Lycium carolinianum	Carolina wolfberry	G4	S1			Coastal sand spits	LCP, Cumberland Island, Camden Co.
Malaxis spicata	Florida adders-mouth orchid	G4?	S1			Low hammocks; spring-fed river swamps	UCP, LCP, potentially over Coastal Plain based on Florida distribution; documented recently only from LCP; historic from UCP in Jenkins Co.
Matelea alabamensis	Alabama milkvine	G2	S1		T	Open bluff forests; mesic margins of longleaf pine sandridges	UCP, LCP; on Gulf CP and an area of Atlantic CP along the Altamaha River, Wayne Co..
Matelea pubiflora	Trailing milkvine	G3G4	S2		R	Exposed sandy soils; sandridges	UCP, LCP
Myriophyllum laxum	Lax water-milfoil	G3	S2		T	Bluehole spring runs; shallow, sandy, swift-flowing creeks; clear, cool ponds	UCP, in many watersheds, most often in westcentral Georgia sandhills
Orbexilum virgatum	Slender leather-root	G1	SH			Sandridges	LCP, Charlton Co.
Oxypolis ternata	Savanna cowbane	G3	S2			Wet pine savannas and bogs	UCP, widely scattered

Table A.2: High Priority Plant Species Found in Coastal Georgia (Source: WRD, 2005)							
Scientific Name	Common Name	Global Rank	State Rank	Federal Status	State Status	Habitat in Georgia	Range in Georgia
Peltandra sagittifolia	Arrow arum	G3G4	S2?			Swamps; wet hammocks on pristine sphagnum mats	UCP, LCP; locally abundant in Okefenokee Swamp
Penstemon dissectus	Cutleaf beardtongue	G2	S2?		R	Altamaha Grit outcrops and adjacent pine savannas; rarely sandridges	UCP, endemic to Altamaha Grit (Tifton Uplands)
Phaseolus polystachios var. sinuatus	Trailing bean-vine	G4T3?	S2?			Sandhills; dry pinelands and hammocks	UCP, LCP
Physostegia leptophylla	Tidal marsh obedient-plant	G4?	S2S3		T	Freshwater tidal marshes; perhaps disjunct in wet savannas of extreme SW Georgia	LCP, coastal cos. on tidally influenced shorelines; reports from UCP in SW Georgia need verification
Plantago sparsiflora	Pineland plantain	G3	S2			Open, wet pine savannas; shallow ditches	UCP, LCP
Platanthera blephariglottis var. blephariglottis	White fringed-orchid	G4G5T 4?	S1?				
Platanthera blephariglottis var. conspicua	Southern white fringed-orchid	G4G5T 3T4	S2?			Bogs, seeps, roadsides, wet savannas	UCP, LCP; scattered from Fall Line Sandhills to coast and South Georgia plantations
Platanthera chapmanii	Chapman's fringed-orchid	G4?	S1			Open, wet meadows; pine flatwoods	UCP, LCP, extreme Southeast Georgia; historic in Southwest Georgia
Platanthera integra	Yellow fringeless orchid	G3G4	S2			Wet savannas, pitcherplant bogs	UCP, LCP; documented from 9 cos., scattered on coastal plain
Polygonum glaucum	Sea-beach knotweed	G3	SH			Coastal beaches in dune depressions and among protected accumulations of beach wrack	LCP
Portulaca biloba	Grit portulaca	G1G2	S1			Altamaha Grit outcrops	UCP
Pteroglossaspis ecristata	Wild coco	G2	S1			Grassy saw palmetto barrens; longleaf pine grasslands, sometimes with Schwalbea americana	LCP, UPC; widely scattered, including barrier islands
Ptilimnium sp. 1	Mock bishop-weed	G1	SH			Tidal freshwater marshes	LCP, narrow endemic from Savannah into South Carolina
Rhynchospora breviseta	Short-bristle beakrush	G3G4	SU			Bogs; flatwoods	Uncertain, documentation needed, UCP, LCP
Rhynchospora decurrens	Decurrent beakrush	G3G4	S1?			Swamps	UCP, LCP
Rhynchospora fernaldii	Fernald's beakrush	G3G4	SR			Flatwoods depressions	LCP (only?), to be considered as a rarity from Okefenokee Swamp, whence all specimens from Georgia came
Rhynchospora	Many-bristled	G3	S1?			Peaty, sandhill seepage slopes;	LCP an old record from Coffee Co.

Table A.2: High Priority Plant Species Found in Coastal Georgia (Source: WRD, 2005)							
Scientific Name	Common Name	Global Rank	State Rank	Federal Status	State Status	Habitat in Georgia	Range in Georgia
macra	beakrush					streamhead pocosins	near Douglas
Rhynchospora pleiantha	Clonal thread-leaved beakrush	G2	SH			Margins of limesink depression ponds (dolines)	UCP
Rhynchospora punctata	Spotted beakrush	G1?	S1?			Wet savannas, pitcherplant bogs	UCP, LCP
Ruellia noctiflora	Night-blooming wild petunia	G2	SH			Open, slash pine flatwoods	LCP, outer Coastal Plain on the Barrier Island Sequence
Sageretia minutiflora	Climbing buckthorn	G4	S1?		T	Calcareous bluff forests; maritime forests over shell mounds	UCP, LCP
Sagittaria graminea var. chapmanii	Chapman's arrowhead	G5T3?	S3?			Low woods and seasonal wet swamps with Carex leptalea, Rhynchospora miliacea	UCP, LCP, perhaps widespread, including a pond on Sapelo Island
Sapindus saponaria	Soapberry	G5	S1			Shell mound forests	LCP
Sarracenia flava	Yellow flytrap	G5?	S3S4		U	Wet savannas, pitcherplant bogs	UCP, LCP
Sarracenia minor var. minor	Hooded pitcherplant	G4T4	S4			Wet savannas, pitcherplant bogs	UCP LCP
Sarracenia minor var. okefenokeense	Okefenokee giant	G4T2T3	S2S3			Wet savannas, pitcherplant bogs	LCP, Okefenokee Basin only
Sarracenia psittacina	Parrot pitcherplant	G4	S2S3		T	Wet savannas, pitcherplant bogs	UCP, LCP
Sarracenia rubra	Sweet pitcherplant	G3	S2	(PS)	E	Atlantic white cedar swamps; wet savannas	UCP, in two areas, Atlantic Coastal Plain and Fall Line Sandhills west of Macon
Schoenolirion elliottii	White sunnybell	G3	S1?			Wet savannas	LCP, few observations from Wayne and Brantley Cos.
Scutellaria altamaha	Altamaha skullcap	G2G3	S1?			Sandy, deciduous woods	UCP, LCP. (only?), perhaps adjacent Piedmont, of Southeast Georgia
Scutellaria arenicola	Sandhill skullcap	G3G4	SH			Sandy scrub	LCP, Trail Ridge; Camden Co.
Scutellaria mellichampii	Mellichamp's skullcap	G?Q	S1?			Sandy deciduous woods	LCP, UCP; widely scattered
Sideroxylon sp. 1	Dwarf buckthorn	G3Q	S3			Dry longleaf pine woods with oak understory; often hidden in wiregrass	UCP, LCP
Sideroxylon thornei	Swamp buckthorn	G2	S2		E	Forested limesink depressions; calcareous swamps	UCP, LCP
Sphagnum cyclophyllum	Round-leaved peat-moss	G3	S2			CP: bare sand where wet or submerged for part of the year and then drying, as around seasonal ponds in pine barrens.. PD:	PD, LCP, UCP

Table A.2: High Priority Plant Species Found in Coastal Georgia (Source: WRD, 2005)							
Scientific Name	Common Name	Global Rank	State Rank	Federal Status	State Status	Habitat in Georgia	Range in Georgia
						seepage over granite outcrops	
Spiranthes floridana	Florida ladies-tresses	G1	S1?				
Sporobolus pinetorum	Pineland dropseed	G3	S2?			Wet savannas with wiregrass	LCP
Stewartia malacodendron	Silky camellia	G4	S2		R	Along streams on lower slopes of beech-magnolia or beech-basswood-Florida maple forests	PD, UCP
Tillandsia bartramii	Bartram's airplant	G4	S2				
Vaccinium crassifolium	Evergreen lowbush blueberry	G4G5	SH			Open margins of Carolina bays	LCP, historically in or near Screven Co.
Xyris drummondii	Drummond's yellow-eyed grass	G3	S1			Pine flatwoods	UCP, LCP
Xyris scabrifolia	Harper's yellow-eyed grass	G3	S1			Sedge bogs; pitcherplant bogs; pine flatwoods	UCP, LCP

References

Georgia Department of Natural Resources Wildlife Resources Division (WRD). 2005. *A Comprehensive Wildlife Conservation Strategy for Georgia*. Georgia Department of Natural Resources. Wildlife Resources Division. Social Circle, GA. Available Online: http://www1.gadnr.org/cwcs/Documents/strategy.html.

APPENDIX D

High Priority Plant & Animal Species

(Source: Georgia Stormwater Management Manuals, *Coastal Stormwater Supplement*, August 2009 and GDNR Wildlife Resources Division *Comprehensive Wildlife Strategy for Georgia*, 2005)

At least 71 high priority animal species can be found in coastal Georgia, including 27 birds, 14 reptiles, 10 mammals, 7 amphibians, 7 mollusks, 5 fish and 1 aquatic arthropod (WRD, 2005). In addition, at least 91 high priority plants species can be found in coastal Georgia (WRD, 2005). These high priority animal and plant species are listed in the following tables, along with information on global and state rarity ranks, protected status (if any) under federal or state law and habitat and range in coastal Georgia.

High Priority Animal Species Found in Coastal Georgia (Source: WRD, 2005)							
Scientific Name	Common Name	Global Rank	State Rank	Federal Status	State Status	Habitat in Georgia	Range in Georgia
Cordulegaster sayi	Say's spiketail	G2	S1			Trickling hillside seepages in deciduous forest near weedy fields	Southeastern coastal plain only.
Ambystoma cingulatum	Flatwoods salamander	G2G3	S2	LT	T	Pine flatwoods; moist savannas; isolated cypress/gum ponds	Lower CP, extremely localized throughout large but fragmented range. Only four sites with known extant populations
Desmognathus auriculatus	Southern dusky salamander	G5	S3			In or around the margins of slowly moving or stagnant bodies of water with mucky, acidic soils; cypress swamps, floodplains, sloughs	Lower CP
Necturus punctatus	Dwarf waterdog	G4	S2			Sluggish streams with substrate of leaf litter or woody debris	Atlantic drainages, primarily CP, one record in the PD
Notophthalmus perstriatus	Striped newt	G2G3	S2		R	Pine flatwoods, sandhills; isolated wetlands	CP
Pseudobranchus striatus	Dwarf siren	G5	S3			Swamps; marshes; limesink ponds; cypress ponds	lower CP
Rana capito	Gopher frog	G3G4	S3			Sandhills; dry pine flatwoods; breed in isolated wetlands	CP
Stereochilus marginatus	Many-lined salamander	G5	S3			Sluggish, swampy streams and bayheads with substrate of leaf litter	eastern CP
Aimophila aestivalis	Bachman's sparrow	G3	S3	SAR	R	Open pine or oak woods; old fields; grassy forest regeneration	RV, PD, CP: where appropriate habitat
Ammodramus henslowii	Henslow's sparrow	G4	S3	SAR		Grassy areas, especially wet grasslands; wet pine savanna & flatwoods	CP, PD - historically and migrants
Ammodramus savannarum	Grasshopper sparrow	G5	S4			Grassland surrounded by open country (ag, grassland etc.)	CP, PD predominantly, less common in CU, RV, rare in BR
Calidris canutus	Red knot (SE winter population)	G5	S3	SAR		Beaches and sandbars	Coastal
Charadrius melodus	Piping plover	G3	S1	(LE,LT)	T	Sandy beaches; mud and sand flats; isolated sand spits	CP - coastal
Charadrius wilsonia	Wilson's plover	G5	S2		R	Sandy beaches; sand and mud flats, dunes and back dune swales	CP - coastal
Colinus virginianus	Northern bobwhite	G5	S4			Early successional mixed grass/forb habitat; longleaf pine savanna	CP most numerous; uncommon in PD, RV; scattered in CU, BR
Egretta tricolor	Tricolored heron	G5	S3			Coastal aquatic environments, salt and fresh, nests with other waders in low thick cover	All coastal counties
Elanoides forficatus	Swallow-tailed kite	G5	S2	SAR	R	River swamps and upland adjacent habitats particularly with large, emergent pines and pine islands; marshes	CP - nesting primarily in SE CP with scattered records statewide post breeding

High Priority Animal Species Found in Coastal Georgia (Source: WRD, 2005)							
Scientific Name	Common Name	Global Rank	State Rank	Federal Status	State Status	Habitat in Georgia	Range in Georgia
Falco sparverius paulus	Southeastern American kestrel	G5T4	S3	SAR		Pine sandhills and savannas; open country with scattered trees for nesting; military base habitats; artificial/man-made nesting habitats include nest boxes, power poles, building columns	CP
Grus canadensis pratensis	Florida sandhill crane	G5T2T3	S1			Freshwater prairies	Restricted to Okefenokee and Grand Bay
Haematopus palliatus	American oystercatcher	G5	S2	SAR	R	Sandy beaches; tidal flats; salt marshes, oyster shell bars	CP - coastal
Haliaeetus leucocephalus	Bald eagle	G4	S2	(PS:LT,P DL)	E	Edges of lakes & large rivers; seacoasts	CP - primarily and reservoirs and rivers PD, BR, RV
Himantopus mexicanus	Black-necked stilt	G5	S3	(PS)		Shallow ponds; lagoons; isolated freshwater wetlands; dredge spoil sites; managed wetlands	CP - coastal
Ixobrychus exilis	Least bittern	G4	S3			Freshwater and brackish marshes with tall, dense emergent vegetation. Nests close to open areas	Probably more common as a breeder in CP due to much more potentially suitable habitat than in PD
Lanius ludovicianus migrans	Loggerhead shrike	G4T3Q	S?	SAR		Open woods; field edges; savannas	CP - primary area of abundance; scattered and low number in the PD (none in 20-county metro Atlanta area); low numbers in RV
Laterallus jamaicensis	Black rail	G4	S2?	SAR		Freshwater marsh grassy margins; wet grassy meadows; brackish high marsh	PD, CP - most likely breeding would occur in eastern PD or along Coast
Limnothlypis swainsonii	Swainson's warbler	G4	S3	SAR		Dense undergrowth with heavy litter (CP,M); canebrakes in swamps and river floodplains (CP)	Although found widespread, bulk of population restricted to river floodplains of CP and PD; small BR population
Mycteria americana	Wood stork	G4	S2	(PS:LE)	E	Cypress/gum ponds; freshwater marshes; saltmarshes, river swamps; bays, isolated wetlands, ephemeral wetlands, coastal hammocks	1,200 pairs nesting in Coastal Plain 2002, with post-nest dispersal throughout state
Numenius phaeopus	Whimbrel	G5	S3			Saltmarsh openings, Mud flats, shell rakes, outer barrier sand spits	All coastal counties
Passerina ciris	Painted bunting	G5	S3	SAR		Shrub-scrub and open grassy habitats; open mature pine forest and maritime oak forest associated with freshwater wetlands	CP - primarily barrier islands and immediate coast with scattered occurrences up major river corridors; occurrences in CP agricultural lands reduced and poorly understood

High Priority Animal Species Found in Coastal Georgia (Source: WRD, 2005)							
Scientific Name	Common Name	Global Rank	State Rank	Federal Status	State Status	Habitat in Georgia	Range in Georgia
Picoides borealis	Red-cockaded woodpecker	G3	S2	LE	E	Open pine woods; pine savannas	Found mostly in CP, also lower PD. Disjunct populations in counties of Muscogee, Chattahoochee (Ft Benning); Liberty, Long, Bryan (Ft Stewart); Charlton, Brantley (Okefenokee NWR, private); Jones, Jasper (Piedmont NWR, Oconee NF, Hitchiti); Thomas, Grady
Rallus elegans	King rail	G4G5	S3			Freshwater marshes, often cattail bulrush, cutgrass, for breeding; also brackish marshes non-breeding (saltmarshes?)	Principally Piedmont and CP; possibly R&V
Rynchops niger	Black skimmer	G5	S1			Sandy beaches, isolated accretional sand spits, N and S tips of barrier islands	Strictly outer coast
Sterna antillarum	Least tern	G4	S3	(PS:LE)	R	Sandy beaches; sandbars, large flat gravel roof tops	Coastal Counties
Sterna nilotica	Gull-billed tern	G5	S1		T	Outer sand beaches and mud flats, Salt marshes; fields on barrier islands; Isolated sand spits	Coastal
Tyto alba	Barn owl	G5	S3/S4			Grassland savanna with large cavity trees, also neighborhoods with large cavity trees, generally needs open country	Local: CP, PD, RV, CU, rare in BR
Acipenser brevirostrum	Shortnose sturgeon	G3	S2	LE	E	Estuaries; lower end of large rivers in deep pools with soft substrates	Atlantic drainage large rivers
Elassoma okatie	Bluebarred pygmy sunfish	G2G3	S1S2			Temporary ponds and stream backwaters with dense aquatic vegetation	Fort Gordon
Enneacanthus chaetodon	Blackbanded sunfish	G4	S1		R	Blackwater streams; bays; cypress/gum ponds	Disjunct historic locales in SE GA; T. Peterson (recent) able to find at one historic locale outside of OK Swamp
Lucania goodei	Bluefin killifish	G5	S1		U	Heavily vegetated ponds and streams with little or no current; frequently associated with springs	Lower Flint River system and in McIntosh County on east coast of GA
Micropterus notius	Suwannee bass	G3	S2		R	Flowing water over rocky shoals or large springs and spring runs	Suwanee drainage so. GA
Condylura cristata	Star-nosed mole	G5	S2?			Moist meadows; woods; swamps	Known only from Charlton, Chatham, Clinch, Effingham, Jackson and Union counties
Corynorhinus rafinesquii	Rafinesque's big-eared bat	G3G4	S3?		R	Pine forests; hardwood forests; caves; abandoned buildings; bridges; bottomland hardwood forests and cypress-gum swamps	Range in state disjunct--C.r.rafinesquii found in northern BR and C. r. macrotis found in lower CP. Not known from PD, but either subsp might occur there.

High Priority Animal Species Found in Coastal Georgia (Source: WRD, 2005)							
Scientific Name	Common Name	Global Rank	State Rank	Federal Status	State Status	Habitat in Georgia	Range in Georgia
Eubalaena glacialis	North Atlantic right whale	G1	S1 and S?	LE	E	Inshore and offshore oceanic waters of Georgia	Occurs along the entire Georgia coast and also observed offshore up to 40 nm. Most frequently observed in waters > 8ft. Maximum depth or distance from shore is unknown but strongly suspected to occur West of the Gulf Stream
Geomys pinetis	Southeastern pocket gopher	G5	S4			Sandy well-drained soils in open pine woodlands with grassy or herbaceous groundcover, fields, grassy roadsides	Fairly widespread over CP, but population apparently greatly reduced and fragmented; small local populations
Lasiurus intermedius	Northern yellow bat	G4G5	S2S3			Wooded areas near open water or fields	Has been found only in lower CP
Neofiber alleni	Round-tailed muskrat	G3	S3		T	Freshwater marshes; bogs	Okefenokee and surrounding areas in Camden, Charlton and Ware; also Grand Bay WMA in Lanier and Lowndes; also Brooks.
Sciurus niger shermani	Sherman's fox squirrel	G5T2	S?			Pine forests; pine savannas	Some sources say this subspecies only occurs in extreme SE corner of Georgia around Okefenokee Swamp. However, Turner and Laerm (1993) say S.n. shermani occurs up into Piedmont.
Trichechus manatus	West Indian manatee	G2	S1S2	LE	E	Inshore ocean; estuaries, tidal rivers, warm and fresh water discharges	Found in six coastal counties. These animals are unique because they can migrate between fresh and salt water.
Tursiops truncatus	Bottlenose dolphin	G5	S?			Coastal estuarine and offshore waters of Georgia	Bottlenose dolphins range in all 6 coastal counties; Camden, Glynn, McIntosh, Liberty, Bryan and Chatham. All tidal rivers and creeks provide dolphin habitat. They also extend offshore. CP.
Ursus americanus floridanus	Florida black bear	G5T2	S2			Large undeveloped wooded tracts in areas that include multiple forest types	Parts of Echols, Clinch, Charlton, Ware and Brantley counties support breeding population. Individuals frequently wander into surrounding counties and along Altamaha corridor.
Alasmidonta triangulata	Southern elktoe	G2Q	S1			Large creeks and river mainstems in sandy mud and rock pools	Confined to the Chattachoochee, Flint, Ogeechee, Savannah river drainages

High Priority Animal Species Found in Coastal Georgia (Source: WRD, 2005)							
Scientific Name	Common Name	Global Rank	State Rank	Federal Status	State Status	Habitat in Georgia	Range in Georgia
Alasmidonta varicosa	Brook floater	G3	S2			Small rivers and creeks in sand and gravel shoals	Present distribution includes 4 sites in the Chattooga River in Rabun County (Savannah River drainage).
Elliptio fraterna	Brother spike	G1	SU			Sandy substrates of river channels with swift current	Uncertain of range in Savannah River system
Fusconaia masoni	Atlantic pigtoe	G2	S1		E	Moderate to fast current in substrate of sand or gravel	Historical range included 6 sites in the Ogeechee and Savannah River basins-all of which have been extirpated. One newly discovered population was found in Williamson Swamp Creek in Jefferson County (Alderman 1991).
Medionidus walkeri	Suwannee moccasinshell	G1	SH			Large creeks and medium-sized rivers with sand and gravel substrate	Endemic to the Suwannee River basin in GA and FL
Quincuncina kleiniana	Suwanee pigtoe	GU	S2			Small to large rivers in the Suwannee Basin, in slow to moderate current, pools of flowing rivers, often in detritus. More common in Alapaha and Withalacoochee rivers and tribs	Endemic to the Suwannee River basin in GA and FL
Toxolasma pullus	Savannah lilliput	G2	S2			Altamaha River; Savannah River	Historical distribution included the Altamaha River basin (Johnson 1970, Sepkoski and Rex 1974, Keferl 1981). Present distribution from recent surveys appears to be only the Ohoopee River (Keferl pers. com.).
Caretta caretta	Loggerhead	G3	S2	LT	T	Open ocean; sounds; coastal rivers; beaches	Ocean, sounds, coastal rivers, beaches
Chelonia mydas	Green sea turtle	G3	S2	(LE,LT)	T	Open ocean; sounds; coastal rivers; beaches	Ocean, sounds, coastal rivers, beaches
Clemmys guttata	Spotted turtle	G5	S3		U	Heavily vegetated swamps, marshes, bogs and small ponds; nest and possibly hibernate in surrounding uplands	Widely distributed across CP
Crotalus adamanteus	Eastern diamondback rattlesnake	G4	S4			Early successional habitats on barrier islands and mainland; pine flatwoods; sandhills	CP, including barrier islands
Dermochelys coriacea	Leatherback sea turtle	G3	S2	LE	E	Open ocean; sounds; coastal beaches	Ocean, sounds, beaches
Drymarchon couperi	Eastern indigo snake	G4T3	S3	LT	T	Sandhills; pine flatwoods; dry hammocks; summer habitat includes floodplains and bottomlands	Middle and lower CP
Eumeces anthracinus	Coal skink	G5	S2			Mesic forests; often near streams, springs or bogs	Very little known about range especially in CP

High Priority Animal Species Found in Coastal Georgia (Source: WRD, 2005)							
Scientific Name	Common Name	Global Rank	State Rank	Federal Status	State Status	Habitat in Georgia	Range in Georgia
Eumeces egregius	Mole skink	G4	S3	(PS)		Coastal dunes; longleaf pine-turkey oak woods; dry hammocks	Widespread throughout CP
Gopherus polyphemus	Gopher tortoise	G3	S2	(PS:LT)	T	Sandhills; dry hammocks; longleaf pine-turkey oak woods; old fields	CP
Heterodon simus	Southern hognose snake	G2	S2			Sandhills; fallow fields; longleaf pine-turkey oak	CP
Lepidochelys kempii	Kemp's or Atlantic ridley	G1	S1	LE	E	Open ocean; sounds; coastal rivers; beaches	Ocean, sounds, coastal rivers
Macrochelys temminckii	Alligator snapping turtle	G3G4	S3		T	Large streams and rivers; impoundments; river swamps	Gulf CP drainages
Malaclemys terrapin	Diamondback terrapin	G4	S3			Entire coast, esturine and marine edge. All saltmarsh, beaches	Strictly Coastal
Ophisaurus mimicus	Mimic glass lizard	G3	S2			Pine flatwoods; savannas; seeapge bogs	Lower CP, substantial gaps in range
Pituophis melanoleucus mugitus	Florida pine snake	G4T3?	S3			Sandhills; scrub; old field	CP
Rhineura floridana	Florida worm lizard	G4	S1			Dry upland hammocks, sand pine and longleaf pine-turkey oak sandhills; old fields	Lanier Co. in CP
Tantilla relicta	Florida crowned snake	G5	S1			Sandhills, scrub and moist hammocks	Lowndes Co. in CP

High Priority Plant Species Found in Coastal Georgia (Source: WRD, 2005)							
Scientific Name	Common Name	Global Rank	State Rank	Federal Status	State Status	Habitat in Georgia	Range in Georgia
Amorpha georgiana var. georgiana	Georgia indigo-bush	G3T2	S1			River terraces; floodplain woods; flint kaolin outcrop; mesic habitats with wiregrass,longleaf pine, mixed oaks	UCP
Amorpha herbacea var. floridana	Florida leadbush	G4T?Q	S1			River terraces along the Alapaha River	LCP, if accepted as taxonomically significant
Arabis georgiana	Georgia rockcress	G2	S1	C	T	Rocky or sandy river bluffs and banks, in circumneutral soil	PD, RV, UCP; along Coosa, Oostanaula and lower Chattahoochee Rivers
Aristida simpliciflora	Chapman three-awn grass	G3	SH			Longleaf pine-wiregrass savannas	UCP
Arnoglossum diversifolium	Variable-leaf Indian-plantain	G2	S2		T	Calcareous swamps	UCP
Arnoglossum sulcatum	Grooved-stem Indian-plantain	G2G3	S1			Bottomland forests	UCP
Asplenium heteroresiliens	Morzenti's spleenwort	G2Q	S1		T	Limestone and marl outcrops; tabby ruins	UCP, LCP
Astragalus michauxii	Sandhill milkvetch	G3	S2			Longleaf pine-wiregrass savannas; turkey oak scrub	UCP
Balduina atropurpurea	Purple honeycomb head	G2G3	S2		R	Wet savannas, pitcherplant bogs	UCP, LCP
Baptisia arachnifera	Hairy rattleweed	G1	S1	LE	E	Pine flatwoods	LCP, entire global range in parts of Brantley and Wayne Cos.
Brickellia cordifolia	Heartleaf brickellia	G2G3	S2			Mesic hardwood forests	UCP
Calamintha ashei	Ashe’s wild savory	G3	S2		T	Ohoopee dunes	UCP, Tattnall and Candler Cos.
Campylopus carolinae	Sandhills awned-moss	G1G2	S2?			Fall line sandhills; Altamaha Grit outcrops in partial shade of mesic oak forests	UCP
Carex calcifugens	Lime-fleeing sedge	G2G4	SR			Said by FNA to occur in “Mesic deciduous forests, in sandy loams and sands, usually on stream bank slopes.”	LCP (only?)
Carex dasycarpa	Velvet sedge	G4?	S3		R	Evergreen hammocks; mesic hardwood forests	LCP, UCP
Carex decomposita	Cypress-knee sedge	G3	S2?			Swamps and lake margins on floating logs	LCP, UCP
Carex godfreyi	Godfrey's sedge	G3G4	S3?			Forested depressional wetlands.	UCP, possibly LCP?, uncertain, verification needed

High Priority Plant Species Found in Coastal Georgia (Source: WRD, 2005)							
Scientific Name	Common Name	Global Rank	State Rank	Federal Status	State Status	Habitat in Georgia	Range in Georgia
Carex lupuliformis	Mock hop sedge	G5	SU			Said by FNA to occur in "Wet forests, especially in openings around forest ponds, riverine wetlands, marshes, wet thickets, 0-500 m."	LCP?, uncertain, verification needed
Coreopsis integrifolia	Tickseed	G1G2	S1S2			Floodplain forests, streambanks	UCP, LCP
Ctenium floridanum	Florida orange-grass	G2	S1			Moist pine barrens	LCP
Dicerandra radfordiana	Radford's dicerandra	G1Q	S1			Sandridges	LCP, entire global range consists of 2 small areas in McIntosh Co.
Eccremidium floridanum	Florida eccremidium moss	G1?	S1			Sandy or sometimes clay soil in open, disturbed sites, often in areas that are wet part of the year and quite dry other parts of the year, fields and roadsides, thin soil over rock outcrops, around margins of cypres	UCP
Eleocharis tenuis var. tenuis	Slender spikerush	G5T?	SU			Moist to wet sandy-peaty soils; pine flatwoods	RV, PD, where doubtfully recorded and in need of comparison with other named varieites known to be present
Elliottia racemosa	Georgia plume	G2G3	S2S3		T	Scrub forests; Altamaha Grit outcrops; open forests over ultramafic rock	PD, UCP, LCP; from Ft. Stewart to Ashburn, Turner Co.;disjunct on piedmont on Burks Mtn., Columbia Co.
Epidendrum conopseum	Green-fly orchid	G4	S3		U	Epiphytic on limbs of evergreen hardwoods; also in crevices of Altamaha Grit outcrops	UCP, LCP; widespread, sometimes locally abundant especially in bottomland forests along major rivers in Southeast Georgia
Eriochloa michauxii var. michauxii	Michaux's cupgrass	G3G4T 3T4	S1?			Coastal freshwater and brackish marshes; flatwoods	LCP; map in FNA shows records from Charlton, Glynn, Liberty and McIntosh Cos.
Eupatorium anomalum	Florida boneset	G2G3	SU			Wet, low ground	LCP, UCP; likely close to Florida pending scrutiny of closely related E. mohrii and E. rotundifolium
Evolvulus sericeus var. sericeus	Creeping morning-glory	G5T?	S1		E	Altamaha Grit outcrops; open calcareous uplands	UCP
Forestiera godfreyi	Godfrey's wild privet	G2	S1			Mesic, maritime forests over shell mounds	LCP, Camden Co.
Forestiera segregata	Florida wild privet	G4	S2			Shell mounds on barrier islands in scrub or maritime forests	Restricted to shell middens overlooking or upon barrier islands; LCP
Fothergilla gardenii	Dwarf witch-alder	G3G4	S2		T	Openings in low woods and swamps; edges of seepage bogs	UCP, LCP; widely distributed from Fall Line Sandhills to more southern flatwoods

High Priority Plant Species Found in Coastal Georgia (Source: WRD, 2005)							
Scientific Name	Common Name	Global Rank	State Rank	Federal Status	State Status	Habitat in Georgia	Range in Georgia
Habenaria quinqueseta var. quinqueseta	Michaux's orchid	G4G5T ?	S1			Moist shade, Altamaha Grit outcrops; open pine woods	UCP, LCP; widely scattered sites
Hartwrightia floridana	Hartwrightia	G2	S1		T	Wet savannas; ditches, sloughs and flatwood seeps	LCP, restricted to Okefenokee Basin
Hypericum sp. 3	Georgia St.-John's-wort	G2G3	S2S3			Seepage bogs; roadside ditches	UCP, LCP, upper Ogeechee and Canoochee watersheds (only?) and near Eulonia, McIntosh Co.
Justicia angusta	Narrowleaf water-willow	G3Q	SH			Roadside ditches; perhaps with Hartwrightia in shallow sloughs and wet savannas	LCP
Lachnocaulon beyrichianum	Southern bog-button	G2G3	S1			Flatwoods	UCP, LCP
Leitneria floridana	Corkwood	G3	S1			Swamps; sawgrass-cabbage palmetto marshes	UCP, LCP
Lindera melissifolia	Pondberry	G2	S1	LE	E	Margins of seasonal ponds, both sandhill and limesink with swamp blackgum (Nyssa biflora).	LCP, UCP
Litsea aestivalis	Pondspice	G3	S2		T	Cypress ponds; swamp margins	UCP, LCP; especially southeastern Georgia
Lycium carolinianum	Carolina wolfberry	G4	S1			Coastal sand spits	LCP, Cumberland Island, Camden Co.
Malaxis spicata	Florida adders-mouth orchid	G4?	S1			Low hammocks; spring-fed river swamps	UCP, LCP, potentially over Coastal Plain based on Florida distribution; documented recently only from LCP; historic from UCP in Jenkins Co.
Matelea alabamensis	Alabama milkvine	G2	S1		T	Open bluff forests; mesic margins of longleaf pine sandridges	UCP, LCP; on Gulf CP and an area of Atlantic CP along the Altamaha River, Wayne Co..
Matelea pubiflora	Trailing milkvine	G3G4	S2		R	Exposed sandy soils; sandridges	UCP, LCP
Myriophyllum laxum	Lax water-milfoil	G3	S2		T	Bluehole spring runs; shallow, sandy, swift-flowing creeks; clear, cool ponds	UCP, in many watersheds, most often in westcentral Georgia sandhills
Orbexilum virgatum	Slender leather-root	G1	SH			Sandridges	LCP, Charlton Co.
Oxypolis ternata	Savanna cowbane	G3	S2			Wet pine savannas and bogs	UCP, widely scattered
Peltandra sagittifolia	Arrow arum	G3G4	S2?			Swamps; wet hammocks on pristine sphagnum mats	UCP, LCP; locally abundant in Okefenokee Swamp
Penstemon dissectus	Cutleaf beardtongue	G2	S2?		R	Altamaha Grit outcrops and adjacent pine savannas; rarely sandridges	UCP, endemic to Altamaha Grit (Tifton Uplands)

High Priority Plant Species Found in Coastal Georgia (Source: WRD, 2005)							
Scientific Name	Common Name	Global Rank	State Rank	Federal Status	State Status	Habitat in Georgia	Range in Georgia
Phaseolus polystachios var. sinuatus	Trailing bean-vine	G4T3?	S2?			Sandhills; dry pinelands and hammocks	UCP, LCP
Physostegia leptophylla	Tidal marsh obedient-plant	G4?	S2S3		T	Freshwater tidal marshes; perhaps disjunct in wet savannas of extreme SW Georgia	LCP, coastal cos. on tidally influenced shorelines; reports from UCP in SW Georgia need verification
Plantago sparsiflora	Pineland plantain	G3	S2			Open, wet pine savannas; shallow ditches	UCP, LCP
Platanthera blephariglottis var. blephariglottis	White fringed-orchid	G4G5T4?	S1?				
Platanthera blephariglottis var. conspicua	Southern white fringed-orchid	G4G5T3T4	S2?			Bogs, seeps, roadsides, wet savannas	UCP, LCP; scattered from Fall Line Sandhills to coast and South Georgia plantations
Platanthera chapmanii	Chapman's fringed-orchid	G4?	S1			Open, wet meadows; pine flatwoods	UCP, LCP, extreme Southeast Georgia; historic in Southwest Georgia
Platanthera integra	Yellow fringeless orchid	G3G4	S2			Wet savannas, pitcherplant bogs	UCP, LCP; documented from 9 cos., scattered on coastal plain
Polygonum glaucum	Sea-beach knotweed	G3	SH			Coastal beaches in dune depressions and among protected accumulations of beach wrack	LCP
Portulaca biloba	Grit portulaca	G1G2	S1			Altamaha Grit outcrops	UCP
Pteroglossaspis ecristata	Wild coco	G2	S1			Grassy saw palmetto barrens; longleaf pine grasslands, sometimes with Schwalbea americana	LCP, UPC; widely scattered, including barrier islands
Ptilimnium sp. 1	Mock bishop-weed	G1	SH			Tidal freshwater marshes	LCP, narrow endemic from Savannah into South Carolina
Rhynchospora breviseta	Short-bristle beakrush	G3G4	SU			Bogs; flatwoods	Uncertain, documentation needed, UCP, LCP
Rhynchospora decurrens	Decurrent beakrush	G3G4	S1?			Swamps	UCP, LCP
Rhynchospora fernaldii	Fernald's beakrush	G3G4	SR			Flatwoods depressions	LCP (only?), to be considered as a rarity from Okefenokee Swamp, whence all specimens from Georgia came
Rhynchospora macra	Many-bristled beakrush	G3	S1?			Peaty, sandhill seepage slopes; streamhead pocosins	LCP an old record from Coffee Co. near Douglas
Rhynchospora pleiantha	Clonal thread-leaved beakrush	G2	SH			Margins of limesink depression ponds (dolines)	UCP
Rhynchospora punctata	Spotted beakrush	G1?	S1?			Wet savannas, pitcherplant bogs	UCP, LCP

High Priority Plant Species Found in Coastal Georgia (Source: WRD, 2005)							
Scientific Name	Common Name	Global Rank	State Rank	Federal Status	State Status	Habitat in Georgia	Range in Georgia
Ruellia noctiflora	Night-blooming wild petunia	G2	SH			Open, slash pine flatwoods	LCP, outer Coastal Plain on the Barrier Island Sequence
Sageretia minutiflora	Climbing buckthorn	G4	S1?		T	Calcareous bluff forests; maritime forests over shell mounds	UCP, LCP
Sagittaria graminea var. chapmanii	Chapman's arrowhead	G5T3?	S3?			Low woods and seasonal wet swamps with Carex leptalea, Rhynchospora miliacea	UCP, LCP, perhaps widespread, including a pond on Sapelo Island
Sapindus saponaria	Soapberry	G5	S1			Shell mound forests	LCP
Sarracenia flava	Yellow flytrap	G5?	S3S4		U	Wet savannas, pitcherplant bogs	UCP, LCP
Sarracenia minor var. minor	Hooded pitcherplant	G4T4	S4			Wet savannas, pitcherplant bogs	UCP LCP
Sarracenia minor var. okefenokeense	Okefenokee giant	G4T2T3	S2S3			Wet savannas, pitcherplant bogs	LCP, Okefenokee Basin only
Sarracenia psittacina	Parrot pitcherplant	G4	S2S3		T	Wet savannas, pitcherplant bogs	UCP, LCP
Sarracenia rubra	Sweet pitcherplant	G3	S2	(PS)	E	Atlantic white cedar swamps; wet savannas	UCP, in two areas, Atlantic Coastal Plain and Fall Line Sandhills west of Macon
Schoenolirion elliottii	White sunnybell	G3	S1?			Wet savannas	LCP, few observations from Wayne and Brantley Cos.
Scutellaria altamaha	Altamaha skullcap	G2G3	S1?			Sandy, deciduous woods	UCP, LCP. (only?), perhaps adjacent Piedmont, of Southeast Georgia
Scutellaria arenicola	Sandhill skullcap	G3G4	SH			Sandy scrub	LCP, Trail Ridge; Camden Co.
Scutellaria mellichampii	Mellichamp's skullcap	G?Q	S1?			Sandy deciduous woods	LCP, UCP; widely scattered
Sideroxylon sp. 1	Dwarf buckthorn	G3Q	S3			Dry longleaf pine woods with oak understory; often hidden in wiregrass	UCP, LCP
Sideroxylon thornei	Swamp buckthorn	G2	S2		E	Forested limesink depressions; calcareous swamps	UCP, LCP
Sphagnum cyclophyllum	Round-leaved peat-moss	G3	S2			CP: bare sand where wet or submerged for part of the year and then drying, as around seasonal ponds in pine barrens.. PD: seepage over granite outcrops	PD, LCP, UCP
Spiranthes floridana	Florida ladies-tresses	G1	S1?				
Sporobolus pinetorum	Pineland dropseed	G3	S2?			Wet savannas with wiregrass	LCP

High Priority Plant Species Found in Coastal Georgia (Source: WRD, 2005)							
Scientific Name	Common Name	Global Rank	State Rank	Federal Status	State Status	Habitat in Georgia	Range in Georgia
Stewartia malacodendron	Silky camellia	G4	S2		R	Along streams on lower slopes of beech-magnolia or beech-basswood-Florida maple forests	PD, UCP
Tillandsia bartramii	Bartram's airplant	G4	S2				
Vaccinium crassifolium	Evergreen lowbush blueberry	G4G5	SH			Open margins of Carolina bays	LCP, historically in or near Screven Co.
Xyris drummondii	Drummond's yellow-eyed grass	G3	S1			Pine flatwoods	UCP, LCP
Xyris scabrifolia	Harper's yellow-eyed grass	G3	S1			Sedge bogs; pitcherplant bogs; pine flatwoods	UCP, LCP

References

Georgia Department of Natural Resources Wildlife Resources Division (WRD). 2005. *A Comprehensive Wildlife Conservation Strategy for Georgia*. Georgia Department of Natural Resources. Wildlife Resources Division. Social Circle, GA. Available Online: http://www1.gadnr.org/cwcs/Documents/strategy.html.

APPENDIX E

How Stormwater Management Practices Can Be Used to Satisfy the Stormwater Management Criteria

(Source: Georgia Stormwater Management Manuals, Coastal Stormwater Supplement, August 2009)

How Stormwater Management Practices Can Be Used to Help Satisfy the Stormwater Management Criteria (Source: Georgia Stormwater Management Manual, Coastal Stormwater Supplement (CSS), 2009.)					
Low Impact Development Practices					
Alternatives to Disturbed Pervious Surfaces					
Soil Restoration	**"Credit":** Subtract 50% of any *restored pervious areas* from the total site area and re-calculate the runoff reduction volume (RR_v) that applies to a development site.	**"Credit":** Subtract 50% of any *restored pervious areas* from the total site area and re-calculate the runoff reduction volume (RR_v) that applies to a development site.	**"Credit":** Assume that the post-development hydrologic conditions of any *restored pervious areas* are equivalent to those of open space in good condition.	**"Credit":** Assume that the post-development hydrologic conditions of any *restored pervious areas* are equivalent to those of open space in good condition.	**"Credit":** Assume that the post-development hydrologic conditions of any *restored pervious areas* are equivalent to those of open space in good condition.

How Stormwater Management Practices Can Be Used to Help Satisfy the Stormwater Management Criteria (Source: Georgia Stormwater Management Manual, Coastal Stormwater Supplement (CSS), 2009.)					
Site Reforestation/ Revegetation	**"Credit":** Subtract 50% of any *reforested or revegetated areas* from the total site area and re-calculate the runoff reduction volume (RR_v) that applies to a development site.	**"Credit":** Subtract 50% of any *reforested or revegetated areas* from the total site area and re-calculate the runoff reduction volume (RR_v) that applies to a development site.	**"Credit":** Assume that the post-development hydrologic conditions of any *reforested/revegetated* are equivalent to those of a similar cover type in fair condition.	**"Credit":** Assume that the post-development hydrologic conditions of any *reforested/revegetated areas* are equivalent to those of a similar cover type in fair condition.	**"Credit":** Assume that the post-development hydrologic conditions of any *reforested/revegetated areas* are equivalent to those of a similar cover type in fair condition.

How Stormwater Management Practices Can Be Used to Help Satisfy the Stormwater Management Criteria (Source: Georgia Stormwater Management Manual, Coastal Stormwater Supplement (CSS), 2009.)					
Soil Restoration with Site Reforestation/ Revegetation	**“Credit”:** Subtract 100% of any *restored and reforested/ revegetated areas* from the total site area and re-calculate the runoff reduction volume (RR_v) that applies to a development site.	**“Credit”:** Subtract 100% of any *restored and reforested/ revegetated areas* from the total site area and re-calculate the runoff reduction volume (RR_v) that applies to a development site.	**“Credit”:** Assume that the post-development hydrologic conditions of any *restored and reforested/ revegetated areas* are equivalent to those of a similar cover type in good condition.	**“Credit”:** Assume that the post-development hydrologic conditions of any *restored and reforested/ revegetated areas* are equivalent to those of a similar cover type in good condition.	**“Credit”:** Assume that the post-development hydrologic conditions of any *restored and reforested/ revegetated areas* are equivalent to those of a similar cover type in good condition.

How Stormwater Management Practices Can Be Used to Help Satisfy the Stormwater Management Criteria (Source: Georgia Stormwater Management Manual, Coastal Stormwater Supplement (CSS), 2009.)					
Alternatives to Impervious Surfaces					
Green Roofs	**“Credit”:** Reduce the runoff reduction volume (RR_v) conveyed through a *green roof* by 60%.	**“Credit”:** Reduce the runoff reduction volume (RR_v) conveyed through a *green roof* by 60%.	**“Credit”:** Proportionally adjust the post-development runoff curve number (CN) to account for the runoff reduction provided by a *green roof* when calculating the aquatic resource protection volume (ARP_v) on a development site.	**“Credit”:** Proportionally adjust the post-development runoff curve number (CN) to account for the runoff reduction provided by a *green roof* when calculating the overbank peak discharge (Q_{p25}) on a development site.	**“Credit”:** Proportionally adjust the post-development runoff curve number (CN) to account for the runoff reduction provided by a *green roof* when calculating the extreme peak discharge (Q_{p100}) on a development site.

How Stormwater Management Practices Can Be Used to Help Satisfy the Stormwater Management Criteria (Source: Georgia Stormwater Management Manual, Coastal Stormwater Supplement (CSS), 2009.)					
Permeable Pavement, **No Underdrain**	**"Credit":** Subtract 100% of the storage volume provided by a non-underdrained *permeable pavement system* from the runoff reduction volume (RR_v) conveyed through the *system.*	**"Credit":** Subtract 100% of the storage volume provided by a non-underdrained *permeable pavement system* from the runoff reduction volume (RR_v) conveyed through the *system.*	**"Credit":** Proportionally adjust the post-development runoff curve number (CN) to account for the runoff reduction provided by a *permeable pavement system* when calculating the aquatic resource protection volume (ARP_v) on a development site.	**"Credit":** Proportionally adjust the post-development runoff curve number (CN) to account for the runoff reduction provided by a *permeable pavement system* when calculating the overbank peak discharge (Q_{p25}) on a development site.	**"Credit":** Proportionally adjust the post-development runoff curve number (CN) to account for the runoff reduction provided by a *permeable pavement system* when calculating the extreme peak discharge (Q_{p100}) on a development site.

How Stormwater Management Practices Can Be Used to Help Satisfy the Stormwater Management Criteria (Source: Georgia Stormwater Management Manual, Coastal Stormwater Supplement (CSS), 2009.)				
Permeable Pavement, Underdrain	**"Credit":** Subtract 50% of the storage volume provided by an underdrained *permeable pavement system* from the runoff reduction volume (RR_v) conveyed through the *system.*	**"Credit":** Subtract 50% of the storage volume provided by an underdrained *permeable pavement system* from the runoff reduction volume (RR_v) conveyed through the *system.*		

How Stormwater Management Practices Can Be Used to Help Satisfy the Stormwater Management Criteria (Source: Georgia Stormwater Management Manual, Coastal Stormwater Supplement (CSS), 2009.)					
“Receiving” Low Impact Development Practices					
Undisturbed Pervious Areas, **A/B Soils**	**“Credit”:** Reduce the runoff reduction volume (RR_v) conveyed through an *undisturbed pervious area* located on A/B soils by 90%.	**“Credit”:** Reduce the runoff reduction volume (RR_v) conveyed through an *undisturbed pervious area* located on A/B soils by 90%.	**“Credit”:** Proportionally adjust the post-development runoff curve number (CN) to account for the runoff reduction provided by an *undisturbed pervious area* when calculating the aquatic resource protection volume	**“Credit”:** Proportionally adjust the post-development runoff curve number (CN) to account for the runoff reduction provided by an *undisturbed pervious area* when calculating the overbank peak	**“Credit”:** Proportionally adjust the post-development runoff curve number (CN) to account for the runoff reduction provided by an *undisturbed pervious area* when calculating the extreme peak

How Stormwater Management Practices Can Be Used to Help Satisfy the Stormwater Management Criteria (Source: Georgia Stormwater Management Manual, Coastal Stormwater Supplement (CSS), 2009.)					
Undisturbed Pervious Areas, C/D Soils	**"Credit":** Reduce the runoff reduction volume (RR_v) conveyed through an *undisturbed pervious area* located on C/D soils by 60%.	**"Credit":** Reduce the runoff reduction volume (RR_v) conveyed through an *undisturbed pervious area* located on C/D soils by 60%.	(ARP_v) on a development site.	discharge (Q_{p25}) on a development site.	discharge (Q_{p100}) on a development site.

How Stormwater Management Practices Can Be Used to Help Satisfy the Stormwater Management Criteria (Source: Georgia Stormwater Management Manual, Coastal Stormwater Supplement (CSS), 2009.)					
Vegetated Filter Strips, A/B or Amended Soils	**"Credit":** Reduce the runoff reduction volume (RR_v) conveyed through a *vegetated filter strip* located on A/B or amended soils by 60%.	**"Credit":** Reduce the runoff reduction volume (RR_v) conveyed through a *vegetated filter strip* located on A/B or amended soils by 60%.	**"Credit":** Proportionally adjust the post-development runoff curve number (CN) to account for the runoff reduction provided by a *vegetated filter strip* when calculating the aquatic resource protection volume (ARP_v) on a development site.	**"Credit":** Proportionally adjust the post-development runoff curve number (CN) to account for the runoff reduction provided by a *vegetated filter strip* when calculating the overbank peak discharge (Q_{p25}) on a development site.	**"Credit":** Proportionally adjust the post-development runoff curve number (CN) to account for the runoff reduction provided by a *vegetated filter strip* when calculating the extreme peak discharge (Q_{p100}) on a development site.

How Stormwater Management Practices Can Be Used to Help Satisfy the Stormwater Management Criteria (Source: Georgia Stormwater Management Manual, Coastal Stormwater Supplement (CSS), 2009.)				
Vegetated Filter Strips, C/D Soils	**"Credit":** Reduce the runoff reduction volume (RR_v) conveyed through a *vegetated filter strip* located on C/D soils by 30%.	**"Credit":** Reduce the runoff reduction volume (RR_v) conveyed through a *vegetated filter strip* located on C/D soils by 30%.		

How Stormwater Management Practices Can Be Used to Help Satisfy the Stormwater Management Criteria (Source: Georgia Stormwater Management Manual, Coastal Stormwater Supplement (CSS), 2009.)					
Grass Channels, A/B or Amended Soils	**"Credit":** Reduce the runoff reduction volume (RR_v) conveyed through a *grass channel* located on A/B or amended soils by 25%.	**"Credit":** Reduce the runoff reduction volume (RR_v) conveyed through a *grass channel* located on A/B or amended soils by 25%.	**"Credit":** Proportionally adjust the post-development runoff curve number (CN) to account for the runoff reduction provided by a *vegetated filter strip* when calculating the aquatic resource protection	**"Credit":** Proportionally adjust the post-development runoff curve number (CN) to account for the runoff reduction provided by a *vegetated filter strip* when calculating the overbank peak discharge (Q_{p25}) on a development site.	**"Credit":** Proportionally adjust the post-development runoff curve number (CN) to account for the runoff reduction provided by a *vegetated filter strip* when calculating the extreme peak discharge (Q_{p100}) on a development site.

How Stormwater Management Practices Can Be Used to Help Satisfy the Stormwater Management Criteria (Source: Georgia Stormwater Management Manual, Coastal Stormwater Supplement (CSS), 2009.)				
Grass Channels, C/D Soils	**"Credit":** Reduce the runoff reduction volume (RR_v) conveyed through a *grass channel* located on C/D soils by 12.5%.	**"Credit":** Reduce the runoff reduction volume (RR_v) conveyed through a *grass channel* located on C/D soils by 12.5%.	volume (ARP_v) on a development site.	

How Stormwater Management Practices Can Be Used to Help Satisfy the Stormwater Management Criteria (Source: Georgia Stormwater Management Manual, Coastal Stormwater Supplement (CSS), 2009.)					
Simple Downspout Disconnection, **A/B or Amended Soils**	**"Credit":** Reduce the runoff reduction volume (RR_v) conveyed through a *simple downspout disconnection* located on A/B or amended soils by 60%.	**"Credit":** Reduce the runoff reduction volume (RR_v) conveyed through a *simple downspout disconnection* located on A/B or amended soils by 60%.	**"Credit":** Proportionally adjust the post-development runoff curve number (CN) to account for the runoff reduction provided by a *simple downspout disconnection* when calculating the aquatic resource protection volume (ARP_v) on a development site.	**"Credit":** Proportionally adjust the post-development runoff curve number (CN) to account for the runoff reduction provided by a *simple downspout disconnection* when calculating the overbank peak discharge (Q_{p25}) on a development site.	**"Credit":** Proportionally adjust the post-development runoff curve number (CN) to account for the runoff reduction provided by a *simple downspout disconnection* when calculating the extreme peak discharge (Q_{p100}) on a development site.

How Stormwater Management Practices Can Be Used to Help Satisfy the Stormwater Management Criteria (Source: Georgia Stormwater Management Manual, Coastal Stormwater Supplement (CSS), 2009.)				
Simple Downspout Disconnection, C/D Soils	**"Credit":** Reduce the runoff reduction volume (RR_v) conveyed through a *simple downspout disconnection* located on C/D soils by 30%.	**"Credit":** Reduce the runoff reduction volume (RR_v) conveyed through a *simple downspout disconnection* located on C/D soils by 30%.		

How Stormwater Management Practices Can Be Used to Help Satisfy the Stormwater Management Criteria (Source: Georgia Stormwater Management Manual, Coastal Stormwater Supplement (CSS), 2009.)					
Rain Gardens	**"Credit":** Subtract 100% of the storage volume provided by a *rain garden* from the runoff reduction volume (RR_v) conveyed through the *rain garden*.	**"Credit":** Subtract 100% of the storage volume provided by a *rain garden* from the runoff reduction volume (RR_v) conveyed through the *rain garden*.	**"Credit":** Proportionally adjust the post-development runoff curve number (CN) to account for the runoff reduction provided by a *rain garden* when calculating the aquatic resource protection volume (ARP_v) on a development site.	**"Credit":** Proportionally adjust the post-development runoff curve number (CN) to account for the runoff reduction provided by a *rain garden* when calculating the overbank peak discharge (Q_{p25}) on a development site.	**"Credit":** Proportionally adjust the post-development runoff curve number (CN) to account for the runoff reduction provided by a *rain garden* when calculating the extreme peak discharge (Q_{p100}) on a developme**nt site.**

How Stormwater Management Practices Can Be Used to Help Satisfy the Stormwater Management Criteria (Source: Georgia Stormwater Management Manual, Coastal Stormwater Supplement (CSS), 2009.)					
Stormwater Planters	**"Credit":** Subtract 50% of the storage volume provided by a *stormwater planter* from the runoff reduction volume (RR_v) conveyed through the *stormwater planter*.	**"Credit":** Subtract 50% of the storage volume provided by a *stormwater planter* from the runoff reduction volume (RR_v) conveyed through the *stormwater planter*.	**"Credit":** Proportionally adjust the post-development runoff curve number (CN) to account for the runoff reduction provided by a *stormwater planter* when calculating the aquatic resource protection volume (ARP_v) on a development site.	**"Credit":** Proportionally adjust the post-development runoff curve number (CN) to account for the runoff reduction provided by a *stormwater planter* when calculating the overbank peak discharge (Q_{p25}) on a development site.	**"Credit":** Proportionally adjust the post-development runoff curve number (CN) to account for the runoff reduction provided by a *stormwater planter* when calculating the extreme peak discharge (Q_{p100}) on a development site.

How Stormwater Management Practices Can Be Used to Help Satisfy the Stormwater Management Criteria (Source: Georgia Stormwater Management Manual, Coastal Stormwater Supplement (CSS), 2009.)					
Dry Wells	**"Credit":** Subtract 100% of the storage volume provided by a *dry well* from the runoff reduction volume (RR_v) conveyed through the *dry well*.	**"Credit":** Subtract 100% of the storage volume provided by a *dry well* from the runoff reduction volume (RR_v) conveyed through the *dry well*.	**"Credit":** Proportionally adjust the post-development runoff curve number (CN) to account for the runoff reduction provided by a *dry well* when calculating the aquatic resource protection volume (ARP_v) on a development site.	**"Credit":** Proportionally adjust the post-development runoff curve number (CN) to account for the runoff reduction provided by a *dry well* when calculating the overbank peak discharge (Q_{p25}) on a development site.	**"Credit":** Proportionally adjust the post-development runoff curve number (CN) to account for the runoff reduction provided by a *dry well* when calculating the extreme peak discharge (Q_{p100}) on a development site.

How Stormwater Management Practices Can Be Used to Help Satisfy the Stormwater Management Criteria (Source: Georgia Stormwater Management Manual, Coastal Stormwater Supplement (CSS), 2009.)					
Rainwater Harvesting	**"Credit":** Subtract 75% of the storage volume provided by a *rainwater harvesting system* from the runoff reduction volume (RR_v) captured by the *system*.	**"Credit":** Subtract 75% of the storage volume provided by a *rainwater harvesting system* from the runoff reduction volume (RR_v) captured by the *system*.	**"Credit":** Proportionally adjust the post-development runoff curve number (CN) to account for the runoff reduction provided by a *rainwater harvesting system* when calculating the aquatic resource protection volume (ARP_v) on a development site.	**"Credit":** Proportionally adjust the post-development runoff curve number (CN) to account for the runoff reduction provided by a *rainwater harvesting system* when calculating the overbank peak discharge (Q_{p25}) on a development site.	**"Credit":** Proportionally adjust the post-development runoff curve number (CN) to account for the runoff reduction provided by a *rainwater harvesting system* when calculating the extreme peak discharge (Q_{p100}) on a development site.

How Stormwater Management Practices Can Be Used to Help Satisfy the Stormwater Management Criteria (Source: Georgia Stormwater Management Manual, Coastal Stormwater Supplement (CSS), 2009.)					
Bioretention Areas, **No Underdrain**	**"Credit":** Subtract 100% of the storage volume provided by a non-underdrained *bioretention area* from the runoff reduction volume (RR_v) conveyed through the *bioretention area*.	**"Credit":** Subtract 100% of the storage volume provided by a non-underdrained *bioretention area* from the runoff reduction volume (RR_v) conveyed through the *bioretention area*.	**"Credit":** Proportionally adjust the post-development runoff curve number (CN) to account for the runoff reduction provided by a *bioretention area* when calculating the aquatic resource protection volume (ARP_v) on a development site.	**"Credit":** Proportionally adjust the post-development runoff curve number (CN) to account for the runoff reduction provided by a *bioretention area* when calculating the overbank peak discharge (Q_{p25}) on a development site.	**"Credit":** Proportionally adjust the post-development runoff curve number (CN) to account for the runoff reduction provided by a *bioretention area* when calculating the extreme peak discharge (Q_{p100}) on a development site.

How Stormwater Management Practices Can Be Used to Help Satisfy the Stormwater Management Criteria (Source: Georgia Stormwater Management Manual, Coastal Stormwater Supplement (CSS), 2009.)				
Bioretention Areas, **Underdrain**	**"Credit":** Subtract 50% of the storage volume provided by an underdrained *bioretention area* from the runoff reduction volume (RR_v) conveyed through the *bioretention area*.	**"Credit":** Subtract 50% of the storage volume provided by an underdrained *bioretention area* from the runoff reduction volume (RR_v) conveyed through the *bioretention area*.		

How Stormwater Management Practices Can Be Used to Help Satisfy the Stormwater Management Criteria (Source: Georgia Stormwater Management Manual, Coastal Stormwater Supplement (CSS), 2009.)					
Infiltration Practices	**"Credit":** Subtract 100% of the storage volume provided by an *infiltration practice* from the runoff reduction volume (RR_v) conveyed through the *infiltration practice*.	**"Credit":** Subtract 100% of the storage volume provided by an *infiltration practice* from the runoff reduction volume (RR_v) conveyed through the *infiltration practice*.	**"Credit":** Proportionally adjust the post-development runoff curve number (CN) to account for the runoff reduction provided by an *infiltration practice* when calculating the aquatic resource protection volume (ARP_v) on a development site.	**"Credit":** Proportionally adjust the post-development runoff curve number (CN) to account for the runoff reduction provided by an *infiltration practice* when calculating the overbank peak discharge (Q_{p25}) on a development site.	**"Credit":** Proportionally adjust the post-development runoff curve number (CN) to account for the runoff reduction provided by an *infiltration practice* when calculating the extreme peak discharge (Q_{p100}) on a development site.

How Stormwater Management Practices Can Be Used to Help Satisfy the Stormwater Management Criteria (Source: Georgia Stormwater Management Manual, Coastal Stormwater Supplement (CSS), 2009.)					
Dry Swales, No Underdrain	**"Credit":** Subtract 100% of the storage volume provided by a non-underdrained *dry swale* from the runoff reduction volume (RR_v) conveyed through the *dry swale*.	**"Credit":** Subtract 100% of the storage volume provided by a non-underdrained *dry swale* from the runoff reduction volume (RR_v) conveyed through the *dry swale*.	**"Credit":** Proportionally adjust the post-development runoff curve number (CN) to account for the runoff reduction provided by a *dry swale* when calculating the aquatic resource protection volume (ARP_v) on a development site.	**"Credit":** Proportionally adjust the post-development runoff curve number (CN) to account for the runoff reduction provided by a *dry swale* when calculating the overbank peak discharge (Q_{p25}) on a development site.	**"Credit":** Proportionally adjust the post-development runoff curve number (CN) to account for the runoff reduction provided by a *dry swale* when calculating the extreme peak discharge (Q_{p100}) on a development site.

How Stormwater Management Practices Can Be Used to Help Satisfy the Stormwater Management Criteria (Source: Georgia Stormwater Management Manual, Coastal Stormwater Supplement (CSS), 2009.)				
Dry Swales, Underdrain	**"Credit":** Subtract 50% of the storage volume provided by an underdrained *dry swale* from the runoff reduction volume (RR_v) conveyed through the *dry swale*.	**"Credit":** Subtract 50% of the storage volume provided by an underdrained *dry swale* from the runoff reduction volume (RR_v) conveyed through the *dry swale*.		

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