Chapter 3:
Conservation Principles and Neighborhood Site Design for Low Impact Development

3.1 Introduction to Conservation Principles and Neighborhood Site Design

Many coastal communities are facing the challenge of balancing land development and economic growth with the protection of their unique and valuable local natural resources. The population growth level estimated by Allen and Lu (2003) for the Charleston, Berkeley, and Dorchester area is expected to reach 49% from 1994 to 2030 (263,000 people). Driven by such population growth, the land development process significantly alters the landscape by converting open areas, such as forests and agriculture, into urban or commercial land uses. During this process, clearing and grading are used to remove vegetation and topsoil, while cutting and filling are used to alter natural drainage features and depressional areas to create clear and level building sites. These land disturbing activities have direct negative impacts on both terrestrial and aquatic resources, often leading to a nearly complete loss of natural function. A lack of balance between land development and natural resource protection can result in a wide range of unintended negative impacts such as degradation and/or loss of the freshwater, estuarine, and marine resources found within the coastal plain.

Site assessment and design for LID seeks to minimize impervious cover, conserve more natural areas, and use pervious areas more effectively to treat stormwater runoff. This approach affords greater protection to water resources by reducing both stormwater runoff volume and pollutant loads into downstream waters.

Clearly, a change in development patterns at both the watershed and site scales is needed to balance continued land development with natural resource protection. Fortunately, development projects can be planned and designed to reduce their impact on coastal resources, both aquatic and terrestrial, particularly when an effort is made to protect and conserve natural areas, reduce impervious cover, and integrate stormwater management with site design. These principles, which are collectively known as Better Site Design (BSD), can provide impressive reductions in post-construction stormwater runoff rates, volumes, and pollutant loads. Also, they can reduce devel-
Development costs and increase property values (MacMullan and Reich, 2007; Winer-Skonovd et al., 2006; US EPA, 2007). BSD techniques are applied most readily on new residential and commercial development projects. In addition, many of the techniques are applicable to redevelopment or infill scenarios. Table 3.1-1 provides an overview of the 22 BSD development principles with additional stormwater and other resource issues included. While some of these principles can be applied easily by a developer, others may require changes in local regulations. More detailed information for site assessment and design can be found in documents from the Center for Watershed Protection (CWP, 1998; CWP, 2009; CWP, 2010).

<table>
<thead>
<tr>
<th>Principle</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Street Width</td>
<td>Design residential streets for the minimum required pavement width needed to support travel lanes; on-street parking; and emergency, maintenance, and service vehicle access. These widths should be based on traffic volume.</td>
</tr>
<tr>
<td>Street Length</td>
<td>Reduce total length of residential streets by examining alternative street layouts to determine the best option for increasing the number of homes per unit length.</td>
</tr>
<tr>
<td>Right-of-Way (ROW) Width</td>
<td>Wherever possible, residential street right-of-way widths should reflect the minimum required to accommodate the travel-way, sidewalk, and vegetated open channels. Utilities and storm drains should be located within the pavement section of the ROW wherever feasible.</td>
</tr>
<tr>
<td>Cul-de-sacs</td>
<td>Minimize the number of residential street cul-de-sacs and incorporate landscaped areas to reduce their impervious cover. The radius of cul-de-sacs should be the minimum required to accommodate emergency and maintenance vehicles. Consider alternative turnarounds.</td>
</tr>
<tr>
<td>Vegetated Open Channels</td>
<td>Where density, topography, soils, and slope permit, vegetated open channels should be used in the street right-of-way to convey and treat stormwater runoff.</td>
</tr>
<tr>
<td>Parking Ratios</td>
<td>The required parking ratio governing a particular land use or activity should be enforced as both a maximum and a minimum in order to curb excess parking space construction. Existing parking ratios should be reviewed for conformance taking into account local and national experience to see if lower ratios are warranted and feasible.</td>
</tr>
<tr>
<td>Parking Codes</td>
<td>Parking codes should be revised to lower parking requirements where mass transit is available or where enforceable shared parking arrangements are made.</td>
</tr>
<tr>
<td>Parking Lots</td>
<td>Reduce the overall imperviousness associated with parking lots by providing compact car spaces, minimizing stall dimensions, incorporating efficient parking lanes, and using pervious materials in spill over parking areas.</td>
</tr>
<tr>
<td>Structured Parking</td>
<td>Provide meaningful incentives to encourage structured (e.g. parking garage) and shared parking to make it more economically viable.</td>
</tr>
<tr>
<td>Parking Lot Runoff</td>
<td>Wherever possible, provide stormwater treatment for parking lot runoff using bioretention areas, filter strips, and/or other practices that can be integrated into required landscaping areas and traffic islands.</td>
</tr>
<tr>
<td>Open Space Design</td>
<td>Advocate open space development that incorporates smaller lot sizes to minimize total impervious areas, reduce total construction costs, conserve natural areas, provide community recreational space, and promote watershed protection.</td>
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</table>
### Table 3.1-1. Twenty-two Better Site Design Model Development Principles (CWP, 1998) and updated Stormwater and Other Resource Issues (CWP, 2013).

<table>
<thead>
<tr>
<th>Principle</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Setbacks and Frontages</td>
<td>Reduce side yard setbacks and allow narrower frontages to reduce total road length in the community and overall site imperviousness. Relax front setback requirements to minimize driveway lengths and reduce overall lot imperviousness.</td>
</tr>
<tr>
<td>Sidewalks</td>
<td>Promote more flexible design standards for residential subdivision sidewalks. Where practical, consider locating sidewalks on only one side of the street and providing common walkways linking pedestrian areas.</td>
</tr>
<tr>
<td>Driveways</td>
<td>Reduce overall lot imperviousness by promoting alternative driveway surfaces and shared driveways that connect two or more homes.</td>
</tr>
<tr>
<td>Open Space Management</td>
<td>Clearly specify how community open space will be managed and designate a sustainable legal entity responsible for managing both natural and recreational open space.</td>
</tr>
<tr>
<td>Rooftop Runoff</td>
<td>Direct rooftop runoff to pervious areas, such as yards, open channels, or vegetated areas. Avoid routing rooftop runoff to the roadway and the stormwater conveyance system.</td>
</tr>
<tr>
<td>Buffer System</td>
<td>Create a variable width, naturally vegetated buffer system along all perennial streams. These buffers should also encompass critical environmental features such as the 100-year floodplain, steep slopes and freshwater wetlands.</td>
</tr>
<tr>
<td>Buffer Maintenance</td>
<td>The buffer system should be preserved or restored with native vegetation that can be maintained throughout the planning, delineation, construction, and occupancy stages of development.</td>
</tr>
<tr>
<td>Clearing and Grading</td>
<td>Clearing and grading of forests and native vegetation at a site should be limited to the minimum amount needed to build lots, allow access, and provide fire protection. A fixed portion of any community open space should be managed as protected green space in a consolidated manner by grouping areas of open space together.</td>
</tr>
<tr>
<td>Tree Conservation</td>
<td>Conserve trees and other vegetation at each site by planting additional vegetation, clustering tree areas, and promoting the use of native plants. Wherever practical, manage community open space, street rights-of-way, parking lot islands, and other landscaped areas to promote natural vegetation.</td>
</tr>
<tr>
<td>Land Conservation Incentives</td>
<td>Incentives and flexibility in the form of density compensation, buffer averaging, property tax reduction, stormwater credits, and by-right open space development should be encouraged to promote the conservation of stream buffers, forests, meadows, and other areas of environmental value. In addition, off-site mitigation consistent with locally adopted watershed plans should be encouraged.</td>
</tr>
<tr>
<td>Stormwater Outfalls</td>
<td>New stormwater outfalls should not discharge unmanaged stormwater into jurisdictional wetlands, aquifers, or sensitive areas.</td>
</tr>
</tbody>
</table>
3.2 Conservation of Natural Areas

Some of the key conservation principles for coastal South Carolina include protecting critical resources (such as open space, tree canopies, native vegetation, soils, and buffers) and reducing impervious cover. These conservation principles, as noted in Table 3.1-1, are part of an overall watershed approach to stormwater management. The conservation principles are detailed here and include available science, policy recommendations, and examples.

Coastal counties across the country contain 53% of the nation’s population, yet account for only 17% of U.S. land area, excluding Alaska (Crossett et al., 2004). Furthermore, the coastal counties of the southeastern United States have seen unprecedented growth over the last 30 years, with populations increasing by 64% between 1970 and 1990 (US EPA, 2002). More specifically, between 1973 and 1994, the population of Charleston, SC grew 40% with a disproportionate increase in urban land area of 250% (Allen and Lu, 2003). Most researchers predict that during the next 20 to 30 years, the Southeast will continue to experience high population growth (DeVoe and Kleppel, 1995; NOAA, 1999; Crossett et al., 2004) and most of this growth will occur along the coast due to the influx of retirees and job seekers (US Census Bureau, 1998; Crossett et al., 2004). Alig et al. (2004) noted that the Southeast has more built land per capita than any other coastal plain region. In South Carolina, this development equated to an economic output of about $40 billion in 2000 and 25% of the state’s employment growth (Holland and Sanger, 2008). Coastal land is valuable, and establishing future land development patterns to protect the natural resource will secure the economic value for future generations.

The rapid pace of land conversion to accommodate the coastal population boom has resulted in significant losses of forests, wetlands, and other ecologically valuable lands. For example, the Atlantic and Gulf of Mexico coastal watersheds experienced a net loss of more than 385,000 acres of wetlands between 1998 and 2004 even though the country as a whole showed a net gain in wetland acres during this time (Steadman and Dahl, 2008). Loss of wetlands and forests, combined with the addition of impervious cover associated with urbanization, has been shown to result in a rapid decline in the condition of coastal plain streams, tidal creeks, and estuaries.

Despite the abundance and economic importance of natural features found in the coastal plain, a relatively small proportion is designated for protection by coastal communities. According to a Watershed Planning Needs Survey of Coastal Plain Communities (Law et al., 2008) conducted by the Center for Watershed Protection, 54% of communities reported that less than 10% of the land area in their community was designated for conservation.

Promoting conservation can provide several ecosystem services produced by the interaction of living and non-living elements. Examples of these benefits were discussed in Environmental Benefits of LID in Chapter 1 and are summarized by the Sustainable Sites Initiative:

- Global and local climate regulation
- Air and water cleansing
- Water supply and regulation
- Erosion and sediment control
- Hazard mitigation
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__Land Conservation Strategies__

Urban sprawl in the coastal plain has reduced the amount of ecologically valuable lands, such as forests and wetlands. Allen and Lu (2003) modeled Berkeley, Charleston, and Dorchester urban growth for the next 30 years and found a 5:1 growth ratio (urban growth to population growth) that resulted in 618 square miles of natural or rural land converted to an urban land use. The urban land area predicted by 2030 reduces the area of forest land by 30%, cultivated farmland by 50%, wetlands by 35%, and tidal creeks by 70%. The urban growth in the region around Charleston, SC is estimated to consume forest and agricultural land at a rate six times greater than that of human population growth.

Permanently protecting the most ecologically valuable lands in coastal watersheds is a vital part of improving coastal water quality to reach 303(d) benchmarks\(^1\) in the face of accelerated urbanization. Because local governments have control over land use decisions, they are often the best entity to help fill in the gaps in state or federal natural resources protection. For example, the need for local wetland protection is reflected in the Law et al. (2008) survey results of residents in the US coastal plain (including 12 responses from SC out of 73 total), which shows that 37% of respondents indicated that ditching of wetlands is a problem in their communities and 46% agreed that more should be done to protect their local wetlands.

Protection is difficult without properly documenting natural assets. An up-to-date natural resources inventory is invaluable to assist local governments with conservation of sensitive resources. Natural resources inventory maps can provide geospatial information for natural habitat areas present in a community, including water resources, soils, sensitive natural resource areas, critical habitats, and other unique coastal resources. Prioritization of specific sites is an important step to guide decisions about how to target conservation programs, funding, and local protection regulations. This is especially useful for communities with extensive natural resources who wish to accommodate future growth while protecting the most sensitive or valuable lands.

An effective prioritization system often begins by identifying the lands with the most environmental value (e.g., for drinking water protection, habitat conservation or flood control, or other goals). Next, the identified lands are then ranked by evaluating feasibility factors, potential threats, and using community input, if available. See Table 3.2-1 for some examples of ranking criteria.

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\(^1\) The term 303(d) list refers to the list of impaired and threatened waters that the Clean Water Act requires all states to submit for EPA approval every two years. The states identify all waters where required pollution controls are not sufficient to attain or maintain applicable water quality standards. The states then establish priorities for development of Total Maximum Daily Loads (TMDLs) based on the severity of the pollution and the sensitivity of the uses to be made of the waters, among other factors. For more information, please see [http://water.epa.gov/lawsregs/lawguidance/cwa/tmdl/overview.cfm](http://water.epa.gov/lawsregs/lawguidance/cwa/tmdl/overview.cfm)
Table 3.2-1. Example Criteria for Prioritizing Conservation Areas

<table>
<thead>
<tr>
<th>Type of Ranking Criteria</th>
<th>Example Measures</th>
</tr>
</thead>
</table>
| Environmental            | ♦ Adjacency to existing protected land  
♦ Location in watershed  
♦ Continuity, contiguity, and connectivity of vegetative cover  
♦ Ecological significance (e.g., forest structure or presence of habitat for rare, threatened, or endangered species) |
| Vulnerability            | ♦ Development pressure (based on location of parcels within urban growth area, zoning, distance from major road, or as indicated in a build-out analysis or other development threat data set/map)  
♦ Current protection status  
♦ Projected level of sea level rise |
| Feasibility              | ♦ Landowner willingness to sell or donate  
♦ Status of development plans for the parcel  
♦ Cost per acre  
♦ Anticipated management costs |
| Community                | ♦ Community acceptance of project  
♦ Recreational value |

Many tools are available to assist with natural resource prioritization. Some tools calculate ranking criteria (e.g., patch size of remaining forest, relative influence of a parcel on downstream water quality, connection to nearby resources), while others can take the user’s input data and automatically generate the prioritization.

Ranking land parcels for conservation based on environmental value requires an understanding of the specific functions of interest. For example, some communities may be concerned primarily with conserving lands that protect remaining forest land or critical habitats, while other communities may be more focused on acquiring lands that protect downstream water quality and protect shorelines from erosion. Once the functions of interest have been determined, then the necessary data to assign functions to specific natural resources can be collected. As an example, Tiner (2003) provides a method to assign functions to wetlands based on wetland type and landscape position. This information can be used to identify wetlands that are important for specific functions (Table 3.2-2). If desired, field assessment can be used to supplement and refine the preliminary functional assessment.

Documenting environmental values associated with natural resources may not be sufficient to convince elected officials or residents that a particular parcel or natural resource is worth conserving. However, placing an economic value on the services provided by specific natural resources may serve as a useful tool to justify their protection. Economic valuation of ecosystem services aims to make ecosystem goods and services directly comparable to other sectors of the economy, and can also be incorporated into a prioritization system. An overview of the process of ecosystem valuation and available methods is provided at [http://www.ecosystemvaluation.org/](http://www.ecosystemvaluation.org/).
<table>
<thead>
<tr>
<th>Wetland Functions Associated with Services*</th>
<th>Replacement Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flood protection</td>
<td></td>
</tr>
<tr>
<td>♦ Surface water detention</td>
<td>♦ Stormwater treatment practices (storage)</td>
</tr>
<tr>
<td>♦ Coastal storm surge detention</td>
<td>♦ Dikes and levees</td>
</tr>
<tr>
<td>♦ Advanced floodplain construction design</td>
<td></td>
</tr>
<tr>
<td>Recreation</td>
<td></td>
</tr>
<tr>
<td>♦ Provision of habitat for fish and other aquatic animals</td>
<td>♦ Wetland restoration</td>
</tr>
<tr>
<td>♦ Provision of waterfowl and waterbird habitat</td>
<td>♦ Species stocking</td>
</tr>
<tr>
<td>♦ Provision of other wildlife habitat</td>
<td></td>
</tr>
<tr>
<td>Maintain drinking water quality</td>
<td></td>
</tr>
<tr>
<td>♦ Nutrient transformation</td>
<td>♦ Water filtration plants</td>
</tr>
<tr>
<td>♦ Retention of sediments and other particulates</td>
<td>♦ Develop new water source</td>
</tr>
<tr>
<td>Shoreline property protection</td>
<td></td>
</tr>
<tr>
<td>♦ Shoreline stabilization</td>
<td>♦ Revetments</td>
</tr>
<tr>
<td>♦ Coastal storm surge detention</td>
<td>♦ Stream bank stabilization and repair practices</td>
</tr>
<tr>
<td>♦ Stormwater treatment practices for channel protection</td>
<td></td>
</tr>
<tr>
<td>Maintain baseflow in streams</td>
<td></td>
</tr>
<tr>
<td>♦ Streamflow maintenance</td>
<td>♦ Deeper wells</td>
</tr>
<tr>
<td>♦ Alternative water source</td>
<td></td>
</tr>
<tr>
<td>Wildlife habitat and biodiversity</td>
<td></td>
</tr>
<tr>
<td>♦ Provision of habitat for fish and other aquatic animals</td>
<td>♦ Wetland restoration</td>
</tr>
<tr>
<td>♦ Provision of waterfowl and waterbird habitat</td>
<td>♦ Species stocking</td>
</tr>
<tr>
<td>♦ Provision of other wildlife habitat</td>
<td></td>
</tr>
<tr>
<td>♦ Conservation of biodiversity</td>
<td></td>
</tr>
<tr>
<td>Commercial products from wetlands (e.g., peat, timber, cranberries, rice, fish, shellfish)</td>
<td>♦ Wetland restoration</td>
</tr>
<tr>
<td>♦ Provision of habitat for fish and other aquatic animals</td>
<td></td>
</tr>
<tr>
<td>♦ Provision of waterfowl and waterbird habitat</td>
<td></td>
</tr>
<tr>
<td>♦ Provision of other wildlife habitat</td>
<td></td>
</tr>
<tr>
<td>♦ Conservation of biodiversity</td>
<td></td>
</tr>
<tr>
<td>Reduce pollutants in streams and stormwater</td>
<td>♦ Stormwater facilities with water quality criteria</td>
</tr>
<tr>
<td>♦ Nutrient transformation</td>
<td></td>
</tr>
<tr>
<td>♦ Retention of sediments and other particulates</td>
<td></td>
</tr>
</tbody>
</table>

* functions derived from Tiner, 2003
Incorporating existing local economic data into efforts to educate the public about natural resource values is one alternative to an economic valuation study. For example, collecting data on tourist expenditures and tying these dollars to natural areas in the community (e.g., total amount spent on hunting or fishing) can help make the case for preserving the quality of these resources for future visitors and the local economy.

After identifying and prioritizing parcels with significant natural resources, the resulting map and prioritization of sites for conservation should be included in the local watershed plan, open space plan, and the comprehensive land use plan (if one exists). This allows the community to use this information when making decisions about where to locate future growth, and provides a sound basis for targeting lands for conservation as funds become available. Land conservation planning does not just end here though; communities can play an active role in advocating for raising conservation funds. In fact, many local governments do this successfully given that roughly two-thirds of land conservation funding nationwide comes from local sources, such as sales tax, property tax, and revenue bonds. The natural resources inventory and site ranking can also be used to develop natural resource protection regulations (e.g., an overlay zone for protection of shoreline wetlands and their buffers).

For more information about natural resource inventories and prioritization see the following resources:

- South Carolina Natural Resources Department – Start with the state natural resource department for the mapping resources and other resources available.
  - [http://www.dnr.sc.gov/](http://www.dnr.sc.gov/)
  - See also the SC Heritage Trust Program at [http://www.dnr.sc.gov/mlands/hpprogram.html](http://www.dnr.sc.gov/mlands/hpprogram.html)
- The Community Resources Inventory was designed specifically for coastal South Carolina
  - [www.cri-sc.org](http://www.cri-sc.org)
- NOAA Coastal County Snapshots
  - Search by county to find information related to flood exposure, wetland benefits, and economic value of jobs related to marine resources.
- NatureServe - The NatureServe network collects and analyzes data about the plants, animals, and ecological communities of the Western Hemisphere.
  - [http://www.natureserve.org/biodiversity-science/species-ecosystems](http://www.natureserve.org/biodiversity-science/species-ecosystems)
- National Wetland Inventory (NWI) Maps – show the wetland geographic extent.
- Wetlands-At-Risk Protection Tool (WARPT)
  - [http://www.wetlandprotection.org/](http://www.wetlandprotection.org/)
- US Geologic Survey’s National Gap Analysis Program - species ranges and distribution for conservation planning.
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“Natural Resource-Based Planning for Watersheds: A Practical Starter Kit,” a UConn Cooperative Extension manual by Chet Arnold and Jim Gibbons of UConn’s NEMO (Non-point Education for Municipal Officials) Team.

- http://nemo.uconn.edu/tools/publications.htm

Preserve and Maintain Open Space

Stormwater managers should begin to address stormwater at a regional scale by promoting the preservation of open space and critical ecological features in a site plan. Preserving open space is critical to maintaining water quality at the regional level. Large, continuous areas of open space reduce and slow runoff, absorb sediments, serve as flood control, and help maintain aquatic communities. Preserving ecologically important land, such as wetlands, buffer zones, riparian corridors, and floodplains, is critical for regional water quality.

Open space development, also known as cluster design, is a compact form of development that concentrates density on one portion of the site in exchange for reduced density elsewhere. Minimum lot sizes, setbacks, and frontage distances are relaxed to provide common open space (CWP, 1998). Not only does open space design allows for environmental benefits such as stream protection, but it also provides other benefits like preservation of rural character. Open space design results in less impervious cover and therefore less stormwater runoff. Compared to traditional development, open space development can reduce the annual runoff volume from a site by 40-60%, nitrogen loads by 42-81%, and phosphorus loads by 42-69% (CWP, 1998).

Better Site Design recommends that communities consider making open space development a “by-right” development option (e.g. the property owner has the right to develop or redevelop without reviews as along as the development is consistent with existing ordinances and/or plans for the area) in order to ensure certainty and speed of project approval, which are prime considerations for developers. Zoning is an important consideration for open space design as flexibility in design sharply declines as the density of the base zone increases. Additionally, open space developments can be significantly less expensive to build than conventional subdivision developments as a result of savings in road building and stormwater management (CWP, 1998).

Open Space Case Study: Spring Island, Beaufort County

One example of open space development in the Lowcountry can be found on Spring Island. On the 3,000 acre island, about one third of all land is left as undeveloped, preserved natural areas. The initial plan approved by Beaufort County in 1985 included 5,000 units; the developer chose to reduce that amount by over 90 percent to a total of 410 units, resulting in a gross density of over 7 acres per home site.
Protect Critical Resources: Existing Soils, Vegetation, and Wetlands

Coastal plain natural resources form the basis of the local economy in many communities because they are important for recreation and commercial activities, such as fishing and shellfish harvesting. In fact, the economic benefit provided by coastal and estuarine resources has been estimated at more than $800 billion dollars nationally (Pendleton, 2008). A 2009 study by the University of South Carolina’s Moore School of Business found that 235,000 jobs and $30 billion in economic benefits are tied the state’s natural resources. In addition, coastal resource-based tourism generates $3.5 billion annually and supports 81,000 jobs (USC 2009). While local officials in coastal communities may recognize these values, often they do not prioritize land conservation to protect water quality. The connection between uplands and water resources is less obvious and it is difficult to measure the value of the ‘free’ services provided by these lands. Voluntary land conservation is expensive; however, once these resources are lost, they are expensive to replace. For example, the cost to create wetlands for flood control is on the order of 100 times what it would cost to protect existing wetlands through simple land protection efforts (Costanza et al., 1997).

The Atlantic Coastal Plain hosts an abundance of natural resources, such as hardwood and pine forests; rivers, streams and their floodplains; and extensive wetland complexes. Important coastal resources found here include maritime forests, estuaries, dunes, beaches, groundwater aquifers, tidal creeks, tidal wetlands, and shellfish beds. These natural areas provide a variety of ecological benefits ranging from flood protection and water quality improvement to shoreline protection and wildlife habitat.

Inland Atlantic Maritime Forest is critically imperiled habitat along the coast and has suffered significant losses (Lord, 2013). Coastal plain wetland ecosystems include depressions, pocosins, Carolina Bays, cypress domes, marshes, and bottomland hardwood forests; certain habitats, such as Carolina Bays and longleaf pine savannas, are rare or unique to this area and support threatened or endangered species. For example, longleaf pine savannahs are home to the endangered red-cockaded woodpecker, gopher tortoise, indigo snake, and many threatened songbird populations. The South Carolina Lowcountry is one of the few places in the country to find three unique genera of carnivorous plants: Venus flytraps are found along edges of pocosins, pitcher plants inhabit the wetter depressions of longleaf pine habitats or Carolina bays, and sundews establish themselves on seepage slopes and bogs. These rare and unique plant and animal communities add distinct character and ecological services to the coastal area and should be protected. The SC Department of Natural Resources published a Best Management Practices for Wildlife in Maritime Forest Developments to provide guidance to minimize the impacts on wildlife and their habitats as development along the coast continues. See http://www.dnr.sc.gov/marine/pub/BMPSforCoastWeb.pdf for more information.

South Carolina’s tree cover in the coastal plain consists of oak-hickory-pine forest with deciduous and evergreen hardwoods. Most of the coastal plain was cleared for agriculture in the 1700s and the reforestation that occurred since that time represents the current forest cover. Trees provide several benefits that include habitat for birds and wildlife, recreation, temperature and noise reduction, air and water quality improvements, and coastal storm buffers (McPherson et al., 2006). Trees and forests offer several environmental benefits; however, land development procedures commonly remove all or most trees (see following Protect Tree Canopy section). Preserving open space and providing land conservation protect trees and forests.
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Land Use Planning Science to Policy Case Study:
Northern Beaufort County, South Carolina Regional Plan

Local scientific data and reports (e.g., water monitoring and population growth projections) and community feedback highlighted the need for a Regional Plan and provided the basis for the plan’s basic elements, such as Beaufort County’s Stormwater Best Management Practice (BMP) Manual, Beaufort Resource Protection elements, and Beaufort Special Area Management Plan. Facing a growth projection of approximately 53% by 2025, Beaufort County, the City of Beaufort, and the Town of Port Royal developed a regional comprehensive plan to combat uninhibited urban growth and develop common goals. A steering committee with representatives from each jurisdiction and a technical advisory committee developed the plan. Each jurisdiction agreed to use the regional planning framework in the plan as guidance for local-level planning decisions. The strategy includes a land use plan, transportation planning strategy, the fiscal impacts of growth, environmental standards, regional planning initiatives, and a framework for implementation. Additionally, the plan delineates a future growth boundary that includes preserving over 60% of land for rural use. Recommendations to protect natural resources included regional adoption of the Beaufort County Stormwater BMP Manual, which requires both water quality and quantity control, promotes vegetative buffers, and prohibits development adjacent to high quality water bodies. The Northern Beaufort County Regional Plan is the starting point for an ongoing collaborative regional planning process, dialogue, and action (McBride Dale Clarion 2007). In South Carolina, local research was the starting point for a Regional Plan that led to three improved zoning ordinances and updated comprehensive plans that contain common language for improved water protection, better land use planning, and the prevention of coastal sprawl (Drescher et al., 2011).

Forested wetlands in coastal plains are a transitional land cover type and are especially vulnerable to urban growth and climatic variability (Dai et al, 2013). In the Waccamaw Neck of Georgetown County, SC, a ten year study of coastal forested wetlands indicated that typically wet sites were more impacted by drought conditions than dry or intermediate sites as measured by the aboveground net primary production (Conner et al., 2011).

Coastal wetlands protect inland areas from storm impacts, reduce upland pollutant loads to the nearshore waters, and serve as habitat for fish, birds, and shellfish (Nixon, 1980; Jordan et al., 1986; Valiella, 2000; Morris et al., 2002). Brinson (1993) developed the hydrogeomorphic (HGM) approach of classifying wetlands based on their hydrologic regimes and landscape position. The HGM classification of wetlands also determines the types of functions provided by the wetland (Table 3.2-3).
Table 3.2-3. Hydrogeomorphic Wetland Classification

<table>
<thead>
<tr>
<th>HGM Wetland Type</th>
<th>Description</th>
<th>Common Functions and Values</th>
</tr>
</thead>
</table>
| **Depressional** | Topographic depression with closed contours that may have inlets or outlets, or lack them | ♦ Flood storage  
♦ Habitat  
♦ Pollution treatment  
♦ Erosion control |
| **Slope** | Surface discharge of groundwater on sloping land that does not accumulate | ♦ Habitat  
♦ Pollution prevention  
♦ Erosion control |
| **Flat** | Low topographic gradients, such as old glacial lake beds, with moderate to abundant rainfall | ♦ Habitat  
♦ Pollution prevention  
♦ Flood storage  
♦ Limited recreation |
| **Riverine** | Occur in the floodplain and riparian corridor of larger streams and rivers (e.g., 2nd order and higher) | ♦ Flood conveyance and storage  
♦ Shoreline protection and erosion control  
♦ Pollution treatment  
♦ Fish and waterfowl habitat  
♦ Recreation |
| **Fringe** | Adjacent to lakes or estuaries | ♦ Habitat  
♦ Pollution treatment  
♦ Water supply protection (lake fringe only)  
♦ Shoreline protection and erosion control  
♦ Recreation |

1 based on Brinson (1993)

Although wetlands are valuable ecosystems, wetland loss is common especially in coastal areas. The latest Status and Trends of Wetlands in The US 2004-2009 (Dahl, 2011) reported the loss of approximately 111,000 acres of emergent estuarine wetlands; this is 2.4% of the total wetland area. Key findings include:

✧ In salt water systems, the trend is towards an increase in non-vegetated tidal wetlands.
✧ The increase in tidal non-vegetated area came primarily from former vegetated salt marsh.
✧ Ninety nine percent of losses of estuarine emergent wetlands were attributed to the effects of coastal storms, land subsidence, sea level rise, saltwater intrusion, or other ocean processes.
Conservation Principles and Neighborhood Site Design for Low Impact Development

Chapter 3

Coastal Wetlands and Climate Change

The focus on functions provided by natural resources is one that may be particularly useful to coastal communities subject to sea level rise. Conserving coastal wetlands and their buffers is an effective strategy to protect communities from coastal storms and hurricanes. However, coastal wetlands are also most at risk of impacts from sea level rise, especially in places where levees or seawalls restrict their inland migration. Coastal communities will need to determine local elevation changes and the wetland surface accretion rates to better understand wetland sustainability in their area (US EPA, 2009).

Communities that are further inland can also use wetland protection as one aspect of adapting to changing rainfall patterns by identifying areas with high value for flood control. Stream and river corridors should also rise to the top of the conservation priorities to simultaneously reduce flood damage and stormwater runoff.

- Rising sea levels are expected to continue to inundate or fragment low-lying coastal habitats.
- Coastal habitats will likely be increasingly stressed by climate change impacts that have resulted from sea level rise and coastal storms of increasing frequency and intensity.

South Carolina has lost about 28% of wetlands to agriculture and urbanization. The 28% wetland loss represents an estimated 6.4 million acres of wetlands present in 1780 which decreased to 4.6 million acres. In fact, Charleston’s downtown “upland” peninsula area resulted from filled in salt marshes in the 1700s (Yarrow, 2009). Wetlands serve a critical role for protecting and restoring coastal water quality, habitat, and resiliency from storms. Although wetlands should never be used as the sole stormwater management practice (it is illegal according to the Clean Water Act), protecting wetlands provides many stormwater benefits. Therefore, wetland protection and restoration is an important stormwater management strategy.

The Tidal Creek booklet by Holland and Sanger (2008) outlined tidal creek recommendations at the municipality and county scale, the watershed or neighborhood planning scale, and at the site or homeowner scale based on over fifteen years of coastal SC research. Clemson University Extension Services’s Yarrow (2009) provided the following three basic wetland management plan considerations:

1. Inventory – Determine the wetland type that is targeted for management, the ownership, and the wetland size and condition. All the inventory factors help determine the wetland management strategies needed to attain the goals.
2. Management Considerations - Determine how the area is being used at the present time and will be used in the future. Also, consider relevant local, state, and federal policy guidelines and potential assistance programs.
3. Management Goals – Clearly outline the management goals for the wetland and for the owner.
There are several tools to support wetland protection and restoration available through:

- US Environmental Protection ([http://water.epa.gov/type/wetlands/index.cfm](http://water.epa.gov/type/wetlands/index.cfm)),

A recent tool (developed by the Center for Watershed Protection in cooperation with the US EPA Office of Wetlands, Oceans, and Watersheds) for wetland assessment and protection focused on the local government audience is the Wetlands-At-Risk Protection Tool (WARPT). The WARPT is a process for local governments and watershed groups that acknowledges the role of wetlands as an important part of their community infrastructure, and is used to develop a plan for protecting at-risk wetlands and their functions. The basic steps of the process include quantifying the extent of at-risk wetlands, documenting the benefits they provide at various scales, and using the results to select the most effective protection mechanisms. A free webinar, resources, and the WARPT tool are online at [http://www.wetlandprotection.org/](http://www.wetlandprotection.org/).

**Promote Buffers**

Coastal buffers are another important resource to protect and restore. Protection for coastal forests and coastal wetland areas reduce the harmful effects of land use derived stormwater pollution and provide additional benefits such as habitat and property protection, privacy screening, and additional ecosystem services.

In the coastal plain, well managed and adequately sized aquatic buffers are critical for processing nutrients; filtering pollutants; providing habitat for marsh birds, juvenile fish and shellfish species; dissipating wave energy; retaining floodwaters; and providing protection from erosion. For example, the following five criteria are specified within aquatic buffer ordinances for St. Mary’s County, MD; Ocean City, MD; Northampton County, VA and Wilmington, NC:

- Minimum buffer width
- Minimum requirements for vegetative cover
- Re-vegetation required if vegetation currently does not exist
- Program/mechanism to inform new property owners
- Invasive species control plan, no use of herbicides/pesticides

The SC guidance for buffer ordinances lists the benefits of buffers and suggests solutions to protect property owner rights with flexible buffer ordinances that contain the following (Halfacre-Hitchcock & Hitchcock, 2005):

- Buffer averaging
- Density compensation
- Conservation easements
- Purchase of development rights
- Variances
- Allow selective pruning and clearing to provide a view corridor
South Carolina has several buffer guidance documents that provide buffer definitions, examples, case studies, and recommendations. These buffer guidance documents include:

- The SC Task Force for Forested Riparian Buffers report recommends 100 to 300 foot riparian buffers (SCTFFBR, 2000).
- The “Critical Line Buffer Ordinances: Guidance for Coastal Communities” provides an overview for buffer intent, buffer implementation, and provided case studies in the City of Charleston and the Town of Mount Pleasant (Halfacre-Hitchcock & Hitchcock, 2005).
- The SCDHEC “Backyard Buffers for the South Carolina Lowcountry” provides guidance for buffer implementation and maintenance to homeowners (SCDHEC-OCRM, no 2000).
- The Clemson Carolina Clear H2Ownership factsheet series includes guidance for buffer areas adjacent to salt marshes, including a suggested plant list: http://www.clemson.edu/cy/plants.

Established by South Carolina’s Coastal Tidelands and Wetlands Act, the critical areas in South Carolina (Figure 3.2-1) are the coastal waters, tidelands, and beach/dune systems. In these areas DHEC-OCRM has direct jurisdiction for permits to perform any alteration. Activities covered by a critical area permit include docks, bulkheads, footpaths, and additions to existing structures, such as boat lifts, floating docks, and pier heads. Currently, buffers are added for stormwater management treatment but are not required if stormwater management treatment is accomplished in another way. The NPDES General Permit for Stormwater Discharge From Construction Activities does have buffer requirements during construction, but they are not permanent buffers (SCDHEC, 2013). For more information, see

- Coastal Zone Management Act at http://www.scstatehouse.gov/coderegsc030.php
- Coastal Tidelands and Wetlands at http://www.scstatehouse.gov/code/t48c039.php

Issues with long-term enforcement and maintenance are common. The top three enforcement issues identified in the survey include: a lack of standards for long-term maintenance (60%), enforcement limited to plan review (47%), and encroachment and clearing of buffers by property owners (38%). The practicality of identifying and enforcing buffers given very limited resources is a challenge that is by no means unique to the coastal plain.

Nutrient removal by buffers has been directly correlated with buffer width. Bason (2008) conducted a literature review of studies documenting increasing nitrogen removal with buffer width for coastal plain streams. The data indicate that approximately 80% nitrogen removal is achieved by stream buffers of approximately 80-90 feet, where incremental increases in removal efficiency (2% per additional foot of buffer width) are gained beyond this width. In addition, the data suggest that buffer widths of 150 feet or greater are more likely to consistently achieve their maximum potential for nitrogen removal. Wider buffers tended to remove more phosphorus, but no statistically
significant relationship was found. The minimum 80 foot stream buffer recommended for nitrogen removal was roughly estimated to remove around 66% of total phosphorus.

The recommended buffer vegetation in the coastal plain includes trees and herbaceous vegetation. On average, forested buffers remove 36% more nitrogen than grass buffers (Bason, 2008). Deeper roots from trees pick up nitrogen that is in subsurface flow. Forests also provide other benefits when located along waterways, including regulation of temperature, input of organic matter as an energy source to the stream ecosystem, and creation of habitat from leaf litter and woody debris that fall into the stream.

Effective natural resource protection ordinances specify the types of activities that are allowed or prohibited within the protected zone. Generally, buffer ordinances should limit allowable uses to clearing for shoreline access paths, view corridors, and passive recreation. Typically prohibited uses include paved surfaces, primary structures, grading, pesticide application, mowing, motorized vehicles, or any other activity that causes soil disturbance or contributes to pollution. In addition, septic tanks and drain fields as well as stormwater BMPs are often excluded from the buffer, and must be set back at an even greater distance beyond the buffer zone. Coastal communities may wish to modify these allowable and prohibited uses to allow landowners the views of and access to the water that drew them to the property while still protecting the environmental benefits of the buffer.

Where forested buffers are required but do not exist, native vegetation should be restored. Plants can be established in an aquatic buffer through natural regeneration, direct seeding, and/or planting of nursery-grown plants. If stream channels are incised, restoration and reconnection of the stream to the floodplain prior to reforestation will promote nutrient and sediment attenuation, reduce flow and scour, and encourage natural hydrological functions in the stream corridor. Buffer restoration targeted to headwater streams is particularly effective because that is where the largest proportion of annual stream nutrient loading enters the watershed and where the capacity to remove nitrogen is the greatest.
Policies should reflect the riparian buffer minimum widths recommended from scientific research and other design guidance presented in CWP (2010), Franzen et al. (2006), Bason (2008), Vandiver (2005), and others. A community’s environmental goals can guide the riparian buffer width needed to meet the desired buffer function. For example, to achieve 80% N removal in the coastal plain, the recommended width ranges from 80 (adequate for N removal) to 150 feet (optimal N removal). However, if a community is concerned about a different pollutant or prescribes lower or higher removal efficiency, the width may vary. See Table 3.2-4 for coastal buffer width recommendations, targeted function, and the percentage of communities within the coastal plain that provide the recommended buffers. Efforts should be directed at maximizing buffer widths through compromise with developers and regulatory agencies.

<table>
<thead>
<tr>
<th>Waterbody Type</th>
<th>Recommended Width (ft)</th>
<th>Desired Buffer Function</th>
<th>Coastal Plain Survey Respondents with Buffer Ordinances Providing the Minimum Recommended Width</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nontidal wetlands</td>
<td>50 to 150</td>
<td>Nitrogen removal</td>
<td>31%</td>
</tr>
<tr>
<td>Ephemeral streams</td>
<td>80 to 150</td>
<td>Nitrogen removal</td>
<td>38%</td>
</tr>
<tr>
<td>Intermittent streams</td>
<td>80 to 150</td>
<td>Nitrogen removal</td>
<td>23%</td>
</tr>
<tr>
<td>Tidal wetlands</td>
<td>150(^2) to 500(^3)</td>
<td>Sea level rise protection</td>
<td>6%</td>
</tr>
<tr>
<td>Shoreline</td>
<td>150(^2) to 500(^3)</td>
<td>Sea level rise protection</td>
<td>6%</td>
</tr>
</tbody>
</table>

\(^1\) Ranges are from Bason (2008) recommended buffer widths for adequate (low end of range) and optimal (high end) protection. Optimal protection option provides an estimated 90% N removal on average with at least 78% removal for most buffers.

\(^2\) For sites with steep (> 0.09 rise/run) wetland/upland boundary. Buffer provides protection for an average of 132 years, based on landward migration rates of tidal wetlands for the Inland Bays.

\(^3\) For sites with gradual (≤ 0.08 rise/run) wetlands/upland boundary. Buffer provides protection for an average of 88 years, based on landward migration rates of tidal wetlands for the Inland Bays.

\(^4\) Desired buffer function is based on community and waterway need. N removal and SLR protection examples are provided.

Other communities may be interested in buffers to protect critical habitat for a species of concern, which can increase the recommended widths even further. Additional reasons to utilize buffers are to provide sediment removal, shoreline stability, and protection of a valued waterbody, 303(d) listed waterbody segment, or aquatic habitat protection. Translating coastal-specific findings to define riparian buffer widths and their ecological and economic benefits is critical for these recommendations to hold up in the face of development pressure and/or in areas that may require wider or restored buffers. In addition to the width recommendations above, the following buffer policy recommendations for effective coastal forested riparian buffers are included here (Drescher et al., 2011):
Incorporate buffers into a comprehensive stormwater management strategy that includes source controls through education (Vandiver, 2005).

Ensure mapping of buffers and other natural resources features are included in the comprehensive plan.

Provide stormwater credits to buffers on a site as part of stormwater management for reduced storm flow.

Allow buffer restoration projects in offsite mitigation programs.

Enforce penalties and fines for destroying a buffer and require replanting.

Do not allow piping through the buffer. Buffers will not reduce stormwater pollution or volume if the stormwater is piped through the buffer.

Provide language in the ordinance that clearly defines variances in the buffer regulation to protect the property owner and receiving waters. An effective buffer ordinance also includes specific language detailing buffer inspection, enforcement, maintenance, delineation, allowable uses, restricted uses, and variance criteria (Schueler, 2000a).

Provide buffer education to stakeholders in the community.

Along the SC coast, groundwater has the potential to serve as a significant pollutant transport mechanism; therefore, it is suggested to use deep-rooted indigenous vegetation as a component of the buffer (Vandiver, 2005).

**Protect and Promote Tree Canopy**

Native trees, shrubs, herbaceous material, and grasses are important contributors to the overall quality and viability of the environment. Ideally, local government codes will promote the preservation of trees and native vegetation. In some cases tree protection can be done on a neighborhood or development level. Some private communities, such as Palmetto Bluff in Beaufort County, require the property owner to meet with staff naturalists to lay out home sites prior to development such that trees and buffers are protected; additionally, native vegetation is encouraged. High quality forest stands should be preserved prior to development (see *Protect Native Vegetation and Soils* section above). Tools that can be used for tree conservation include:

- Forest conservation ordinances
- Open space development practices
- Planting vegetation in street rights-of-way
- Preservation of trees during clearing and grading activities
- Reduced parking lot sizes with vegetated islands

Tree calculators can provide background and justification for the benefit or value of trees. To estimate the value of a tree, parameters such as air quality, water quality, dollars saved, dollars spent, and others are provided in the following tree calculators:

- US Forest Service Urban FORests Effects (UFORE) using i-Tree
  - i-Tree at [http://www.itreetools.org/](http://www.itreetools.org/)

American Forests Individual Tree Calculating Tools


Research conducted in Charleston, SC was used to calculate tree costs and benefits, based on “typical” trees planted in residential yards, public streets, and parks (McPherson et al., 2006). Coastal plain cities spend about $18 per tree each year, including yard and public trees. Tree benefits were mostly from reduced stormwater runoff and energy as well as increased aesthetics and property values. Urban forests are estimated to reduce stormwater runoff 2 to 7 percent. In Charlotte, NC, street trees reduced stormwater runoff by 28 million cubic feet at an estimated value of $2 million per year. Annual average benefits for different types of trees are summarized here:

- Large: $107 to $127
- Medium: $31 to $40
- Small: $14 to $19
- Conifer: $40 to $62

The Charleston study used representative species such as Southern live oak (*Quercus virginiana*), Southern magnolia (*Magnolia grandiflora*), flowering dogwood (*Cornus florida*), and loblolly pine (*Pinus taeda*) to model the large, medium, small, and conifer trees, respectively, with growth curves adjusted for city street trees. This report provides an overview for coastal SC tree benefits, estimates values and costs, outlines tree planting guidance, and includes two town scenarios to demonstrate how communities can use the report’s information for urban forest improvements.

The landscape community can promote, maintain, and educate the public to use better landscape practices, protect trees and buffer areas, and understand the benefit of plants in and around LID practices. Some trees and shrubs can be added to stormwater management practices such as in bioretention or tree planters (Day and Dickinson, 2008). Using trees for stormwater management has gained momentum in cities. This increased use of trees has led to research guidance for soil substrate (Davis, 2001), tree selection, and site constraints such as utilities, maintenance, and runoff reduction (McPherson et al., 2006; Drescher et al., 2012). Also, trees and shrubs can be added to cities in streets and sidewalks. A survey of 137 cities found that 95% have adopted tree management ordinances and 47% have tree canopy goals (City Policy Associates, 2008).

One important consideration for tree planting is the maintenance needed to keep the tree healthy and ensure that it provides the intended benefits. For example, increased tree canopy in an urban center means more leaf litter accumulates on the streets. While trees in urban areas provide multiple benefits in the community and can help to re-establish a more natural watershed nutrient cycling capacity, there is a potential for leaf litter to add to the nutrient loads associated with already impacted urban streams (Law et al., 2013; Walsh et al., 2005; Cowen and Lee, 1973). In urban watersheds, stormwater runoff quickly washes off the hardened landscape carrying leaf litter into storm drains. The urban system short circuits the natural nutrient processing that a forest would typically provide, such as pollutant transformation via filtering and decomposition; therefore, leaf pick up and street sweeping programs in urban areas are important to reduce leaf litter before it enters the storm drain network and streams. In Charleston County, nearly 59,000 tons of yard waste per year...
Oak Terrace Preserve is a 55-acre sustainable redevelopment project located in Park Circle, North Charleston. In the 1940s, the federal government built temporary housing on this site for World War II shipyard workers. The houses were never intended for long-term habitation, and eventually fell into disrepair. The property was bought in 2003 by the City of North Charleston through a unique public-private partnership: the City of North Charleston as owner and the Noisette Company as development manager (starting in 2010, the Cedrus Development company took over management of the property). The redevelopment provided green sustainable features in home construction in addition to pocket parks, public space, an LID stormwater management system, and an extensive tree preservation program.

The Oak Terrace Preserve project will consist of approximately 300 single-family homes and 74 townhomes when complete. The project was designed to provide affordable housing, with prices starting in the $200,000s, and to promote sustainable design. Development activity commenced in 2006 (Phase 1) and should continue through 2014 (Phase 3).

An important aspect incorporated into the Oak Terrace Preserve project was the protection of its tree resources. Prior to development, Oak Terrace Preserve was home to over 600 trees, many of them were grand trees with 24 inch or larger diameters, including oaks, magnolias, and additional old-growth trees that are rarely found in a new community. Tree preservation and management was a top priority. A certified arborist performed a tree survey and assessment before construction. During site construction activities, fencing protected the trees and their critical root zone. The certified arborist’s continued involvement on site was a major factor for the successful tree protection.

Oak Terrace Preserve has a more enhanced natural and sustainable stormwater management system than is typically designed in today’s SC master planned communities. Oak Terrace used a combination of linear bioswales, temporary pocket park detention, and pervious alleyways for stormwater management. The linear bio-swales include engineered soil media designed to be porous and run continuously parallel on one side of the street. The streets are slightly sloped at about a 2% grade to drain to the 15 foot wide, v-shaped bio-swale. Currently, the Home Owner’s Association owns and maintains the pervious alleys and pocket parks and other common areas on site (annual HOA fees are $420); the City of North Charleston retains ownership of the roads and bioswales that fall within the road rights-of-way and the HOA maintains the bioswales.

Pervious alleys and protected trees at Oak Terrace Preserve
are collected and composted at the 36-acre Bees Ferry Landfill. This compost is then made available for purchase by the bag or ton. For more information, please see http://www.charlestoncounty.org/departments/SolidWaste/compost-facility.htm.

**Reduce Impervious Cover**

Perhaps the most defining characteristic of urban streams is the increase in the amount and velocity of stormwater or surface runoff to those systems (US EPA, 2012). As shown in Figure 3.2-2, impervious surfaces associated with urbanization reduce infiltration and increase surface runoff, altering the pathways by which water (and any associated contaminants) reaches urban streams. Common impervious surfaces include:

- Roads
- Parking lots
- Rooftops
- Driveways and sidewalks
- Compacted soils

All of the impervious surfaces that are present in a watershed constitute the watershed’s impervious cover.

![Figure 3.2-2. Visual representation of the differences in the volume and rate of stormwater runoff between an undeveloped forested watershed and a developed urban environment. The magnitude of the differences is represented by the size of the arrows as well as the height and width of the peaks in the graphs. (Image from SC Sea Grant, SC Department of Natural Resources, and National Oceanic and Atmospheric Administration)](image-url)

Coastal communities struggle to balance the demand for prime real estate and increased revenues with the demand to protect the local resources that make these areas desirable. The coastal plain is a unique area for development and redevelopment due to its proximity to natural resources, limited available space, and stricter “critical zone” regulations. Land use changes over time have increased the impervious cover (IC) and managed turf, consequently reducing the landscape’s ability to filter...
stormwater runoff efficiently or effectively. Managing IC is critical because increased IC is linked to impacts on water quality, wildlife, and human health through degraded water quality impacts (e.g., bacteria) (Mallin, 2000; Mallin et al., 2001; Holland et al., 2004; Schueler and Fraley-McNeal, 2009). The IC model (Schueler, 1994), which relates IC to receiving water quality, was recently updated (Schueler and Fraley-McNeal, 2009; Figure 1). The more recent analysis confirmed the stream quality thresholds identified by earlier research and added ranges to the IC thresholds to account for the variability in the response of watersheds as they transition from sensitive, impacted, non-supporting, and urban drainage classification of stream quality. For example, a watershed with 20 to 25% IC is “impacted” and exhibits a greater number of fair or good streams than “non-supporting”

Figure 3.2-3. Aerial image comparison of two developments with quarter-acre lots: (A) is from Beaufort, SC (~25% impervious surface) and (B) from Mt. Pleasant, SC (45% impervious cover). Images from Anne Blair, NOAA Hollings Marine Laboratory, and Google Earth.

Figure 3.2-4. Impervious Cover Model update (Schueler & Fraley-McNeal, 2009). Reproduced with permission from ASCE.
watersheds but fewer fair or good streams than sensitive watersheds. For a comparison, see Figure 3.2-3. This means that the lives and livelihood of coastal residents deteriorate if urban sprawl continues as anticipated because poor water quality means reduced recreation, tourism, shellfish harvesting, etc.

The Impervious Cover Model (ICM) estimates stream quality based on percentage IC area (Figure 3.2-4). The hatched bars show the threshold from one classification to the next. Sharply defined thresholds were found to be rare and streams typically follow a continuous but variable gradient of stream degradation. The cone represents the observed variability in the response of stream indicators to urban disturbance as represented by the percent IC. For example, there is less variability in stream quality found at higher levels of IC, compared to watersheds with lower IC.

The suburban sprawl development pattern of the past 50 years needs to be reversed if coastal communities are to protect their watershed resources in the face of certain population growth. In its simplest form, comprehensive land use planning should determine where to develop and what development type to allow in each location. Comprehensive planning can direct and improve development patterns, e.g., transfer of development rights, purchase of development rights, and unsubsidized coastal flood insurance (as recently demonstrated by the Biggert-Waters Flood Insurance Reform Act of 2012). Impervious cover removal and preventing the creation of more impervious cover protects natural habitats and waterways. Impervious cover reduction, such as parking lot removal, can also be a standalone BMP or be coupled with additional stormwater management practices such as soil amendments or other LID practices.

Approaches for limiting and mitigating IC increases include:

- Limit IC at the site level through better layout of the development or by incorporating low impact development (LID), such as pervious pavement.
- Allocate land uses to the most appropriate areas of the community. Direct development to areas with existing development and infrastructure and/or already degraded subwatersheds and limit it in areas with known hazard areas, natural resources, drinking water sources, and pristine subwatersheds.
- Use transfer of development rights to encourage property owners near environmentally-sensitive areas (“sending areas”) to transfer their development rights to designated areas (“receiving areas”) that are better able to accommodate growth, such as infill sites. The “receivers” have the benefit of increased development capacity, and the “senders” get financial compensation for their transferred rights.
- Adopt a watershed or regional approach to land use planning to work with neighboring communities to minimize impacts to shared resources (e.g., drinking water supplies).
- Preserve ecologically important land by performing a natural resources inventory and directing new development away from these areas.
- Incorporate coastal hazard response, long-term shoreline change, and emergency management into plans by identifying potential hazard areas, restricting or discouraging development in these areas, or determining how to reduce risk to life and property in areas that were already developed.
- Encourage redevelopment and infill over conversion of natural lands to new development.
There are coastal South Carolina communities that limit their impervious cover. For example, the Town of Pawley's Island sets limits for impervious cover at 1,000 to 4,000 square feet and not exceeding 40% of the lot size. The Pawley's Island impervious cover limits are per the Article III, Zoning Regulations [3-5.8(A)] Lot Area Coverage. Another example is the Town of Sullivan's Island, where 50% of the property must be landscaped surfaces. The Town of Sullivan's Island Article III RS-Single Family Residential District, Town, and Zoning Ordinances provide additional details about their impervious cover limits. High percentages of impervious cover in a catchment or watershed result in degraded water quality and poor habitat. These coastal South Carolina communities provide examples for limiting impervious cover for development.

Beaufort County has also established limits on impervious surface cover. Beginning in 1998, the County’s BMP manual has incorporated a water quality worksheet designed to evaluate whether a proposed development plan meets the goal of 10% effective imperviousness (Beaufort County, 2012). A site with an “effective” or “equivalent” imperviousness of 10% will generate the quantity of runoff that would be generated by a site with 10% uncontrolled impervious surface. This goal was established based on pollutant-loading characteristics of low-density development with imperviousness of 10%, which prevents pollutants from reaching levels that threaten water quality and environmental wellbeing.

### 3.3 Neighborhood Site Design Considerations

Some planning guidance for the types of LID designs, such as open space development, have been covered in previous sections of this manual. This section addresses design considerations related to the layout of a neighborhood or development, such as roadways, parking, and landscaping.

**LID Roadway Design**

Up to 65% of the total impervious cover in the landscape can be classified as “habitat for cars” including streets, parking lots, and driveways (CWP, 1998). Streets constitute 40-50% of impervious cover in traditional residential developments. Shifting to narrower streets can result in a 5-20% reduction in impervious area in typical residential subdivisions (Schueler, 1995). A central concept in LID planning is minimizing impervious cover, and reductions in the total area of streets and parking lots can greatly lower a site’s overall impervious cover.

**Street Widths:**

One way to reduce the amount of impervious cover is to minimize street widths. Residential streets should be designed to be as narrow as possible, based on current and future traffic volumes, without compromising safety (Table 3.3-1).
Table 3.3-1. Example Road Widths for Local Streets

<table>
<thead>
<tr>
<th>Minimum Road Width (ft)</th>
<th>Parking</th>
<th>Average Daily Trips (ADT)</th>
<th>Number of Dwellings Served</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>Both sides</td>
<td>&lt;200</td>
<td>20</td>
</tr>
<tr>
<td>22</td>
<td>One side</td>
<td>200-400</td>
<td>20-40</td>
</tr>
<tr>
<td>26</td>
<td>Both sides</td>
<td>400-2,000</td>
<td>40-200</td>
</tr>
<tr>
<td>28</td>
<td>One side</td>
<td>&gt;2,000</td>
<td>&gt;200</td>
</tr>
<tr>
<td>32</td>
<td>Both sides</td>
<td>&gt;2,000</td>
<td>&gt;200</td>
</tr>
</tbody>
</table>

(RI DEM & CRMC, 2011)

Conventional roadway design often calls for residential streets that are 32 to 40 feet wide, even if they only serve a few dozen homes. In less populated areas or where people make fewer average daily trips (ADTs), these wide stretches of pavement are unnecessary and create a number of problems:

- Vehicle speeds can increase, posing a safety risk to both drivers and pedestrians
- Construction and maintenance costs are higher than costs for a smaller road
- Associated rights of way (ROW) are larger, reducing the available land for development

Several national engineering organizations recommend that residential street widths can be 22 to 26 feet, provided that they serve neighborhoods with traffic volumes less than 500 trips per day, or 50 homes (AASHTO, 1994; ASCE, 1990). The narrower dimensions do not sacrifice emergency access, on-street parking, or vehicle and pedestrian safety. Some communities have implemented narrow street widths successfully (see Table 3.3-2). Residential streets between 18 and 22 feet wide earn positive credit in the CWP Codes and Ordinance Worksheet (CWP, 2013). Another strategy includes requiring permit applicants to minimize street width to the extent possible. For example, in Georgetown County, SC applicants for stormwater permits must show they have reduced road and driveway widths while maintaining a standard consistent with health and safety requirements and the county land use ordinance (GCSC, 2006).
### Table 3.3-2. Road Width Recommendations

<table>
<thead>
<tr>
<th>Road Type</th>
<th>Residential Street Width (ft)</th>
<th>Maximum Average Daily Trips</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beaufort County, SC</td>
<td>20 local residential</td>
<td>240 (max peak hour volume)</td>
</tr>
<tr>
<td></td>
<td>26 local residential (1 parking lane)</td>
<td>240 (max peak hour volume)</td>
</tr>
<tr>
<td></td>
<td>34 local residential (2 parking lanes)</td>
<td>240 (max peak hour volume)</td>
</tr>
<tr>
<td></td>
<td>28 local nonresidential</td>
<td>1,000 (max peak hour volume)</td>
</tr>
<tr>
<td></td>
<td>22 residential collector</td>
<td>800 (max peak hour volume)</td>
</tr>
<tr>
<td></td>
<td>22 residential collector</td>
<td></td>
</tr>
<tr>
<td></td>
<td>21 drive</td>
<td></td>
</tr>
<tr>
<td></td>
<td>19.5 court</td>
<td></td>
</tr>
<tr>
<td></td>
<td>17.5 residential alley</td>
<td></td>
</tr>
<tr>
<td></td>
<td>22 commercial alley</td>
<td></td>
</tr>
<tr>
<td>Dorchester County, SC</td>
<td>22 collector</td>
<td>&gt;3,000</td>
</tr>
<tr>
<td></td>
<td>21 drive</td>
<td>1,000 - 3,000</td>
</tr>
<tr>
<td></td>
<td>19.5 court</td>
<td>&lt;1,000</td>
</tr>
<tr>
<td></td>
<td>17.5 residential alley</td>
<td>&lt;250</td>
</tr>
<tr>
<td></td>
<td>22 commercial alley</td>
<td>&lt;500</td>
</tr>
<tr>
<td>State of New Jersey¹</td>
<td>20 (no parking)</td>
<td>0 - 3,500</td>
</tr>
<tr>
<td></td>
<td>20 (one side parking)</td>
<td>0 - 3,500</td>
</tr>
<tr>
<td>Bucks County, PA¹</td>
<td>12 (alley)</td>
<td>--</td>
</tr>
<tr>
<td></td>
<td>16 - 18 (no parking)</td>
<td>200</td>
</tr>
<tr>
<td></td>
<td>20 - 22 (no parking)</td>
<td>200 - 1,000</td>
</tr>
<tr>
<td></td>
<td>26 (one side)</td>
<td>200</td>
</tr>
<tr>
<td></td>
<td>28 (one side)</td>
<td>200 - 1,000</td>
</tr>
</tbody>
</table>

¹CWP, 1994

A common misconception is that wide streets are a necessity for pedestrian safety. However, it has been shown that narrower streets actually slow traffic, which helps to prevent accidents. Figure 3.3-1 illustrates that accidents are less common with narrower streets (Longmont, CO Study).

![Figure 3.3-1. Relationship between Street Width and Accidents (Swift, et al., 1998 as in CWP, 1998)](image-url)
Emergency vehicle access is an important consideration in road design and very wide roads are often designed to ensure it. However, the width is often excessive for emergency vehicles including fire trucks. A number of local fire codes (Table 3.3-3) permit roadway widths as narrow as 18 feet. In many residential areas, a minimum roadway width of 26 feet provides a 12-foot driving lane that accommodates fire truck passage as well as 7-foot parking or queuing lanes on each side of the driving lane (CWP, 1998).

### Table 3.3-3. Street Width Requirements for Fire Vehicles

<table>
<thead>
<tr>
<th>Width (ft)</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>26 local urban streets (parking on both sides)</td>
<td>AASHTO 2011</td>
</tr>
<tr>
<td>18-20</td>
<td>US Fire Administration</td>
</tr>
<tr>
<td>24 (on-street parking) 16 (no on-street parking)</td>
<td>Baltimore County Fire Department</td>
</tr>
<tr>
<td>18 minimum</td>
<td>Virginia State Fire Marshall</td>
</tr>
<tr>
<td>24 (no parking) 30 (parking on one side) 36 (parking on both sides) 20 (for fire truck access)</td>
<td>Prince Georges County Department of Environmental Resources</td>
</tr>
<tr>
<td>18 (parking on one side) 26 (parking on both sides)</td>
<td>Portland Office of Transportation</td>
</tr>
</tbody>
</table>

(CWP, 1998)

**Right-of-Way Width:**

The right-of-way (ROW) is the total land area that contains all of the cross-sectional features of the roadway, including pavement width, curbing, buffers, sidewalks, utilities, drainage, and grading (RI DEM & CRMC, 2011). The South Carolina Department of Transportation defines the ROW as “the land secured and reserved by the Department for the construction, improvement, and maintenance of the highway” (SC DOT, 2008). The Institute of Traffic Engineers (ITE) guidelines recommend a minimum ROW width of 50 feet for low density development and 60 feet for medium and high-density developments (ITE, 1997). Therefore, ROWs between 50 and 60 feet in width are common.

The standard 50 to 60 foot width can be excessive in many situations. While a wide ROW does not necessarily create more impervious cover, it can work against better site design. The wider ROW subjects a greater area to clearing and grading during road construction, and also consumes land that could be used for development. The ROW should only be wide enough to contain the necessary elements as shown in Figure 3.3-2. Generally, widths of 24 to 52 feet are sufficient. See Table 3.3-4 for examples of narrower ROW widths for residential streets. These ROW widths should be preserved even where street widths are narrower and building footprints should not be allowed to expand into ROWs.
Figure 3.3-2. Right-of-way cross sections. Both roadways have a 50-ft ROW. The top cross-section shows how a typical road produces excessive impervious cover with 26 feet of pavement and sidewalks on both sides of the street. The bottom cross section demonstrates how an LID design includes roadside swales, narrower travel lanes, and a single sidewalk (Image: Center for Watershed Protection).
### Table 3.3-4. Examples of ROW Widths

<table>
<thead>
<tr>
<th>Source</th>
<th>ROW Width (ft)</th>
<th>Pavement Width (ft); Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Berkeley County, SC&lt;sup&gt;1&lt;/sup&gt;</td>
<td>50</td>
<td>22; local street (curb &amp; gutter)</td>
</tr>
<tr>
<td></td>
<td>66</td>
<td>66; local street (open ditch)</td>
</tr>
<tr>
<td>Town of Bluffton, SC&lt;sup&gt;2&lt;/sup&gt;</td>
<td>24</td>
<td>12; rear lane</td>
</tr>
<tr>
<td></td>
<td>24</td>
<td>24; rear alley</td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>24; road (2 lanes, no parking)</td>
</tr>
<tr>
<td></td>
<td>40</td>
<td>19; street (1 lane, 1 side parking)</td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>26; street (2 lanes, 1 side parking)</td>
</tr>
<tr>
<td>Portland, OR&lt;sup&gt;3&lt;/sup&gt;</td>
<td>35</td>
<td>20; residential street</td>
</tr>
<tr>
<td></td>
<td>40</td>
<td>26; residential street</td>
</tr>
<tr>
<td>Montgomery County, MD&lt;sup&gt;3&lt;/sup&gt;</td>
<td>20</td>
<td>16; residential alley</td>
</tr>
<tr>
<td></td>
<td>44</td>
<td>20; residential street</td>
</tr>
<tr>
<td></td>
<td>46-60</td>
<td>26; residential street</td>
</tr>
<tr>
<td>ASCE 1990 recommendation&lt;sup&gt;3&lt;/sup&gt;</td>
<td>24-26</td>
<td>22-24; residential alley</td>
</tr>
<tr>
<td></td>
<td>42-46</td>
<td>26; residential street</td>
</tr>
</tbody>
</table>

<sup>1</sup> Berkeley County (1999)  
<sup>2</sup> Town of Bluffton Unified Development Ordinance (2011)  
<sup>3</sup> Better Site Design (CWP, 1998)

Municipalities should consider adjusting ROW requirements based on conditions and needs of the site. Additionally, it should be noted that a narrow ROW may not be desirable if stormwater is conveyed by vegetated open channels along the road (see Open Channels in Chapter 4). Well-designed swales require 10 to 12 feet along one or both sides of the road, thereby increasing the necessary ROW width.

**Cul-de-sacs and Alternate Turnarounds:**

Cul-de-sacs became prominent in new residential subdivisions after World War II (Nielsen, 2006). These residential streets are open at one end and feature a large “bulb” at the closed end which allows vehicles to turn around. Many communities require that the cul-de-sac bulb be 50 to 60 feet or more in radius. This results in paved areas over 11,000 square feet just for the turning portion of the roadway (RI DEM & CRMC, 2011). Because of their geometry, even a small reduction in bulb radius leads to a significant reduction in impervious cover.

Ensuring adequate access for emergency and service vehicles often leads to excessive cul-de-sac widths. However, newer fire trucks and other service vehicles have reduced turning radii, and therefore the paved radius may be reduced to 30 to 40 feet in some cases (ASCE, 1990). Additionally, school buses do not usually enter cul-de-sacs, but pick up the students at one pre-arranged location. See Table 3.3-5 for examples of communities allowing smaller radii.
Table 3.3-5. Recommended Cul-de-sac Turnaround Radii

<table>
<thead>
<tr>
<th>Turning radius (ft)</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>40</td>
<td>Beaufort County, SC</td>
</tr>
<tr>
<td>20 (residential alley)</td>
<td></td>
</tr>
<tr>
<td>25 (court)</td>
<td>Dorchester County, SC</td>
</tr>
<tr>
<td>40 (drive)</td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>Horry County, SC</td>
</tr>
<tr>
<td>35 (with approval of fire department)</td>
<td>Portland, OR Office of Transportation¹</td>
</tr>
<tr>
<td>38 (outside turning radius)</td>
<td>Bucks County, PA Planning Commission¹</td>
</tr>
<tr>
<td>45</td>
<td>Fairfax County, VA Fire and Rescue Department¹</td>
</tr>
<tr>
<td>35</td>
<td>Baltimore County, MD Fire Department¹</td>
</tr>
<tr>
<td>45</td>
<td>Montgomery County, MD Fire Department¹</td>
</tr>
<tr>
<td>43</td>
<td>Prince Georges County, MD Fire Department¹</td>
</tr>
</tbody>
</table>

¹ CWP 1998

**Pervious Islands:**

Impervious area can also be minimized through the use of a landscaped vegetated area in the center of a cul-de-sac or road; however, a sufficient paved width must be maintained (ITE recommends a minimum of 25 feet; also note that in the CWP Better Site Design Codes & Ordinances Worksheet that the user gets credit for using less than 35 feet or less than 45 feet). For an additional benefit, the vegetated island can be designed to receive and treat stormwater. For example, the island can be designed as a bioretention area using the criteria in Chapter 4. Concerns regarding sight impairment can be mitigated by using ground-cover or low-growing plants.

**Alternative Turnarounds:**

T-shaped turnarounds (also known as a hammerhead) and loop roads offer alternative designs to the traditional bulb and loop cul-de-sac (See Figure 3.3-3). T-shaped turnarounds generate approximately 75% less impervious cover than a cul-de-sac with a radius of 40 feet (See Table 3.3-6). They may be appropriate for streets less than 200 feet in length or where lot sizes are large. The minimum dimensions for a T-shaped turnaround are 60 feet by 20 feet. A loop road is a curved road that joins with another road at each end, providing two points of entry and exit. Loop roads can carry double the traffic volume of a cul-de-sac and therefore may serve twice as many units (Bucks County, 1980).

An additional benefit of alternative turnarounds is a reduction in construction costs. Asphalt alone costs $0.50-$1.00 per square foot, so reducing the amount of paved area in a development can result in significant savings (US EPA, 2010).
Table 3.3-6. Impervious Cover Created by Turnaround Option

<table>
<thead>
<tr>
<th>Turnaround Option</th>
<th>Impervious Area (square ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>40-foot radius</td>
<td>5,024</td>
</tr>
<tr>
<td>40-foot radius with island</td>
<td>4,397</td>
</tr>
<tr>
<td>30-foot radius</td>
<td>2,826</td>
</tr>
<tr>
<td>30-foot radius with island</td>
<td>2,512</td>
</tr>
<tr>
<td>Hammerhead</td>
<td>1,250</td>
</tr>
</tbody>
</table>

1 Schueler, 1995

**Intersection Geometry:**

The most common intersection design is a four-way intersection with two crossing perpendicular streets. Often, four-way intersections are designed to be much wider than necessary, which increases impervious cover. Larger intersection curb radii can minimize lane encroachments by turning vehicles, but they also lead to greater vehicle speeds and a less pedestrian-friendly environment. Therefore, curb radii should be set to the minimum size required by turning vehicles and lane configurations. AASHTO recommendations are sufficient for the purposes of efficient and safe travel and range from 15 feet for smaller roads to 25 feet for collector streets (AASHTO, 2001).

Tee-style intersections offer several advantages over crosses. They tend to be safer (ITE, 1997), provide attractive terminating vistas, decrease vehicle speeds, and reduce points of pedestrian-vehicle conflict (Burden, 1999). To minimize conflict between adjacent intersections, tees should be spaced at least 125 feet apart (ITE, 1997). A sub-collector road with loop roads terminating in tee-style intersections offers a good opportunity to minimize impervious cover, enhance pedestrian safety, and reduce vehicle speeds, while increasing the overall flow of traffic (RI DEM & CRMC, 2011).

Local codes can make it very difficult to design alternatives to large scale 90-degree cross intersections. Community officials should provide adequate flexibility within their local codes to allow designers to assign the appropriate radius to proposed intersections depending on anticipated traffic volumes and goals for managing impervious surfaces.
Chapter 3  Conservation Principles and Neighborhood Site Design for Low Impact Development

**Curb Requirements:**

Curb should be eliminated wherever possible in favor of road drainage into open channel systems or other stormwater management practices. While vertical curbing is recommended by ITE for all medium- to high-density developments (ITE, 1997), rolled curbing is the recommended practice for low-density developments (less than four units per acre). Rolled curbing allows runoff to be channeled into surface BMPs like swales or bioretention systems. Rolled curbing also allows for on-street parking using part of the shoulder (WA DOT, 1997), potentially decreasing road paved widths.

There are several disadvantages to using a raised curb design approach, particularly relative to LID implementation. One disadvantage to curbing is cost; it is much more expensive to build a road with curbs and a closed drainage system than one with vegetated shoulders and open swales. By preventing stormwater runoff from infiltrating along the side of the road, curbs may also create concentrations of pollutants, such as debris, sediment, and bacteria. As a result, curbed streets experience increased runoff with higher pollutant concentrations. In addition, curb-and-gutter conveyance systems quickly carry stormwater to downstream water bodies, which increases peak flows that can cause flooding and erosion problems.

One common argument against eliminating curbs is the potential for surface erosion or failure of the road surface at the pavement edge. Often, erosion can be mitigated by hardening the pavement-grass interface through the use of grass pavers (concrete or plastic grid pavers) or a low-rising concrete strip or ribbon curb (CWP, 1998). The use of such a strip also increases the visibility of the roadway edge, enhancing traffic safety at night. Another common concern from residents is that open drainage is unattractive, difficult to maintain, and may pose a health risk from standing water. These challenges can be addressed by careful design of the swale system following the criteria outlined in Chapter 4.

**Sidewalks:**

Codes and ordinances often require excessive sidewalk surface area in residential developments. For example, residential developments can be required to construct and maintain sidewalks on both sides of the street. The sidewalk material required is often impervious concrete or asphalt. Additionally, sidewalks can increase the site footprint further when setbacks are required. Setbacks are often 2 to 10 feet from the road.

Sidewalks promote pedestrian access in the community. Flexible sidewalk codes and ordinances will allow sidewalk placement and design that reduce impervious surfaces and promote pedestrian traffic where it makes the most sense. For example, a tailored approach may include sidewalks on one side of the street, reduced sidewalk width, and/or reduced setbacks from the road. Such approaches can incorporate water quality improvement goals and better community planning goals.

Finally, alternative surfaces such as pervious concrete (see Figure 3.3-4) can be used to promote infiltration. In Oak Terrace Preserve, recycled tire material allowed for more infiltration and provided a softer walking surface than typical concrete sidewalks. Where possible, sidewalks can be graded away from the street surface and toward grassy areas for infiltration and conveyance. Installing pervious sidewalks and grading away from the street allows stormwater to infiltrate prior to entering the stormwater management system.
Recommended better sidewalk practices (CWP, 1998; CGRDC & EMC, 2008):

- Locate sidewalks on one side of the street
- Use sidewalks that are 5 feet wide in high-use areas and 4 feet wide elsewhere
- Utilize pervious surface materials
- Grade sidewalks to adjacent grassy areas or stormwater management practices

Flexible sidewalk codes and ordinances can reduce the impervious surfaces, promote better pedestrian patterns, and support clean water goals in residential areas. Please refer to [www.ada.gov](http://www.ada.gov) for information and technical assistance with complying with the sidewalk requirements set forth in the Americans with Disabilities Act.

**Driveway Design:**

As much as 20% of the impervious cover in a typical residential development consists of driveways (Scheuler, 1994). Lot impervious cover should be reduced by minimizing driveway width and length, allowing shared driveways wherever possible, and encouraging alternative pervious sur-

![Image of driveways and sidewalks](image-url)
faces (as depicted in Figure 3.3-4). Most suburban driveways create 400 to 800 square feet of impervious cover, or enough space to park two to four cars. The single-lane driveway for a residential home is typically 10 to 12 feet wide, while the double lanes used for homes with a two-car garage are usually 18 to 20 feet wide. Often, narrower driveways would be sufficient, and communities could reduce overall impervious cover by specifying a narrower driveway width. For example, less than 9 feet for one lane and less than 18 feet for 2 lanes is recommended by the CWP (COW question 14, page 19 in *Better Site Design*).

Subdivision and community codes indirectly influence the length of the driveway by requiring excessive front yard setbacks, which dictate how far houses must be from the street, are required. Driveway length can be reduced by relaxing these front yard setbacks. Flexible setback requirements allow for more creativity in site planning and development, and allow for more compact lots and a greater amount of open space. See *LID and Compact Development* in Section 2.4 for additional guidance.

There are several misconceptions related to front yard setbacks. One is that decreased setbacks and shorter driveways do not provide enough parking spaces. However, the average number of vehicles per household is 1.86 (US DOT, 2011). Typically this can be accommodated between the driveway, garage, and on-street parking (Pisarski, 1996). Another issue raised regarding decreased front yard setbacks is that it will reduce drivers’ sight distance, or the length of roadway that can be easily viewed. However, sight distance impediments can be avoided by placing visual obstructions (e.g., garages, front porches) at least two feet back from the curb. This setback is far less than the 30-foot setback required by many jurisdictions (AASHTO, 1994; CWP, 1998). Additionally, the concern that decreasing the front setback will increase traffic noise can be mitigated by traffic calming strategies. As traffic noise is a function of driving speed, narrower streets or other measures to slow traffic will reduce noise (AASHTO, 1994; FHA, 1996).

Another way to reduce the total impervious area generated by driveways is to use shared driveways. These are privately owned and maintained driveways, typically 12 to 16 feet wide. Careful design can provide sufficient space for overflow parking while reducing the overall area required. Important considerations for shared driveways include:

- The maximum allowable number of homes that may be served by a common driveway, typically two to six homes
- The type of shared driveway covenant that will be used by the homeowners to ensure that maintenance responsibilities are clearly described and adequately enforced
- The potential for locating other shared features such as mail repositories and trash removal pads at the end of the driveway. Communities may wish to include design specifications for these areas to ensure aesthetic appeal and the reduction of potential nuisances

Shared driveways are usually discouraged or sometimes even prohibited in local codes. This is primarily because there is a concern that multiple homeowners may not be able to agree on the long-term maintenance of the driveway. Further, depending on the working schedules of different homeowners, many people are concerned with the ability of homeowners to “come and go as they please” for fear that parked cars close to the driveway entrance will block access. These are valid concerns that can be addressed by proper design. For example, a shared driveway that is long enough to accommodate a few automobiles on both sides can be designed so that the entrance way...
is close to the recommended minimum width of 12 feet as it is unlikely any cars would be parked at the mouth of the driveway. However, where a shared driveway is only long enough to accommodate two parked cars for each owner, the entranceway should be wider to allow adequate access (CWP, 1998).

Most driveways are constructed of concrete or asphalt, but the use of alternative, porous materials can decrease impervious cover. Several alternative driveway surfaces exist that reduce impervious cover and provide increased infiltration. Table 3.3-7 compares the durability, cost, and relative performance of several alternative paving materials.

| Material               | Initial Cost | Maintenance Cost | Water Quality Effectiveness
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional Asphalt/Concrete</td>
<td>Medium</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Pervious Concrete</td>
<td>High</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Porous Asphalt</td>
<td>High</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Turf Block</td>
<td>Medium</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Brick</td>
<td>High</td>
<td>Medium</td>
<td>Medium</td>
</tr>
<tr>
<td>Natural Stone</td>
<td>High</td>
<td>Medium</td>
<td>Medium</td>
</tr>
<tr>
<td>Permeable Pavers</td>
<td>High</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Gravel</td>
<td>Low</td>
<td>Medium</td>
<td>Medium</td>
</tr>
<tr>
<td>Wood Mulch</td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
</tr>
<tr>
<td>Cobble</td>
<td>High</td>
<td>Medium</td>
<td>Medium</td>
</tr>
</tbody>
</table>

1 BASMAA, 1997 as in CWP, 1998; updated based on RI DEM & CRMC, 2010 and UNHSC, 2009
2 Relative effectiveness in meeting stormwater quality goals

Developers are sometimes concerned that alternative driveway surfaces are less marketable than conventional paving materials. However, the use of these alternative materials, such as permeable pavers, is being sought out by a range of customers (Ewing et al., 1996). In addition, aesthetically pleasing alternative driveways (e.g., brick pavers) are highly marketable. There is also a common misconception that alternative driveway surfaces may limit disability access. Although the Americans with Disabilities Act (ADA) requires accessible routes on firm and stable surfaces to and between public facilities, single family homes are not necessarily bound by this requirement. In addition, developers can choose to provide some houses with conventional paving and some with alternative surfaces that allow for reliable access.
Benefits Related to LID Roadway Design:

Adopting codes that limit the amount of impervious area required for roads and driveways allows for better stormwater management. When impervious area is reduced, the quantity and peak flow of runoff from a neighborhood is significantly reduced. Additionally, allowing flexibility in terms of the drainage network system (curb-and-gutter vs. open section), can help achieve a design goal of greater infiltration and water treatment at the development scale.

Decreasing the total amount of pavement, curbing, sidewalks, and storm sewer infrastructure required for a development can greatly decrease the construction costs (CWP, 1998). In addition, vegetated stormwater practices, such as bioretention areas or open channel drainage, throughout a neighborhood are less expensive than an extensive catch basin/manhole/pipe system that discharges to a larger stormwater management practice, such as a wet pond. The cost of a curb-and-gutter/storm drain pipe system is typically about 2 to 3 times more expensive than an engineered swale (SMBIA, 1990; CWP, 1998). Increased vegetation, narrower streets, destination walkways, and a variety of turnaround styles can also increase the appeal of a neighborhood, and thus, the overall value (CWP, 1998).

For example, consider a jurisdiction that requires all residential streets with one parking lane to be a minimum of 28 feet wide. If the jurisdiction adopts a new standard, 18-foot wide queuing streets, this new standard would reduce the overall imperviousness associated with a 300 foot road by 35% and construction costs by $5,000 (CWP, 1998). Recently, the City of Charleston saved $18,000 by reducing the paved width of the West Ashley Greenway from 10 feet to 8 feet (Behre, 2012).

LID Parking Guidance

Similarly to road and driveway design, impervious cover from a site or development can be reduced significantly by adjusting the design of parking areas. Some effective methods of reducing impervious area include angled parking, smaller spaces, median rather than maximum lot size, and pervious parking materials. In addition, allowing or incentivizing parking practices that decrease the amount of impervious surfaces and/or increase the stormwater management requirements can be effective. It also enhances both aesthetics and function to have features like vegetated swales, bioretention areas, depressed (rather than raised) parking lot islands, and decorative porous pavers (GCSC, 2006).

Parking is a necessity to keep our business communities viable and our residential neighborhoods safe. However, parking lots are often designed to be overly large and local codes do not always allow developers flexibility in terms of innovative approaches to parking. This section discusses planning strategies that emphasize parking efficiency and provides suggestions for reducing impervious cover.

Alternative Parking Surfaces:

Use alternative porous surfaces for parking areas and/or overflow areas where possible. In addition to reducing the parking standards, pervious materials can be used for parking areas and/or overflow parking areas to reduce the total impervious area. Pervious pavers can replace conventional asphalt or concrete, and can range from medium to relatively high effectiveness in meeting stormwater quality goals. The different types of alternative pavers include gravel, cobbles, wood mulch, brick, grass pavers, turf blocks, natural stone, pervious concrete, and porous asphalt, and are outlined in Driveway Design (SMRC, 2010; RI DEM & CRMC, 2010). Figure 3.3-5 depicts some local examples of alternative parking surfaces along the coast.
Parking Ratios:

Parking ratios should be based on average demand rather than on projected peak demand. The general perception regarding parking requirements is that the public’s interest is best served by adopting a conservative approach to minimize the likelihood of an undersupply of spaces. In an effort to provide more than enough parking to satisfy the public’s need, local planners have traditionally relied upon minimum parking ratios as the primary tool to regulate parking. Parking ratios are set by local communities and express the number of parking spaces that must be provided for a particular use (e.g., one space per 1,000 square feet of commercial space; one space per three seats for restaurants; or two spaces per bed for hospitals). Parking ratios typically represent the minimum number of spaces needed to accommodate the highest hourly parking during the peak season at the site (Wells, 1994).

However, these ratios are not typically derived from an analysis of local parking needs, but rather from those of neighboring communities or from the parking generation rates and standards that are published by the Institute of Transportation Engineers (ITE) which may or may not apply well in local situations. Table 3.3-8 illustrates the discrepancy between parking ratio and actual parking demand for some typical land uses.

<table>
<thead>
<tr>
<th>Land Use</th>
<th>Typical Minimum Parking Ratio</th>
<th>Typical Range</th>
<th>Actual Average Parking Demand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single Family Homes</td>
<td>2 spaces per dwelling unit (d.u.)</td>
<td>1.5 – 2.5</td>
<td>1.11 spaces per d.u.</td>
</tr>
<tr>
<td>Shopping Center</td>
<td>5 spaces per 1,000 sq ft GFA²</td>
<td>4.0 – 6.5</td>
<td>3.97 per 1000 sq ft GFA</td>
</tr>
<tr>
<td>Industrial</td>
<td>1 space per 1,000 sq ft GFA</td>
<td>0.5 – 2.0</td>
<td>1.48 per 1,000 sq ft GFA</td>
</tr>
<tr>
<td>Medical/Dental Office</td>
<td>5.7 spaces per 1,000 sq ft GFA</td>
<td>4.5 – 10.0</td>
<td>4.11 per 1,000 sq ft GFA</td>
</tr>
</tbody>
</table>

¹CWP, 1998
²Abbreviated GFA refers to the gross floor area of a building, without storage and utility spaces.
When tailoring parking standards, communities should consider requiring a maximum parking allowance that restricts the total number of spaces at a development site. A potential strategy for setting a maximum parking allowance is for each community to consider using its current minimum parking ratio as the new maximum requirement, as was done several years ago in the Town of Exeter, RI. However, in many cases, these allowances could still be too high and each community will need to tailor these maximums through discussions with their planning and permitting agencies to get a sense of what is appropriate in each district (RI DEM & CRMC, 2011).

Another common misconception regarding parking supply is that large supplies of ample free parking are necessary for business viability. In fact, overdevelopment of parking areas consumes valuable developable land area and decreases potential tax revenue. Optimizing the amount of

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### Minimizing Parking Case Study:
**City of Greenville, SC**

Smaller lots make better use of available land, improve water quality, and save money. Upstate Forever, Furman University, and the City of Greenville conducted a study of commercial parking lots to determine the optimal number of parking spaces for different uses. Researchers used aerial photography and on-the-ground monitoring of 120 commercial parking lots during peak and non-peak hours. The study concluded that there was an excess of off-street parking, with up to 65% of parking spaces empty during peak hours.

<table>
<thead>
<tr>
<th>Land Use</th>
<th>Peak Parking Occupancy</th>
<th>Excess Parking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grocery Stores</td>
<td>35%</td>
<td>65%</td>
</tr>
<tr>
<td>Other Restaurants</td>
<td>39%</td>
<td>61%</td>
</tr>
<tr>
<td>Discount/Dept. Stores</td>
<td>45%</td>
<td>55%</td>
</tr>
<tr>
<td>Pharmacies</td>
<td>45%</td>
<td>55%</td>
</tr>
<tr>
<td>Medical Facilities</td>
<td>52%</td>
<td>48%</td>
</tr>
<tr>
<td>Offices</td>
<td>58%</td>
<td>42%</td>
</tr>
<tr>
<td>Drive-thru Restaurants</td>
<td>58%</td>
<td>42%</td>
</tr>
<tr>
<td>Shopping Centers</td>
<td>63%</td>
<td>37%</td>
</tr>
<tr>
<td>Health Clubs</td>
<td>74%</td>
<td>26%</td>
</tr>
</tbody>
</table>

Based on the findings from the study, the city of Greenville adjusted its parking requirements. For example, the parking requirement for a medical facility was reduced from 5 spaces per 1,000 square feet to 1.7 spaces per 1,000 feet. The change resulted in a reduction of 3.3 spaces per 1,000 square feet and represents an approximate $6,000-$18,000 cost savings for the developer. Under the current code, developers have two options: 1) install the minimum parking spaces required in the new policy or 2) use LID practices to manage the stormwater generated by parking spaces over the minimum requirement. Upstate Forever is working with the City of Greenville to create a third alternative in which developers would pay a fee in-lieu of using LID. This new revenue stream will fund local clean water projects.
active commercial space should be the priority for designated growth areas. Excessive parking requirements would be one of the most influential obstacles toward achieving that goal. Further discussion of fiscal impacts associated with excessive parking requirements can be found in Litman (2006).

**Shared and Off-Site Parking:**

Parking requirements should be flexible and include shared off-site parking allowances under certain development scenarios. It can be a challenge for businesses to deal with excess parking demand, especially during peak periods. Often, excess demand is a perceived problem. Several studies have documented that occupancy rates tend to be lower than expected, even during peak periods. For example, the City of Olympia found that in 18 out of 31 sites had less than 75% occupancy during peak periods (Wells, 1994). The Center for Watershed Protection BSD guide discusses how to allow and incentivize shared parking, model shared parking agreements, and reduce parking ratios if shared parking is in place (2013, page 16).

For situations where excess demand does occur, creative solutions can mitigate the problem. For example, the businesses in the Avondale district of Charleston, SC share valet service to deal with peak demand (Thursday through Saturday night). Parking issues in adjacent neighborhoods required them to contract with a valet service and nearby businesses that are open during the day only – such as banks and retail stores – to use their parking as valet spaces at night.

As discussed in the *Parking Ratios* section, parking lots are often designed based upon pre-established ratios for each land use, without taking into account whether adjacent land uses can share parking areas. This type of shared parking can significantly reduce the number of required parking spaces needed by allowing adjacent land uses to share parking lots. This arrangement is possible when peak demands for the adjacent land uses occur at different times during the day or week. For example, many businesses or government offices experience their peak business hours during the daytime on weekdays, while restaurants and bars peak in the evening hours and on weekends. This presents an opportunity for shared parking arrangements where several different groups can use an individual parking lot without creating conflicts.

Table 3.3-9 shows a typical approach to calculating shared parking requirements and illustrates that a simple peak demand analysis can significantly reduce the combined requirements for office and retail use shared parking. In this example, the combined minimum requirements are 370 spaces, while the demand analysis shows an actual requirement of 286 spaces: 23% less than required.

Nonetheless, regulations in most communities require all new development and redevelopment to provide all parking on-site. This can make it difficult, if not impossible, for many redevelopment sites and compact mixed use centers to comply with conventional on-site parking demands.

An integral piece to providing adequate flexibility within parking regulations involves allowing on-site parking requirements to be met through off-site facilities. These off-site allowances are particularly important in redevelopment sites and compact mixed use centers, where lot geometry and pre-existing development patterns can make it impossible for existing structures to comply with conventional on-site parking demands. Allowing business owners to negotiate with each other across property boundaries encourages a more integrated private sector approach and a much more efficient use of land. Recommended zoning provisions for off-site parking include the following:
 Establishment design standards that require well-marked, safe pedestrian travel paths from the parking lot to the target site (e.g. improvements to sidewalks, lighting, crosswalks, and crossing signals between the site and pedestrian and vehicular access points at the off-site parking location).

- Establish a maximum distance that the parking lot may be from the target site. Typical values range from 350 – 1,000 feet (walking distance).

- Reduce parking ratios for shared parking and provide a model shared parking agreement.

- Finally, a condition of any approval should be a legally defensible agreement between property owners that guarantees access to the parking lot, outlines any shared maintenance agreements, and addresses issues of shared liability.

<table>
<thead>
<tr>
<th>Table 3.3-9. Example Shared Parking Calculation</th>
<th>Office Use</th>
<th>Retail Use</th>
<th>Shared</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Minimum Parking Required</td>
<td>Percentage of Parking Required</td>
<td>Adjusted Parking (actual spaces needed)</td>
</tr>
<tr>
<td>Weekday Daytime</td>
<td>160</td>
<td>100%</td>
<td>160</td>
</tr>
<tr>
<td>Weekday Evening</td>
<td>160</td>
<td>10%</td>
<td>16</td>
</tr>
<tr>
<td>Weekend Daytime</td>
<td>160</td>
<td>10%</td>
<td>16</td>
</tr>
<tr>
<td>Weekend Evening</td>
<td>160</td>
<td>5%</td>
<td>8</td>
</tr>
<tr>
<td>Nighttime</td>
<td>160</td>
<td>5%</td>
<td>8</td>
</tr>
</tbody>
</table>

1RI DEM & CRMC, 2011, Adapted from Montgomery County, MD

**Stall and Aisle Geometry:**

Typical dimensions for a parking stall, or space, are up to 10 feet wide and 20 feet long. The parking aisle refers to the travel lane within a parking facility that allows for cars to reach the parking stalls. Parking aisles are typically 12 feet wide and parking facilities normally have two-way traffic resulting in 24 feet of travel space between opposing parking stalls.

A minor reduction in parking stall dimensions can result in a significant impact on the overall size of a parking lot and impervious area. Reducing stall dimensions to 9 feet wide and 18 feet long would result in a 28% reduction in the stall area. Additionally, encouraging one-way aisles in conjunction with angled parking can reduce the amount of aisle space needed to access each stall, as shown in Figure 3.3-6. Another option is to allow for a portion of parking lots to be comprised of compact car spaces. Compact car spaces can be provided as 8 feet by 16 feet stalls.

One of the major challenges in addressing the dimensional standards of parking stalls and aisles is the perception that larger vehicles will not fit into smaller parking stalls. Many communities fear
that limiting stall and aisle dimensions will result in deteriorated parking conditions. However, this perception does not often meet with reality as the majority of larger vehicles, such as sport utility vehicles (SUVs) and vans can comfortably fit into smaller stalls without the risk of damaging other vehicles or conflicting with pedestrian needs (CWP, 1998). Additionally, trends in auto sales show that Crossover Utility Vehicles (CUVs) are becoming a more popular alternative to compact cars than SUVs. In 2012, they were the largest segment of auto sales at 23.8% compared to 7.2% for SUVs (AAM, 2013). CUVs are built on car platforms so they are more easily able to fit into parking spaces designed for cars.

Parking Lot Landscaping:

Parking lot landscaping standards should allow applicants to include LID techniques for managing stormwater runoff. While many communities require parking lot landscaping, they do so in a manner that supports aesthetics and tree canopy cover, but not always in a manner that supports stormwater management. For example, many communities require a certain number of landscaped islands per parking space or a specific spacing of trees within the lot. Providing mechanisms in ordinances for LID treatment practices will allow designers to create systems that are tailored to the unique geometry and topography of a given lot.

LID stormwater practices such as vegetative swales and bioretention basins exhibit unique design characteristics that can be difficult to fit into a regimented landscaping formula. The following are recommended innovative approaches to parking lot landscaping:

- Use vegetative swales to direct stormwater into shallow bioretention areas that temporarily detain the water and allow for partial infiltration while pre-treating the remaining stormwater before it is discharged into waterways.
- For parking lots of 10 or more spaces, require that 10% of the parking lot area be dedicated to landscaped areas that can include LID stormwater practices. A more detailed discussion of landscaping practices and plant selection is provided in the LID Landscaping guidance in this chapter.
- Mandate landscaping within parking areas to “break up” pavement at fixed intervals. However, it is important to provide relief from these frequencies when a developer wishes to use landscaping as part of stormwater management practices so they have the flexibility necessary to site and design vegetated BMPs adequately.
 Require a minimum amount of tree canopy coverage over on-site parking lots. Many municipalities use this standard for aesthetics and to mediate the urban heat island effect. Requirements generally range between 25% and 30% canopy coverage.

The Fort Bragg (North Carolina) vehicle maintenance facility parking lot is an excellent example of the benefits of rethinking parking lot design (NRDC, 1999). The redesign incorporated stormwater management features such as detention basins located within grassed islands and an on-site drainage system that took advantage of existing sandy soils. The redesign reduced impervious cover by 40%, increased parking by 20%, and saved 20% or $1.6 million on construction costs over the original, conventional design.

![Figure 3.3-7. Conventional Parking Lot Layout](RI DEM, 2011)

Conventional parking designs clear the entire site, that later needs to be revegetated, and creates one massive area for parking.

![Figure 3.3-8. Parking Lot Layout Using LID Techniques](RI DEM, 2011)

The LID design leaves undisturbed buffers of native vegetation, incorporates landscaped islands that treat stormwater, and disperses the parking into smaller areas.
**Summary of Benefits Associated with LID Parking:**

Adopting codes that limit the amount of parking spaces required for land development activities and provide flexibility in design can contribute greatly to better stormwater management. By reducing the number and size of required spaces, more flexible parking standards can reduce the amount of impervious area for both residential and non-residential development.

Zoning ordinances that require excessive amounts of parking for non-residential use are one of the primary causes of commercial sprawl. These developments miss a significant economic potential and can fall short of meeting the tax base needs of their host communities (Litman, 2006). Providing flexible parking standards is one of the more important tools for optimizing the economic potential of non-residentially zoned land.

Finally, reducing parking requirements and enhancing design standards for parking areas can help shape a community’s character. LID parking design contributes to the revitalization of commercial areas and their overall aesthetic appeal. Replacing vast unbroken expanses of asphalt with smaller, well-landscaped parking areas provides a much more appealing development style and enhances the designer’s ability to provide more organized traffic patterns and speeds, as well as pedestrian connectivity (see Figures 3.3-7 and 3.3-8).

**LID Landscaping**

Many South Carolina counties and municipalities in the Coastal Zone provide landscaping requirements and guidelines as part of their Land Development Ordinances. However, the requirements for location, spacing, size, and maintenance for street trees, planting and screening can vary significantly from one community to the next. Some communities reference LID guidelines and require project proponents to demonstrate LID practices, but lack specificity with respect to soil amendments, preservation of natural vegetation, or utilization of native species. Additionally, landscaping ordinances tend not to document the potential negative impacts of highly fertilized and irrigated turf areas or limit the allowable amount of turf on an applicant’s project.

In order to protect water resources, coastal South Carolina communities should develop and adopt an LID Landscaping section in their land development regulations that specifically addresses the link between a functional landscape and the protection of water resource quality.

Landscaping requirements and objectives vary as a function of land use and activity. Residential landscape requirements need to be different from commercial, industrial, or institutional requirements. Project location and density also need to be considered, as the type of plantings and other landscape features within an urban shopping center will be different from a suburban subdivision. Furthermore, LID Landscaping should include various types of landscaped and vegetated areas (see Figure 3.3-9 for an example):

- Residential lots of varying size
- Open space areas
- Recreational areas
- Drainage features, such as swales and stormwater management practices
- Project entrance features
Buffer areas from “improved” site areas to water resources (e.g., streams, wetlands, coastal shoreline features)

- Areas disturbed for utility construction and easements
- Plazas, parking lots, sidewalks, and building planters
- Streets, roads, and cul-de-sacs
- Planting requirements, densities, soil amendments, and requirements for each land use, density and location category
- Street signage and street/courtyard furniture

It is important to distinguish between “typical” landscaping, such as vegetation in the medians in a parking lot, and LID landscaping, such as vegetation in bioretention used to treat stormwater in a parking lot. First, the landscape and maintenance crews should determine if the area is used for stormwater management. This can be accomplished through the following techniques:

Ask the property owner and/or property manager:

1. Assess the site for common stormwater features such as inlets and outlet structures
2. Consult site plans
3. Consult a stormwater professional, such as a landscape architect or professional engineer

If the area in question is part of an LID stormwater treatment practice, please refer to the guidelines in Chapter 4 or Appendix F for specific maintenance guidance. Also, the Chesapeake Stormwater Network and Center for Watershed Protection have created short (~15 minute) videos for LID Stormwater Construction Practices and Stormwater BMP & LID Maintenance that include landscaping tips in the context of LID construction and maintenance. These videos are available in English and Spanish and available online at: http://www.youtube.com/user/CenterforWatershed?feature=watch.

The property manager and/or owner should communicate before, during, and after landscaping at an LID site to ensure the proper maintenance occurred. Improper maintenance can lead to LID failure and water pollution impacts. However, proper maintenance will ensure the LID functions as designed for the expected lifetime of the practice.

There are many factors to consider when creating a low impact landscape. The Sustainable Sites Initiative, a collaborative project of the American Society of Landscape Architects, Lady Bird Johnson Wildflower Center, and the United States Botanic Garden, seeks to establish and encourage sustainable practices in landscape design, construction, operations, and maintenance. Table 3.3-10 describes some design, construction, and maintenance factors to assess a holistic low impact landscape design.
## Table 3.3-10. Summary of Sustainable Landscaping Practices

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Suggested landscaping practices</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Site Selection</strong></td>
<td>♦ Protect floodplain functions</td>
</tr>
<tr>
<td></td>
<td>♦ Preserve wetlands</td>
</tr>
<tr>
<td></td>
<td>♦ Preserve threatened or endangered species and their habitats</td>
</tr>
<tr>
<td></td>
<td>♦ Select brownfields or greyfields for redevelopment</td>
</tr>
<tr>
<td></td>
<td>♦ Select sites within existing communities</td>
</tr>
<tr>
<td></td>
<td>♦ Maintain natural, undisturbed areas</td>
</tr>
<tr>
<td><strong>Site Design – Water</strong></td>
<td>♦ Reduce potable water used for landscape irrigation</td>
</tr>
<tr>
<td></td>
<td>♦ Protect and restore riparian, wetland, and shoreline buffers</td>
</tr>
<tr>
<td></td>
<td>♦ Maintain water features to conserve water and other resources</td>
</tr>
<tr>
<td></td>
<td>♦ Minimize stormwater runoff</td>
</tr>
<tr>
<td></td>
<td>♦ Use alternative paving materials that promote infiltration of precipitation and maximize solar reflectance (albedo)</td>
</tr>
<tr>
<td><strong>Site Design – Soil and Vegetation</strong></td>
<td>♦ Control and manage known invasive plants found on site</td>
</tr>
<tr>
<td></td>
<td>♦ Use appropriate, non-invasive plants and native plants</td>
</tr>
<tr>
<td></td>
<td>♦ Create a soil management plan</td>
</tr>
<tr>
<td></td>
<td>♦ Minimize soil disturbance in design and construction</td>
</tr>
<tr>
<td></td>
<td>♦ Preserve or restore appropriate plant biomass on site</td>
</tr>
<tr>
<td></td>
<td>♦ Preserve or restore appropriate plant communities native to the ecoregion</td>
</tr>
<tr>
<td></td>
<td>♦ Use vegetation to minimize building heating and cooling requirements</td>
</tr>
<tr>
<td></td>
<td>♦ Reduce urban heat island effects</td>
</tr>
<tr>
<td></td>
<td>♦ Reduce the risk of catastrophic wildfire</td>
</tr>
<tr>
<td><strong>Site Design – Materials Selection</strong></td>
<td>♦ Reuse salvaged materials and plants</td>
</tr>
<tr>
<td></td>
<td>♦ Use recycled content materials</td>
</tr>
<tr>
<td></td>
<td>♦ Use regional materials</td>
</tr>
<tr>
<td></td>
<td>♦ Support sustainable practices in plant production and materials manufacturing</td>
</tr>
<tr>
<td><strong>Site Design – Human Health and Well-Being</strong></td>
<td>♦ Protect and maintain unique natural, cultural and historical places such as shell rings, Carolina Bays, tabby structures, and cemeteries</td>
</tr>
<tr>
<td></td>
<td>♦ Provide views of vegetation and outdoor spaces for mental restoration</td>
</tr>
<tr>
<td><strong>Construction</strong></td>
<td>♦ Restore soils damaged by previous development</td>
</tr>
<tr>
<td></td>
<td>♦ Reuse or recycle vegetation, rocks, and soil generated during construction</td>
</tr>
<tr>
<td><strong>Operations and Maintenance</strong></td>
<td>♦ Compost organic matter generated during site operations and maintenance</td>
</tr>
</tbody>
</table>

1Adapted from the Sustainable Sites Guidelines and Performance Benchmarks 2009
Benefits of LID Landscaping:

Landscaping, which includes both vegetation and hardscaping, affects stormwater quantity and quality. Landscaping that incorporates LID strategies for stormwater management should absorb and treat stormwater runoff and pollutants to the greatest extent possible on-site. LID landscaping includes the use of vegetated practices and other features that use soil to mimic natural hydrologic features and functions. The following benefits are likely derived from implementing LID landscaping techniques (RI DEM & CRMC, 2011; SCDHEC-OCRM, no date):

1. **More effective stormwater management and water quality treatment.** Vegetation can reduce the amount of stormwater pollution in receiving waterbodies by capturing sediment, nutrients, and chemicals. Vegetation slows the velocity of runoff and helps reduce erosion.

2. **Reduced demand for irrigation and use of potable water supplies.** Once established, native vegetation requires minimal supplemental irrigation. Native plants can attain the moisture they need from normal rainfalls, but a 1,000 square foot lawn requires 10,000 gallons of water per summer to keep it green (SCNPS, 2014). Additionally, the high organic content of the soils encourages healthy growth, absorbs and retains rainwater on site as soil moisture, and minimizes irrigation demands and generation of runoff.

3. **Fewer chemical inputs.** Native plant communities are more resistant to drought and require less fertilizers, pesticides, and herbicides if planted in native soils. In-situ soils are often stripped during development, which causes both native and non-native plants to struggle.

4. **Save money.** Native plant communities can be less costly to maintain and manage because they do not require frequent mowing or chemical inputs (fertilizers and herbicides).

5. **Improve site aesthetics.** Naturalized landscapes may be more enjoyable due to the comfort of shade from trees and the opportunities for recreation activities such as bird watching.

6. **Carbon sequestration.** Carbon is stored in biomass (branches, foliage and roots) and soils when trees, grasses and other plants take up atmospheric carbon dioxide through photosynthesis.

General Standards:

The selection and location of turf, trees, ground cover (including shrubs, grasses, perennials, and flower beds), pedestrian pavement, and other landscaping elements should be used to absorb rainfall, prevent erosion, and meet the functional and visual goals of these standards. Examples of functional and visual goals include defining spaces and directing circulation patterns. Where possible, the landscaping design should combine form and function, invisibly incorporating drainage features into the landscape through applications like shallow surface drainage areas and parking lot islands.

Landscaping should be designed to remain functional and attractive during all seasons of the year through a thoughtful selection of deciduous, evergreen, flowering and non-flowering plant varieties. Prominent natural or man-made features of the landscape such as mature trees, surface waters,
or roadways should be retained and incorporated into the landscape plan where possible. The addition of new features, such as ornamental rocks or fencing, is encouraged. One example of a landscape feature is a Carolina Fence™ Garden (SCWF, 2014), which has been designed to include both natural and cultural state symbols of South Carolina: split rail fence, blue granite, Carolina Wren house, and native plants.

Existing, undisturbed natural areas should be maintained to the maximum extent practical; for example, a minimum of 25% of the lot for single-family homes and 15% for multi-family residential areas (RI DEM & CRMC, 2011). Depending on local ordinances, it may be possible to count existing trees and shrubs retained post-construction for any compatible required plantings. Natural re-growth, mulched planting beds, and alternative groundcover plant varieties are preferred. Lawn areas should be kept to a minimum; however, lawns less than six feet in width, especially adjacent to roads or parking areas, are discouraged since such areas require watering and maintenance, but have little utility and are less likely to thrive (RI DEM & CRMC, 2011).

Less hardy, exotic, or higher maintenance plant varieties may be used to supplement minimum landscaping requirements where appropriate, but are not encouraged. Exotic, invasive species should never be planted and should be removed from the site if they are found pre-development.

- The South Carolina Exotic Pest Plant Council (SC-EPPC) maintains a list of unacceptable exotic invasive vegetation, including English ivy, bamboo, and ligustrum. For more information, please see [http://www.se-eppc.org/southcarolina/invasivePlants.cfm](http://www.se-eppc.org/southcarolina/invasivePlants.cfm).

Parking lots should have formal planting areas designed as bioretention areas or swales that accept and treat parking lot runoff. The swales and bioretention areas should contain a mixture of woody and herbaceous material. When curbs are utilized around parking lot bioretention or swale areas, they should have a shallow descending cut to allow drainage to flow from the parking lot into the curbed planting areas for infiltration. See Section 4.2 Bioretention in this manual for design criteria.
Disturbed areas intended for natural re-growth should be, at a minimum, graded, loamed, and seeded with wildflowers, perennial grasses, or similar varieties. The planting of native trees, shrubs, and other plant varieties is encouraged. The planting of native shrubs such as blueberry \((Vaccinium sp.)\), wax myrtle \((Myrica cerifera)\), native azaleas \((Rhododendron sp.)\), American beautyberry \((Callicarpa americana)\), and yaupon holly \((Ilex vomitoria)\) along the edge of cleared woodlands provides for an attractive transition between natural woodland and more formally landscaped portions of a site.

Where woodland areas are intended to serve as buffers (see Figure 3.3-10), such plantings can fill in voids by rapidly reestablishing undergrowth. Perennial flower beds are also encouraged (RIDEM, 2011).

**Soil Preparation:**

The soils of the Coastal Plain are composed of marine sediments deposited during the millions of years (Eocene Period to present day) it took the Atlantic Ocean to recede from the “fall line” to its current location. Generally, these soils are sandy loams or loamy sands with a fine texture and high clay content. The soils tend to be acidic, have high levels of phosphorus, and are low in cation exchange capacity (CEC) and organic matter content (Polomski, 2007).

Site soil characteristics can modify stormwater runoff and treatment. Topsoil is the uppermost horizon of undisturbed soils and is generally assumed to be about 6 to 8 inches deep. This is the region of maximum biological activity in the soil profile. Eighty percent of the roots are located here, along with a diverse mixture of bacteria, fungi, and other living organisms such as earthworms, insects and moles. The topsoil is also where the majority of nutrient cycling occurs when leaves, twigs, roots and other organisms decompose (Polomski, 2007). The loss of good quality topsoil from sites during construction results in significant increases in runoff quantities; post development, these sites often have compacted soil that mimics impervious cover. This is because the soil horizons underneath topsoil typically have a higher clay content. Additionally, removing topsoil reduces the amount of organic material in soils – which have the ability to absorb many pollutants. In fact, peat and compost provide considerable pollutant removal and are used in various treatment strategies (RIDEM, 2011). See Appendix C for more information about compost amendments for soils.

Soil analysis of new or renovated turf areas provides a determination of soil characteristics, including: percentage of organic matter, approximate soil infiltration rate, and pH. At a minimum, soil testing should be conducted before any planting occurs to establish a fertilization plan and make any necessary amendments. Soil testing is provided, for a fee, by professional geotechnical companies or Clemson University Cooperative Extension service. See Clemson Cooperative Extension's Home & Garden Information Center Factsheet 1652 for more information: http://www.clemson.edu/extension/hgic/plants/pdf/hgic1652.pdf.

Soil amendments, when instituted with landscaping, will likely result in increased water conservation, increased nutrient retention, better aesthetics, reduced use of chemicals, and cost-savings to the private property owners and municipalities (RI DEM & CRMC 2011). Use of soil amendments is encouraged to improve water drainage, moisture penetration, soil oxygenation, and/or water holding capacity. Soil amendments are organic matter such as compost, mulch, and forestry by-products, but do not include topsoil or any mix with soil as an element. Incorporation of organic matter such as compost improves the structure of the soil. In sandy soils, compost increases the water holding capacity and nutrient retention. The physical and chemical properties of most soils can be improved significantly by blending in compost. Compost should be well-aged (6-12 months) and
well-aerated. Turf grass shall not be utilized for compost since it can have significant levels of pesticides, herbicides, or nutrients. The quantity of compost to be incorporated into a site is determined by the final organic content goal for the soil and is dependent on its existing organic content – a soil test will help determine the appropriate amount to add to existing soils. Please see Appendix C for more information related to soil compost amendments.

Compacted soils restrict root penetration, impede water infiltration, have a higher runoff coefficient, and contain few macropore spaces needed for adequate aeration. Generally, an ideal soil for plant growth is about equally divided between solid materials and pore space on a volume basis, and the pore space is equally divided between air-filled and water-filled pores (Polomski, 2007). Avoiding construction activities on parts of the site will help prevent compaction. In areas where this is not practical, methods to compensate for the compaction shall be employed. To facilitate deep water penetration and soil oxygenation, landscape areas should be deep tilled to a depth of at least 12 inches to restore soils that are compacted during construction.

Existing topsoil should not be removed during construction, but should be stockpiled on site and reused in landscaped areas to promote the retention of native seed stocks and soil microbes. However, properties with existing invasive plant species require some additional precautions. It is possible for invasive plants to sprout from vegetative cuttings associated with land disturbing activities, as well as germinate from soil seed banks for many years after removal. Property managers should disturb as little soil as possible to prevent vegetatively propagating pest plant species, and the invasive plants should be removed as they develop.

For newly landscaped areas where topsoil is limited or nonexistent, or where soil drainage is impeded due to subsurface hardpan, a minimum of six inches of sandy loam topsoil should be spread in all planting and turf areas. This should be in addition to the incorporation of organic matter into the top horizon of the imported soil.

**Mulching:**

Mulch for areas not used for drainage should be applied regularly and maintained in all planting areas to assist soils in retaining moisture, reducing weed growth, and minimizing erosion. Mulches can be organic, inorganic, or synthetic. Organic mulches include materials such as pine straw and shredded hardwood bark. As they decompose, organic mulches add valuable nutrients to the soil. Inorganic mulches include materials such as decomposed lava rock, cobble, and gravel. Synthetic mulches include rubber pellets, plastic sheets or geotextile fabrics. It is important to note that the use of plastic warms the soils, which can be an advantage in the spring or detrimental in the summer (Polomski, 2007).

Mulches for stormwater management areas should be well-aged (6 months) hardwood mulch also known as “triple shredded mulch” (NCDENR, 2009) and applied to maintain a depth of 2 to 3 inches. Hardwood mulches tend to stay in place, whereas softwood mulches are more likely to float away during storm events. This is a twofold issue where softwood mulch use means a loss of function (i.e., mulch lost) and added organic material to the stormwater piped system (i.e., added gross solid pollutant load).
Vegetation:

Turf areas produce considerably more runoff due to compaction and more pollutant contribution, due to the frequently-occurring overuse of fertilizers and pesticides, as well as excessive irrigation. For example, lawn area in residential development shall be limited to 20% of the overall lot size or 5,000 square feet, whichever is less (RIDEM 2011). Generally, some turf area should be included, but not an expansive monoculture. A more desirable landscape is diverse and provides wildlife habitat, shade, and beauty along with small scale turf areas. As an alternative to lawn, landscape strips should be mulched or planted with native groundcover plant varieties. The South Carolina Native Plants Society provides guidance on reducing lawn size and incorporating native grasses into landscapes in this fact sheet: http://scnps.org/wp-content/uploads/2012/04/SCNPS_AlternativeLawns.pdf.

Using herbaceous and woody native plants is recommended in landscaping and LID BMPs. This category of vegetation helps preserve the beauty and identity of indigenous ecosystems while providing valuable stormwater treatment services. Native plants are species that have an evolutionary history with the biological and physical factors specific to a region. Because native plants are adapted to local soils, insects, and climate conditions, they generally require less watering, pesticides and fertilizing than non-natives do. Plant varieties selected should be salt tolerant where appropriate, drought resistant, able to withstand the moisture regime of its planting location (e.g. upper bank versus bottom of a bioretention unit), and require minimal maintenance. Education and guidance for plant selection in the coastal zone is provided by Clemson’s Carolina Yards Program and the South Carolina Native Plant Society (http://scnps.org). SCNPS has two local chapters in the coastal zone: Lowcountry (Charleston area) and South Coast (Beaufort & Hilton Head). For more information, please see

- The Clemson Carolina Yards program plant list is available at www.clemson.edu/cy/plants.

Installation Recommendations:

- Planting Specifications should follow recommendations from Clemson University Cooperative Extension (http://www.clemson.edu/extension/hgic/plants/pdf/hgic1001.pdf):
  - Areas intended as planting beds for shrubs or hedges shall be cultivated to a depth of not less than 18 inches. All other planting beds shall be cultivated to a depth of not less than 12 inches.
  - Holes for planting trees or shrubs shall be at least twice and preferably up to five times wider than the root ball. Locate the topmost layers of roots in the root ball so that they will be level with the surrounding soil surface; check that there is not an excess layer of soil already covering the root ball. Never place the rootball on loosened soil, as it will settle over time and cause the plant to sink too deep. In poorly drained or compacted soil, the plant should be placed about 2 to 4 inches above the surrounding soil (Polomski & Shaughnessy, 2004).
• Cultivated areas shall be covered with a 2- to 4-inch deep layer of mulch after planting. To reduce chances of stem rot and insect damage, do not allow mulch to touch the stem or trunk (Polomski & Shaughnessy, 2004). Replenish mulch as needed to maintain depth or desired appearance.

• Little if any pruning should be required at the time of transplant from container to ground. All broken or damaged branches should be removed. Trees with poor structure should be pruned at planting to correct the problem (Polomski & Shaughnessy, 2004).

• All plants should be nursery-grown native or low-maintenance species. No invasive species are permitted as per the list kept by the South Carolina Exotic Pest Plant Council (http://www.se-eppc.org/southcarolina/).

❖ Retention of Existing Natural Vegetation

• The boundary of areas to be cleared should be well defined in the field with tree markings, construction fencing or silt fencing as appropriate to avoid unnecessary cutting or removal.

• Care should be taken to protect root systems from damage due to excavation or compaction. Maintain the tree protection barrier, noting that impacts from soil compaction are often not evident for years.

• Individual trees and other landscape features to be retained should be clearly marked and bounded in the field.

**Maintenance:**

Many maintenance problems can be avoided by growing healthy plants in appropriate soil conditions. Ideally, soil testing should be conducted prior to planting and about once a year afterward to monitor any changes. Additionally, selecting low maintenance, drought-, insect-, and disease-tolerant plant varieties is encouraged so that buffer areas and other required landscaping can be maintained with minimal care (e.g. watering, pesticides, or fertilizers). For these reasons, native species are preferred since such plant species are well adapted to the local environment.

Generally, one inch of water is required per week for most plants; this includes both irrigation and rainfall inputs. If the irrigation system is on a timer, consider attaching a rain shut off device so the system will not run when it is raining. Organic matter, such as compost or peat, should be added to the soil before planting to increase the water holding capacity of the soil and to provide nutrients. Thus, the addition of organic material will help avoid maintenance problems and the need for excessive watering. Irrigation systems should be used only as needed. They can be installed with moisture meters or other devices designed to avoid unnecessary or excessive watering. Alternatively, irrigation systems can be manually operated. Whenever possible, less frequent, longer applications of irrigation are preferred as they promote deep root growth essential for plant survivability.

On an as-needed basis, repair any eroded areas and remove sediment, leaves, and debris from landscaping and LID BMPs. Pruning should only be necessary to remove damaged or diseased limbs or for ornamental reasons determined by the property owner. Take into consideration the mature height and spread of a plant before selecting a location to place it. A property owner will have to prune shrubs and trees more regularly if they have grown too large for their environment – for example, under telephone wires or too close to other structures.
Use mulch and dense plantings (taking advantage of groundcovers) to reduce the amount of required weeding. Once plants become established and have a suitable mulch cover, the amount of weeding should decrease over time. A factsheet for mulching (HGIC 1604) is available at Clemson’s HGIC website: [http://www.clemson.edu/extension/hgic/plants/other/compost_mulch/hgic1604.html](http://www.clemson.edu/extension/hgic/plants/other/compost_mulch/hgic1604.html).

**Perceptions and Realities:**

Some misconceptions that have limited the use of LID landscaping are included in Table 3.3-11.

<table>
<thead>
<tr>
<th>Perception</th>
<th>Realities and Challenges</th>
</tr>
</thead>
<tbody>
<tr>
<td>Native plants are not available.</td>
<td>Native plants are becoming more common and typically can be ordered easily. They can be found at many local gardening centers, “big box” stores, and on the internet. As requests for native plants increase, so will the market supply.</td>
</tr>
<tr>
<td>Many landscaping contractors are less familiar with planting strategies.</td>
<td>More and more communities and organizations are offering training and education about the benefits of native plant materials, so landscaping contractors are becoming more familiar with these installations.</td>
</tr>
<tr>
<td>Some property owners prefer a more manicured appearance.</td>
<td>LID Landscaping can be designed with a more manicured look where necessary. While it is true that native species are preferred, many cultivars will work just as well and can achieve both environmental benefits as well as aesthetic appeal.</td>
</tr>
<tr>
<td>Many property owners desire lush green lawn areas and some prefer large expanses of turf.</td>
<td>The switch from a lush green lawn to a natural “xeriscapes” will require education and will not be for everyone.</td>
</tr>
<tr>
<td>Micro drainage can be difficult to get established, and minor erosion gulling prior to stabilization can be a frequent issue.</td>
<td>Careful design and – equally important – construction oversight and inspection can resolve most of these issues. Some minor gulling is to be expected prior to stabilization and will require minor repairs.</td>
</tr>
<tr>
<td>Vegetative systems require a long-term commitment to maintenance.</td>
<td>All stormwater management systems require routine and sometimes non-routine maintenance. However, vegetative systems can reduce the overall maintenance burden by maintaining infiltration capacity even in the midst of significant sediment loading.</td>
</tr>
</tbody>
</table>

Excerpted from RI DEM & CRMC, 2011
3.4 References:


45. Lord, Lisa. 22 July 2013. Personal communication.


63. SCDHEC. 2013. NPDES general permit for stormwater discharges from large and small construction activities. SCDHEC, Bureau of Water. SCR100000. Available at: http://www.scdhec.gov/Environment/WaterQuality/Stormwater/Overview/


71. SCNPS. 2014. Available at http://scnps.org


Chapter 3                       Conservation Principles and Neighborhood Site Design for Low Impact Development


