Introduction

This appendix has been prepared to provide supplemental information and further explanation of the encouraged Sustainable Design Guidelines for your neighborhood. The appendix describes techniques and their impacts on sustainability at the individual lot level, neighborhood level, and beyond. In the appendix the following topics have been emphasized:

**A. Energy**
- Solar Orientation A 4
- Solar Energy A 6
- Urban Heat Island Effect A 7
- Green roofs A 8
- Materials A 10

**B. Landscape**
- Composting A 12
- Trees A 13
- Landscaping A 15
- Irrigation and Water Conservation A 17

**C. Traffic Calming**
- Textured Pavements A 19
- Speed Tables and Crosswalks A 19
- Curb Extensions A 20
- Center Island Narrowing and Chicanes A 22
- Traffic Circles A 23

**D. Water**
- Stormwater A 26
- Engineered Soils A 28
- Pervious Pavement A 29
- Rain Garden A 30
- Bioswales A 31
- Rain Barrels A 32
- Rainwater Pillows A 33

In order to better understand the impacts and functions of various sustainable techniques, a matrix has been created. The matrix is a quick summary of the approaches and resulting benefits of the implementation of the sustainable guidelines. The matrix highlights each section and subsection of the appendix to indicate how the application of specific guidelines and techniques can contribute directly or indirectly to enhancing sustainability at the neighborhood level and on a larger scale. The techniques and suggestions which are made in the guidelines and expanded in the appendix are listed left side of the matrix. Benefits of the techniques include:

- Aesthetic Value
- Benefits Air Quality
- Conserve Water
- Enhance Soil Nutrients
- Enhance Water Quality
- Improve Safety
- Improve Walkability
- Provide Habitat
- Recharge Groundwater
- Reduce Erosion
- Reduce Greenhouse Gas
- Reduce Noise
- Reduce Stormwater Runoff
- Reduce Urban Heat Island Effect
- Reduce Waste
- Save Energy
- Save Money

To see the impacts of a technique, simply follow the cells horizontally, and every impact that applies is colored green. For example, if you apply a greenroof in your house, the benefits will include Aesthetic Value, Benefits Air Quality, Enhance Water Quality, Reduce Greenhouse Gas, Reduce Noise, Reduce Stormwater Runoff, Reduce Urban Heat Island Effect, and Save Energy.
<table>
<thead>
<tr>
<th>Techniques</th>
<th>Impacts/functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. ENERGY</td>
<td></td>
</tr>
<tr>
<td>Solar orientation of buildings and windows</td>
<td></td>
</tr>
<tr>
<td>Light shelves and roof overhangs</td>
<td></td>
</tr>
<tr>
<td>Solar PV systems</td>
<td></td>
</tr>
<tr>
<td>Rooftop materials with high solar reflectance index</td>
<td></td>
</tr>
<tr>
<td>Green Roofs</td>
<td></td>
</tr>
<tr>
<td>Materials with recycled content</td>
<td></td>
</tr>
<tr>
<td>Materials that are manufactured and distributed locally</td>
<td></td>
</tr>
<tr>
<td>Reuse of structures from an existing building</td>
<td></td>
</tr>
<tr>
<td>Recycling</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>B. LANDSCAPING</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Composting and mulch</td>
<td></td>
</tr>
<tr>
<td>Trees</td>
<td></td>
</tr>
<tr>
<td>Landscaping for energy efficiency</td>
<td></td>
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<tr>
<td>Native plants</td>
<td></td>
</tr>
<tr>
<td>Efficient irrigation</td>
<td></td>
</tr>
<tr>
<td>Xeriscaping</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>C. WALKABILITY</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Crosswalk</td>
<td></td>
</tr>
<tr>
<td>Sidewalks</td>
<td></td>
</tr>
<tr>
<td>Traffic calming</td>
<td></td>
</tr>
<tr>
<td>Speed tables</td>
<td></td>
</tr>
<tr>
<td>Curb extensions</td>
<td></td>
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<tr>
<td>Chicanes</td>
<td></td>
</tr>
<tr>
<td>Center island narrowings</td>
<td></td>
</tr>
<tr>
<td>Traffic Circles</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>D. WATER</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Bioswales</td>
<td></td>
</tr>
<tr>
<td>Engineered soils</td>
<td></td>
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<tr>
<td>Pervious pavement</td>
<td></td>
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<tr>
<td>Rain barrels</td>
<td></td>
</tr>
<tr>
<td>Rain gardens</td>
<td></td>
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<tr>
<td>Stormwater management</td>
<td></td>
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</tbody>
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A-1 Solar Orientation

The energy efficiency of a building can be increased by designing the layout of the house to complement the movement of the sun. This is called passive solar orientation. The sun's energy can be utilized both to help light a house and to heat it in the cooler months, reducing energy costs. In the warmer months, proper design can help reduce the amount of heat that enters the house, thus reducing the costs associated with cooling the house.

A-1a Buildings should be designed so that the longest side of the building faces the south and the shortest sides should face the east and west.

This allows the building to capture heat from the sun during the winter months, while blocking excess solar heat during the summer months. The best orientation of a building is to have the longest side face directly south, but the building can be oriented up to 30 degrees away from due south and still receive most of the benefits of the sun's energy.1

A-1b Large glass windows on the southern-facing wall ensure a building receives optimal solar energy in the winter to help heat the home.

A good rule is that the total surface area of windows on the south wall should account for 7% of the building's total square footage. 1

A-1c A large amount of glass surface area on the west-facing wall should be avoided.

During the warmer months, a considerable amount of the sun’s heat can enter the building and raise internal building temperature significantly, increasing cooling costs. The amount of window surface area on the western wall should not exceed 2% of the total square footage of the house. 1
Roof overhangs and light shelves should be used over southern facing windows.

This will help prevent much of the sun’s energy from heating a building during summer months, while still allowing the winter sun to enter through the window and warm the building naturally. The appropriate depth of an overhang or light shelf should be calculated to ensure proper shading during the summer and solar heat gain during the winter. The depth will depend on many variables including: latitude, climate, window size and type, and other solar factors. It is best to have an experienced solar designer or builder assist in calculations. ²

Windows and skylights can be strategically placed to take advantage of the variations in daylight availability.

Natural daylight can be used to reduce the amount of electric lighting needed to illuminate a building, this term is called ‘daylighting’. Natural light has also been shown to increase the satisfaction and visual comfort of building users. Proper window placement and design should be used to allow for natural daylight, while avoiding glare and overheating.

Windows on the north side of a building will receive the greatest amount of daylight. South-facing windows provide the second best source of daylighting, but should be protected from the intensity of the summer sun with light shelves or overhangs. The east and west sides of a house are the least desirable for daylighting because it is difficult to eliminate direct beam sunlight during the mornings (on the east side) and in the afternoons (on the west side). ³ ⁴
A-2 Solar Energy

Sunlight can be captured by electronic devices and converted into electricity. Sunlight is the most abundant and free form of energy and the process of capturing and converting the sun’s energy to electricity does not produce pollution that is common with other forms of non-renewable energy production methods (fossil fuel, nuclear energy, hydroelectric). Solar energy can be used to help reduce a building’s energy costs. Solar panel systems, also called photovoltaic (PV) systems, provide free energy to a building and they can also be connected to the electricity grid system so that any extra electricity produced will be ‘sold’ to the local electric company.  

A-2a Solar PV systems can be installed on the roofs of buildings to capture the sun’s energy and convert it to electricity.

Several different solar cell technologies exist that allow solar PV systems to come in a variety of styles:

- Traditional solar cells are typically flat-plate panel PV systems and are the most efficient. A typical residence will require about 10-20 solar panels to power the home. To best capture sunlight, panels are typically mounted so that they face the south. Panels can also be mounted on a tracking device that will follow the movement of the sun. These devices allow for the greatest amount of the sun’s energy to be captured.

- Thin-film solar cells allow the solar PV system to be incorporated into rooftop shingles, tiles and even glazing for skylights. These PV systems are less obvious than panels because they lie flush with the roof surface.

When installing solar PV systems, variables to consider include the tree cover, as well as other shade characteristics of the site.  

Illustration of a solar panel system on a residential home.
Urban Heat Island Effect

‘Heat island’ is a term that is used to describe developed areas that are warmer than more rural areas. Materials used in horizontal surfaces such as rooftops and paved surfaces can absorb or reflect the sun’s energy. In developed areas with a lot of man-made horizontal surfaces, the temperature is often warmer than in nearby less developed areas as a result of materials that absorb the sun’s energy. 7

Roads and parking lots can also contribute significantly to the ‘urban heat island effect.’ Planting trees that provide shade to the paved area will protect the paved surface from the sun. This will reduce the amount of heat and also prolong the life of the paved surface. 8 For more information on trees and the urban heat island effect, reference B2-f in Section B (Landscape) of the appendix.

Rooftop materials that can both reflect the sun and release heat back out to space can reduce individual energy costs by lowering heat gain indoors and on a larger scale, can help prevent the ‘urban heat island effect’.

A cooler roof will transfer less heat to the building, therefore the building will stay cooler and will require less energy for air conditioning. Reducing usage of non-renewable energy is also important because a by-product of the production of this type of energy is pollution. A rating system called the Solar Reflectance Index (SRI) is used to determine how well a material radiates and reflects solar energy and can be used to predict how hot a surface will get when exposed to the sun. The higher the SRI value, the cooler the material will remain when exposed to the sun. Roof materials with a higher SRI value are preferred over those with a lower SRI value. Reference the table at the right for the SRI values of common roofing materials. 9

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**Table: Solar Reflective Index (SRI) for Typical Roofing Materials**

<table>
<thead>
<tr>
<th>Example SRI Values for Generic Roofing Materials</th>
<th>Solar Reflectance</th>
<th>Infrared Emittance</th>
<th>Temperature Rise</th>
<th>Solar Reflectance Index (SRI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gray EPDM</td>
<td>0.23</td>
<td>0.87</td>
<td>68F</td>
<td>21</td>
</tr>
<tr>
<td>Gray Asphalt Shingle</td>
<td>0.22</td>
<td>0.91</td>
<td>67F</td>
<td>22</td>
</tr>
<tr>
<td>Unpainted Cement Tile</td>
<td>0.25</td>
<td>0.9</td>
<td>65F</td>
<td>25</td>
</tr>
<tr>
<td>White Granular Surface Bitumen</td>
<td>0.26</td>
<td>0.92</td>
<td>63F</td>
<td>28</td>
</tr>
<tr>
<td>Red Clay Tile</td>
<td>0.33</td>
<td>0.9</td>
<td>58F</td>
<td>36</td>
</tr>
<tr>
<td>Light Gravel on Built-Up Roof</td>
<td>0.34</td>
<td>0.9</td>
<td>57F</td>
<td>37</td>
</tr>
<tr>
<td>Aluminum</td>
<td>0.61</td>
<td>0.25</td>
<td>48F</td>
<td>56</td>
</tr>
<tr>
<td>White-Coated Gravel on Built-Up Roof</td>
<td>0.65</td>
<td>0.9</td>
<td>28F</td>
<td>79</td>
</tr>
<tr>
<td>White Coating on Metal Roof</td>
<td>0.67</td>
<td>0.85</td>
<td>28F</td>
<td>82</td>
</tr>
<tr>
<td>White EPDM</td>
<td>0.69</td>
<td>0.87</td>
<td>25F</td>
<td>84</td>
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<tr>
<td>White Cement Tile</td>
<td>0.73</td>
<td>0.9</td>
<td>21F</td>
<td>90</td>
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<tr>
<td>White Coating - 1 Coat, 8 mils</td>
<td>0.8</td>
<td>0.91</td>
<td>14F</td>
<td>100</td>
</tr>
<tr>
<td>PVC White</td>
<td>0.83</td>
<td>0.92</td>
<td>11F</td>
<td>104</td>
</tr>
<tr>
<td>White Coating - 2 Coats, 20 mils</td>
<td>0.85</td>
<td>0.91</td>
<td>9F</td>
<td>107</td>
</tr>
</tbody>
</table>

Source: LBNL Cool Roofing Materials Database. These values are for reference only and are not for use as substitutes for actual manufacturer data.

http://laccd.stonearchsoftware.com/projects/dcs/pub/Sustain%20Design%20Standards/released/TableSolarRefIndex_1.1.jpg
A-4 Green Roofs

Green roofs are vegetative roofs that may be a longer lasting, attractive alternative to traditional roofs. They can be planted with low growing, low maintenance plants or be as elaborate as a park. Green roofs offer many benefits including:

- Absorbing air pollution, collecting airborne particulates, and storing carbon
- Protecting underlying roof material by eliminating exposure to the sun’s ultraviolet (UV) radiation and extreme daily temperature fluctuations
- Reducing noise transfer from the outdoors
- Insulating a building
- Capturing and temporarily storing rain water, reducing run-off volumes

A green roof can be constructed as a modular or a built-in-place system. A modular system typically comes preassembled with drainage layers, filter cloth, growing media and plants. Each unit is movable and interlocks with the other units to create the green roof. Built-in-place systems involve installing each component of the green roof system separately in layers.

Both systems require that the roof have a waterproofing layer and have the ability to support the extra weight of the soil, plants, and water. If a green roof is added to an existing building, additional structural support is often needed for the building to support the weight of the roof. The extra costs of a green roof can be offset by the extended life of the roof, as well as the energy savings from the extra insulation.

Plants typically used on green roofs include moss, sedum, grass, and herbs. These plants are low maintenance; they
Green roofs would be recommended on:

- Houses or porches
- Apartment buildings
- Industrial complexes
- Commercial Buildings
- Retail Stores
- Sheds
- Carports or garages
- Public buildings such as libraries and schools
- Restaurants
- Hospitals

require no additional irrigation and need minimal to no trimming and weeding. ¹⁰

According to the City of Greenville’s Stormwater Management plan, “Vegetated roofs provide protective covers on buildings and have been shown to produce long lasting and low maintenance rooftops. Some older urban communities are planting vegetated roofs as part of new development, redevelopment, and retrofitting of existing development.”

Green roofs on garages incorporate traditional grassy plants and colorful tulips. Modular green roofs come preassembled for easy installation.
A-5 Materials

Materials used on a site can have a wide range of environmental impacts. Material choices can impact air pollution, greenhouse gas emission, availability of natural resources, and energy consumption/costs.

When materials have fulfilled their usefulness and are no longer wanted, they should be recycled. Recycling reduces the amount of materials entering landfills, saves energy, decreases greenhouse gas emissions, prevents pollution, and helps conserve natural resources such as timber, mineral, and water.  

The City of Greenville provides bins and weekly curb side pick-up of a variety of materials including items such as cardboard, aluminum cans, glass jars and glass bottles. In addition to weekly pick-up, there is a drop-off center that accepts the standard recyclable items mentioned above, along with other household goods such as vehicle tires, ink cartridges, batteries, and cell phones. A complete list of accepted items is available on the City’s web site.

A-5a New materials that are made with recycled content are preferred.

Materials manufactured with recycled content require less energy to produce and use less raw materials.  

A-5b The use of materials that are harvested from sustainably managed sources is recommended.

Preferred materials have an independent certification. Certification organizations recognize companies and products that follow ecologically friendly practices in the production of materials. Examples include organizations such as the Forest Stewardship Council (FSC) for lumber products and Green Seal, which certifies various products and services.  

Examples of material reuse

Middle Left: Sidewalk reused in a patio
Middle Right: Bricks reused in a chimney
Left: Sidewalk reused in a retaining wall
A-5c Materials that are manufactured and distributed locally are preferred.
Locally produced items save energy and resources in the transportation of materials to the site, and this cuts down on greenhouse gas emissions. A guideline for locally produced materials is a radius of 500 miles from your area. 15, 16

A-5d Reuse of structures from an existing building (ex: flooring, siding, joists, and fixtures) or hardscapes (sidewalks, retaining walls, etc.) in a new building or landscape is recommended when possible. Also encouraged is the use of materials salvaged from other local projects (bricks, lumber, etc).
This reuse will minimize the amount of waste material that is deposited in landfills, as well as reduce the consumption of energy and raw materials. 14, 17 It can also help preserve the architectural character and history of the neighborhood.
B-1 Composting

Composting is nature’s own recycling process, and is easy to do at home. It uses the natural process of decomposition to recycle organic household material such as kitchen scraps and grass clippings into a humus rich soil amendment known as compost. This keeps waste out of landfills, turning it instead to a beneficial soil amendment for the home garden.

Composting requires a place to store your compost, usually a wooden or plastic bin. These can be constructed or purchased to fit your space and composting requirements. A compost bin should be placed where it can receive winter sunlight, and should be kept moist. Turning your compost pile will allow air to penetrate the pile, and speed up the composting process. Turning, or mixing the pile for several days will allow the compost to complete in as little as a month.

Composting can be done in batches, and many people choose to use two or three composting bins at once. This permits one compost bin to be filled while the other bin is processing. Alternating between two bins is one way of ensuring a steady supply of compost for your garden. Avoid placing fats, meats, sugars, or pet waste into your compost bin. The following materials make for great, pest-free composting:

- Leaves
- Lawn clippings and tree trimmings
- Fruit and vegetable scraps (including egg shells)
- Bread and grains
- Coffee grounds and filters
- Newspapers
B-2 Trees

Trees are valuable resources. Trees add to the attractiveness of a neighborhood or home landscape. They provide shade that reduces summer energy costs and reduces the urban heat island effect. Trees provide food and habitat for wildlife. They also stabilize soil and improve soil quality by adding organic matter and improving water infiltration. Trees also store or capture carbon dioxide, known as carbon sequestration. Carbon dioxide is a greenhouse gas that contributes to global climate change. Preserve healthy existing trees by protecting their roots from compaction during construction.

Limbs should be trimmed to allow clearance for delivery trucks, and damaged limbs should be removed. Periodic surveying of the trees is important for catching health and safety issues before they present a hazard.

B-2a Street Tree Selection

Street trees contribute shade, improve the comfort and aesthetics of a neighborhood, slow traffic, and improve the infiltration rate of soil. In order to provide the most benefit, street trees must be selected and planted correctly. Correct selection is based in large part on two factors:

1. The mature height of the tree and the size of space available
2. The ability of the tree to grow and survive its location with minimal maintenance and threat of hazard

New street trees are an important part of protecting a sustainable and aesthetically pleasing community. Select trees that will require little maintenance. Select trees that will not overgrow the available space, or interfere with sidewalks, above and below ground utilities. Follow proper planting procedures to provide the best results for the life of the tree.

New trees planted between the sidewalk and road may need to be permitted with the city. This curb lawn area is part of the public right-of-way. Avoid trees that are susceptible to breakage or disease, are prone to grow large surface roots, or that produce large fruit or nuts that may present a hazard to pedestrians. Suggested street trees: 2,6,9

- Large Trees: Willow Oak, Red Maple, White Oak, Lacebark Elm, Ginkgo, Baldcypress, Honey Locust, Zelkova
- Medium trees (25-35’): Crape Myrtle, Golden Raintree,
- Small Trees (<25’): Eastern Redbud, Kwanzan Cherry

www.treesaregood.com/treecare/images/

The image above illustrates the location of tree roots. This area is vital to tree health, and soil compaction in this area will result in tree stress and higher maintenance. 2
**B-2c Use landscape trees to reduce energy costs.**

Deciduous trees can be used to reduce home energy costs by shading cooling systems and/or south and south western windows and doors. ¹

**B-2d Trees sequester carbon dioxide.**

Trees capture and hold carbon dioxide gas in their trunks and roots. This gas is a natural byproduct of breathing, but it is the production of carbon dioxide from the burning of fossil fuels that has scientists worried. Carbon dioxide is one of the “greenhouse gasses” that make planet Earth inhabitable. However, the rate at which we are creating this gas is believed to be contributing to global climate change. Trees may live for hundreds of years, and their wood may last even longer. Capturing and storing carbon in trees is known as “carbon sequestration,” and is seen as a good thing to do for our planet. ¹²

**B-2e Trees are good for soil quality.**

Tree roots capture and hold soil, and keep it from washing away during rain storms. Additionally, as tree roots grow, they help to aerate the soil. When tree roots die, they contribute organic material to the soil that is needed for good soil quality and fertility. ⁷

**B-2f Trees reduce the urban heat island effect.**

By shading hot dark surfaces such as rooftops, driveways, and roadways, trees effectively combat the urban heat island effect, the tendency of urban spaces to be hotter than otherwise would be expected. This increase in temperature contributes to the formation of ground level ozone, an air pollutant common on hot summer days, and one that is unhealthy for the respiratory system. ¹²
Landscaping

Plants should be selected based on their ability to fit a site’s space, light, wind, and water conditions. It is important to consider how large the plant will be when it is full-grown, and make sure it is planted in an area with enough room. Select plants that will not block the line of sight from and to front doors, intersections, and driveway entrances. Maintaining this visibility will promote neighborhood conviviality and security. 4,5

B-3a Use landscape plants and trees instead of lawn

Trees and landscape plants are encouraged as a replacement or addition to lawn grass. Lawns require water, fertilizer and mowing that are not environmentally friendly. Landscape trees and plants promote water infiltration and reduce stormwater runoff, especially when they are surrounded by a 2”-4” thick layer of mulch. 7

B-3b Mulch plants and trees to protect soil and promote plant health.

Mulch protects your soil from drying out, compaction, and erosion. Use lawn clippings and fallen leaves to mulch around plants. 2”-4” of mulch protects the plant roots from drying out and from temperature extremes. This mulch serves as a slow release fertilizer for your plants, and over time will help improve soil quality. 7

B-3c Use native plants to reduce maintenance cost and water consumption.

Native plants are preferred for their ability to thrive with minimum care. Use only plants that are nursery grown and legally harvested. Species that require additional water, fertilizer and trimming are not encouraged. 11
B-3d Avoid invasive plants to protect local plants and wildlife.

Invasive plants spread and take over natural plant and wildlife habitat are discouraged. Some invasive plants continue to be sold in local plant nurseries. These plants may have attractive characteristics that tempt their use in the landscape. However, they ultimately do more harm than good. Use only plants that are nursery grown, legally harvested, or salvaged for reuse from on or off site.

Some common invasive plants are listed below:

- **Vines and Groundcovers**: Kudzu, Periwinkle, Wisteria, Creeping Euonymous, Japanese Honeysuckle, English Ivy, Multiflora Rose, Japanese Climbing Fern, Tall Fescue, Akebia
- **Shrubs and tall grasses**: Nandina, Eleagnus/Autumn Olive, Vitex, Bamboo, Chinese Silvergrass, Pampas Grass, Privet, Burning Bush, Japanese Barberry
- **Trees**: Bradford Pear, Mimosa, Princess Tree, Tree-of-Heaven, Popcorn Tree, Norway Maple

B-3e Protect soil from compaction and erosion.

Healthy soils effectively cycle nutrients; store carbon as organic matter; minimize runoff and maximize water holding capacity; absorb excess nutrients, sediments, and pollutants; provide a healthy rooting environment and habitat to a wide range of organisms; and maintain their structure and aggregation.

Limit grading to reduce costs for construction machinery and transport of imported soils. Restore soils disturbed during construction in all areas that will be re-vegetated (all areas that will not be built upon) to rebuild soils' ability to support healthy plants, biological communities, water storage and infiltration.

The photos here are of several of the invasive plant species common here in Upstate South Carolina. These plants are to be avoided, as indicated by the X in the corner of each photo. Top Left is Wisteria; Top Right is kudzu; Bottom Left is Vinca, also known as periwinkle; Bottom Right is privet. These plants spread via seed and vine into areas where they are not wanted and should be avoided.
Sustainability Appendix

Irrigation and Water Conservation

Irrigation is an important aspect of water conservation. Methods for conserving water in landscape irrigation are explained below.

Select drought tolerant and native plants for a low maintenance and beautiful landscape.

Conserve water by selecting plants adapted to the periodic cycles of drought common in this region. Plants poorly suited for an environment require more water, maintenance and fertilizer than plants adapted to survive the existing conditions of a site.

Water in a method and at a time that conserves the most water and best benefits the plants.

If supplemental irrigation is required, choose watering systems that apply the water directly to the soil around the plant’s roots. Timing and duration of watering are also important concerns. The best watering time is in the morning while the temperature is coolest. Watering in midday loses water through evaporation, and watering at night promotes fungus on your plants. All irrigation should be done for short periods of time, since landscape plant and grass roots occupy only the top few inches of soil. Established tree and plant roots go deep enough that they should not require watering, although extended periods of drought may necessitate additional watering.

Xeriscaping is a landscaping technique that promotes water conservation.

Xeriscaping is landscaping for water conservation. This can be done by choosing plants, such as native plants, that have little need for additional water. It can also be accomplished by grouping plants with similar watering requirements. Irrigation methods that apply the water directly to the soil around the plant are preferred over methods that spray it in the air. Preferred irrigation types include soaker hoses and drip irrigation systems.
C-1 Traffic Calming

Traffic calming is a system of design and management applications that aim to balance traffic on streets with other uses. The idea is that streets should help create and preserve a sense of place, that they are a place for people to interact, an important civic realm. The tools utilized in traffic calming take a different approach from simply treating the street as infrastructure for vehicles passing through at the greatest possible speed. They include techniques designed to lessen the impact of the automobile by slowing it down, helping to build human-scale environments friendly to people on foot.¹

Besides its ability to improve the livability of a place, another benefit of traffic calming is that it can be applied in ways that also address issues of stormwater management. Rain gardens, bioswales, and/or appropriate landscaping choices increase pervious opportunities for water to infiltrate locally, reducing demands on engineered systems and improving water quality. They also contribute to the aesthetic character of the neighborhood.

This section will provide further examples of traffic calming approaches that enhance the pedestrian realm and additionally address other sustainability issues. It is important to understand that these applications can serve multiple purposes when their implementation is thoughtfully planned.

- Textured Pavements
- Speed Tables and Crosswalks
- Curb Extensions and Stormwater Management
- Center Island Narrowing and Chicanes
- Traffic Circles and Environmental Education

Textured pavement is a roadway material that tends to slow vehicle movement with its raised and slightly rough surface. Examples include brick and stamped asphalt.
C-2 Textured Pavements

Textured and colored pavements include the use of stamped pavement or alternate paving materials to create a coarse textured surface for vehicles to traverse. The change in materials also provides a visual cue to drivers that they are entering a pedestrian zone. They may be used to emphasize either an entire intersection or a pedestrian crossing, and are sometimes used along entire street blocks.2

C-3 Speed Tables and Crosswalks

Speed tables, similar to speed humps (see graphic on the left), are areas of raised pavement that extend across all lanes of traffic. Speed tables are wider and flatter than speed humps allowing vehicles to rest horizontally on top, and are often used in conjunction with pedestrian crosswalks since they provide the necessary width and level surface.3

Speed tables are:

- Easier on large vehicles (such as fire trucks) than speed humps3
- Effective in reducing speeds and can be used in conjunction with curb extensions (see following section) and textured pavements
- Can provide active public spaces for the street

This graphic illustrates the difference between speed humps, speed tables, and speed bumps. Speed humps and tables used in conjunction with curb extensions are recommended.
C-4 Curb Extensions

Curb extensions at intersections or mid-block reduce the roadway width from curb to curb. They shorten crossing distances for pedestrians, slow traffic by reducing road width, and remind drivers they are in a pedestrian zone. They are also known as neckdowns, chokers, nubs, bulbouts, intersection narrowings, and corner bulges.

Most forms of curb extensions provide excellent opportunities to treat stormwater runoff from streets and improve water quality. Several examples are shown in the images to the right.

Curb Extensions:

• Improve pedestrian safety and circulation
• Provide a prominent area for landscaping, public art, lighting fixtures, or signs
• Create protected on-street parking bays
• Reduce speeds, especially for right-turning vehicles
• Provide an area for street trees, other landscaping, or groundwater recharge areas: rain gardens and bioswales (see water section)
• Should be kept free of structures and plants that block visibility

This bulb-out creates an on-street parking bay, reduces pervious pavement cover, slows traffic, and provides the opportunity for amenity landscaping.

Curb extensions calm traffic and allow for landscaping that serves both beautification and water quality goals.
These graphics as well as other valuable resources, are available at both www.epa.gov/smartgrowth and www.epa.gov/greeninfrastructure.
C-5 Center Island Narrowing

A center island narrowing (also called medians) is a raised island located along the centerline of a street that narrows the travel lanes. Center island narrowings are often landscaped to provide a visual amenity and increase pervious surface. Placed at the entrance to a neighborhood, and often combined with textured pavement, they introduce distinct communities or districts and can be called “gateway islands.” When fitted with a gap to allow pedestrians to walk through at a crosswalk, they are also called “pedestrian refuges.”

- Center island narrowings increase pedestrian safety and reduce traffic volumes.
- They add to the character of a neighborhood by providing space for landscaping and signage.
- They can be coupled with crosswalks to provide a mid street pedestrian refuge.
- By landscaping these islands, impervious surfaces are reduced, improving water quality, and helping with stormwater management.

Above: Center island narrowings slow traffic and provide for attractive landscaping. Below: The can introduce neighborhoods with plantings and signage. When used for this purpose the median is referred to as a ‘gateway’ island.
Chicanes are created with curb extensions that alternate from one side of the street to the other. They form s-shaped curves along low traffic streets. Chicanes can also be created by alternating on-street parking, either angled or parallel, between one side of the street and the other. Each parking bay can be created either by re-striping the roadway or by installing raised, landscaping islands at the ends of each parking bay.

- Chicanes discourage high speeds by forcing horizontal deflection.
- They are easily negotiable by large vehicles like fire trucks and school buses.
- Chicanes can be landscaped to add aesthetic value to streets and neighborhoods.
- When landscaped, chicanes reduce impervious surfaces helping with stormwater management goals.

Chicanes can be effective in designating the street as a pedestrian zone in low traffic neighborhoods while providing for stormwater quality control.

C-6 Chicanes

Traffic Calming
C-7 Traffic Circles

Traffic circles are islands in the middle of intersections, around which traffic circulates. They are good for calming intersections and directing traffic especially within neighborhoods, where large vehicle traffic is not a major concern but speeds, volumes, and safety are problems.8

- Traffic circles are very effective in moderating speeds and improving safety8
- If designed well, they can have positive aesthetic value and can also serve as important stormwater management applications as seen in following images
- Placed at an intersection, they can calm two streets at once
- They can also provide opportunities for environmental education and community development (See example, ‘Bringing It All Together’ on following page)
Bringing It All Together

An elementary school in Philadelphia installed a rain garden in their traffic circle to improve water quality and on-campus stormwater management. The project served as an important environmental education tool.

(Upper right) AFTER: traffic circle is more effective; installed rain garden adds beauty and addresses stormwater issues.

(Lower right) BEFORE: confusing traffic circle and large expanse of impervious surface.
D-1 **Stormwater**

Stormwater, or “stormwater runoff” as it is also called, is rain water on the ground that is not absorbed into the soil.\(^1\) Stormwater runoff is increased when it falls on hard surfaces that are not absorbant. Surfaces can be categorized as either absorbant, also known as “pervious surfaces,” or unabsorbant, also known as “impervious surfaces.” Impervious surfaces do not absorb stormwater while pervious surfaces will absorb some stormwater and slow it down. Pervious surfaces are strongly encouraged wherever possible. How much a pervious surface can absorb and slow down stormwater varies; for instance, mulch holds more water than grass and will also slow the stormwater down. This is important because stormwater runoff:\(^2\)

- Causes erosion
- Can lead to flooding
- Often requires expensive infrastructure (pipes)
- Hurts habitat and drinking water by carrying pollutants and chemicals into streams and other bodies of water
- Can damage property, and create a safety problem for vehicles and pedestrians

At this construction site, stormwater erodes the soil and pulls it into the road where there is also standing water.

Left: Stormwater infrastructure carries water and empties. Right: This bank has been severely eroded by stormwater.
D-1 Stormwater (continued)

There are many ways to manage stormwater so that it is less of a problem. Some of the stormwater management options are:

- Engineered Soils
- Rain Gardens
- Bioswales
- Pervious Pavement
- Rain Barrels

These options (above) can be attractive, blend in to the existing neighborhood, and can be designed to accomplish multiple objectives such as traffic calming. Many such options can be adapted to work on a small scale, such as an individual lot, or on a larger scale, such as along a block.

These stormwater management practices are helpful because:

- stormwater is captured
- stormwater is available for reuse
- plants filter pollutants
- stormwater velocity is decreased

Driving conditions can become dangerous when stormwater is not managed properly.
Engineered Soils

Engineered soils are a specific mixture of soils, such as compost, expanded clay, and sand among others, that are combined to perform a certain task or tasks. Engineered soil can be mixed with existing soils or used as a replacement. Engineered soils allow stormwater to sink into the ground. This reduces stormwater volume by retaining it and filters the water as it passes through the soil. Additionally, engineered soils can be used under paved surfaces, where they allow tree root growth without disturbing the above surfaces.

Gravel can be used under engineered soil to provide additional water storage. Protect the gravel from getting clogged by using a filter cloth to separate it from the engineered soil. This is a technique that is often used with rain gardens, bioswales and pervious pavement.3

Engineered soils can be used under:

- rain gardens
- bioswales
- lawns
- roads and sidewalks
- pervious pavement
D-3  **Pervious Pavement**

Pervious pavement allows water to flow through and into the soil below. When the soil under pervious pavement is gravel or engineered soil, it will take in the water and can act in a similar way to a rain garden or bioswale. Because the pavement is porous, it can require some maintenance such as regular sweeping to keep it from getting clogged with debris. Pervious pavement needs to be sized and placed to fit the stormwater needs of each location where it is to be installed. Pervious pavement comes in several varieties, and is a safe walking or driving path, however it may not be suitable under heavy loads such as firetrucks or in high use traffic lanes.

Pervious pavement would be recommended in:
- areas of the neighborhoods that have or will have sidewalks, but do not have room for a vegetative buffer
- parking areas, especially the parking stalls
- driveways

**Reduced Impervious Pavement**

While pervious pavement allows water to infiltrate immediately, it may not be appropriate for all situations. In many cases, reducing the impervious surface may be a more suitable option. Some ways to do this include:

- Leaving a strip of vegetation in the middle of a driveway (country lane effect)
- Interlocking concrete pavers that leave spaces for vegetation or gravel for drainage

Reduced impervious pavement would be recommended in:
- Parking lots
- driveways
Rain Gardens

Rain Gardens are bowl-shaped vegetated areas that collect and filter stormwater, and can be planted with a variety of plants and grasses. In addition to being bowl shaped, if the current soil does not absorb water well, layers of engineered soil can be added to improve permeability. When used adjacent to roads, use rain gardens to capture and clean stormwater runoff.6

Rain gardens can be used in:

- residential landscaping
- vegetative buffers between streets and sidewalks
- road medians and bumpouts

This rain garden collects water from the grass and has a curb cut to allow stormwater from the street to enter.

The cross section shows the various components of a rain garden and how it retains water.

http://www.thecoves.ca/project.php?id=22
Bioswales are used to conduct stormwater from one place to another. Bioswales are constructed in topographic low points. They are vegetated, often with low maintenance native plants. Plants promote water infiltration, an attractive appearance and remove some of the pollutants from the stormwater. Bioswales typically use an engineered soil that allows water to be absorbed. For bioswales to be most effective, surrounding hard, impervious surfaces should be graded to direct the water to the bioswale. If bioswales are used beside roads, curb cuts, or openings in the concrete curbing, can be used to allow the runoff from the roads to enter the bioswale.

Bioswales can be used in place of ditches in the following locations:

- vegetative buffer between sidewalks and roads
- road medians
- residential lots
- parking lots

Stormwater runoff from impervious surfaces flows into this bioswale, where it is slowed down and cleaned of sediment and some pollutant.
Rain Barrels

Rain barrels are containers that capture the roof’s water. These are useful because they capture stormwater and allow for reuse of the water for irrigation. These can be fairly inexpensive to install if there is already a gutter in place. Rain barrels can be constructed or purchased, come in a variety of shapes and styles to fit any home design. They are commonly made from recycled plastic drums, whisky barrels, or constructed of plastic to resemble whisky barrels. Although rain barrels come in many shapes and sizes, they are usually 40-60 gallons in size, and include a spigot near the bottom. 

Rain barrel fittings and access points should be tight fitting to prevent leaks. Any openings should be screened with fine mesh to keep out mosquittos. Rain barrels can be linked together to provide more storage room, and should be equipped with an overflow hose to handle rainfall that exceeds the barrel capacity. Elevate your rain barrels on flat stone, bricks, or block to increase head pressure and flow rate. Disconnect your rain barrels and store them through the winter to prevent damage from freezing.

Rain barrels would be most appropriate at:

- residences
- schools
- other public buildings

Right: Systems of rain barrels can be set up to allow for more storage of stormwater. This can then be used to save drinking water by watering plants and washing cars among other things. Rain barrels such as these may be most suitable in areas that are screened from public view.
D-7 Rainwater Pillows

Rain pillows act in a similar way as rain barrels. They are connected to gutters of a building to collect and store the stormwater. However, they are made of a material that will fill and deflate as water is stored and used. These are typically unseen and make use of wasted space under decks, porches and in crawlspaces. The capacity for water storage with a rain pillow is much greater than that of a rain barrel, typically from 1,000 gallons to 40,000 gallons. A pump can be used to extract the water for irrigation, and a filter should be used to keep debris from the roof and gutters out of the rain pillow.⁹

Rainwater pillows would be most appropriate at:

- residences
- schools
- other public buildings
Additional Information

For Further Energy Information

**Solar Orientation**
Solar Orientation of house:
http://www.oikos.com/esb/42/solar.html

Solar Orientation of Windows:
http://www.energysavers.gov/your_home/windows_doors_skylights/index.cfm/mytopic=13360

Light shelves and roof overhangs:
http://www.energysavers.gov/your_home/designing_remodeling/index.cfm/mytopic=10280

Daylighting:
http://www.energysavers.gov/your_home/lighting_daylighting/index.cfm/mytopic=12290
http://www.wbdg.org/resources/daylighting.php

**Solar Energy**
How Solar Photovoltaic (PV) Systems Work:
http://www1.eere.energy.gov/buildings/residential/solar.html

Information on state, local, utility, and selected federal incentives that promote renewable energy:
http://www.dsireusa.org/

**Urban Heat Island**
Minimizing 'Urban Heat Island' effect:
www.epa.gov/hiri/

**Green Roofs**
A database of green roof projects:

**Materials**
South Carolina directory of environmentally friendly products/services:
www.scgreenbuildingdirectory.org/

**Salvaged materials:**
www.greenguide.com/exchange/search.html
www.redo.org

Environmentally responsible products and services:
www.greenseal.org/findaproduct/index.cfm
www.fscus.org/certified_companies/

City of Greenville approved recyclable materials:
Energy References


Additional Information

For Further Landscape Information

**Trees**
Benefits of Urban Trees from the SC Forestry Commission:
http://www.state.sc.us/forest/urbben.htm

Tree Selection Guide from the SC Forestry Commission:
http://www.state.sc.us/forest/urbsg04.htm

Greenville City Tree Ordinance

**Sustainability**
Sustainable Sites Initiative:
http://www.sustainablesites.org/

EPA Website Clearinghouse Dedicated to Sustainable Landscapes
http://www.epa.gov/epawaste/conserve/rrr/greenscapes/index.htm

Clemson University Website With Multiple Documents about Landscaping
http://www.clemson.edu/extension/hgic/plants/other/

**Invasives**
Field Guide of Invasive Plants with Pictures:

Website Dedicated to Invasive Species:
http://www.invasive.org/

**Xeriscaping**
Clemson University Extension Booklet with How-To and Plant Information:
http://www.clemson.edu/extension/hgic/plants/other/landscaping/ec672_xeriscape.pdf


Additional Information

Landscape References


Additional Information

For Further Traffic Calming Information

Practical guide to traffic calming and neighborhood traffic management:
http://www.trafficcalming.org/

How to make cities more livable:
http://www.livablestreets.com/streetswiki

Making a neighborhood more bicycle and pedestrian friendly:
http://www.activelivingresources.org

Resource for creating and sustaining public places that build communities:
http://www.pps.org/
Traffic Calming References


Additional Information

For Further Water Information

**Stormwater**
Why it is important:
http://www.upstateforever.org/onthemove/OTM_14_jun08.pdf

Informative Reference:
http://www.seswa.org/

“What’s in your stormwater” and urban stormwater education:
http://ppc.uaex.edu/storm_water/SEAR/default.htm

**Engineered Soils**
Video and explanation of engineered soil and what it does:
http://www.dca.state.ga.us/development/EnvironmentalManagement/programs/engineeredSoils.asp

Information about soils for urban trees:

**Pervious Pavement**
Informative Reference:
http://www.perviouspavement.org/

Video showing it working:
http://www.perviouspavement.org/Pervious-Pavement-Demo-Video.html

Educational Video:
http://www.stormwaterpa.org/pervious-pavement.html

General information and several references:

**Rain Garden**
Manual explaining “How to” for homeowners:

General information:
http://www.lowimpactdevelopment.org/raingarden_design/whatisaraingarden.htm

How and where to install a rain garden:
http://www.epa.gov/nps/toolbox/other/cwc_raingardenbrochure.pdf

How to build a rain garden:
http://www.epa.gov/nps/toolbox/other/KSMO_buildRainGarden.pdf

**Bioswales**
What are they and why they are useful:

Design and use of:
http://www.deq.state.or.us/wq/stormwater/docs/nwr/biofilters.pdf

**Rain Barrels**
What is a rain barrel:
http://www.epa.gov/Region3/p2/what-is-rainbarrel.pdf

Using Rain Barrels to safely water vegetable gardens:
http://www.uri.edu/ce/healthylandscapes/Rain%20barrel%20bro.pdf

Building and installing rain barrels:

How to build a rain barrel video (HGGTV):
http://www.youtube.com/watch?v=MGFDikJOdAM

How to DIY (includes mosquito concerns):

Making rain barrel with pictures:
http://www.upstateforever.org/onthemove/OTM_14_jun08.pdf

**Rain Pillows**
Manufacturers with information about size, installation, uses:
http://www.rainwaterpillow.com/
Water References


