Greenville County Technical Specification for:

WQ-14 RAIN GARDEN

1.0 Rain Garden

1.1 Description

Rain Gardens are landscaped depressions that receive stormwater runoff and allow the runoff to slowly infiltrate through a filter media. Rain Gardens are small stormwater collection areas intended to provide water quality management by filtering stormwater runoff before release into a stormwater conveyance system or stabilized outfall. Rain Gardens may be used as a stand-alone practice or in series with other stormwater management practices as part of a treatment train. Use individual Rain Gardens for drainage areas up to 2,500 square feet in size. Larger drainage areas require installation of Bioretention with an overflow riser, see Specification WQ-05 for Bioretention.

Stormwater runoff enters a Rain Garden and is temporarily stored in a shallow pond on top of a filter media layer. The ponded water then slowly filters down through the filter media and is also absorbed by the plantings. As the excess water filters through the system it is temporarily stored and collected by an underdrain system that eventually discharges to a designed stormwater conveyance system or stabilized outfall.

Rain Gardens are applicable for small areas where stormwater runoff rates are low and can be directed into the Rain Garden through a downspout, pipe, or swale. Because Rain Gardens are sensitive to fine sediments, do not install them on sites where the contributing area is not completely stabilized or is periodically being disturbed. Applicable sites include:

- Individual residential home sites,
- Common areas, and
- Cul-de-sacs.

Rain Gardens are capable of removing typical pollutants found in stormwater runoff such as bacteria, nutrients, metals, suspended solids, oil and grease, and litter and trash.

1.2 Design

1.2.1 General Design Criteria

The required method to design an individual Rain Garden or to design a Rain Garden as part of a treatment train with other water quality BMPs is to use the Greenville County IDEAL Model to demonstrate overall site compliance with applicable County water quality standards. See County Design Manual for site-specific applicable water quality standards.

Design Rain Gardens to fit around natural topography and complement the surrounding landscape. Rain Gardens can be of any reasonable shape and can be fit around sensitive areas, natural vegetation, driveways, and sidewalks.

Do not design Rain Gardens to be within 10 feet of a building.

Do not design Rain Gardens to be uphill from or within 25 feet of a septic drain field.

A summary of the design characteristics for Rain Gardens is shown in Table 1.

Table 1. General Design Characteristics for Rain Gardens

Infiltration Rate	Optimal range between 1 and 6 inches per hour for filter media.
Maximum Water Depth	Range from 6 to 8 inches.
Surface Area	Varies, but typically 20-30% of the contributing watershed.
Water Table	Minimum vertical distance of 18 inches between bottom of Rain Garden and seasonally high ground water table.
Places to Avoid	Areas that regularly flood (at least once a year), areas within 10 feet of a building, areas uphill from or within 25 feet of a septic drain field.
Mulch	A minimum of 2 to 3 inches is required. Use hardwood, not pine bark nuggets (float). Double-shredded hardwood works well.
Stone for Gravel Layer	Aggregate No. 57 or No. 5 stone. Separate the gravel from the filter media with a permeable non-woven geotextile fabric.

Source: Adapted from Clemson University Public Service Activities Carolina Clear, Rain Gardens, A Rain Garden Manual for South Carolina, 2009 and Rain Gardens Urban Waterways / Urban Stormwater Structural Best Management Practices (BMPs), North Carolina Extension Service, June, 1999.

1.2.2 Surface Area

To assist in the Rain Garden design, the initial surface area may be estimated by the following equation which was adapted from Bioretention research by the North Carolina Extension Service, 1999. It has been modified to account for differences in the structure and function of Rain Gardens compared to Bioretention:

$$\text{RGSA} = \frac{1.6(\text{DA})(Rv)}{D_{avg}}$$

Where:

RGSA = Rain Garden surface area (feet^2)
DA = Contributing drainage area of Rain Garden (feet^2)
R_v = Runoff volume (feet), use 0.083-feet (1-inch) as a rule of thumb for estimation
D_{avg} = Average ponding water depth above ground (feet), use 0.5 feet (6 inches)

1.3 Materials

Rain Gardens consist of an underdrain system, filter media, an overflow spillway, plantings, and a mulch layer.

1.3.1 Underdrain System

Place an underdrain system beneath the filter media for **all** Rain Gardens in Greenville County, as many of the native soils do not allow for adequate infiltration. The perforated underdrain drain pipe must be connected to a stormwater conveyance system or discharge to a stabilized outlet that daylights (emerges from the ground and is open to the air).

In extreme situations where an underdrain is not feasible due to unique site constraints, infiltration rate must be a minimum 0.5 inches per hour, verified by site specific soil samples at the elevation of the bottom of the Rain Garden where infiltration will occur.

Provide an underdrain system that consists of a continuous closed joint perforated plastic pipe underdrain with a minimum 4-inch diameter, an 8-inch minimum gravel filter layer, non-woven geotextile filter fabric

to wrap the perforated pipe and separate the gravel layer from the native soils and the filter media. Provide an outlet pipe that is non-perforated PVC with a minimum diameter of 4 inches.

Table 2 describes material specifications for underdrains.

Table 2: Underdrain Material Specifications

Material	Specification
Aggregate	Use coarse Aggregate No. 57 or No. 5 consisting of crushed slag or gravel.
Pipe Underdrains	Use PVC perforated pipe (AASHTO M 252) underdrain with a minimum diameter of 4 inches.
Outlet Pipe	Use non-perforated PVC pipe with a minimum diameter of 4 inches.
Non-woven Geotextile Fabric	Use Class 2 Type C non-woven geotextile fabric.

1.3.2 Filter Media

The filter media provides a medium for physical filtration for the stormwater runoff with enough organic matter content to support growth and provide water and nutrients for plant life.

Ensure the filter media of the Rain Garden is level to allow uniform ponding over the entire area. The maximum ponding depth above the filter media is 6 inches to 8 inches to allow the Rain Garden to drain within a reasonable time and to prevent long periods of plant submergence. Provide a filter media with a minimum infiltration rate of 1 inch per hour (optimal range is 1 to 6 inches per hour). The filter media is to be furnished, and on-site soils are not acceptable. The filter media shall be a uniform mix of sand and organic material meeting the following criteria.

Sand

- 75% to 85% composition by weight
- Medium to coarse washed sand
- Washed river sand and concrete/masonry sand are acceptable
- Do not use lime stone screenings

Organic Material

- 15% to 25% composition by weight
- Compost material that is well decomposed, stable, and weed free
- Derived from leaves, yard debris, wood waste, food waste, or other organic materials
- Does not include manure or biosolids
- Do not use manure-based mushroom compost
- US Composting Council Seal of Testing Assurance (STA) compost is preferred

Acidity/Alkalinity (pH)

- Between 5.2 and 8.0 with an optimal range of 6.0 to 7.5
- Tested prior to installation with documentation to be provided to County
- Utilizing Clemson Extension Agricultural Service Laboratory is recommended. For more information, visit their website at https://www.clemson.edu/public/regulatory/ag-srvc-lab/soil-testing/index.html.

Should the filter media pH fall outside of the acceptable range, modify with pelletized lime (to raise pH) or iron sulfate plus sulfur (to lower pH). Uniformly mix lime or iron sulfate into the filter media prior to use in Rain Garden.

The Engineer will submit the source and makeup of the filter media and the pH test results to the County prior to the start of construction of Rain Garden. Do not add material to a stockpile of filter media once a stockpile has been sampled. Allow sufficient time for filter media preparation and testing. It is recommended that the Engineer or Contractor consult the County regarding the list of landscape suppliers with the acceptable material that are capable of providing pre-mixed filter media in order to reduce testing and mobilization time and construction delays.

Use a filter media that is uniform, free of stones, stumps, roots or other similar objects larger than 2 inches excluding mulch. Do not mix or dump materials or substances within the Rain Garden that may be harmful to plant growth, or prove a hindrance to the planting or maintenance operations.

A filter media that fails to meet the minimum requirements must be amended or replaced. The recommended depth of the filter media is shown in Table 3.

Table 3: Filter Media Depth

Vegetation	Filter Media Depth (ft)
Turf Grass Only	2.0
Native Grasses or Shrubs	3.0
Small Trees	4.0

1.3.3 Overflow Spillway

Design an overflow spillway to pass runoff volumes greater than the designed volume to a stormwater conveyance system or stabilized outlet. Install the overflow spillway at the elevation of the maximum 6- to 8-inch ponding depth above the Rain Garden surface.

1.3.4 Plantings

Use plantings that conform to the standards of the current edition of *American Standard for Nursery Stock* as approved by the American Standards Institute, Inc.

Use plant materials that have normal, well developed stems or branches and a vigorous root system. Only use plantings that are healthy, free from physical defects, plant diseases, and insect pests. Symmetrically balance shade and flowering trees. Ensure major branches do not have V shaped crotches capable of causing structural weakness. Ensure trunks are free of unhealed branch removal wounds greater than a 1 in. diameter.
Use plant species that are tolerant to wide fluctuations in soil moisture content. Use plantings capable of tolerating saturated soil conditions for the length of time anticipated for de-watering, as well as anticipated runoff constituents.

Acceptable Rain Garden plantings include:

- Turf Grass only,
- Native Grasses and Perennials,
- Shrubs, and
- Small Trees.

1.3.4.1 Turf Grass Only

Use turf grass species with a thick dense cover, slow growing, applicable to the expected moisture conditions (dry or wet), do not require frequent mowing, and have low nutrient requirements. The preferred method of establishing turf grass is sodding. Use temporary erosion control blankets to provide temporary cover when establishing turf grass by seeding.

1.3.4.2 Native Grasses and Perennials

Create a low maintenance native grass or wildflower meadow with native grasses and native perennial species. Temporary erosion control blankets may be used in lieu of a hardwood mulch layer. Plant native grasses and perennials of the same species in clusters 1.0 to 1.5 feet on-center.

1.3.4.3 Shrubs

Provide shrubs a minimum of 2 feet in height. Do not plant shrubs near the inflow and outflow points of the Rain Garden. Plant shrubs of the same species in clusters 10 feet on-center.

1.3.4.4 Small Trees

Provide small trees with a minimum 1-inch caliper. Plant trees near the perimeter of the Rain Garden. Do not plant trees near the inflow and outflow points of the Rain Garden. Do not plant trees directly above underdrain. Plant trees at a density of one tree per 250 square feet.

1.3.4.5 Planting Plan

A Rain Garden landscape plan includes all planting types, total number of each species, and the location of each species used. The plan includes a description of the contractor's responsibilities including a planting schedule, installation specifications, initial maintenance, a warranty period, and expectations of plant survival. A planting plan includes long-term inspection and maintenance guidelines. Use planting plans prepared by a qualified landscape architect, botanist or qualified extension agent. Use native plant species over non-native species. Ornamental species may be used for landscaping effect if they are not aggressive or invasive. Typical plantings for Rain Gardens are shown in Table 4.

The Carolina Yards Plant Database (www.clemson.edu/cy/plants) provides a searchable plant database that allows for selection of plants based on yard characteristics and intended plant use and includes a guidance for Rain Gardens.

The South Carolina Waterways Fact Sheet Series (www.clemson.edu/hgic/water) provides detailed information for numerous Rain Garden friendly plants.

Table 4: Native Plant Species for Rain Gardens

Perennials/Grasses	Shrubs	Trees
Spotted Geranium *(Geranium maculatum)*	Beautyberry *(Callicarpa americanas)*	Hackberry *(Celtis occidentalis)*
Swamp Milkweed *(Asclepias incarnata)*	Button Bush *(Cephalanthus occidentalis)*	Serviceberry *(Amelanchier canadensis)*
Butterfly Milkweed *(Asclepias tuberosa)*	Sweet Pepperbush *(Clethra ainifolia)*	Ironwood - American Hornbeam (*Carpinus caroliniana*)
White Turtlehead *(Chelone glabra)*	Winterberry Holly *(Ilex verticillatta)*	Black Gum / Black Tupelo (*Nyssa sylvatica*)
Joe Pye Weed *(Eupatorium purpureum)*	Virginia Sweetspire *(Itea virginica)*	Fringetree (*Chionanthus virginicus*)
Swamp Sunflower *(Helianthus angustifolius)*	Spicebush *(Lindera benzoin)*	Flowering Dogwood *(Cornus florida)*
Rose / Swamp Mallow *(Hibiscus moscheutos)*	Possumhaw *(Viburnum nudum)*	Mayhaw, May Hawthorn *(Crataugus aestivalis)*
Cardinal Flower *(Lobelia cardinalis)*		
Cutleaf Coneflower *(Rudbeckia laciniata)*	**Evergreens**	**Evergreens**
Goldenrod *(Solidago spp.)*	Inkberry Holly *(Ilex glabra)*	American Holly *(Ilex Opaca)*
Ironweed (Vernonia noveboracensis)	Yaupon Holly *(Ilex vomitoria)*	Sweetbay Magnolia *(Magnolia virginiana)*
Grasses	Waxmyrtle *(Myrica cerifera)*	
Big Bluestem *(Andropogon gerardii)*		
River Oats *(Chasmanthium latifolium)*	**Ferns**	
Slender Indiangrass *(Sorghastrum elliotti)*	Cinnamon Fern *(Onoclea cinnamomea)*	
Tussock Sedge *(Carex stricta)*	Royal Fern *(Osmunda regalis)*	
Switch Grass *(Panicum virgatum)*	Hayscented Fern *(Dennstaedtia punctilobula)*	
Little Bluestem *(Schiachyrium scoparium)*		

Note: Prior to selection, review detailed Rain Garden plant lists in Clemson Extension Rain Garden Manual or other botanical resource for more detailed information regarding inundation, drought and salt tolerance for each species.

1.3.5 Mulch Layer

Provide a uniform 2- to 3-inch layer of mulch on the surface of the Rain Garden that provides an environment to enhance plant growth, enhance plant survival, suppress weed growth, reduce erosion of the filter media, maintain soil moisture, trap fine sediments, promote the decomposition of organic matter, and pre-treat runoff before it reaches the filter media.

Provide shredded hardwood bark that consists of bark from hardwood trees milled and screened to a maximum 4-inch particle size, uniform in texture, free from sawdust and foreign materials, and free from any artificially introduced chemical compounds detrimental to plant life. Provide mulch that is well aged a minimum of 6-months.

Do not use pine needles or pine bark mulch due to the ability of floatation.

Use alternative surface covers such as native groundcover, erosion control blankets, river rock, or pea gravel as directed by the Engineer. Use alternative surface covers based on function, cost and maintenance.

Do not provide a mulch layer for Rain Gardens that utilize turf grass as the vegetation material.

1.4 Construction Requirements

Do not construct Rain Gardens until all contributing drainage areas are stabilized as directed by the Engineer. Do not use Rain Gardens as sediment control facilities for during construction sediment control. Do not operate heavy equipment within the perimeter of Rain Gardens during excavation, underdrain placement, backfilling, planting, or mulching.

Separate Rain Gardens from the water table to ensure groundwater does not enter the facility leading to groundwater contamination or failure of Rain Garden. Ensure a vertical distance of 18 inches between the bottom of the Rain Garden and the seasonally high ground water table, to be verified by a geotechnical report if requested by the County.

1.4.1 Site Preparation

Because Rain Gardens are sensitive to fine sediments, do not install them on sites where the contributing area is not completely stabilized or is periodically being disturbed.

1.4.2 Installation

Install Rain Gardens around the natural topography to complement the surrounding landscape by fitting around sensitive areas, natural vegetation, driveways, and sidewalks. Rain Gardens should be installed at least 10 feet away from buildings. Install a stable overflow spillway to pass flows in excess of the designed volume.

1.4.2.1 Excavation

Excavate the Rain Garden to the dimensions, side slopes, and elevations shown on the Plans. Side slopes should not exceed 3H:1V. Excavate Rain Gardens to the required depth based on the plantings utilized. Refer to Table 3 for recommended filter media depth for Rain Garden plantings.

Ensure excavation minimizes the compaction of the bottom of the Rain Garden. Operate excavators and backhoes on the ground adjacent to the Rain Garden or use low ground-contact pressure equipment. Do not operate heavy equipment on the bottom of the Rain Garden.

Remove excavated materials from the Rain Garden and dispose of them properly.

1.4.2.2 Underdrain System

Prior to placing the underdrain system, alleviate compaction on the bottom of the Rain Garden by using a rototiller or equivalent method.

Remove any ponded water from the bottom of the excavated area. Line the excavated area with a permeable nonwoven geotextile fabric.

Place a layer of No. 5 or No. 57 Aggregate 3 feet wide, and minimum of 3 inches deep on top of the non-woven filter fabric in the area where the underdrain will be placed. Place the underdrain pipe on top of the underlying aggregate layer. Underdrain pipes will be wrapped in non-woven geotextile filter fabric before they are installed. Lay the underdrain pipe at a minimum 0.5% longitudinal slope. The perforated underdrain drain pipe may be connected to a stormwater conveyance system or stabilized outlet. Cap the upstream end of underdrain pipe which does not connect to outlet pipe.

Place No. 5 or No. 57 Aggregate around the pipe underdrain system to a minimum depth of 8 inches. Place a permeable non-woven geotextile fabric between the boundary of the gravel and the filter media to prohibit the filter media from filtering down to the perforated pipe underdrain.

1.4.2.3 Filter Media

Install a permeable non-woven geotextile filter fabric between the filter media and the on-site soils on the side slopes of the Rain Garden. Place and grade the filter media using low ground-contact pressure equipment or excavators and/or backhoes operating on the ground adjacent to the Rain Garden. Do not use heavy equipment within the perimeter of the Rain Garden before, during, or after the placement of the filter media. Place the filter media in vertical layers with a thickness of 12 to 18 inches. Compact the filter media by saturating the entire Rain Garden after each lift of filter media is placed until water flows from the underdrain system. Apply water for saturation by spraying or sprinkling. Perform saturation of each lift in the presence of the Engineer. Do not use equipment to compact the filter media. Use an appropriate sediment control BMP to treat any sediment-laden water discharged from the underdrain during the settling process.

The Engineer will provide documentation from the supplier to verify the makeup of the pre-mixed filter media to the County.

1.4.2.4 Plantings

Plant all Rain Garden grasses, native grasses, perennials, shrubs, small trees, and other plant materials as specified by applicable landscaping standards.

Ensure all plant materials are kept moist during transport and on-site storage. Plant the root ball so 1/8th of the ball is above final filter media surface. Ensure the diameter of the planting pit/hole is at least 6 inches larger than the diameter of the planting ball. Set and maintain the plant straight during the entire planting process. Thoroughly water all plantings after installation.

Brace trees as necessary. Ensure stakes are equally spaced on the outside of the tree ball.

1.4.2.5 Mulch

Immediately mulch the entire Rain Garden to a uniform thickness of 2 to 3 inches after all plantings are in place. Do not use mulch for Rain Gardens that utilize turf grass as the only vegetation material.

1.5 Inspection and Maintenance

Regular inspection and maintenance are critical to the effective operation of Rain Gardens. Maintenance responsibility of the Rain Garden is vested with a responsible authority by means of a legally binding and enforceable maintenance agreement that is executed as a condition of plan approval.

The surface of the ponding area may become clogged with fine sediments over time. Perform light core aeration or cultivate un-vegetated areas as required to ensure adequate filtration. Other required maintenance includes but is not limited to the tasks listed in Table 5.

Table 5: Summary of Maintenance Requirements

Required Maintenance	Frequency
Pruning and weeding.	As needed
Remove trash and debris.	As needed
Inspect inflow points for clogging. Remove any sediment.	Semi-annual (every 6 months)
Repair eroded areas. Re-seed or sod as necessary.	Semi-annual (every 6 months)
Mulch void areas.	Semi-annual (every 6 months)
Inspect trees and shrubs to evaluate their health.	Semi-annual (every 6 months)
Remove and replace dead or severely diseased vegetation.	Semi-annual (every 6 months)
Removal of invasive vegetation.	Semi-annual (every 6 months)
Test filter media for nutrient/fertilizer requirements.	Annual
Nutrient management per soil test results.	As needed
Pesticide management.	As needed
Water vegetation, shrubs and trees.	Semi-annual (every 6 months)
Remove mulch, reapply new layer.	Annual
Test filter media for pH.	Annual
Apply pelletized lime if pH < 5.2.	As needed
Add iron sulfate + sulfur if pH > 8.0.	As needed
Place fresh mulch over entire area.	As needed

1.6 IDEAL Modeling

The County's required method of demonstrating compliance with its water quality standards is to use the Greenville County IDEAL model. To facilitate use of this model, Table 6 shows how to represent this BMP and BMPs similar to this one in the IDEAL model. It lists the parameters needed to successfully run the model and the parameters that affect the sediment trapping efficiency of the BMP.

Table 6: IDEAL Modeling Guide

Rain Garden Modeling in IDEAL		
What to Model as in IDEAL	Bioretention Cell	
Similar BMPs	Stormwater Alley	
	Green Roofs	
	Planter Box	
	Natural Infiltration Area/Basin	
	Bioretention Area/Swale/Basin	
Specifications Needed for IDEAL	Cell area and number of layers within the cell	
	If applicable, underdrain details such as: - Subgrade infiltration soil texture and degree of saturation - Underdrain orifice diameter	
	Type of media and depth of each layer of the cell	
	Type, shape, and dimensions of the overflow spillway if present	
	Direct loading of bacteria that will be entering the cell	
Parameters that Drive Performance	Feature	How Value Affects Sediment Trapping Efficiency (TE)
	Underlying Soil Texture	Soils with higher infiltration capabilities increase TE
	Area	Increasing area increases TE
	Amount of Clay in Media	More clay increases TE but decreases infiltration rate

1.7 References

Clemson University Extension Carolina Clear, A Guide to Rain Gardens in South Carolina, 2016.

Clemson University Public Service Activities Carolina Clear, Rain Gardens, A Rain Garden Manual for South Carolina, 2009.

NCDENR Stormwater BMP Manual, Chapter 12 Bioretention, Chapter Revised July, 2009.

Rain Gardens Urban Waterways / Urban Stormwater Structural Best Management Practices (BMPs), North Carolina Extension Service, June, 1999.