*http://www.stormwatercenter.net/Assorted%20Fact%20Sheets/Tool4_Site_Design/AlternativePavers.htm*

*Stormwater Management Fact sheet: Green Parking*
*http://www.stormwatercenter.net/Assorted%20Fact%20Sheets/Tool4_Site_Design/GreenParking.htm*

*Stormwater Management Fact sheet: Porous Pavements*
*http://www.stormwatercenter.net/Assorted%20Fact%20Sheets/Tool6_Stormwater_Practices/Infiltration%20Practice/Porous%20Pavement.htm*

# Certifying the Landscape Community in Rain Garden Installation: the North Carolina Experience

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***Abstract.*** *Low Impact Development (LID) stormwater practices are being utilized to a greater extent in new construction to mitigate pollutant loads and hydrologic impacts associated with development. However, many cities are trying to find ways to improve water quality from existing non-LID developments. As a result, retrofit programs are becoming more common. Homeowners are often interested in improving water quality in their neighborhood, and backyard rain gardens are a practice that has become popular in North Carolina. Few homeowners have the technical expertise to size and construct a rain garden; therefore, they often hire a landscaper to complete these tasks. Faculty at N.C. State University and extension agents of N.C. Cooperative Extension have developed a 1.5-day certification course that offers landscapers a detailed understanding of how to properly site, design, install, and maintain a residential rain garden. Attendees listen to six hours of presentations and participate in in-class exercises on rain gardens, and then take a two hour tour of local rain gardens that have previously been installed. On the second day of the workshop, attendees take both an in-class and a field exam. Four workshops were delivered from March to November 2009, with a total of 73 people certified. The certification passing rate is approximately 80%. Some of the certified landscapers are actively advertising their certification. Similar programs could easily translate to other communities throughout the country. Rain gardens help to control runoff at its source, and may make meeting watershed-wide LID hydrology goals easier to obtain.*

**Keywords.** Rain garden, certification, workshop, landscaping, water quality, stormwater BMP, Low Impact Development, LID

## Introduction

Stormwater Best Management Practices (BMPs) are often used to meet LID hydrology goals. LID practices attempt to modify post-development hydrology to more closely resemble pre-development conditions (Davis et al. 2009). Bioretention, or variations such as rain gardens and bioinfiltration, have become increasingly popular BMPs to meet LID metrics. Bioretention cells (areas) are depressed areas in the landscape that infiltrate and store stormwater and clean pollutants from stormwater by adsorption, filtration, and plant uptake. They are engineered systems that have specially designed soil media, are planted with trees, shrubs, and/or grass, and often have perforated underdrains that help to dewater the system between storm events.

Bioretention performance has been evaluated both in the laboratory and in the field (Kim et al. 2003; Hsieh and Davis, 2005; Davis et al. 2006; Dietz and Clausen 2006; Hunt et al. 2006; Davis 2007; Hsieh et al. 2007; Hunt et al. 2008; Li et al. 2009). Research shows that effluent concentrations of TN, TP, TSS, hydrocarbons, and heavy metals are low in comparison to other stormwater BMPs. Also, bioretention can effectively mitigate peak flow rates and volumes through exfiltration of stormwater to the *in situ* soil. For these reasons, bioretention has become one of the most popular BMPs when LID principles are employed. Pollutant removal and hydrologic improvements from bioretention studies are presented in Table 1.

**Table 1. Pollutant removal and hydrologic mitigation from bioretention studies in the mid-Atlantic region**

| **TN Removal** | | | | |
|---|---|---|---|---|
| Site Location | Load Reduction (%) | Influent Concentration (mg/L) | Effluent Concentration (mg/L) | Reference |
| Louisburg, NC | 65 | 1.7 | 1.25 | Li et al. (2009) |
| Greensboro, NC | 40 | 1.35 | 4.38 | Hunt et al. (2006) |
| Charlotte, NC | N/A | 1.68 | 1.14 | Hunt et al. (2008) |
| Haddam, CT | 32 | 1.2 | 0.9 | Dietz and Clausen (2006) |
| Graham, NC | 56 | 1.66 | 0.76 | Passeport et al. (2009) |
| Graham, NC | 47 | 1.66 | 0.76 | Passeport et al. (2009) |
| **TP Removal** | | | | |
| Louisburg, NC | 69 | 0.28 | 0.18 | Li et al. (2009) |
| Greensboro, NC | -240 | 0.11 | 0.56 | Hunt et al. (2006) |
| Charlotte, NC | N/A | 0.19 | 0.13 | Hunt et al. (2008) |
| Haddam, CT | -111 | 0.015 | 0.059 | Dietz and Clausen (2006) |
| College Park, MD | 79 | 0.61 | 0.15 | Davis (2007) |
| College Park, MD | 77 | 0.61 | 0.17 | Davis (2007) |

| | | | | |
|---|---|---|---|---|
| Graham, NC | 53 | 0.14 | 0.05 | Passeport et al. (2009) |
| Graham, NC | 68 | 0.14 | 0.06 | Passeport et al. (2009) |
| **TSS Removal** | | | | |
| Charlotte, NC | N/A | 49.5 | 20 | Hunt et al. (2008) |
| College Park, MD | 59 | 34 | 18 | Davis (2007) |
| College Park, MD | 54 | 34 | 13 | Davis (2007) |
| **Zn Removal** | | | | |
| Charlotte, NC | 71 | 72 | 17 | Hunt et al. (2008) |
| College Park, MD | 54 | 107 | 48 | Davis (2007) |
| College Park, MD | 69 | 107 | 44 | Davis (2007) |

Rain gardens are smaller and less-engineered "cousins" of bioretention areas. They typically are smaller in surface area than bioretention cells, and may not require specialized soil media or underdrains. Two rain gardens were studied in Haddam, CT (Dietz and Clausen, 2005). The rain gardens substantially increased lag time and reduced peak flow rates. TN was reduced from 1.2 mg/L in the roof runoff to 0.8 mg/L and 1.0 mg/L in the underdrain of each rain garden. TP inlet concentrations were very low (1.9 µg/L), resulting in export of phosphorus from the rain gardens. Media depth was shallow (0.6 m), which resulted in a lack of runoff temperature reduction. One of the two rain gardens was modified to create an internal water storage (IWS) zone of 0.5 m (Dietz and Clausen, 2006). Over a 1-yr study period, effluent concentrations of TN, TP, $NO_3$, TKN, and $NH_3$ from the rain garden with an IWS layer were 56%, -160%, 66%, 33%, and 75% less than roof runoff concentrations, respectively. Effluent concentrations were lower for the rain garden with an IWS layer than the rain garden without an IWS zone for every pollutant. TP was leached from the soil, as determined by a 31% decrease in soil P over the study period.

During the past decade, public perception of water resources issues in the Mid-Atlantic region has shifted tremendously. The Albemarle Sound, Pamlico Sound, and Chesapeake Bay each drain parts of North Carolina, Virginia, Maryland, Pennsylvania, New York and/or West Virginia. These water bodies have low flushing rates; thus, pollutants tend to collect over time. High nutrient loads in stormwater runoff from urban and agricultural areas lead to eutrophication in these estuaries. This causes hypoxic conditions, which leads to fish kills. Stormwater runoff also carries harmful pathogenic bacteria to these water bodies, leading to closure of many shell fishing waters. In the Appalachian Mountains, stormwater runoff from urban areas causes stream temperatures to spike, leading temperature intolerant trout species to cooler waters. Since these issues tie economic factors to stormwater, public interest in protecting water quality has grown in the Mid-Atlantic region. Homeowners have become specifically interested in practices to manage runoff from their property. An ideal practice for residential areas is a rain garden, which can be sized to treat impervious surfaces associated with driveways and rooftops.

Because most homeowners do not have the expertise to design or install a rain garden, they often contact professionals, typically landscapers or landscape architects, to provide expertise. N.C. State University faculty and members of N.C. Cooperative Extension have organized a series of certification workshops that have been held to educate practitioners on design, siting, installation, and maintenance of residential rain gardens. Thus far, four such workshops have been given throughout North Carolina, and five more are planned (see Figure 1).

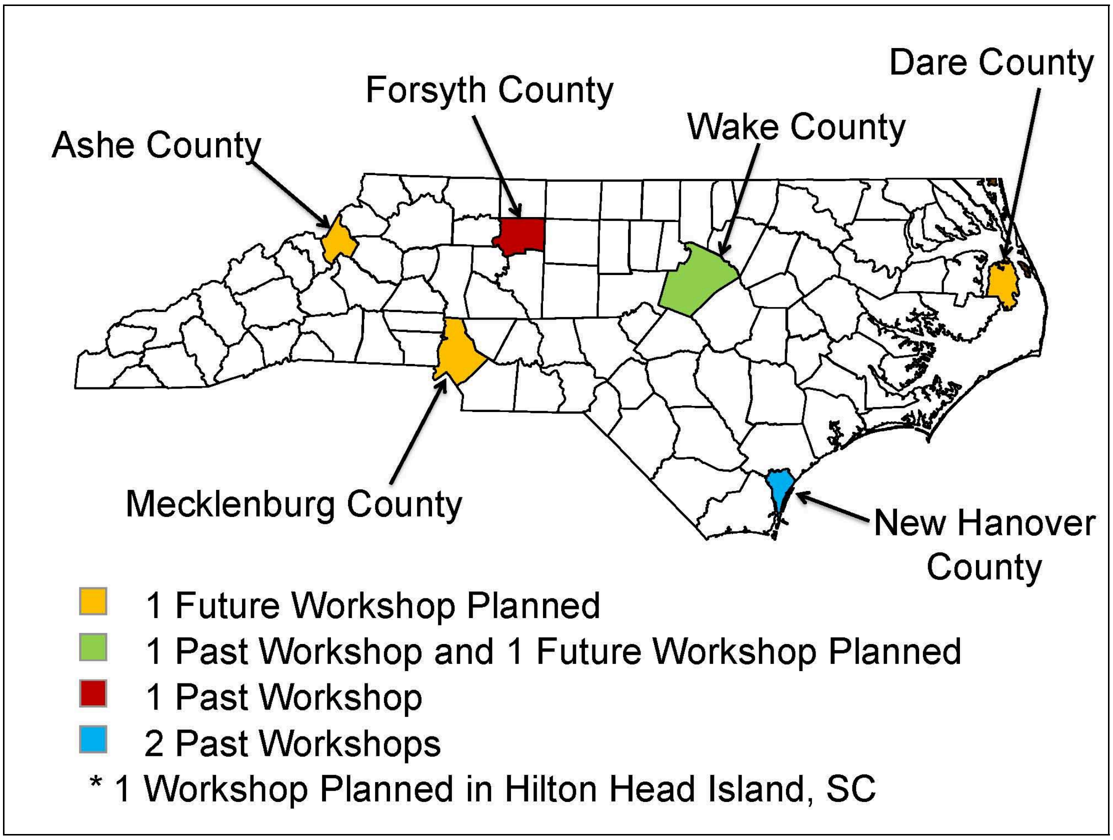


**Figure 1. Locations of residential rain garden certification workshops.**

Presentations are delivered by members of the N.C. State University Department of Biological and Agricultural Engineering faculty, who have expertise in the design, construction, and maintenance of rain gardens and bioretention cells. Presentations on residential rain garden installation, maintenance, and plant selection are given by members of N.C. cooperative extension who have expertise in water resources and horticulture, respectively.

## Description of Workshops

The rain garden certification workshop focuses on all aspects of siting, design, construction, and maintenance residential rain gardens. Landscape professionals, landscape architects, and engineers have attended to obtain an N.C. State-sponsored certification to install and maintain these practices. The workshop is split into two days; the first day involves presentations on rain gardens with a pair of interactive in-class exercises, followed by a tour of local rain garden installations in the host city. The second day of the workshop is reserved for the in-class and field portions of the certification exam. Attendees must receive a 75% on the exam to receive the residential rain garden certification. Each portion of the workshop is sequentially described below.

***Stormwater Management***

A background on the importance of stormwater management was given, with an emphasis on water quality problems in North Carolina and stormwater BMPs. Sources of pollutants were discussed, including construction sites, fertilizer, pet waste, atmospheric deposition, brake wear, and oil leaks. These sources lead to the major pollutants in surface waters in North Carolina, which include TSS, TN, TP, oil and grease, heavy metals, pathogenic bacteria, and temperature. An overview of stormwater BMPs was presented, including stormwater wetlands, bioretention, permeable pavement, wet ponds, dry ponds, filter strips, and cisterns. Residential rain gardens were introduced, and the highlights of the upcoming talks were given.

***Rain Garden Overview***

This section of the workshop presented the benefits of residential rain gardens, including water quality improvements, flood mitigation, groundwater recharge, wildlife habitat, and beautification of the landscape. An overview of how to locate rain gardens, sizing rain gardens, plants for rain gardens, and maintenance was presented. Resources were given for designing rain gardens and funding for construction of residential rain gardens.

***Rain Garden Site Selection***

This presentation focused on the site considerations and constraints that are present on any residential lot. Rain gardens should be located by using the existing topography and locations of existing downspouts. This will minimize the costs of grading. Designers need to complete a site visit to determine flow paths on the site, and observe the site during a rain event, if possible. Minimum distances were presented for separating rain gardens from wells (>10 ft), house foundations (>10 ft), and septic system drain fields (>25 ft). Emphasis was placed on locating utilities before any digging begins. Soil testing was also stressed, both for phosphorus index (P-index) and drainage rate. Preferably, P-index should be kept below 50, with a maximum limit of 100. Drainage rate tests should be completed at various potential rain garden locations on the property. A small hole should be dug to a depth of 1 ft below the expected bottom of the rain garden cut. The hole is then filled with water, and the drainage time determined. Depending upon dewatering time, various rain garden configurations are recommended, including a wetland garden if the test hole doesn't empty in less than 4 days. The final design constraint presented was the location of the water table; the designer must maintain a 2 ft separation between the bottom of the rain garden and the seasonally high water table.

***Rain Garden Design***

Rain garden design must be based upon the drainage rate test described above. Standard rain garden design uses a flat rain garden bottom with a 7.5- 15 cm (3-6 inch) ponding depth. A zoned rain garden has varying ponding depths for improved plant survival, with an average ponding depth of 6 inches. Instructors presented on how to delineate a watershed and calculate watershed imperviousness. Options for choosing a runoff capture depth (typically 1" in NC) and choosing a rain garden ponding depth (typically 3" or 6") are then presented. A simple calculation for determining rain garden size may be based upon the total impervious area in the watershed. For a 6" ponding depth, rain garden size was determined as the total impervious area divided by 20. Overflow weir lengths were tabulated for the attendees based upon total impervious area. One example was presented, including mathematical determination of watershed size, total impervious area, ponding depth, rain garden size, and overflow weir size.

***In-class Example Problem***

An in-class example was provided to the participants, including an aerial photograph of the site, with associated contours and constraints (i.e. locations of utilities and wells). Attendees were instructed to work in groups to size and locate a rain garden. The example problem is very similar to and meant to serve as preparation for one of the examination questions. The workshop coordinators then led a discussion to detail an answer to the problem, including watershed delineation and the associated calculations for sizing the rain garden. In the reviews of the workshop, this was one of the sections that attendees find the most useful.

***Plant Selection***

A horticulture agent has always given the plant talk at the past four rain garden certification workshops. Emphasis was placed on using specific plants in three different "zones" of the rain garden: the wet zone, the intermediate zone, and the dry zone. Trees and shrubs were recommended based upon their tolerance to inundation with water. Plant recommendations were made based upon experience with survivability in bioretention cells throughout North Carolina. Recommendations were made for mulch (typically 2-4" of triple shredded hardwood).

***Rain Garden Construction***

Examples of the construction of rain gardens were presented in this section. This included a review of the initial siting steps (drainage tests, working with topography). An explanation of digging methods (shovel vs. backhoe) was given, with the caveat that if underdrains will be installed, a backhoe is strongly recommended for construction. Engineered fill media and underdrains were discussed for those areas with clayey in-situ soils. Best methods for planting in each zone of the rain garden were given. Also, attention was given to fertilizer, which should be avoided in a rain garden, except for initial plant establishment.

***Maintenance and Inspection***

Maintenance tasks for rain garden upkeep were presented in this section. Watering the rain garden should be needed only during the first growing season, right after planting, and during extreme droughts. Pruning of vegetation in the rain garden should be done annually, as should mulch renewal. Every third year, mulch should be completely replaced to avoid hardpan formation from sealing the rain garden. Trash and sediment should be removed from the rain garden as needed. A stable watershed will help to prevent clogging of the rain garden. Relating the similarities of typical landscape feature "maintenance" and rain garden maintenance is one of the objectives of this section.

***Site Visits***

Site visits were planned in each host city to give attendees examples of rain gardens that were previously installed. If possible, the owner or installer spoke on the design, installation, and challenges involved with each rain garden. The site visits also helped to prompt attendees to ask questions. The tour visited roughly 5 rain gardens at each workshop. At one workshop (in Winston-Salem), a rain garden was installed as a portion of the class. This was noted on evaluations as a highlight of the workshop by many attendees, and this feature of the workshop is being considered at many of the upcoming rain garden certification events.

***Certification Exam***

Following a short question and answer session at the beginning of the second day of the workshop, the certification exam was given. The exam consisted of both an in-class and a field portion. The in-class test is multiple choice and short answer, and tests the attendee's knowledge of the important concepts that were highlighted during day 1 of the workshop. During the field portion of the exam, participants were transported to a local residence, where they were instructed to design a rain garden. While walking the property, test-takers had the opportunity to choose a drainage area, and then had to size and locate an appropriate rain garden. Answers were drawn to scale on a topographic map of the site. Mathematical justification of their sizing and weir lengths was required. The best exam responses were then presented to the homeowner, who has often used the recommendation to construct a rain garden on the property. Workshop attendees taking the field portion of the exam are shown in Figure 2. To pass the exam, attendees must correctly answer 75% of the questions, as graded by NCSU faculty and staff.

**Figure 2. Workshop attendees taking the field portion of the certification exam.**

## Expected Outcomes

This workshop provided attendees with the knowledge needed to design, install, and maintain a functioning rain garden. They should be able to choose an appropriate rain garden location on a residential lot, and delineate the watershed and its percent imperviousness. Based upon the imperviousness of the watershed, they should be able to specify the correct size of the rain garden and its associated overflow weir length. They should also have basic understanding of rain garden plants, mulch, and soil media. Finally, they should be able to install or oversee installation of a residential rain garden, and maintain it to preserve its functionality.

## Changes to the Workshop

The first Rain Garden Certification workshop was held in Wilmington, NC on March 4, 2009. The workshop was scheduled to be 1 day in length (8:30 AM to 4 PM), with all of the talks (see above), site visits, and both the in-class and field portions of the test. However, the workshop ran much longer than expected, and some participants finished their field tests at 6:30 PM. This led to complaints on the evaluations about length of the workshop. Since the first workshop, it is now presented over 1.5 days, or 2 days if a rain garden installation is included in the workshop.

Some changes have also been made to the content of the workshop, usually due to suggestions from workshop participants. One suggestion that has been incorporated is to have plant examples while the plant talk is being delivered. Initially, the simple method was used to size the rain garden and the weir equation to calculate the weir length. However, many of the attendees did not have the mathematical background to use these equations; instead, sizing charts and simplified equations are now provided to attendees. Short sections on general rain garden terminology and underdrains are in the planning stages. The workshop is constantly evolving due to feedback received in evaluations.

## Lessons Learned from Evaluations

At the end of each workshop, attendees were encouraged to fill out an anonymous evaluation. The evaluation prompted them to rate the speakers and handouts on a 1 to 5 scale (5 highest), level of knowledge prior to and after the workshop (0% up to 100%) and whether they would utilize the information in the future. Results for three workshops are presented in Table 2 for the speakers and handouts.

**Table 2. Evaluation results for speakers and handouts.**

| Wilmington, NC Evaluations (March 4, 2009) | | | | | |
|---|---|---|---|---|---|
| Rating | 1 | 2 | 3 | 4 | 5 |
| Speakers | 1 | | 1 | 6 | 15 |
| Handouts | 1 | 1 | | 5 | 17 |
| Winston-Salem, NC Evaluations (November 4-5, 2009) | | | | | |
| Rating | 1 | 2 | 3 | 4 | 5 |
| Speakers | | | | 3 | 12 |
| Handouts | | | | 3.5 | 11.5 |

| Cary, NC (November 12-13, 2009) | | | | | |
|---|---|---|---|---|---|
| Rating | 1 | 2 | 3 | 4 | 5 |
| Speakers | | | 1.5 | 12.5 | 16 |
| Handouts | 1 | | 5 | 12 | 11 |

The highest evaluation ratings for both handouts and speakers were received at the Winston-Salem workshop, where 80% and 77% of ratings for speakers and handouts were "5," respectively. This probably had to do with "extras" that were planned at this workshop, including a rain garden installation and plant examples during the plant talk. Interestingly, the Cary, NC workshop had the greatest number of participants pass the certification (30 people) and the greatest percentage of passing grades (96.7%), but was the workshop that had the lowest average rating for handouts (4.10) and speakers (4.48).

Attendees also rated their level of knowledge prior to the workshop (PTW) and level of knowledge after the workshop (ATW). Results are presented below in Table 3.

**Table 3. Evaluation results for level of knowledge.**

| Wilmington, NC Evaluations (March 4, 2009) | | | | | | |
|---|---|---|---|---|---|---|
| Rating | 0% | 20% | 40% | 60% | 80% | 100% |
| PTW | 2 | 4.5 | 8.5 | 4.5 | 3.5 | 1 |
| ATW | | 1 | | 3.5 | 14 | 6.5 |
| Winston-Salem, NC Evaluations (November 4-5, 2009) | | | | | | |
| Rating | 0% | 20% | 40% | 60% | 80% | 100% |
| PTW | | 1 | 4.5 | 5.5 | 4 | |
| ATW | | | | 2 | 4 | 9 |
| Cary, NC (November 12-13, 2009) | | | | | | |
| Rating | 0% | 20% | 40% | 60% | 80% | 100% |
| PTW | 1 | 4.5 | 5.5 | 9 | 7 | 3 |
| ATW | | | | 1.5 | 13.5 | 15 |

The workshop with the lowest PTW level of knowledge was Wilmington with an average of 45%. This workshop also had the lowest ATW level of knowledge, at 80%. This was probably due to the fact that it was the first time the workshop was given. The Winston-Salem and Cary workshops had similar levels of PTW and ATW knowledge, at around 57% and 89%, respectively.

The final evaluation metric was whether the participants would use this information in the future. In Wilmington, Winston-Salem, and Cary, the number of respondents who answered "quite possibly" was 5, 2, and 10, respectively. Those who answered "without a doubt" were 18, 12, and 19, respectively. Only one respondent out of the three workshops answered "somewhat" and no one answered "no way." Therefore, the audience that attended the workshops appeared to be our target audience.

A post-workshop evaluation is currently in the planning stages. All prior workshop attendees will receive an online survey, which will help the workshop presenters to better plan future workshops. Questions will include areas of the course that were