IISG23-RCE-PXP-001 - ID-533-W

Authors

Kara Salazar, Assistant Program Leader for Community Development, Purdue Extension; Sustainable Communities Extension Specialist; Illinois – Indiana Sea Grant; Purdue University Department of Forestry and Natural Resources

Dr. Sara Winnike McMillan, Professor, Agricultural & Biosystems Engineering, Iowa State University

Payton Ginestra, Purdue University Natural Resources and Environmental Science undergraduate student; 2022 Illinois-Indiana Sea Grant Intern

Laura A. Esman, Research Associate & Lab Manager, Department of Forestry and Natural Resources; Managing Director, Indiana Water Resources Research Center

John Orick, Purdue Extension Master Gardener State Coordinator, Department of Horticulture and Landscape Architecture

INTRODUCTION TO

Rain Garden Design

Overview and Benefits of Rain Gardens

When stormwater runs off streets, driveways, roofs, and other impervious surfaces, it can move pollutants such as oil, fertilizers, heat, and chemicals to storm drains and eventually to natural bodies of water, such as lakes, streams, and rivers. These natural water sources are valuable resources for recreation, irrigation, and drinking water. Green infrastructure projects, such as rain gardens, can improve the quality of stormwater, reduce flooding, minimize pollution, enhance biodiversity and pollinator habitat, and create educational and recreational opportunities.

Green infrastructure includes a range of practices that allows stormwater to infiltrate into the soil or be stored for later use, thereby reducing flows to sewer systems and surface waters (U.S. EPA, 2022). A rain garden is one such practice. It is a small-scale landscape feature planted with native shrubs, perennial plants, or flowers in a shallow depression. It captures and stores runoff, allowing it to slowly infiltrate into the soil. At the property scale and when properly located, rain gardens lessen erosion in steeply sloped areas, reduce the potential for water to flow into basements, and minimize ponding in areas with poor drainage. The net effect of multiple green infrastructure practices can reduce streambank erosion and downstream flooding as stream flows decrease. Water quality is also affected as plants and microbes in the soil filter nutrients and some heavy metals as the stormwater soaks into the soil.

BENEFITS OF RAIN GARDENS

1. Easy to design, install and maintain
2. Provide aesthetic appeal while blending into landscape
3. Provide habitat for wildlife, butterflies, and beneficial insects
4. Improve water quality by filtering nutrients and some heavy metals
5. Minimize flood risk by storing and infiltrating stormwater

Rain gardens can be sized to accommodate flows on most residential properties. Larger gardens, also called bioretention areas, require substantially more design to ensure that the larger flow rates and more complex flow dynamics are considered. Regardless of scale, rain gardens can amplify other ecosystem services by becoming collaborative, shared spaces for communities, and adding wildlife habitat to areas that may be lacking. When designing any rain garden, especially those on public or community-accessed land, it is essential to understand the community needs and potential concerns.

By engaging with community early in a green infrastructure project, designers can create a functional space that serves residents' needs and generates more use (Albro, 2019). In addition to providing a community space, there are many co-benefits to rain gardens, such as providing resources for pollinators, increasing biodiversity, and nature education opportunities (U.S. EPA, 2022).

Steps for building a rain garden

1. Siting and Sizing

Locate the rain garden on your site

Choose a location on your property where the rain garden will intercept runoff from impervious surfaces (rooftops, driveways, sidewalks) and that is near the runoff destination (low spots, storm drains). It is helpful to observe the water flow on the property during a rain event to see where the water flows naturally. A gentle slope will help direct stormwater into the rain garden, but steep slopes can cause additional problems by increasing erosion. To avoid damage to nearby structures from infiltrating water, the rain garden should be at least 10 feet from any foundations or sublevels and 20 feet from basements. It should also be at least 25 feet away from any septic system drain field (Schmidt et al., 2007).

Avoid underground utilities by calling the local Call Before You Dig number. There may be private underground utilities, such as water service lines and sanitary sewer laterals, that will not be marked on private property. Use the Call Before You Dig markings and your best judgment to estimate where these may be – and stay at least 10 feet from them. It is also best to avoid areas with poor natural drainage. These spots collect and hold surface water after rain events, leading to flooding (Bonsack, 2022). If you have poor urban soils or poor draining soils, use native plants with deep roots to bring the infiltration and evapotranspiration rates up. Note that your discharge or overflow point may need to start lower than for areas with higher infiltration rates. The overflow points can be modified to hold more water over time as you observe the infiltration rates increasing as your plants get established.

Determine infiltration potential of your soil

The type of soil at the rain garden site impacts the rate of drainage. Water will infiltrate more quickly through sandy soils, whereas clay soils have slower infiltration rates. One useful resource when determining soil type is the Web Soil Survey from the U.S. Department of Agriculture (websoilsurvey.sc.egov.usda.gov) (USDA, 2019). Water should drain from a rain garden basin within 24 to 48 hours. That prevents plants from being submerged in saturated soil for extended periods of time and ensures that the rain garden will not attract mosquitoes, because mosquitos cannot complete their breeding cycle in that time (EPA 2005).

An infiltration test is used to determine the design depth of the rain garden, aiming for infiltration within 24 to 48 hours.

- **Step 1:** Dig a hole in the ground that is 8 inches deep and 8 inches wide
- **Step 2:** Fill the hole completely with water and allow it to soak for two hours to saturate the ground
- **Step 3:** After the two hours, refill the hole with water until it is 1 inch from the top of the hole
- **Step 4:** With a ruler or tape measure, mark the starting depth and measure the depth multiple times over the next few hours. For sandy soils use 15- or 30-minute increments; for slow-draining clay soils use one-hour increments.
- **Step 5:** Determine the infiltration rate based on the collected data and convert it to the total depth of water that can infiltrate over a 48-hour period. This number will be the depth of the rain garden rounded up to the nearest inch. For well-drained soils, the 48-hour infiltration depth may exceed 12 inches. In this case, a depth of 12 inches is selected. It is best not to have a rain garden over 18 inches deep regardless of infiltration rates.

INFILTRATION TEST CALCULATION

Infiltration test calculation: inches / hours x 24 hours / day = inches / day

Example: 2 inches of water dropped in infiltration test hole over 5 hours

(2 inches / 5 hours) x 24 = 9.6 inches / day

Rain garden pool = 10 inches deep

Determine the size and shape of your rain garden

The size of the rain garden is affected by factors that include soil type, square footage of contributing impervious surfaces, and the amount of rain an area receives (Schmidt et al., 2007). The size of the rain garden basin is designed to hold about an inch of rainfall at a time. To estimate the area (in square feet), designers need two numbers:

1. Impervious area: Determine the area of impervious surfaces (rooftops, driveways, or sidewalks) directly flowing into the rain garden. You can use Google maps or the Indiana map website (maps.indiana.edu) measuring tool to do this calculation. Other states may have similar websites or online tools.
2. Rain garden area: Divide the square footage of the impervious area by the depth of the rain garden in inches determined from the infiltration test. This calculation will give an approximate area of the rain garden in square feet (Schmidt et al., 2007). The area of the rain garden can fluctuate depending on the site and the shape desired.

   Rain gardens can incorporate additional features, such as multiple basins, flowerbeds along the perimeter, or rock-lined swales to direct the flow of water. The rain garden is intended to hold about 1 inch of rainfall during heavy rain events, with excess water diverting out of the rain garden. If there is not enough area to hold the 1-inch rainfall, it is OK to design for a smaller amount. Every little bit helps!

RAIN GARDEN SIZING CALCULATION

Rain garden sizing calculation: Area of impervious surface in square feet / depth of rain garden calculated from infiltration test

Example:

Roof area flowing into downspout to rain garden = 500 sq ft

Depth of rain garden = 10 in

500 ft / 10 = 50 sq ft rain garden

Design inlets and outlets

After determining the size of the rain garden, design how the water will enter and exit the basin (Figure 1). There are several options for water to flow into the rain garden. Plastic drainpipe is often used to direct stormwater from downspouts to the garden. The transition from the downspout to the rain garden is at risk of erosion as concentrated flow spreads out. However, placement of rock or gravel will help protect this area from erosion. Add texture and visual appeal to the rain garden by using large rocks, gravel or clumps of native grasses. For rain gardens capturing runoff from larger areas, bioswales or vegetated channels can be used to convey water across a property and can be lined with river rock to protect erosion-prone areas, such as slope changes or curves (Caflisch & Callahan, 2015).

When digging the rain garden in an area with poor infiltration or soil, you may need to dig a little deeper to remove unsuitable soil (for example, soils with high clay content or low organic matter). This soil can be used to create a berm on the downslope edge to retain water in the garden for infiltration and should include an outlet weir for excess water to gently flow out during the largest events. Outlets should be lined with rocks or gravel to minimize erosion of the berm and maintain mulch levels.

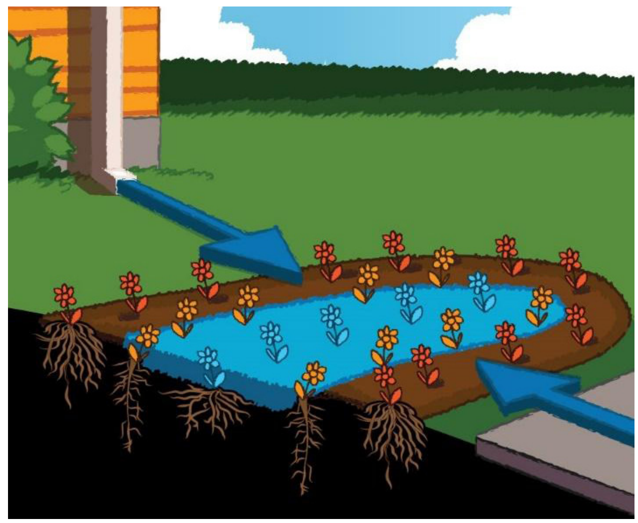

Figure 1: *Inlets of a rain garden*

2. Plant Selection and Garden Design

Native plants appropriate for your climate zone will help create soil conditions that increase infiltration of stormwater, capture carbon, and absorb pollutants. They can be selected to support additional ecosystem services, such as pollination. Determine the USDA plant hardiness zones to select plants adapted for the geographic region (planthardiness.ars.usda.gov) (USDA, 2021). Consider native plant species that are indigenous to an area and uniquely adapted to grow in the ecosystem. Well-adapted horticultural species with deep roots are also appropriate. The deep roots may increase your infiltration rates, even in poorly drained soils.

Within a rain garden there are three zones: the bottom, side, and top (Schmidt et al., 2007) (Figure 2). The bottom of the rain garden receives the most water and has average to moist soil. The plants for this area will need to tolerate prolonged saturated soil conditions. The plants for the sides of the rain garden experience a wide range of soil moisture conditions and should be resilient in both wet and dry conditions. The plants on the top receive little runoff and therefore must be drought-tolerant. Rain garden plants that thrive in both sun and shade are available; comprehensive lists make choosing

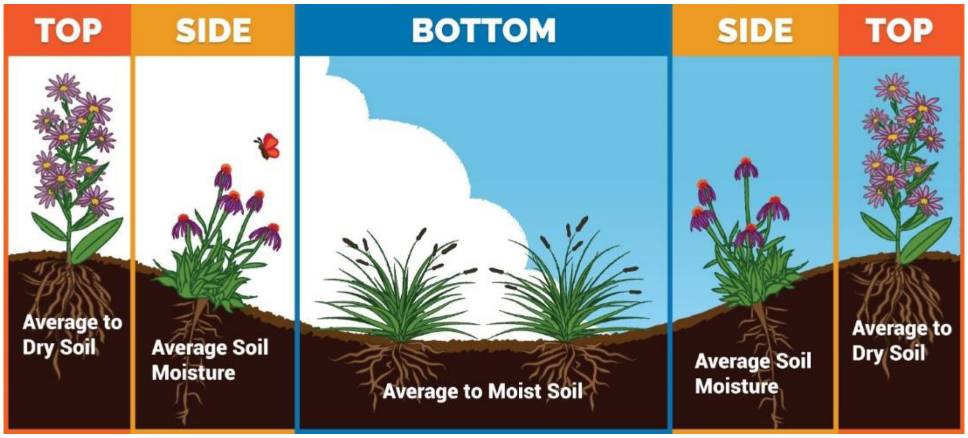

Figure 2: *Soil moisture of differing levels within a rain garden*

RAIN GARDEN PLANT SELECTION

Several resources are available to learn about rain garden plant selection.

The University of Connecticut Rain Garden web-based app (https://rgapp.nemo.uconn.edu) is a free tool that provides a step-by-step guide for how to properly install a rain garden; it features video tutorials and various tools. The Purdue Rainscaping Education Team developed an Indiana-specific rain garden plant list, with photos, to include in this app. Select Indiana from the dropdown list of states.

The Marion County Soil and Water Conservation District's *Rain Gardens for Homeowners* guidebook (https://marionswcd.org/wp-content/uploads/Rain-Garden-SWCD-Guide-Online-Version.pdf) contains suggested plant lists suitable for Central Indiana.

The University of Illinois' *Red Oak Rain Garden* provides a living laboratory resource of rain garden plants (https://redoakraingarden.org/plants-of-the-red-oak-rain-garden/).

Red Oak Rain Garden's companion publications include:

Woodland Garden (https://iiseagrant.org/publications/woodland_garden/)

Woodland Border Garden (https://iiseagrant.org/publications/woodland-border-garden/)

Wet Woodland Garden (https://iiseagrant.org/publications/wet-woodland-garden/)

Dry Woodland Garden (https://iiseagrant.org/publications/dry-woodland-garden/)

Native Spring Ephemerals (https://iiseagrant.org/publications/native-spring-ephemerals/)

plants easier. If the rain garden is located within a site that regularly receives runoff from salted roads, select plants that have some level of salt tolerance (Schmidt et al., 2007). Finally, space plants in the garden considering the mature size and spread. Select different heights, varieties, and colors of plants to beautify your rain garden by adding texture and seasonal interest. Planting plugs up to gallon size will provide a faster established rain garden. These also help with early maintenance practices, such as weeding, to keep your landscape as designed.

3. Installation

Proper installation is critical to the success of any rain garden. Before starting the installation process, know the location of underground utilities. When determining the final layout of a rain garden, outline different configurations within the site using flags, string, a garden hose, or spray paint (Figure 3). Choose a shape that will incorporate the rain garden into the existing landscape to ensure the garden flows throughout the property. Before finalizing the shape, consider maintenance needs, such as space for mowing adjacent turfgrass. Remove existing vegetation, including roots, from the site. Use a sod cutter, or cover the grass with black plastic or a tarp. Killing the grass by covering with plastic or a tarp will take several weeks before installation can begin.

Next, loosen the soil and prepare for planting by using a shovel or rototiller. Dig the rain garden to the determined depth and area, making sure the basin is flat-bottomed and has gently sloping sides. Some soil types with heavy amounts of clay or sand may require amendments to the soil, such as additional compost or another source of organic matter. These amendments will improve the drainage of the soil while also providing better growing conditions for the plants. When adding soil amendments, dig the rain garden deeper than the final design depth, mix in soil amendments as needed, and then reshape the bottom and sides. Infiltration rates may have changed, so consider performing an additional infiltration test before plants are installed to ensure proper design depth. Using the soil from the basin, construct the berm to retain water; create an outlet to direct any overflow. Add a 3-inch layer of hardwood shredded mulch to the rain garden. That type of mulch is more stable during rain events, will not float away, and will not need to be replaced as often as other varieties (Schmidt et al., 2007).

It is often helpful to stage your plants to ensure proper spacing. Dig a hole approximately twice the size of the root ball, place the plant in the hole and fill with soil. Place mulch around each plant, making sure to leave space near the stems. Once the rain garden installation is complete, water should infiltrate within 24 to 48 hours. After planting, if water is not infiltrating fast enough you may want to lower your discharge point. This should be temporary; once the plants get their roots established, infiltration and evapotranspiration rates will increase.

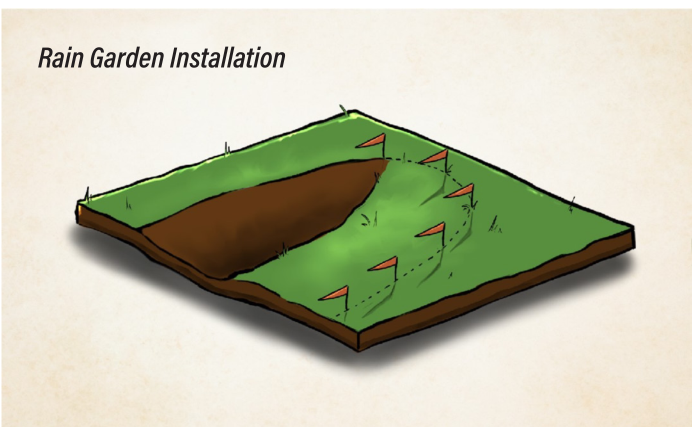

Figure 3: *Rain garden installation showing placement of flags along border*

4. Maintenance

During the first growing season, plants typically need to be watered weekly to an equivalent of about one inch of water. A consistent supply of water will help them grow and establish root systems (Schmidt et al., 2007). After the first season, the plants will need to be watered only during extremely dry periods. Remove weeds throughout the growing season every 2-4 weeks as needed. While weeding, check the level of mulch on the rain garden. Heavy storms can wash mulch away, and if it is less than 3 inches deep, add more mulch. At the end of each growing season, it is important to remove any dead plant material from the garden. This includes weeds, dead

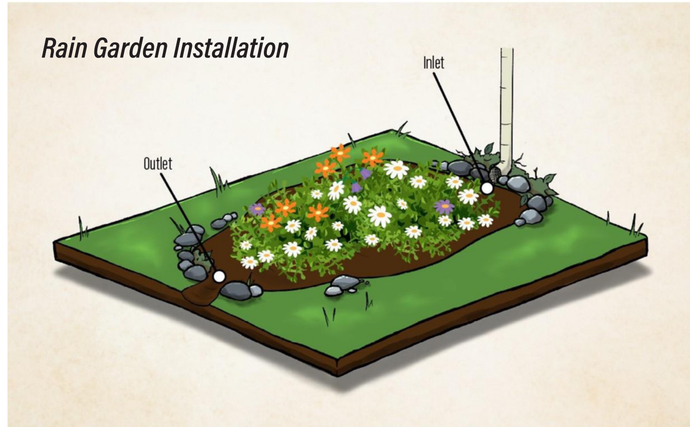

Figure 4: *Rain garden maintenance*

plants, and leaf litter blocking inlets and outlets (Figure 4). You may want to leave flower heads through the winter to provide architecture, habitat, and food sources for wildlife. If after three to five years you want to cut and remove plant material, do it by hand or with a weed eater. Do not cut below 4 to 6 inches. If you like flowers, it is best to do this in the late fall or early winter, so your plants have all spring to regrow and flower again.

Create a maintenance plan with a list of general maintenance and seasonal tasks essential to managing the rain garden, including who is responsible and when tasks should be completed. Including a plant design map and a list of plant species used in the rain garden will make choosing replacement plants easier. If the rain garden is a public utility, a maintenance plan will also aid in shifts in leadership and will inform new caretakers about the rain garden.

EXAMPLE MAINTENANCE PLAN

Task	Time of year	Who is responsible
Weeding	Growing season: Every two to four weeks or as needed	
Watering	Growing season: Weekly in first two years during dry periods	
Removing plant materials	Fall	
Cleaning out inlet and outlet	Year-round, as needed	
Adding mulch	Spring	

Bibliography

Albro, S.L. (2019). *Vacant to Vibrant- Creating Successful Green Infrastructure Networks* . Island Press.

Bonsack, K. (2022). *Rain Gardens*. CT NEMO Program- Center for Land Use Education and Research. Retrieved from https://nemo.uconn.edu/raingardens/

Caflisch, M., & Callahan, K. (2015). *An Introduction to Bioswales*. Home & Garden Information Center, Clemson University, South Carolina. Retrieved from https://hgic.clemson.edu/factsheet/an-introduction-to-bioswales/

Environmental Protection Agency, Office of Water. (2005). *Stormwater structures & mosquitoes.* EPA 833-F-05-003.

Environmental Protection Agency. (2022). *What is Green Infrastructure?* EPA. Retrieved from https://www.epa.gov/green-infrastructure/what-green-infrastructure

Schmidt, R., Shaw, D.B., & Dods, D. (2007). *The Blue Thumb Guide to raingardens: Design and installation for homeowners in the Upper Midwest: A guide for planting zones 3, 4 and 5*. Waterdrop Innovations.

United States Department of Agriculture. (2019). *Web Soil Survey*. USDA Natural Resources Conservation Service. Retrieved from https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm

United States Department of Agriculture . *USDA Plant Hardiness Zone Map*. (2021). Retrieved from https://planthardiness.ars.usda.gov/

Reviewers

John Hazlett, District Manager, Marion County Soil and Water Conservation District

Brian Neilson, P.E., LEED AP, Environmental Resource Engineer

Purdue Extension Rainscaping Education Team

Brooke Alford, ANR Educator, Purdue Extension, Marion County

Eliana Brown, Stormwater Specialist, University of Illinois Extension, Illinois-Indiana Sea Grant

Karen Mitchell, Department of Horticulture and Landscape Architecture

Amanda Mosiman, ANR Educator, Purdue Extension, Warrick County

Hans Schmitz, Lead Agronomist, Purdue Extension Conservation Cropping Systems Initiative

Nikky Witkowski, ANR Educator, Porter County

Phil Woolery, ANR Educator, Purdue Extension, Pulaski and Starke counties

Videos and more

For more information, including publications and videos, visit the Rainscaping site:
https:/extension.purdue.edu/rainscaping/

Illinois Extension
UNIVERSITY OF ILLINOIS URBANA-CHAMPAIGN

CONSERVATION LEARNING GROUP

Sea Grant ILLINOIS-INDIANA

This publication was produced by Purdue Extension in collaboration with the Conservation Learning Group at Iowa State University and Illinois-Indiana Sea Grant.