# Green Infrastructure Opportunities that Arise During Municipal Operations

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# INTRODUCTION

Green infrastructure uses natural processes to improve water quality and manage water quantity by restoring the hydrologic function of the urban landscape, managing stormwater at its source, and reducing the need for additional gray infrastructure in many instances. These practices are designed to restore the hydrologic function of the urban landscape, managing stormwater at its source and reducing or eliminating the need for gray infrastructure. An important objective of green infrastructure is to reduce stormwater volume, which improves water quality by reducing pollutant loads, stream bank erosion, and sedimentation. When green infrastructure is employed as part of a larger-scale stormwater management system, it reduces the volume of stormwater that requires conveyance and treatment through conventional means, such as detention ponds.

Green infrastructure practices can be integrated into existing features of the built environment, including streets, parking lots, and landscaped areas. Green infrastructure practices can be a viable option for managing stormwater in highly urbanized and infill situations where development density is desired and offsite mitigation is not a preferred alternative.

This document provides approaches local government officials and municipal program managers (Figure 1) in small to midsize communities can use to incorporate green infrastructure components into work they are doing in public spaces. The guide demonstrates ways in which projects can be modified relatively easily and at a low cost recognizing that municipal resources can be limited.

Implementing projects in public spaces can showcase the aesthetic appeal of green infrastructure practices and provide a visual demonstration of how they can function. This real-life context will also allow residents, businesses, and local governments to experience additional benefits and values of many green infrastructure practices—more walkable streets, traffic calming, green public spaces, shade, and enhanced foot traffic in retail areas.  Municipal managers can then use the experience gained from the design, installation and maintenance green infrastructure projects to help tailor regulations and incentive programs and make green infrastructure easier to implement in the future.

These highlighted examples and case studies show how integrating green infrastructure methods can enhance retrofits and maintenance projects and also provide multiple community benefits. Local governments are in a unique leadership position to further green infrastructure within their communities. The U.S. Environmental Protection Agency (EPA) hopes that by using this guide localities can begin to institutionalize the use of green infrastructure in their municipal operations.

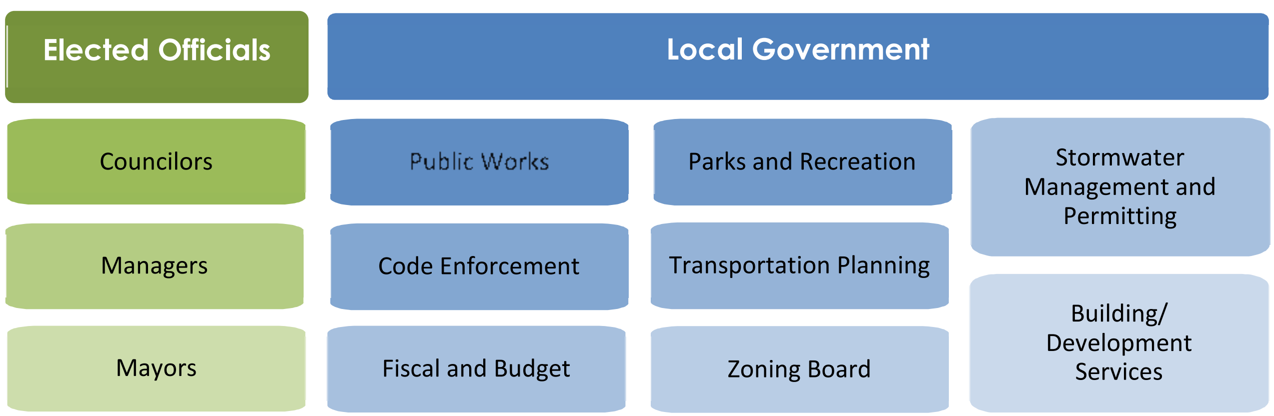


Figure 1. Intended audience

## GREEN INFRASTRUCTURE COSTS AND BENEFITS

Local agencies are often tasked with retrofitting a property or installing or replacing stormwater and drainage infrastructure. Overall, green infrastructure has been shown to be more cost-effective when compared with traditional gray infrastructure approaches, and green infrastructure offers numerous ancillary benefits (Figure 2). The visible, above-ground and accessible qualities of green infrastructure, as opposed to gray infrastructure, provide other benefits, including, improving air and water quality, improving quality of life, and offering public education opportunities, as described in Figure 3.

Though green infrastructure can potentially have higher installation costs in redevelopment and retrofit settings, this is not always the case due to the site-specific opportunities and constraints on many infrastructure projects. Since gray infrastructure retrofits can also be costly, green infrastructure can be integrated into already planned infrastructure improvement projects to help mitigate demolition and disposal costs.

From a life cycle perspective, it is important to compare the long-term maintenance and replacement costs associated with green and gray infrastructure. The vegetation characteristic of many green infrastructure practices becomes enhanced as it grows over time, whereas gray infrastructure's engineered materials only deteriorate over the long term. The maintenance required for green infrastructure practices typically does not require heavy equipment, whereas maintaining gray infrastructure's pipes, forebays, basins, and embankments can be more costly.

Green infrastructure can be a cost-effective strategy to help local governments meet regional water quality objectives. Besides green infrastructure's ability to improve water quality and reduce stormwater pollution, green infrastructure reduces the cost of total maximum daily load (TMDL) implementation by reducing pollutant loads associated with stormwater. Green infrastructure can reduce the cost to implement a stormwater management program because the amount of stormwater to be conveyed and treated is reduced.

### *Green Infrastructure Economics*

Several recent publications evaluated the economic benefits associated with green infrastructure:

- **Banking on Green: A Look at How Green Infrastructure Can Save Municipalities Money and Provide Economic Benefits Community-wide**: http://www.americanrivers.org/assets/pdfs/reports-and-publications/banking-on-green-report.pdf
- **Case Studies Analyzing the Economic Benefits of Low Impact Development and Green Infrastructure Programs**: http://water.epa.gov/polwaste/green/upload/lid-gi-programs_report_8-6-13_combined.pdf
- **Reducing Stormwater Costs through Low Impact Development (LID) Strategies and Practices**: http://water.epa.gov/polwaste/green/costs07_index.cfm
- **The Value of Green Infrastructure: A Guide to Recognizing its Economic, Environmental, and Social Benefits:** http://www.americanrivers.org/wp-content/uploads/2013/09/Value-of-Green-Infrastructure.pdf?c8031c.

**Green Roofs**

- Have a longer lifespan than traditional roofs
- Reduce energy costs
- Buildings with green roofs can command rental premiums
- Vegetation provides habitat for wildlife

**Trees**

- Intercept and absorb rainfall
- Reduce urban heat island
- Improve habitat and aesthetic value
- Provide shade in summer and block wind in winter, reducing heating and cooling costs
- Reduce greenhouse gases by absorbing $CO_2$
- Capture urban air pollutants (dust, $O_3$, CO)

**Rain Barrels and Cisterns**

- Reduce water consumption and associated costs
- Reduce demand for potable water
- Increase available water supply for other uses
- Can significantly reduce stormwater discharges from roofs

**Bioswales and Rain Gardens**

- Improve property and neighborhood aesthetics
- Reduce localized flooding
- Promote infiltration and groundwater recharge
- Enhance pedestrian safety when used in traffic calming applications

**Permeable Pavements**

- Reduce stormwater runoff and standing water
- Promote infiltration and groundwater recharge
- Improve the longevity of infrastructure
- May be easier to maintain than standard pavement

**Green Space**

- Increase soil porosity
- Reduces stormwater runoff volume
- Reduces peak stormwater flows
- Helps reduce the risk of flooding

Figure 2. Benefits of green infrastructure practices

## Improved Air Quality/Climate Change

### Urban Heat Island
Green infrastructure practices that include trees and other vegetation can reduce the urban heat island effect, which reduces energy use and the incidence and severity of heat-related illnesses.

### Air Quality
Green infrastructure improves air quality by increasing vegetation, specifically trees, that absorb air pollutants, including $CO_2$, $NO_2$, $O_3$, $SO_2$, and $PM_{10}$.

### Greenhouse Gases
Green infrastructure's ability to sequester carbon in vegetation can help to meet greenhouse gas emission goals by contributing to a carbon sink.

## Water Quality and Quantity

### Water Conservation
Green infrastructure that incorporates locally adapted or native plants reduce the need for irrigation, which reduces demand for potable and recycled water. Rain barrels and cisterns that capture rainwater also reduce water use.

### Water Quality and Flood Mitigation
Green infrastructure can decrease the frequency and severity of local flooding by reducing stormwater discharge volumes and rates.

### Habitat
Vegetated green infrastructure can provide habitat for wildlife, particularly birds and insects, even at small scales of implementation.

## Quality of Life

### Public Health
Residents have more recreational opportunities in the presence of large-scale green space in their community, which can improve public health and well-being.

### Public Safety
Green streets that include curb bump-outs at pedestrian crossings improve pedestrian safety by slowing traffic and decreasing the distance that pedestrians must travel in the roadway.

### Recreational Opportunities
Larger-scale green infrastructure facilities that include public access, such as constructed wetlands, offer recreational opportunities.

### Property Aesthetics
Green infrastructure that includes attractive vegetation can improve property aesthetics, which can translate into increased property values.

## Educational Opportunities

### Public Education
The visible nature of green infrastructure offers enhanced public education opportunities to teach the community about mitigating the adverse environmental impacts of our built environment. Signage is used to inform viewers of the features and functions of the various types of facilities.

Figure 3. Additional green infrastructure benefits

## STEPS TO IMPLEMENT GREEN INFRASTRUCTURE PROJECTS

There are a few steps that municipalities should take before undertaking a green infrastructure project: reviewing planning documents and codes, securing funding, planning for maintenance, training staff, and identifying potential projects. Figure 4 summarizes these steps, and the remainder of this guide provides more detail on specific actions that are needed to begin planning, installing, and maintaining green infrastructure. In the meantime, municipalities can start thinking about incorporating green infrastructure into projects that have already been approved or are in the planning stages. For example, if plans are underway to repair sidewalks from tree root damage, or a failing street tree is slated for replacement, relatively minor modifications can be made to the plans to include a tree box that filters stormwater. Also, when work is being done to repair/replace curbs, a grass swale in a median could readily be modified into a bioretention area.

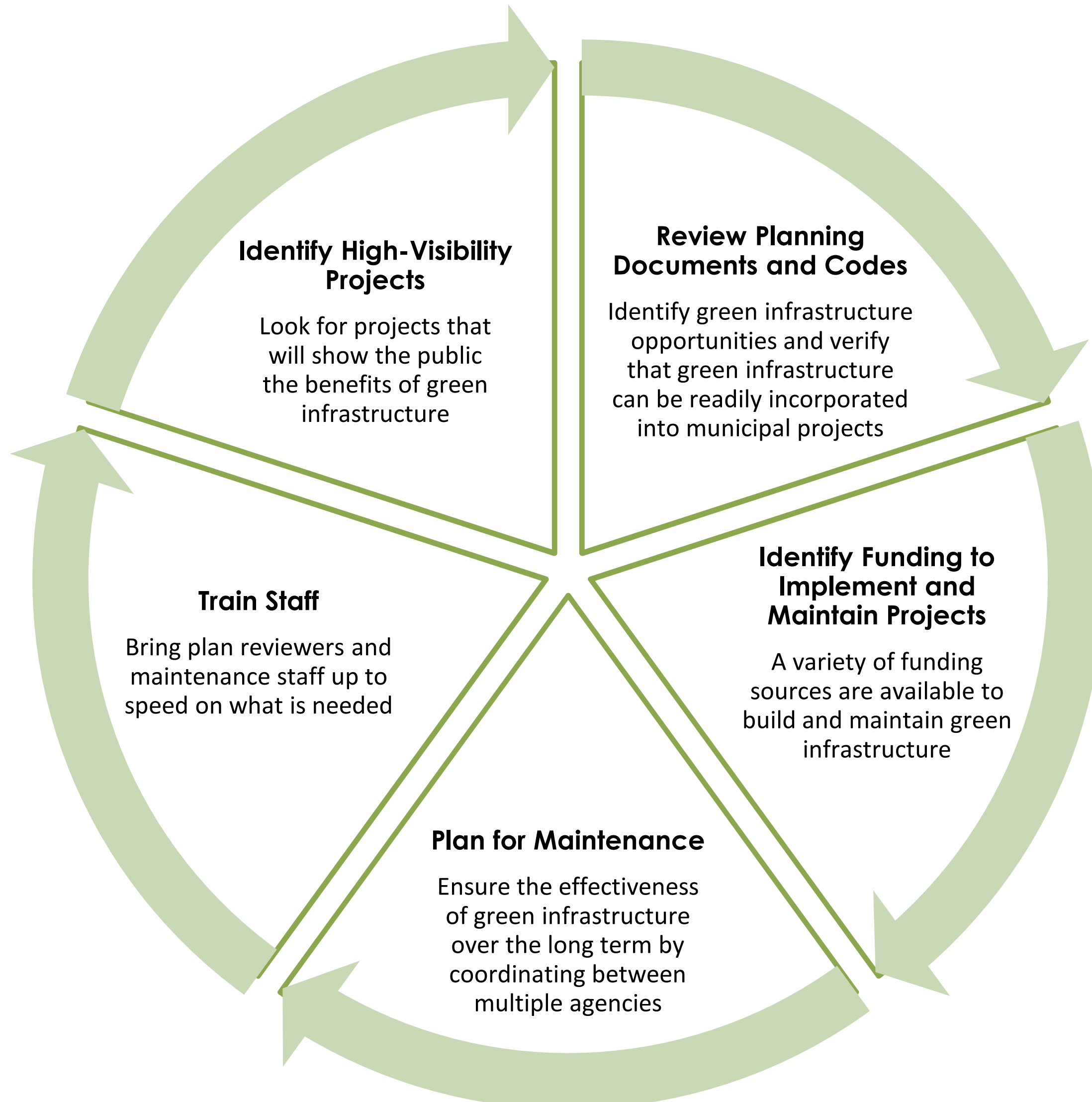


Figure 4. Steps to implement green infrastructure

## Review Planning Documents and Codes

Before moving forward, it is advisable to first check if local codes, design standards, or planning documents pose barriers to implementing green infrastructure projects. If so, steps can be taken to remove those barriers by adopting green infrastructure retrofit standards for major street projects or adopting technical specifications and design templates for green infrastructure on public property. Below are two resources that outline a process for evaluating and revising development codes:

- The Center for Watershed Protection's (1998) ***Better Site Design: A Handbook for Changing Development Rules in Your Community***, available at www.cwp.org, outlines 22 guidelines for better developments and provides a detailed rationale for each principle. The guide also examines current practices in local communities, details the economic and environmental benefits of better site designs, and presents case studies from around the country.
- EPA's (2009) ***Water Quality Scorecard: Incorporating Green Infrastructure Practices At Municipal, Neighborhood, and Site Scales***, guides municipal staff through a review of relevant local codes and ordinances across multiple municipal departments to ensure that these codes work together to support a green infrastructure approach. It can be downloaded at www.epa.gov/dced/pdf/2009_1208_wq_scorecard.pdf.

Training may be needed for plan reviewers to identify green infrastructure opportunities on public projects. The following are training opportunities available online or in person:

- EPA offers a **Green Infrastructure Webcast Series** and other training resources on their "Where Can I Get More Training?" website. http://water.epa.gov/infrastructure/greeninfrastructure/gi_training.cfm
- North Carolina State University Cooperative Extension offers **Stormwater Education Events and Workshops** throughout the year in North Carolina in all aspects of green infrastructure design, maintenance, and management. Upcoming events can be found at http://www.bae.ncsu.edu/stormwater/training.htm.

EPA compiled a set of resources for planning for green infrastructure, including:

- **Policy guides** to assist municipalities in devising policy and planning strategies to encourage, require, and implement green infrastructure: http://water.epa.gov/infrastructure/greeninfrastructure/gi_policy.cfm
- **Design and implementation resources** to help practitioners better design, install, and maintain practices: http://water.epa.gov/infrastructure/greeninfrastructure/gi_design.cfm
- **Modeling tools** to assess green infrastructure performance, costs, and benefits: http://water.epa.gov/infrastructure/greeninfrastructure/gi_modelingtools.cfm

### *Once you determine that green infrastructure can be readily incorporated into municipal projects:*

- Start by including small-scale green infrastructure practices in individual municipal projects that are currently in the planning stage.
- Examine integrating green infrastructure into already-scheduled maintenance projects as a way to reduce costs or to retrofit an area, e.g., replacing or repairing infrastructure under streets.
- Consider requiring that all local road projects allocate a minimum amount of the total project cost to green infrastructure elements.
- Incorporate green infrastructure requirements into competitive bid packages for portions of projects that will be completed by outside contractors.

## Identify Funding to Install and Maintain Projects

Green infrastructure projects range in cost from a few thousand dollars (e.g., curb cuts to direct flows to an open space area) up to millions of dollars for large-scale, complex projects that treat a large drainage area. Costs will vary based on the setting, as well: projects implemented on sites that were not previously developed can be less expensive than those in redevelopment or retrofit situations because of compacted soils, space constraints, utility conflicts, and other site-specific factors that require specialized designs.

In addition to capital improvement funds that are typically used for municipal projects, there are a variety of funding sources available to municipalities to design and build green infrastructure projects and ensure long-term maintenance, including borrowed funds, revenue from local sources, state and federal grants, and private sector funding. The options discussed herein offer individual funding sources but also may be blended to reflect a mix of local, state, and federal funding mechanisms.

Because green infrastructure has multiple benefits in addition to improving water quality, a key to finding funding and financing is to determine how a green infrastructure project can meet the goals of various users and funding sources. Green infrastructure has a greater chance of being funded by sources other than traditional infrastructure sources because it can appeal to funders' desires to achieve public health benefits, community revitalization, and habitat creation, among other benefits. Figure 5 summarizes the sources, and Table 1 describes advantages and disadvantages of each.

### Revenue Sources

Local revenue sources, such as stormwater utilities and special fees, are a common funding option for municipal stormwater programs. Stormwater utilities generate funds for the costs of implementing stormwater programs, including regulatory compliance, planning, maintenance, and maintaining or constructing infrastructure. Stormwater utilities are similar to water, sewer, or fire districts in that they are stand-alone service units within a government that generate revenues through user fees for services directly related to the control and treatment of stormwater. Special fees may also be collected for permit and plan reviews, and inspections and should be directly linked to stormwater management. Further, special developer impact fees are a one-time fixed fee charged for new development, used to compensate for the effects of new development. Fees derived from special charges and stormwater utilities offer a consistent source of dedicated funds for green infrastructure projects. Grants, bonds, and loans are other options for financing green infrastructure projects. Both private loans and public sources such as Clean Water State Revolving Funds may be used to finance projects or fund development of a utility or other related capital projects.

### *Funding Resources*

EPA’s report, ***Getting to Green: Paying for Green Infrastructure: Financing Options and Resources for Local Decision-Makers***, provides a description of funding mechanisms available to support stormwater management programs or finance individual projects, along with an overview of the advantages and disadvantages of each approach. The report offers a resource to local governments for determining how to finance green infrastructure projects. http://www.epa.gov/nep

EPA’s ***Managing Wet Weather with Green Infrastructure Municipal Handbook: Funding Options*** provides local governments with a step-by-step guide to growing green infrastructure in their communities. It identifies and discusses stormwater fees and loan programs communities can use to fund green infrastructure. http://water.epa.gov/infrastructure/greeninfrastructure/upload/gi_munichandbook_funding.pdf

EPA also compiled a set of resources to help municipalities better understand the cost-benefits of green infrastructure and to identify funding opportunities. They include:

- **Cost-benefit resources** to conduct cost benefit analyses of green infrastructure approaches. Completed analyses demonstrate that the value of green infrastructure benefits can exceed those of gray. http://water.epa.gov/infrastructure/greeninfrastructure/gi_costbenefits.cfm
- **Funding opportunities** including federal funding sources and funding tools that project sponsors can use to locate a variety of federal funding sources. http://water.epa.gov/infrastructure/greeninfrastructure/gi_funding.cfm

**Borrowing**

**Bonds**

Bonds are not a true revenue source but are a means of borrowing money. Green bonds are a new source of funding dedicated to environmentally-friendly projects, including clean water projects

**Loans**

Low interest loans may be secured but are generally used for planning and capital projects

**Local Revenue**

**Fees**

Funds raised through charges for services such as inspections and permits. Funds raised through developer impact fees are one-time charges linked with new development

**Stormwater Utility**

Generates revenue through user fees, which go into a separate fund that only can be used for stormwater services

**Taxes/General Funds**

Funds raised through property, income, or sales taxes that are paid into a general fund

**Grants**

**State and Federal Grants**

State and federal grants provide additional funding for water quality improvements

**Private Sector**

**Public-Private Partnerships**

Contractual agreements between public agencies and private sector entities that allow for private sector participation in stormwater facility financing, planning, design, construction, and maintenance

Source: USEPA 2014

Figure 5. Funding sources for green infrastructure

Table 1. Advantages and disadvantages for green infrastructure funding sources

| Funding Source | Advantages | Disadvantages |
|---|---|---|
| **Bonds** | • Existing sources available for stormwater-related funding<br>• Can support construction-ready projects<br>• Can provide steady funding stream over the period of the bond | • One-time source of funds require individual approval for each issuance<br>• Require full repayment<br>• Possible interest charges<br>• Require dedicated repayment revenue stream<br>• May require design-level documents to be prepared in advance<br>• Likely require voter approval<br>• Can have high transaction costs relative to requested amount<br>• May require significant administrative preparation to issue |
| **Fees** | • Specific permit and inspection fees allows for more direct allocation of costs for services provided<br>• Addresses potential stormwater impacts related to new construction | • Funding not available for larger projects or system-wide improvements<br>• Developer impact fees may be an unreliable source when development slows (due to market downturns/contractions)<br>• Require administrative framework to assess and manage |
| **Loans** | • Existing sources available for stormwater-related funding<br>• Some programs offer low- or no-interest financing; private loans may be at market rate | • One-time source of funds<br>• Require full repayment |
| **Public-Private Partnerships** | • Can reduce costs to government<br>• Significantly leverage public funding and government resources<br>• Ensure adequate, dedicated funding<br>• Improved O&M<br>• Shared risk | • Perceived loss of public control<br>• Assumption that private financing is more expensive and belief that contract negotiations are difficult |
| **State and Federal Grants** | • Existing sources available for stormwater-related funding<br>• Does not require repayment | • Competitive<br>• Typically one-time, project-specific, or time-constrained funds<br>• Often require a funding match |
| **Stormwater Utilities** | • Dedicated funding source<br>• Directly related to stormwater impacts<br>• Sustainable, stable revenue<br>• Shared cost<br>• Improved watershed stewardship<br>• Addresses existing stormwater issues | • Feasibility study required for implementation, fee structure, and administration of utility<br>• Approval by vote of the local legislative body<br>• Perception by the public of a "tax on rain" |
| **Taxes/ General Funds** | • Consistent from year-to-year<br>• Utilizes an existing funding system | • Competition for funds<br>• Tax exempt properties do not contribute<br>• Not equitable system (does not fully reflect contribution of stormwater runoff) |

Source: USEPA 2014

## Plan for Maintenance

Maintenance is critical to ensure the longevity and continued effectiveness of green infrastructure practices. Below are ways municipalities can ensure that green infrastructure is maintained over the long term.

### Identify Staff Resources for Inspection and Maintenance

A municipality needs to determine if green infrastructure inspections and maintenance can be accomplished with existing staff, if additional staff needs to be hired, if specialized training is needed, or if it would be more cost-effective to hire an experienced contractor. Consider which municipal departments have the equipment and skillsets to inspect and maintain green infrastructure, such as parks or public works. Training may be needed for both municipal staff and contractors who perform inspections and maintenance.

### *Maintenance Resources*

The University of New Hampshire Stormwater Center created **Maintenance Guidelines and Checklists** for pervious pavements, subsurface gravel wetlands, and bioretention and tree box systems, which are available for download at http://www.unh.edu/unhsc/maintenance.

The Oregon State University Extension Service hosts the **Field Guide: Maintaining Rain Gardens, Swales, and Stormwater Planters**, which was developed by numerous practitioners to assist contractors and maintenance staff. http://extension.oregonstate.edu/stormwater/sites/default/files/fieldguide.pdf.

American Rivers and Green for All's ***Staying Green: Strategies to Improve Operations and Maintenance of Green Infrastructure in the Chesapeake Bay Watershed***: http://greenforall.org/focus/water/staying-green-strategies-to-improve-operations-and-maintenance-of-green-infrastructure-in-thechesapeake-bay-watershed.

EPA's ***The Importance of Operation and Maintenance for the Long-Term Success of Green Infrastructure***: http://water.epa.gov/grants_funding/cwsrf/upload/Green-Infrastructure-OM-Report.pdf.

### Identify Maintenance Triggers

It is important to identify common problems that require non-routine maintenance to aid inspectors in the field. Such maintenance triggers include excess sediment accumulation, trash and debris, overgrown vegetation, dead or diseased vegetation, signs of erosion, structural damage, or standing water present more than 72 hours after a rain storm.

### Update Standard Operating Procedures

If municipalities have standard operating procedures for routine landscape and infrastructure maintenance, they should be updated to incorporate green infrastructure maintenance triggers and remedial actions. Additionally, if contractors are used to maintain practices, include specific language in contracts that require training of maintenance crews. Maintenance schedules should be set for each type of practice, and a tracking system should be in place to ensure that maintenance is performed as prescribed.

### Secure Funding for Maintenance

As with all infrastructure, expenses for green infrastructure maintenance are ongoing. Sources of funding typically pursued for green infrastructure projects, such as state and federal grants and loans, cannot be used for ongoing maintenance. Local funding sources such as tax revenue or utility fees can provide a stable source of funding for maintenance of green infrastructure practices.

### Enlist the Help of Volunteers

Some routine maintenance, such as removing trash and weeds from bioretention areas, can be accomplished by partnering with neighborhood organizations, greenway groups, or garden clubs to leverage their funds/volunteers.

### Procure Equipment

Municipalities should also consider the equipment needed to maintain green infrastructure and determine if additional equipment is needed. Most of the necessary equipment is typical of general landscape maintenance, as shown below. Note that heavy equipment is discouraged for routine maintenance, because it can cause soil compaction, which reduces the effectiveness of the practices.

## *Green Infrastructure Equipment Needs*

Leaf litter, trash, debris, and sediment can be removed with **rakes**, **shovels**, and **trash grabbers**.

**Flat-blade shovels** are especially useful for scraping accumulated sediment from inlets and along curbs/gutters.

Vegetation can be kept healthy and attractive using **pruning shears** and **weed pullers**, and **mowers** can be used to maintain turf grass at an appropriate height.

Watering during the plant establishment period and in extended droughts can be done with a **hose**, **irrigation system**, or **tree watering bags**.

A **ladder** is needed for inspecting roof drains that connect to rainwater harvesting systems.

Permeable pavement is best maintained using a **vacuum-powered street sweeper**, and **replacement pavers** are sometimes needed for repairs.

Heavy equipment, such as **backhoes** and **front-end loaders**, may be needed infrequently if the facilities need to be replaced or if large amounts of sediment have accumulated.

***Routine maintenance on vegetated green infrastructure practices is largely similar to general landscape maintenance: removing trash, leaf litter, and debris; keeping plants healthy; and cleaning out accumulated sediment and pollutants. Regular inspections will indicate if the practices are not functioning as intended.***

## Identify High-Visibility Projects Where Possible

Projects located in high traffic areas not only exhibit a locality's commitment to green infrastructure, but allow residents to experience the benefits of these practices first hand. In addition, these projects provide an opportunity to educate the community about that particular green infrastructure practice while garnering support for future projects.

The following section is a series of fact sheets that highlight short-term, relatively easy-to-install projects that can serve as a starting point for implementing green infrastructure. Figure 6 summarizes the project types showcased in the fact sheets.

The projects are intended to have a large public impact with lower capital investment and maintenance needs. Each fact sheet presents:

- An overview of the project
- The types of green infrastructure that are appropriate for the setting
- Potential project partners
- Relative costs and project complexity
- Anticipated benefits
- Expected maintenance
- Case study examples of similar projects implemented in communities throughout the U.S.

***Projects should use native vegetation and be located in high visibility areas such as City Hall, the local farmers market, a public park, the community library, or schools.***

## OPPORTUNITIES TO INTEGRATE GREEN INFRASTRUCTURE

**Fact Sheet 5:**

Create stormwater microparks

**Fact Sheet 1:**

Build in green features during routine right-of-way maintenance and operations


**Fact Sheet 4:**

Design traffic safety features to manage stormwater and improve aesthetics

**Fact Sheet 2:**

Build or retrofit parking facilities to be greener

**Fact Sheet 3:**

Build rain gardens at public facilities

Figure 6. Green infrastructure project fact sheets

## RESOURCES


### Code Review

Center for Watershed Protection. 1998. *Better Site Design: A Handbook for Changing Development Rules in Your Community*. Center for Watershed Protection, Ellicott City, MD.

USEPA. 2009. *Water Quality Scorecard: Incorporating Green Infrastructure Practices at Municipal, Neighborhood, and Site Scales*. Accessed December 2014. http://www.epa.gov/dced/pdf/2009_1208_wq_scorecard.pdf.

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### Maintenance

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UNH. 2010. *UNH Stormwater Center—Maintenance*. University of New Hampshire Stormwater Center. Accessed December 2014. http://www.unh.edu/unhsc/maintenance.

USEPA. 2013. *The Importance of Operation and Maintenance for the Long-Term Success of Green Infrastructure: A Review of Green Infrastructure O&M Practices in ARRA Clean Water State Revolving Fund Projects*. PA-832-R-12-007, March 2013. Accessed December 2014. http://water.epa.gov/grants_funding/cwsrf/upload/Green-Infrastructure-OM-Report.pdf.

### Planning

USEPA. 2014. *Water: Green Infrastructure—Design and Implementation Resources.* Accessed December 2014. http://water.epa.gov/infrastructure/greeninfrastructure/gi_design.cfm.

USEPA. 2014. *Water: Green Infrastructure—Modeling Tools.* Accessed December 2014. http://water.epa.gov/infrastructure/greeninfrastructure/gi_modelingtools.cfm.

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### Training

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USEPA. 2014. *Where Can I Get More Training?* Accessed December 2014. http://water.epa.gov/infrastructure/greeninfrastructure/gi_training.cfm.

# Build in Green Features during Routine Right-of-Way Maintenance and Operations

## FACT SHEET #1

A variety of green infrastructure practices can be used to manage stormwater and enhance the walkability and aesthetics of streets. Green infrastructure implemented in the street right-of-way can be used to

- Reduce impervious area
- Infiltrate/filter runoff from the street and adjacent property
- Provide shade using trees
- Improve air quality
- Reduce the urban heat island effect
- Create a sense of place
- Showcase public art
- Calm traffic
- Provide wildlife habitat
- Create a welcoming area
- Enhance aesthetics

This green street features low-maintenance vegetation and mature trees.

## GREEN INFRASTRUCTURE OPPORTUNITIES

**Permeable pavement** Choose permeable pavement for lower volume traffic areas, such as parking spaces, bike lanes, sidewalks, medians, and alleys.

**Bioretention** Install bioretention in the right-of-way between the curb and sidewalk, in curb bump-outs, and in medians or roundabouts to filter stormwater and beautify the streetscape.

**Trees** Plant trees or install tree boxes in the right-of-way between the curb and sidewalk, in curb bump-outs, in medians or roundabouts for enhanced stormwater infiltration, shade, and aesthetics.

**Reduce impervious area** Replace pavement in medians, centerline safety strips, and roundabouts with pervious surfaces, and create shallow depressions to capture more runoff.

### *Project Complexity*

Medium

### *Timeframe*

1–3 years

### *Installation Costs*

$50,000 and up, depending on site and scale

### *Factors Affecting Costs*

- Scale of the project
- Retrofit, infill, or new development setting
- Green infrastructure practices selected
- If existing utilities require relocation or special designs
- Performance goals

### *Financing Opportunities*

- Capital improvement funds
- Property tax assessments
- Stormwater utility fees
- State or private grants
- State revolving loans
- Private funding
- Bonds
- Federal funds

### *Necessary Maintenance*

- Hand weeding
- Debris and sediment removal
- Plant trimming and pruning
- Plant replacement
- Vacuum sweeping of permeable pavement
- Soil replacement

## THINGS TO CONSIDER BEFOREHAND

- Design for public safety and access
- Green streets and alleys are most cost-effective to complete in conjunction with necessary street or infrastructure improvements or rehabilitation projects.
- Select plants that do not impede driver sight lines or hide pedestrians from view.
- Design practices with sufficient access and features that make maintenance easier, such as inlets that are easy to clean.
- Choose vegetation that is densely rooted to filter debris and pollutants.
- Use salt-tolerant plants where salt will be used for snow and ice control.
- Select native or locally adapted plants where possible to reduce maintenance and help to ensure longevity.
- Use wheel stops or curb cuts to ensure that cars do not drive over bioretention areas.
- Where possible, site stormwater retrofits in locations where pavement already drains in the right direction to avoid regrading.

Permeable pavement can be used for lower volume traffic areas such as parking and bicycle lanes.
Photo credit: Dan Christian, Tetra Tech, Inc.

## POTENTIAL PROJECT PARTNERS

**Downtown business associations, civic leagues, neighborhood associations,** and **environmental groups** can provide input into the design and placement of the practices for maximum community benefit and can provide volunteer resources to keep the facilities free of trash and weeds. Partner groups could apply for grants to assist in the design or installation of key portions of the project or share costs on portions of the project. For example, an **arts council** might be willing to partner with a municipality to convert a pervious plaza into a park with an interpretive rain garden if the space incorporated public art.

Roadside bioretention can include trees and attractive, low maintenance vegetation to enhance streetscapes.

## FOR MORE INFORMATION

- National Complete Streets Coalition: www.smartgrowthamerica.org/complete-streets
- Federal Highway Administration's Street Design: Part 1 – Complete Streets: www.fhwa.dot.gov/publications/10julaug/03.cfm and Street Design: Part 2 – Sustainable Streets: www.fhwa.dot.gov/publications/11marapr/02.cfm
- Portland Green Streets website: www.portlandoregon.gov/bes/44407
- Seattle Streetscape Design Guidelines: Green Streets: www.seattle.gov/transportation/rowmanual/manual/6_2.asp

## CASE STUDY: NORTH STREET GREEN RETROFIT—PITTSFIELD, MASSACHUSETTS

The City of Pittsfield, Massachusetts is working to retrofit existing roadways with green street technology for stormwater management. One portion of the city's larger project is a 1,200 foot section of North Street in urban Pittsfield, where an existing streetscape plan included plantings and bump-outs for traffic calming. The city updated the original plan to incorporate three rain gardens to help manage stormwater. To successfully execute the rain gardens, the city needed to consider both urban conditions and local weather conditions. For example, the rain gardens were adapted for bioinfiltration with a specified medium, mulch, and appropriate plants that could withstand harsh New England conditions while aiding in pollutant removal.

In total, the three rain gardens covered an area of 520 square feet. The addition of rain gardens to North Street's renovation plan added the benefit of reducing stormwater pollutants from entering the West Branch of the Housatonic River. The rain gardens also reduce the volume of stormwater that is captured in catch basins and pumped to the municipal stormwater system with no treatment (Ogden et al. 2010). In addition to stormwater benefits, the retrofit achieves street calming measures in a downtown area that is emerging as an artistic and cultural hub in Pittsfield. The project successfully contributes to the goal of linking the city's dense urban center with green infrastructure (Greene et al. 2005). The cost of constructing the rain gardens along North Street totaled $44,379 (Ogden et al. 2010).

North Street before (top) and after (bottom) rain garden retrofits.
Photo credits: VHB, Inc., 2104

References:

Greene, C., S.P. Barr, S. Ibendahl, W. Sedovic, R.G. Shibley, and A. Livingston. 2005. Pittsfield SDAT: Sustainable Urbanism in the Heart of the Berkshires. Sustainable Design Assessment Team. http://www.aia.org/aiaucmp/groups/aia/documents/pdf/aias078159.pdf.

Ogden, K.M., M.J. Seluga, and B.E. Eisenberg. 2010. Green street retrofits in the Northeast: Design and acceptance challenges for stormwater management retrofits. Low Impact Development 2010: pp. 628-641.

## CASE STUDY: PLAINFIELD AVENUE—GRAND RAPIDS, MICHIGAN

In 2012, the City of Grand Rapids, Michigan updated the design of Plainfield Avenue to incorporate stormwater management features. The arterial roadway was redesigned to incorporate linear below-grade bioretention islands in the median that are designed to capture the first 0.5 inch of rainfall, eliminating the discharges to the storm sewer system from the most frequently occurring small storms. The islands effectively reduce 420,000 cubic feet of runoff, 60% of sediment, and 65% of phosphorus loading that would otherwise directly enter Grand River in flash flood events every year. In addition to runoff reduction and water quality benefits, the Plainfield Avenue island also serves the community by increasing pedestrian safety, calming traffic, and improving the area's aesthetics.

Design and construction costs of the Plainfield Avenue island totaled $264,000, which was funded by a collaboration of federal, local and private sources. Funding contribution sources included the Michigan Department of Transportation Enhancement Grant, Creston Neighborhood Association, Creston Business Association, Fishbeck, Thompson, Carr & Huber, Inc., and the West Michigan Environmental Action Council. In addition to capital costs, maintenance is expected to cost about $1,500 annually, $30,000 of which was endowed by the Cranston Business Association (SEMCOG 2013).

Reference:

SEMCOG. 2013. Great Lakes Green Streets Guidebook: A Compilation of Road Projects Using Green Infrastructure. http://www.semcog.org/uploadedFiles/Programs_and_Projects/Water/Stormwater/GLGI%20Guidebook_web.pdf.

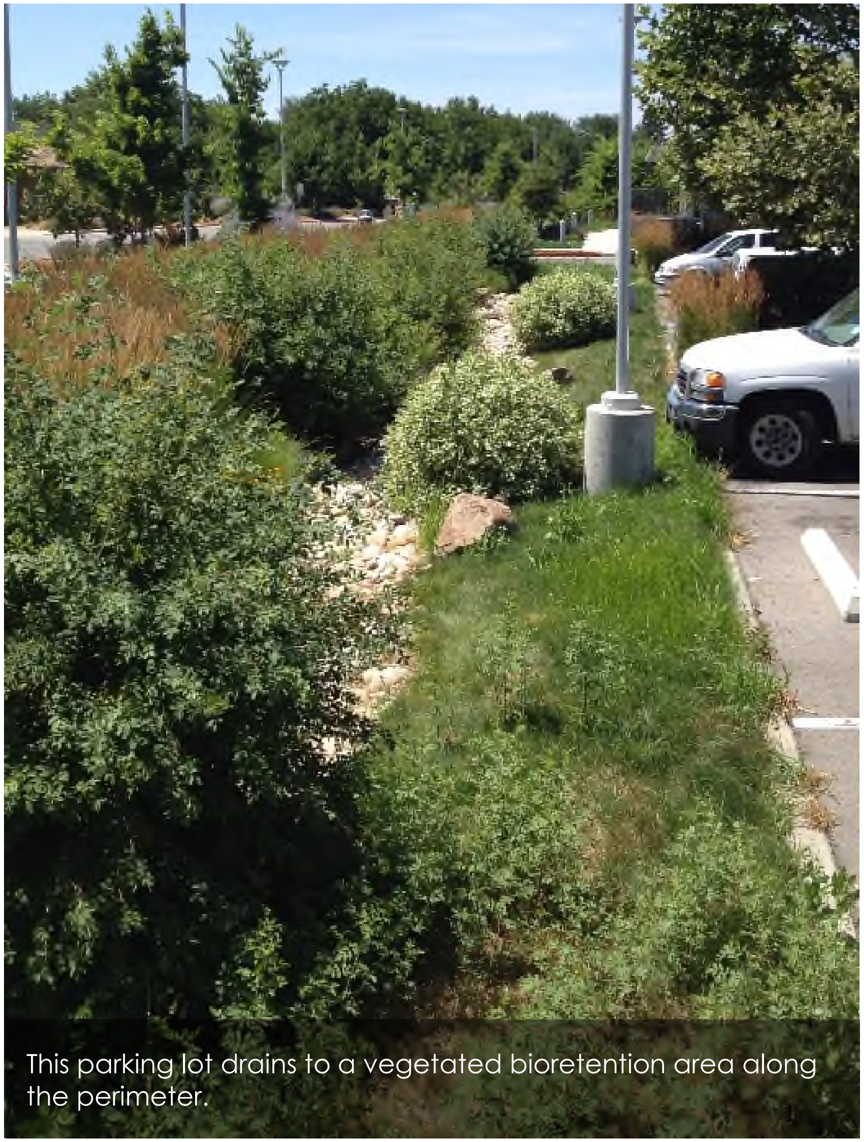
One of seven bioretention islands on Plainfield Avenue.
Photo credit: David Kidd, Governing Magazine.

# Build or Retrofit Parking Facilities to be Greener

## FACT SHEET #2

Parking lot pavement at municipal facilities constitutes a substantial portion of urban and suburban impervious surface area. These lots, as well as medians, curbs, and bump-outs, present opportunities for municipalities to incorporate green infrastructure features into new parking lot designs or retrofit existing parking lots with green infrastructure to capture runoff from parking spaces, parking lanes, and buildings before it leaves the site. Greener parking can be used to:

- Reduce effective impervious area
- Infiltrate runoff from parking lanes and stalls
- Improve parking lot drainage
- Provide shade when trees are used
- Improve pedestrian safety with curb bump-outs to reduce crossing distances
- Improve aesthetics
- Provide wildlife habitat



This parking lot drains to a vegetated bioretention area along the perimeter.

## GREEN INFRASTRUCTURE OPPORTUNITIES

| | |
|---|---|
| **Permeable pavement** | Choose permeable pavement for areas with low volume traffic, such as parking stalls, fire lanes, pedestrian walkways, and overflow parking. |
| **Bioretention** | Install or convert areas between parking rows to bioswales. Install bioretention along the parking lot perimeter and in corners where cars cannot park. Use curb bump-outs with bioretention at the end of stalls to calm traffic and reduce pedestrian crossing distances. |
| **Trees** | Plant trees between parking rows, in bump-outs, and along perimeters. Use stormwater tree boxes in wide sidewalks and entrance courts. |
| **Reduce impervious area** | Create shallow depressions in medians, centerline safety strips, and roundabouts and plant with low-profile vegetation. For retrofits, redirect stormwater flow from storm sewers to bioretention areas. |

### *Project Complexity*

Medium

### *Timeframe*

1–3 years

### *Installation Costs*

$10,000 and up, depending on site and scale

### *Factors Affecting Costs*

- Scale of the project
- Retrofit, infill, or new development setting
- Green infrastructure practices selected
- If existing utilities require relocation or special designs

### *Financing Opportunities*

- Capital improvement funds
- Property tax assessments
- Smart growth grants
- State or private grants
- State revolving loans
- Issuing bonds

### *Necessary Maintenance*

- Hand weeding
- Debris and sediment removal
- Plant trimming and pruning
- Plant replacement
- Vacuum sweeping of permeable pavement

## THINGS TO CONSIDER BEFOREHAND

- Select plants that do not impede driver sight lines or hide pedestrians from view.
- Use salt-tolerant plants where salt will be used for snow and ice control.
- Select native or locally adapted plants where possible to reduce maintenance and help to ensure longevity.
- Design practices with sufficient access and features that make maintenance easier, such as paved forebays for easy sediment removal.
- Choose vegetation that is densely rooted to filter debris and pollutants.
- Use wheel stops or curbs with cuts to ensure that cars do not drive over bioretention.
- Grade drainage to slope toward bioretention areas or permeable pavement; avoid concentrated flows.
- Design curb cuts and inflow areas to manage adequate flow.

## POTENTIAL PROJECT PARTNERS

Seek input from **business improvement districts** and **neighborhood associations** regarding desired features and amenities of green parking areas. Solicit funding from business associations to improve municipal parking areas serving a commercial district. Engage **civic leagues, environmental groups,** and **garden clubs** to provide support and volunteers to help build and maintain green infrastructure. Provide municipal incentives to **private property owners** to build new parking with green features.  Consider provision of design assistance and expedited permit reviews.

## FOR MORE INFORMATION

- EPA Office of Sustainable Development Green Parking Lot Fact Sheet: www.epa.gov/regionn2/ sustainability/parking/index.html
- Green Parking Council: www.greenparkingcouncil.org
- Parking Spaces/Community Places: Finding the Balance through Smart Growth Solutions: www.epa.gov/smartgrowth/pdf/EPAParkingSpaces06.pdf

Permeable pavers are used in compact parking stalls, which have lower traffic volume than the driving lanes.

A bioretention area treats runoff from the parking surface and is planted with low-maintenance vegetation.

## CASE STUDY: LANCASTER PARKING LOT TRANSFORMATIONS—LANCASTER, PENNSYLVANIA

The City of Lancaster, Pennsylvania has taken on a series of four city-owned parking lot renovations in the city's southeast region. The renovated parking lot designs incorporate stormwater management features. Stormwater measures added to the parking lots on Plum Street, Dauphon Street, Pennsylvania Avenue, and Mifflin Street include repaving with permeable concrete, tree plantings, rain gardens, and reorganization of parking area placement to accommodate additional vehicles without expanding paved surface area (City of Lancaster 2014). The four renovated parking lots are each estimated to intercept between 600,000 and 700,000 gallons of stormwater that drains from surrounding blocks every year. Prior to the renovations, stormwater entered the sewer system and was overwhelming the treatment capacity of the facility, leading to raw sewage discharges into the Conestoga River, and ultimately the Chesapeake Bay (Harris 2011). Each of the parking lot renovations is estimated to cost about $160,000, with funding provided by a loan from the Pennsylvania Infrastructure Investment Authority and grant funding from the National Fish and Wildlife Foundation. The parking lot renovations are part of a series of green projects that the City of Lancaster implemented as an alternative to a $300 million grey infrastructure approach of building storage tanks to hold overflow until it could be treated (Harris 2011).

Plum Street parking lot retrofits.
Photo credit: CH2M Hill.


References:

City of Lancaster. 2014. *Parking Lots: Southeast Parking Lot Transformation*. http://www.saveitlancaster.com/local-projects/parking-lots/.

Harris, B. 2011, November 27. Lancaster city alley gets 'green' makeover. *Lancaster Online*. http://lancasteronline.com/news/lancaster-city-alley-gets-green-makeover/article_f05a7df8-8a75-5ab5-b799-c251c92905ec.html.

## CASE STUDY: ST. LANDRY PARISH VISITOR'S CENTER—ST. LANDRY PARISH, LOUISIANA

The St. Landry Parish Visitor Center in Louisiana, was constructed to achieve LEED certification by incorporating sustainable materials with both aesthetic and functional purposes. For example, construction incorporated recycled building materials and stormwater control measures including permeable recycled asphalt in the conservatively sized parking lots. Stormwater runoff from the parking lot and roof is entirely retained on site by cisterns, rain gardens, and a series of bog ponds that collect and filter runoff. Native plants landscape the building's exterior, reducing maintenance and eliminating irrigation needs. In addition to stormwater control features, the visitor center incorporates energy saving measures, such as wind turbines, daylighting, low-energy insulated glazing, minimized east and west exposure to reduce solar heat gain, personal temperature controls, dual flush toilets, and energy star rated appliances. The resulting visitor center complements the existing landscape in a way that maximizes the natural meadow and landscape space and showcases sustainable strategies that are not only effective from ecological and monetary standpoints, but also serves as an educational example of the benefits of green infrastructure. The project was funded through public funding from federal and parish sources. Costs totaled approximately $330,000, with $130,000 allocated to parking sitework, walkways, and bioswales. The remaining $200,000 was split equally between landscaping, and utilities, drainage, gabion walls, and dirtwork. The stormwater measures incorporated in the visitor center are estimated to provide over 10% savings in construction costs compared to traditional site design and development and should result in long-term savings from landscaping that will not require potable water for irrigation.

Rain chains direct roof runoff to a cistern and infiltration area.
Photo credit: Jeffrey Carbo Landscape Architects.

Reference:

ASLA. No date. Green Infrastructure & Stormwater Management Case Study: St. Landry Parish Visitor's Center. http://www.asla.org/uploadedFiles/CMS/Advocacy/Federal_Government_Affairs/Stormwater_Case_Studies/Stormwater%20Case%20128%20St%20Landry%20Parish%20Visitor's%20Center,%20LA.pdf.

# Build Green Infrastructure at Public Facilities

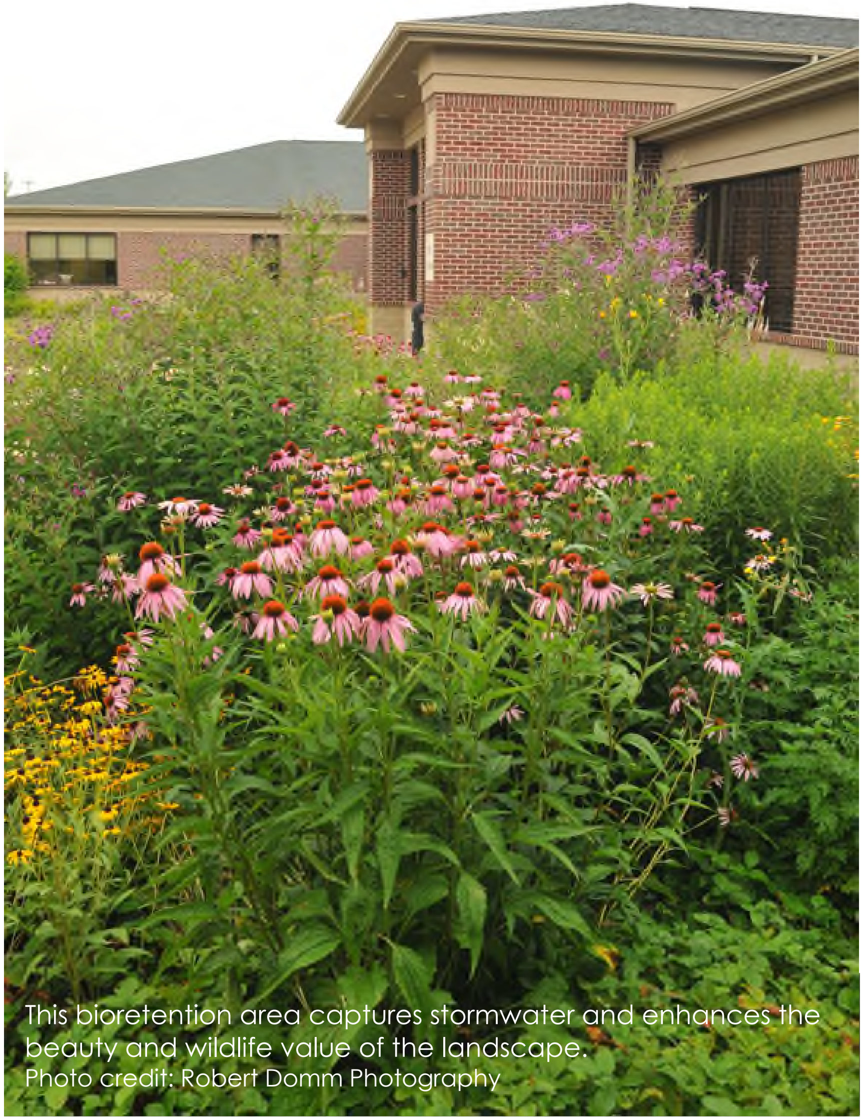
## FACT SHEET #3

Municipal buildings, libraries, public parking lots, schools, community centers and parks offer opportunities for highly visible green infrastructure retrofits. Projects can be undertaken as part of the capital improvement process, ideally in conjunction with other needed maintenance such as building additions and modifications, repaving, re-landscaping, or infrastructure repair or replacement. Green infrastructure offers the following benefits:

- Reductions in impervious area
- Infiltration of runoff from paved areas and rooftops
- Public education opportunities (signage)
- Shade when trees are used
- Wildlife habitat
- Welcoming area
- Creation of park-like areas

## GREEN INFRASTRUCTURE OPPORTUNITIES

| | |
|---|---|
| **Permeable pavement** | Choose permeable pavement for areas with low volume traffic, such as parking stalls, fire lanes, sidewalks, medians, and alleys. |
| **Flow-through planters** | Install fully-lined flow-through planters at the foot of buildings to slow the flow of runoff from rooftops to the storm drain system. |
| **Bioretention** | Replace paved and gravel areas between the curb and sidewalk, in parking islands and medians, and parking aisles with shallow depressions planted with low-maintenance vegetation. |
| **Trees** | Plant trees or install tree boxes in the right-of-way between the curb and sidewalk, in curb bump-outs, in medians or roundabouts, and in landscaped areas to provide shade and improve aesthetics. |
| **Rainwater harvesting** | Install cisterns and rain barrels to collect runoff from roof downspouts for nonpotable reuse (e.g., irrigation, wash water). |
| **Reduce impervious area** | Convert unused parking to open space or bioretention. Replace pavement in medians and traffic islands with vegetation. |



This bioretention area captures stormwater and enhances the beauty and wildlife value of the landscape.
Photo credit: Robert Domm Photography

### *Project Complexity*

Medium

### *Timeframe*

1–3 years

### *Installation Costs*

$50,000 and up, depending on site and scale

### *Factors Affecting Costs*

- Scale of the project
- Retrofit, infill, or new development setting
- Green infrastructure practices selected
- If existing utilities require relocation or special designs

### *Financing Opportunities*

- Property tax assessments
- Stormwater utilities
- Smart growth grants
- State and private grants
- State revolving loans
- Issuing bonds

### *Necessary Maintenance*

- Hand weeding
- Debris and sediment removal
- Plant trimming and pruning
- Plant replacement
- Vacuum sweeping of permeable pavement

## THINGS TO CONSIDER BEFOREHAND

- Retrofitting public property to include green infrastructure features is most efficient and cost-effective when it occurs in conjunction with other needed maintenance and upgrades.
- Incorporate signage to educate the public about how stormwater is managed by the facilities.
- Choose vegetation that is densely rooted to filter debris and pollutants.
- Use salt-tolerant plants where salt will be used for snow and ice control.
- Select native or locally adapted plants where possible to reduce maintenance and help to ensure longevity.
- Where possible, site stormwater retrofits in locations where pavement already drains in the right direction to avoid regrading.
- Site and design practices with sufficient access and features that make maintenance easier, e.g., include paved forebays for easy sediment removal.

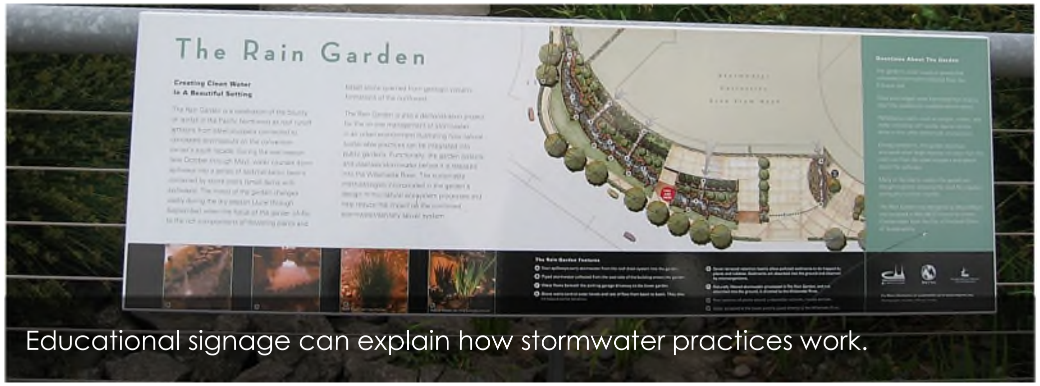
## POTENTIAL PROJECT PARTNERS

**School districts and students, parent/teacher associations, friends of the library, and downtown business associations** can provide input into the design and placement of the practices for maximum utility and can provide volunteer resources to keep the facilities free of trash and weeds. Partner groups could apply for grants to assist in the design or installation of key portions of the project or share costs. Students can study, monitor, and maintain water quality facilities on school grounds as part of their science curriculum.

## FOR MORE INFORMATION

EPA Green Infrastructure Page: http://water.epa.gov/infrastructure/greeninfrastructure

American Society of Landscape Architects Green Infrastructure Page: http://www.asla.org/greeninfrastructure.aspx and Stormwater Case Studies: http://www.asla.org/stormwatercasestudies.aspx



Educational signage can explain how stormwater practices work.


Tree boxes and other green infrastructure features enhance the aesthetics of a plaza space, create shade, and infiltrate stormwater.

## CASE STUDY: NORTH AND SOUTH RIVERS WATERSHED ASSOCIATION RAIN GARDENS—SOUTH SHORE, MASSACHUSETTS

The South Shore Region of the Massachusetts Bays National Estuary Program (MassBays) and its host organization, the North and South Rivers Watershed Association (NSRWA), have worked to implement and encourage green infrastructure techniques throughout the region. Between 2006 and 2008, MassBays/NSRWA installed a rain garden in nearly every town on the South Shore. Partnering with local organizations to identify areas that receive high volumes of stormwater runoff, MassBays/NSRWA installed rain gardens in key public locations like schools and libraries in towns including Hull, Weymouth, Hingham, Norwell, Hanover, Pembroke, Scituate, Marshfield, Duxbury, Kingston, and Plymouth. Funding for the rain gardens was sourced by a 104b3 grant from EPA and MassDEP. MassBays/NSRWA also helped the Towns of Kingston and Pembroke obtain EPA 319 grants through MassDEP in 2006 to install green infrastructure practices like rain gardens, permeable pavement and pavers, and plastic grid at the Kingston Intermediate School and Pembroke's Town Hall and Oldham Pond boat ramp. In 2010, NSRWA/MBP worked with the Town of Marshfield to secure a 604b ARRA grant from the EPA and MassDEP for bacterial source tracking in the South River and subsequent design of stormwater BMPs to remediate bacterial pollution.

In 2011, MassBays provided funding to the town of Kingston received funding to evaluate the feasibility of installing green infrastructure at stormwater outfalls that discharge into the Jones River and Kingston Bay to address deteriorating water quality that resulted in restrictions on shellfish harvesting.  Beginning with 35 known stormwater outfalls to the Jones River, the town identified a subset at which to perform water quality sampling during two storm events.  Based upon the results of the sampling, local site conditions, and proximity of the site to the Bay, green infrastructure-based BMPs for 10 of the sites were brought to a conceptual design stage. Since 2012, detailed engineering designs have been developed for the most promising sites with funding from the state Office of Coastal Zone Management, and two BMPs are now in place. Based upon the conceptual designs, a materials quantity takeoff was performed and a construction cost estimate developed for each location. Construction costs were increased by 15% to cover contingencies and 25% to cover the cost of services for final design and construction inspection. The total construction cost, including final engineering design, construction, and construction inspection for all ten locations, was estimated to be $556,392. Based upon the matrix analysis results, two sites were selected for preliminary design. Two drawings were completed for the preliminary designs. Preliminary design at the paved swale on Delano Avenue was proposed to be comprised of a trench drain at the toe of the road, two 5’ drain manholes with 4’ sumps, and two 18’ diameter rain gardens. Based on the preliminary designs, a total construction cost estimate of $268,778 has been calculated for the two catchment areas. The total construction cost includes 10% for construction contingencies and 25% for services related to design and construction inspection. The total construction cost estimate to mitigate all twelve outfalls is $825,170.

Rain garden off of Delano Avenue in Kingston, MA.
Photo credits: Maureen Thomas, Town of Kingston.

## CASE STUDY: BAMBOO BROOK HISTORIC WATER SYSTEM RESTORATION—MORRIS COUNTY, NEW JERSEY

The Bamboo Brook Outdoor Education Center, formerly Merchinston Farm, underwent a restoration effort in 2009 to restore the existing but deteriorated system of scenic pools, streams, and tanks constructed by the original owner, a pioneer of landscape architecture. The design included water conservation measures such as bioswales, native plants, and rainwater harvesting devices. The system can now capture the runoff generated by a 2-year storm event. The restoration of the stormwater project was estimated between $1M and $5M, with public funding from state, local, New Jersey grant and Morris County Park Commission funding. The state estimates that 7 employment years were created by this project. To complete the project, approximately 6,346 hours were needed for planning and design; 6,820 hours for construction, and approximately 4,000 hours needed for annual maintenance.

Reference:

ASLA. No date. Green Infrastructure & Stormwater Management Case Study: Bamboo Brook Historic Water System Restoration. http://www.asla.org/uploadedFiles/CMS/Advocacy/Federal_Government_Affairs/Stormwater_Case_Studies/Stormwater%20Case%20055%20Bamboo%20Brook%20Historic%20Water%20System%20Restoration,%20Morris%20County,%20NJ.pdf.

Bamboo Brook Outdoor Education Center restoration.
Photo credit: Patricia M. O'Donnell, Heritage Landscapes LLC.

# Design Traffic Safety Features to Manage Stormwater and Improve Aesthetics

## FACT SHEET #4

This curb bump-out integrates bioretention and art. Its location at a crosswalk shortens the crossing distance for pedestrians.

Municipalities are tasked with ensuring that vehicles, pedestrians, and cyclists are safe on roads and sidewalks. Traffic-calming features, such as chicanes, roundabouts, and curb bump-outs, slow vehicle traffic and enhance pedestrian safety by drawing attention to pedestrians and reducing the distance pedestrians must travel to cross the road. These safety features offer opportunities to integrate green infrastructure. By building new streets and retrofitting existing streets with green infrastructure traffic calming measures, a municipality can do the following:

- Reduce street and sidewalk impervious area
- Infiltrate runoff from streets, sidewalks, and adjacent properties
- Calm vehicle traffic
- Enhance pedestrian safety
- Encourage multimodal transportation
- Improve streetscape aesthetics
- Provide wildlife habitat
- Improve water quality

## GREEN INFRASTRUCTURE OPPORTUNITIES

**Bioretention** Use bioswale islands at skewed intersections to decrease impervious area and make traffic paths more obvious. Install bioretention chicanes and bumpouts to slow vehicle traffic. Install curb bump-outs with bioretention at pedestrian crossings for increased visibility, safety, and convenience. Use narrow strips of bioretention (i.e., green gutters) to provide a visual barrier and buffer between bicycle and vehicle lanes.

**Trees** Incorporate street trees for shade and aesthetic benefits.

**Permeable pavement** Use permeable pavement for bicycle lanes to distinguish them from automobile travel lanes and to reduce standing water and ice formation.

**Reduce impervious area** Convert raised medians and traffic islands to swales with curb cuts. Replace the center of paved cul-de-sacs with vegetated, shallow roundabouts.

### *Project Complexity*

Low to medium

### *Timeframe*

Months to several years depending on complexity

### *Installation Costs*

$10,000 and up, depending on site and scale

### *Factors Affecting Costs*

- Scale of the project
- Retrofit, infill, or new development setting
- Green infrastructure practices selected
- If existing utilities require relocation or special designs

### *Financing Opportunities*

- Property tax assessments
- Stormwater utilities
- Transportation planning grants
- State and private grants
- Issuing bonds

### *Necessary Maintenance*

- Hand weeding
- Debris and sediment removal
- Plant trimming and pruning
- Plant replacement
- Vacuum sweeping of permeable pavement

## THINGS TO CONSIDER BEFOREHAND

- Ensure that traffic-calming measures do not interfere with emergency response vehicles.
- Select vegetation that will not impede driver sight lines or block pedestrians from view.
- Use salt-tolerant plants where salt will be used for snow and ice control.
- Select native or locally adapted plants where possible to reduce maintenance and help to ensure longevity.
- Select vegetation that will be less likely to be stolen.
- Design facilities to manage the appropriate flow volumes to avoid blow-outs.
- Design to allow easy maintenance and reduce the potential for clogging.
- Consider a pilot project to incorporate green infrastructure and traffic calming features at an intersection or along a residential or commercial corridor that has a history of conflicts between drivers, cyclists, and pedestrians.
- Where possible, site stormwater retrofits in locations where pavement already drains in the right direction to eliminate the need for regrading.

## POTENTIAL PROJECT PARTNERS

Residents can help municipalities identify areas of known conflicts between vehicles, cyclists, and pedestrians. Business associations benefit from slower traffic in commercial corridors and measures that encourage foot traffic. Public health organizations support measures that encourage walking and biking and reduce injuries to pedestrians. State highway departments can partner with municipalities to undertake projects on state-managed roads.

## FOR MORE INFORMATION

National Complete Streets Coalition: www.smartgrowthamerica.org/complete-streets

Federal Highway Administration's Street Design: Part 1 – Complete Streets: www.fhwa.dot.gov/publications/10julaug/03.cfm and Street Design: Part 2 – Sustainable Streets: www.fhwa.dot.gov/publications/11marapr/02.cfm

Portland Green Streets website: www.portlandoregon.gov/bes/44407

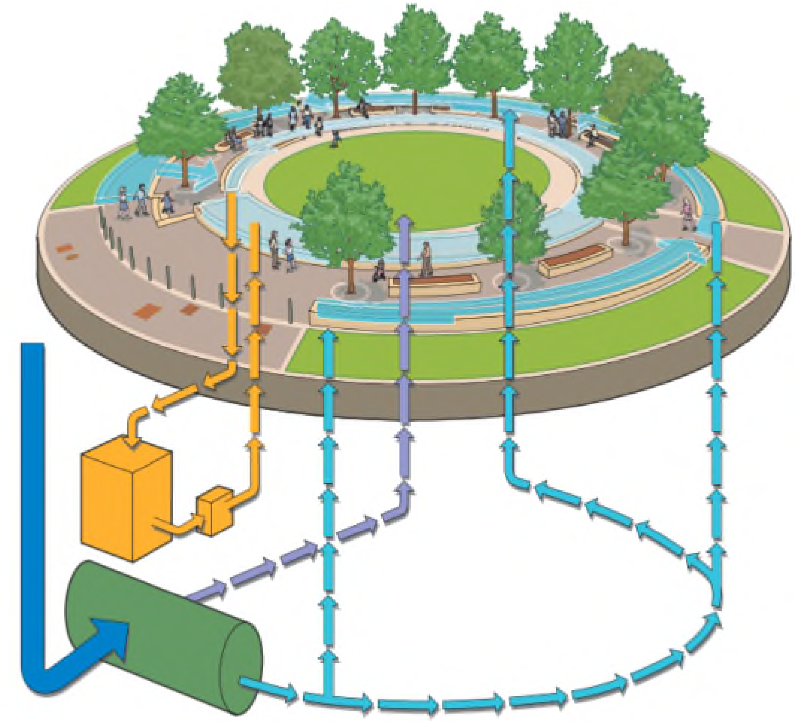
Seattle Streetscape Design Guidelines: Green Streets: www.seattle.gov/transportation/rowmanual/manual/6_2.asp

This bioretention bump-out captures runoff and slows traffic on a road frequented by cyclists and pedestrians.

## CASE STUDY: UPTOWN CIRCLE TRAFFIC CALMING AND BIORETENTION PROJECT—NORMAL, ILLINOIS

Uptown Circle unites four Central Business District streets in Normal, Illinois. Completed as part of a larger business district redevelopment plan, the completed traffic circle transforms a formerly awkward intersection into a shared environment for motorists, pedestrians, and bicyclists, while providing community benefits such as slowed traffic, improved air quality, and reduced and mitigated stormwater runoff (Context Sensitive Solutions.org 2005).

The center of the circle provides innovative stormwater management by collecting stormwater using an obsolete storm sewer converted into a cistern. Subsequently, the stormwater flows via a series of filters into two subsurface channels where the water is filtered by plants in the outer channel and is slowed by a textured surface in the inner channel. SilvaCell™ trees and a grassy area enhance aesthetics and create a park-like setting (Context Sensitive Solutions.org 2005). The cistern beneath the traffic circle holds as much as 75,000 gallons of stormwater collected from the nearly 3 acres of paved surfaces draining to the system (Context Sensitive Solutions.org, no date).



Uptown Circle design.
Photo credit: Hoerr Schaudt, Landscape Architects

The project cost $1.5 million for Uptown Circle (Landscape Architecture Foundation, no date). The Landscape Architecture Foundation (no date) estimates many cost savings and environmental benefits from the traffic circle construction that include:

- Capture and reuse of 1.4 million gallons of stormwater onsite resulting in an estimated $7,600 annual potable water savings from the 58,800 square foot area.
- 1.4 million gallon reduction in stormwater load entering the municipal storm sewer from stormwater reuse for irrigation, onsite water feature, groundwater recharge, and water uptake by onsite green features (e.g., tree wells, planter areas, or underground storage facilities).
- Improved onsite water quality resulting from the sand, UV and bog filter systems. Estimates suggest that 91% of total suspended solids, 79% of total phosphorous, and 64% of total nitrogen can be removed each pass through the various filtration systems.
- Expected cost savings of over $60,000, across a 50 year period, from increased street tree lifespan resulting from the use of underground structural cells; thus, reducing costs associated with new street tree purchase and installation.
- Expected average carbon sequestration of more than 103 pounds of carbon annually from each of the 104 newly planted trees.
- Increase in Uptown financing district property values. Property values in the financing district increased by $1.5 million (or 9%) from 2009 to 2010, which translates to a 31% increase from 2004.
- Increase in revenue of more than $680,000 from conference events held in the newly developed multi-phase, mixed use Uptown Redevelopment project.

References:

Context Sensitive Solutions.org. 2005. Uptown Circle. http://contextsensitivesolutions.org/content/case_studies/uptown_circle/.

Context Sensitive Solutions.org. No date. The Uptown Normal Circle: A Living Plaza. http://contextsensitivesolutions.org/content/case_studies/uptown_circle/resources/b4/.

Landscape Architecture Foundation. No date. Uptown Normal Circle and Streetscape. http://landscapeperformance.org/case-study-briefs/uptown-normal-circle.

## CASE STUDY: 14TH AVENUE NEIGHBORHOOD STREET FUND PROJECT—SEATTLE, WASHINGTON

Rain garden along Seattle's 14th Avenue.
Photo credit: Aaron and Jennifer Britton

The City of Seattle, Washington is benefitting from improvements to 14th Avenue that address previous stormwater treatment challenges while enhancing the appearance of the avenue. The project location has historically been susceptible to stormwater impacts due to soil with naturally low permeability and close proximity to a non-combined sewer system. To control stormwater impacts, 14th Avenue was redesigned at a cost of $75,000 to divert runoff through vegetated swales that are lined with a layer of aggregate and bioretention soil to promote retention and slow water velocity by a series of check dams. Additional water that is not retained by the bioswales is diverted to an existing stormwater system via curb cuts. While the city did not record water treatment improvement specific to this project, they estimate an 80 to 85 percent improvement in non-point source pollutants, based on a similar local project (ASLA 2013).

In addition to stormwater management improvements, pedestrian safety was addressed with the addition of a planted pedestrian island and curb bulb extensions that reduce the distance to cross the avenue and increase visibility distance for both pedestrians and motorists. Aesthetic appeal was enhanced with the installation of trees and public art (ASLA 2013, City of Seattle 2009).

The project was a collaborative effort among the city of Seattle, the 14th Ave Visioning project group, and the East Ballard Community Association and was implemented by the Seattle Department of Transportation. The $75,000 budget covered both stormwater and pedestrian safety features. Funding was sourced from the Neighborhood Street Fund, a local levy. The green infrastructure approaches were a cost effective alternative that the city estimates to have saved over 10% compared to traditional design approaches (ASLA 2013).

References:


ASLA. No date. Green Infrastructure & Stormwater Management Case Study: 14th Avenue Neighborhood Street Fund Project. http://www.asla.org/uploadedFiles/CMS/Advocacy/Federal_Government_Affairs/Stormwater_Case_Studies/Stormwater%20Case%20422%2014th%20Avenue%20Neighborhood%20Street%20Fund%20Project,%20Seattle,%20WA.pdf.

City of Seattle. 2009. 14th Avenue S Street Improvements. http://www.seattle.gov/transportation/14ave_south_improvements.htm.

# Create Stormwater Microparks

## FACT SHEET #5

Urban landscapes have many small-scale pockets of space that are underutilized and sometimes unsightly. These spaces often are located in triangles at junctions of diagonal streets, in spaces between buildings, in vacant lots, or in corners of parking lots. These underused areas are often paved or have high-maintenance turf that offers limited amenity value. They can be converted to a bioretention area or community garden with trees and attractive vegetation, and can accomplish the following:

- Reduce impervious surface
- Infiltrate runoff from the right-of-way and adjacent property
- Protect and restore water quality
- Improve aesthetics
- Create park-like areas
- Provide shade
- Showcase public art
- Provide wildlife habitat
- Promote urban agriculture

The low concrete walls of stormwater planters in a courtyard serve as seating. The project was designed with mixed textures and prominent structure to be safe for the visually impaired.

## GREEN INFRASTRUCTURE OPPORTUNITIES

**Permeable pavement** Incorporate pavers into walkways and areas in deep shade where vegetation might not thrive.

**Flow-through planters** Use these practices, which are fully lined to prevent infiltration from undermining building foundations or other structures, alongside buildings to temporarily detain rooftop runoff from downspouts.

**Bioswales** Remove pavement or gravel and create a shallow depressed area with ornamental grasses, shrubs, and trees.

**Trees** Incorporate trees into microparks for shade, stormwater and climate change benefits, and to improve aesthetics.

**Soil amendments** Evaluate in-situ soils and amend them with organic matter or till them as necessary to improve infiltration and plant growth.

**Reduce impervious area** Remove pavement at underused sites to increase stormwater infiltration. Convert vacant lots and larger sites to community gardens for the benefit of neighborhood residents. Convert one or more street parking spaces to a micropark that serves as a seating area or gathering space.

### *Project Complexity*

Easy

### *Timeframe*

Less than 1 year to several years

### *Installation Costs*

$5,000 and up, depending on site and scope

### *Factors Affecting Costs*

- Scale of the project
- Green infrastructure practices selected
- If existing utilities require relocation or special designs

### *Financing Opportunities*

- Neighborhood revitalization funding
- Parks bonds
- Property tax assessments
- Stormwater utility
- Smart growth grants

### *Necessary Maintenance*

- Hand weeding
- Debris and sediment removal
- Plant trimming and pruning
- Plant replacement
- Vacuum sweeping of permeable pavement

## THINGS TO CONSIDER BEFOREHAND

- Review local codes (setback requirements, sidewalk widths, parking requirements, etc.) to ensure there is space for green infrastructure practices.
- Identify possible conflicts with existing utilities.
- Ensure that there is adequate light for plant growth, or select shade-tolerant plants for microparks surrounded by buildings.
- For microparks adjacent to streets, consider enhanced pedestrian safety measures, such as wheelstops, railings, buffers, curb extensions, and painted crosswalks.
- Consider maintenance requirements and confer with public works staff who maintain such systems and landscapes.
- Use salt-tolerant plants where salt will be used for snow and ice control.
- Select native or locally adapted plants where possible to reduce maintenance and help to ensure longevity.

## POTENTIAL PROJECT PARTNERS

**Business associations, neighborhood associations, garden clubs,** and **private sponsors** can provide funding and volunteers to help build and maintain microparks. They can also offer input into the design and placement to maximize the benefit to the community.

## FOR MORE INFORMATION

EPA Green Infrastructure Page: http://water.epa.gov/infrastructure/greeninfrastructure

American Society of Landscape Architects Green Infrastructure Page: http://www.asla.org/greeninfrastructure.aspx and Stormwater Case Studies: http://www.asla.org/stormwatercasestudies.aspx

The concrete walls of this drywell offer seating around the perimeter of a courtyard, and an artful downspout creates a focal point.


The low stone walls on either side of this sidewalk artfully funnel rainwater to a flow-through planter along the side of a building.

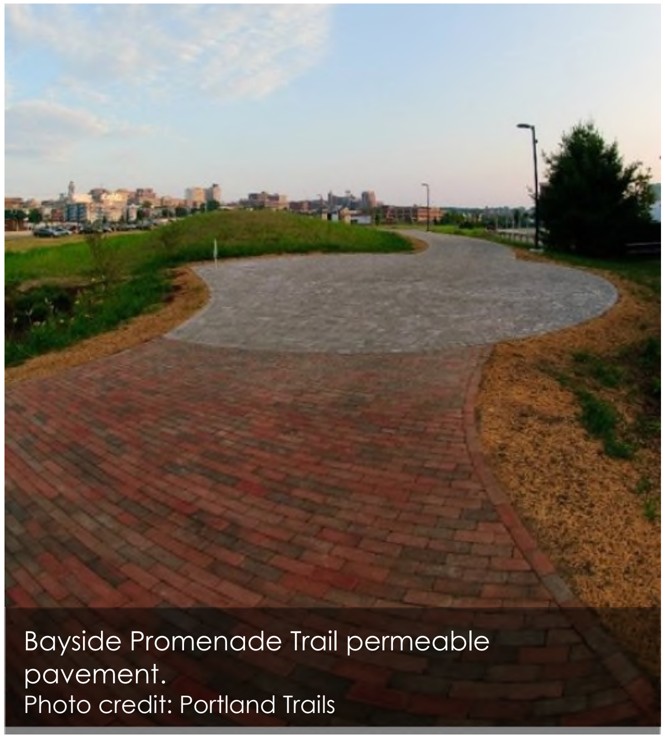
## CASE STUDY: BAYSIDE PROMENADE TRAIL MICROPARK AND REDEVELOPMENT PROJECT—PORTLAND, MAINE

In association with the City of Portland, Portland Trails, the Trust for Public Lands, and the Bayside Neighborhood Association, the 1.2-mile shared-use Bayside Promenade was constructed as a "spine" throughout the City, allowing pedestrian and bicycle access to pocket parks, residential areas, schools, and local businesses. The trail utilizes an abandoned railroad right-of-way and was constructed in the heart of the revitalized commercial and residential neighborhoods in Bayside and East Bayside.

No stormwater reduction analyses were performed for the full scale project; however, the project is expected to reduce stormwater runoff by 10% to 20% through a combination of newly installed LID practices including bioretention, rain gardens, bioswale, porous pavers, and curb cuts. The project cost between $100,000 and $500,000 and used public funding from federal, state, and local sources. Planning, design, construction, and long-term maintenance of the project increased jobs and boosted the local economy.

Reference:

ASLA. No date. Green Infrastructure & Stormwater Management Case Study: Bayside Promenade Trail. http://www.asla.org/uploadedFiles/CMS/Advocacy/Federal_Government_Affairs/Stormwater_Case_Studies/Stormwater%20Case%20332%20Bayside%20Promenade%20Trail,%20Portland,%20ME.pdf.



Bayside Promenade Trail permeable pavement.
Photo credit: Portland Trails

## CASE STUDY: RINCON HEIGHTS MICROPARKS PROJECT—TUCSON, ARIZONA

As part of a larger neighborhood-scale retrofit project, a previously abandoned lot in the Rincon Heights Neighborhood in Tucson, Arizona, was retrofitted into a pocket park with multiple green infrastructure practices to capture stormwater runoff, improve water quality, and reduce flooding. The project features a 5,000 square foot pocket park featuring curb cuts, bioretention facilities (e.g., swale, gravel-filled trenches, basins), curb extensions, and removal of unnecessary impervious pavement onsite.

The estimated project cost was approximately $500,000 and included grant funding from the Arizona Department of Environmental Quality; Rincon Heights Neighborhood Association, the City of Tucson Department of Transportation, and Tucson Clean and Beautiful/Trees for Tucson were project partners. The project now showcases an innovative sustainable design in a previously underutilized residential area in Tucson. The green infrastructure practices aim to slow traffic and increase onsite infiltration providing aesthetic, safety, and stormwater benefits.

Reference:

Watershed Management Group. 2014. Demonstration Sites. http://watershedmg.org/demo-sites/tucson.

Rincon Heights, Feld Davis pocket park.
Photo credit: Alisha Goldstein