5. Site-Level Stormwater Design Strategies

5.1 Introduction to Site-Scale Design

Just as small amounts of rain add up quickly to large volumes of water downstream, individual sites' measures to manage stormwater can accumulate to significant and noticeable improvements in the overall health of a watershed. Site-scale stormwater management strategies complement regional and community-level stormwater management efforts with tangible tools that can be used throughout a community to help protect water quality.

This section focuses on managing stormwater at the scale of a front yard, neighborhood street, parking lot, or development parcel. It introduces a toolbox of site-level stormwater management strategies that can help Sussex County better manage stormwater while also creating appealing streetscapes that are safe and comfortable for drivers, bicyclists, and pedestrians. The design ideas presented are simple, easy to implement, and cost effective. Individually, they are small and manageable to build, and when reproduced throughout a city or watershed, they accumulate to make significant improvements in downstream water quality. The ideas presented here are meant to be a starting point for discussions about design. This is not a technical manual for engineering and construction.

Communities across the U.S. have implemented many of these design strategies to protect their watersheds, calm traffic, beautify streetscapes, and educate residents about natural resource protection.

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Figure 16. Site-level design begins with the first drops of rain.

EPA

Figure 17. Sustainable stormwater design balances the needs of our communities with the needs of our natural environment.

EPA

Figure 18. Prime Hook National Wildlife Refuge is one of the beautiful natural places that Sussex County residents value.

5.1.1 Conventional Stormwater Design in Sussex County

Sussex County has some sustainable stormwater projects, but most development follows the conventional philosophy of conveying stormwater "out of sight, out of mind." In most cases, untreated runoff is quickly whisked away through a system of underground pipes to the back corner of a development, or it is carried off site to eventually spill into a stream, river, or bay. Stormwater is treated as a waste rather than a resource.

Some Sussex County developments employ landscape-based stormwater facilities in the form of wet or dry ponds. Most of these traditionally engineered approaches rely on underground pipe systems for stormwater conveyance and are often expensive to build. Stormwater management methods that quickly drain stormwater ignore and counteract the landscape's ability to act as a sponge and to slow, filter, and absorb water where it falls. They allow substantial volumes of runoff to accumulate, which necessitates larger facilities. In addition, wet ponds and dry ponds are difficult to build in more densely developed areas and on land-constrained sites.

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Figure 19. Conventional stormwater design is common in both new and existing development in Sussex County.

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Figure 20. Typical dry pond design solution in new development in Sussex County.

EPA

Figure 21. Typical wet pond design solution in new development in Sussex County.

5.1.2 What Is Sustainable Stormwater Design?

Sustainable stormwater design strives for a balanced and cost-effective approach to stormwater management. It incorporates the landscape's inherent ability to slow, filter, and absorb water into the development and redevelopment of streets, parking lots, and buildings. At the site scale, sustainable stormwater management can dramatically reduce pollution, decrease runoff volume, reduce runoff temperature, protect aquatic habitat, and create more interesting places to walk, ride, drive, and visit. Sustainable stormwater management works best in conjunction with a shift in attitude: from stormwater as a waste that is dealt with by someone else somewhere downstream, to stormwater as a resource and a local responsibility for everyone to steward.

Figure 22. Sustainable stormwater design model.

Four guiding principles of sustainable stormwater management are:

1. **Reduce impervious surfaces and preserve natural resources** through efficient site design. Build on already degraded sites whenever possible.

2. **Sustainable stormwater design begins with a raindrop.** Manage stormwater at the source and on the surface. As soon as rain falls on a street, parking lot, or rooftop, begin to slow, filter, and absorb the water. Allow it to infiltrate into the ground as soon as possible.

3. **Use plants and soil** to slow, filter, and absorb runoff. Let nature do its work.

4. **Design stormwater facilities that are simple and cost effective and enhance the community.** Stormwater facilities can be beautiful!

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Figure 23. A residential green street. Plants slow filter and absorb stormwater as it flows on the landscape surface.

5.2 Site-Scale Stormwater Management Strategies

Sustainable, site-scale stormwater management involves two fundamental steps: 1) design sites efficiently (i.e., locate streets, parking lots, and buildings in ways that minimize their footprint and their impact on the landscape); and 2) increase the amount of stormwater that is captured and absorbed on site. This section introduces both concepts and explores their application. Where possible, this section provides detailed guidance and examples to demonstrate how streets, alleys, and parking lots in Sussex County could be designed or retrofitted to manage stormwater using more sustainable approaches.

The specific site strategies and techniques discussed in this section are separated into three categories:

1) Site Layout Strategies

Site layout strategies are the first step in managing stormwater in a way that mimics natural hydrology. Using land more efficiently for development, preserving critical ecological areas, and reducing runoff through better site design are vital to maintaining a healthy watershed. This section introduces the following site layout strategies:

5.2.1 Design Sites Efficiently

5.2.2 Protect and Enhance Natural Resources

5.2.3 Protect and Plant Trees

5.2.4 Design Interconnected Surface Stormwater Management

5.2.5 Provide Transportation Choices

2) Rain-Absorbing Footprint Strategies

Rain-absorbing footprint strategies design streets, parking lots, and buildings to absorb as much stormwater as possible, outside of the use of rain gardens. These strategies use surface materials to make otherwise impervious surfaces pervious or to collect water for reuse. This section discusses the following strategies:

5.2.6 Use Pervious Paving

5.2.7 Harvest and Reuse Rainwater

5.2.8 Use Green Roofs

3) Rain Garden Strategies

"Rain garden" is the general term used to describe stormwater strategies that use plants and soils to filter, absorb, and slow stormwater on the landscape surface. Rain gardens come in many forms and can be incorporated into a wide range of site conditions. This section discusses the following strategies:

5.2.9 Use Swales

5.2.10 Use Planters

5.2.11 Use Infiltration Gardens

5.2.12 Use Curb Extensions

5.2.13 Disconnect Residential Downspouts

These site-scale stormwater strategies can apply to a range of development contexts within Sussex County, including streets, alleys, parking lots, and buildings.

Residential streets: Residential streets in Sussex County vary. Some are simply 20-foot-wide strips paved with asphalt; others are more elaborate with attractively landscaped medians and street trees that signal entrance to a neighborhood. However, multiple opportunities exist in Sussex County for new construction and for retrofitting existing streets to green streets. Many residential streets in Sussex County have long, uninterrupted stretches of space that can support rain gardens. Some streets have medians or curb extensions that can be retrofitted to manage stormwater. Other streets have travel lanes or shoulders that could be narrowed to integrate stormwater features and support a more comfortable and safer walking environment.

Commercial main streets and town centers: Many of the historic main streets in Milton, Lewes, Georgetown, and other towns in Sussex County have a community-oriented, small-town character that the residents cherish. However, like most towns in the United States, it can be difficult to find space for stormwater management when the town must also find room for cars, parking, bikes, pedestrians, street trees, lighting, and other amenities. Transforming commercial streets into green streets requires creativity and balancing multiple objectives. Design strategies that the county could consider to integrate stormwater into its most active streets include combinations of swales, planters, curb extensions, and pervious paving.

Highways and arterial streets: Many of the highways and arterial streets in Sussex County would be well suited to sustainable stormwater management strategies. The long, linear stretches of uninterrupted space along highways and arterial streets create opportunities for rain gardens. Highways and arterials also have large landscape areas adjacent to the roadway or included in the right of way, such as grassy medians and side strips, that could be retrofitted for stormwater management. Some roadways may not have landscape space in place but do have travel lanes or paved shoulders that could be narrowed to create space for features such as swales. This space could also be used for sidewalks, on-street bike lanes, or landscape-separated bike greenways. If Sussex County would like to see its highways retrofitted in this way, it would have to work with DelDOT.

Alleys: Sussex County has some residential alleys designed in the neo-traditional or new urbanist style, including in Paynter's Mill and Cannery Village. With alleys, garages can be put behind a home, allowing the street to be more pedestrian friendly, and the architectural detail of the home is no longer dominated by a front-loading garage. Providing alley access and eliminating the driveways at the front of homes not only enhances the overall streetscape, but also allows a more contiguous landscape area along the street frontage and front yards. This extra landscape space presents an opportunity to employ various green street strategies. Many communities are applying site-level stormwater management strategies to alleys. For example, Chicago, Illinois, has a green alley program that retrofits public alleys throughout the city with pervious paving. Objectives of the city's program include improving stormwater management and reducing flooding.

Parking lots: Large or small, parking lots offer many opportunities for applying sustainable stormwater management strategies. Designing lots efficiently by reducing parking stalls and drive aisles can yield significant space for landscape areas. Even if landscape areas are not considered for rain gardens, they remove

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Figure 24. Flexibility in the design of this parking lot preserved existing trees and natural resources. Simply preserving these trees and maximizing landscape area help achieve better water quality even if stormwater facilities are difficult to build.

impervious area and can be used for planting large canopy trees, native shrubs, and groundcovers. Pervious paving is widely accepted in parking lots and is particularly useful in small parking lots where space is tight. Stormwater swales are the most universal rain garden strategy used in parking lots. Long, linear swales fit well between rows of parking. Even curb extensions and infiltration gardens can be used in parking lots. As in street applications, rain gardens in parking lots should be carefully designed to ensure safe pedestrian circulation.

Buildings: Sussex County has many different building types, ranging from historic town center buildings in places like Georgetown, Lewes, and Milton, to newer commercial centers and residential communities. Managing stormwater from buildings involves dealing with stormwater generated from roofs, either on or off the building. On-building techniques include using green roofs, rainwater harvesting, and flow-through planter systems. Off-building strategies employ infiltration planters, swales, and gardens. Each strategy or combination of strategies depends on the building type, its surrounding context, and the amount of landscape space surrounding the building.

5.2.1 Design Sites Efficiently

One of the first questions designers, developers, or municipal or county staff should ask about a project is: Has the site been designed in the most efficient way possible? Examples of efficient site design include higher or vertical density, vertical integration of land uses, structured parking lots when appropriate, connected street network with narrower street and road designs, and parking spaces that meet expected demand. However, sometimes what makes sense from a design perspective is not allowed under existing regulations. For this reason, designers and policy makers work together to achieve better site-specific stormwater management. Efficient site design is an important first step if the site will include rain gardens because carefully laying out the site makes it easier to find room for these stormwater facilities. This is especially evident with street and parking lot retrofit projects.

Richard Drdul-www.flickr.com

Figure 25. This street could be narrowed to create space for rain gardens and sidewalks.

Efficient Site Design and Streets

Some ideas for designing streets more efficiently include:

- Narrowing travel lanes from 12 feet to 10 feet (or less) reduces impervious area, can reduce new development infrastructure costs, can calm traffic in pedestrian-oriented areas, and can help create room for stormwater applications.
- Consolidating travel lanes and on-street parking can yield space for rain gardens, bike lanes, or wider sidewalks. Designers, developers, and county officials could consider whether a travel lane on a multi-lane street could be eliminated, or whether some parking spaces could be reduced to increase landscape area along a street.
- Unused asphalt next to travel lanes can be converted into landscape. Figures 26 and 27 illustrate how underused impervious street edge could be redesigned to maximize the landscape area along the street.

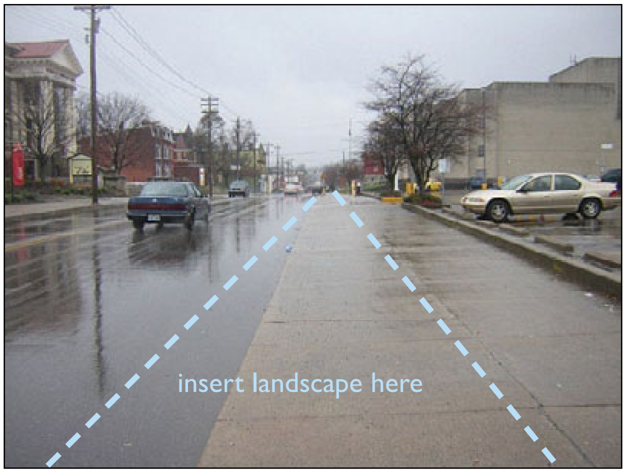

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Figure 26. Underused space on this street could be converted into conventional landscape space or used for rain gardens.

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Figure 27. The same street with additional landscaping, a stormwater swale, and street trees.

Efficient Site Design and Parking Lots

To use parking lots more efficiently in sites, consider these options:

- Shortening parking stall lengths from 18 feet to 15 feet still allows a standard SUV to fit in the stall's striping. Shortening the drive aisles from 24 feet to 22 feet allows cars to comfortably back up and travel within the parking lot. Portland, Oregon, and other cities have similar or stricter parking lot sizing standards that accommodate drivers while also protecting pedestrians and providing room for stormwater management. For retrofits, shortening parking stalls and drive aisles often provides the space needed to add stormwater swales and planters.
- Consider how much parking is needed on an average day. Too often, parking lots sit half full for most of the year. This is especially true with shopping mall and big box store parking lots. For more discussion of parking standards, see Section 4.3.

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Figure 28. This parking lot has large areas of wasted space.

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Figure 29. The same parking lot redesigned to efficiently use space yielded a parking lot swale, sidewalk, and landscape zone for street trees.


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Figure 30. This apartment complex allows cars to park under the building's second floor, which uses the site more efficiently.

Efficient Site Design and Building Envelopes

Buildings and their immediate surroundings can also be designed to efficiently use space. For new construction, buildings can be designed to allow parking stalls under the second-floor podium. This provides additional space on the project site for rain garden applications. Buildings that already have conventional landscaping that does not have any additional function other than screening or aesthetics offer great opportunities to convert the landscape area into functional rain gardens, thereby using the land more efficiently.

5.2.2 Protect and Enhance Natural Resources

For any kind of land development where protecting natural resources is a goal, attention should be paid to designing "with nature" and not against it. When designing a particular development, protecting a site's natural resources can have the same importance as planning and designing streets, residences, and commercial centers. Existing stands of trees, wetland areas, riparian buffers, and open spaces can be protected, enhanced, and integrated into a site's development. Not only do a site's natural resources provide habitat area and help naturally manage stormwater runoff, but when well-integrated into a site's design, these preserved features can provide a distinctive identity and can help market the project.

Some strategies to help preserve and protect natural resource areas include:

- Identify resource areas early in the design process and overlay their boundaries over the development programming.
- Large stands of trees can be protected by carefully designing them into street medians or traffic circles or simply preserving them next to buildings. Roads, sidewalks, parking lots, and buildings can be designed around existing trees to protect them.
- A site's wetland areas can be used as natural overflow points for stormwater. However, runoff can be filtered through rain gardens before entering the natural wetland areas.


carnozet-www.flicker.com

Figure 31. The existing vegetation and natural resources on the site of this development have been eliminated.


newgarden.org

Figure 32. Protecting riparian buffers like this one can help protect and integrate natural resources into a site's development.

In forested areas, it may be next to impossible to save all existing trees and vegetation and still have a plausible development project. In these situations, developers can save extensive "clusters" of natural vegetation to balance the need for development and resource protection.

5.2.3 Protect and Plant Trees

Preserving healthy trees wherever possible is important to managing stormwater runoff. Trees slow, absorb, and filter rainwater by intercepting raindrops on leaf surfaces, slowing the flow of water through the landscape, and drinking water that has infiltrated into the soil. Some steps to consider include:

- An inventory of existing trees prior to design provides a baseline and can help guide the design and location of streets, buildings, parking lots, and rain gardens. The inventory can include the species, age, typical life span, and health of trees. Also important is whether the tree species can tolerate frequent inundations. Consider whether the facility can be designed around the trees and whether the trees can tolerate construction around the roots.

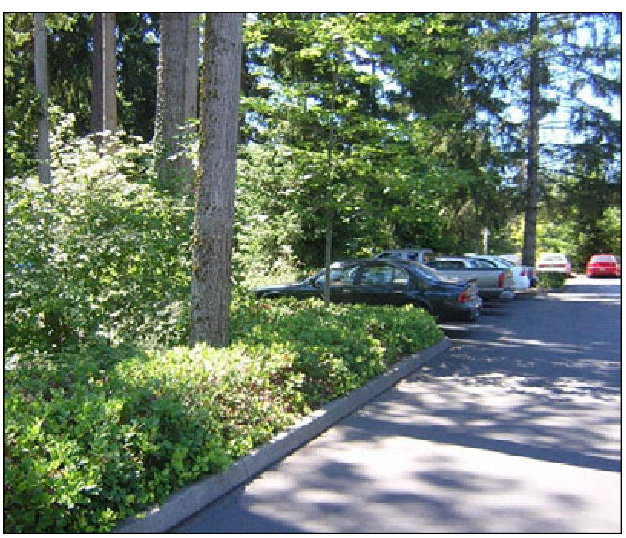

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Figure 33. A parking lot with mature landscaping and trees.

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Figure 34. These trees will help soak up stormwater, cool the parking lot, provide an aesthetic amenity, and filter pollutants out of the air and water.

- Mature trees may be able to soak up water at a comparable rate that it can be infiltrated in a swale, so, in terms of overall stormwater benefit, it may be worth reducing stormwater facility size to save a mature tree.

Planting new trees where possible will help slow, filter, and absorb stormwater runoff.

5.2.4 Design Interconnected Surface Stormwater Management

In natural conditions, once rain fell on the land, it would slowly infiltrate into the ground or would flow to interconnected low spots in the landscape. To mimic a more natural hydrologic condition, a site can have a similar interconnected stormwater system. Large development projects that want to use a more natural approach to stormwater management could consider designing multiple small-scale rain gardens rather than relying solely on a "pipe to pond" system. Reducing the amount of underground pipe infrastructure and encouraging minimal pipe design (MPD) promote the use of landscape swales and surface runnels to interconnect and slowly convey stormwater to each downstream rain garden. Using an MPD design approach not

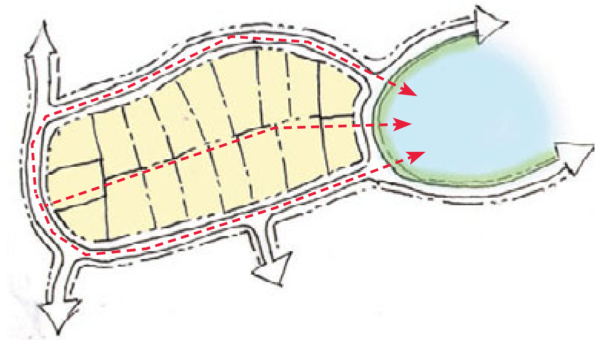

Figure 35. A conventional residential site plan. Stormwater is whisked away quickly via underground pipes into a large storage pond.

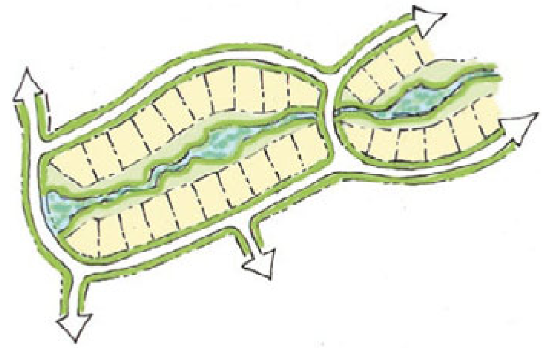

Figure 36. A redesigned site plan with a well-connected stormwater system. Rainfall is collected and conveyed through interconnected rain gardens, creating a more natural condition while still allowing development to occur.

Figure 37. A well-integrated residential rain garden.

only mimics a more natural drainage condition, it also has the potential to save the project significant infrastructure costs.

Sometimes having an overflow pond system to manage large storm events will be necessary. However, by designing the site to first manage stormwater on the surface and within smaller interconnected rain gardens, the footprint of the overflow pond might be reduced to allow for more developable land and a more aesthetically pleasing project. This was the case in the High Point development in Seattle, Washington. By using an interconnected network of natural infiltration techniques, the development was able to use a one-acre wet pond instead of a five-acre pond. This "saved" four acres that could then be developed. A smaller wet or dry pond allows more flexibility to design the facility so it blends in better and becomes a neighborhood amenity.

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Figure 38. A conventional strip mall site. Is there any incentive to walk along this streetscape?

npgreenway-www.flickr.com

Figure 39. A separated bike path gives people a choice to walk, bike, or drive.

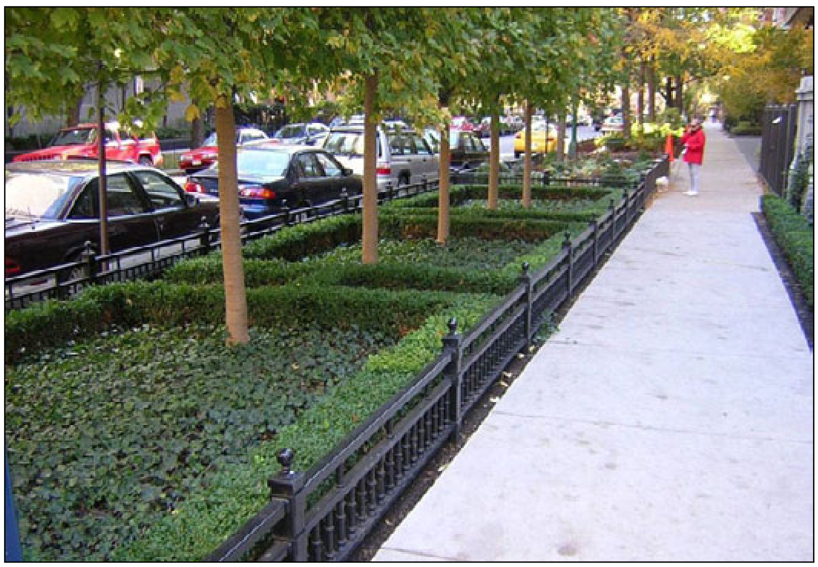

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Figure 40. In a pedestrian-friendly streetscape, streets are designed to make walking safe, comfortable, and convenient.

5.2.5 Provide Transportation Choices

Designing stormwater management systems that allow plants and soils to clean pollutants running off of streets and parking lots addresses pollution at the end point. The beginning point, and a more indirect water quality improvement strategy, is to tackle the pollution at the source by reducing the pollutants from motor vehicles. Communities can accomplish this goal by giving people more transportation choices, such as walking, biking, and public transit. The equation is simple: a reduction in automobile use equals a reduction in the pollution associated with automobiles. In many communities, the street environment makes it difficult, inconvenient, or unsafe for people to walk, ride their bikes, or hop on a bus. Section 4.2 discussed some neighborhood-level ways that give people choices in how they move around, thereby making it easier for people to leave their cars at home. The design of individual streets can help reinforce neighborhood-wide planning for more bike- and pedestrian-friendly streets by protecting pedestrians and bicyclists from traffic and by adding trees and other vegetation to shade the sidewalks and make them more appealing. Both strategies offer stormwater management benefits as well when they include rain gardens as described in Sections 5.2.9–12.

Another important component of sustainable stormwater design is to increase the amount of stormwater that is managed on site—that is, to use plants and soil to slow, filter, and absorb stormwater on site. This section introduces strategies that increase on-site stormwater capture, absorption, and filtration. Before-and-after sketches are provided to illustrate the potential application of these techniques to the redesign of streets and parking lots in Sussex County. The sketches are based on sites that the team saw during its August 2007 visit to the area around Lewes. The goal of illustrating these strategies in context is to provide a broad range of potential site-scale applications. Many of the concepts illustrated can be applied broadly across Sussex County.

5.2.6 Use Pervious Paving

Pervious paving refers to paving materials (asphalt, concrete, pavers, grass-pave) that allow water to drain through the paving system and into soils below. These systems are alternatives to conventional, impervious pavement and can provide the structural integrity needed for cars, trucks, and high-traffic pedestrian areas.

This section introduces the use of pervious paving systems. It discusses the potential applications of these systems and the pros and cons of different paving systems. Before-and-after sketches show complete and partial applications of pervious paving to a residential alley and residential street in Paynter's Mill. This section concludes with a discussion of how pervious paving could be applied to a parking lot.

Good places for pervious paving:

- Streets
- Parking lots
- Parking strips
- Alleys
- Patios

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Figure 41. This street shows how permeable pavers can help define the streetscape.

Community benefits:

- Can be safer than traditional paving because puddles are less likely to accumulate.
- Provides aesthetic appeal.
- Defines a distinctive community character.
- Delineates parking areas or pedestrian zones.
- Introducing a pattern in a large area of paving can give the illusion of narrower or smaller spaces and help slow traffic.

Pervious Asphalt and Concrete

Pervious asphalt and concrete production is similar to that of standard asphalt and concrete; the main difference is that the fine-grained sediments that typically fill the pores between the larger aggregates are left out of the aggregate added to the mixture. This leaves small holes in the concrete that allow water to drain through the surface.

Advantages:

Pervious paving has been successfully used on interstates and other limited access roads. Pervious paving reduces the accumulation of puddles and danger of hydroplaning on high-speed roads.

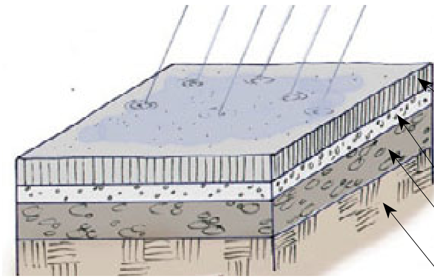

Figure 42. Pervious concrete profile.

Figure 43. Porous concrete allows water to pass through pore spaces in the aggregate.

Figure 44. A pervious asphalt parking lot. The force applied by tires at turning, stopping, and starting locations can be hard on the paving surface.

Figure 45. There is no wet sheen on the pervious asphalt in the parking stalls in this parking lot, compared to the conventional asphalt paving in the drive aisles.

In snowy conditions, pervious paving allows melted snow and ice to drain and the surface to dry faster, so there is less danger of re-freezing.

Issues to consider:

Pervious asphalt is somewhat malleable, so the force that is applied by a turning tire, as well as vehicles stopping and starting, can create depressions and tear up the paving surface (see Figure 44). This can be avoided by using a different surface where most of the tire turning, stopping, and starting occurs.

When installing pervious asphalt and concrete, the subgrade must be properly prepared and the surface poured correctly. Where pervious asphalt and concretes fail, it is usually due to incorrect installation.

Pervious asphalt and concrete are most economical in large batches. They work well for large roadway or parking lot applications and accept higher vehicle traffic loads and speed. However, the price makes it more difficult to use them for small applications or to repair small areas. Pervious asphalt is less expensive than pervious concrete.

Figure 46. Pervious pavers in a parking lot application. Any overflow from the pervious pavers drains into a swale.

Permeable Pavers

Any pavers can create a porous surface if there are spaces between them that are filled with sand or other aggregate that allows water to drain. The pavers discussed here are interlocking concrete pavers, which are designed specifically for stormwater management applications. Interlocking concrete unit pavers are designed to allow water to pass through joint gaps that are filled with sand or gravel and infiltrate into a thick gravel sub-grade. This system can be used for small or large paving applications and allows a small section to be removed when repairs are needed. They can be installed with trucks designed to efficiently install large areas of pavers, and they have been used successfully in industrial sites, including the port of San Francisco. Pervious interlocking pavers have a lot of design flexibility in color, style, joint configuration, and paving pattern. Interlocking concrete pavers tend to be more costly to install than pervious asphalt or pervious concrete.

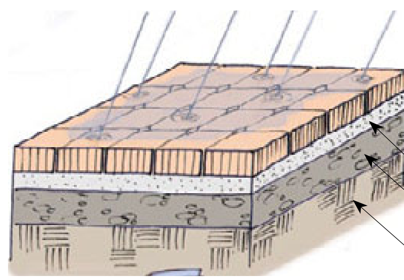

Figure 47. Sand-set pervious paver profile.

Figure 48. Interlocking concrete unit pavers create gaps between adjoining pavers, allowing water to soak into the ground.

Reinforced Gravel Paving

A gravel pave system uses gravel without the fines and a structure that helps provide support and create a rigid surface. Gravel can be a viable alternative to a traditional paved surface in areas of lower use that need a rigid surface.

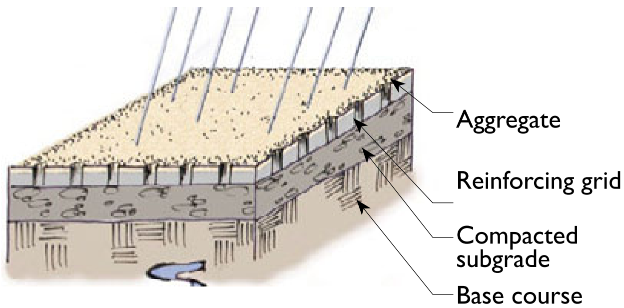

Figure 49. Reinforced gravel paving profile.

Figure 50. Reinforced gravel paving in parking stalls.

Reinforced Grass Paving

In the right situations, grass-pave, or other hybrids between paving and planting, could be an option. Reinforced grass paving provides structural support but also allows some plants to grow and water to soak through into the soil. Grass paving cannot always be used interchangeably with standard asphalt or concrete, but it may be appropriate in the right low-use areas.

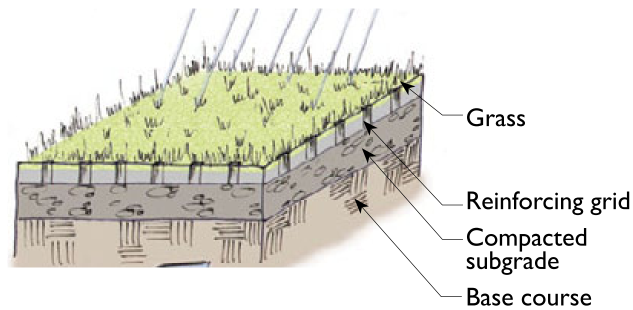

Figure 51. Reinforced grass paving profile.

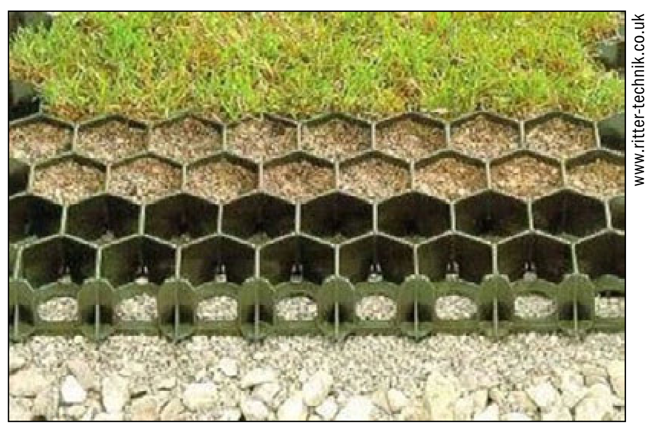

Figure 52. Reinforced grass paving allows water to pass through the grass root zone and into the underlying soil while still maintaining a hard surface for vehicular travel.

Figure 53. Residential alley in Paynter's Mill.

Option for Pervious Pavers—Complete Application

This example shows pervious pavers as an alternative to traditional asphalt. A concrete band on both sides of the alley creates an edging material for the pavers. In this example, the street profile is flat (see Appendix C for a discussion of street profiles), so when rain falls, it soaks directly through the pavers without concentrating sediments in one location. Pervious asphalt or concrete could also be used instead of pervious pavers.

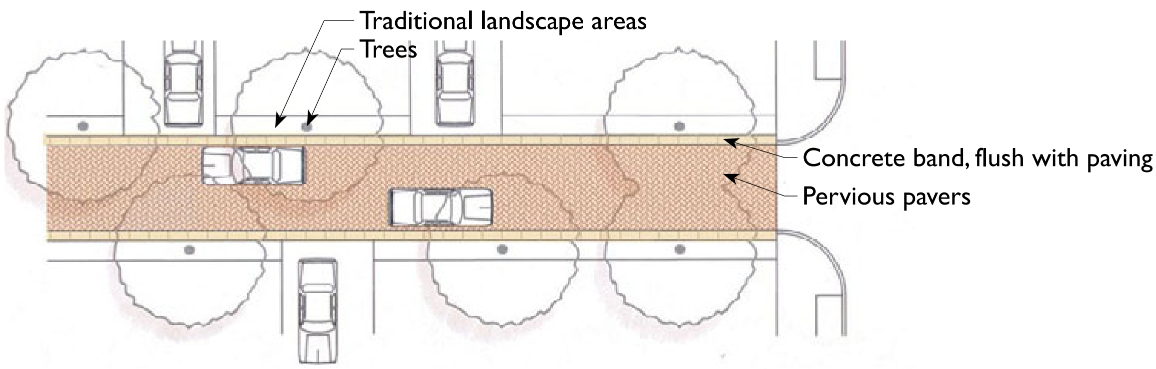

Figure 54. Complete application of pervious paving—plan view.

Figure 55. ***Retrofit potential:*** **Complete application of pervious paving in a residential alley.**

Figure 56. Residential alley in Paynter's Mill.

Option for Pervious Pavers—Center Strip

In this example, the alley is transformed with a strip of pervious pavers down the center. The alley is graded to drain towards the center strip of pavers. Note that when water is directed to pervious pavers from another surface, it can carry sediments with it and can clog pervious pavers more quickly. In this situation, pervious paving must be well maintained and sized appropriately.

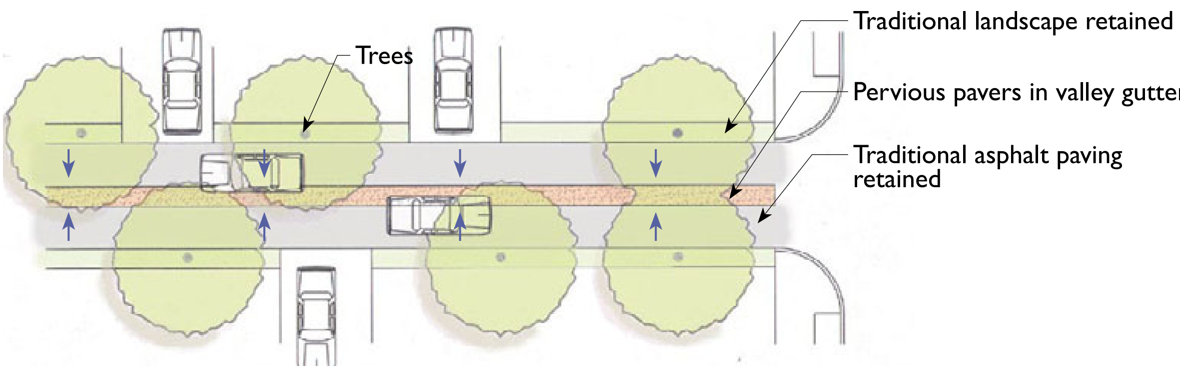

Figure 57. Center strip application of pervious paving—plan view.

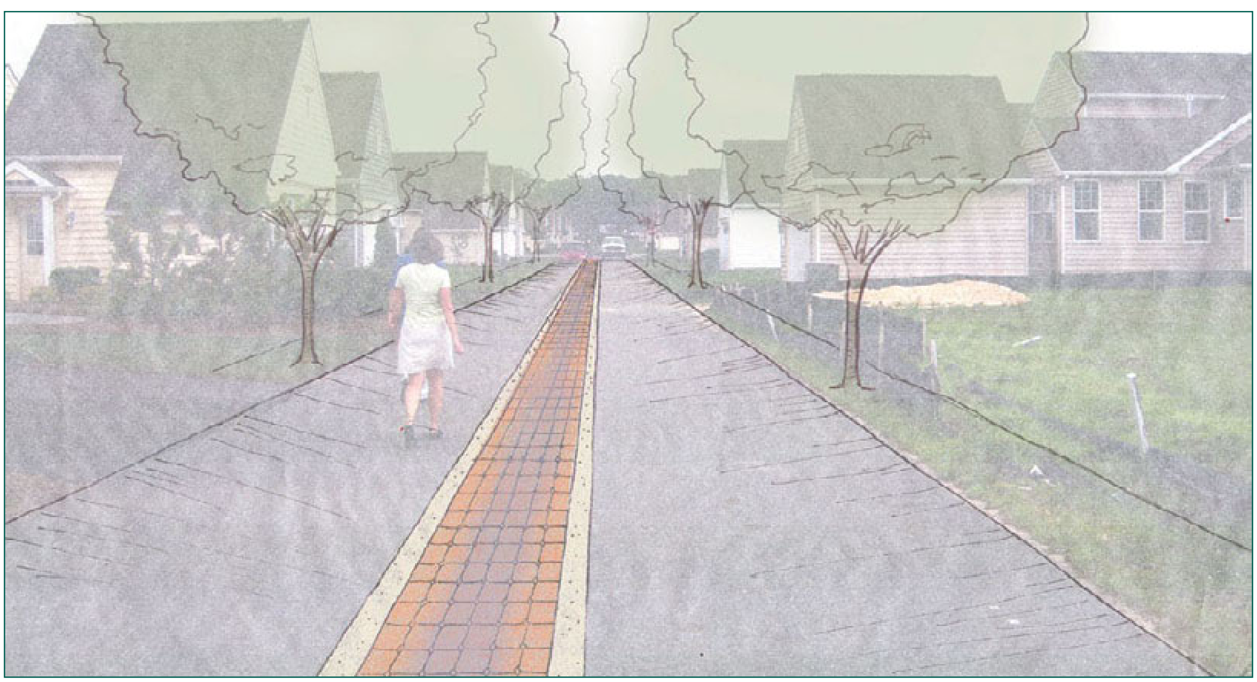

Figure 58. *Retrofit potential:* Center strip of pervious paving in a residential alley.

Figure 59. Residential street in Paynter's Mill.

Option for Pervious Paving—Parking Zone

This example illustrates pervious paving in the parking zone of a low-density residential street. Pervious paving can be used in new construction or retrofitted in existing streets. Pervious paving can also be applied to the entire street surface. One of the advantages of using pervious concrete or sand-set pervious pavers strictly in the parking zone of a street is that there is a perceived narrowing of the street due to the contrast between the conventional asphalt and the pervious paving material. This effect can reduce traffic speeds in residential areas.

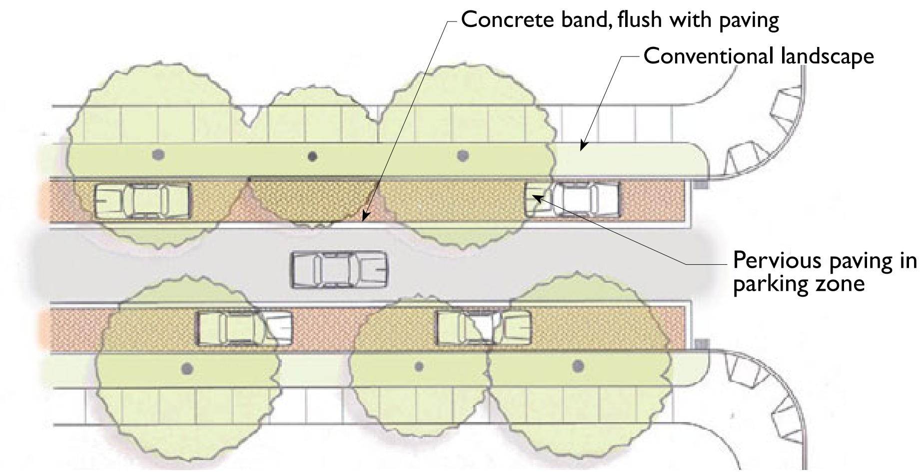

Figure 60. Pervious paving in parking zone—plan view.

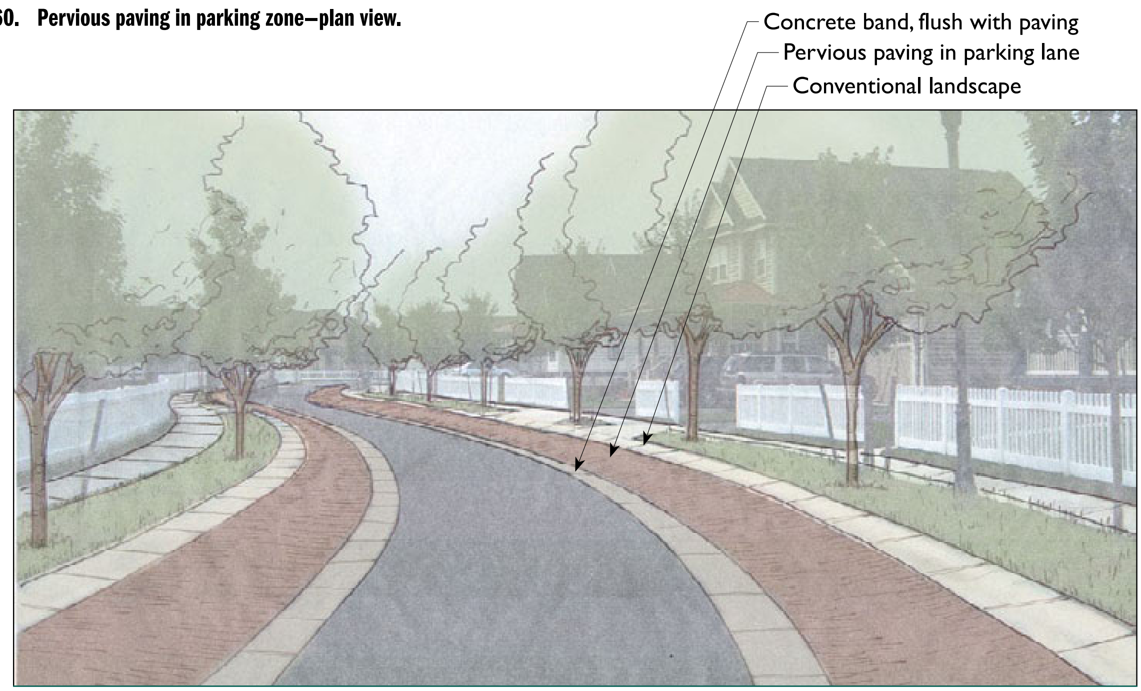

Figure 61. *Retrofit potential:* Adding pervious paving on both sides of this residential street allows two-way travel and parking on both sides of the street.

Figure 62. This parking lot uses pervious concrete in the parking stalls.

Option for Pervious Paving—Parking Stalls

The example below employs pervious paving in the parking stalls and allows overflow to drain into the existing storm inlet. Using pervious paving in parking stalls can reduce impervious area by up to 50 percent. A parking lot could be designed entirely with pervious paving, but it may be most cost effective to use it only in parking stalls, especially in larger parking lots. The example below illustrates a parking lot that is internally drained, but pervious paving can also be used in parking lots that drain runoff to the periphery of the site.

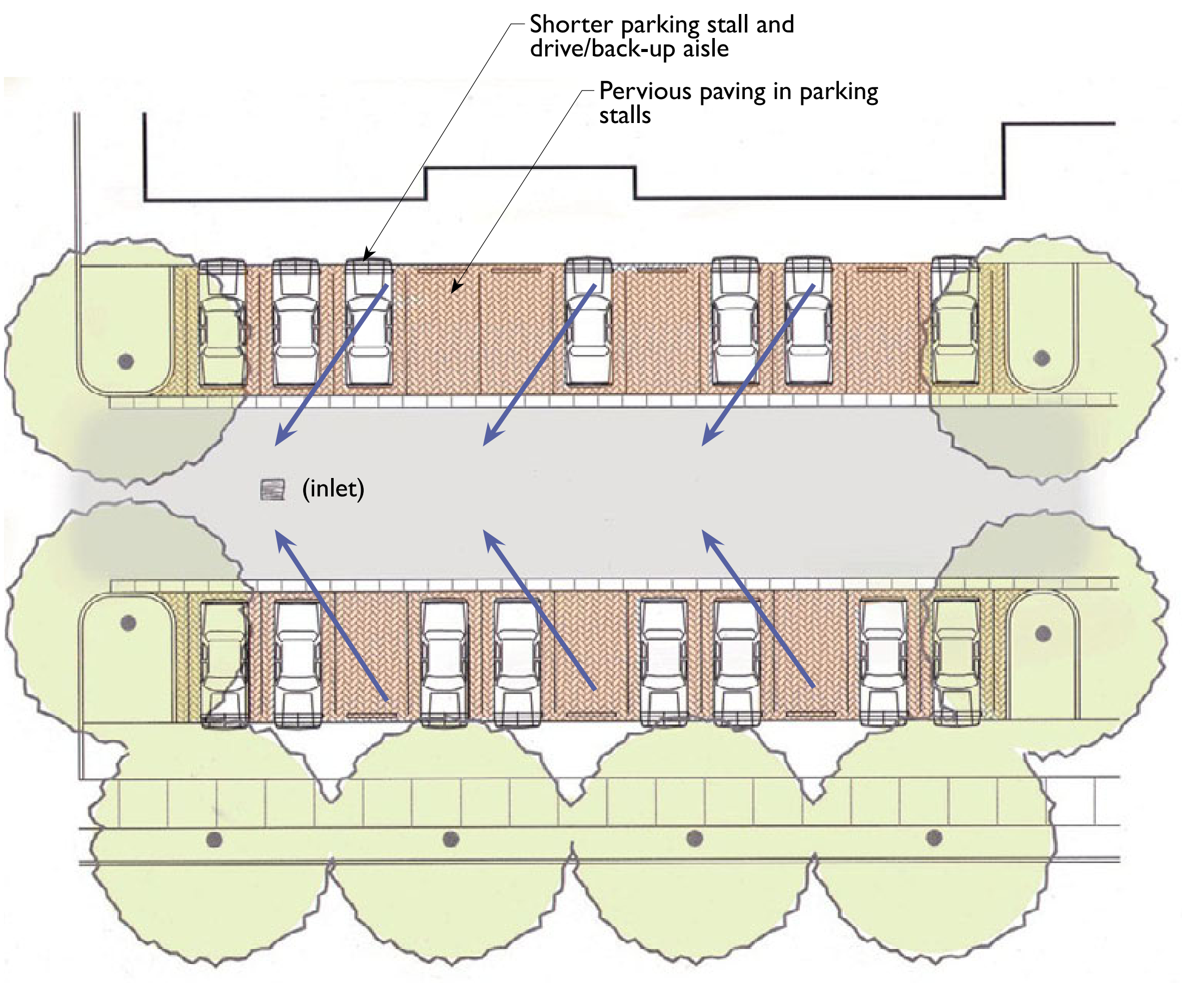

Figure 63. Pervious paving in parking stalls—plan view.

Foundation Industries

Figure 64. Large-scale commercial cisterns can hold large volumes of rainwater for reuse in toilets and irrigation systems.

www.arttec.net

Figure 65. A residential rain barrel can collect water for later reuse in the home garden.

5.2.7 Harvest and Reuse Rainwater

Rainwater harvesting captures stormwater runoff from rooftops and stores it in a durable container for later use. This helps to absorb water from the drainage system and slow and filter runoff that does eventually reach drainage.

Good places for rainwater harvesting:

- Large industrial buildings
- Office buildings
- Homes and garages

Community benefits:

- Water can be used for non-potable purposes, which leaves more water in public reservoirs to fill drinking water needs.
- Systems can be artfully designed in concert with the building's architecture.
- Systems can be a good educational tool to teach about watersheds.
- Harvesting rainwater can help create an awareness of water as a precious resource and promote its conscientious management.

Rainwater harvesting has been used for thousands of years. Today, in developed countries where drinking water is plentiful from the tap, rainwater harvesting captures rainfall primarily for non-potable uses such as supplemental irrigation, flushing toilets, car washing, and clothes washing. Capturing rainfall and treating it for potable water is also possible.

Harvesting rainwater can be used at various scales: from households harvesting water for personal use in a rain barrel to larger commercial applications where water is captured for irrigation. One can capture as much rainfall as a particular container can hold. Systems can be as simple as disconnecting a residential downspout and directing the water to a rain barrel.

5.2.8 Use Green Roofs

Green roofs are rooftop landscapes that intercept rain as it falls on a building. Water that normally runs off the roof and into a sewer system is absorbed by soils and plants on the roof or evaporates. The water that does run off the surface takes longer to do so. Any water that does run off the surface can then be treated in a rain garden or used in the building for landscaping and irrigation.

Good places for green roofs:

- Dense areas where land value is at a premium
- Large industrial buildings
- Office buildings
- Homes and garages
- In retrofit projects if building structure can support the added weight

Community benefits:

- Decreases heating and cooling costs by insulating and shading buildings.
- Helps reduce the urban heat island effect.
- Provides wildlife habitat.
- Improves the overall aesthetics of buildings.
- In more densely developed areas where land value is at a premium, provides additional green spaces for people to enjoy.

Green roofs can thrive on flat or sloped roofs, residential or commercial buildings, and small or large building footprints. A green roof can host a thin and simple palette of plants or thick, intensely planted landscapes. A green roof's ability to manage stormwater runoff depends on its vegetation and the type and thickness of the soil mixture. Green roofs tend to cost more to install than conventional roofs, but long-term energy savings from insulating the building can help mitigate the initial costs.

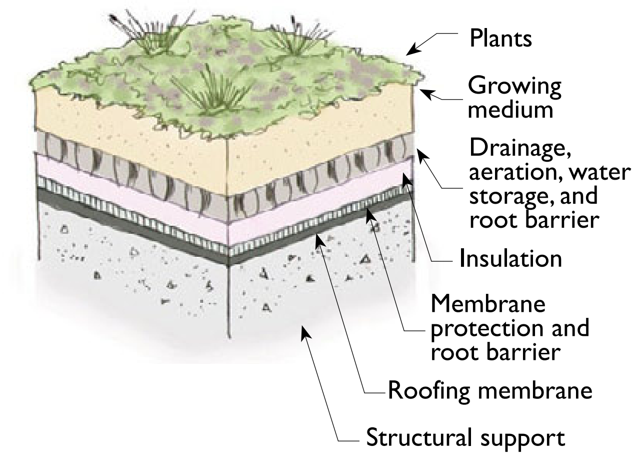

Figure 66. Green roof profile.

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Figure 67. Green roof on a parking garage.

www.nemo.uconn.edu

Figure 68. Green roof on a commercial building.

Green roofs work well for industrial uses where building footprints account for a large amount of the impervious surface. In industrial areas, it can be difficult to find enough land to manage stormwater on the surface. Designing buildings in these industrial areas to absorb more rainwater means less land is needed for rain garden strategies.

Though their benefits shine in highly built environments because they decrease the overall impervious surface of a site, green roofs can also be used in low-density residential settings. The versatility in the design of green roofs has encouraged their use throughout the United States.

5.2.9 Use Swales

Swales can be integrated into streets, parking lots, and buildings to better manage stormwater while also creating an aesthetic amenity and making streets safer and more comfortable for residents to walk and bicycle. Sample applications of swales are shown in this section with potential applications to streets and alleys in Sussex County.

Good places for swales:

In new design:

- Subdivisions
- Arterial streets
- Parking lots

In retrofits:

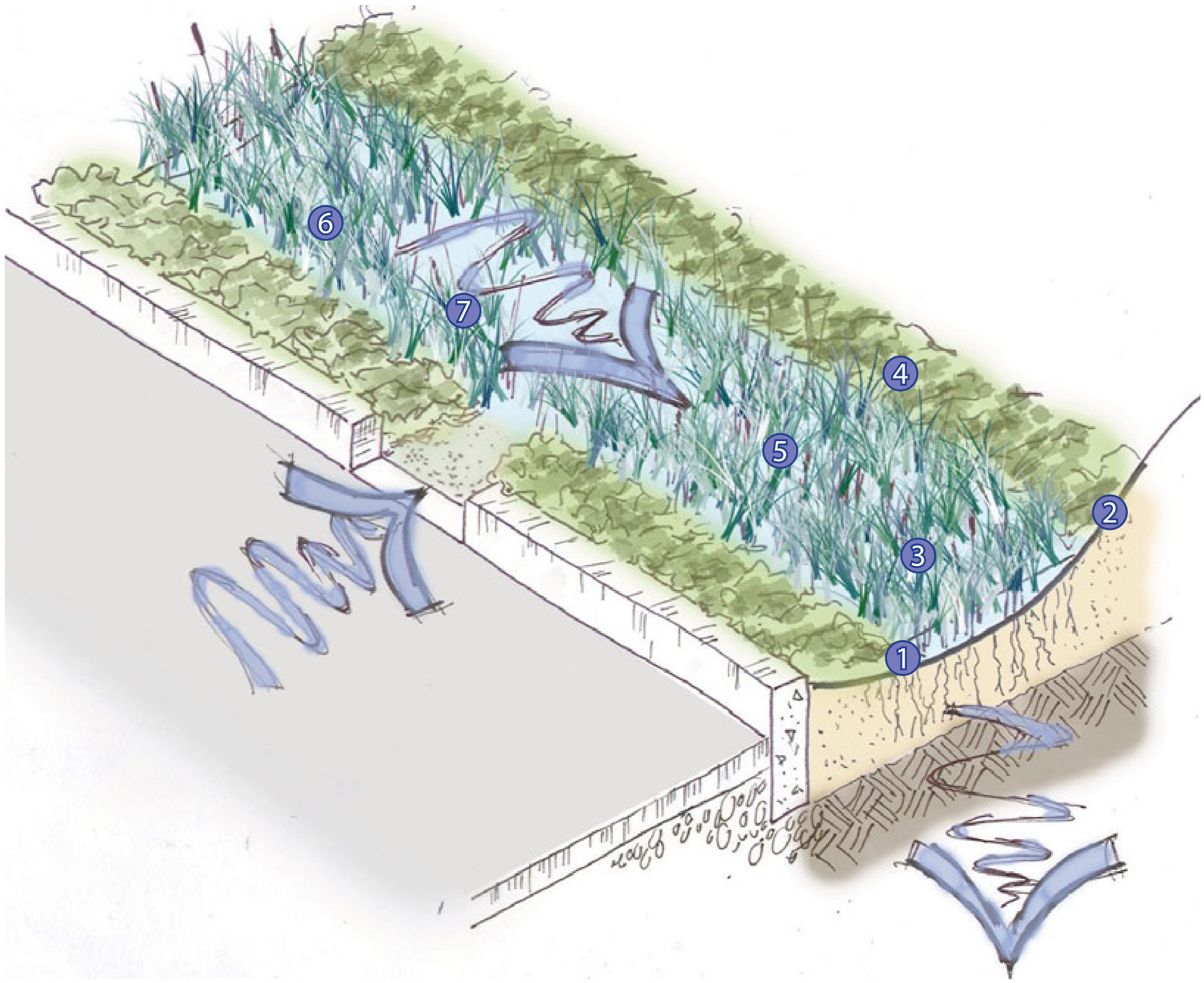
- Rural roads
- Parking lots
- Between buildings
- Planting strips

Community benefits:

- Attractive neighborhood amenity

EPA

Figure 69. A residential street with a stormwater swale.



1	Depth:	Maximum depth of 6”
2	Side slopes:	4:1 ideal, 3:1 maximum slope
3	Bottom:	3’ minimum, 7’ maximum, rounded or flat
4	Plants - side slopes:	Drought-tolerant ground covers and shrubs, 3’ maximum height
5	Plants - bottom:	Rushes, sedges, and trees adapted to inundation and drought
6	Longitudinal slope:	6% maximum
7	Check dams:	At least 1 check dam for every 6” of vertical drop
	Trees (not shown):	In bottom of swale, drought tolerant, wet tolerant

Figure 70. Design and construction characteristics of a swale.

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Figure 71. The dashed lines show where a swale could be added in an existing planting strip on a residential street in Paynter's Mill.

As water flows through a swale, plants and soils slow its flow, allowing sediments and pollutants to settle out. Some water soaks into the soil and is absorbed by plants or infiltrates into the ground if native soils are well drained. The water that continues to flow downstream travels more slowly than it would through pipes in a traditional system. Swales can be planted with a variety of plants, ranging from mown grass or a simple palate of grasses, sedges, and rushes, to a mixture of trees, shrubs, and groundcovers.

Swales are best implemented in areas of continuous landscape. A longer continuous swale allows more time for filtering to occur. Rural roads, arterial streets, and medians commonly offer this type of uninterrupted linear space. New subdivisions and parking lots can also offer good opportunities for swale design.

Stormwater swales are relatively inexpensive, simple to construct, and widely accepted as a stormwater management strategy.

Swales and Streets

On a new street:

Streets can be ideal places to incorporate swales. The long and linear character of streets can accommodate a swale's need for long uninterrupted stretches of landscape. Often streets have long stretches of underused right-of-way.

On an existing street:

- Look for long, unplanted, unused median strips or planting strips between the sidewalk and the street.
- Is the center turn lane necessary? Can turn lanes be removed, travel lanes moved to center, and swales added on sides?
- How is water currently moving in pipes through the site? Is there a way to move that water on the surface?
- Can the travel lane widths on a particular street be reduced? Sometimes reducing a lane by just a few feet can make a swale work alongside a street.

Options for Swales—Residential Street

The street shown in Figure 72 uses conventional lawn in the planting strips between the street and the sidewalks. The design could have substituted swales in the planting strips, with a curbless condition to allow water to sheet flow into the swales. Using this approach could reduce the space needed for a facility to treat all the runoff from this development in one location and allow more developable land parcels. Having no driveway curb cuts along the street, with garage access via alleys behind the homes, provides the long, continuous landscape space that swales need.

The designs on the following two pages show additional options for introducing swales on residential streets, depending on how the street drainage is designed and whether on-street parking exists.

Figure 72. Residential street in Paynter's Mill.

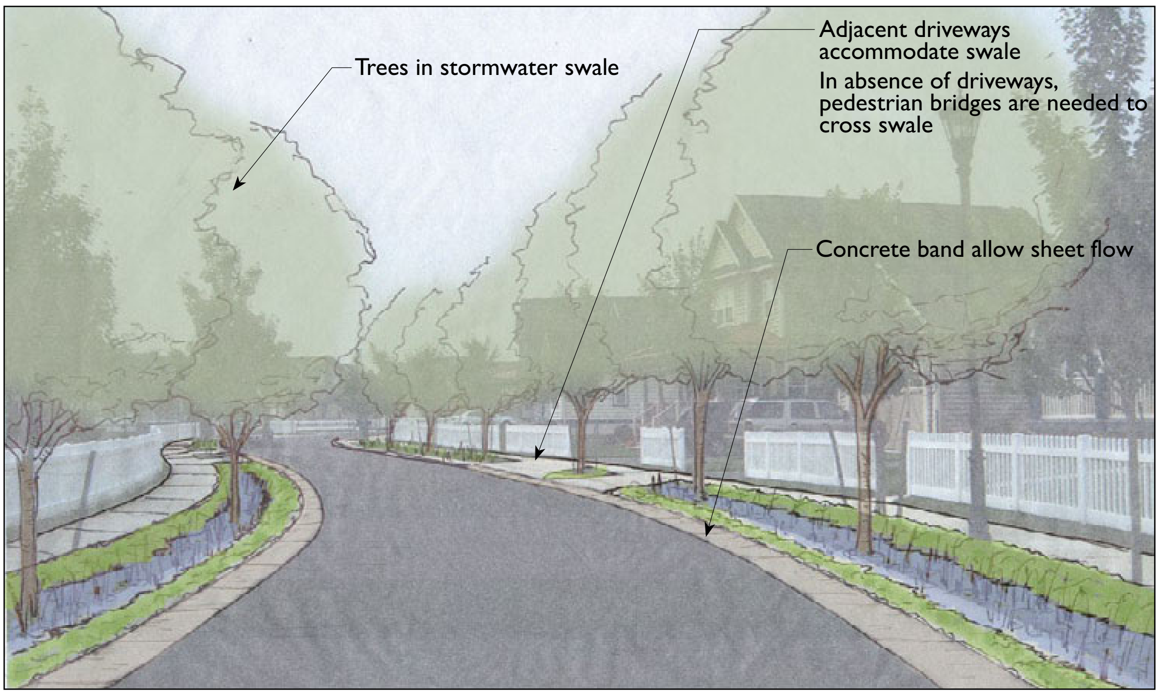

Figure 73. ***Retrofit potential:*** **Swales on both sides of "curbless" street to accept sheet flow of runoff.**

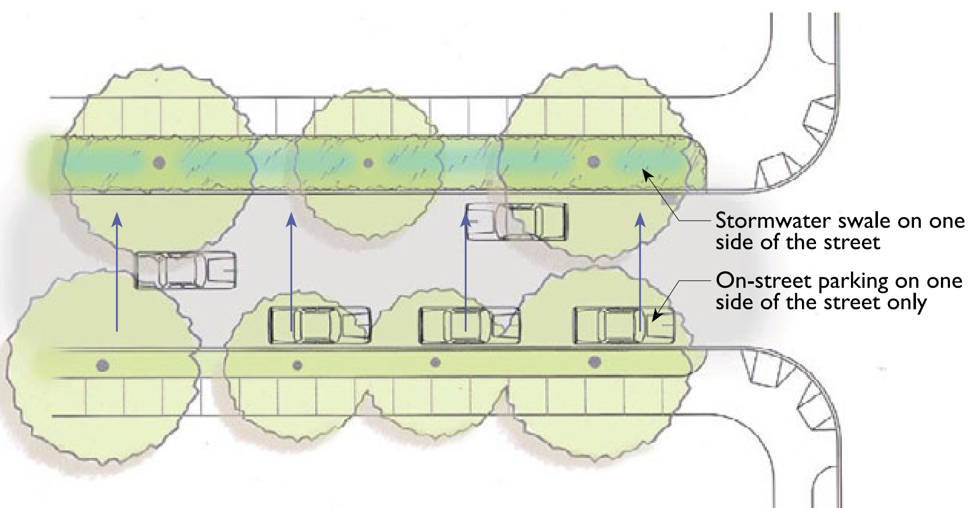

Figure 74. One side swale (parking on one side)—plan view.

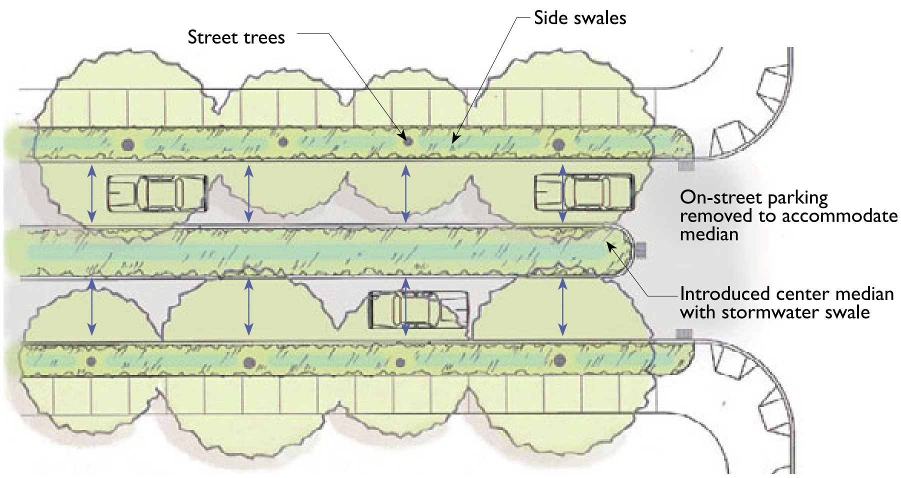

Figure 75. Two side swales and median swale (no parking)—plan view.

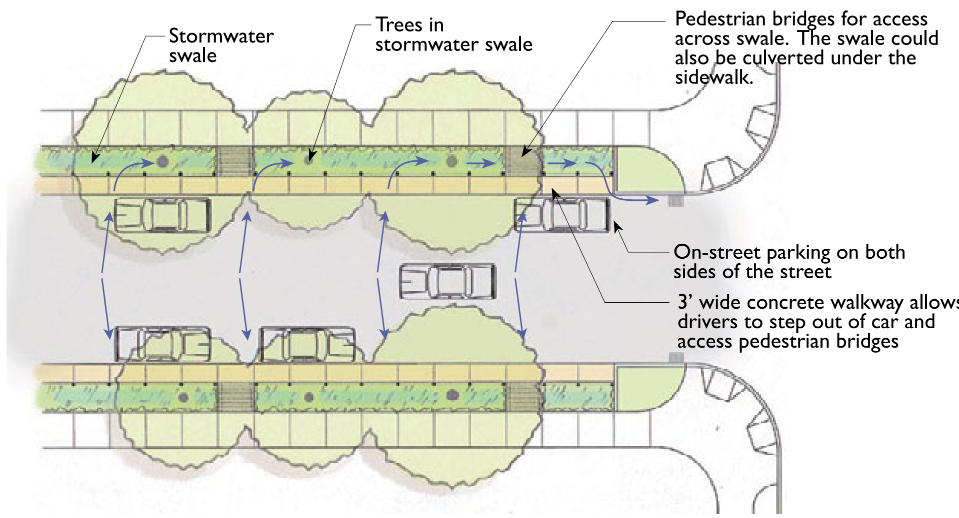

Figure 76. Two side swales (parking on both sides)—plan view.

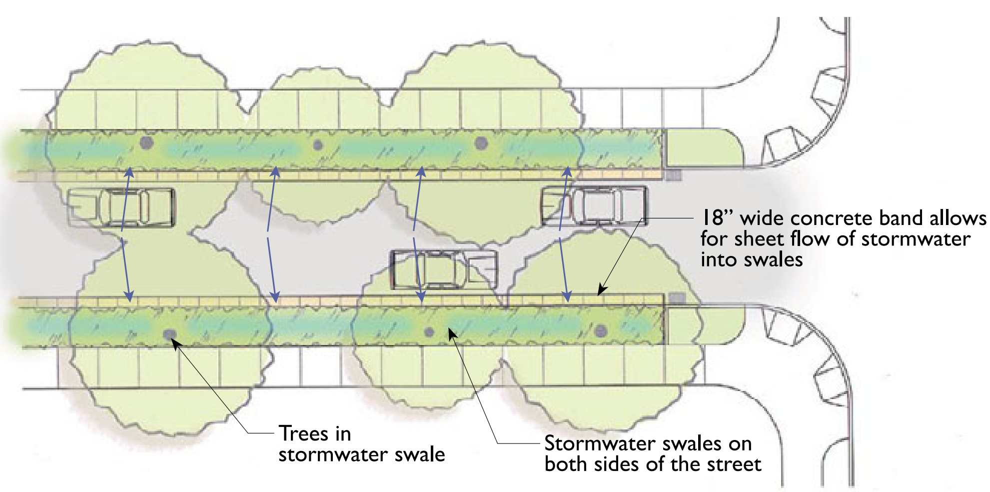

Figure 77. Two side swales (no parking)—plan view.

Figure 78. Residential alley in Paynter's Mill.

Option for Swales—Residential Alley

This example transforms the alley by draining water to the sides into narrow swales. An alternative could be to drain the whole alley to a swale on one side. This example shows a curbless condition, with sheet flow of stormwater into the swales. Driveways can intersect with the swales either by a culvert or by having runoff flow through a driveway valley gutter. Small pedestrian bridges can be added to provide access directly between back yards and the alley or a place to put trash and recycling for pickup.

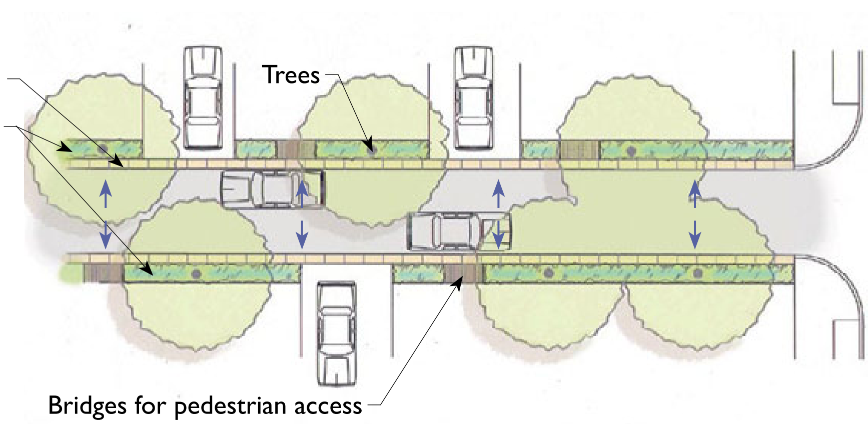

Figure 79. Side swales—plan view.

Figure 80. *Retrofit potential:* Side swales in a residential alley.

Option for Swales—Commercial Area

This option shows a commercial area with on-street parking and high pedestrian activity. Here, short curb extensions are added to calm traffic and shorten street crossing distances at the intersection. A bike lane is added to make biking safer. A 3-foot-wide sidewalk zone is provided for people to access parked cars. This example shows a curbless condition, where water sheet flows into the swales in the planter strip, but a swale could also be implemented with a curbed street with curb cuts to provide stormwater inlets.

Sussex County is a coastal community. One way in which that history and tradition can be incorporated and reflected in the stormwater management system is by designing pedestrian walkways as boardwalks (see Figure 81).

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Figure 81. Stormwater swale in a mixed-use community. Boardwalks link pedestrians to the sidewalk zone of the street.

Grandpa Hoo-www.picasa.com

Figure 82. Boardwalks, such as this one in Cape May, New Jersey, are a common example of coastal vernacular.

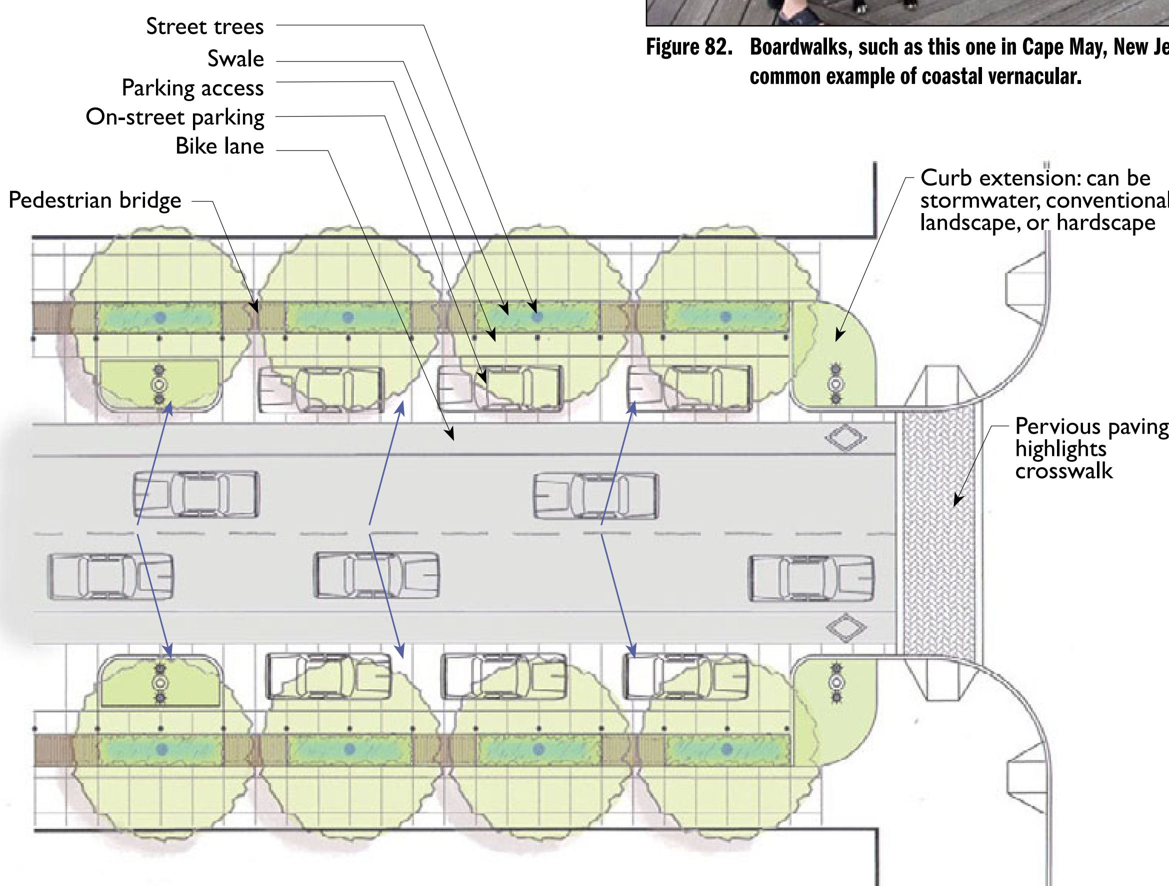

Figure 83. Curbless street with swales (parking on both sides)—plan view.

Figure 84. Commercial area in The Villages of Five Points in Lewes.

Option for Swales—Commercial Area

This design narrows a vehicular travel lane and converts a portion of the existing sidewalk zone into a stormwater swale. In a commercial area like the one shown in Figure 84, pedestrians need to access the stores from cars parked on the street. The illustration below depicts how pedestrians can access their destinations while still allowing stormwater to flow underneath these access points through a series of trench drains.

For a more detailed discussion of how to maintain safe and effective pedestrian circulation and access when introducing stormwater facilities, see Appendix C.

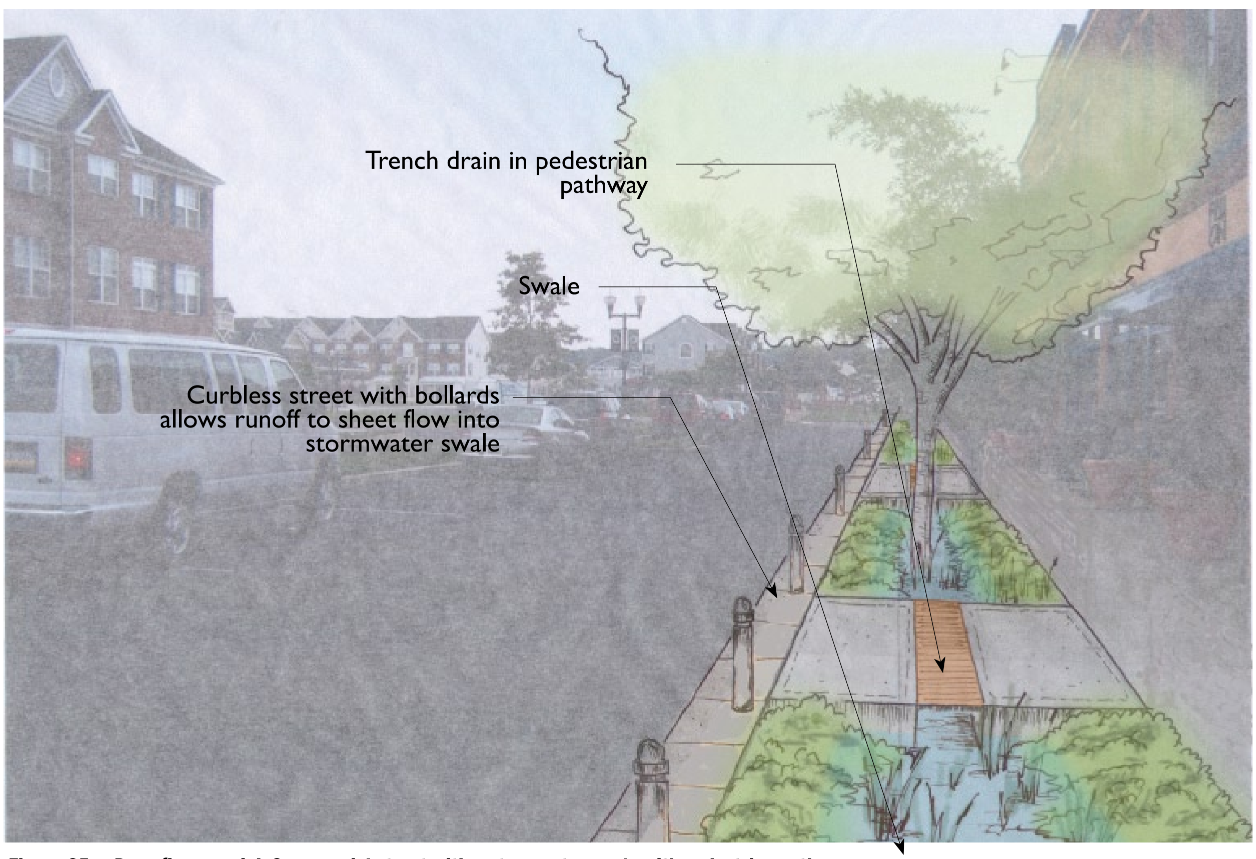

Figure 85. ***Retrofit potential:*** **Commercial street with a stormwater swale with pedestrian pathways.**

Figure 86. Multi-lane boulevard with wide sidewalk in Kentucky.

Option for Swales—Boulevard

This example shows how part of a wide sidewalk could be reclaimed and used for a street swale. This example is next to a park, which makes it an ideal place for an interpretive sign to educate passers-by about watershed health and stormwater management.

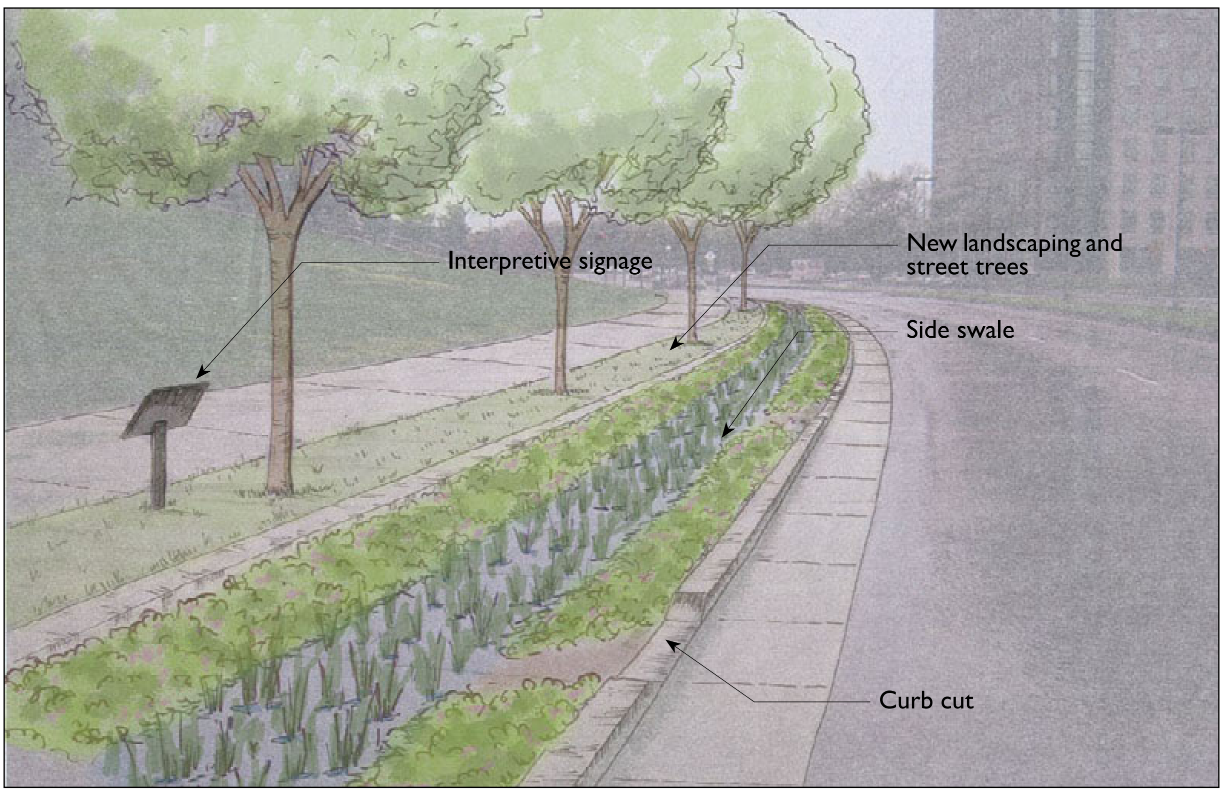

Figure 87. ***Retrofit potential:*** **Consolidating sidewalk space allows for a stormwater swale and street trees along this boulevard.**

Figure 88. **Highway 113 near Selbyville, Delaware. The wide shoulder and utility zone could be used more efficiently.**

Option for Swales—Arterial or Highway

This four-lane arterial has enough room in the shoulder and utility zone to build a bike lane, sidewalk, safety buffer, and swale. Variations can be made to this design to preserve the shoulder if it is critical.

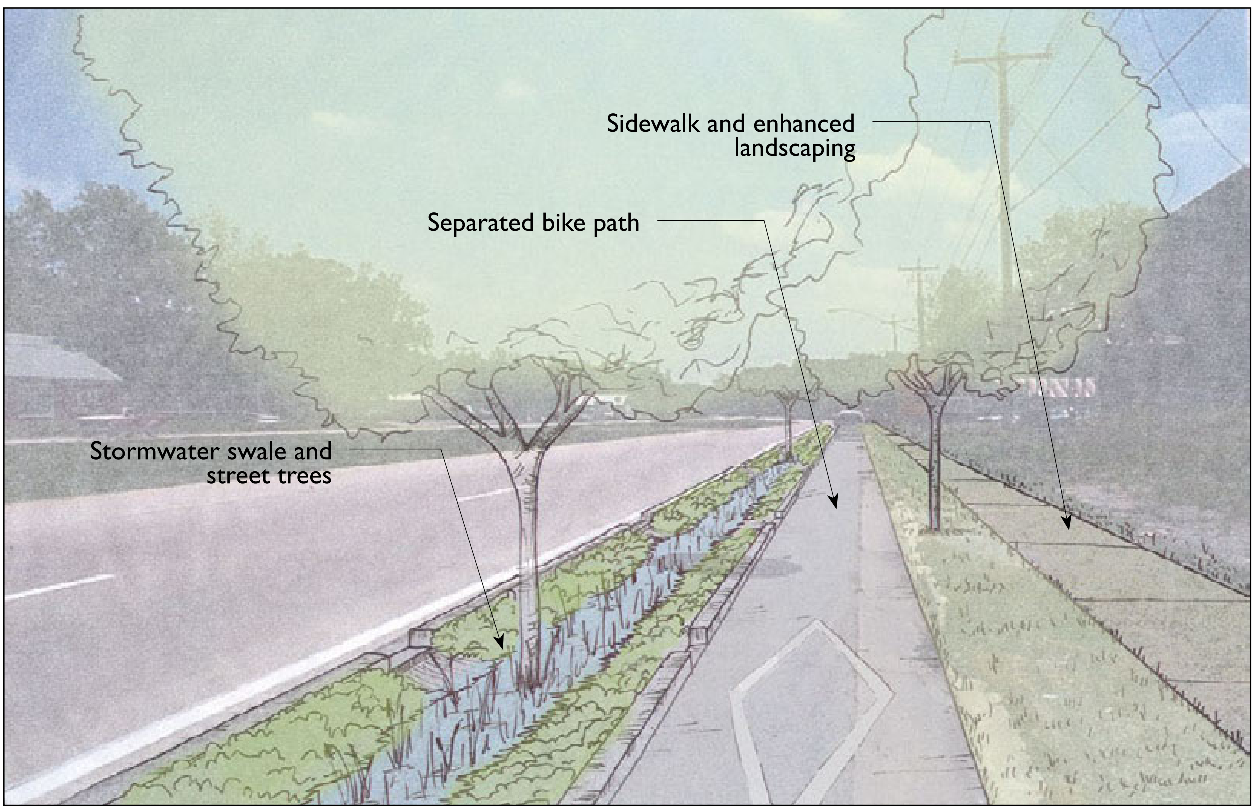

Figure 89. ***Retrofit potential:*** **A new stormwater swale and street trees combined with a separated bike path and sidewalk system.**

Kevin Robert Perry-City of Portland

Figure 90. A stormwater swale retrofit at an elementary school parking lot.

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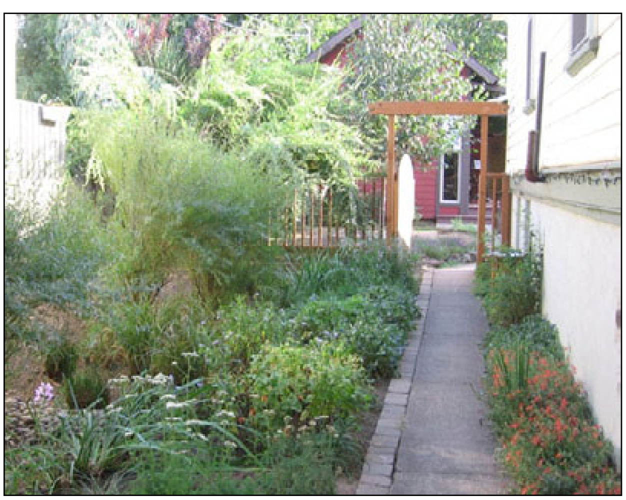
Figure 91. These oversized parking stalls could be made a few feet shorter to make room for swales.



Olena Turula

Figure 92. A stormwater swale retrofit in a residential side yard.

Swales and Parking Lots

In a new parking lot:

Parking lots are a great fit for swales. Long drive aisles lend themselves well to the continuous spaces swales need. There are many creative ways to include swales in parking lots. For example, shorter parking stalls can yield a few extra feet of area, especially when a high number of parking spaces are required by code. Consolidating travel lanes is often another option.

In an existing parking lot:

Often parking lots can be retrofitted without losing any parking spaces. It may not always be obvious how a parking lot might be retrofitted; look for:

- Parking lots with very long stalls;
- Wider than necessary travel lanes; or
- Angled parking with unused space in front of or behind each space.

Swales and Buildings

Near a new building:

Swales can treat stormwater runoff captured from buildings. The most important design considerations are getting water away from the building foundation and lining swales to prevent foundation damage. Usually a minimum of 10 feet of clearance from the building is required. Lining swales with a waterproof material protects building foundations by preventing infiltration and achieves the benefits of plants and soil slowing and filtering stormwater.

Near an existing building:

In more densely developed areas, swales can be a good option for the linear spaces between buildings, provided that foundations and basements are protected. Look for:

- Long, narrow, underused spaces between buildings;
- Spaces between buildings and the public right-of-way; or
- Narrow side yards.

Option for Swales—Parking Lot

A perimeter side swale is one of the most common and effective means of managing stormwater runoff in a parking lot. In many cases, simply employing a better site design and reducing parking lot stall lengths can help yield the 4 to 6 feet of space needed for a stormwater swale.

The top consideration for parking lot design is the grading of the parking lot and how the water flows into the rain gardens. It is best to sheet flow the water across the surface of the lot and get it into swales or planters as soon as possible. When grading a parking lot, remember that it doesn't take much effort to redirect sheet flow of water. Figure 93 shows a small speed bump that helps direct water into a swale.

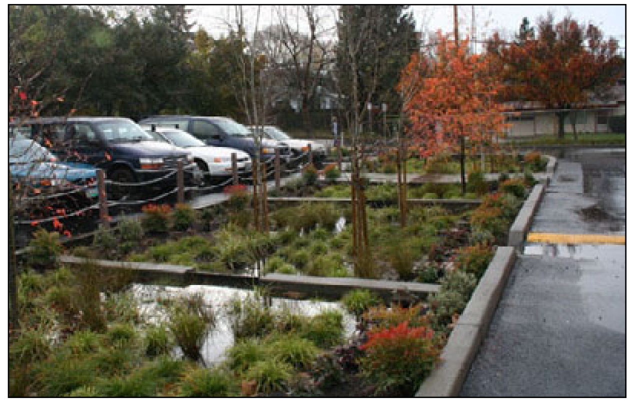


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Figure 93. Parking lot swale with curb cuts and a speed bump used to direct stormwater flow.

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Figure 94. Parking lot swale with sheet flow between parking wheel stops.

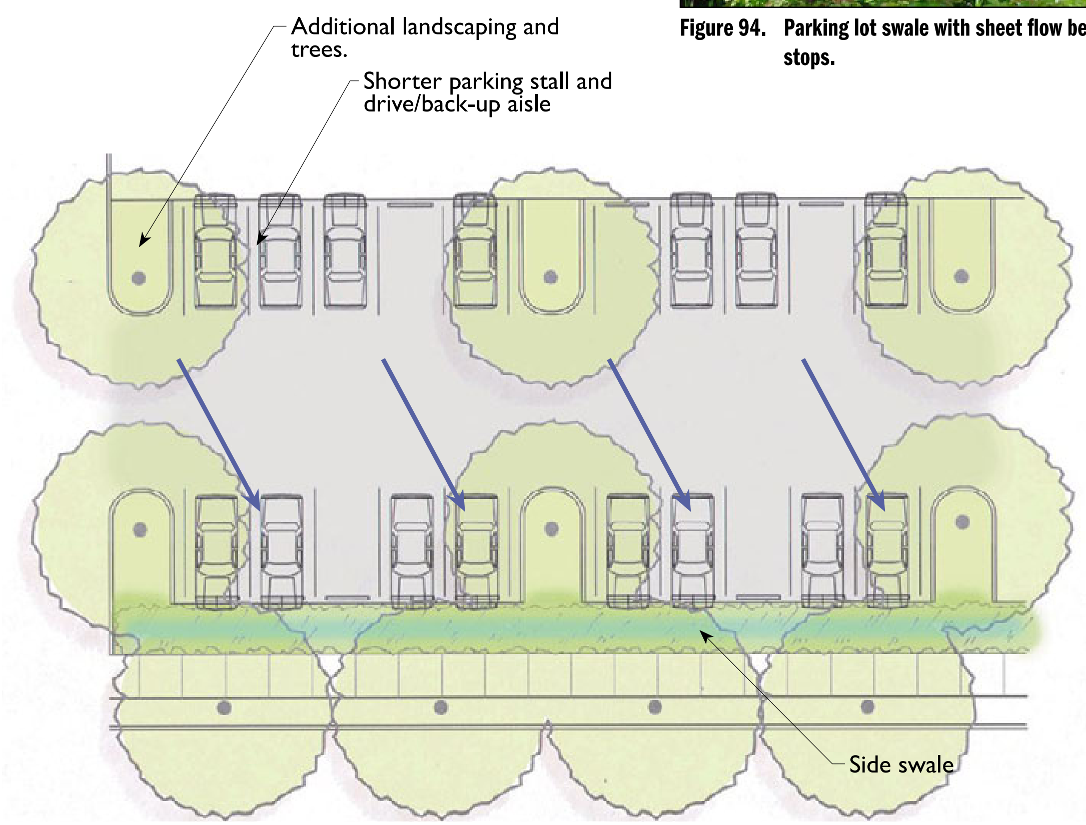


Figure 95. Perimeter side swale in parking lot—plan view.

Figure 96. An existing restaurant and parking lot site in Lewes.

Option for Swales—Parking Lots

This example shows how swales can be combined with other stormwater management techniques such as planters (discussed in Section 5.2.10).

This existing commercial site has oversized parking stalls and travel aisles as well as an adjacent street frontage with no sidewalks or street trees. By making simple design adjustments, this site could be retrofitted with several stormwater amenities. Building runoff could be directed into a series of stormwater planters. A new plaza space could be created for outdoor seating. A large stormwater swale could collect runoff from the parking lot, and a new sidewalk and stormwater curb extension could be added along the street frontage.

While this is a real site in Sussex County, the conceptual illustration below is only a hypothetical situation and showcases the potential for site improvements, not an actual demonstration project.

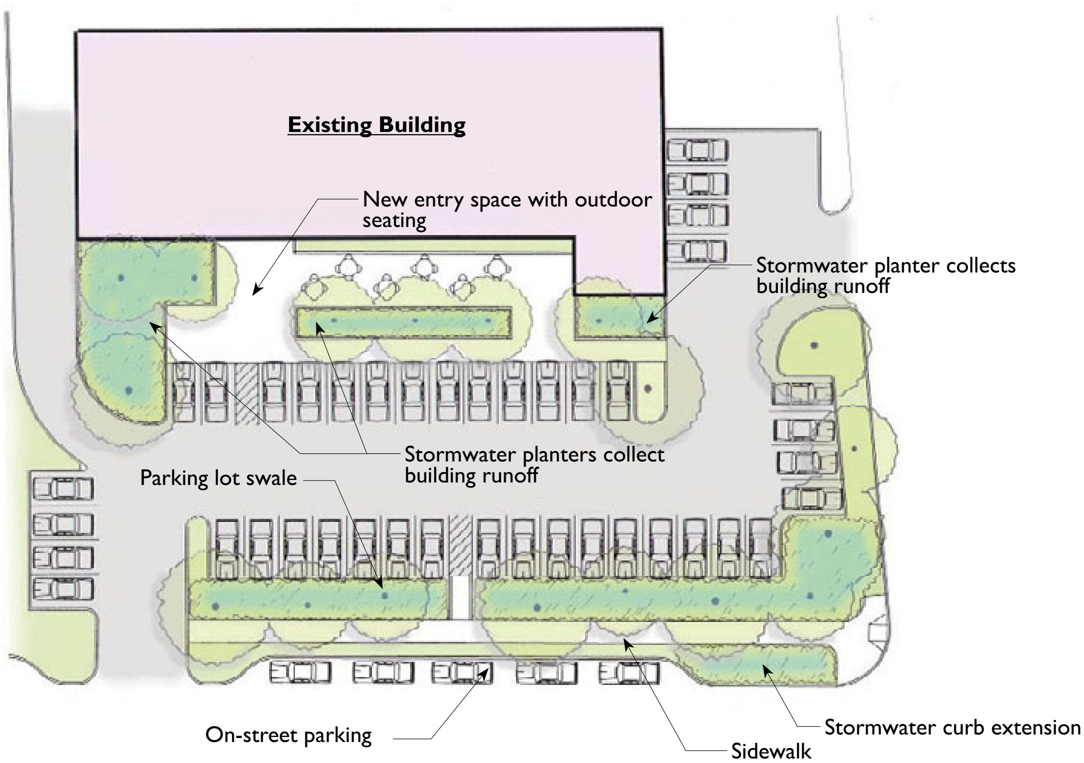


Figure 97. ***Retrofit potential:*** **A more efficient site design allows several stormwater strategies to be employed on this site, such as a parking lot swale, building planters, and a stormwater curb extension.**

Figure 98. **Commercial main street in Portland, Oregon, with stormwater planters.**

5.2.10 Use Planters

Planters can be integrated into commercial areas and parking lots. Particular attention should be paid to balancing on-street parking and planters and retrofitting planters into underused parking lot islands and parking stalls. A before-and-after sketch illustrates how a planter could be integrated into Bank Street in Lewes.

Good places for planters:

In new design:

- Urban areas
- Furnishing zones
- Next to buildings

In retrofits:

- Near condominiums
- Street furnishing zones

Community benefits:

- Buffer between street and sidewalk calms traffic and makes pedestrians feel safer.
- Beautifies urban spaces with trees and plants.

Planters are best used where space is limited or where the cleaner look of a clearly defined rain garden is desirable. Flow-through planters are a viable alternative when infiltration is not possible, such as close to building foundations or in areas of poorly drained soils. Planters can store more water than swales because they are often deeper and have vertical side walls that provide additional capacity compared to side slopes. Water flows into the planter, absorbs into the topsoil, fills to a predetermined overflow elevation, and overflows into the system provided. Infiltration planters infiltrate stormwater, while flow-through planters absorb only as much water as they are designed to hold within their walls. Planters are very versatile and can be connected one after the other to gain lots of stormwater benefit.

Planters can cost more to build than swales because they rely on more hardscape infrastructure, but they are still relatively inexpensive. They are easily incorporated in places where space is limited. They can be built to fit between driveways, utilities, trees, and other existing site elements.

Planters and Streets

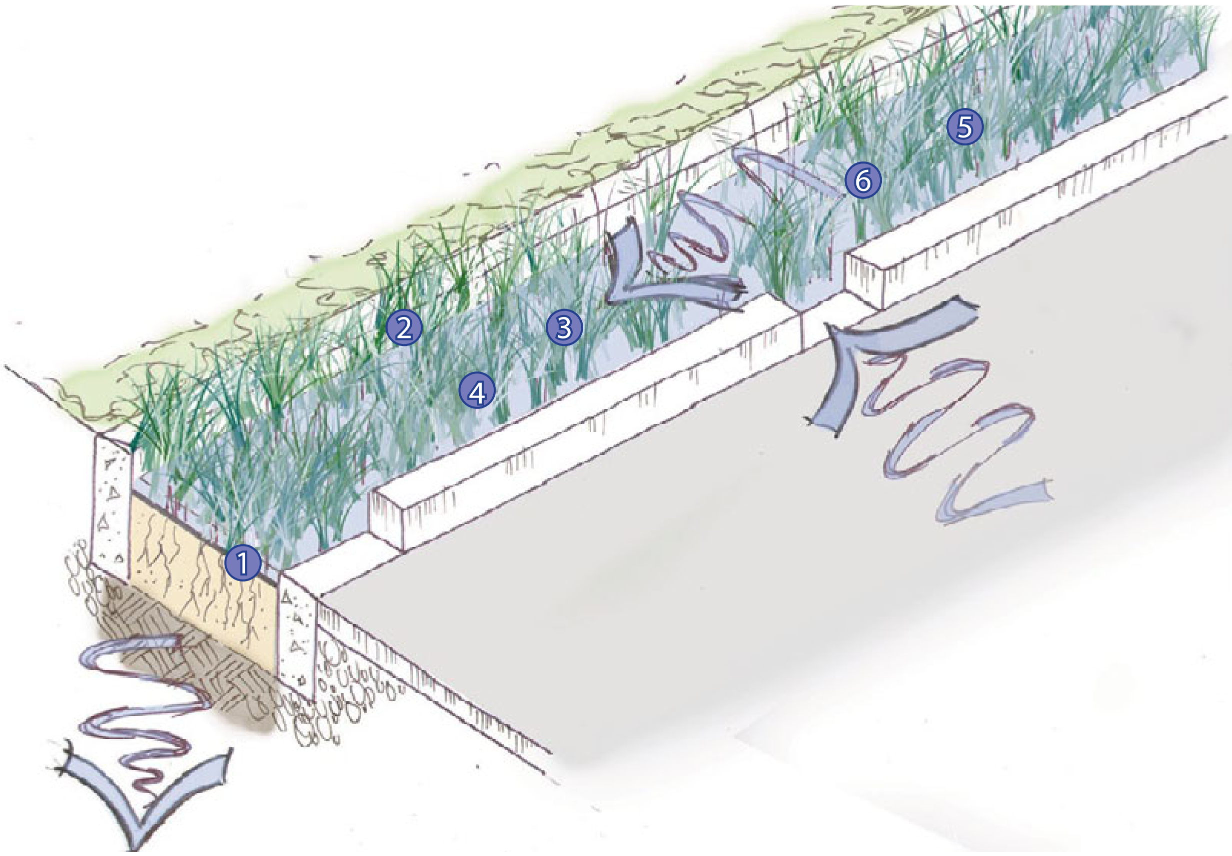
On a new street:

When planters are built along streets, they are usually in an urban setting. Planters take up less space than other rain garden strategies and therefore are a good candidate for tricky urban places where parking, signs, and other street furnishings vie for valuable real estate.

On an existing street:

Planters are commonly used to retrofit urban streets. They are relatively straightforward to retrofit because they can treat a lot of water in a relatively small footprint, and so can be squeezed into places other rain gardens cannot fit. Look for:

- Dense areas where parking is critical; or
- Furnishing zones with extra space and sidewalk areas that are wider than necessary.



1	Depth:	Retains no more than 8” of runoff
2	Side slopes:	None - vertical
3	Bottom:	Flat. Sealed in flow-through planter, open in infiltration planter
4	Plants:	Wet- and drought-tolerant rushes, sedges, shrubs, and trees
5	Longitudinal slope:	Up to 6%. If hillside is sloped more than 6%, several planters can be terraced.
6	Check dams:	At least one check dam for every 6” of vertical drop
	Trees (not shown):	Drought tolerant, wet tolerant

Figure 99. Design and construction characteristics of a planter.

Figure 100. Stormwater planters along a downtown street allow on-street parking to be retained. A strip of pervious pavers allows access to parked cars.

Option for Stormwater Planters With On-Street Parking

This design adds stormwater planters to the furnishing zone while retaining on-street parking. A band of paving, which can be pervious paver, concrete, or another paving material, allows access to cars parked on the street.

This design links a series of flow-through planters or infiltration planters. Water flows into the first one; when it fills up, water can flow back out to the street gutter and into the next planter, and so on. If any stormwater overflows at the end, after the last planter, it flows into the existing storm drain. An advantage of using planters in downtown areas is that they treat a given amount of water in tighter spaces because of their vertical walls. In addition, they add greenery and can make the streetscape more appealing.

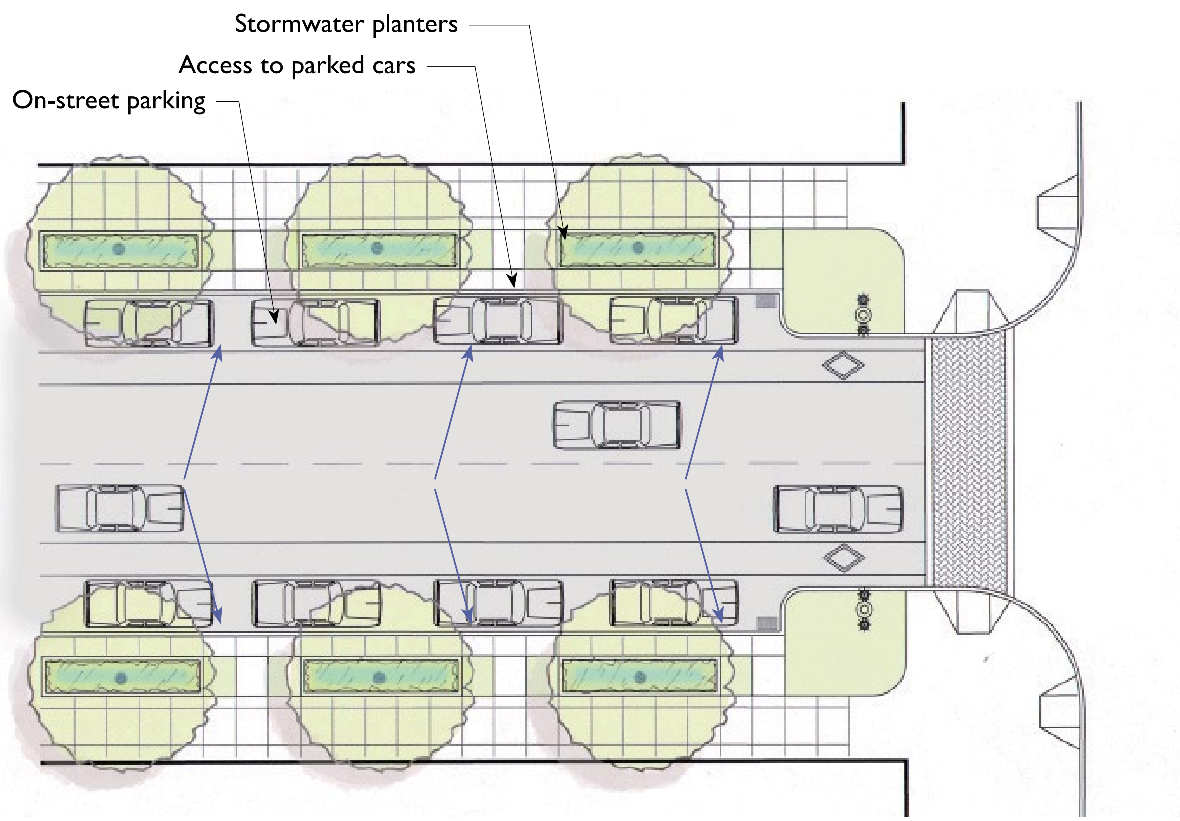


Figure 101. Stormwater planters (parking on both sides)—plan view.

Option for Stormwater Planters and No On-Street Parking

This example shows stormwater planters on a two- or four-lane road without on-street parking. The stormwater planter can be designed to fit in between street furnishings or utility lines. With no on-street parking, stormwater planters can be built right up to the edge of the curb and do not need to accommodate an egress space for pedestrians to get in and out of their vehicles. This allows more design freedom for stormwater management in tight spaces.

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Figure 102. Planters can be retrofitted on urban streets with overly wide sidewalk zones. Dashed lines show where a planter could be added.

Kevin Robert Perry-City of Portland

Figure 103. Stormwater planters accepting runoff from a commercial street.

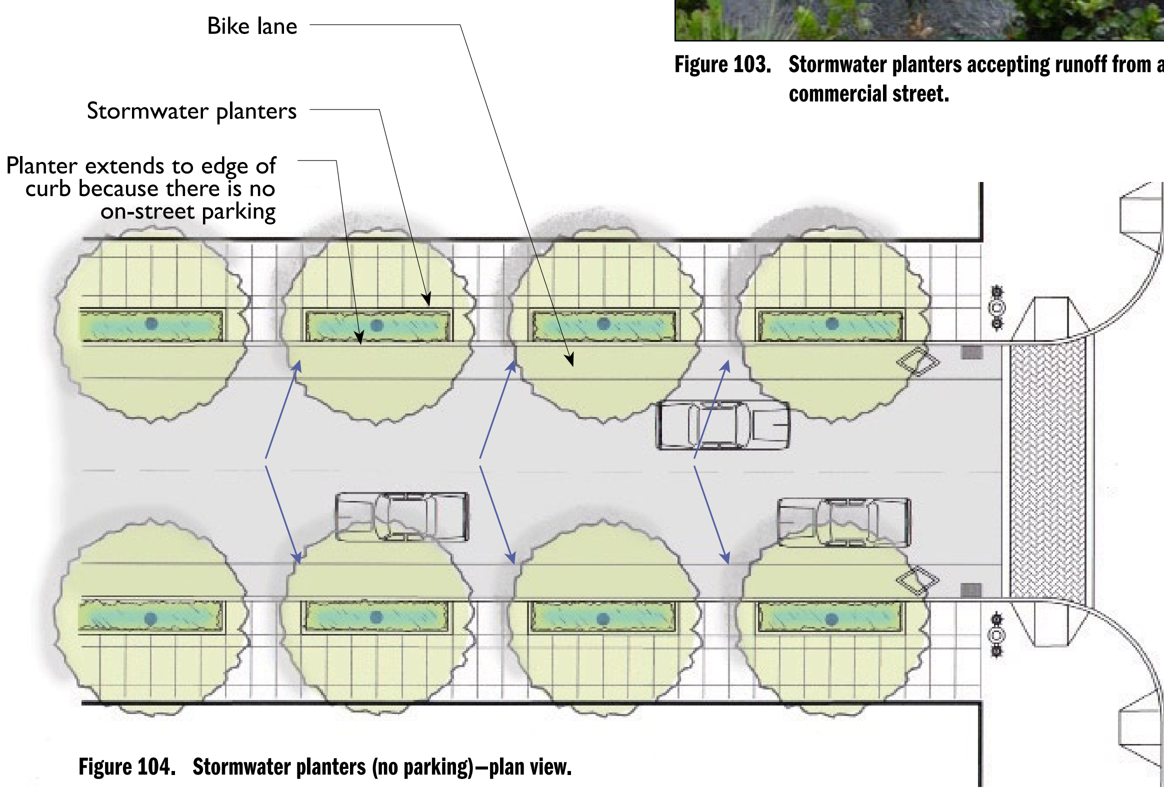


Figure 104. Stormwater planters (no parking)—plan view.

Figure 105. Bank Street in Lewes.

Option for "Green Gutter" Narrow Planter

This example shows how a narrow street could be retrofitted for stormwater management. By narrowing this one-way street by a couple of feet, a narrow and shallow planter, or "green gutter," can be implemented. The parking side of the street could be retrofitted with pervious paving. Water flowing into green gutters is best designed as sheet flow curbless condition; however, Figure 106 shows a standard curb with frequent curb cut openings. Introducing even smaller stormwater facilities can provide water quality benefits.

Figure 106. ***Retrofit potential:*** **A "green gutter" and permeable paving in the parking zone.**

Planters and Parking Lots

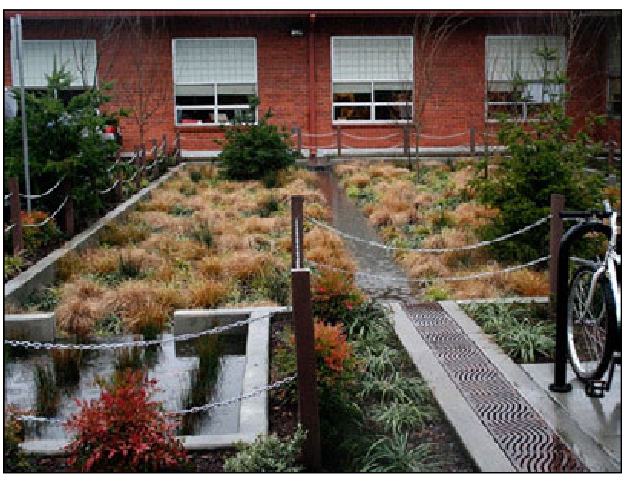
In a new parking lot:

Planters are easy to incorporate into parking lot designs. Parking lot planters can be designed to take the place of one parking spot. Water can be designed to flow into one planter, overflow, and flow across the parking lot surface into the next planter.

In an existing parking lot:

As with swales, parking lots can often be retrofitted to include planters without losing any parking spaces. Planters take up less space than swales and thus may be a better choice in parking lots where less space is available. Look for:

- Parking lots with very long stalls;
- Travel lanes that are wider than necessary; or
- Angled parking with unused space in front of or behind each space.



Kevin Robert Perry-City of Portland

Figure 107. A large stormwater planter at a middle school accepts water from both a parking lot and the building's rooftop.

Planters and Buildings

Next to a new building:

Flow-through and infiltration planters are a great way to capture and treat rainwater off of buildings. They can be designed to fit the architecture of a building. They offer many opportunities for artistic expression through the design of scuppers and interesting gutters.

Next to an existing building:

Flow-through planters are a good way to freshen up an old foundation planting. While they are not as simple to retrofit onto buildings as they are to integrate initially, all it takes is the ability to dig a deep enough hole next to the building to be able to line the planter. Look for:

- Old foundation plantings; or
- Leftover spaces between buildings and parking lots.

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Figure 108. A stormwater planter next to a multi-family residential complex.

Figure 109. This parking lot manages a portion of its stormwater runoff in multiple landscape islands.

Option for Stormwater Planters—Parking Lot Islands

Like streets, parking lots can also use planters to manage stormwater runoff when space is tight. The example below shows how planters can be used in parking lot islands. Converting parking stalls into new landscape islands that can accept stormwater runoff is a relatively inexpensive retrofit. However care can be taken to assure than water can effectively move in and out of the landscape island, and that there is adequate space for people to get in and out of their vehicles without walking on the stormwater facility. A 2-foot clear space at the side of a parking lot island planter will provide better access for pedestrians to safely enter and exit their vehicles.

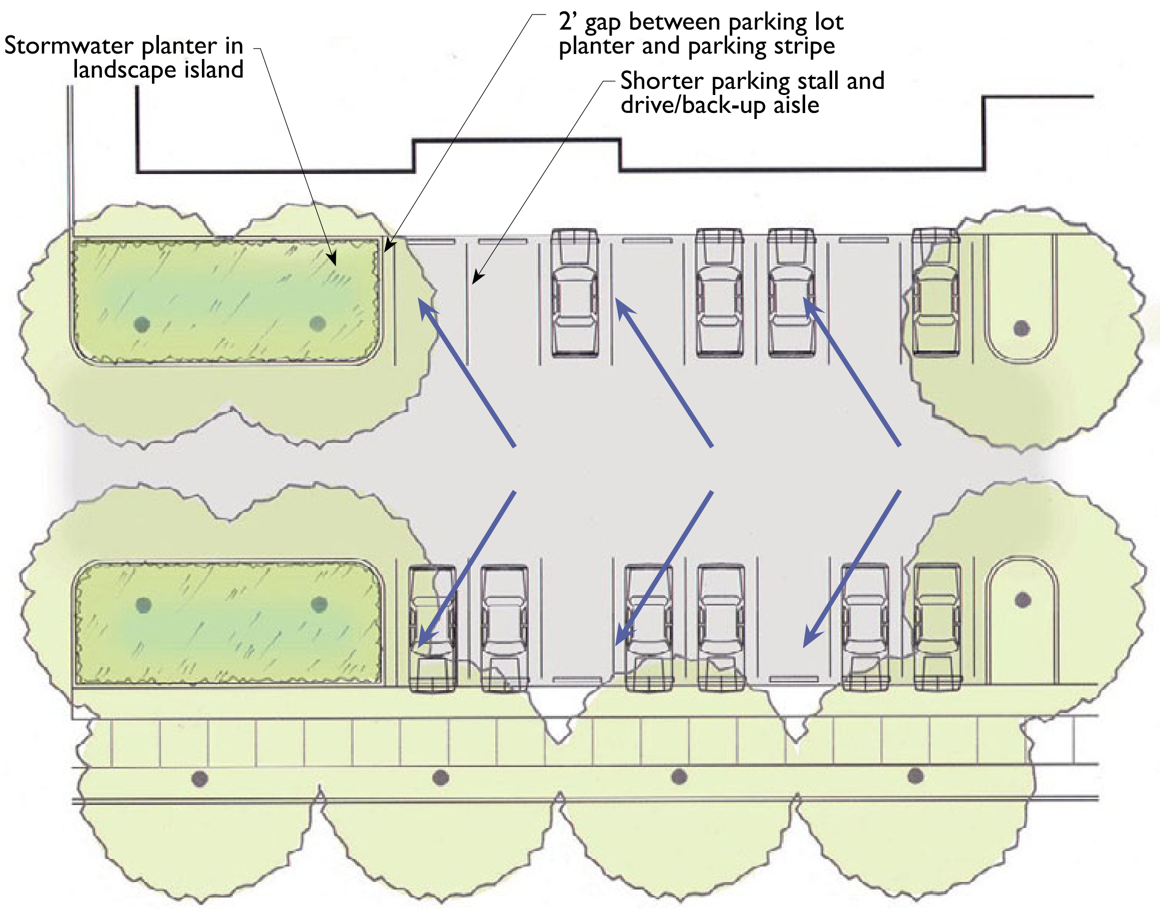

Figure 110. Stormwater planters in parking lot–plan view.

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Figure 111. Long parking stalls can be a good opportunity to reclaim a few feet for a stormwater facility.

Option for Shorter Parking Stalls for a Center Median Swale/Planter

Shortening the length of the stalls can create space to infiltrate stormwater and plant trees. The parking lot is also made safer by creating narrower drive aisles that help minimize reckless driving. Trees help keep the asphalt cooler and reduce the heat island effect.

Figure 112. ***Retrofit potential:*** 18-foot-long parking stalls are converted to 15 feet, which yields enough space for a 6-foot parking lot swale or planter.

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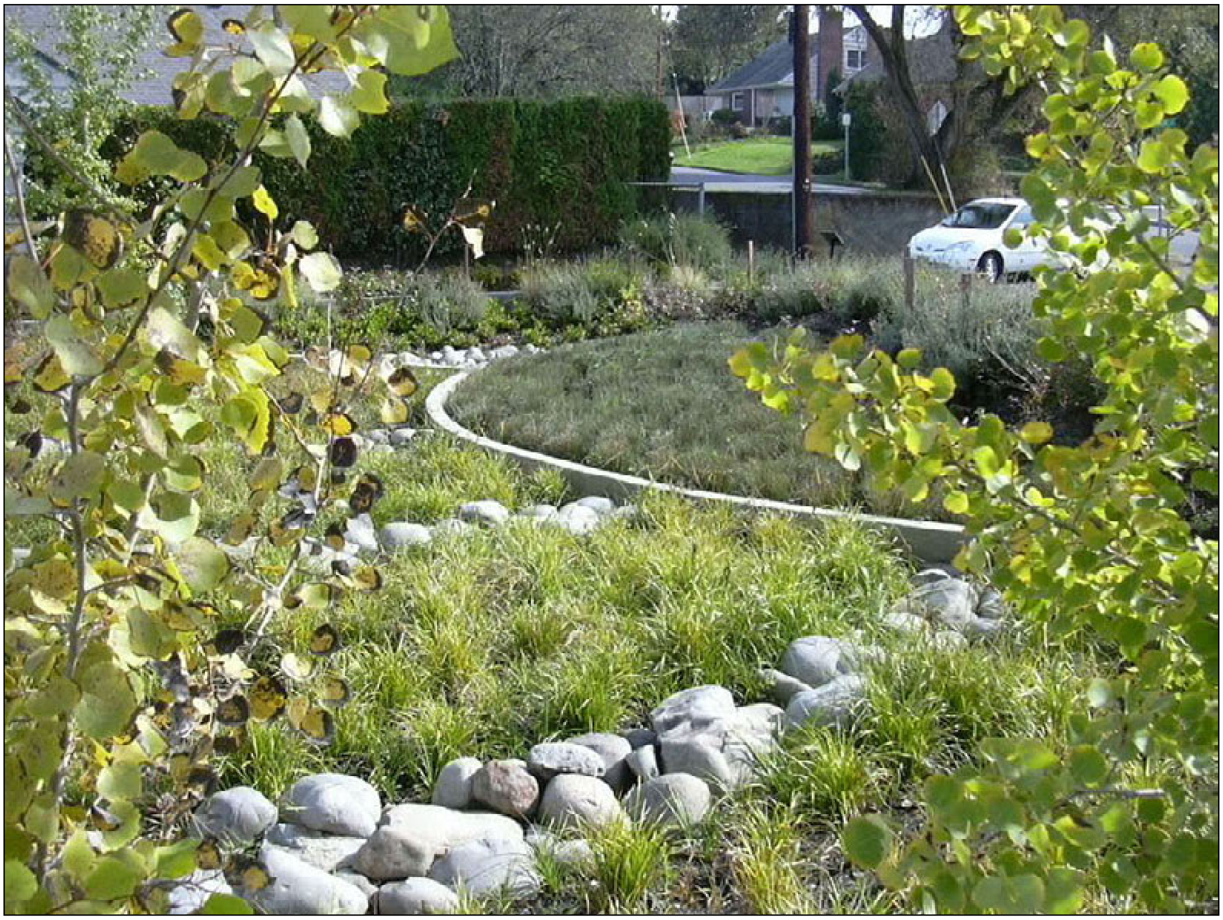
Figure 113. Angled parking creates an unused space between the wheel stop and the edge of the planter strip.

Option for Planters Using Leftover Space in Front of Angled Parking Spaces

Conventional angled parking creates an unused space between the wheel stop and the edge of the planter strip. This space could be converted to a swale (or could have been designed as a swale initially). This retrofit creates space for a stormwater swale without decreasing the number of parking spaces or altering vehicular circulation in the parking lot. Trees can make this a friendlier atmosphere and help to absorb stormwater.

Figure 114. ***Retrofit potential:*** **The space in front of angled parking stalls can easily be combined with other landscaping and converted into a stormwater swale.**



Kevin Robert Perry-City of Portland

Figure 115. Infiltration garden in a residential neighborhood.

5.2.11 Use Infiltration Gardens

Infiltration gardens are shallow, vegetated depressions in the landscape. They can be rectilinear or rounded and are often as wide as they are long.

As the name suggests, infiltration gardens infiltrate stormwater. Because they cover more surface area, they can accommodate a larger volume of water.

Good places for infiltration gardens:

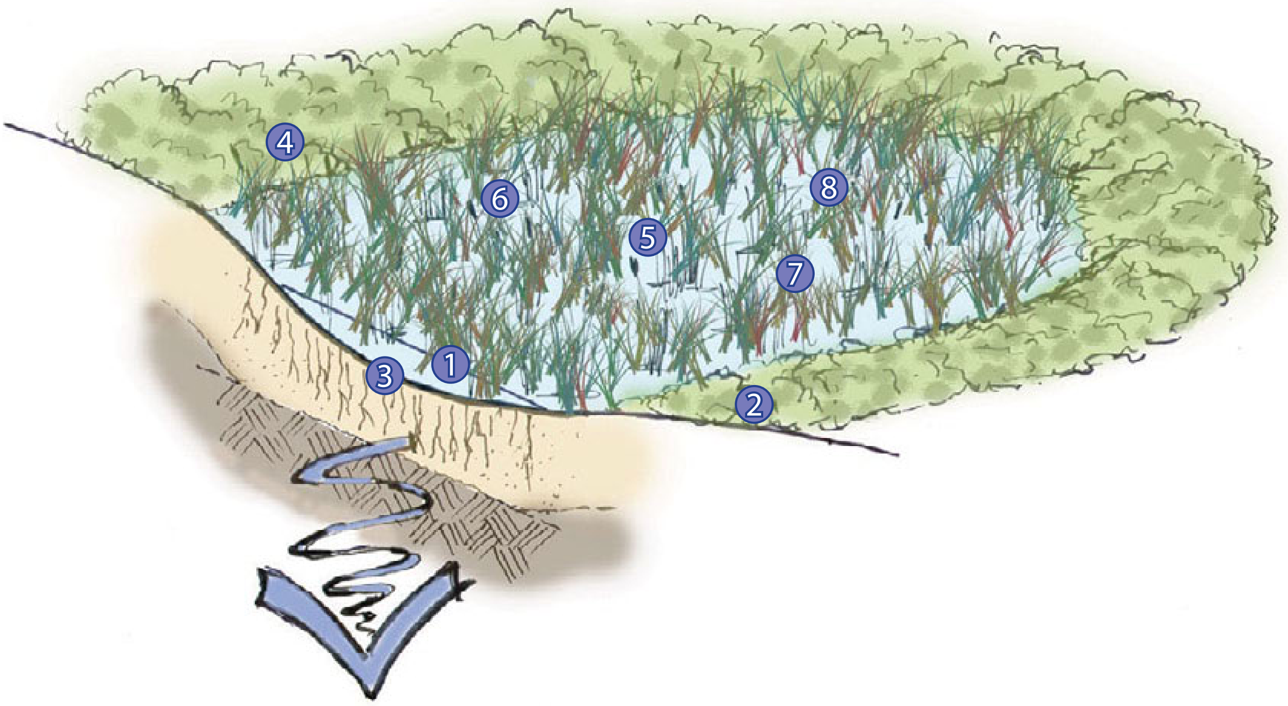
- Parking lots
- Awkward intersections
- Leftover spaces

Community benefits:

- Beautifies and softens parking lots and streets by adding plants, reducing overall impervious surface area.

Infiltration gardens share similarities with swales and planters. However, they are described as a separate strategy based on the spaces in which they fit. Their primary advantage is their versatility. They can be any size or shape and are often molded to fit into "leftover" landscape spaces in parking lots, at intersections with diagonal streets, or in underused areas around buildings.

Construction costs of infiltration gardens vary greatly depending on their size, shape, and use. Generally, because they cover more surface area, they cost more, but they can also hold, filter, and absorb a large volume of stormwater.



1	Depth:	Retains no more than 8" of runoff
2	Side slopes:	Can be vertical or have side slopes
3	Bottom:	Flat, open to native soil
4	Plants - side slopes:	Drought-tolerant ground covers and shrubs, 3' maximum height
5	Plants - bottom:	Wet- and drought-tolerant rushes, sedges, shrubs, and trees
6	Slope:	None - used to pond and infiltrate water
7	Check dams:	Used to promote ponding of water and aid in grading if facility is not in a flat location
8	Trees:	Drought tolerant, wet tolerant

Figure 116. Design and construction characteristics of an infiltration garden.

www.ia.nres.usda.gov

Figure 117. A residential street infiltration garden.

Infiltration Gardens and Streets

On a new street:

In new design, infiltration gardens can be incorporated at street intersections, in the centers of roundabouts, or similar places.

On an existing street:

Infiltration gardens can be retrofitted in a variety of areas. Many downtowns, industrial areas, neighborhoods, and rural areas have large areas of pavement on streets and parking lots that could be converted to infiltration gardens. Look for:

- Unused or inefficiently used pavement; or
- Lawn areas at street intersections.

Infiltration Gardens and Parking Lots

In a new parking lot:

Infiltration gardens can be used in parking lots in conditions where swales and planters cannot handle all the runoff and where they can overflow into a larger infiltration garden. Infiltration gardens are also a good option if there is a focal area that could be beautified and be used as an interpretive area.

In an existing parking lot:

Parking lots sometimes have more spaces than necessary, and those spaces could be used for infiltration gardens. Look for parking lots with:

- Excess spaces;
- Underused areas nearby; or
- Very long stalls or wider than necessary travel lanes that could be redesigned more efficiently to create space for an infiltration garden.

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Figure 118. Large, underused areas of asphalt can easily be converted into infiltration gardens.

Kevin Robert Perry-City of Portland

Figure 119. An infiltration garden at an elementary school.

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Figure 120. Unused landscape space is a prime retrofit opportunity.

Infiltration Gardens and Buildings

Near a new building:

New development is a great opportunity for integrated design of buildings and infiltration gardens. Imagination is the limit to the ways in which infiltration gardens can complement building architecture and use of indoor-outdoor space. Many opportunities exist for integrating infiltration gardens with rain-absorbing footprint strategies such as rainwater harvesting.

Near an existing building:

Infiltration gardens can be designed as an amenity to existing buildings by redesigning surrounding landscapes or by reclaiming unused paved areas near buildings. Look for:

- Unused space in industrial areas;
- Schools, churches, and other public buildings with excess space;
- Spaces between buildings;
- Courtyards; or
- Garden areas that can be redesigned to accommodate stormwater.

City of Portland-Environmental Services

Figure 121. An infiltration garden treats roof runoff from a commercial building.

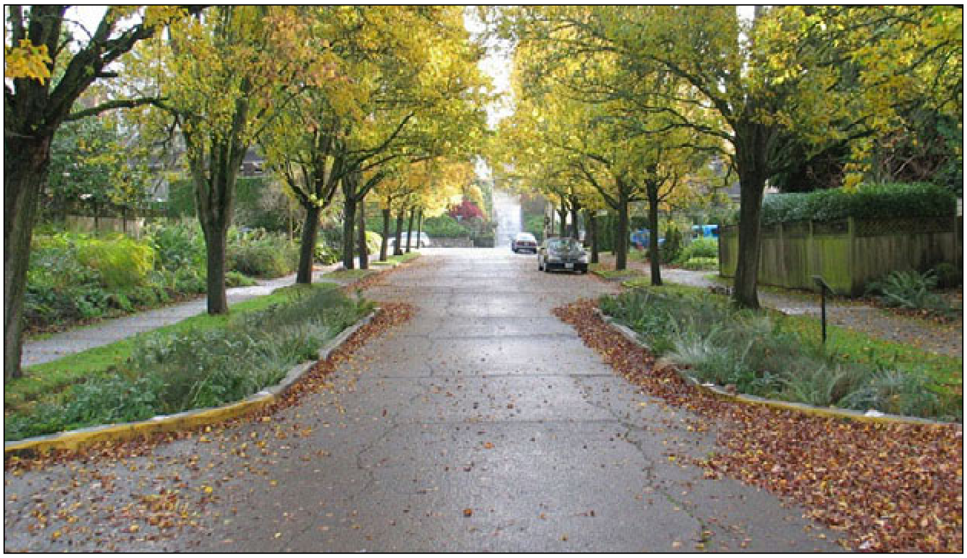


Figure 122. This stormwater curb extension project in Portland, Oregon, provides stormwater management and traffic calming benefits.

5.2.12 Use Curb Extensions

Curb extensions extend the street edge into the street. Within their boundaries, they share the characteristics of swales, planters, or infiltration gardens, depending on the site. Curb extensions intercept water running along a curb and gutter before it reaches the catch basin. This section discusses the application of curb extensions to residential and commercial streets and the retrofitting of existing curb extensions with stormwater management features. Before-and-after sketches illustrate potential curb extensions in Paynter's Mill and along a historic main street in Milton.

Good places for curb extensions:

- Any streets that can afford some on-street parking loss
- Awkward street intersections
- Streets needing traffic calming

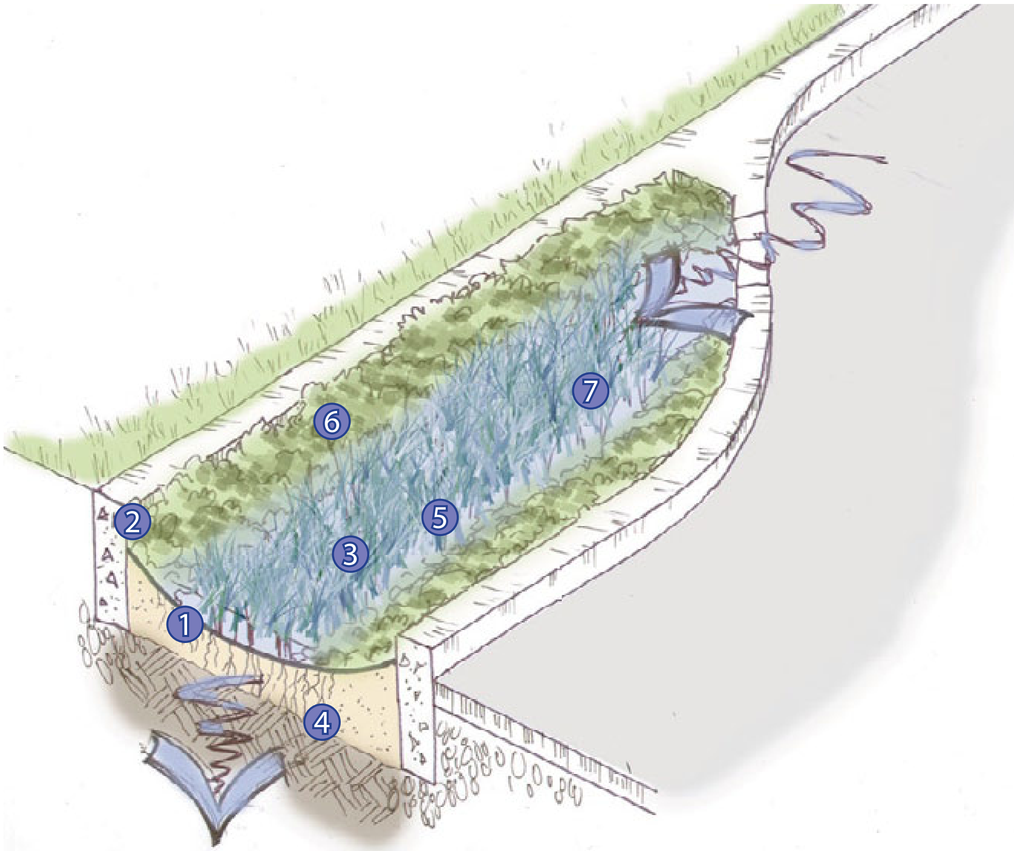
Community benefits:

- Beautifies streets with trees and vegetation.
- Creates shorter street crossing distances for pedestrians.
- Calms traffic.
- Creates a distinctive community identity.

Like infiltration gardens, stormwater curb extensions are discussed independent of swales and planters because of their unique street application. Conventional curb extensions, also known as bulb-outs, chokers, or chicanes, have been used for decades to protect pedestrians and help calm traffic. Communities can add a stormwater benefit by allowing water to flow into a curb extension.

Plants slow and filter rainwater flowing through curb extensions so that it moves more slowly than it would in a traditional storm sewer pipe system. Water flowing through curb extensions has a chance to soak into the ground before excess water flows back out to the curb and into a catch basin.

Using curb extensions is particularly advantageous in retrofits because they can often be added to existing streets with minimal disturbance. The relatively small footprint of stormwater curb extensions allows for an efficient stormwater management system, and hence they often perform well at a relatively low implementation cost.



1	Depth:	Retains no more than 6" of runoff
2	Side slopes:	Can have vertical walls or side slopes, depending on street context
3	Bottom:	3' wide minimum, rounded or flat. Can be sealed, as in flow-through planter, or open as shown.
4	Plants - side slopes:	Drought-tolerant ground covers and shrubs, 3' maximum height
5	Plants - bottom:	Wet- and drought-tolerant rushes, sedges, shrubs, and trees
6	Longitudinal slope:	6% maximum
7	Check dams:	At least one check dam for every 6" of vertical drop
	Trees (not shown):	Drought tolerant, wet tolerant

Figure 123. Design and construction of a curb extension.

Curb Extensions and Streets

Curb extension shapes and sizes:

Stormwater curb extensions are commonly added to residential streets because they are simple, easy to retrofit, inexpensive to construct, and can be built in many different shapes and sizes. Figures 124 and 125 show simple curb extensions that take up one or two parallel parking spaces.

On a new street:

In new design, curb extensions can be incorporated at street intersections or at mid block. Making curb extensions as long as possible will maximize stormwater management.

On an existing street:

Curb extensions are useful in retrofitting existing streets. They are placed wherever there is available space and the existing drainage works well. To find places to retrofit curb extensions in residential areas and commercial town centers, look for:

- Wide streets where parallel parking zones are underused;
- Intersections with diagonal streets;
- Wide, unused paved areas;
- Traffic circles; or
- Planted landscapes that can be converted to rain gardens.

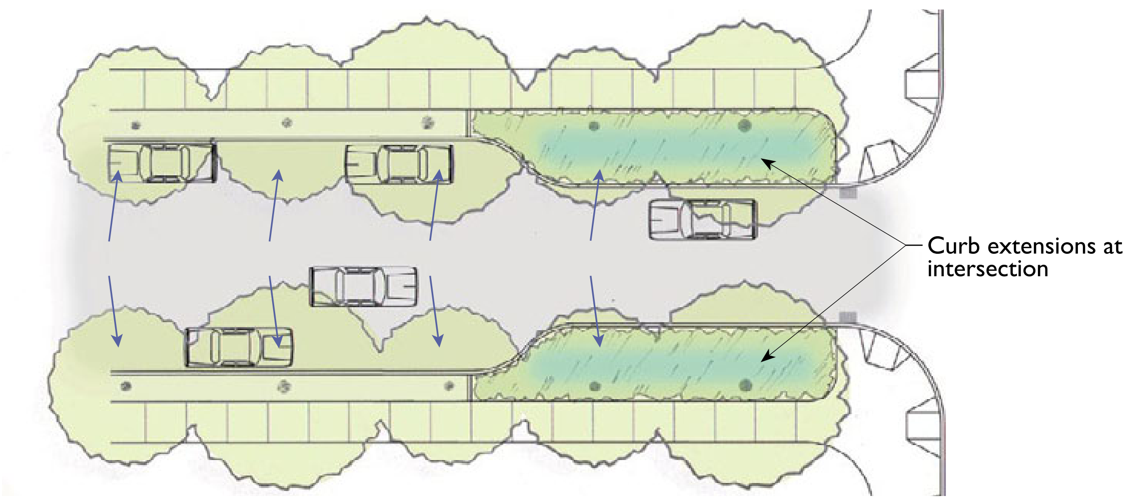


Figure 124. End-block curb extension—plan view.

Figure 125. Mid-block curb extension (staggered layout)—plan view.


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Figure 126. Curb extensions in Paynter's Mill.

Option for Curb Extensions at Intersections

In Paynter's Mill, intersections have curb extensions that calm traffic and increase landscape area. Including planters or swales in these curb extensions could improve the quality and quantity of stormwater discharging from the area.

Figure 127. ***Retrofit potential:*** **Planters or swales in these curb extensions could significantly improve stormwater quality and quantity.**

Figure 128. Typical small-town main street in Milton.

Option for Mid-Block Curb Extensions

The curb extensions shown for residential streets can be adapted to commercial streets. These curb extensions have planters in them and are about the size of one parking space, much shorter than the curb extensions shown in the residential examples. They can be implemented mid-block, at the ends of a block, and in a series. Symmetrical placement of mid-block curb extensions helps calm traffic by narrowing the street at specific points.

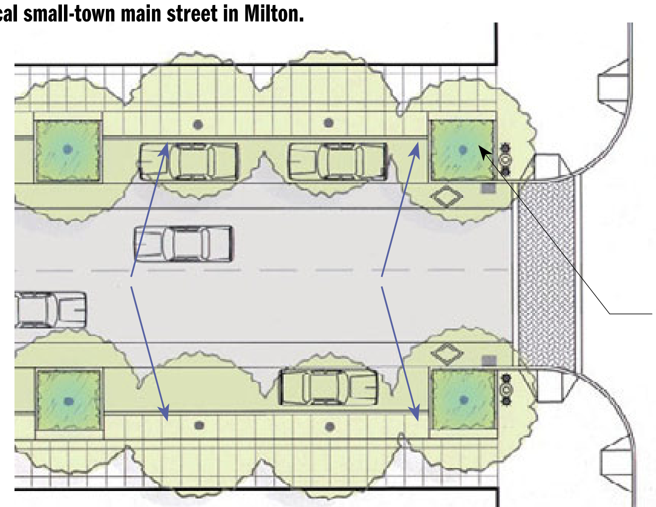

Figure 129. Mid-block curb extensions—plan view.

Figure 130. *Retrofit potential:* Commercial main street with mid-block stormwater curb extensions.


EPA

Figure 131. Conventional curb extensions in Lewes.


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Figure 132. A commercial street with curb extensions and a landscaped median in Eugene, Oregon.

Option for Curb Extensions and a Median Swale

This example shows how stormwater can be managed in a swale in the landscaped median of the street. This option is more viable in new construction or if the entire street is being rebuilt. The primary advantage of having a median swale is that the stormwater is directed into facilities in the center of the street, allowing more room for parking, pedestrians, and utilities on the sides of the street. The disadvantage is that many streets don't have enough right-of-way for this scenario. Also, the median swale, in using a reversed-crown profile, will need to be large enough to manage the runoff for the entire street instead of only half of the street. To help better allocate the management of stormwater, a combination of a median swale and curb extensions can be used in a double-crowned street profile, as illustrated below in Figure 133.

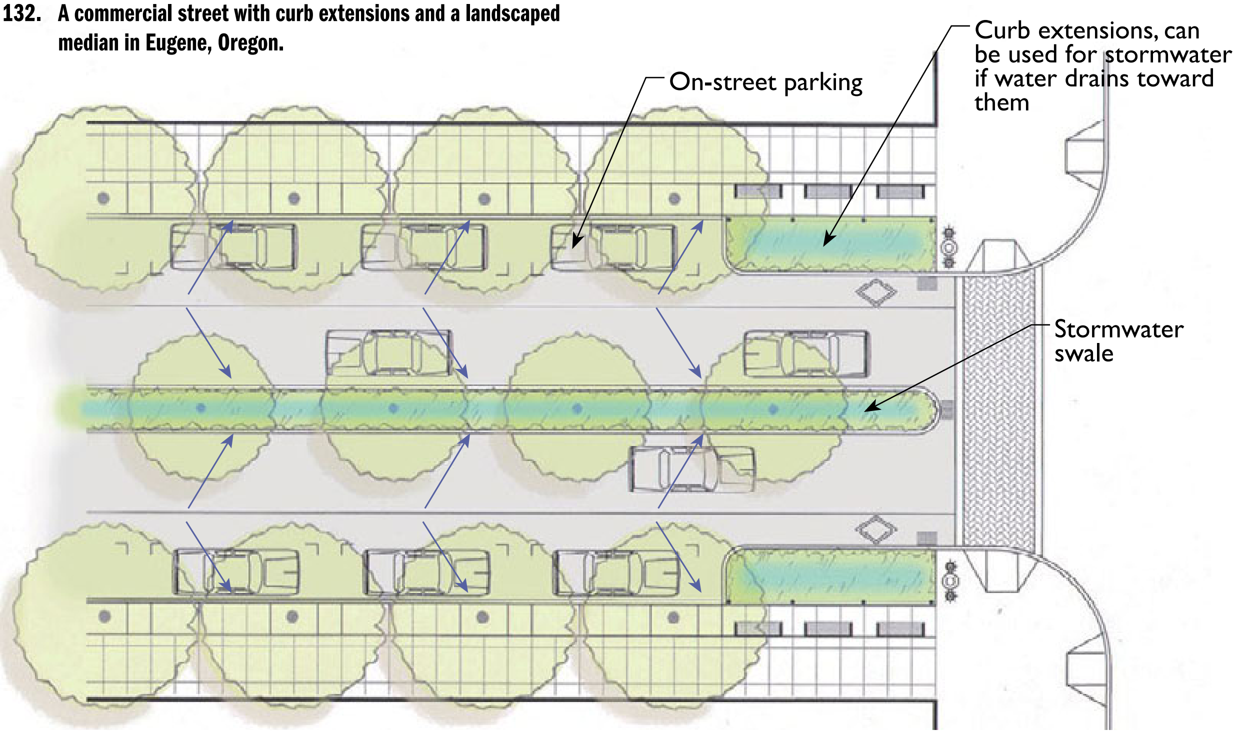

Figure 133. Stormwater curb extensions with a median swale—plan view

Option for Curb Extensions at Intersection and Pervious Paving in Parallel-Parking Zone

This example shows end-block curb extensions combined with pervious paving in the parking zone of the street. Stormwater curb extensions in commercial streets help "green" the streetscape and provide a distinctive identity. However, losing on-street parking to accommodate the stormwater facility can be a concern. To help minimize the parking loss, pervious paving can be used to manage a portion of the runoff. In the scenario shown in Figure 134, pervious paving is used to initially manage runoff, and stormwater curb extensions capture overflow. Because of this combined effort, the curb extensions can be smaller than if there were no pervious paving.

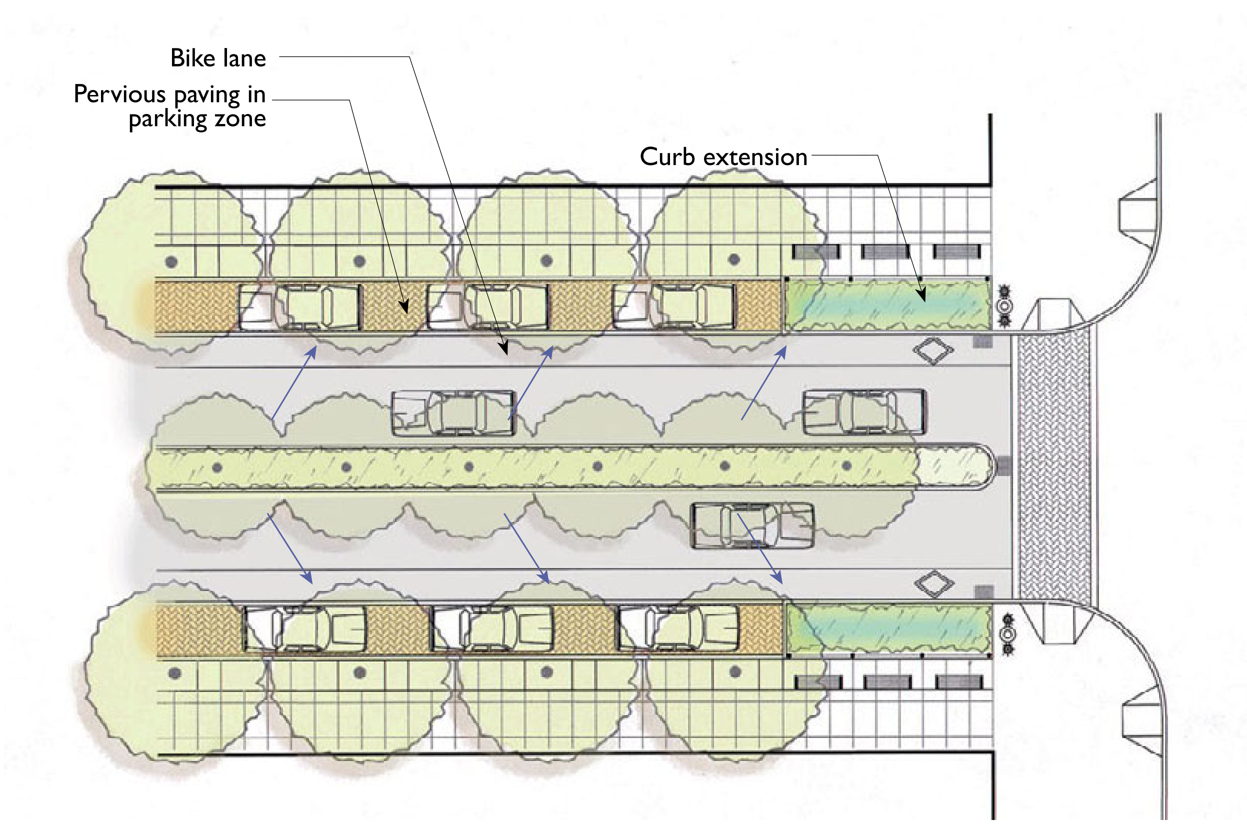

Figure 134. Stormwater curb extensions with pervious paving in parking zone—plan view.

Option for Using Curb Extensions With Angled Parking

Some commercial streets in Sussex County use angled on-street parking. One green street design scenario consolidates one or more parking spaces into large curb extension areas. This can be a relatively simple retrofit application if a few parking spaces can be lost. Using curb extensions in angled parking spaces can add more landscaping to the street, which in turn can make storefronts more attractive.

Tim Kiser- www.wikimedia.org

Figure 135. Angled parking along Second Street in Lewes.

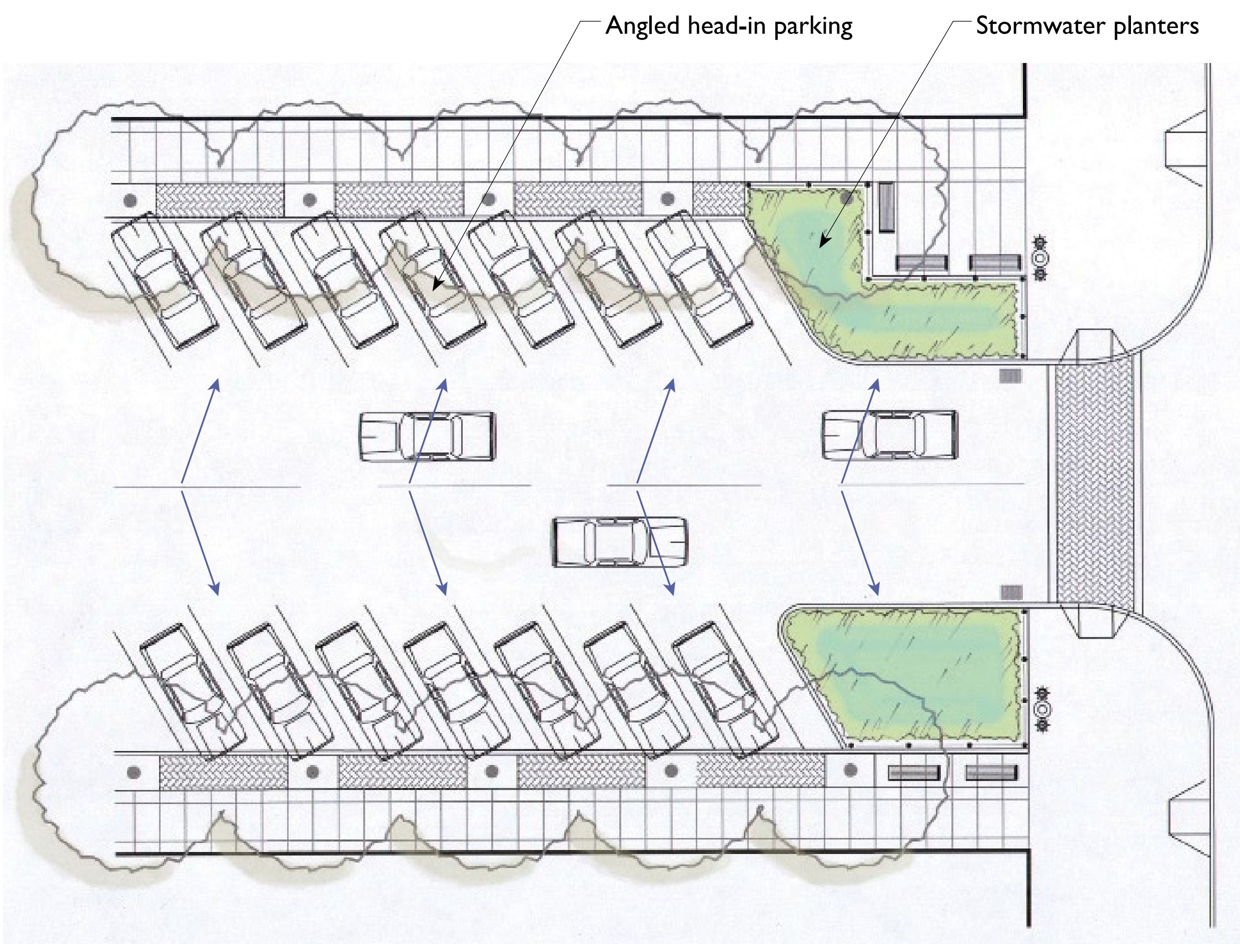

Figure 136. Stormwater curb extensions with angled parking—plan view.

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Figure 137. A disconnected residential downspout.

5.2.13 Disconnect Residential Downspouts

Most gutters and downspouts are connected to the public storm sewer or a combined sewer system. Downspouts can be disconnected from the sewer systems and redirected onto lawn areas, into rain gardens, or a rainwater harvesting system such as described in Section 5.2.7. Directing runoff onto lawn areas slows and filters rainwater and lets it absorb into soils locally instead of sending it in a pipe to stormwater treatment downstream.

Good places for downspout disconnection:

- Single-family homes
- Small multifamily buildings
- Small office buildings

Community benefits:

- Educates homeowners about watershed system.
- Is a simple action that almost any home or property owner can take to contribute to comprehensive stormwater management strategies in a community.