Stormwater Management Handbook

Implementing Green Infrastructure in Northern Kentucky Communities

Appendices

Appendix A: EPA Smart Growth Implementation Assistance

Communities around the country are looking to get the most from new development and to maximize their investments. Many places that have been successful in ensuring that development improves their community, economy, and environment have used smart growth principles to do so (see box). Smart growth describes development patterns that create attractive, distinctive, and walkable communities that give people of varying age, wealth, and physical ability a range of safe, convenient choices in where they live and how they get around. Growing smart also means that we use our existing resources efficiently and preserve the lands, buildings, and environmental features that shape our neighborhoods, towns, and cities.

However, communities often need additional tools, resources, or information to achieve these goals. In response to this need, the Environmental Protection Agency's Development, Community, and Environment Division launched the Smart Growth Implementation Assistance (SGIA) program to provide technical assistance—through contractor services—to selected communities.
The goals of this assistance are to improve the overall climate for infill, brownfields redevelopment, and the revitalization of non-brownfield sites—as well as to promote development that meets economic, community, public health, and environmental goals. EPA, with its contractor ICF Consulting, assembles teams whose members have expertise that meets community needs. While engaging community participants on their aspirations for development, the team can bring their experiences from working in other parts of the country to provide best practices for the community to consider.

SD1 requested assistance through EPA's SGIA program because SD1 was interested in developing stormwater management strategies that will allow Northern Kentucky to continue to grow, develop, and prosper. As part of the technical assistance, a team of EPA staff and consultants visited Northern Kentucky for a four-day on-site visioning and urban design workshop held from Monday, March 31 to Thursday, April 3, 2008. The objectives of the workshop were:

- to learn more about existing physical, social, and institutional conditions in Northern Kentucky;
- to listen to the community's concerns, interests, and wishes; and
- to begin to develop a set of green stormwater management strategies that could be applied throughout SD1's service area.

At the core of the workshop were public outreach and fact-finding meetings with elected officials, developers, staff and commissioners of local planning agencies, and public-interest advocates and other interested members of the public. Beyond the concerns for water quality, what the team heard repeatedly during meetings with stakeholder and residents was the desire for livable, attractive, and economically vital communities.

SMART GROWTH PRINCIPLES

Based on the experience of communities around the nation, the Smart Growth Network developed a set of ten basic principles:

- Mix land uses.
- Take advantage of compact building design.
- Create a range of housing opportunities and choices.
- Create walkable neighborhoods.
- Foster distinctive, attractive communities with a strong sense of place.
- Preserve open space, farmland, natural beauty, and critical environmental areas.
- Strengthen and direct development towards existing communities.
- Provide a variety of transportation choices.
- Make development decisions predictable, fair, and cost effective.
- Encourage community and stakeholder collaboration in development decisions.

SOURCE: WWW.SMARTGROWTH.ORG/ABOUT/PRINCIPLES/DEFAULT.

Appendix B: Stormwater Strategy Matrix

CHOOSING STORMWATER FACILITIES THAT BEST FIT FOR DIFFERENT CONDITIONS

Strategy	SPACE REQUIRED	STRATEGY TYPES		PRIMARY STORMWATER GOAL	APPLICABILITY FOR STEEP SLOPES	PRIMARY APPLICATION
Green Roofs	1:1 relationship	Rain-absorbing footprint	Medium-high	Water quality/ flow	N/A	Building
Pervious Paving	1:1 relationship	Rain-absorbing footprint	Medium-high	Water quality/ flow/ volume	Low	Street/ parking lot
Rainwater Harvesting	1:1 relationship	Rain-absorbing footprint	Low-high	Water quality/ volume	N/A	Building
Swales	6’ minimum width	Rain garden	Low	Water quality/ flow	Low-medium	Street/ parking lot/ building
Planters	2’ minimum width	Rain garden	Low-medium	Water quality/ flow/ volume	High	Street/ parking lot/ building
Infiltration Gardens	10’ minimum width	Rain garden	Low-medium	Water quality/ flow/ volume	Low	Street/ parking lot/ building
Stormwater Curb Extensions	4’ minimum width	Rain garden	Low-medium	Water quality/ flow/ volume	Medium-high	Street/ parking lot/ building
Downspout Disconnection	N/A	Rain garden	Low	Flow/ volume	Medium	Building

Appendix C: Street Profile

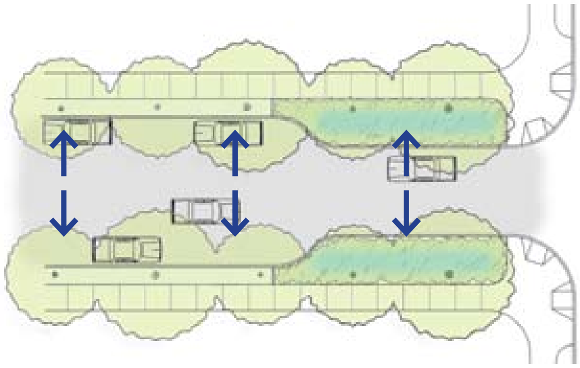


Figure C-1: **Crowned Street**

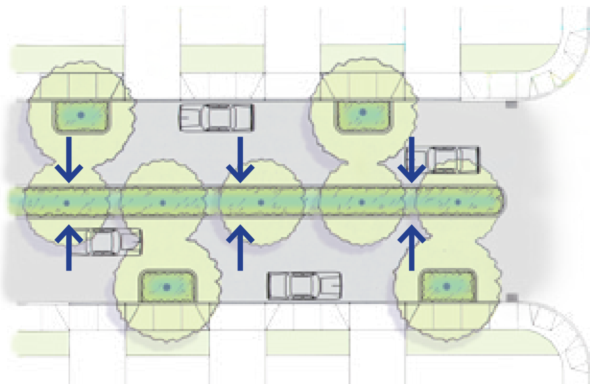


Figure C-2: **Reverse Crowned Street**

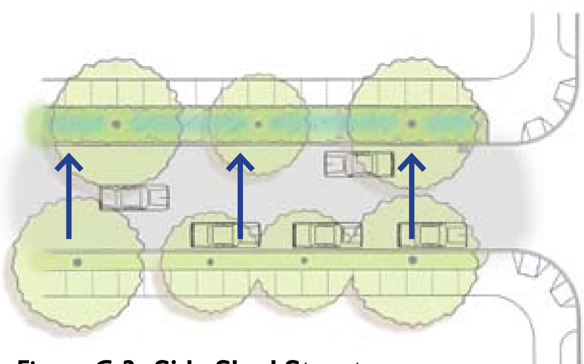


Figure C-3: **Side Shed Street**

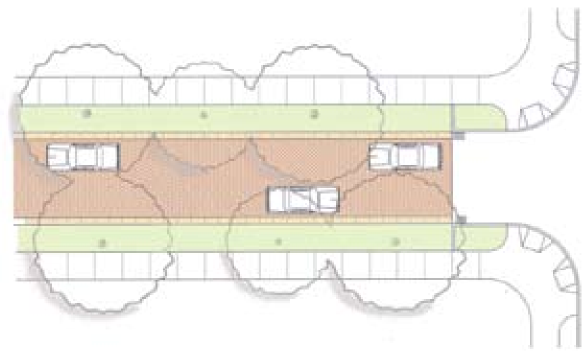
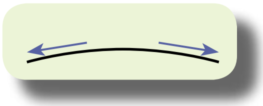


Figure C-4: **Flat Street**

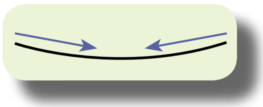
The street profile determines how stormwater runoff flows off of a street. Streets can be crowned or reverse crowned, drain to one side, or be flat.

Crowned



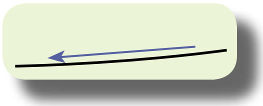
The most common street profile is a crowned street with stormwater draining to the sides of a street, often with a curb and gutter system directing flow into a drain inlet. These drain inlets are located at the middle or end of each block depending on the block length. A variation of the crowned street is a "double crowned street." This type of street is two crowned profiles next to each other with a median in the middle. This type of street profile is common with arterial streets and boulevards.

Reverse crowned



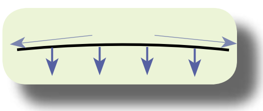
A reverse crowned street, just the opposite of a crowned street, directs runoff to the center line of the street. This type of street is common with alley ways, arterial streets, and even freeways.

Side Shed



Streets can be also be designed to shed all the water to one side of the street.

Flat



A flat street has little or no cross drainage and typically used in the context of pervious paving. With pervious paving, the primary drainage of water is directly through the paving surface into the subsoil. Typically these streets are slightly graded so they drain to the sides or center if there is too much water to filter through the paving.

Appendix C: Street Profile

New Construction:

When building new streets, deciding the street profile for a particular street is one of the first steps in determining what kind of stormwater solution should be used. A green street's design should maximize the amount of stormwater runoff that enters a stormwater facility, keeping in mind the physical capability for the landscape to effectively manage the runoff. For new construction, there is far more flexibility in street design because the street profile can be designed in a variety of ways. Retrofit projects sometimes offer little flexibility.

Retrofit Conditions:

When retrofitting existing streets, one of the first details to look for is how stormwater drains from the street. It can often be prohibitively expensive to rebuild the street profile and underground infrastructure. Hence, conforming to the existing street profile, and identifying stormwater solutions that work with this drainage condition, is the simplest and most cost-effective approach to retrofitting a street. Using this approach not only saves money, but it also minimizes the amount of street reconstruction.

Figure C-7 illustrates a crowned street with a center median at the high point of the crown. It looks like a great opportunity to retrofit this landscape median for stormwater management. However, the existing profile of the street drains water *away* from the median to the outside curb of the street. Regrading the street would turn a simple retrofit into an expensive project. In this case, a better option would be to build rain gardens between the street and sidewalk or use stormwater curb extensions.


SOURCE: NEVUE NGAN ASSOCIATES

Figure C-5: *This new green street is designed as a reverse crowned street, allowing runoff to flow into a center median vegetated swale.*


SOURCE: NEVUE NGAN ASSOCIATES

Figure C-6: *This green street retrofit is designed with a narrow curb extension that captures runoff from an existing crowned street.*


SOURCE: NEVUE NGAN ASSOCIATES

Figure C-7: *This crowned street has a landscaped center median. Unfortunately, stormwater runoff is directed away from it.*

Appendix D: Pedestrian Circulation

SOURCE: KEVIN PERRY- CITY OF PORTLAND

Figure D-1: *This street that uses stormwater planters adjacent to on-street parking and provides a 3-foot walkway that allows people to access the sidewalk and parking zone.*

SOURCE: NEVUE NGAN ASSOCIATES

Figure D-2: *A series of "stormwater bridges" allows people to cross over a vegetated swale.*

SOURCE: NEVUE NGAN ASSOCIATES

Figure D-3: *A perimeter concrete curb was installed around this urban rain garden to help protect both pedestrians and the stormwater facility.*

SOURCE: NEVUE NGAN ASSOCIATES

Figure D-4: *Low-profile railing systems can be an aesthetically pleasing way to direct pedestrian traffic.*

Street Applications:

Providing adequate pedestrian circulation along streets should always be a priority and should not be compromised when considering stormwater facilities. Many green streets can help offer solutions for better pedestrian circulation by providing more buffer against vehicular traffic, reducing pedestrian crossing distances, or improving sight angles at intersections. Most conflicts between pedestrian circulation and stormwater facilities stem from the need to provide on-street parking. These potential conflicts can be remedied with proper design.

When on-street parking is next to a stormwater facility, it is critical to consider where people will walk when they get out of their cars. People should have adequate room and a place to step when they get out of their car without interfering with the stormwater facility. This is called an egress zone, and it should be a minimum of three feet wide adjacent to stormwater facilities. Furthermore, pedestrians need to have sufficient access from the street to the parking zone. This can be provided with frequent walkways or bridges across stormwater facilities. Figure D-1 illustrates how on-street parking can be accommodated with stormwater planters and still allow pedestrians to access parked vehicles and the sidewalk.

Another consideration for pedestrian circulation is assuring that people can safely detect where there is a drop in grade adjacent to walkways. Where there is a vertical grade change of more than six inches deep immediately adjacent to a sidewalk zone, as is common with planters and some rain gardens, the design should allow pedestrians to visually and/or physically detect this drop in grade. There are several ways to accomplish this, such as installing a raised curb edge, a low-profile railing, or warning paver/strips. Providing these design elements gives people, especially the visually impaired, a chance to safely navigate around any uncommon grade changes.

Parking Lot Applications:

Pedestrian circulation is also an important design consideration when using stormwater facilities in parking lots. Inadequate accommodation of pedestrians could lead to people cutting through rain gardens and trampling the plants. Where is/are the primary pedestrian destination(s) in relation to the parking lot? For stormwater management, aligning landscaped facilities perpendicular to the sheet-flow of water maximizes the potential for capturing runoff. Sometimes this optimum alignment is in conflict with the desired pedestrian flow to and from a destination. It is important to design a parking lot to allow people to cross stormwater facilities by providing bridges or pathways over the rain garden or by providing sidewalks for people to safely walk alongside the rain gardens.


SOURCE: NEVUE NGAN ASSOCIATES

Figure D-5: *Failed pedestrian circulation in a parking lot. Due to poor design, people have trampled this vegetated swale to the point where the landscape cannot grow.*

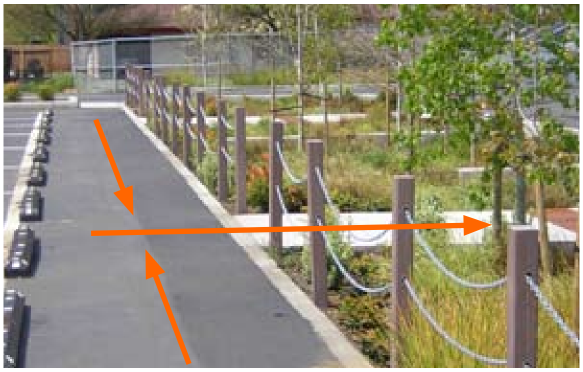

SOURCE: NEVUE NGAN ASSOCIATES

Figure D-6: *Good circulation in a parking lot. This vegetated swale has several walkways that allow pedestrians to access their destination without walking through the landscaped area.*

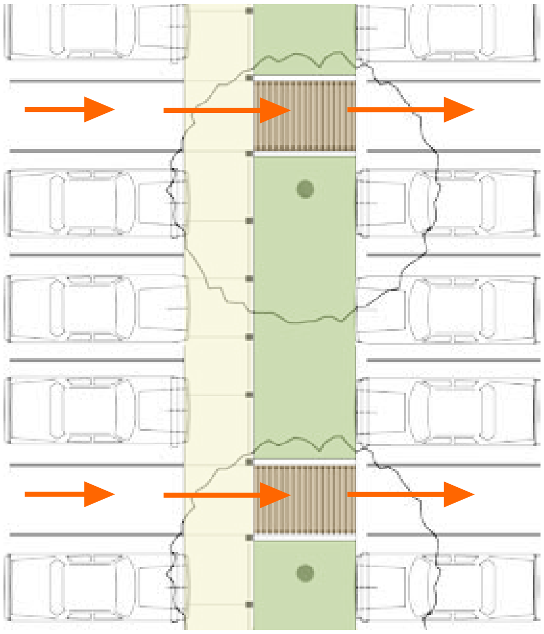


Figure D-7: *Pedestrian circulation perpendicular to a stormwater facility.*

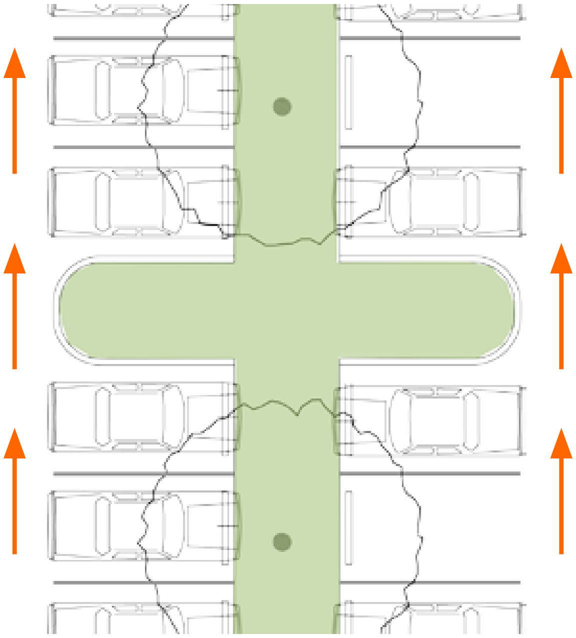


Figure D-8: *Pedestrian circulation parallel to a stormwater facility.*

SOURCE: NEVUE NGAN ASSOCIATES

Figure E-1: *A steep site condition in Northern Kentucky.*

SOURCE: SEATTLE PUBLIC UTILITIES

Figure E-2: *Terraced concrete weirs allow a vegetated swale to be graded with a much shallower slope than the adjacent street's grade.*

SOURCE: NEVUE NGAN ASSOCIATES

Figure E-3: *Closely spaced check dams help terrace the interior landscape of this stormwater curb extension project. The slope of this street is approximately 6%.*

As mentioned previously, developing on steep hillside slopes in Northern Kentucky should be avoided whenever possible. For those sites that will ultimately develop in steeper-than-ideal conditions or for retrofitting developments already built on steep slopes, there are various design elements to consider.

First, look for ways to improve the overall site design so that space can be provided for stormwater facilities to help reduce the velocity of stormwater runoff.

Second, consider building terraced stormwater planters and swales. Developing rain garden projects along streets, within parking lots, and next to buildings on slopes greater than 6 percent will require very closely spaced check dams or even a terraced planter system. These design elements will help to slow water down as it flows though the rain garden's landscape area. Figures E-6 and E-7 show how using closely spaced check dams in a swale and terracing a planter system can allow for rain gardens on moderately sloping terrain. Depending on the underlying soil conditions, some of this water might also infiltrate into the native soil.

A geotechnical engineer should be consulted to evaluate and analyze steep areas for susceptibility to landslides during the design process.

Using Check Dams and Weirs

Check dams and weirs are the "speed bumps" of stormwater management. They are designed and strategically placed within a stormwater facility to slow the flow of runoff. Check dams can be defined as structures in the landscape that retain stormwater. Weirs are a notch within a checkdam with an adjustable height to allow for varied amounts of stormwater retention. Check dams should retain stormwater to relatively shallow depths, with a maximum ponding depth of 6 to 8 inches of runoff during storm events.

Check dams and weirs can be made out of any durable material, including rock, concrete, metal, or wood. A check dam or weir should generally be placed in a rain garden facility for every 4 to 6 inches of elevation change. Check dams may also be used in swales and planters that have little or no slope to promote infiltration. This should be done only where soil conditions are conducive to infiltration (Class A or B soils) or if there is an underdrain system installed in the stormwater facility.

Steep grade conditions (over 6 percent) may require hardscape check dams (i.e., concrete, stone, wood, metal) and weirs to terrace rain gardens down the steep slope.

***Figure E-4:** This adjustable weir can control how much water is to be retained in a rain garden.*

***Figure E-5:** Simple check dams made of stacked rocks or gravel can be used on mildly sloped stormwater facilities.*

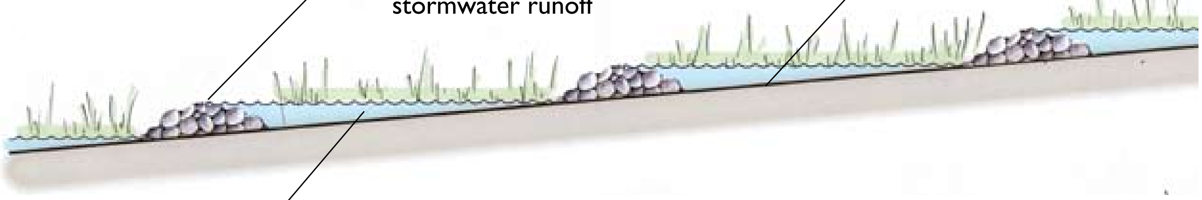


Figure E-6: **Vegetated Swale Example**

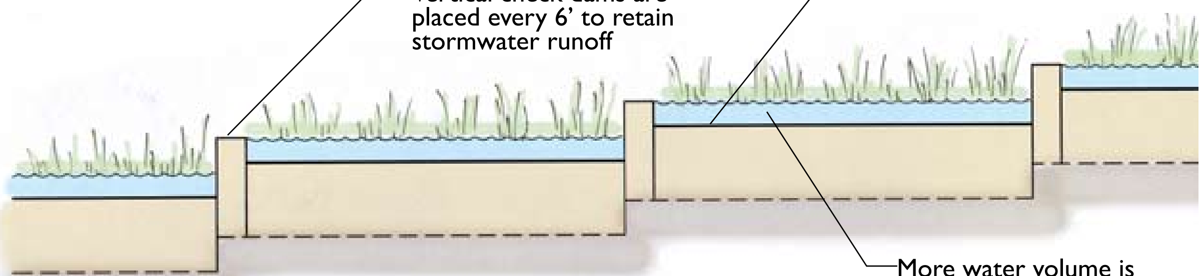


Figure E-7: **Planter Example**

SOURCE: NEVUE NGAN ASSOCIATES

***Figure F-1:** These mature street trees were saved by allowing the sidewalk to curve around the trees. However, the new sidewalk alignment also reduced the size of the adjacent stormwater swale.*

Selection of appropriate tree species for rain gardens is beyond the scope of this document and doesn't necessarily affect the basic design of stormwater facilities. Existing trees, however, can be a big influence in how rain gardens are designed, especially for retrofit projects. It is important to inventory existing street trees prior to design. This inventory should include the species, age, typical life span, and health. Another important consideration is whether an existing tree can tolerate frequent inundations? Can the rain garden itself be designed around the existing trees, and can the existing tree roots survive during the construction process? Should the tree simply be replaced? Mature trees may be able to soak up water at a rate comparable to what a rain garden can infiltrate. So, in terms of overall stormwater benefit, it may be worth reducing a rain garden's size to save a mature tree.

SOURCE: NEVUE NGAN ASSOCIATES

***Figure F-2:** This stormwater curb extension was built to save both the existing curb of the street as well as the 30-year old ornamental pear trees.*

Appendix G: Getting the Water In - Sheet Flow or Curb Cuts?

One of the primary considerations for designing stormwater facilities associated with streets and parking lots is determining how the runoff enters the facility. There are two primary ways that runoff is directed into stormwater facilities: sheet flow or curb cuts. Sheet flow describes stormwater runoff that enters a stormwater facility evenly distributed on the pavement surface. Curb cuts, within a raised curb condition, allow stormwater to enter a stormwater facility at specific points, thus concentrating runoff both in velocity and volume.

Of the two methods, sheet flow is preferable because it mimics the natural flow of water across the landscape, employs a less complicated design, and is less prone to failure. Sheet flow, or curbless streets and parking lots, typically employs a concrete band edging that is flush with both the rain garden and the street or parking lot surface. This concrete band provides a clean separation between the more malleable asphalt surface and the rain garden. In addition, the concrete band is easier to fine-grade than asphalt in order to direct water into the stormwater facility.

Curb cuts along a raised curb system are commonly used to allow water to flow into stormwater facilities. However, this approach channelizes water flow and can be prone to failure if the curb cut is poorly designed and/or sediment or debris builds up at the curb cut. If curb cuts are used, careful attention should be paid during design, such as spacing the curb cuts as frequently as possible to distribute the water flow evenly within the stormwater facility. Also, curb cuts should be designed at least 18 inches wide to avoid the potential for sediment to clog the entry point. Figures G-1 and G-2 illustrate the most common ways that runoff enters street and parking lot rain gardens.

SOURCE: NEVUE NGAN ASSOCIATES

***Figure G-1:** This "curbless" street example allows sheet flow of runoff into a vegetated swale.*

SOURCE: KEVIN ROBERT PERRY - CITY OF PORTLAND

***Figure G-2:** A typical curb cut used to allow water to enter a stormwater curb extension.*

SOURCE: NEVUE NGAN ASSOCIATES

***Figure G-3:** This notched curb cut is way too small and constantly overloaded with sediment.*

Appendix H: Types of Curb Cuts

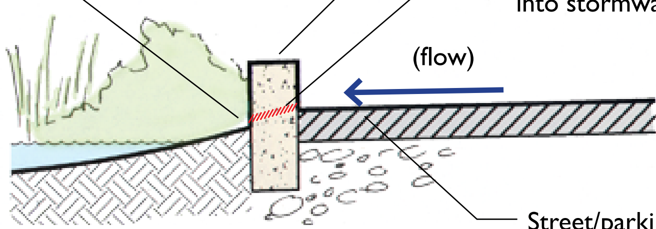


***Figure H-1:* Standard Curb Cut-Section View**

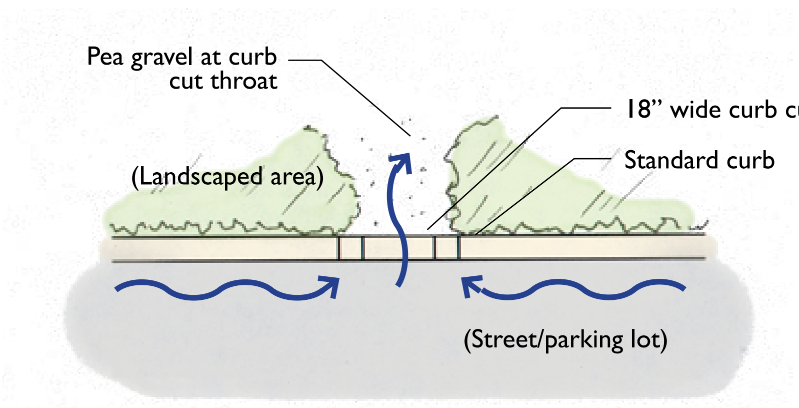


***Figure H-2:* Standard Curb Cut-Plan View**

Figure H-3: *A standard curb cut allows stormwater runoff to enter a parking lot rain garden. This curb cut has 45 degree chamfered sides.*

KEY DESIGN ELEMENTS

- Opening should be at least 18" wide
- The curb cut can have vertical sides or have chamfered sides at 45 degrees (as shown)
- Works well with relatively shallow stormwater facilities that do not have steep side slope conditions
- Slope the bottom of the concrete curb cut toward the stormwater facility
- A minimum 2" drop in grade should occur between the curb cut entry point and the finish grade of the stormwater facility
- Pea gravel can be used as a stable mulch material at the curb cut opening

Appendix H: Types of Curb Cuts

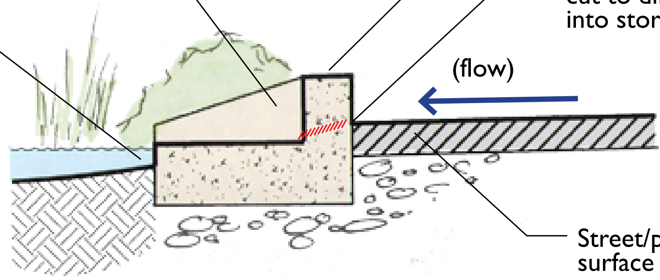


Figure H-4: **Standard Curb Cut With Wings-Section View**

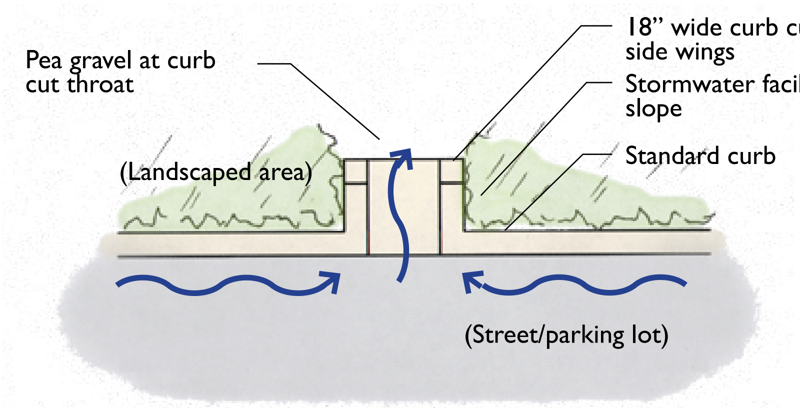


Figure H-5: **Standard Curb Cut With Wings-Plan View**

KEY DESIGN ELEMENTS

- Opening should be at least 18" wide
- Works well with stormwater facilities that have steeper side slope conditions
- Slope the bottom of the concrete curb cut toward the stormwater facility
- A minimum 2" drop in grade should occur between the curb cut entry point and the finish grade of the stormwater facility
- Pea gravel can be used as a stable mulch material at the curb cut opening

SOURCE: KEVIN ROBERT PERRY - CITY OF PORTLAND

Figure H-6: *A standard curb with wings allows stormwater runoff to enter a stormwater facility. The wings help retain the side slope grade on each side of the curb cut opening.*

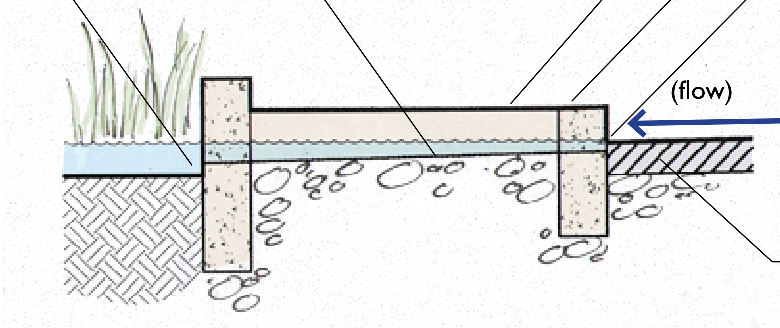


Figure H-7: **Grated Curb Cut-Section View**

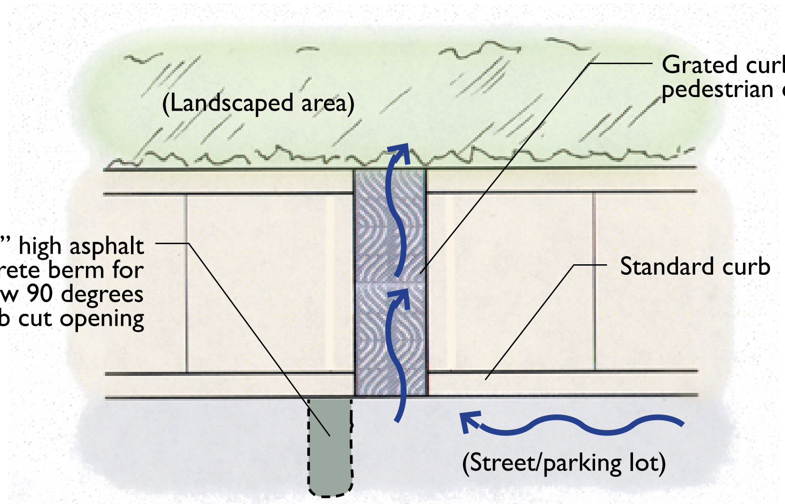


Figure H-8: **Grated Curb Cut-Plan View**

SOURCE: KEVIN ROBERT PERRY - CITY OF PORTLAND

Figure H-9: *A grated curb cut allows stormwater to pass under a street stormwater planter's pedestrian egress zone.*

KEY DESIGN ELEMENTS

- Grated curb cuts allow stormwater to be conveyed under a pedestrian walkway. The curb cut opening should be at least 18" wide, need to be ADA compliant, and have sufficient slip resistance

- An optional 1-2" high asphalt or concrete berm can be placed on the downstream side of the curb cut to help direct runoff into the curb cut

- A minimum 2" drop in grade should occur between the flush curb and the finish grade of the stormwater facility

Appendix I: Conveying Water With Trench Drains and Speed Bumps

Conveying stormwater runoff on or near the surface can be accomplished with a number of techniques. Trench drains and small-scale speed bumps are good ways to efficiently direct runoff to landscape areas without using underground pipes.

Trench drain systems are designed to convey stormwater runoff within a shallow channel while maintaining unimpeded pedestrian or vehicular access. Trench drain grates can vary considerably in size and shape, as well as material choice and patterns. Trench drain channels can also be designed with a variety of profiles and depths.

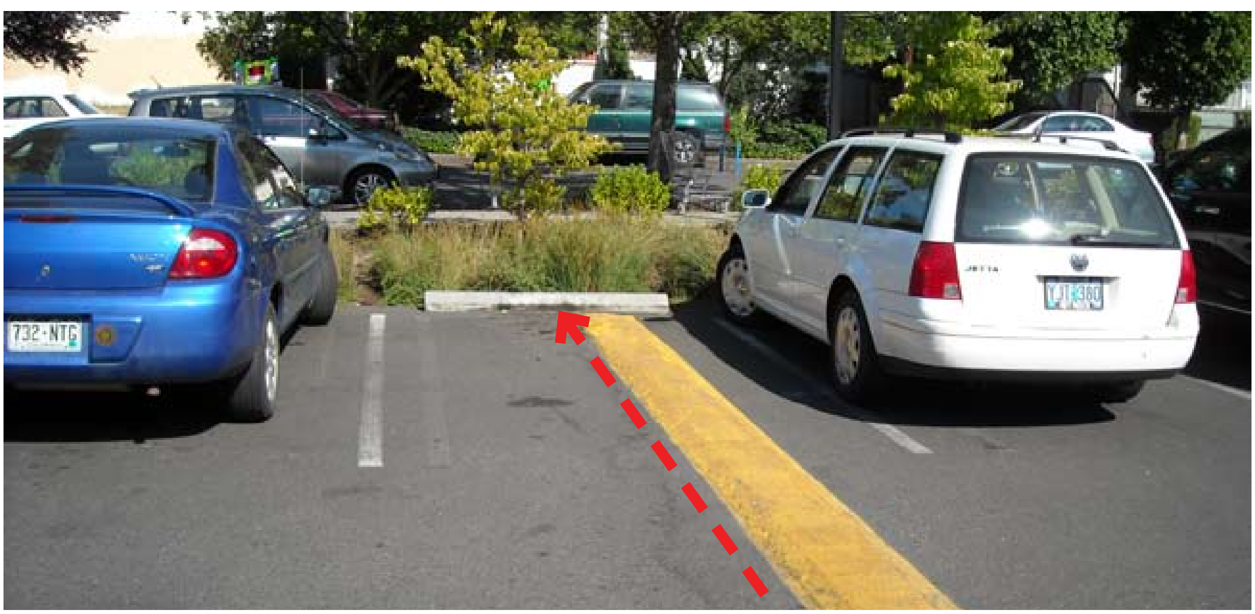
Using speed bumps to direct water into landscaped areas is a simple and inexpensive design strategy. Speed bumps can be used to direct surface runoff "higher up" within a stormwater facility to help ensure more treatment time. Also, small speed bumps can be installed as a "backstop" near curb cut entries to direct water into the stormwater facility. Speed bumps do not have to be very high. A 1 to 2 inch high speed bump is adequate for directing stormwater flow.

SOURCE: NEVUE NGAN ASSOCIATES

Figure I-1: *This trench drain example connects two stormwater facilities in an industrial parking lot site.*

SOURCE: NEVUE NGAN ASSOCIATES

Figure I-2: *A concrete unit paver is placed at the exit point of this trench drain. The pad helps dissipate water velocity as it drops from the trench drain to the finish grade of the stormwater facility.*



SOURCE: NEVUE NGAN ASSOCIATES

Figure I-3: *This asphalt speed bump redirects stormwater into a vegetated swale. Without the speed bump, stormwater runoff would enter the vegetated swale much lower in the system, bypassing some of the area available for treatment.*

SOURCE: NEVUE NGAN ASSOCIATES

Figure J-1: *A sediment forebay in a stormwater curb extension.*

SOURCE: NEVUE NGAN ASSOCIATES

Figure J-2: *A small, 18"-wide sediment forebay at the entry curb cut of a street stormwater planter.*

SOURCE: NEVUE NGAN ASSOCIATES

Figure J-3: *A 3x3' concrete pad is used a sediment forebay for a large street rain garden. The plant material acts as a dam, allowing debris to settle on the pad for regular removal.*

In sheet-flow situations, sediments drop out evenly along the length of the rain garden, which can reduce the need for frequent removal of sediment. However, when curb cuts are used, water enters the rain garden in a concentrated flow, bringing with it a sediment load. In most curb cut conditions, a sediment forebay should be used to allow material to collect at one spot and make sediment removal easier. A sediment forebay should be sized and designed so that it is seamlessly integrated into the landscape area. It can be as simple as leaving a small, shallow-graded, non-planted area right after the entry curb cut.

Because the velocity of stormwater flows can be high as the water enters a curb cut, mulching the sediment forebay with pea gravel minimizes erosion. High-density planting located on the downstream side of a sediment forebay can help act as a containment dam for sediment and debris. The use of sediment forebays is highly dependent on how much sediment debris the street typically produces. Some rain gardens may not need a sediment forebay at all. Other rain gardens, particularly those located on streets that have high traffic loads or substantial leaf drop, would most likely benefit from having a sediment forebay and a regular maintenance schedule to clear debris from it.

Appendix K: Overflow Options

Overflow within rain gardens can be managed in several ways, depending on what type of stormwater infrastructure is already in place. Generally it is preferable to have viable surface overflow as the primary overflow and the piped system as a secondary overflow. In retrofit conditions, the most cost-effective and least intensive option is to simply allow water to overflow the landscape area through a curb cut and exit back into the street to where it can eventually be captured by an existing storm inlet. Another option is to allow overflow runoff to enter a new storm inlet located either within the curb extension or immediately adjacent to an exit curb cut.

SOURCE: TOM LIPTAN - CITY OF PORTLAND

***Figure K-1:** Overflow from this rain garden enters a 4" riser connected to the storm system.*

SOURCE: KEVIN ROBERT PERRY - CITY OF PORTLAND

***Figure K-2:** Overflow from a mid-block stormwater curb extension exits from a curb notch and flows back onto the street.*

SOURCE: NEVUE NGAN ASSOCIATES

***Figure K-3:** An adjustable weir retains stormwater to an 8" depth within this vegetated swale before overflowing into the storm system.*

Appendix L: Soil Preparation

SOURCE: KEVIN ROBERT PERRY - CITY OF PORTLAND

***Figure L-1:** Native soil is rototilled to break up construction compaction.*

SOURCE: KEVIN ROBERT PERRY - CITY OF PORTLAND

***Figure L-2:** New imported topsoil is placed within a planter. Soil is graded 2" lower than finish grade to account for a mulch layer.*

SOURCE: KEVIN ROBERT PERRY - CITY OF PORTLAND

***Figure L-3:** A 2" layer of pea gravel mulch is applied to a stormwater planter.*

In deciding a soil preparation procedure, one should first assess the natural hydrology and geology of the site. The type and extent of soil amendments and the overall green infrastructure goal will depend on how well the natural soils infiltrate. Many sites, especially retrofit conditions, have little or no organic material in the soil structure because they have been paved over for many years. Amending soils with organic material promotes healthy plant growth and the microbiological processes needed for pollutant removal.

If possible, consult with a soil scientist to determine the best mix for a site's imported topsoil. However, a general rule of thumb is to use a three-way mix of weed-free compost, sand, and loamy topsoil. Rototill newly imported soil in with native soil in 6 inch lifts. Use only foot compaction or a landscape roller to finish the grade of rain gardens, but avoid over-compaction.

The final level of the topsoil should be at least two inches below the final level of the rain garden to take into account a mulch layer. Otherwise, the rain garden is graded too high, and water cannot get in. The mulch material can be organic material (i.e., bark mulch), or it can consist of rocks. For organic mulches, care should be taken to use a weed-free source. Rocks of different sizes are a good choice with stormwater facilities that experience high velocity or high erosion potential. Using large rocks is recommended only for building application (roof runoff has a lower sediment load than a street or parking lot) because there will be little or no need to clean out sediment from the larger void space between rocks. If using a rock mulch for a street or parking lot application, the best rock mulch is pea gravel because sediment can be more easily removed.

Appendix M: Protecting The Building Foundation

To protect a building's foundation or basement, waterproof liners for flow-through rain garden facilities should be considered in areas with contaminated soils or a high groundwater table. Liners should also be considered along streets with heavy traffic to protect street subgrades. Material used may include vertically placed plastic liners for street applications, geomembrane liners, or concrete planter walls to completely contain stormwater.

The rule of thumb for infiltrating water next to buildings is to locate the stormwater facility at least 10 feet from building foundations. However, every site is different, and it may be possible to infiltrate closer, or it may be necessary to locate further away.

SOURCE: NEVUE NGAN ASSOCIATES

Figure M-1: *In this scenario, the infiltration planter is offest 8' from the building edge.*

SOURCE: NEVUE NGAN ASSOCIATES

Figure M-2: *A plastic liner is adhered to the building foundation, but runoff can still infiltrate.*

SOURCE: NEVUE NGAN ASSOCIATES

Figure M-3: *A close-up look at how a liner is placed upon a building foundation.*

Appendix N: Long-Term Maintenance Considerations

Maintenance plans are specific to each type of stormwater facility and are not in the scope of this handbook. However, here are some key considerations for maintaining rain garden systems.

The first and foremost consideration for assuring long-term success of rain gardens is to determine early on during the design process who will conduct and fund maintenance activities. Because rain gardens are designed on both public land (such as streets) and private land (predominately parking lots and buildings), there can be considerable confusion as to who is responsible for what. Once the responsible party is identified, it is important to determine how much maintenance will be required, keeping in mind not to design a stormwater facility that can't realistically be maintained by the responsible party. In some cases, a maintenance agreement might be needed between a public agency and private entity (property owner, neighborhood associations, developers, etc.) to assure collaboration on maintenance tasks.

Because most of the rain garden design strategies illustrated in this handbook have a very strong landscape component, it makes sense to have a maintenance crew that understands how to maintain landscape systems, not pipe systems. However, the simpler the rain garden design is, the greater the ability for residents to maintain the space themselves without considerable effort.

Taking care of rain gardens is like taking care of people. During the first years of life, the initial investment should be high to assure that the "infant" rain garden can grow up healthy and achieve a long life. The two predominant maintenance activities that will occur during the first years of the establishment (infancy) period include weeding by non-chemical means and summer irrigation as needed. Supplemental maintenance activities during the establishment period include plant trimming, plant replacement, and mulching. Providing an aggressive and regular maintenance program during the establishment period gives a rain garden the best opportunity to thrive in the long term. A general rule of thumb is to conduct quarterly maintenance visits for the first two years.

Ongoing maintenance activities for rain gardens, performed during and after the establishment period, include sediment removal, keeping stormwater entry and exit points clear of debris, and removing litter. The schedule of these activities may vary considerably depending on the type and location of the rain garden. For example, stormwater planters accepted rooftop runoff will typically have far less sedimentation than a stormwater planter managing runoff from a parking lot or street. Hence, street and parking lot stormwater applications will need more frequent maintenance to remove sediment from rain garden entry points. It is important to write maintenance plans that are relatively specific to the type of rain garden involved and where the runoff is originating from.

SOURCE: NEVUE NGAN ASSOCIATES

Figure N-1: *Private volunteer groups helping maintain public rain gardens can help reduce the frequency of maintenance visits by municipal crews.*

Appendix O: Additional Resources

For additional information on the issues in this handbook, refer to the resources below that deal with green infrastructure for stormwater management, including both on-site treatment measures and smart growth principles as they relate to water protection. Many more are available at www.smartgrowth.org/library (resources are searchable by issue, state, and other criteria) and at www.epa.gov/watertrain/smartgrowth/resources/index.htm.

Using Smart Growth Techniques as Stormwater Best Management Practices
U.S. Environmental Protection Agency, December 2005
http://www.epa.gov/smartgrowth/

Protecting Water Resources with Smart Growth
U.S. Environmental Protection Agency, May 2004
http://www.epa.gov/smartgrowth/

Protecting Water Resources with Higher-Density Development
U.S. Environmental Protection Agency, January 2006
http://www.epa.gov/smartgrowth/

"Balancing Water Quality and Smart Growth Goals" (webcast)
International City/County Management Association, July 2007
http://icma.org/main/ld.asp?ldid=20314&hsid=1&tpid=8&t=0

"Planning for Stormwater: Alternatives to Traditional Stormwater Management Techniques" (website)
University of Connecticut
http://nemo.uconn.edu/tools/stormwater/parking_lots.htm

Rooftops to Rivers: Green Strategies for Controlling Stormwater and Combined Sewer Overflows
Natural Resources Defense Council, May 2006
http://www.nrdc.org/water/pollution/rooftops/contents.asp

California Stormwater Best Management Practice Handbook
California Stormwater Quality Association, January 2003
http://www.cabmphandbooks.com/Development.asp

Portland Stormwater Management Manual
City of Portland (Oregon), September 2004
http://www.portlandonline.com/bes/index.cfm?c=35122

Stormwater Guidelines for Green, Dense Redevelopment
City of Emeryville (California), December 2005
http://www.ci.emeryville.ca.us/planning/stormwater.html

"Green Values Stormwater Toolbox" (website)
Center for Neighborhood Technology
http://greenvalues.cnt.org/