Stormwater Management Handbook

Implementing Green Infrastructure in Northern Kentucky Communities

May 2009

<< Sanitation District No. 1 Headquarters, Fort Wright, Kentucky

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This handbook is a guide to help Northern Kentucky communities manage, and reduce, their stormwater runoff while still allowing the region to grow and prosper with more homes, businesses and jobs. Where and how development occurs in Northern Kentucky can dramatically affect the region's watersheds, wastewater treatment systems, and water supplies. Effectively engaging at the regional, neighborhood, and site scales can help Sanitation District No. 1 (SD1) address regulatory requirements and help Northern Kentucky communities to better balance development decisions with environmental protection.

This handbook includes land use policies and strategies that could be applied regionally across Northern Kentucky and in other areas of the United States to reduce stormwater runoff volumes without hindering growth. Communities in other areas of the US have found these strategies to be effective at reducing stormwater volumes while allowing for economic growth and creating attractive, livable neighborhoods. Strategies include preserving open space that both improves water quality and provides recreational opportunities and wildlife habitat, and using land efficiently by directing growth to already developed areas.

Equally important as where development is located is how it is built. The handbook, therefore, looks at development strategies and policies such as compact development, mixed-use zoning, and revised street and parking standards. These practices no only manage stormwater, but also create streets that invite visitors and residents to walk, and provide a setting for shops, cafes and restaurants that cater to pedestrians.

The majority of the handbook illustrates innovative site-level design strategies that reduce runoff from development and how they could be successfully applied in Northern Kentucky. The strategies, policies, and designs illustrate the handbook's goal– to provide communities in Northern Kentucky environmentally responsible planning and design alternatives that can reduce water pollution, decrease runoff volume, protect aquatic habitat, and have the additional community benefit of creating more interesting places to live, work and play.

SOURCE: SANITATION DISTRICT NO. 1 OF NORTHERN KENTUCKY

1.0 General Background


SOURCE: SANITATION DISTRICT NO. 1 OF NORTHERN KENTUCKY

Figure 1-1: *A creek in Northern Kentucky.*

SD1 is the agency responsible for collecting and treating wastewater and managing stormwater in the counties of Boone, Campbell, and Kenton, located along the southern bank of the Ohio River, across from the city of Cincinnati. SD1's service area has in recent years experienced rapid population growth, which has strained the capacity of the region's sewer systems. At the same time, development has paved over more land for buildings, roads, and parking lots. This has increased the amount of stormwater runoff, since paved, or "impervious," land cannot absorb stormwater, which instead runs off the surface. Population growth and land development in Northern Kentucky have contributed to numerous sewer overflows from both the combined and the sanitary sewer systems. In April 2007, SD1, as the regional wastewater and stormwater utility, entered into a consent decree with the U.S. Environmental Protection Agency (EPA), the Kentucky Energy and Environment Cabinet, and the U.S. Department of Justice to address these sewer overflows.

The consent decree calls for a comprehensive watershed approach for assessing and addressing all sources of water pollution in the region and the cumulative impacts of these sources on receiving waters. The watershed-based approach is expected to attain faster improvements in water quality. This approach can also create places that are environmentally and economically sustainable, interesting, and attractive places to live, work and play.

To assist SD1, EPA provided a team of consultants to participate in a design workshop that discussed how Northern Kentucky communities could grow and prosper while addressing stormwater issues and the requirements of the consent decree (see Appendix A for a description of EPA technical assistance program and the workshop objectives). Residents and other stakeholders who participated in the workshop repeatedly voiced a desire for attractive and economically vital communities and the safe, walkable streets. This handbook presents green infrastructure strategies that SD1, Northern Kentucky communities, and other communities in the US, could adopt to manage stormwater at the regional, neighborhood, and site scales while also while creating safe, attractive and walkable communities. This handbook is not a technical manual for engineering and construction. For those purposes, refer to the Sanitation District No. 1 Best Management Practices Manual available from SD1.

One approach that will enable SD1 to address the requirements of the consent decree and create additional community benefits are green infrastructure strategies. A green infrastructure approach to stormwater management means using the landscape's inherent ability to slow, filter, and absorb rainfall as close as possible to where it hits the ground. This approach reduces the frequency and intensity of overflows from combined sewers. It also reduces the risk of flooding, polluted runoff, and erosion to stream channels caused by a high volume of runoff (Figure 1-3).

A comprehensive green infrastructure approach applies to development at the regional, neighborhood and site scale and includes the following concepts:

Preserve: Protect and enhance natural features, such as undisturbed forests, meadows, wetlands, and other natural areas.

Recycle: Recycle land by directing development to already degraded land, e.g., parking lots, vacant buildings, or abandoned malls.

Reduce: Reduce land consumption and the development footprint by using land efficiently.

Reuse: Capture and reuse stormwater by directing it back into the ground through infiltration, reusing it for other purposes such as irrigation, or allowing it to evaporate.

SOURCE: NEVUE NGAN ASSOCIATES

***Figure 1-2:** The conventional approach to stormwater management is treating rainfall runoff as a waste rather than a resource.*

SOURCE: BRUCE MCGRANAHAN

***Figure 1-3:** Urban runoff affects natural systems in a wide variety of ways such as stream bank erosion.*

***Figure 1-4:** The Sustainable Stormwater Design Model: A balance of economy, ecology, and community.*

2.0 A Regional Green Infrastructure Approach

Rolling hills, woods, pastures, and river and stream channels give Northern Kentucky a unique sense of identity and provide valuable water quality benefits by absorbing much of the region's rainfall. Conventional low-density development evident in much of region not only diminishes the scenic beauty but also contributes to degradation of the region's streams and rivers. Growth provides employment, housing, and recreational and cultural opportunities, but it can be designed and planned to use land efficiently, reinforce a community's "sense of place," and improve the region's water quality. Two complementary strategies at the regional scale could help Northern Kentucky achieve its water quality goals while allowing the region to grow and prosper:

- Preserving open space; and
- Encouraging growth in already developed areas.

Figure 2-2, a drawing of the Covington area produced during the design workshop, illustrates how thinking at a larger, city-wide scale can have water quality benefits, promote continued growth, and create multiple recreational and community benefits. The organizing "framework" for the drawing is an open space network connecting downtown Covington, the city's major parks and open spaces, with the Ohio and Licking Rivers. Preserving open spaces does not restrict growth in the city since there are significant redevelopment opportunities on sites that are either vacant or underused. Redevelopment of these sites could create pleasant, walkable neighborhoods and catalyze revitalization in surrounding neighborhoods–without contributing increased runoff to the combined sewer system. In fact, new development that adopts the land use and design recommendations outlined in this handbook could actually reduce runoff volume while also reducing growth pressures on the region's natural lands. Allowing growth and managing stormwater is a win-win situation for the region.

Similar strategies could be applied to less urban communities across Northern Kentucky's three counties. The steps are similar: preserve high-priority open spaces such as forests, meadows, stream corridors, and steep hillsides that not only absorb rainfall, but also provide valuable opportunities for recreation and wildlife habitat. Next, identify possible areas of redevelopment, such as vacant industrial lands or an underused regional retail center; and then use the land efficiently by considering a mix of land uses and housing that includes townhomes, apartments and condominiums.

SOURCE: SANITATION DISTRICT NO. 1 OF NORTHERN KENTUCKY

Figure 2-1: *Managing growth effectively and preserving open space can protect water quality in creeks, streams, and rivers in Northern Kentucky.*

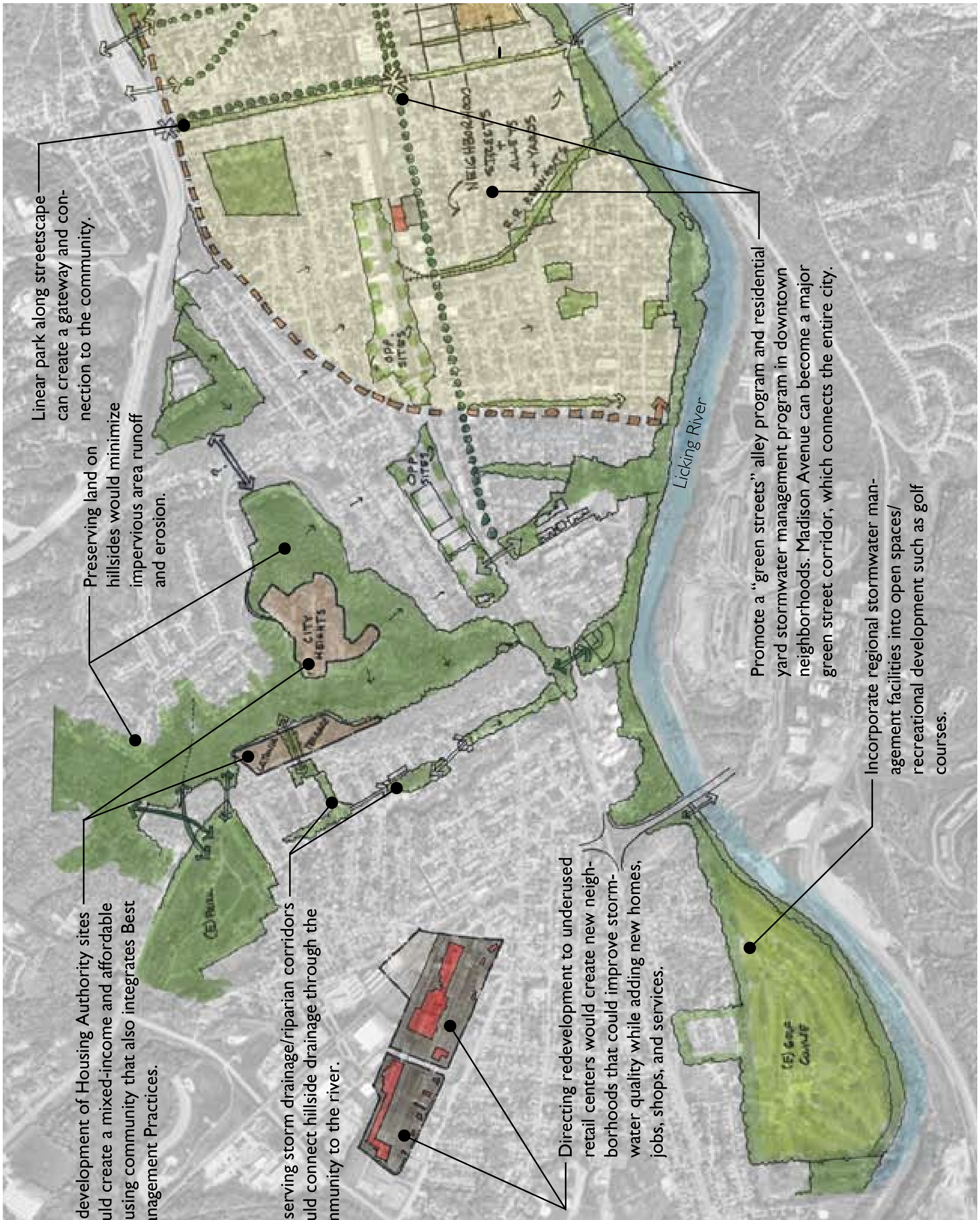


Figure 2-2: *Redeveloping areas in Northern Kentucky that are currently under-performing can help direct growth away from open space.*

2.1 Preserving Open Space

Preserving open space in the Northern Kentucky region is critical to maintaining water quality and reducing runoff, but it does not mean that growth opportunities need be restricted. The investment in open space "pays back" by reducing runoff and flooding risks, protecting scenic character, providing wildlife habitat, and creating recreational opportunities for the area's residents and visitors. The following are some tools that Northern Kentucky communities could use to preserve open space:

SOURCE: ABBY HALL - US EPA

Lenexa, Kansas, is a growing suburb in metropolitan Kansas City that faces increasing pressure from the impacts of new development and associated increases in stormwater runoff. In an effort to protect local water quality, as well as prevent flooding and improve the quality of life for residents, Lenexa's comprehensive plan, Vision 2020, initiated Rain to Recreation, an innovative and integrated watershed protection program. The program outlines a number of policies and programs to protect land from future development and introduce new green infrastructure practices that limit imperviousness and manage runoff on-site, including protection of priority natural resource areas in the watershed, to creation of riparian greenways through the application of a stream setback ordinance, to requiring low-impact development practices on site, Lenexa is investing in green infrastructure at all three scales, including the regional watershed, neighborhood, and site levels.

•Transfers of development rights (TDRs) allow a community to direct development to areas targeted for growth while preserving undeveloped land elsewhere. Purchases of development rights (PDRs) operate similarly to TDRs except that the developer is required to purchase those development rights.

•Up-zoning and down-zoning are practices that can be used individually or in tandem with TDR/PDR programs. These tools restrict development in areas that are more appropriately left undeveloped while encouraging more efficient use of land targeted for growth.

•Conservation easements, or conservation restrictions, are legal agreements between a landowner and a land trust or government agency that allow the landowner to continue to own and use the land and to sell it or pass it on to heirs. The landowner gives up some of the rights associated with the land, such as the ability to develop it.

•Buffer ordinances would require vegetated zones between waterways and proposed developments in order to protect water quality.

•Steep-slope ordinances would place development restrictions on areas that, due to their topography, are particularly susceptible to erosion and sediment loss.

Encouraging Growth in Already Developed Areas

Just as communities in Northern Kentucky can use the land to absorb rainfall, they can identify locations in the region that can absorb future development without consuming valuable open space. Using land more efficiently reduces and better manages stormwater runoff by reducing total impervious area. The most effective strategy for efficient land use is redeveloping already degraded sites such as abandoned shopping centers or underused parking lots rather than paving greenfield sites. The drawing of Covington (Figure 2-2) identified some possible redevelopment opportunities on sites with underused parking lots, and Figure 3-4 in the following section illustrate a development plan for one of the sites. By redeveloping an underused site that is already paved, the net increase in runoff from development would likely be zero–or actually decrease, depending on the on-site green infrastructure practices used (presented in Chapter 4). Northern Kentucky communities have the options of directing and concentrating new development in areas specifically targeted for growth. By doing so communities can reduce development pressure on undeveloped parcels, protect sensitive natural lands, provide access to open space for recreational purposes, and create more vibrant neighborhoods. In addition to TDRs/PDRs and up-zoning and down-zoning mentioned previously, additional tools can direct growth to already developed areas:

•Priority funding areas use financial incentives to direct growth to already developed areas or to areas targeted for development.

• Local government incentives such as density bonuses and accelerated permitting process for infill and redevelopment projects.

•Reduced impact fees for infill development based on less demand for new infrastructure.

•Differentiating sewer and water connection fees would allow municipalities and utility authorities to offer discounts for development in desired areas.

•Capital or financing from local governments for infrastructure improvements (water, sewer, road, sidewalk, etc. upgrades) in identified growth areas.

•Tax Incremental Financing districts to encourage redevelopment.

•Stormwater management requirement provision that reduces on site management requirements for projects that decrease total imperviousness on previously developed sites

•Large-lot/agricultural zoning (e.g., 1 unit/160 acres) outside of growth boundary or at the edge of a city to restrict development and to preserve rural character.

SOURCE: US EPA

The redevelopment of the former Mizner Park shopping mall in Boca Raton, Florida, illustrates the opportunities of redevelopment. Originally a large retail structure surrounded by surface parking lots, the 29-acre site now designed as a village within the city. The project has a residential density five times higher than the rest of the city and a mix of large and small retailers, restaurants and entertainment venues. The final build-out of Mizner Park decreased overall impervious surface by 15 percent by replacing asphalt with a landscaped plaza, flower and tree planters and an amphitheater.

3.0 A Neighborhood-Scale Green Infrastructure Approach

SOURCE: VAN METER WILLIAMS POLLACK

Figure 3-1: *The shaded areas in this diagram represent the impervious area associated with streets.*

SOURCE: VAN METER WILLIAMS POLLACK

Figure 3-2: *The shaded areas in this diagram represent the impervious area associated with streets and buildings in the same neighborhood represented in Figure 3-1.*

SOURCE: VAN METER WILLIAMS POLLACK

Figure 3-3: *The shaded areas in this diagram represent the impervious area associated with streets, buildings, and parking lots, again in the same neighborhood.*

Regional decisions of where to develop will be accompanied by equally important decisions at the neighborhood scale of how to build new development. Neighborhood scale green infrastructure approaches reduces imperviousness by compacting development and integrating natural features into streets and parking lots. This chapter looks at three neighborhood-scale strategies that could help Northern Kentucky communities reduce stormwater runoff and associated pollutants while creating more interesting and attractive neighborhoods:

- Compact mixed-use development;
- Revised street design standards; and
- Revised parking requirements.

Strategies in this chapter can be thought of as creating the "space" in which the site-level designs presented in Chapter 4 can be incorporated.

Figure 3-4 is a conceptual plan that illustrates an infill neighborhood development in Covington that uses land efficiently. The development replaces a retail center with a new neighborhood that has a mix of uses closer together, making it easier for people to walk, bike, or take transit to meet their daily needs. Not only do the narrower streets, smaller parking areas, and "pocket parks" significantly reduce runoff in comparison to the previous use, they also improve community character and could spark revitalization in adjacent neighborhoods.

Figures 3-1 through 3-3 are diagrams of the neighborhood that surround the concept plan area in Figure 3-4 (the area of the concept plan is in the lower left corner of the diagrams). At this scale, the amount of impervious surface associated with the conventional design of streets, parking lots, and buildings becomes apparent. These surfaces are the most significant contributors to the volume of runoff that causes combined sewer overflows (CSOs) into the rivers and streams of Northern Kentucky. In areas of the region with separated sewer systems where the storm sewers discharges directly into the waterways, the volume of stormwater runoff erodes the river and stream banks, and the pollutants picked up by the runoff degrade water quality.

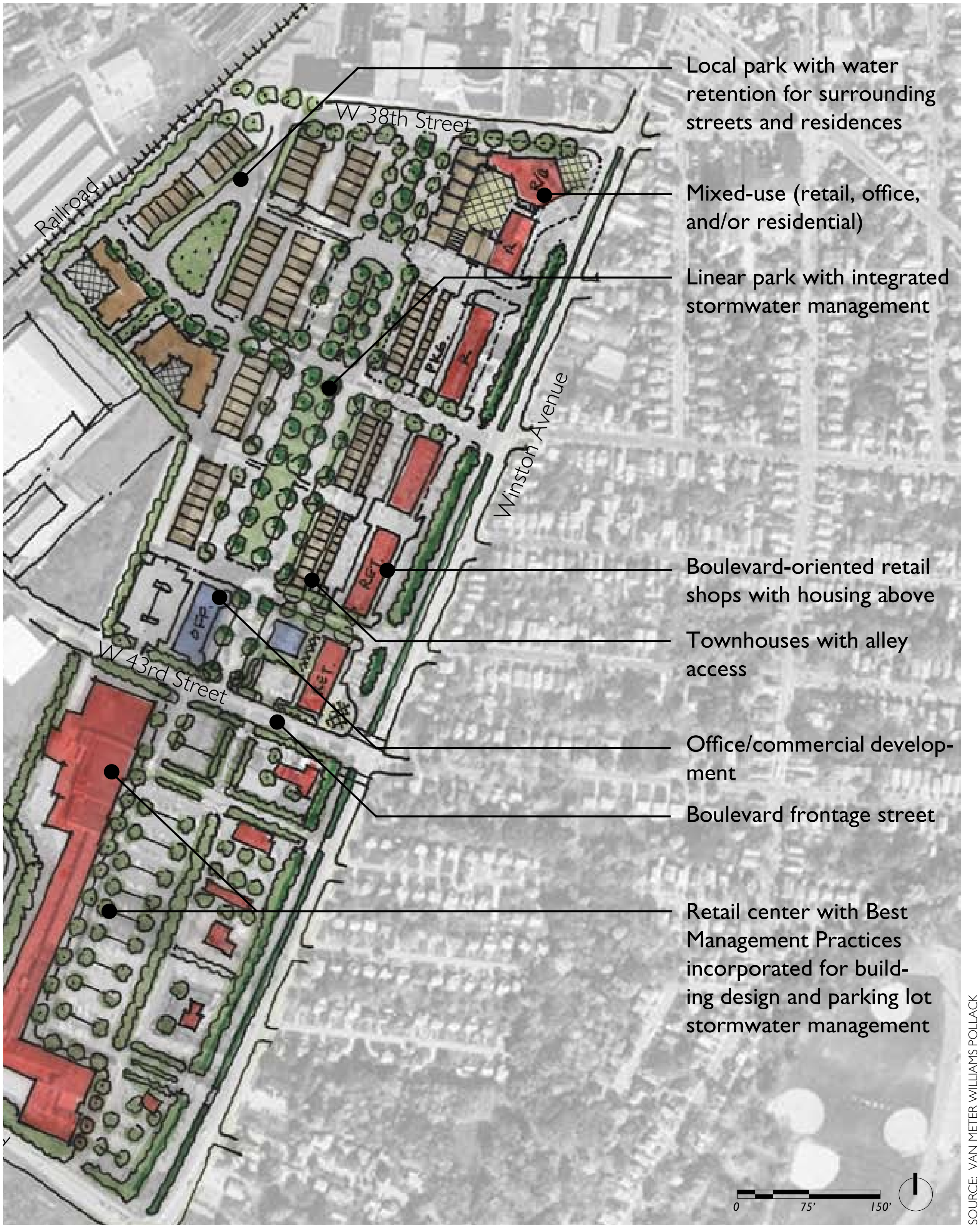


Figure 3-4: *New and existing neighborhoods, such as this conceptual example in Covington, Kentucky, could increase density, preserve open space, and introduce more site-level stormwater strategies.*

3.1 Compact Mixed-Use Development

Compact, mixed-use development is not a new planning concept in Northern Kentucky. Many of the region's older downtowns and neighborhood centers have homes, shops, offices, and schools built closer together and connected by a fine grid of streets that allow people to walk, bike or take transit in order to meet their daily needs. This approach not only replicates the pedestrian-friendly character of the older parts of the cities, but also benefits water quality by reducing the overall amount of impervious surface dedicated to streets and parking lots. Recreating such neighborhoods today can sometimes be difficult because of inflexible planning and zoning regulations. Several tools can help communities address these barriers:

SOURCE: VAN METER WILLIAMS POLLACK

Figure 3-5: *New and existing neighborhoods can be built to increase density, preserve open space, and introduce more site-level stormwater strategies.*

SOURCE: VAN METER WILLIAMS POLLACK

Figure 3-6: *Traditional neighborhood development maximizes green space, creates attractive communities, and provides more pedestrian and bike connectivity.*

•Form-based zoning codes regulate building appearance rather than density and use. By stressing the appearance of the streetscape or the public realm, form-based codes allow greater development intensity while still promoting good design.

•Traditional Neighborhood Development (TND) codes, a subset of mixed-use codes, seek to replicate the look and feel of attractive, old-fashioned neighborhoods with a combination of street grid, short blocks, pedestrian orientation, and architectural interest.

•Planned unit developments (PUDs) are zoning overlays that allow several parcels in a subdivision to be planned as a single unit. This provides flexibility in parking and open space requirements and/or mixing land uses.

•Overlay zoning districts permit increased density or development intensity in areas where this is appropriate, such as downtowns, along commercial corridors, or near transit stations.

•Density bonuses allow a developer to increase the number of housing units or square feet of commercial or office space if specific design criteria are met, such as including a green roof or developing an infill site.

Streets offer unique opportunities for handling and treating their runoff, but conventional street design practices focus primarily on moving the automobile and diverting runoff to the curb and gutter, contributing to increased runoff volume and poor water quality. Figures 3-7 and 3-8 illustrate the before-and-after concept of a street in Covington that could be redesigned to better manage stormwater runoff. Space in the street is reallocated to accommodate a bike lane and landscaping that improves the look of the street as well as manages stormwater. The narrower street still safely accommodates cars. The following are some tools that communities could consider to create more attractive, environmentally responsible streets:

•Reducing street widths provides a host of benefits, including less impervious surface, more attractive streetscapes, slower traffic speeds, and improved safety for pedestrians and cyclists. Communities could review their street-width standards— usually found in their zoning or subdivision regulations—and require the minimum travel-lane and right-of-way widths necessary to meet safety and traffic concerns.

•Adopting "Green Streets" design standards would provide better environmental performance while creating more attractive and safe environments. Green street features include: landscaped medians, planted curb extensions, planter strips along sidewalks, street trees, and pervious paving, all of which are illustrated in the Chapter 4.

SOURCE: NEVUE NGAN ASSOCIATES

Figure 3-7: *A typical urban street in downtown Covington, Kentucky.*

SOURCE: NEVUE NGAN ASSOCIATES

Figure 3-8: *The same street redesigned to accommodate a new bike lane, enhanced landscaping, and stormwater management.*

SOURCE: NEVUE NGAN ASSOCIATES

Figure 3-9: *Well-landscaped streets, such as this example in Chicago, Illinois, provide a unique and attractive character to neighborhoods.*

3.3 Revised Parking Requirements

SOURCE: GOOGLE EARTH

Figure 3-10: *This photo shows a large parking lot in Northern Kentucky that is underused.*

SOURCE: NEVUE NGAN ASSOCIATES

Figure 3-11: *Shortening these oversized parking spaces by just a few feet could create space for swales.*

SOURCE: NEVUE NGAN ASSOCIATES

Figure 3-12: *Here, shorter parking stalls yielded space for landscape-based stormwater management.*

Parking lots, like streets, make up large areas of impervious surface across Northern Kentucky and contribute to polluted runoff. Communities in the region could consider the following tools to reduce impervious surface for parking and allow the space in a parking lot to be reallocated to accommodate sustainable stormwater management features (which are discussed in Chapter 4):

•Set appropriate parking ratios for development projects that, because of their location, users, or project features, can be expected to have lower-than-average parking demand. Such land uses include compact, mixed-use, and transit-oriented developments; those in downtowns, near transit stations and along commercial corridors; and those catering to students, the elderly, and other demographic groups with lower-than-average car ownership rates.

•Allow businesses to count underused nearby on-street parking spaces toward meeting their parking requirements.

•Shared parking reduces the number of spaces that each development has to provide while still meeting the needs of drivers. For example, an office building parking lot might be full during the day but empty at nights and weekends. Sharing a parking lot with a movie theater, where demand is greatest at night and on weekends, would reduce the total parking required.

•Provide transportation alternatives that reduce the need for parking by encouraging people to carpool, use transit, walk, bike, telecommute, or shift their trips to non-peak periods. These are most often implemented by employers.

This section provides developers, designers, policy makers, and the general public with a toolbox of site-level design strategies to consider that can protect water quality and make streets and development more attractive in Northern Kentucky. Site-level strategies build off of the regional and neighborhood-scale strategies presented in Chapters 2 and 3, and are divided into two categories: Rain-Absorbing Footprint Strategies and Rain Garden Strategies. Supporting technical information is provided in the Appendix.

Rain-Absorbing Footprint Strategies design streets, parking lots, and buildings to absorb as much rainwater as possible. They use alternative surface materials to make otherwise impervious surfaces pervious or collect water for reuse. Green roofs and harvesting strategies are particularly appropriate in locations in Northern Kentucky with clay soils. Practices include:

- Green roofs;
- Pervious paving; and
- Rainwater harvesting.

Rain Garden Strategies use plants and soils to filter, absorb, and slow rainwater on the landscape surface. They are vegetated depressions in the landscape with plants adapted to inundation and drought. Types of rain garden practices include:

- Swales;
- Planters;
- Infiltration gardens;
- Curb extensions; and
- Residential downspout disconnections.

One of the simplest strategies to manage stormwater runoff on site is to preserve and protect a site's existing natural resources, such as stands of trees, wetland areas, and riparian buffers. Another strategy is to convert excess impervious area, such as wide swathes of concrete and asphalt, to landscape space. A typical project site could reduce 25 percent of its stormwater runoff if an equal 25 percent of impervious space was converted into pervious area. Transforming "gray space" it into "green space" not only reduces stormwater runoff volume,but it also provides room for additional trees and plants, beautifying the community.

For example, Figures 4-1 and 4-2 illustrate how an underused portion of a street can be redesigned to add landscape area along the street frontage. Figure 4-2: Same commercial street retrofitted with stormwater swale, bike lane, additional conventional landscaping, and street trees.

SOURCE: NEVUE NGAN ASSOCIATES

Figure 4-1: *A typical low-density commercial street in Covington, Kentucky.*

SOURCE: NEVUE NGAN ASSOCIATES

Figure 4-2: *Same commercial street frontage retrofitted with stormwater swale, bike lane, additional conventional landscaping and street trees.*

4.1 Green Roofs

SOURCE: SANITATION DISTRICT NO. 1 OF NORTHERN KENTUCKY

Figure 4-3: *A green roof demonstration project at the Sanitation District No. 1 headquarters in Fort Wright, Kentucky.*

Green roofs, also called "eco-roofs" or "living roofs," are living landscape systems that are designed to intercept rain as it falls on building rooftops. 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 and may be treated in a rain garden or used in the building in a graywater system (a system that collects nonpotable water for use in landscaping and irrigation). Green roofs have the added benefit of insulating buildings.

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 rooftop landscapes.

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 where building structure can support the added weight

Additional Benefits:

- Decrease heating and cooling costs by insulating and shading buildings
- Help reduce the urban heat island effect
- Provide wildlife habitat

Green Roofs 4.1

There are two types of green roofs: extensive and intensive

Extensive green roofs are lightweight vegetated systems consisting of low-profile grasses, sedums, and/or wildflowers growing in a 3 to 5-inch thick soil medium (Figure 4-4).

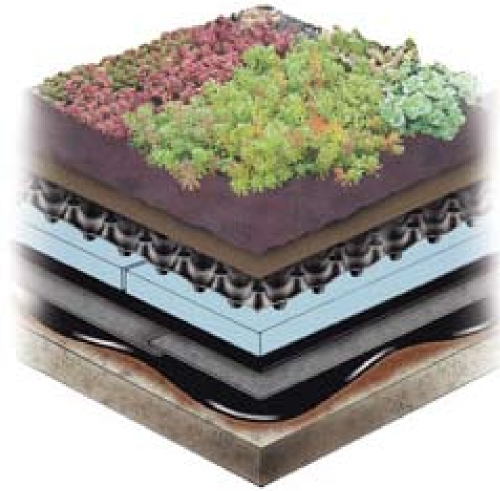
Intensive green roofs have a minimum 5-inch depth soil profile and typically include a larger variety of plants and trees (Figure 4-5). Intensive green roofs can be elaborately designed and include large shrubs and trees, depending on the soil depth. These green roofs are required to be structurally sound to account for the additional weight from soil, plant, and water retention.

Both intensive and extensive green roof systems require installation of specialized soil media, drainage mats and overflow systems, and a waterproofing membrane.

A green roof's ability to manage stormwater runoff depends on its vegetation and the type and thickness of the soil mixture. The city of Portland, Oregon has reported that a green roof can capture and transpire 10 to 100 percent of the rainfall landing on the roof.

Green roofs reduce rooftop temperatures, decrease heating and cooling costs, help reduce the urban heat island effect, provide wildlife habitat, and can make buildings more attractive. In more densely developed areas where land value is at a premium, they also can provide additional green spaces for people to enjoy. Green roofs also work well in industrial uses where building footprints account for a large amount of impervious surface, and it is difficult to find enough land to manage stormwater on the ground.

Retrofitting conventional roofs with green roofs is possible, but it is necessary to determine whether the structure can accept the additional loading. The structural reinforcement needed for green roofs and the waterproof membrane are typically the highest costs in installing a green roof.



SOURCE: AMERICAN HYDROTECH, INC.

Figure 4-4: *Typical profile for an extensive green roof system.*

SOURCE: AMERICAN HYDROTECH, INC.

Figure 4-5: *Typical profile for an intensive green roof system.*

4.2 Pervious Paving

Figure 4-6: *Pervious paving used in the parking zone on a residential street in Portland, Oregon.*

Pervious paving systems provide the structural integrity needed for cars, trucks, and high traffic pedestrian areas, while allowing water to drain through the paving system and into soils below. There is a range of pervious paving types, from those that look most like traditional paving, such as pervious asphalt and concrete, to those that are indistinguishable from lawn, such as structural grass-paving systems.

Pervious paving should be limited to those locations in Northern Kentucky with well draining soils. Locations with poorly draining soils would require an underdrain system that would slow the water somewhat, but would not necessarily reduce overall volume.

Good Places for Using Pervious Paving:

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

Additional Benefits:

- Can be safer than traditional paving because puddles are less likely to accumulate
- Provide aesthetic appeal
- Define a distinctive community character
- Delineate parking areas
- Calm traffic

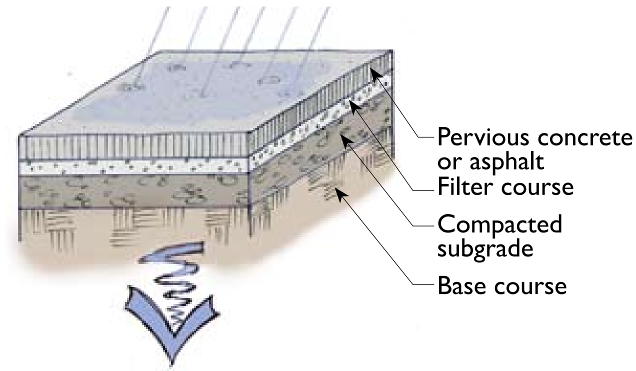


Figure 4-7: **Pervious concrete/asphalt.**

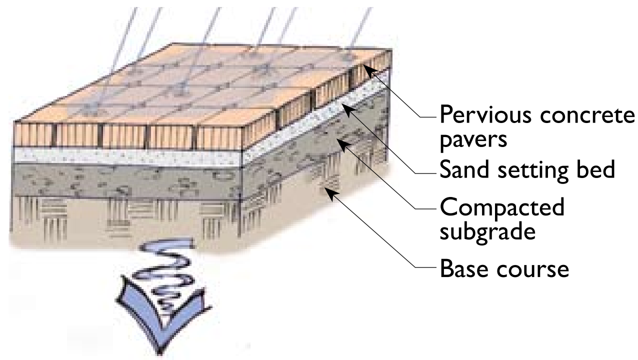


Figure 4-8: **Pervious concrete unit pavers.**

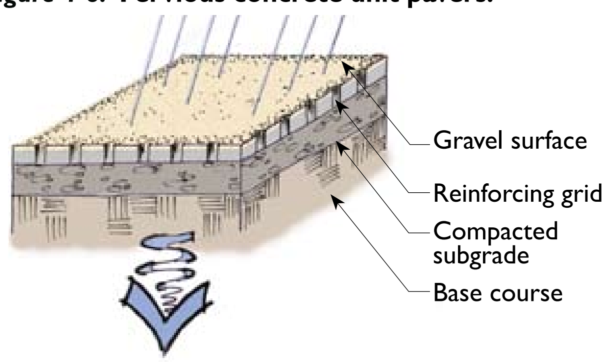


Figure 4-9: **Reinforced gravel paving.**

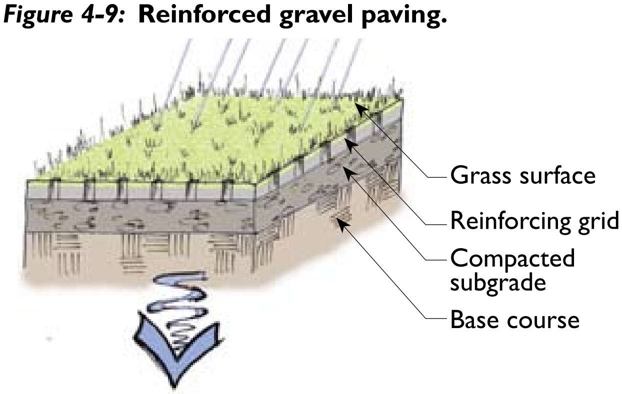


Figure 4-10: **Reinforced grass paving.**

Figure 4-11: *The difference between drainage on pervious asphalt and impervious asphalt is evident in this photo.*

SOURCE: NEVUE NGAN ASSOCIATES

Figure 4-12: *This residential driveway uses pervious pavers in San Mateo County, California.*

SOURCE: NEVUE NGAN ASSOCIATES

Figure 4-13: *A plastic grid system filled with gravel provides the structural strength to support a vehicle.*

SOURCE: NEVUE NGAN ASSOCIATES

Figure 4-14: *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.*

SOURCE: WWW.RITTER-TECHNIK.CO.UK

4.2 Pervious Paving

SOURCE: WWW.HANNEMANANDFINES.COM

Figure 4-15: *Pervious concrete allows water to pass through pore spaces in the aggregate.*

SOURCE: NEVUE NGAN ASSOCIATES

Figure 4-16: *Pervious concrete's light color helps reflect heat rather than absorb it.*

Pervious Asphalt and Concrete:

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

Pervious paving reduces the accumulation of puddles. 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. Pervious paving has been successfully used on interstates and other limited-access roads because there are no turning vehicles.

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.

SOURCE: NEVUE NGAN ASSOCIATES

Figure 4-17: *Pervious asphalt in the parking stalls at the Sanitation District No. 1 headquarters.*

Pervious 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. Interlocking concrete unit pavers are designed for stormwater management and allow water to pass through joint gaps that are filled with sand or gravel and infiltrate into a thick gravel sub-grade. This system is widely applicable to both small and large paving applications and allows a small section to be removed when repairs are needed.

Reinforced Gravel Paving:

A gravel paving 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.

Reinforced Grass Paving:

In the right situations, grass paving, 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 low-traffic areas.

SOURCE: ABBY HALL-EPA

***Figure 4-18:** Pervious pavers in a parking lot. Any overflow from the pervious pavers drains into a swale.*

SOURCE: NEVUE NGAN ASSOCIATES

***Figure 4-19:** A close-up view of gravel paving within a reinforced plastic grid system.*

SOURCE: NEVUE NGAN ASSOCIATES

***Figure 4-20:** Grass paving installed in a residential driveway.*

4.3 Rainwater Harvesting

Figure 4-21: *Residential rain barrels used for summertime irrigation.*

Rainwater harvesting has been used for thousands of years. It involves the capture of stormwater runoff from rooftops into containers for later use. This effectively slows and filters runoff before it reaches the drainage system. 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. Rainwater harvesting is a viable method of managing stormwater runoff volume in areas in Northern Kentucky with poorly draining soils where infiltration is difficult.

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 (see Figures 4-22 to 4-24). Systems can be as simple as disconnecting a residential downspout and directing the water to a rain barrel.

Good Places for Rainwater Harvesting:

- Large industrial buildings
- Office buildings
- Homes and garages

Additional 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 (see Figure 4-24)
- Systems can be a good educational tool to teach about watersheds

SOURCE: WWW.HARVESTINGWATER.COM

Figure 4-22: *Rainwater cisterns can come in all shapes and sizes.*

SOURCE: WWW.LAKECOUNTYIL.GOV

Figure 4-23: *Simple residential rain barrels are commonly used to capture and reuse rainwater for irrigation during dry periods.*

SOURCE: NEVUE NGAN ASSOCIATES

Figure 4-24: *This new LEED-certified building in Little Rock, Arkansas, included a large cistern in the interior stairwell of the building.*

4.4 Stormwater Swales

Swales are shallow landscaped areas designed to capture, convey, and potentially infiltrate stormwater runoff as it moves downstream.

SOURCE: ABBY HALL-EPA

Figure 4-25: *A new residential street incorporates a stormwater swale to collect stormwater runoff in Seattle, Washington.*

Swales are long, narrow, gently-sloping vegetated depressions in the landscape. They are primarily used to move stormwater runoff on the landscape surface. 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 storm drainage system. Swales can be planted with a variety of plants, ranging from turf 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.

Good Places for Swales:

- Subdivisions
- Arterial streets
- Parking lots

Potential Retrofit Opportunities:

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

Additional Benefits:

- Attractive neighborhood amenity

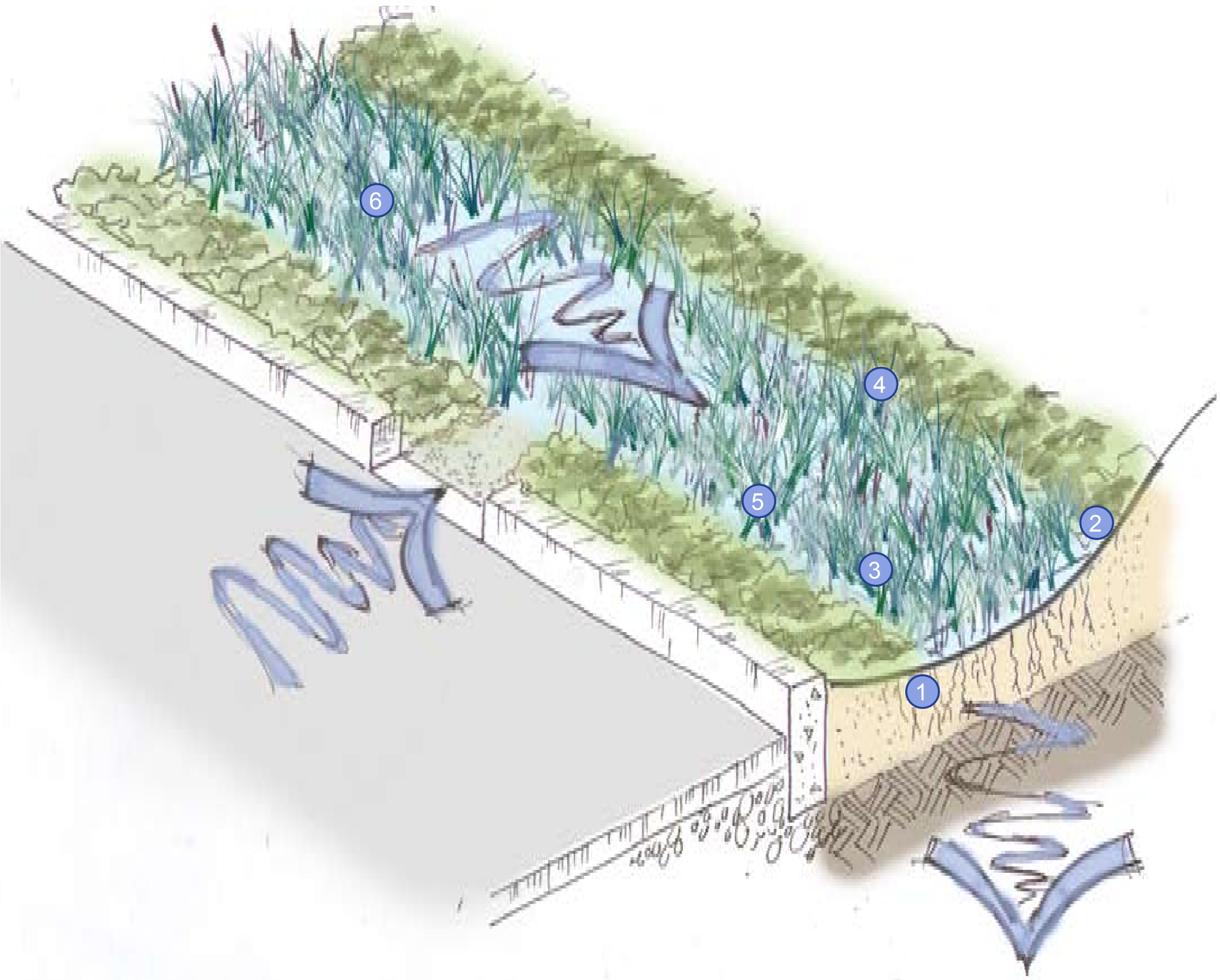


Figure 4-26: **Key Design Considerations for a Stormwater Swale**

1	Depth:	Maximum depth: 6 inches
	Side Slopes:	4:1 ideal, 3:1 maximum slope
	Bottom Width:	3 feet minimum, 7 feet maximum, rounded or flat
	Plants - Side Slopes:	Drought-tolerant ground covers and shrubs, 80% evergreen
	Plants - Bottom:	Wet-tolerant rushes, sedges, shrubs, and trees
	Longitudinal Slope:	6 % maximum

<u>Not shown:</u>

Check Dams:	At least 1 check dam for every 6 inches of vertical drop maximum
Trees:	In bottom of swale, drought tolerant and wet tolerant
Maintenance:	Keep entry and exit points clear of debris; ensure check dams retain correct water depth with no erosion or standing water 48 hours after rain event; weed and trim plants semi-annually

SOURCE: SEATTLE PUBLIC UTILITIES

***Figure 4-27:** A residential street with a stormwater swale.*

SOURCE: NEVUE NGAN ASSOCIATES

***Figure 4-28:** A potential residential street swale opportunity in existing planting strip. Dashed lines show where a vegetated swale could be added.*

SOURCE: KEVIN ROBERT PERRY - CITY OF PORTLAND

***Figure 4-29:** An elementary school parking lot with a stormwater swale.*

Swales and Streets

On a new street:

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 right-of-way that is underused.

On an existing street:

- Look for long, unplanted, unused median strips or planting strips between the sidewalk and the street.
- Can turn lanes be removed, travel lanes moved to center, and swales added on sides?
- Is there a way to move that water on the surface rather than in a pipe?
- Can travel lanes on a particular street be narrowed?
- Does a street effectively use on-street parking, or can that extra impervious area be consolidated into swales? Can parking be moved to one side and a swale be placed on the other side?

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.

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. An important design consideration is getting water away from the building foundation and lining swales to prevent foundation damage. Usually a minimum 10-foot clearance from the building is required.

SOURCE: NEVUE NGAN ASSOCIATES

Figure 4-30: *These parking spaces could be made just a few feet shorter to provide room for swales between rows of parked cars.*

SOURCE: NEVUE NGAN ASSOCIATES

Figure 4-31: *This stormwater swale at the Sanitation District No. 1 of Northern Kentucky headquarters collects runoff from the building's rooftop.*

4.5 Stormwater Planters

***Figure 4-32:** Stormwater planters are used to infiltrate stormwater runoff on a downtown street in Portland, Oregon.*

Planters are long, narrow, often rectangular landscaped areas contained within vertical walls and with flat, unsloped bottoms. Planters slow the flow of water and absorb water into plants and soils, reducing the volume and intensity of water flowing downstream. Infiltration planters infiltrate stormwater, while flow-through planters absorb only as much water as they are designed to hold within their walls.

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 as found in areas of Northern Kentucky. 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 overflow system provided.

Good Places for Planters:

- Urban areas
- Street furnishing zones
- Adjacent to buildings
- Parking lots

Potential Retrofit Opportunities:

- Near condominiums
- Street furnishing zones
- Between buildings

Additional Benefits:

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

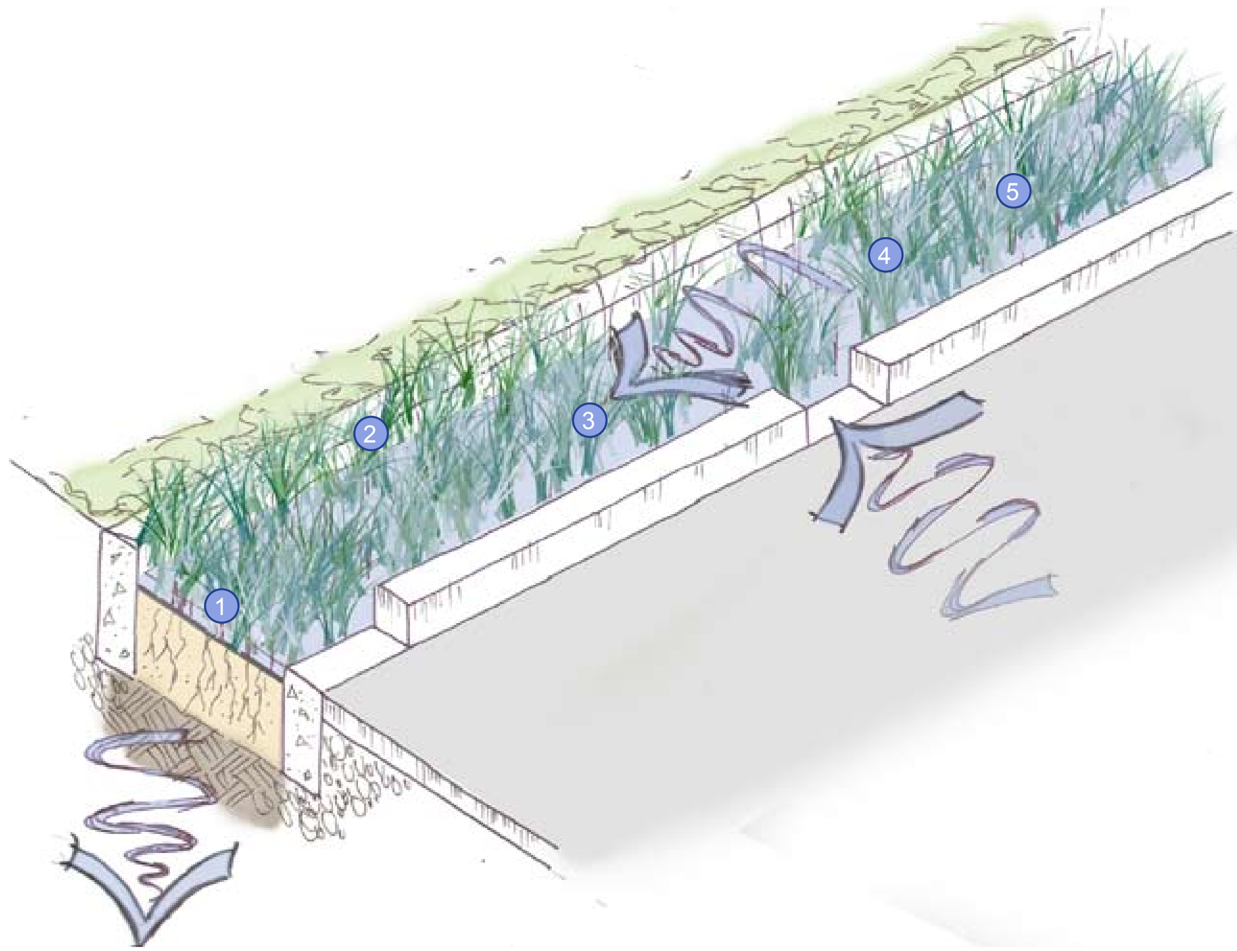


Figure 4-33: **Key Design Considerations for a Stormwater Planter**

1	Depth:	Maximum depth of 8 inches
2	Side Slopes:	None - vertical
3	Bottom Width:	Flat; sealed in flow-through planter, open in infiltration planter
4	Plants - Bottom:	Wet-tolerant rushes, sedges, shrubs, and tree
5	Longitudinal Slope:	Up to 6 %. If hillside is sloped more than 6% several planters can be terraced

Not shown:

Check Dams:	At least 1 check dam for every 6 inches of vertical drop maximum
Trees:	In bottom of planter, drought tolerant and wet tolerant
Maintenance:	Keep entry and exit points clear of debris; ensure check dams retain correct water depth with no erosion or standing water 48 hours after rain event; weed and trim plants semi-annually

4.5 Stormwater Planters

SOURCE: KEVIN ROBERT PERRY - CITY OF PORTLAND

Figure 4-34: *An urban street infiltration planter.*

SOURCE: NEVUE NGAN ASSOCIATES

Figure 4-35: *Planters can be retrofitted on urban streets with overly wide sidewalk zones. Dashed lines show where a planter could be added.*

SOURCE: NEVUE NGAN ASSOCIATES

Figure 4-36: *A narrow stormwater planter on the edge of a parking lot.*

Planters and Streets

On a new street:

Planters take up less space than other rain garden strategies and therefore are a good candidate for urban settings where parking, signs, and other street furnishings vie for valuable real estate.

On an existing street:

Planters are commonly used to retrofit dense urban streets because they can treat a lot of water in a relatively small footprint, and fit into places where traditional rain gardens wouldn't fit. Look for:

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

Planters and Parking Lots

In a new parking lot:

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

In an existing parking lot:

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;
- Overly wide travel lanes; or
- Angled or heado-in parking with unused space in front of each space.

Planters and Buildings

In a new building:

Flow-through and infiltration planters can be designed to fit the architecture of a building and treat its runoff. They offer many opportunities for artistic expression through the design of scuppers and interesting gutters.

In an existing building:

Flow-through planters are a good way to 'freshen up'' an old foundation planting. What is required is the ability to dig a deep enough hole next to the building to be able to line the planter to avoid seepage into the building's foundation (see Appendix M for methods to protect a building's foundation). Look for:

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

SOURCE: NEVUE NGAN ASSOCIATES

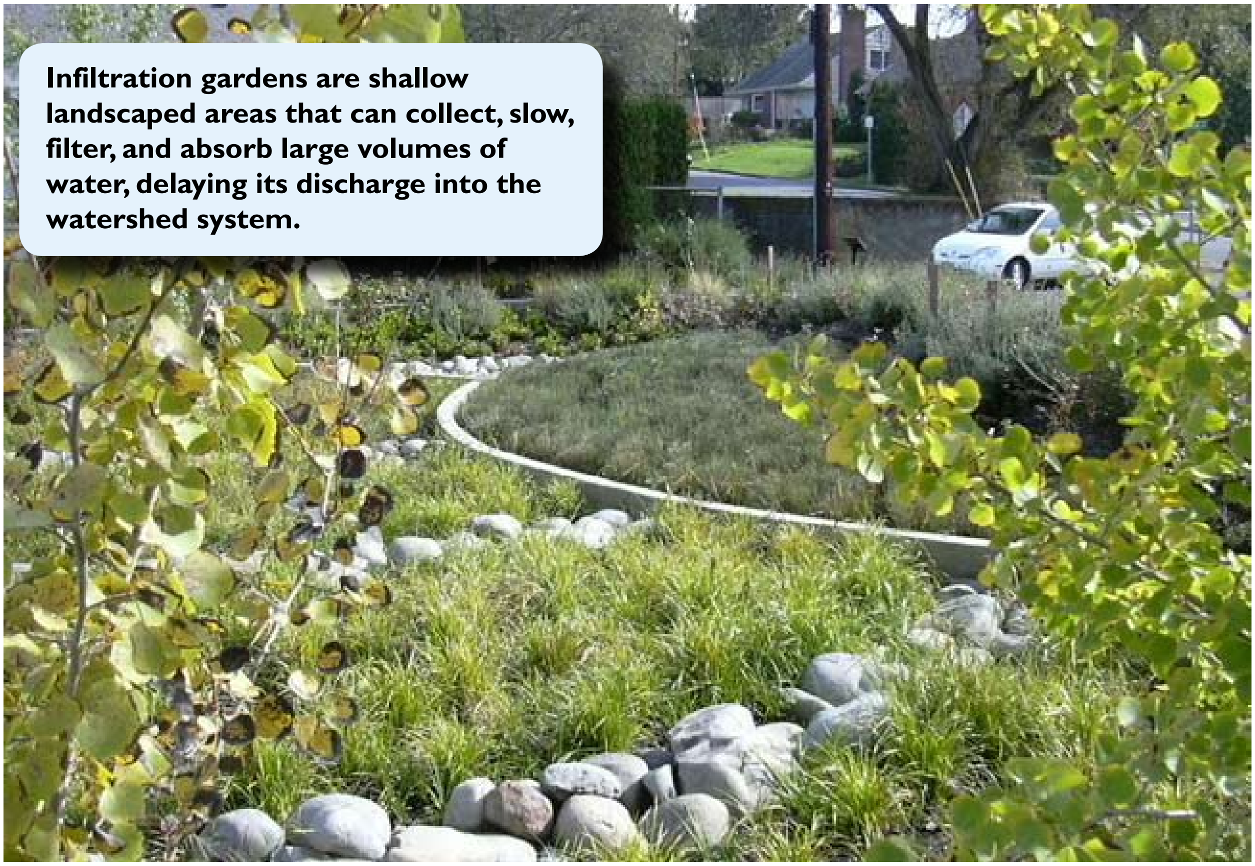
Figure 4-37: *A stormwater planter next to a multi-family complex.*

SOURCE: NEVUE NGAN ASSOCIATES

Figure 4-38: *A stormwater planter accepts stormwater runoff from a fast food restaurant's rooftop.*

4.6 Infiltration Gardens

Infiltration gardens are shallow landscaped areas that can collect, slow, filter, and absorb large volumes of water, delaying its discharge into the watershed system.



SOURCE: KEVIN ROBERT PERRY - CITY OF PORTLAND

Figure 4-39: *An infiltration garden adjacent to an elementary school in Portland, Oregon.*

Infiltration gardens are shallow, vegetated depressions in the landscape. Like swales, they typically have side slopes and flat bottoms. They can be any size or shape and are often molded to fit in "leftover" landscape spaces in parking lots, at intersections with diagonal streets, or in underused areas around buildings. They can be designed as one connected space, rectilinear or rounded, and are often as wide as they are long.

As the name suggests, infiltration gardens infiltrate stormwater and therefore are suitable primarily in locations with well-draining soil. Although infiltration gardens have similarities with swales and planters, they are categorized as a separate strategy based on the spaces in which they fit. Their primary advantage is their versatility in size and shape.

Good Places for Infiltration Gardens:

- Parking lots
- Awkward street intersections
- Adjacent to buildings
- Under-utilized spaces

Additional Benefits:

- Beautifies and softens parking lots and streets by adding plants
- Courtyards; or
- Garden areas that can be redesigned to accommodate stormwater runoff

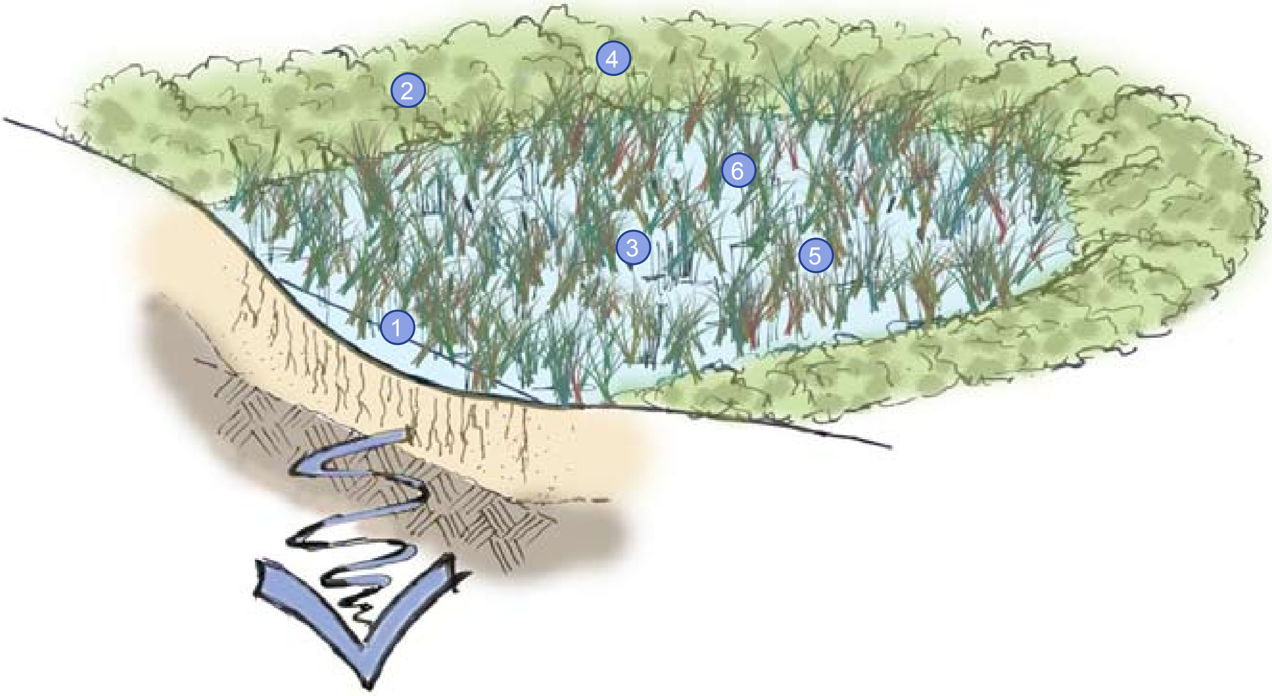


Figure 4-40: **Key Design Considerations for an Infiltration Garden**

1	Depth:	Maximum depth of 8 inches
2	Side slopes:	Can be vertical, or have side slopes
3	Bottom Width:	Flat, open to infiltrate into native soil
4	Plants - Side Slopes:	Drought-tolerant ground covers and shrubs, 80% evergreen
5	Plants - Bottom:	Wet-tolerant rushes, sedges, shrubs, and trees
6	Slope:	None - used to pond and infiltrate water

Not shown:

Check Dams:	Used to promote ponding of water and aid in grading if facility is not in a flat location
Trees:	In bottom of infiltration garden, drought tolerant and wet tolerant
Maintenance:	Keep entry and exit points clear of debris; ensure check dams retain correct water depth with no erosion or standing water 48 hours after rain event; weed and trim plants semi-annually

4.6 Infiltration Gardens

SOURCE: NEVUE NGAN ASSOCIATES

***Figure 4-41:** Large under-used areas of asphalt can easily be converted into infiltration gardens.*

SOURCE: NEVUE NGAN ASSOCIATES

***Figure 4-42:** A triangle-shaped infiltration garden retrofitted along a busy arterial street.*

SOURCE: NEVUE NGAN ASSOCIATES

***Figure 4-43:** An infiltration garden retrofitted within a middle school's parking lot.*

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 in central medians.

On an existing street:

Many downtowns, industrial areas, neighborhoods, and rural areas have large areas of unused or inefficiently used 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 requiring more treatment area than swales and planters can provide. 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 can be taken over for infiltration gardens. Look for:

- Parking lots with excess spaces;
- Parking lots with underused landscaped or asphalt areas nearby; or
- Parking lots with very long stalls or wider than necessary travel lanes that could be redesigned to create space for an infiltration garden.

Infiltration Gardens and Buildings

Near a new building:

Imagination is the limit to the ways in which infiltration gardens can complement building architecture. 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.

SOURCE: TOM LIPTAN - CITY OF PORTLAND

Figure 4-44: *An infiltration garden installed within an apartment complex in Portland, Oregon.*

SOURCE: KEVIN ROBERT PERRY - CITY OF PORTLAND

Figure 4-45: *A large infiltration garden accepts stormwater runoff from a middle school's rooftop.*

4.7 Stormwater Curb Extensions

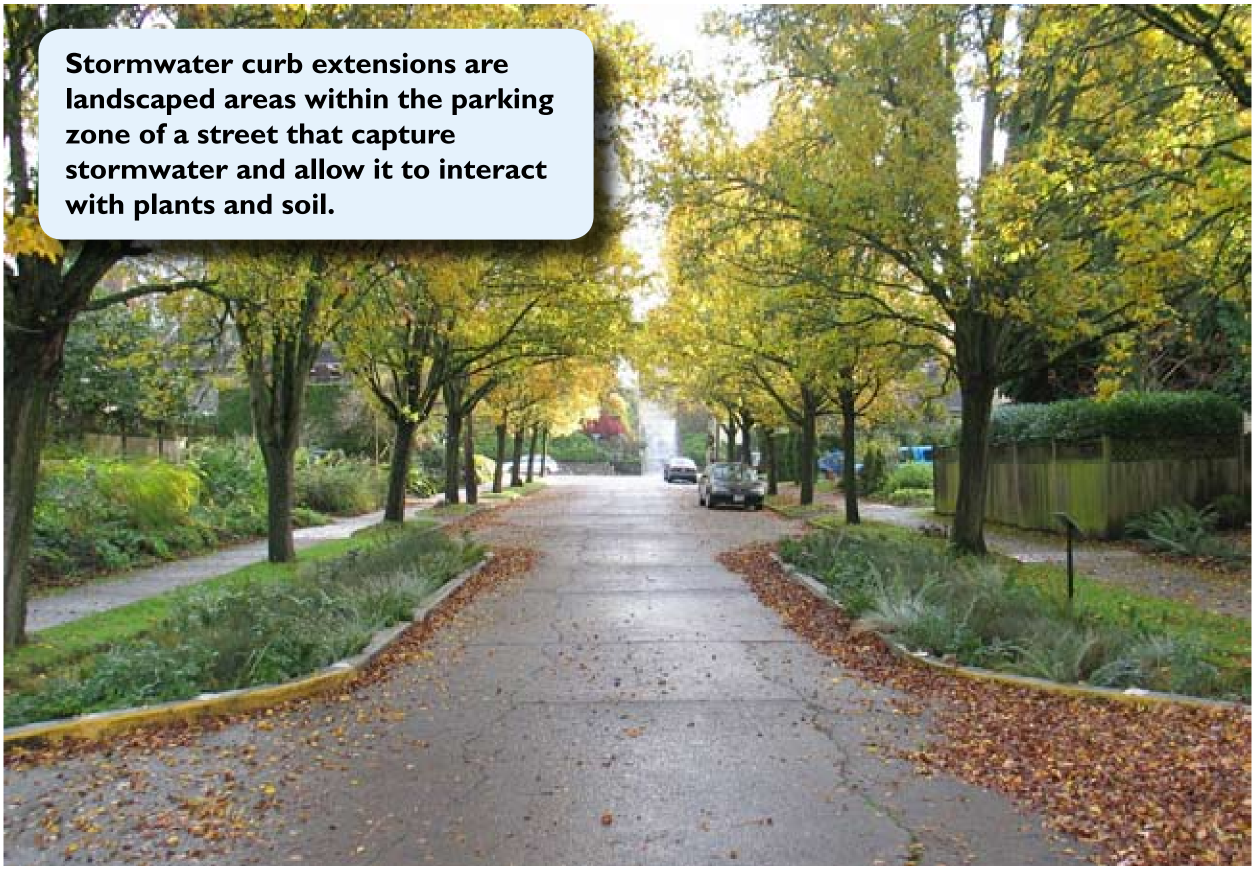


Figure 4-46: *Stormwater curb extensions used on a residential street in Portland, Oregon.*

Conventional curb extensions, also known as curb 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. Within the curb extension boundary, they share the characteristics of swales, planters, or infiltration gardens, but are discussed independently due to their unique street application.

Curb extensions intercept water running along a curb and gutter before it reaches the catch basin. 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 where soil permits 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.

Good Places for Curb Extensions:

- At entry of slower residential street from a busier street to calm traffic

Additional Benefits:

- Beautifies the street
- Creates shorter crossing distances for pedestrians and calm traffic

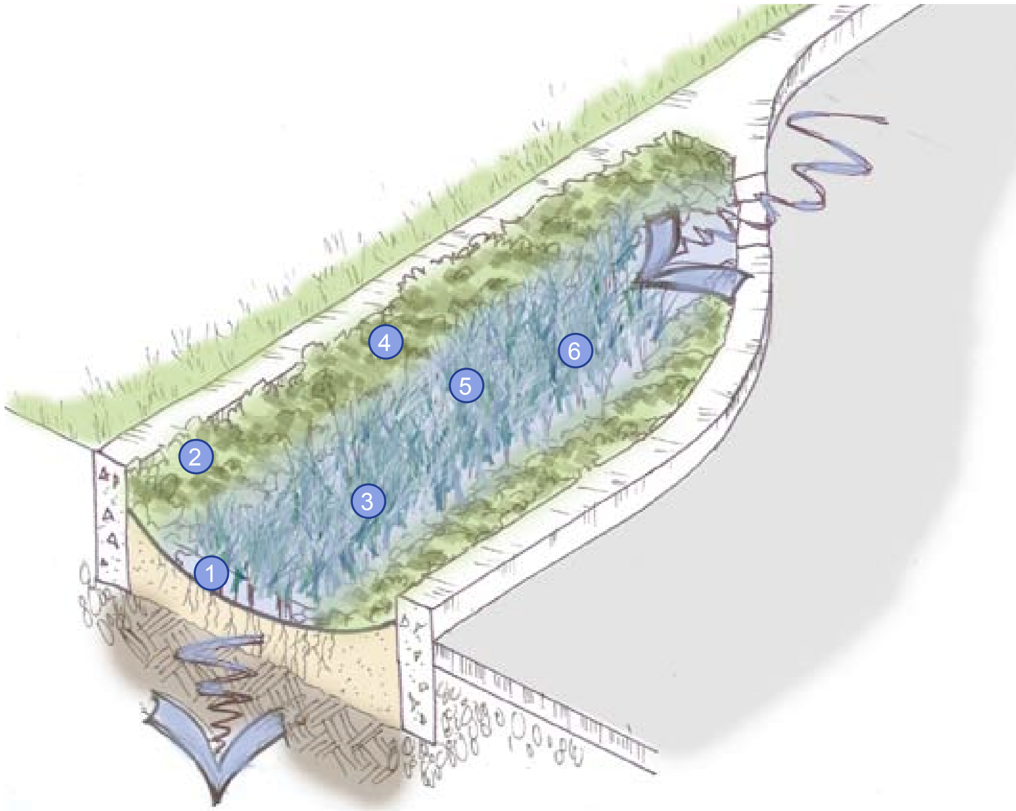


Figure 4-47: **Key Design Considerations for a Stormwater Curb Extension**

1	Depth:	Maximum depth of 8 inches
2	Side Slopes:	Can have vertical walls or side slopes, depending on street context
3	Bottom Width:	3 feet wide minimum, rounded or flat; can be sealed, as in a flow-through planter, or open as shown
4	Plants - Side Slopes:	Drought-tolerant ground covers and shrubs, 80% evergreen
5	Plants - Bottom:	Wet-tolerant rushes, sedges, shrubs, and trees
6	Longitudinal Slope:	Up to 6%. If hillside is sloped more than 6%, several planters can be terraced

Not shown:

Check Dams:	Used to promote ponding of water and aid in grading if facility is not in a flat location
Trees:	In bottom of curb extension, drought tolerant and wet tolerant
Maintenance:	Keep entry and exit points clear of debris; ensure check dams retain correct water depth with no erosion or standing water 48 hours after rain event; weed and trim plants semi-annually

4.7 Stormwater Curb Extensions

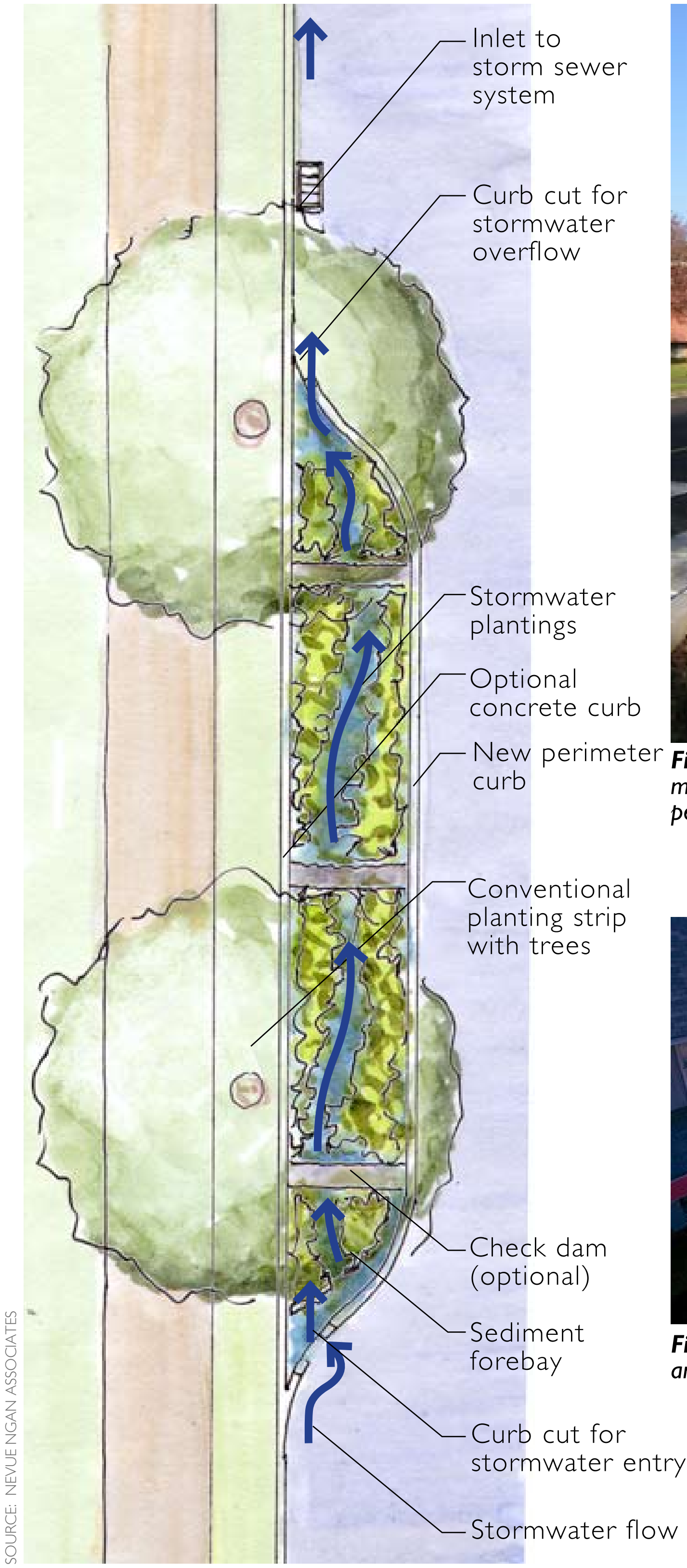


Figure 4-48: *A diagram of how stormwater runoff typically flows within a stormwater curb extension.*

Figure 4-49: *Curb extensions can provide stormwater management opportunities and safer crossings for pedestrians.*

Figure 4-50: *Curb extensions can fit nearly anywhere and help calm traffic to protect pedestrians.*

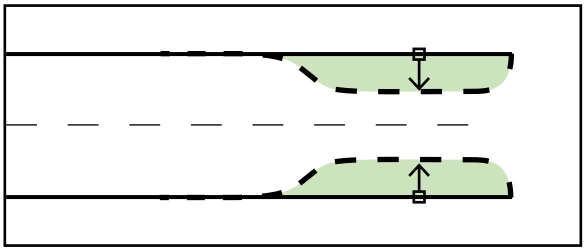


Figure 4-51: *Stormwater curb extensions commonly have a symmetrical orientation at intersections.*

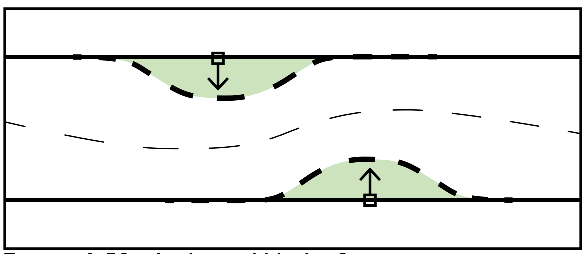


Figure 4-52: *At the mid-block of a street, stormwater curb extensions can have be symmetrical or staggered orientation.*

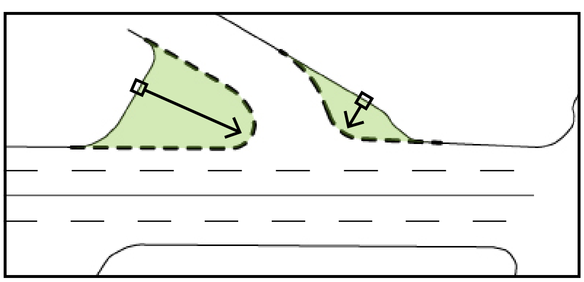


Figure 4-53: *When streets connect at odd angles, stormwater curb extensions can help create safer pedestrian crossings as well as manage stormwater runoff.*

SOURCE: DAVE ELKIN - CITY OF PORTLAND

Figure 4-54: *Accessible pedestrian ramps can also be integrated into the design of stormwater curb extensions.*

SOURCE: NEVUE NGAN ASSOCIATES

Figure 4-55: *A pair of stormwater curb extensions installed along a neighborhood street.*

SOURCE: NEVUE NGAN ASSOCIATES

Figure 4-56: *A large stormwater curb extension retrofit along a busy arterial street.*

4.8 Downspout Disconnection

Figure 4-57: *Roof downspouts can be easily disconnected and allow runoff to flow into surrounding landscaped areas.*

Downspout disconnection is one of the simplest ways that a homeowner, even one with a small yard, can help with stormwater management. Most gutters and downspouts are connected to the public storm sewer or a combined sewer system. Disconnecting the downspouts and 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.

Downspout disconnection can be easily integrated with rainwater harvesting (see Section 4.3 for more details about rainwater harvesting).

Good Places for Downspout Disconnection

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

Additional Benefits:

- Educates homeowners about watershed system
- Is a simple action that almost everyone can take to contribute to comprehensive stormwater management strategies in a community

SOURCE: NEVUE NGAN ASSOCIATES

Figure 4-58: An office building in Covington has disconnected roof downspouts that allow water to flow into a landscaped area.

SOURCE: NEVUE NGAN ASSOCIATES

Figure 4-59: A residential example of downspout disconnection in Covington.

SOURCE: CITY OF PORTLAND

Figure 4-60: An example of allowing water to cascade from a building rooftop into a landscaped area.