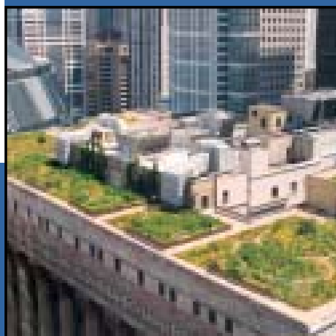
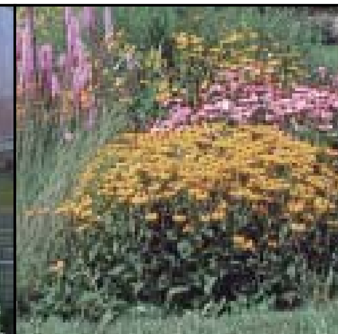
A Guide to
Stormwater Best Management Practices

Chicago's Water Agenda




City of Chicago
Richard M. Daley
Mayor

A Message From
Mayor Richard M. Daley

Like the air we breathe, water is a vital natural resource and an important part of our quality of life. We all need to be aware of the importance of water in our daily lives and we must protect it now, so that it never becomes an endangered resource. We must take this into account when designing residential, commercial and industrial developments.

As part of Chicago's Water Agenda, the City is demonstrating and promoting innovative alternatives to managing stormwater, including roof gardens, permeable paving surfaces and rain gardens. These are examples of attractive and water-friendly alternatives to conventional stormwater management practices.

The use of Best Management Practices for stormwater can be a cost-effective means to protect our water resources. The City of Chicago is using these Best Management Practices to address issues of water quality and water quantity in a way that is easier on our shared water resource, our pocketbook, and our quality of life.

This booklet highlights eight practices as a guide to evaluating options in managing stormwater. I encourage you to consider these practices when preparing for stormwater at your home and place of business.

Remember, because of our location at the edge of Lake Michigan, we have a special responsibility to protect our water resources. Stormwater management is one important part of a comprehensive series of action steps to conserve, protect and manage our water resources for future generations.

Richard M. Daley, Mayor
City of Chicago

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Introduction

"Chicago's world-class status is owed largely to its position at the confluence of the Chicago River and Lake Michigan. These waterways signified transportation and trade to Chicago settlers and continue to attract millions of visitors to our city every year.

Beyond the Lake Michigan shoreline, our water resources extend beyond, and beneath, the City. They are the Chicago River, Lake Calumet, the Calumet River, thousands of acres of wetlands, creeks, streams, and lagoons, as well as canals and channels. Equally important are the thousands of miles of pipes, man-made tributaries, that have – for over a hundred years – delivered drinking water and helped us manage stormwater.

These resources are critical to our public health, safety, economy and quality of life. They provide recreational opportunities like boating, fishing and swimming. Our waterways provide natural experiences in an urban setting. We are fortunate to live near some of the cleanest drinking water in the world." City of Chicago's Water Agenda 2003, released by Mayor Richard M. Daley, April 8, 2003.

This guide is intended to be a first step in addressing the challenge of better managing our water. Specifically, it provides guidance to developers, residents, and other community members on methods to protect our water resources by reducing the amount of stormwater draining into the sewer system and local waterways.

Stormwater runoff from developed land in the City of Chicago causes a number of problems when it is not effectively managed. Excess stormwater can cause basement and street flooding, as well as overflows to the Chicago River and backflows to Lake Michigan that result in beach closings. Where stormwater is discharged directly to waterways, such as the Chicago River, it degrades water quality. Since most runoff in the City is captured by combined sewers and routed to treatment plants, increased runoff raises the cost of wastewater pumping and treatment by the Metropolitan Water Reclamation District.

When does stormwater become a problem rather than a resource? First, we need to understand how stormwater moves through the City. Increased stormwater runoff is caused principally by impervious (impenetrable) surfaces – conventional rooftops, parking lots, roads, alleys, playgrounds, and sidewalks. Developers typically seek to rapidly move stormwater away from the development site via gutters, sewers and artificial channels. While this approach is intended to prevent local flooding and undesired water ponding, it may actually cause flooding. It also short-circuits the opportunity for water to naturally soak into the ground – to water plants and recharge groundwater resources.

Fortunately, there are both proven and evolving alternatives to conventional drainage techniques and site designs that can substantially reduce surface runoff quantities and resultant pollutant loadings. These alternative development techniques, commonly called Best Management Practices or BMPs, are aimed at soaking up every drop of rainwater close to where it falls. Common goals of Best Management Practices are to:

- reduce the amount of impervious surface areas to reduce stormwater runoff; and
- utilize the landscape and soils to naturally move, store and filter stormwater runoff before it leaves the development site.

While it is true that some of the Best Management Practices recommended in this guide will require a rethinking of current stormwater design philosophy, there are many opportunities to incorporate the recommended approaches on most development sites, including design layouts for individual buildings and larger developments. Many of these practices can reduce both construction costs and long-term maintenance costs. Every development can benefit by applying Best Management Practices. In assessing which practices are best for a site, it's necessary to consider site features, size, location, and usage.

In some cases, concerns have been raised about maintenance, public safety, and aesthetics. Developers sometimes perceive environmentally conscious designs as being more expensive and less marketable to buyers. They are also concerned about possible time delays in getting approvals for non-conventional project designs. These types of concerns generally can be addressed through better information, improved design guidance, and public education.

A number of national organizations, such as the Urban Land Institute, National Association of Home Builders, and American Society of Civil Engineers have clearly documented the rationale for and advantages of alternative site design approaches incorporating Best Management Practices.

Natural drainage practices, in combination with design approaches that minimize impervious areas, can significantly reduce development costs. These savings can improve construction affordability and maintain acceptable standards of public health, safety and welfare.

Drainage swales are one of the Best Management Practices that can effectively move water from parking and other areas.

Stormwater Runoff Impacts

Stormwater runoff causes two key impacts: (1) excess water volume, or quantity, and (2) degraded water quality.

Runoff quantity is affected by the addition of impervious surfaces and by soil compaction caused by grading activities. These changes dramatically increase the rate and volume of stormwater runoff, and reduce the opportunity for natural absorption and groundwater recharge. Further, site grading and drainage devices, such as storm sewers and lined or compacted channels, eliminate natural depressions and convey runoff water downstream at a much faster rate. This causes a number of negative consequences:

Increased flooding: Flood flow rates can increase by 100 to 200 percent or more without effective stormwater controls. In Chicago, excess stormwater increases the frequency and severity of basement and street flooding.

Combined Sewer Overflows: When there is too much stormwater entering Chicago's combined wastewater and stormwater sewers, the sewers overflow, and untreated waste and stormwater is released into the Chicago River.

Backflows to Lake Michigan: Due to large volumes of water in sewers, in severe storm conditions excessive runoff requires the opening of structures that allow flow of contaminated waters to Lake Michigan. Elevated pathogen levels associated with backflows result in beach closings, which have been shown to be on the rise in recent years. Backflows also contribute various pollutants to Lake Michigan that degrade near-shore water quality.

Chicago's Green Bungalows program encourages the use of green roofs. Green roofs are one of the many BMPs that will be recommended in this guide to handle stormwater runoff.

Urban stormwater is contaminated with a number of pollutants including sediment, heavy metals, petroleum-based hydrocarbons, nutrients, pesticides, chlorides, bacteria and oxygen-demanding organic matter. Stormwater runoff quality is a particular concern for developments that drain directly to the river system. Impacts include sediment contamination, toxicity to aquatic life, bacterial contamination, and excessive phosphorus and other nutrients in the water body (causing unwanted algae growth in rivers and lakes).

Much can be done to address these issues and utilize stormwater as the resource that it is.

OVERVIEW

This guide presents several practical site design and drainage Best Management Practices for developments in the City of Chicago. Most of the Best Management Practices apply to residential, commercial and industrial developments. All of them are effective in reducing the quantity and improving the quality of stormwater runoff. The guide provides the following information for each of the recommended Best Management Practice approaches:

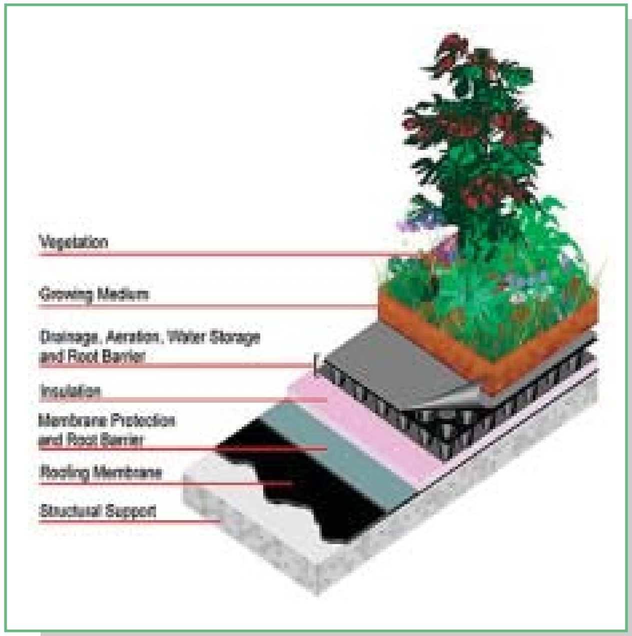
- a description of the Best Management Practice, its effectiveness and other benefits;
- applicability to different urban development and redevelopment settings;
- maintenance considerations;
- cost considerations compared to conventional designs; and
- local examples.

Although this guide is designed to provide enough information to begin a conversation on the use of Best Management Practices to manage stormwater runoff, it is not the intent of this guide to provide in-depth "how to" guidance. There are a number of detailed manuals that provide technical guidance for designing and installing alternative stormwater and site design techniques. These references are included in the back of this guide.

It is recommended that Best Management Practices be combined in sequence to maximize their benefits. This design philosophy is known around the country by terms such as the *runoff reduction hierarchy* or *stormwater treatment train.* Examples of integrated applications for urban residential and commercial/ institutional sites are provided at the end of the guide.

Natural landscaping is another BMP that can help manage stormwater and be aesthetically pleasing at the same time. Shown here is the Peirce School of International Studies in Chicago.

GREEN ROOFS



"Green" roofs are layers of living vegetation installed on top of buildings, from small garages to large industrial structures. They help manage stormwater and contribute to improved water quality by retaining and filtering rainwater through the plant's soil and root uptake zone. The water that does leave the roof is slowed, kept cooler and is filtered to be cleaner. Green roofs can also further insulate the building, reducing cooling and heating costs.

Key considerations for implementing green roofs include the structural and load-bearing capacity of the building, plant selection, waterproofing, and drainage or water storage systems. The quantity of rainfall retained or detained by a green roof can vary. For small rainfall events little or no runoff will occur and the majority of the precipitation will return to the atmosphere through evaporation and transpiration. It has been estimated that green roofs, in comparison to conventional roofs, can reduce cadmium, copper and lead in runoff by over 95 percent and zinc by 16 percent; nitrogen levels also can be diminished.

In addition to the stormwater benefits, green roofs extend the life of roofs two to three times. They can help preserve habitat and biodiversity in an otherwise sterile urban environment. Green roofs can also improve air quality by helping to reduce the "urban heat island" effect. Finally, they can provide garden areas and attractive views for other buildings.

The two most effective types of green roofs are:

- Extensive systems, with 2 to 4 inches of soil, 12 to 40 pounds per square foot of roof area, short plants with shallow root systems, and easy maintenance. Extensive systems absorb stormwater and provide insulation.

- Intensive systems are similar to gardens on the ground. They have a minimum of 6 to 12 inches of soil, 80 to 150 pounds per square foot, host deeper-rooted plants, including shrubs and trees, and require more maintenance. This type of roof provides more stormwater benefits, including insulation, water filtration, storage and increased habitat opportunities.

Applicability

In both new building designs and rehab opportunities, the load-bearing capacity of the roof may dictate the most appropriate type of system. Green roofs are appropriate in most of the properties in the City including *residential, commercial, industrial and institutional* properties.

Maintenance Considerations

Once a green roof is well established, maintenance requirements are usually minimal. Maintenance requirements may include inspection of the roof membrane and drainage flow paths. Some watering may be required during the first few years when root systems are getting established. Depending on the dimensions of the planting, some weed removal may be necessary as well. Of course, the more complex the garden, the more it needs to be maintained like a typical garden.

Cost Considerations

In the United States, green roof costs - including everything from waterproofing to plants - tend to range from $18 to $25 per square foot, depending on how intensive the system is. The initial capital and ongoing maintenance costs of a green roof are offset by some long-term cost savings - most notably roof maintenance and replacement and utility costs. A vegetated roof, on average, can be expected to prolong the life of a conventional roof by at least 20 years because the vegetation prevents the roof from being exposed to ultraviolet radiation and cold winds.

Local Examples

As part of the City's Urban Heat Island Initiative, a 20,300 square foot semi-extensive green roof was installed in 2000 on top of Chicago's City Hall. The rooftop garden was the first of its kind in Chicago (right). Many sites throughout Chicago have worked to establish rooftop gardens, especially container collections. The Chicago Center for Green Technology has established an extensive green roof and has also installed nine test plots to monitor water quality and quantity aspects of different types of green roofs. The Garfield Park Conservatory is conducting a study demonstrating a variety of plants, roof slopes, depths and types of media used in green roof systems.

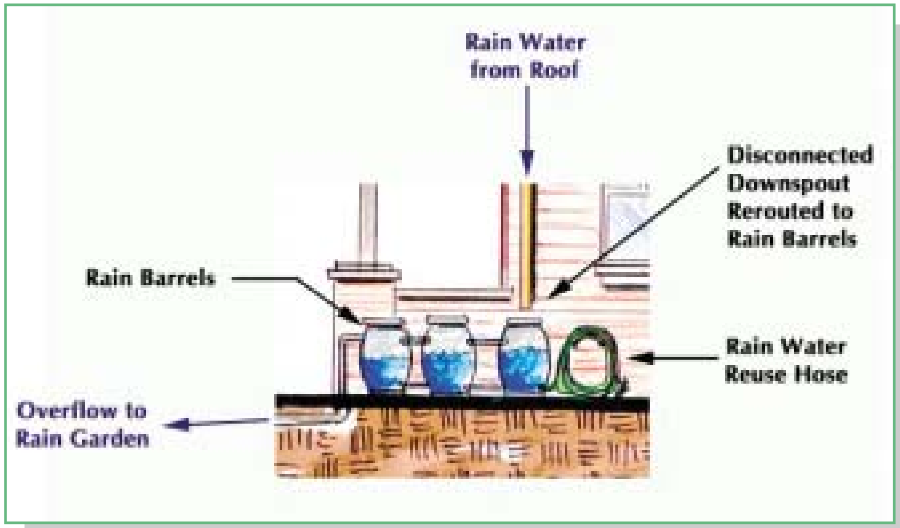
Green roof on top of Chicago's City Hall.

Downspouts, Rain Barrels and Cisterns

Traditionally, roof runoff in Chicago has been routed via downspouts directly into the sewer system. However, the City of Chicago encourages the careful disconnection of downspouts so that roof runoff can flow directly into vegetated areas. There are several options for doing this:

- Runoff can be sheeted across the lawn (see *"filter strip"* discussion).
- Runoff can be routed via a surface swale into a *rain garden* or onsite *detention* or *retention* facility (see separate discussions of these approaches).
- Runoff can be temporarily stored in *rain barrels* or *cisterns*.

Rain barrels can effectively capture and store the runoff from small to moderate storms. The stored water then can be used to irrigate lawns and landscaped areas in between storm events.



Why take from the lake what you can get from the sky? Lawn and landscape irrigation can be provided by rain barrels.

The effectiveness of rain barrels (or cisterns) is a function of their storage volume in comparison to the size of the roof. In a simple residential example, a 1,200 square foot roof could utilize 55-gallon barrels to store runoff from downspouts at the four corners of the house. The resultant storage is equivalent to about 0.3 inches of runoff. While this volume will not substantially reduce flooding from large storms, it can considerably reduce direct runoff from smaller storms and divert water from the combined sewer system. The actual effectiveness of this approach will depend on the regular draining of rain barrels (such as for irrigation) between storm events. In that respect, rain barrels are most effective when used during the growing season.

Applicability

Effective downspout disconnection requires that there be adequate landscaping or vegetation available to accept the water. Rain barrels are appropriate where vegetation is limited, provided that the collected water can overflow to open green space areas. Diversion and/or storage of roof runoff with rain barrels or cisterns is applicable to most *residential, commercial and institutional* properties in the City.

Maintenance Considerations

Occasional cleaning may be necessary to remove debris, such as leaves, coming off the rooftop. A mesh filter can be inserted at the top of a rain barrel. The barrel must be sealed during the warm months of the year to avoid mosquito breeding. To avoid freezing, the rain barrel should be drained prior to winter.

Cost Considerations

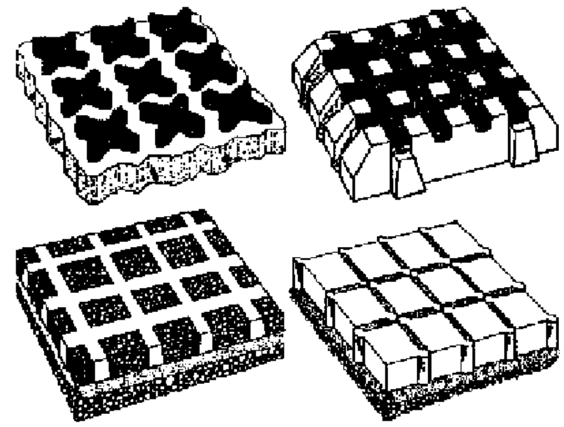
Typical costs for a ready-made rain barrel range from $20 to $150. Homeowners can reduce costs by making their own.

Local Examples

Much of the rain that falls on Chicago Center for Green Technology's roof flows into four 3,000-gallon cisterns and is later used to water the landscape (right). Some of Chicago's Green Bungalows utilize rain barrels in yard and garden areas (below).

PERMEABLE PAVING

Permeable paving refers to paving materials – typically concrete, stone or plastic – that promote absorption of rain and snowmelt. The discussion that follows focuses primarily on one form of permeable pavement – paving blocks and grids, as they are the most common and available type of permeable paving. These modular systems contain openings that are filled with sand and/or soil. Some can support grass or other suitable vegetation, providing a green appearance. A portion of rainfall is trapped in the block's depressions and infiltrates into the underlying soil.



Paving Blocks and Grids

Permeable paving is effective in reducing the quantity of surface runoff, particularly for small to moderate-sized storms. It also reduces the runoff pollutants associated with these events. Permeable paving in Chicago will be most effective in areas closer to Lake Michigan that are underlain with sandy, permeable soils. Effectiveness can be improved by designs that:

- maximize the openings in the paving material and
- provide an effective permeable sub-layer (e.g., at least 12 inches).

Permeable paving may have aesthetic and marketing advantages over conventional paving, depending on the materials selected. Vegetated pavers, in particular, could substantially improve the aesthetic appeal of paved areas. Vegetated pavers also can be effective in reducing the "urban heat island" effect.

An alternative form of permeable paving is porous pavement that relies on larger particles in the aggregate to rapidly infiltrate precipitation into an underlying stone "reservoir." While not discussed at length in this guide, porous pavement may be a suitable option for certain low-impact applications. Porous pavement may be prone to clogging, be adversely affected by the freeze/thaw cycle and can have higher maintenance requirements than permeable paving. However, some recent reports - mostly from warmer climates - conclude that porous pavement may be a reliable, cost-effective alternative. One key consideration when using porous pavement is to ensure that the aggregate is sufficiently durable.

Applicability

Permeable paving is particularly appropriate for the following applications: *overflow and special event parking, driveways, utility and access roads, emergency access lanes, fire lanes and alleys.*

Maintenance Considerations

Vegetated paving blocks may require occasional mowing. Snow plowing may require special care due to the slightly uneven surface of the pavement.

Cost Considerations

Installation costs for permeable paving can be as much as two to three times greater than conventional concrete or asphalt. However, there are indications that permeable paving requires less frequent replacement. Also, because it substantially reduces runoff quantities, permeable paving can substantially reduce related stormwater engineering and infrastructure (e.g., curbs, gutters and storm sewer) costs. These savings can at least partially offset the higher installation costs.

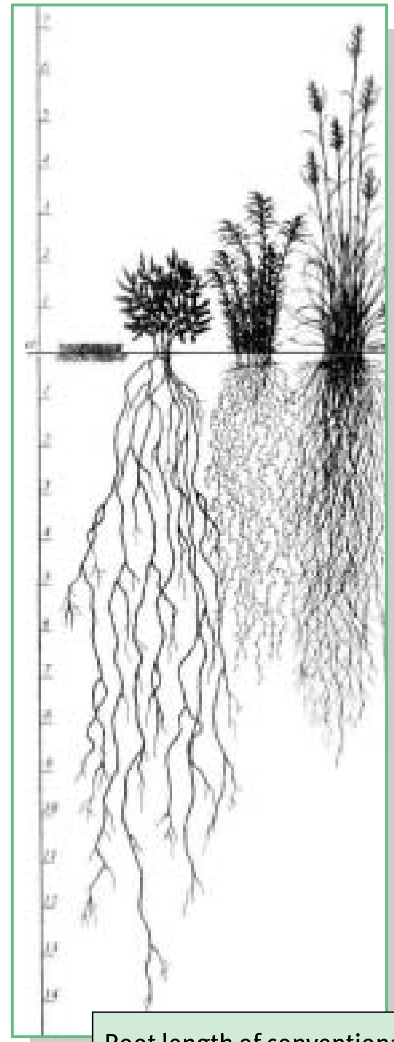
Local Example

Gad's Hill Center at 1919 W. Cullerton uses permeable paving for its parking lot (left). The Chicago Department of Transportation used paving blocks in a demonstration project in the 48th Ward. The Chicago Center for Green Technology (right) has permeable paving in the demonstration garden area.

NATURAL LANDSCAPING

Natural landscaping refers to the use of native vegetation – particularly prairie, wetland and woodland species – on a development or redevelopment site. Native vegetation is a low-cost alternative to traditional landscaping that utilizes turf grass and ornamental plantings.

A site that is naturally landscaped will produce substantially less stormwater runoff than a conventional landscape. Native vegetation enhances both absorption of rainfall and evaporation of soil moisture due to extensive root systems that extend down 3 to 10 feet or more. In contrast, the root zone of turf grass typically extends only about 3 to 4 inches. The benefits of natural landscaping are enhanced if runoff from impervious surfaces is routed across native vegetation buffer strips. A local residential site assessment indicated that annual storm runoff volumes from a residential development could be reduced by as much as 65 percent by utilizing swales and filter strips with native wet prairie and prairie vegetation. Similarly, natural landscaping reduces pollutants associated with urban runoff. In the residential site assessment, it was estimated that removal rates for suspended solids and heavy metals (such as cadmium and lead) could be as high as 80 percent and removal rates for nutrients (such as phosphorus and nitrogen) could be as high as 70 percent for a residential development utilizing natural drainage and native landscaped filter strips.



Root length of conventional turf grass (left) as compared to native plant roots (right).

In addition to reducing stormwater runoff, natural landscaping provides a host of other benefits. Deep-rooted native plants effectively stabilize soils and prevent erosion along streambanks and detention basin edges. The reduced maintenance needs of natural landscaping not only save money, but also reduce air, water and noise pollution. Natural landscaping also provides habitat for native and migrating birds, butterflies, and insects. Natural landscapes, especially trees, also moderate temperature extremes (such as the "urban heat island" effect), resulting in reduced heating and air conditioning costs. Finally, natural landscaping provides four seasons of color and textures not commonly found in conventional landscapes and requires less maintenance over time.

Applicability

Natural landscaping is feasible on nearly all sites as an alternative to conventional landscaping. It should be tailored to individual site characteristics, factoring in topography, soils, drainage patterns and sun exposure. On some sites natural landscaping can be installed or preserved in an informal setting; on others, native plants can be used in more formal settings in place of imported species. Suggested site applications include: *river or wetland edges, detention basin and drainage features, parks, green roofs, residential areas and gardens, commercial, industrial and institutional developments.*

Maintenance Considerations

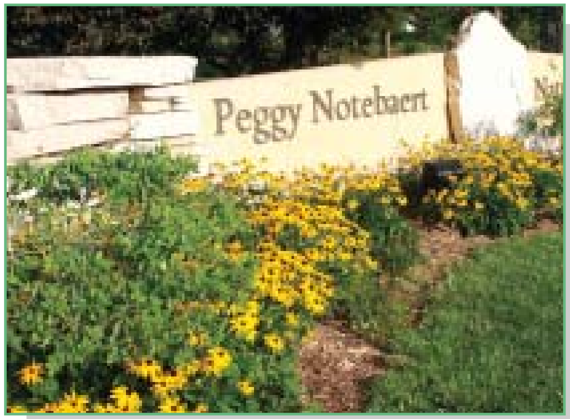
Natural landscaping requires much less maintenance – less irrigation, mowing, fertilizer and pesticides – than conventional landscaping. Natural landscape maintenance typically involves annual mowing or controlled burning. Burning may not be possible on small lots but it is one of the best methods of maintaining natural landscaping. Some initial watering and spot spraying to control invasive weeds also may be needed, but this need diminishes rapidly once the natural landscape is well established (generally within 3-4 years).

Cost Considerations

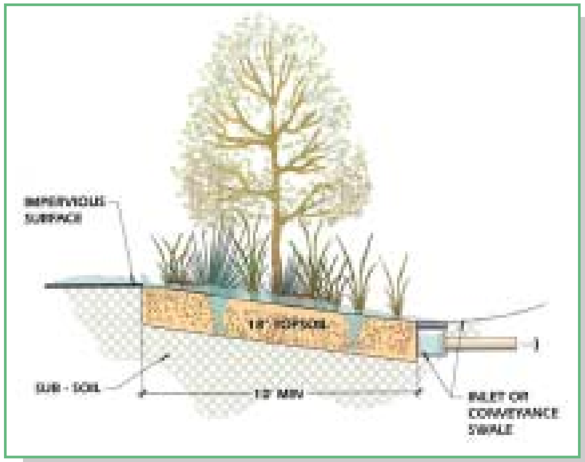
Costs will vary from site to site depending on site size, plant selection and other factors. In general, it is expected that installation costs will be similar for both conventional turf and natural landscapes (roughly $2,000 - $4,000 per acre). Conventional landscaping costs will be higher if sod and irrigation systems are installed. In the long run, maintenance costs for natural landscapes will be much lower than conventional landscapes – typically half or as little as one-fifth the cost of conventional landscapes.

Local Examples

The Peggy Notebaert Nature Museum of the Chicago Academy of Sciences has installed a natural landscape on its campus (center and right) that links to the naturalized shoreline of the North Pond in Lincoln Park.



Filter Strips



Filter strips are vegetated areas that are designed to receive runoff from adjacent impervious surfaces. They work by slowing runoff speed, trapping sediment and other pollutants, and providing some absorption. While frequently planted with turf grass, filter strips may also employ native vegetation, which is more effective in removing nutrients. Filter strips can reduce both the rate and volume of stormwater runoff on a site. This is achieved principally by absorbing runoff into the soil.

Well maintained filter strips can be very effective in reducing runoff volumes, particularly when the impervious drainage area is not overly large (such as more than 4 to 5 times the filter strip area.) Filter strips are most effective in reducing surface runoff volumes – by up to 40 percent – for small storm events (storms up to the magnitude that may occur, on average, once every year or every other year).

Filter strips remove suspended solids through settling and filtration. Dissolved pollutants are removed and/or transformed as runoff infiltrates into the ground. Effectiveness is improved when there is dense vegetation. The use of native vegetation can provide additional benefits for pollutant filtering and runoff absorption. The plants selected should be able to withstand flowing water, and both wet and dry periods. A properly designed and maintained filter strip may remove up to 70 percent to 95 percent of suspended solids and metals (such as cadmium and lead), 25 percent to 65 percent of nutrients (such as phosphorus and nitrogen), and biochemical oxygen demand (the degree of organic pollution in water leading to the depletion of oxygen). However, soluble inorganic compounds (most notably road salt) are generally not well removed in the soil and will eventually migrate downstream or into deep groundwater.

Filter strips function best when applied on gentle slopes, thereby keeping runoff speed low and maximizing opportunities for absorption of runoff and filtering of pollutants. The longer the water moves through a treatment such as this, the more it can be absorbed and the cleaner it will get. Filter strips must disperse the flow as evenly as possible to avoid straight, deep channels, which can reduce effectiveness. Where feasible, a filter strip width of at least 20 feet is recommended, although narrower widths can be effective on flat slopes.

Applicability

Roof runoff and parking lot runoff can be distributed over the width of lawn areas to promote absorption and filtering. Filter strips are strongly recommended in buffer zones between developed areas and sensitive aquatic environments. They are particularly appropriate as buffers for land uses that generate high pollutant loads, such as roadways and parking lots, and are useful in controlling erosion and sediment wash off during construction. Filter strips are probably most appropriate on developments where there are significant expanses of pervious areas (green spaces) adjacent to impervious surfaces (such as parking lots). Specifically, they may be used in the following applications: *residential (roof runoff), commercial (roof and parking lot runoff) and vegetated buffers (adjacent to stream or wetland areas).*

Maintenance Considerations

Typically, maintenance involves normal activities such as mowing, trimming, removal of invasive species and additional planting if necessary.

Cost Considerations

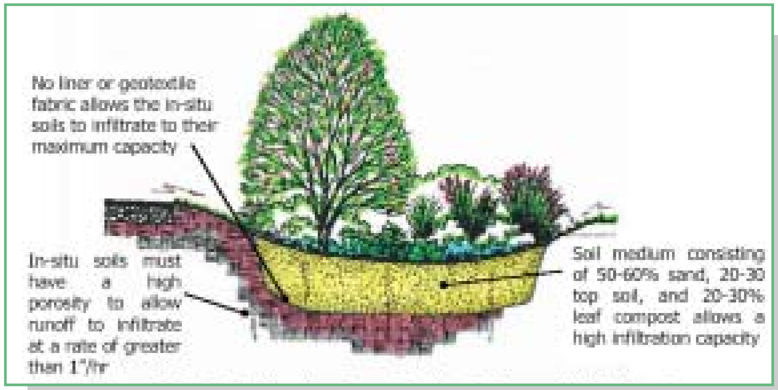
In most cases there is no additional cost associated with establishing filter strips. Typically, all that is required is to direct runoff to an open vegetated area rather than a storm sewer. If the runoff is concentrated, a level spreader (fanning out the water from the immediate source through the use of a wide-mouthed gutter or small culvert into gravel) may be necessary to evenly spread runoff water. Eliminating the need for a local storm sewer may offset the cost of this device. Although periodic cleaning may be required, filter strips should never need to be "replaced." Since filter strips remove sediment and other pollutants, they should lower maintenance costs for downstream catch basins, detention basins and absorption devices.

Local Examples

The Chicago Center for Green Technology (right) uses filter strips to convey runoff on-site. When used appropriately, disconnected downspouts in residential and commercial buildings will cause the roof runoff to route over a filter strip in a back, side, or front yard.

Bioinfiltration: Rain Gardens

Bioinfiltration systems are shallow, landscaped depressions used to promote absorption and infiltration of stormwater runoff. This management practice is very effective at removing pollutants and reducing the volume of runoff, especially when used for parking lot islands. Stormwater flows into the bioinfiltration area, ponds on the surface, and gradually infiltrates into the soil bed. Filtered runoff is infiltrated into the surrounding soils via an absorption basin or trench. Excess water can be collected by an under-drain system and discharged to the storm sewer system or directly into receiving waters. Bioinfiltration systems typically are designed to store and treat runoff from relatively small storms, such as those that occur every year or every other year. Bioinfiltration systems should be located at least 10 feet away from buildings to ensure water does not drain into the foundations. Ideally, pretreatment should be provided to remove suspended solids from the runoff before it enters the system.



A rain garden is a simple form of bioinfiltration that typically relies on the underlying soils for drainage. Therefore it may not function properly if underlying soil is compacted by heavy equipment and/or its absorption rate is slow. Where appropriate, however, rain gardens can be fitted with French drains, or other types of underdrains, to move more water through the soil.

Rain gardens can be aesthetically pleasing. The plants provide food and shelter for many birds, butterflies, and beneficial insects, such as dragonflies, which eat mosquitoes. Plants can include a combination of shrubs, grasses and flowering perennials where the soil medium is between 6 and 8 inches deep. Ideally, plants should consist of native wetland and prairie grasses, and wildflowers. Suggested designs incorporate perennial flowers in the spring and summer, and vividly colored or patterned shrubs and grasses in the fall and winter. Some suggested plants for rain gardens include: Black-eyed Susan, Butterflyweed, Golden Alexander, Obedient Plant, Purple Coneflower, Spiderwort, Wild Columbine and Wild Geranium. (See the resource section at the end of this guide for additional information on creating rain gardens).

Applicability

Bioinfiltration is suitable for developments that have sufficient room for the water to be absorbed. Suggested applications include: *parking lot islands, residential developments utilizing swale drainage for pre-treatment, commercial developments utilizing filter strips adjacent to parking lots for pre-treatment, and campus developments utilizing swale drainage and filter strips for pre-treatment.*

If the surrounding soils are permeable, the system can be designed so runoff absorbs into the soils. The soils should allow the structure to drain in a reasonable amount of time, generally 72 hours or less. This design would be most effective in Chicago areas with relatively sandy lake bed soils. In tighter soils, underdrains may be necessary. Bioinfiltration may not be appropriate for industrial land uses where there is a high potential for groundwater contamination from infiltrated runoff. Rain gardens can be incorporated into front and back yards of residential areas, parkway planting strips, parking lot planter islands and under roof downspouts.

A rain garden is not a pond. It should not provide a breeding ground for mosquitoes. Mosquitoes need at least four days of standing water to develop as larva. Rain gardens generally should be designed to drain within six hours (water may pond for longer times during winter and early spring).

Maintenance Considerations

Bioinfiltration maintenance includes periodic inspection to ensure the system is operating properly, along with management of the vegetation. If a practice fails due to clogging, rehabilitative maintenance will restore it to proper operation. Incorporating pretreatment helps to reduce the maintenance burden of bioinfiltration and reduces the likelihood that the soil bed will clog over time. Rain garden maintenance is similar to that for a typical garden - including weeding and reestablishing plants as necessary. Periodically removing sediment may be required to ensure the proper functioning of these systems. It is best for runoff to be pretreated via swales and/or filter strips before entering the rain garden to avoid sediment accumulation. Plants should be selected to reduce maintenance needs and to tolerate snow storage and winter salt and sand, where appropriate.

Cost Considerations

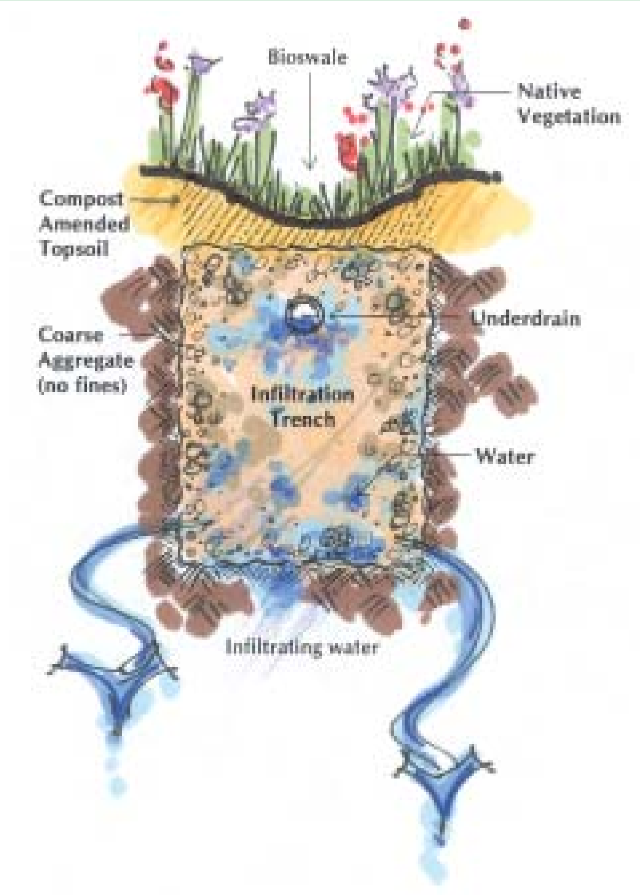
Bioinfiltration costs can range between $10 to $40 per square foot, based on the need for plants, control structures, curbing, storm drains and underdrains. Bioinfiltration should reduce the size and cost of necessary downstream conveyance and storage devices. Bioinfiltration may need to be replaced periodically due to sediment accumulation. The costs of rain gardens will vary depending on how much work is completed by the owner and the types of plants desired. Rain garden installations average $3 to $4 per square foot depending on soil condition and density and types of plants used. If planned and designed properly, a rain garden is likely to retain its effectiveness for over 20 years.

Local Examples

Rain gardens are used at the Green bungalows and in parkways around the City of Chicago. The photo depicts a rain garden using native plants.

Drainage Swales

A swale is a broad, vegetated channel used for the movement and temporary storage of runoff. Swales also can move a portion of the runoff into the ground and filter out runoff pollutants. Drainage swales that are planted with native vegetation are commonly called bioswales. Swales can be effective alternatives to enclosed storm sewers and lined channels, where their only function is to rapidly move runoff from a developed site. On some sites, natural drainage courses may still be present and it is recommended that they be retained as part of the site drainage plan. Drainage swales are different from filter strips in that swales are primarily used for conveying water.



In contrast to conventional curb-and-gutter/storm sewer systems, swales can reduce both the rate and volume of stormwater runoff on a site. Since this is achieved via absorption of runoff into the soil, swales in sandy soils will be much more effective than swales in clay soils. Swales are most effective in reducing runoff volumes for small storm events and on an annual basis can reduce storm runoff volumes by up to 15 percent in clay soils.

Pollutant removal rates in swales are highly variable depending on the condition of the swale, particularly its slope, soils, and vegetation. Estimated removal rates range from 30 percent to 70 percent of suspended solids and metals (such as cadmium and lead) and 10 percent to 30 percent of nutrients (such as phosphorus and nitrogen), biochemical oxygen demand, and other organic compounds. As discussed earlier, soluble inorganic compounds (most notably road salt) generally cannot be removed in the soil and will eventually migrate downstream or into deep groundwater.

Swales can provide limited wildlife habitat when planted with native vegetation. Preserving existing drainageways on a development site also protects aquatic habitat.

Applicability

Drainage swales are applicable on virtually all development sites. In dense urban settings swales generally will be used in conjunction with storm sewers, rather that in lieu of storm sewers. Suggested applications include: *office campus, commercial, industrial, multi-family residential, parking lots, residential parkways and highway drainage* (where right-of-way widths are adequate). One type of swale is a depressed median – a recessed, landscaped area within paved surfaces. Depressed medians can be used as an alternative to raised parking lot islands, allowing water to flow into them from the surrounding pavement. Using vegetation is important in order to filter contaminants that may enter the median from the surrounding pavement.

Maintenance Considerations

Drainage swales may require periodic cleaning but this cost should be minimized if upstream sources of sediment, particularly from construction activities, are well controlled. In comparison, storm sewer catch basins need to be cleaned periodically and manholes, storm sewer pipes, and curbs will need occasional repair.

Another maintenance issue sometimes raised for swales is ponding water and the potential to breed mosquitoes. This can be avoided by providing adequate slopes and/or underdraining to avoid ponding. Alternatively, the swale can be vegetated with wetland plants that can aid in the evaporation of water and provide habitat for mosquito predators such as dragonflies.

Cost Considerations

Roadside swales in residential settings achieve substantial documented cost savings over conventional curb and gutter and storm sewers. In a suburban example, a savings of about $800 per residence was estimated. Swale drainage in commercial, industrial, and parking lot settings has great potential in Chicago and also has documented cost savings over conventional storm sewer approaches. In several case studies done in Portland, Oregon, savings ranged from $4,000 to $5,500 per acre of developed area. A related consideration is replacement costs. Although periodic cleaning may be required, swales should never need to be replaced, in contrast to storm sewers.

Local Examples

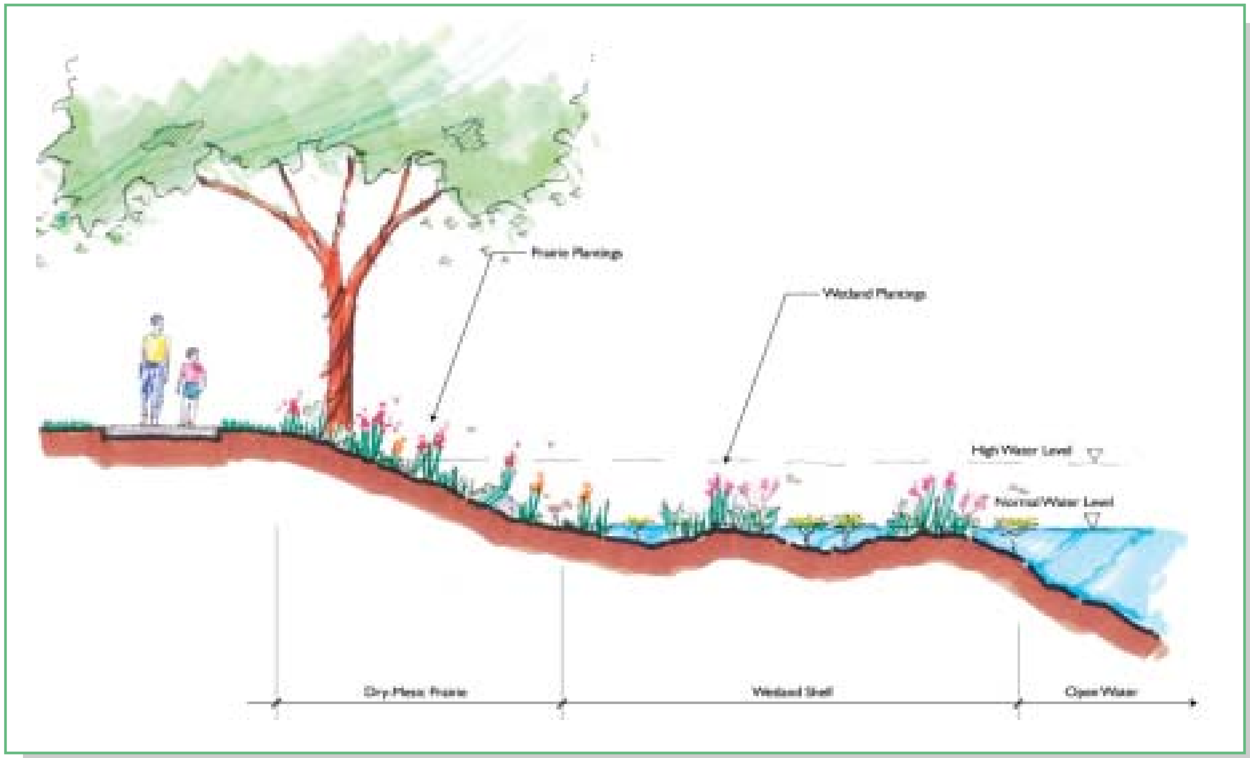
Commercial and institutional applications of swales are fairly common. The Chicago Department of Transportation is creating a drainage swale at 126th Place in the Calumet area. Other Chicago developments incorporating swales in their site designs include the Ford/Centerpoint Supplier Park and Solo Cup developments in the Calumet area.

An example of a drainage swale near a parking area at the Chicago Center for Green Technology.

NATURALIZED DETENTION BASINS

Conventional detention is designed to prevent flooding by temporarily storing stormwater runoff and releasing it gradually to the downstream drainage system. Naturalized detention is intended to serve multiple functions, in addition to flood prevention, including pollutant removal and creation of wildlife habitat (where appropriate). Natural detention basin designs emulate natural lake or wetland systems by utilizing native plants along the water's edge and on side slopes. The design generally incorporates flat slopes at the edge of the water or wetland, shallow zones of emergent vegetation at the edge of wet basins, and a combination of vegetated and open water areas in wetland basins.

Effective detention designs will dramatically reduce runoff rates and prevent most increases in flooding associated with new development. However, unless underlying soils are highly permeable, detention will not significantly reduce flood volumes. The greatest benefit of naturalized designs is the reduction of runoff pollutants. Suspended sediments and attached pollutants, which are removed primarily by settling, can be reduced by 60 percent to 90 percent. Some dissolved pollutants, including nutrients and organic matter, can be reduced by 40 percent to 80 percent. Because wet basins are more effective at removing pollutants, in some instances they are a beneficial alternative to dry bottom basins. Naturalized basins also will not experience shoreline erosion, further improving water clarity.



Naturalized detention also can provide desirable habitat for birds and aquatic organisms and at the same time discourage nuisance populations of Canada geese that are commonly found around conventional basins. In addition, many property owners prefer the appearance of a well-designed natural basin over the more manicured look of a conventional basin (such as coarse gravel shorelines and/or concrete channels), thereby enhancing property values.

Applicability

Natural detention basin designs are suitable for all development types. Detention may not be feasible on very small sites – such as individual lots – due to the need for very small outlet structures. On very small sites, *rain garden* or *bioinfiltration* designs may be more appropriate.

Maintenance Considerations

Conventional basins require regular mowing of side slopes and/or basin bottoms. In contrast, naturalized detention basins typically require only annual (or less frequent) mowing once the vegetation is established. Also, because native vegetation provides effective shoreline stabilization, there should be little need to repair shoreline erosion problems commonly found in conventional wet basins. Other maintenance concerns – occasional sediment removal and trash control – are similar for naturalized and conventional basins.

Cost Considerations

The construction costs of naturalized detention basins are generally comparable or less than the costs of conventional detention basins. Some cost savings may result from the use of native vegetation for shoreline stabilization versus coarse gravel, stone or concrete. In the long term, costs for naturalized basins will be lower due to reduced needs for conventional turf maintenance.

Local Examples

A notable example of a naturalized detention basin in the City is at the CET1 power plant located at 117th & Torrence Avenue. The Chicago Center for Green Technology on Sacramento has an effective naturalized detention basin (right).

SUMMARY AND APPLICATIONS

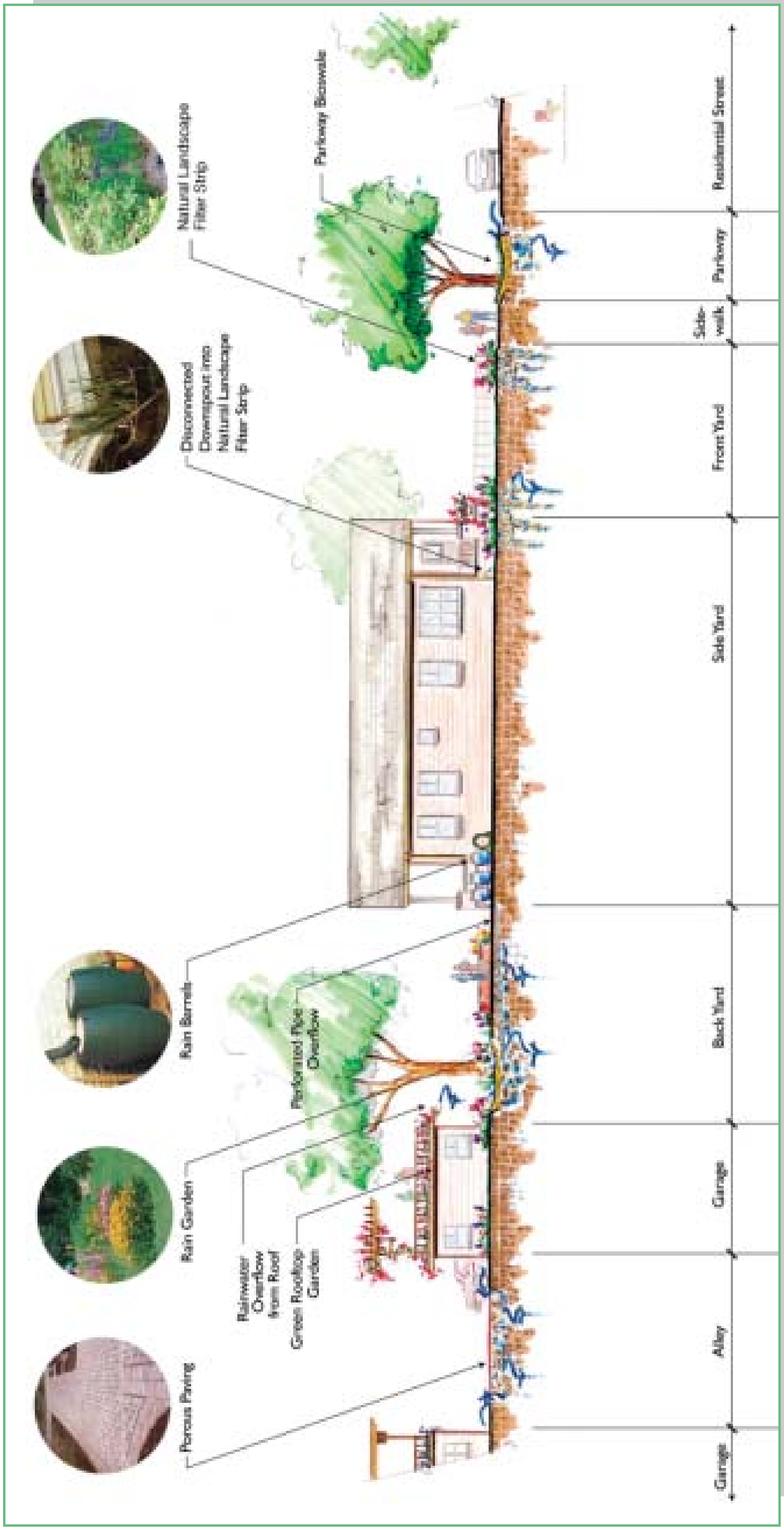
There are many benefits, advantages and costs associated with the use of stormwater Best Management Practices. The table below highlights just a few of the many benefits. The Best Management Practices described in this guide are meant to be a starting point. Please consult the list of resources at the end of the guide for further information and materials about each of the Best Management Practices, as well as additional Best Management Practices not mentioned in this guide. On the next two pages are examples of how stormwater Best Management Practices can be applied in the residential and commercial/industrial context. The residential application diagram is based on a typical Green Bungalow in Chicago. The commercial application is based on the Chicago Center for Green Technology, located at 445 North Sacramento.

BMP	Typical Initial Cost	Percentage Reduction in Water Volume or Pollutants *
Green Roof **Extensive** **Intensive**	 $8-12/sq.ft. $15-25/sq.ft.	Cadmium, copper & lead: 95% reduction Zinc: 16% reduction Captures and stores runoff from small to moderate storms.
Rain Barrel	$20-150 each	Captures and stores runoff from small to moderate storms.
Permeable paving	2-3 times conventional costs	Reduces quantity of surface runoff from small to moderate storms.
Natural landscaping	Similar to conventional costs: from $2,000-4,000/acre	Suspended solids & heavy metals (such as cadmium & lead): 80% Nutrients (such as phosphorus & nitrogen): 70% Reduces residential runoff by 65%
Filter strip	Similar to conventional costs	Suspended solids & heavy metals (such as cadmium & lead): 70-90% Nutrients (such as phosphorus & nitrogen) and organics: 25-65%
Rain Garden	$3-4/sq. ft.	Removes runoff and pollutants from small storms.
Bioinfiltration	$10-40/sq.ft.	Best option for reducing surface runoff as well as removing pollutants.
Drainage Swale	Less than conventional costs	Suspended solids: 30-70% removal; nutrients: 10-30% removal. Best at removing runoff in small storms.
Detention Basin	Similar to conventional costs	Reduces stormwater runoff rates and pollutants. Suspended sediments & pollutants: 60-90% removal. Nutrients & organic matter: 40-80% removal.

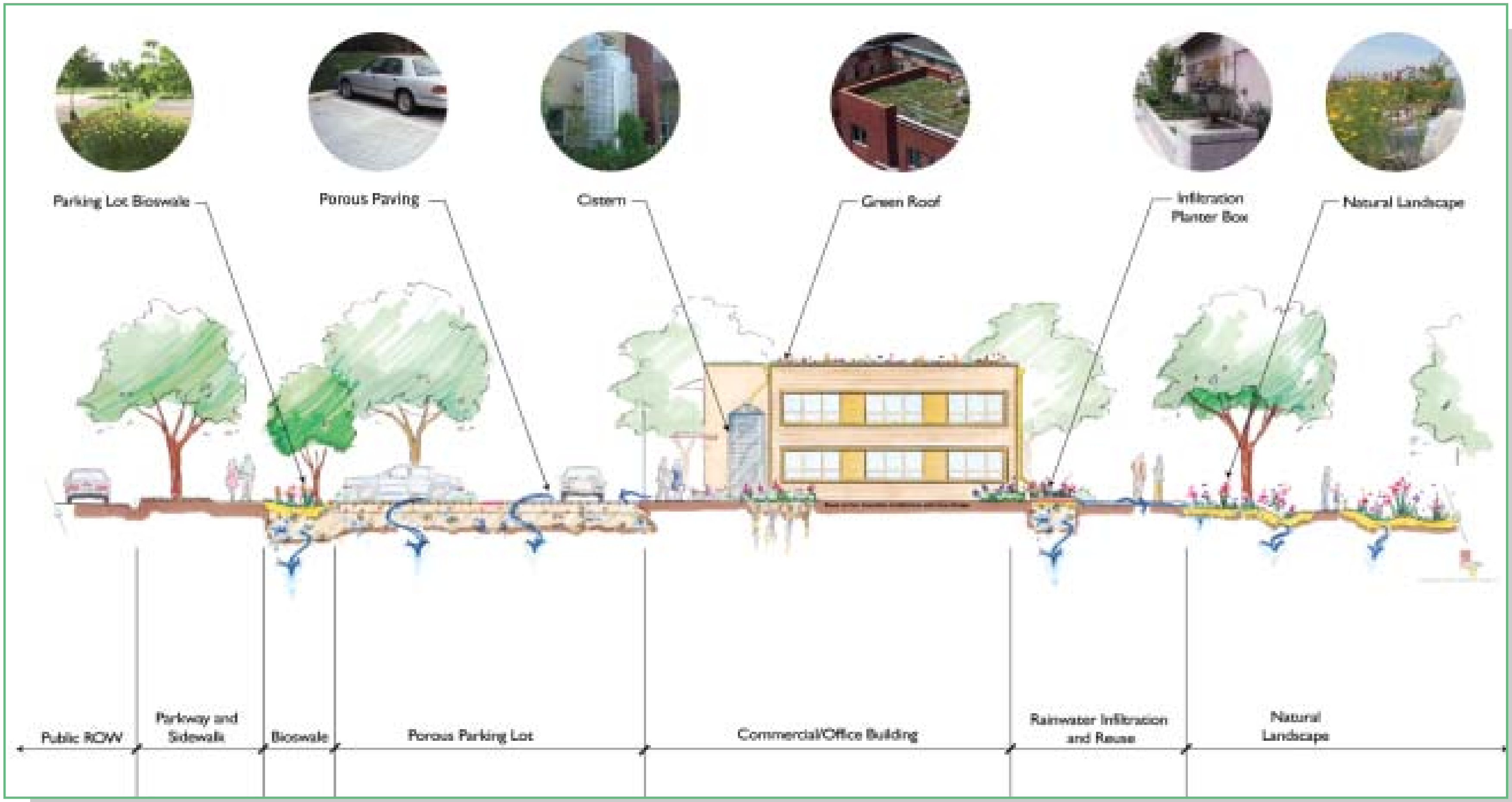
* Chart figures based on information provided by Northeastern Illinois Planning Commission.

** While some of the initial costs may be higher than conventional costs, many stormwater BMPs pay for themselves via reduced maintenance costs over several years.

RESIDENTIAL SITE



COMMERCIAL/INDUSTRIAL SITE



WHERE TO FIND MORE!

Index of Resources

City of Chicago Departments

Chicago Department of Environment
30 North LaSalle Street, 25th Floor
Chicago, IL 60602
(312) 744-7606
www.cityofchicago.org/environment

Chicago Center for Green Technology
445 N. Sacramento Boulevard
Chicago, IL 60612
(312) 746-9642
www.cityofchicago.org/Environment/GreenTech
CCGT manages stormwater and demonstrates many other green building principles. Come for a visit. Open every day of the week.

Chicago Department of Transportation
30 North LaSalle Street, 11th Floor
Chicago, IL 60602
(312) 744-2600
www.cityofchicago.org/transportation

Chicago Department of Water Management
1000 East Ohio, Suite 104
Chicago, IL 60611
(312) 744-7001
www.cityofchicago.org/watermanagement

Northeastern Illinois Planning Commission

222 South Riverside Plaza, Suite 1800, Chicago Illinois, 60606
(312) 454-0400
www.nipc.cog.il.us

Conservation Design Resource Manual
(NIPC and Chicago Wilderness, 2003)
www.chicagowilderness.org/pubprod/miscpdf/cd_resource_manual.pdf

Protecting Nature in Your Community (NIPC, 2000).

Reducing the Impacts of Urban Runoff: The Advantages of Alternative Site Design Approaches (Dreher and Price, 1997).

Natural Landscaping: A Source Book for Public Officials (NIPC, 1996)

Urban Stormwater Best Management Practices for Northeastern Illinois, a course curriculum (NIPC, 2000).

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Chicago Department of Planning and Development.
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City of Portland *2002 Stormwater Management Manual (2002).*
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Maryland Department of the Environment. *Maryland Stormwater Design Manual (2000).*
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Metropolitan Council Environmental Services. *Minnesota Urban Small Sites BMP Manual: Stormwater Best Management Practices for Cold Climates (2001).*
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Natural Resources Conservation Service. *Illinois Urban Manual: A Technical Manual Designed for Urban Ecosystem Protection and Enhancement (2003).*
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Schueler, T.R., *Site Planning for Urban Stream Protection,* for the Metropolitan Washington Council of Governments, Washington, D.C. (1995). Download from www.cwp.org/SPSP/TOC.htm or purchase from the Center for Watershed Protection (410) 461-8323.

United States Department of Agriculture, Natural Resources Conservation Service. *Native Plant Guide for Streams and Stormwater Facilities in Northeastern Illinois (1987).*
Contact (847) 468-0071 [in north Cook County] or (815) 462-3106 [in south Cook] for the Soil and Water Conservation District.

Specific References

Permeable Paving

United States Environmental Protection Agency. *Post-Construction Storm Water Management in New Development & Redevelopment: Alternative Pavers.*
http://cfpub.epa.gov/npdes/stormwater/menuofbmps/post_1.cfm

Green Roofs

City of Chicago's City Hall Rooftop Garden.
Can be viewed from Chicago Department of Environment, 30 North LaSalle, 25th Floor.
www.cityofchicago.org/Environment/rooftopgarden

City of Chicago Department of Environment.
Chicago's Green Rooftops: A Guide to Rooftop Gardening.
www.cityofchicago.org/Environment/html/9493DOE.pdf

Greenroofs.com
www.greenroofs.com

Low Impact Development Center, Inc. *Green Roofs.*
www.lid-stormwater.net/greenroofs/greenroofs_home.htm

Roof Runoff

City of Chicago Guide to Disconnecting Downspouts.
www.cityofchicago.org/environment/html/DownspoutDisconnect.html

Low Impact Development Center, Inc. *Specifications of Rain Barrels and Cisterns.*
www.lid-stormwater.net/raincist/raincist_specs.htm

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Natural Landscaping

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United States Environmental Protection Agency natural landscaping website: www.epa.gov/greenacres/

Drainage Swales

United States Environmental Protection Agency. *Post-Construction Storm Water Management in New Development & Redevelopment: Grassed Swales.*
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Filter Strips

Center for Watershed Protection. "Grass Filter Strip" fact sheet in Stormwater Manager's Resource Center (2000).
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Naturalized Detention

United States Environmental Protection Agency. *Post-Construction Storm Water Management in New Development & Redevelopment: Wet Ponds.*
http://cfpub.epa.gov/npdes/stormwater/menuofbmps/post_26.cfm

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