Strategies for “Climate Prosperity”
Part I: Green Infrastructure

Overview
How can cities green their water and sewer systems in a fiscally responsible way? What support is available at the federal level?

Materials

“Green Infrastructure Prevents Sewer Overflows and Protects Water Quality,” Sierra Club.


“Green Streets: A Conceptual Guide to Effective Green Streets Design Solutions,” EPA.


Speakers

Neil Weinstein, P.E., R.L.A., AICP, MASCE is the Executive Director and one of the founders of the Center. Neil is a registered engineer and landscape architect and is a member of the American Institute of Certified Planners and the ASCE Urban Water Resources Research Council. He has a M.S. in Environmental Engineering from Johns Hopkins University and a M.L.A. from the University of Georgia. For the last 10 years Neil has primarily been focused on the planning, research, and design of innovative stormwater management practices, including LID. Prior to that he worked as a development engineer and planner on municipal, institutional, and private sector projects.

Dominique H. Lueckenhoff has over 25 years experience in the environmental field. She currently serves as an Associate Director of the Water Protection Division and Director of the Office of State and Watershed Partnerships for the United States Environmental Protection Agency’s Region 3 Office in Philadelphia.

In this capacity, she is responsible for direct oversight of a variety of programs, including federal grants totaling over half a billion dollars under the Clean Water Act (CWA), covering the states of Pennsylvania, Maryland, Virginia, West Virginia, Delaware and the District of Columbia.

Some of these programs and activities include: The CWA Section 106 Water Pollution Control grants program, Non-Point Source Program (Section 319), the National Estuary Program (Section 320), the Coastal Zone Act Reauthorization Amendments (CZARA), Mining Program, Interstate River Basin Commission coordination for the Delaware, Ohio, Potomac, and Susquehanna Rivers, Targeted Watershed Grants, a variety of watershed studies and restoration efforts, and watershed planning and related partnering activities for the Mid-Atlantic region.

Her leadership in advancing innovative approaches and green practices to achieve sustainable environmental protection, economic vitality and improved community quality of life - is highlighted by her vision and creation of the Green Communities Program over 15 years ago. This effort has resulted in a widely adopted incentive-based program to promote green buildings and infrastructure at a community scale.
Ms. Lueckenhoff has also served as the visionary and driver of the Mid-Atlantic Green Highways Partnership (GHP), a public/private, collaborative effort promoting environmental stewardship, safety and sustainability for the transportation sector – particularly highways. Since its inception in 2004, the GHP has served as a principal incubator of green highway and green street design and development throughout the US. Through this effort and her leadership, the town of Edmonston, MD, was able to build the “greenest street in the Chesapeake,” thereby serving as a national model for small to mid-size communities to “green” their infrastructure while creating green jobs.

Due to its tremendous success as both an expansive “partnership” (government, business, industry, academia, non-profit organizations and community/watershed groups) and in promoting and demonstrating a host of innovative practices that out-perform traditional approaches, the GHP has been selected to receive the US EPA’s highest honor in 2007 - a Gold Medal for outstanding leadership and service. GHP activities range from integrated, strategic planning through the use of geospatial tools and green infrastructure considerations to green design, low impact development and green construction, operation and maintenance. Her leadership efforts in this area have also been recognized by the American Concrete and Pavement Association, which bestowed its first ‘Outstanding Health, Safety, and Environmental Stewardship Award upon her during the 2007 Transportation Research Board’s (TRB) Annual Meeting. Ms. Lueckenhoff served as a subcommittee member of the TRB (ADC10), a major component of the National Academy of Science.

She holds an M.S. in Microbiology and Biophysics from the University of Houston and Rice University as a National Science Foundation Fellow, and a B.S., Cum Laude, in Microbiology and Chemistry from the University of Southwestern Louisiana.

H. J. “Bud” Schardein, Jr. is the Executive Director of the Louisville and Jefferson County Metropolitan Sewer District. He is responsible for operations, maintenance, capital projects and a budget $170 million annual budget, and supervises 600 employees. Mr. Schardein oversees emergency response and is responsible for coordinating all MSD response efforts to natural, accidental, mechanical systems and intentional events that affect MSD operations and systems. He also oversees community relations and is responsible for presenting MSD projects, programs and initiatives to government, civic groups, neighborhood associations and media.

Mr. Schardein serves on the University of Louisville Board of Overseers and the Greater Louisville, Inc. Executive Board. He is past Chair for Central Kentucky of the American Public Works Association. Mr. Schardein attended Morehead State University, served in the U.S. Army, and earned a degree in Communications from Spalding University. He is married and has two children.

Kansas City Mayor Mark Funkhouser has earned an international reputation as an expert in efficient, effective, innovative and honest government. Governing magazine, named Funkhouser a national “Public Official of the Year” in its November 2003 issue
A former city auditor, Funkhouser was elected mayor on March 27, 2007 after a spirited, populist campaign for “a city that works for regular folks.”

Under Funkhouser’s leadership, the City took greater control of its spending by adopting a budget which set realistic measures for what the City ought to spend in the coming year. For decades, prior mayoral administrations and City Council’s had passed budgets which allowed expenditures to exceed revenues, causing a structural imbalance. These previous budgets also failed to adequately fund basic services such as snow removal and street repair. As a result, the city had a low reserve fund, threatening its credit rating. With the first budget, the mayor and Council made over $50 million in changes to restore the fund balance to an acceptable level and put the city on stronger financial footing. In his first State of the City Address, delivered on April 24, 2008, Funkhouser declared that Kansas City is a strong city and that it would emerge as a world-class community of choice if City leaders would meet ten challenges. These included increasing funding for basic services so that neighborhoods can be made clean and safe, streamlining government functions to make the city’s financial condition stronger. He also announced two new initiatives. The first was a summit of leaders from the largest cities in Missouri to form an “Urban Alliance” to lobby at the state capitol and Washington D.C. for increased support for cities and metropolitan areas. The second was to create “New Tools” for economic development which would be specifically targeted for more challenged areas of the urban core.

Funkhouser’s quest build alliances with other elected officials has not been limited to the Kansas City metropolitan area. He signed on as a partner with the Brookings Institution’s “Blueprint for American Prosperity: Unleashing the Potential of a Metropolitan Nation. This is a multi-year national initiative to promote an economic agenda which builds on the assets of America’s metropolitan areas. On Sept. 27, 2007, Funkhouser delivered a major address to the National Conference of Editorial Writers promoting the initiative prior to its official launch, and he active participation in the initiative’s strategy sessions.

Funkhouser has been married to the same woman, Gloria Squitiro, since 1979 and he has two children, Tara and Andrew
Introduction

We often think of rainwater as being "pure" and "natural". Standing in a spring shower, or watching rivulets bubble into a stream after a storm, it seems certain that we are looking at "clean" water.

It may come as a surprise, then, that rainwater—in the form of urban runoff—is considered a major source of water pollution. Some researchers suggest that stormwater runoff in the U.S. may be responsible for up to 15% of river and lake water impairment, and over 25% of problems with estuaries. [1] Science is learning that a raindrop, passing through the atmosphere, across the landscape and into open water, is by no means "pure."

Because it's long term ramifications can be quite subtle (and even short term effects are difficult to determine) stormwater is unlikely to get the public attention or activism of other more visible environmental issues. Yet, managing the quality and effects of stormwater has become a key environmental issue of the 21st Century. There are several factors influencing this.

Stormwater, as a diffuse, non-point source, is found everywhere, so problems related to it cut across all sectors of society and the economy. Increases in the levels of storm runoff and water contamination are intimately linked to growth in population and development, meaning that the concerns will expand over time. And stormwater problems involve millions of actions by millions of people, making management and control particularly difficult.

In this issue we will be looking at how stormwater may threaten environmental quality, and at some of the steps being taken to lessen that threat. Though managing stormwater runoff to control floods is an ancient practice (understood by civilizations as early as the Egyptians), the variety of contaminants now found in stormwater gives the issue new urgency. The ever growing number of people affected by runoff makes understanding it an important part of environmental awareness.

What comes down...

As we've noted before (see KYE 4/01) rainfall is part of the predictable hydrological cycle. In settings with minimal development—forests or meadows for example—rainwater is absorbed by the soil and ultimately enters the surface water (lakes and streams) or percolates into deeper soils to become part of the groundwater. When the infiltration capacity and rate of inflow of the soil is exceeded—i.e. when no more water can be absorbed—additional rainfall pools on the surface and follows the local contours of the land, usually ending up in a natural stream channel.

Flooding is the term commonly used to indicate excess overland flow. It is a perfectly natural phenomena and occurs regularly in areas with or without human development. In nature, however, flood events tend to follow predictable patterns. This is because larger storms occur less frequently than smaller ones and, for the most part, landscape features have developed in conjunction with the natural rhythms of infiltration and flow.
That changes when human development enters the picture. One of the key features of development of human construction is covering pieces of land with structures that block rain flow. These so-called "impervious surfaces" can range from driveway to a superhighway, from the roof of a tool shed to the roof of a sports complex.

According to the Natural Resources Defense Council (NRDC), impervious surfaces come in three categories: "rooftop imperviousness from buildings and other structures; transport imperviousness from roadways, parking lots, and other transportation-related facilities; and impaired pervious surfaces, also known as urban soils, which are natural surfaces that become compacted or otherwise altered and less pervious through human action."

All of these, however, have one thing in common: almost every location now covered by an impervious surface was once a site where rainwater could reach the soil. By blocking the infiltration of water, these surfaces also effectively channel and redirect it.

With the natural patterns of runoff changed, we begin to see just how much stormwater was being absorbed by the soil. An inch of rain, for example, falling on a fifty acre parking lot might translate into over a million gallons of water that has to end up somewhere.

In many cases that "somewhere" is into a storm drain and out— in a high volume pulse— to a stream or waterway. The City of Santa Monica, California, for example, has over 2000 catch basins and 64 storm drain lines running to 5 outfalls that empty directly into the Santa Monica Bay and the Pacific Ocean. In Chesapeake, Virginia, 275 miles of piping and 1300 hundred miles of ditches and channels run— untreated— directly to the Elizabeth River and ultimately to the Chesapeake Bay.

Though runoff is a natural phenomena, studies indicate that only 10% of the rain falling on a natural landscape is typically converted to surface flow. The remainder infiltrates the soil, enters groundwater or returns to the atmosphere. On impervious surfaces this changes drastically. The runoff from that 50 acre parking lot may be as much as would be produced by 800 acres of meadowland.

The results of this rapid surface flow and storm pulse are well understood. Table 1 compares the immediate effects of landscape impermeability (e.g., increased runoff volume) with the larger scale results such as flooding and habitat destruction. All of the immediate effects are due to changes in previous conditions.

While it is true that natural conditions can fluctuate just as much as those influenced by humans, in most cases natural changes develop more slowly, or natural systems return to their previous state more quickly. Since the time frame of most impervious surfaces is indefinite, (how often do you see parking lots made back into meadows?), the natural systems will have to make long term adjustments to their presence.

Increases in the volume of runoff, and increases in the volume and duration of the peak flow period (the largest volume of water during the storm) are, for obvious reasons, related. The more water that isn't getting absorbed by the soil, the more that will have to make its way into the waterways. Not only does this result in excess flooding and erosion, but a strong storm pulse can "scour" the stream bed, removing sediment and destroying habitat. Changes in the shape of a stream are one of the key factors that will degrade the diversity of the wildlife present in it.
Table 1. Effects of Impervious Surfaces on Watersheds

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Source: National Resources Defense Council

"Baseflow," also called "dry weather" flow, is the groundwater that slowly enters and sustains a stream during non-rainy periods. With an increase in impervious surfaces, less water is able to infiltrate into the groundwater, making less water available during dry periods to recharge the stream.

Moreover, because baseflow water is cooler than surface water (a result of being underground) the increase in impervious surfaces will indirectly result in an increase temperature in natural stream systems. This can in turn have a number of adverse effects on the stream's ecological system, most notably a change in the level of dissolved oxygen and a decline in fish species.

While not all flooding is simply the result of impervious surfaces, there is no question that development, including such surfaces, has resulted in flooding becoming the most costly form of natural disaster in the United States. Between 1989 and 1999 just over 45 billion dollars in losses were sustained during floods, and more importantly, almost 1000 people lost their lives.

Yet, as great as the need to manage flood waters, contamination of stormwater may be a more critical issue. In recent years, it has moved stormwater management to the forefront of environmental challenges.

As pure as rainwater?

It is important to realize that stormwater runoff, particularly in urban areas, is not moving across pristine surfaces. Rather, as the NRDC points out, it travels "across rooftops, roads, parking lots, baseball diamonds, construction sites, golf courses, lawns, and other surfaces in our cities and suburbs."

Each of these surfaces has its own complement of natural and human produced substances that can carried into streams either as particles or solutions. From 1977 to 1983 the U.S. government conducted an extensive survey of stormwater pollutants from a total of 2300 storms in 28 major metropolitan areas. The resulting report [3]—known as the National Urban Runoff Program (NURP)—gave a sobering look at a little suspected problem and formed the basis for subsequent governmental action.
Among the substances the NURP study examined were nutrients, like phosphorous and nitrogen, and heavy metals like copper and lead. Subsequent studies have suggested that some of the NURP figures were over- or understated—not surprising, considering that sampling techniques have improved in the past twenty years. However, there is no question that all of these pollutants can still be found in varying amounts in stormwater runoff.

Research results also support concerns over the presence of contaminants in stormwater. One study [4] indicated that exposure to concentrations of some runoff as low as 10% can have detrimental effects on fish larvae. The same study indicated that the toxicity of stormwater is directly proportional to the level of urban development of in a watershed. Other studies [5] have shown that water samples collected in stormwater retention ponds have toxin levels that are considered dangerous to wildlife. Fish in such ponds have been found to have significant concentrations of heavy metals.

Recent studies by NASA [6] indicate that the danger of contaminants to waterways is directly related to the percentage of land covered by impervious surfaces. According the Goddard Spaceflight Center's EOS Project Science Office "when 10 percent to 15 percent of an area is covered by impervious surfaces, the increased sediment and chemical pollutants in runoff have a measurable effect on water quality." Between 15 and 25 percent is associated with reduced levels of oxygen available to stream life. And, with greater than 25 percent of an area covered "many types [of organisms] in streams die from concentrated runoff and sediments."

The ways in which pollutants can enter stormwater are as numerous as they are varied. Gasoline spills reaching stormwater—even the few drops that land on the parking lot when fueling a car—can total up to thousands of gallons a year in urban areas, introducing into runoff both gasoline and additives, such as benzene and ethanol. As we saw last year (KYE 7/00), methyl tertiary-butyl ether (MTBE), an additive designed to combat air pollution, can enter water supplies through just such spills. Even in minuscule amounts, pollutants can add odors and tastes to water that leads to public outcry.

Construction is a major contributor to contaminants in stormwater runoff. Because the construction process often removes natural vegetation and alters the topography of a piece of land, runoff may be amplified as much as it would be on pavement. Construction also characteristically disrupts soil and adds dust, sediment and other particulate matter to the watershed. A variety of chemicals are used in construction processes and these too can enter the surface water through runoff.

It should be noted however, that even after construction is completed, residential development remains one of the most significant contributors to runoff contamination. Research shows that the level of toxins in residential runoff can be just as damaging to aquatic life as runoff from industrial and commercial settings. Examples of residential practices that contribute to runoff contamination include lawn fertilizing, automobile oil changes, car washing, or leaching from improperly disposed grass clippings. Most of these practices, when conducted by individual citizens, are only now starting to be regulated.

The NRDC notes that the "EPA ranks urban runoff and storm-sewer discharges as the second most prevalent source of water quality impairment in our nation's estuaries, and the fourth most prevalent source of impairment of our lakes." The New Jersey Department of Environmental Protection [7] puts it more plainly: "Undisputedly, the main threat to our water quality today is stormwater/nonpoint pollution."

As a result of these observations, in 1987 the US Congress amended the Clean Water Act (CWA), to require municipalities and other stormwater sources to take responsibility for the pollutants generated by their runoff. However, despite the best efforts of Congress to address the stormwater issue, progress has been slow.
As the Congressional Research Office [8] observes "the issue of how to regulate stormwater discharges had a lengthy history of regulatory proposal, delays and legal challenges, and court decisions." In fact, according to a chronology collected by the NRDC, most of the major enforcement moves by the EPA on this matter have been the results of court orders following citizen lawsuits.

The National Pollution Discharge Elimination System (NPDES) is the program designed to oversee and regulate discharges from "point-source" polluters under the CWA. With the 1987 amendments to the CWA, municipal stormwater discharges are considered to be a point source. Under the CWA, all dischargers of point source pollutants—including municipal stormwater—are required to have a permit from the NPDES.

Interpreting stormwater as a point source contaminant, however, has aroused significant criticism from many of those who are required to follow the regulations. The National Association of Flood and Stormwater Management Agencies (NAFSMA), representing many of the affected municipalities, believes [9] "Rainwater falling on cities and flowing through the local storm drainage system and eventually into streams, rivers, and lakes is a non-point pollution problem that differs fundamentally from point sources of discharge."

The NAFSMA insists that "it is not logical to apply the same water quality standards to municipal stormwater as are applied to point sources." In this view, the requirements of the Clean Water Act are being distorted to address an entirely different class of problem. They believe that "the Clean Water Act should be amended to properly define municipal stormwater water into a specific stormwater program that is neither point source nor non-point source."

Recognizing the complexity of the problem, the legislation provides extended time for implementation, calling for a phased process that requires larger sources of runoff to take steps sooner. Starting in 1992, as the result of a court ruling, the EPA issued regulations requiring municipalities with a population greater than 100,000 to have a permit issued under Phase I of the NPDES. To obtain these permits, municipalities had to take specific steps, including passing and enforcing local ordinances, that would reduce stormwater pollution.

Many municipalities however balk at the costs which compliance with the regulations will require. Moreover, although a 1995 consent decree required the EPA issue regulations to commence Phase II of the law affecting smaller municipalities, there continues to be delays and objections to the plan.

The National Association of Counties (NACo) has pointed out [10] in comments on the pending Phase II regulations, that the average Phase I compliance plan cost municipalities $600,000. Phase II they suggest, will cost far more, to small cities and groups far less able to pay.

William D. Dugat III, managing partner of a Texas environmental law firm is explicit in criticizing the move: "Phase II, as proposed, imposes significant administrative and regulatory burdens on local governments in Texas without any funding and with no regard for actual water quality impacts." [11] Writing that the EPA lacks jurisdiction for imposing such requirements on local governments, Dugat also argues that the regulations are flawed in that they base requirements on population rather than local water quality criteria.

Others writers, however, citing the NURP report and other studies, would counter that the level of contaminant in urban runoff is remarkably similar from one metropolitan area to the next, and that it is the level of land use and development, usually linked to population, that determines the amount of contamination typically found. Given that urban non-point pollution derives from a diffuse range of
causes, proponents of the regulations argue that population numbers are the only viable way to approximate impacts on the waterways.

Though the 1987 Amendments to the CWA required Phase II compliance by 1993, delays in setting regulations have pushed that date back to March, 2003. Legislation, supported by the NACo, was proposed in this Congressional session that would make some modifications in the specific requirements of the regulations. Thus far that bill remains in committee.

**Best Management Practices**

Despite the concerns over cost and the opposition to the regulations by some groups, a number of cities have begun to take steps to comply with the anticipated permit requirement. These requirements direct the operators of small municipal stormwater sewers (MS4’s)—as Phase I did for larger municipal systems—to reduce pollutants to the Maximum Extent Possible (MEP), to protect water quality and to follow the Clean Water Act.

Given that stormwater is ubiquitous, and given that the pollutants in stormwater are so varied as to make regulation of individual polluters impossible, what are the alternatives available to municipalities to deal with this problem? Put another way, regulations can't stop the rain, and they can't stop the runoff; what then can they do to stop the flow of pollutants?

Actually, there are a variety of steps communities and individuals can take to decrease contaminants in stormwater runoff. The NRDC has done a study of various methods and found many that can be effective depending on the location and the characteristics of the surrounding landscape. These are often referred to as "Best Management Practices" (BMP's) a term originally coined to describe agricultural methods that reduce erosion. (It should be noted that runoff from agricultural land also presents major problems for waterways, but we are not discussing it here as the remedies and regulations are usually separate from the urban runoff issue.)

The selection and implementation of BMP's is key to how municipalities manage their runoff. The NPDES program, in granting permits, it is designed to promote municipalities using a "toolbox" of BMP's, drawing on a mix of both structural and nonstructural practices designed to address the specific needs of the locale. And while some of these may be costly "structural" BMP's, like stormwater basins or retention tanks, others, the so-called "nonstructural" BMP's may be simple and relatively inexpensive.

In order for the operator of an MS4 to qualify for a permit under Phase II, they must implement a stormwater management program that includes each of six "minimum control measures." These are: public education and outreach, public participation and involvement, detection of illicit discharge, controlling runoff from construction sites and from developed areas following construction, and a category of activities known as "pollution prevention and good housekeeping."

Some of these steps, like controlling runoff from development, are self evident. Others may be less apparent.

For example, few people think of street sweeping as a way of lessening water pollution. Ultimately, though, everything on the streets ends up in the gutter, and just as inevitably, everything in the gutter gets washed into storm drains. And usually, what goes in those drains ends up in waterways. This includes both contaminants and so-called "floatables," i.e. litter that gathers and clogs storm drains. Practices as simple as street cleaning, properly disposing of leaves and grass clippings, and recycling household chemicals can have a limited but tangible effect on the quality of stormwater runoff.
Public education is an important nonstructural BMP and is a specific requirement for communities receiving the NPDES permit. In San Mateo County, California, for example, the Storm Water Pollution Prevention Program (STOPP) coordinates activities that range from stenciling storm drains with warnings not to dump to producing fact sheets that instruct homeowners in techniques for lessening the dumping of contaminants.

"Illicit" discharges are a major part of the stormwater problem. An EPA study in Sacramento found that almost half of the water in the storm drains was not directly attributable to rainfall. In theory, storm sewers are not designed to handle any discharges other than stormwater. (Hence the motto of STOPP: "Only rain in the storm drain.")

The NPDES rules include requirements that each municipality have an ordinance in place to prohibit illicit discharges and that it map its storm sewers in order to identify unauthorized hook ups. They are then directed to have a plan for enforcement and public education.

Illicit does not necessarily mean illegal. In many cases the discharge is due to lack of information. Private activities like car washing and radiator flushing are not commonly thought of as criminal behaviors. Jacksonville FL, for example—recognizing that dumping in storm drains is often due to lack of awareness rather than criminal intent—elicits aid from churches, schools and community groups to make people aware of the problem.

In other cases, however, the illicit use of storm sewers may represent efforts to avoid environmental laws. In such cases law enforcement becomes a tool preventing stormwater contamination. Effectively carrying out such enforcement, however, remains a significant challenge in implementing stormwater policy.

Although some small utilities do not have the power to enact legislation, most jurisdictions now have laws to control introducing waste into storm sewers. Shreveport LA, and Huntsville AL, for example, both have specific city ordinances with permit systems and penalties for discharging contaminants into storm drains.

But, while there is no question that quick and low-cost steps can be taken to address stormwater pollution, other larger scale actions will be required for municipalities to comply with the NPDES requirements. These costlier, structural BMP's often involve collecting, redirecting or treating the urban runoff. As such, they may involve significant capital investment on the part of responsible parties. In some cases these costs may be paid by the developers making changes to the watershed, but larger systems often require public funds. In any case it is the responsibility of the local government to design ordinances and enforcement mechanisms to ensure that these BMP's are utilized.

Many of these structural BMP's go to the heart of the runoff problem—i.e. the role of impervious surfaces in blocking storm water from returning to the soil. In general the EPA recommends three methods for offsetting impervious surfaces—storage, infiltration and vegetative practices. The first two involve collecting and storing the water, allowing it to slowly infiltrate into an area of soil or releasing it slowly into the waterway. The third—vegetative BMP's—refers to using plants and grasses to remove pollutants.

One of more common practices for decreasing flood pulses and minimizing contaminants is the use of one or more permanent storage ponds to detain the water, allow time for sediment and pollutants to settle out, and then release it to a natural waterway or wetlands. This practice has proven very effective in flood control and is showing considerable promise for the removal of toxins.
Storage ponds have become a common feature in the developed landscape. Chesapeake VA, for example, a city of 200,000 reports over 140 such ponds in its 350 square mile area, while Portland OR manages 365 in just 130 square miles. While the exact number of storm management ponds nationwide is unknown, it would almost certainly be in the tens of thousands.

Some municipalities are attempting to use stormwater ponds as landscape amenities, placing them in parks or designing them to serve as natural habitat. Designers have suggested that the ponds offer multiple use options, serving social and natural goals while also controlling stormwater.

The use of ponds, however, is not without controversy. Because these are utilitarian structures, they are often seen as marring the landscape while displacing natural ecosystems. Since they are placed in highly populated areas, there are safety concerns with having open water in proximity of children, and there are recurrent nuisance issues like mosquitoes and algal blooms.

Most recently, concerns have arisen [12] that the sediment collected in the pond, containing heavy metals and other runoff may be hazardous to the wildlife and people in their immediate proximity. Studies of the ponds recommend extreme care be taken in their design and that there be an on-going program of monitoring and maintenance, including removal of sediment.

Because of the strong public works orientation of stormwater management, there is a tendency to seek engineering solutions to stormwater problems. Others, such as the NRDC, however, maintain that the central features of stormwater runoff lie in the patterns of land use and development in the urbanizing of the nation. In this view, land use planning, watershed planning, and political entities may play a more crucial role than specific structures and machinery.

According to the NRDC, "the most important category of stormwater strategies focuses on land use and development. It encompasses a wide range of measures, from regional planning to the use of site-specific structural and nonstructural measures." In this view problems can best be handled by prevention, i.e. by not creating the excess runoff in the first place. "One of the best strategies a municipality can employ is to minimize the aggregate amount of new impervious surfaces."

For many cities, however, limiting impervious surfaces is often seen as limiting economic growth. Only in recent years has coping with stormwater contamination been given a significant role in planning. Moreover, planning for preventative step cannot be easily carried out in areas already urbanized. "These measures...apply more in developing and suburban areas than in ultra-urban areas that are already built up." In those areas that are "largely covered by impervious surfaces, municipalities will need to rely more on the other elements of a stormwater program or on stormwater treatment measures."

This again, however, raises questions of enforcement and finances. For small municipalities, the costs of such programs may be quite daunting. Also, unlike many EPA programs, there has been no money set aside for grants to help localities defray the costs of the regulations.

Faced with uncertain expenses for items ranging from drain stenciling to pond inspections, groups like the NACo and the NAFSWM have expressed deep reservations about the implementation of the Phase II regulations. The politics of the question has become more polarized as some critics consider the stormwater regulation to be an "unfunded mandate," i.e. a directive from the federal government that lacks money to support it. Opposing unfunded mandates has become a major cause, independent of the specifics of stormwater pollution.
On the other hand, environmental groups, faced with understandable concerns over delays and possible effects on water quality, stand ready to again pursue litigation that would compel the EPA to enforce these provisions.

Conclusion

Unlike many environmental issues, which seem to pit government bodies against the private sector, the stormwater controversy is being contested squarely within the public sector. Industrial sites have generally shown greater willingness to retain and manage stormwater. Although the regulations would be felt at all levels of society, the crux of the issue lies with the intergovernmental dispute over local government being induced to take actions for which it feels it does not have sufficient resources.

Scientific evidence, however, supports the argument that non-point source pollution—of which urban runoff is a major component—is having a decidedly detrimental effect on surface water quality. Many would suggest that further delay in action will lead to a variety of environmental impacts, including habitat loss and toxic accumulations.

Perhaps the most intractable aspect of the contamination of urban runoff, is that the "blame" can only be placed on society as a whole. Lacking the "point" of a point source polluter to curtail, the answer to the urban runoff problem must come from widespread adjustments in the habits and practices of millions of individuals and communities. This will be no small task, regardless of the Best Management Practices employed and regardless of the regulations ultimately issued.

References

7. NJ DEP, 1999. *Phase II - Stormwater Permitting Program: Improving Water Quality and the Quality of Life.* NJ Department of Env. Protection, Division of Water Quality, Bureau of Nonpoint Pollution Control. [go back]
Green Infrastructure Prevents Sewer Overflows and Protects Water Quality

What is Green Infrastructure?

Green infrastructure is an interconnected network of green space that provides benefits to the community and the environment. Green infrastructure techniques typically utilize natural or engineered systems that mimic natural landscapes in order to capture, cleanse and reduce stormwater runoff. Green infrastructure can include parks and nature preserves, rain gardens, rain barrels, green roofs, wetlands, permeable pavement and other methods intended to significantly reduce the amount of stormwater runoff entering the sewer system and our waterways.

Community Benefits

The benefits of green infrastructure techniques are far reaching in many areas including the environment, the economy, and public health.

Fewer Sewer Overflows, Reduced Flooding - Green infrastructure reduces stormwater runoff by capturing and absorbing water. This can result in fewer sewer overflows, cleaner water, and reduced flooding or wet basements.

Reduced Water Pollution - Stormwater runoff is a major source of water pollution in the United States. In urban areas, rain water runs off of buildings and pavement, picking up chemicals and a variety of other pollutants. Green Infrastructure techniques help prevent pollutants from entering nearby storm drains and sewers, which then flow into our waterways.

Improved Air Quality - The plants and soils included in green infrastructure not only look good, but they also help improve the surrounding air quality by removing CO2 and other pollutants from the air.

Reduced Energy Demands – Cities and dense urban environments trap heat from the sun, increasing average air temperature and leading to heat related deaths. Green infrastructure techniques, especially green roofs, can help alleviate this heat build-up and reduce the need for air conditioning in buildings. This saves money and reduces global warming pollution.

Additional Wildlife Habitat and Recreational Space - All forms of green infrastructure can provide increased access to recreational space and create new wildlife habitat.
Across the country, cities are realizing the benefits of green infrastructure in addressing water quality problems from stormwater runoff and sewer overflows. Many innovative solutions can be used to protect water quality.

Cincinnati, OH

The Metropolitan Sewer District (MSD) of Greater Cincinnati has adopted green infrastructure as a key means to reducing combined sewer overflows. MSD’s combined sewers overflow over 14 billion gallons of sewage and stormwater a year. By using green infrastructure, MSD intends to reduce the stormwater runoff going into the combined system, and thereby reduce the volume and frequency of overflows. This will also mean a reduction in the size and costs of conventional pipes and treatment plant systems as well as a reduction in energy use. MSD is in the process of developing new ordinances, zoning and incentives for green infrastructure. MSD’s current plan is on the web at www.msdgc.org/wetweather/greenreport.htm. Photo of rain garden provided by the Sierra Club.

Chicago, IL

As one of the most innovative cities when it comes to green infrastructure, Chicago has implemented green roofs, rain gardens, permeable pavement, and downspout disconnection/rainwater collection. The Chicago Green Roof Program began with a 20,300 square foot demonstration on city hall, which retains more than 75% of the volume from a one-inch rain storm, preventing this water from reaching the combined sewer system. In 2005, Chicago began providing $5,000 grants for residential and commercial buildings, resulting in more than one million square feet of green roofs. The city has seen benefits such as reducing the heat island effect and improving energy efficiency in buildings, along with water quality benefits. Image source www.cityofchicago.org.

Columbus, OH

The Community Watershed Stewardship Project of the Columbus Department of Public Utilities partnered with the Friends of the Lower Olentangy Watershed to offer a rain barrel program. Participants in the program receive a rain barrel at a significant discount of $30 when they attend a workshop. The program includes 11 workshops during 2007-2008 with more than 250 rain barrels purchased by residents. The average home can collect anywhere from 50-200 gallons of water every time it rains, depending on how may rain barrels they use. Another notable green project is a 15,000-square-foot rooftop garden on the Lazarus building in downtown Columbus, which keeps the building cooler and recycles rain water for toilets. Rain barrel photo courtesy of Rain Brothers.

Washington, D.C.

Using a grant from the EPA, Washington, D.C. created a program to quantify the stormwater management benefits of green roofs and trees. The study determined that moderate coverage for green roofs and trees could prevent over 311 million gallons of stormwater from entering the sewer system, reducing sewer discharges into the river by 282 gallons and combined sewer overflow frequencies by 16 individual events. Results from a more intense coverage of green roofs and trees showed a reduction of 1 billion gallons of combined sewer overflows into local rivers. From the results of the program, Casey Trees strongly recommended the use of green roofs and trees throughout the city, stating that they could potentially provide significant savings, ranging from $1.4 to $5.1 million annually, because of the decreased amount of water treatment required in addition to improved water quality. Photo of community tree planting courtesy of Casey Trees, a partner in this project.
The future of stormwater has arrived, and that future is green. Green infrastructure, that is.

First, a definition. Green infrastructure is the interconnected network of open spaces and natural areas — greenways, wetlands, parks, forest preserves, and native plant vegetation — that naturally manages stormwater, reduces the risk of floods, captures pollution, and improves water quality.

In cities and other urbanized areas, that network can be extended by means of rain gardens, green roofs, tree planting, permeable pavement, and other landscape-based drainage features. They restore, protect, and mimic natural hydrologic functions within the built environment.

Growth in paved and other impermeable surfaces increases stormwater runoff pollution, even if that pollution is directed toward conventional stormwater infrastructure. But green infrastructure provides an antidote by intercepting rainfall before it reaches sewers. And green infrastructure usually costs less to install and maintain when compared to conventional “gray” forms of water infrastructure that rely on concrete gutters, sewers, and end-of-pipe treatment. This is important in a time of shrinking financial resources and increasing public and regulatory demand for clean water.

Green infrastructure projects also foster community cohesiveness by engaging residents in planning, planting, and maintaining highly visible stormwater infrastructure that beautifies and adds value to neighborhoods.

For planners, examples from Prince George’s County, Seattle, Portland, Minneapolis-St. Paul, and Chicago show how green infrastructure features can help improve water quality and general quality of life. They also show how green infrastructure approaches can support broad planning goals pertinent to clean water, neighborhood development, and community livability.

**Green common ground**

Places employing green infrastructure have several things in common. They all recognize the multiple ecological, financial, and community objectives green infrastructure serves. And each is using pilot projects on individual sites to expand green best management practices to broader block and neighborhood scales within existing and planned urban landscapes.

Consistent evidence from pilot projects shows that green infrastructure can capture, retain, infiltrate, or evapotranspirate 90 percent or more of the rain from typical storms delivering an inch or less of precipitation. This is crucial because the majority of runoff pollutants are carried in the first half-inch to one-inch “first flush” of precipitation.

Monitoring studies show that green infrastructure practices retain or remove 30 to 90 percent of runoff pollution, depending on the pollutant and the particular practice. Tools such as the Chicago-based Center for Neighborhood Technology’s Green Values Calculator can be used to evaluate site-level costs and impacts, comparing green and gray infrastructure costs and runoff impacts.

At this point, several cities have developed regulations encouraging or requiring green infrastructure or low-impact development in most projects. Seattle’s city council is considering a requirement that green infrastructure technologies “must be incorporated throughout a project site wherever feasible.”
The local regulations are accompanied by design specifications to ensure their hydrological effectiveness, and to give clarity to planners and builders on acceptable approaches. Key standards cover siting in relationship to buildings and other infrastructure, sizing to absorb target storm volumes and rates, soil conditions that may limit infiltration or present risk based on previous contamination, and limiting duration of ponded water to prevent mosquito infestation.

Perhaps most significantly, the leading green infrastructure cities are integrating these practices into a wide range of public and private spaces, at both new and developments and existing sites.

**Taking it to the streets**

Integration with transportation plans is a common element of many green infrastructure programs. By designing vegetated drainage and porous materials into streets, alleys, rights of way, and parking lots, cities can increase on-site neighborhood stormwater capacity. Green streets and green parking areas take advantage of the need for periodic resurfacing, adding stormwater management elements when paved areas are repaired or replaced.

Green infrastructure is also becoming a component of the movement toward complete streets, in which the landscape is used to integrate transit, pedestrian access and safety, and stormwater management. And green infrastructure is closely tied to smart growth practices like cluster development, reduced parking ratios, and the general reduction of impervious area.

The current wave of low-impact development can be traced to Prince George's County, Maryland. In 1992, Larry Coffman, then associate director of the Environmental Services Division, created a prototype rain garden in response to concerns about pollution reaching Chesapeake Bay. He inverted a parking lot island, creating a planted island that sat below the surface level of the parking lot. By cutting an opening in its curb, replacing soil with a more porous mixture, replanting with local forest species, and letting runoff drain through the below-grade soil and vegetation, Coffman showed that it was possible to keep runoff out of sewers and enhance natural filtration.

Extended experiments through the early 1990s, many led by the Maryland-based Low Impact Development Center and the Center for Watershed Protection, helped the division formulate early guidelines for the practice of bioretention, ultimately including a technical design manual in 1999, and an updated version in 2002. The results were impressive. Extensive installation of rain gardens and swales at a subdivision in Somerset, Maryland, netted a 20 percent reduction in runoff compared to a conventional subdivision, and implementing the low-impact development practices cost a mere 25 percent of their gray counterparts.

Those early efforts have grown into a statewide standard. The 2007 Maryland Stormwater Management Act mandated environmental site design to the maximum extent possible. The Maryland draft standard includes objectives to capture stormwater on site, maintain 100 percent predevelopment groundwater recharge, and prevent pollution.

The standard also requires early design steps to protect functional local hydrology and recommends a variety of “micro scale” practices to drain areas of less than one acre, describing many practices like green roofs, permeable pavement, rain gardens, swales, downspout disconnection, and rainwater harvesting in barrels or cisterns to treat runoff at its source.

**Best practices go west**

Green infrastructure practices appeared in the Pacific Northwest in the 1990s, partly in response to the requirements of the federal Clean Water Act and Endangered Species Act, both of them pertinent to the endangered salmon.

Seattle’s urban forestry effort became an offshoot of its infrastructure system in 1994, when it committed capital from its Cumulative Reserve Fund for parkland forest restoration. By 2005, a mayoral executive order was issued requiring that two trees be planted for each one removed.

Seattle’s 2007 Urban Forestry Management Plan set broad goals to increase canopy cover from 18 to 30 percent, requiring about 650,000 trees in 30 years. Among the key benefits from the strategy is the trees’ stormwater retention, valued at an estimated $10 million per year out of $14 million in total benefits. Those also include improved air quality, carbon sequestration, energy savings, and aesthetics.
Seattle's best-known green infrastructure demonstration project is called Street Edge Alternatives, the prototype of its current SEA Streets program. In that first project, completed in 2001, the city narrowed a street to create a meandering, river-like road that reduced impermeable coverage by 11 percent. The street was 14 feet wide, with 18-foot intersection flares and a sidewalk on only one side.

This project, also known as SEA Street #1, involved replacing a gravel shoulder and surface drainage with colorfully planted drainage swales along a block in the salmon-bearing watershed of Piper's Creek, including 100 new evergreens and 1,100 shrubs. The results were convincing, both financially and hydrologically: Runoff volume was reduced by 98 percent, at a cost 25 percent below that of conventional street designs.

In another experiment, the city built its prototype Cascade design on a sloped street, linking several stepped bioretention features into a feature that resembles local waterfalls and captures at least half the runoff and up to 92 percent of pollutants through infiltration and plant uptake.

The ecological, economic, and community success of SEA Streets has led to neighborhood-scale green infrastructure approaches. Seattle Public Utilities is now working with green grids rather than individual blocks. The 15-block Broadview green grid manages stormwater from the adjacent 10-acre neighborhood but also 22 acres nearby, combining the SEA Streets and Cascade designs.

The Cascade design cost $285,000 per block, and the Broadview green grid $280,000 per block, compared with $520,000 for a comparable street with conventional drainage.

A third project is a combined effort of Seattle Public Utilities and the Seattle Housing Authority. The 129-acre mixed income housing redevelopment called High Point covers eight percent of the Longfellow Creek sub-watershed. High Point spreads 1,600 housing units and mixed use areas over 34 blocks of new streets.

There, curb cuts drain into swales along the street edges, most downspouts are disconnected from storm drains and flow into grassy areas or rain gardens, some streets and sidewalks are made of porous pavement, and a conveyance system and detention pond absorb the impacts of larger storms.

According to the Seattle Public Utilities website, "Longfellow Creek will receive no more flow from High Point during and after a two-year, 24-hour storm than it would if the 129-acre site were still a grassy pasture.”

Seattle now has a proposed drainage code that will require green infrastructure in new and redeveloped areas and will give residents credits against utility fees for installing recognized features. The city has also instituted a “Green Factor” program that requires property owners to install minimum landscaping, potentially including green roofs, street trees, and permeable paving and other natural drainage system practices on commercial properties.

**Portland’s response to growth**

In Portland, Oregon, sustainable stormwater initiatives grew out of goals similar to Seattle's: the need to meet federal requirements for water quality and helping endangered wild salmon. Although Portland is building a conventional sewage deep tunnel to divert combined sewer overflows from the Willamette River to its treatment plant, it is counting on green infrastructure to limit the overall runoff volume over the long term — an important strategy in a city facing rapid growth.

Portland’s Bureau of Environmental Services began testing experimental vegetated swale designs in 1998. Those tests showed native plants were superior in performance to turf grass swales. The initial monitored results led to further pilot efforts, particularly in ecoroofs, swales built into curb extensions, and streetside planters.

Another strategy, launched in 1996, has had a positive effect throughout the city. Home owners have two options for disconnecting from the city's combined sewer system so that stormwater can flow over appropriate vegetated sites. The city will pay home owners who disconnect their own downspouts, or city crews will disconnect them for free.

Downspout disconnection is one of several actions eligible for residential utility fee discounts under Portland’s Clean River Rewards Incentive system. By disconnecting nearly 60,000 downspouts, the city diverted 1.5 billion gallons annually from combined sewers.

Another Portland project — native gardens built along the sides of Siskiyou Street — have become nationwide models of affordable green infrastructure projects that work. The 2003 Northeast Siskiyou Green Street Project converted 590 square feet of street pavement into landscape in curb extension bump-outs, also called "pocket swales.” The areas were excavated to 14 inches below grade and refilled with an amended soil mix and a selection of drought-tolerant plants. Both sides of the
residential block are involved, and 9,300 square feet of adjacent pavement are drained by means of four planted compartments that capture the street's runoff through native vegetation.

Simulated flow tests showed the street swales to be effective enough at reducing peak flow to prevent basements from flooding. They also controlled 85 percent of runoff volume for a simulated 25-year storm (1.89 inches in six hours, with a peak intensity of 3.32 inches per hour). The project was designed as a simple retrofit for existing streets and costs $20,000 to build.

Numerous additional pilot projects involving green roofs, swales, rain gardens, and streetside planters in a variety of locations led to Portland's adoption in 2007 of a Green Streets policy. It recognizes that green streets manage stormwater on-site, improve water quality and groundwater recharge, and lead to "attractive streetscapes that enhance neighborhood livability by enhancing the pedestrian environment and introducing park-like elements into neighborhoods."

Under the new policy, green street facilities will be incorporated into all city-funded development, redevelopment, or enhancement projects, according to Portland's stormwater management manual. The policy seeks to foster cross-departmental communication and encourage programs among bureaus in the interest of water quality and watershed health. It also explicitly seeks to use green streets to connect neighborhoods and save on infrastructure costs.

Under the Green Streets policy, designers and planners can find precise minimum design specifications (including section drawings) for the types of green infrastructure elements that are allowed, their location, materials, and varying conditions — for example, designs to use when an installation is adjacent to parking spaces. Those design standards can be adapted to fit right-of-way patterns in the city's transportation system plan.

Like Seattle, Portland helps engage the public in sustainable stormwater initiatives. It provides plant selection lists, design ideas, and extensive neighborhood outreach to stimulate the involvement of private land owners. The city also gives grants for certain private projects, and offers workshops for residential and commercial developers on green infrastructure techniques, costs, and benefits.

**Greening Middle America**

Green infrastructure is being adopted in the Midwest as well. In Minnesota's Twin Cities region, the seven-county Metropolitan Council issued technical guidance encouraging use of green practices in 2002. "A lot of those planning elements that make communities more livable also make them better for water resource management," says senior planner Karen Jensen.

Revisions to be made this year to the Metro Council comprehensive plan will include a surface water management requirement for on-site infiltration of the first half inch of stormwater. Some Twin Cities watershed districts have already increased that requirement to on-site capture of the first inch of rainfall.

Those requirements, combined with cost-share grant funding, have helped spread green infrastructure throughout the region. Ramsey-Washington Metro Watershed district provides a 50 percent best management practice cost share, up to $2,000 for residential or $30,000 for commercial or governmental projects. "It's amazing in the Twin Cities how there has been this tremendous momentum in the last couple of years," says Virginia Gaynor, open space naturalist for the city of Maplewood.

Her community and nearby Burnsville undertook early neighborhood-scale rain gardens. Maplewood built 350 rain gardens in a series of six street redevelopment projects between in 1996 and 2004. By 2008, the city had 400 home gardens and 25 on city property. Those projects led Maplewood to incorporate rain gardens in all future street redevelopment projects.

For home owners willing to host a stormwater garden in the right-of-way in front of their house, the city provides excavation, amended soil, plants, and technical assistance. Home owners can also pick one of 10 standard rain garden designs, developed for climatic resilience, aesthetics, and easy maintenance.

Collaboration with home owners helps keep city costs in control, as home owners take responsibility for maintaining rain gardens on their property. Gaynor says failures in early efforts showed the importance of helping developers avoid problems such as soil compaction during garden construction.
In Burnsville, the rain garden project began in 2002 and became operational in 2004 in an effort to protect nearby Crystal Lake. Seventeen rain gardens were installed in a 25-lot, five-acre neighborhood that was built in the 1980s with existing traditional curb and gutter infrastructure. The Burnsville rain gardens were designed to hold runoff from a 0.9-inch storm, with their results measured against an untreated similar neighborhood as a "paired watershed" experiment. They turned out to be more effective, retaining 90 percent of runoff even when storms were larger than the target size.

The Burnsville retrofit project cost $7.50 per square foot of rain garden, but can cost half as much for new developments, according to Burnsville water resource specialist Daryl Jacobson. He says the city has adopted a "first inch infiltration" standard to bring green infrastructure into new developments. Now Burnsville wants to replicate its pilot program in other neighborhoods, aiming to retrofit one neighborhood per year as part of its street maintenance cycle, Jacobson says.

"If you get (green infrastructure) in at the front end and make it part of your stormwater management, it will get you the level of water quality treatment you need and is cost-effective," Jacobson says.

The Burnsville project also is addressing the question of cold climate performance. Results there are similar to those in New Hampshire and other cold regions where native plant roots and porous soil help to keep rain gardens infiltrating runoff even during winter.

Minnesota green stormwater projects are addressing the need to spread beyond individual sites. St. Paul Riverfront Corporation — a nonprofit advocacy and design organization — published a Water Quality Manual in 2007 that describes various green practices in terms of their application at site, block, neighborhood, and city scales. Within each of those categories, the manual describes various techniques as well as sequential green infrastructure features — "treatment trains" — that can be connected to progressively purify runoff.

The Heritage Park redevelopment created a treatment train designed to handle 1.25-inch storms on a 130-acre area and to manage drainage on 300 off-site acres in what was historically part of the Bassett Creek drainage area. Stormwater treatment is done using medians and developed blocks, in which runoff filters through a sediment forebay into a filtration basin and pond before reaching a storm drain at the end of the train.

The Heritage Park redevelopment created a treatment train designed to handle 1.25-inch storms on a 130-acre area and to manage drainage on 300 off-site acres in what was historically part of the Bassett Creek drainage area. Stormwater treatment is done using medians and developed blocks, in which runoff filters through a sediment forebay into a filtration basin and pond before reaching a storm drain at the end of the train.

The system is designed to remove 70 to 80 percent of the runoff's total phosphorus and 85 percent of its sediment (exceeding the local requirement for 70 percent suspended solid removal) while creating water amenities for the new neighborhood.

**Back alley story**

Chicago's green infrastructure efforts underscore the city's declared quest to be "the greenest city" in the nation. Chicago now has about two million square feet of vegetated roof, with another two million planned or under construction. The city's stormwater ordinance, which took effect this year, requires that the first half inch of runoff be captured, or that there be a 15 percent reduction in impermeable surface, on most development and redevelopment projects. But Chicago has taken a creative path to innovative green practices.

The Chicago Department of Transportation began experimenting with permeable alley designs in 2006, seeking to take advantage of the city's 1,900 miles of alleys — which include 3,500 acres of impermeable surfaces. Green alley experiments on the first 40 alleys required the development of porous concrete and asphalt mixes using local and recycled materials. The city learned that alley designs using a partial porous surface, such as a center trench or porous edges, worked well and cost less than full porous surfaces. Another 48 green alleys are scheduled for completion this year.

The pilots led to an award-winning Green Alley handbook and led the city to work toward a sustainable streets approach. While the city will continue to repave its alleys to improve drainage, green infrastructure along rights of way now integrates design for stormwater drainage with transit, pedestrian access, energy, and air quality.

The latest project, a retrofit along part of Cermak Boulevard on the city's south side that is planned for construction this year, integrates drainage swales, permeable pavement, energy-efficient lighting, and bike lanes. Chicago is even testing a photocatalytic pavement coating originally developed to keep the Vatican from graying in Rome's polluted air. As a street surface, the coating is intended to filter street-level air pollutants.

"Good sustainable design is integrated design, that sweet spot that occurs when all disciplines work together to achieve quality, beauty, and efficiency," says Janet Attarian, project director of Chicago's Sustainable Streetscape and Design Program. "When designing the public right-of-way, old fashioned
principles of walkability, access, and great public space have to be combined with new technologies and best management practices to maximize the use of these spaces and create beautiful places for people to live, work, and play."

Steve Wise is the Natural Resources Program Manager at the Center for Neighborhood Technology in Chicago.

1,000 Points of Infiltration (or Thinking Big)

Communities around the U.S. are expanding their green infrastructure practices to embrace entire neighborhoods and cities. Here are a few examples.

• Milwaukee Metropolitan Sewerage District Greenseams
As part of a comprehensive green infrastructure program, the Milwaukee Metropolitan Sewerage District, in collaboration with the Conservation Fund, has invested nearly $12 million to acquire 1,700 acres of undeveloped riparian and forested areas. The district estimates that the increase in natural storage in four otherwise fast-developing watersheds would equal a $300 million investment in structural storage.

• Philadelphia: Clean Waters, Green City
Philadelphia's Watersheds Office is developing a "60 percent solution" to manage runoff from three-fifths of the city's impervious area. The city will reduce sewage overflows from stormwater runoff by enforcing an ordinance requiring first-inch on-site capture at regulated developments, setting stormwater rates according to impervious area, providing tax credit and permit incentives for green infrastructure, and building projects on public streets, schools, parks, buildings, and roofs. One goal is to uncover every buried stream in the city's watersheds.

• Washington's 20-20-20 Vision
What would happen if green roofs replaced 20 percent of the surface area of conventional roofs measuring more than 10,000 square feet? In studying Washington, D.C., the Casey Trees Foundation and LimnoTech, an Ann Arbor-based consultant, have estimated that 20 million square feet of green roofs would be built there in 20 years. According to the study, such a program would produce the equivalent of 430 million gallons of annual runoff storage, reduce sewer overflows by 15 percent, and remove nearly 17 metric tons of air pollutants.

• Kansas City's 10,000 Rain Gardens
About 400 new rain gardens have been installed so far in Kansas City, Missouri, through a collaboration between the city, the private sector, and the Mid-America Regional Council. Now the city is considering using green infrastructure as a feature of its official sewer overflow control program, currently under negotiation with U.S. EPA. Fort Wayne, Indiana, is aiming for 1,000 rain gardens under its EPA stormwater consent decree.

• Portland’s Grey to Green Initiative
Portland Mayor Sam Adams has proposed a five-year, $50 million Grey to Green infrastructure initiative, including 43 acres of green roofs, 920 green streets, 88,000 street and yard tree plantings, 419 acres of land acquisition, and 350 acres of natural area plantings. The anticipated results include better stormwater flow, habitats, livability, air quality, energy efficiency, carbon sequestration, and cost-effectiveness.

• Chicago’s Growing Water Projects
Chicago's UrbanLab design studio won a national design competition for its "Growing Water" strategy, which would create eco-boulevards running east along the city’s major thoroughfares. In this 100-year vision, natural treatment of stormwater and wastewater would lead to big changes: re-reversing the Chicago River (turned toward the Mississippi River in 1900 to send the city’s waste away from Lake Michigan) and converting the city’s deep tunnel sewage collector into a subway line. UrbanLab and the Illinois Institute of Technology are developing pilot projects.

Resources
Images: Top — Seattle installed its first Street Edge Alternatives project in 2001 — a 14-foot-wide, meandering road that uses plantings to filter pollutants from stormwater. Photo courtesy City of Seattle. Middle — In Portland, Oregon, the Northeast Siskiyou Green Street Project uses landscape curb extensions to capture street runoff from 9,300 square feet of paved surfaces. Photo Portland Department of Environmental services. Bottom — Burnsville, Minnesota — a Twin Cities suburb — has built 17 rain gardens in a five-acre neighborhood. The aim is protect nearby Crystal Lake. Photo courtesy Dakota County Soil & Water Conservation District.


On the web: For more on Seattle's natural drainage system: www.seattle.gov/dpd/Permits/Greenfactor

Learn about Portland's water gardens at www.portlandonline.com


The Center for Neighborhood Technology Green Values Took Kit: www.greenvalues.cnt.org

See the American Planning Association's Policy Guide on Water Resources Management: www.planning.org/policyguides/waterresources.htm

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San Mateo County Sustainable Green Streets and Parking Lots Design Guidebook

First Edition ~ January 2009

Prepared by:

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<< El Camino Real
Green Street Concept Sketch
San Mateo County, California
For much of the last century, drainage systems have been engineered to quickly collect runoff in underground pipes and carry it away using an “out of sight, out of mind” approach. This design philosophy treats rainfall runoff as a waste, and many people are unaware of the stormwater flowing in pipes underneath city streets when it rains.

Sustainable stormwater design treats rainfall runoff as a valuable resource. It is based on balancing urban development while preserving natural hydrological functions. Furthermore, sustainable stormwater design achieves the multiple goals of being cost effective, improving water quality, and addressing community concerns. Mimicking the natural hydrologic function of healthy ecosystems in street and parking lot landscapes can dramatically reduce pollution, decrease runoff volume, reduce runoff temperature, protect aquatic habitat, and create more interesting places to live.

The following pages illustrate how the natural environment functions prior to urban development, the overall effects of creating impervious area, and methods of redesigning urban landscapes to help bring healthy hydrological functions back into our neighborhoods.

**Sustainable Stormwater Design Principles**

1. Manage stormwater at the source and on the surface. As soon as rainfall lands on a street or parking lot, allow it to infiltrate into the ground or provide surface flow to nearby landscaping.

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

3. Design stormwater facilities that are simple, cost-effective and enhance community aesthetics. Stormwater facilities can be beautiful!

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

Figure 1-3: Sustainable stormwater design strives for a more natural, cost effective, and visible approach to managing runoff.

Figure 1-4: The Sustainable Stormwater Design Model. A balance of economy, ecology, and society.
Infrastructure can be designed to minimize its impact on natural drainage systems. Our infrastructure can help maintain the balance of natural drainage systems by capturing, slowing, and absorbing stormwater, as well as filtering the pollutants that urban development introduces.

Figure 1-7: Infrastructure can help protect creeks and streams by capturing, slowing, and absorbing stormwater and filtering pollutants.
The Three Stormwater Management Goals

Sustainable stormwater design should achieve the following three goals to the greatest extent possible:

**Water Quality Goal**
Stormwater facilities should filter and remove excess sediments and other pollutants from runoff. By allowing water to interact with plants and soil, water quality improvements are achieved through a variety of natural physical and chemical processes. Even if soils are not conducive to infiltration, or if there is a high water table, water quality is still enhanced through pollutant settling, absorption into the soil, and uptake by plants.

**Flow Reduction Goal**
Stormwater facilities should slow the velocity of runoff by detaining stormwater in the landscape. Flow rate reduction can often be achieved by integrating design strategies (such as pervious paving, planter boxes, swales, and rain gardens) that provide stormwater detention. By detaining and delaying runoff, peak flow rates are attenuated and downstream creeks are protected from erosive flows. Conveying runoff through a system of naturalized surface features mimics the natural hydrological cycle and minimizes the need for underground drainage infrastructure.

**Volume Reduction Goal**
Whenever possible, facilities should collect and absorb stormwater to reduce the overall volume of runoff. Retention facilities offer long-term stormwater collection and storage for reuse or groundwater recharge. Plants contribute to retention capacity by intercepting rainfall, taking up water from the soil, and assisting infiltration by maintaining soil porosity. Volume reduction does not require stormwater facilities to be extremely deep. In fact, it is usually best to employ a highly integrated and interconnected system of shallow stormwater facilities.
WHAT ARE GREEN STREETS AND GREEN PARKING LOTS?

There is a lot of variability in how a “green street” or “green parking lot” is defined. For the purposes of this guidebook, they include streets and parking lots designed with a landscape and/or paving system that captures, slows, filters, and potentially infiltrates stormwater runoff. Green streets and parking lots provide stormwater reduction and water quality benefits to runoff before discharging to local creeks. Specific design strategies are discussed in detail in Chapter 2.

Figure 1-11 below describes different levels of green design based on how aggressively a particular site manages runoff. For example, a street or parking lot with substantial landscape areas and a system of broad canopy trees to capture rainfall is a Level 2 design, even though it has no dedicated stormwater treatment measures. On days with minimal rainfall, a majority of the rainfall may be captured within the tree structure and ground landscaping.

However, green streets and parking lots are most commonly thought of as introducing some type of stormwater treatment measure (e.g., vegetated swale, planter, rain garden, etc.) to actively capture and manage surface runoff at its source. This is a Level 3 design and represents the most common perception of a green street or parking lot. But green streets can move beyond a Level 3 design.

The concepts of livability and stormwater management are intertwined for Level 4 and 5 designs and are primarily related to green streets rather than parking lots. A Level 4 green street not only encompasses the attributes of Levels 1, 2, and 3, but also provides a direct emphasis on alternative modes of transportation including mass transit, biking, and walking.

**Green Streets and Parking Lots** are designed with a landscape element and/or pervious pavement system that captures, slows, filters, and potentially infiltrates stormwater runoff into the ground.

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**Figure 1-11:**

**GREEN STREETS AND PARKING LOTS CAN BE “MULTIPLE SHADES OF GREEN”**

- **Level 1**: Maximizes landscape areas along the street and minimizes overall impervious areas of the land. Some runoff from sidewalks may be managed in landscape areas.

- **Level 2**: Significant tree canopy is added to the urban streetscape.

- **Level 3**: Fully manages street, sidewalk, and driveway runoff by using a landscape system. Design solutions are cost effective, provide direct environmental benefits, and are aesthetically pleasing.

- **Level 4**: Green street provides direct focus on alternative modes of transportation including mass transit, biking, and walking.

- **Level 5**: Green street frontage manages both public and private stormwater runoff. Building, site, and street frontage become one integrated space designed for stormwater management.

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on alternative transportation options, such as walking, biking, and/or using mass transit. More people using alternative transportation lessens the number of vehicles generating pollution. Furthermore, incorporating mass transit stops, bike lanes and racks, carpool drop off areas, or other similar site design measures can reduce the overall impervious area required.

The “greenest,” and most difficult level to achieve, is a Level 5 design. This comprehensive approach allows stormwater to be managed within the entire street “envelope,” which blurs the line between public and private space. Stormwater from private driveways and buildings could be managed within the public right-of-way. Conversely, stormwater from the street could utilize available landscape space within private property. This is currently not a widely-accepted condition here in the United States; however, in many European cities, this type of a green street is becoming more common.

New and redevelopment projects offer more opportunities to achieve a Level 4 or 5 design. Other projects (especially retrofits), due to a multitude of site constraints, might only be able to achieve a Level 3 design. Regardless, the most important consideration is to always strive to reach the highest level of green design possible. When a high level of green design is applied to street and parking lot sites throughout the County, the overall health of the watershed, the San Francisco Bay, and the Pacific Ocean will improve.
Urban development leads to an increase in impervious surfaces and a corresponding increase in surface runoff and pollutants from vehicles and other urban sources. The problem is exacerbated when increased stormwater runoff reaches a creek channel that is not capable of handling increased flows without significant erosion and degradation. Creeks with tributary areas having greater than 10% impervious surfaces are likely to have degraded water quality and habitat.

In San Mateo County, many of the regional storm drain systems were designed to outdated standards and lower service populations. Steady growth and urbanization over recent decades has left some local storm drain systems unable to handle the quantity of runoff produced by larger storm events, resulting in local flooding and associated damage. Besides being under-designed, other storm drain system inadequacies exist for a variety of reasons, including:

- Existing storm drain infrastructure has deteriorated
- Local neighborhood catch basins are inadequate
- Culverts have reduced capacity due to siltation
- Culverts are too low to drain by gravity during tidal conditions

Figure 1-15: When it rains on our streets, pollutants are washed directly into pipes and then into creeks, the Bay, or the Pacific Ocean.

Figure 1-16: Even small parking lots contribute to the larger problem of increased stormwater runoff.

Figure 1-17: There is only so much that the existing storm drain infrastructure can take. Green streets and parking lots can help relieve over-taxed systems.
Flooding from an overwhelmed storm drain system results in a myriad of problems, such as:

- Storm drain backups and localized flooding
- Property damage
- Creek bank and bed erosion and downstream sedimentation
- Settled creek levees
- Restricted vehicular access
- Damaged roads
- Damaged or deteriorated bridge structural members

**Figure 1-18:** The red lines indicate creeks and small streams in urban areas that have been replaced by decades of built underground pipe infrastructure. This scenario is all too common in communities throughout the United States.

**Water Pollution from Streets and Parking Lots**

San Mateo County’s storm drain system was designed to prevent local flooding by channeling stormwater runoff ultimately into the San Francisco Bay or the Pacific Ocean. This system provides no inherent water quality treatment. Stormwater runoff accounts for a majority of the pollutants entering local creeks and the San Francisco Bay. Potential pollutants include:

- Oil, grease, antifreeze, heavy metals from leaking and deteriorating cars and trucks, and brake pad and tire wear
- Pesticides, herbicides, and fertilizers from our residential and commercial landscapes
- Solvents and household chemicals (e.g., paint thinner, detergents, and paint)
WHY USE GREEN STREETS AND GREEN PARKING LOTS?

• Animal waste, litter, decomposing vegetation, and sewage from leaks

• Construction debris, such as fresh concrete or mortar

Certain creeks, coastlines, and water bodies in San Mateo County have been identified under the Clean Water Act’s section 303(d) as impaired by specific types of pollutants, such as sediment (see Appendix C). Sediment impairment of creeks is often caused by non-point sources associated with past and current land use practices. Conventional development practices may degrade the environment at a substantial cost to the larger community.

The Multiple Benefits of Using Green Streets and Parking Lots

Implementing landscape-based stormwater management facilities as part of green streets and parking lots in San Mateo County has the potential to minimize pollution, stream degradation, and localized flooding. Reintroducing bioretention into the hydrologic cycle reduces peak runoff rates and volumes by holding back and slowing down the water that would otherwise flow quickly into the storm drain system. By increasing natural storage and infiltration of rainwater, municipalities can slow peak flows and ease the burden of overwhelmed storm drain infrastructure. However, the benefits of using green streets and parking lots go beyond the obvious and include many ancillary environmental and community benefits.

Trash Removal

The effects of trash is another important water quality issue in San Mateo County. Improperly discarded trash is often washed into drainage systems during rains and finds its way into local creeks and the San Francisco Bay. In addition to physical pollution, trash can contribute chemical pollutants when it includes batteries, fluorescent tubes, and other such toxic waste. While there is no substitute for keeping trash out of the drainage system, green streets and parking lots can serve as localized collectors. Trash that would otherwise end up in San Mateo County’s waterways can be regularly removed, recycled, or discarded in an environmentally appropriate way.
Community and Neighborhood Benefits

Green streets are not just about better stormwater management, but they are also about creating more beautiful and livable neighborhoods and communities in San Mateo County. Effectively “greening” the urban fabric helps provide a unique quality of life that increases the desirability of living in a particular community. Furthermore, incorporating green streets and parking lots offers people a very tangible way to learn about environmental sustainability. These types of projects can be built where we live, work, shop, learn, and play, and are constant reminders that rainwater is a resource, not a waste.

Air Quality Benefits

Significant tree plantings throughout a parking lot or along a street site help mitigate local air quality issues. Trees help settle out particulate matter, reduce low-level ozone, and help mitigate the urban heat island effect. Light-colored permeable pavement further mitigates the heat island effect, since it increases the albedo, or diffuse reflectivity, of the paved area.

Economic Benefits

Providing more landscaping in the urban environment makes good economic sense. Project Evergreen (2008) states the following:

• Smart Money magazine indicated that consumers value a landscaped home up to 11.3% higher than its base price

• Studies by the University of Washington showed that drivers found it easier to locate businesses on a street when they were framed by trees and landscaping, rather than having this green material removed

• A recent study has also found that consumers are willing to pay, on average, a 12% premium for goods purchased in retail establishments that are accompanied by quality landscaping
Since the major opportunity in San Mateo County is to retrofit the existing built environment, the overall goal should be to reduce costs as much as possible and deliver additional non-stormwater-related benefits when applying design solutions. In general, retrofitting green street and parking projects is more costly than implementing new development projects simply because the former have site constraints that must be addressed. For example, there are often extra costs associated with removing existing concrete or asphalt in order to make way for new green space. In some cases, using a “green” approach might cost more, but the ancillary benefits (such as traffic calming, improved neighborhood aesthetics, and a safer pedestrian environment) should also be considered.

The following describes four ways to reduce costs when implementing green street and parking lot projects:

**Minimize Existing Impacts**

One way to reduce construction costs is to minimize the impact to the existing storm drain infrastructure as much as possible and maintain existing storm drain inlet locations. Altering drain inlet locations and installing new storm drains at intersections can be very cost prohibitive in some projects. In many cases, stormwater facilities constructed up-gradient of existing storm drain inlets may require little, if any, alteration to infrastructure. Many green streets projects in Portland, Oregon were built inexpensively because they minimized impacts to the existing piped infrastructure. For example, the NE Siskiyou Green Street project installed two stormwater curb extensions just upstream of the existing stormwater drain inlets and never touched the existing storm infrastructure. By avoiding any such impact, the project’s overall costs were reduced significantly. Further details of Portland’s green street projects can be found in Appendix A “Further Resources.”
Look for High-Opportunity Projects

When searching for cost effective green street projects, look for candidate sites that have minimal site constraints and maximum space for stormwater facilities. In some cases, there is available landscape space that can be easily regraded and planted to provide stormwater management. In other cases, there are streets and parking lots that have excess asphalt area that can be converted into a stormwater facility at minimal cost. High-opportunity projects also include street and parking lot projects that have willing stakeholders, agencies, owners, or neighbors that can help provide advocacy or funding for a particular project.

Combine Green Streets with Other Street Improvements

Continual capital improvements are needed to maintain street longevity. Asphalt paving often needs to be replaced; curbs, sidewalks, and utility lines need to be repaired; and overall traffic/pedestrian improvements are constantly being planned. The most opportune time to incorporate a green street element is when a street is already planned and budgeted for improvement. Coordinating the efforts between regular street improvements and green street improvements can help reduce the cost of green street implementation by achieving positive economies of scale. In many situations, green street projects can be integrated and budgeted as part of solutions for local traffic problems. For example, stormwater curb extensions can help narrow street widths, provide traffic calming benefits, and potentially be paid for by a non-green street-related budget.

Figure 6-6: Simple green streets, such as this residential example in Portland, Oregon, convert under-utilized landscape area next to streets into stormwater facilities. Since the improvements consist largely of regrading and planting, the projects can be very cost effective to build.

Figure 6-7: A prime retrofit candidate in San Mateo County. This landscape strip along El Camino Real could be retrofitted with new landscaping and curb cuts to create an inexpensive green street example.

Figure 6-8: This green street curb extension project was funded in conjunction with a pedestrian safety and traffic calming project.
Keep Design Solutions Simple

During the design phase of green street and parking lot projects, it is important to keep the design as simple as possible. Highly engineered design solutions can often increase project costs. Remember, green streets rely on a natural, landscape-approach to stormwater management.

One often over-designed component in green street and parking lot construction is the means by which water gets in and out of landscape stormwater facilities. Over-designed inlet structures not only increase project costs, but they often detract from the aesthetics of a project. Keeping the design simple and allowing water to surface flow in and out of stormwater facilities will help keep costs more manageable. Likewise, using only surface overflow to an existing downstream storm drain inlet, when possible, can simplify a project’s design and greatly reduce costs.

Another effective cost saving strategy is to limit the amount of imported hardscape materials. For example, it may be tempting to use deeper concrete walls to facilitate greater ponding depth, but the marginal benefit compared to shallower stormwater facilities, which use less resources, may not justify the additional expense.

With larger construction projects, the designer should balance the total cut and fill on a project. It can be expensive to excavate, haul, and dispose of excess soil.
With 21 different municipalities within San Mateo County using this design guidebook as a reference document, it would be difficult to account for all of the code conflicts that could arise in implementing green street and parking lot projects. However, some relevant policy and code information from various County municipalities is presented, separate from this guidebook, on the SMCWPPP website (www.flowstobay.org).

There are three major ways to help encourage code changes that support the use of green streets and parking lots: 1) build demonstration projects; 2) provide the opportunity for open communication and collaboration between municipal staff to discuss issues; and 3) provide flexibility in green street and parking lot design standards.

**Changing Code with Demonstration Projects**

One of the best methods to help municipalities change their development codes to favor green street and parking lot projects is to build demonstration projects. By labeling a project as a “demonstration” or “pilot” project, it often allows city staff to relax their standards and allow the use of alternative methods without the burden of implementing widespread change. Demonstration projects allow city staff to evaluate the particular code on the site level rather than a city-wide scale. This can provide a much clearer perspective of what issues are truly in conflict. Most importantly, when city staff experience first-hand that the particular code conflict is not as critical in light of the other benefits provided by the demonstration project, they tend to standardize the approach for widespread application.

**Changing Code with Staff Collaboration**

Another other major tool for helping change existing municipal codes is to provide an avenue for inter-city and inter-county collaboration of ideas and concerns. The ideal condition would be for all municipalities within the County to adopt a uniform and consistent set of codes and policies that support the needs of green street and parking lot projects. This would undoubtedly take a great deal of time, effort and political will to accomplish, but this effort would provide the most comprehensive approach to dealing with potential code conflicts. More realistically, resolution of code and policy conflicts that arise during implementation of green street and parking lot projects will occur through discussion and negotiation among municipal staff. Staff will need to consider multiple perspectives to arrive at a reasonable compromise that serves the greatest good.

**Providing Flexibility in Green Street and Parking Lot Design Standards**

It is important to note that it is possible for municipalities to rush to provide inflexible green street and parking lot design standards prior to developing a comprehensive array of design solutions for a wide variety of conditions. As a result, developers and municipalities could be limited to only one or two design solutions that are not well suited to the varying street and parking lot conditions in San Mateo County. It is best to provide flexible design guidelines that can be easily updated as green street solutions are refined and properly tested in demonstration projects.

**Figure 6-12:** This green street project built in 2004 in Portland, Oregon was a first-of-its-kind on a commercial street. Demonstration projects like this one have helped spur other green street projects, as well as provided the impetus for changing municipal design standards and codes.
There are several options for creating incentives for municipalities and property owners to retrofit green streets or parking lots. As described below, these incentives can be classified into three different categories: reward-based incentives, mandate-based incentives, and community-based incentives.

**Reward-based Incentives**

Reward-based incentives compensate a developer or property owner for incorporating green street and parking lot elements into their project. This type of incentive may include utility fee discounts, tax benefits, project grant funding, or even expedited review of development proposals. Reward-based incentives are particularly applicable to private development associated with parking lot projects. However, when private development occurs in conjunction with public streets, reward-based incentives can also apply. An example of a reward-based incentive is the City of Portland’s Clean River Rewards Discount Program that allows up to a 35% reduction in residential or commercial stormwater utility fees for employing certain landscape-based stormwater management strategies on-site.

**Mandate-based Incentives**

This type of incentive require a developer or property owner to employ green street and/or parking lot strategies or their on-site stormwater management fee will be levied or increased. Mandate-based incentives can result in a more wide-spread application of green street and parking lot projects, but they can also set a more negative tone to a positive effort. Mandate-based incentives may also create a burden for municipal staff by creating a larger green street and parking lot program than originally anticipated.

**Community-based Incentives**

Many neighborhoods and business districts see the value of “greening” their environment in terms of improving quality of life, increasing property values, and increasing business profits. Local neighborhoods are often willing to combine resources and help pay for a green street project, or agree to undertake long-term maintenance, or simply provide advocacy for a municipality’s green street efforts.

One way to bring to bear full community resources is to form a community benefit district. Such an entity is comprised of a network of businesses and other property owners within a defined area who voluntarily agree to pay additional property tax in order to finance capital improvements and services that enhance, but do not replace, those provided by the city. Alternatively, parking benefit districts serve the same function, but derive their funding from on-street parking meters or non-resident parking passes.

General problem-solving is another common form of community-based incentives. For example, green street and parking lot projects have the potential to reduce neighborhood flooding, provide traffic calming, and provide pedestrian safety benefits. Communities are more inclined to endorse and provide incentives toward green street projects when they are part of a more comprehensive solution to neighborhood problems.
KEY IMPLEMENTATION STRATEGY: Public Education and Outreach

One of the best tools for successful stormwater management is educating the general public. There is a lot of confusion and misconceptions about using various stormwater management strategies. People sometimes think of stormwater facilities as "swamps" or "mosquito nests" and are unaware of well-designed stormwater facility examples. Likewise, people may not realize well-designed stormwater facilities can look just as good as conventional landscapes.

Therefore, it is important to show the general public specific examples of successful demonstration projects (local or otherwise) in order to assure them that stormwater facilities can help protect the environment and can also provide a unique and attractive neighborhood amenity. There are several ways to promote stormwater education and outreach, such as:

- Conduct public tours of successful stormwater projects built in the local area, including field trip tours for school children who would like to learn more about environmental sustainability.
- Offer public meetings/workshops on the topic of sustainable stormwater management. Provide specific education materials that explains that well-designed stormwater facilities should not allow any prolonged periods of standing water that promote mosquito breeding.
- Send out brochures or provide fact sheets that describe different ways to manage stormwater runoff.
- Install interpretative signs for key stormwater demonstration projects. The signs should describe the particular elements of a project and where to find more information.
Green street and parking lot demonstration projects can be selected and designed using one or a combination of three approaches. Depending on the approach taken, demonstration projects can range from small to large, retrofit to new construction, and simple to complex.

**Strategic Approach**

This approach locates stormwater facilities intermittently, but strategically, to provide the most efficient level of stormwater management. Because this approach uses smaller facilities, it tends to be the least expensive to construct and maintain. This approach is widely used for retrofitting existing streets. An example project using this approach is the SW 12th Avenue Green Street in Portland, Oregon (Figure 6-17).

**Opportunity Approach**

This approach locates stormwater facilities in areas where there are very few constraints and that offer high demonstration value. By using this approach, under-utilized landscape or impervious areas are converted into stormwater facilities of any size. An example of this approach are the five rain gardens located along NE Sandy Boulevard in Portland, Oregon (Figure 6-18).

**Full-Integration Approach**

This green street approach integrates the entire street frontage for stormwater management. A full-integration approach offers the most stormwater management benefits, but it is usually the most expensive to build and maintain. This approach is most compatible with new construction projects or if a street is planned to be completely rebuilt. An example of this approach is the Street Edge Alternatives in Seattle, Washington (Figure 6-19).
The American Recovery and Reinvestment Act (ARRA), Green Reserve of 2009, through the State Revolving Fund, provides funding for a wide variety of qualifying projects in the categories of: green infrastructure, energy efficiency, water efficiency, and other innovative projects. For more information on ARRA, to find out if your current or future planned project meets the necessary criteria, and how to apply, visit www.Recovery.gov.

A Green Street is a street that uses natural processes to manage stormwater runoff at its source.

A CONCEPTUAL GUIDE TO EFFECTIVE GREEN STREETS DESIGN SOLUTIONS

Green Streets

Residential Streets
Commercial Streets
Arterial Streets
Alleys

Green Street designs provide better environmental performance while creating attractive, safer environments.

Streets comprise a significant percentage of publicly owned land in most communities, and thus offer a unique opportunity to manage for environmental outcomes. A Green Street uses a natural systems approach to reduce stormwater flow, improve water quality, reduce urban heating, enhance pedestrian safety, reduce carbon footprints, and beautify neighborhoods. Through various combinations of plants and soils, these objectives—and several others—can be met on different types of streets in many settings. Green Street features include vegetated curb extensions, sidewalk planters, landscaped medians, vegetated swales, permeable paving, and street trees. This guide provides an overview of different strategies that can be employed in transportation rights-of-way at the local or neighborhood scale.
Residential Streets

Residential streets offer the greatest potential for building Green Streets in new neighborhoods or retrofitting existing streets because the streets are typically slower, less trafficked, and likely to already have some landscape elements.

These days, it is fairly common for homes to have rain gardens incorporated into their landscaping to collect and store stormwater runoff from rooftops, driveways, and patios. “Rain garden” is the general term used to describe stormwater strategies that use plants and soils to filter, absorb, and slow rainwater on the landscape surface.

Similar types of rain gardens can take various forms within the street right-of-way itself—the edges of the street can be built to allow stormwater to flow into a landscape area, or space within the paved area of the street can be converted to landscape, increasing permeability. Additionally, permeable paving that is durable, load-bearing, and built with an underlying reservoir can temporarily store water prior to infiltration.

In new construction situations, Green Streets can be designed to handle significant volumes of water. In retrofit situations, they can typically handle all of the rain from small storms, while excess water from large storms can overflow into existing storm sewer systems.

Rain gardens are beautiful landscape features that naturally filter runoff and require less maintenance than turf grass.

STORMWATER CURB EXTENSIONS

Conventional curb extensions (also known as curb bulb outs, chokers, or chicanes) have been used for decades to enhance pedestrian safety and help in traffic calming.

A stormwater curb extension simply incorporates a rain garden into which runoff flows.
PERMEABLE PAVING

Permeable paving (pavers, or porous asphalt and pervious concrete) in the parking lane converts impervious surfaces to allow stormwater to absorb into the ground, which reduces the amount of runoff without any loss of parking on the street.

The aesthetics of permeable paving can also give the illusion of a narrower street and therefore help calm traffic.

VEGETATED SWALES

Swales are long, shallow vegetated depressions, with a slight longitudinal slope. As water flows through the swale, it is slowed by the interaction with plants and soil, allowing sediments and pollutants to settle out. Water soaks into the soil and is taken up by plants, and may infiltrate further into the ground if the soil is well-drained.
Commercial streets in most urban areas need to accommodate a wide range of users and uses including pedestrians, drivers, bikers, transit riders, on-street parking, outdoor seating, lighting, trees, etc. Because of all these demands, finding space to collect and manage stormwater can at first appear challenging. There are, however, several design options that towns and cities can consider when integrating stormwater management into even their most active streets.

The key is thinking creatively in finding space that can accommodate multiple purposes in one space, such as a street tree pit designed to collect runoff, or the curb extensions (also known as “pedestrian bulb outs”) at the corners designed to reducing crossing distances for pedestrians that can also contain a rain garden. These design options are more easily accommodated in new streets where the location of underground utilities is considered from the start. More strategic design is necessary for streets with existing utilities. The pay-off of these efforts, though, is a more attractive, walkable street that considerably reduces polluted runoff.

**STORMWATER PLANTERS**

Planters are long, narrow landscaped areas with vertical walls and flat bottoms, typically open to the underlying soil. They allow for more storage volume than a swale in less space.

Water flows into the planter, absorbs into the plants and topsoil, fills to a predetermined level, and then, if necessary, overflows into a storm sewer system. If desired, planters can accommodate street trees.

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A community’s identity is often most evident on its commercial streets. Green Street techniques not only achieve environmental goals but can greatly improve the look and feel of a community.
Stormwater Curb Extensions

Stormwater curb extensions on commercial streets are similar to those on residential streets. They are rain gardens typically located near the corners that can also provide the pedestrian with a more comfortable crossing.

Curb extensions can also be located mid-block by converting one or more parking spaces.

Permeable Paving

Permeable paving on commercial streets can be incorporated into sidewalks and parking lanes.

Recent advances in permeable paving technologies now make many appropriate for higher speeds or where large, heavy vehicles are expected to be parked—areas such as loading zones and bus stops.
Arterial streets in towns and cities are often characterized by wide expanses of pavement, little greenery, and little to address pedestrian needs. Should an arterial street already have landscape areas adjacent to the roadway or within grassy medians, then retrofitting these areas to accommodate rainwater will significantly reduce runoff and help protect water quality.

Where adjacent landscape space does not exist, a process of “road dieting” can be undertaken. This involves determining just how much paved surface is necessary to safely manage travel, and how much can be converted to green space. In addition to managing runoff, this is also an opportunity to retrofit the functionality of arterial streets, making them more “multi-modal” by incorporating sidewalks, on-street bike lanes, or landscape-separated bike greenways.

Again, as with residential and commercial streets, though it is easier to plan and design all of these uses into a roadway from the beginning, most arterials present opportunities to incorporate Green Street features, and can be highly successful.

Busy arterials need not only be a conduit for traffic. They have the potential to be attractive, green boulevards that reduce runoff and reinforce a community’s identity.
In many towns and cities, alleys comprise a significant amount of impervious surface and are sometimes prone to flooding because they are often not connected to the sewer system. Green Street techniques like vegetated swales and permeable paving effectively reduce and treat runoff, alleviate flooding, and are far less expensive than installing connections to sewers.

**PERMEABLE PAVING**

Alleys are typically low-speed and low-trafficked streets and therefore suitable locations for using permeable paving. The entire surface could be permeable, or if heavier vehicles are anticipated for loading and unloading, or the alley is “reversed crowned” (sloping toward the center line), then only the middle section needs to be permeable.

**VEGETATED SWALES**

If the alley is crowned in such a way that water flows to the side, then stormwater can be accommodated by simply greening edges of the alley with swales and planters.

If necessary, water can flow through pipes or covered trenches to allow vehicle access to garages and driveways.

Illustrations and photographs used in this brochure are from the EPA publication Stormwater Management Handbook—Implementing Green Infrastructure in Northern Kentucky Communities and were created by Nevue Ngan Associations of Portland, Oregon.

This handbook, as well as other valuable resources, are available at both www.epa.gov/smartgrowth and www.epa.gov/greeninfrastructure.
FOR IMMEDIATE RELEASE
December 3, 2009

Contact:
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Washington, D.C. – Representatives Donna F. Edwards (D-MD), Russ Carnahan (D-MO), and Steve Driehaus (D-OH) today introduced the Green Infrastructure for Clean Water Act of 2009. Green Infrastructure is a stormwater management technique that preserves the natural hydrology of an area to help reduce stormwater runoff from hard surfaces.

Green infrastructure techniques rely on natural systems to absorb and filter stormwater in a way that relies on soil and plant life to remove toxins and recharge ground water supplies. Implementing green infrastructure provides numerous benefits, which include enhancing water resources, protecting the environment, reducing the urban heat island effect, increasing community health, creating green jobs, and saving money through reduced capital costs.

“Access to clean water is a necessity and must be protected to ensure the future prosperity and well-being of the United States,” said Rep. Edwards. “A growing threat to water quality throughout the U.S. is due to polluted stormwater runoff from highly urbanized areas flowing into surface waters without being treated. This is especially for the 4th Congressional District and metropolitan area bordering the Anacostia and Potomac Rivers and ultimately impacting the Chesapeake Bay. If we do not begin to address this problem, water quality gains made over the last forty years will be lost. Green infrastructure is a proven method that can help address this challenge. The Green Infrastructure for Clean Water Act of 2009 is an innovative, environmental and economically cost-effective approach to manage storm water flows and improve water quality throughout the nation. I am proud to be joined by Reps. Carnahan and Driehaus to introduce this important bill.”

“We are at a crossroads where as a nation we must commit to developing innovative technology of the future that will create clean-energy jobs right here in America,” said Rep. Carnahan. “In addition to creating clean-energy jobs by investing in ‘green’ infrastructure we also reduce costs down the road and continue down the path of becoming the world’s prominent leader in clean-energy technology. A step closer to solidifying an American clean-energy economy is to enable different regions across the U.S. to develop the best approaches for wastewater treatment as we enhance our aging water infrastructure.”

“This legislation will help us move toward a clean-energy economy while producing innovative solutions to serious infrastructure problems. Green infrastructure development will play a critical role in the future of areas such as greater Cincinnati, where the aging infrastructure is no longer adequate. I applaud Representative Edwards for her leadership on this issue and I’m proud to cosponsor this bill,” said Rep. Driehaus.
The bill would establish up to five Centers of Excellence for green infrastructure in the United States charged with conducting research on green infrastructure that is relevant to the geographic region in which the center is located, and provide communities with training and technical assistance on how to implement green infrastructure best management practices. The legislation would also provide incentive funding to help communities develop green infrastructure technologies.

Finally, the legislation would require the Environmental Protection Agency (EPA) to examine how green infrastructure approaches can be incorporated into clean water programs including permitting and enforcement.

An October 2008 study by the National Research Council determined that existing federal stormwater programming relies on ineffective stormwater management and enforcement mechanisms. The study recommends that instead of monitoring individual pollutants from various sources the EPA should instead focus on strategies that reduce solid surfaces and overall storm water flow volume, which can cause pollution as well as physical and biological changes to waterways. Today’s legislation seeks to implement these recommendations.

The bill is supported by the National Association of Clean Water Agencies (NACWA), the Natural Resources Defense Council (NRDC), American Rivers, the American Public Works Association (APWA), the Water Environment Federation (WEF), the Center for Neighborhood Technology (CNT), Clean Water Action, and the Association of State and Interstate Water Pollution Control Administrators (ASIWPCA).

The Green Infrastructure for Clean Water Act of 2009 is expected to be referred to the House Transportation and Infrastructure Water Resources & Environment Subcommittee as well as the House Science and Technology Committee on which Edwards and Carnahan serve.

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Managing Urban Stormwater with Green Infrastructure: Case Studies of Five U.S. Local Governments

July 30, 2007

Prepared by
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for
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This report was prepared by Lise Valentine, Vice President and Director of Research at the Civic Federation.
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EXECUTIVE SUMMARY

This report examines the resources that several U.S. cities are devoting to “green infrastructure” and analyzes their early experiences with alternative stormwater management. To achieve this goal, the report:

1) defines and describes green infrastructure;
2) discusses barriers to green infrastructure implementation by local governments; and
3) reviews the funding and personnel devoted to green infrastructure by the Metropolitan Water Reclamation District of Greater Chicago, City of Chicago, City of Philadelphia, City of Seattle, and the Milwaukee Metropolitan Sewerage District.

Findings

1. Strict comparison of the resources that each local government devotes to green infrastructure is not possible, in large part because none of the governments examined segregates green stormwater spending from “traditional” stormwater spending.
2. Principal barriers to implementation of green infrastructure include a lack of performance data, cost, and decentralization.
3. The small-scale, cumulative nature of green infrastructure practices in urban environments may make them inefficient until broad implementation is achieved.
4. A common characteristic shared by the City of Seattle, Philadelphia Office of Watersheds, City of Chicago, and Milwaukee Metropolitan Sewerage District was a strong leader with an environmental ethos. This leader chose to embark on green infrastructure projects and partnerships despite the barriers of cost, decentralization, and lack of data. This environmental ethos, not a strict cost/benefit analysis, was what drove the decision to try green infrastructure.
5. Green infrastructure projects and approximate expenditures of the five governments are as follows:
   - Metropolitan Water Reclamation District of Greater Chicago:
     - native prairie landscaping, rain barrels, stormwater management plan
     - approximately $0.9 million in projected 2007 expenditures on green infrastructure
   - City of Chicago:
     - stormwater reduction practices feasibility study, new stormwater ordinance, green roofs, green alleys, sustainable streetscapes, GreenStreets
     - total expenditures figure not available
   - City of Philadelphia:
     - new stormwater management regulations, watershed plans, Schuykill Action Network, Fairmount Park Waterworks Interpretive Center, best practices recognition program, other partnership programs
     - total expenditures figure not available
   - City of Seattle
     - natural drainage systems, street edge alternatives, cascades, effectiveness monitoring
     - approximately $7.4 million to be spent on green infrastructure in 2007, and $68.2 million from 2000-2012
   - Milwaukee Metropolitan Sewerage District:
     - strategic plan for runoff reduction, Greenseams, environmental management system, best practices partnerships for pilot projects, effectiveness and monitoring reports
     - approximately $8.8 million to be spent on green infrastructure in 2007, and $47.7 million for all years included in the capital plan
OVERVIEW
The purpose of this report is to examine the resources that several U.S. cities are devoting to “green infrastructure” and analyze their early experiences with alternative stormwater management techniques. The cities of Seattle, Milwaukee, Philadelphia, and Chicago were selected because they have been leaders in the implementation of green infrastructure approaches to stormwater management. Their experiences are described here in order to provide information that can inform the Metropolitan Water Reclamation District of Greater Chicago as it exercises its new authority over stormwater management throughout Cook County, Illinois.

To achieve this goal, the report:

1) defines and describes green infrastructure;
2) discusses barriers to green infrastructure implementation by local governments; and
3) reviews the funding and personnel devoted to green infrastructure by the Metropolitan Water Reclamation District of Greater Chicago, City of Chicago, City of Philadelphia, City of Seattle, and the Milwaukee Metropolitan Sewerage District.

Strict comparison of the resources that each local government devotes to green infrastructure is not possible, in large part because none of the governments examined segregates green stormwater spending from “traditional” stormwater spending. As a result, this report cannot provide a comprehensive accounting of resources dedicated to green stormwater approaches, but rather gives a general indication of government spending levels and the cost/benefit analyses used to guide decisions about green infrastructure spending.

INTRODUCTION

Definition of Green Infrastructure
“Green infrastructure” is a term used to refer to a number of strategies for handling storm precipitation at its source rather than after it has entered a sewer system. Green infrastructure is thus understood as an alternative to conventional stormwater management approaches, which typically involve building containment and treatment facilities for collecting and cleaning stormwater before releasing effluent into natural waterways. Green infrastructure employs natural systems such as vegetation, wetlands, and open space to handle stormwater in populated areas. It can also involve manufactured solutions such as rain barrels or permeable pavement. These specific strategies are sometimes referred to as “low impact development” (LID) or “alternative best management practices” (BMPs).

Green Infrastructure vs. Conventional Stormwater Management
Stormwater sewer systems are necessary in urban and suburban environments where substantial amounts of impervious surfaces (e.g., buildings, pavement) have replaced natural pervious surfaces (e.g., soil, wetlands) that once absorbed storm precipitation. It is estimated that a typical city block generates over five times the amount of surface runoff as a wooded area of the same
size. The imperviousness of urban areas increases not only the amount of runoff, but also the velocity (flow rate) and pollution of that runoff. Without stormwater management systems, even minimal precipitation would cause urban areas to flood routinely due to the lack of permeable surfaces, and polluted water would flow directly into area waterways. In order to contain the large volumes of water that fall during significant storms, conventional stormwater management systems often include massive underground tunnels and/or reservoirs. In Cook County, Illinois this system is called the Tunnel and Reservoir Plan (TARP) or “Deep Tunnel”.

In many older urban communities, including approximately 40% of Cook County, the wastewater and stormwater sewer systems are combined in such a way that residential and commercial wastewater is mingled with the relatively clean water that falls as storm precipitation. The combined water is sent through the sewer systems to treatment plants, which clean the water to meet environmental standards and then release it into natural and constructed waterways. When large storm events send more water into the combined sewer system than can be conveyed and treated, the system releases untreated water directly into area waterways in what is called a “combined sewer overflow” (CSO). If it were not released this way, the combined stormwater and wastewater would back up into area basements and streets. Stormwater systems such as TARP are designed to provide greater stormwater capacity and reduce the incidence of CSOs, which pollute local waterways.

In more recently developed communities, there are separate sewer systems for stormwater and wastewater. Stormwater sewers typically release directly into area waterways. Although stormwater is cleaner than wastewater, it can still carry high levels of pollutants washed off of roads, roofs, and parkways. Urban runoff pollution from these various sources is a form of “non-point source pollution” in contrast to pollution that is discharged from single sources such as sewage treatment plants or industrial facilities. In addition to delivering pollutant loads, stormwater runoff also degrades waterways when there is a large volume or high flow rate of runoff. This causes erosion and abrupt changes that disrupt the stream ecology. Green infrastructure approaches are aimed at reducing stormwater runoff pollution, volume, and flow rate into area waterways.

While conventional stormwater management systems are said to address a symptom (stormwater runoff volume), green infrastructure focuses on the root problem—the imperviousness brought on by land development. The goal of green infrastructure is to recreate natural hydrology and

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3 The MWRD covers 91% of the land area of Cook County (See MWRD General Superintendent’s Budget Recommendations: 2007 Budget, October 23, 2006, p. ii). Forty-three percent of the MWRD’s land area uses a combined sewer system (see http://www.mwrd.org/Engineering/OurCommunityFlooding/OCFBody0103.htm).
4 For more on non-point source pollution see http://www.epa.gov/nps/. Although stormwater begins as non-point source pollution as it flows over urban surfaces, it becomes point source pollution when it is collected and discharged from a pipe.
ecological systems for managing stormwater. Green infrastructure keeps stormwater out of the sewer systems by intercepting it where it falls and either containing it for later use in gardens and grey water systems, or allowing it to infiltrate the earth and be absorbed by plants or returned to the aquifer.\textsuperscript{6} Green infrastructure allows for both a reduction in the amount of water flowing into conventional stormwater systems (and thus a reduction in the need to build or expand these systems) and a reuse of stormwater at the source. The use of a 50-gallon rain barrel for landscape irrigation, for example, both reuses stormwater that fell on an impermeable roof and reduces the demand for water from the municipal water system.

As real estate development increasingly changes natural landscapes and replaces pervious surfaces with impervious ones, effective stormwater management becomes ever more essential to both flood control and the reduction of pollution in waterways. Although green infrastructure is not expected to eliminate the need for conventional stormwater management systems, it can reduce the amount of “hard infrastructure” needed for stormwater containment and treatment.

**Barriers to Green Infrastructure Implementation**

The 20\textsuperscript{th} century witnessed vast improvements in both the collection and treatment of urban wastewater and stormwater, and massive civil engineering projects such as TARP have significantly improved the health of both urban residents and riparian ecologies. A recognition that green infrastructure approaches to stormwater management can also be effective and provide multiple benefits is relatively recent. The following sections examine some existing barriers to green infrastructure implementation, including a lack of performance data, cost, and decentralization.

**Lack of Performance Data**\textsuperscript{7}

Conventional stormwater management has been refined over the past 50 years to a precise science with decades of associated performance data and proven effectiveness in containing and treating stormwater runoff. By comparison, green infrastructure is a relatively new approach to stormwater management and suffers from a lack of performance data with which to plan for its implementation. Sewer districts are required by federal, state, and local laws to provide a certain level of stormwater management which includes reducing or eliminating incidences of combined sewer overflows. Their reliance on tried-and-true conventional methods to fulfill that critical mandate is responsible and prudent.

The foremost challenge currently facing green infrastructure initiatives is the paucity of performance data reliably demonstrating their effectiveness in different environments. In a March 16, 2007 letter urging the U.S. Environmental Protection Agency (EPA) to devote more

\textsuperscript{6} Grey water is another term for domestic washwater (e.g., dishwashing, bath water) that has a relatively low level of chemical and biological contaminants, and is distinguished from black water (toilet water), which contains human waste. Grey water is not potable, but can be used for purposes such as irrigation or minimally treated and reused indoors for limited uses such as toilet flushing.

\textsuperscript{7} Throughout this report, the term “performance data” refers to scientific monitoring of how well the system manages water (flow, volume, pollutant loads, etc.). It does not include cost considerations.
resources to green infrastructure research and regulation, the National Resources Defense Council and the National Association of Clean Water Agencies wrote:

There are communities across the country that are now looking for efficient and effective ways to reduce stormwater pollution, minimize combined sewer overflows, and ensure that there will be safe and clean water resources for the future that are stymied due to lack of data, lack of modeling tools, lack of familiarity with these approaches by regulators and the public, and other roadblocks.8

Until there is sufficient data demonstrating that green infrastructure can provide quantifiable and cost effective alternatives to conventional stormwater management, it may be difficult for some government agencies to justify the expenditure of public dollars on these alternatives.

However, there is evidence that non-profits, local governments, and the U.S. EPA are coalescing to dismantle this barrier. In an April 19, 2007 “Green Infrastructure Statement of Intent,” the U.S. EPA, National Association of Clean Water Agencies, Natural Resources Defense Council, Low Impact Development Center, and the Association of State and Interstate Water Pollution Control Administrators expressed a joint commitment to promoting green infrastructure. Their strategies include:

• Developing and making available nationwide models for green infrastructure practices;
• Examining incentives for green infrastructure practices in EPA stormwater permits;
• Creating guidance materials for regulatory officials to credit the use of green infrastructure in meeting Clean Water Act requirements; and
• Providing assistance, training, and outreach to local governments and agencies seeking technical expertise in green infrastructure.9

While the Statement does not include financial commitments, it represents an important step toward facilitating green infrastructure implementation nationwide.

A number of green infrastructure demonstration projects across the U.S. have monitored performance in terms of retention volume, flow reduction, and pollutant removal. As this body of literature grows it will become more useful to stormwater managers, but current data is still very limited particularly in terms of its applicability to different regions. Since green infrastructure is based on vegetation, its applicability varies significantly with climate, soil, topography, and geology. At this stage, the most reliable way for a stormwater manager to assess the effectiveness of a green infrastructure approach may be to undertake local pilot projects and monitor their performance, then generalize to larger areas.


There have been a number of attempts to fill this lack of data. We will highlight three examples here. Computer modeling is a common tool for designing traditional stormwater management appurtenances. The U.S. EPA has been updating its stormwater management computer modeling applications to include green infrastructure and low impact development techniques. Two EPA reports published in July 2006 reviewed new modeling approaches for finding the optimal mix of traditional and green infrastructure stormwater controls.\textsuperscript{10} The primary challenge is to redesign these models to allow for “micro-scale” modeling of small areas (e.g., driveways, gardens) and small storm events over multiple years, to better represent the effectiveness of decentralized green infrastructure applications.\textsuperscript{11}

A recent Minnesota Department of Transportation study conducted an historical review of the stormwater literature in order to evaluate the cost effectiveness of different practices in removing pollutants. They compared published reports from across the U.S. and performed statistical analyses on both the performance and cost data to develop formulas with which planners can estimate cost effectiveness of stormwater practices. The authors emphasize that their results are best regarded as rough estimates useful as a preliminary tool.\textsuperscript{12}

Finally, the University of New Hampshire’s Stormwater Center methodically evaluates a range of conventional and “green” stormwater management practices side-by-side, allowing for control of variables such as pollutant load and climate. The Center has installed numerous stormwater treatments beside a nine-acre commuter parking lot and designed to channel equal amounts of runoff into the various treatments.\textsuperscript{13}

\textbf{Cost}

There is no question that managing stormwater in urban environments is expensive. Phase I of the MWRD’s Tunnel and Reservoir Plan (TARP) was completed in 2006 after more than 30 years of construction and expenditures of over $2.3 billion.\textsuperscript{14} Work is currently underway on two additional reservoirs, which are scheduled for completion between 2013 and 2023.\textsuperscript{15} They will provide TARP with a total holding capacity of 18.1 billion gallons, and may cost an additional $1.1 billion.\textsuperscript{16}

\begin{itemize}
\item \textsuperscript{10} Heaney and Lee, “Methods for Optimizing Urban Wet-Weather Control System,” and Wayne C. Huber, LaMarr Cannon and Matt Stouder, “BMP Modeling Concepts and Simulation,” United States Environmental Protection Agency, 600/R-06/033, July 2006. Available at \url{http://www.epa.gov/ednnrmrl/publications/reports/index.htm}
\item \textsuperscript{11} Huber, Cannon and Stouder, “BMP Modeling Concepts and Simulation,” pp. 1-8 and 1-9.
\item \textsuperscript{12} Peter T. Weiss, John S. Gulliver, and Andrew J. Erickson, “The Cost and Effectiveness of Stormwater Management Practices,” Minnesota Department of Transportation, June 2005.
\item \textsuperscript{13} University of New Hampshire Stormwater Center, 2005 \textit{Data Report}. \url{www.unh.edu/erg/cstev}
\item \textsuperscript{14} Paul Pisztkiewicz, MWRD Budget Officer, e-mail to the author, June 27, 2007. See also Metropolitan Water Reclamation District of Greater Chicago, \textit{Comprehensive Annual Financial Report for the Year Ended December 31, 2006}, p. 16
\item \textsuperscript{15} \url{http://www.mwrdfc.dst.il.us/mo/csoapp/cso.htm}
\end{itemize}
Green infrastructure advocates point to the potential for green infrastructure to reduce the need for expensive investments in such “hard infrastructure” solutions. Furthermore, many green infrastructure strategies have additional benefits beyond stormwater management, such as improving air quality, reducing urban “heat island” effects, and enhancing aesthetics. For example, American Forests, a non-profit conservation organization, calculated in 2000 that the tree canopy in the Houston, Texas area reduced the volume of stormwater runoff by 2.4 billion cubic feet. Given the $0.66 per-cubic-foot cost of stormwater management in Harris County, the estimated value of the urban forest in terms of stormwater management was $1.33 billion in one-time construction costs. American Forests also calculated the tree canopy air pollution removal value at $209 million annually, and $26 million annually in energy savings due to shade.

Introducing green infrastructure into mature urban environments carries significant costs as well. While green BMPs in new developments may be comparable to or even less expensive than traditional construction, retrofitting existing properties with green roofs or other vegetative solutions is expensive, and alternative materials such as porous pavement are in many areas still more expensive than traditional asphalt. As the market for these alternatives grows, prices can be expected to fall, but early implementers generally pay a premium. It is also important to note that green alternatives do require maintenance that may increase costs. In some cases they may require less maintenance than traditional solutions. For example, native plantings eliminate the need for lawn mowing. But other alternatives require more maintenance. For example, porous pavement must be vacuumed and swept regularly in order to preserve its permeability.

Stormwater managers should consider not only the total costs, but also the cost effectiveness of green infrastructure as compared to conventional techniques in terms of volume, flow and pollution levels of stormwater released into area waterways during storm events. Performance data must be combined with cost data to provide an accurate analysis of cost effectiveness.

**Decentralization**

In contrast with conventional engineered stormwater management systems, green infrastructure is a decentralized, flexible approach. There are many benefits to decentralization, including the accomplishment of multiple goals. For example, green roofs serve to improve air quality, reduce the urban “heat island” effect, conserve energy, extend roof life, contribute to urban aesthetics, and reduce stormwater runoff. Green infrastructure is flexible in that a variety of strategies, ranging from open space preservation to rain gardens to porous pavement, can be chosen to fit targeted goals for specific communities. These strategies can be retrofitted to existing development or introduced in new development.

However, green infrastructure is most effective when it is designed and coordinated to meet the specific needs of a watershed, whose boundaries may cross many political jurisdictions. Green infrastructure demands a regional approach, and can also be used to address multiple environmental priorities in addition to stormwater management.

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18 Ibid., p. 2.
The flexibility of green infrastructure also introduces the possibility of alternative funding sources. While conventional stormwater management typically consists of large taxpayer-funded public works projects, green infrastructure projects often seek funding from a variety of sources including government, developers, and existing property owners.

However, the decentralized and flexible nature of green infrastructure can also be a barrier to its implementation. Centralized stormwater management systems have clear lines of funding, control, and accountability. Sanitary districts such as the MWRD are distinct legal entities that are charged specifically with treating wastewater and mitigating flooding. They are required to comply with federal and state laws in meeting their mandate. Operation and maintenance of the conventional stormwater system is the duty and responsibility of the District, whereas on-site green infrastructure strategies such as rain barrels and green roofs must be maintained by the property owner. Without proper maintenance, these strategies lose their efficacy. A related potential challenge is ensuring the continued existence of green infrastructure features on private property over the long-term. For example, a homeowner with a rain garden could decide to build an addition on the house and eliminate the rain garden, or an enterprise with a green roof could go out of business or could decide to demolish the building. Given the critical importance of effective stormwater management, the diffusion of responsibility for implementing and maintaining alternative stormwater strategies can become a disadvantage. It may be possible to address this problem through regulatory solutions and municipal ordinances (e.g., fining property owners who fail to maintain their alternative stormwater systems). Public education and community outreach may also assist in strengthening residents’ commitment to voluntarily maintaining green infrastructure. For example, the Seattle Street Edge Alternatives pilot project included extensive community participation during the planning process and residents agreed to weed and mow the new vegetation as necessary.19

**METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO**

The Metropolitan Water Reclamation District of Greater Chicago (MWRD) is a state-authorized sanitary district responsible for treating wastewater and protecting the potable water source (Lake Michigan) for over 90% of Cook County, Illinois. The following section will describe the responsibilities and finances of the MWRD, and discuss its green infrastructure initiatives.

**Responsibilities and Finances**

The MWRD provides wastewater treatment and flood prevention services to the City of Chicago and 125 other municipalities in Cook County. The service area spans 883 square miles of Cook County and serves a population of 5.25 million people, with an additional commercial and industrial equivalent of 4.5 million people.20

The District owns 554 miles of intercepting sewers, 109 miles of tunnels, seven treatment plants, and 23 pumping stations. It controls 76 miles of navigable waterways used for treated effluent

19 Seattle Public Utilities, “SEA Street Virtual Tour,” http://www2.cityofseattle.net/util/tours/seastreet/slide5.htm
conveyance, urban drainage, and commercial and recreational navigation, and owns roughly 9,500 acres of land in Cook, DuPage and Will Counties. This land includes access and riparian buffers along the waterways, stormwater reservoirs, water reclamation plants and other facilities.21

Forty-three percent, or 375 square miles, of the District’s service area uses a combined sewer system.22 The MWRD’s interceptor sewers collect stormwater and wastewater flowing from municipalities’ combined sewer systems in this area. There is some degree of separated sanitary and storm sewers in 24 townships’ unincorporated areas and 104 municipalities in the MWRD service area. The MWRD receives wastewater from the separate sewer areas but it does not handle those communities’ stormwater, which is generally detained in surface reservoirs and/or released directly into area waterways.

The District’s sewer permit ordinance, enacted in 1972, controls the municipal sewer construction permitting process in suburban Cook County and requires that stormwater runoff flow rates not exceed those of the land in an undeveloped state.23 Developments over five acres in separate sewer areas must provide on-site stormwater detention.24 All new developments and redevelopments are required to include separate storm and wastewater sewers, even in combined sewer areas where both sewer systems ultimately discharge into the MWRD interceptors.25 This requirement is in anticipation of some future date at which the local combined sewer system could be replaced with separate sewers by the local sewer agency.26

**Tunnel and Reservoir Plan**

In order to mitigate flooding and waterway pollution from combined sewer overflows, the District developed the Tunnel and Reservoir Plan (TARP) in the 1970s. TARP serves the City of Chicago and 52 suburban municipalities,27 and consists of two phases: Phase I of TARP is primarily for pollution control and Phase II is primarily for flood control, although both are necessary to control combined sewer overflows (CSO). The Upper Des Plaines TARP system, consisting of 6.6 miles of tunnel and one 400 million gallon reservoir became fully operational in 1998.28 Phase I was completed in March 2006 and consists of 109 miles of “Deep Tunnels” ranging from 9 to 33 feet in diameter and 150 to 300 feet underground.29 The tunnels are designed to hold 2.4 billion gallons of combined sewage and stormwater during wet weather events.30 From the completion of the first 31 miles in 1985 through 2003, the District estimates

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21 Paul Piszkiewicz, MWRD Budget Officer, e-mail to the author, June 27, 2007.
22 [http://www.mwrd.org/Engineering/OurCommunityFlooding/OCFB0dy0103.htm](http://www.mwrd.org/Engineering/OurCommunityFlooding/OCFB0dy0103.htm)
23 Ibid.
26 Paul Piszkiewicz, MWRD Budget Officer, e-mail to the author, May 9, 2007.
27 [http://www.mwrd.org/Engineering/OurCommunityFlooding/OCFB0dy0103.htm](http://www.mwrd.org/Engineering/OurCommunityFlooding/OCFB0dy0103.htm)
28 Paul Piszkiewicz, MWRD Budget Officer, e-mail to the author, May 9, 2007.
that 741 billion gallons of what would have been combined sewer overflows were instead captured and conveyed to treatment plants in Deep Tunnels.\textsuperscript{31} The tunnels currently capture roughly 85\% of CSOs.\textsuperscript{32}

Phase II consists of two additional reservoirs that will increase the CSO capture rate to 99\%, and provide a total TARP holding capacity of 18.1 billion gallons.\textsuperscript{33} The O’Hare reservoir was completed in 1998,\textsuperscript{34} and Thornton and McCook reservoirs are scheduled for completion between 2013 and 2023.\textsuperscript{35}

U.S. EPA provided approximately 75\% of the funding for Phase I of TARP, for which the total cost was $2.33 billion.\textsuperscript{36} The remaining Phase II construction will depend on funding from the District and the U.S. Army Corps of Engineers (Corps). For the Thornton Reservoir the District will pay 100\% of the cost. For the McCook Reservoir, the District will fund approximately 30\% of the cost and the Corps will fund the remaining 70\%.\textsuperscript{37}

\textit{Stormwater Management}

In November 2004, Public Act 93-1049 authorized creation of a comprehensive stormwater management program in Cook County, to be managed by the MWRD. Prior to the Act, stormwater management in Cook County had been handled in piecemeal fashion by municipalities, the MWRD, the State, and federal agencies. These efforts are integrated into watershed plans under the new Cook County Stormwater Management Plan developed by the MWRD and adopted on February 15, 2007.\textsuperscript{38} The MWRD now has responsibility for stormwater management throughout Cook County, including areas outside of its service boundaries. In 2007, work will begin on an ordinance that will establish countywide stormwater management regulations for drainage, detention, floodplain management, wetland protection, riparian habitat, soil erosion, and water quality.\textsuperscript{39}

Watershed plans for the six Cook County watersheds will be developed to prioritize and organize capital projects to mitigate stormwater management problems. Each plan will include assessment of existing conditions, hydrologic and hydraulic modeling, identification of stormwater problems, determination of possible solutions, and cost/benefit analyses.\textsuperscript{40}

\begin{footnotesize}
\begin{enumerate}
\item http://www.mwrdgc.dst.il.us/mo/csoapp/cso.htm
\item Metropolitan Water Reclamation District of Greater Chicago, 2007 Final Budget, p. 1.
\item Ibid., p. 2.
\item http://www.mwrdgc.dst.il.us/mo/csoapp/cso.htm
\item Paul Piszkiewicz, MWRD Budget Officer, e-mail to the author, June 27, 2007. See also Metropolitan Water Reclamation District of Greater Chicago, \textit{Comprehensive Annual Financial Report for the Year Ended December 31, 2006}, p. 16
\item Ibid.
\item http://www.mwrdgc.dst.il.us/engineering/stormwater/Final%20PDF%20Version%200201507/CCSMP.htm
\item Metropolitan Water Reclamation District of Greater Chicago, 2007 Final Budget, p. 5.
\item Ibid., p. 381.
\end{enumerate}
\end{footnotesize}
**Budget**

The MWRD has an FY2007 total operating and capital budget of $1.024 billion, of which $362.3 million is appropriated for the Corporate Fund and $24.4 million is appropriated for the Stormwater Management Fund.\(^{41}\)

The District’s largest single revenue source for operating funds is a property tax levy. The FY2007 levy is $416.2 million, and the rate is 0.3188% of taxable value (31.88 ¢ per $100 Equalized Assessed Value).\(^{42}\) In FY2006, property taxes represented 72% of the MWRD’s operating revenues.

![MWRD FY2006 Operating Revenues by Source](image)


In addition to the property tax, MWRD also collects a user charge from large industrial, commercial, and institutional customers.\(^{43}\) These users discharge more than 25,000 gallons a day, have discharges with a biochemical oxygen demand of 25 pounds a day, or have suspended solids discharges of 35 pounds a day.\(^{44}\) As shown in the graph above, FY2006 user charge revenues were $54.0 million, or 10% of total operating revenues. User rates are determined each

\(^{41}\) Ibid., p. 16.

\(^{42}\) Ibid., p. 45.


\(^{44}\) Ibid.
year based on operating cost data from the previous year and pollutant loading levels from two years prior. In 2006, the annual rates were $225.80 per million gallons, $239.79 per 1,000 pounds of biological oxygen demand (over 5 days), and $183.41 per 1,000 pounds of suspended solids.\textsuperscript{45}

In order to finance the MWRD’s new stormwater management duties, Public Act 93-1049 authorized the MWRD to levy an additional stormwater property tax of up to 5¢ per $100 Equalized Assessed Value, which amounts to approximately $50 million dollars per year. This levy is not subject to the Property Tax Extension Limitation Law, which limits most of the District’s property tax levy. To date, the MWRD has shown restraint in levying much less than the maximum allowable under law because the early planning stages of its countywide stormwater management duties have not required large expenditures. The 2006 stormwater levy was $15.5 million, and the 2007 levy was only $3.9 million due to a large unexpended appropriation in 2006.\textsuperscript{46} The following table shows the District’s five-year forecast of stormwater fund levies and appropriations. The 2008 levy is expected to increase to $22.2 million, then decline again to $18.8 million in 2009 and $13.7 million in 2010. These are minimum, initial expectations. District appropriations will increase as projects are identified in the detailed watershed plans for implementation.\textsuperscript{47}

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<tr>
<td>Stormwater Property Tax Levy</td>
</tr>
<tr>
<td>Total All Funds Property Tax Levy</td>
</tr>
<tr>
<td>Stormwater Annual Appropriation</td>
</tr>
<tr>
<td>Total All Funds Appropriation</td>
</tr>
</tbody>
</table>


The MWRD budgeted 2,094 full-time positions for FY2007, with 48 positions in the stormwater management fund. The 48 stormwater fund positions include 11 planning positions in Engineering Department, 36 waterway maintenance positions in the Maintenance and Operations Department, and one public information position in the General Administration Department.\textsuperscript{48} The number of positions in the Stormwater Fund will increase as construction projects are implemented under the detailed watershed plans.\textsuperscript{49}

The MWRD reports that the National Association of Clean Water Agencies (NACWA) 2005 biennial survey of wastewater agencies serving populations greater than 1 million showed that the MWRD had the lowest operating cost per million gallons of wastewater treated, at $531. The Milwaukee Metropolitan Sewerage District cost was $728, and the City of Philadelphia Water Department cost was $1,373.\textsuperscript{50}

\textsuperscript{46} Metropolitan Water Reclamation District of Greater Chicago, \textit{2007 Final Budget}, pp. 16, 60.
\textsuperscript{47} Paul Piszkiewicz, MWRD Budget Officer, e-mail to the author, June 27, 2007.
\textsuperscript{49} Paul Piszkiewicz, MWRD Budget Officer, e-mail to the author, June 27, 2007.
\textsuperscript{50} Metropolitan Water Reclamation District of Greater Chicago, \textit{2007 Final Budget}, p. 15.
Green Infrastructure Initiatives

The MWRD has undertaken some green infrastructure projects in the areas of native plantings, rain barrel distribution, and stormwater planning.

Native Prairie Landscaping

In 2003, the MWRD began a Native Prairie Landscaping program at two of its water reclamation facilities that replaced turf grass with native plants. The original impetus for the project was to reduce landscape maintenance costs for the District, but numerous environmental benefits became apparent immediately.\(^5^1\) According to the MWRD web site, the goals of the project are to:

- show good land stewardship;
- reduce the long-term cost of grounds maintenance;
- be an example of a best management practice to infiltrate stormwater;
- increase biodiversity and wildlife habitat; and
- sequester carbon.\(^5^2\)

In fall 2006, signs were posted at two native prairie landscaping sites explaining that the plantings are a “low-maintenance and ecological alternative to turf grass;” however, these signs do not mention stormwater management benefits of prairie plantings.\(^5^3\)

The project has expanded over three years to replace 31 acres of District turf grass with native prairie vegetation. Ultimately, the District intends to install native prairie plantings at each of its seven treatment facilities as well as other District properties.\(^5^4\) Annual monitoring reports by the Conservation Design Forum assess the status of the vegetation and make maintenance recommendations. This monitoring does not include stormwater infiltration data.\(^5^5\)

From 2003-2009, the Native Prairie Landscaping projects are expected to cost $538,836 including consulting, installation, and maintenance.\(^5^6\)

Rain Barrels

The District will spend $68,400 in 2007 to purchase 1,000 55-gallon rain barrels for distribution in suburban combined sewer areas.\(^5^7\) The program will also include delivery, a service to assist residents with the installation of the rain barrels, and instruction on proper use and maintenance. These services are expected to cost an additional $80,000.\(^5^8\) This program will complement the City of Chicago’s rain barrel initiative. Although it is not expected to measurably reduce

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\(^5^1\) Paul Piszkiewicz, MWRD Budget Officer, in discussion with the author, May 8, 2007.
\(^5^2\) See http://www.mwrdgc.dst.il.us/RD/native_prairie/default.htm
\(^5^3\) http://www.mwrdgc.dst.il.us/RD/native_prairie/NPL%20Sign%20092706.jpg
\(^5^4\) See http://www.mwrdgc.dst.il.us/RD/native_prairie/default.htm
\(^5^5\) Ibid.
\(^5^6\) Paul Piszkiewicz, MWRD Budget Officer, letter to the author, May 7, 2007.
\(^5^7\) Paul Piszkiewicz, MWRD Budget Officer, e-mail to the author, June 27, 2007.
\(^5^8\) Ibid.
Stormwater impacts, the District will use the program as a vehicle through which to educate the public about rain water and pollution.59

**Stormwater Management Plan**

The MWRD estimates that $909,132 or 22.2% of its 2007 Stormwater Fund expenditures were attributable to green infrastructure projects. These include a range of efforts, from creating a watershed management ordinance to designing and installing pervious pavement at the District’s largest treatment plant. The following table provides a breakdown of these green infrastructure expenditures.

<table>
<thead>
<tr>
<th>Project</th>
<th>Expenditure Type</th>
<th>Total Current and Future Years Budget Amount</th>
<th>Projected 2007 Green Infrastructure Projects ($)</th>
<th>Projected Green Infrastructure as % of 2007 Expenditure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Development of Cook County Watershed Management Ordinance</td>
<td>Consultant Fees</td>
<td>$2,455,000</td>
<td>$716,042</td>
<td>27.1%</td>
</tr>
<tr>
<td>Detailed Watershed Plans for Cal-Sag Channel, Little Calumet River, and Upper Salt Creek</td>
<td>Consultant Fees</td>
<td>$5,300,000</td>
<td>$1,858,333</td>
<td>5.0%</td>
</tr>
<tr>
<td>Stormwater Management Plans for all MWRD Treatment Plants</td>
<td>Consultant Fees</td>
<td>$240,000</td>
<td>$120,000</td>
<td>100.0%</td>
</tr>
<tr>
<td>Stickney Treatment Plant Pervious Pavement Design</td>
<td>Consultant Fees</td>
<td>$20,000</td>
<td>$20,000</td>
<td>100.0%</td>
</tr>
<tr>
<td>Stickney Treatment Plant Pervious Pavement Installation and Performance Analysis</td>
<td>Research Project</td>
<td>$277,709</td>
<td>$277,709</td>
<td>100.0%</td>
</tr>
<tr>
<td>Buffalo Creek Wetland Design</td>
<td>Capital Project</td>
<td>$450,000</td>
<td>$150,000</td>
<td>100.0%</td>
</tr>
<tr>
<td>Training</td>
<td>Operating</td>
<td>$7,393</td>
<td>$7,393</td>
<td>100.0%</td>
</tr>
<tr>
<td>Staff Time</td>
<td>Operating</td>
<td>$940,760</td>
<td>$47,038</td>
<td>5.0%</td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td><strong>$9,690,862</strong></td>
<td><strong>$4,090,237</strong></td>
<td><strong>22.2%</strong></td>
</tr>
</tbody>
</table>

Source: Paul Piszkievicz, MWRD Budget Officer, letter to the author, May 7, 2007

**Other Projects**

The District is pursuing additional “green” projects such as a wetlands nutrient abatement area downstream of its treatment plant outflows, the purchase of electric-hybrid and flex fuel vehicles for on-road use, and the purchase of electric vehicles ($421,500) for use in its treatment plants.60 Those projects are not examined here because they are not directly related to source management of stormwater.

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60 Paul Piszkievicz, MWRD Budget Officer, e-mail to the author, June 27, 2007.
CITY OF CHICAGO

The City of Chicago has a number of green infrastructure programs that create direct and indirect stormwater management benefits. These programs have been implemented by various City departments independently or as joint efforts.

The following section will describe the stormwater responsibilities of the City of Chicago and green infrastructure projects that have been undertaken by different City departments.

City of Chicago Stormwater Responsibilities

The City of Chicago operates a combined sewer system that is designed to accommodate a 5-year storm event, equivalent to roughly 1.8 inches of rain falling in one hour. The City sewers connect to the MWRD’s interceptor sewers, which convey the water to MWRD treatment facilities. When the combined stormwater/wastewater exceeds the capacity of the interceptor sewers, they overflow into the MWRD’s Tunnel and Reservoir Plan (TARP) system. When TARP’s capacity is exceeded, untreated sewage and stormwater overflows directly into area waterways.61 Because very heavy rains sometimes cause basement and street flooding restrictors have been installed in some neighborhoods to slow the flow of stormwater into sewers and alleviate basement flooding. However some restrictors have subsequently been removed because they were believed to exacerbate street flooding.62

There are 195 combined sewer outfalls owned by the City of Chicago all of which are hydraulically connected to the MWRD system. In addition, the MWRD has six permitted outfalls within the City limits. The MWRD tracks CSO data for the City’s outfalls, but each government has a separate National Pollutant Discharge Elimination System permit from the Illinois Environmental Protection Agency and is responsible for its own CSOs.63

The City expresses a firm commitment to maintaining and improving its “hard infrastructure” approaches to stormwater management and to the MWRD’s Tunnel and Reservoir Plan. But on the web page describing its combined sewer system, the City also articulates a strong interest in green infrastructure as a tool for managing stormwater:

The City of Chicago recognizes the importance of the built infrastructure in terms of managing stormwater. The City’s Department of Water Management spends approximately $50 million per year to clean and upgrade 4,400 miles of sewer lines and 340,000 related structures. Additionally, the City acknowledges the importance of the Tunnel and Reservoir Plan, known as Deep Tunnel, in the long-term management of stormwater.

61 City of Chicago, “Combined Sewers,” http://egov.cityofchicago.org/city/webportal/portalContentItemAction.do?BV_SessionID=@@@@0285138729.1177684603@@@@&BV_EngineID=cccdadkkjellmkecfelldfhhdfjg0&contentOID=536910787&contenTypeNam e=COCEDITORIAL&topChannelName=HomePage
63 Peter Mulvaney, City of Chicago Department of Water Management, in conversation with the author, May 9, 2007, and Joyce Coffee, e-mail to the author, July 16, 2007.
However, the City believes that the “built” infrastructure alone will not meet all of our needs for managing wastewater and stormwater. Managing stormwater and protecting the quality of our water resources will require a combination of upgrading our “built” infrastructure and creating a “green” infrastructure. Through this green infrastructure, the City will demonstrate forward-thinking ways to reduce the burden on our sewer system and keep stormwater in the environment.64

The City’s green infrastructure initiatives are diffuse with many different departments pursuing Mayor Richard M. Daley’s environmental agenda independently. Although departments often collaborate with each other, such joint projects are developed on a case-by-case basis.65 This fragmentation is evident on the City’s web site. Numerous pages of the web site are devoted to public education and information about green stormwater approaches including downspout disconnection, green roofs, rain gardens, and permeable pavement;66 however, the web pages are interspersed among the many different departments.

It is extremely difficult to capture the full range of the City’s green infrastructure programs. Other “green” projects such as tree planting that are not pursued to achieve an explicit stormwater goal may still serve stormwater purposes by increasing the urban tree canopy and providing more uptake capacity. Trees are planted on public land by the City’s Department of Streets and Sanitation, Department of General Services, Department of Transportation, Chicago Public Schools, Chicago Park District, and various other local governments – and by the private sector based on governmental policies.67 A comprehensive accounting of all these activities is beyond the scope of this report. Furthermore, the City’s numerous water conservation efforts are also related to its stormwater management activities in that those conservation projects with the greatest impact on the combined sewer system may be prioritized over other conservation projects.68

The following sections highlight the green infrastructure programs of various City departments.

**Department of Environment**

The City of Chicago Department of Environment’s (DOE) responsibilities include encouraging “green” development throughout the City, enforcing environmental regulations, and developing the City’s conservation and energy policies. The DOE also manages the Chicago Center for Green Technology, which serves as a green building resource center and features programs and practices that are in alignment with the DOE mission. DOE urges Chicagoans to treat stormwater as a resource rather than a waste product.69

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64 City of Chicago, “Combined Sewers”.
66 See http://egov.cityofchicago.org
67 Joyce Coffee, City of Chicago Department of Environment, e-mail to the author, May 9 and July 16, 2007.
68 Joyce Coffee, City of Chicago Department of Environment, e-mail to the author, July 13, 2007.
69 City of Chicago 2007 Budget: Program and Budget Summary, p. 201.
DOE had a FY2006 budget of $30.8 million with 87 full-time equivalent positions. The vast majority of the budget is grant-funded. Grant sources include federal grants, state grants, and environmental remediation grants from corporations.

**Stormwater Reduction Practices Feasibility Study**

In 2004 DOE commissioned a Stormwater Reduction Practices Feasibility Study for the Norwood Park neighborhood to determine what green stormwater management practices would be most effective in that area.\(^{70}\) The study used a computer model to predict the potential effectiveness of downspout disconnection, rain gardens, rain barrels, green roofs, and porous parking lots to determine which would produce the greatest reduction in volume and frequency of CSOs. The study found that downspout disconnection and rain gardens were most effective in reducing total runoff volume during small storms, but that none of the practices were very effective in larger storm events because the soil available for infiltration was quickly saturated.\(^{71}\)

**New City of Chicago Stormwater Ordinance**

The Chicago City Council passed a new stormwater ordinance that will take effect January 1, 2008. The ordinance requires that any building with a footprint over 15,000 square feet or any parking lot over 7,500 square feet detain at least the first ½ inch of rain on-site. Alternatively, the building or parking lot may meet the requirements of the ordinance by reducing prior imperviousness of the site by 15%.\(^{72}\)

The new requirements are aimed at reducing stormwater flow into the City’s combined sewer system, and subsequently to the MWRD system. Parts of the City’s sewer infrastructure are well over 100 years old, and as the City’s impervious surface area has increased over time, so has the strain on the aging infrastructure. In some neighborhoods, wet weather basement back-ups and street flooding continue to be a problem. A reduction in stormwater runoff will reduce the flows in the sewer system, and green practices such as rain gardens and rain barrels have the added benefit of reducing potable water use.\(^{73}\)

Joyce Coffee, Department of Environment Director of Project Development, provided the DOE’s estimated 2004-2007 green stormwater expenditures in the table below, but notes that these estimates present an incomplete picture. She stresses that “integrating stormwater best management practice into a variety of environmental options is a key strategy for the department, and this integration does not lend itself to clear balance sheets describing our green infrastructure


\(^{71}\) Ibid.

\(^{72}\) See the ordinance and regulations at http://egov.cityofchicago.org/city/webportal/portalContentItemAction.do?BV_SessionID=@@@@1157922782.1183052303@@@@&BV_EngineID=ccceddflkljljcecelldflhdffn.0&contentOID=536951042&contentTypeName=COC_EDITORIAL&topChannelName=Dept&blockName=Environment%2F1+Want+To&context=dept&channelId=0&programId=0&entityName=Environment&deptMainCategoryOID=

work.” Furthermore, some grant funding is shared with other departments. For example, the Calumet Stormwater grant of $454,040 was used primarily by the Chicago Department of Transportation. Likewise, the Water Outreach Campaign project was a joint effort with the Department of Water Management. A combined $700,000 in costs for implementing stormwater best management practices at the Center for Green Technology, running the Household Hazardous Waste Collection Site, and Ford Centerpoint Industrial Campus could not be disaggregated and is not included in the table below.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Staff (37% of 2 positions)</td>
<td>2004</td>
<td>2005</td>
<td>2006</td>
<td>2007</td>
</tr>
<tr>
<td>$ 57,563</td>
<td>$ 60,441</td>
<td>$ 63,463</td>
<td>$ 66,636</td>
<td></td>
</tr>
<tr>
<td>Stormwater Outreach Projects</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2007 Stormwater Management Ordinance, Rain Barrels, Cisterns, Rain Gardens</td>
<td>$ -</td>
<td>$ -</td>
<td>$ -</td>
<td>$ 400,000</td>
</tr>
<tr>
<td>2006 Rain Barrel Program</td>
<td>$ -</td>
<td>$ -</td>
<td>$ 100,000</td>
<td>$ -</td>
</tr>
<tr>
<td>2006 stormwater management ordinance</td>
<td>$ -</td>
<td>$ -</td>
<td>$ 80,000</td>
<td>$ -</td>
</tr>
<tr>
<td>2005 special projects porous paving, downspout disconnection, Stormwater BMP guide</td>
<td>$ 15,000</td>
<td>$ -</td>
<td>$ -</td>
<td>$ -</td>
</tr>
<tr>
<td>2004 Water Outreach Campaign</td>
<td>$ 289,813</td>
<td>$ -</td>
<td>$ -</td>
<td>$ -</td>
</tr>
<tr>
<td>2004 Rain Barrel and Rain Garden Program</td>
<td>$ 46,000</td>
<td>$ -</td>
<td>$ -</td>
<td>$ -</td>
</tr>
<tr>
<td>Stormwater Grants</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>USEPA Great Cities Grant &quot;A Market-Based Approach for accelerating the Implementation of Stormwater Best Management Practices in Chicago&quot;</td>
<td>$ -</td>
<td>$ -</td>
<td>$ -</td>
<td>$ 125,000</td>
</tr>
<tr>
<td>IEPA 319 Calumet Stormwater BMP 130th and Torrence</td>
<td>$ -</td>
<td>$ -</td>
<td>$ -</td>
<td>$ 454,040</td>
</tr>
<tr>
<td>USEPA NHEERL sub to CNT (rain garden monitoring)</td>
<td>$ -</td>
<td>$ -</td>
<td>$ -</td>
<td>$ 12,000</td>
</tr>
<tr>
<td>2004 Rain Garden Forest Service Grant</td>
<td>$ 13,074</td>
<td>$ -</td>
<td>$ -</td>
<td>$ -</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>$ 406,449</strong></td>
<td><strong>$ 75,441</strong></td>
<td><strong>$ 243,463</strong></td>
<td><strong>$ 1,057,676</strong></td>
</tr>
</tbody>
</table>

Source: Joyce Coffee, City of Chicago Department of Environment, e-mail to the author, May 8, 2007.

**Department of Planning and Development**

The City of Chicago Department of Planning and Development (DPD) promotes economic development in the City and regulates new and re-developments. DPD’s mission includes encouraging “green” practices such as the Green Matrix program for creation of green roofs. In 2007 the Department is launching the Green Roof Improvement Fund to assist owners of downtown buildings in converting their existing roofs to green roofs; funding for this program will come from the Central Loop Tax Increment Financing District.

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74 Joyce Coffee, City of Chicago Department of Environment, e-mail to the author, July 20, 2007.
75 Joyce Coffee, City of Chicago Department of Environment, e-mail to the author, May 8, 2007.
76 Ibid.
77 City of Chicago 2007 Budget: Program and Budget Summary, p. 83.
78 Ibid., p. 84.
DPD had a FY2006 budget of $49.1 million and a staff of 177 full-time equivalent positions.\textsuperscript{79}

\textbf{Green Roofs}

The City of Chicago’s Building Green/Green Roof policy requires that construction projects receiving public assistance or qualifying as planned or lakefront developments must be reviewed by the Department of Planning and Development. The policy requires that the developments meet certain “green” criteria, including partial green roofs and Leadership in Energy and Environmental Design certification.\textsuperscript{80}

Chicago’s City Hall was one of the first and certainly the most well known green roof in the City. Energy savings resulting from the green roof are estimated at $5,500 annually, or $0.14 per square foot.\textsuperscript{81} Computer models estimate that the roof retains 70\% of rainfall and returns it to the air through evapo-transpiration, which contributes to the cooling effects of the roof.\textsuperscript{82}

Michael Berkshire, Department of Planning and Development Green Projects Administrator, echoes the sentiments of Joyce Coffee in expressing how difficult it is to estimate what the City spends every year on green roof initiatives. Mr. Berkshire offered the following figures as a rough estimate of DPD’s green roof expenditures in 2007. However, he added that much of the green infrastructure being developed in Chicago is done at the expense of private landowners whose expenditures are not represented here.

\begin{center}
\begin{tabular}{|l|c|}
\hline
\textbf{City of Chicago Department of Planning and Development} & \textbf{Estimated Expenditures for Green Roofs: 2007} \\
\hline
1.5 full-time-equivalent positions & $150,000 \\
Green Roof Test Plots & $85,000 \\
Green Roof Grant Program & $200,000 \\
Green Roof Improvement Fund & $500,000 \\
Green Roof Installations on Public Buildings & $500,000 \\
\hline
\textbf{TOTAL} & $1,435,000 \\
\hline
\end{tabular}
\end{center}

Source: Michael Berkshire, City of Chicago Department of Planning and Development Green Projects Administrator, e-mail to the author, May 8, 2007.

The Green Roof Grant Program provides grants of $5,000 to both residential and small commercial buildings. Berkshire estimates that DPD made 20 grants in 2006, the first year of

\textsuperscript{79} Ibid., p. 85.
\textsuperscript{80}http://egov.cityofchicago.org/city/webportal/portalContentItemAction.do?BV_SessionID=@@@0352909816.1 183046376@@@&BV_EngineID=cccadddfklmgdhefececelldfldfhdhg.0&contentOID=536912719&contenTypeN ame=COC_EDITORIAL&topChannelName=Dept&blockName=Planning+And+Development%2FGreen+Building s%2FGreen+Roofs%2FI+Want+To&context=dept&channelId=0&programId=0&entityName=Planning+And+Deve lopment&deptMainCategoryOID=-536884767
\textsuperscript{81} Michael Berkshire, City of Chicago Department of Planning and Development Green Projects Administrator, e-mail to the author, May 8, 2007.
the grant program, and 40 grants are expected in 2007.83 In addition, many developments and redevelopments supported by Tax Increment Financing (TIF) in the city include green roofs. Mr. Berkshire estimates that there are at least 300 green roof projects currently underway in the city, covering over 3 million square feet of rooftops.84

Although the City’s green roof initiatives have spurred the construction of many green roofs, there are currently no maintenance or monitoring requirements, and few inspectors assigned to verify that the roofs have been built correctly. Mr. Berkshire notes that monitoring data would be helpful in demonstrating the stormwater and energy-saving benefits of green roofs, and more focus in the future should be directed toward maintenance to ensure that the green roofs continue to function as intended.85

**Department of Water Management**

The Department of Water Management provides potable water to the City of Chicago and 125 suburban communities, and sewer services to the City of Chicago. The sewer system includes 4,392 miles of sewers that transport waste and stormwater to the MWRD interceptor sewers.86 In FY2006 the Department had a total budget of $684.0 million and 2,536 full-time equivalent positions. Water Department revenues come from enterprise funds for water and sewer fees. The water fee is currently $1.33 per 1,000 gallons and the sewer rate is 83% of a property owner’s water fee.87 Sewer fee exemptions are available for qualifying senior citizens and certain not for profits.88

The Water Department’s Peter Mulvaney notes that the City does not know how many downspouts have been disconnected citywide, and this lack of data makes it difficult to determine the effect on stormwater runoff in the city. An additional challenge is that concentrating green infrastructure spending in the locations with the greatest stormwater problems can be inhibited by the political nature of some capital spending projects. This political reality makes it difficult to coordinate green approaches in the most environmentally effective way. However, as more green roofs and green alleys are built across the city, eventually the cumulative effect will be to reduce flooding and ease the strain on the combined sewer system.89

83 Michael Berkshire, City of Chicago Department of Planning and Development Green Projects Administrator, in conversation with the author, May 8, 2007.
84 Ibid.
85 Ibid.
86 City of Chicago 2007 Budget: Program and Budget Summary, p. 265.
87 http://egov.cityofchicago.org/city/webportal/portalContentItemAction.do?BV_SessionID=@@@@0300311482.1183048237@@@@@@@&BV_EngineID=ccccadlkllhmicceceldfhdfgL.0&contentOID=536923258&contentTypeNa me=COC_EDITORIAL&topChannelName=Dept&blockName=Water%2FPermits%2C+Fees+%26+Standards%2F I+Want+To&context=dept&channelId=0&entityName=Water&deptMainCategoryOID=-536892336.
88 http://egov.cityofchicago.org/city/webportal/portalContentItemAction.do?BV_SessionID=@@@@0300311482.1183048237@@@@@@@&BV_EngineID=ccccadlkllhmicceceldfhdfgL.0&contentOID=536922423&contentTypeNa me=COC_EDITORIAL&topChannelName=Dept&blockName=Water%2FSenior+Exemptions%2F&context=dept&channelId=0&entityName=Water&deptMainCategoryOID=-536892350, and Joyce Coffee, e-mail to the author, July 16, 2007.
89 Peter Mulvaney, City of Chicago Department of Water Management, in conversation with the author, May 9, 2007.
The City estimates that 50% of Mr. Mulvaney’s time will be spent on green infrastructure issues in FY2007, and 100% of a Senior Engineer’s time, for a value of $177,375 in staffing. Joyce Coffee notes that at least six other engineers assist the Water Department’s Senior Engineer in calculating stormwater flow rates for developments over 15,000 square feet.

**Department of Transportation**

The Chicago Department of Transportation (CDOT) had a FY2006 budget of $260.6 million and 862 full-time equivalent positions. CDOT’s Streetscape and Sustainable Urban Design Program includes one project director, one assistant project director, and seven project managers working on various sustainable projects including green infrastructure. Some of the programs described below also include the participation of an additional six project managers and support staff.

**Green Alleys**

Alleys present an excellent opportunity for green infrastructure because they are large tracts of impermeable surface with relatively low traffic volume. The City of Chicago has an estimated 1,900 miles of public alleys with 3,500 acres of paved impermeable surface. CDOT operates an active Green Alley Program and has produced a handbook for the public explaining the benefits of green alleys and the specific techniques used to reduce surface runoff in alleys. The Green Alley Handbook exemplifies the City’s holistic approach to “green” projects, in that it also includes information encouraging residents to implement recycling, composting, tree planting, native landscaping, rain gardens, rain barrels, permeable pavement, green roofs, energy efficient/dark sky lighting, natural stormwater detention, and bioswales. The Handbook, designed by Hitchcock Design Group, won a 2007 award for communications from the American Society of Landscape Architects.

CDOT spent approximately $900,000 on six Green Alley pilot projects in 2006, and 15 additional projects are scheduled for 2007. Throughout the pilot projects, CDOT has experimented with pavers, porous concrete, and porous asphalt to find the materials best suited to Chicago conditions. A design toolbox has been developed for CDOT engineers to build green alleys meeting the following environmental goals: 80% stormwater infiltration, heat reduction, use of recycled materials, energy conservation, and streetlight glare reduction.

91 Ibid.
93 David Leopold, City of Chicago Department of Transportation, e-mail to the author, July 13, 2007.
94 Ibid.
95 http://www.hitchcockdesigngroup.com/experience/urb/greenalleys.html
96 David Leopold, City of Chicago Department of Transportation, e-mail to the author, July 13, 2007.
98 David Leopold, City of Chicago Department of Transportation, e-mail to the author, July 13, 2007.
Road Improvements and Sustainable Streetscapes

CDOT is integrating green stormwater management techniques into a number of street improvement projects.

A realignment and grade separation project at 130th Street and Torrence Avenue near the Calumet River will reconfigure the roadway runoff to discharge into a new treatment pond and vegetated swale rather than directly into the river. The entire project, including mitigation of nearby wetlands, is expected to cost $140 million, with the green stormwater best practices amounting to $2 million. Similarly, a realignment of U.S. Route 41 through the USX Southworks site will include permeable pavement, infiltration pipes, and other treatment structures to reduce the volume and pollution of runoff into Lake Michigan and the combined sewer system.99

A major green streetscape pilot project is planned for 2.13 miles of Cermak Road from Halsted Street to Ashland Avenue. This project will incorporate and evaluate various environmental streetscape practices for possible use throughout the city. The stormwater management goal is 100% diversion from the combined sewer system for a 2-year storm event. Nearby Benito Juarez High School will include a permeable entrance plaza and a stormwater-based water feature to educate students about sustainable stormwater management design techniques. The estimated design cost for the streetscape project is $1.16 million, with construction costs not yet determined.100

Other smaller initiatives illustrate CDOT’s interest in integrating green stormwater management throughout its many projects. Permeable pavers were installed in 0.3 mile of parkways on Roscoe Street between Leavitt St. and Damen Ave. to infiltrate sidewalk runoff; materials and construction were estimated at $170,000. The Couch Place alley in the theater district of downtown Chicago was converted into a green alley for a total design and construction cost of $1.1 million. A cul-de-sac at 18th St. and Prairie Ave. is being fitted with rain gardens at a cost of $227,000. Permeable pavers were installed at the 33rd Ward Yard Public Works Facility parking lot, for $826,000 in design and construction. The new streetscape for the Maxwell Street Market will include a 50,000 square foot permeable plaza including a landscaped bioswale for on-site stormwater management. The total plaza cost is estimated at $1 million. Finally, three blocks of streets originally constructed by the Works Progress Administration will be rebuilt to include permeable asphalt parking lanes at a cost of $1.7 million.101

Department of Streets and Sanitation

The Department of Streets and Sanitation’s Bureau of Forestry is responsible for planting trees on residential streets and small commercial streets. The downtown area and arterial streets’ trees are part of Mayor Daley’s GreenStreets program administered by the Department of

99 Ibid.
100 Ibid.
101 Ibid.
Transportation.\textsuperscript{102} As noted earlier, the trees are not planted specifically as stormwater trees, but the tree canopy does have a stormwater runoff reduction function.

The Bureau of Forestry’s FY2006 budget was $17.1 million with 241 full-time equivalent positions.\textsuperscript{103}

The Bureau’s FY2006 expense for planting 6,805 trees was $3.4 million. Trees are purchased and planted by private contractors, then maintained by city workers. Approximately 3,000 additional trees were planted through the GreenStreets program in 2006, and 5,500 trees were planted by other City departments and private landowners.\textsuperscript{104}

\textbf{Department of General Services}

The Department of General Services manages and maintains 525 city buildings.\textsuperscript{105} It had a FY2006 budget of $178.2 million and 480 full-time equivalent positions.\textsuperscript{106}

General Services estimates that it has installed eight green roofs on City buildings.\textsuperscript{107} The Department is also responsible for planting trees on many City properties.\textsuperscript{108}

\textbf{CITY OF PHILADELPHIA}

The City of Philadelphia’s green infrastructure efforts are led by the Philadelphia Water Department’s Office of Watersheds (OOW). The Office of Watersheds was created in 1999 by combining the Water Department’s separate programs for Combined Sewer Overflow, Stormwater Management, and Source Water Protection.\textsuperscript{109}

The following section will describe the responsibilities and finances of the Water Department, review new municipal stormwater regulations, and discuss the Office of Watersheds’ green infrastructure initiatives.

\textbf{Philadelphia Water Department: Responsibilities and Finances}

The Philadelphia Water Department is a municipal utility that provides water, wastewater, and stormwater services to customers in the City of Philadelphia and portions of Bucks, Montgomery, and Delaware counties. The potable water system serves approximately 1.7 million customers while the wastewater system serves approximately 2.2 million customers.\textsuperscript{110}

\begin{itemize}
  \item \textsuperscript{102} Joe McCarthy, City of Chicago Bureau of Forestry, in conversation with the author, May 9 2007.
  \item \textsuperscript{103} City of Chicago 2007 Budget: Program and Budget Summary, p. 231.
  \item \textsuperscript{104} Joe McCarthy, City of Chicago Bureau of Forestry, in conversation with the author, May 9 2007.
  \item \textsuperscript{105} City of Chicago 2007 Budget: Program and Budget Summary, p. 51.
  \item \textsuperscript{106} Ibid., pp. 51-58.
  \item \textsuperscript{107} Al Mark, City of Chicago Department of General Services, in conversation with the author, May 7, 2007.
  \item \textsuperscript{108} Joe McCarthy, City of Chicago Bureau of Forestry, in conversation with the author, May 9 2007.
  \item \textsuperscript{110} http://www.phila.gov/waterrev/about.html
\end{itemize}
The mission of the Water Department is threefold:

- Plan for, operate, and maintain the infrastructure and organization necessary to purvey high quality drinking water;
- Provide an adequate and reliable water supply for all household, commercial, and community needs; and
- Sustain and enhance the region’s watersheds and quality of life by managing wastewater and stormwater effectively.111

The Water Department treats over 300 million gallons of Delaware and Schuylkill river water daily at three treatment plants to produce potable water for the Philadelphia area. It also treats over 450 million gallons of sewage daily at three wastewater plants and recycles biosolids at a 73-acre facility. The Water Department maintains 3,300 miles of water mains, 3,000 miles of sewers, 75,000 storm sewer inlets, 27,500 fire hydrants, and related infrastructure.112 Roughly half of the City has a combined sewer system, and there are 165 combined sewer outfalls on the Schuylkill and Delaware Rivers or their tributaries.113 The Water Department had a staff of 2,239 full-time employees in 2006.114

The Department is financed through the Water Fund, a city enterprise fund for water, wastewater, and stormwater services. The Water Revenue Bureau handles water and sewer fee billing and collections on behalf of the Water Department and has a staff of 219 employees.115

Water, wastewater, and stormwater fees are set by the Water Commissioner after recommendations are made by a hearing officer who holds public hearings on potential rate changes.116 Currently, fees are based on water meter size, so properties without water meters (such as parking lots) do not pay for stormwater service. The Water Department is preparing to implement a new stormwater fee system based on gross area and impervious cover for non-residential properties over 5,000 square feet.117 Office of Watersheds Director Howard Neukrug notes that the City hopes this change will better reflect the true stormwater management cost of imperviousness and will encourage property owners to reduce impervious cover.118

In 2005, the Water Department determined that additional revenues of $282 million would be needed for the years 2005-2008.119 A schedule of rate increases was set such that over four years, rates would increase an average of 8.73% a year, adding an average of $16.53 to the

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115 http://www.phila.gov/waterrev/about.html
116 Ibid.
monthly residential bill for water, sewer, and stormwater services. This reflected an increase from an average residential bill of $41.77 per month to $58.30 in 2008.\textsuperscript{120} A 25% rate discount is available to seniors age 65 and older with a household income under $27,300. This discount is also available to non-profit hospitals, churches, charities, schools, and universities.\textsuperscript{121}

In FY2006, total actual expenses for the Water Fund were $455.4 million.\textsuperscript{122} The FY2007 operating budget for stormwater services is $92.0 million and includes debt service, billing, metering, sampling, industrial waste disposal, and other expenses.\textsuperscript{123} The operating budget for selected key stormwater programs is $64.7 million.\textsuperscript{124} As shown in the graph below, the FY2007 Office of Watersheds budget was $7.3 million for staff and contracts, not including capital projects or costs of field staff from other units, and $4.1 million was budgeted for Public Affairs and Education.\textsuperscript{125} The Office of Watersheds has 50 full-time personnel, of which five are dedicated to green infrastructure initiatives.\textsuperscript{126}

\begin{center}
\textbf{Philadelphia Water Department Operating Budget for Key Stormwater Services: FY2007 ($ millions)}
\end{center}

\begin{itemize}
\item \textbf{Total: $64.7 million}
\item \textbf{Sewer Reconstruction} $22.5, 35%
\item \textbf{Sewer Maintenance and Flow Control} $18.6, 29%
\item \textbf{Collector Systems Support} $1.4, 2%
\item \textbf{Public Affairs and Education} $4.1, 6%
\item \textbf{Inlet Cleaning} $4.4, 7%
\item \textbf{Abatement of Nuisances} $6.5, 10%
\item \textbf{Office of Watersheds} $7.3, 11%
\end{itemize}

Source: Chris Crockett, Office of Watersheds Manager of Watershed Sciences & Engineering, e-mail to the author, May 7, 2007

\begin{footnotes}
\item\textsuperscript{120} Ibid., p. 15.
\item\textsuperscript{121} \url{http://www.phila.gov/water/water_sewer_bill.html}
\item\textsuperscript{123} Howard Neukrug, Director of Philadelphia Office of Watersheds, e-mail message to the author, July 13, 2007.
\item\textsuperscript{124} Chris Crockett, Office of Watersheds Manager of Watershed Sciences & Engineering, e-mail message to the author, May 7, 2007.
\item\textsuperscript{126} Howard Neukrug, Director of Philadelphia Office of Watersheds, e-mail message to the author, June 9, 2007.
\end{footnotes}
In addition to the Water Department, several other city departments are involved in projects that contribute to the city’s green infrastructure through tree planting, green roofs, porous pavement, and land conservation. These include the City Planning Department, Recreation Department, Fairmount Park, and the Neighborhood Transformation Initiative.127

**Office of Watersheds’ Integrated Green Infrastructure Approach**

The creation of the Office of Watersheds in 1999 signaled a shift toward an integrated approach to stormwater management. By merging the Combined Sewer Overflow, Stormwater Management, and Source Water Protection programs into the new Office of Watersheds, the Water Department demonstrated a belief that all three issues are best handled through a coordinated approach because they are deeply interrelated. The Office of Watersheds’ mission is to “preserve and enhance the health of the region’s watersheds through effective wastewater and stormwater services and the adoption of a comprehensive watershed management approach that achieves a sensible balance between cost and environmental benefit and is based on planning and acting in partnership with other regional stakeholders.”128

Green infrastructure initiatives are included in the Office of Watersheds’ efforts to improve the health of area waterways because of their numerous beneficial effects. Office of Watersheds Director Howard Neukrug describes the benefits of a green approach this way:

> If we can keep stormwater out of our sewers by using our land or facilities to take on nature’s role while at the same time creating a green community amenity, then we are doing our job. When we can solve flooding or sewer overflow problems by providing kids with a basketball court or a soccer field that is ideal to play on and that at the same time efficiently drains stormwater back into the earth’s groundwater, we have not only improved the environment, but we have also improved the quality of life for the residents of Philadelphia.129

While green infrastructure provides numerous benefits to the community, the Office of Watersheds recognizes that it must complement, not replace, structural stormwater systems in a mature city. This holistic approach recognizes that mature cities must maintain and even expand structural systems in order to meet stormwater management goals, but that the introduction of green infrastructure will, over time, keep more and more stormwater out of the traditional system, thus reducing the need for future investments in pipes, vaults, and pumps. The City’s Long-Term CSO Control Plan includes major structural projects such as an inflatable dam that will help to regulate CSO discharges to the Schuylkill River, as well as the integrated watershed-planning approach that involves green infrastructure projects and regulations aimed at reducing stormwater runoff.130

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127 Ibid.
128 [http://www.stormwaterbmp.org/stormwaterbmp/](http://www.stormwaterbmp.org/stormwaterbmp/)
It will take many years to create enough green infrastructure to measurably reduce demand on the City’s traditional stormwater system and thus reduce costs. Nonetheless, the Office of Watersheds does consider cost savings estimates in its green infrastructure planning. Stormwater storage tanks currently cost $10 per gallon and tunnels cost $2-3 per gallon to build, so green infrastructure projects are designed to cost less than this. 131 Chris Crockett, Office of Watersheds Manager for Watershed Sciences and Engineering, estimates that the City’s new stormwater regulations (described below) will keep at least 17 million gallons of stormwater out of the system each year. That stormwater will be infiltrated on-site by private landowners at no cost to the City. Crockett notes that because of these regulations, $170 million in tanks will not need to be built. The regulations will cost at most $1 million to administer, so the net savings to the City is $169 million. Over twenty years, the Water Department projects a 30% reduction in stormwater runoff citywide, and at least $750 million savings in infrastructure costs. 132

**New Stormwater Management Regulations**

New City of Philadelphia stormwater regulations became effective January 1, 2006. The new regulations changed both the requirements for on-site stormwater management as well as the process for review and approval of development and redevelopment designs. Any building project that will disturb more than 15,000 square feet of earth (or 5,000 square feet in the Darby-Cobbs watershed) must be designed to infiltrate at least the first inch of rain on-site. This first inch represents 82% of all rainfall in Philadelphia. 133

In order to streamline the process for developers, the new regulations also create a pre-zoning approval process in which the Water Department will review design concepts and make recommendations. Director Neukrug notes that providing open communication earlier in the process has greatly facilitated stormwater compliance for developers. 134

As in most mature cities, however, the development/redevelopment rate is relatively slow. Just 1% of the City, or roughly 1 square mile, is developed/redeveloped every year, and 55% of all impervious cover is held by private landowners. 135 Thus it will take many years before development regulations alone will have a significant impact on stormwater runoff. Tax incentives for green infrastructure improvements are one way to encourage landowners to retrofit their properties. On April 17, 2007, Philadelphia Mayor John Street signed an ordinance to create a “Green Roofs Tax Credit” through the municipal business privilege tax. Eligible business owners can receive credit for 25% of green roof construction costs, up to a maximum of $100,000. In order to qualify for the credit, applicants must agree to maintain the green roof for a minimum of five years. 136

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131 Chris Crockett, Office of Watersheds Manager of Watershed Sciences & Engineering, e-mail to the author, May 7, 2007.
132 Ibid.
133 Ibid.
135 Ibid.
Green Infrastructure Projects and Partnerships

The decentralized nature of green infrastructure makes it highly dependent on partnerships to create a shared sense of stewardship. Each of the following green infrastructure programs has involved creative partnership.

Watershed Plans

The Office of Watersheds has partnered with other governments and community groups in the creation of comprehensive watershed plans for each of the seven Philadelphia-area watersheds. Three plans have been completed and four more are expected to be completed by 2009. It is estimated that each watershed plan will cost $5-$10 million for the first five years of implementation.

Watershed plans can include everything from new stormwater and low-impact development regulations to implementation of demonstration projects and land conservation. Taking a watershed approach is complex, as noted by Watershed Programs Manager Joanne Dahme:

It requires land-use planning and coordination, the resources needed to model the pollution sources in a water body, mutually agreed upon goals for the water body, a cooperative regulatory climate, city and suburban dialogue and agreement, and a consensus on a solution and the sharing of costs.

The watershed planning process begins with baseline conditions monitoring. Once the baseline conditions are determined, goals can be set for improved conditions. Progress toward the goals must be tracked, and communication of this progress is essential to maintaining public interest.

Schuylkill Action Network

The Schuylkill Action Network is a consortium of government and non-profit groups that are developing a watershed-level restoration plan for the Schuylkill watershed. The Office of Watersheds participates in the Network and provides critical water quality data. The Network leveraged a $1.15 million U.S. EPA grant in FY2005 for a number of restoration projects including implementation of stormwater best management practices at local schools and universities with large volumes of runoff.

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138 Ibid.
**Best Management Practices Recognition Program**

The Office of Watersheds participates in a best management practices recognition program to recognize exemplary green stormwater projects such as rain gardens, green roofs, permeable pavement, and bioswales. This program is intended to support stormwater awareness and education efforts, and inspire others to implement these best practices.  

**Fairmount Park**

The Water Department provides funding for the Fairmount Park Water Works Interpretive Center, which educates public about non-point source pollution, local waterways, and water quality.  

**Other Partnerships**

The Office of Watersheds has provided financial support or technical assistance in a number of other partnership programs, including:

- Implementation of stormwater best management practices in the Mill Creek development by Philadelphia Public Housing
- Rain barrel distribution (roughly 500 annually)  
- TreeVitalize, a City tree planting program
- Campus Park initiative for public schools, including implementation of green infrastructure such as green roofs and porous pavement on basketball courts
- Golf Course certification program to encourage stormwater best management practices
- Green City partnership with the Philadelphia Horticultural Society, transforming vacant lots into green spaces with stormwater infiltration

Each of these partnerships has a strong educational component, since increasing public awareness about the effects of stormwater runoff is a key to generating interest and compliance with green infrastructure best practices.

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142 [http://www.stormwaterbmp.org/stormwater](http://www.stormwaterbmp.org/stormwater)
144 Chris Crockett, Office of Watersheds Manager of Watershed Sciences & Engineering, e-mail to the author, May 7, 2007.
145 Ibid.
CITY OF SEATTLE

The City of Seattle has introduced a number of green infrastructure programs that target areas of the City with inadequate stormwater management systems and flood hazards. Concern about the health of local salmon populations and riparian habitats also sparked interest in ways to mitigate the impact of stormwater runoff on area waterways.

These stormwater initiatives have been implemented primarily by Seattle Public Utilities (SPU), an enterprise arm of Seattle’s municipal government that provides water, sewer, drainage, and solid waste services to residents and businesses of Seattle. The following section will describe the responsibilities and finances of SPU, review the results of early pilot programs, and discuss recent expansion of the programs.

Seattle Public Utilities Drainage and Wastewater Fund

Seattle Public Utilities is a municipal utility that provides water, sewer, and solid waste services to 1.3 million customers. Each of these services is financed through a separate enterprise fund. The SPU Drainage and Wastewater Fund has drainage responsibilities that include flood mitigation, reduction of water pollution due to storm runoff, and compliance with federal stormwater regulations. Wastewater activities include operation of the City’s sewer systems and conveyance to the King County Department of Natural Resources Wastewater Treatment System, which handles wastewater treatment. Combined sewers serve 47.5 square miles of Seattle, or roughly 56% of the City’s total area, while the remainder are separate sanitary and storm sewers.146

According to the City of Seattle’s 2007-2012 Capital Improvement Program document, SPU’s sewer and drainage systems include the following:

- 530 miles of sanitary sewers
- 500 miles of storm drains
- 1,000 miles of combined sewers
- 768 pump stations
- 93 permitted CSO outfalls
- 277 storm drain outfalls
- 34 CSO control detention tanks/pipes147

The primary revenue source for SPU’s stormwater management activities is a drainage fee. Drainage fees are set by City Council ordinance and appear on property tax bills. Single family and duplex residential properties are charged a flat fee per parcel, as shown in the table below. Qualified low income, senior, or disabled customers can receive a 50% discount on their drainage fee. All other property types are charged a fee per acre based on the imperviousness of

146 http://dnr.metrokc.gov/WTD/cso/page02graph.htm
the land. The “Very Heavy” category would include parking lots, which are often 100% impervious.  

<table>
<thead>
<tr>
<th>Single Family and Duplex Residential</th>
<th>Annual Fee Per Parcel</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$ 142.00</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>All Other Properties (% impervious)</th>
<th>Annual Fee Per Acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open Space (0-2%)</td>
<td>$ 187.31</td>
</tr>
<tr>
<td>Undeveloped (0-15%)</td>
<td>$ 325.49</td>
</tr>
<tr>
<td>Light (16-35%)</td>
<td>$ 539.49</td>
</tr>
<tr>
<td>Medium (36-65%)</td>
<td>$ 978.87</td>
</tr>
<tr>
<td>Heavy (66-85%)</td>
<td>$ 1,275.27</td>
</tr>
<tr>
<td>Very Heavy (86-100%)</td>
<td>$ 1,584.92</td>
</tr>
</tbody>
</table>

Source:  

SPU also offers a 10% drainage fee discount to new or retrofitted commercial properties that harvest rainwater. A qualifying system must harvest or infiltrate the amount of stormwater that falls on the roof during a one-year, 24-hour storm event. Greywater systems that reuse the harvested water indoors must be permitted through the Seattle-King County Department of Public Health.

The SPU Drainage and Wastewater Fund has a FY2007 budget of $250.0 million. SPU uses an asset management approach to prioritize capital projects, and is beginning to apply the same approach to its operating budget in order to generate efficiencies. This approach evaluates projects for their economic, social, environmental, and customer service benefits. These benefits are weighed against the costs, including ongoing maintenance expenditures, and projects that are not cost-effective are dropped.

Operating and capital budget appropriations are categorized by budget control level. The following list highlights some 2007 appropriations for green infrastructure:

- 2007 appropriations for the Low-Impact Development budget control level are $4.0 million, with 7.81 full-time equivalent (FTE) personnel.
- The 2007 Other Operating Control Level for the Science, Sustainability, and Watersheds program includes $100,000 and 1.0 FTE for a Senior Planning and Development Specialist.

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to work on the Restore Our Waters campaign (see page 41 below) and to provide technical assistance for aquatic habitat grants.154

- The Other Operating Control Level for Utility Systems Management includes $256,000 and 1.0 FTE for a Senior Civil Engineer to provide support on initiatives including revision of the stormwater code and the City Department of Planning and Development Green Building Team.155

- The Protection of Beneficial Uses Control Level is a capital improvement program dedicated to mitigating the harmful effects of stormwater runoff on area waterways by improving water and habitat quality.

- The Stormwater & Flood Control budget control level is charged with alleviating flooding, with a primary focus on public health, safety, and protection of property. Low Impact Development was previously part of this Control Level but was separated during a recent reorganization.

- The Wastewater Conveyance Budget Control Level is funded by wastewater revenues, not drainage fees, but includes some funding for the Lakewood Raincatcher Pilot program, a downspout disconnection initiative in a combined sewer area.156

The following table summarizes selected 2007 budget appropriations, which include both operating and capital spending. Budget Control Levels with an asterisk include spending on green infrastructure. Some hard infrastructure categories such as Control Structures (combined sewer system overflow controls) are also included for comparison.

<table>
<thead>
<tr>
<th>Budget Control Level</th>
<th>Appropriation</th>
<th>Full-Time-Equivalent Positions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control Structures (CSOs)</td>
<td>$ 6,995,000</td>
<td>24.6</td>
</tr>
<tr>
<td>Low Impact Development *</td>
<td>$ 4,022,000</td>
<td>7.8</td>
</tr>
<tr>
<td>Other Operating Budget</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Engineering Services</td>
<td>$ 2,618,001</td>
<td>24.9</td>
</tr>
<tr>
<td>Field Operations</td>
<td>$ 13,060,834</td>
<td>94.2</td>
</tr>
<tr>
<td>Science, Sustainability &amp; Watershed*</td>
<td>$ 4,088,854</td>
<td>28.9</td>
</tr>
<tr>
<td>Utility Systems Management*</td>
<td>$ 6,249,624</td>
<td>46.1</td>
</tr>
<tr>
<td>Protection of Beneficial Uses*</td>
<td>$ 4,717,000</td>
<td>14.5</td>
</tr>
<tr>
<td>Stormwater &amp; Flood Control*</td>
<td>$ 3,947,530</td>
<td>21.5</td>
</tr>
<tr>
<td>Wastewater Conveyance*</td>
<td>$ 8,841,000</td>
<td>22.3</td>
</tr>
<tr>
<td><strong>TOTAL Drainage &amp; Wastewater Utility</strong></td>
<td><strong>$ 250,016,923</strong></td>
<td></td>
</tr>
</tbody>
</table>

*All or part of these budget lines include green stormwater management.

The combined 2007 appropriation for categories that include green infrastructure is $31.9 million, or 12.7% of the total $250.0 million budget. As we will see in the Capital Improvement Plan section on page 42, this is similar to the estimated percentage of capital spending on green infrastructure projects.

154 Ibid., p. 461.
155 Ibid., p. 462.
156 Ibid., p. 468.
**Natural Drainage Systems Goals**

Seattle calls its green infrastructure approaches to stormwater management “Natural Drainage Systems” (NDS). The primary goal of NDS is to reduce the volume and rate of stormwater runoff into area waterways through the use of vegetation and alternative street designs. Much of NDS involves reducing impervious area. NDS strives to replicate pre-development drainage conditions.

SPU recognized that its traditional stormwater systems using pipes and vaults were sending excessive volumes of stormwater runoff into area streams at high velocities, thus impairing stream ecology. NDS projects seek to reduce runoff volume by using vegetation to increase infiltration and evapotranspiration. They also reduce flow rate using techniques such as stepped pools.

In addition to the benefits to local waterways, SPU cites the following benefits of NDS over traditional “vault and pipe” stormwater management approaches:

1. Integration into the landscape and beautification, which encourage landowner acceptance and maintenance;
2. Failure of one or more small NDS sites does not compromise the integrity of the entire system;
3. Improved effectiveness over time of vegetation, as opposed to deterioration over time of pipes and vaults;
4. Source control of runoff reduces the need for expensive conveyance, detention, and treatment systems, as well as waterway remediation; and
5. Reduction of impervious surfaces reduces costs of street and drainage improvements in low to medium density residential areas.\(^{157}\)

SPU also notes a number of challenges posed by natural drainage systems. Improperly draining vegetated swales can create a mosquito hazard; mosquitoes require six days of standing water to breed, therefore swales are designed to drain completely in 3-5 days. Excessive infiltration can create a landslide hazard, so NDS infiltration areas are limited to areas with minimal slope. The NDS street designs reduce impervious area, thus reducing available parking and creating narrower or non-standard street designs. This may require code variations and negotiation with fire and public safety services to maintain sufficient emergency vehicle access. Finally, if residents do not voluntarily maintain the NDS vegetation, there will be additional costs for city workers to perform the maintenance.\(^{158}\)

An overarching barrier to NDS identified by SPU is the issue of retrofitting. Seattle is developed at a rate of less than 1% each year, so introducing NDS through regulations affecting only new development and redevelopment would take a prohibitively long time before substantial implementation. This problem is common to all mature cities. The City of Seattle decided that in order to achieve its water quality and flood mitigation goals in a reasonable timeframe, a

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\(^{158}\) Ibid.
proactive retrofitting approach was necessary. Seattle was the first major U.S. city to retrofit existing city streets with low impact development techniques. Retrofitting poses an implementation challenge, however, due to its cost and the need to work with existing residents and property owners.

**Early Pilot Programs**

Seattle tested its NDS ideas through a number of demonstration projects. The programs began in 1998 with a series of City planning grants made in celebration of the millennium. The first project, Viewlands Cascade, was completed in the fall of 2000. The second project, called Street Edge Alternatives (SEA Street), was completed in the spring of 2001. Both projects were extensively monitored by researchers from the University of Washington’s Department of Civil and Environmental Engineering, who published their report in October 2004. SPU’s early NDS pilot programs have drawn national and international attention, and won a 2004 “Innovations in American Government Award” from Harvard University’s Kennedy School of Government.

**Street Edge Alternatives**

The Street Edge Alternatives project was designed to accomplish a variety of goals, foremost of which was to reduce runoff volume and flow rate into Pipers Creek. Pollution mitigation was also a concern, but the project scope specified that large amounts of fast moving water caused the most disruption to local stream ecosystems. Residents of the pilot project neighborhood had also expressed a desire for streetscape improvements, including the addition of sidewalks, since their area did not have a traditional curb/gutter/sidewalk system in place.

The SEA Street project redesigned a 660 ft. long residential city block on 2nd Avenue NW from NW 117th street to NW 120th street. The street was narrowed from 25 ft. to 14 ft., angled parking spots were created, a sidewalk was added on one side, and paved area was reduced from 0.38 acre to 0.31 acre. The street was given a sinuous shape to direct runoff into vegetated swales. The total catchment area is 2.3 acres and drains to a ditch that discharges into Pipers Creek.

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159 Ibid.
161 Levitt and Bergen, p. 8.
163 Levitt and Bergen, pp. 9 and 11.
165 “S.E.A. Streets: An Urban Creeks Legacy Millennium Project, Scope of Work.”
The original construction cost was bid at $244,000.\textsuperscript{166} However, the project required extensive community input in order to reach consensus and satisfy neighborhood concerns. The final cost totaled $850,000 including design and communications costs for working with residents. Nonetheless, SPU indicates that future SEA Street projects will cost less than traditional street improvements.\textsuperscript{167}

The University of Washington research team monitored the SEA Street stormwater discharge and compared it to baseline data gathered in the five months before construction began. They found that the SEA Street project prevented 100% of dry season runoff and 99% of wet season runoff, and estimated that a traditional Seattle streetscape would have discharged 100 times as much stormwater to Pipers Creek than did the SEA Street alternative over three years. The team also found that while every rain event during the baseline monitoring period created a discharge, only 6% of events following the SEA Street construction created discharges. Finally, the report notes that the SEA Street has retained increasingly more stormwater over time and attributes this growing capacity to the maturation of vegetation.\textsuperscript{168}

**Viewlands Cascade**

The Viewlands Cascade project replaced a narrow concretized drainage ditch that flowed into Pipers Creek with a series of wide, stepped pools ringed with vegetation. While the SEA Street project was designed to retain stormwater where it falls, the Cascade project is considered an “end-of-pipe” natural drainage system. The primary goal of the Cascade is to slow the flow rate of stormwater while also trapping pollutants and reducing flooding.

The Viewlands Cascade runs just south of the SEA Street project along one block of 105\textsuperscript{th} street between 3\textsuperscript{rd} and 4\textsuperscript{th} Avenue NW. The catchment area is roughly 21 acres, and is in a moderately sloped residential neighborhood with approximately 29% impervious cover.\textsuperscript{169} The construction cost of the Viewlands Cascade was $225,000.\textsuperscript{170} The final cost is estimated at $525,000.\textsuperscript{171} The UW research team monitored Viewlands Cascade discharge and compared it to baseline data gathered in the six months before construction began. They estimated that the Viewlands Cascade reduced the peak flow of runoff by 60% on average and prevented half of the total stormwater volume from ever reaching Pipers Creek over a period of three years. However, during large storms events, very little flow or volume reduction occurs. As compared to the traditional ditch that preceded the Cascade, the NDS alternative reduced runoff volume by a factor of three and cut flow velocities by 20% during the wet seasons.\textsuperscript{172}

\textsuperscript{166} Horner, Lim, and Burges, p. 2.
\textsuperscript{168} Horner, Lim, and Burges, p. 30.
\textsuperscript{169} Horner, Lim, and Burges, pp. 1-2. Per Tracey Tackett, SPU Low Impact Development Program Manager, this estimate is low. E-mail to the author, June 7, 2007.
\textsuperscript{170} Horner, Lim, and Burges, p. 2.
\textsuperscript{172} Horner, Lim, and Burges, p. 29.
The research team notes that the SEA Street strategy of retaining stormwater at its source is substantially more efficient on a per-unit basis than the “downstream” Cascade approach. SEA Street retained almost one-third as much runoff volume as Viewlands Cascade despite serving a catchment basin less than 10% as large. However, the SEA Street project was much less efficient in terms of cost per unit retained. The researchers observe that this would not necessarily be true of all “upstream” NDS approaches, but was true of these specific projects.173

The SPU web site provides a large amount of information on these and subsequent NDS projects, including “virtual tours” of the SEA Street and Cascade projects, environmental and community benefits, and links to monitoring reports.174

2004 “Restore Our Waters” Strategy and SPU Comprehensive Drainage Plan

Following the documented success of the first two natural drainage system projects, Seattle Mayor Greg Nickels launched his “Restore Our Waters” (ROW) Strategy in September 2004.175 The ROW Strategy is a framework for coordinating and concentrating the City’s efforts to restore the health of area waterways. In addition to focusing City agencies’ efforts, the Strategy also provides for educational initiatives, incentives for other stakeholders to take active stewardship roles, and ways to leverage City financial resources. The Strategy requires quantifiable goals and performance measurements for assessing the effectiveness of resource allocation.

The ROW Strategy adopts the scientific approach of Seattle Public Utilities in prioritizing critical actions that need to be taken. It was emphasized that the highest priority for creek restoration is to reduce the rate and volume of stormwater runoff into local creeks.176 Part of the strategy includes updating the City’s stormwater code to include options for green infrastructure alternatives to stormwater control. The code is currently undergoing an extensive public review and revision process, with implementation expected in early 2008.177

Also in 2004, Seattle Public Utilities drafted a new Comprehensive Drainage Plan as groundwork for the 2005-2010 Capital Improvement Program. While the previous 1995 Comprehensive Drainage Plan focused on public safety and mitigation of property damage, the 2004 Plan broadened the scope of SPU’s drainage management to include infrastructure, public safety and mobility, and aquatic resource protection.178 The new Plan included stormwater policies requiring consideration of natural drainage systems in lieu of traditional systems where appropriate to address stormwater flow control and water quality. The Plan also called for regulatory changes and incentives to encourage innovative stormwater management techniques on private land. SPU stressed the importance of continued effectiveness monitoring and the

173 Horner, Lim, and Burges, pp. 27-28.
175 See http://www.seattle.gov/mayor/issues/row.htm
development of technical resources for public and private entities wishing to implement natural drainage systems.

Several more NDS projects have been initiated following the success of the SEA Street and Cascade projects:

- The Broadview Green Grid project at N 107th Street and 4th Avenue N covers 15 city blocks (32 acres) in the Pipers Creek watershed and combines features of the first SEA Street project with cascades similar to the Viewlands Cascade project. Construction was completed in 2005 and the total project cost is $5.2 million.
- The Pinehurst Natural Drainage System at 19th Avenue NE and 155th Street covers 12 city blocks and is designed to improve stormwater conveyance, reduce runoff, and mitigate spot flooding. It includes new sidewalks and extensive use of vegetated swales with native landscaping. The projected total cost is $4.7 million at completion in 2007.
- The High Point Natural Drainage System will cover 34 dense urban blocks (120 acres) from 35th Avenue SW to High Point Drive SW and SW Juneau Street to SW Myrtle Street in the Seattle Housing Authority’s High Point redevelopment area. The project retrofits 9% of the Longfellow Creek Watershed with vegetated swales, French drains, and porous pavement. SPU calculates that the project meets flood control and water quality objectives at a lower cost than it would using a traditional drainage and water quality facility, or through retrofit of currently-developed streets with NDS. It is scheduled for completion in 2009 at a total projected cost of $5.3 million; $2.4 million had been spent at the close of FY2005. Ongoing maintenance costs are projected at $65,000 a year.179

The Broadview Green Grid and High Point Natural Drainage System are being monitored for their effectiveness over three years, as were the original SEA Street and Viewlands Cascade projects.

2007-2012 Capital Improvement Plan

The 2007-2012 Capital Improvement Plan (CIP) for the Seattle Public Utilities Drainage and Wastewater Fund includes many green infrastructure projects. The table below summarizes selected capital improvements that were easily identifiable as involving green stormwater management. The selected line items should be regarded as a general indicator of green infrastructure spending, not as a precise accounting. As noted previously, it is very difficult to accurately segregate green infrastructure spending from other spending, and such segregation in many cases creates artificial distinctions for multifunctional projects and activities. Likewise, “green” projects such as sediment dredging that are not directly related to stormwater source control are not included in the table, although they may accomplish common goals such as aquatic habitat restoration. Finally, the resources spent by other City departments on “green” initiatives that may directly or indirectly reduce stormwater runoff are not included here.

A number of the projects listed below are NDS projects, including the Broadview Green Grid, High Point Drainage System, Pinehurst Natural Drainage System, and Venema Creek natural Drainage System. The CIP includes operating and maintenance costs for these projects. For the Broadview, Pinehurst, and Venema projects, projected annual operating costs are $5,000-$7,000 upon completion. Maintaining these projects in top condition for both performance and aesthetic value could require 3-4 times this amount in annual operating support, however, depending on resident participation. Operating costs for the massive High Point development are projected at $65,000 per year following completion. Additional drainage projects such as Bitter Lake/ N 137th Stormwater and Lower Densmore Drainage Improvement may include NDS elements if cost-benefit analysis recommends them.

Some projects such as Natural Drainage System Improvements include funding for cost-benefit analysis of alternatives to traditional stormwater management. The Water Reuse Projects fund rain barrel procurement, public education, and pilot projects to disconnect residences from the combined sewer system while monitoring on-site detention and infiltration of stormwater. The Raincatcher projects support evaluation and implementation of customer-based strategies such as cisterns and rain gardens for high-priority watersheds. The Demand Management project will fund small capital projects aimed at reducing demand for combined sewer infrastructure by using decentralized techniques to keep stormwater out of the system. A number of projects also fund partnerships with community groups, other City departments, or private entities, and provide technical assistance and monitoring to those groups.

### Seattle Public Utilities Drainage and Wastewater Fund 2007-2012 Capital Improvement Plan: Selected Green Infrastructure Projects

<table>
<thead>
<tr>
<th>Project</th>
<th>Timeframe</th>
<th>Expenses through 2005</th>
<th>2006</th>
<th>2007</th>
<th>Total All Years through 2012</th>
<th>Operating Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>SEA 3rd Ave. NW &amp; NW 107th (Broadview Green Grid)</td>
<td>2000-2007</td>
<td>$5,028,000</td>
<td>$69,000</td>
<td>$94,000</td>
<td>$5,191,000</td>
<td>$35,000</td>
</tr>
<tr>
<td>Best Management Practices Projects</td>
<td>2000-2012</td>
<td>$605,000</td>
<td>$375,000</td>
<td>$595,000</td>
<td>$13,437,000</td>
<td>$-</td>
</tr>
<tr>
<td>Bitter Lake/ N 137th Stormwater</td>
<td>2001-2012</td>
<td>$14,000</td>
<td>-</td>
<td>$26,000</td>
<td>$1,872,000</td>
<td>$10,000</td>
</tr>
<tr>
<td>Capital Planning—Low Impact Development</td>
<td>2007-2012</td>
<td>-</td>
<td>-</td>
<td>$321,000</td>
<td>$719,000</td>
<td>$-</td>
</tr>
<tr>
<td>Capitol Hill Water Quality Project</td>
<td>2006-2012</td>
<td>-</td>
<td>-</td>
<td>$1,653,000</td>
<td>$4,776,000</td>
<td>$8,000</td>
</tr>
<tr>
<td>Citywide Source Control</td>
<td>2006-2007</td>
<td>-</td>
<td>$100,000</td>
<td>$103,000</td>
<td>$203,000</td>
<td>$-</td>
</tr>
<tr>
<td>Creek Flow Control Implementation</td>
<td>2010-2012</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>$6,866,000</td>
<td>$45,000</td>
</tr>
<tr>
<td>Creeks Vegetation Program</td>
<td>2005-2012</td>
<td>$129,000</td>
<td>$150,000</td>
<td>$185,000</td>
<td>$1,131,000</td>
<td>$-</td>
</tr>
<tr>
<td>Demand Management</td>
<td>2007-2012</td>
<td>-</td>
<td>-</td>
<td>$600,000</td>
<td>$3,433,000</td>
<td>$-</td>
</tr>
<tr>
<td>Drainage and Wastewater Partnership Program</td>
<td>2007-2007</td>
<td>-</td>
<td>-</td>
<td>$350,000</td>
<td>$7,250,000</td>
<td>$-</td>
</tr>
<tr>
<td>High Point Drainage System</td>
<td>2002-2011</td>
<td>$2,431,000</td>
<td>$1,100,000</td>
<td>$1,376,000</td>
<td>$5,344,000</td>
<td>$294,000</td>
</tr>
<tr>
<td>Lakewood Raincatcher Pilot Project</td>
<td>2005-2012</td>
<td>$78,000</td>
<td>$628,000</td>
<td>$851,000</td>
<td>$1,825,000</td>
<td>$-</td>
</tr>
<tr>
<td>Lower Densmore Drainage Improvement</td>
<td>2005-2008</td>
<td>$152,000</td>
<td>$225,000</td>
<td>$6,000</td>
<td>$388,000</td>
<td>$-</td>
</tr>
<tr>
<td>Natural Drainage System Improvements</td>
<td>2003-2012</td>
<td>$82,000</td>
<td>$396,000</td>
<td>$169,000</td>
<td>$3,500,000</td>
<td>$-</td>
</tr>
<tr>
<td>Nblh.Drainage/Climate Bonus Matching Grant Project</td>
<td>2007-2012</td>
<td>-</td>
<td>-</td>
<td>$150,000</td>
<td>$900,000</td>
<td>$-</td>
</tr>
<tr>
<td>Pinehurst Natural Drainage System</td>
<td>2002-2008</td>
<td>$3,356,000</td>
<td>$1,287,000</td>
<td>$30,000</td>
<td>$4,687,000</td>
<td>$27,000</td>
</tr>
<tr>
<td>Raincatcher Creek Pilot Project</td>
<td>2007-2008</td>
<td>-</td>
<td>-</td>
<td>$235,000</td>
<td>$447,000</td>
<td>$-</td>
</tr>
<tr>
<td>South Lake Union</td>
<td>2004-2009</td>
<td>$131,000</td>
<td>$1,130,000</td>
<td>$137,000</td>
<td>$1,547,000</td>
<td>$-</td>
</tr>
<tr>
<td>Stormwater Mitigation Partnership Program</td>
<td>2005-2010</td>
<td>$1,000</td>
<td>$50,000</td>
<td>$50,000</td>
<td>$218,000</td>
<td>$-</td>
</tr>
<tr>
<td>Venema Creek Natural Drainage System</td>
<td>2003-2012</td>
<td>$486,000</td>
<td>$405,000</td>
<td>$309,000</td>
<td>$2,619,000</td>
<td>$15,000</td>
</tr>
<tr>
<td>Water Reuse - Stormwater</td>
<td>2001-2008</td>
<td>$50,000</td>
<td>$50,000</td>
<td>$29,000</td>
<td>$153,000</td>
<td>$-</td>
</tr>
<tr>
<td>Water Reuse - Wastewater</td>
<td>2001-2008</td>
<td>$392,000</td>
<td>$14,000</td>
<td>$97,000</td>
<td>$540,000</td>
<td>$-</td>
</tr>
<tr>
<td>Watershed Base Creek Flow Control</td>
<td>2005-2011</td>
<td>$35,000</td>
<td>$150,000</td>
<td>$71,000</td>
<td>$1,166,000</td>
<td>$-</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td>$12,970,000</td>
<td>$6,129,000</td>
<td>$7,437,000</td>
<td>$68,212,000</td>
<td>$434,000</td>
</tr>
</tbody>
</table>

| Drainage and Wastewater Fund Total                   |               | $85,848,000           | $43,665,000 | $52,012,000 | $519,316,000                   |
| Green Infrastructure as % of Total                  |               | 15.1%                 | 14.0%      | 14.3%      | 13.1%                          |

Source: City of Seattle, Washington 2007-2012 Adopted Capital Improvement Program

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Based on the table above, it is estimated that $7.4 million will be spent on the selected green infrastructure projects in 2007, out of $52.0 million in total proposed capital spending by the Drainage and Wastewater Fund. This represents 14.0% of the Drainage and Wastewater Fund total capital budget for 2007, and is similar to the 12.7% of total 2007 appropriations identified on page 37.

MILWAUKEE METROPOLITAN SEWERAGE DISTRICT

The Milwaukee Metropolitan Sewerage District (MMSD) has initiated a number of green stormwater management projects and a substantial public education campaign centered on reducing stormwater runoff and pollution.

The following section will describe the responsibilities and finances of MMSD, review the results of early pilot projects, and discuss other related green infrastructure programs.

Responsibilities and Finances

The Milwaukee Metropolitan Sewerage District is a state-chartered unit of local government that provides wastewater services to 28 municipalities and 1 million people over a 420 square-mile area in and around Milwaukee, Wisconsin. Roughly 5%, or 20 square miles of the District’s area is a combined sewer system while 95% is a separate sewer system. MMSD owns 2,220 miles of collector sewers and 310 miles of intercepting and main sewers.\textsuperscript{182} The system includes deep tunnel storage that currently holds 405 million gallons and is expected to reach 520 million gallons of maximum capacity by 2010. The deep tunnel is estimated to have prevented 65.9 billion gallons of wastewater from flowing into Lake Michigan since 1994.\textsuperscript{183}

The District owns two wastewater treatment plants that process over 200 million gallons daily and recycle biosolids to produce a fertilizer called Milorganite®. Treated effluent is released into Lake Michigan, which is also the local source of potable water and a popular recreation site. The District’s plants, biosolid recycling, and field operations are managed by United Water Services, a private contractor.\textsuperscript{184}

The District’s operating expenses are partially funded by a sewer service charge billed to the municipalities served by MMSD. The charge is based on waste strength, flow volume, and number of connections. User charge billings were budgeted at $47.1 million in FY2007. Other operating revenue sources include Milorganite® sales and miscellaneous revenues. The capital budget is financed by a property tax and additional capital fees for participating municipalities outside the District’s legal boundary. Property tax revenue was budgeted at $78.5 million in FY2007. The total operating budget for FY2007 is $67.6 million and the capital budget is

\textsuperscript{182} Milwaukee Metropolitan Sewerage District 2007 Annual Budget, p. 5.
\textsuperscript{184} Milwaukee Metropolitan Sewerage District 2007 Annual Budget, p. 6.
There are 249 full-time equivalent positions. MMSD uses a three-year strategic planning cycle to establish goals and implementation plans. The 2007-2009 Strategic Plan and Goals detailed in the FY2007 budget document clearly indicate the District’s leadership role in green stormwater management initiatives for the Milwaukee region:

<table>
<thead>
<tr>
<th>Goals</th>
<th>Strategies</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Continue to provide District services to improve water quality,</td>
<td>• Minimize point source pollution</td>
</tr>
<tr>
<td>protect the environment, public health, and property</td>
<td>• Promote the reduction of non-point source pollution</td>
</tr>
<tr>
<td></td>
<td>• Minimize impacts of flooding</td>
</tr>
<tr>
<td></td>
<td>• The District will collaborate to define its future role in an integrated</td>
</tr>
<tr>
<td></td>
<td>water resource management plan</td>
</tr>
<tr>
<td>2. Maintain the District’s contribution to a competitive regional</td>
<td>• Maximize the efficient use of District resources</td>
</tr>
<tr>
<td>economy, consistent with its role in environmental protection</td>
<td>while striving to minimize cost of services to keep user charge</td>
</tr>
<tr>
<td></td>
<td>billings and tax levy increases at a minimum</td>
</tr>
<tr>
<td></td>
<td>• Maximize the stability of user charge billings and the tax levy</td>
</tr>
<tr>
<td></td>
<td>• Maximize utilization of local resources</td>
</tr>
<tr>
<td>3. Continue to provide regional leadership in educating the public</td>
<td>• Maximize public participation and access to District planning efforts</td>
</tr>
<tr>
<td>to understand the various causes and impacts of water pollution</td>
<td>and operations</td>
</tr>
<tr>
<td></td>
<td>• Develop and further deliver educational programs to communities and</td>
</tr>
<tr>
<td></td>
<td>environmental groups, focusing on water conservation and</td>
</tr>
<tr>
<td></td>
<td>reduction of non-point source pollution</td>
</tr>
</tbody>
</table>

The budget for each department is organized to demonstrate how it is meeting objectives related to these District-wide goals. The Office of Executive Director is the locus for the majority of MMSD’s green infrastructure initiatives, reflecting the strong leadership and environmental ethos demonstrated by the current Executive Director, Kevin Shafer. The Office’s budget and objectives clearly indicate the importance of these initiatives, with 22.8% of the Office’s 2007 operating budget and 44.5% of the capital budget dedicated to green infrastructure-related purposes as shown in the table below. The Office of the Executive Director staff includes a Project Manager for the Greenseams program and a Planner for the 2020 Facility Plan Stakeholder Involvement project and stormwater best management practices.

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185 Ibid., pp. 6 and 19.
186 Ibid., p. 37.
187 Ibid., 8-9.
188 Ibid., p. 54.
The Environmental Management System included in the table above is part of the District’s Environmental Sustainability policy for its own facilities. The policy requires all new and reconstructed MMSD facilities to be designed according to green infrastructure best practices. Outreach programs referenced in the table include the District’s rain barrel program, which has sold 5,000 rain barrels to date, and is used as an educational tool to inform the public about the importance of stormwater runoff reduction.

Greenseams is a land acquisition and conservation program for non-structural flood and stormwater management that began in 2002. MMSD purchases or obtains conservation easements on land along riparian corridors and floodplains to prevent their development. Between 2002 and 2006, 39 properties totaling 1,274 acres were acquired. MMSD has leveraged additional revenues from the Wisconsin Department of Natural Resources for purchase of these lands. The Conservation Fund manages the Greenseams program on behalf of MMSD.

MMSD’s capital budget includes the projects in the Office of the Executive Director as well as other green initiatives in the 2020 Facilities Plan, a long-term capital improvement plan. Some programs fund actual installation of green infrastructure while others support educational and outreach components or monitoring studies.

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[192] Ibid., p. 232.
### MMSD 2007 Capital Budget Green Initiatives

<table>
<thead>
<tr>
<th>Project #</th>
<th>Name</th>
<th>2007</th>
<th>Total all Years</th>
</tr>
</thead>
<tbody>
<tr>
<td>M03011</td>
<td>Rain Water Rerouting</td>
<td>$200,250</td>
<td>$5,034,317</td>
</tr>
<tr>
<td>M03015</td>
<td>2020 Facilities Plan--Stormwater BMPs</td>
<td>$110,188</td>
<td>$8,727,553</td>
</tr>
<tr>
<td>M03024</td>
<td>2020 Facilities Plan--Wet Weather Peak Flow Reduction</td>
<td>$3,146,336</td>
<td>$4,400,453</td>
</tr>
<tr>
<td>M03029</td>
<td>2020 Facilities Plan Implementation Evaluation &amp; Planning--Water Quality Studies</td>
<td>$875,487</td>
<td>$1,774,954</td>
</tr>
<tr>
<td>M03030</td>
<td>Stormwater BMPs</td>
<td>$100,000</td>
<td>$100,000</td>
</tr>
<tr>
<td>W97002</td>
<td>Greenseams</td>
<td>$3,012,247</td>
<td>$27,709,372</td>
</tr>
<tr>
<td><strong>SUBTOTAL green initiatives</strong></td>
<td></td>
<td>$7,444,508</td>
<td>$47,746,649</td>
</tr>
<tr>
<td><strong>TOTAL CAPITAL BUDGET</strong></td>
<td></td>
<td>$285,713,000</td>
<td>$1,752,821,109</td>
</tr>
</tbody>
</table>


The Rain Water Rerouting project is aimed at preventing stormwater from entering the sewer systems by separating storm and sanitary sewers, and using green infrastructure to manage stormwater. The budget document notes that to the extent that the volume of water entering the tunnels and treatment plants is reduced, operating costs for pumping and treatment will also decline. However, these savings may be offset by increased maintenance costs. The net savings are estimated at $1,000 annually.193

The 2020 Facilities Plan Stormwater BMPs are demonstration projects that are owned and operated by partner organizations but supported by MMSD. Several of these projects are discussed in greater detail beginning on page 51. The Wet Weather Peak Flow Reduction program will include structural as well as non-structural measures to reduce infiltration and inflow of stormwater into the sewer system during wet weather events.194 The Water Quality Studies will provide data to aid communities in choosing the most effective green infrastructure practices for their watersheds.195

### Strategic Plan for Stormwater Runoff Reduction

In 2003 MMSD established its Strategic Plan for Stormwater Runoff Reduction, which was created to provide data and guidelines for alternative methods to reduce stormwater runoff volume and pollution levels. The Runoff Reduction Plan would also provide information on capital and operating costs, implementation and maintenance requirements, and effectiveness of green stormwater alternatives to inform the District’s 2020 Facilities Plan. The 2020 Facilities Plan is a capital plan that was presented to the MMSD Board of Commissioners in June 2007 and takes a watershed approach to water resource planning for the District. It includes a recommended list of capital projects to be undertaken through the year 2020.196

193 Ibid., p. 240.
194 Ibid., p. 249.
195 Ibid., p. 252.
196 Milwaukee Metropolitan Sewerage District 2007 Annual Budget, p. 118.
MMSD’s investigation of alternative approaches to stormwater management was driven by its goals of eliminating sanitary sewer overflows, reducing combined sewer overflows, improving water quality, and exercising sound fiscal management.197 According to a 2003 memorandum evaluating stormwater reduction practices, MMSD expected to reap the following benefits from this integrated approach:

- System Benefits:
  - Reduced CSOs/SSOs
  - Reduced conveyance, storage, and treatment costs
  - Increased storage available for sanitary flow during wet weather
  - Reduced peak flows and runoff volumes
  - Delayed runoff

- Environmental Benefits:
  - Improved water quality
  - Reduced erosion, scouring, and drainage problems
  - Improved green space and habitat

- Public Benefits:
  - Enhanced public education and involvement
  - Improved environmental stewardship198

The July 2003 Strategic Plan for Stormwater Runoff Reduction included four principal elements:

1. Pilot projects to evaluate the implementation, cost, and effectiveness of alternative stormwater BMPs;
2. A summary of BMP experience and analysis in other communities;
3. An examination of local stormwater regulations and recommendations on ways to permit or promote use of stormwater BMPs; and
4. A public education program to promote awareness of and involvement in reduction of stormwater runoff.199

The Final Report of the Stormwater Runoff Reduction Program was published in February 2007 and included evaluations of the four elements listed above.

Seventeen alternative stormwater runoff reduction practices were included for evaluation in the MMSD’s 2003 Runoff Reduction Plan:200

198 Ibid.
199 Milwaukee Metropolitan Sewerage District 2005 Annual Budget, p. 263.
• Downspout disconnection
• Rain gardens
• Green parking lots
• Pocket wetlands
• Inlet restrictors/pavement storage
• Stormwater rules and redevelopment policies

• Rain barrels
• Green roofs
• Stormwater trees
• Bioretention
• French drains and dry wells
• Onsite filtering practices

• Cisterns
• Rooftop storage
• Porous pavement
• Infiltration sumps
• Compost amendments

Not all of these alternatives to traditional storm sewers and tunnel systems necessarily employ vegetation. For example, French drains and dry wells reduce runoff into sewers by using gravel-filled trenches to contain roof runoff and allow it to slowly percolate into soil. However, all of these alternatives serve to reduce stormwater runoff into the MMSD sewer system. Some have added benefits such as pollution control, reduced stormwater treatment costs, energy and water savings, aesthetic enhancements, and habitat improvement.

The 2003 memorandum evaluating stormwater reduction practices reviewed the literature on these seventeen practices and compared their advantages and disadvantages to those of conventional stormwater systems. The memo noted the following important issues to consider when comparing green stormwater practices to each other, or to conventional practices:

1. The practices apply to different locations and situations, and consequently the amount of water they handle differs substantially.
2. Most green practices offers benefits beyond stormwater management.
3. Green infrastructure approaches are generally small-scale and cumulative in their effects, which may make them less efficient than traditional stormwater management until broad implementation is achieved.
4. Green approaches include structural, non-structural, educational, and institutional elements. They require partnerships among governments, property owners, non-profits, developers, and citizens.
5. Green approaches provide opportunities to educate the public on environmental, health, and urban planning matters.201

These five cautions reflect the decentralized nature of green approaches, in contrast to traditional centralized, engineered systems.

The 2003 memorandum evaluated each of the seventeen practices for their effect on stormwater flow, environmental impact, implementation issues, function (infiltration, evapotranspiration, or storage), maintenance requirements, promotion of environmental awareness, and cost. The evaluation tables are reproduced with permission of MMSD in Appendix A of this report.202

201 Ibid., p. 47.
Computer Modeling

MMSD commissioned a consultant, Camp Dresser & McKee (CDM), to create computer model simulations of selected green stormwater practices. CDM designed baseline models for typical Milwaukee-area 6-acre residential and commercial city blocks and ran a continuous hydrologic model for the period from 1995 to 2002 for both combined and separate sewer systems.\textsuperscript{203}

The model was then altered to include green infrastructure practices. For the residential model CDM included downspout disconnection, rain barrels, rain gardens, compost amendments, porous pavement, and stormwater trees. In the commercial area the model included green roofs, roof storage, bioretention, green parking lots, and cisterns.

CDM found that in the residential area, the simulations showed a 12-38% reduction in combined sewer overflow volume and a peak flow reduction of 5-36% during major storm events. In the commercial area, CSO volume was reduced by 22-76% and peak flow was reduced by 13-69%. The table below shows simulated volume reductions.

<table>
<thead>
<tr>
<th>Computer-Simulated CSO Volume Reductions (Assumes 100% Implementation of BMPs)</th>
<th>CSO Volume (millions of gallons a year)</th>
<th>Percent Reduction from Baseline</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Residential</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baseline</td>
<td>0.28</td>
<td>--</td>
</tr>
<tr>
<td>Downspout disconnection</td>
<td>0.25</td>
<td>12%</td>
</tr>
<tr>
<td>Rain barrel</td>
<td>0.24</td>
<td>14%</td>
</tr>
<tr>
<td>Rain garden</td>
<td>0.18</td>
<td>36%</td>
</tr>
<tr>
<td>Rain garden &amp; rain barrel</td>
<td>0.17</td>
<td>38%</td>
</tr>
<tr>
<td><strong>Commercial</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baseline</td>
<td>1.17</td>
<td>--</td>
</tr>
<tr>
<td>Green roof</td>
<td>0.91</td>
<td>22%</td>
</tr>
<tr>
<td>Bioretention</td>
<td>0.35</td>
<td>70%</td>
</tr>
<tr>
<td>Green parking lot</td>
<td>0.28</td>
<td>76%</td>
</tr>
</tbody>
</table>


However, it is critical to note that these results assumed 100% implementation of the green infrastructure practices. The researchers found that at 50% implementation, rain gardens’ effectiveness at reducing CSO volume would go from a 36% reduction to only 20% reduction from baseline. At only 12.5% implementation, the CSO volume reduction would fall to 5% from baseline.\textsuperscript{204} These figures suggest that in order to produce significant benefits, broad implementation of these practices would be necessary.


\textsuperscript{204} Ibid., p. 9.
Pilot Projects

MMSD’s Strategic Plan for Stormwater Runoff Reduction included 19 pilot projects that were implemented during 2003-2006 in partnership with public and private entities. MMSD provided partial funding for the projects, but the planning, design, implementation, maintenance, and/or monitoring were all conducted by the partner organization. Each partner was also required to submit a report or other specified deliverables such as monitoring data or educational materials. The District’s 2007 Stormwater Runoff Reduction Program Final Report provides details on each of the pilot projects, summarized in the table below. The District cost for these 19 projects was $2.0 million, or 43.8% of total costs.

<table>
<thead>
<tr>
<th>Project #</th>
<th>Project Name</th>
<th>Partner(s)</th>
<th>MMSD Cost</th>
<th>Partner Cost</th>
<th>Deliverables</th>
</tr>
</thead>
<tbody>
<tr>
<td>M03015C03</td>
<td>Great Lakes Water Institute Green Roof</td>
<td>Great Lakes Water Institute</td>
<td>$110,000</td>
<td>$132,695</td>
<td>Installed green roof. Monitoring data. Educational program.</td>
</tr>
<tr>
<td>M03015C04</td>
<td>Johnson’s Park Low Impact Development</td>
<td>African American World Cultural Center</td>
<td>$44,810</td>
<td>$54,660</td>
<td>Design brochure. Stormwater mgmt. plan that incorporates LID.</td>
</tr>
<tr>
<td>M03015C05</td>
<td>Menomonee Valley Stormwater Park</td>
<td>City of Milwaukee, Sixteenth Street Community Health Center, Menomonee Valley Partners, University of Wisconsin - Milwaukee</td>
<td>$60,661</td>
<td>$225,011</td>
<td>Stormwater park design.</td>
</tr>
<tr>
<td>M03015C06</td>
<td>Trinity Creek Constructed Wetlands Educational Signage</td>
<td>City of Mequon</td>
<td>$27,462</td>
<td>$24,670</td>
<td>Draft designs. Affordable signage.</td>
</tr>
<tr>
<td>M03015C07</td>
<td>Highland Gardens Public Housing Rain Barrel Installation</td>
<td>Milwaukee Community Service Corps</td>
<td>$31,500</td>
<td>$3,500</td>
<td>Rain barrels available to public. Educational brochures.</td>
</tr>
<tr>
<td>M03015E10</td>
<td>Menomonee Valley Bioretention Facility</td>
<td>City of Milwaukee</td>
<td>$682,500</td>
<td>$682,500</td>
<td>Bioretention facility. Tour, PowerPoint, brochure, signage.</td>
</tr>
<tr>
<td>M03015E06</td>
<td>Miller Brewing Co. Rain Garden and Bioretention Swale</td>
<td>Miller Brewing Co.</td>
<td>$131,080</td>
<td>$136,430</td>
<td>Education with signage and brewery tour.</td>
</tr>
<tr>
<td>M03015E08</td>
<td>Milwaukee County Zoo Green Roof</td>
<td>Zoological Society of Milwaukee</td>
<td>$31,500</td>
<td>$31,500</td>
<td>Webcam, flow and temperature monitoring, educational kiosk.</td>
</tr>
<tr>
<td>M03015E21</td>
<td>Milwaukee School of Engineering Pervious Parking Project</td>
<td>Milwaukee School of Engineering, TEL Corporation</td>
<td>$331,800</td>
<td>$331,800</td>
<td>Magazine articles, project signage, student education.</td>
</tr>
<tr>
<td>M03015E26</td>
<td>Josey Heights Green Pavement - Phase I</td>
<td>City of Milwaukee, Walnut Way Conservation Corp., Coach House Development</td>
<td>$95,000</td>
<td>$95,000</td>
<td>Brochures and information for homeowners to education them on the values of methods and maintenance measures.</td>
</tr>
</tbody>
</table>

| TOTAL COST | $2,077,555 | $2,661,523 |

The 2007 report describes successes and failures among these pilot projects. For example, some Auto Recycler rain gardens flourished but others were stunted due to inadequate water supply and small plantings. The Residential Action in Neighborhood (RAIN) had substantial success in motivating homeowners to disconnect downspouts and install rain gardens once initial concerns about aesthetics and possible overflow were addressed through a comprehensive education campaign. Challenges posed by maintenance and continuity issues were also described in the report. For example, the rain garden installed for the Zabest Group project died because the planned commercial tenant never occupied the site, thus the garden was not maintained. The Starbucks franchise that subsequently purchased the site removed the remains of the rain garden and planted conventional vegetation. The Milwaukee School of Engineering also experienced several problems with its porous pavement applications before finding a suitable solution.

MMSD took the lead on a number of larger pilot projects in addition to the partnerships described above. The Shorewood Wet Weather Flow Volume and Peak Management Project was a joint project of MMSD and the Village of Shorewood aimed at alleviating basement flooding. The Shorewood project combines traditional stormwater management with green infrastructure alternatives in order to reduce flooding and CSO volumes. A public education campaign for downspout disconnection resulted in disconnection of 35% of all connected downspouts, or 126 roofs. This represented an 8% reduction in imperviousness, or 5.64 impervious acres removed from the combined sewer system, with a volume reduction of 20,500 cubic feet of runoff per 1 inch of rain. Fifty rain gardens and eighty rain barrels were also installed. Eighteen catch basins were disconnected from the combined sewer system and rerouted to separate storm sewers in coordination with the Village’s street reconstruction program.

The Milwaukee Downtown Downspout Disconnection Project evaluated 137 public and institutional buildings in downtown Milwaukee for downspout disconnection feasibility. Many buildings could not be disconnected due to internal downspouts or inadequate pervious area for infiltration. The study concluded that 16 buildings were appropriate for downspout disconnection and several others could be partially disconnected.

In 2005 the District awarded roughly $200,000 in grants for four projects that conducted tests to evaluate green stormwater practices for their risk of creating seepage into sanitary sewer lines. They found, for example, that rain gardens should be placed laterally at least 2 feet away from sewer lines to prevent seepage, and that the City’s liner requirements for wet and dry detention basins had been sufficient to prevent infiltration around the systems.

As described above, some of the pilot projects included performance monitoring. However, the Final Report of the Stormwater Runoff Reduction Program noted that more rigorous, instrumented, and long-term monitoring would be required to adequately measure the

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205 Ibid., pp. 10-39.
206 Ibid., pp. 10-39.
207 Ibid., p. 46.
208 Ibid., p. 46.
209 Ibid., pp. 50-51.
effectiveness of the green stormwater alternatives.\textsuperscript{210} Considerable performance differences are to be expected in different seasons and locations, and the effects of different materials and maintenance practices merit careful testing.

**Local Ordinance Audit**

MMSD conducted an audit of local stormwater ordinances to determine legal and regulatory barriers to green infrastructure practices and seek recommendations on ways to overcome them and encourage green practices. Benchmark criteria were taken from a Center for Watershed Protection publication, and the ordinances of 27 communities were evaluated on nine criteria. The audit found that most communities already required new development plans to address stormwater management, but few encouraged use of green alternatives to reduce impervious surfaces and runoff. The final report included 29 recommendations on ways to improve local ordinances such that they would encourage use of green stormwater practices. The recommendations included procedural and plan review measures, streetscape guidelines, materials, and maintenance contracts.\textsuperscript{211}

In order to facilitate implementation of these recommendations the audit committee developed a model ordinance for use by the communities and a voluntary review schedule with deadlines for each community to review its ordinance and propose revisions. They also offered support in promoting the value of green infrastructure practices and planned to monitor compliance in order to determine if additional incentives were needed for green infrastructure implementation.

**Public Education**

Public education is a major focus of MMSD’s green infrastructure projects and its stormwater runoff reduction efforts generally. Printed materials, public presentations, and interpretive signs are all aimed at accomplishing five goals:

- Inform the public about stormwater pollution problems and potential solutions
- Create environmental awareness and knowledge
- Increase participation and support
- Assist with implementation of green stormwater alternatives
- Seek input on public concerns and priorities\textsuperscript{212}

The MMSD leadership has emphasized the critical importance of taking a partnership approach to green stormwater management, since successful implementation depends on the participation of many different parties.\textsuperscript{213} This is why public education was so central to the stormwater

\textsuperscript{210} Ibid., pp. 70 and 73.
\textsuperscript{211} Ibid., pp. 61-68.
\textsuperscript{212} Ibid., p. 69.
\textsuperscript{213} Kevin Shafer, Executive Director, Milwaukee Metropolitan Sewerage District, presentation at the Center for Neighborhood Technology’s “Stormwater Solutions that Hold Water” conference, Chicago IL, May 31 2007.
runoff reduction strategy. Public feedback also informs MMSD on the incentives required to generate widespread implementation of best practices.\footnote{Milwaukee Metropolitan Sewerage District, \textit{Stormwater Runoff Reduction Program: Final Report}, p. 69.}

However, the Final Report of the Stormwater Runoff Reduction Program warned that public education is necessary but not sufficient to ensure the broad implementation that is required in order for green infrastructure to make a measurable contribution to stormwater runoff reduction. Regulations, incentives, and community-led grassroots implementation programs are critical to successful implementation.\footnote{Ibid., p. 77.}

The MMSD web site is an important educational tool and provides extensive information on the District’s various green infrastructure initiatives. In additional to explaining the traditional sewer systems and deep tunnel structures, it describes the problems caused by stormwater runoff from impervious surfaces. Detailed information about downspout disconnection, rain barrels, and rain gardens is provided in a manner that encourages their implementation.\footnote{See http://www.mmsd.com/index.cfm}

\section*{SUMMARY}

This report reviewed some common barriers to green infrastructure implementation and examined the resources that several U.S. cities devote to green infrastructure. Strict comparison of the resources that each local government devotes to green infrastructure was not possible, in large part because none of the governments examined segregates green stormwater spending from “traditional” stormwater spending. As a result, this report provided only anecdotal evidence of government spending on green infrastructure.

The common barriers to implementation of green alternatives to traditional urban stormwater management are a lack of performance data, cost, and decentralization. Green stormwater management practices are relatively new and the body of research regarding their effectiveness has not yet matured. Without reliable longitudinal data on the effectiveness of green infrastructure in reducing runoff flow, rate, and pollutant loads, stormwater managers may be understandably reluctant to invest in them due to the critical importance of meeting their legal mandates. Although traditional stormwater systems are very expensive to build and maintain, green infrastructure can also be costly, especially when retrofitting is required. Finally, the decentralized nature of green infrastructure can be a barrier because it diffuses control and accountability. Maintenance responsibilities, for example, may be transferred from the stormwater agency to individual property owners. Maintenance failures reduce the effectiveness of the green infrastructure. Yet green infrastructure must be broad-scale in order to produce measurable reductions in stormwater volume.

The five stormwater agencies examined in this report have confronted these barriers to varying degrees and in different ways. Several of the agencies embarked on green infrastructure pilot projects despite a paucity of performance data. Seattle Public Utilities monitored its early pilot projects and collected performance data in order to guide decision-making about future projects. The Milwaukee Metropolitan Sewerage District also required some of its BMP partners to
collect performance data, but other pilot projects were allowed to proceed without monitoring. Monitoring adds costs to the projects and in some cases agencies may choose to forgo data collection in favor of funding additional projects. This is unfortunate, since pilot projects are part of a learning process in which both success and failure provide important information.

For those agencies that funded substantial pilot projects, cost does not seem to have been a major factor. As in any pilot project, initial costs are generally higher than they would be in subsequent implementations, and pilot projects also reveal hidden costs that may not have been predicted. For example, Seattle Public Utilities found that its first SEA Street project included significant costs for community relations and planning that were not expected, but that could be minimized in the future. Other agencies have minimized costs by seeking partnerships. For example, the Milwaukee Metropolitan Sewerage District’s BMPs shared costs between the District and the partners.

Another important way to share costs is to pass ordinances that require developments and re-developments to include green infrastructure. This shifts costs for construction to property owners. However, exclusive use of the regulatory approach will bring very slow change to mature cities, which redevelop at rates of roughly 1% a year, as in the cases of Seattle and Philadelphia. Stormwater fees can encourage faster implementation among private property owners by offering discounts for green infrastructure retrofits. But compliance with regulations must be verified on a regular basis. As noted by Michael Berkshire of the City of Chicago, inspection and enforcement of green infrastructure regulations is critical to their effectiveness.

The problem of decentralization, particularly in terms of maintenance, is addressed by several agencies through public education campaigns. The City of Chicago, Seattle Public Utilities, City of Philadelphia, and Milwaukee Metropolitan Sewerage District all have numerous web pages and publications intended to inform the public about alternative stormwater practices and encourage them to treat stormwater as a resource. Several of the MMSD’s BMP projects required partners to create signage or provide public presentations about their project. Seattle’s first SEA Street involved deep engagement by the residents and fostered their commitment to maintaining the vegetation. However, SPU is aware that it may need to pay for city workers to maintain the plantings if volunteer maintenance lags. As Michael Berkshire at the City of Chicago notes, it is important to require not just construction but also maintenance of green infrastructure on private property.

A common characteristic shared by the City of Seattle, Philadelphia Office of Watersheds, City of Chicago, and Milwaukee Metropolitan Sewerage District was a strong leader with an environmental ethos. This leader chose to embark on green infrastructure projects and partnerships despite the barriers of cost, decentralization, and lack of data. This environmental ethos, not a strict cost/benefit analysis, was what drove the decision to try green infrastructure. The data collected by these early implementers and their success at tackling the problems of decentralization and cost effectiveness will be critical in encouraging other agencies to implement green infrastructure.
Remaking Main Street

A small Prince George's County town sets out to 'green' its thoroughfare and help out the bay

Edmonston Mayor Adam Ortiz, left, and system designer Neil Weinstein show off a "bio retention cell" and a tree box along the town’s main drag, Decatur Street. (Baltimore Sun photo by Barbara Haddock Taylor / November 23, 2009)

By Timothy B. Wheeler Baltimore Sun reporter

November 25, 2009

http://www.baltimoresun.com/features/green/bal-md.gr.street25nov25,0,2052577.story

This little town in the paved-over heart of suburban Washington, where cows grazed long ago, is "greening" its main street — showing what Baltimore and other cities in the region may need to do to help save the Chesapeake Bay.
In a bid to make the working-class community of 1,500 more walkable and environmentally friendly, Edmonston has begun a $1.1 million makeover of busy Decatur Street, narrowing the two-lane residential thoroughfare to make room for pollution-absorbing trees and grasses, a bike lane and energy-efficient, classic-looking street lamps to be run on wind power purchased from out of state.

"Our priority is to redefine the American main street and get it from top to bottom as sustainable and community-oriented as possible," explained Adam Ortiz, the town's part-time mayor. He and other town officials celebrated Tuesday the recent launch of construction work by showing it off to state and federal officials, including Environmental Protection Agency Administrator Lisa P. Jackson.

Jackson called this "one of the greenest streets in the country" and said this Prince George's County town "can show the way for other communities across America."

Tucked between Hyattsville and Bladensburg on the banks of the Anacostia River, Edmonston was home to a dairy farm until the turn of the 20th century. Since the town's incorporation in the 1920s, it has been a bedroom community of the nation's capital, its streets lined by modest frame and brick cottages and bungalows.

It's also long been plagued by serious flooding, which was only alleviated two years ago by new flood controls installed by the U.S. Army Corps of Engineers. While pressing for the new controls, the mayor said he and others realized that much of the water inundating the town's streets came not from the river but from storm water washing off all the parking lots, streets and rooftops of all the communities that had built up in the area over the years. Edmonston was simply the lowest point around for all that runoff to collect, he said.

Storm-water runoff from urban and suburban communities like Edmonston is a major — and growing — problem for streams and rivers and the Chesapeake Bay. New developments and redevelopments face tightening regulations requiring them to reduce the amount of runoff and to filter out any pollutants in water draining from their sites. But roughly 90 percent of the developed land in the bay region was built before storm-water controls were required, says Robert Summers, Maryland's deputy secretary of the environment.

For older communities like Edmonston and Baltimore, he said, "we've got to go back in and retrofit."

In Edmonston's case, the retrofit is being underwritten with a federal economic stimulus grant. Town officials say they expect that the streetscape overhaul will provide work for 50 or 60 laborers, landscapers and technicians before it's finished next year.

The street, which was widened after World War II to accommodate growing suburban traffic, is now being narrowed, from 30 feet to 24 feet. Rainfall running down the street will be diverted away from the storm drains into newly created landscaped areas planted with trees and a variety of grasses. Porous pavers will replace asphalt along the curbs to mark bike lanes and allow more rainfall to soak into the ground.
These pavers and the "bio-retention cells," as environmental planners call the landscaped areas, should soak up 80 percent of the runoff from gentle and even moderate rains, explained Neil Weinstein, executive director of the Low-Impact Development Center, who's helped the town design its project.

Town officials aim to line the street with native oaks, maples and sycamores, which they hope will thrive with careful ground preparation and ample water from runoff. Once mature, those trees should provide much-needed shade, help clear the air and attract birds and other wildlife.

"We also have a mosquito problem," the mayor said, "so we want to rebuild the habitat for birds and bats so they can help us fight the mosquitoes, because right now the mosquitoes are definitely winning."

The project is about making Edmonston a more attractive, walkable community as well as a greener one, Ortiz said. To get more residents out and about, town officials say sidewalks are being widened to allow mothers with strollers and the disabled to use them. Traffic will be slowed and made quieter by narrowing the street and by introducing a "wiggle" into its previously arrow-straight alignment. Trucks will be banned, and the streetlights, with their harsh sodium vapor glare, will be replaced with shorter, more historic looking street lamps, illuminated with energy efficient LED bulbs. Ortiz said the town is contracting with an energy provider that buys power generated by wind turbines.

The bike lane down the town's main street will connect with a hiker-biker trail that runs along the Anacostia all the way into the National Arboretum in the District of Columbia. Anticipating the linkup will bring more sightseers to Edmonston, the mayor said the town intends to post signs along its revamped street explaining its green features, in hopes they may inform and inspire others.

It's not cheap — $1.1 million overhauls just 2/3 of a mile, from Kenilworth Avenue to Route 1. To do similar greening along the tens of thousands of miles of city and suburban streets in the bay watershed is a "multibillion-dollar effort," MDE's Summers said. Montgomery and Prince George's counties have imposed taxes to help pay for storm-water pollution controls, but other localities have balked.

Legislation recently introduced in Congress by Sen. Benjamin Cardin, Rep. Elijah Cummings and others would authorize up to $1.5 billion in federal money toward retrofitting pollution controls in bay communities, but Summers said state and local governments will also have to chip in.

For Edmonston's mayor, the cost of greening the town's main street is not much more than would have had to be spent upgrading and replacing aging infrastructure anyway. But the benefits are many and widespread.

"If every street and sidewalk in the watershed incorporated these very basic storm-water practices, we could have a thriving watermen's industry and crabbing industry," Ortiz said. "It'll increase the value of property and make this a more desirable place to live."
A main street goes green

The town of Edmonston is using stimulus money to transform its main street, Decatur, into a “green” street.

Wind-powered LED lighting.

Native trees will provide shade and reduce heat.

“Bump-outs” will make streets narrower, resulting in slower traffic speeds.

Rain gardens will reduce runoff from storms.

Bike lanes connect to Anacostia Trail. Porous pavers in lane let rainwater soak through to soil.


BALTIMORE SUN GRAPHIC
Greenseams Program Unites Unlikely Coastal Allies

An Innovative Partnership between the Milwaukee Metropolitan Sewerage District and The Conservation Fund Combats Flooding, Safeguards Water Quality, and Preserves Open Space.

October 3, 2006

Contact: Jena Thompson, 703.525.6300

Milwaukee, Wisconsin – In August 2006, the Greenseams Program, a joint initiative between The Conservation Fund (TCF) and the Milwaukee Metropolitan Sewerage District (MMSD) in Wisconsin, celebrated the conservation of nearly 925 acres in metro Milwaukee’s anticipated growth corridors, at a total cost of less than $8 million.

Greeted with skepticism when it began in 2001, Greenseams now enjoys enthusiastic support from a broad swath of Milwaukee’s civic leaders, utility customers, government officials, landowners, and conservationists.

The program reduces future flood risk and protects water quality through nonstructural flood mitigation—a mechanism in which properties with hydric soils near major waterways are purchased and left undeveloped to maximize their water-absorbing capacities. These lands, which preserve wildlife habitat, often become treasured community assets for residents who enjoy hiking, bird-watching, and other outdoor pursuits.

“It has taken patience and persistence to develop working relationships and trust among all the parties involved in this effort, but it has definitely been worth the effort,” says Peg Kohring, the director of the Fund’s Midwest office in Sawyer, Michigan.

By acquiring lands outright and through conservation easements, Greenseams permanently protects key properties in the Milwaukee, Menomonee, Oak Creek, and Root River watersheds, where major suburban growth is expected to occur.

All property sales are voluntary and all land remains as open space. Greenseams, part of the sewerage district’s flood management program, has also received generous grants and/or in-kind services from the Wisconsin Department of Natural Resources, Wisconsin Coastal Management Program, and U.S. Fish and Wildlife Service.

“We have seen great success with Greenseams,” says Michael Friis, manager of the Wisconsin Coastal Management Program (WCMP). The WCMP helped fund Greenseams’ outreach efforts to landowners and has also underwritten the acquisition of certain properties. “It fits in very well with several of our program areas, such as habitat protection, public access, and nonpoint source pollution control. It is an effective way to deal with water quality and quantity issues,” he adds.

Using the Land to Prevent Future Flooding

Like most large cities during the twentieth century, Milwaukee had managed flood risks and water quality mainly through structural mechanisms such as dams, channels, and reservoirs. But, by century’s end, rapid development had dramatically increased impervious surfaces, while undeveloped acreage that had once absorbed floodwaters was greatly diminished.

Flooding brings increased water quality problems, according to Steve Jacquart, intergovernmental coordinator for the sewerage district.
“The majority of pollution in our waterways comes from stormwater runoff, which is true of urban watersheds across the country. As outlying areas near Milwaukee are becoming developed, rainwater has nowhere to go.

“Greenseams is an important part of our regional flood-management efforts, because flooding and stormwater runoff do not respect municipal boundaries,” adds Jacquot.

**Broad vision, local networking**

Bringing together an environmentally oriented organization such as the Fund with a water management agency such as the sewerage district was an unusual undertaking.

“An initial challenge was that the people in these organizations just didn’t know one another very well. They hadn’t sat down together on a regular basis, and they had some misconceptions and skepticism” says Kohring.

It took time for Kohring to convince local conservation organizations that the sewerage district was truly interested in achieving similar goals. Some in the sewerage district also felt misgivings about working closely with the area’s environmentalists. Moreover, customers of the water utility needed assurance that the Greenseams program would benefit them without imposing unreasonable rate increases.

“My advice to organizations who want to develop similar partnerships is to be patient, keep the lines of communication open, and allow that trust to develop. ‘Forgive and forget’ is an important concept,” says Kohring.

Greenseams encouraged local participation, forging close ties with leaders and developing relationships with landowners in the districts’ 28 communities. Each property acquired is managed by a local community or land trust and subject to a conservation easement held by the sewerage district.

The wide geographic area of the program—it is spread out among four counties and 15,000 properties—and the rapid pace of suburban development sometimes creates daunting conditions for land acquisition.

Challenges notwithstanding, Kohring believes that the program is one that can be successfully applied to other metro areas. “We haven’t yet found another place in which to implement Greenseams,” notes Kohring, “but if we can save some another community with similar problems from reinventing the wheel, we’d love to do that.”
The Greenseams Program

More than a million people live and work in the Milwaukee metro area; many in flood prone neighborhoods. For the past seven years, we’ve helped the Milwaukee Metropolitan Sewerage District fight flooding by managing “Greenseams,” a program that has protected 1,914 acres of key lands containing water-absorbent (hydric) soils to date. In 2008, Greenseams protected 227 acres over four such properties with support from Hyatt Regency Chicago, Bielinski Homes and grants from the Wisconsin Department of Natural Resources’ Stewardship Fund.

Greenseams reaches over 2,000 acres!

In December 2009, Greenseams reached a major milestone: the program surpassed 2,000 acres! Why is this such a great achievement?

Summary

Milwaukee’s Metropolitan Sewerage District is working with the Fund to implement its Greenseams program, an innovative flood management program that uses land conservation as a tool to safeguard the community and its water supply.

Challenge

The Milwaukee Metropolitan Sewerage District sought a cost-effective approach to flood management for its service area, incorporating 28 communities and 1.1 million people in a 420 square-mile area.

Solution

The Milwaukee Metropolitan Sewerage District chose the Fund to implement its Greenseams program, an ambitious initiative to conserve water and prevent flooding through land protection. The Fund helps the MMSD acquire land along river corridors containing hydric soils that can rapidly absorb millions of gallons of water when left undeveloped.

Watch this video—featuring the Fund’s Peg Kohring—and learn how this innovative program is on “the cutting edge” of the green infrastructure movement

Source URL: http://www.conservationfund.org/project/greenseams_program
Green Infrastructure Community Profile
Washington, D.C.

Summary
The extraordinarily poor quality of the Anacostia River, increasing impervious area and resulting stormwater runoff has spurred Washington D.C. to take action. The District’s Combined Sewer Overflow (CSO) long-term control plan (LTCP) will incorporate Green Infrastructure, or Low Impact Development (LID), throughout the city into planned large capital projects. Of the $1.9 billion budget allocated for the LTCP, $3 million has been allocated for advocating and assisting with green infrastructure retrofits. A $2 million program supplemental to the LTCP will install raingardens, tree plantings and green roofs in collaboration with community groups. An additional $1 million will go to cost-sharing grants for Low Impact Development installations in CSO areas.

Washington’s ambitious “20-20-20” plan calls for installation of 20 million square feet (sf) of green roofs, approximately equal to 20% of the roof area of all city buildings over 10,000 sf, over the next 20 years. It will contribute significantly to CSO mitigation by capturing stormwater equal to 15% of planned deep tunnel capacity.

Ordinance/Legal Framework

- D.C. Law 13-311 Storm Water Permit Compliance Amendment Act established the Storm Water Administration within the DC Water and Sewer Authority (DCWASA) and provides for the collection of fees to fund work directly related to the city’s National Pollution Discharge Elimination System Municipal Separate Sewer System permit.
- In FY 2003 WASA completed negotiations for a consent decree to settle a lawsuit alleging that it violated federal CSO Policy. Under the consent decree, WASA has agreed to fund a U.S. EPA supplemental environmental project focusing on Green Infrastructure.
- Changes to building codes in 2004 allowed disconnected downspouts.
- In December 2005, the Mayor and the City Council created the new D.C. Department of Environment (DOE), and have designated DOE to be the Storm Water Administrator beginning in February 2007.

Program Details

20-20-20 Plan

The “Re-Greening Washington D.C.” (August 2005) report found that if 80% of all proposed and 20% of all existing buildings with footprints greater than 10,000 sf had green roofs, the resulting 21,700,000 square feet of green roofs would, among others, provide the following storm water benefits:

- 30 million gallon increase in the city’s storm water storage capacity, 15% of the LTCP deep tunnel’s planned storage of 194 million gallons
- 430 million gallons of rainwater stored over the course of an average year, equivalent to 1,700 Olympic-sized swimming pools
- 1.7% reduction in citywide runoff
- 15% reduction in the total number of CSO discharges per year

For more information, contact Steve Wise, Natural Resources Portfolio Manager
“Put a LID on It!”

The Watershed Protection of the District’s Bureau of Environmental Quality established grants to promote innovative Green Infrastructure projects and supported several demonstration raingardens and other features.

Other District projects include:

• **Washington Navy Yard LID project**
  Naval District Washington adopted a low impact development (LID) approach to stormwater retrofit and new facilities construction projects. The LID Center installed numerous pilot projects in 2001. About $500,000 was spent on retrofits that included downspout disconnection, rain gardens, tree box filters, and permeable pavement. Future plans call for LID retrofitting at five other naval facilities in the Chesapeake Bay watershed.

• **LID at DCWASA Facilities**
  WASA has committed $3 million to installation of pervious pavement, green roofs and other Green Infrastructure at its own facilities. The first phase of the LID program has been to install several LID projects at the DCWASA Bryant Street Pumping Station. Plans include a public education program and proposed changes in development and redevelopment regulations, such as building code provisions.

**Monitoring Results**

The Washington Navy Yard is monitoring the LID projects for resulting stormwater volume reductions, stormwater discharge frequency, and water quality improvements.

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**For More Info**

DC WASA  
[http://www.dcwasa.com/default.cfm](http://www.dcwasa.com/default.cfm)

DDOE  

LID Center  
[http://www.lowimpactdevelopment.org/navyyard.htm](http://www.lowimpactdevelopment.org/navyyard.htm)

Greenroofs  
WATER POLLUTION:
City's 'all green' stormwater plan raises eyebrows at EPA

Taryn Luntz, E&E reporter (Greenwire, 12/24/2009)

Philadelphia has a groundbreaking idea about what to do with stormwater: Use it to feed grass and trees instead of letting it rush into the sewers.

The concept may seem obvious. But for most cities, a stormwater management plan that doesn't expand sewers or treatment plants is counterintuitive.

Stormwater poses a costly and burgeoning problem in the United States, where 772 cities have sewer systems that collect wastewater and storm runoff in the same pipes. The systems are designed to overflow during heavy rains, sending raw sewage and other waste into streams and rivers so as not to overwhelm treatment plants.

In New York City, for example, which averages an overflow a week, a rainy day means 500 million gallons of filthy discharges pouring into waterways, according to nonprofit watchdog group Riverkeeper. That foul brew contaminates drinking water, forces beach closures and pollutes shellfish beds.

Most cities are working with U.S. EPA to curb overflows as part of a mandate to cleanse waters to federal standards.

But the traditional options are expensive. Philadelphia, for one, found it would need to build a $10 billion sewage tunnel under the Delaware River to solve its overflow problem the standard way -- with so-called "gray" infrastructure.

So the city is proposing an alternate solution: Invest $1.6 billion to turn a third of the city green in the next 20 years. The plan involves replacing streets, parking lots and sidewalks with water-absorbing porous pavement, street-edge gardens and trees.

"We want to do anything we can do to return us as close as possible to the way nature intended the water cycle to be," said Howard Neukrug, director of the Philadelphia Water Department's watersheds office. "But we need to do that within the context of a city that is fully grown, with incredible impervious cover everywhere."

Philadelphia is examining a number of options, Neukrug said, including digging up streets, planting trees and redesigning tree pits and curbs to trap water before it reaches sewer inlets. The city also may push for green roofs, rain barrels and other water-conserving measures for new and existing homes and buildings.

"We recognized that if we manage stormwater where it lands, whether on the ground or on a roof, that in very many circumstances we can not only prevent that gallon of water from
overflowing, but we may be able to find additional benefits for our customers," Neukrug said. "Things that impact the urban heat island effect, things that improve the aesthetic of a community."

The department contends the plan could give the city an economic boost, as well.

"The city officials see this as a way of revitalizing their community," said Nancy Stoner, co-director of the Natural Resources Defense Council's water program. "They see it as making it a more attractive place for people to live and work. Making it more healthful, creating green jobs, raising the property values, taking pollution out of the air."

A sewage tunnel would do none of those things, Neukrug said.

"Every dollar you can spend above ground that would give you an equivalent water quality result to below ground, it's probably better to spend that dollar above ground," he said.

**EPA's decision**

Cities ranging from New York to Kansas City, Mo., have said they are eager to explore green infrastructure, and a number of them already are using it to help them manage stormwater.

But experts said Philadelphia is the first city to propose an all-green stormwater solution to federal regulators.

"It's different from what any other city in the country is doing at his point," Stoner said. "It's the only stormwater plan I know of that basically is all green. It's really impressive for a place that's as densely populated and as paved over and urbanized as Philadelphia is."

The city's plan is now in the hands of EPA, which must decide whether to approve it.

While the agency officially encourages cities and states to use green infrastructure, EPA has never been asked whether it alone is an acceptable way to address combined-sewer overflows.

"The fact that they're proposing it to meet Clean Water Act regulatory requirements is fairly unique," said Jon Capacasa, director of water protection for EPA's Region 3 office in Philadelphia. "I think one of the key challenges will be putting the institutional measures in place to ensure the good vision here can be achieved."

Various city departments that oversee streets, sewers and development all must overhaul their regulations and coordinate their new policies to promote green measures if such a plan is to work, Capacasa said.

For example, developers who aim to control stormwater through green technologies may find themselves stymied by road and building codes that demand traditional materials and designs.
"There are a lot of barriers, because things have been done differently for years," Stoner said. "The structures just are not set up to facilitate this kind of integrated thinking."

Philadelphia also estimates its plan will fall slightly short of EPA requirements.

The city says it would capture 80 percent of its sewage and wastewater under the proposal. That's 5 percent less than EPA wants.

"The plan that's been submitted to us, in our initial review, doesn't get all the way to the endpoint," Capacasa said. "So there may be more work to do."

**More challenges ahead**

Neukrug said Philadelphia already is tackling the task of standardizing its building policies.

The city reworked its stormwater regulations in 2006 to require all new buildings to capture the first inch of rainwater and to grant expedited permit reviews to developers that use green infrastructure.

And the Water Department is creating design templates and standardized instructions for other utilities, departments and private developers to use, he said.

"The city of Philadelphia fully endorses this concept," Neukrug said. "Our sister agencies are working very closely with us to figure out how to implement this program."

But Neukrug acknowledges that addressing existing buildings will be a challenge.

"How do you encourage private landowners, who for the next 50 years do not plan to make any changes to their property, how do you get them to change?" he said. "That's where it's most costly."

While the department is still hashing out the details, Neukrug said it is firm in its commitment to the idea.

"We're not sure yet how we're going to be doing things five years from now, 10 years from now, other than we're pretty darn sure we're going to be moving forward with this green infrastructure concept," he said. "We can get there with green infrastructure. We just need time."

Source URL: http://www.eenews.net/public/Greenwire/print/2009/12/24/1
Overview

MetroGreen is a proposed 1,144-mile interconnected system of public and private open spaces, greenways, and trails designed to link seven counties in the Kansas City metropolitan area. The MetroGreen system plan covers Leavenworth, Johnson, and Wyandotte counties in Kansas and Cass, Clay, Jackson, and Platte counties in Missouri. MetroGreen builds on the area’s tradition of valuing green space by extending the “parkways and boulevards” concept of the 1894 Kessler Plan for Kansas City, Missouri. MetroGreen identifies 85 separate corridors that form a regional network of greenways connecting many of the area’s most valuable natural assets. By the end of 2008 MetroGreen had succeeded in creating 252 miles of greenway trails and protecting about 91,000 acres of stream corridors.

Highlights

- The MetroGreen Plan of 2001 linked a regional vision for recreational greenways (the MetroGreen Vision of 1991) with a regional Natural Resources Inventory (2004) and recommends implementing planning and engineering regulations in jurisdictions across the Kansas City metropolitan area.
- The Mid-America Regional Council (MARC), the metropolitan planning organization for the 125 city and nine county governments in the bi-state Kansas City region, has brought together parks, natural resource, and public works agencies in a unique commitment to couple green infrastructure with more traditional grey infrastructure needs such as stormwater management, water quality protection, and planning for roads, sewers and such. [Note: The MetroGreen Plan was originally developed for seven of the nine counties that MARC serves, but MARC anticipates its future expansion.]
- MARC and key regional partners are developing a strategy to make the Greater Kansas City metropolitan region a “green region.” Green infrastructure is one of the core indicators of success of this strategy.

“To effectively address green infrastructure issues, local communities must view themselves as part of a larger regional or watershed context. Water and air flow in and out of communities, as do traffic, people, and wildlife. Urban and nearby residents need to learn how their land-use decisions affect one another and how they might work together to achieve common goals.”

—Kansas City Region. “Green Infrastructure: Designing with Nature”
Background and Context

The confluence of the Kansas and Missouri Rivers has long served as a crossroads. Traditionally home to the Kaw Nation, the area played host to the westward expansion of the United States. The Lewis and Clark expedition camped near present-day Kansas City along their journey up the Missouri River and toward the Pacific Ocean. Fur trappers throughout the Midwest and the upper Rockies used the Missouri River as the gateway to shipping across the world. And Kansas City was the starting point for thousands of settlers migrating westward along the Santa Fe and California Trails.

The rivers and historic trails provided a framework for Kansas City’s first green space plan. In the early 1890s, George Kessler and August Meyer proposed an integrated network of protected greenways, parks, boulevards, and open space. The 1894 Kessler plan used the ridgelines and land along the waterways for boulevards to create a chain of natural parks along some of the most rugged terrain and bluffs near the river. Other parks featured more formal features, such as fountains, elegant bridges, sunken gardens, and walkways. The Plan actually guided the city’s growth by reorienting Kansas City away from the riverfront and the original downtown, creating beautiful new residential districts, and fostering redevelopment of older areas.

Kansas City has built on this green space tradition through the MetroGreen initiative. During their 1991 annual conference, members of the American Society of Landscape Architects (ASLA) sponsored a local service project. The ASLA Community Assistance Team, inspired by the Kessler Plan, established a Vision for MetroGreen that identified a regional greenway system for the Kansas City area. The proposed system consisted of a 90-mile urban loop surrounded by a 140-mile outer loop through suburban areas. The two loops were connected with multiple spokes that followed stream valleys and existing park lands and that linked to agricultural landscapes and such rural greenspaces as upland prairie, wooded slopes, and streams.

The 1991 Vision also called for the development of a MetroGreen Master Plan. The 2001 MetroGreen Regional Initiative provided that plan.

Expanding on that effort, the Mid-America Regional Council (MARC), the area’s metropolitan planning organization, and a consultant team of Greenways, Inc., Patti Banks Associates, ETC/Leisure Vision, and The Trust for Public Land, defined a 100-year implementation strategy: the MetroGreen Action Plan (December 2007). This Plan called for development of a 1,144-mile integrated network of greenways and open space throughout the metro region.

![Figure 1: MetroGreen Counties](image)
Goals and Objectives

The MetroGreen Plan outlines the following goals:

1. Preserve and protect stream corridors throughout the metropolitan area
2. Link people to outdoor resources close to where they live, work and play.
3. Link MetroGreen corridors to on-road bicycle and pedestrian facilities to create an interconnected alternative transportation network for non-motorized use.
4. Provide opportunities for the area’s residents to learn about the region’s natural landscapes and celebrate their heritage through interpretive programs and cultural facilities located within MetroGreen corridors.
5. Protect the native habitat of plants and animals throughout the Metro region.
6. Implement the vision of a metropolitan green space system first envisioned by George Kessler in 1893, and as articulated in 1991 by the American Society of Landscape Architects.

Process

The Prairie Gateways chapter of the American Society of Landscape Architects developed the initial Vision for the MetroGreen system through a community service project during the ASLA national conference in 1991. ASLA then brought the Vision home to the Mid-America Regional Council (MARC) as the lead coordinator for planning and promotion. The MetroGreen Vision has served as the guide for metropolitan greenway development. Local communities have developed local plans and constructed trail segments consistent with this regional vision.

In 2001, MARC led the creation of the MetroGreen Regional Greenway Initiative Plan (the “MetroGreen Plan”). On the heels of the MetroGreen Plan, MARC undertook the regional Natural Resources Inventory which provided the framework for implementing local planning and engineering regulations to protect stream buffers, manage stormwater, and restrict development along stream corridors. The MetroGreen Action Plan provided the specific goals to implement green infrastructure in the 16 priority corridors. Implementation of the Action Plan includes a mix of acquisition, education, outreach, incentives, voluntary initiatives, ordinances, funding, and other conservation and policy tools. As of December 2007, the region had successfully protected through public ownership about 9,700 acres of the priority regional greenways. Another 8,300 acres are protected “blueways” or open water corridors. Stream setback ordinances protect an additional 8,000 acres, ensuring these areas will remain undeveloped, allowing opportunities for connections and possible restoration. Overall, about 17,100 acres of the initial 42,800-acre conservation goal remain to be protected.

Kansas City has also intensified its green efforts and is now seeking to green the region. MetroGreen is a central element of the region’s broader sustainability efforts. Throughout 2008, Sustainable Measures, Inc. has been developing a framework to measure progress toward a “green region” vision, using system and performance indicators on economic (the region’s carbon footprint), social (the region’s “green” employment), and environmental (the regional green infrastructure).
The MetroGreen Action Plan designated priority corridors as the roadmap to catalyze the next generation of plan implementation. With 200 miles of the entire MetroGreen system's 1,100 corridor miles protected, MetroGreen needed to establish priorities for focusing energy and attention. The 16 priority corridors comprise about half the overall system. A broad coalition of the region's stakeholders—including local and regional staff, elected officials, and civic leaders—participated in identifying the regional greenway priorities. The priority greenway planning integrated GIS (geographic information system) analysis of existing natural resource information and development trends; extensive stakeholder consensus building; and targeted outreach efforts including regional prioritization workshops and review by conservation ecologists.

The data assessment led to preliminary identification of the most valuable and threatened conservation lands. Stakeholders then reviewed the preliminary conservation

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**Network Design**

**Table 1: Draft Green Infrastructure Indicators**

<table>
<thead>
<tr>
<th>Regional Indicators</th>
<th>Organizational Indicators</th>
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<td>Green Infrastructure:</td>
<td>MARC:</td>
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<tr>
<td>• Total amount of impervious surface</td>
<td>• Number of miles/ acres of Metro Green plan completed</td>
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<tr>
<td>• Total amount of open space permanently protected</td>
<td>• Number of municipalities and counties with adequate green infrastructure standards, regulations, and ordinances</td>
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<tr>
<td>• Number of days that air quality was unhealthy</td>
<td>• Percent of regional stream miles with x feet of riparian buffer</td>
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<tr>
<td>• Percent of region’s waterways meeting water quality standards</td>
<td>Municipalities</td>
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<td></td>
<td>• Percent of development projects permitted that include land conservation</td>
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<td></td>
<td>• Percent of land area that is green infrastructure land vs. developed land</td>
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<td>Developers</td>
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<tr>
<td></td>
<td>• Percent of project area that is preserved as green infrastructure</td>
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<td>State and Federal Agencies</td>
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<td>• Funding for green infrastructure projects</td>
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<td>Landowners:</td>
</tr>
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<td></td>
<td>• Percent of land that is developed vs. percent providing ecosystem services</td>
</tr>
</tbody>
</table>

*Source: Mid-America Regional Council and Sustainable Measures, Inc.*
Figure 2: Map of MetroGreen
opportunities at a special workshop. A preliminary field review augmented the initial analysis and stakeholder input. The Regional Conservation Priorities Map was drawn up and compared with the regional natural resources inventory mapping and stream asset mapping from Kansas City Stormwater Mapping Plan and Johnson County. Finally, the Regional Conservation Priorities Map was reviewed at a second regional workshop.

In 2004, MARC advanced the network design further through the preparation of a regional Natural Resources Inventory (NRI). This inventory is a geographic information system (GIS)-based effort to help the area plan for future development while considering natural systems. Financial support from foundations, U.S. Environmental Protection Agency, and the natural resource agencies of Missouri and Kansas enabled MARC’s leadership on the NRI. Under contract to MARC, Applied Ecological Services reconciled land cover data from two states, secured gap analysis data from the U.S. Fish and Wildlife Service, and spent countless hours of field survey work to identify and map the most valuable natural resource assets and ecological features in the Kansas City region.

The resulting NRI provides a critical tool for conservation planning among the region’s communities and spurred a growing acceptance of habitat protection and restoration. MARC used the NRI to help 14 jurisdictions adopt stream buffer ordinances as well as over a dozen jurisdictions adopt ecologically-informed stormwater planning and engineering guidelines for site development. Coupling the MetroGreen Regional Initiative and the NRI demonstrated the links between greenways and natural resources and built support for green infrastructure in the region.

Implementation

The MetroGreen Action Plan of December 2007 outlined specific implementation goals to conserve, connect, and restore 16 priority regional corridors over 10 to 20 years. According to the Plan, potential strategies include regulatory tools such as stream setback ordinances and parkland dedication; funding strategies like sales and property taxes; and other tools like conservation easements. The plan also targets state and federal funding opportunities and technical assistance programs and highlights the importance of nonprofit and private sector partners.

The MetroGreen Action Plan includes action plans specific to each county, as well as for Kansas City, Missouri and the Missouri River Corridor. Each county action plan incorporates technical analysis plus input from local staff and elected officials on local profiles, strategies, and funding opportunities. MARC coordinated a series of public meetings with each county which helped to build “corridor by corridor” support throughout the planning process.

In 2008, the Kansas City region began crafting performance and system indicators to measure progress for a “green region”. The indicators process included green infrastructure as one of the core measures of success. MARC is integrating the indicators into its strategic planning process, further institutionalizing green infrastructure in the region (see Table 1: Sample Indicators). MARC continues to promote the network and foster collaborative leadership within each corridor by, in the words of MARC’s environmental program director, “knitting together a patchwork of community leaders and institutions.”

Priority Corridors

The Metro Green Action Plan identifies 16 priority regional corridors to focus efforts on the most important regional asset. Thirteen of these corridors are along waterways while two provide important overland connections.

The corridors are:
- Missouri River
- Kansas River
- Katy Trail Connection
- Blue River
- Fishing River
- Grand River
- Little Blue River
- Platte River
- Cedar Creek
- Line Creek
- Second Creek
- Shoal Creek
- Stranger Creek
- North Brush Creek (Platte County)
- Wyandotte/Leavenworth County Line Connection
- I-435 Corridor
Table 2: MetroGreen Implementation Strategies

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*Source: Mid-America Regional Council, METROGREEN: Preserving the Possibilities, December 2007.*
Leadership Group

MARC looked at Chicago Wilderness as a model but adapted the Chicago framework to the Kansas City region. Since Kansas City had fewer organizations on the ground than Chicago, MARC helped local groups build their capacity for implementation and management.

By design, MARC provides regional leadership and coordination of the MetroGreen implementation but nurtures the support and energy of numerous local groups (see Stewardship/Management). MARC’s support formed the basis for the MetroGreen Alliance, designed to strengthen the area’s resolve for an integrated regional network, instead of a “bits and pieces” approach carried out by area cities and counties.

In 2007, the MetroGreen Alliance used the past tools and planning processes to update the vision for the next few hundred miles of the overall network. The effort, called “Preserving the Possibilities” by MARC, focused on promoting the vision to create collaborative “corridor by corridor” support that knit together the patchwork of people, organizations, links, and hubs into a rich quilt of green infrastructure, with natural resource protection as its foundation.

Currently MARC is preparing a communications plan, building the Alliance’s constituency, and conducting public outreach and education. Much of its work is shifting to 16 priority corridors in an effort to preserve the most significant resources first.

Financing

Since its inception the MetroGreen effort has relied on numerous funding sources. The original MetroGreen Vision was completed under the auspices of the Prairie Gateway chapter of the American Society of Landscape Architects and the Community Assistance Team associated with their 1991 national conference. At its completion, the Vision came under the auspices of MARC, which has served as its champion, maintaining an active role in fundraising and building capacity among local jurisdictions while forging partnerships with the public and private sectors.

For the 2001 MetroGreen planning process MARC secured substantial philanthropic support from the Hall Family Foundation and William T. Kemper Foundation. The U.S. Environmental Protection Agency provided $150,000 in support to MARC, working in collaboration with the University of Missouri’s Center for Agroforestry and the U.S. Department of Agriculture’s National Agroforestry Center, to develop the regional natural resource inventory. Additional support for the MetroGreen Action Plan came from the Grace Harris Philanthropic Fund of the Greater Kansas City Community Foundation. More recently, the 2008 FHWA Eco-Logical grant of $90,000 provided a boost to the programmatic planning; MARC also received $70,000 from a 2007 EPA Wetlands Grant and $135,000 in water quality protection planning funds from the Missouri Department of Natural Resources.

MARC provides the base funding for the regional coordination but depends on local support for implementation of the green infrastructure network. The initiative, however, lacks dedicated funding for regional implementation, relying instead on local commitments of support.

The region’s 125 municipalities and nine counties support the MetroGreen Vision, but, while several counties and municipalities have local funding sources, local financial commitments vary widely. Local property, parks, and stormwater taxes; bonds; and Congestion Mitigation and Air Quality (CMAQ) and Transportation Enhancement resources resulted in the first 200 miles of greenway creation. The initial focus was largely on the area’s recreational needs but throughout the process, environmental professionals and activists have promoted the need to link recreational and natural assets.

One example of this link is in the community of Lenexa, Kansas. Lenexa passed a 3/8 cent sales tax in 2000 that funded trail creation as part of a broader watershed protection effort. The city’s local plan, From Rain to...
Table 3: Metrogreen Regional Priority Corridor Summary

<table>
<thead>
<tr>
<th>Category</th>
<th>Cass</th>
<th>Clay</th>
<th>Jackson</th>
<th>Johnson</th>
<th>Kansas City</th>
<th>Platte</th>
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<td>7</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>376</td>
</tr>
<tr>
<td>Crop and Pasture Land for Restoration (acres)</td>
<td>975</td>
<td>730</td>
<td>275</td>
<td>1,380</td>
<td>780</td>
<td>1,840</td>
<td>675</td>
<td>7,000</td>
</tr>
</tbody>
</table>

Source: Mid-America Regional Council, MetROgReen: Preserving the Possibilities, December 2007

Estimated Cost (10-Year Implementation Period):
- Protection goal: $122 to $206 million
- Connection goal: $125 million
- Maintenance and restoration goal: $46 to $53 million
- Total: $300 to $380 million

Existing or planned funding sources: $80 to $100 million

Additional funding needed: $220 to $280 million

Future land acquisition: 1,700 to 2,000 acres

Future trail construction: 100 miles

Notes:
- Excludes Missouri River corridor
- Excludes Incorporated Kansas City
Recreation, aims to reduce flooding, protect water quality and natural habitat, and provide educational and recreational opportunities for the citizens of Lenexa.

According to Jacobs, green infrastructure helps make a strong argument for line item support in local capital improvement plans (CIPs). In 2000, Lenexa included stream restoration as a line item in its CIP which has generated more than $10 million to support neighborhood stream restoration, flood control, sediment control, park improvements, and greenway creation. Lenexa also instituted a stream setback ordinance and undertook the area’s first natural resources inventory (prior to the MetroGreen NRI).

Other local commitments include actions by Johnson County, Kansas and Platte County, Missouri. Johnson County has had, since 1991, a 1/10-cent sales tax and property tax increase dedicated for a 20-year, $192 million park expansion program. Johnson County is also trying to address flooding problems. The county directed proceeds from the sales tax to pay for stormwater projects in the county and its cities. In 2001, these proceeds provided $7 million for about 20 new projects. Since 2000, Platte County has had a ½-cent sales tax to fund parks, trails, and stormwater projects and, in 2001, completed a Northland Master Trail Plan with Clay County.

Results

The most tangible results of the MetroGreen Vision have been the protection of 200 corridor miles and approximately 91,000 riparian acres. MARC has developed the MetroGreen master plan, the natural resources inventory, and the action plan. MARC has also established a standing MetroGreen committee. Numerous local jurisdictions are engaged in implementing design guidelines, plans, stormwater management practices, stream buffer regulations, funding mechanisms, and conservation programs. According to Tom Jacobs of MARC, the biggest result may be that green infrastructure is “now an intrinsic part of the dialogue within the region.”

Jacobs points to the Federal Highway Administration’s Eco-Logical grants. MARC was one of 10 recipients in FHWA’s first competitive grant program promoting adoption of an ecosystem based approach to mitigate the impacts of transportation infrastructure projects. MARC received $90,000 to create a regional green infrastructure mitigation strategy and conduct outreach that meshes green infrastructure with transportation planning in a Linking Environmental and Transportation Planning Action Plan. The plan identifies specific mitigation opportunities such
as land acquisition, stream buffers, restoration, and right-of-way best management practices. Jacobs notes that MARC would have been unprepared to pursue this grant opportunity a few years ago but now MARC is leading the way as one of the select recipients.

The 1,144-mile system is huge, but Jacobs notes that the “incremental progress adds up.” In his words, MARC has helped instigate “pockets of energy, leadership, and capability” that support the local implementation, management, and stewardship of this network.

**Management/Stewardship**

The MetroGreen Action Plan outlined regional goals and implementation strategies at the local and regional levels. The plan recommended institutionalizing a MetroGreen Alliance for regional implementation followed by local implementation and action plans for each county, the Missouri River corridor, and Kansas City, Missouri. A regional land conservancy could help further knit together a regional commitment to management of the network.

For now, however, MARC provides the regional leadership and coordination for the MetroGreen Vision and Plan. MARC supports local efforts by, for example, facilitating meetings on alignment and other issues in the first-ring suburbs along the Turkey Creek corridor. Creation and ongoing protection of the network, however, lies with the web of municipal, county, and state governments, independent agencies, and nonprofit interest groups and organizations. By design, MARC’s approach cultivates locally based support and energy to drive projects. One example is the community foundation that established a fund to support trail development along the Little Blue River. Network management and stewardship relies on local commitment to implement and monitor conserved land as well as establish design guidelines, stormwater manuals, local plans, and other tools.

**Benefits**

MetroGreen is designed to provide multiple community, health, environmental, and economic benefits to the Kansas City region. Benefits range from cost-effective improvement of air and water quality; stream stabilization; reduction of flood risk; wildlife habitat protection; opportunities for biking, hiking, and walking; and the structure for more sustainable urban development patterns.

“Green infrastructure is now an intrinsic part of the dialogue within the region.”

—Tom Jacobs, Mid-America Regional Council

**Application of GI Principles**

1. **Protect green infrastructure before development.**

   The Kansas City region, like so many areas, has witnessed land development rates at a faster pace than population increases. Since 1982, the metro area population has jumped by 17 percent while developed land area increased by approximately 27 percent. Residents are increasingly concerned with the loss of green space and the impact on ecological function.

   Kansas City has a long tradition of valuing green space and MetroGreen seeks to extend the “parkways and boulevards” concept of the 1894 Kessler Plan. MetroGreen works to ensure upfront protection where possible but also restore high-value natural areas where needed. The region recognizes that to create an interconnected 1,144-mile network, it needs to work together. The Mid-America Regional Council has been working with numerous partners to identify and prioritize opportunities.

2. **Engage a diverse group of stakeholders.**

   MARC serves as regional coordinator of the green infrastructure initiative, in partnership with numerous other federal, state, and local agencies and organizations. MARC works closely with the local entities responsible for implementing the network, helping build their capacity and conducting outreach to strengthen local commitment and understanding the connection to the broader landscape and watershed. MARC also engages citizens through direct outreach and participation in the planning and implementation as well as through festivals, planning charrettes, school events, and the media.

3. **Linkage is key.**

   Connection is at the heart of the MetroGreen vision and action. The three goals outlined in the
action plan are, in sum: protect, restore, and connect. The MetroGreen network aims to protect and restore natural resource linkages as well as connect people to the natural, cultural, and historic heritage and to each other. The MetroGreen Action Plan identified 16 corridors for protection and set specific connection goals to extend existing trails, construct trails that connect regional natural areas, and restore natural resource linkages in the priority corridors.

4. **Work at different scales and across boundaries.**

The MetroGreen initiative covers the broader Kansas City region, touching 1.8 million people, 125 cities, nine counties, and two states. By design MetroGreen seeks regional coordination and local implementation, working at a variety of scales to achieve green infrastructure protection.

5. **Use sound science.**

The Natural Resources Inventory of 2004 provided the essential technical analysis of the region’s natural resources, layering water resources (lakes, rivers, streams, wetlands, 100-year floodplain, and lowland vegetation) with upland resources (including forests, woodlands, grasslands, and steep slopes), important natural resource sites, and the parks and existing and planned MetroGreen trails.

The result fleshed out the regional conservation plan and demonstrated the worth of the green infrastructure protection efforts. The NRI also called for linking the natural resources data with recreational possibilities to set regional policy, support municipal and county conservation planning, and connect related plans for recreation, economic development, stormwater management, and community quality of life.

6. **Fund up-front as a public investment.**

MARC has located a variety of funding streams supporting research, planning, protection, restoration, and implementation. However, most funding depends on the local commitment to dedicate resources and attention to the green infrastructure. This commitment varies greatly across the region, with a few outstanding jurisdictions providing tremendous support while others provide little or no support.

7. **Green infrastructure benefits all.**

MetroGreen is designed to connect Kansas City-area residents to nature—and to protect and restore natural resources for the benefit of people and the ecological systems. MetroGreen is inspired by the need to connect children to nature and create a higher quality of life. But MetroGreen is also meant to reduce flood risks, stabilize streams, protect wildlife habitat, improve air and water quality, provide opportunities for hiking, biking, and walking, and offer a framework for more sustainable urban development patterns.

8. **Make green infrastructure the framework for conservation and development.**

The implementation of the green infrastructure network is intended to help direct development and provide a higher quality of life in the Kansas City metropolitan area. The NRI served as the framework for conservation planning and restoration by indicating locations for commercial, residential, and industrial development, examining transportation corridors, and assessing how conservation interests can enhance the community’s development potential. MetroGreen recognizes that natural resource protection is essential to the region’s quality of life. The region’s existing woodlands, grasslands, and vegetation provide the most cost-effective stormwater management, leading to cleaner water and healthier stream corridors. MetroGreen seeks to protect these resources.
**Evaluation**

Unique or outstanding elements

- The MetroGreen plan has attracted support across the metro area, resulting in a regional vision and broader public understanding of the need for natural resource protection. MetroGreen has succeeded in creating more than 250 miles of greenways and protecting over 90,000 acres of stream corridors. The green infrastructure is now an “intrinsic part of the dialogue in the region” according to Tom Jacobs of MARC.

This commitment has led to the region’s successful award of one of the first Federal Highway Administration Eco-Logical grants to revise its long-term transportation plan to include a host of mitigation strategies. A few years ago, such a proposal would never have occurred.

- MARC provides strong regional leadership and works with local governments for implementation and stewardship of the network.

- MARC and the key regional partners are at the forefront of connecting green infrastructure to a broader “green region” vision and the system and performance indicators for measuring success.

**Challenges**

- The network protection, management, and stewardship are carried out at the local level. Also, funding for the network’s implementation is a local responsibility; political support varies greatly across the area.

  MARC works to build local commitment but ultimately, the creation of strong design guidelines, stormwater regulations, and plans require steadfast and ongoing support from communities and elected officials. Pockets of energy, leadership, and capability mean incremental, but not insignificant, progress toward realizing the overarching green infrastructure goal.

- MARC provides staff for MetroGreen and base funding for regional coordination but program staff is sometimes shared with other priority projects.

  Implementation of a green infrastructure network requires coordination between multiple stakeholders. Yet, variable, and occasionally competing, interests among community and professional stakeholder groups at times interfere with the implementation of a fully collaborative regional agenda.

**References and Sources**


Interview of Tom Jacobs, Mid-America Regional Council, August 11, 2008.


Review by Jennifer Blattman, Metro Green Planner, Mid-America Regional Council, January 2009.
About the Author

Kendra J. Briechle is the Senior Training Associate with The Conservation Fund’s Conservation Leadership Network. Since 2003, Ms. Briechle has coordinated, facilitated, and presented at numerous workshops, conferences, and meetings to advance strategic conservation, sustainable economic development and smart growth. She also authored the first nationwide study on Conservation Based Affordable Housing: Improving the Nature of Affordable Housing to Protect Place and People (June 2006).

About Green Infrastructure

Green infrastructure is a strategic approach to land and water conservation that links lands for the benefit of nature and people, helps identify conservation priorities, and provides a planning framework for conservation and development. Green infrastructure is different from conventional approaches to conservation because it looks at conservation values and actions in concert with land development and growth management. Green infrastructure projects bring public and private partners together to work collaboratively toward a common land conservation goal. They help move beyond jurisdictional and political boundaries by providing a process for identifying, protecting, and restoring interconnected green space networks that conserve natural ecosystem functions and provide associated benefits to human populations. The green infrastructure approach appeals to people concerned about biodiversity, habitat, and land conservation as well as people interested in open space and land use planning at the community, region, or statewide scale. It also appeals to smart growth advocates because of its potential to lessen impacts and reduce the costs of built infrastructure.

Green Infrastructure Case Study Series

This series of case studies highlights successful and innovative green infrastructure projects from around the country. The series was undertaken so that readers can learn from and improve upon approaches tried by others. We hope that thorough, well-documented examples will allow readers to see the many possibilities and to adapt successful practices to their unique situations and challenges. Each case study addresses the same basic pieces of the story: overview, highlights, background and context, process, public education and participation, results and products, management and stewardship, financing, application of green infrastructure principles, and evaluation. Eight principles of green infrastructure, which are elements of most successful efforts, form the core of the case studies. The series illustrates concrete, real-life examples of how to assess and protect green infrastructure, including details about how each step was implemented.

About The Conservation Fund

The Conservation Fund is a national, nonprofit land conservation organization that forges partnerships to protect America’s legacy of land and water resources. Through land acquisition, community planning, and leadership training, the Fund and its partners demonstrate sustainable conservation solutions emphasizing the integration of economic and environmental goals. Since 1985, the Fund has protected more than 6 million acres of open space, working farms and forests, wildlife habitat, and historic sites across America.

The Conservation Fund’s Green Infrastructure Program was created in 1999 to build the capacity of land conservation professionals and their partners to undertake strategic conservation activities that are proactive, systematic, well integrated, and applied at multiple scales. The program is a cooperative effort of the Fund and multiple public and private partners. Program products include a national course, workshops and conference sessions, publications, case studies, demonstration projects, a website, and related educational materials.

The Conservation Fund would like to thank the Surdna Foundation and the USDA Forest Service for providing support for this and other Green Infrastructure Program products.
Chicago’s Water Agenda
A Guide to
Stormwater Best Management Practices
INTRODUCTION

Chicago's world-class status is owed largely to its position at the confluence of the Chicago River and Lake Michigan. Beyond the Lake Michigan shoreline, our water resources extend beyond, and beneath, the City. They are the Chicago 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.

When does stormwater become a problem rather than a resource? First, we need to understand how stormwater moves through the City. 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.

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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 include:

- 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 approaches, incorporating Best Management Practices can effectively move water from parking areas and other areas.

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 that incorporate Best Management Practices. Developments incorporating best management practices can significantly reduce development costs. These innovative techniques can reduce both construction costs and long-term maintenance costs. Natural drainage practices, in combination with design approaches that incorporate Best Management Practices,

- can effectively move water from parking and other areas.
- can improve construction efficiency and maintain acceptable standards of public health, safety, and welfare.

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.

To consider site features, size, location, and use: public education, improved design guidance, and best management practices. Developers can realize savings on non-conventional stormwater designs. These types of concerns generally can be addressed through better information, improved design guidance, and public education. The costs of conventional project designs are higher, and these types of concerns generally can be addressed through better information, improved design guidance, and public education. The costs of conventional project designs are higher, and these types of concerns generally can be addressed through better information, improved design guidance, and public education.
Stormwater runoff causes two key impacts: (1) excess water volume, or quantity, and (2) degraded water quality.

Excess water volume 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, reduce water quality, and increase the frequency and severity of basement and street flooding.

Degraded water quality is a particular concern for developments that drain directly to the water body (causing unwanted algae growth in rivers and lakes), and other nutrients in the water body (causing unwanted algae growth in lakes). Urban stormwater is contaminated with a number of pollutants including sediment, heavy metals, petroleum-based hydrocarbons, nutrients, pathogens, and other pollutants. Combined sewer overflows, when there is too much stormwater entering Chicago's combined wastewater and stormwater sewers, the sewers overflow, and untreated stormwater and wastewater is released into the Chicago River. Combined sewer overflows increase the frequency and severity of basement and street flooding.

Stormwater runoff quality is a particular concern for developments that drain directly to the water body. Combined sewer overflows also contribute various pollutants to the Chicago River that allow flow of contaminated waters to take Milwaukee. 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 the Chicago River, which are released into the Chicago River. Combined sewer overflows, when there is too much stormwater entering Chicago's combined wastewater and stormwater sewers, the sewers overflow, and untreated stormwater and wastewater is released into the Chicago River. Combined sewer overflows increase the frequency and severity of basement and street flooding.

Increased flooding: Flood flow rates can increase by 200 to 300 percent or more without effective stormwater controls. In Chicago, excess stormwater increases the frequency and severity of basement and street flooding.

Much can be done to address these issues and utilize stormwater as the resource that it is.
This guide presents several practical site design and drainage Best Management Practices for developments in the City of Chicago. Most of these 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
- examples of integrated or stormwater treatment train, examples of integrated or stormwater treatment train.

This design philosophy is known around the country combined in sequence to maximize their benefits. It is recommended that Best Management Practices be combined in sequence to maximize their benefits. 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.

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.

Integrating Best Management Practices into new developments improves the quality and appearance of stormwater runoff. The city’s waterways and open spaces. The guide provides the following information for each of the recommended best management practice approaches.

This guide presents several practical site design and drainage Best Management Practices for developments in the City of Chicago.
"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 filtered to be cleaner.

Key considerations for implementing green roofs include the structural and load-bearing capacity of the roof, the type of roof, the amount of rainfall retained or detained, and the selection of plant species. 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 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 60 percent; nitrogen levels are also diminished.

Areas and attractive views for other buildings, including increased habitat opportunities, can 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, 8 to 14 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, 60 to 150 pounds per square foot, and require more water, more root space, and deeper maintenance, making them " أفضل types of green roofs.

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.

Green roofs are appropriate in most 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 roof membrane and drainage flow paths, some watering may be required during the first few years when roof 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 system, the more maintenance is needed to be maintained-like a typical garden.

Cost Considerations

In the United States, green roof costs—including everything from waterproofing to plants—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 lower 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-intensive green roof was installed on Chicago’s City Hall (right). The rooftop garden was the first of its kind in Chicago and opened a new frontier in cutting-edge green technology. The Chicago Center for Green Container Collections, the Chicago Center for Green Technology, has established a rooftop garden, especially for educational and research purposes. The Garfield Park Conservatory is conducting a study demonstrating the benefits of using green roofs to reduce the heat island effect.
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. Effective downspout disconnection requires that there be adequate landscaping or vegetative overflow to accept the water. Rain barrels are appropriate where vegetation is limited, provided that the collected water can overflow to open green space areas.

There are several options for doing this:

1. Runoff can be sheeted across the lawn (see "filter strip" discussion).
2. Runoff can be routed via a surface swale into a rain garden or onsite detention or retention facility (see separate discussions of these approaches).
3. Runoff can be routed to a storm sewer or store runoff from downspouts at the four corners of the house.
4. Runoff can be temporarily stored in rain barrels or cisterns.

Rain barrels can effectively capture and store the runoff from downspouts. Rain barrels can be temporarily stored in rain barrels (see discussions of these approaches). The resulting 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 the resulting storage is a function of their storage volume in comparison to the size of the roof. In a simple 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 applicability of rain barrels (or cisterns) is a function of their storage volume in comparison to the size of the roof.

Applicability are most effective when used during the growing season. 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. 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 example, a 1,200 square foot roof could utilize 55-gallon barrels to store runoff from downspouts at the four corners of the house.

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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

Some of Chicago’s Green Bungalows utilize rain barrels in yard and garden areas (below). Much of the rain that falls on Chicago Center for Green Technology’s rooftop flows into four 3,000-gallon cisterns and is later used to water the landscapes (right).
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. These modular systems contain openings that are filled with sand and/or soil. Some contain permeable grids that allow water to pass through, while others are solid concrete. Permeable paving refers to paving materials that allow water to pass through, reducing the quantity of surface runoff and increasing the amount of water that seeps into the soil. Permeable paving can be effective in reducing the "urban heat island" effect, which is the phenomenon where paved areas absorb and retain heat more efficiently than natural vegetation, leading to higher temperatures in urban areas compared to surrounding natural areas. Permeable paving is particularly effective in areas with sandy, permeable soils, such as those near Lake Michigan. Permeable paving systems can be designed to maximize the permeability of the materials used, allowing water to penetrate deeper into the soil. This can be achieved by selecting materials that are porous and have a high water infiltration rate. Additionally, permeable paving can be used to reduce the impact of small to moderate-sized storms, as well as to reduce the amount of pollutants associated with runoff. Permeable paving can also be used to reduce the "urban heat island" effect by allowing water to seep into the soil, which can help to cool the surrounding area.
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

Gads Hill Center at 199 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.

Vegetated paving blocks may require occasional mowing. Snow plowing may require special care due to the slightly uneven surface of the pavement.
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. 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 associated with urban runoff could be as high as 70 percent. Natural landscaping also provides a host of other benefits. Deep-rooted native plants effectively stabilize soils and prevent erosion along streambanks and river edges. Natural drainage and native landscaping filter strips.

Applicability

Natural landscaping is feasible on nearly all sites as an alternative to conventional landscaping. It should be tailored to individual site characteristics, taking into account such factors as site topography, drainage patterns, and sun exposure. In some cases, native landscaping can be installed as part of projects in places of high development density, and it can be extended to isolated sites as a component of environmental improvements. Natural landscaping may be part of a comprehensive approach to water management, sustainability, and stormwater quality. It is a low-cost alternative to traditional landscaping that utilizes turf grass and ornamental plantings.

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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 landscapes. 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-third 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 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.

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 on developments where there are significant expanses of pervious areas (green spaces). Filter strips are probably most appropriate on developments 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 such as roadways and parking lots.

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Maintenance Considerations

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

Cost Considerations

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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 runoff to route over a filter strip in a back, side, or front yard. Roof runoff may also be conveyed to a filter strip to prevent soil erosion and bypass the use of a wider-mounded gutter or small culvert into a storm sewer. 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.

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) may be necessary to evenly spread runoff water. Eliminating the need for a local storm sewer may offset the cost of this device.
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.

Rain gardens are aesthetically pleasing. The plants provide food and shelter for many birds, butterflies, and beneficial insects, such as spiders and pollinators. Wildflowers, which are most effective, can include a combination of shrubs, grasses and flowering perennials. Suggested plants include: Black-eyed Susan, Butterfly Weed, Golden Alexander, Obedient Plant, Purple Conflower, Spiderwort, and Wild Geranium. The resource section at the end of this guide provides 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
- 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 single family homes, while larger rain gardens can be designed into commercial or large industrial and institutional areas. There is little or no concern about mosquito vector control when using rain gardens, although they should not be a source of standing water, which is required for mosquito development. Rain gardens can be incorporated into front and back yards of single family homes, while larger rain gardens can be designed into commercial or large institutional areas. There is little or no concern about mosquito vector control when using rain gardens, although they should not be a source of standing water, which is required for mosquito development. "City of Chicago: The photo depicts a rain garden using native plants."

**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.

**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 other stormwater conveyance devices before being discharged into the rain garden. The maintenance of the rain garden itself is similar to that of a typical garden, with periodic inspection and management of the vegetation. The cost of maintaining a rain garden includes periodic inspection and management of the vegetation.

**Cost Considerations**

Bioinfiltration costs can range between $20 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 structures. For plants, control structures, curbing, storm drains, and underdrains, bioinfiltration incorporates pretreatment 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 of a typical garden, with periodic inspection and management of the vegetation.

**Bioinfiltration: Rain Gardens**

A rain garden is not a pond. It should not provide a breeding ground for mosquitoes, which need at least four days of standing water to develop as larvae. Rain gardens generally should be designed to drain within six hours (water may pond for longer times during winter and early spring). A rain garden is not a pond. It should not provide a breeding ground for mosquitoes, which need at least four days of standing water to develop as larvae. Rain gardens generally should be designed to drain within six hours (water may pond for longer times during winter and early spring).
A drainageway is a broad, vegetated channel used for the movement and temporary storage of runoff. Swales can be effective alternatives to enclosed storm sewers and lined channels, since their only function is to rapidly move runoff away from the site. Drainage swales are different from filter strips in that swales are primarily used for conveying water.
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 cuffs will need occasional repair.

Cost Considerations

Roadside swales in residential settings achieve substantial documented cost savings over conventional curb and gutter and storm sewers. Although periodic cleaning may be required, swales should never need to be replaced, in contrast to storm sewers. Studies done in Portland, Oregon, showed savings ranging from $4,000 to $5,000 per acre of developed area. A related consideration is replacement of drainage swales in the Portland area. The Portland area has a great potential in Chicago and also has documented cost savings over conventional storm sewers. In several cases settings had a substantial decrease in water pollution and also documented cost savings. In commercial, industrial, and parking lots, roadside swales in residential settings achieve substantial documented cost savings over conventional curb and gutter and 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 include the Ford/Centerpoint Supplier Park and incorporation of drainage swales in their site designs. In several case studies done in Portland, Oregon, savings were reported from $4,000 to $5,000 per acre of developed area. A related consideration is replacement of drainage swales in the Portland area. The Portland area has a great potential in Chicago and also has documented cost savings over conventional storm sewers. In several cases settings had a substantial decrease in water pollution and also documented cost savings. In commercial, industrial, and parking lots, roadside swales in residential settings achieve substantial documented cost savings over conventional curb and gutter and storm sewers.

A related consideration is replacement costs. Although periodic cleaning may be required, swales should never need to be replaced, in contrast to storm sewers. 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.

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 cuffs will need occasional repair.
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 removal and creation of wildlife habitat (where appropriate). Natural detention basin designs emulate natural lake or wetland systems by incorporating natural drainage systems. 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 removal and creation of wildlife habitat (where appropriate). Natural detention basin designs emulate natural lake or wetland systems by incorporating natural drainage systems.

Naturalized detention also can provide desirable habitat for birds and aquatic organisms and at the same time discourage nuisance shorelines and/or concrete channels, thereby enhancing property values. Improving water clarity, further experience shoreline erosion, further treatment of shoreline erosion. The greatest benefit of naturalized designs is the reduction of runoff desirous is the reduction of runoff. However, unless underlying soils are well-permeable, detention will not prevent most increases in flooding associated with new development. Effective detention designs will dramatically reduce runoff rates and prevent most increases in flooding associated with new development.
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 gardens or bioinfiltration designs may be more applicable. 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 gardens or bioinfiltration designs may be more applicable.

Maintenance Considerations

Conventional basins require regular mowing of side slopes and/or basin bottoms. In contrast, naturalized detention basins require regular mowing of side slopes and/or basin bottoms. 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 is the CET1 power plant located at 117th & Torrence Avenue, The Chicago Center for Green Technology on Sacramento Avenue. The Chicago Center for Green Technology on Sacramento Avenue. The Chicago Center for Green Technology on Sacramento Avenue.
### BMP Typical Initial Cost

<table>
<thead>
<tr>
<th>BMP</th>
<th>Percentage Initial Cost Reduction in Water Volume or Pollutants</th>
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<tr>
<td><strong>Extensive/Intensive</strong></td>
<td><strong>Typical Initial Cost</strong></td>
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<tr>
<td><strong>Green Roof</strong></td>
<td>Removes runoff and pollutants from small storms.</td>
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<td><strong>Rain Barrel</strong></td>
<td>Captures and stores runoff from small to moderate storms.</td>
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<tr>
<td><strong>Permeable Paving</strong></td>
<td>Captures and stores runoff from small to moderate storms.</td>
</tr>
<tr>
<td><strong>Filter Strip</strong></td>
<td>Removes suspended solids and runoffs from small to moderate storms.</td>
</tr>
<tr>
<td><strong>Rain Garden</strong></td>
<td>Captures and stores runoff from small to moderate storms.</td>
</tr>
<tr>
<td><strong>Bioinfiltration</strong></td>
<td>Best option for reducing surface runoff as well as remooling pollutants.</td>
</tr>
<tr>
<td><strong>Detention Basin</strong></td>
<td>Best option for reducing surface runoff as well as remooling pollutants.</td>
</tr>
<tr>
<td><strong>Drainage Swale</strong></td>
<td>Best at removing nutrient in small storms.</td>
</tr>
<tr>
<td><strong>Bioretention</strong></td>
<td>Similar to conventional costs</td>
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<tr>
<td><strong>Retention Basin</strong></td>
<td>Similar to conventional costs</td>
</tr>
<tr>
<td><strong>Natural Landscaping</strong></td>
<td>Reduces residential runoff by 65%</td>
</tr>
<tr>
<td><strong>Biofilter</strong></td>
<td>Reduces stormwater runoff.</td>
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</tbody>
</table>

* 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.
SUMMARY AND APPLICATIONS

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www.cityofchicago.org/PlanAndDevelop

City of Portland

Maryland Department of the Environment.
www.mde.state.md.us/environment/wma/stormwatermanual

Metropolitan Council Environmental Services.
www.metrocouncil.org/environment/Watershed/bmp/manual.htm

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www.il.nrcs.usda.gov/engineer/urban/index.html


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Contact (847) 468-0071 [in north Cook County] or (815) 462-3106 [in south Cook County] for the Soil and Water Conservation District.

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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

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Mayors Innovation Project
Climate Prosperity

Presented in Washington, DC
January 22-23, 2010

Louisville, Kentucky
- Possibility City
- City of Parks - adding 4,000 of new parks
- Louisville Loop - 100 mile loop around the community
- Waterfront Park along the Ohio River
www.louisvilleky.gov

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Local Green Drivers
- Improved Water Quality
- Improved Air Quality
- Public Desire
- Improved Quality of Life
- Economy

Green Strategic Initiative Vision
- Take stock of projects underway in city government and the Partnership for a Green City - and develop environmental baseline (or carbon footprint)
- Analyze cost-benefit of options to reduce environmental impact and energy consumption
- Focus on financially sustainable measures that improve air and water quality, land use and energy efficiency
- Establish Louisville Metro as a model employer - from energy-efficient buildings to encouraging transit use - to promote "green" actions from other employers
- Energize projects underway that focus on environmentally responsible land-use - including reclamation of brownfields; Community of Trees; conservation subdivisions; incentives for development near public transit.

Green Initiatives
- Develop a Climate Change Strategy for Metro Community
- Develop an Energy Efficiency Strategy for Metro Government
- Implement an Environmental Education Program for Metro Government employees
- Promote Alternate Transportation Opportunities
- Improve Metro’s “Green” performance and profile
- Improve Metro’s Fleet Energy Usage and Fuel Consumption
- Develop and Expand Metro’s Green Infrastructure
- Expand Internal and Community Recycling Programs
Green Partners

- Partnership Groups
  - Partnership for a Green City
  - Community of Trees
- Public and Private Partners
  - Louisville Metro Government and all Departments
  - Louisville and Jefferson County Metropolitan Sewer District
  - Jefferson County Public Schools
  - University of Louisville
  - 21st Century Parks
  - Olmsted Parks
  - General Electric
  - Ford Motor Company
  - and numerous other commercial and industrial entities

Louisville and Jefferson County Metropolitan Sewer District

- Primary Services
  - Wastewater Collection and Treatment
  - Stormwater / Drainage
  - Ohio River Flood Protection
- 225,000 customer accounts (population of 700,000)
- 780 miles of streams and rivers
- 3,200 miles of sewer
- 600 employees

Green Infrastructure

- Under Wet Weather Consent Decree to abate sewer overflows
  - Technical Approval of Gray / Green Plan
  - Total Cost approximately $850M
  - Utilizes Green to offset Gray
  - Green Projects = $47M, $40 M in first six years
  - Ability to move more gray to green if beneficial
- Negotiating Updated Water Quality Permit for the Community
  - Anticipate additional controls and requirements

Green Infrastructure

- Green Roads
- Green Alleys
- Green Parking Lots
- Bioinfiltration
- Green Roofs
- Rain Gardens
- Rain Barrels
- Downspout Disconnection
- Urban Reforestation

Challenges

- Communication
- Cooperation
- Maximizing all potential benefits from each initiative
- Developing an incentive program to expand private participation
- Inventory and Reporting
- Maintenance

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