Rooftops to Rivers II:

Green strategies for controlling stormwater and combined sewer overflows

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EXECUTIVE SUMMARY

An estimated 10 trillion gallons a year of untreated stormwater runs off roofs, roads, parking lots, and other paved surfaces, often through the sewage systems, into rivers and waterways that serve as drinking water supplies and flow to our beaches, increasing health risks, degrading ecosystems, and damaging tourist economies. But cities of all sizes are saving money by employing green infrastructure as part of their solutions to stormwater pollution and sewage overflow problems.

Green infrastructure helps stop runoff pollution by capturing rainwater and either storing it for use or letting it filter back into the ground, replenishing vegetation and groundwater supplies. Examples of green infrastructure include green roofs, street trees, increased green space, rain barrels, rain gardens, and permeable pavement. These solutions have the added benefits of beautifying neighborhoods, cooling and cleansing the air, reducing asthma and heat-related illnesses, lowering heating and cooling energy costs, boosting economies, and supporting American jobs.

NRDC's *Rooftops to Rivers II* provides case studies for 14 geographically diverse cities that are all leaders in employing green infrastructure solutions to address stormwater challenges—simultaneously finding beneficial uses for stormwater, reducing pollution, saving money, and beautifying cityscapes. These cities have recognized that stormwater, once viewed as a costly nuisance, can be transformed into a community resource. These cities have determined that green infrastructure is a more cost-effective approach than investing in "gray," or conventional, infrastructure, such as underground storage systems and pipes. At the same time, each dollar of investment in green infrastructure delivers other benefits that conventional infrastructure cannot, including more flood resilience and, where needed, augmented local water supply.

NRDC identifies six key actions that cities should take to maximize green infrastructure investment and to become "Emerald Cities":

- Develop a long-term green infrastructure plan to lay out the city's vision, as well as prioritize infrastructure investment.
- Develop and enforce a strong retention standard for stormwater to minimize the impact from development and protect water resources.
- Require the use of green infrastructure to reduce, or otherwise manage runoff from, some portion of impervious surfaces as a complement to comprehensive planning.
- Provide incentives for residential and commercial property owners to install green infrastructure, spurring private owners to take action.
- Provide guidance or other affirmative assistance to accomplish green infrastructure through demonstration projects, workshops and "how-to" materials and guides.
- Ensure a long-term, dedicated funding source is available to support green infrastructure investment.

Although cities and policy makers have taken enormous strides forward in their understanding and use of green infrastructure since the first *Rooftops to Rivers* report was published in 2006, much work remains at the local, state and federal levels. Local officials need better information about the benefits of green infrastructure and how to target investments to maximize benefits. States should undertake comprehensive green infrastructure planning, ensure permitting programs drive the use of green infrastructure, and eliminate hurdles (whether from building and development codes or funding) to ensure green infrastructure is adequately funded.

Most importantly, the U.S. Environmental Protection Agency (EPA) must reform the national Clean Water Act rules that apply to stormwater sources to require retention of a sufficient amount of stormwater through infiltration, evapotranspiration, and rainwater harvesting to ensure water quality protection. The rules should apply throughout urban and urbanizing areas. The EPA should also require retrofits in already developed areas and as part of infrastructure reconstruction projects. In so doing, the EPA will embody the lessons learned from cities across this country and the leaders who understand that, from an environmental, public health, and economic perspective, green infrastructure is the best approach to cleaning up our waters.

Table ES-1: "Emerald Cities," listed darkest to lightest by the number of key green infrastructure actions taken

City	Long-term green infrastructure (GI) plan	Retention standard	Requirement to use GI to reduce some portion of the existing impervious surfaces	Incentives for private-party actions	Guidance or other affirmative assistance to accomplish GI within city	Dedicated funding source for GI
Philadelphia, PA	★	★	★	★	★	★
Milwaukee, WI		★	★	★	★	★
New York, NY	★		★	★	★	★
Portland, OR		★	★	★	★	★
Syracuse, NY	★		★	★	★	★
Washington, D.C.		★	★	★	★	★
Aurora, IL	★	★			★	★
Toronto, Ontario, Canada	★	★		★	★	
Chicago, IL		★		★	★	
Kansas City, MO				★	★	★
Nashville, TN	★				★	★
Seattle, WA				★	★	★
Pittsburgh, PA		★				
Rouge River Watershed, MI					★	

CHAPTER 1: THE GROWING PROBLEM OF STORMWATER RUNOFF

According to the National Research Council, "Stormwater runoff from the built environment remains one of the great challenges of modern water pollution control, as this source of contamination is a principal contributor to water quality impairment of water bodies nationwide."[1] The challenges to handle stormwater are varied: shifting development patterns, a corresponding loss of pervious surfaces, deficiencies in stormwater infrastructure and regulatory structures, and impacts from both climate change and increasing population trends. This chapter explores those issues, and the next chapter describes solutions that more and more municipalities are turning to as a way of meeting these challenges: green infrastructure.

DEVELOPMENT AND LOSS OF PERVIOUS SURFACES

Development as we have come to know it in the United States—large metropolitan centers, often situated next to waterways, surrounded by sprawling suburban regions—contributes greatly to the pollution of the nation's waters. As previously undeveloped land is paved over and built upon, the amount of stormwater running off roofs, streets, and other impervious surfaces into nearby waterways increases. The increased volume of stormwater runoff and the pollutants carried within it degrade the quality of local and regional water bodies. As development continues, the watershed's ability to maintain a natural water balance is lost to a changing landscape and new impervious surfaces. This problem is compounded by impacts of climate change on our stormwater systems.

Developed land use increased 56 percent from 1982 to 2007; this increase represents one-third of all developed land in the continental United States.[2] If this trend continues, there will be 68 million more acres of developed land by 2025.[3] And this is a strong possibility: urban land area quadrupled from 1945 to 2002, increasing at about twice the rate of population growth.[4]

The combination of developed land and the increased amount of impervious surfaces (roads, driveways, rooftops, etc.) that accompany it presents a primary challenge to stormwater mitigation. Existing stormwater and wastewater infrastructure is unable to manage stormwater to adequately protect and improve water quality, as it fails to reduce the amount of runoff from urban environments or effectively remove pollutants. Traditional development practices not only contribute pollution but also degrade freshwater ecosystems more generally. When the amount of impervious cover surrounding a stream segment reaches 25 to 60 percent, it no longer performs hydrologic functions or meets habitat, water quality, or biological diversity standards.[5] These streams are so degraded they can never fully recover their original function. Stream segments surrounded by more than 60 percent impervious cover are no longer considered functioning streams, but simply serve as a conduit for floodwaters.[6] Some studies suggest that in California, impervious area should be capped at 3 percent to fully protect biological habitat and physical integrity of water bodies.[7]

The trees, vegetation, and open space typical of undeveloped land capture rain and snowmelt, allowing it to largely infiltrate or evaporate where it falls. Under natural conditions, the amount of rain converted to runoff is less than 10 percent of the rainfall volume, while roughly 50 percent is infiltrated and another 40 percent goes back into the air.[8] In the built environment, these processes are altered. Stormwater, no longer captured and retained by natural vegetation and soil, flows rapidly across impervious surfaces and into our waterways in short, concentrated bursts.[9] Not only does the increased stormwater volume increase susceptibility to flooding, but the runoff also picks up and carries with it a range of pollutants as it flows over impervious surfaces, including fertilizers, bacteria, pathogens, animal waste, metals, and oils, which degrade the quality of local and regional water.[10] High stormwater volumes also erode natural streambanks. During storm events, large volumes of stormwater can also trigger overflows of raw sewage and other pollutants into waterways.

While only 3 percent of the United States is classified as urban, research shows that urban stormwater runoff is responsible for impairing, at a minimum, 13 percent of all impaired river miles, 18 percent of impaired lake acres, and 32 percent of impaired square miles of estuaries. These numbers are likely conservative, as they are based only on surveyed waters, not all waters.[11] These impaired waters harm fish and wildlife populations, kill native vegetation, contribute to streambank erosion, foul drinking water supplies, and make recreational areas unsafe and unpleasant.

FOUR FACTORS MAKE STORMWATER MANAGEMENT BOTH DIFFICULT AND IMPORTANT

Throughout the United States, population growth, changing landscapes, aging infrastructure, and climate change are placing increasing pressures on stormwater management. The 2010 U.S. Census reported that 308.7 million people live in the United States; just under 84 percent live in metropolitan areas with 50,000 people or more. The population number reflects a 9.7 percent increase from the 2000 Census, with the vast majority of that growth occurring in urban areas.[12] Recent estimates based on the 2000 Census project that, by 2050, the U.S. population will grow to 439 million, an increase of 42 percent,[13] with population growth in the limited space of the nation's coastal areas reflecting the overall rate of growth and imperiling critical habitat, green space, and biodiversity.[14]

As our population shifts to a more urbanized setting, our landscape shifts as well. Grassland, prairie, and forestland are replaced with impervious surfaces, dramatically altering how water moves across and under the land and increasing the amount of pollutants flowing into our rivers, lakes, and estuaries. In some areas, roads and parking lots constitute up to 70 percent of the community's total impervious cover, and most of these structures (up to 80 percent) are directly connected to the drainage system. Roads and parking lots also tend to capture and export more pollutants into the storm system and waterbodies than does any other type of impervious area.[15]

The nation's water infrastructure—drinking water treatment plants, sanitary and stormwater sewer systems, sewage treatment plants, drinking water distribution lines, and storage facilities—is also aging, and much of it needs to be replaced. In some parts of the country, existing water infrastructure is literally falling apart. Washington, D.C., for example, averages one pipe break per day.[16] The costs to repair and replace our nation's aging water infrastructure are enormous, with investment needs of $298 billion or more over the next 20 years.[17] In 2009, the American Society of Civil Engineers gave the nation's wastewater facilities a grade of D-minus due to the billions of gallons of untreated wastewater discharged into U.S. surface waters each year.[18]

Climate change will exacerbate the problems caused by aging and failing infrastructure and current development patterns. Higher temperatures; shifts in the time, location, duration, and intensity of precipitation events; increases in the number of severe storms; and rising sea levels are expected to shrink water supplies, increase water pollution levels, increase flood events, and cause additional stress to wastewater and drinking water infrastructure.[19] A report issued by the United States Global Change Research Program finds that climate changes are already affecting water resources as well as energy supply and demand, transportation, agriculture, ecosystems, and health.[20] NRDC recently released a report, *Thirsty for Answers*, that compiles findings from climate researchers about local, water-related climate changes and impacts to major cities.[21] The report found that coastal cities such as New York, Miami, and San Francisco can anticipate serious challenges from sea level rise; that Southwest cities such as Phoenix face water shortages; and that Midwest cities such as Chicago and St. Louis, along with Northeast cities such as New York, should expect more intense storms and floods.[22] Some cities, such as Chicago, New York, and Portland, are responding by developing their own climate change action plans.[23]

THE DEFICIENCIES OF CURRENT URBAN STORMWATER INFRASTRUCTURE

Since 1987, the prevention, control, and treatment of stormwater discharges have been regulated primarily by state permitting authorities and state environmental agencies through the National Pollutant Discharge Elimination System (NPDES) program under the federal Clean Water Act (CWA). Under these regulations, most stormwater discharges are treated as point sources and are required to be covered by an NPDES permit. Stormwater management in urban areas has traditionally focused on collecting and conveying stormwater rather than reducing its volume or substantially reducing pollutant loads carried with it. Two systems are currently used: separate stormwater sewer systems and combined sewer systems. Separate stormwater sewer systems collect only stormwater and transmit it with little or no treatment to a receiving waterbody, where stormwater and the pollutants it has accumulated are released. Combined sewer systems collect stormwater and convey it in the same pipes that are used to collect sewage, sending the mixture to a municipal wastewater treatment plant. During rainfall events, combined systems, unable to handle the tremendous increase in volume, commonly overflow at designated locations, dumping a blend of stormwater and sewage into waterways. Both types of sewer systems fail to protect water quality under ordinary conditions.

Table 1-1: Urban Stormwater Pollutants	
Pollutant	**Source**
Bacteria	Pet waste, wastewater, collection systems
Metals	Automobiles, roof shingles
Nitrogen and phosphorous	Lawns, gardens, atmospheric deposition
Oil and grease	Automobiles
Oxygen depleted substances	Organic matter, trash
Pesticides	Lawns, gardens
Sediment	Construction sites, roadways
Toxic chemicals	Automobiles, industrial facilities
Trash and debris	Multiple sources

Source: U.S. Environmental Protection Agency, Protecting Water Quality from Urban Runoff, Nonpoint Source Control Branch, EPA841-F-03-003, February 2003; and U.S. EPA, Report to Congress: Impacts and Control of CSOs and SSOs, Office of Water, EPA-833-R-04-001, August 2004.

Separate Stormwater Sewer Systems

Many communities across the country have separate systems for wastewater and rainwater collection. One system carries sewage from buildings to wastewater treatment plants; the other carries stormwater directly to waterways. The large quantities of stormwater that wash across urban surfaces and discharge from separate stormwater sewer systems contain a mix of pollutants, shown in Table 1-1: Urban Stormwater Pollutants, deposited from a number of sources.[24,25] Stormwater pollution from separate systems affects all types of water bodies and continues to pose a largely unaddressed threat to the health of the nation's waterways. Stormwater runoff is the most frequently identified source of beach closings and advisory days; in 2010, 36 percent of all swimming beach advisory and closing days attributed to a known source were caused by polluted runoff and stormwater.[26] Table 1-2: Urban Stormwater's Impact on Water Quality shows the percentage of impaired waters in the United States for which stormwater has been identified as a significant source of pollution. Overall, the EPA views urban runoff as one of the greatest threats to water quality in the country, calling it "one of the most significant reasons that water quality standards are not being met nationwide."[27]

In Los Angeles, studies have found that concentrations of trace metals in stormwater frequently exceed toxic standards, and concentrations of fecal indicator bacteria frequently exceed bacterial standards.[28] The studies show that fecal bacteria in particular can be elevated in the surf zone at beaches adjacent to storm drain outlets, and that the number of adverse health effects experienced by swimmers at beaches receiving stormwater discharges increases with rising densities of fecal bacteria indicators in the water.[29] One study found that as a consequence of greater controls being placed on discharges from traditional point sources such as sewage treatment plants and industrial facilities, relatively uncontrolled discharges from stormwater runoff now contribute a "much larger portion of the constituent inputs to receiving waters and may represent the dominant source of some contaminants such as lead and zinc."[30]

Combined Sewer Systems

While pollution from separate sewer systems is a problem affecting a large majority of the country, pollution from combined sewer systems (CSSs) tends to be a more regional problem, concentrated in the older urban sections of the Northeast, the Great Lakes region, and the Pacific Northwest. Combined sewers were first built in the United States in the late 19th century as a cost-effective way to dispose of sewage and stormwater in burgeoning urban areas, the notion being that by diluting the wastewater, it would be rendered harmless. In the late 19th century, Louis Pasteur and John Snow demonstrated relationships between discharged wastewater and disease outbreaks;[31] as a result, wastewater began to receive treatment prior to discharge.

Table 1-2: Urban Stormwater's Impact on Water Quality		
Water Body Type	**Stormwater's Rank as Pollution Source**	**% of Impaired Waters Affected**
Ocean shoreline	1st	55% (miles)
Estuaries	2nd	32% (sq. miles)
Great Lakes Shoreline	2nd	4% (miles)
Lakes	3rd	18% (acres)
Rivers	4th	13% (miles)

Source: "Urban Stormwater's Impact on Water Quality:," U.S. EPA, National Water Quality Inventory, 2000 Report, Office of Water, EPA-841-R-02-001, August 2002.

During dry periods or small wet weather events, combined sewer systems carry untreated sewage and stormwater to a municipal wastewater treatment plant where the combination is treated prior to discharge. However, larger wet weather events can overwhelm a combined sewer system by introducing more stormwater than the collection system or wastewater treatment plant is able to handle. In these situations, rather than backing up sewage and stormwater into basements and onto streets, the system is designed to discharge untreated sewage and stormwater directly to nearby water bodies through outfalls that release raw sewage and other pollutants. These are called combined sewer overflows (CSOs). Even small amounts of rainfall can trigger a CSO event; Washington D.C.'s combined sewer system can overflow with as little as 0.2 inch of rain.[32] And in certain instances, despite the presence of sewer overflow points, basement and street overflows still occur.

Because CSOs discharge a mix of stormwater and sewage, they are a significant environmental and health concern. They can lead to the contamination of drinking water

Table 1-3: Pollutants in CSO Discharges

Pollutant	Median CSO Concentration	Treated Wastewater Concentration
Pathogenic bacteria, viruses, parasites • Fecal coliform (indicator bacteria)	215,000 colonies/100 mL	< 200 colonies/100mL
Oxygen-depleting substances (BOD5)	43 mg/L	30 mg/L
Suspended solids	127 mg/L	30 mg/L
Toxins • Cadmium • Copper • Lead • Zinc	 2 µg/L 40 µg/L 48 µg/L 156 µg/L	 0.04 µg/L 5.2 µg/L 0.6 µg/L 51.9 µg/L
Nutrients • Total phosphorus • Total Kjeldahl nitrogen	 0.7 mg/L 3.6 mg/L	 1.7 mg/L 4 mg/L
Trash and debris	Varies	None

Source: U.S. EPA, Report to Congress: Impacts and Control of CSOs and SSOs, Office of Water, EPA-833-R-04-001, August 2004.

supplies, water quality impairments, beach closures, shellfish bed closures, and other problems. CSOs contain pollutants from roadways, as well as pollutants typical of untreated sewage, such as bacteria, metals, nutrients, and oxygen-depleting substances. CSOs pose a direct health threat in the areas surrounding the CSO discharge location because of the potential exposure to bacteria and viruses. In some studies, estimates indicate that CSO discharges are composed of approximately 89 percent stormwater and 11 percent sewage.[33,34] Table 1-3: Pollutants in CSO Discharges shows the concentration of pollutants in CSO discharges.

Today, CSSs are present in 772 municipalities containing approximately 40 million people nationwide.[35] As of 2002, CSOs discharged 850 billion gallons of raw sewage and stormwater annually, and 43,000 CSO events occurred per year. Under the NPDES program, CSSs are required to implement mitigation measures, such as infrastructure upgrades that increase capacity to capture and treat sewage and runoff when it rains, and stormwater management measures that reduce the volume of runoff entering the system. However, approximately one-fifth of these still lack enforceable plans either to reduce their sewage overflows sufficiently to meet water quality standards in the receiving waters, or to rebuild their sewer systems with separate pipes for stormwater and sewage.[36] Many are years, or even decades, from full implementation.[37]

Clean Water Act

These extended compliance timelines were not envisioned by the Clean Water Act (CWA), passed in 1972. The goal of the CWA is "to restore and maintain the chemical, physical, and biological integrity of the Nation's waters."[38] Subsequently, the law called for a national goal "that the discharge of pollutants into the navigable waters be eliminated by 1985."[39] The 1994 CSO Policy, which Congress incorporated into the CWA in 2000, established a two-year rule of thumb for developing and submitting plans, and required that such plans be implemented "as soon as practicable".

In 1987 Congress added Section 402(p) of the CWA, bringing stormwater control into the NPDES program. In 1990 EPA issued the Phase I Stormwater Rules, which require NPDES permits for operators of municipal separate storm sewer systems (MS4s) serving more than 100,000 people and for runoff associated with industry, including construction sites five acres or larger. The Phase II Stormwater Rule, issued in 1999, expanded the requirements to small MS4s and construction sites between one and five acres in size.

Most municipal stormwater discharges are regulated as point sources under the CWA and require an NPDES permit. However, end-of-pipe treatment and controls typical of other permitted point-source discharges are often not implemented to control the sometimes more significant pollution problems caused by runoff, for a variety of reasons, including the large volumes of stormwater generated and space constraints in urban areas.

Many permits for urban stormwater require municipalities to develop a stormwater management plan and to implement best management practices, such as public education and outreach, illicit discharge detection and elimination, construction site runoff and post-construction controls, and other pollution prevention programs that keep pollutants from entering the nation's waterways.[40] These management measures have been typically used in lieu of specific pollutant removal requirements and quantified pollution limits; in other words, performance-based standards are generally not required. Instead, "minimum control measures," that is, implementing specific practices for permit compliance is considered sufficient.

Continuing local pollution problems, often very significant, have prompted some regulators to move to an improved, results-oriented approach more typical of how the CWA addresses other pollution sources—a positive development that improves outcomes and can make program implementation more efficient, targeted, and quantitative. For example, the NPDES Municipal Stormwater Permit for Los Angeles County prohibits "discharges from the [storm sewer system] that cause or contribute to the violation of Water Quality Standards or water quality objectives."[41]

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CHAPTER 2: THE MULTIPLE BENEFITS OF GREEN INFRASTRUCTURE SOLUTIONS

Often the best way to avoid runoff-related pollution and overburdening water infrastructure is to reduce the volume of stormwater flowing to the storm drains. Green infrastructure restores or mimics natural conditions, allowing rainwater to infiltrate into the soil, or evapotranspirate into the air. Green infrastructure techniques, include porous pavement, green roofs, parks, roadside plantings, and rain barrels. Such approaches keep stormwater runoff from overloading sewage systems and triggering raw sewage overflows or from carrying pollutants directly into bodies of water. These smarter water practices on land not only address stormwater runoff but also beautify neighborhoods, cool and cleanse the air, reduce asthma and heat-related illnesses, save on heating and cooling energy costs, boost economies, and support American jobs.

Comprehensive urban stormwater and combined sewer overflows (CSOs) strategies that incorporate green infrastructure are more flexible, more effective, and often less costly than traditional approaches. Adopted across North America and other parts of the world, these strategies integrate conventional and greener alternatives, placing greater emphasis on the natural hydrologic processes of infiltration and evapotranspiration, and on rainwater reuse, to filter out pollutants and minimize the amount of runoff generated. These techniques address stormwater problems at the source by restoring some of the natural hydrologic function of developed areas where impervious surfaces have replaced pervious ones. Green infrastructure can also involve protecting sensitive headwaters regions and groundwater recharge areas.

Green infrastructure can be applied in many forms and at many scales. At the larger, more regional scale, green infrastructure refers to the interconnected network of waterways, wetlands, woodlands, wildlife habitats, and other natural areas that maintain ecological processes by preserving, creating, or restoring vegetated areas and corridors such as greenways, parks, conservation easements, and riparian buffers.[1] At this level, green infrastructure planning has traditionally been more focused on overall ecosystem services than on stormwater management; however, recent efforts such as "Nashville: Naturally," that city's 2011 open space plan, have begun to weave stormwater management goals and objectives into this larger context.[2,3] When linked through an urban environment, open areas, trees, forests, and riparian buffers provide rain management benefits similar to those offered by natural undeveloped systems, thereby reducing the volume of stormwater runoff.

At the neighborhood and site-level scale, green infrastructure practices generally reflect those used on a larger scale, but focus more on restoration activities such as planting trees and bioswales, restoring wetlands, maintaining open spaces, and incorporating existing landscape features into site design plans. For example, the Village Homes community in Davis, California, uses a system of vegetated swales and meandering streams to manage stormwater. The natural drainage system infiltrates and retains a rainfall volume greater than that of a 10-year storm without discharging to the municipal storm sewer system. The leaf canopies and root systems of urban forests and native plants take up rainfall and prevent stormwater from entering sewer systems. The roots also help to maintain soil porosity, which is crucial to increasing storage capacity for rainwater and infiltration. Mature deciduous trees can intercept 500 to 700 gallons of water per year, and mature evergreens more than 4,000 gallons per year.[4]

Most green stormwater controls are literally green, in that they consist of trees and plants, but other green controls, such as permeable pavements and cisterns, while not vegetated, also provide the water infiltration and retention capabilities of natural systems. Green infrastructure practices include design features such as narrower street widths to reduce impervious surface area; curbless streets and parking lots bordered by drainage swales; and green roofs.[5]

STORMWATER VOLUME CONTROL

The National Research Council noted that conventional stormwater management focuses on flood control to protect life and property from extreme rainfall events but does not adequately address the water quality problems it causes.[6] This approach also focuses on strategies for detention and/or diversion of water away from developed areas, ultimately releasing it to local waterways, in contrast to green infrastructure approaches that keep runoff volumes out of sewers and waterways entirely, eliminating associated pollutant loads and protecting against streambank erosion.

Conventional systems ignore smaller, more frequent storm events, which, more and more, cities are challenged to handle. Capturing small storms, in the range of 85th-95th-percentile events, retains a large percentile of the total annual runoff volume, reducing discharge volume and pollutant loads.

Whether from small or large storms, reducing runoff volume decreases the amount of stormwater discharged from separate stormwater sewer systems and supplements combined sewer systems by decreasing the overall volume of water entering them, thus reducing the number and size of overflows. When rainwater is retained in an area, it also provides critical recharge and base flow functions.[7]

POLLUTANT REMOVAL

Green infrastructure does more than decrease pollutant loads by reducing runoff volumes. There is a growing body of work indicating that green infrastructure practices are effective at removing pollutants directly from stormwater. Using natural processes, green infrastructure filters pollutants or biologically or chemically degrades them, which is especially advantageous for separate storm sewer systems that do not provide additional treatment before discharging stormwater. The combination of volume reduction and pollutant removal is an effective means of reducing the total mass of pollution released to the environment. Consequently, open areas and buffer zones are often designated around urban streams and rivers to provide treatment and management of overland flow before it reaches the waterway. Two readily available sources for pollutant removal performance data for green infrastructure practices are the International Stormwater BMP Database[8] and the Center for Water Protection's National Pollutant Removal Performance Database for Stormwater Treatment Practices, Version 3.[9] The Water Environment Research Foundation also regularly publishes information on best management practices performance.[10]

WATER CONSERVATION

Green infrastructure practices such as rainwater harvesting techniques (cisterns and rain barrels) and drought-tolerant landscaping help capture and conserve water. Practices such as downspout disconnections, infiltration trenches, swales, rain gardens, and buffer strips, as well as curbless parking lots and narrower roads, can help replenish and sustain groundwater. These practices also give communities more flexibility to deal with projected population increases and climate change, both of which are forecast to exacerbate current or expected water supply shortfalls. Water conservation can help alleviate these threats by allowing communities to maximize their existing and planned water supply sources and prevent the need for costly expansion of water treatment, storage, and transmission facilities.[11] Particularly in the Southwest, where annual rainfall is low and water resources scarce, green infrastructure techniques are critical to both replenish groundwater and capture stormwater for beneficial use.[12]

A study conducted by NRDC and the University of California, Santa Barbara, *A Clear Blue Future*, found that implementing green infrastructure practices that emphasize on-site infiltration or capture and reuse had the potential to increase local water supplies by up to 405,000 acre-feet per year by 2030 at new and redeveloped residential and commercial properties in Southern California and the San Francisco Bay area. This represents roughly two-thirds of the volume of water used by the entire city of Los Angeles each year. The water savings translate into electricity savings of up to 1,225,500 megawatt-hours—which would decrease the release of carbon dioxide (CO_2) into the atmostphere by as much as 535,500 metric tons per year—because more plentiful local water reduces the need for energy-intensive imported water. And, perhaps most importantly, these benefits would increase every year.[13]

This analysis led to the inclusion of green infrastructure as a strategy in California's "Land Use Planning and Management," signifying the state's recognition of green infrastructure's value in water supply State of California.[14] Green infrastructure was also included as a strategy in California's Global Warming Solutions Act of 2006 (AB 32), in recognition of its ability to to reduce energy demand associated with the transport of water.[15] Similar benefits, at least in terms of the quantity of water supply, are available throughout the country. An NRDC report on rainwater capture released at the same time as this report demonstrates that the volume of rain falling on rooftops in eight different cities, if captured in its entirety, would be enough to meet the annual water needs of 21 percent to 75 percent of each city's population. Even under more conservative assumptions, the study demonstrated that each of the cities modeled could capture hundreds of millions to billions of gallons of rainwater each year—amounts equivalent to the total annual water use of tens of thousands to hundreds of thousands of residents.[16]

NON-WATER BENEFITS

Green infrastructure can be used to achieve multiple environmental, social, and economic goals in addition to reducing stormwater volume and pollution. This cannot be said about funds spent on conventional approaches, which ordinarily deliver only one benefit: stormwater management. The range of human health, social, and community benefits offered by green infrastructure include:

- **Improved air quality.** Trees and plants literally filter the air, capturing pollution (including dust, ozone, and carbon monoxide) in their leaves and on their surfaces. In 1994, trees in New York City removed an estimated 1,821 metric tons of air pollution at an estimated value to society of $9.5 million.[17]
- **Lower air temperature.** Trees and plants cool the air through evapotranspiration, the return of moisture to the air through evaporation from soil and transpiration by plants.[18] The shade provided by trees also reduces air temperatures and buildings' energy use. The cooling savings from trees range from 7 percent to 47 percent.[19]

Figure 2-1: Green Infrastructure Benefits and Practices

Benefit	Reduces Stormwater Runoff											Improves Community Livability						
	Reduces Water Treatment Needs	Improves Water Quality	Reduces Grey Infrastructure Needs	Reduces Flooding	Increases Available Water Supply	Increases Groundwater Recharge	Reduces Salt Use	Reduces Energy Use	Improves Air Quality	Reduces Atmospheric CO_2	Reduces Urban Heat Island	Improves Aesthetics	Increases Recreational Opportunity	Reduces Noise Pollution	Improves Community Cohesion	Urban Agriculture	Improves Habitat	Cultivates Public Education Opportunities
Practice										CO_2								
Green Roofs	Yes	Yes	Yes	Yes	No	No	No	Yes	Yes	Yes	Yes	Yes	Maybe	Yes	Maybe	Maybe	Yes	Yes
Tree Planting	Yes	Yes	Yes	Yes	No	Maybe	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Maybe	Yes	Yes
Bioretention & Infiltration	Yes	Yes	Yes	Yes	Maybe	Maybe	No	No	Yes	Yes	Yes	Yes	Yes	Maybe	Maybe	No	Yes	Yes
Permeable Pavement	Yes	Yes	Yes	Yes	No	Maybe	Yes	Maybe	Yes	Yes	Yes	No	No	Yes	No	No	No	Yes
Water Harvesting	Yes	Yes	Yes	Yes	Yes	Maybe	No	Maybe	Maybe	Maybe	No	No	No	No	No	No	No	Yes

Yes Maybe No

Source: Center for Neighborhood Technology (CNT) and American Rivers, *The Value of Green Infrastructure: A Guide to Recognizing Its Economic, Environmental and Social Benefits* (Chicago: CNT, 2011), p3. Available at cnt.org. Reprinted with permission.

- **Reduced urban heat island effect.** An urban heat island is a metropolitan area that is significantly warmer than the surrounding suburban and rural areas due to its large amount of impervious surfaces. Green roofs and lighter-colored surfaces in urban areas reflect more sunlight and absorb less heat, significantly reducing the heat island effect.
- **Reduced energy use.** Additional insulation provided by the growing media of a green roof can reduce a building's energy consumption by providing superior insulation compared with conventional roofing materials. When properly placed, trees provide shade, which can help cool the air and reduce the amount of heat reaching and being absorbed by buildings. In warm weather, this can reduce the energy needed for air-conditioning. Trees reduce wind speeds, which can have a significant impact on the energy needed for heating, especially in areas with cold winters.
- **Conservation of water.** Green infrastructure creates organic matter on the soil surface, and tree and plant roots increase soil permeability, resulting in reduced surface runoff, reduced soil erosion, less sedimentation of streams, and increased groundwater recharge.

Because green infrastructure approaches provide multiple benefits, development projects using green infrastructure will frequently be more cost-effective than projects aimed solely at stormwater control. Cost savings in environmental, social, and health care services; reductions in energy use; and better adaptation to climate change can result in overall economic benefits to communities.[20] "The Value of Green Infrastructure: A Guide to Recognizing Its Economic, Environmental and Social Benefits," released by the Center for Neighborhood Technology, captures the range of benefits provided by green roofs, tree planting, bioretention, infiltration, permeable pavement, and water harvesting (see Figure 2-1: Green Infrastructure Benefits and Practices).

Green infrastructure can be designed to achieve multiple environmental, economic, and social goals, allowing cities to use varied funding sources. And, as the analyses above show, green infrastructure's ability to deliver multiple benefits makes it a better investment of taxpayer dollars, enabling governments to maximize the impact of their limited infrastructure funds.

THE COST TO ADDRESS COMBINED SEWER OVERFLOWS AND STORMWATER POLLUTION

The increased recognition of green infrastructure's economic value couldn't be timelier: mitigating CSOs and stormwater, especially using conventional infrastructure, is costly. The EPA's 2008 Clean Watersheds Needs Survey (CWNS) estimated that $63.6 billion is needed to address CSOs nationwide over the next 20 years. In separately sewered areas, an additional $42.3 billion is required for both regulatory and non-regulatory stormwater management investments, reflecting an increase of $16.9 billion, or 67 percent, since the 2004 projections. Much of this increase is due to better communication and documentation by states of their needs and to emerging efforts to utilize green infrastructure. More surprising, however, is that the CWNS reflects the needs of only 22 percent of the nation's MS4 facilities that responded,[21] meaning that $42.3 billion is likely a sizeable underestimate. New Hampshire's Department of Environmental Services, for example, has estimated that the state's actual needs are likely three times the CWNS estimate.[22]

Moreover, the CWNS data do not include costs associated with flood control and drainage improvements, apart from water pollution control needs.[23] Table 2-1: 2008 Clean Water Needs Survey breaks down the most recent figures.

Table 2-1: 2008 Clean Water Needs Survey—Total Stormwater and CSO Correction Needs (January 2008 dollars, in billions)

Category	Total Need ($B)
Stormwater Management[a]	$42.3
General Stormwater Management[b]	$2.9
Conveyance Infrastructure	$7.6
Treatment Systems	$7.4
Green Infrastructure	$17.4
CSO Prevention & Control[c,d]	$63.6

Source: U.S. EPA. "Clean Watersheds Needs Survey. Report to Congress. 2008," p. 2-18; http://water.epa.gov/scitech/datait/databases/cwns/upload/cwns2008rtc.pdf.

Notes:
a Thirty-eight states submitted data for 1,500 municipal stormwater management facilities and 688 unregulated facilities.
b In prior surveys, all needs were reported as "stormwater management." Many of these needs are still valid, in additional to the $2.9 billion iidentified in this latest survey.
c CSO estimates were primarily obtained from completed Long Term Control Plans (LTCPs). Where LTCPs or other engineering documents were not available, states used cost curves.
d CSO estimates do not include overflow control costs allocated to flood control, drainage improvements, or the treatment or control of stormwater in separate storm systems.

Separating combined sewer lines and building deep storage tunnels are the two traditionally preferred methods of CSO control. In Onondaga County, New York, which includes Syracuse, the cost to separate combined sewers, disconnect stormwater inlets from the combined sewer system and direct them to a newly installed separate storm sewer system ranged from $500 to $600 per foot of sewer separated, or $2.6 million to $3.2 million for each mile of combined sewer separated.[24] When Minneapolis, Minnesota, separated its sewer systems, the city replaced more than 200 miles of storm sewers.[25] However, while sewer separation can eliminate the release of untreated sewage through CSOs, exclusive reliance on that approach increases the volume of untreated stormwater discharges.

Communities with combined sewer systems also use large underground tunnels with millions of gallons of storage capacity to hold the excess surge of sewage and stormwater during wet weather events. These systems eventually direct the detained wastewater to the municipal treatment plant as combined sewer flow rates subside, although in some cases this wastewater still receives only partial treatment before discharge. If sized, constructed, and operated properly, deep tunnels can significantly reduce CSO discharges. However, deep tunnels take many years to build and are very costly; it is also difficult to adequately size the tunnels to accommodate for changing population patterns, increased impervious surfaces and climate change. Several cities have built or are in the process of building deep tunnel projects costing hundreds of millions or billions of dollars, as outlined in Table 2-2: Examples of Deep Storage Tunnel Projects.

Conventional forms of infrastructure, such as deep tunnels, are an important part of the solution to manage stormwater. However, as noted by the National Research Council report, "individual controls on stormwater discharges [such as deep tunnels] are inadequate as the sole solution to stormwater in urban watersheds."[26] That report calls for reshaping the regulatory system to reduce imperviousness and runoff volume and to create comprehensive solutions to stormwater that complement traditional approaches with natural systems that work with nature, rather than against it.

Table 2-2: Examples of Deep Storage Tunnel Projects

City	Project Duration	Completion Date	Storage Capacity	Cost
Chicago, IL[a,b]	40+ years	2029	17.5 billion gallons[g]	$4 billion
Milwaukee, WI[c,d]	17 years (Phase 1)	1994	405 million gallons	$2.3 billion
	8 years (Phase 2)	2005	88 million gallons	$130 billion
Portland, OR[e]	20 years	2011	123 million gallons	$1.4 billion
Washington, DC[f]	20 years	2025	194 million gallons	$2.2 billion

Notes:

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e "Working for Clean Rivers," Portland Bureau of Environmental Services, accessed at http://www.portlandonline.com/bes/index.cfm?c=31000

f "Combined Sewer," District of Columbia Water and Sewer Authority, accessed at http://www.dcwater.com/about/cip/cso.cfm.

g "Tunnel and Reservoir Plan," Metropolitan Water Reclamation District of Greater Chicago, accessed at http://www.mwrd.org/irj/portal/anonymous/tarp. This tunnel volume includes capacity to deal with flooding issues, not just CSOs.

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CHAPTER 3: THE ECONOMICS OF GREEN INFRASTRUCTURE

As communities face significant costs to improve water quality and the infrastructure that supports it, they are increasingly turning to green infrastructure as a cost-effective investment. A 2007 U.S. EPA study found that "in the vast majority of cases…[green infrastructure] practices save money for developers, property owners and communities while protecting and restoring water quality."[1] The American Society of Landscape Architects released a survey in October 2011 that found green infrastructure reduced or did not influence costs 75 percent of the time.[2] As outlined in the previous chapter, green infrastructure can create a range of water quality, supply, and other benefits, making it a powerful tool for community improvement.

Because green infrastructure techniques are cost-effective pollution controls with multiple benefits, communities are designing programs to incentivize or finance the implementation of these approaches. This chapter explores the economics of green infrastructure, including how it can be less expensive than some conventional infrastructure investments and mitigate the costs of energy use and flooding. The chapter also identifies how green infrastructure is being woven into existing development and redevelopment. It concludes with a description of traditional and innovative financing mechanisms, including how community incentives spur additional green infrastructure investment.

GREEN INFRASTRUCTURE REDUCES COSTS OF IMPROVEMENTS TO AGING INFRASTRUCTURE

According to U.S. Census Bureau estimates, state and local governments spent $46.7 billion in 2007–08 on the construction, operation, and maintenance of sanitary and stormwater sewer systems and sewage disposal and treatment facilities, including $18.8 billion in capital outlays. Nearly all of these expenditures were the responsibility of local governments.[3] While the Census estimates did not break out the amount spent on stormwater alone, earlier estimates for 2002–2006, as reported by the 2008 Clean Watersheds Needs Survey, indicated that local governments spent approximately $15 billion per year to address capital wastewater needs and approximately $2 billion per year on capital stormwater needs.[4]

Green infrastructure is often more cost-effective, able to reduce CSOs and stormwater runoff at a lower cost than conventional infrastructure alternatives alone. For example, Sanitation District No. 1 in Kentucky developed an integrated, watershed-based plan that includes green infrastructure. Officials expect this plan to save up to $800 million and reduce bacteria and nutrient pollution relative to the gray-only plan initially developed.[5] The green infrastructure components are expected to annually reduce the CSO burden by 12.2 million gallons. Philadelphia estimates that an all-gray approach to reducing CSOs would have cost billions more than its state-approved green infrastructure plan, which will achieve comparable results.[6]

Preserving, restoring, and incorporating trees, meadows, wetlands, and other forms of soil and vegetation can also reduce stormwater management costs. For example, a study performed by the Urban Forest Coalition found that the existing tree cover in Boston reduces stormwater runoff by 314 million gallons per year, helping the city to avoid capital costs of more than $142 million.[7] Preserving trees reduces polluted stormwater discharges and the need for engineered controls. Conversely, when trees are cut down and their functions are lost, those costs are passed on to municipal governments, which then pass them on to their citizens. These important services are predictable enough that today many communities use the "iTree" analytic program developed by the U.S. Forest Service to estimate the value of their urban tree systems, including stormwater management values.[8]

GREEN INFRASTRUCTURE CAN REDUCE COSTS OF STORMWATER MANAGEMENT IN NEW DEVELOPMENT AND REDEVELOPMENT

Incorporating green infrastructure into new development projects is almost always more efficient and cost-effective than using conventional stormwater management or centralized CSO approaches. Replacing curbs or gutters with vegetated swales or strips of permeable paving can be cheaper than using conventional paving. For example, studies in Maryland and Illinois in 2000 and 2005, respectively, indicate that new residential developments saved $3,500 to $4,500 per lot by utilizing green infrastructure stormwater technologies.[9,10] In 2007, the U.S. EPA conducted an analysis of 17 developments and found that, in all but one, upfront costs of construction were lower when applying green infrastructure practices than when using gray approaches alone, with savings ranging from 15 to 80 percent.[11] These savings were separate from any achieved from the avoidance of other environmental costs, the increase in the number of units developed, or the expanded marketing potential, which would have driven the savings up even higher.[12] A joint project undertaken by the University of New Hampshire Stormwater Center and Virginia Commonwealth University recently evaluated stormwater management options for new commercial and residential developments in New Hampshire. In both cases, the use of green infrastructure was calculated to provide more economic and environmental benefits, with stormwater management cost savings of 6 percent for the residential development and 26 percent for the commercial development, compared with conventional stormwater management.[13]

The economics of integrating greener stormwater controls into redevelopment projects in existing urban areas differ slightly from new development, but there is little evidence that this practice raises costs. An analysis of three communities cosponsored by NRDC, Smart Growth America, American Rivers, and the Center for Neighborhood Technology found that developers are already incorporating stronger stormwater controls to meet strict volume-reduction and water-quality standards in both redevelopment and greenfield projects.[14] While complying with such stormwater standards is a cost consideration, it is rarely, if ever, a driving factor in decisions to undertake redevelopment projects.

There is a significant opportunity to incorporate green infrastructure into communities with large amounts of impervious surfaces and degraded land and water quality. Based on the results of pilot projects, Seattle officials expect that the cost of future green infrastructure installations will be lower, in most cases, than that of more conventional stormwater controls.[15] Philadelphia anticipates it will achieve the majority of its targeted retrofits of impervious areas through the application of stormwater retention standards to redevelopment projects.[16]

GREEN INFRASTRUCTURE CAN BE INTEGRATED COST-EFFECTIVELY INTO THE DESIGNS OF OTHER INFRASTRUCTURE PROJECTS

Incorporating green infrastructure into the scheduled replacement of existing infrastructure is often more cost-effective than traditional approaches in both short and long time periods. On average, roofs are replaced every 15 to 30 years, walkways every 20 to 25 years, and driveways every 10 years.[17] There are approximately 4.06 million miles of roads in the United States,[18] with another 32,300 lane-miles added each year.[19] Approximately 69 percent of these roads are local, with low traffic loads, providing opportunities for “green street” practices to be employed as they are paved or repaved. Driveways, pedestrian sidewalks, and parking lots provide similar opportunities.[20] Cities like Philadelphia and New York are developing specifications for infrastructure projects in the public right-of-way that incorporate green infrastructure as a standard design element.[21]

Unlike regular streets, green streets use a combination of narrower street widths, landscaping, permeable pavement, bioretention, and swales to reduce the amount of stormwater runoff that enters the public drainage system. In Portland, Oregon, green streets have been installed since 2003 and are more cost-effective in some cases than installing new sewer pipes because they avoid basement and creek flooding and the need for alterations to existing storm pipe infrastructure. Comparison of the cost-effectiveness of green and gray approaches to CSO abatement in Portland found that downspout disconnections, curb extensions with vegetated swales, and parking lot infiltration are more cost-effective than conventional CSO abatement options.[22] Costs can be further reduced by minimizing impacts to existing piped infrastructure, identifying sites with minimal constraints and maximum space, keeping designs simple, and combining greening projects with other planned improvements.[23] It is also important to consider the ancillary benefits, such as traffic calming, safer pedestrian environment, and community aesthetics, when evaluating green streets and parking retrofit projects.[24]

GREEN INFRASTRUCTURE REDUCES ENERGY COSTS AND FLOODING RISK

It is important to look beyond comparative construction costs to consider the full range of benefits that green infrastructure provides, compared with conventional approaches.[25]

The cost of reducing stormwater pollution before it fouls the nation's waters, and the cost of replacing aging and failing infrastructure, often pale in comparison to the economic burden resulting from flood losses or water pollution. Data compiled from the private property insurance industry in a study conducted in 2008 revealed that, between 1972 and 2006, 531 flood events resulted in $94 billion in losses, representing average losses of $2.67 billion annually and $176 million per storm.[26] The Federal Emergency Management Agency estimates that up to 25 percent of economic losses from flooding are the result of urban drainage, not from being located in a floodplain.[27]

The cost of cleaning up polluted water is also significant. The EPA estimates that programs to clean up the nation's waters (known as Total Maximum Daily Load, or TMDL, programs) could cost states $63 million to $69 million for planning, and between $900 million and $4.3 billion dollars annually for implementation over a 15-year period (in 2001 dollars).[28]

Additionally, under a business-as-usual scenario for climate change, it will cost $200 billion per year by 2025 to provide water to the western United States due to intensified drought conditions, and property owners will suffer $34 billion per year in real estate losses due to rising sea levels.[29]

If adopted widely, the economic benefits of green infrastructure can address many of these issues, especially in areas facing water supply constraints in the future. A 2010 report by NRDC and Tetra Tech demonstrates the significant impact that climate change will have on the sustainability of water supplies in the coming decades. The study found that more than 1,100 counties—one-third of all counties in the lower 48 states—will face higher risks of water shortages by midcentury as the result of global warming. More than 400 of these counties will face extremely high risks of water shortages.[30]

Water-constrained areas, especially those with high water supply costs, benefit from infiltration practices that enhance local supplies. They also save on energy costs. *A Clear Blue Future*, a report issued by NRDC and the University of California Santa Barbara, quantified the ability of green infrastructure to save water (see page 2.2). NRDC's report *Energy Down the Drain* quantified the connection between energy and water use. One example: San Diego could save enough energy to provide electricity for 25 percent of its households if it conserved 100,000 acre-feet of water instead of piping that amount in from Northern California.[31]

Table 3-1: City-wide present value benefits of key CSO options: Cumulative through 2049 (2009 millions USD)

Benefit categories	50% LID option[a]	30′ Tunnel option[c]
Increased recreational opportunities	$524.5	
Improved aesthetics/property value (50%)	$574.7	
Reduction in heat stress mortality	$1,057.6	
Water quality/aquatic habitat enhancement	$336.4	$189.0
Wetland services	$1.6	
Social costs avoided by green collar jobs	$124.9	
Air quality improvement from trees	$131.0	
Energy savings/usage	$33.7	$(2.5)
Reduced (increased) damage from SO_2 and NOx emissions $46.3	$(45.2)	
Reduced (increased) damage from CO_2 emissions	$21.2	$(5.9)
Disruption costs from construction and maintenance	$(5.6)[b]	$(13.4)
Total	**$2,846.4**	**$122.0**

Source: Stratus Consulting (2009). A Triple Bottom Line Assessment of Traditional and Green Infrastructure Options for Controlling CSO Events in Philadelphia's Watersheds Final Report, p. S-2, accessed at http://www.phillywatersheds.org/ltcpu/Vol02_TBL.pdf.

Notes:

a "Runoff from 50 percent of impervious surface in Philadelphia managed through green infrastructure."

b Parentheses indicate negative values.

c "A system of storage tunnels with an effective diameter of 30 feet, serving all watersheds in Philadelphia."

In addition, green infrastructure can provide value to recreational users of water bodies. A 2011 study by Londoño and Ando estimated the willingness of households in Champaign-Urbana (Illinois) to pay for stormwater management that improves environmental quality. The households surveyed would achieve a combined annual benefit of $1.5 million for stormwater management that increases infiltration rates by 25 percent and improves water quality from boatable to fishable.[32]

Together, the multiple benefits are significant. Stratus Consulting compared the full range of economic, social, and environmental benefits and external costs (i.e., costs not accounted for in capital, operations, and maintenance budgets) of a range of CSO control alternatives that were under consideration by the Philadelphia Water Department (PWD), including approaches based largely on green infrastructure. This "triple bottom line" analysis quantified the total social, economic, and environmental benefits from green infrastructure—such as additional recreational user-days in the city's waterways; reduction of premature deaths and asthma attacks caused by air pollution and excessive heat; increased property values in greened neighborhoods; the ecosystem values of restored or created wetlands; poverty reduction from the creation of local green jobs; and energy savings from the shading, cooling, and insulating effects of vegetation. It also quantified some external costs of a gray approach that are avoided under the green approach, such as the carbon and other air pollution emissions associated with the energy needed, under the gray alternatives, to manufacture and install concrete tunnels and to pump and treat runoff. The city selected a primarily green infrastructure–based approach, and the study's conclusions indicate that, over 45 years, the city will reap more dollar value in benefits than it invests.[33] PWD estimates that achieving a similar amount of CSO reduction through gray infrastructure alone would cost billions of dollars more, without accruing the same non-water-quality benefits.[34] As Table 3-1: City-wide present value benefits of key CSO options: Cumulative through 2049 (2009 millions USD) shows, a green infrastructure approach provides a wide array of "important environmental and social benefits to the community, and … these benefits are not generally provided by the more traditional alternatives."[35]

INCENTIVIZING GREEN INFRASTRUCTURE THROUGH CODES AND ZONING CHANGES

Standards in planning and zoning ordinances, building codes, and design manuals are changing to support green infrastructure. The International Green Construction Code, the International Association of Plumbing and Mechanical Officials' Green Code Supplement, and the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED®) are incorporating green infrastructure into standard building practices.[36] The Sustainable Sites Initiative (SITES™) is creating national guidelines and performance benchmarks for sustainable land design, construction, and maintenance that reflect the latest practices and integrate the principles of green infrastructure. Just as the U.S. Green Building Council has, with LEED®, increased standardization and reduced uncertainty in green-building design, SITES™ aims to bring similar guidance to built landscapes.
In addition, many municipalities are revising existing stormwater and other land-use ordinances to allow—and in some cases, require—green infrastructure as the primary strategy to address stormwater.

Zoning and development rules that allow for and encourage greater density in order to reduce sprawl and associated environmental degradation, along with carefully selected green infrastructure practices, can help rebuild urban cores with more effective stormwater management.[37] Incorporating stormwater management requirements into green building programs can also be a simple and effective tool. Portland's Green Building Policy requires that various levels of LEED® be met for city-constructed and -financed green building projects, as well as the use of green roofs for city-owned buildings needing roof replacement. The policy mandates that all future land purchases be evaluated to determine the property's on-site stormwater mitigation, vegetation and habitat-restoration capacity to reduce negative environmental and social impacts.[38]

FINANCIAL TOOLS TO IMPLEMENT GREEN INFRASTRUCTURE

While the gaps between needs and funding levels have increased over time, states and municipalities have traditionally relied on federal contributions to State Revolving Funds (SRF) for both Drinking Water and Clean Water to help finance drinking and wastewater infrastructure. As outlined in other parts of this report, there is a need to invest nearly $300 billion over the next 20 years for water and wastewater infrastructure in the United States, of which $63.6 billion is needed for CSO correction.[39]

In 2009, as part of the American Recovery and Reinvestment Act (ARRA), Congress provided an additional $6 billion for clean water and drinking water infrastructure, of which at least 20 percent—$1.2 billion—was targeted for a "Green Project Reserve," to fund green infrastructure, water and energy efficiency, and environmental innovation.

Unfortunately, this funding increase did not represent the beginning of a trend. The Clean Water SRF (and its companion Drinking Water SRF) has been a target for cuts during recent budget debates: funding was reduced dramatically in 2011, and additional cuts of nearly $1 billion have been proposed for fiscal year 2012.[40]

Besides state revolving funds, the EPA and other federal agencies support a number of targeted grant programs to encourage community-level efforts to address water quality, potentially through green infrastructure.

- The EPA funds local projects through the Community Action for a Renewed Environment (CARE) program.[41]
- The EPA's Section 319 funds are intended to support efforts by state and local organizations to control nonpoint pollution sources and can be used for green infrastructure projects.[42]
- The EPA also funds the Targeted Watersheds Grants Program for innovative local approaches to community-based water quality improvement.[43]
- The Department of Housing and Urban Development administers the Community Development Block Grant Program, which can be used for green infrastructure.[44]

Despite these federal resources, local ratepayers fund most wastewater treatment needs, and as these needs grow, the availability of an array of financing approaches helps communities identify mechanisms suited to local needs.[45] In addition to direct outlays from general funds, many communities have begun to rely on other sources, such as bonds, stormwater utilities and other public enterprises, taxes, and community assessments. A summary of funding sources is provided in Table 3-2: Funding Generation: Methods for raising funds for green infrastructure;[46] bonds and stormwater utility fees are explained in more detail below, followed by a discussion of incentives to spur private action. The chapter concludes with a look at four innovative approaches borrowed from the energy efficiency field that show great promise for financing green infrastructure (the Property Assessed Clean Energy [PACE] program, on-bill financing, off-balance-sheet financing, and credit enhancement to accelerate private investment in retrofits) and a summary of two additional mechanisms, environmental tax shifts and reverse auctions, that have been used in a limited way to finance green infrastructure.

Selling bonds is a traditional approach to public capital project financing and has been used for stormwater investment funding. Functionally, it is the equivalent of taking loans from bond purchasers. As an example, on November 2, 2004, Los Angeles voters overwhelmingly passed Proposition O, authorizing the city to issue a series of general obligation bonds for up to $500 million. The measure funds improvements to safeguard water quality; provide flood protection; and increase water conservation, habitat preservation, and open space.[47]

The popularity of stormwater utility fees has risen over recent years as a dedicated source of funding. These are fees charged to both taxpaying and tax-exempt properties, often based on the property's total area or amount of impervious surface, that can be added to water, sewer, or utility bills, or charged separately. In 2008, on average, the quarterly fee charged to a single-family home is $11, though it can range from $2 to $40.[48] In setting the price, it is important to first identify underlying goals and objectives—for example, installing green roofs on every building, reducing imperviousness, or increasing infiltration—and then set prices accordingly. Moreover, if one objective is behavior change, such as encouraging property owners to reduce imperviousness, the fee must be high enough to serve as an incentive to achieve such change.[49]

As stormwater fees and stormwater utilities gain popularity, an important consideration is the need to ensure that stormwater charges are equitable and based on the actual burden an individual property places on the sewer system. For example, the Philadelphia Water Department (PWD) is transitioning its monthly Stormwater Management Service charge, which had been based on the size of the water meter (reflecting the volume of potable water usage), to an impervious area–based charge for all nonresidential properties within city limits. This change in the rate structure is revenue-neutral and more accurately represents a fair cost of service. It also allows PWD to charge properties that contribute to the stormwater problem but are currently not customers (like parking lots, vacant lots, and others without water or sewer service). The new fee structure also provides property owners an opportunity to claim credits that reduce (or even nearly eliminate) their fees, if they retrofit their parcels to manage runoff on-site. NRDC is working with PWD to develop financing mechanisms that capitalize on this incentive structure to catalyze large-scale investments of private capital to underwrite the costs of retrofits.[50]

Additional methods outlined in Table 3-2: Funding Generation: Methods for raising funds for green infrastructure include a number of one-time fees, including special assessments, which are similar to stormwater utility fees. Butler County, Ohio, charges certain property owners a user fee based on their contribution to stormwater runoff.[51] Other types of charges that have been used to offset stormwater management costs include development fees, drinking water/wastewater fees, impact/facility fees, and permit and inspection fees.

INCENTIVIZING GREEN INFRASTRUCTURE THROUGH GOVERNMENT-RUN FINANCING AND INDUCEMENTS

Incentives encourage developers and property owners to modify certain behaviors. For developers, key motivators include revenue increases, cost reductions, streamlined permitting and inspection processes, and reduced risk.[52] For property owners and the general public, cash rebates, discounts, tax credits, and small community grants motivate action.[53] In the case of Philadelphia's improved stormwater fee, property owners can receive credits for adding green stormwater infrastructure to their properties or for making their properties less impervious. Education, outreach, and technical assistance programs that engage communities, increase public understanding and acceptance, and train professionals are also critical to the success of green infrastructure programs.[54]

When green infrastructure provides benefits for developers and homeowners, they are willing to share the costs and maintenance responsibilities. A survey of Portland residents found that they are more willing to invest in on-site stormwater projects that provide aesthetic and functional benefits for them than those that simply reduce sewer burdens.[55] This survey found that private homeowners and business owners are willing to contribute increasing amounts as long as the city's share of the total cost increases more. Some people view green infrastructure as personally beneficial, and they are willing to help maintain and pay for it when it is designed to provide benefits they appreciate. In a separate survey of Portland residents, more than half reported that they would be willing to donate one to three hours per month to maintain green infrastructure vegetation.[56] Green infrastructure has the potential to be a neighborhood resource and point of pride that pipes and storage tanks cannot be.

INNOVATIVE APPROACHES TO COST-EFFECTIVELY IMPLEMENT GREEN INFRASTRUCTURE

A new generation of innovative financing approaches, which have been deployed primarily in the energy efficiency and renewable energy financing sector to date, hold great potential for financing stormwater retrofits. These approaches depend upon a municipality having in place a stormwater billing structure that includes a credit for owners who install stormwater retrofits. Under such a fee structure, when the value of the credit is large enough, property owners can realize ongoing savings from investments in retrofits, and lenders, or third-party investors, can make available the necessary capital to fund retrofit installation by relying on the property owners' savings as a "cash flow" that is available to pay back those up-front capital costs. Four financing approaches that rely on such a fee structure are summarized below: Property Assessed Clean Energy (PACE), on-bill financing, off-balance-sheet project financing, and credit enhancement to accelerate private investment in retrofits.[57]

Property Assessed Clean Energy (PACE)

Under a typical PACE model, a municipality issues special revenue bonds, the proceeds are then used by participating property owners to pay for improvements to their property such as renewable energy installations, energy efficiency retrofits, or in this case, stormwater retrofits. Property owners who receive PACE financing agree to repay the costs of the retrofit through an assessment on their property taxes for the useful life of the improvements. Because the assessment is part of the property tax, it is attached to the property, not the individual owner. PACE thereby addresses two of the primary challenges in energy-related property retrofits: up-front cost, and the risk that the owner will not be able to recover the retrofit costs through energy savings by the time the property changes hands. As of October 2011, 27 states and the District of Columbia have PACE-enabling legislation in place, providing legal authority for municipalities to implement PACE programs.[58] To date, no PACE program has been established that allows the use of PACE funds for stormwater retrofits, although some state legislation does authorize financing for water efficiency improvements, and it is possible that some stormwater retrofits could be included under that umbrella. Most states, however, would likely need to amend PACE- enabling legislation to explicitly include stormwater retrofits.

On-bill financing

Under an on-bill financing structure, a utility provides the up-front capital for improvements to private property and the utility collects repayment, typically with no to low interest, through the monthly billing process.[59] Financing for the retrofits can come from ratepayer funds, from other state or local funds, or from a private investor who relies on the history of ratepayer default rates as a yardstick for repayment of retrofit funds lent. In these cases, the investor would have a contractual agreement with the utility to receive a predetermined amount from each participating property owner's utility bill, as a means to recoup the capital outlay. The loan repayment obligation can run such that, if the property is sold during the repayment period, the new owner would assume responsibility for paying the on-bill charges through the utility bill.

Off-balance-sheet financing

Because commercial building owners are often unwilling or unable to encumber their balance sheets with additional debt to finance retrofits, a class of energy efficiency investment firms has arisen which provide "off balance sheet" financing for efficiency retrofits. These firms do not loan capital to the building owner but instead act as energy efficiency "project developers" or "energy solution providers."[60] With variations in precise structure, these firms cover all up-front costs for the energy retrofit (hence the project is taken off the building owner's balance sheet). In exchange, the project developer enters into a contractual agreement with the building owner whereby the owner pays the developer in installments based on a portion of the energy savings resulting from the retrofit, with the owner retaining the balance of the savings. The project developer is also responsible for maintaining the retrofit installation and monitors and verifies subsequent energy savings. Unlike the PACE and on-bill financing models, municipalities or utilities need not be directly involved in the off-balance-sheet financing approach.

Credit enhancement to accelerate private investment in retrofits

Credit enhancement refers to methods that provide a financial backstop for a specified percentage of losses in a portfolio of debt-financed projects. Because credit enhancement facilities take responsibility for initial losses, credit enhancement can go a long way toward bringing lenders to the table for projects that otherwise might be considered too risky, allowing a wider range of borrowers to gain access to capital at lower interest rates and with longer repayment periods than would otherwise be available. Credit enhancement facilities can be set up by private firms (who often take a fee from participating borrowers), public entities, or public-private partnerships.

Additional financing tools

Two more concepts worth additional study and consideration are environmental tax shifts and reverse auctions. The former is an innovative funding alternative that, while not popular in the United States, has been successfully used in other countries to place taxes on things society wants to reduce, such as air pollution or stormwater runoff.[61] One example of a creative environmental tax shift addressing stormwater runoff was a pay-to-pave tax proposal in Massachusetts that was identified but not implemented.[62,63]

While the concept is still new and unproven in the application of stormwater management, some communities are using reverse auctions to encourage homeowners to implement green infrastructure techniques on their properties. In a reverse auction, homeowners compete to offer the lowest price at which they will implement green infrastructure, and then the stormwater authority pays the winning, lowest bid. An analysis of a procurement auction of rain gardens and rain barrels in the Midwest found that an auction can promote more participation in green infrastructure than education alone, and at a cheaper per-unit control cost than a flat stormwater control plan.The study also found that relatively minimal financial incentives (approximately 55 percent of the bids were for $0) can result in homeowners' willingness to accept green infrastructure techniques on their properties. The authors conclude that "in the absence of a strict regulatory cap, an auction is a cost-effective tool for implementing controls on stormwater runoff quantity at the parcel level."[64]

Finally, Congress is currently considering a bill called the Green Infrastructure for Clean Water Act of 2011, which would, among other things, allow the EPA to finance federal cost-share grants for planning and implementation of green infrastructure programs and to establish incremental targets for stormwater management.[65] Known as the Green Infrastructure Portfolio Standard, these targets would increase the use of green infrastructure over time, similar to renewable portfolio standards that most states have adopted to reach renewable energy targets.[66] The creation of these standards, included in both the House and Senate versions of the bill, would move green infrastructure front and center as a stormwater management strategy.

Table 3-2: Funding Generation: Methods for raising funds for green infrastructure		
Financing Source	**General Description**	**Example**
State & Federal Loans	A number of federal and state programs provide low and no-interest loan options, including EPA's Clean Water State Revolving Fund, which distribute federal funds to states and then communities.	Much of traditional water infrastructure.
General Fund	Property and sales tax revenue paid into a general fund can be used for stormwater management activities. However, as stormwater needs increase, it puts more pressure on general fund budgets, which has led to more fee-based programs.	Much of traditional water infrastructure.
Bonds	Selling bonds is a traditional approach for public financing of capital projects. Functionally, it is the equivalent of taking loans from bond purchasers.	Voters in the City of Los Angeles passed a $500 million bond initiative for water quality, flood protection, water conservation, and habitat protection.
Stormwater Utility Fees	A type of public enterprise fee charged as part of a standard utility bill. Property owners are charged based on estimated contribution of stormwater runoff.	Cities such as Philadelphia, Pennsylvania, Lenexa, Kansas and Portland, Oregon calculate user fees for commercial, multi-family residential and industrial properties by their total lot size and percentage of imperviousness.[a] When establishing user fees, it is important to set the price appropriately at the first opportunity, as it may be years before enough political support can be garnered to warrant a rate hike.[b]
Special Assessments	When a specific stormwater project is implemented and only benefits a particular area, property owners within that area can be levied an assessment in proportion to the benefit each receives.	Butler County, Ohio enacted a stormwater district in order to fund required stormwater controls.[c]
Development Fees	System development charges or stormwater development fees are one-time fees which are assessed in connection with construction of new impervious area or a new development to pay for necessary (new) stormwater infrastructure.	The Southeast Metro Stormwater Authority in Colorado charges a System Development Fee to developers to pay for new stormwater infrastructure that the developers make necessary.[d]
Drinking Water/ Wastewater Fees	Drinking water and wastewater fees are usually based on metered water flow, though this bears little relationship to stormwater runoff.	Common financing tool.
Impact/Facility Fees	Impact fees are one-time fees related to the impact generated by the new development project; they require special local enabling legislation.	The Lenexa City Council adopted a Systems Development Charge, which requires new development to pay a one-time fee at the time of building permit as a means for recovering costs for capital improvement activities within the Rain to Recreation program so that growth pays for growth.[e]
Permit And Inspection Fees	Local governments can set regulatory fees to cover the cost of permitting and inspection programs.	The Sussex Conservation District in Delaware charges a construction inspection fee on all new development, both public and private, based on the size of the project to contribute to stormwater and erosion control.[f]
Property Assessed Clean Energy (PACE) Program	A municipality issues special revenue bonds; the proceeds are used by participating property owners to pay for improvements to their property. Payments are made through property taxes.	No example yet available for green infrastructure.
On-bill financing	A utility provides the upfront capital for improvements to private property and the utility collects repayment, typically with low to no interest, through the monthly billing process.	No example yet available for green infrastructure.

Table 3-2: Funding Generation: Methods for raising funds for green infrastructure		
Financing Source	**General Description**	**Example**
Off balance sheet project financing	An outside firm covers all upfront costs for a retrofit and the building owner repays this investment based on a portion of the savings resulting from the retrofit.	No example yet available for green infrastructure.
Credit enhancement to accelerate private investment in retrofits	Credit enhancement refers to methods that provide a financial backstop for a specified percentage of losses a portfolio of debt-financed projects. Because credit enhancement facilities take responsibility for initial losses, credit enhancement can help bring lenders to the table for projects that otherwise may be considered too risky, allowing a wider range of borrowers to gain access to capital at lower interest rates and with longer repayment periods than would otherwise be available.	No example yet available for green infrastructure.
Environmental tax shifts	Used in other countries to place taxes on things society wants to reduce, such as air pollution or stormwater runoff.[g]	A "pay-to-pave" tax was introduced in Massachusetts, but not implemented.[h,i]
Reverse auction	Homeowners compete to offer the lowest price at which they will install green infrastructure, and then the stormwater authority pays the winning, lowest bid.	A procurement auction of rain gardens and rain barrels in the Midwest was found to promote more participation in green infrastructure than education alone and at a cheaper per-unit control cost than a flat stormwater control plan.[j]
Funding Allocation: Methods for implementing green infrastructure projects and targeting funding		
Public Works	The standard means for managing grey infrastructure, through public construction and ownership, is still likely the most direct approach for green infrastructure as well, particularly for large-scale projects on dedicated sites.	Common.
Public-Public Collaborations	There are opportunities for multiple public agencies to meet goals through green infrastructure, such as collaborations with parks, schools, and other publicly-owned potential sites. This is most promising when green infrastructure provides benefits such as education and aesthetics that are beneficial on-site.	Schools, such as Thurston Elementary in Ann Arbor, Michigan, have installed rain gardens for both water quality and education benefits.[k]
Public-Private Collaborations	Similar to public-public collaboration, many private institutions and businesses experience benefits sufficient to support on-site green infrastructure, which might be partially expanded via public cost-sharing.	Businesses in Portland, Oregon's Tabor to the River Corridor such as New Seasons Market and Fred Meyers have constructed rain gardens in their parking lots with support from the city.[l]
Private Grants and Loans	Public and private groups are providing low and deferred interest loans as well as grants to homeowners and businesses for on-site green infrastructure capital costs. Often, the private recipients stay involved by providing operation and maintenance.	Lexington, Kentucky provides Stormwater Quality Project Incentive Grants to businesses, non-profits, and residences for onsite stormwater projects like installation of permeable pavements. The Water Quality Management Fee funds the program.[m]
Tax Credits	One-time or continuing tax reductions are a means to motivate private installation and maintenance of green infrastructure.	Anne Arundel County, Maryland offers property tax credits for owners who implement onsite stormwater control such as removal of impervious surfaces.[n]
Fee Reductions	Various fees, such as sewer fees, can be reduced as a means of motivating private green infrastructure. If the green infrastructure provides private benefits as well, there are opportunities for cost-sharing.	In Philadelphia, Portland and Seattle, fee discounts and credits provide an opportunity for property owners to reduce the amount they pay by decreasing impervious surfaces or by using green infrastructure techniques that reduce the amount of stormwater runoff.

Notes:

a U.S. EPA, "Managing Wet Weather with Green Infrastructure: Municipal Handbook Funding Options," September, 2008, p. 3; http://www.epa.gov/npdes/pubs/gi_munichandbook_funding.pdf.

b Changnon, S.A. (April 2008). "Assessment of Flood Losses in the United States," *Journal of Contemporary Water Research & Education*, 138: 38-44, accessed at http://onlinelibrary.wiley.com/doi/10.1111/j.1936-704X.2008.00007.x/pdf

c "Butler County Stormwater District," accessed at http://www.stormwaterdistrict.org/index.htm.

d "Southeast Metro Stormwater Authority (SEMSA)," accessed at www.semswa.org.

e U.S.EPA, p. 10.

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CHAPTER 4: POLICY RECOMMENDATIONS FOR LOCAL, STATE AND NATIONAL DECISION-MAKERS

Since *Rooftops to Rivers* was first published in 2006, there has been a remarkable uptake of green infrastructure policy at the national and local levels. The U.S. EPA has issued multiple policies on integrating green infrastructure into regulatory programs and developed a national green infrastructure strategy. Congress set aside funding that could be used for green infrastructure through the Green Project Reserve as part of the additional State Revolving Loan funding made possible by the American Recovery and Reinvestment Act (ARRA). Key developments include:

APRIL 2011

- April 29: EPA Deputy Administrator Bob Perciasepe announces the release of EPA's "Strategic Agenda to Protect Waters and Build More Livable Communities. Through Green Infrastructure,"[1] a document that identifies how the agency will help communities implement green infrastructure approaches.

- April 29: Deputy Administrator Perciasepe announces EPA's green infrastructure community partnership effort. EPA will work with 10 communities on green infrastructure implementation issues.[2]

APRIL 2011

- April 20: EPA Assistant Administrator Cynthia Giles, Office of Enforcement and Compliance Assurance and Acting Assistant Administrator Nancy Stoner, Office of Water, release a joint memorandum, "Protecting Water Quality With Green Infrastructure in EPA Water Permitting and Enforcement Programs." The document "strongly encourages and supports the use of green infrastructure approaches to manage wet weather through infiltration, evapotranspiration and rainwater harvesting."[3]

FEBRUARY 2009

- Feb 21: As part of the American Recovery and Reinvestment Act of 2009, Congress and President Obama target 20 percent of the Clean Water and Drinking Water State Revolving Funds to green infrastructure and other environmentally innovative projects.

OCTOBER 2008

- October 15: The National Research Council releases "Urban Stormwater Management in the United States," which identifies a series of regulatory and other hurdles to stormwater management and recommends green infrastructure as a critical part of the solution.

JANUARY 2007

- January 4: Congress passes the "Energy Independence and Security Act of 2007." Section 438, "Stormwater Runoff Requirements for Federal Development Projects," requires new and redevelopment projects "to maintain or restore, to the maximum extent technically feasible, the predevelopment hydrology of the property with regard to the temperature, rate, volume, and duration of flow.[4]

APRIL 2007

- April 19: EPA (with NRDC and other national organizations) is a signatory to the 2007 *Green Infrastructure Statement of Intent* "…to promote the benefits of using green infrastructure in protecting drinking water supplies and public health, mitigating overflows from combined and separate sewers and reducing stormwater pollution, and to encourage the use of green infrastructure by cities and wastewater treatment plants as a prominent component of their Combined and Separate Sewer Overflow (CSO & SSO) and municipal stormwater (MS4) programs."[5]

MARCH 2007

- March 5: EPA Assistant Administrator Benjamin H. Grumbles issues a memorandum entitled, "Using Green Infrastructure to Protect Water Quality in Stormwater, CSO, Nonpoint Source and Other Water Programs,"[6] identifying the cost-effectiveness of green infrastructure and the range of its benefits, outside of infiltration, evapotranspiration and/or reuse of stormwater.

AUGUST 2007

- August 16: EPA Water Permits Division Director Linda Boornazian issues a memorandum entitled, "Use of Green Infrastructure in NPDES Permits and Enforcement," describing how permittees can "utilize green infrastructure approaches, where appropriate, in lieu of or in addition to more traditional controls."[7]

The EPA has followed guidance with action. As its Assistant Administrator for Enforcement and Compliance Assurance wrote in a letter to the U.S. Conference of Mayors:[8]

> The EPA and the Department of Justice strongly believe that green infrastructure presents an exciting opportunity for stormwater management approaches that help eliminate CSOs in a cost-effective manner, while simultaneously securing a host of important environmental and community benefits, including improved water and air quality, increased energy efficiency, green spaces and economic development. For these reasons, the EPA is committed to the use of green infrastructure projects in CSO settlements wherever it is feasible and appropriate. The EPA and the DOJ strongly encourage all CSO communities to consider green infrastructure, as part of an integrated approach to CSO control.

In the past five years, the EPA and the Department of Justice have negotiated consent decrees incorporating significant green infrastructure controls with Cincinnati, Louisville, Cleveland, Indianapolis, and Kansas City, among other cities. In the Cleveland area, the Northeast Ohio Regional Sewer District will invest $42 million over 10 years to implement green infrastructure projects, to prevent 44 million gallons of sewage and stormwater from entering Lake Erie annually, with an opportunity to substitute more green in lieu of planned gray infrastructure in the future.[9] States have also required significant green infrastructure investment in their own consent orders with municipalities, covering such places as, Onondaga County (which includes Syracuse) and Philadelphia, as well as a proposed order in New York City.

As rapidly as national policy has evolved, many U.S. cities have gone even further, as identified by the case studies in this report. Many have set on-site stormwater retention standards, to help manage stormwater and to address other regulatory and/or planning issues. In Philadelphia, the first inch of rainfall must be managed on-site through infiltration (if feasible), in all new development and redevelopment projects with at least 15,000 square feet of earth disturbance;[10] in Pittsburgh, the first inch of rainfall must be retained on-site through infiltration, evapotranspiration, or rain harvesting for new development and redevelopment larger than 10,000 square feet.[11] Smaller cities have done so as well. Aurora, Illinois requires the first 0.75 inch of rainfall to be stored or retained on-site.[12]

On-site retention standards are not limited to individual cities; some states and counties have such requirements that apply as part of their MS4 permit obligations. South Carolina mandates the retention of the first 1.5 inches of rainfall in certain ecologically sensitive areas. Massachusetts and New Jersey require the on-site retention of the difference between the pre-development and post-development runoff volume. Vermont calls for the capture of 90 percent of annual storms, and several MS4 permits in California, including those for Ventura County, Orange County, and the San Francisco Bay Region, require the retention of the 85th percentile storm volume. While some of these requirements apply only in areas served by municipal storm sewer systems, some pertain to all developments over a certain size. New Hampshire, West Virginia, and Tennessee require the on-site retention of the first inch of rainfall.[13]

As detailed throughout this report, cities (and states) are encouraging green strategies using incentives, zoning and permitting programs, as well as investing their own money on public property. For example, Portland, Oregon has one of the most comprehensive city green programs in the country. From 2008 to 2013, the city budgeted $50 million in stormwater management fees to invest on city property; this is expected to add 43 acres of ecoroofs, build 920 green street facilities, plant 33,000 yard trees and 50,000 street trees, reduce invasive weeds, and purchase 419 acres of high-priority natural areas.[14] New York's Department of Environmental Protection has committed more than $190 million over the next four years retrofit public spaces with green infrastructure across the city as well as install three focused, neighborhood-scale demonstration areas of 18 to 40 acres each.[15,16] As part of a $2.4 billion Long Term Control Plan, Philadelphia will invest at least $1.67 billion of public funds, while leveraging additional private investment through a performance standard for redevelopment projects, to transform 34 percent of impervious surfaces draining to its combined sewer system into greened acres that manage the first inch of runoff on-site.

This progress provides many lessons that can be applied to address the full magnitude of stormwater and sewer overflow problems nationwide. More local and national policy progress can and must be made at the federal, state and local levels.

RECOMMENDED FEDERAL ACTION: EPA

It is clear that the EPA recognizes the value of green infrastructure. However, it can do more to fully integrate green infrastructure into its permitting and regulatory programs.

Reform Clean Water Regulations and Guidance for Stormwater Sources

As this report goes to press, EPA is poised to take advantage of a once-in-a-generation opportunity to reform the minimum requirements applicable to urban and suburban runoff sources. Existing EPA regulations for sources of runoff pollution, designed more than 20 years ago, have not been implemented in a particularly rigorous way. As discussed elsewhere in this report, permits for stormwater systems historically have done a poor job of ensuring that discharges from those systems will not contribute to degraded water quality conditions. In particular, municipal sewer systems and private developers frequently have not been required to meet quantitative limits on stormwater runoff volumes, and associated pollution levels, from sites undergoing development or redevelopment, and have rarely been required to retrofit developed sites to reduce runoff pollution. Moreover, current requirements typically do not apply to rapidly-developing areas outside of existing urbanized areas.

Fortunately, EPA has initiated an effort to improve the requirements that govern how stormwater sources are controlled to protect water quality. In response to litigation filed by NRDC and the Waterkeeper Alliance several years ago over EPA's failure to update its standards for pollution from construction and development activities, the agency expects to update the requirements that apply to long-term runoff from developed sites by proposing a rule winter 2011 and finalizing it in November 2012.[17]

To adequately address water quality concerns posed by runoff pollution, the EPA's new rules must adopt objective performance requirements for control of runoff volume from new development and redeveloped sites, which will create strong incentives for the deployment of green infrastructure approaches. The EPA should also require retrofits in existing public and private developed areas and as part of infrastructure reconstruction projects. Likewise, the agency needs to ensure that significant runoff sources are covered wherever they are located.

The EPA's new rules can and should address new development and redevelopment in both combined sewer and separately sewered areas. Additionally, for combined sewer areas, the agency should update its 16-year-old guidance on the development of CSO Long Term Control Plans to make clear that, under the CSO Control Policy that Congress codified in 2000, CSO communities must conduct integrated planning that identifies opportunities to use green infrastructure in cost-effective combinations with (or, where appropriate, as substitutions for) gray infrastructure. EPA should also provide detailed guidance to its regional offices and to states that explains how to draft enforceable green infrastructure requirements for inclusion in Clean Water Act permits and compliance orders pertaining to CSOs, MS4s, and sanitary sewer overflows (SSOs).

Use Authority Under the Current Law

Even before the EPA reforms its rules, the agency (and state agencies) should use their authority under the current law to ensure that communities implement strong green infrastructure-based plans that achieve critical water quality goals for receiving waters. For instance, communities developing CSO long-term control plans increasingly rely on enforceable commitments to install green infrastructure as a major component of reducing overflows. NRDC strongly encourages this approach. The Philadelphia Water Department and state environmental officials recently signed an ambitious agreement that commits the city to deploy, over the next 25 years, the most comprehensive network of green infrastructure found in any U.S. city; key performance metrics will also be incorporated into the city's CWA permits.[18] Cleveland, Cincinnati, Kansas City and other cities have similar requirements, which are focused initially on near-term investments in green infrastructure, with opportunities to substitute more green in lieu of planned gray infrastructure in future years.

Applicable CWA standards for reducing CSOs clearly require practicable steps like green infrastructure, and the EPA should ensure that all future CSO permits and orders incorporate green infrastructure as part of an integrated approach; the same should also apply to SSOs, wherever excessive inflow and infiltration are major contributors to overflows. Likewise, because green infrastructure commonly will be a cost-effective strategy for reducing pollution from separate stormwater systems, EPA and its state counterparts should develop CWA permits for these systems that promote green infrastructure by requiring on-site retention of stormwater, and that require green infrastructure directly, in the form of direct mandates to install specific practices throughout the service area. For example, under an EPA permit issued in October 2011, many development projects in the nation's capital will soon be subject to a strong retention standard. The Washington, D.C. MS4 permit requires that the first 1.2 inches of rainfall be retained on-site on all new development and redevelopment sites that disturb an area greater than 5,000 square feet.[19] The permit also specifies that the District must install at least 350,000 square feet of green roofs on city properties and plant 4,150 or more trees per year.[20]

RECOMMENDED FEDERAL ACTION: DEPARTMENT OF TRANSPORTATION

The U. S. Department of Transportation (DOT) should provide guidance and funding to address the significant contributions of pollutants caused by road and highway construction. Contaminants from vehicles and activities associated with road and highway construction and maintenance are washed from roads and roadsides when it rains or when snow melts. A large amount of this runoff pollution is carried directly to water bodies.

The DOT participates in the Partnership for Sustainable Communities along with the EPA and the U.S. Department of Housing and Urban Development (HUD); the Partnership awards grants to support livable and sustainable communities. The Partnership's grants include DOT's Transportation Investment Generating Economic Recovery (TIGER) grants, which are awarded on a competitive basis for capital investments in surface transportation projects that will have a significant impact on the nation, a metropolitan area, or a region. Since the TIGER grant program began, only a few projects have received funding to implement green infrastructure. One of these is the Mercer Corridor project in Seattle, which will use TIGER grant funds to reduce Mercer Street's impervious area by 0.7 acre, install natural drainage using a "wet median" and rain gardens, and increase the tree canopy along the corridor.[21] In the future, TIGER grants should go further, requiring that some percentage of highway funds be used for environmental protection. For example, recipients of federal transportation dollars should be required to use green infrastructure to protect water bodies.

RECOMMENDED FEDERAL ACTION: CONGRESS

Fully Fund EPA's Clean Water State Revolving Fund

As noted in Chapter 3, there is a need to invest nearly $300 billion over the next 20 years in water and wastewater infrastructure; $63.6 billion is needed for CSO correction alone.[22] In the long term, Congress should help states and local communities reach these investment levels by substantially increasing the federal resources available to meet clean water needs through the creation of a trust fund or other dedicated source of clean water funding. But Congress also needs to act today, by increasing annual funding to the Clean Water State Revolving Fund (CWSRF), which provides critical assistance for projects that repair and rebuild failing water and wastewater infrastructure, and which, in recent years, has also focused funding on green infrastructure projects. Unfortunately, the CWSRF has been a target for cuts during recent federal budget debates. Money for the revolving fund was cut dramatically for the current fiscal year, and President Obama has suggested cutting nearly $1 billion from the CWSRF and its companion program, the Safe Drinking Water State Revolving Fund.[23]

At a minimum, Congress should restore these critical funds. And there is a strong case that they should be enhanced, not only because there are enormous unmet needs, but also because these investments yield tremendous economic benefits. In a recent letter, for example, 35 members of the Senate from across the political spectrum hailed the societal payback that comes from investments in water infrastructure:

> "The U.S. Conference of Mayors notes that each public dollar invested in water infrastructure increases private long-term gross domestic product output by $6.35. The National Association of Utility Contractors estimates that every $1 billion invested in water infrastructure creates more than 26,000 jobs. In addition, the Department of Commerce estimates that each job created in the local water and sewer industry creates 3.68 jobs in the national economy and each public dollar spent yields $2.62 dollars in economic output in other industries. This is a highly leveraged Federal investment that results in significant job and economic benefits for every dollar spent."[24]

Just before this report went to press in November, 2011, the "Water Quality Protection and Job Creation Act of 2011" was introduced by Representatives Tim Bishop (D-NY), Nick J. Rahall (D-WV), Tom Petri (R-WI) and Steven LaTourette (R-OH).[25] The bill authorizes $13.8 billion over five years for wastewater infrastructure through the State Revolving Fund. The bill looks promising, although it lacks specifics. Projects that "will achieve water-efficiency goals, energy-efficiency goals, stormwater runoff mitigation, or environmentally sensitive project planning, design and construction"[26] will receive additional subsidies, but the bill does not make clear what those subsidies are. The bill would also provide "economic incentives to encourage the adoption of energy- and water-efficient technologies and practices to maximize the potential for efficient water use, reuse, and conservation, and energy conservation, and realize the potential corresponding cost-savings for water treatment"[27]—again, promising language, but lacking in specifics. There is no direct mention of green infrastructure as a means to achieve the water quality benefits envisioned by the legislation.

The bill does establish a Clean Water Trust Fund, which can provide up to $10 billion annually that will encourage "projects that utilize green infrastructure approaches, energy- or water- efficiency improvements, and/or the implementation of best management practices."[28] Unfortunately, the bill does not establish a long-term funding mechanism for the Trust Fund, but rather directs the Congressional Budget Office to study how to capitalize it.

Green Infrastructure for Clean Water Act

The goal of the Green Infrastructure for Clean Water Act (H.R. 2030 and S. 1115) is to help overcome barriers to wide-scale green infrastructure implementation by improving the knowledge base about green infrastructure, supporting real-world demonstrations, and better integrating green infrastructure into the day-to-day regulatory structure with which communities and developers are already familiar.

Introduced by Representative Donna Edwards (D-MD) and Senators Tom Udall (D-NM) and Sheldon Whitehouse (D-RI), the Green Infrastructure for Clean Water Act would:

- Establish three to five Centers of Excellence for Green Infrastructure in universities or research institutions located in various regions of the United States to investigate regionally relevant green infrastructure issues, develop manuals and best practices, and provide technical assistance to state and local governments.
- Provide green infrastructure project grants to state and local governments and to stormwater and wastewater utilities to plan and develop green infrastructure projects, code revisions, fee structures, and/or training materials.
- Direct the EPA to promote and coordinate the use of green infrastructure in permitting programs, research, technical assistance, and funding guidance. Notably, it would direct the EPA to incorporate green infrastructure into consent decrees (something the agency is increasingly doing today).

Transportation Legislation

- Congress periodically passes bills that fund and authorize federal surface transportation projects around the country, and the federal transportation bill is due to be renewed. These bills provide a major opportunity to address runoff pollution from highways and roads; any new bill should require roadway projects to retain a certain amount of the runoff that their impervious surfaces generate. As noted above, in the Energy Independence and Security Act of 2007, Congress previously required certain federal facilities to maintain the "predevelopment hydrology" of a site in undertaking specified development projects. This kind of approach could serve as a model for transportation legislation.
- In addition, if Congress delays in passing a comprehensive transportation bill, or if it acts on a bill lacking needed stormwater standards, it can and should pass stand-alone legislation requiring federally funded roads and highways to control runoff pollution to an objective retention standard. Senator Ben Cardin (D-MD) has introduced such a bill, the Safe Treatment of Polluted Stormwater Runoff Act (S. 898, also known as the STOPS Runoff Act), which would require new highways and highway improvement projects to maintain or restore the predevelopment hydrology of the project site to the maximum extent technically feasible.

RECOMMENDED LOCAL ACTION

NRDC's Emerald City metric identifies six actions cities should undertake to fully realize their green infrastructure investment. Each action is identified below, along with specific policy recommendations for local leaders. Only one of the cities profiled in this report, Philadelphia, met all six criteria.

- **Develop a long-term green infrastructure plan**
  A comprehensive plan lays out a vision for how green infrastructure will be implemented across a city. Reducing or preventing stormwater runoff remains the most effective way to minimize pollution because it prevents pollutants from being transported to water bodies and it reduces the total volume that sewer systems must capture and treat. Cities that incorporate green infrastructure into the earliest stages of community development, and into redevelopment of already built-out areas, can negate or limit the need for larger-scale, more expensive stormwater controls.[29] As reported in Chapter 3, a recent survey by the American Society of Landscape Architects (ASLA) found that green infrastructure reduced or had no impact on development costs 75 percent of the time.[30] Minimizing imperviousness, preserving existing vegetation, and incorporating green space into designs all decrease the impact that urbanization has on water quality.

  Six of the cities profiled have long-term green infrastructure plans in place (Aurora, Nashville, New York, Philadelphia, Syracuse and Toronto). Each plan is tailored for its city, although there are similarities. Although not a comprehensive plan, Milwaukee modeled part of its green infrastructure strategy, Fresh Coast Solutions[31] (and the underlying analysis) on Philadelphia's Green City, Clean Waters plan.[32] Aurora modeled its plan on the 2006 *Rooftops to Rivers* report, but tailored it by incorporating a number of neighborhood, open space and master planning efforts.

- **Develop and enforce a strong retention standard for stormwater**
  Cities should identify appropriate retention standards for new development and redevelopment to minimize the volume of runoff discharged from developed sites. State and local stormwater regulations should be revised to require retention of a sufficient amount of stormwater through infiltration, evapotranspiration, and rainwater harvesting to ensure water quality protection. Eight of the cities profiled have retention standards in place or will have them soon. They range from Washington, DC's 1.2-inch retention standard for new development and redevelopment, achieved through evapotranspiration, infiltration, and rainwater harvesting to Chicago's half-inch standard for new development.

- **Require the use of green infrastructure to reduce, or otherwise manage runoff from, some portion of the existing impervious surfaces**
  In addition to planning for green infrastructure, cities must require its use, specifically to replace impervious surfaces or otherwise capture runoff from those areas, over a specified period. Six of the cities profiled in this report (Milwaukee, New York, Philadelphia, Portland, Syracuse and Washington, DC) have such a requirement. As part of Philadelphia's 25-year Green City, Clean Waters plan, the city is committed to transform at least 34 percent of its impervious surface in combined sewer areas (about 9,500 acres) into greened acres that manage the first inch of runoff onsite. The plan also includes binding interim targets in five-year increments. Portland also has a requirement to develop a retrofit plan for existing impervious surfaces, and has programs designed to replace city-owned impervious surfaces along streets and on municipal building roofs.

  Local zoning requirements and building codes should also be revised to require or encourage the use of green infrastructure. New York City's zoning rules prohibit buildings in low-density districts from paving over their entire front yards.[33] Toronto will require mandatory downspout disconnections starting in November 2011[34] and the city adopted construction standards in 2009 requiring all new buildings and retrofits with more than 2,000 square meters of floor area (roughly 21,500 square feet) to include a green roof.[35]

- **Provide incentives for residential and commercial private party use of green infrastructure**
  Communities should continue to develop innovative ways to incentivize the use of green infrastructure on private property. Ten of the cities profiled in this report (Chicago, Milwaukee, Nashville, New York, Philadelphia, Portland, Seattle, Syracuse, Toronto and Washington, DC) provide incentives in at least one of the following categories: permitting advantages or financial incentives.

  Permitting Advantages
  Many communities offer advantages in the building and development permitting process to those projects that incorporate certain green infrastructure elements. For example, fast-track permitting procedures have been instituted in Chicago (for buildings with green roofs),[36] in Nashville (for buildings with various green features),[37] and in Philadelphia (for properties with 95 percent or more of their impervious area disconnected from the sewer system).[38] Alternatively, communities often offer permitting "bonuses" to green infrastructure projects: Chicago gives density and building height bonuses for projects with green roofs in the city's business district;[39] Portland has offered developers proposing buildings in the Central City Plan District floor area bonuses if a green roof is installed;[40] and Washington, D.C. is planning to implement a "Green Area Ratio" incentive for bonus density and land uses, based on a sliding scale of green infrastructure practices.[41] These permitting advantages provide an incentive for green infrastructure at little or no cost to the local government.

  Financial Incentives
  Cities around the United States implement grant programs that directly pay for the installation of green infrastructure practices on private land. New York City uses grants to stimulate innovation in green infrastructure, providing over $6 million thus far to non-profit organizations, community groups, and private property owners.[42] Syracuse developed a $3 million "Green Improvement Fund" offering grants for green infrastructure retrofits on private property in combined sewer drainage areas.[43] While not a "grant program" per se, Philadelphia offers low-interest (1%) loans for green infrastructure retrofits on non-residential property.[44]

  Rather than directly paying private parties to install practices, some cities indirectly finance green infrastructure by reducing what private parties pay in taxes and fees. Chicago waives permitting fees up to $25,000 for developments with a particularly high level of green strategy implementation, including exceptional water management.[45] New York City and Philadelphia both offer a property tax credit for properties with green roofs.[46,47]

Additionally, many cities charge private properties a stormwater fee based on the amount of impervious surface area on the property, while providing a financial incentive, in the form of a credit or discount on the fee, if property owners install qualifying green infrastructure practices. Such systems have already been implemented in Kansas City,[48] Nashville,[49] Philadelphia,[50] Portland,[51] and Seattle.[52] Washington D.C. is preparing to add a discount component to its imperviousness-based fee system.[53] However, as noted in Chapter 3, it is critical that the fee be set at a level such that the discount actually acts as an incentive for customers to invest in green infrastructure.

- **Provide guidance or other affirmative assistance to accomplish green infrastructure**

Cities should proactively promote the use of green infrastructure through guidance and affirmative action. Guidance includes demonstration projects, planning workshops and technical manuals. Other activities include identifying and overcoming code and zoning barriers.

Downspout disconnections, rain barrels, rain gardens, and green roofs may individually manage a relatively small volume of stormwater but collectively can have a significant impact. Eight of our cities (Nashville, New York, Philadelphia, Portland, Seattle, Syracuse, Toronto and Washington, D.C.) undertake these programs. Portland and Toronto provide citizens with assistance and free labor as part of their downspout disconnection programs.[54,55] Portland's downspout disconnection program, for example, now diverts 1 billion gallons of stormwater away from the combined sewer system each year.

In Toronto, the municipal government issued management guidelines for implementing its Wet Weather Flow Master Plan in 2007; the previous year, it removed code barriers to allow for indoor rainwater use. Washington, D.C. passed a Green Building Act and has implemented a comprehensive zoning code review. It also provides design and construction assistance as part of its "River Smart Homes" program, which helps homeowners reduce stormwater runoff from their properties.[56] Other cities actually go so far as to provide residents with tools and materials needed to complete green infrastructure projects. New York,[57] Philadelphia,[58] and Syracuse[59] have all operated rain-barrel giveaway programs.

A recent survey[60] identified the most common technical barrier to more widespread use of green infrastructure as uneven knowledge, and lack of experience concerning green infrastructure design, maintenance, and benefits at the local, state, and even federal level.

- **Ensure dedicated funding source for green infrastructure**
  Cities must ensure that adequate funding exists to support stormwater management programs. Ten of the cities profiled (Aurora, Kansas City, Milwaukee, Nashville, New York, Philadelphia, Portland, Seattle, Syracuse and Washington, D.C.) have a dedicated funding source for green infrastructure. Many cities charge private properties a stormwater fee based on the amount of impervious surface area on the property. These fee systems often include a credit or discount component where customers pay smaller fees if they install qualifying green infrastructure practices on their properties. As noted above, these fee structures also create a financial incentive for property owners to invest in green infrastructure.

RECOMMENDED STATE ACTION

States also have a critical role in promoting green infrastructure by integrating it into state guidance and regulatory actions.

- **Undertake state-wide green infrastructure planning**
  In the same way that transportation planners link roads, highways and bridges, states should develop green infrastructure plans that connect natural systems to maximize ecological and environmental benefits. The goal of Maryland's Green Infrastructure Assessment is to provide a "comprehensive strategy for land conservation and restoration."[61] Florida's Statewide Greenways System is a physical plan to put such a system in place.[62]

- **Develop and enforce permitting programs that require the use of green infrastructure**
  Most states are authorized to implement the National Pollutant Discharge Elimination System (NPDES) program. States should use this authority, as well as inherent state authorities, to establish performance standards and green infrastructure requirements for new development, redevelopment, and retrofitting of existing developed areas. Some states, including California, Maryland, Maine, Minnesota, New Jersey, and Wisconsin, already incorporate green infrastructure into NPDES permitting requirements. Maine's stormwater regulations include a retention standard that applies to developments over a certain size in the watershed of an impaired stream. It also "strongly encourages applicants to incorporate low-impact development [green infrastructure] measures where practicable.[63]

  And, as noted above, a number of states have on-site retention requirements that apply statewide.

- **Ensure that state building and other development-related codes and standards do not pose an unreasonable barrier to green infrastructure**
  States play a central role in conditioning and setting standards applicable to development and redevelopment projects through state building codes and other regulations. These may include adopting green "stretch" codes developed by bodies like the International Code Council's International Green Construction Code and the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED®) standards. Green infrastructure practices such as swales, pervious pavement, cisterns and water reuse, among others, are more readily included in construction projects when standards and specifications are clear. When developers must surmount additional hurdles to gain approvals for green infrastructure elements in projects, or where each request to do so is dealt with on a case-by-case basis, these cost-saving approaches may be viewed as more trouble than they are worth. States can address this problem by adopting clear standards and guidelines for green infrastructure techniques, assuring that their inclusion in development and redevelopment will not be slowed by confusion surrounding applicable regulations.

- **Eliminate hurdles to ensure availability of appropriate funding sources**
  The Clean Water State Revolving Loan Fund (SRF) programs have always been available to fund stormwater management projects, although the vast majority of SRF money typically goes to wastewater treatment projects. States should ensure that no eligibility hurdles remain (Illinois's statute previously limited eligibility of these funds to wastewater projects) for municipalities to implement a range of green infrastructure projects, including water reuse and the installation of graywater and rainwater systems. Other, specific revenue streams can also be dedicated to environmental improvements, including green infrastructure. For example, New York state's Environmental Protection Fund is funded by a real estate transfer fee and supports programs such as Water Quality Improvement Project grants, which fund stormwater and green infrastructure projects.[64] States can also establish their own dedicated sources of funding to support environmental improvements like green infrastructure, such as through bond acts (as in Los Angeles) and real estate transfer taxes (as in New York state).

  Additionally, states should ensure that local governments are authorized to establish self-sustaining stormwater utilities that can charge fees to property owners based on the size of their impervious areas and provide credits for retrofits that reduce impervious area or otherwise manage runoff onsite. Further, in combination with such fee structures that incentivize on-site stormwater management, states can authorize retrofit financing programs, such as on-bill financing and PACE-type mechanisms (described in Chapter 3), which can accelerate investment in green infrastructure retrofits.

  State transportation agencies should also ensure that their regulations match or exceed federal guidelines. As with the recommendations made above for the U.S. Department of Transportation, state agencies should require state-funded roadway projects to retain a certain amount of the runoff generated by their impervious surfaces. They could require that some percentage of highway funds be used for environmental protection. For example, recipients of state transportation dollars should be required to use green infrastructure to protect water bodies.

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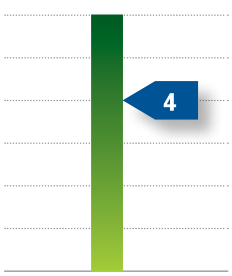
AURORA, ILLINOIS

A CASE STUDY OF HOW GREEN INFRASTRUCTURE IS HELPING MANAGE URBAN STORMWATER CHALLENGES

TYPES OF GREEN INFRASTRUCTURE USED: Rain barrels/cisterns, permeable pavement, rain gardens, infiltration trenches or vaults, vegetated swales, street trees, planter boxes, downspout disconnection, naturalized storm basins

The city of Aurora based its green infrastructure plan on the 2006 *Rooftops to Rivers* report. The city later developed a Naturalized Stormwater Management Corridor Plan (NSMCP) to address the role of green infrastructure as its single sewer pipe was replaced with two pipes. Aurora's mayor, Tom Weisner, has successfully integrated green infrastructure (GI) into the planning done by all city departments. Aurora follows Kane County's retention ordinance and has both dedicated funding and guidance on the use of green infrastructure. Unfortunately, the city has established few incentives for private-party actions, although it was instrumental in the passage of a revised stormwater ordinance for Kane County that provides incentives for developers to use green infrastructure best management practices (including rain gardens and permeable pavement) to reduce detention pond sizes. The city has no existing requirement to use GI to reduce existing impervious surfaces.

AURORA, ILLINOIS



Total Criteria Score
Out of a possible 6

EMERALD CITY CRITERIA*

- ☐ Existing requirement to use GI to reduce some portion of the existing impervious surfaces?
- ☐ Incentives for private-party actions?
- ☑ Long-term Green Infrastructure (GI) Plan?
- ☑ Retention Standard?
- ☑ Guidance or other affirmative assistance to accomplish GI within City?
- ☑ Dedicated funding source for GI?

BACKGROUND

Aurora, the second-most populous city in Illinois, lies 35 miles west of Chicago and straddles Kane, DuPage, Kendall, and Will counties. Aurora has a combined sewer system that dates back to the 1800s. To date, the city has spent more than $200 million to reduce combined sewer overflows as well as improve stormwater conveyance. In 2009 the city initiated a *Rooftops to Rivers* stormwater infrastructure project designed to provide a more comprehensive, integrated approach to citywide sustainability planning, with the 2006 *Rooftops to Rivers* publication serving as inspiration.[1] The city is developing a 20-year Combined Sewer Overflow Long-term Control Plan to address overflows. A draft of the plan, submitted to the Illinois EPA in 2010, identifies both green and conventional infrastructure approaches to stormwater control.[2] Most recently, Aurora alleviated the impacts of wet weather on its combined sewer system in three target areas by constructing 16,000 linear feet of storm sewer at a cost of $3.8 million.[3]

© Rivers Edge Bioswale

Aurora used the 2006 *Rooftops to Rivers* report as a planning framework to bring together a range of plans and guidance documents that include land use controls and direction for the use of green infrastructure practices in recreational, development, redevelopment, and brownfield projects.

While Aurora occupies parts of four separate counties, the city adheres to Kane County's Stormwater Management Ordinance. Adopted in 2002, the Kane County ordinance includes volume control measures that require runoff from up to a 0.75-inch rainfall event to be stored or retained on-site. While the runoff volume can evapotranspirate or infiltrate into a subsurface drainage system, no direct positive connection to downstream areas is allowed. Green infrastructure practices such as leaving soils undisturbed during construction and maximizing vegetation, which promotes infiltration and evapotranspiration, and may be used in lieu of traditional detention practices for developments requiring less than 1 acre-foot of detention. The stormwater manual was modified in 2009 to allow the use of permeable pavements, rain gardens, infiltration trenches, level spreaders and filter strips, and naturalized stormwater basins.[4]

PLANNING

As mentioned earlier, Aurora used the 2006 *Rooftops to Rivers* report as a framework to bring together a range of plans and guidance documents that include land use controls and direction for the use of green infrastructure practices in recreational, development, redevelopment, and brownfields projects.[5] In 2010 Aurora also completed a Naturalized Stormwater Management Corridor Plan (NSMCP) to address the role of green infrastructure as a single sewer pipe is replaced with two pipes. While the separation will reduce CSO occurrences, it will also increase the amount of stormwater flowing into the Fox River. To counteract this, green infrastructure will be used to reduce pollution and stormwater volumes. The NSMCP identifies a system of interconnected green infrastructure corridors and addresses stormwater strategies at the neighborhood, block, and site levels.

WATER CONSERVATION

The Fox River, which runs through downtown Aurora, is a primary source of drinking water for Aurora and several nearby towns. The health of the river, which is on the EPA's list of impaired waters, is seen as critical not for just the revitalization of downtown Aurora but for the protection of drinking water for Aurora and communities downstream. Slowing flow and cleaning water prior to its reaching the stream also helps recharge groundwater, which is another source of drinking water for Aurora, and reduces treatment costs for the Aurora Water Treatment Plant. In light of this, in 2006 the city implemented a year-round water conservation ordinance and water conservation education program.[6] In addition, Mayor Tom Weisner recently helped form the NorthWest Water Planning Alliance, which consists of elected county and municipal leaders from 79 communities and five counties. Their mission is to work collaboratively to address regional water supply and groundwater recharge issues in an economically and environmentally sound manner.[7]

FINANCE STRATEGY

To finance the city's green infrastructure and stormwater management projects, Aurora relies on stormwater funds, bonds, loans, and grants. Sewer separation projects, budgeted at $4 million for 2011, are financed through the Water and Sewer Fund, which for 2011 is supported largely by a 2006 water revenue bond and interest-free loans from the Illinois EPA. Sewer separation work performed in 2010 was covered primarily through an American Recovery and Reinvestment Act grant and interest-free loans from the Illinois EPA.[8]

Aurora 's Stormwater Management Fee Fund is financed primarily through a $6.90 bimonthly charge to each residential and business water and sewer service account. Other sources of funding include loans from the Illinois EPA and grants through the Clean Water Act.[9] Over the past five years, the city has completed $68 million of transportation and utility projects (with $52 million from grant sources, some of which is specifically targeted for stormwater control).[10] As a result of the *Rooftops to Rivers* planning process, the city also identified and completed three green infrastructure demonstration projects and developed a stormwater tool kit with funding from a Clean Water Act grant through the state.

The city does not currently utilize many incentives to encourage the use of green infrastructure. In 2010 a green permit program was developed to encourage and recognize green building construction. Under the plan, points are awarded for site-development and land-use measures that reduce water consumption, such as floodplain conservation, the addition of conservation areas, and graywater collection.[11] As part of the 2006 water conservation ordinance, developers are also provided educational materials on water-efficient measures during the construction process, and past efforts have included the distribution of water conservation kits. In addition, as part of its partnership with the state of Illinois to provide up to $20 million in tax incentives and funding to help revitalize its downtown riverfront, the River Edge Redevelopment Initiative also allocates EPA grants in the amount of $2 million to help with environmental remediation.

*EMERALD CITY RATING SYSTEM

Each of the cities profiled in *Rooftops to Rivers II* is a leader in green infrastructure investment—rethinking the design of municipal services and infrastructure. These cities leverage funding in creative ways. They provide tools to residential and commercial land owners to retrofit private properties and realize the multiple benefits provided by green infrastructure. In short, they are changing how cities look and function.

NRDC's Emerald City Rating System identifies six actions cities should undertake to maximize their green infrastructure investment. Our metric does not directly compare one city to another, due to geographical, population, budgetary and other differences. Instead, it identifies the presence or absence of common factors of success that NRDC believes are essential elements of a robust green infrastructure commitment. Only one city profiled, Philadelphia, is undertaking each of the actions identified, although each city is undertaking at least one.

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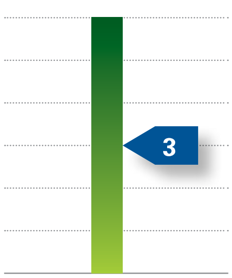
CHICAGO, ILLINOIS

A CASE STUDY OF HOW GREEN INFRASTRUCTURE IS HELPING MANAGE URBAN STORMWATER CHALLENGES

TYPES OF GREEN INFRASTRUCTURE USED: Green roofs, rain barrels/cisterns, permeable pavement, rain gardens, infiltration trenches or vaults, vegetated swales, street trees, planter boxes, stream buffers

Chicago has been and continues to be a green infrastructure leader in many areas, including urban forestry, green roofs, and green alleys. Its Climate Action Plan recognizes the importance of green infrastructure in adapting to climate change and sets some ambitious goals in terms of canopy cover and green roofs, which the city is close to meeting. Its "Adding Green to Urban Design" manual provides guidance to implement green infrastructure, although many of its recommendations on ordinance changes have not occurred. Chicago has some challenges, most notably the lack of a comprehensive plan to integrate its GI programs and the absence of a requirement to use green infrastructure to reduce impervious surfaces. It also lacks a dedicated funding source, and although the city has successfully leveraged partners and outside funding sources to provide incentives and implement projects, those sources may not be available in the future. Chicago also has a new mayor, Rahm Emanuel (elected in May 2011), whose environmental agenda is still being formed. Mayor Emanuel's challenge (and opportunity) is to take the individual green infrastructure successes the city has enjoyed over the past 20 years to the next level. For example, Chicago created a detailed sewer model that would allow the city to strategically place green infrastructure in areas to reduce basement flooding and (eventually) combined sewer overflows; however, there is currently no process to integrate green infrastructure into the sewer capital planning process.

CHICAGO, ILLINOIS



Total Criteria Score
Out of a possible 6

EMERALD CITY CRITERIA*

- ☐ Long-term Green Infrastructure (GI) Plan?
- ☐ Existing requirement to use GI to reduce some portion of the existing impervious surfaces?
- ☐ Dedicated funding source for GI?
- ☑ Incentives for private-party actions?
- ☑ Retention Standard?
- ☑ Guidance or other affirmative assistance to accomplish GI within City?

BACKGROUND

The city of Chicago, the third most populous city in the United States, lies at the confluence of the Chicago River and Lake Michigan. In 1856, Chicago built a combined stormwater conveyance system to help reduce flooding in the burgeoning city.[1] Worries about flooding were quickly followed by concerns about the water quality of Lake Michigan—the city's source of drinking water—and in the early 1900s, city engineers from what is now known as the Metropolitan Water Reclamation District (MWRD) reversed the Chicago River's natural flow to keep sewage and stockyard pollution from entering the lake.

© Chicago DOT

As of 2010, more than 215,000 square feet of permeable pavement have been installed in parking lots, sidewalks, parking lanes, bike lanes, and plazas.

More than a century later, flooding and water quality still remain major issues for the city, and the River continues to receive CSO discharges following rain events of as little as 0.67 inch in a 24-hour period.[2] Additionally, MWRD currently does not disinfect the treated sewage effluent discharged to the river, as is done in virtually every other major U.S. city, although it recently agreed, under pressure from the U.S. EPA, to begin installation of disinfection equipment at two of its three major treatment plants.[3] These plants also discharge large amounts of phosphorus, known to fuel algal blooms, impacting downstream waters all the way to the Gulf of Mexico, where the Chicago watershed is the largest single contributor to Gulf "dead zone" conditions.[4]

The river also faces newer threats, such as climate change and invasive species. In fact, the most recent incursion of bighead and silver Asian carp is considered one of the most acute aquatic invasive species threats facing the Great Lakes region today.[5] As a consequence of these various issues, the Chicago River was recently named one of the "most endangered rivers" by American Rivers.

To tackle the flooding and CSO problems, the MWRD initiated the building of a $3.4 billion deep tunnel and reservoir system in 1972. However, the end date has continually been pushed back, and the system remains many years away from completion.

While MWRD has been slow to consider the use of green infrastructure, the city of Chicago has embraced it since 1998 under the leadership of former Mayor Richard M. Daley. At that time, Chicago's stormwater management program, as well as other initiatives throughout the city, began placing greater emphasis on the utilization of green infrastructure, such as vegetated swales, infiltration trenches, rain gardens, and green roofs. Two of Chicago's initiatives profiled in the 2006 *Rooftops to Rivers* report, green roofs and green alleys, have seen significant growth in the past five years. In addition, the city launched the Chicago Climate Action Plan (CCAP) in 2008. It outlines how Chicago will achieve its goals of reducing greenhouse gas emission to 25 percent below 1990 levels by 2020, and 80 percent by 2050. Two green infrastructure strategies are central to the effort: capturing stormwater on-site and cooling the city with green roofs and trees.

CHICAGO'S GREEN ROOF PROGRAM

As Chicago, a national leader in green roof installations, Chicago has nearly 500 green roofs totaling almost 5.5 million square feet either completed or under way.[6] The city is completing an assessment using satellite imagery to more accurately calculate the total square footage of green roofs that have been built and to evaluate their health. Results are expected to be released later this year.[7]

Chicago started its program in 2001 with the installation of a 20,000-square-foot green roof on City Hall. Since then, the city has initiated various incentives, including a density/building height bonus for green roofs in Chicago's business district, a fast-track permitting process (the Green Permit Program), and, for those developments with a particularly high level of green strategy implementation, including exceptional water management, a maximum waiver of $25,000 for processing the building permit and associated fees.[8,9] Between 2005 and 2007, Chicago also had a Green Roof Grants Program that assisted with the costs of more than 70 green roof projects.[10] According to the Green Roofs for Healthy Cities 2011 Annual Industry Survey, Chicago was the leading U.S. city in installing green roofs in 2010.[11]

Chicago requires all new city buildings to have at a minimum a partial green roof and to achieve silver LEED® certification. The majority of green roofs have been installed under regulations requiring every developer receiving city assistance (either financial or zoning) to include a cool roof, per city code, or vegetated roof, per the Sustainable Development Policy, with the remainder of the roof meeting Energy Star–level reflectivity requirements.[12] And with all the green roofs going up, Chicago has seen the cost of installation go down, with the average price dropping from $25 to $15 per square foot.[13]

GREEN ALLEYS AND SUSTAINABLE STREETS

Greening strategies in the city are not limited to buildings. Another initiative, Greening Chicago's Alleys, uses permeable pavements, as well as proper grading and pitch, in the city's more than 13,000 alleys to improve infiltration and reduce runoff. As Chicago has grown, its originally gravel and dirt alleys, which allowed some water to infiltrate the soils, were paved over, increasing the likelihood of flooding both within the alleys and on surrounding properties during storm events.[14] In 2006, the city conducted five pilot projects to see whether permeable pavements would provide an alternative to connecting sewer mains from the alleys to the city's sewer system, which would be cost-prohibitive, create an increased burden on the combined sewer systems, and increase basement flooding.[15] The Chicago Department of Transportation (CDOT) incorporated green alleys into a term contract for alley reconstruction going out for bid in 2007; on average, 20 to 40 alleys are reconstructed per year. There was just one green alley identified in the first *Rooftops to Rivers* report, but since then, more than 150 have been installed.[16] As for costs, CDOT saw prices come down as a market for permeable paving began to develop;[17] the agency recently stated that the costs of constructing green streets is no more expensive than the cost of traditional alleys.[18]

CDOT is now integrating green stormwater management techniques into its street improvement projects; as of 2010, more than 215,000 square feet of permeable pavement have been installed in parking lots, sidewalks, parking lanes, bike lanes, and plazas. CDOT recently started construction on a comprehensive Sustainable Streetscape demonstration project. This 1.5-mile-long pilot project on the city's near southeast side demonstrates sustainable design techniques and associated benefits of green infrastructure for the urban ecosystem. The comprehensive streetscape project has established eight environmental performance goal areas. Background data and monitoring data are already being collected, and a final report will include pre-improvement conditions, predicted outcomes based on stormwater modeling, the monitoring plan, documentation of equipment installation, and monitoring results.[19]

URBAN FORESTS AND RIVERBANK PROTECTION

Annually, Chicago spends roughly $8 million to $10 million to plant 4,000 to 6,000 trees (with another 2,500 trees planted by the Chicago Park District), which has helped to increase the tree canopy from 11 percent in 1991 to 17.6 percent in 2008.[20] In 2009, Chicago created an Urban Forest Agenda to continue to strengthen the city's natural environment by maintaining and conserving trees, expanding the urban forest, integrating green infrastructure, and fostering stewardship. The agenda, an effort to tie the maintenance and planting of street trees to stormwater management,[21] sets a goal of achieving a citywide average tree canopy cover of 20 percent by 2020 through a public/private effort called the Chicago Trees Initiative.[22] To account for the impacts of climate change, the city's planting experts are also reevaluating their tree planting standards and plant lists, with an eye toward comprehensive tree diversity and the use of only those species able to endure future climate conditions.[23]

Chicago has also made a concerted effort to protect land along the river from development. Since 1998, the city has built or expanded nine parks along the Chicago River, reconstructed 4,000 linear feet of riverbanks, and, with the assistance of the private sector, installed 13 miles of river walk. The Chicago Park District has also purchased 43 acres of new parkland along the river since 2005.[24]

FINANCE STRATEGY

Chicago does not have a dedicated stormwater fee. Its green infrastructure initiatives are embedded across a number of departments, each with its own finance stream, including the general fund, grants, the water enterprise fund, and the sewer enterprise fund. As a result, the costs and fees associated with green infrastructure are not separated out from those of traditional infrastructure services.[25]

The absence of a dedicated stormwater fund limits opportunities for the city to provide incentives for reductions in impervious surfaces or the use of green infrastructure practices. Regardless, Chicago has done a good job over the years of offering incentives through various programs. The Department of the Environment, which is funded largely by federal and state grants and settlement funds, oversees the promotion of green development, environmental enforcement activities, and conservation and energy policies. Chicago's Sustainable Backyard Program offers rebates to residents for up to 50 percent of the cost of trees, native plants, and rain barrels, building upon a rain barrel program that has offered nearly 7,000 subsidized barrels to residents since 2004.[26] The Sustainable Development Division and pilot tax increment financing Green Roof Improvement Fund (GRIF) fall under the new Department of Housing and Economic Development. However, the Green Roof Grants Program and GRIF are currently unfunded.

Green permits, which include green buildings and buildings with exceptional water management, are a function of the Department of Buildings.[27] A stormwater ordinance went into effect in 2008 (and was updated in 2011); while it places greater emphasis on reducing imperviousness and implementing green infrastructure techniques, it requires the capture of only the first half-inch of rain (or a 15 percent reduction in impervious surface[28]). Further, it applies only to developments of more than 15,000 square feet in size and impervious open-space areas (such as parking lots) of 7,500 square feet or more.[29]

Potable water, wastewater and stormwater runoff, and the cleaning and upgrading of sewer lines are the responsibility of the Department of Water Management, and revenues to support these services come primarily from two enterprise funds for water and sewer.[30] Green alleys and green streetscapes projects are managed by CDOT, and tree plantings are primarily the responsibility of the Department of Streets and Sanitation's Bureau of Forestry, CDOT's Green

Streets, and the Chicago Park District. Funding for these sources comes largely from the Capital Improvements Funds and neighborhood capital improvement bonds, as well as the vehicle tax and motor fuel tax funds, which are both special revenue funds.[31] As Chicago continues to advance its sustainability work, especially through increasing green infrastructure and permeable areas, the Chicago Climate Action Plan (CCAP) is intended to be an important tool for guiding next steps and prioritizing goals.

*EMERALD CITY RATING SYSTEM

Each of the cities profiled in *Rooftops to Rivers II* is a leader in green infrastructure investment—rethinking the design of municipal services and infrastructure. These cities leverage funding in creative ways. They provide tools to residential and commercial land owners to retrofit private properties and realize the multiple benefits provided by green infrastructure. In short, they are changing how cities look and function.

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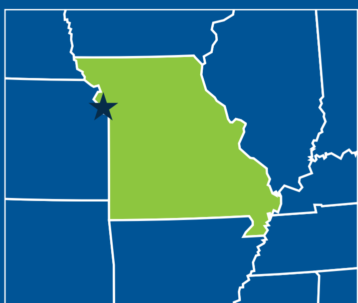
KANSAS CITY, MISSOURI

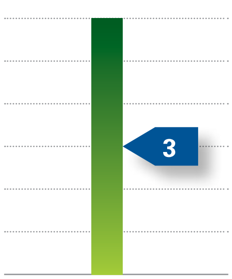
A CASE STUDY OF HOW GREEN INFRASTRUCTURE IS HELPING MANAGE URBAN STORMWATER CHALLENGES

TYPES OF GREEN INFRASTRUCTURE USED: Green roofs, rain barrels/cisterns, permeable pavement, rain gardens, infiltration trenches or vaults, vegetated swales, street trees, stream buffers, downspout disconnection



Kansas City has only recently turned to green infrastructure as a means of reducing stormwater runoff and CSO events. The city broke ground in June 2011 on its first wide-scale pilot project, the Middle Blue River Basin Green Solutions Pilot Project. The project will focus on green infrastructure as the sole control for CSOs in a 100-acre residential area of the city's Marlborough neighborhood and will serve as a model for future funding of projects to utilize green infrastructure as a CSO control method. The city had earlier kicked off a "10,000 Rain Gardens" initiative in 2005 to encourage residents to voluntarily install rain gardens on their property as a means of reducing stormwater runoff. Kansas City also added measures under its CSO Overflow Control Plan to integrate green infrastructure into city planning and to promote preservation and enhancement of green infrastructure in the city as a tool for economic development. The intended approach is based on adaptive management strategies to determine where and how much volume reduction can realistically be achieved. However, funding for initiatives such as a further rain gardens and downspout disconnection campaign has been uncertain, the city has yet to offer strong incentive programs for private application of green infrastructure, and it has yet to fully integrate green infrastructure into its long term planning overall. Hopefully Kansas City's initial efforts will serve as a catalyst for further, and more comprehensive, efforts to incorporate the use of green infrastructure into its planning.

KANSAS CITY, MISSOURI



Total Criteria Score
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EMERALD CITY CRITERIA*

- ☐ Existing requirement to use GI to reduce some portion of the existing impervious surfaces?
- ☐ Long-term Green Infrastructure (GI) Plan?
- ☐ Retention Standard?
- ☑ Incentives for private-party actions?
- ☑ Guidance or other affirmative assistance to accomplish GI within City?
- ☑ Dedicated funding source for GI?

BACKGROUND

Kansas City, Missouri, sits at the confluence of the Kansas and Missouri rivers and is part of a metropolitan area that extends into the state of Kansas. Like those of many older cities in the United States, Kansas City's sewer systems are aging. Each year, combined sewer overflows discharge 6.5 billion gallons of untreated effluent, and sanitary sewer overflows discharge another 100 million gallons.[1] During large storms, these systems can become overwhelmed by excess water, causing flow volume and bacteria levels to impact surrounding water quality,[2] and the sewer systems to reach their conveyance capacity. This increases the likelihood of sewer backup and localized flood events. In 2010, as part of a Clean Water Act settlement, Kansas City entered into a consent decree with the U.S. EPA to eliminate all discharges from its sanitary sewer system and reduce discharges from CSOs by 5.4 billion gallons per year by 2025, at an estimated cost of $2.5 billion.[3]

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Kansas City's 10,000 Rain Gardens initiative began in 2005 to address existing stormwater and overflow control problems; its goal is to install 10,000 rain gardens, vegetated swales, and rain barrels in the greater metropolitan area.

The city submitted an Overflow Control Plan in 2008 under which it would invest $28 million in pilot projects over five years to evaluate the effectiveness of green infrastructure as a widespread, systemic solution to sewer overflows, with allowances for gray infrastructure to be swapped with green if the pilot proved successful. Upon review, the city council directed the Water Services Department to move ahead with efforts to shift more emphasis onto green solutions,[4] and in 2009 the city submitted a plan that budgeted $78 million for green infrastructure projects. In total, the plan includes the $28 million pilot project, plus, upon successful implementation of the pilot, an additional $40 million for green infrastructure controls, $5 million for rain garden and downspout disconnection incentives, and $5 million for green-collar jobs,[5] making it one of the largest municipal green infrastructure projects in the nation to control combined sewer overflows.[6] The plan has also budgeted $24 million for monitoring and modeling necessary to evaluate the success of all project components.[7]

The development of both the Overflow Control Plan and management of stormwater fell under the Wet Weather Solutions Program of Kansas City's Water Services Department. Under its 2008 Manual of Best Management Practices for Stormwater Quality, created for the Kansas City Metropolitan Area and the Mid-America Regional Council planning region, the city added volume controls and a treatment train approach to stormwater management that serves to filter pollution out of runoff and slow the flow of runoff so it can percolate into the soil.[8] Over the past two years, Kansas City has also instituted additional measures in order to incorporate green concepts into the culture of all city operations and achieve the triple bottom line goals of environmental quality, social equity, and economic vitality. Highlights from a stormwater perspective include the adoption of:

- a stream buffer ordinance with a minimum 100-foot buffer as measured from the edge of the stream;
- a goal to plant an additional 120,000 trees in streetscapes and parks;[9]
- a Green Solutions Policy to integrate green solutions—including green infrastructure practices—into city planning and development processes;[10] and
- an Economic Development and Incentives Policy that promotes preservation and enhancement of the city's green infrastructure as tools for economic development.[11]

MIDDLE BLUE RIVER BASIN PILOT PROJECT

The first green infrastructure pilot under Kansas City's Overflow Control Plan is the 100-acre Middle Blue River Basin Green Solutions Pilot Project, located in a largely residential area of the city's Marlborough neighborhood that drains to two combined sewer outfalls. While the city's draft plan of 2008 called for two underground tanks to store and transfer 3 million gallons of overflow from the outfalls, in the final plan these tanks were replaced with at least 3.5 million gallons of storage through the use of gray and green infrastructure techniques.[12] The Marlborough project represents the largest focused installation of green infrastructure as a sole control for CSOs in the nation. As such, its success or failure could have a large impact on other green infrastructure efforts throughout the country. In addition to providing valuable performance data regarding the ability of green infrastructure to reduce combined sewer overflows and stormwater runoff, this pilot will also evaluate socio-economic benefits, assess construction and maintenance techniques and costs, and develop preliminary green design standards for Kansas City. The project, which broke ground in June 2011, is scheduled to be completed by 2017.[13] The Water Services Department estimates that implementing these green infrastructure practices will potentially save the city $10 million in capital costs, relative to what would have been spent if only gray infrastructure techniques were utilized.[14]

10,000 RAIN GARDENS

Kansas City's 10,000 Rain Gardens initiative began in 2005 to address existing stormwater and overflow control issues. Largely, the program's goal was exactly what its name suggests: the installation of 10,000 rain gardens, vegetated swales, and rain barrels in the greater metropolitan area. However, it went beyond that goal to create awareness of the problem in a way that highlights how individuals, businesses, and municipal entities can be part of the solution. It also provided training to city employees, private landscapers, and retailers at a cost of $50 per participant.

To keep costs low, the 10,000 Rain Gardens website was used as the primary method for relaying information. In the program's first two years, the group gave 62 rain garden presentations; conducted two media campaigns using TV commercials and appearances, newspaper inserts, and radio ads; and distributed a quarterly electronic newsletter to almost 1,100 people. Through the media campaigns alone, it was estimated that the program reached more than 1 million people in 2006 and more than 3 million in 2007. As a result of these efforts, by July 2008, at the writing of the long-term CSO Control Plan, 303 rain gardens had been registered on the www.rainkc.com website.[15] Unfortunately, progress has stalled since then, and efforts to register additional rain gardens have ceased.[16] While the Overflow Control Plan itself budgets $5 million for an aggressive rain garden and downspout disconnection campaign,[17] the money has yet to flow, leaving the program without capacity.

FINANCE STRATEGY

Kansas City's Wet Weather Solutions Program includes improvements to address wastewater and stormwater problems that occur when it rains. In order to help pay for the burgeoning costs of wet weather management and incentivize the use of green infrastructure, the city created a stormwater utility that began operation in 1999. Fees are based on the amount of a property's total impervious surface, as determined primarily by the use of aerial photographs. A typical residential customer pays $2.50 per month, based on a fee of $0.50 per month for each 500 square feet (runoff unit) of impervious surface on a property.

Owners who maintain large pervious areas to absorb runoff (with a ratio of total property area to runoff surface area of at least 30:1), or who install properly maintained stormwater detention structures, can receive a credit not to exceed 75 percent of the total monthly fee.[18] The city is working to amend this policy to allow property owners to distinguish between directly connected impervious surfaces and disconnected impervious surfaces that will not contribute to runoff. However, the rather small monthly fee does not appear to provide a strong enough incentive for property owner participation. The city does not currently provide credit for the inclusion of stormwater retention structures such as rain gardens because the administrative costs to the city would be too high relative to the low monthly stormwater fee.[19]

In a comprehensive stormwater management report, Kansas City identified funding as the primary obstacle to improved stormwater management and water quality, and cited a need to implement innovative approaches and solutions that combine local, state, and federal funding.[20] Both a stormwater fee and a dedicated sales tax exist to fund the city's stormwater services; however, neither currently covers all operation, maintenance, and capital costs. Based on the city's own review, doing so will require a "significant increase" in the stormwater utility fee that could be implemented through a transition period over several years. Other possible funding sources that were identified include system development charges and state and federal grant funding that can leverage local revenues.[21] For fiscal year 2010–2011, the city anticipated collecting $10.5 million in stormwater fees.[22]

*EMERALD CITY RATING SYSTEM

Each of the cities profiled in *Rooftops to Rivers II* is a leader in green infrastructure investment—rethinking the design of municipal services and infrastructure. These cities leverage funding in creative ways. They provide tools to residential and commercial land owners to retrofit private properties and realize the multiple benefits provided by green infrastructure. In short, they are changing how cities look and function.

NRDC's Emerald City Rating System identifies six actions cities should undertake to maximize their green infrastructure investment. Our metric does not directly compare one city to another, due to geographical, population, budgetary and other differences. Instead, it identifies the presence or absence of common factors of success that NRDC believes are essential elements of a robust green infrastructure commitment. Only one city profiled, Philadelphia, is undertaking each of the actions identified, although each city is undertaking at least one.

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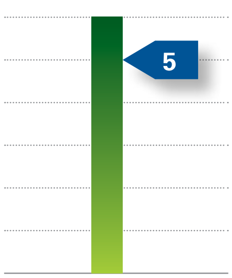
MILWAUKEE, WISCONSIN

A CASE STUDY OF HOW GREEN INFRASTRUCTURE IS HELPING MANAGE URBAN STORMWATER CHALLENGES

TYPES OF GREEN INFRASTRUCTURE USED: Green roofs, blue roofs, rain barrels/cisterns, permeable pavement, rain gardens, infiltration trenches or vaults, vegetated swales, street trees, planter boxes, downspout disconnection, stream buffer

The Milwaukee Metropolitan Sewerage District (MMSD) is a regional and national wastewater utility leader in its integration of green infrastructure into its combined sewer overflow reduction strategy. While MMSD has numerous green infrastructure planning projects under way, including specific targets within its 2035 plan to reduce the number of CSOs to zero and a triple-bottom-line analysis modeled on Philadelphia's, it does not have a regional plan. In 2008 MMSD undertook a code and ordinance review for the communities in its service area and cataloged the efforts to date over the summer of 2011. It has dedicated capital funds to support green roof grants ($5 million in 2010–2011), rain barrels, and rain gardens, as well as resident education and an online cost-benefit tool. MMSD recognizes the value of partnering with local and national organizations and agencies to accomplish its goals, including a program to purchase and restore land upstream of Milwaukee to prevent flooding and overflow problems from occurring in the first place.

MILWAUKEE, WISCONSIN



Total Criteria Score
Out of a possible 6

EMERALD CITY CRITERIA*

- ☐ Long-term Green Infrastructure (GI) Plan?
- ✓ Existing requirement to use GI to reduce some portion of the existing impervious surfaces?
- ✓ Incentives for private-party actions?
- ✓ Retention Standard?
- ✓ Guidance or other affirmative assistance to accomplish GI within City?
- ✓ Dedicated funding source for GI?

BACKGROUND

Like other cities with combined sewer systems, Milwaukee has a history of overflows. As a result, from 1977 to late 1993, the regional wastewater treatment agency, Milwaukee Metropolitan Sewerage District (MMSD), invested approximately $1 billion to build a deep tunnel storage system to eliminate sanitary sewer overflows and limit combined sewer overflows to an average of 1.4 per year. While the tunnel reduced both the number and the volume of sanitary sewer outflows by more than 80 percent (from 8–9 billion gallons to about 1 billion gallons annually), the district still experiences an average of 4.1 sanitary sewer overflows and 2.6 CSOs each year.[1]

As noted in the first *Rooftops to Rivers* report, MMSD serves a combined population of approximately 1.1 million people. The agency manages wastewater from 28 municipalities, each with its own sewer system that drains into MMSD's 300 miles of regional sewers. On a dry day, the district's two wastewater treatment plants each process about 50 million to 80 million gallons of wastewater.[2] The treated wastewater is discharged into Lake Michigan, which is also the city's drinking water supply.[3] About 5 percent of MMSD's service area, including parts of Milwaukee and the village of

Installation of porous pavers at the Energy Exchange (November 2009).

Shorewood, utilizes a combined sewer system, with overflow points located along rivers that flow into Lake Michigan. This area, which measures 14,338 acres, is about 30 percent impervious.[4] The rest of MMSD's service area has separate sewer systems for stormwater and wastewater.

MMSD'S GREEN INFRASTRUCTURE APPROACH

To complement the deep tunnel system and reduce overflows and stormwater runoff even further, MMSD began to explore the potential of utilizing green infrastructure practices in 2002. It is notable that MMSD undertook its green infrastructure investments absent federal or state action. One of its first initiatives was a downspout disconnection program to redirect building downspouts to rain barrels. A second effort was a cooperative partnership with public entities and private businesses in the Village of Shorewood (which is adjacent to Milwaukee) to install 60 rain gardens. The combined cost of the two projects was approximately $170,000.[5]

Nearly 10 years later, MMSD's downspout disconnection, rain barrel, and rain garden programs are still going strong. In addition, since the first *Rooftops to Rivers* publication, MMSD's stormwater management manual has been revised to include volume control, impervious surface reduction, and standard operating and maintenance requirements that encourage the use and long-term maintenance of green infrastructure practices. This manual is a guide to meet MMSD's stormwater management rules, which are applicable to both new construction and redevelopment throughout the watersheds upstream of the estuary that drains into Lake Michigan.[6,7] Between MMSD and the Housing Authority of the City of Milwaukee (HACM), 5.6 acres of green roofs have been installed as of May 2011; 1.2 acres were installed by HACM.[8] Also, MMSD partners with The Conservation Fund on a land acquisition program called Greenseams™, further described below.

The Water Quality Initiative,[9] a joint effort of MMSD and the Southeastern Wisconsin Regional Planning Commission, identified the reduction of non-point sources of water pollution as the most important action, and green infrastructure as a tool to reduce peak stormwater flows from the 100-year and smaller storm events. In 2009, MMSD's vision for integrated watershed management set forth the laudable goal of becoming a model of sustainability, with a healthier Milwaukee region and a cleaner Lake Michigan accomplished through the agency's leadership in attaining zero overflows, zero basement backups, and improved stormwater management. MMSD further noted that, to deal with stormwater issues during large storm events, a regional approach to planning was needed, with a shift in focus from political boundaries to watershed boundaries. Also in 2009, MMSD prepared a publication, *Fresh Coast Green Solutions*, to provide a triple-bottom-line assessment of green infrastructure's benefits.[10]

PROMOTING RAIN BARRELS, RAIN GARDENS, AND GREEN ROOFS

Public education and outreach programs, such as MMSD's downspout disconnection and rain garden installation programs are considered cost-effective approaches for managing stormwater and improving water quality. Along with the city of Milwaukee and 27 other communities, MMSD encourages businesses, municipalities, and homeowners to manage stormwater on site through the installation of green roofs and the redirection of downspouts into rain barrels and rain gardens. To do so, MMSD funds community workshops and pilot programs and provides cost-share partnership funding to support the costs of green roofs. From 2003 to 2009, 1.7 acres of green roofs were installed through a partnership program.[11] For 2010 and 2011, MMSD provided a matching-fund program to maximize resources and encourage engagement in shared stormwater outcomes. In 2010, 2.6 acres of green roofs were installed through MMSD's Regional Green Roof Initiative, and another 1.7 acres are pending completion in 2011.[12] MMSD budgeted $5 million as a matching-fund program to retrofit building rooftops with green roof technology. As part of the program, MMSD will gather quantitative data on the impact of green roofs and qualitative data on the feasibility of green roofs in its service area.[13]

As part of its public education and outreach efforts, MMSD recently launched H2OCapture.com to educate the region about green infrastructure and engage area residents and businesses to help reach a goal of capturing 500 million gallons of rain—a quantity nearly equal to the storage capacity of its deep tunnels—during storm events. Besides information on performance and cost, the site includes a calculator, developed by NRDC, that individuals can use to determine how much rain is captured by different types of green infrastructure. The site also allows MMSD to highlight "signature projects" like the one in the Walnut Way community, where 38 downspout disconnections, 38 rain gardens priced at $1,200 each, and 4 cisterns were installed to divert about 552,000 gallons each year from the sewer system to natural infiltration.[14] The site provides up-to-date news on events and incentives and is a cost-effective way for the district to engage the public.[15]

WATERSHED-SCALE INNOVATIONS: PROTECTING LANDS THROUGH GREENSEAMS™

Greenseams™ is a program that began in 2002 to provide nonstructural flood and stormwater management protection. Through it, MMSD partners with The Conservation Fund to acquire conservation easements on land along riparian corridors, wetlands, and floodplains to protect their natural functions. Since its inception, the program has acquired, restored as necessary, and placed development restrictions on 75 properties totaling more than 2,254 acres. Management of these properties is handled by either a local municipality or a land trust, subject to a conservation easement held by MMSD.[16] For 2011, MMSD's approved budget includes approximately $1.5 million for the Greenseams™ project to cover the acquisition of 6 properties totaling 225 acres.[17]

MILWAUKEE'S FIRST "GREEN CORRIDOR"

MMSD's green infrastructure commitment has also helped reinvent portions of the city. MMSD is working with the city of Milwaukee, American Rivers, Gateway to Milwaukee, and the Energy Exchange to transform a three-mile stretch of 6th Street, on Milwaukee's south side, into the city's first "green corridor." A combination of bioswales (the city installed 15 during the summer of 2011), planters, and porous pavement will help combat flooding and control stormwater in the neighborhood, and solar-powered bus stops and LED lighting will reduce energy use and greenhouse gas emissions.

MEASURING THE EFFECTIVENESS OF MILWAUKEE'S GREEN INFRASTRUCTURE

MMSD has done an excellent job of monitoring the success of its green infrastructure pilot projects, both in terms of tracking distribution of rain barrels and implementation of practices such as rain gardens and permeable pavements, and in evaluating the large-scale impact of such projects. Of particular interest since the 2006 *Rooftops to Rivers* report is a study conducted to determine whether infiltration from green infrastructure practices might negatively affect leaky sanitary pipes. In 2005 and 2006, MMSD studies detected

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Bio-retention swales for stormwater treatment along Grange Avenue in the Village of Greendale.

no inflow and infiltration for large-scale stormwater ponds placed 60 feet or more from pipes. As for smaller-scale practices, the studies recommended that these be placed at least 10 feet from pipes but found that shorter distances were possible. MMSD determined that future research is needed to evaluate the impact of soil type on the ability of green infrastructure to complement inflow and infiltration reductions.[18]

In addition to monitoring, MMSD has utilized modeling to evaluate the effectiveness of green infrastructure practices on a wider scale. In 2007, for example, the district evaluated the ability of select green infrastructure practices, implemented at varying densities, to reduce CSOs in a typical 6-acre section of Milwaukee that included both residential and commercial lots. It was found that, for residential areas, practices such as porous pavement, downspout disconnections, rain barrels, rain gardens, trees, and compost amendments could reduce CSO volume by 12 to 38 percent and could lessen peak flows by 5 to 36 percent. At 50 percent implementation, CSO volume effectiveness from baseline would drop to 20 percent, and at 12.5 percent implementation, it would diminish to 5 percent from baseline. The conclusion was that, to produce the greatest benefit, widespread implementation is necessary.[19]

FINANCE STRATEGY

MMSD's capital budget is financed primarily through a tax on district properties based on their value, and a similar charge placed on 10 nonmember communities outside Milwaukee County that are also serviced by MMSD. The tax also funds acquisitions and improvements that enhance MMSD's sewerage service.[20] For 2011, tax revenue and nonmember billings are estimated to be $111 million. MMSD's operating expenses are funded primarily through sewer service charges, which are an estimated $66.7 million for 2011. Revenue also comes from the sale of fertilizer manufactured from sewage sludge, with estimated net income of $7.8 million for 2011. MMSD actively reviews ways to reduce expenses by implementing programs such as Greenseams™, described earlier, by providing incentives to achieve compliance, by public outreach and awareness programs, and by maximizing funding from private and government-sector grants and subsidies.[21]

2010 was a particularly challenging year for MMSD. After a catastrophic storm in July, MMSD delayed its regular budget cycle as it evaluated options and strategies "to address what seem to be more frequent and expansive issues in wet weather management."[22] As a result, the district's 2011 budget expanded its "Private Property Infiltration and Inflow Reduction" program to address issues of aging or deteriorating infrastructure and improved stormwater management to make it more resilient in the future. In particular, the program is addressing issues related to clear water entering the system through infiltrating leaky pipes, which has been identified as one of the primary causes of system capacity problems.[23]

To incentivize participation, MMSD places an emphasis on leading by example, offering public outreach and technical assistance, and developing grant and cost-sharing opportunities, as discussed above. In addition, MMSD's 2011 capital budget includes $1 million in funding for the 28 communities it serves to help them implement various green infrastructure projects. The district allocates funding among all 28 communities, and in the two communities with combined sewer systems, at least 25 percent of the funding must be expended in the combined area.[24]

The district has very few regulatory requirements for green infrastructure. For development or redevelopment projects that include an increase of one-half acre or more of impervious surface, porous pavement, or vegetated roof, or where the disturbed area is greater than 2 acres, the area is subject to runoff requirements.[25] In reality, however, relatively few development or redevelopment projects exceed this threshold.[26] One other potentially applicable requirement is Chapter NR 216 of the Wisconsin Administrative Code, which may require communities to reduce the total suspended solids in runoff from the developed urban area by 40 percent.[27]

*EMERALD CITY RATING SYSTEM

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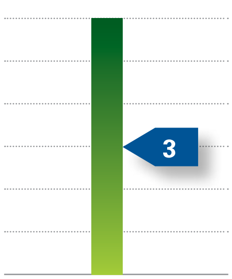
NASHVILLE, TENNESSEE

A CASE STUDY OF HOW GREEN INFRASTRUCTURE IS HELPING MANAGE URBAN STORMWATER CHALLENGES

TYPES OF GREEN INFRASTRUCTURE USED: Green roofs, rain barrels/cisterns, permeable pavement, rain gardens, vegetated swales, street trees, planter boxes, downspout disconnection, stream buffer, open space preservation

While Nashville's green infrastructure programs are still getting up and running, the city has shown a commitment to increasing its requirements and incentives for green infrastructure in the near future. Nashville's Green Infrastructure Master Plan analyzed the benefits that widespread green infrastructure implementation could achieve in the city's combined sewer system area; identified potential projects the city can implement; and suggested incentives that Nashville can offer to private properties to install green infrastructure, such as stormwater fee discounts, rebates, installation financing, and awards and recognition programs. The city also developed a fairly robust public engagement initiative consisting of online resources and high-profile demonstration projects, and it has a stormwater user fee based on impervious surface area, with credit available for on-site mitigation. Despite this progress, Nashville faces significant work ahead. It has not established a retention standard (within the next four years, the city's new MS4 permit will make on-site retention mandatory where possible). Nashville has no requirement to use green infrastructure to reduce impervious surfaces, nor has it established incentives for private actions. While the updated version of Nashville's stormwater management manual, currently under development, will establish an alternative compliance path based on stormwater volume reduction, this approach will be voluntary.

NASHVILLE, TENNESSEE



Total Criteria Score
Out of a possible 6

EMERALD CITY CRITERIA*

- ☐ Requirement to use GI to reduce some portion of the existing impervious surfaces?
- ☐ Incentives for private-party actions?
- ☐ Retention Standard?
- ☑ Long-term Green Infrastructure (GI) Plan?
- ☑ Guidance or other affirmative assistance to accomplish GI within City?
- ☑ Dedicated funding source for GI?

BACKGROUND

Nashville, located on the Cumberland River in Tennessee, covers 526 square miles and has a metropolitan area that spans 13 counties. The Metro Nashville area still has 47 percent of its urban tree canopy; in the city center, the figure dips to 13 percent.[1] The city's combined sewer system (CSS) was built in the late 1880s. It carried both stormwater and sewage to the Cumberland River without treatment until the late 1950s, when the city constructed the Central Wastewater Treatment Plant to treat wastewater prior to release. Today Nashville has a CSS servicing 7,878 acres, or 12.3 square miles, in the core of the city. Its land cover is 46.5 percent impervious and contains 19.5 percent of the urban tree canopy.[2] Of the 2,500 miles of streams running through Nashville and Davidson County, 350 miles are on Tennessee's official list of impaired waters.[3]

Nashville completed one of the first green streets in the Southeast, transforming a major downtown road into a pedestrian-friendly corridor by incorporating sidewalk-level bioretention planters, bioretention curb bump-outs, a landscaped median, porous concrete sidewalks, and planting 102 shade trees.

NASHVILLE'S STORMWATER MANAGEMENT BACKGROUND

In August 2007, the Metropolitan Government of Nashville and Davidson County signed a consent decree with the United States and the state of Tennessee that called for a nine-year plan to reduce the estimated 765.2 million gallons of combined sewer overflow (CSO) discharged to the Cumberland River each year.[4] In response, the Metropolitan Department of Water and Sewerage Services of Nashville and Davidson County (MWS) are currently leading efforts to develop a CSO long-term control plan. In 2008, Metro Nashville established a Stormwater Master Planning District covering the entire CSS area and directed MWS and other Metro Nashville departments to develop a green infrastructure plan for the area; it was completed in 2009 and is explained below.[5] The remainder of Nashville is serviced by separate sewer systems that are regulated through a National Pollutant Discharge Elimination System (NPDES) Phase I MS4 permit.[6] A new MS4 permit for Nashville is expected to be issued in late 2011 or early 2012.

Responsibility for Metro Nashville's stormwater program also belongs to MWS,[7] and in 2006 the agency updated Metro Nashville's Stormwater Management Manual (SWMM). The manual provides the framework for site development, including erosion and sediment control during construction and post-development water quantity and quality requirements. The 2006 SWMM contains guidance for green infrastructure practices including green roofs, bioretention, and use of pervious pavement.[8] MWS is currently in the process of developing a new volume of the SWMM designed to encourage the use of green infrastructure, which will establish an alternative compliance path based on stormwater volume reduction and will provide incentives for the use of bioretention, permeable pavements, trees, green roofs, cisterns, and other green infrastructure practices that reduce stormwater volume. The approach will remain voluntary until required under the city's new MS4 permit.

Under Mayor Karl Dean's guidance, the use of green infrastructure to address stormwater and flooding concerns has taken on increased significance. In 2008 Metro Nashville joined a group of local governments promoting sustainability through peer-to-peer advice on stormwater issues. That same year, the mayor signed a green building permits and green certificate of occupancy ordinance; appointed an environmental sustainability manager; and created both a Green Ribbon Committee and a Green Team Committee, whose members, among other things, provided guidance on the use of green infrastructure to address stormwater runoff and commissioned a downtown Tree Master Plan.

In 2009, the Green Ribbon Committee released a full report that set forth 16 goals, including the establishment of tree canopy and tree-planting objectives for various property types to achieve; the greatest reduction of stormwater runoff possible; the establishment of a dedicated source of funding for stormwater management; and the removal of all Nashville streams from the state's list of impaired waters by 2020.[9] In May 2010, these efforts were diverted for a time to deal with the aftermath of a catastrophic flood that caused the loss of 11 lives and more than $2 billion of private property damage. As the city recovered from the experience, however, a new approach to open-space planning took shape. Since then, Nashville has moved forward with a plan to buy and remove more than 300 structures in the floodway to restore and preserve the land as open space. The city is also addressing stormwater by increasing the number of incentives and requirements that encourage the use of green infrastructure practices.[10]

NASHVILLE'S GREEN INFRASTRUCTURE MASTER PLAN

Downtown Nashville's 12.3-square-mile CSS was designated a stormwater planning district in 2008 under an ordinance that directed MWS, the Metropolitan Planning Department, the Metropolitan Development and Housing Agency, and the Department of Public Works to create a Green Infrastructure Master Plan; the plan was finalized and approved in the fall of 2009. In addition to identifying various green infrastructure practices in the stormwater planning district, the plan provides a detailed analysis of the impacts that four types of practices have on the volume of stormwater runoff: rainfall harvesting; green roofs; urban trees; and three infiltration practices (bioinfiltration areas, permeable surfaces, and tree planters).

For rainfall harvesting, the plan evaluated the effect that capturing runoff from the 1,300 acres of rooftops in the CSS area would have on stormwater runoff. On average, rooftops in Nashville were estimated to generate 65.5 gallons per day per 1,000 square feet, for a total of 1.36 billion gallons of runoff per year. If all of the 708 buildings suitable for green roofs were converted, 112 million gallons of runoff could be removed from the annual total. Similarly, the plan evaluated the impact of additional tree plantings within the CSS area and found 51,800 acceptable new planting sites; these would add 811 acres of urban trees and increase the canopy coverage from 19.5 percent to 30 percent. By doing so, Metro Nashville could expect to reduce stormwater volume by 660 million gallons annually. Similar evaluations were prepared for other green infrastructure practices. In addition, the plan identified 50 potential green infrastructure projects that MWS could implement and provided brief overviews of six. Under the ordinance, the list of green infrastructure projects must be updated annually, and MWS was authorized to promulgate and enforce rules and regulations for the implementation of green infrastructure techniques.[11]

NASHVILLE'S OPEN-SPACE PLAN: *NASHVILLE: NATURALLY*

In April 2011, Nashville released its first open-space plan, which aims to protect 22,000 acres over the next 25 years, including 10,000 acres of floodplain. The plan "Nashville: Naturally," builds upon the lessons learned from the flood of 2010 by focusing protection efforts on land in each of the nine bends of the Cumberland River. The network of open spaces is intended to provide buffers against floodwaters, improve water quality, protect agricultural soils, and offer recreational opportunities. Other goals include the restoration of the endangered Nashville crayfish population and the removal of all area streams from the impaired waters list. The plan further aims to double the 85-acre downtown tree canopy within 10 years and to transition 110 acres, or 20 percent, of the suitable impervious surfaces downtown to pervious or natural plantings.

To help Nashville reach these goals, the plan makes numerous policy recommendations to connect wildlife and water networks, support urban and rural farming, connect people to green infrastructure, and preserve historic and iconic resources. From a stormwater perspective, some of the more important recommendations are to:

- integrate Metro department activities related to forest and water resource protection
- create incentives that encourage green infrastructure stormwater management on private properties;
- establish a stronger stream buffer to protect and restore a riparian buffer system;
- institute a no-adverse-impact policy that restricts development in flood-prone areas and requires development that alters flooding conditions to mitigate the impact of such actions; and
- explore sustainable open space funding and incentive programs that could be offset by the creation of green spaces such as green roofs in dense urban areas.[12]

The Metro Council and Mayor Dean have already set aside $5 million from Metro Nashville's capital spending budget to begin an acquisition fund; they expect to build the fund with private contributions. Additionally, they've taken the first step toward meeting the 22,000-acre green space goal by agreeing to purchase a 135-acre former private airport for $1.2 million. Doing so will serve to connect two adjacent parks, create a 936-acre swath of open space, and provide an additional buffer to surrounding neighborhoods to protect them from future flood events. To raise funds, Metro is partnering with the Land Trust for Tennessee and the Friends of Shelby Park.[13]

OTHER GREEN INFRASTRUCTURE INITIATIVES

Metro Nashville and MWS have implemented several other projects to better engage and inform the general public on the purpose and utility of green infrastructure practices. To encourage rain gardens, MWS has partnered with the Nashville District of the Army Corps of Engineers and the Cumberland River Compact, a nonprofit organization that engages businesses, individuals, community organizations, and government in the restoration and protection of the Cumberland River, to create a resource guide.[14] In the spring of 2011, the Cumberland River Compact, MWS, and Impact Nashville built 50 rain gardens on residential properties with the help of volunteers. The rain gardens were offered free to homeowners (or renters with owner permission) and were concentrated within the watershed of Brown's Creek, one of Nashville's most polluted small streams.[15] Plans are in place for Nashville Metro to partner with the Cumberland River Compact, the Nashville Tree Foundation, the Nashville Earth Day Festival, and Sound Forest to plant shade trees with the greatest benefits for stormwater mitigation on selected residential properties and in community spaces around Davidson County. While individual websites exist for each program, Nashville has developed a unique site, Impact Nashville (impactnashville.net), aimed at engaging residents in various citywide initiatives.

In 2009, Nashville completed a $4.5 million pilot "green street" project along Deaderick Street, converting a major downtown road into a pedestrian-friendly corridor by incorporating sidewalk-level bioretention planters, bioretention curb bump-outs, a landscaped median, and porous concrete sidewalks, and by planting 102 shade trees. It is also one of the first green streets constructed in the Southeast.[16]

FINANCE STRATEGY

In 2008, MWS prepared a stormwater business plan that found the stormwater program's annual budget of $12 million was below projected needs; an additional $85 million was necessary just to resolve the backlog of projects, and to fully operate the stormwater program an annual operating budget of $25.8 million was required. To fill the gap, the business plan recommended that a dedicated user fee for stormwater drainage be developed, with the rate structure based on a property's total impervious surface area. For customers with existing MWS water accounts, the fee would be billed monthly on the MWS utility bill. For customers without water accounts, a quarterly "stormwater only" bill would be issued.[17] In 2009, a stormwater user fee came into effect for Metro Nashville. Currently, monthly rates for residents range from $0 to $4.50, with an average residential bill of $3.00.[18] Nonresidential property rates range from $0 to $400, depending on the amount of impervious surface.[19] Property owners can receive a credit for mitigating stormwater runoff impacts through education or the implementation of source controls for water quantity or quality (up to 20 percent for each practice, capped at 50 percent).[20] However, the monthly stormwater fee does not appear to be significant enough to make much difference in customer behavior. In other words, the cost savings resulting from stormwater improvements seem unlikely to offset the cost of installing them.

In addition to the stormwater fee, Metro Nashville draws from its general fund, internal service fund, federal funds, and private funding to implement stormwater, open space, green building, and tree planting programs. And to encourage green buildings, the Metro Codes Department established a fast-track permitting process in 2009. To receive the green stamp of approval, units must be third-party certified.[21] However, no additional incentives other than fast-track permitting are offered at this time, nor has Metro Nashville included any stormwater management requirements that encourage the use of green infrastructure practices in their green building permitting process, such as requiring green roofs or the use of volume-based controls on-site.

Like many of the original case studies in 2006, Nashville's green infrastructure programs are still developing tools and incentives used to encourage green infrastructure practices are expected to increase over the years. The Green Infrastructure Master Plan, which provides a summary of various incentive practices that other cities use to encourage green infrastructure, provides some hints as to incentives Metro Nashville might implement to encourage participation. From these incentives, five were selected for further consideration for Metro Nashville: stormwater fee discounts, rebates and installation financing, development incentives, grants, and awards and recognition programs.[22] In addition, Metro Nashville is working to identify incentives that will be incorporated in the upcoming stormwater management low-impact development manual.[23]

*EMERALD CITY RATING SYSTEM

Each of the cities profiled in *Rooftops to Rivers II* is a leader in green infrastructure investment—rethinking the design of municipal services and infrastructure. These cities leverage funding in creative ways. They provide tools to residential and commercial land owners to retrofit private properties and realize the multiple benefits provided by green infrastructure. In short, they are changing how cities look and function.

NRDC's Emerald City Rating System identifies six actions cities should undertake to maximize their green infrastructure investment. Our metric does not directly compare one city to another, due to geographical, population, budgetary and other differences. Instead, it identifies the presence or absence of common factors of success that NRDC believes are essential elements of a robust green infrastructure commitment. Only one city profiled, Philadelphia, is undertaking each of the actions identified, although each city is undertaking at least one.

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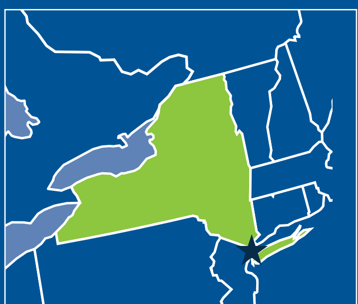
NEW YORK, NEW YORK

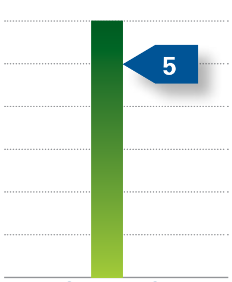
A CASE STUDY OF HOW GREEN INFRASTRUCTURE IS HELPING MANAGE URBAN STORMWATER CHALLENGES

TYPES OF GREEN INFRASTRUCTURE USED: Green roofs, blue roofs, rain barrels/cisterns, permeable pavement, vegetated swales, street trees



New York City, facing one of the nation's largest sewage overflow problems, is rapidly developing one of the most extensive programs of public investment in green infrastructure in the United States. In its least densely developed areas, the city already makes significant use of constructed or restored wetlands for stormwater management. Elsewhere, the city has installed and is monitoring a range of demonstration projects in the public right-of-way and on developed properties, both publicly- and privately-owned. Guided by a new Green Infrastructure Plan, New York is expanding the use of green infrastructure citywide, with an initial focus on greening municipal capital projects and implementing several neighborhood-scale demonstration projects. To encourage retrofits on private property, the city relies on incentives including a green roof tax credit, rain barrel giveaways, and a direct grant program. There is no runoff retention standard for new development and redevelopment projects. The city has proposed a draft stormwater management rule and accompanying technical guidelines that may create some incentives for runoff volume reduction but would not require it. The city funds its green infrastructure investments through bond financing and sewer rate revenues, supplemented by federal and other grants when available. A proposed new consent order with the state of New York includes binding near-term and long-term commitments to build green infrastructure to reduce CSOs, requiring a total anticipated investment of over $1 billion. Further, the city is developing CSO Long Term Control Plans that will integrate planning for green and gray projects in individual watersheds; these may result in additional, cost-effective green infrastructure investments to help satisfy Clean Water Act requirements.

NEW YORK, NEW YORK



Total Criteria Score
Out of a possible 6

EMERALD CITY CRITERIA*

- ☑ Long-term Green Infrastructure (GI) Plan?
- ☑ Existing requirement to use GI to reduce some portion of the existing impervious surfaces?
- ☑ Incentives for private-party actions?
- ☐ Retention Standard?
- ☑ Guidance or other affirmative assistance to accomplish GI within City?
- ☑ Dedicated funding source for GI?

BACKGROUND

In New York City, one of the most densely developed cities in the nation, nearly three-quarters of the surface area is composed of impervious surfaces, such as streets, sidewalks, rooftops, and other paved spaces.[1] Half of the city's total land area, representing about two-thirds of the city's sewered areas, is served by a combined sewer system. The other half is served by municipal separate sewers or drains directly to local waterways.[2]

In dry weather an average of 1.3 billion gallons of sanitary sewage per day are channeled through more than 7,000 miles of sewers and treated at 14 wastewater treatment plants (WWTPs).[3] In wet weather, however, as little as one-tenth of an inch of rain can overwhelm the combined sewer system, causing raw sewage from more than 400 outfalls to be dumped into virtually every waterway in the city—including

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Porous concrete sidewalk Paerdegat Basin, CSO Detention Facility, Brooklyn, New York.

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An enhanced tree pit on Autumn Avenue, Brooklyn, New York.

the iconic Hudson River and Long Island Sound; Jamaica Bay, home to the nation's only wildlife refuge accessible by subway; and the long-neglected Bronx River, which public-private partnerships have been working for years to revitalize.[4]

Over the past 20 years, the city has invested more than $1.5 billion in CSO upgrades, including sewer, regulator, and pumping station improvements as well as four major storage tanks.[5] The system now captures about 72 percent of the annual wet-weather flow, up from a mere 30 percent annually in the 1980s.[6]

Nonetheless, the city continues to discharge nearly 30 billion gallons of CSO annually,[7] with overflows in some areas occurring up to 75 times in a typical year.[8] Even as the city moves ahead with a new "comprehensive waterfront plan" aimed at bringing residents back to local waterways, this untreated sewage poses a threat to people who use, or wish to use, the rivers, creeks, bays, and other waters along the city's 600-plus miles of shoreline for recreation. Additionally, although the city's public beaches along the Atlantic Ocean and Long Island Sound are usually unaffected by CSOs because of their distance from combined sewer outfalls, many private beaches are severely affected, and polluted runoff from municipal separate storm sewers and/or CSOs triggers occasional closures and advisories each year at public beaches.[9] Polluted runoff from the separately sewered portions of the city also causes localized water quality impairments in some places.[10]

Under a legal settlement with New York State, the city's Department of Environmental Protection (DEP), which operates the city's water, sewer, and wastewater systems, is currently developing Long Term Control Plans (LTCPs) to satisfy Clean Water Act requirements to reduce sewage overflows.[11] DEP has extensive experience using green infrastructure for stormwater management in its Staten Island "Bluebelt," a series of restored open spaces, such as wetlands that serve as natural treatment and drainage systems for stormwater runoff.[12] Between 1997 and 2007, DEP created 10,000 acres of Bluebelt, which saved the city an estimated $80 million in infrastructure costs while increasing nearby property values and saving homeowners flood damage costs.[13] However, in 2007, when DEP submitted a series of plans that serve as precursors to LTCPs, it became apparent that the city still viewed the more widespread use of green infrastructure in the more densely developed remainder of the city only as a subject for future study. Those plans relied entirely on traditional gray infrastructure for any quantifiable CSO volume reduction.[14]

Since that time, New York City—urged on by advocates and energized by the formation of a mayoral Office of Long-Term Planning and Sustainability—has undertaken substantial planning and outreach to identify, and begin to implement, more sustainable means of managing its water and sewer infrastructure. As described later, the city now anticipates, among other things, investing more than $1 billion in green infrastructure over the next 20 years to achieve specific CSO reduction targets and advance overall sustainability goals.[15]

GREEN INFRASTRUCTURE AS A TOOL FOR LONG-TERM URBAN SUSTAINABILITY

In 2007, Mayor Michael Bloomberg announced a long-term sustainability plan for New York City, known as "PlaNYC 2030," comprising more than 100 initiatives on a range of issues such as housing, open space, transportation, energy, climate change, and water quality. The main new water quality initiatives focused on using green infrastructure to capture stormwater and reduce sewer overflows. These included expanding the Bluebelt program by 4,000 acres within Staten Island over 25 years and applying the Bluebelt approach, where possible, in other low-density areas of the city; installing and monitoring several pilot projects, such as enhanced tree pits with below-grade water catchments

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A green roof at Paerdegat Basin, CSO Detention Facility, Brooklyn, New York.

and vegetated swales along parkways; amending zoning rules to require planted areas as part of any new parking lots; and creating a property tax credit for the installation of green roofs.[16]

PlaNYC recognized the overlap between water quality initiatives and the city's parks and open space initiatives. For example, it noted that an ongoing program to plant 1 million new trees would also provide stormwater capture benefits, adding to the estimated 870 million gallons of stormwater that existing street trees capture each year. It also estimated that planted areas in new "Greenstreets" (vacant traffic islands and medians converted into green spaces) would create a further 4 million gallons of stormwater retention capacity.[17]

To further investigate green infrastructure opportunities, *PlaNYC* established an "Interagency Best Management Practices (BMP) Task Force," coordinated by the Mayor's Office of Long-Term Planning and Sustainability, to oversee pilot projects and identify practices and designs that are well suited to New York City's environment. The Task Force included many agencies that had not previously considered stormwater management a part of their mission, even though they are responsible for infrastructure or development that significantly affects storm runoff. In addition to DEP, the task force included the Departments of Design and Construction, Parks and Recreation, Sanitation, Transportation, Buildings, City Planning, and others.[18]

In 2008, as a complement to *PlaNYC*, the City Council passed detailed legislation requiring the city to develop a "sustainable stormwater management plan."[19] Pursuant to that legislation, the mayor's sustainability office, working with the interagency BMP Task Force, issued a *Sustainable Stormwater Management Plan* that analyzed the city's land use patterns to identify green infrastructure potential; it also provided a preliminary analysis of the cost-effectiveness of various green infrastructure methods. This report identified substantial opportunities for using green stormwater infrastructure to reduce CSOs and established a green infrastructure agenda for the next several years that included, but also went beyond, the initiatives in *PlaNYC*.

GREEN INFRASTRUCTURE PROGRAMS UNDER WAY

The city has made significant progress with many of the initiatives set forth in *PlaNYC* and the Sustainable Stormwater Management Plan. In the last several years, city agencies have implemented (or planned) more than 30 green infrastructure demonstration projects and added 65 acres to the Bluebelt system on Staten Island while designing two new Bluebelt locations in Queens.[20] Through the state Environmental Facilities Corporation's Greening Innovation Grant Program,[21] the city also secured $2 million in federal stimulus funding to install at least 26 Greenstreets designed specifically to maximize stormwater capture, and another $15 million to restore 38 acres of wetlands and natural grasslands abutting Jamaica Bay, which will also serve to capture and filter stormwater.[22]

While city agencies worked on implementing pilots, DEP focused on developing a comprehensive approach to substantial, long-term, citywide investment in green infrastructure. The result was the *NYC Green Infrastructure Plan*, released in September 2010. In the plan, the city proposed to use decentralized stormwater retention and detention measures to manage, on-site, runoff from at least 10 percent of the impervious surfaces in combined sewer watersheds. These decentralized measures would combine $1.6 billion in public investment with $900 million in private investment to reduce CSOs by an estimated 1.5 billion gallons. Most of the public investment ($1.1 billion) would be in the public right-of-way, where the city would rely primarily on vegetated approaches to retain runoff. The city estimates that, over a 20-year period, new vegetated spaces created under this approach would generate between $139 million and $418 million in benefits through reduced energy bills, increased property values, improved health, and mitigation of carbon dioxide emissions.[23]

DEP immediately began putting into place some of the elements of its proposed 20-year plan. It established a new Green Infrastructure Task Force in December 2010, composed of city agencies, to identify the best opportunities to systemically incorporate green infrastructure into capital projects on an ongoing basis, using DEP capital funds and other available funding. The Task Force is also developing approved specifications for green infrastructure techniques to streamline design and permitting processes.[24] By the end of 2012, the city plans to install more than 100 bioswales in combined-sewer areas and begin design on green infrastructure projects for public schools, New York Housing Authority (NYCHA) properties, and other publicly owned land.[25]

The city has also used direct grants to stimulate innovation in green infrastructure, both on private property and in the public right-of-way. In two rounds of grant-making, DEP has provided more than $6 million to nonprofit organizations, community groups, and private property owners for projects such as curbside bioswales, rain gardens, porous sidewalks and parking lots, and a number of green roofs, some of which will also serve as rooftop farms or gardens.[26]

The city has adopted several new zoning requirements and incentive programs to promote green infrastructure on private property and in new developments. In 2008 the city adopted zoning rules to require new parking lots of more than 6,000 square feet, or with 18 or more parking spaces, to incorporate perimeter and interior landscaping, with paved spaces graded to drain into the planted areas.[27] Further zoning code amendments require new developments in all districts to plant street trees and, in lower-density areas, install continuous planting strips along sidewalks; another amendment prohibits residential properties in lower-density districts from paving over their entire front yards for parking.[28]

Within the past several years, city agencies have also developed design guidelines for public projects that promote green infrastructure principles. These include a Street Design Manual, High Performance Landscape Guidelines, and a Sustainable Urban Site Design Manual.[29,30,31]

The City also instituted a pilot property tax credit of $4.50 per square foot (up to a maximum of $100,000) for installing a green roof. To qualify, property owners must green 50 percent of their total roof surface and commit to maintaining the green roof for at least three years.[32]

DEP also gave away 2,000 rain barrels to homeowners in Brooklyn, Queens, the Bronx, and Staten Island from 2008 through 2011.[33]

DEP established a green infrastructure advisory committee in February 2011 to help guide the agency's efforts. It meets quarterly and is composed of representatives from the development community, environmental and other nonprofit groups, academia, and design professionals.[34] Early next year the agency will convene a technical advisory group of independent experts to periodically review the city's green infrastructure efforts and offer recommendations based on performance results from pilot programs and recently installed projects.[35]

LOOKING AHEAD: A 20-YEAR GREEN INFRASTRUCTURE PLAN FOR NYC

In October 2011, the DEP announced a proposed modification to its consent decree with New York State, which would modify existing gray infrastructure requirements and add new requirements to implement key aspects of the city's Green Infrastructure Plan. The proposed order eliminates some planned gray projects and substitutes certain others, which are projected to achieve comparable CSO volume reductions on a citywide basis, for a net savings of $1.4 billion. It also defers until 2017 any decisions on two potential CSO detention tunnels, estimated to cost $2 billion, to allow the city an opportunity to develop green alternatives that could substitute for, or allow the downsizing of, those projects.[36]

Under the order, much of the savings on gray investments would be reinvested to meet new green infrastructure requirements. Debt payments and operations and maintenance costs are funded through water and sewer rate revenues. By 2013, the city would be required to retrofit three neighborhood-scale demonstration areas (18 to 40 acres each) with an array of green infrastructure installations, in order to measure the cumulative effect of intensive greening efforts. Citywide, by 2015, the order would set a target of managing the first inch of runoff from at least 1.5 percent of the impervious surfaces in combined sewer areas citywide, at an anticipated cost to the city of $187 million. By 2016, the order would require the city to complete updated modeling analyses, using monitoring data from the three demonstration areas, to refine the Green Infrastructure Plan's estimates of CSO volume reductions associated with green infrastructure. Over the next 20 to 25 years, the city would be required to meet the Green Infrastructure Plan's target of managing the first inch of runoff from at least 10 percent of the impervious surfaces in combined sewer areas citywide—and to achieve corresponding CSO volume reductions. Finally, on a rolling basis through 2017, the order would require DEP to complete Long-Term Control Plans for each of the combined sewer areas within the city. These plans, subject to review and approval by the state, would specify any additional green and gray infrastructure improvements necessary to meet the Clean Water Act's water quality requirements, in each of the city's waterways, as well as a compliance schedule to implement such projects.[37,38]

The DEP's capital program, including both gray and green projects, is primarily financed with bonds. (Stormwater rates are currently based on potable water usage; however, in 2010, DEP instituted a pilot program that bases fees on impervious area, specifically for parking lots.[39]) DEP will also pursue other funding sources for green infrastructure, such as Clean Water Act State Revolving Fund monies and other federal funds, private funds, ecological restoration funding from the Army Corps of Engineers and other governmental partners, and other resource commitments from community and civic groups. As of September 2010, DEP was expecting to receive approximately $30 million a year in the State Revolving Fund's Green Reserve, based on recent allocation levels.[40] DEP recently updated its Ten-Year Capital Plan to include $735 million for its planned green infrastructure investments.[41]

DEP anticipates that over the next 20 years, the majority of impervious acreage to be retrofitted for on-site stormwater management will be on private property, where redevelopment projects will have to meet new performance standards that DEP is developing for the combined sewer portion of the city.[42] For a half-acre property, the proposed performance standard would reduce short-term (6-minute) peak discharges into the system by 80 to 90 percent, and would reduce longer-term (1-hour) peak discharges into the system by 20 to 50 percent.[43] However, the performance standard would limit the rate of release into the sewer system, rather than requiring any reduction in the volume of runoff through infiltration, evapotranspiration, or harvesting for reuse, as other cities require.[44] While this detention-based approach should help reduce CSOs by limiting peak wet-weather flows into the combined sewer system, the city's preliminary analysis indicates that it would achieve less CSO reduction than would be achieved if runoff volume reduction measures were installed across a comparable number of acres.[45] The city's intended approach would also fail to ensure the full range of benefits that genuinely green—i.e., vegetated—stormwater infrastructure provides, although the proposed rule provides property owners with the option to satisfy some portion of their compliance obligations with volume reduction techniques like green infrastructure. As this report goes to press, DEP is accepting comment on its draft regulation.[46]

*EMERALD CITY RATING SYSTEM

Each of the cities profiled in *Rooftops to Rivers II* is a leader in green infrastructure investment—rethinking the design of municipal services and infrastructure. These cities leverage funding in creative ways. They provide tools to residential and commercial land owners to retrofit private properties and realize the multiple benefits provided by green infrastructure. In short, they are changing how cities look and function.

NRDC's Emerald City Rating System identifies six actions cities should undertake to maximize their green infrastructure investment. Our metric does not directly compare one city to another, due to geographical, population, budgetary and other differences. Instead, it identifies the presence or absence of common factors of success that NRDC believes are essential elements of a robust green infrastructure commitment. Only one city profiled, Philadelphia, is undertaking each of the actions identified, although each city is undertaking at least one.

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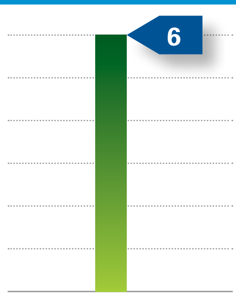
PHILADELPHIA, PENNSYLVANIA

A CASE STUDY OF HOW GREEN INFRASTRUCTURE IS HELPING MANAGE URBAN STORMWATER CHALLENGES

TYPES OF GREEN INFRASTRUCTURE USED: Green roofs, rain barrels/cisterns, permeable pavement, infiltration trenches or vaults, vegetated swales, street trees, planter boxes, downspout disconnection, green streets, naturalized storm basins, wetland creation and restoration

Over the next 25 years, Philadelphia is committed to deploying the most comprehensive urban network of green infrastructure in the United States. Philadelphia's Green City, Clean Waters plan, recently approved by state regulators, requires the retrofit of nearly 10,000 acres (at least one-third of the impervious area served by a combined sewer system) to manage runoff on-site; relies on green infrastructure for a majority of the required CSO reductions; calls for the investment of more public funds in green infrastructure (at least $1.67 billion) than in traditional gray approaches; and leverages substantial investments from the private sector, primarily through application of a one-inch retention standard for new development and redevelopment projects citywide. The city will fund its share of the costs with a stormwater fee based on impervious area, supplemented by state and federal grants as available. To encourage retrofits on private property beyond that required by the retention standard, the city offers incentives such as reduced stormwater fees, free design assistance and low-interest loans to owners of large impervious properties, a green roof tax credit, rain barrel giveaways, and expedited permit reviews. Philadelphia also has installed dozens of green infrastructure demonstration projects, has published a technical design manual, and is developing a maintenance manual.

PHILADELPHIA, PENNSYLVANIA



Total Criteria Score
Out of a possible 6

EMERALD CITY CRITERIA*

- ✓ Existing requirement to use GI to reduce some portion of the existing impervious surfaces?
- ✓ Incentives for private-party actions?
- ✓ Long-term Green Infrastructure (GI) Plan?
- ✓ Retention Standard?
- ✓ Guidance or other affirmative assistance to accomplish GI within City?
- ✓ Dedicated funding source for GI?

BACKGROUND

Like many burgeoning cities of the 19th century, Philadelphia experienced rapid population growth and increased industrial output in the mid 1900s. This surge in development resulted in the release of large amounts of untreated waste and sewage into local streams and rivers, which caused frequent widespread epidemics. In an attempt to safeguard public health, Philadelphia developed a series of sewer systems to transport waste away from its drinking water sources.[1]

Today, 60 percent of the city is served by combined sewers, and 40 percent by separate storm and sanitary sewers.[2] The Philadelphia Water Department (PWD) oversees approximately 3,000 miles of sewer piping, 79,000 stormwater inlets, three sewage treatment plants, 164 CSO outfalls, and more than 450 stormwater outfalls.[3] The combined sewer system serves more than three-quarters of the city's residents, covers an area of about 40,000 acres (64 square miles), and discharges into the Delaware and Schuylkill rivers as well as the Cobbs, Pennypack, and Tacony-Frankford creeks.[4] Elsewhere, separate storm sewers discharge into additional water bodies, such as Wissahickon Creek and its tributaries.[5]

When it rains, runoff from the city's vast impervious areas triggers CSO events, in some locations up to 85 times per year.[6] The overflows inundate local waterways with pathogens, debris, and other pollutants that impair water quality and make area waters unsafe for recreational use following storms. Additionally, the high volume of polluted runoff carries high sediment loads and contributes to elevated water temperatures, low dissolved oxygen levels, and streambank erosion, degrading riparian and aquatic habitats.[7] At least one local water body, Wissahickon Creek, is subject to a total maximum daily load (TMDL) for excessive sediment loadings.[8]

In 1997, PWD completed a CSO Long Term Control Plan (LTCP), which addressed the "nine minimum controls" required by the U.S. EPA's CSO Policy, as well as $150 million in capital improvements to the combined sewer system, such as installation of real-time controls, elimination of certain outfalls, and sewer conveyance improvements. Following the 1997 LTCP, the city also conducted detailed monitoring of water quality and overall stream health in much of the city. This monitoring supports, among other things, the development of integrated watershed management plans (IWMPs) to improve water quality during wet and dry weather and improve aquatic habitat in both combined and separate sewer areas.[9] The IWMPs include further commitments by PWD, including $56 million in sewer rehabilitation and relining.[10]

PROMOTING GREEN INFRASTRUCTURE ON PRIVATE PROPERTY

Philadelphia is promoting the use of green stormwater infrastructure in new and existing development through a combination of local regulations and incentive programs. In 1978 Pennsylvania enacted the Stormwater Management Act (Act 167), which required municipalities to adopt and implement ordinances that regulate development in accordance with county watershed-based stormwater management plans.[11] As a result, the Darby-Cobbs Watershed Stormwater Management Plan was developed in 2004. The stormwater management plan suggested capturing or infiltrating the first inch of stormwater runoff from all new impervious surfaces and was the impetus for the development of a new stormwater rule.

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Although schools represent only 2 percent of impervious cover in the combined sewer area, Philadelphia's Water Department believes the high visibility and educational opportunities associated with schools make them important places to showcase green infrastructure.

In 2006, the city adopted new rules that require on-site management of the first inch of rainfall in all new development and redevelopment projects with at least 15,000 square feet of earth disturbance. This must be achieved through infiltration, unless it is demonstrated to be technically infeasible on the basis of specified criteria, in which case PWD allows alternative management for the portion of the inch that cannot be infiltrated.[12] The rule does not require developers to exhaust opportunities for evapotranspiration or harvesting of the first inch of rainfall before resorting to alternative compliance methods. However, the alternative approaches do require that some (20 percent in combined sewer areas) or all (100 percent in separate sewer areas) of the non-infiltrated portion of the first inch of runoff be routed to an approved "volume reducing" stormwater management practice, such as planter boxes, bioretention with underdrains, green roofs, rain barrels, and cisterns. In combined sewer areas, any portion of the first inch of runoff that is not infiltrated must be released into the sewer system at a rate not to exceed 0.24 cubic foot per second, per acre of impervious drainage area.[13]

There are also channel protection and flood control standards that require slow release of the one-year, 24-hour storm event (which is larger than a one-inch storm); redevelopment projects are exempt if they reduce directly connected impervious area by at least 20 percent.[14]

Prior to any new development receiving its building permit, an Operation and Maintenance (O&M) Agreement is recorded against the land deed(s) of the project. This O&M agreement specifies the stormwater infrastructure used on the property as well as the maintenance practices and schedules for each type of infrastructure.[15]

Developers must submit stormwater plans early in the permitting process, which ensures that stormwater management is included in the overall site design. To simplify and streamline the process for permit review, inspection, and approval, PWD created a partnership with the Department of Licenses and Inspections and the City Planning Commission. Further, any project with 95 percent or more of its impervious area disconnected from the sewer system can qualify for a fast-track review, meaning that the stormwater management section of the project will be reviewed within five days of submittal.[16] PWD estimates that projects approved under the rule, as of June 2011, will keep roughly 1 billion to 1.2 billion gallons of stormwater out of the city's combined and separate sewer systems annually.[17]

In 2007, Philadelphia instituted a tax credit for property owners who construct a green roof and commit to maintaining it for five years.[18] Eligible green roofs must cover 50 percent of the total rooftop or 75 percent of the rooftop space that is structurally able to support a green roof. The one-time credit is for 25 percent of the total cost of installation, with a maximum credit of $100,000.[19] Maintenance obligations are written into the property's deed, but the city retains the right to inspect the green roof.

In 2010, Philadelphia adopted a new stormwater utility fee structure for nonresidential properties. Being phased in over four years, it creates incentives for using green infrastructure. Rather than charging a stormwater fee based on the size of a property owner's water meter, PWD now charges for stormwater services based in part on the area of impervious surface on a property, which directly correlates with the amount of stormwater the property generates. The charge also applies to properties such as parking lots, which may not have a water meter at all. Property owners who utilize green infrastructure, such as permeable pavement and green roofs, can receive a credit of up to 100 percent of their impervious-area-based fee.[20] For customers with large lots who will see substantial increases in their stormwater fees, PWD will provide free assistance through site inspections and design recommendations to identify opportunities for property owners to decrease the size of their impervious area.[21] In addition, PWD offers a low-interest (1 percent) loan program for green infrastructure retrofits on nonresidential property, administered by the Philadelphia Industrial Development Corporation.[22]

PWD offers other voluntary programs to promote green infrastructure, including a rain barrel give-away to residents who participate in a free workshop that includes instruction on proper installation and use. Initially, as a pilot project in 2002, PWD distributed 215 rain barrels to residents in one targeted watershed. PWD later expanded the program city-wide. As of 2009, the city had given away more than 2,000 barrels.[23]

DEMONSTRATION PROJECTS IN PUBLIC SPACES

PWD has also built green infrastructure demonstration projects in public spaces. To date, the agency has installed dozens of such projects around the city, with dozens more in the construction or design phase.[24] While a large majority of the demonstration sites are in combined sewer areas, some projects are located in separately sewered areas—especially in the Wissahickon Creek watershed, where they help reduce sediment from overland runoff and in-stream erosion sources, pursuant to a TMDL. A more comprehensive plan for implementing that TMDL is under development.[25]

Among the demonstration sites is the Greenfield School in the Schuylkill watershed, which utilizes rain gardens, permeable pavers, and a porous safety surface. Another site, the Waterview Recreation Center in the Tacony-Frankford watershed, showcases tree trenches, street runoff diversion, and a disconnected roof leader (gutter or pipe that drains runoff from a roof), rain barrel, and cistern.[26] Additionally, the Model Neighborhoods program is a collaborative effort among PWD, nonprofit civic and environmental organizations, and other city agencies to focus demonstration projects in 14 communities. Four blocks in each neighborhood will be retrofit with green stormwater infrastructure, such as street tree trenches, sidewalk planters, and vegetated street bump-outs. PWD received a $30 million loan from PENNVEST (the Pennsylvania Infrastructure Reinvestment Authority, which administers the state's Clean Water State Revolving Fund) to cover the design and construction costs in the first three neighborhoods.[27]

These and other demonstration projects have helped garner public support for green infrastructure and allowed the city to test different technical approaches to refine its overall program. The city continues to refine its technical designs, based on experience gained through scaled-up program implementation.[28]

GREEN CITY, CLEAN WATERS

Building on the programs described above, the city is now organizing its CSO efforts around an ambitious, 25-year plan to reduce runoff in the combined sewer area by transforming at least one-third[29] of the impervious surfaces into "greened acres." In every greened acre, stormwater practices, primarily green infrastructure, will be installed to manage on-site the first inch of rainfall in any given storm; on an annual basis, this amounts to 80 to 90 percent of runoff from these areas.[30]

This plan, called Green City, Clean Waters, was approved by the Pennsylvania Department of Environmental Protection (PADEP) in June 2011. The plan—including targets for greened acres, CSO volume reduction, and pollutant loading reductions—now constitutes a legally enforceable update to the city's CSO Long Term Control Plan under the Clean Water Act. It includes at least $1.67 billion of investments in greened acres and $345 million in expanded sewage treatment plant capacity. An additional $420 million is budgeted to be spent on whatever combination of additional green and gray infrastructure proves most cost-effective to achieve the targeted CSO reductions.[31]

The approved plan requires Philadelphia to reduce annual CSO volume by 7.96 billion gallons, with the majority of that reduction coming from green infrastructure. Enforceable numeric targets for green acres installed and annual gallons of CSO reduced by the 5-, 10-, 15-, 20-, and 25-year marks of the plan, as well as annual pollutant mass loading reductions by the 25-year mark, will be incorporated into the city's Clean Water Act permits when they are renewed in 2012.[32] PWD aims to complement all of these efforts with stream corridor restoration projects.[33]

Philadelphia considers its green infrastructure efforts part of a broader strategy to provide "more equitable access to healthy neighborhoods" for its residents and make Philadelphia the "greenest city in America."[34] The city commissioned a "triple bottom line" analysis to quantify the total social, economic, and environmental benefits of these programs—such as additional recreational use of the city's waterways; reduction of premature deaths and asthma attacks caused by air pollution and excessive heat; increased property values in greened neighborhoods; the ecosystem values of restored or created wetlands; poverty reduction from the creation of local green jobs; and energy savings from the shading, cooling, and insulating effects of vegetation. The city concluded that, over 45 years, it will reap more dollar value in benefits than it invests.[35] PWD estimates that achieving a similar amount of CSO reduction through gray infrastructure alone would cost billions of dollars more, without accruing the same non-water quality benefits.[36]

A unique aspect of Philadelphia's proposed plan is that it leverages private investment in green infrastructure to help satisfy Clean Water Act obligations. The plan takes advantage of stormwater improvements that private property owners will install over time, as private-sector redevelopment occurs and is subject to the city's on-site stormwater management rules. The state-approved plan requires at least 9,564 greened acres over the next 25 years.[37] PWD estimates that at a roughly 1 percent projected annual redevelopment rate, the stormwater rule could generate roughly 2,500 to 5,500 greened acres over the next 25 years.[38]

The balance of the greened acres in the next 25 years would come mainly from PWD investments in retrofits on publicly owned land, such as city properties, streets, and right-of-ways, which collectively make up 45 percent of the entire city's impervious area.[39] PWD will coordinate other city agencies to incorporate green infrastructure designs as standard practice in city projects, using PWD's budget (funded by stormwater fee revenues), along with any available state or federal grants, to supplement other agencies' capital budgets.[40]

As of August 2011, PWD had completed or was in the process of designing 91 stormwater tree trenches, 33 downspout planters, 24 rain gardens, 12 porous paving projects, 9 stormwater bump-outs, 9 swales, 7 stormwater planters, 6 infiltration/storage trenches, 3 stormwater wetlands, and 1 stormwater basin. Each of these projects is identified on the city's Green Stormwater Infrastructure Project Map.[41]

Looking ahead, in the first five years of the Green City, Clean Waters program, PWD initiatives will include implementation of a geographically concentrated array of green infrastructure retrofits in each of several "early action areas."[42] PWD will monitor wet weather flows in each area to assess the cumulative impact of green infrastructure on combined sewer system flows.[43]

Over the 25-year life of the program, the primary focus of PWD's green infrastructure investments will be streets and sidewalks, since they account for 38 percent of impervious cover in the combined sewer areas. The agency will focus on streets slated for capital improvements or routine repaving by the city Streets Department or state Department of Transportation; streets slated for repair or replacement of PWD's existing water and sewer infrastructure or flood-control-related construction; and streets where cable, gas, or phone infrastructure are being repaired and replaced. When such utility and road work is planned, PWD can also design and fund the installation of tree trenches and expanded tree pits, sidewalk planters and bump-outs, porous pavement, and other green infrastructure features to be installed simultaneously. This will limit the project costs by avoiding the need to repeatedly dig up and replace portions of streets and sidewalks, making the stormwater improvements a small marginal cost of the overall capital improvement expenditure. It will also limit inconvenience to residents.[44]

Although schools represent only 2 percent of impervious cover in the combined sewer area, PWD believes the high visibility and educational opportunities associated with schools make them important places to showcase green infrastructure.[45] As of late 2009, PWD had completed projects at five schools, including a green roof, rain gardens, permeable pavers, and rainwater harvesting for reuse.[46] PWD aims to retrofit up to half of all schools over 20 years, with a special focus on using pervious pavement and trees in parking and recreation areas to transform heat-trapping asphalt surfaces into cooler, greener, more welcoming spaces.[47]

A central tenet of the city's approach is adaptive management. The precise locations of the impervious areas to be converted to greened acres over a 25-year period cannot practicably be determined at the start, nor can the mix of green infrastructure investments. Through detailed tracking of individual retrofit installations, PWD will measure progress against 5-year incremental targets for greened acres and will make adjustments to stay on course for reaching the required number of greened acres over 25 years.[48] The focus on streets will be supplemented, as needed, with programs aimed at retrofitting public facilities, parking lots, public open space, alleys, driveways, walkways, homes, and industrial, commercial, and institutional properties, using a combination of direct PWD investment and incentives for private investment.[49]

Adaptive management also includes monitoring the performance of green infrastructure at the site- and sewershed scale, as well as the resulting CSO reductions and water quality improvements. PWD is developing a comprehensive monitoring plan to ensure that green stormwater infrastructure projects perform as expected. The plan will address monitoring of natural and engineered systems, including surface waters, groundwater, rainfall, CSO discharges, sewer flows, and green infrastructure performance. It will also describe performance-tracking protocols, including hydrologic and hydraulic modeling with verification using metered data.[50]

PWD is developing an operation and maintenance manual for all types of green stormwater infrastructure included in the Green City, Clean Waters plan. The manual is intended for use both by city agencies and by private property owners with responsibility for maintenance of green stormwater infrastructure.[51] PWD plans to invest more than $200 million in operation and maintenance of green stormwater infrastructure on public property over the next 25 years and upwards of $30 million each year thereafter.[52]

PWD recognizes that implementation of this program will require extensive coordination with other city agencies, both on specific retrofit projects and on broader regulatory and policy changes needed to facilitate the widespread use of green infrastructure. For example, PWD is engaging with the Zoning Commission to clarify PWD's ability to provide review and comment on stormwater impacts and mitigation measures prior to the approval of special district master plans. In addition, PWD has provided comments on planned revisions to the Open Space and Natural Resources section of the zoning code, especially regarding steep slope protection and stream buffers, and is working with the city Streets Department to develop a Green Streets Manual.[53]

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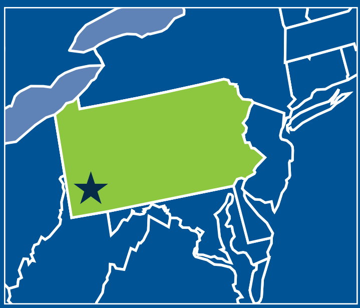
PITTSBURGH, PENNSYLVANIA

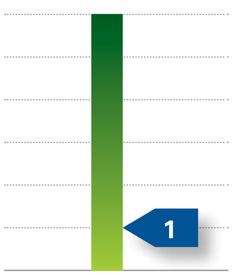
A CASE STUDY OF HOW GREEN INFRASTRUCTURE IS HELPING MANAGE URBAN STORMWATER CHALLENGES

TYPES OF GREEN INFRASTRUCTURE USED: Green roofs, rain barrels/cisterns, permeable pavement, rain gardens, infiltration trenches or vaults, vegetated swales, street trees, downspout disconnection, open space preservation



Pittsburgh has attempted to incorporate green infrastructure projects and practices into its stormwater management program and its efforts to reduce CSOs in the region. However, its most tangible accomplishment toward full-scale green infrastructure implementation is the passage of a stormwater ordinance that establishes stormwater volume reduction standards, including a requirement that developments larger than 10,000 square feet retain the first inch of rainfall on-site. Pittsburgh lacks a long-term green infrastructure plan, although it has enacted a number of programs aimed at creating permanent green spaces or at greening vacant or abandoned lots throughout the city. It has also made an effort to encourage community participation in green infrastructure projects, particularly through use of Community Development Block Grants and support for individual greening projects. Yet the city has only a limited array of incentive programs or guidance available to the public or developers for incorporating green infrastructure, and does not have a dedicated funding source for green infrastructure. Pittsburgh's work to promote green building practices and remove hurdles to green infrastructure (for instance, by changing city codes to allow for downspout disconnections) have fared well. But the city could benefit from a more integrated approach to incorporate green infrastructure in its long-term planning.

PITTSBURGH, PENNSYLVANIA



Total Criteria Score
Out of a possible 6

EMERALD CITY CRITERIA*

- ☐ Long-term Green Infrastructure (GI) Plan?
- ☐ Requirement to use GI to reduce some portion of the existing impervious surfaces?
- ☐ Incentives for private-party actions?
- ☐ Guidance or other affirmative assistance to accomplish GI within City?
- ☐ Dedicated funding source for GI?
- ☑ Retention Standard?

BACKGROUND

Pittsburgh is an older, post-industrial city struggling to repair years of environmental degradation wrought by its manufacturing past. The city, which lies at the confluence of three rivers—the Allegheny, the Monongahela, and the Ohio—has seen its population decline over the past several decades, due in part to the collapse of the steel industry. Left behind are pollution nuisances such as brownfields and slag heaps, as well as a shrinking urban center. Rather than leave abandoned properties sitting unused, Pittsburgh has redeveloped and reclaimed large parcels of land for greenways and parks.[1] Today it is experiencing a rebirth as a technology industry hub, with nearly 2,400 high-tech firms employing more than 90,000 people.[2]

The city's Green Up Pittsburgh Initiative, which started with a $50,000 Community Development Block Grant, supports projects to transform city-owned vacant land into community gardens, parks and green spaces. It provides resources such as plants, pots, soil, and water, and covers liability, while residents are responsible for maintenance.

From late 1800s to the early 1900s, combined sewers were put in place throughout the Pittsburgh region. Today, the larger metropolitan area's 4,000 miles of sewer pipes and at least 450 combined and separate sewer overflow structures[3,4] release about 22 billion gallons of untreated municipal waste directly into receiving waters each year.[5] As little as one-tenth of an inch of rainfall can cause overflows, and during the boating season (May 15 to September 30), river advisories are issued on an average of 70 days, or about 50 percent of the season.[6] Complicating matters is that Pittsburgh is one of 83 separate municipalities serviced by the Allegheny County Sanitary Sewer Authority (ALCOSAN), with each municipality responsible for its own collection system. Under a 2007 federal court consent decree, ALCOSAN must submit a detailed wet weather plan (addressing both SSOs and long-term control of CSOs) by 2013, and must complete implementation of that plan by 2026.[7] ALCOSAN has estimated that to repair and expand the system using traditional stormwater management practices would cost more than $3 billion.[8] More recently, city and county officials placed the cost at $10 billion to $50 billion.[9]

Water and sewer services for the city of Pittsburgh and the surrounding area are provided by the Pittsburgh Water and Sewer Authority (PWSA). Overall, PWSA is responsible for a combined collection system that serves approximately 80 square miles, includes 194 permitted CSO outfalls along the system's approximately 1,230 miles of pipes, and discharges into a system of interceptors owned and operated by ALCOSAN.[10] In 2004, the city of Pittsburgh and PWSA entered into a consent order and agreement with the Pennsylvania Department of Environmental Protection and the Allegheny County Health Department. The order required that the city and the sewer authority: inventory the collection system; assess the sewers and the performance of repairs; monitor the flow within the sewers and the implementation of an operation and maintenance plan for SSOs and Nine Minimum Controls for CSOs; and, collaborate with ALCOSAN to develop a long-term control plan.[11,12]

Since the first *Rooftops to Rivers* report, Pittsburgh has added several programs and incentives to revitalize the city with a strong green undercurrent. Some programs and policies, which were pilot projects in the past, have been incorporated into the city's operations. Pittsburgh encourages participation by individuals and the private sector by providing various incentives and by creatively engaging the public. However, CSO and stormwater issues are still prevalent, and local nonprofit organizations are working with the city and PWSA to encourage them to make greater use of green infrastructure practices for stormwater management.

GREEN INFRASTRUCTURE IN PITTSBURGH

Since 2006, the city has enacted several new ordinances to enhance efforts to reduce CSOs and better prevent stormwater from entering sanitary sewer lines in separately sewered areas. First, in separately sewered areas, a local law requires that all illegal surface stormwater connections to city sanitary sewers be disconnected, allowing for dye testing of surface stormwater connections. Evidence of compliance is required as a condition of the sale of property and the issuance of city lien verification letters.[13]

Second, in 2007, Pittsburgh enacted a citywide stormwater ordinance establishing stormwater volume reduction standards for properties greater than 10,000 square feet in size, including on-site retention of the first inch of rainfall through any combination of infiltration, evapotranspiration, and rainwater harvesting. The local law also promotes practices such as preserving natural drainage systems, maintaining or extending riparian buffers, minimizing soil disturbance and compaction, and disconnecting impervious surfaces by directing runoff to pervious areas.[14] In 2010, the city expanded its ordinance to apply a more protective standard to publicly subsidized projects, citing the performance standard Congress has adopted for federal facilities as a model. These projects must use green infrastructure techniques to retain, to the maximum extent technically feasible, all runoff produced by rainfall events less than or equal to the 95th-percentile storm (1.5 inches).[15]

In addition, the Green Infrastructure Network, which is coordinated by the Pennsylvania Environmental Council and a nonprofit organization called 3 Rivers Wet Weather (3RWW), was formed as a voluntary partnership in 1998. It comprises more than 35 organizations, businesses, universities, authorities, and government entities (including the city of Pittsburgh and PWSA) that recognize the benefits of using green infrastructure in managing Allegheny County's stormwater. The network encourages the use of green infrastructure over gray where feasible, by cataloging existing green infrastructure in the region (available at www.pag4g.org) and developing standardized monitoring protocols to document its effectiveness.[16] By early 2012, 3RWW expects to have an online database that identifies existing projects, in order to help identify locations where green infrastructure has the highest potential to reduce CSOs, and provide property owners with site-specific options and cost estimates.[17]

Further, in 2010, Allegheny County—working with environmental groups including the Pennsylvania Environmental Council and 3RWW—modified its plumbing code to allow downspout disconnections. Property owners can now direct rooftop runoff to pervious areas so it will infiltrate into the ground, or to rain barrels or other capture devices so it can be stored and reused.[18] Prior to the code revision, all downspouts were required to be connected to either a separate or a combined sewer system.

UTILIZING "GREEN" TO PROVIDE MULTIPLE BENEFITS

The city has also begun utilizing green infrastructure in other ways. In 2007, Mayor Luke Ravenstahl began a Green Up Pittsburgh initiative to reduce blight and public safety hazards, inspire community pride, and promote environmental values. The initiative, which started as a pilot project with a $50,000 Community Development Block Grant,[19] consisted of three parts: support for individual greening projects; post-demolition greening; and community-wide strategic greening. To support individual projects, the city provides resources such as plants, pots, soil and water, and covers liability, while residents are responsible for conducting maintenance. For buildings being torn down, the city invests Green Up resources into specific parcels and works with the contractor to provide clean fill and low-maintenance grass. For community-wide efforts, the city works with community leaders to prioritize demolitions, identify potential garden sites, and create community-wide projects.

In the pilot phase, the city successfully transformed 40 city-owned vacant lots while engaging hundreds of volunteers. On the basis of the project's success, it was expanded in 2008, doubling its demolition budget. It was also boosted by a $500,000 grant from the state's Department of Community and Economic Development. To date, the program has transformed more than 120 vacant lots into functioning green spaces. Information on the application process and on existing and past projects (as well as an interactive map showing locations) is maintained online.[20] The city also encourages individuals to plant gardens in vacant city-owned lots through its Garden Waiver Program, which allows residents to maintain the land while the city maintains legal liability for the parcel.

Taking these efforts one step further, in 2010 a team of experts and neighborhood stakeholders helped the East Liberty Development Corporation finalize the nation's first green overlay plan for a distressed urban district. The East Liberty Green Vision comprehensively inventories the environmental systems within the East Liberty community, creates guidelines and indicators for a sustainable neighborhood, and recommends strategies for currently blighted public spaces. Such strategies include the use of green infrastructure practices such as street trees with larger tree pits, porous pavement, green roofs, and curb cutouts for better stormwater management. With this program, East Liberty is serving as a pilot site for green strategies within the city of Pittsburgh.[21]

GREEN BUILDINGS

Pittsburgh is ranked eighth in the nation in the number of LEED® certified buildings. In 2003, its David L. Lawrence Center was built as the world's first LEED® Gold certified green convention center. By incorporating rainwater harvesting features, the building also uses 60 percent less potable water than other similar, non-LEED® buildings. In 2005, the Phipps Conservatory and Botanical Gardens underwent a major expansion and installed the nation's first LEED® certified visitor center, which included a rain garden, a 15,000-square-foot green roof, and a cistern to store rainwater for use in ornamental ponds.[22] To encourage more green buildings, the city enacted a 20 percent height and floor density bonus for LEED® certified buildings in 2007. It also instituted a requirement that publicly financed development projects costing more than $2 million or measuring more than 10,000 square feet attain LEED® Silver certification. With these incentives, the city now has 39 LEED® certified buildings, and an additional 60 new city projects are pursuing certification.[23] The city has not, however, taken the extra step to specifically incentivize green infrastructure stormwater controls as part of its green building program.

GREENWAYS, OPEN SPACE, URBAN TREE ASSESSMENTS, AND TREE VITALIZE

Pittsburgh's topography is dramatic, with hills adding beauty to the urban landscape. In total, hillsides account for nearly 20 percent of Pittsburgh's land area. Development in these areas, however, is less desirable due to the high cost of city services and potential slope instability. As a result, there are a high number of small tax-delinquent parcels in these areas. To provide a strategy for their use, Pittsburgh started the Greenways for Pittsburgh program in 1979 to designate select vacant parcels as permanent green space.[24] Working with the city's Real Estate Department, the Department of City Planning acquires designated properties as greenways and continues to expand the program to include contiguous parcels that are either tax delinquent or vacant.[25]

The city views the Greenways program not just as a means of protecting natural, cultural, and scenic resources, but also as a way to enhance quality of life and stimulate economic development.[26] Additionally, the city's Department of City Planning is currently developing an Open Space, Parks, and Recreation Plan to address issues of connectivity, ownership, management, and maintenance. This plan will be one of 12 components of PLANPGH, the city's first-ever comprehensive plan, and will encompass the city's vision and policy recommendations for future land use, infrastructure, and public services.[27]

In order to strategically identify areas with tree canopy needs, Tree Pittsburgh, in partnership with various city departments, performed a street tree inventory in 2005. With this information, the city completed a cost-benefit analysis that showed for every dollar spent on a municipal forestry program, three dollars in benefits are received in the form of stormwater control, reduced energy costs for cooling, increased property values, and more. In total, Pittsburgh's street trees were estimated to provide $1.6 million in net annual benefits. In 2010 Tree Pittsburgh began creating an urban forest master plan. Information gathered in the master planning process is being used to develop a coordinated approach between public and private stakeholders to protect, maintain, and restore the city's tree canopy.[28] One result of this work has been the establishment of TreeVitalize Pittsburgh, a joint project of Allegheny County, the city of Pittsburgh, Tree Pittsburgh, the Pennsylvania Department of Conservation and Natural Resources, and the Western Pennsylvania Conservancy. TreeVitalize Pittsburgh has set a target to plant 20,000 trees by 2012 throughout the Pittsburgh region.[29]

NINE MILE RUN AND PANTHER HOLLOW WATERSHED

In 2006, the city of Pittsburgh and the Army Corps of Engineers were near the completion of a $7.7 million restoration of Nine Mile Run, a highly degraded stream that runs through a 455-acre park and recreation area. (The city and the Three Rivers Wet Weather Demonstration Program contributed $2.7 million, while $5 million came from the Corps.) The stream is one of the few in the city that have not been encased in concrete. Now complete, the restoration involved not just the repair of the stream itself but reductions in sources of wet weather pollution to Nine Mile Run.[30]

The Nine Mile Run Watershed Association (NMRWA) continues to ensure the protection of the restored stream, and in 2009, after a severe storm impacted a number of hydraulic features constructed during the 2006 restoration, the association secured funding for repairs.[31] In addition, NMRWA has installed more than 1,320 rain barrels since 2004 and is currently gathering data to measure their impact on runoff.[32,33]

One ecologically significant component of Nine Mile Run is the 384-acre Panther Hollow Watershed, an important natural and recreational area that encompasses the Panther Hollow Run and Phipps Run streams, which join above Panther Hollow Lake.[34] In the fall of 2010, the Pittsburgh Parks Conservancy secured a $1 million grant from the Richard King Mellon Foundation to partly fund the restoration of the watershed by reducing stormwater runoff and preventing further degradation of the hollow and its man-made lake. The Pittsburgh Parks Conservancy, in partnership with the City of Pittsburgh, is considering green stormwater approaches such as residential rain gardens, street trees, and bioswales as part of the solution.[35]

FINANCING STRATEGY

The ways in which Pittsburgh encourages participation in city greening programs, such as converting vacant lots into garden areas, is unique, allowing community members to actively engage in turning public eyesores—rundown, vacant lots—into public goods. The city has also used other incentives to encourage investment in green infrastructure.[36]

Capital improvement programs such as distribution, sewer conveyance, water supply and filtration projects, dye tests, and the repair of aging infrastructure is the responsibility of PWSA. PWSA's work is partly covered by a service charge, which increased 7.7 percent at the beginning of 2011. At the end of 2009, PWSA implemented a 5 percent Distribution Infrastructure System Charge on all water bills to cover a major investment in infrastructure upgrades.[37] For 2011, the fund's budget was projected to be $6.3 million. In addition, the PWSA doubled its capital improvement budget from $20 million in 2009 to $41.7 million in 2010.[38]

*EMERALD CITY RATING SYSTEM

Each of the cities profiled in *Rooftops to Rivers II* is a leader in green infrastructure investment—rethinking the design of municipal services and infrastructure. These cities leverage funding in creative ways. They provide tools to residential and commercial land owners to retrofit private properties and realize the multiple benefits provided by green infrastructure. In short, they are changing how cities look and function.

NRDC's Emerald City Rating System identifies six actions cities should undertake to maximize their green infrastructure investment. Our metric does not directly compare one city to another, due to geographical, population, budgetary and other differences. Instead, it identifies the presence or absence of common factors of success that NRDC believes are essential elements of a robust green infrastructure commitment. Only one city profiled, Philadelphia, is undertaking each of the actions identified, although each city is undertaking at least one.

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PORTLAND, OREGON

A CASE STUDY OF HOW GREEN INFRASTRUCTURE IS HELPING MANAGE URBAN STORMWATER CHALLENGES

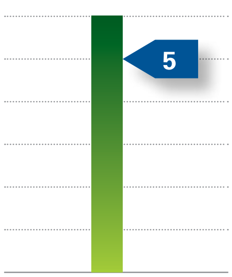
TYPES OF GREEN INFRASTRUCTURE USED: Green roofs, rain barrels/cisterns, rain gardens, permeable pavement, infiltration trenches or vaults, vegetated swales, street trees, planter boxes, green streets

Portland has made a very strong community commitment to green infrastructure. Through a combination of requirements and voluntary measures the city has initiated, green infrastructure is a central component of the community's program for reducing stormwater runoff and its efforts to address overflows from the parts of the city covered by the combined sewer system. In particular, a runoff retention standard with a priority for green infrastructure implementation is in place and applies to new and redevelopment projects involving as little as 500 square feet of impervious area. Portland also has a requirement to develop a retrofit plan for existing impervious areas, and has programs designed to replace city-owned impervious areas along streets and on municipal building roofs. Its 2011 Public Facilities Plan specifies particular intersections for green infrastructure installation—more than 2,200 facilities for green infrastructure are targeted.

The city has an impressive array of incentives for private parties to implement green infrastructure, including its "treebate" program, development area bonuses and grant programs for ecoroofs, and the ability to reduce applicable stormwater fees by implementing green infrastructure practices. The city is working in a number of ways to facilitate green infrastructure. For instance, the city reviews local codes to identify and work to remove barriers to green infrastructure, conducts training programs for a variety of stakeholders whenever it updates its stormwater manual, and sponsors green-roof workshops to educate those working in the local markeplace: designers, suppliers, and contractors. Finally, there are sewer and stormwater fees paid by ratepayers and developers that help supply funding to keep these programs running.

A key to the success of Portland's program has been its willingness to experiment with green infrastructure initiatives, adapt its programs based on implementation experience, and explore solutions that are tailored to the needs of particular watersheds in the city.

PORTLAND, OREGON



Total Criteria Score
Out of a possible 6

EMERALD CITY CRITERIA*

- ☐ Long-term Green Infrastructure (GI) Plan?
- ☑ Existing requirement to use GI to reduce some portion of the existing impervious surfaces?
- ☑ Incentives for private-party actions?
- ☑ Retention Standard?
- ☑ Guidance or other affirmative assistance to accomplish GI within City?
- ☑ Dedicated funding source for GI?

BACKGROUND

For years, Portland, Oregon, has been a leader in green infrastructure, actively promoting innovative stormwater management through various educational, funding, and incentive programs. The city promotes a wide range of green infrastructure technologies, including green roofs (or "ecoroofs"), permeable pavements, infiltration planters, rain gardens, street trees, landscaping requirements, and sustainable street design ("green streets"). One reason the city has remained at the leading edge of the green infrastructure movement is its focus on monitoring the effectiveness of decentralized stormwater management technologies. This has enabled city departments to further refine technologies

The City of Portland is taking a holistic approach toward improving the health of the local watershed with the Brooklyn Creek Basin Program. The program introduces the first prototype for "green" main streets in the country, manages more than 1 million gallons of stormwater runoff, and creates 126 jobs during construction.

and give department employees the confidence to evaluate the effectiveness and promote the use of stormwater designs before they are put into place.

As with many cities, part of Portland's motivation to achieve more successful stormwater strategies comes from a history of pollution and a desire to repair local ecosystems. One of Portland's primary ecological concerns is the Willamette River, which has been subjected to considerable industrial and urban pollution. A significant portion of this pollution has come from overflows of the city's combined sewer system. In 2002 Portland experienced 50 overflow events and discharged 2.8 billion gallons of combined overflow into local waterways.[1] In addition, a significant portion of Portland—roughly 22,000 acres—is served by a separate municipal storm sewer system (MS4), which discharges to area waterways.[2]

To alleviate its combined sewer overflow (CSO) problem, Portland has pursued a dual approach: improving upon its public gray infrastructure to add storage capacity to the overloaded sewer system, and pursuing lot- level green infrastructure strategies to manage stormwater. The Big Pipe project, Portland's primary combined sewage control solution, is set to come online in late 2011, slightly ahead of schedule and within its $1.4 billion budget. Already, a combination of infrastructure improvements and private-property stormwater management initiatives has virtually eliminated CSOs to the Columbia Slough, which discharges into the Willamette River, and has eliminated or controlled eight Willamette River CSO outfalls. Upon completion, the number of CSO events is expected to shrink to an average of four every winter and one every third summer.[3] The project is being paid for by Portland residents via sanitary and stormwater utility fees.[4]

Portland's green infrastructure techniques are designed to address the region's rainfall patterns, which are characterized by small, frequent storms. These storms produce the type of runoff events that green infrastructure technologies—such as vegetative infiltration and ecoroofs—are most successful at mitigating. More than half of Portland's land area is impervious, with streets making up 25 percent of impervious surfaces and rooftops representing 40 percent. These surfaces create an opportunity and a need for green infrastructure development.

Accordingly, Portland's stormwater manual requires that new development and redevelopment projects with more than 500 square feet of impervious surface comply with pollution-reduction and flow-control standards, and requires the use of green infrastructure before other measures can be considered.[5] The city launched a Grey to Green Initiative in 2008 to encourage greater investment in green infrastructure and complement the city's conventional pipe investment. In 2008, the city budgeted $50 million in stormwater management fees to invest in green infrastructure over five years; this is expected to add 43 acres of ecoroofs (a term coined to illustrate that, even in the dry season when very little is green, these roofs still perform well), build 920 "green street" components, plant over 80,000 trees in yards and along streets, and buy 419 acres of "high priority natural areas.[6]

Portland encourages sustainable stormwater management through a series of policy initiatives. Its Green Building Policy, for example, requires green building principles to be incorporated into all newly constructed city facilities and city-funded projects, and requires that all new city-owned buildings have at least 70 percent of their rooftop space covered by ecoroofs.[7] In 2007 the Portland City Council approved a green street resolution, report, and policy to promote and incorporate the use of green street facilities in public and private development.[8] And in 2009, the City Council and the Multnomah County Board approved a Climate Action Plan that calls for a 40 percent reduction in carbon emissions by 2030 and an 80 percent reduction by 2050. The plan, which identifies products and services related to green infrastructure as one of its guiding visions, calls for the city to implement, by 2012, an outreach campaign to educate residents about the benefits of trees and green infrastructure. Also by 2012, the city must evaluate both green and gray alternatives for public infrastructure projects. In addition, the Climate Action Plan calls for the city to increase its tree canopy from 26 percent to 33 percent by 2030.[9]

STORMWATER RETENTION AND GREEN INFRASTRUCTURE REQUIREMENTS

As noted earlier, a portion of Portland is served by a separate sewer system, which is covered by a discharge permit under the Clean Water Act. The Oregon Department of Environmental Quality issued a new permit for the system in January 2011; it contains important requirements that foster green infrastructure in the city.

Beginning in 2014, the stormwater system is required to have a post-construction program ensuring, among other things, that new and redevelopment projects with 500 square feet or more of impervious area "[i]ncorporate site-specific management practices that target natural surface or predevelopment hydrologic functions as much as practicable."[10] Along those lines, projects are supposed to prioritize green infrastructure. In addition, the permit contains a performance-based site retention standard: projects must be designed to "[c]apture and treat 80 percent of the annual average runoff volume, based on a documented local or regional rainfall frequency and intensity." Consistent with these requirements, the permit holder must also review existing barriers to minimize runoff and impervious area, with specific attention to green infrastructure, and must also have an enforceable stormwater management manual that provides guidance on implementing the permit mandates.

Portland's permit also requires the MS4 to create a "stormwater quality retrofit strategy" to achieve water quality goals via retrofit projects. In particular, the plan must make progress toward any relevant cleanup plan for the receiving water body, describe efforts to implement retrofits, and identify priority areas for retrofit projects.[11]

DOWNSPOUT DISCONNECTIONS TO PRIVATE PROPERTY RETROFITS

Portland recently wrapped up its nearly 20-year Downspout Disconnection Program, which provided free work or incentives to disconnect downspouts from its combined sewer system in targeted locations. The city is now focusing on designing and constructing stormwater management facilities on private property in areas with localized stormwater management problems. In total, the city disconnected more than 56,000 downspouts from over 26,000 properties within its CSO area from 1993 to mid-2011, allowing more than 1.2 billion gallons of stormwater to infiltrate into the ground annually.[12,13] The Downspout Disconnection Program started out with a two-year pilot to provide Portland's Bureau of Environmental Services (BES) time to identify and address safety concerns and/or discrepancies with local building and plumbing codes, building setbacks, and right-of-way setbacks; to evaluate slopes, soils, and the amount of area necessary to allow water to infiltrate; and to define targeted residential areas that would benefit from such a system-wide approach. According to the BES, those two years were essential to ensure that the program identified and addressed safety concerns and target areas where downspout disconnections were an effective method of stormwater management.[14]

Now, as the city shifts its focus from strict system-wide CSO concerns to more localized issues, such as basement flooding resulting from stormwater that exceeds local line capacity, its implementation strategy is shifting as well. Through the Private Property Retrofits program, BES is now offering a variety of partnership opportunities to manage stormwater on-site, including the design and implementation of multiple permanent solutions (such as rain gardens, stormwater planters, and ecoroofs) on participating private properties. The agency is currently focusing on projects within the Seven Corners stormwater retrofit area.[15]

PORTLAND GREEN STREET PROGRAM

In 2006, *Rooftops to Rivers* reported on two green street pilot projects Portland conducted. The first, installed in 2003, was a vegetated curb extension on N.E. Siskiyou Street that captures stormwater through an attractive landscaped area. The city conducted flow tests to ensure water would be infiltrated in the right-of-way and found that the vegetated curb extensions reduced peak flow from a 25-year storm event (approximately two inches in six hours) by 88 percent—enough retention to protect local basements from flooding—and reduced total runoff to the combined sewer system by 85 percent. The project took two weeks to install and cost $15,000. Portland also installed curb extensions on S.E. Ankeny Street and street projects at the intersection of S.W. 12th Avenue and S.W. Montgomery Street, and at the intersection of N.E. 131st Avenue and N.E. Fremont Street.

Since that time, the pilot has become a comprehensive, city-wide program with the adoption of a Green Street Policy in 2007, which requires all city-funded development or redevelopment infrastructure projects involving the right-of-way to manage stormwater runoff on-site at both the source and the surface. The use of vegetated practices that improve water quality and infiltration capacity are encouraged, and projects that do not manage stormwater are subject to an off-site project or off-site management fee. Projects that do not trigger the use of the Stormwater Management Manual, such as retrofits or expansions, are required to pay 1 percent of the total construction cost into a fund that supports green street projects that are not otherwise required by the manual.[16]

This policy takes advantage of transportation corridors to capture and treat stormwater runoff, create green space and pedestrian areas, and create attractive streetscapes that enhance neighborhood livability. By the end of 2010, approximately 950 green street facilities had been constructed.[17] Data from the city's 2010 Stormwater Management Facility Monitoring Report show that infiltration facilities, which include green streets, have tremendous potential to manage stormwater flow rates and flow volumes.[18] Besides investments as part of its Grey to Green Initiative, the adopted FY2010-2011 budget also included $20 million in capital improvement expenditures to construct green street facilities along high-priority bicycle boulevards.[19]

Expanding on these efforts to take an integrated approach to stormwater management, Portland is planning to implement hundreds of sewer, stormwater, and watershed projects to improve the sewer and stormwater systems in a 1,400-acre section of the southeast quarter of the city. Under the "Tabor to the River" (T2R) program, the city will add more than 500 green street facilities such as vegetated curb extensions and streetside planters, plant approximately 3,500 trees, work with private property owners to install vegetated areas or pervious pavement to capture runoff from disconnected downspouts and parking lots, conduct a comprehensive public involvement and outreach effort, and repair or replace 81,000 feet of sewer pipe.[20] More than 135 green street facilities were completed in 2010 and 2011. The city estimates that resolving flooding and other problems caused by runoff in the region using only conventional infrastructure and pipe solutions would have cost an estimated $144 million, compared with an estimated $86 million price tag using largely green infrastructure approaches, which provide the added benefits of enhancing water quality and watershed health.[21,22] Portland's experience with the T2R program has increased the city's confidence in implementing projects that blend watershed health and sewer improvements in other highly urbanized areas of the city.

PORTLAND'S ECOROOFS

The first green roof in Portland was installed in 1996. In 2001 the city created a Green Building Policy requiring that green building principles and practices are incorporated in the construction of new city facilities (LEED® Silver) and city-funded projects (LEED®) to the fullest extent possible. The policy also requires that the city evaluate all future land purchases to reduce environmental impacts through such efforts as on-site stormwater mitigation, vegetation, and habitat restoration. It updated this policy in 2005 to strengthen the ratings to LEED® Gold and Silver for city facilities and city-funded projects, respectively, and to require new city-owned buildings and existing buildings in need of a roof replacement to install a green roof on at least 70 percent of the roof area, with any remaining area covered with Energy Star–rated roofing material.[23]

Green roofs are required only on city-owned buildings, though Portland encourages their installation on private buildings through a number of incentives. In 2006, when the first *Rooftops to Rivers* publication went to print, the city offered developers proposing buildings in Portland's Central City Plan District floor area bonuses if an ecoroof were installed. As a result, a dozen or so developers installed 200,000 square feet of ecoroofs and earned almost 600,000 square feet of additional floor area.[24] Since then, the city launched an Ecoroof Grant Program that offers grants of up to $5 per square foot for ecoroof projects within city limits. To be eligible, the roofs must manage stormwater and have a designated project manager. An internal committee reviews applications twice a year.[25] Since 2006, property owners have received discounts of up to 100 percent of the on-site portion of their stormwater utility fee by installing an ecoroof to retain stormwater (discussed below). In addition, Portland provides education and outreach on the design, installation, and maintenance of ecoroofs. A Portland Ecoroof Handbook was released in 2009, and a do-it-yourself guide for homeowners was released in 2010. As of May 2011, Portland had 288 ecoroofs totaling nearly 14 acres.[26]

One motivation for developing ecoroofs in Portland is concern about reducing peak flows to retain capacity in combined sewers and protect local creeks and streams; accordingly, ecoroofs are a component of Portland's Grey to Green Initiative. The city has continuously monitored several ecoroofs for runoff over time, and in its most recent Stormwater Management Facility Monitoring Report Summary, issued in 2010, the city included data from three ecoroofs. It was found that all three did an excellent job of reducing peak flows. For the most intensive rain events, reductions of 85 percent to 100 percent were observed, which helps lower the risk of sewer backups. Volume retention was higher in the summer than during the winter months, and varied for individual storm events, depending upon rainfall intensity, duration, and pattern. Of the three ecoroofs studied, the one on the Portland Building had the highest annual and winter retentions. With only a three-inch soil depth, the difference in retention abilities was attributed to the three-inch foam roof insulation sheets on top of the membrane. Overall performance differences among the three ecoroofs were attributed to the soil media used and the irrigation applied, with soil mixed with fine particles appearing to better hold water against gravity. Phosphorus concentrations in the runoff appeared to be decreasing as the ecoroofs became more established but were still high in comparison with the water benchmarks (0.13-0.16 mg/L) established in some Portland watersheds. Zinc and copper levels in the runoff varied greatly, but all concentrations were well below human health guidelines.[27]

FINANCE STRATEGY

Portland's adopted budget for FY2010-11 for the Bureau of Environmental Services included $1.5 million in capital improvement project funds to support innovative watershed enhancements over five years, with priority given to projects that leverage other funding, demonstrate new technologies, or address multiple goals. Under its Grey to Green initiative, the bureau also intends to invest $48 million over four years in ecoroofs, green street facilities, tree plantings, the protection of high-priority natural areas, and other priorities. It will spend another $20 million in capital improvement project funds for FY 2010-11 through FY2012-13 to construct green street facilities along high-priority bicycle boulevards.[28]

To pay for improved stormwater and wastewater control, Portland's projects have been funded through operating capital; paid directly by ratepayers; debt, which is repaid through public utility fees on developed property; and system development charges, incurred when there is new development or a change in use. Stormwater management utility fees are based on rates per thousand square feet of impervious area. The city established fixed impervious area values for single-family residences and duplexes (2,400 square feet) and for multifamily residential developments with less than five dwelling units (1,000 square feet per unit). All other multifamily residential and nonresidential properties, including industrial and commercial sites, are charged on the basis of measured impervious area.[29] Portland residents pay among the highest combined sanitary and stormwater rates in the country, with average monthly fees increasing from $30 in 2001 to $53 in 2011. Average monthly fees are expected to reach $69 by 2016.[30]

In addition, the city utilizes a Stormwater System Development Charge (SSDC) for new residential structures, ranging from $783 for one- or two-unit residences to $1,243 for a four-family dwelling. For new commercial, industrial, and multifamily residential properties, developers are charged an SSDC of $164 per 1,000 square feet of impervious surface for on-site management; for off-site management the fee is $5.12 per linear foot of frontage and $2.68 per daily vehicle trip.[31] These fees can be lowered, however, by reducing the number of square feet of impervious area by installing vegetation, pervious pavement, or other measures.[32] Portland also supports construction of green streets through the One Percent for Green fund, created by the City Council in 2007.[33]

The Clean River Rewards program was implemented in 2006 to offer a stormwater fee discount of up to 100 percent of the on-site portion of the bill, or up to 35 percent of the total stormwater charge, for retaining stormwater on-site through green infrastructure practices. For a single-family home, the discount is based on roof runoff management. Partial credit for residential properties can also be received for tree-planting, installing ecoroofs, and having less than 1,000 square feet of impervious surfaces. For commercial, industrial, and multifamily residential properties, the discount is based on runoff managed from roofs and paved areas. The discount is applied on a sliding scale, depending on how much and how well runoff is managed in terms of flow control, water quality, and disposal location.[34] In estimating the impact that an ecoroof installation could have on the average homeowner's bill, one study found that a homeowner with a 2,000-square-foot house can save $69.30 a year. For commercial and industrial properties with acres of impervious surface area, the credit becomes even more significant.[35]

Looking beyond user fee and SSDC discounts, in 2005 Portland undertook an EPA-funded study to evaluate the feasibility of implementing a credit trading system for stormwater volume controls. While the study determined that developing a stormwater trading program would be cost-prohibitive, it went on to identify several innovative market-based strategies, such as the Ecoroof Grant Program and development density bonuses, that the city could use to better motivate private investment in stormwater management. Another city-run initiative is the Treebate program, started in 2010 and continuing to 2014 that provides homeowners with a credit of up to $50 on their utility bill for every tree planted. Without much overhead expense, the city persuaded local home and garden centers to publicize the program. In 2010, 1,000 trees were planted.[36]

*EMERALD CITY RATING SYSTEM

Each of the cities profiled in *Rooftops to Rivers II* is a leader in green infrastructure investment—rethinking the design of municipal services and infrastructure. These cities leverage funding in creative ways. They provide tools to residential and commercial land owners to retrofit private properties and realize the multiple benefits provided by green infrastructure. In short, they are changing how cities look and function.

NRDC's Emerald City Rating System identifies six actions cities should undertake to maximize their green infrastructure investment. Our metric does not directly compare one city to another, due to geographical, population, budgetary and other differences. Instead, it identifies the presence or absence of common factors of success that NRDC believes are essential elements of a robust green infrastructure commitment. Only one city profiled, Philadelphia, is undertaking each of the actions identified, although each city is undertaking at least one.

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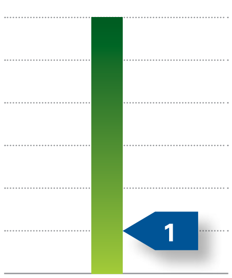
ROUGE RIVER WATERSHED, MICHIGAN

A CASE STUDY OF HOW GREEN INFRASTRUCTURE IS HELPING MANAGE URBAN STORMWATER CHALLENGES

TYPES OF GREEN INFRASTRUCTURE USED: Rain barrels/cisterns, permeable pavement, rain gardens, vegetated swales, street trees, downspout disconnection, wetland creation and restoration, stream buffers

Green infrastructure initiatives in the Rouge River watershed are in their beginning phases and vary somewhat due to the fact that the watershed contains 48 different communities and three counties. These jurisdictions share a watershed-based NPDES permit that generally coordinates their activities, but each county maintains its own stormwater rules and ordinances, none of which require retention or the use of green infrastructure. An alliance of local jurisdictions prepares watershed-wide management plans which identify green infrastructure as one of several strategies to restore the watershed. These plans' green infrastructure components have remained largely the same since 2006. Overall, most of the watershed's communities seem to focus primarily on demonstration projects and guidance and have not yet developed strong incentives or requirements for green infrastructure. Detroit, the largest city in the watershed, faces financial challenges due to the recession and massive population decline; these challenges are leading the city to incorporate some limited green infrastructure retrofit programs into its CSO control plan.

ROUGE RIVER WATERSHED, MICHIGAN



Total Criteria Score
Out of a possible 6

EMERALD CITY CRITERIA*

- ☐ Long-term Green Infrastructure (GI) Plan?
- ☐ Existing requirement to use GI to reduce some portion of the existing impervious surfaces?
- ☐ Incentives for private-party actions?
- ☐ Retention Standard?
- ☐ Dedicated funding source for GI?
- ☑ Guidance or other affirmative assistance to accomplish GI within City?

BACKGROUND

As reported in the first *Rooftops to Rivers* report, the Rouge River Watershed in southeast Michigan covers nearly 450 square miles, includes 127 miles of major streams, and is home to the historically industrial city of Detroit.[1] Fifty percent of the watershed is urbanized, with more than 1.3 million people in 48 communities and three counties living within its boundaries. The remainder of the watershed is characterized as either developing or rural.[2] As a tributary and major source of pollution entering the Detroit River, the Rouge River was designated an Area of Concern by the International Joint Commission in the Great Lakes in the late 1980s due to its significant impact on the health of the Great Lakes. In the early 1990s, the Rouge River National Wet Weather Demonstration Project (Rouge Project) was initiated by the Wayne County Department of the Environment to address the existence of 168 combined sewer overflows (CSOs) in three distinct phases.[3,4]

The Rouge Project, the Alliance of Rouge Communities, and the Michigan Department of Environmental Quality advance the use of green infrastructure to address stormwater runoff in the Rouge River watershed by transporting excess stormwater through a second, "green" conveyance system.

While the early focus of water restoration efforts was on controlling CSOs, such controls alone were insufficient to reverse the river's state of decline. Stormwater runoff, as well as discharges from illicit connections and failed on-site septic systems, had led to excessive flows into the Rouge River, eroding 60 to 90 percent of its banks, damaging riparian habitat, and introducing pollutants.[5] Eight water quality monitoring stations were installed; then data showed that standards for dissolved oxygen were met only 30 percent of the time.[6] Without addressing these issues, CSO controls alone would fail to solve the problem. Wayne County also determined that before the river could be fully restored, its wetlands, habitat, and lakes also had to be restored. In response, the county shifted its restoration focus in the early 1990s, expanding its wet weather pollution controls to include green infrastructure practices and wetland restoration projects and forming the Rouge River Project with funding support from the EPA.[7] The overarching Alliance of Rouge Communities (ARC), which helps oversee implementation of the watershed-wide National Pollutant Discharge Elimination System (NPDES) permit for stormwater discharges, is maintained largely by membership dues of its participating communities and project grants,[8] with Michigan's Wayne County playing a leadership role.

Early in its formation, the Rouge Project adopted a watershed-based approach for wet weather pollution control. In 1997, the communities, working with the Michigan Department of Environmental Quality (MDEQ), were issued NPDES watershed-based general stormwater permits that required them to develop a watershed management plan and individual stormwater pollution prevention initiatives. To handle this large task, the communities divided the watershed into seven sub-watersheds, forming an advisory group for each. In 2001 they completed planning and began implementing a series of goals, actions, and measures designed to address wet weather pollution in the sub-watersheds. In addition to watershed-based stormwater permits, individual NPDES permits also established compliance schedules to control pollutant contributions from 168 permitted CSO outfalls in 17 Rouge River communities (see excerpt from 1990 Rouge River Remedial Action Plan as source of statistical information). Since the project's creation, major progress has been made. CSO pollutant loads have been cut by 90 to 100 percent during most storm events, 89 of the 127 miles of larger streams are free of public health threats, the majority of the waters meet standards for dissolved oxygen (monitoring stations report meeting water quality standards for dissolved oxygen 99 percent of the time), ecosystem health has improved, and, for the first time in decades, it is safe to consume certain types of fish caught in the Rouge River watershed.[9] Numerous sanitary sewer overflows (SSOs), which were also discovered throughout the Rouge, have been controlled, and progress is being made on those remaining.[10] Building upon these successes, the seven sub-watershed plans were updated and consolidated in 2008 and 2009 by the ARC, to lay the groundwork for future efforts, and a strategy to delist the Rouge River Watershed as an Area of Concern in the Great Lakes Basin Ecosystem is currently being finalized.[11,12]

While the river is generally improving, particularly with respect to control of CSOs and reduction of organic loading, certain challenges remain. Current data show a high rate of bacteria violations throughout the watershed in both dry and wet weather conditions. Many of the violations occur in areas unaffected by CSO discharges. Because the sources of dry weather violations have not been determined, bacteria violations will likely continue for the foreseeable future even after all the CSO, illicit connection removal, and stormwater management controls have been completed.[13] The watershed's high level of urbanization also remains a challenge, with impervious areas such as parking lots, roads, and rooftops reducing the ability of rainfall to be retained and infiltrated back into the soils, resulting in significant contributions to excessive flows in the Rouge River and its tributaries.[14]

WATERSHED RESTORATION THROUGH GREEN INFRASTRUCTURE

Over the years, various programs have been implemented under the Rouge Project to restore the watershed. These include a focus on correcting SSOs and CSOs, an Illicit Discharge Elimination Program (IDEP), public education programs, community-specific projects, and green infrastructure projects. In its 2009-2013 Watershed

Management Plan (WMP), numerous structural and nonstructural green infrastructure practices are identified to help the ARC reach three overarching goals: reduce pollution sources that threaten public health; reduce the quantity and rate of runoff through sustainable stormwater management; and encourage partnerships between the ARC and local, state, and federal government.[15]

The green infrastructure practices listed in ARC's updated WMP have not changed much since the original *Rooftops to Rivers* report was released in 2006. In addition rain gardens, rain barrels and rainfall harvesting, and catch basin disconnect programs, ARC utilizes practices such as constructed wetlands/wetland retention (e.g., the 14-acre Inkster Wetlands demonstration project discussed in the 2006 report) and dam modification or removal to reduce stormwater volume and pollution and improve hydrology, habitat, and aquatic diversity.[16] Another focus of the Rouge Project has been the use of grow zones along streams, where designated no-mow areas are planted with native species and allowed to grow naturally. Such areas help reduce flashiness and increase the stability of riverbeds while slowing and filtering stormwater before it reaches the waterways.[17] The Rouge River WMP aims to reduce stormwater runoff volume by 300 million cubic feet over 30 years through the use of various green infrastructure technologies.[18]

UTILIZING GREEN INFRASTRUCTURE TO SOLVE CSOs IN DETROIT

Over the years, efforts of the Rouge Project, ARC, and Michigan DEQ have helped advance the use of green infrastructure to address CSO and stormwater runoff concerns in the Rouge River watershed. The concept is simple: keep the stormwater out of the sewer system, encourage infiltration, and transport the excess stormwater through a second, "green" conveyance system. Its integration into existing CSO and stormwater programs, however, is ultimately the responsibility of local communities and the Detroit Water and Sewerage Department (DWSD).

From 1994 to 2008, more than $750 million was spent in new "gray," or conventional, infrastructure projects to construct CSO control facilities within the Rouge River watershed. Projects included the installation of 7 CSO retention/treatment basins, 5 vertical capture shafts, 1 screening and disinfection facility, and 3 equalization basins; there were also 25 sewer separation projects, 12 in-system storage projects, and a major expansion of the wastewater plant's capacity to pump and treat wet weather flows.[19] By 2008, the city of Detroit's investments alone came to $421 million.[20] That same year, however, as the nation's economic crisis worsened and major auto companies began feeling the financial crunch, Detroit's population continued its dramatic decline and the city's unemployment rate soared to 28.9 percent, leaving the city unable to continue with many of its long-term CSO plans.[21] In the face of massive debt service payments on two new major capital improvement projects totaling $1.3 billion, the city was forced to terminate those construction contracts. The city then began to develop less costly alternatives that focused on innovative green infrastructure solutions.

Part of Detroit's new plan focuses on the use of vacant lots throughout the city. Much like Pittsburgh, Detroit has seen its population decline over the years after peaking at 1.8 million in 1950. According to the most recent U.S. Census, between 2000 and 2010 the city's population declined from 951,270 to 713,777 people—a staggering decrease of 25 percent.[22] DWSD's plan calls for the removal of vacant structures, to be taken off the sewer system and replaced with pervious land covers. Other aspects of the $50 million plan, to be implemented over the next 20 years, include residential downspout disconnections, rain barrel installations, the use of bioswales and tree trenches to intercept runoff, tree plantings, and the management of stormwater runoff in underutilized parks. Officials estimate that the program will reduce stormwater inputs to the combined sewer system by at least 10 to 20 percent. The Southeast Michigan Council of Governments (SEMCOG) received funding to work with DWSD through 2012 to develop numeric goals and a long-term strategy.[23]

In total, the new CSO control plan calls for $832 million to be spent on a mix of gray and green infrastructure along the Rouge and Detroit Rivers over the next 25 years, averaging about $57 million in annual debt payments per year, much less than the annual debt payments of $115 million that the city planned to spend under its previous control program.[24] In addition to these efforts, SEMCOG has received a $2.58 million Sustainable Communities Regional Planning Grant through HUD that supports the development of a green infrastructure vision for the entire seven-county region (much of which is served by DWSD). The vision includes a land cover mapping process; an analysis of how green infrastructure can be utilized to manage stormwater runoff, provide air quality benefits, and contribute to the economic vitality of the region; and a study of the potential to reuse vacant properties to increase green infrastructure within the watershed.[25]

FINANCE STRATEGY

As a demonstration project, the Rouge Project is supported largely by $300 million in federal grant funds, all of which was matched, dollar for dollar, by the communities. With the end of grant funding, much of the stormwater management programs are now supported through local budgets, membership dues to the Alliance of Rouge Communities, and community matching funds. For 2011, total local commitment to the ARC was $2.07 million (including $1 million of grant funds).

In the case of the Detroit Water and Sewerage Department, funding for green infrastructure projects as part of its alternative CSO control program comes largely from debt financing, leveraged by state and federal funding, to take advantage of low-interest loans and government grant programs. Foundations and private parties also provide support.[28] DWSD has committed $50 million over 20 years through its rate structure. To stretch its dollars further and ensure that efforts are not duplicated, DWSD's strategy is to coordinate and complement existing programs. For instance, HUD operates a Neighborhood Stabilization Program (NSP) to demolish abandoned buildings in blighted areas. While NSP focuses on areas of the community where blight is an issue, DWSD focuses its greening efforts in areas of the community where neighborhood stabilization is key, such as around schools. In the spring of 2011, DWSD planted 1,000 trees in such areas, with street trees accounting for roughly half of these, and the other half being placed in "stormwater forests"[29] and parks.[30] For the most part, DWSD and others are at the beginning stages of implementing green infrastructure projects as part of the long-term CSO control plan, and their finance strategy is not fully in place.

*EMERALD CITY RATING SYSTEM

Each of the cities profiled in *Rooftops to Rivers II* is a leader in green infrastructure investment—rethinking the design of municipal services and infrastructure. These cities leverage funding in creative ways. They provide tools to residential and commercial land owners to retrofit private properties and realize the multiple benefits provided by green infrastructure. In short, they are changing how cities look and function.

NRDC's Emerald City Rating System identifies six actions cities should undertake to maximize their green infrastructure investment. Our metric does not directly compare one city to another, due to geographical, population, budgetary and other differences. Instead, it identifies the presence or absence of common factors of success that NRDC believes are essential elements of a robust green infrastructure commitment. Only one city profiled, Philadelphia, is undertaking each of the actions identified, although each city is undertaking at least one.

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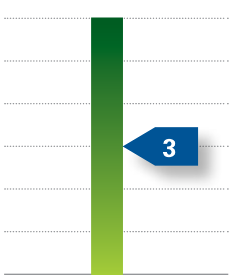
SEATTLE, WASHINGTON

A CASE STUDY OF HOW GREEN INFRASTRUCTURE IS HELPING MANAGE URBAN STORMWATER CHALLENGES

TYPES OF GREEN INFRASTRUCTURE USED: Green roofs, rain barrels/cisterns, permeable pavement, rain gardens, vegetated swales, street trees, green streets

Seattle has been working at green infrastructure for over a decade, and its commitment over many years has resulted in a serious overall program. The city does not yet have a comprehensive citywide green infrastructure plan; its Comprehensive Drainage Plan is generally supportive of green infrastructure (which it dubs "natural drainage strategies"), but does not spell out an overall vision of its implementation. On the other hand, Seattle contains broadly-applicable requirements to use green infrastructure "to the maximum extent feasible," for both new and redevelopment projects and the city requires certain projects to achieve specific numeric targets for peak runoff following development. Seattle has strong resources to assist private parties to implement green infrastructure and an equally major investment in implementing green infrastructure in practice to achieve stormwater and CSO reduction goals. Specifically, the city has stormwater and right-of-way improvement design manuals laying out stormwater design strategies for different kinds of projects, and it has demonstrated green infrastructure via numerous roadway improvement projects and green roofs. These initiatives now are accompanied by regulatory green infrastructure programs—Green Factor—which demands that development projects achieve minimum scores based on landscaping features that promote the use of green infrastructure, as well as the stormwater code, which requires for most projects the use of green stormwater infrastructure best management practices (BMPs) to mitigate stormwater where feasible. As a complement to these resources, Seattle also provides green infrastructure incentives—rebates for installing rain barrels and cisterns to capture stormwater in a particular basin served by the combined sewer system. Other incentives are integrated into the city's stormwater fees, which help pay for the implementation of stormwater control strategies; non-residential properties' fee is directly related to the amount of on-site impervious area, and all property owners in the city can receive a parcel credit for installing green infrastructure features as well as other flow control and treatment BMPs. Additionally, city officials report that the CSO reduction strategy is committing to using green infrastructure, which will be formalized through the Long Term Control Plan efforts currently underway.

SEATTLE, WASHINGTON



Total Criteria Score
Out of a possible 6

EMERALD CITY CRITERIA*

- ☐ Long-term Green Infrastructure (GI) Plan?
- ☐ Requirement to use GI to reduce some portion of the existing impervious surfaces?
- ☐ Retention Standard?
- ☑ Incentives for private-party actions?
- ☑ Guidance or other affirmative assistance to accomplish GI within City?
- ☑ Dedicated funding source for GI?

BACKGROUND

Located between Puget Sound and Lake Washington, Seattle is a highly urbanized area that retains a strong connection to its waterways, many of which serve as salmon spawning grounds. Seattle is primarily located within the Lake Washington and Puget Sound watersheds and receives its drinking water from the Cedar River, the South Fork of the Tolt River, and three groundwater wells. Stormwater runoff has long been identified as a threat to the aquatic habitat of Puget Sound and the sensitive salmon streams. However, controlling stormwater volumes and flow rates is a complicated task in a city where the majority of development predated stormwater regulations. Consequently, water quality in the region is impaired and the hydrology of rivers and creeks is altered.

Seattle's Green Factor Program, a landscape requirement designed to increase the quantity and quality of planted areas in parts of the city, was the first of its kind in the United States. While developers and designers have flexibility to meet the requirements, the program does encourage the use of large plants and green roofs in publicly visible areas. Its scoring system provides bonuses for food cultivation, native and drought-tolerant plants, and rainwater harvesting.

Seattle's network of sewer and drainage systems is the responsibility of Seattle Public Utilities (SPU). The system includes approximately 968 miles of combined sewers with 92 permitted CSO outfalls, 38 CSO control detention tanks/pipes, 448 miles of sanitary sewers, and 460 miles of storm drains with 170 storm drain outfalls.[1] During heavy rains, the combination of stormwater (about 90 percent of the volume) and sewage exceed the drainage system's capacity, causing annual overflows of approximately 100 million gallons per year (down from 30 billion gallons in 1970).[2] SPU's approach to green infrastructure as it relates to stormwater and CSO control involves the testing of technologies or projects as pilots and then rolling out programs with broader application. SPU's Green Stormwater Infrastructure (GSI) program also supports the use of GSI at the site level through full street right-of-way improvements with natural drainage systems and through larger development planning and design. Factors such as Seattle's hilly topography, soil conditions, and street widths limit the sites for which GSI solutions are appropriate.

In September 2004, Seattle Mayor Greg Nickels introduced his "Restore Our Waters" (ROW) Strategy, a framework for coordinating and concentrating the city's efforts to rehabilitate local waterways. The strategy requires updating the city's stormwater code to include options for GSI alternatives to stormwater control. In response, SPU drafted a new Comprehensive Drainage Plan, broadening the scope to include infrastructure, public safety, and aquatic resource protection, and developed an SPU Urban Watershed Strategy to develop clear goals, indicators, and performance measures.

USING NATURAL DRAINAGE SYSTEMS TO MANAGE STORMWATER RUNOFF

In the late 1990s, the city began to install green stormwater infrastructure to mitigate urban stormwater runoff, and SPU developed pilot projects using the purpose of natural drainage system (NDS) strategies. The concept of NDS is to provide improved stormwater management by mimicking the natural hydrologic functions typically lost in an urban setting. NDS uses alternative street designs and vegetated BMPs to reduce the volume and rate of stormwater runoff, striving to replicate pre-development hydrologic function. In order to expedite the achievement of its water quality and flood mitigation goals, Seattle takes a proactive approach, retrofitting existing city streets using these green infrastructure techniques. NDS projects involve community members in all stages of implementation, from planning and construction to public education meetings on its importance and benefits. At one point, the program faced challenges from the city's emergency and transportation departments, which questioned the system's safety, integrity, and applicability. SPU worked with these departments to establish new road designs that met both the goals of the NDS program and the needs of emergency vehicles. The outcome has been innovative neighborhood and stormwater system designs with results exceeding expectations. Information obtained from NDS pilots has been used to develop the Seattle Right-of-Way Improvement Manual and the Stormwater Flow Control and Water Quality Treatment Technical Requirement Manual.

Descriptions of the Viewlands Cascade, Second Avenue Street Edge Alternative (SEA), 110th Street Cascade, Broadview Green Grid, and Pinehurst Green Grid NSD pilots were included in the 2006 *Rooftops to Rivers* publication. More recent work includes the Swale on Yale, scheduled to be constructed in the fall of 2011 – 2013, and the Ballard Roadside Raingardens, which began in June 2010. When complete, the $10 million Swale on Yale will consist of four extra-wide planting areas, 270 feet long by 10.5 to 16.5 feet wide, between the sidewalk and roadway. This area will treat an average of 190 million gallons of stormwater annually, greatly reducing the amount of pollution flowing into Lake Union. A diversion vault under Yale Avenue North will divert stormwater into the biofiltration swales; it will also spin the stormwater to create a vortex so that large solids and trash can be separated and collected by a sump, which will be regularly cleaned by SPU crews. The project will require approximately 2,000 feet of new storm drain to convey untreated stormwater into the diversion vault, swirl concentration, and biofiltration swales. Treated stormwater will then go back into the storm drain to be discharged into the lake.[3]

Recently, Seattle was reminded of the necessity of careful planning, design, construction, and community engagement when designing and installing GSI in a dense urban setting. Sewage and drainage from Seattle's Ballard neighborhood flows into a combined sewer system that overflows into the Salmon Bay waterway approximately 70 to 80 times per year. To reduce the frequency of these overflows, SPU set out to install a series of rain gardens across 10 city blocks in the public right-of-way to treat 50,000 gallons of stormwater annually while providing attractive landscaping.[4,5] The project, known as the Ballard Roadside Rain Gardens pilot project, was implemented on an expedited schedule in 2010 when SPU received $1.4 million in federal stimulus money to initiate the $1.9 million project.

Due to the fast-tracked schedule, technical risks such as the adequacy of infiltration rates and the presence of underground springs were not fully considered during the design phase of the project. As a result, several of the rain gardens did not drain properly after construction. Further, due to the expedited process, SPU conducted only limited community outreach activities during the project's planning process, allowing insufficient time or opportunity to develop community acceptance, and leaving residents dissatisfied and concerned with the resulting standing water. SPU has recently been forced to spend another $500,000 to address the drainage issues.

The knowledge gained through this pilot project highlighted the need to allow adequate time to review data and technical assumptions and specifications, and the importance of community outreach and engagement. However, SPU emphasizes that bioretention is an effective technology for reducing flows when applied where conditions are appropriate. As a strategy, SPU will continue to value bioretention as a tool for reducing CSO volumes, as well as to provide flow control in creek basins, and expects to continue to construct roadside rain gardens for both purposes.

GREEN FACTOR PROGRAM AND GREEN ROOFS

Seattle's Green Factor Program, the first of its kind in the United States, was instituted in 2006 and provides a flexible approach to GSI through development regulations. The Green Factor is a landscaping requirement for development intended to encourage design features such as large plants, green roofs, and vegetated walls to be installed in publicly visible areas. Developments are rated using a Green Factor Scorecard in order to ensure that a certain percentage of green (based on the development's underlying zoning) is included in the design. Minimum required scores range from 30 percent of a parcel in a commercial zone to 50 percent coverage in multifamily residential zones. Aesthetically, the scoring system promotes the implementation of GSI techniques in areas visible to the public, with bonuses provided for food cultivation, native and drought-tolerant plants, and rainwater harvesting. Besides reducing stormwater runoff and associated public infrastructure costs, such elements are intended to provide air quality benefits, create wildlife habitat, and alleviate the urban heat island effect.[6]

The landscaping requirements of the Seattle Green Factor can be met in part through the use of green roofs, and the program is expected to increase the number of green roofs within the city. At the end of 2009, there were 62 known green roofs in the city, with a total area of 359,375 square feet. An additional four buildings have designated 3,631 square feet of area for food production in planter boxes, and eight large at-grade green "lids" make up an additional 1,445,347 square feet of vegetated area. In all, 8.5 acres of the city's total roof surface area of 13,150 acres was covered with a green roof or rooftop garden.[7]

Besides the Green Factor Program, green roofs are encouraged by the 2009 Stormwater Code, which requires projects to implement GSI, including green roofs, to the maximum extent feasible, and through the LEED® green building certification program, which awards a point for a green roof.[8] Seattle also currently provides an impervious surface reduction credit that lists green roofs and roof gardens as acceptable strategies.[9]

Additionally, SPU is actively monitoring four green roof test projects to determine the extent to which the green roofs can absorb and delay stormwater flow. Starting in 2005, SPU began collecting information from green roofs at the Woodland Park Zoo's Zoomazium, the Ballard Library, Fire Station 10, and the Ross Park Shelterhouse.[10] With support from the King Conservation District, SPU and its partners have collected three years' worth of data for each of the green roofs and are now completing a data set that will eventually be used to calibrate local hydrological models for green roof stormwater flow performance.[11]

FINANCE STRATEGY

For 2010–2015, Seattle has identified several GSI projects as part of its CSO control program. The overall CSO program for 2010–2015 is expected to reduce stormwater by a total of 7,924,000 gallons at a cost of $88 million to $255 million.[12] Historically, combined sewer overflow funding through Seattle's Drainage and Wastewater Fund (DWF) capital improvements project (CIP) has come primarily from the sale of revenue bonds. In 2003, DWF adopted a financial policy to gradually increase cash contributions from Seattle Public Utility to fund the CIP. Today, 25 percent of total CIP costs are funded by a cash contribution from SPU's capital and operating budget, with the remaining capital needs debt financed.[13]

The city of Seattle charges property owners a fee for stormwater management services based on each property's estimated impact on the city's drainage system. Instead of appearing on utility bills, these fees are billed as a separate line item on King County property tax statements. Prior to 2008, all property owners were charged a flat fee. Starting in 2008, Seattle changed the rate structure that underlies the calculation of drainage fees, in order to more closely tie such fees to customers' actual impacts on the drainage system. Residential properties are now charged on the basis of parcel size, and nonresidential properties on the basis of the amount of impervious surface.[13] In 2011, residential drainage bills ranged from $134.06 to $298.32 per year, regardless of the amount of impervious surface, and annual nonresidential bills ranged from $19.72 to $66.90 per 1,000 square feet, depending on the amount of impervious surface. In total, expected revenues from drainage fees were approximately $59 million for 2010 and $67.2 million for 2011,[14] up from $31.6 million in 2005.[15]

To incentivize GSI, Seattle Public Utilities has a Stormwater Facility Credit Program (SFCP) for property owners who have installed a fully functioning, well-maintained stormwater system—with such features as vaults, rain gardens, green roofs, rooftop gardens, permeable pavements, and filtration systems—that provides water quality treatment and/or slows down stormwater runoff from impervious surfaces such as rooftops, driveways, and walkways. Systems that are in compliance with the city's stormwater code standards[16] can qualify for the program, which, while open to anyone, is most beneficial to parcels with large amounts of impervious surface being managed by a stormwater system.[17] The maximum allowable parcel credit is 50 percent; the average awarded credit in 2008 was 9 percent.[18]

In addition to this program, the city provides RainWise Rebates for cisterns and rain gardens in a target CSO basin in the Ballard neighborhood. There, the city pays for most of the costs of installing rain gardens and cisterns, depending on how many square feet of roof runoff is controlled.[19] If successful, the city plans to extend the pilot project to other CSO target basins. While not currently active, Seattle Public Utilities has also provided Aquatic Habitat Matching Grants to individuals, business owners, nonprofits, and community groups wanting to protect or restore Seattle's aquatic habitat. This project was cut, however, as a cost-saving measure.

*EMERALD CITY RATING SYSTEM

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NRDC's Emerald City Rating System identifies six actions cities should undertake to maximize their green infrastructure investment. Our metric does not directly compare one city to another, due to geographical, population, budgetary and other differences. Instead, it identifies the presence or absence of common factors of success that NRDC believes are essential elements of a robust green infrastructure commitment. Only one city profiled, Philadelphia, is undertaking each of the actions identified, although each city is undertaking at least one.

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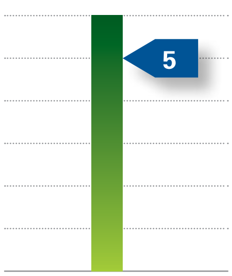
SYRACUSE, NEW YORK

A CASE STUDY OF HOW GREEN INFRASTRUCTURE IS HELPING MANAGE URBAN STORMWATER CHALLENGES

TYPES OF GREEN INFRASTRUCTURE USED: Green roofs, rain barrels/cisterns, permeable pavement, rain gardens, vegetated swales, street trees, green streets, planter boxes

In 2009, when Onondaga County gained federal court approval of its new Save the Rain program, Syracuse became the first community in the United States with a legal requirement to reduce sewage overflows with green infrastructure. The county's strategy integrates both green and gray approaches to meet binding CSO targets phased in over nine years. Green infrastructure investments, totaling nearly $80 million, will account for nearly two-thirds of future CSO reductions. The program is funded with a combination of sewer fees and low-interest loans and grants from the state. The county has installed a number of demonstration projects and expects to complete at least 50 projects by the end of 2011. To encourage green infrastructure on private property, the county has launched a comprehensive public outreach and education program and provides financial incentives in the form of a direct grant program and rain barrel giveaways. There is currently no retention standard for new development or redevelopment, but the county is working with the city of Syracuse on a new ordinance that may include such a standard.

SYRACUSE, NEW YORK



Total Criteria Score
Out of a possible 6

EMERALD CITY CRITERIA*

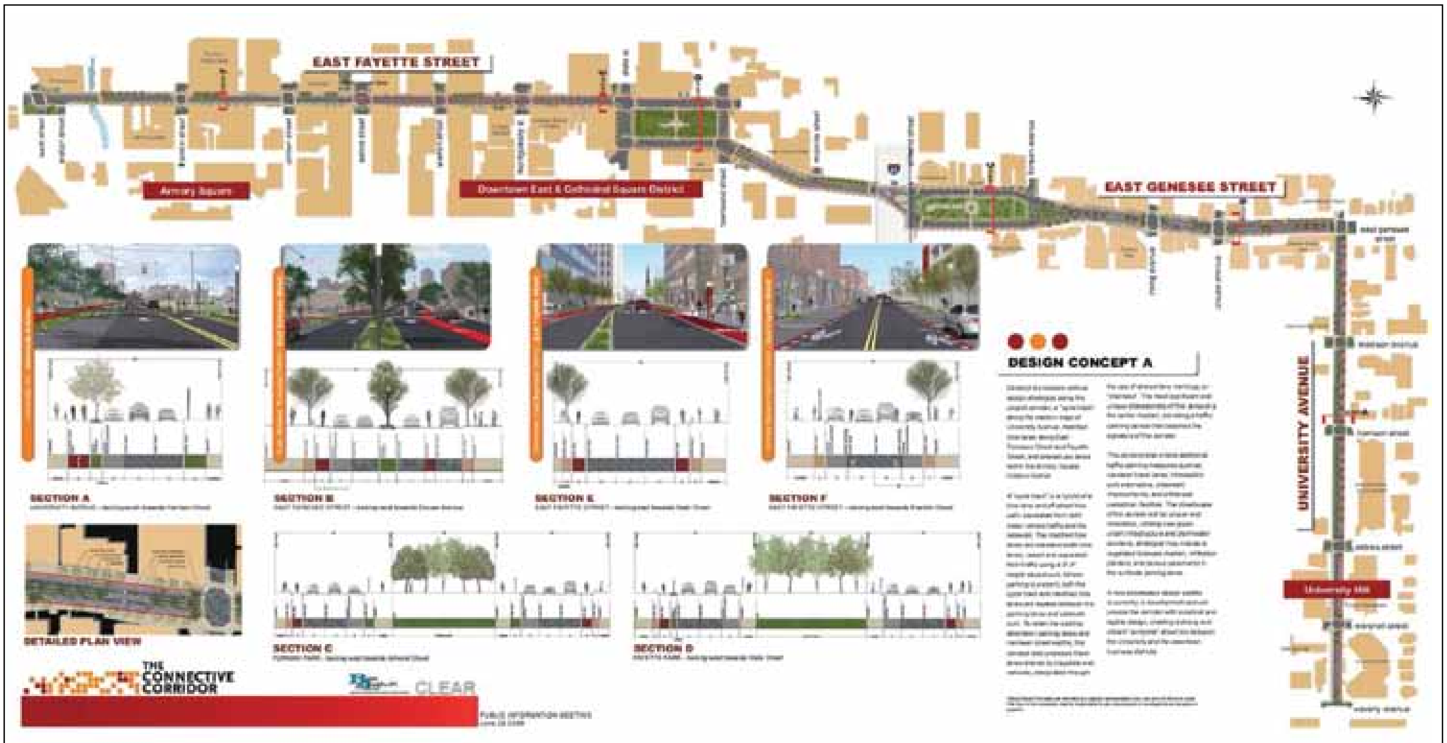
- ☐ Retention Standard?
- ✓ Long-term Green Infrastructure (GI) Plan?
- ✓ Existing requirement to use GI to reduce some portion of the existing impervious surfaces?
- ✓ Incentives for private-party actions?
- ✓ Guidance or other affirmative assistance to accomplish GI within City?
- ✓ Dedicated funding source for GI?

BACKGROUND

Onondaga Lake, located on the northern edge of Syracuse, was at one time "arguably the most polluted lake in the United States."[1] The roughly 4.6-square-mile lake, whose 285-square-mile drainage area includes two counties, one city, 18 towns, six villages, and the Onondaga Nation Territory,[2] has long suffered from pollution problems due to its highly urbanized surroundings.[3,4] As a means of addressing this pollution, in 2009 Onondaga County (which includes the city of Syracuse) became the first metropolitan area in the United States with a binding legal obligation to build green infrastructure to achieve specific, quantitative reductions in combined sewer overflows (CSOs).

Beginning in the 1800s, power plants, steel mills, and other manufacturers used the lake and its tributaries as a dumping ground for their waste.[5] With little or no regulation, industrial pollution from mercury, PCBs, pesticides, creosotes, heavy metals, PHAs, and volatile organic compounds severely degraded the lake's water quality.[6] Parallel to the industrial discharges, wastewater from municipal sources has similarly been a problem since the late-19th century. In the 1940s the

© Save the Rain



The Connective Corridor showcases the diverse art and cultural assets of Syracuse, igniting a resurgence of economic development, tourism, and urban residential smart growth. In addition to its focus on culture, the Connective Corridor will feature creative lighting, sustainable transportation options, green infrastructure, technological hot spots, and more.

lake was deemed unsuitable for swimming. In 1970, fishing was banned due to concern over the level of contaminants in fish.[7,8] Although regulation of discharges after the passage of the Clean Water Act in 1972 helped to mitigate industrial pollution and improve the lake's condition, the damage has been lasting. In 1994 the entire lake bottom as well as certain sites around the lake were added to the federal Superfund list.[9]

As industrial pollution waned, water pollution from municipal sources came sharply into focus. One major pollution source was the discharge of excess ammonia and phosphorus from Onondaga County's Metropolitan Sewage Treatment Facility. Another key source was—and continues to be—the county's aging combined sewer infrastructure.[10,11]

In 1988 the Atlantic States Legal Foundation (ASLF), joined by the state of New York and the New York State Department of Environmental Conservation (NYSDEC), brought a lawsuit against Onondaga County to prevent raw sewage overflows from polluting Onondaga Lake and to reduce pollutant loadings from the Metro plant. The case resulted in a consent judgment, in 1989, requiring the county to evaluate the need for upgrading Metro and providing treatment of the CSOs in the Metro service area.[12] In 1998, the consent judgment was amended to incorporate a 15-year schedule to construct various upgrades to the Metro plant and the sewer system. At that time, the system was capturing and treating only 74 percent of the annual wet weather flow through the combined sewer system; the amended consent judgment required the county to achieve 95 percent capture and treatment.[13]

SYRACUSE'S 2009 AMENDED CONSENT JUDGMENT

Over the next two decades, the county proceeded down a path that strictly used gray infrastructure to mitigate its water problems. While nutrient loading has been significantly reduced since the 1989 judgment,[14] millions of gallons of sewage overflow continue to pollute the lake and its tributaries after storm events.[15] Further, the county's gray infrastructure approach to CSO abatement was met with increasing resistance from the community, especially after the first of four regional treatment facilities (RTFs) was built in 2007 amid much controversy in a low-income, primarily African-American neighborhood.[16,17,18] Community groups and organizations had strongly objected to the construction of this RTF for fear it would put unfair burdens on the disadvantaged neighborhood and its residents, including being inconvenienced during construction and subjected to potential odors and stigma when it was completed. This local opposition, coupled with the potential for cost savings, was largely the impetus behind the decision to seek an alternative to the three additional RTFs slated for construction.

With the election of new local officials in 2008, ASLF and the Onondaga Nation initiated talks about the alternatives with county and city officials, who then solicited input from local environmental and community groups, the State University of New York Environmental College of Science and Forestry (SUNY ESF), and the New York State Department of Environmental Conservation (DEC) to identify green alternatives for CSO mitigation.[19] In November 2009, with consensus among these stakeholders and an official statement of support from EPA,[20] the federal court approved an amendment to the consent judgment that eliminated the three planned RTFs and explicitly required the use of green infrastructure technology to reduce sewer overflows to Onondaga Lake and its tributaries.[21,22,23] Syracuse and Onondaga County thus became the first community in the United States to be legally required to meet binding targets for CSO reduction by using green infrastructure.

As of 2009, the county's sewer system was capturing 84.6 percent of wet weather flow in a typical year. The amended decree requires 95 percent capture by 2018 using a combination of green and gray approaches—resulting in more pollution reduction than the original decree, since the RTFs would have provided only partial treatment of combined sewage and stormwater, whereas green infrastructure both treats stormwater and frees up capacity for sewage treatment plants to accept, and fully treat, greater volumes of sanitary sewage.[24] Nearly two-thirds of the future CSO reductions will come from the use of green infrastructure.[25]

ONONDAGA COUNTY'S SAVE THE RAIN CAMPAIGN

The county is now embracing the unique opportunity to meet its CSO reduction mandates by using green infrastructure practices. The County Executive's office has launched Save the Rain, a comprehensive plan to incorporate green infrastructure into all types of land use in the city to manage stormwater, restore Onondaga Lake, and more generally to "cultivate a green urban culture in Syracuse," while also including certain localized gray infrastructure improvements such as storage facilities and sewer separation.[26] The use of green infrastructure will be divided into 10 program types, including streets, parks and open space, rooftops, public facilities, grants that will incentivize green infrastructure retrofits on private property, and a stormwater ordinance. Each program type has more than one strategy for implementing green infrastructure retrofits. The total 2011–2018 green infrastructure budget for the Save the Rain program, with funding from sewer fees, state low-interest loans, and grants, is approximately $78 million.[27,28] Notably, some estimates have indicated that Save the Rain, with its balance of gray and green infrastructure, will save the county as much as $20 million compared with traditional CSO mitigation programs.[29,30]

A handful of projects have already been implemented. The Pearl Street parking lot retrofit project, completed in 2010, transformed an existing 1-acre asphalt/gravel lot into a lot partially covered with porous pavement, including 25,000 square feet of subsurface infiltration to capture an estimated 1.3 million gallons of stormwater runoff annually.[31] A stormwater retrofit project at City Parking Lot #3 included the conversion of a traditional lot into one with porous pavement, plus the planting of 26 trees in the interior of the lot and along its perimeter; an estimated 678,000 gallons of stormwater will be captured annually there.[32] The Townsend Median stormwater retrofit project, completed in 2011, included redesigning the median to be below surface grade to allow approximately 317,000 gallons of stormwater runoff capture per year. The project also included the planting of four "stormwater trees," with new inlets built into the existing curb to allow stormwater runoff to infiltrate the soil around the trees.[33]

AN AMBITIOUS PLAN FOR GREEN INFRASTRUCTURE: SAVE THE RAIN–PROJECT 50

After several years of extensive planning, Onodaga County began construction on a long list of green infrastructure projects. The county has identified 82 potential projects to date and has a goal of advancing 50 during calendar year 2011: the Save the Rain–Project 50 campaign.[34,35] Projects in the pipeline vary widely in their size and expense, ranging from a 3,500-square-foot porous sidewalk that will capture around 60,000 gallons of water annually to a 12-acre wetlands project that will capture an estimated 14.9 million gallons per year.[36]

To meet its commitment to 95 percent total volume capture by 2018, the county will need to capture 250 million gallons per year. While it aims to achieve this capture for an average of about 35 cents per gallon, the county is willing to spend more on certain high-profile projects because "they will generate significant dialogue in the community, and also showcase the whole [green infrastructure program] nationwide."[37] One key example is the project planned for the War Memorial Arena, home to the Syracuse Crunch hockey team: the installation of a $1 million system to collect rainwater from the roof in cisterns and then filter, disinfect, and use the rainwater to make ice for the hockey rink. The collected rainwater will also be used for irrigation around the facility, and will potentially replace potable water in the facility's heating/cooling system.[38, 39,40] The county recently received a $712,000 grant for the system, which will capture around 366,000 gallons per year,[41] through the New York State Environmental Facilities Corporation's Green Innovation Grant Program.[42]

Another prominent project will be the construction of a massive green roof on top of the Nicholas J. Pirro Convention Center. Built for an estimated $1 million, the 1.5 acre green roof will be one of the largest in the Northeast, absorbing an estimated 1 million gallons of rain annually that would otherwise run into the combined sewer system.[43,44,45]

ADDITIONAL PROGRAMS AND STRATEGIES TO REDUCE STORMWATER IN SYRACUSE

In addition to the short-term goal of advancing 50 green infrastructure projects in 2011, Save the Rain includes a number of longer-term programs that aim to implement, or promote the implementation of, green infrastructure on public and private property. For example, Onondaga County is initiating an Urban Forestry Program. Partnering with the city of Syracuse, the county will plant 8,500 trees in neighborhoods throughout the city.[46] Tree species will be chosen on the basis of their appropriateness for the region and ability to sustain a canopy for maximum rainwater capture, and a long-term maintenance program will be implemented to ensure that these trees are being cared for appropriately. Additionally, a sophisticated asset management system called Maximo will be used to manage these trees.[47,48] Onondaga County is also adding green infrastructure elements to its conventional storm water storage projects. Interceptor sewer construction restoration includes rain gardens, tree plantings and infiltration boxes, and more than 10 million gallons of constructed storm water storage facilities include rainwater reuse systems and bioretention.[49]

The county is also taking steps to encourage the use of green infrastructure on private property. A rain barrel program, funded in 2009 by grant money through New York State's Green Innovation Grant Program, provides free rain barrels to homeowners in designated CSO sewer sheds in Syracuse. To receive a rain barrel, residents must attend a brief workshop on rain barrel installation and maintenance; a companion guide is available online. To date, the county has distributed more than 300 rain barrels to local residents[50,51,52] and aims to have more than 1,000 in use within the next two years. The county also aims to develop a more sophisticated tracking system for the rain barrel program, making use of GIS data to pinpoint where the barrels are located.[53]

Additionally, the county has developed a multimillion-dollar Green Improvement Fund (GIF) that offers grants for green infrastructure retrofits on private property, including businesses and nonprofits, in combined sewer drainage areas.[54,55,56] Projects that have received funding include, but are not limited to, tree trenches, planter boxes, porous swales, rain gardens, green roofs, green streetscapes, and cisterns.[57,58]

Save the Rain has launched a comprehensive public outreach campaign that includes green infrastructure education at the neighborhood level, within the public school system, and via a new website (www.savetherain.us). Green infrastructure design charrettes, public meetings, and workshops are frequently held within local communities, and every third-grade glass in the city of Syracuse is learning about green infrastructure. The county has also partnered with a number of community-based organizations that offer additional support for green infrastructure. For example, some groups offer workshops for residents on creating rain gardens and constructing rain barrels. The county is considering fee structures based on impervious area for future implementation and is currently working with the city of Syracuse on revisions to the current ordinance that may ultimately require enhanced stormwater mitigation on redevelopment projects.[59,60]

GREEN JOBS TRAINING IN SYRACUSE

While Onodaga County proceeds with its Save the Rain campaign and continues to identify and execute green infrastructure projects, two programs providing green jobs training for Syracuse residents, particularly those in underemployed demographic groups, have been established in the region. SUNY ESF operates a training program that partners with regional organizations to train unemployed or underemployed residents in development and implementation of green infrastructure projects such as rain gardens, permeable pavers, and urban forests.[61] Additionally, in 2010 CNY Works won a $3.7 million grant from the U.S. Department of Labor to train up to 750 Syracuse residents in energy efficiency, renewable energy, and green infrastructure jobs over a two-year period.[62]

MEASURING THE EFFECTIVENESS OF SYRACUSE'S GREEN INFRASTRUCTURE

To satisfy the CSO reduction requirements of the amended consent judgment, the effectiveness of all green infrastructure projects must be quantifiable. Onondaga County uses a cost-effectiveness calculator on every project to compare the proposed project costs with actual costs of completed projects of similar scope, to ensure that the county is paying for the most cost-effective green infrastructure projects.[63] For every project undertaken with public funds, the Save the Rain website will include fact sheets detailing costs and stormwater capture volumes, as well as technical plans and specifications.[64] After projects are completed, performance evaluations are used to monitor the effectiveness of different types of capture practices. Additionally, as mandated by the amended consent judgment, the county has developed a comprehensive Ambient Monitoring Program (AMP) for Onondaga Lake and its tributaries to assess the program's overall performance and impact on the lake. If the green infrastructure projects undertaken under the Save the Rain program are functioning properly, then AMP data should demonstrate reduced nutrient loading from captured runoff as well as reduced contamination from CSO events.[65]

Currently, metrics illustrating the ancillary benefits of green infrastructure are being developed. The county has partnered with a number of organizations to measure these additional benefits, including U.S. EPA, Syracuse University, and SUNY ESF. A few examples of the benefits that will be studied include air quality improvements, economic impacts, mitigation of the urban heat island effect, energy savings, and recreational and transportation improvements. Syracuse University recently approached the county about conducting on-site monitoring of the aforementioned Nicholas J. Pirro Convention Center green roof. In addition to measuring the roof's stormwater capture, the university will also measure energy savings and the reduction of the heat island effect.[66]

On April 20, 2011, the EPA recognized Onondaga County's efforts by selecting it as one of 10 green infrastructure partner communities in the United States. the EPA's Green Infrastructure Partnership program focuses on identifying opportunities and providing technical assistance to communities implementing green infrastructure approaches to control stormwater runoff.[67] The EPA will partner with Onondaga County to exchange information regarding green infrastructure best management practices utilized in Syracuse, highlighting the county's program as a model for other municipalities on how to implement effective green infrastructure programs.

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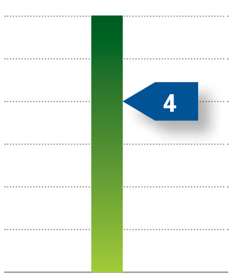
TORONTO, ONTARIO, CANADA

A CASE STUDY OF HOW GREEN INFRASTRUCTURE IS HELPING MANAGE URBAN STORMWATER CHALLENGES

TYPES OF GREEN INFRASTRUCTURE USED: Green roofs, blue roofs, rain barrels/cisterns, permeable pavement, rain gardens, infiltration trenches or vaults, vegetated swales, street trees, planter boxes, downspout disconnection

Toronto has made green infrastructure a central component in its efforts to reduce urban stormwater runoff and sewage overflows that contribute pollution to Lake Ontario. The city has enacted a long-term Wet Weather Flow Master Plan that establishes a comprehensive strategy to use both gray and green infrastructure approaches to eliminate adverse effects of wet weather runoff, with a focus on managing rainwater where it falls. The city has implemented programs for downspout disconnection, which became mandatory in 2011, adopted construction standards to require buildings to include green roofs, established rainwater-capture pilot and demonstration projects, and provided funding for tree plantings to double the city's existing tree canopy, among other initiatives. Toronto is also using green infrastructure to reduce the costs of implementing its Master Plan. The city estimates that its downspout disconnection program and initiative to increase tree cover will help reduce costs for stormwater infrastructure and capital improvement projects, and that further savings could be realized by replacing impervious surfaces in alleys and laneways with permeable pavements.

TORONTO, ONTARIO, CANADA



Total Criteria Score
Out of a possible 6

EMERALD CITY CRITERIA*

- ☐ Requirement to use GI to reduce some portion of the existing impervious surfaces?
- ☐ Dedicated funding source for GI?
- ☑ Incentives for private-party actions?
- ☑ Long-term Green Infrastructure (GI) Plan?
- ☑ Retention Standard?
- ☑ Guidance or other affirmative assistance to accomplish GI within City?

BACKGROUND

Toronto, the largest city in Canada, covers 248 square miles and is home to 2.5 million residents, with another 5 million people living within the larger metropolitan area. The city contains an extensive network of sewer infrastructure, including 2,800 miles of storm sewers with more than 2,600 outfalls, and 807 miles of combined sewers with 79 CSos.[1,2] Toronto's urban stormwater is a leading cause of water pollution in Lake Ontario and its tributaries, and under a 1972 bilateral Canada-U.S. Great Lakes Water Quality Agreement, was identified as the primary cause for the city being listed as an Area of Concern for the Great Lakes. In response to this listing, Toronto established a Remedial Action Plan (RAP) in 1987 to develop plans for the restoration of drinkable, fishable, swimmable, and aesthetically pleasing water and habitat areas within the city and surrounding watersheds.[3]

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Toronto's City Council adopted construction standards in May 2009 that require all new buildings and retrofits with more than 2,000 square meters (approximately 21,528 square feet) of floor area to include a green roof; since the bylaw went into effect, approximately 1 million square feet of additional green roofs have entered the planning phase.

Faced with the difficult challenge of limiting stormwater runoff and pollution, Toronto developed a unique policy approach for managing stormwater, with the goal of eliminating adverse effects of wet weather flows and achieving measurable improvement in ecosystem health within the watershed. In 2000, it established what was considered a stringent sewer-use bylaw to restrict what can be disposed of through the sewer and in what quantities.[4] Three years later, Toronto's City Council approved a 25-year, $1.03 billion* stormwater plan, the Wet Weather Flow Master Plan, that sets forth a comprehensive strategy utilizing both traditional and green stormwater methods to deal with surface water quality and quantity, sewage overflows, and habitat and wildlife protection, with an emphasis on managing rainwater where it falls.[5]

The city adopted management guidelines in 2007 to provide further guidance for developers on the design and implementation of stormwater source control measures necessary to achieve the Wet Weather Flow Master Plan's long-term goals. Instead of mandating specific best management practices, however, the plan provides a flexible framework for the city to consider any innovative approach that can demonstrate specific performance objectives with respect to controls for peak flows, flood management, water quality, and annual runoff volume.[6] Specific water quality targets include removing 80 percent of total suspended solids annually over the entire site; specific runoff volume targets encourage infiltration, evapotranspiration, and rainfall harvesting. These include maintaining the pre-development volume of overland runoff, allowing a maximum runoff of 50 percent of annual precipitation, and require a minimum retention of 5 millimeters per event, an equivalent of .20 inches.[7]

DOWNSPOUT DISCONNECTIONS

Toronto's Downspout Disconnection Program was established as a voluntary program in 1998. The program, which was adopted by the City Council, provided free downspout disconnections to property owners whose downspouts were legally and directly connected to either the combined or separate sewer system. Its objective was to reduce the amount of stormwater entering the systems and reduce pressures on flood-prone areas. The city's 2003 Wet Weather Flow Master Plan identified downspout disconnections as one of the most effective and readily available source control options. It estimated that 40 percent of all properties could be disconnected through a voluntary program and made this goal a focus of the implementation plan.[8]

In 2003 and 2004, the Downspout Disconnection Program aimed its efforts at two particular neighborhoods and tributaries with combined sewer systems, as well as properties that were subject to basement flooding. The focus area was enlarged in 2004 and 2005.[9] In a review of the program in 2006, it was reported that a total of 26,000

*All money figures are given in U.S. dollars.

downspouts had been disconnected, at an average rate of 2,300 downspouts disconnected each year with $1.5 million in annual funding.[10] In November 2007, the City Council voted to move from a voluntary program to one that would be mandatory starting in November 2011, with all areas of the city phased in by the end of 2016.[11]

TORONTO'S GREEN ROOFS AND GREEN STANDARD

In 2000, Toronto's City Council adopted an environmental plan that recommended the city develop a strategy to encourage green roofs and rooftop gardens. In 2002, an official plan was approved that promoted green building designs and construction practices, such as green roofs and green spaces. After a Green Roof Task Force was formed in 2003 to investigate and promote the benefits of green roofs, a 2005 Ryerson University study estimated that if a green roof were installed on every flat roof, the city would save nearly $270 million in municipal capital costs and more than $30 million annually.[12,13] Subsequently, a Green Roof Task Force discussion paper identified a list of options and strategies, both financial and regulatory, to implement green roof technologies.[14] This led to the development and approval of a green roofs strategy in 2006.[15] As a result of this process, a two-year Green Roof Incentives Pilot Program was formed, with an initial budget of $200,000, to provide financial incentives of up to $20,000 per project to property owners through Toronto Water, the agency responsible for implementing the city's Wet Weather Flow Master Plan.[16,17]

In 2006, *Rooftops to Rivers* reported that there were 100 green roofs built or planned in Toronto. That same year, the passage of the City of Toronto Act gave the city the authority to mandate green roofs on new development. In May 2009, the Toronto City Council adopted construction standards requiring all new buildings and retrofits with more than 2,000 square meters of floor area (roughly 21,500 square feet) to include a green roof. Today there are approximately 135 built green roofs, totaling about 120,000 square feet in the city.[18] Moreover, according to Stephen Peck, founder of Green Roofs for Healthy Cities, approximately 1 million square feet of additional new green roofs have entered the planning phase since the bylaw went into effect.[19]

Toronto's building certification program, the Toronto Green Standard, was originally adopted in 2006. It sets performance targets related to site and building design in order to promote more environmentally sustainable development. The system is broken into two tiers, with Tier 1 being mandatory for all new planning applications as of January 31, 2010, and Tier 2 being voluntary and including higher levels of environmental performance. To encourage participation in Tier 2, Toronto refunds 20 percent of all development charges related to planning review and obtaining permits.[20] The University of Toronto Faculty of Architecture, Landscape and Design found that the benefits of building greener under the Toronto Green Development Standard overwhelmingly outweigh the associated costs, and that stormwater management requirements bring no additional financial burden to developers, consumers, and municipalities.[21] Instead, as compared with conventional systems, green stormwater management requirements lower initial and life-cycle costs while improving water quality, and reduce the need for stormwater systems to expand as quickly to accommodate growth and development. The study reported that water conservation requirements are also highly cost effective, when considering the avoided energy costs (for pumping, heating, and treatment) and the avoided costs for water treatment and sewage treatment plant expansion. [22] As part of the Toronto Green Development Standard, the city also put together design standards for greener parking lots and established green stormwater management standards for development.[23]

RAIN BARRELS, TREE PLANTINGS, AND OTHER GREEN INITIATIVES

The number of green infrastructure demonstration projects and programs within Toronto continues to increase. Typically, each initiative starts out as a pilot, to provide the city time to evaluate and revise existing codes, measure success, and identify ways to expand the pilot into a full-fledged program. In 2006, for example, the Ontario Building Code was amended to allow the use of rainwater inside a building, and the city is currently piloting demonstration projects at the city's Automotive Building at Exhibition Place and the Metro Zoo to evaluate the use of roof catchments with dual plumbing systems.[24,25] The 5 millimeter minimum retention standard put forth by the Wet Weather Flow Master Plan has also acted as a driver for rainwater harvesting, particularly in the densely packed urban center.[26] Additionally, the city's Urban Forestry Services has initiated numerous tree planting efforts. In 2006, for example, Toronto Water provided $1 million to the Parks, Forestry and Recreation Division, to plant more than 11,000 trees.[27] With the approval of its Climate Change Action Plan in 2008, the city made a commitment to double the existing tree canopy to increase shade, reduce the urban heat island effect, and reduce stormwater runoff.[28]

FINANCING STRATEGY

The City Council's 2003 Wet Weather Master Plan was projected to cost $1 billion over 25 years. While population pressures, increased flooding events due to CSOs combined sewer overflows could push the cost higher, Toronto views green infrastructure as a means to bring costs down. For example, Toronto Water estimates that downspout disconnections thus far have saved the city about $140 million in infrastructure costs. More than 350,000 residential downspouts were estimated to still be directly connected as of 2007, with each downspout costing the city from $1,000 to $1,330 to disconnect. As a result, the cost for the city to maintain its voluntary disconnect program could have been substantial. But as the city moved to a mandatory program in 2007 to ensure that inflow into the system under extreme storm events would be controlled—effectively transferring costs of disconnection over to homeowners, where the cost of disconnection is considerably lower—the city is expected to save an additional $8 million in short-term capital costs over three years.[29,30,31] A 2008 study on the Toronto Green Development Standard estimated that, at a cost of $36 million over 10 years, borne largely by private building owners and developers, 6 percent of Toronto's roofs can become green roofs, resulting in an annual savings of $100 million in stormwater costs and $40 million in CSO capital costs. Replacing the city's 1,864 miles of narrow alleys, or laneways, with permeable pavements would provide a net benefit of $27 million to $40.5 million in stormwater infrastructure savings. The study additionally estimated that by doubling its urban tree cover to 40 percent, Toronto could reduce stormwater flow by 20 to 30 percent, resulting in $7 billion in stormwater infrastructure cost savings.[32]

Toronto Water established a Stormwater Management unit in 2005 to oversee the plan's implementation.[33] The city generally implements water, sewage, and stormwater projects using pay-as-you-go financing, with revenue coming from the sale of water, a wastewater levy, and other miscellaneous revenue. Reserve funds are used to fund capital projects and lessen water rate impacts when unforeseen circumstances arise; these funds come from a water rate charged to water customers, net operating surplus, development charges, and interest income. To continue its pay-as-you-go approach, since 2002 Toronto Water has issued annual rate increases of approximately 9 percent.[34] One other source of funding available for green infrastructure projects is the Environmental Protection Reserve Fund, which the city created in January 2009 to fund the city's Climate Change Action Plan and several other key projects. Money from this fund has been used toward meeting the city's urban tree canopy goals.[35]

*EMERALD CITY RATING SYSTEM

Each of the cities profiled in *Rooftops to Rivers II* is a leader in green infrastructure investment—rethinking the design of municipal services and infrastructure. These cities leverage funding in creative ways. They provide tools to residential and commercial land owners to retrofit private properties and realize the multiple benefits provided by green infrastructure. In short, they are changing how cities look and function.

NRDC's Emerald City Rating System identifies six actions cities should undertake to maximize their green infrastructure investment. Our metric does not directly compare one city to another, due to geographical, population, budgetary and other differences. Instead, it identifies the presence or absence of common factors of success that NRDC believes are essential elements of a robust green infrastructure commitment. Only one city profiled, Philadelphia, is undertaking each of the actions identified, although each city is undertaking at least one.

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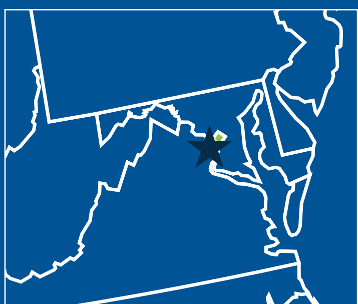
WASHINGTON, D.C.

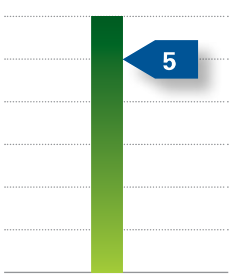
A CASE STUDY OF HOW GREEN INFRASTRUCTURE IS HELPING MANAGE URBAN STORMWATER CHALLENGES

TYPES OF GREEN INFRASTRUCTURE USED: Green roofs, rain barrels/cisterns, permeable pavement, rain gardens, street trees, downspout disconnection, green streets, vegetated swales



Thanks to its newly issued federal stormwater permit, Washington, D.C., has the makings of a very strong green infrastructure program. Containing a 1.2-inch retention standard for new development and redevelopment—to be achieved through evapotranspiration, infiltration, and harvesting—and numeric retrofit targets for street trees and green roofs, the permit will strongly encourage the use of green infrastructure on properties throughout the District. Washington's Department of the Environment is considering implementing the permit's retention standard through an innovative credit market that would be the first of its kind. Even prior to the new permit's issuance, D.C. agencies had begun a vigorous public education and assistance campaign, providing subsidies and technical help for the installation of a wide array of green infrastructure practices. A stormwater fee based on impervious area, along with a proposed discount program for on-site retention of runoff, provide an additional incentive for green infrastructure implementation.

WASHINGTON, D.C.



Total Criteria Score
Out of a possible 6

EMERALD CITY CRITERIA*

- ☐ Long-term Green Infrastructure (GI) Plan?
- ✓ Existing requirement to use GI to reduce some portion of the existing impervious surfaces?
- ✓ Incentives for private-party actions?
- ✓ Retention Standard?
- ✓ Guidance or other affirmative assistance to accomplish GI within City?
- ✓ Dedicated funding source for GI?

BACKGROUND

Washington, D.C., which is bordered by Virginia and Maryland, encompasses 61.4 square miles. It is located at the confluence of the Potomac and Anacostia Rivers and includes two other major streams, Rock Creek and Oxon Run. While 35 percent of the District's area is covered by tree canopy,[1] its rivers are significantly affected by urbanization. About 39 percent of the District was covered with impervious surfaces as of 2008, with the amount of imperviousness varying by neighborhood or ward from 30 to 60 percent.[2] Development and urbanization have taken a toll on the natural features within Washington; over the past 30 years, the District has lost 64 percent of its areas with heavy tree cover and experienced a 34 percent increase in stormwater runoff.[3]

The District of Columbia Water and Sewer Authority (D.C. Water), which was established in 1996, operates 1,800 miles of sanitary and combined sewers.[4] One-third of the city is served by a combined sewer system dating to the beginning of the 1900s and earlier. Today, an estimated 1.5 billion gallons of combined sewer overflows are discharged to the

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To help incentivize privately financed green roofs, Washington, D.C.'s Department of the Environment initiated a green roof subsidy program. The Department provides a rebate of $3 per square foot for installed green roofs; as a result, more than 50,000 square feet of green roof projects are under construction. The rebate has since grown to $5 per square foot.

Anacostia River, 850 million gallons into the Potomac, and 52 million gallons into Rock Creek each year.[5,6] The Anacostia River, which has 15 outfall locations and receives 60 percent of the CSO discharges, is one of the most polluted in the nation. In one study, 50 percent of brown bullhead catfish collected from the river had cancerous liver tumors, and approximately 25 percent had cancerous skin tumors.[7]

To correct the CSO problems, D.C. Water entered into a consent decree with the U.S. EPA in 2005 to build three huge tunnels over 15 years to hold combined stormwater and sewage during storm events, and then to slowly release the diluted sewage to the massive Blue Plains wastewater treatment plant after each storm subsides. Dubbed the Clean Rivers Project, the tunnels are now expected to cost the city $2.6 billion rather than the $1.9 billion reported in the 2006 *Rooftops to Rivers* report.[8]

While the city's existing CSO control plan focuses primarily on the deep tunnel system and partial sewer separation, it also recognizes to a limited extent the importance of incorporating green infrastructure within the city. The current Long Term Control Plan includes a provision for $3 million to fund low-impact-development retrofits at D.C. Water facilities.[9] D.C. Water has also conducted a rain barrel distribution pilot project. In addition, to meet its overarching water quality goals, the city and the District Department of the Environment (DDOE) have adopted the use of green infrastructure practices such as green roofs, rain barrels, rain gardens, "bayscaping" (landscape designed to help improve local streams and waterways within the Chesapeake Bay watershed), and pervious pavements to capture and slow stormwater before it hits the pipes,[10] with combined sewer overflows identified as one of multiple motivators for incorporating green infrastructure practices.[11] This includes funding for the D.C. Department of Transportation (DDOT) to plant more than 3,500 trees throughout the public right-of-way and to retrofit a major intersection in the city with green infrastructure.[12]

The portions of the city without a combined sewer system are served by a Municipal Separate Storm Sewer System (MS4) that collects stormwater runoff for direct discharge to Rock Creek and the Potomac and Anacostia Rivers. The District's existing MS4 permit, which went into effect in 2004 and was scheduled to end in 2009, was modified in 2007 to incorporate an aggressive schedule for implementing pollution reduction technologies and policies throughout the District. Under a new MS4 permit finalized in October 2011, the city will be required to promote and install various green infrastructure practices such as tree plantings and green roofs with numeric goals attached to each. The MS4 permit also includes new performance standards requiring that the first 1.2 inches of stormwater be retained on-site for all new development and redevelopment over 5,000 square feet; the District is also required to retrofit 18 million square feet of impervious surfaces to meet this standard. The permit also requires a new monitoring strategy for compliance with Total Maximum Daily Loads (TMDLs) for impaired waterways, which include the Potomac and Anacostia rivers and Rock Creek.[13]

Several significant planning and green development studies have helped drive the implementation of green infrastructure. The Green Build-Out Model (GBOM) developed by Casey Trees and Limnotech demonstrates the benefits of green infrastructure on a citywide basis. The original GBOM applied a scenario of significant additions of green roofs and trees throughout the District to study the potential stormwater and CSO reductions. A moderate greening scenario, which involves increasing the tree cover from 35 to 40 percent by adding trees and green roofs where practical and reasonable to do so, would prevent more than 311 million gallons of stormwater from entering the sewer systems, reducing discharges to the river by 282 million gallons and reducing cumulative CSO frequency by 1.5 percent (16 fewer CSO discharges per year). In total, D.C. Water could expect to save $1.4 million to $5.1 million per year due to reduced pumping and treatment costs.[14] In April 2009 the District adopted an Urban Tree Canopy Goal of 40 percent by 2035.[15]

A subsequent Enhanced Green Build-Out Model, developed in 2009, added five more green practices: rain gardens, rain barrels, permeable pavement, and streetside and curb bump-out bioretention, to the green roofs and trees used in the original GBOM. These five additional modeled practices represent 107,500 individual retrofit practices deployed citywide. The Enhanced GBOM, assuming an average rainfall year and using an "intensive greening" scenario that applied all seven practices wherever physically possible, found that the enhanced model would prevent more than 4 billion gallons of stormwater each year from entering the sewer systems—a 26 percent annual runoff discharge reduction—including 2 billion gallons of reduced stormwater in the Anacostia watershed. The Enhanced GBOM also would reduce CSO discharges to the District's rivers by close to 1 billion gallons. This would be a 43 percent reduction in total annual CSO discharge volume and would reduce cumulative CSO frequency by 14.7 percent (162 fewer CSO discharges per year).[16]

The upshot is that Washington's water resource officials are working to establish green infrastructure as a significant solution to the District's water resource needs, to work in tandem with gray infrastructure projects. The Director of D.C. Water, George Hawkins, has noted that he hopes an aggressive greening of the District will curtail the need for future CSO tunnels planned for Rock Creek and the Potomac (while construction proceeds on the Anacostia tunnel).[17]

LOW-IMPACT DEVELOPMENT AT THE NAVY YARD ON THE ANACOSTIA RIVER

The Washington Navy Yard along the banks of the Anacostia River was included as one of the case studies in the original 2006 *Rooftops to Rivers* report. At that time, several significant green infrastructure pilot projects were being constructed at the Navy Yard. Since the release of the first *Rooftops to Rivers* report, many more projects have been constructed as parts of retrofits or as public works maintenance projects. This is primarily due to the Navy's Low Impact Development (LID) Policy, which was adopted in 2007, as well as the commitment of the base commander.[18]

The LID Policy, which affects both new construction projects in excess of $750,000 and renovation projects that cost more than $5 million at Navy and Marine bases across the country, required the incorporation of green infrastructure wherever possible in fiscal years 2008 to 2010, and full implementation in 2011 and thereafter.[19] New projects have included bioretention planter boxes, bioretention parking lot retrofits, and permeable paver areas. Monitoring of the initial pilot projects has shown these practices to be extremely effective at removing metals and reducing the volume of runoff.[20]

WASHINGTON'S GREEN ROOFS AND BUILDINGS

Washington's first commercial green roof was installed in 2004. The 3,500-square-foot green roof was a collaboration between two nonprofit organizations and the real estate company that owns the building. There have been several substantial privately and publicly funded green roof projects since then. For example, as part of a 2003 lawsuit settlement, D.C. Water provided more than $300,000 to the Chesapeake Bay Foundation to administer grants to design, install, and maintain green roof demonstration projects. More than 121,000 square feet of green roofs were constructed in connection with this effort, providing estimated annual stormwater retention of 1.8 million gallons.[21] One project that was funded in part from the settlement program was a 3,000–

square-foot green roof installed in 2006 at the headquarters of the American Society of Landscape Architects (ASLA). Subsequent monitoring over a 10-month period showed that the green roof was able to retain 75 percent of total rainfall.[22] Although pollutant concentrations have gone up, total pollutant loads have gone down because the volume of stormwater leaving the site has been greatly reduced.[23]

To help incentivize privately financed green roofs, in 2007 the District Department of the Environment (DDOE) initiated a green roof subsidy program offering a rebate of $3 per square foot, which resulted in the installation of 10 green roof projects totaling 50,137 square feet.[24] The rebate has since grown to $5 per square foot, with a maximum of 5,000 square feet for new development and no maximum for retrofits.[25] The District also administers grants that fund green infrastructure efforts by nonprofit groups and community organizations.

Through June 2010, approximately 1 million square feet of green roofs have been installed or approved for construction in the District.[26] Dr. Hamid Karimi, Deputy Director of the DDOE, noted in the spring of 2011 that "with more than 100 green roofs installed, the District is demonstrating how a model green city should look and perform."[27] DDOE Director Christophe Tulou has announced that D.C. will soon challenge Chicago's place as the top-ranking city for square footage of green roofs.[28] In addition to the grant and incentive programs described above, much of this success has been spurred on by several laws and programs promoting more sustainable development, including the Green Building Act of 2006,[29] the RiverSmart Homes program initiated in 2007 (and discussed below), and the Clean and Affordable Energy Act of 2008.[30] The Green Building Act of 2006 and subsequent amendments to the building code were particularly helpful in removing impediments to downspout disconnection and mandating green building practices that reduce urban heat island effects. The city is currently seeking to amend its zoning code to remove other impediments to green building practices by incorporating a Green Area Ratio (GAR) incentive for bonus density and land uses. The plan would provide a sliding scale of practices tailored to particular zones to reduce the amount of impervious area and encourage the use of green infrastructure techniques such as trees, permeable pavers, and green roofs.[31] In addition, the DDOT has released a Low Impact Development Action Plan, with associated deadlines for incorporating green infrastructure and reducing the amount of impervious surfaces in right-of-way construction projects.[32]

RIVERSMART HOMES

Another program initiated by DDOE in 2007 provides incentives to homeowners interested in reducing stormwater runoff from their properties. Known as RiverSmart Homes, the program provides outreach and education, design and construction assistance, materials and facilities, and incentives for communities, businesses, and homeowners. The program addresses some of the key roadblocks for implementation at the scale of the individual homeowner, including installation assistance so homeowners don't have to transport materials or find knowledgeable contractors, and assistance in negotiating the regulatory system for construction permits.[33]

To date, the RiverSmart Homes program has audited more than 1,500 homes in D.C., installed 1,000 rain barrels, planted 700 trees, replaced 25 impervious surfaces, and installed 100 rain gardens and 175 BayScapes.[34] This program includes using local vendors and contractors for designs and installations. Tree planting has been done in partnership with the Casey Trees Foundation, which provides training, inventory, and rebates for tree planting, as well as conducts its own tree planting efforts.[35] The District has also partnered with the Rock Creek Conservancy to reach out to homeowners for intensive greening of two target neighborhoods; as of 2011 the Conservancy's extensive and intensive outreach, including block meetings, has yielded requests by 40 percent of owners for a DDOE audit to determine whether their property was eligible for up to $5,000 in landscaping improvements.[36]

FINANCING STRATEGY

To cover the costs of stormwater management under the city's MS4 program and the federally mandated Long Term Control Plan, D.C. Water customers receive two charges on their utility bills. The stormwater fee, which is paid to the DDOE, was established in 2001; it was originally a flat fee to single-family residences and based on total water consumption for other customer classes.[37] In 2009, legislation was enacted to allow DDOE to assess stormwater fees based on impervious cover. The District's stormwater fee is structured to generate approximately $13.2 million annually. This revenue total addresses only the costs of the Stormwater Management Program required by the current MS4 permit. The costs of achieving compliance with the District's Total Maximum Daily Load (TMDL) requirements and of addressing stormwater runoff impacts in general are likely to be orders of magnitude greater.[38] The Impervious

Area Charge (IAC), also implemented in 2009, is paid to D.C. Water to recover costs related to the CSO Clean Rivers Project. All District property owners pay both fees.

By basing both the stormwater fee and the IAC on impervious surfaces, the intent was to shift costs from multifamily residential properties, such as apartment buildings, which typically have relatively small amounts of impervious area but consume larger amounts of water, to properties that generate larger volumes of stormwater runoff, such as large office complexes and parking lots. For the stormwater fee, this also served to increase the federal government's burden from 15 to 24 percent of the total revenue collected.[39] Basing the fees on imperviousness creates a market incentive for new development to pave less and for existing buildings to retrofit paved areas with greener stormwater management practices. To further incentivize practices that reduce stormwater runoff, the District is also developing a Stormwater Fee Discount Program for properties that install stormwater retention practices,[40] and is considering revising its stormwater regulations to promote an innovative stormwater credit market that DDOE hopes will encourage the use of green infrastructure.[41]

Other grants and incentives for property owners to install green infrastructure on District, residential, and commercial buildings include subsidy programs for the installation of rain barrels, shade trees, rain gardens, and pervious pavers, as well as energy efficiency programs for homeowners, nonprofits, small businesses, and condominiums.[42] In 2010, DDOE also gained access to a new source of revenue through the District's disposable bag fee. This fee, enacted by the Anacostia River Clean Up and Protection Act of 2009, places a five-cent fee on disposable plastic and paper bags provided by any District retailer selling food or alcohol. Revenue generated by this fee is directed to a special-purpose fund dedicated to activities to clean up and protect the Anacostia River and other impaired waterways. Revenue projections from the bag fee are difficult to make; the District expects that over time the fee will discourage consumers from using disposable bags, resulting in a gradual decrease in revenue. Between January 2010 (when the bag fee went into effect) and January 2011, the District collected $2 million in revenue from the fee, and bag use dropped from 270 million bags in 2009 to 55 million bags in 2010.[43]

*EMERALD CITY RATING SYSTEM

Each of the cities profiled in *Rooftops to Rivers II* is a leader in green infrastructure investment—rethinking the design of municipal services and infrastructure. These cities leverage funding in creative ways. They provide tools to residential and commercial land owners to retrofit private properties and realize the multiple benefits provided by green infrastructure. In short, they are changing how cities look and function.

NRDC's Emerald City Rating System identifies six actions cities should undertake to maximize their green infrastructure investment. Our metric does not directly compare one city to another, due to geographical, population, budgetary and other differences. Instead, it identifies the presence or absence of common factors of success that NRDC believes are essential elements of a robust green infrastructure commitment. Only one city profiled, Philadelphia, is undertaking each of the actions identified, although each city is undertaking at least one.

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COMPOSITE CASE STUDIES

The preceding case studies illustrate that green infrastructure and low-impact development techniques are being applied in a variety of settings and climates, and on a variety of scales, all across the nation. As Nathan Gardner-Andrews of the National Association of Clean Water Agencies observes, "Clearly green infrastructure is the new wave—it's the new thing that all cities are doing, not just because it's trendy but because green infrastructure is actually working." Many cities in the United States beyond those highlighted in this report are successfully incorporating green infrastructure and others are in the process of constructing and implementing their first green infrastructure pilots. Countless additional cities are in the nascent stages of planning for future green infrastructure projects.

This section discusses a number of community efforts that further illustrate the movement toward green infrastructure. The cities differ in how far along they are in their respective programs, but they are alike in doing interesting, innovative projects that warrant recognition.

INDIANAPOLIS, INDIANA

In 2008 the wastewater treatment and sewer system in Indianapolis, Indiana, was averaging 7.8 billion gallons of overflow annually,[1,2] overflowing 40 to 60 times per year.[3] The city was determined to meet the goals of a 2006 federal consent decree to reduce overflows more than 90 percent, to approximately 642 million gallons annually.[4] Looking for opportunities to incorporate more sustainable solutions, the mayor's office opted to revamp a project to expand the city's wastewater treatment systems. At the time, the project was running $300 million over its $3.5 billion budget and was months behind schedule.[5,6]

In partnership with the city's Public Works Department, the mayor's office transformed the plan for managing wastewater. The new program's chief components include an expansion of the sewer system and an improved sewage treatment facility design (including a 54-million-gallon Deep Rock Tunnel Connector extending between Indianapolis's two wastewater treatment plants), combined with green infrastructure techniques to absorb stormwater runoff before it reaches the enhanced water treatment plants.[7,8] The city's early success in reducing the number and frequency of overflows led to a modification to the consent decree in 2010. Indianapolis must now reduce the volume of total annual overflows to approximately 414 million gallons; even as the project's cost will be reduced by approximately $440 million. This cost reduction, coupled with driving down the original budget overrun, will result in a savings of approximately $740 million. Notably, the incorporation of green infrastructure and sustainable approaches helped achieve these savings.[9]

As part of the effort to enhance green infrastructure in Indianapolis, the mayor's office created the Office of Sustainability, or SustainIndy. SustainIndy works to facilitate and integrate green infrastructure practices across all city agencies and departments. Before the creation of this office, there were few examples of green infrastructure within the city. Today, many projects have been implemented or are in development. These projects include:[10]

- **Tree planting:** In partnership with Keep Indianapolis Beautiful, six thousand trees will be planted in 2011, and a total of 100,000 will be planted by 2017. Stormwater reduction is a key goal: trees in urban areas can significantly reduce runoff by intercepting rainfall before it reaches the pavement. Models show that a mature deciduous tree can intercept 500 to 700 gallons of rain per year and that a mature evergreen can intercept up to 4,000 gallons per year.[11]
- **Rain gardens:** The city promotes rain gardens and native plantings, and the city's Rain Garden Resource Center provides aid in the design and construction of rain gardens. Program participants who register their rain gardens with the city are exempted from a high weeds and grass ordinance. The resource center enables the city to estimate how much stormwater is being diverted from the combined sewer system.

- **The Sustainable Infrastructure Initiative:** This program encourages green infrastructure in private development. Its centerpiece, the Green Supplemental Document, provides guidance on incorporating green infrastructure into stormwater treatment design. Permit review is expedited for plans that meet necessary stormwater requirements and incorporate green infrastructure techniques.
- **The Green Infrastructure Master Plan:** Completed in December 2010, it targets green infrastructure investment to reduce CSOs.
- **The Green Checklist:** As of January 2011, all capital improvement projects in Indianapolis must include this checklist, which requires consideration of green infrastructure elements. The checklist has resulted in the incorporation of green infrastructure in public projects.
- **Pilot projects:** A number of demonstration projects have been conducted throughout the city. For example, the Ohio Street project, located on a two-block CSO location with a history of flooding and overflow problems, replaced old sidewalks with porous pavement and installed rain gardens to improve drainage. The project has the potential to remove an estimated 1.3 million gallons of stormwater from the combined sewer system annually. Although porous concrete often costs more than traditional paving, the material serves a critical drainage function that would otherwise have to be accomplished using drains, pipes, and other structural BMPs. In that respect, the porous pavement is cost-effective: $37,500 was spent on Ohio Street, as opposed to the $85,150 that would have been required for traditional sidewalks plus the required drainage infrastructure.[12]

Although the Office of Sustainability is admittedly on a learning curve and still needs hard data to quantify the benefits of the city's new green infrastructure projects, Indianapolis has been making progress to implement green infrastructure since SustainIndy's inception in 2008.

CLEVELAND, OHIO

Cleveland is also utilizing green infrastructure as part of the solution to its CSO problems, and now has a federal mandate to implement green infrastructure to help meet the requirements of the region's consent decree.

On December 22, 2010, the EPA and the Department of Justice announced a landmark Clean Water Act (CWA) settlement with the Northeast Ohio Regional Sewer District (NEORSD) to address the flow of untreated sewage into Cleveland waterways and Lake Erie.[13] At the time of the settlement, NEORSD was discharging between 4.5 billion and 5 billion gallons of raw sewage annually from 126 combined sewer overflow locations, with some sites overflowing 70 to 80 times per year.[14]

The settlement requires NEORSD to spend approximately $3 billion on traditional infrastructure to bring total annual discharges down to 537 million gallons. Significantly, the settlement also requires the sewer district to invest at least $42 million in green infrastructure projects to capture an additional 44 million gallons of CSO discharges. The settlement also enables NEORSD to look for opportunities to propose additional green infrastructure in exchange for reducing the scope of conventional, or "gray," infrastructure projects.[15,16] According to Kyle Dreyfuss-Wells, NEORSD's manager of watershed programs, the district "will look across its [$3 billion] gray infrastructure program for opportunities to replace gray with green infrastructure."[17] Environmental justice considerations will play a considerable role in NEORSD's green infrastructure work, which could have significant implications for addressing blight in Cleveland. Currently the city has a significant problem with vacant land and foreclosed properties, and the sewer district has the potential to transform these blighted areas with green infrastructure projects. Concentrating such projects in areas of need will connect the objectives of CSO control with planning and economic development opportunities.[18]

CINCINNATI, OHIO

Another Ohio city looking to green infrastructure to help address its CSO problems is Cincinnati. A 2004 consent decree with the EPA mandated that the Metropolitan Sewer District (MSD) treat, capture, or remove 85 percent of the annual 14 billion gallons of CSOs in the district's service area, as well as eliminate all sanitary overflows—approximately 100 million gallons per year.[19] In August 2010, the consent decree was amended, providing the sewer district the opportunity to substitute green infrastructure for gray infrastructure on a project-by-project basis; green for gray proposals will likely be submitted in 2012.[20]

To meet EPA mandates, MSD launched Project Groundwork, a multiyear initiative composed of hundreds of sewer improvement and stormwater mitigation projects.[21] Many of the strategies being evaluated for Project Groundwork include green infrastructure techniques; the most significant and large-scale effort is a three-year pilot in the Lick Run watershed. The watershed, located in Lower Mill Creek on Cincinnati's west side, covers about 2,700 acres. The consent decree requires the development of a three-year action plan to determine how to achieve an initial 2-billion-gallon reduction in CSOs within Lower Mill Creek by 2018.[22] The federal government identified a deep tunnel system as the preferred remedy, but MSD has until December 2012 to an alternative, more sustainable way to achieve this reduction goal. Many subprojects featuring green infrastructure are already showing promise as alternatives to the deep tunnel system.[23]

Importantly, MSD's Communities of the Future initiative seeks to address the CSO problem while combining source control strategies and community revitalization. MaryLynn Lodor, environmental programs manager at MSD, explains that the aim is to "craft a project so that [MSD's] investment can be the seed for further investments in the community to come about." The Lick Run Basin is located in South Fairmount, an underserved community that suffers from a number of social and economic challenges. MSD designed Lick Run as its first "fully integrated effort to develop a sustainable solution for the community based on source control."[24] The Communities of the Future's whole-system approach for Lick Run includes a mix of gray and green infrastructure; it combines the installation of 75,000 linear feet of storm sewer or reconstructed waterways and retention basins for storage with reforestation and downspout disconnections in selected areas.[25] Ideally this watershed-based approach will reduce CSO volume and also bolster the quality of life in South Fairmount by serving as a catalyst for revitalization.

MINNEAPOLIS, MINNESOTA

Minneapolis, with three streams and the Mississippi River running through it and a multitude of lakes nearby, has carried out projects to improve water quality for more than a decade. Its stormwater ordinance requires public and private redevelopment sites of 1 acre or more to include on-site stormwater management. Since the adoption of the ordinance, approximately 700 structural best management practices (BMPs) have been used at more than 370 sites within Minneapolis. The vast majority of these BMPs are rain gardens (an estimated 1,216 as of December 2010); other techniques include stormwater ponds/wetlands, underground infiltration, bioswales, manufactured BMPs, and green roofs. Additionally, properties in Minneapolis must pay a stormwater utility fee. The utility has a substantial credit program in place: a credit of up to 50 percent is granted to property owners who make water quality improvements, and a credit of up to 50 percent is available for properties designed to retain a 10-year, 24-hour storm event on-site. For retention of a 100-year event, a property is eligible for a credit of up to 100 percent.[26]

Although green infrastructure is not mandated in Minneapolis, the Surface Water and Sewers division of Minneapolis's Public Works Department seeks to include green infrastructure in some of its routine utility and street projects. Current pilots include the implementation of nearly 11,000 Silva cell frames along 24 blocks in downtown Minneapolis as a stormwater mitigation measure. Silva cells are rigid, stackable structures of glass and polystyrene compound with galvanized steel tube frames. Installed as a subsurface under sidewalks or other paved areas, they provide a maximum amount of soil volume for tree root growth in challenging urban environments. They also provide uncompacted soil "reservoirs" for storage of stormwater runoff.[27,28] When Silva cells take in stormwater, the water either is taken up by the trees or infiltrates into the ground. By maximizing root growth, a large canopy of healthy, mature trees will also, in the future, provide stormwater management through significant interception and evapotranspiration. Models predict a 10 percent reduction in peak stormwater flows as a result of Silva cell installation, and research indicates that the filtration offered by the soil within the cells will potentially remove more than 80 percent of phosphorus, 60 percent of nitrogen, and more than 90 percent of lead, copper, zinc, and iron.[29]

The city's 143-acre Heritage Park development illustrates how green infrastructure can be implemented on a large-scale to transform communities. In 1992, the Minnesota Legal Aid Society and the National Association for the Advancement of Colored People brought a lawsuit against Minneapolis and the U.S. Department of Housing and Urban Development regarding segregation and concentration of poverty. An agreement was reached in a 1995 consent decree to demolish four public housing developments and rebuild the area as a mixed-income, mixed-density community now known as Heritage Park. The distressed public housing was originally constructed over filled wetlands and along the former alignment of Bassett Creek, which was rerouted to underground pipes. The project's design accommodated the site's variable soil conditions, using the most developable areas for housing and creating a system of interconnected ponds and trails in the more challenging areas, bringing parklike amenities to a previously underserved part of the city. The project's green infrastructure features use stormwater captured both from the redevelopment area and from pipes that previously carried untreated stormwater toward the Mississippi River from the surrounding neighborhood.[30] The stormwater treatment system is designed to remove 70 percent of suspended solids and also to reduce nutrients and metals, using a "treatment train" approach to remove pollutants. The process uses underground grit chambers, trench forebays or sedimentation basins, grass filter strips, level spreaders, a series of rain gardens planted with native plants, and stormwater ponds.[31]

JACKSONVILLE, FLORIDA

Jacksonville does not have CSOs, but it does have a number of stormwater-related pollution problems, including sanitary sewer overflows during severe rains and elevated nitrogen and phosphorus levels in multiple area waterways. Jacksonville is tackling the issue of nitrogen and phosphorus pollutant loading with a strategy that includes ordinances regulating fertilizer, irrigation, and pet waste and encouraging "Florida-friendly" landscaping that conserves water and reduces water pollution for all new developments. Additionally, Jacksonville is starting to focus on green infrastructure as an important component of reducing nitrogen and phosphorus pollution and improving the health of the Lower St. Johns River Basin tributaries. Efforts include implementation of a Basin Management Action Plan to meet total maximum daily loads for the river.[32,33,34]

Under the Basin Management Action Plan, governments, stakeholders, and the Florida Department of Environmental Protection regularly work together to develop strategies to address water quality problems in their watersheds. According to Franklin Baker, EPA Region 4 Florida Watershed Coordinator, when local interest groups come together to discuss water quality improvements, "LID and green infrastructure are tools that are regularly identified as being part of the answer."[35]

Jacksonville's public works department has started to incorporate green infrastructure into select road and flood improvement projects, and some private developers have incorporated green infrastructure components in their plans.[36] Additionally, the city is currently developing a low-impact-development procedure manual for the county, slated for completion in early 2012. Outlining green infrastructure practices and benefits, the manual will serve as an important tool for developers, architects, engineers, and government employees while providing clear specifications for those who seek permitting for green infrastructure construction. In a future iteration of the manual, the city plans to include design specifications for underground cisterns, pervious pavement systems, rain barrels, rain gardens, and other green infrastructure techniques.[37]

The EPA has identified Jacksonville as a priority area, partnering with the city to focus resources on its historically underserved downtown urban core. Green infrastructure practices are being concentrated in this area for benefits to the community that extend beyond water quality.[38] "We are doing green infrastructure for water quality improvement," says Maryann Gerber, EPA's Region 4 Green Infrastructure Coordinator, "but we also want to show how the quality of life for communities can be improved as you do these types of projects."[39]

TUCSON, ARIZONA

Due to Tucson's arid climate and average rainfall of only about 11 inches per year, the city necessarily views rainwater as a valuable resource. Tucson embraces rainwater harvesting to supplement other available water supplies.[40]

The nation's first municipal rainwater harvesting ordinance for commercial projects, Commercial Rainwater Harvesting Ordinance No. 10597, took effect in Tucson on June 1, 2010. Facilities that are subject to the ordinance must meet 50 percent of their landscape demand using harvested rainwater, prepare a site water harvesting plan and budget, meter outdoor water use, and use irrigation controls that respond to soil moisture levels. Facilities have three years to meet the 50 percent requirement, and the rule is waived during periods of drought. In general, commercial sites in Tucson should be able to comply using passive water harvesting systems,[41,42] defined as systems that passively infiltrate rainwater into soil or porous pavement by use of vegetation.[43] A Residential Gray Water Ordinance also took effect on June 1, 2010, requiring all new residential development to have the necessary plumbing to accommodate a gray water system[44,45]

Educating Tucson's residents about how to harvest rainwater is a critical endeavor, and the city is partnering with several nonprofits and organizations to provide technical assistance to individuals, neighborhoods, and businesses undertaking rainwater harvesting projects. A number of incentives are also in place to encourage rainwater harvesting and water conservation on private property. The city offers guidance schematics for Tucson residents who want to install curb cuts for street-runoff harvesting,[46] and grants are made through Tucson's water department for small-scale neighborhood water harvesting. Statewide tax incentives also exist: residents who install a water conservation system may take a one-time tax credit of up to 25 percent of the cost of the system, up to a maximum of $1,000.[47]

PERSONAL COMMUNICATION—ENDNOTES

NACWA
Personal communication with Nathan Gardner-Andrews, General Counsel, National Association of Clean Water Agencies (NACWA), April 2011.

Indianapolis
Personal communication with Allyson Pumphrey, Project Manager, Indianapolis Office of Sustainability, April 2011.

Cleveland
Personal communication with Kyle Dreyfuss-Wells, Manager of Watershed Programs, Northeast Ohio Regional Sewer District, April 2011.

Cincinnati
Personal communication with MaryLynn Lodor, Environmental Programs Manager, Metropolitan Sewer District of greater Cincinnati, April 2011.

Jacksonville
Personal communication with Vincent Seibold, Chief, Environmental Quality Division, City of Jacksonville, Florida, April 2011.

Syracuse
Personal communication with Samuel Sage, President, Atlantic States Legal Foundation, May 2011.

Personal communication with Matthew Millea, Deputy County Executive for Physical Services, Office of the County Executive, Onondaga County, May 2011.

Personal communication with Susan Pfeffer, Green Initiatives Program Coordinator, Onondaga County Department of Water Environment Protection, May 2011.

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12 October 2011

TO: NRDC
FROM: ECONorthwest
SUBJECT: GREEN INFRASTRUCTURE ECONOMIC BENEFITS AND FINANCING LITERATURE REVIEW

This memo provides a review of the recent literature on the economic benefits of green infrastructure. It also provides recent studies that provide insights into solutions for financing green infrastructure projects. The identified studies are generally sorted to highlight those that are themselves most heavily referenced, an indication of their relevance to the overall effort of gaining a better understanding of the potential benefits of green infrastructure. This review focused on studies from 2007 and after, because an earlier review on the topic by ECONorthwest addressed studies released prior to 2007.

Summary of Findings

The most recent literature reiterates the now established notion that green infrastructure is not only a cost-effective way to reduce stormwater runoff, but that it also provides a number of additional economic benefits that grey infrastructure alternatives generally do not provide. We can also draw a number of common themes from this recent literature.

- While each case is highly site-specific, the recent literature reaffirms the accepted view that green infrastructure can be a cost-effective tool in reducing stormwater runoff.
- Green infrastructure can provide economic benefits that grey infrastructure alternatives do not.
- In some cases, the most cost-effective approach to reducing stormwater runoff may be a blend of green and grey infrastructure.
- Many of the economic benefits of green infrastructure are not quantifiable, but that doesn’t mean they don't have value.
- Not all BMPs are created equal. The cost-effectiveness of green infrastructure varies by location and technique.
- Households may value the direct and indirect benefits of green infrastructure, but many individuals and professionals do not recognize the value of green infrastructure itself. This may create social and attitudinal preference barriers to implementation.

BENEFIT-COST ANALYSES AND COST-EFFECTIVENESS

Table 1 below presents a summary of the common economic benefits valued in the recent green infrastructure literature.

Table 1: Common Economic Benefits Valued in Selected Literature

	Stormwater Management	Environmental Quality	Community Livability	Regulatory Management	Ecosystem Services
Londoño and Ando (2011)	√	√			
EPA (2010)	√	√	√	√	√
Roseen et al (2011)	√	√	√		
CNT (2010)	√	√	√		√
Gunderson et al (2011)	√	√			
Gunderson et al (2011b)	√			√	
Jaffe et al (2010)	√	√			
Sullivan et al (2010)		√		√	
Montalto et al (2007)				√	

- Source: ECONorthwest staff
- Notes: This list of economic benefits is not comprehensive. An interested reader may find a more comprehensive list of economic values of green infrastructure from CNT (2010).
- Benefits of stormwater management include: reduced water treatment needs, reduced grey infrastructure needs, reduced flooding costs
- Benefits of environmental quality include: increased groundwater recharge, improved air quality, improved air quality, reduced atmospheric CO_2, reduced urban heat island, lower home cooling expenses, and climate change adaptation
- Benefits of community livability include: improved aesthetics, increased public and educational opportunities, reduced noise pollution, improved community cohesion
- Benefits of ecosystem services include: channel protection and integrity, increased recreational opportunities, improved habitat
- Benefits of regulatory management include a municipalities' increased ability to meet regulatory requirements, including CSOs under NPDES permits and TMDL restrictions.

The following annotated bibliography provides a review of relevant recent reports on the economics of green infrastructure, with a particular focus on those studies on cost and benefit analyses. The bibliography is divided into three categories. First, we present cutting edge and foundational literature that either examines the economic benefits of green infrastructure in innovative ways or provides a comprehensive and rigorous analysis that policy makers and researchers will likely rely on in future discussions. Second, we present those studies which are of good quality and notable. These are recent studies with sound economic analysis, with findings that future research will likely build upon. Third, we present one study with findings that we should interpret with caution.

Widely Known and Referenced

Londoño, C. and A. Ando. 2011. "Valuing Preferences over Stormwater Management Outcomes Given State-Dependent Preferences and Heterogeneous Status Quo." <u>Agricultural</u>

& Applied Economics Association's 2011 AAEA & NAREA Joint Annual Meeting. Pittsburgh, Pennsylvania. July.
Using a choice-experiment survey of households in Champaign-Urbana, Illinois, this paper estimates the values of multiple attributes of stormwater management outcomes and identifies households' willingness-to-pay for different attributes of stormwater management controls. The paper finds that households have a positive willingness-to-pay for reductions in flooding frequency, and in particular basement flooding, and improved environmental quality. The paper also finds that an individuals' WTP values depend on his or her status quo condition.

Environmental Protection Agency. 2010. "Green Infrastructure Case Studies: Municipal Policies for Managing Stormwater with Green Infrastructure." EPA-841-F-10-004. August.
This report presents the common trends in how 12 local governments developed and implemented stormwater policies to support green infrastructure. The paper presents a range of benefits derived from green infrastructure for the social, economic, and environmental conditions of a community. The paper also presents and discusses a variety of municipal incentive programs.

Stratus Consulting Inc. 2009. "A Triple Bottom Line Assessment of Traditional and Green Infrastructure Options for Controlling CSO Events in Philadelphia's Watersheds." Final Report. City of Philadelphia Water Department. August.
This paper presents a cost-benefit analysis of Philadelphia's grey and green infrastructure CSO control alternatives under consideration, with a particular emphasis on triple bottom line aspects, including their respective abilities to provide environmental, social, public health, and other goods. The paper focuses, in particular, on the benefits and external costs of these alternatives. The paper finds that LID-based green infrastructure approaches provide a wide array of important environmental and social benefits to the community, benefits which traditional infrastructure alternatives generally do not provide.

Center for Neighborhood Technology. 2010. "The Value of Green Infrastructure: A Guide to Recognizing Its Economic, Environmental, and Social Benefits."
This guide outlines the full-range of potential economic benefits of green infrastructure investments, by type of practice. The guide examines the steps necessary to calculate the performance benefits of green infrastructure techniques and, where possible, demonstrates simplified examples that estimate the magnitude and value of these benefits.

MacMullan, E. and S. Reich. 2007. "The Economics of Low-Impact Development: A Literature Review." ECONorthwest. November.
This report describes the methods economists use when measuring the costs and benefits of low impact development and conventional stormwater controls and summarizes the literature that identifies and measures the economic costs and benefits of managing stormwater using LID. The report's intended audience is municipal officials, stormwater managers, ratepayer stakeholders and other non-economists. The review found that most economic studies of LID focused on comparing costs between green and grey projects. Many limited their comparison to installation and ignored O&M. Few studies attempted to compare apples to apples and recognize the additional benefits green infrastructure projects provide.

Good Quality and Notable

Roseen, R., T. Janeski, J. Houle, M. Simpson, and J. Gunderson. 2011. "Forging the Link: Linking the Economic Benefits of Low Impact Development and Community Decisions." University of New Hampshire Stormwater Center, the Virginia Commonwealth University, and Antioch University New England. July.
This paper presents the economic benefits, including construction and project life-cycle costs, of green infrastructure to municipalities, commercial developers, and others. The paper also presents ways in which green infrastructure can build community resiliency in water management to climate change.

Gunderson, J., R. Roseen, T. Janeski, J. Houle, and M. Simpson. 2011. "Cost-Effective LID in Commercial and Residential Development." Stormwater. March-April.
This paper examines the cost-effectiveness of two LID projects—one on a residential development and one on a large-scale commercial development. Both projects displayed environmental quality improvements, including a measurable improvement in water-quality and lower home cooling expenses, and stormwater management benefits, including reduced flooding costs and avoided grey infrastructure costs.

Gunderson, J., R. Roseen, T. Janeski, J. Houle, and M. Simpson. 2011b. "Economical CSO Management." Stormwater. May.
Using case studies, this paper shows how green infrastructure can help cities and municipalities reduce stormwater runoff volumes entering combined systems and lower treatment costs. They conclude that using a blend of grey and green infrastructure strategies to manage CSOs can be more economically viable than using grey infrastructure alone.

Jaffe, M., M. Zellner, E. Minor, H. Ahmed, M. Elberts, H. Sprague, S. Wise, and B. Miller. 2010. "Using Green Infrastructure to Manage Urban Stormwater Quality: A Review of Selected Practices and State Programs." Illinois Environmental Protection Agency. September.
This paper reviews the peer-reviewed scientific reports and articles related to green infrastructure in Illinois and five other states. The authors examine whether green infrastructure is as effective as conventional controls in reducing total suspended solids and total nitrogen in receiving water bodies and the effectiveness of these techniques on reducing runoff volumes and peak flow discharge compared to conventional controls. The authors use an economic model to find green infrastructure techniques result in a substantial cost-savings in both construction and life-cycle costs compared to conventional controls. The authors also address some of the indirect benefits of green infrastructure, including ecosystem services.

Sullivan, M., B. Busiek, H. Bourne, and S. Bell. 2010. "Green Infrastructure and NPDES Permits: One Step at a Time." Water Environment Federation.
This paper describes the benefits of green infrastructure, particularly in the context of NPDES permits and GI's role in controlling CSOs. The paper provides several examples of case studies where municipalities are incorporating green infrastructure into requirements under their NPDES permits.

Thurston, H., M. Heberling, and A. Schrecongost. 2009. Environmental Economics for Watershed Restoration. Boca Raton, FL: CRC Press, Taylor & Francis Group.

This book provides guidance to watershed groups interested in incorporating economic valuation for prioritizing watershed restoration projects or to justify the expenses of such projects. The book's intended audience is stakeholders with little to no background in economics who are interested in these issues and want to understand the economics more fully.

Montalto, F., C. Behr, K. Alfredo, M. Wolf, M. Arye, and M. Walsh. 2007. "Rapid assessment of the cost-effectiveness of low impact development for CSO control." Landscape and Urban Planning doi: 10.1016/j.landurbplan.2007.02.004.
This paper presents a model for assessing the cost-effectiveness of green infrastructure for reducing CSOs in municipalities. The paper does not present other types of economic benefits associated with green infrastructure. The paper finds differing level of cost-effectiveness between settings, but also concludes that under a variety of performance and cost scenarios, green infrastructure may be a cost-effective alternative for municipalities to consider in their efforts to reduce CSOs.

LimnoTech and Casey Trees. 2007. "The Green Build-out Model: Quantifying the Stormwater Management Benefits of Trees and Green Roofs in Washington, DC." EPA Cooperative Agreement CP-83282101-0. April.
This paper presents the Green Build-out Model, a planning tool that quantifies the cumulative stormwater management benefits of trees and green roofs in the District of Colombia. The paper compares two planning scenarios with the Green Build-out Model: an "intensive greening" scenario, which considered putting trees and green roofs wherever physically possible, and a "moderate greening" scenario, which considered putting trees wherever practical and reasonable. With a variety of findings, the paper concludes that trees, green roofs, and large tree boxes provide substantial benefits to the District as reductions in stormwater runoff and untreated discharges in sewer systems.

Sands, K. and T. Chapman. "Rain Barrels—Truth or Consequences." Milwaukee Metropolitan Sewerage District. Milwaukee, Wisconsin.
This paper describes the use and function of rain barrels. It also tests the performance of this green infrastructure technique against some benefit assumptions, including water quality issues.

Eckles, K. "A Public Works Perspective on the Cost vs. Benefit of Various Stormwater Management Practices." City of Woodbury.
In this presentation, Karen Eckles evaluates the costs and benefits of various BMPs on a project level and site-specific basis. She finds pollutant loading that is direct to and treated by a particular BMP and the amount of time that BMP is physically treating stormwater heavily influence its cost-effectiveness. She also finds that passive systems are the least cost-effective BMP alternatives, while active systems are a very cost-effective way to remove phosphorous from stormwater at low levels.

Needs More Attention

Jaffe, M. 2010. "Reflections on Green Infrastructure Economics." Environmental Practice 12(4): 357-365. December.
This paper uses economic modeling in Illinois to show that the benefits of green infrastructure related to flood and pollution risk-mitigation exceed their direct construction and maintenance costs. The paper also finds that green infrastructure is cost-effective in managing urban

stormwater when compared to conventional grey infrastructure under a number of development scenarios. The paper makes a case against valuing the indirect economic benefits when conducting benefit-cost analyses of green infrastructure, because of the uncertainty and analytical complexity of such studies. The author believes economic studies can find cost-effectiveness in green infrastructure without examining indirect benefits.

Note:

We should interpret these conclusions with caution. While in many cases the direct economic benefits of green infrastructure may greatly outweigh their costs, there are cases where it is the indirect benefits that make green infrastructure a more cost-effective and viable alternative to traditional alternatives. Moreover, the fact that many of these indirect benefits are difficult or impossible to quantify does not mean that they do not have value nor does it preclude policy makers from considering these benefits qualitatively when they weigh alternatives. In fact, the accepted professional guidelines for conducting economic analyses require policy makers to consider the full range of non-market values, including indirect and unquantifiable values, in any economic valuation of a policy decision.[1]

Incentives and Financial Mechanisms

The annotated bibliography below reviews reports and information sources on the financing of green infrastructure, including financing mechanisms, incentives, and programs.

Thurston, H., M. Taylor, W. Shuster, A. Roy, and M. Morrison. 2010. "Using a reverse auction to promote household level stormwater control." Environmental Science & Policy 13: 405-414.
The paper hypothesizes that it may be more cost effective for smaller communities to use stormwater incentives, instead of traditional, large infrastructional best management practices, to control runoff at the parcel level. The paper tests the effectiveness of a procurement auction as the coordinating mechanism for encouraging installation of parcel-scale rain gardens and rain barrels in the Midwest. The paper finds that even relatively minimal financial incentives can result in homeowners' willingness-to-accept stormwater management practices on their properties.

Weston Solutions. 2010. "Rain Barrel/Downspout Disconnect Best Management Practice Effectiveness Monitoring and Operations Program: Final Report." City of San Diego, Stormwater Department, Pollution Prevention Division. San Diego, CA. June.
This paper uses six watershed management areas within the City of San Diego to test the effectiveness of a rain barrel downspout disconnect (RBDD) best management practices. The paper assess the effectiveness of the RBDD system and determines the cost-effectiveness of implementing RBDD systems as a qualifying watershed water quality activity under San Diego's MS4 Permit.

Huber, M., D. Willis, J. Haynes, and C. Privette. 2010. "Incentive Policies to Promote the Use of Enhanced Stormwater BMPs in New Residential Developments." Southern Agricultural Economics Association Annual Meeting. Orlando, FL. February.

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[1] For more information on guidelines for conducting economic analysis, see: EPA. Guidelines for Preparing Economic Analysis. Washington, DC. 2010.

This paper presents the conceptual framework for the Stormwater Banking Program (SBP), which allows a developer to build at a greater density in exchange for paying a portion of their participation profits to the SBP and installing green infrastructure, as an alternative to traditional stormwater controls. The authors argue the SBP increases developers' profits; raises additional revenue that officials can use to retrofit outdated and/or poorly functioning BMPs in existing developments; and achieves stormwater runoff control well above the minimum regulatory requirement on new developments.

Environmental Protection Agency. 2009. "Managing Wet Weather with Green Infrastructure—Municipal Handbook: Incentive Mechanisms." EPA-833-F-09-001. June.
The paper comprehensively lists the types and places where municipalities around the United States are currently using incentive mechanisms. The paper organizes the types of these incentives in five categories, including: stormwater fee discount, development incentives, grants, rebates and installation financing, and awards and recognition programs.

Meder, I. and E. Kouma. 2009. "Low Impact Development for the Empowered Homeowner: Incentive Programs for Single Family Residencies." December.
This paper outlines the experience of the City of Lincoln, which implemented three incentive programs to improve stormwater quality with green infrastructure techniques. The paper notes these programs have created a citywide awareness of and interest in green infrastructure among homeowners.

Roy, A., S. Wenger, T. Fletcher, C. Walsh, A. Ladson, W. Shuster, H. Thurston, R. Brown. 2008. "Impediments and Solutions to Sustainable, Watershed-Scale Urban Stormwater Management: Lessons from Australia and the United States." Environmental Management 42: 344-359.
This paper compares the experiences of Australia and the United States to identify seven major impediments to sustainable urban stormwater management. The paper offers several examples of successful, regional green infrastructure techniques. The paper also identifies solutions to each of the listed impediments that should encourage implementation of green infrastructure techniques.

Struck, S. 2008. "Incentives for Adoption of Low Impact Development Approaches on a Larger Scale." ASCE Conference Proceedings. World Environmental and Water Resources Congress 2008: Ahupua's Proceedings of the World Environmental and Water Congress 2008.
This paper proposes developers use a watershed sustainability index based on holistic water management strategies that would provide a framework for evaluation and a transparent rating system for new and redevelopment projects. The watershed index, which an expert panel would develop, would define a set of standards and apply a numerical "credit" method to measure the degree to which a development meets these standards. The author also proposes that an independent, third-party verify the scoring process of a development's design and incorporation of these techniques.

Bitting, J. and C. Kloss. "Managing Wet Weather with Green Infrastructure—Municipal Handbook: Green Infrastructure Retrofit Policies."
This paper explores the policies and incentives that municipalities use to facilitate green infrastructure among homeowners and developers. The paper presents these policies by type of technology, but notes that approaches for one green infrastructure technique are applicable to another or there is overlap among goals and outcomes. The paper concludes with common

themes from successful green infrastructure retrofit policy and recommendations for policy makers looking to implement incentives through policy.

Dietz, M., J. Clausen, and K. Filchak. 2004. "Education and Changes in Residential Nonpoint Source Pollution." Environmental Management 34(5): 684-690.
This paper examines whether educating homeowners and implementing best management practices can improve stormwater quality in a suburban neighborhood. The paper uses a paired watershed design to test the effectiveness of these practices. The paper finds some changes in measured behavior and some improvements in measurable water quality parameters.

BARRIERS TO GREEN INFRASTRUCTURE

The annotated bibliography below reviews papers that discuss the common economic and social barriers to widespread implementation of green infrastructure techniques.

LaBadie, K. 2010. "Identifying Barriers to Low Impact Development and Green Infrastructure in the Albuquerque Area." The University of New Mexico. Albuquerque, NM. May.
Using a focus group of local professionals, this study identifies barriers to the widespread implementation of green infrastructure in the Albuquerque region. The study reveals these professionals display a preference for well-known, low cost techniques, but also that these professionals have a lack of knowledge about other techniques or an uncertainty over their effectiveness. Based on these discussions, the study makes six recommendations for overcoming barriers, particularly in the semi-arid conditions of New Mexico.

Stockwell, A. 2009. "Analysis of Barriers to Low Impact Development in the North Coast Redwood Region, California." Humboldt State University. December.
Using a literature review and interviews with stormwater professionals, this paper examines the barriers to green infrastructure on the North Coast. It finds these barriers include: institutionalized conventional practices, budget and staff constraints, and challenging local conditions.

Souto, L. 2009. "Overcoming Barriers to Changing the Landscape." Managing Wet Weather with Green Infrastructure Conference. Ft. Myers, FL. June.
In this presentation, Leesa Souto introduces a variety of social and attitudinal preference barriers to low impact development, including: appearance preferences, disconnection to landscape, perceived capability, and social norms. The author also discusses a variety of strategies to address these barriers.

Godwin, D., B. Parry, F. Burris, S. Chan, and A. Punton. 2008. "Barriers and Opportunities for Low Impact Development: Case Studies from Three Oregon Communities." Oregon State University, Sea Grant Extension Program. Corvallis, OR.
This paper, based on discussions from a workshop involving local decision-makers and residents in three Oregon communities, addresses the barriers to implementing green infrastructure practices, the need for education on green infrastructure, and the audiences to which policy makers should direct these efforts. The paper presents several findings and opportunities based on themes that emerged from these discussions.

OTHER

The annotated bibliography below presents some other useful and notable recent studies related to the economics of green infrastructure.

Morgan, T., K. Riley, R. Tannebring, and L. Veldhuis. 2011. "Evaluating the Impacts of Small-Scale Urban Greenspace: A Case Study of Harlem Place in Los Angeles." Donald Bren School of Environmental Science & Management, University of California, Santa Barbara. May.
This paper examines the net effects of small-scale interstitial greenspace in downtown Los Angeles, where greenspace is nearly non-existent. The authors use literature reviews, GIS data, and modeling to assess the economic, ecological, and social effects of integrating small-scale greenspace into downtown LA. This project is not final.

Vandermuelen, V., A. Verspecht, B. Vermeire, G. Van Huylenbroeck, and X. Gellynck. 2011. "The use of economic valuation to create public support for green infrastructure investments in urban areas." Landscape and Urban Planning. Article in Press.
This paper describes a model that municipal officials can use to describe the value of green infrastructure techniques in economic terms. The paper presents monetary valuation techniques, with an emphasis on site-specific considerations, including benefit-cost analysis and multiplier analysis. The paper concludes that using this model will help to justify policy support for and investment in green space.

U.S. Green Building Council and Berkebile, Nelson, Immenschuh, McDowell. 2011. "Multi-Variate Study of Stormwater BMPs: 2008 Green Building Research Fund Grants." Final Report. Kansas State University. March.
This paper presents the results of monitoring of several BMPs with the objective of improving these practices for effective onsite stormwater management. For each BMP, the paper documents water quality parameters, soil infiltration rates, soil sampling, facility sizing, performance baselines and measures, and costs.