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

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Prepared by

The Civic Federation

for

The Center for Neighborhood Technology

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THE CIVIC FEDERATION
177 N. State, Suite 400
Chicago, Illinois 60601
(312) 201-9066 (phone)
(312) 201-9041 (fax)
civicfed@civicfed.org (e-mail)

VISIT OUR WEB SITE AT
WWW.CIVICFED.ORG

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EXECUTIVE SUMMARY

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

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

Findings

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

OVERVIEW

The purpose of this report is to examine the resources that several U.S. cities are devoting to "green infrastructure" and analyze their early experiences with alternative stormwater management techniques. The cities of Seattle, Milwaukee, Philadelphia, and Chicago were selected because they have been leaders in the implementation of green infrastructure approaches to stormwater management. Their experiences are described here in order to provide information that can inform the Metropolitan Water Reclamation District of Greater Chicago as it exercises its new authority over stormwater management throughout Cook County, Illinois.

To achieve this goal, the report:

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

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

INTRODUCTION

Definition of Green Infrastructure

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

Green Infrastructure vs. Conventional Stormwater Management

Stormwater sewer systems are necessary in urban and suburban environments where substantial amounts of impervious surfaces (e.g., buildings, pavement) have replaced natural pervious surfaces (e.g., soil, wetlands) that once absorbed storm precipitation. It is estimated that a typical city block generates over five times the amount of surface runoff as a wooded area of the same

size.[1] The imperviousness of urban areas increases not only the amount of runoff, but also the velocity (flow rate) and pollution of that runoff.[2] Without stormwater management systems, even minimal precipitation would cause urban areas to flood routinely due to the lack of permeable surfaces, and polluted water would flow directly into area waterways. In order to contain the large volumes of water that fall during significant storms, conventional stormwater management systems often include massive underground tunnels and/or reservoirs. In Cook County, Illinois this system is called the Tunnel and Reservoir Plan (TARP) or "Deep Tunnel".

In many older urban communities, including approximately 40% of Cook County, the wastewater and stormwater sewer systems are combined in such a way that residential and commercial wastewater is mingled with the relatively clean water that falls as storm precipitation.[3] The combined water is sent through the sewer systems to treatment plants, which clean the water to meet environmental standards and then release it into natural and constructed waterways. When large storm events send more water into the combined sewer system than can be conveyed and treated, the system releases untreated water directly into area waterways in what is called a "combined sewer overflow" (CSO). If it were not released this way, the combined stormwater and wastewater would back up into area basements and streets. Stormwater systems such as TARP are designed to provide greater stormwater capacity and reduce the incidence of CSOs, which pollute local waterways.

In more recently developed communities, there are separate sewer systems for stormwater and wastewater. Stormwater sewers typically release directly into area waterways. Although stormwater is cleaner than wastewater, it can still carry high levels of pollutants washed off of roads, roofs, and parkways. Urban runoff pollution from these various sources is a form of "non-point source pollution" in contrast to pollution that is discharged from single sources such as sewage treatment plants or industrial facilities.[4] In addition to delivering pollutant loads, stormwater runoff also degrades waterways when there is a large volume or high flow rate of runoff. This causes erosion and abrupt changes that disrupt the stream ecology. Green infrastructure approaches are aimed at reducing stormwater runoff pollution, volume, and flow rate into area waterways.

While conventional stormwater management systems are said to address a symptom (stormwater runoff volume), green infrastructure focuses on the root problem—the imperviousness brought on by land development.[5] The goal of green infrastructure is to recreate natural hydrology and

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[1] United States Environmental Protection Agency, "Protecting Water Quality from Urban Runoff," 841-F-03-003, February 2003.

[2] James P. Heaney and Joong G Lee, "Methods for Optimizing Urban Wet-Weather Control System," United States Environmental Protection Agency, 600/R-06/034, July 2006, p. 2-4. Available at http://www.epa.gov/ednnrmrl/publications/reports/index.htm

[3] The MWRD covers 91% of the land area of Cook County (See MWRD *General Superintendent's Budget Recommendations: 2007 Budget*, October 23, 2006, p. ii). Forty-three percent of the MWRD's land area uses a combined sewer system (see http://www.mwrd.org/Engineering/OurCommunityFlooding/OCFBody0103.htm).

[4] For more on non-point source pollution see http://www.epa.gov/nps/ . Although stormwater begins as non-point source pollution as it flows over urban surfaces, it becomes point source pollution when it is collected and discharged from a pipe.

[5] Christopher Kloss and Crystal Calarusee, "Rooftops to Rivers: Green Strategies for Controlling Stormwater and Combined Sewer Overflows," Natural Resources Defense Council, June 2006. Available at http://www.nrdc.org/water/pollution/rooftops/contents.asp

ecological systems for managing stormwater. Green infrastructure keeps stormwater out of the sewer systems by intercepting it where it falls and either containing it for later use in gardens and grey water systems, or allowing it to infiltrate the earth and be absorbed by plants or returned to the aquifer.[6] Green infrastructure allows for both a reduction in the amount of water flowing into conventional stormwater systems (and thus a reduction in the need to build or expand these systems) and a reuse of stormwater at the source. The use of a 50-gallon rain barrel for landscape irrigation, for example, both reuses stormwater that fell on an impermeable roof and reduces the demand for water from the municipal water system.

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

Barriers to Green Infrastructure Implementation

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

Lack of Performance Data[7]

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

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

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

[7] Throughout this report, the term "performance data" refers to scientific monitoring of how well the system manages water (flow, volume, pollutant loads, etc.). It does not include cost considerations.

resources to green infrastructure research and regulation, the National Resources Defense Council and the National Association of Clean Water Agencies wrote:

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

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

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

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

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

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

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[8] Natural Resources Defense Council and National Association of Clean Water Agencies, letter to The Honorable Benjamin Grumbles, Assistant Administrator, U.S. Environmental Protection Agency, 16 March 2007. Available at www.nacwa.org/getfile.cfm?fn=2007-03-16Green.pdf

[9] U.S. Environmental Protection Agency, National Association of Clean Water Agencies, Natural Resources Defense Council, Low Impact Development Center, and the Association of State and Interstate Water Pollution Control Administrators, "Green Infrastructure Statement of Intent", April 19, 2007. http://www.epa.gov/npdes/pubs/gi_supportstatement.pdf

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

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

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

Cost

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

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[10] Heaney and Lee, "Methods for Optimizing Urban Wet-Weather Control System," and Wayne C. Huber, LaMarr Cannon and Matt Stouder, "BMP Modeling Concepts and Simulation," United States Environmental Protection Agency, 600/R-06/033, July 2006. Available at http://www.epa.gov/ednnrmrl/publications/reports/index.htm

[11] Huber, Cannon and Stouder, "BMP Modeling Concepts and Simulation," pp. 1-8 and 1-9.

[12] Peter T. Weiss, John S. Gulliver, and Andrew J. Erickson, "The Cost and Effectiveness of Stormwater Management Practices," Minnesota Department of Transportation, June 2005.

[13] University of New Hampshire Stormwater Center, *2005 Data Report.* www.unh.edu/erg/cstev

[14] Paul Piszkiewicz, MWRD Budget Officer, e-mail to the author, June 27, 2007. See also Metropolitan Water Reclamation District of Greater Chicago, *Comprehensive Annual Financial Report for the Year Ended December 31, 2006*, p. 16

[15] http://www.mwrdgc.dst.il.us/mo/csoapp/cso.htm

[16] Metropolitan Water Reclamation District of Greater Chicago, *2007 Budget: General Superintendent's Budget Recommendations October 23, 2006*, p. 377 and "Chicago's Deep Tunnel Nears Completion," Environment News Service, February 14, 2006. Available at http://www.ens-newswire.com/ens/feb2006/2006-02-14-04.asp

Green infrastructure advocates point to the potential for green infrastructure to reduce the need for expensive investments in such "hard infrastructure" solutions. Furthermore, many green infrastructure strategies have additional benefits beyond stormwater management, such as improving air quality, reducing urban "heat island" effects, and enhancing aesthetics. For example, American Forests, a non-profit conservation organization, calculated in 2000 that the tree canopy in the Houston, Texas area reduced the volume of stormwater runoff by 2.4 billion cubic feet.[17] Given the $0.66 per-cubic-foot cost of stormwater management in Harris County, the estimated value of the urban forest in terms of stormwater management was $1.33 billion in one-time construction costs. American Forests also calculated the tree canopy air pollution removal value at $209 million annually, and $26 million annually in energy savings due to shade.[18]

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

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

Decentralization

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

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

[17] American Forests, "Urban Ecosystem Analysis For the Houston Gulf Coast Region," December 2000, p. 5.
[18] Ibid., p. 2.

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

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

METROPOLITAN WATER RECLAMATION DISTRICT OF GREATER CHICAGO

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

Responsibilities and Finances

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

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

[19] Seattle Public Utilities, "SEA Street Virtual Tour," http://www2.cityofseattle.net/util/tours/seastreet/slide5.htm
[20] Metropolitan Water Reclamation District of Greater Chicago, *2007 Final Budget*, p. ii.

conveyance, urban drainage, and commercial and recreational navigation, and owns roughly 9,500 acres of land in Cook, DuPage and Will Counties. This land includes access and riparian buffers along the waterways, stormwater reservoirs, water reclamation plants and other facilities.[21]

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

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

Tunnel and Reservoir Plan

In order to mitigate flooding and waterway pollution from combined sewer overflows, the District developed the Tunnel and Reservoir Plan (TARP) in the 1970s. TARP serves the City of Chicago and 52 suburban municipalities,[27] and consists of two phases: Phase I of TARP is primarily for pollution control and Phase II is primarily for flood control, although both are necessary to control combined sewer overflows (CSO). The Upper Des Plaines TARP system, consisting of 6.6 miles of tunnel and one 400 million gallon reservoir became fully operational in 1998.[28] Phase I was completed in March 2006 and consists of 109 miles of "Deep Tunnels" ranging from 9 to 33 feet in diameter and 150 to 300 feet underground.[29] The tunnels are designed to hold 2.4 billion gallons of combined sewage and stormwater during wet weather events.[30] From the completion of the first 31 miles in 1985 through 2003, the District estimates

[21] Paul Piszkiewicz, MWRD Budget Officer, e-mail to the author, June 27, 2007.
[22] http://www.mwrd.org/Engineering/OurCommunityFlooding/OCFBody0103.htm
[23] Ibid.
[24] Metropolitan Water Reclamation District of Greater Chicago, *Stormwater Management for Cook County: A New Role for the Metropolitan Water Reclamation District of Greater Chicago*, (no date) http://www.mwrdgc.dst.il.us/Engineering/Stormwater/Stormwater%20Mgmt%20Brochure.PDF .
[25] Metropolitan Water Reclamation District of Greater Chicago, *Sewer Control Ordinance Manual of Procedures*, Article 6-1(d).
[26] Paul Piszkiewicz, MWRD Budget Officer, e-mail to the author, May 9, 2007.
[27] http://www.mwrd.org/Engineering/OurCommunityFlooding/OCFBody0103.htm
[28] Paul Piszkiewicz, MWRD Budget Officer, e-mail to the author, May 9, 2007.
[29] Metropolitan Water Reclamation District of Greater Chicago, *2007 Final Budget*, p. ii.
[30] Ibid., p. 1.

that 741 billion gallons of what would have been combined sewer overflows were instead captured and conveyed to treatment plants in Deep Tunnels.[31] The tunnels currently capture roughly 85% of CSOs.[32]

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

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

Stormwater Management

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

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

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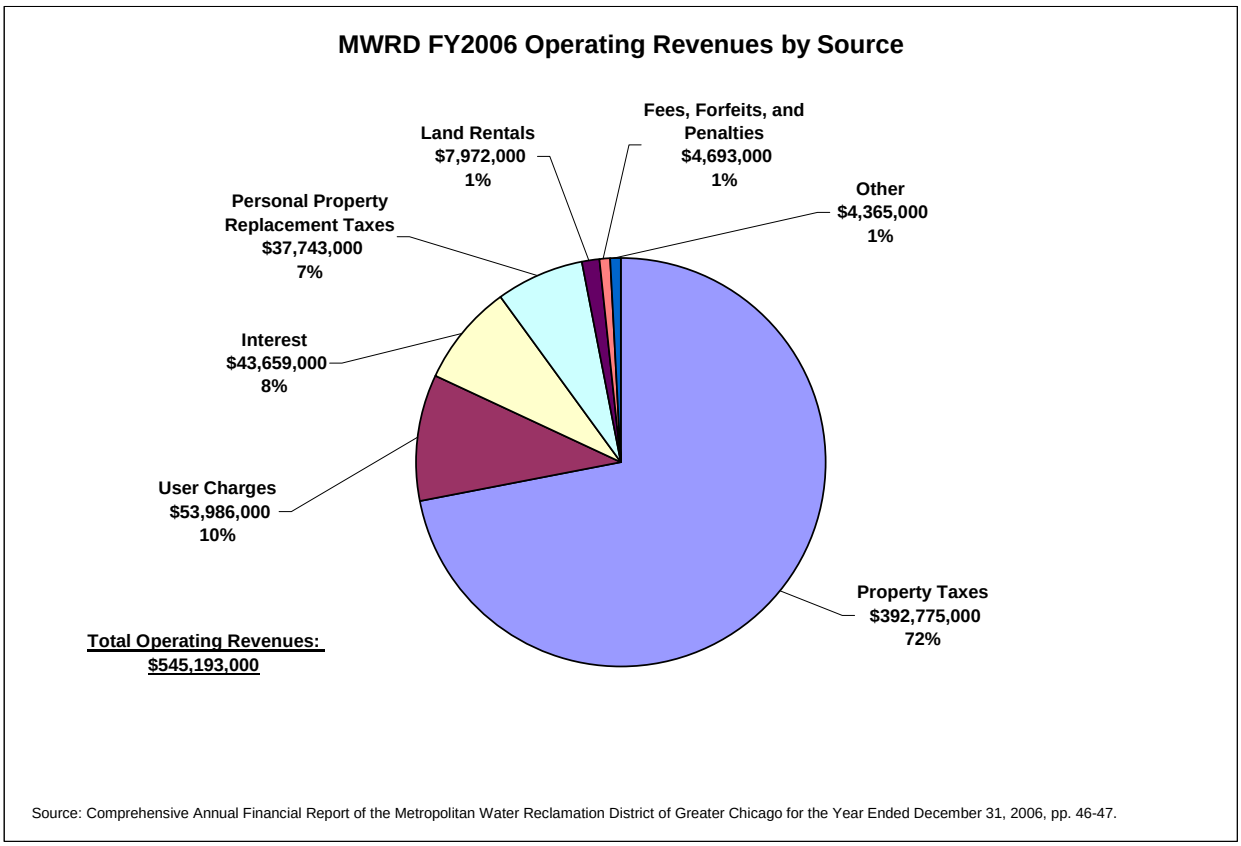
[31] http://www.mwrdgc.dst.il.us/mo/csoapp/cso.htm
[32] Metropolitan Water Reclamation District of Greater Chicago, *2007 Final Budget*, p. 1.
[33] Ibid., p. 2.
[34] "Chicago's Deep Tunnel Nears Completion," Environmental News Service, February 16, 2006. http://www.stormwaterauthority.org/library/view_article.aspx?id=425
[35] http://www.mwrdgc.dst.il.us/mo/csoapp/cso.htm
[36] Paul Piszkiewicz, MWRD Budget Officer, e-mail to the author, June 27, 2007. See also Metropolitan Water Reclamation District of Greater Chicago, *Comprehensive Annual Financial Report for the Year Ended December 31, 2006*, p. 16
[37] Ibid.
[38] http://www.mwrdgc.dst.il.us/engineering/stormwater/Final%20PDF%20Version%20021507/CCSMP.htm
[39] Metropolitan Water Reclamation District of Greater Chicago, *2007 Final Budget*, p. 5.
[40] Ibid., p. 381.

Budget

The MWRD has an FY2007 total operating and capital budget of $1.024 billion, of which $362.3 million is appropriated for the Corporate Fund and $24.4 million is appropriated for the Stormwater Management Fund.[41]

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



Source: Comprehensive Annual Financial Report of the Metropolitan Water Reclamation District of Greater Chicago for the Year Ended December 31, 2006, pp. 46-47.

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

[41] Ibid., p. 16.
[42] Ibid., p. 45.
[43] Metropolitan Water Reclamation District of Greater Chicago User Charge Ordinance, As Amended October 19, 2006. http://www.mwrdgc.dst.il.us/RD/ordinances/2007%20Ordinance%20101906.pdf. User charges do apply to property-tax exempt institutions; however, local government institutions used for governmental purposes and discharging only domestic wastes do not pay user charges.
[44] Ibid.

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

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

MWRD Stormwater Management Fund Projected Property Tax Levies and Appropriations: 2007-2011

	2007	2008	2009	2010	2011
Stormwater Property Tax Levy	**$ 3,942,000**	**$ 22,172,000**	**$ 18,795,000**	**$ 13,710,000**	**$ 13,851,000**
Total All Funds Property Tax Levy	$ 415,840,000	$ 448,124,000	$ 468,276,000	$ 478,841,000	$ 517,617,000
Stormwater Annual Appropriation	**$ 24,500,000**	**$ 32,042,000**	**$ 25,578,000**	**$ 19,053,000**	**$ 19,231,000**
Total All Funds Appropriation	$ 931,596,000	$ 1,255,142,000	$ 1,147,469,000	$ 1,318,031,000	$ 762,438,000

Source: Metropolitan Water Reclamation District of Greater Chicago, 2007 Final Budget, p. 63.

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

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

[45] Metropolitan Water Reclamation District of Greater Chicago, *Comprehensive Annual Financial Report for the Year Ended December 31, 2006*, p. 136.
[46] Metropolitan Water Reclamation District of Greater Chicago, *2007 Final Budget*, pp. 16, 60.
[47] Paul Piszkiewicz, MWRD Budget Officer, e-mail to the author, June 27, 2007.
[48] Metropolitan Water Reclamation District of Greater Chicago, *2007 Final Budget*, p. 382.
[49] Paul Piszkiewicz, MWRD Budget Officer, e-mail to the author, June 27, 2007.
[50] Metropolitan Water Reclamation District of Greater Chicago, *2007 Final Budget*, p. 15.

Green Infrastructure Initiatives

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

Native Prairie Landscaping

In 2003, the MWRD began a Native Prairie Landscaping program at two of its water reclamation facilities that replaced turf grass with native plants. The original impetus for the project was to reduce landscape maintenance costs for the District, but numerous environmental benefits became apparent immediately.[51] According to the MWRD web site, the goals of the project are to:

- show good land stewardship;
- reduce the long-term cost of grounds maintenance;
- be an example of a best management practice to infiltrate stormwater;
- increase biodiversity and wildlife habitat; and
- sequester carbon.[52]

In fall 2006, signs were posted at two native prairie landscaping sites explaining that the plantings are a "low-maintenance and ecological alternative to turf grass;" however, these signs do not mention stormwater management benefits of prairie plantings.[53]

The project has expanded over three years to replace 31 acres of District turf grass with native prairie vegetation. Ultimately, the District intends to install native prairie plantings at each of its seven treatment facilities as well as other District properties.[54] Annual monitoring reports by the Conservation Design Forum assess the status of the vegetation and make maintenance recommendations. This monitoring does not include stormwater infiltration data.[55]

From 2003-2009, the Native Prairie Landscaping projects are expected to cost $538,836 including consulting, installation, and maintenance.[56]

Rain Barrels

The District will spend $68,400 in 2007 to purchase 1,000 55-gallon rain barrels for distribution in suburban combined sewer areas.[57] The program will also include delivery, a service to assist residents with the installation of the rain barrels, and instruction on proper use and maintenance. These services are expected to cost an additional $80,000.[58] This program will complement the City of Chicago's rain barrel initiative. Although it is not expected to measurably reduce

[51] Paul Piszkiewicz, MWRD Budget Officer, in discussion with the author, May 8, 2007.
[52] See http://www.mwrdgc.dst.il.us/RD/native_prairie/default.htm
[53] http://www.mwrdgc.dst.il.us/RD/native_prairie/NPL%20Sign%20092706.jpg
[54] See http://www.mwrdgc.dst.il.us/RD/native_prairie/default.htm
[55] Ibid.
[56] Paul Piszkiewicz, MWRD Budget Officer, letter to the author, May 7, 2007.
[57] Paul Piszkiewicz, MWRD Budget Officer, e-mail to the author, June 27, 2007.
[58] Ibid.

stormwater impacts, the District will use the program as a vehicle through which to educate the public about rain water and pollution.[59]

Stormwater Management Plan

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

MWRD Stormwater Management Fund Green Infrastructure Expenditures					
Project	**Expenditure Type**	**Total Current and Future Years Budget Amount**	**Projected 2007 Expenditure**	**Projected 2007 Green Infrastructure Projects ($)**	**Projected Green Infrastructure as % of 2007 Expenditure**
Development of Cook County Watershed Management Ordinance	Consultant Fees	$ 2,455,000	$ 716,042	$ 194,075	27.1%
Detailed Watershed Plans for Cal-Sag Channel, Little Calumet River, and Upper Salt Creek	Consultant Fees	$ 5,300,000	$ 1,858,333	$ 92,917	5.0%
Stormwater Management Plans for all MWRD Treatment Plants	Consultant Fees	$ 240,000	$ 120,000	$ 120,000	100.0%
Stickney Treatment Plant Pervious Pavement Design	Consultant Fees	$ 20,000	$ 20,000	$ 20,000	100.0%
Stickney Treatment Plant Pervious Pavement Installation and Performance Analysis	Research Project	$ 277,709	$ 277,709	$ 277,709	100.0%
Buffalo Creek Wetland Design	Capital Project	$ 450,000	$ 150,000	$ 150,000	100.0%
Training	Operating	$ 7,393	$ 7,393	$ 7,393	100.0%
Staff Time	Operating	$ 940,760	$ 940,760	$ 47,038	5.0%
TOTAL		**$ 9,690,862**	**$ 4,090,237**	**$ 909,132**	**22.2%**

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

Other Projects

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

[59] Paul Piszkiewicz, MWRD Budget Officer, letter to the author, May 7, 2007.
[60] Paul Piszkiewicz, MWRD Budget Officer, e-mail to the author, June 27, 2007.

CITY OF CHICAGO

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

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

City of Chicago Stormwater Responsibilities

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

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

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

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

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[61] City of Chicago, "Combined Sewers," http://egov.cityofchicago.org/city/webportal/portalContentItemAction.do?BV_SessionID=@@@@0285138729.1177684603@@@@&BV_EngineID=cccdaddkkjellmkcefecelldffhdfgm.0&contentOID=536910787&contenTypeName=COC_EDITORIAL&topChannelName=HomePage

[62] Emma Graves Fitzsimmons, "As city cleans up, blaming begins," *Chicago Tribune*, June 28, 2007, p. 1.

[63] Peter Mulvaney, City of Chicago Department of Water Management, in conversation with the author, May 9, 2007, and Joyce Coffee, e-mail to the author, July 16, 2007.

> However, the City believes that the "built" infrastructure alone will not meet all of our needs for managing wastewater and stormwater. Managing stormwater and protecting the quality of our water resources will require a combination of upgrading our "built" infrastructure and creating a "green" infrastructure. Through this green infrastructure, the City will demonstrate forward-thinking ways to reduce the burden on our sewer system and keep stormwater in the environment.[64]

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

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

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

Department of Environment

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

[64] City of Chicago, "Combined Sewers".
[65] Joyce Coffee, City of Chicago Department of Environment, in conversation with the author, May 3, 2007.
[66] See http://egov.cityofchicago.org
[67] Joyce Coffee, City of Chicago Department of Environment, e-mail to the author, May 9 and July 16, 2007.
[68] Joyce Coffee, City of Chicago Department of Environment, e-mail to the author, July 13, 2007.
[69] City of Chicago *2007 Budget: Program and Budget Summary*, p. 201.

DOE had a FY2006 budget of $30.8 million with 87 full-time equivalent positions. The vast majority of the budget is grant-funded. Grant sources include federal grants, state grants, and environmental remediation grants from corporations.

Stormwater Reduction Practices Feasibility Study

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

New City of Chicago Stormwater Ordinance

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

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

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

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[70] Chicago Department of Environment, *Stormwater Reduction Practices Feasibility Study*, (conducted by CDM), June 11, 2004.
[71] Ibid.
[72] See the ordinance and regulations at http://egov.cityofchicago.org/city/webportal/portalContentItemAction.do?BV_SessionID=@@@@1157922782.1183052303@@@@&BV_EngineID=ccceaddlfkkljlfcefecelldffhdffn.0&contentOID=536951042&contenTypeName=COC_EDITORIAL&topChannelName=Dept&blockName=Environment%2FI+Want+To&context=dept&channelId=0&programId=0&entityName=Environment&deptMainCategoryOID=
[73] Joyce Coffee, City of Chicago Department of Environment, in conversation with the author, May 3, 2007, and e-mail to the author, July 16, 2007.

work."[74] Furthermore, some grant funding is shared with other departments. For example, the Calumet Stormwater grant of $454,040 was used primarily by the Chicago Department of Transportation.[75] Likewise, the Water Outreach Campaign project was a joint effort with the Department of Water Management. A combined $700,000 in costs for implementing stormwater best management practices at the Center for Green Technology, running the Household Hazardous Waste Collection Site, and Ford Centerpoint Industrial Campus could not be disaggregated and is not included in the table below.[76]

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

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

Department of Planning and Development

The City of Chicago Department of Planning and Development (DPD) promotes economic development in the City and regulates new and re-developments. DPD's mission includes encouraging "green" practices such as the Green Matrix program for creation of green roofs.[77] In 2007 the Department is launching the Green Roof Improvement Fund to assist owners of downtown buildings in converting their existing roofs to green roofs; funding for this program will come from the Central Loop Tax Increment Financing District.[78]

[74] Joyce Coffee, City of Chicago Department of Environment, e-mail to the author, July 20, 2007.
[75] Joyce Coffee, City of Chicago Department of Environment, e-mail to the author, May 8, 2007.
[76] Ibid.
[77] City of Chicago *2007 Budget: Program and Budget Summary*, p. 83.
[78] Ibid., p. 84.

DPD had a FY2006 budget of $49.1 million and a staff of 177 full-time equivalent positions.[79]

Green Roofs

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

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

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

City of Chicago Department of Planning and Development Estimated Expenditures for Green Roofs: 2007		
1.5 full-time-equivalent positions	$	150,000
Green Roof Test Plots	$	85,000
Green Roof Grant Program	$	200,000
Green Roof Improvement Fund	$	500,000
Green Roof Installations on Public Buildings	$	500,000
TOTAL	**$**	**1,435,000**

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

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

[79] Ibid., p. 85.

[80] http://egov.cityofchicago.org/city/webportal/portalContentItemAction.do?BV_SessionID=@@@@0352909816.1183046376@@@@&BV_EngineID=cccdaddlfklmgdhcefecelldffhdfhg.0&contentOID=536912719&contenTypeName=COC_EDITORIAL&topChannelName=Dept&blockName=Planning+And+Development%2FGreen+Buildings%2FGreen+Roofs%2FI+Want+To&context=dept&channelId=0&programId=0&entityName=Planning+And+Development&deptMainCategoryOID=-536884767

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

[82] Weston Design Consultants, "Urban Heat Island Initiative Pilot Project: City Hall Green Roof Final Report," (no date), p. 29.

the grant program, and 40 grants are expected in 2007.[83] In addition, many developments and redevelopments supported by Tax Increment Financing (TIF) in the city include green roofs. Mr. Berkshire estimates that there are at least 300 green roof projects currently underway in the city, covering over 3 million square feet of rooftops.[84]

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

Department of Water Management

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

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

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[83] Michael Berkshire, City of Chicago Department of Planning and Development Green Projects Administrator, in conversation with the author, May 8, 2007.
[84] Ibid.
[85] Ibid.
[86] City of Chicago *2007 Budget: Program and Budget Summary*, p. 265.
[87] http://egov.cityofchicago.org/city/webportal/portalContentItemAction.do?BV_SessionID=@@@@0300311482.1183048237@@@@&BV_EngineID=ccceaddlfklihmicefecelldffhdfgk.0&contentOID=536923258&contenTypeName=COC_EDITORIAL&topChannelName=Dept&blockName=Water%2FPermits%2C+Fees+%26+Standards%2FI+Want+To&context=dept&channelId=0&programId=0&entityName=Water&deptMainCategoryOID=-536892336.
[88] http://egov.cityofchicago.org/city/webportal/portalContentItemAction.do?BV_SessionID=@@@@0300311482.1183048237@@@@&BV_EngineID=ccceaddlfklihmicefecelldffhdfgk.0&contentOID=536922423&contenTypeName=COC_EDITORIAL&topChannelName=Dept&blockName=Water%2FSenior+Exemptions%2FI+Want+To&context=dept&channelId=0&programId=0&entityName=Water&deptMainCategoryOID=-536892350, and Joyce Coffee, e-mail to the author, July 16, 2007.
[89] Peter Mulvaney, City of Chicago Department of Water Management, in conversation with the author, May 9, 2007.

The City estimates that 50% of Mr. Mulvaney's time will be spent on green infrastructure issues in FY2007, and 100% of a Senior Engineer's time, for a value of $177,375 in staffing.[90] Joyce Coffee notes that at least six other engineers assist the Water Department's Senior Engineer in calculating stormwater flow rates for developments over 15,000 square feet.[91]

Department of Transportation

The Chicago Department of Transportation (CDOT) had a FY2006 budget of $260.6 million and 862 full-time equivalent positions.[92] CDOT's Streetscape and Sustainable Urban Design Program includes one project director, one assistant project director, and seven project managers working on various sustainable projects including green infrastructure. Some of the programs described below also include the participation of an additional six project managers and support staff.[93]

Green Alleys

Alleys present an excellent opportunity for green infrastructure because they are large tracts of impermeable surface with relatively low traffic volume. The City of Chicago has an estimated 1,900 miles of public alleys with 3,500 acres of paved impermeable surface.[94] CDOT operates an active Green Alley Program and has produced a handbook for the public explaining the benefits of green alleys and the specific techniques used to reduce surface runoff in alleys. The Green Alley Handbook exemplifies the City's holistic approach to "green" projects, in that it also includes information encouraging residents to implement recycling, composting, tree planting, native landscaping, rain gardens, rain barrels, permeable pavement, green roofs, energy efficient/dark sky lighting, natural stormwater detention, and bioswales. The Handbook, designed by Hitchcock Design Group, won a 2007 award for communications from the American Society of Landscape Architects.[95]

CDOT spent approximately $900,000 on six Green Alley pilot projects in 2006, and 15 additional projects are scheduled for 2007.[96] Throughout the pilot projects, CDOT has experimented with pavers, porous concrete, and porous asphalt to find the materials best suited to Chicago conditions.[97] A design toolbox has been developed for CDOT engineers to build green alleys meeting the following environmental goals: 80% stormwater infiltration, heat reduction, use of recycled materials, energy conservation, and streetlight glare reduction.[98]

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[90] Joyce Coffee, City of Chicago Department of Environment, e-mail to the author, May 8, 2007.
[91] Ibid.
[92] City of Chicago *2007 Budget: Program and Budget Summary*, pp. 233-248.
[93] David Leopold, City of Chicago Department of Transportation, e-mail to the author, July 13, 2007.
[94] Ibid.
[95] http://www.hitchcockdesigngroup.com/experience/urb/greenalleys.html
[96] David Leopold, City of Chicago Department of Transportation, e-mail to the author, July 13, 2007.
[97] Janet Attarian, City of Chicago Department of Transportation, presentation at the Center for Neighborhood Technology's "Stormwater Solutions that Hold Water" conference, Chicago IL, May 31, 2007.
[98] David Leopold, City of Chicago Department of Transportation, e-mail to the author, July 13, 2007.

Road Improvements and Sustainable Streetscapes

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

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

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

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

Department of Streets and Sanitation

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

[99] Ibid.
[100] Ibid.
[101] Ibid.

Transportation.[102] As noted earlier, the trees are not planted specifically as stormwater trees, but the tree canopy does have a stormwater runoff reduction function.

The Bureau of Forestry's FY2006 budget was $17.1 million with 241 full-time equivalent positions.[103]

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

Department of General Services

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

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

CITY OF PHILADELPHIA

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

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

Philadelphia Water Department: Responsibilities and Finances

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

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[102] Joe McCarthy, City of Chicago Bureau of Forestry, in conversation with the author, May 9 2007.
[103] City of Chicago *2007 Budget: Program and Budget Summary*, p. 231.
[104] Joe McCarthy, City of Chicago Bureau of Forestry, in conversation with the author, May 9 2007.
[105] City of Chicago *2007 Budget: Program and Budget Summary*, p. 51.
[106] Ibid., pp. 51-58.
[107] Al Mark, City of Chicago Department of General Services, in conversation with the author, May 7, 2007.
[108] Joe McCarthy, City of Chicago Bureau of Forestry, in conversation with the author, May 9 2007.
[109] Center for Watershed Protection, "Spotlight on Superior Stormwater Programs: Philadelphia, Pennsylvania," *Runoff Rundown* (e-newsletter), Spring 2007. http://www.cwp.org/runoff_rundown_spring2007.htm
[110] http://www.phila.gov/waterrev/about.html

The mission of the Water Department is threefold:

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

The Water Department treats over 300 million gallons of Delaware and Schuylkill river water daily at three treatment plants to produce potable water for the Philadelphia area. It also treats over 450 million gallons of sewage daily at three wastewater plants and recycles biosolids at a 73-acre facility. The Water Department maintains 3,300 miles of water mains, 3,000 miles of sewers, 75,000 storm sewer inlets, 27,500 fire hydrants, and related infrastructure.[112] Roughly half of the City has a combined sewer system, and there are 165 combined sewer outfalls on the Schuylkill and Delaware Rivers or their tributaries.[113] The Water Department had a staff of 2,239 full-time employees in 2006.[114]

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

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

In 2005, the Water Department determined that additional revenues of $282 million would be needed for the years 2005-2008.[119] A schedule of rate increases was set such that over four years, rates would increase an average of 8.73% a year, adding an average of $16.53 to the

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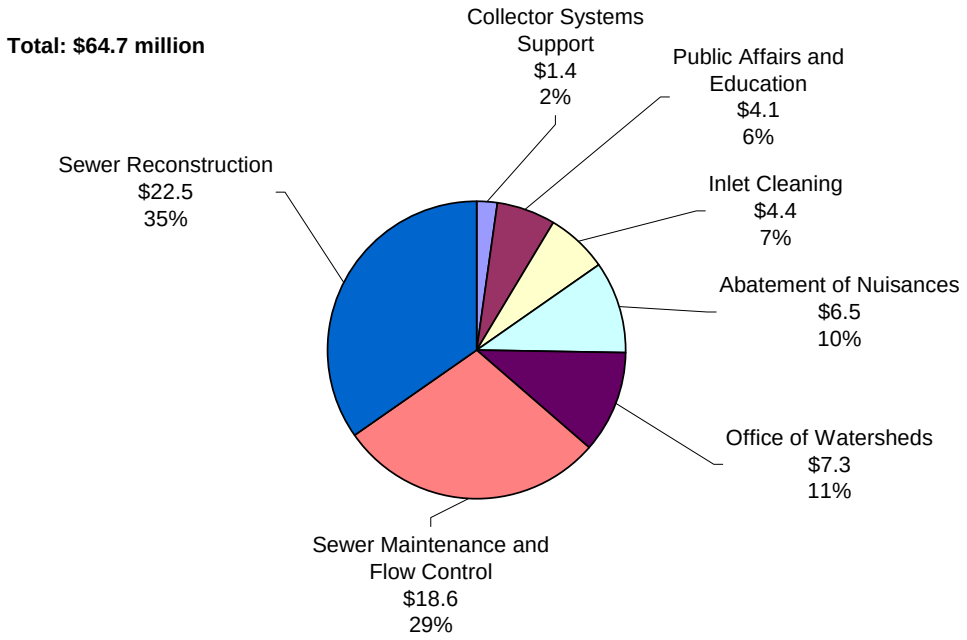
[111] City of Philadelphia Water Department, "About the Philadelphia Water Department," http://www.phila.gov/water/aboutpwd_mission.html.
[112] City of Philadelphia, *Five-Year Financial Plan: Fiscal Year 2005-Fiscal Year 2009*, July 7, 2004, p. 141.
[113] http://www.phila.gov/water/urban_water_cycle.html . See also Sierra Club, "Building Better II: A Guide to America's Best New Development Projects," November 2006, p. 20. http://www.sierraclub.org/buildingbetter/
[114] City of Philadelphia, *Comprehensive Annual Financial Report for the Fiscal Year Ended June 30, 2006*, p. 163.
[115] http://www.phila.gov/waterrev/about.html
[116] Ibid.
[117] Howard Neukrug, Director of Philadelphia Office of Watersheds, e-mail message to the author, June 9, 2007.
[118] Howard Neukrug, Director of Philadelphia Office of Watersheds, presentation at the Center for Neighborhood Technology's "Stormwater Solutions that Hold Water" conference, Chicago IL, May 31, 2007.
[119] Philadelphia Water Department, *2005 Financial Report*, p. 15.

monthly residential bill for water, sewer, and stormwater services. This reflected an increase from an average residential bill of $41.77 per month to $58.30 in 2008.[120] A 25% rate discount is available to seniors age 65 and older with a household income under $27,300. This discount is also available to non-profit hospitals, churches, charities, schools, and universities.[121]

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

Philadelphia Water Department Operating Budget for Key Stormwater Services: FY2007 ($ millions)



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

[120] Ibid., p. 15.
[121] http://www.phila.gov/water/water_sewer_bill.html
[122] City of Philadelphia, *Comprehensive Annual Financial Report for the Fiscal Year Ended June 30, 2006*, p. 19.
[123] Howard Neukrug, Director of Philadelphia Office of Watersheds, e-mail message to the author, July 13, 2007.
[124] Chris Crockett, Office of Watersheds Manager of Watershed Sciences & Engineering, e-mail to the author, May 7, 2007.
[125] Center for Watershed Protection, "Spotlight on Superior Stormwater Programs: Philadelphia, Pennsylvania," *Runoff Rundown* (e-newsletter), Spring 2007. http://www.cwp.org/runoff_rundown_spring2007.htm
[126] Howard Neukrug, Director of Philadelphia Office of Watersheds, e-mail message to the author, June 9, 2007.

In addition to the Water Department, several other city departments are involved in projects that contribute to the city's green infrastructure through tree planting, green roofs, porous pavement, and land conservation. These include the City Planning Department, Recreation Department, Fairmount Park, and the Neighborhood Transformation Initiative.[127]

Office of Watersheds' Integrated Green Infrastructure Approach

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

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

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

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

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[127] Ibid.
[128] http://www.stormwaterbmp.org/stormwaterbmp/
[129] Bill Tice, "Integrating Stormwater," *Stormwater* (January/February 2007). http://www.forester.net/sw_0701_integrating.html
[130] Joanne Dahme and James T. Smullen, "Innovative Strategy Helps Philadelphia Manage Combined Sewer Overflows," *Stormwater* (no date). http://www.forester.net/sw_0011_innovative.html

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

New Stormwater Management Regulations

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

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

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

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[131] Chris Crockett, Office of Watersheds Manager of Watershed Sciences & Engineering, e-mail to the author, May 7, 2007.
[132] Ibid.
[133] Ibid.
[134] Howard Neukrug, Director of Philadelphia Office of Watersheds, presentation at the Center for Neighborhood Technology's "Stormwater Solutions that Hold Water" conference, Chicago IL, May 31, 2007.
[135] Ibid.
[136] See the ordinance at http://webapps.phila.gov/council/attachments/3533.pdf.

Green Infrastructure Projects and Partnerships

The decentralized nature of green infrastructure makes it highly dependent on partnerships to create a shared sense of stewardship.[137] Each of the following green infrastructure programs has involved creative partnership.

Watershed Plans

The Office of Watersheds has partnered with other governments and community groups in the creation of comprehensive watershed plans for each of the seven Philadelphia-area watersheds. Three plans have been completed and four more are expected to be completed by 2009. It is estimated that each watershed plan will cost $5-$10 million for the first five years of implementation.[138]

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

> It requires land-use planning and coordination, the resources needed to model the pollution sources in a water body, mutually agreed upon goals for the water body, a cooperative regulatory climate, city and suburban dialogue and agreement, and a consensus on a solution and the sharing of costs.[139]

The watershed planning process begins with baseline conditions monitoring. Once the baseline conditions are determined, goals can be set for improved conditions. Progress toward the goals must be tracked, and communication of this progress is essential to maintaining public interest.[140]

Schuylkill Action Network

The Schuylkill Action Network is a consortium of government and non-profit groups that are developing a watershed-level restoration plan for the Schuylkill watershed. The Office of Watersheds participates in the Network and provides critical water quality data. The Network leveraged a $1.15 million U.S. EPA grant in FY2005 for a number of restoration projects including implementation of stormwater best management practices at local schools and universities with large volumes of runoff.[141]

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[137] Center for Watershed Protection, "Spotlight on Superior Stormwater Programs: Philadelphia, Pennsylvania," *Runoff Rundown* (e-newsletter), Spring 2007. http://www.cwp.org/runoff_rundown_spring2007.htm

[138] Ibid.

[139] Joanne Dahme and James T. Smullen, "Innovative Strategy Helps Philadelphia Manage Combined Sewer Overflows," *Stormwater* (no date). http://www.forester.net/sw_0011_innovative.html

[140] Center for Watershed Protection, "Spotlight on Superior Stormwater Programs: Philadelphia, Pennsylvania," *Runoff Rundown* (e-newsletter), Spring 2007. http://www.cwp.org/runoff_rundown_spring2007.htm

[141] Chris Crockett and Kathy Klein, "The Schuylkill River Watershed Initiative," (2004 EPA Targeted Watershed Grant Proposal), no date. http://www.epa.gov/twg/2004/2004proposals/04schuylkill.pdf . See also City of Philadelphia, "Mayor's Report on City Services, Fiscal Year 2005," p. 41. http://www.phila.gov/reports/pdfs/FY05MayorsReportHR.pdf

Best Management Practices Recognition Program

The Office of Watersheds participates in a best management practices recognition program to recognize exemplary green stormwater projects such as rain gardens, green roofs, permeable pavement, and bioswales. This program is intended to support stormwater awareness and education efforts, and inspire others to implement these best practices.[142]

Fairmount Park

The Water Department provides funding for the Fairmount Park Water Works Interpretive Center, which educates public about non-point source pollution, local waterways, and water quality. [143]

Other Partnerships

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

- Implementation of stormwater best management practices in the Mill Creek development by Philadelphia Public Housing
- Rain barrel distribution (roughly 500 annually) [144]
- TreeVitalize, a City tree planting program
- Campus Park initiative for public schools, including implementation of green infrastructure such as green roofs and porous pavement on basketball courts
- Golf Course certification program to encourage stormwater best management practices
- Green City partnership with the Philadelphia Horticultural Society, transforming vacant lots into green spaces with stormwater infiltration[145]

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

[142] http://www.stormwaterbmp.org/stormwater
[143] Center for Watershed Protection, "Spotlight on Superior Stormwater Programs: Philadelphia, Pennsylvania," *Runoff Rundown* (e-newsletter), Spring 2007. http://www.cwp.org/runoff_rundown_spring2007.htm
[144] Chris Crockett, Office of Watersheds Manager of Watershed Sciences & Engineering, e-mail to the author, May 7, 2007.
[145] Ibid.

CITY OF SEATTLE

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

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

Seattle Public Utilities Drainage and Wastewater Fund

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

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

- 530 miles of sanitary sewers
- 500 miles of storm drains
- 1,000 miles of combined sewers
- 768 pump stations
- 93 permitted CSO outfalls
- 277 storm drain outfalls
- 34 CSO control detention tanks/pipes[147]

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

[146] http://dnr.metrokc.gov/WTD/cso/page02graph.htm
[147] City of Seattle, Washington *2007-2012 Adopted Capital Improvement Program* (Ordinance 122298), p.559. http://www.seattle.gov/financedepartment/0712adoptedcip/2007-2012_ADOPTED_CIP_BOOK.pdf

the land. The "Very Heavy" category would include parking lots, which are often 100% impervious.[148]

Seattle Public Utilities Drainage Rates 2007	
	Annual Fee Per Parcel
Single Family and Duplex Residential	$ 142.00
All Other Properties (% impervious)	**Annual Fee Per Acre**
Open Space (0-2%)	$ 187.31
Undeveloped (0-15%)	$ 325.49
Light (16-35%)	$ 539.49
Medium (36-65%)	$ 978.87
Heavy (66-85%)	$ 1,275.27
Very Heavy (86-100%)	$ 1,584.92

Source:
http://www.seattle.gov/util/Services/Drainage_&_Sewer/Rates/DRAINAGER_200312020900545.asp

SPU also offers a 10% drainage fee discount to new or retrofitted commercial properties that harvest rainwater. A qualifying system must harvest or infiltrate the amount of stormwater that falls on the roof during a one-year, 24-hour storm event. Greywater systems that reuse the harvested water indoors must be permitted through the Seattle-King County Department of Public Health.[149]

The SPU Drainage and Wastewater Fund has a FY2007 budget of $250.0 million.[150] SPU uses an asset management approach to prioritize capital projects, and is beginning to apply the same approach to its operating budget in order to generate efficiencies.[151] This approach evaluates projects for their economic, social, environmental, and customer service benefits. These benefits are weighed against the costs, including ongoing maintenance expenditures, and projects that are not cost-effective are dropped.[152]

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

- 2007 appropriations for the Low-Impact Development budget control level are $4.0 million, with 7.81 full-time equivalent (FTE) personnel.[153]
- The 2007 Other Operating Control Level for the Science, Sustainability, and Watersheds program includes $100,000 and 1.0 FTE for a Senior Planning and Development Specialist

[148] http://www.seattle.gov/util/Services/Drainage_&_Sewer/Rates/DRAINAGER_200312020900545.asp
[149] Seattle Public Utilities, *2004 Comprehensive Drainage Plan*, p. 10-27. Available at http://www.seattle.gov/util/About_SPU/Drainage_&_Sewer_System/Plans/Comprehensive_Drainage_Plan/index.asp
[150] City of Seattle, Washington *2007 Adopted and 2008 Endorsed Budget* (Ordinance 122298), p. 448. http://www.seattle.gov/financedepartment/0708adoptedbudget/default.htm
[151] City of Seattle, Washington *2007 Adopted and 2008 Endorsed Budget* (Ordinance 122298), p. 445.
[152] City of Seattle, Washington *2007-2012 Adopted Capital Improvement Program* (Ordinance 122298), p. 560.
[153] City of Seattle, Washington *2007 Adopted and 2008 Endorsed Budget* (Ordinance 122298), p. 458.

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

- The Other Operating Control Level for Utility Systems Management includes $256,000 and 1.0 FTE for a Senior Civil Engineer to provide support on initiatives including revision of the stormwater code and the City Department of Planning and Development Green Building Team.[155]
- The Protection of Beneficial Uses Control Level is a capital improvement program dedicated to mitigating the harmful effects of stormwater runoff on area waterways by improving water and habitat quality.
- The Stormwater & Flood Control budget control level is charged with alleviating flooding, with a primary focus on public health, safety, and protection of property. Low Impact Development was previously part of this Control Level but was separated during a recent reorganization.
- The Wastewater Conveyance Budget Control Level is funded by wastewater revenues, not drainage fees, but includes some funding for the Lakewood Raincatcher Pilot program, a downspout disconnection initiative in a combined sewer area.[156]

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

Seattle Public Utilities Drainage and Wastewater Utility Selected 2007 Appropriations		
Budget Control Level	**Appropriation**	**Full-Time-Equivalent Positions**
Control Structures (CSOs)	$ 6,995,000	24.6
Low Impact Development *	$ 4,022,000	7.8
Other Operating Budget		
Engineering Services	$ 2,618,001	24.9
Field Operations	$ 13,060,834	94.2
Science, Sustainability & Watershed*	$ 4,088,854	28.9
Utility Systems Management*	$ 6,249,624	46.1
Protection of Beneficial Uses*	$ 4,717,000	14.5
Stormwater & Flood Control*	$ 3,947,530	21.5
Wastewater Conveyance*	$ 8,841,000	22.3
TOTAL Drainage & Wastewater Utility	**$ 250,016,923**	

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

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

[154] Ibid., p. 461.
[155] Ibid., p. 462.
[156] Ibid., p. 468.

Natural Drainage Systems Goals

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

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

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

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

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

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

[157] Seattle Public Utilities, "Natural Drainage Systems: Benefits and Challenges," http://www.seattle.gov/util/About_SPU/Drainage_&_Sewer_System/Natural_Drainage_Systems/Natural_Drainage_Overview/NaturalDrainageOverviewdocs/spu01_002612.asp .
[158] Ibid.

proactive retrofitting approach was necessary.[159] Seattle was the first major U.S. city to retrofit existing city streets with low impact development techniques.[160] Retrofitting poses an implementation challenge, however, due to its cost and the need to work with existing residents and property owners.

Early Pilot Programs

Seattle tested its NDS ideas through a number of demonstration projects. The programs began in 1998 with a series of City planning grants made in celebration of the millennium.[161] The first project, Viewlands Cascade, was completed in the fall of 2000. The second project, called Street Edge Alternatives (SEA Street), was completed in the spring of 2001. Both projects were extensively monitored by researchers from the University of Washington's Department of Civil and Environmental Engineering, who published their report in October 2004.[162] SPU's early NDS pilot programs have drawn national and international attention, and won a 2004 "Innovations in American Government Award" from Harvard University's Kennedy School of Government.[163]

Street Edge Alternatives

The Street Edge Alternatives project was designed to accomplish a variety of goals, foremost of which was to reduce runoff volume and flow rate into Pipers Creek. Pollution mitigation was also a concern, but the project scope specified that large amounts of fast moving water caused the most disruption to local stream ecosystems.[164] Residents of the pilot project neighborhood had also expressed a desire for streetscape improvements, including the addition of sidewalks, since their area did not have a traditional curb/gutter/sidewalk system in place.[165]

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

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[159] Ibid.
[160] James N. Levitt and Lydia K. Bergen, "Using Nature's Plumbing to Restore Aquatic Ecosystems: The City of Seattle's Natural Drainage System," *The Report on Conservation Innovation*. The Program on Conservation Innovation at the Harvard Forest, Harvard University, Fall 2004, p. 11. http://harvardforest.fas.harvard.edu/research/pci/RCI_Fall_2004.pdf.
[161] Levitt and Bergen, p. 8.
[162] Richard R. Horner, Heungkook Lim, and Stephen J. Burges, "Hydrologic Monitoring of the Seattle Ultra-Urban Stormwater Management Projects: Summary of the 2000-2003 Water Years," University of Washington Department of Civil and Environmental Engineering, Water Resources Series Technical Report No. 181, October 2004.
[163] Levitt and Bergen, pp. 9 and 11.
[164] "S.E.A. Streets: An Urban Creeks Legacy Millennium Project, Scope of Work," http://www.seattle.gov/util/stellent/groups/public/@spu/@esb/documents/webcontent/scope_200406180904038.pdf
[165] "S.E.A. Streets: An Urban Creeks Legacy Millennium Project, Scope of Work."

The original construction cost was bid at $244,000.[166] However, the project required extensive community input in order to reach consensus and satisfy neighborhood concerns. The final cost totaled $850,000 including design and communications costs for working with residents. Nonetheless, SPU indicates that future SEA Street projects will cost less than traditional street improvements.[167]

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

Viewlands Cascade

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

The Viewlands Cascade runs just south of the SEA Street project along one block of 105th street between 3rd and 4th Avenue NW. The catchment area is roughly 21 acres, and is in a moderately sloped residential neighborhood with approximately 29% impervious cover.[169] The construction cost of the Viewlands Cascade was $225,000.[170] The final cost is estimated at $525,000.[171]

The UW research team monitored Viewlands Cascade discharge and compared it to baseline data gathered in the six months before construction began. They estimated that the Viewlands Cascade reduced the peak flow of runoff by 60% on average and prevented half of the total stormwater volume from ever reaching Pipers Creek over a period of three years. However, during large storms events, very little flow or volume reduction occurs. As compared to the traditional ditch that preceded the Cascade, the NDS alternative reduced runoff volume by a factor of three and cut flow velocities by 20% during the wet seasons.[172]

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[166] Horner, Lim, and Burges, p. 2.
[167] Seattle Public Utilities, "Street Edge Alternatives Community Cost and Benefits," http://www.seattle.gov/util/About_SPU/Drainage_&_Sewer_System/Natural_Drainage_Systems/Street_Edge_Alternatives/COMMUNITY_200406180902084.asp
[168] Horner, Lim, and Burges, p. 30.
[169] Horner, Lim, and Burges, pp. 1-2. Per Tracey Tackett, SPU Low Impact Development Program Manager, this estimate is low. E-mail to the author, June 7, 2007.
[170] Horner, Lim, and Burges, p. 2.
[171] Jim Johnson, Seattle Public Utilities, personal communication, May 29, 2007.
[172] Horner, Lim, and Burges, p. 29.

The research team notes that the SEA Street strategy of retaining stormwater at its source is substantially more efficient on a per-unit basis than the "downstream" Cascade approach. SEA Street retained almost one-third as much runoff volume as Viewlands Cascade despite serving a catchment basin less than 10% as large. However, the SEA Street project was much less efficient in terms of cost per unit retained. The researchers observe that this would not necessarily be true of all "upstream" NDS approaches, but was true of these specific projects.[173]

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

2004 "Restore Our Waters" Strategy and SPU Comprehensive Drainage Plan

Following the documented success of the first two natural drainage system projects, Seattle Mayor Greg Nickels launched his "Restore Our Waters" (ROW) Strategy in September 2004.[175] The ROW Strategy is a framework for coordinating and concentrating the City's efforts to restore the health of area waterways. In addition to focusing City agencies' efforts, the Strategy also provides for educational initiatives, incentives for other stakeholders to take active stewardship roles, and ways to leverage City financial resources. The Strategy requires quantifiable goals and performance measurements for assessing the effectiveness of resource allocation.

The ROW Strategy adopts the scientific approach of Seattle Public Utilities in prioritizing critical actions that need to be taken. It was emphasized that the highest priority for creek restoration is to reduce the rate and volume of stormwater runoff into local creeks.[176] Part of the strategy includes updating the City's stormwater code to include options for green infrastructure alternatives to stormwater control. The code is currently undergoing an extensive public review and revision process, with implementation expected in early 2008.[177]

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

[173] Horner, Lim, and Burges, pp. 27-28.
[174] http://www.seattle.gov/util/About_SPU/Drainage_&_Sewer_System/index.asp
[175] See http://www.seattle.gov/mayor/issues/row.htm
[176] City of Seattle, "Restore Our Waters Strategy," September 14, 2004, p. 5. http://www.seattle.gov/mayor/issues/pdf/040913rowStrat.pdf
[177] Seattle Department of Planning and Development, "Stormwater, Grading, and Drainage Code Revisions," http://www.seattle.gov/dpd/Planning/Stormwater_Grading_and_Drainage_Code_Revisions/Background/default.asp
[178] Seattle Public Utilities, *2004 Comprehensive Drainage Plan.*

development of technical resources for public and private entities wishing to implement natural drainage systems.

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

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

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

2007-2012 Capital Improvement Plan

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

[179] Seattle Public Utilities Drainage and Wastewater Fund, *Financial Statements for the Years Ended December 31, 2005 and 2004*, p. 6. See also City of Seattle, Washington 2007-2012 Adopted Capital Improvement Program (Ordinance 122298), p. 624. http://www.seattle.gov/financedepartment/0712adoptedcip/2007-2012_ADOPTED_CIP_BOOK.pdf

A number of the projects listed below are NDS projects, including the Broadview Green Grid, High Point Drainage System, Pinehurst Natural Drainage System, and Venema Creek natural Drainage System. The CIP includes operating and maintenance costs for these projects. For the Broadview, Pinehurst, and Venema projects, projected annual operating costs are $5,000-$7,000 upon completion.[180] Maintaining these projects in top condition for both performance and aesthetic value could require 3-4 times this amount in annual operating support, however, depending on resident participation.[181] Operating costs for the massive High Point development are projected at $65,000 per year following completion. Additional drainage projects such as Bitter Lake/ N 137th Stormwater and Lower Densmore Drainage Improvement may include NDS elements if cost-benefit analysis recommends them.

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

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

Project	Timeframe	Expenses through 2005	2006	2007	Total All Years through 2012	Operating Costs
SEA 3rd Ave. NW & NW 107th (Broadview Green Grid)	2000-2007	$ 5,028,000	$ 69,000	$ 94,000	$ 5,191,000	$ 35,000
Best Management Practices Projects	2000-2012	$ 605,000	$ 375,000	$ 595,000	$ 13,437,000	$ -
Bitter Lake/ N 137th Stormwater	2001-2012	$ 14,000	$ -	$ 26,000	$ 1,872,000	$ 10,000
Capital Planning--Low Impact Development	2007-2012	$ -	$ -	$ 321,000	$ 719,000	$ -
Capitol Hill Water Quality Project	2006-2012	$ -	$ -	$ 1,653,000	$ 4,776,000	$ 8,000
Citywide Source Control	2006-2007	$ -	$ 100,000	$ 103,000	$ 203,000	$ -
Creek Flow Control Implementation	2010-2012	$ -	$ -	$ -	$ 6,866,000	$ 45,000
Creeks Vegetation Program	2005-2012	$ 129,000	$ 150,000	$ 185,000	$ 1,131,000	$ -
Demand Management	2007-2012	$ -	$ -	$ 600,000	$ 3,433,000	$ -
Drainage and Wastewater Partnership Program	2007-2012	$ -	$ -	$ 350,000	$ 7,250,000	$ -
High Point Drainage System	2002-2011	$ 2,431,000	$ 1,100,000	$ 1,376,000	$ 5,344,000	$ 294,000
Lakewood Raincatcher Pilot Project	2005-2012	$ 78,000	$ 628,000	$ 851,000	$ 1,825,000	$ -
Lower Densmore Drainage Improvement	2005-2008	$ 152,000	$ 225,000	$ 6,000	$ 388,000	$ -
Natural Drainage System Improvements	2003-2012	$ 82,000	$ 396,000	$ 169,000	$ 3,500,000	$ -
Nbhd.Drainage/Climate Bonus Matching Grant Project	2007-2012	$ -	$ -	$ 150,000	$ 900,000	$ -
Pinehurst Natural Drainage System	2002-2008	$ 3,356,000	$ 1,287,000	$ 30,000	$ 4,687,000	$ 27,000
Raincatcher Creek Pilot Project	2007-2008	$ -	$ -	$ 235,000	$ 447,000	$ -
South Lake Union	2004-2009	$ 131,000	$ 1,130,000	$ 137,000	$ 1,547,000	$ -
Stormwater Mitigation Partnership Program	2005-2010	$ 1,000	$ 50,000	$ 50,000	$ 218,000	$ -
Venema Creek Natural Drainage System	2003-2012	$ 486,000	$ 405,000	$ 309,000	$ 2,619,000	$ 15,000
Water Reuse - Stormwater	2001-2008	$ 50,000	$ 50,000	$ 29,000	$ 153,000	$ -
Water Reuse - Wastewater	2001-2008	$ 392,000	$ 14,000	$ 97,000	$ 540,000	$ -
Watershed Base Creek Flow Control	2005-2011	$ 35,000	$ 150,000	$ 71,000	$ 1,166,000	$ -
TOTAL		**$ 12,970,000**	**$ 6,129,000**	**$ 7,437,000**	**$ 68,212,000**	**$ 434,000**
Drainage and Wastewater Fund Total		$ 85,848,000	$ 43,665,000	$ 52,012,000	$ 519,318,000	
Green Infrastructure as % of Total		**15.1%**	**14.0%**	**14.3%**	**13.1%**	

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

[180] City of Seattle, Washington 2007-2012 Adopted Capital Improvement Program (Ordinance 122298), p. 624. http://www.seattle.gov/financedepartment/0712adoptedcip/2007-2012_ADOPTED_CIP_BOOK.pdf .
[181] Jim Johnson, Seattle Public Utilities, personal communication, May 29, 2007.

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

MILWAUKEE METROPOLITAN SEWERAGE DISTRICT

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

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

Responsibilities and Finances

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

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

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

[182] Milwaukee Metropolitan Sewerage District *2007 Annual Budget*, p. 5.
[183] See http://www.mmsd.com/wastewatertreatment/overflow_reduction_plan.cfm and http://www.mmsd.com/wastewatertreatment/index.cfm#main_body .
[184] Milwaukee Metropolitan Sewerage District *2007 Annual Budget*, p. 6.

$285.7 million, for a combined budget of $353.3 million.[185] There are 249 full-time equivalent positions.[186]

MMSD uses a three-year strategic planning cycle to establish goals and implementation plans. The 2007-2009 Strategic Plan and Goals detailed in the FY2007 budget document clearly indicate the District's leadership role in green stormwater management initiatives for the Milwaukee region:

Milwaukee Metropolitan Sewerage District Goals and Strategies: 2007	
Goals	**Strategies**
1. Continue to provide District services to improve water quality, protect the environment, public health, and property	• Minimize point source pollution • Promote the reduction of non-point source pollution • Minimize impacts of flooding • The District will collaborate to define its future role in an integrated water resource management plan
2. Maintain the District's contribution to a competitive regional economy, consistent with its role in environmental protection	• Maximize the efficient use of District resources while striving to minimize cost of services to keep user charge billings and tax levy increases at a minimum • Maximize the stability of user charge billings and the tax levy • Maximize utilization of local resources
3. Continue to provide regional leadership in educating the public to understand the various causes and impacts of water pollution	• Maximize public participation and access to District planning efforts and operations • Develop and further deliver educational programs to communities and environmental groups, focusing on water conservation and reduction of non-point source pollution[187]

The budget for each department is organized to demonstrate how it is meeting objectives related to these District-wide goals. The Office of Executive Director is the locus for the majority of MMSD's green infrastructure initiatives, reflecting the strong leadership and environmental ethos demonstrated by the current Executive Director, Kevin Shafer. The Office's budget and objectives clearly indicate the importance of these initiatives, with 22.8% of the Office's 2007 operating budget and 44.5% of the capital budget dedicated to green infrastructure-related purposes as shown in the table below. The Office of the Executive Director staff includes a Project Manager for the Greenseams program and a Planner for the 2020 Facility Plan Stakeholder Involvement project and stormwater best management practices.[188]

[185] Ibid., pp. 6 and 19.
[186] Ibid., p. 37.
[187] Ibid.,. 8-9.
[188] Ibid., p. 54.

Milwaukee Metropolitan Sewerage District Office of the Executive Director Budget: 2007			
Selected Goals	**Objectives**	**Operating $**	**Capital $**
Continue to provide District services to improve water quality, protect the environment, public health, and property.			
	Minimize non-point source pollution through District programs such as the Household Hazardous Waste Collection Program, and the implementation of the Environmental Managagement System. Implement stormwater best management projects that demonstrate methods to minimize stormwater runoff.	$ 1,264,515	$ 100,000
	Continue Greenseams Program to increase conservation acres to help reduce risk of flood related property damage.	$ 35,451	$ 3,012,247
	Encourage stakeholder participation in the District's efforts to improve water quality through the development of the 2020 Facility Plan.	$ 35,451	$ 667,241
Continue to provide regional leadership in education the public to understand the various causes and impacts of water pollution.			
	Define and deliver outreach programs for the education of students, citizen groups, and policy makers that present a consistent message on sources of pollution.	$ 88,628	$ -
	SUBTOTAL green initiatives	**$ 1,424,045**	**$ 3,779,488**
	TOTAL Office of Executive Director	$ 6,250,203	$ 8,495,269
	% green initiatives	**22.8%**	**44.5%**

Source: Milwaukee Metropolitan Sewerage District 2007 Annual Budget, p. 52.

The Environmental Management System included in the table above is part of the District's Environmental Sustainability policy for its own facilities. The policy requires all new and reconstructed MMSD facilities to be designed according to green infrastructure best practices.[189] Outreach programs referenced in the table include the District's rain barrel program, which has sold 5,000 rain barrels to date, and is used as an educational tool to inform the public about the importance of stormwater runoff reduction.[190]

Greenseams is a land acquisition and conservation program for non-structural flood and stormwater management that began in 2002. MMSD purchases or obtains conservation easements on land along riparian corridors and floodplains to prevent their development. Between 2002 and 2006, 39 properties totaling 1,274 acres were acquired. MMSD has leveraged additional revenues from the Wisconsin Department of Natural Resources for purchase of these lands.[191] The Conservation Fund manages the Greenseams program on behalf of MMSD.[192]

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

[189] Kevin Shafer, Executive Director, Milwaukee Metropolitan Sewerage District, presentation at the Center for Neighborhood Technology's "Stormwater Solutions that Hold Water" conference, Chicago IL, May 31 2007.
[190] See http://www.mmsd.com/rainbarrel/index.cfm
[191] Milwaukee Metropolitan Sewerage District *2007 Annual Budget*, p. 57.
[192] Ibid., p. 232.

MMSD 2007 Capital Budget Green Initiatives			
Project #	**Name**	**2007**	**Total all Years**
M03011	Rain Water Rerouting	$ 200,250	$ 5,034,317
M03015	2020 Facilities Plan--Stormwater BMPs	$ 110,188	$ 8,727,553
M03024	2020 Facilities Plan--Wet Weather Peak Flow Reduction	$ 3,146,336	$ 4,400,453
M03029	2020 Facilities Plan Implementation Evaluation & Planning--Water Quality Studies	$ 875,487	$ 1,774,954
M03030	Stormwater BMPs	$ 100,000	$ 100,000
W97002	Greenseams	$ 3,012,247	$ 27,709,372
	SUBTOTAL green initiatives	**$ 7,444,508**	**$ 47,746,649**
	TOTAL CAPITAL BUDGET	$ 285,713,000	$ 1,752,821,109
	green initiatives % of total	**2.6%**	**2.7%**

Source: Milwaukee Metropolitan Sewerage District 2007 Annual Budget, pp. 115-303.

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

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

Strategic Plan for Stormwater Runoff Reduction

In 2003 MMSD established its Strategic Plan for Stormwater Runoff Reduction, which was created to provide data and guidelines for alternative methods to reduce stormwater runoff volume and pollution levels. The Runoff Reduction Plan would also provide information on capital and operating costs, implementation and maintenance requirements, and effectiveness of green stormwater alternatives to inform the District's 2020 Facilities Plan. The 2020 Facilities Plan is a capital plan that was presented to the MMSD Board of Commissioners in June 2007 and takes a watershed approach to water resource planning for the District. It includes a recommended list of capital projects to be undertaken through the year 2020.[196]

[193] Ibid., p. 240.
[194] Ibid., p. 249.
[195] Ibid., p. 252.
[196] Milwaukee Metropolitan Sewerage District *2007 Annual Budget*, p. 118.

MMSD's investigation of alternative approaches to stormwater management was driven by its goals of eliminating sanitary sewer overflows, reducing combined sewer overflows, improving water quality, and exercising sound fiscal management.[197] According to a 2003 memorandum evaluating stormwater reduction practices, MMSD expected to reap the following benefits from this integrated approach:

- System Benefits:
    - Reduced CSOs/SSOs
    - Reduced conveyance, storage, and treatment costs
    - Increased storage available for sanitary flow during wet weather
    - Reduced peak flows and runoff volumes
    - Delayed runoff
- Environmental Benefits:
    - Improved water quality
    - Reduced erosion, scouring, and drainage problems
    - Improved green space and habitat
- Public Benefits:
    - Enhanced public education and involvement
    - Improved environmental stewardship[198]

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

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

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

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

[197] Milwaukee Metropolitan Sewerage District, *Memorandum: Evaluation of Stormwater Reduction Practices*, March 1, 2003, p. 3.
[198] Ibid.
[199] Milwaukee Metropolitan Sewerage District *2005 Annual Budget*, p. 263.
[200] Milwaukee Metropolitan Sewerage District, *Memorandum: Evaluation of Stormwater Reduction Practices*.

- Downspout disconnection
- Rain gardens
- Green parking lots
- Pocket wetlands
- Inlet restrictors/pavement storage
- Stormwater rules and redevelopment policies
- Rain barrels
- Green roofs
- Stormwater trees
- Bioretention
- French drains and dry wells
- Onsite filtering practices
- Cisterns
- Rooftop storage
- Porous pavement
- Infiltration sumps
- Compost amendments

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

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

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

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

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

[201] Ibid., p. 47.
[202] The tables in the Appendix are reproduced from the Milwaukee Metropolitan Sewerage District, *Stormwater Runoff Reduction Program: Final Report*, February 28, 2007, pp. 5-7.

Computer Modeling

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

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

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

Computer-Simulated CSO Volume Reductions (Assumes 100% Implementation of BMPs)

	CSO Volume (millions of gallons a year)	Percent Reduction from Baseline
Residential		
Baseline	0.28	--
Downspout disconnection	0.25	12%
Rain barrel	0.24	14%
Rain garden	0.18	36%
Rain garden & rain barrel	0.17	38%
Commercial		
Baseline	1.17	--
Green roof	0.91	22%
Bioretention	0.35	70%
Green parking lot	0.28	76%

Source: Metropolitan Sewerage District, Stormwater Runoff Reduction Program: Final Report, February 28, 2007, p. 8

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

[203] Milwaukee Metropolitan Sewerage District, *Stormwater Runoff Reduction Program: Final Report*, February 28, 2007, p. 8.
[204] Ibid., p. 9.

Pilot Projects

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

Milwaukee Metropolitan Sewerage District Pilot Project Partnerships: 2003-2006					
Project #	**Project Name**	**Partner(s)**	**MMSD Cost**	**Partner Cost**	**Deliverables**
2003 BMP Partnerships					
M03015C10	Auto Recyclers Rain Gardens (12)	Automotive Recyclers Cooperation Compliance Program	$ 45,375	$ 24,500	Installed rain gardens. Infiltration monitoring data. Education materials.
M03015C03	Great Lakes Water Institute Green Roof	Great Lakes Water Institute	$ 110,000	$ 132,895	Installed green roof. Monitoring data. Educational program.
M03015C04	Johnson's Park Low Impact Development	African American World Cultural Center	$ 44,610	$ 54,660	Design brochure. Stormwater mgmt. plan that incorporates LID.
M03015C05	Menomonee Valley Stormwater Park	City of Milwaukee, Sixteenth Street Community Health Center, Menomonee Valley Partners, University of Wisconsin - Milwaukee	$ 60,061	$ 225,011	Stormwater park design.
M03015C06	Trinity Creek Constructed Wetlands Educational Signage	City of Mequon	$ 27,462	$ 24,670	Draft designs. Affordable signage.
M03015C07	Highland Gardens Public Housing Rain Barrel Installation	Milwaukee Community Service Corps	$ 31,500	$ 3,500	Rain barrels available to public. Educational brochures.
M03015C08	Urban Ecology Center Green Roof	Urban Ecology Center	$ 40,000	$ 134,300	Constructed green roof. Educational elements. Construction photos.
M03015C09	Pervious Parking Lot and Rain Garden (reatil development)	Zabest Commercial Group	$ 79,900	$ 29,400	Constructed pavement and rain garden. Flow monitoring. Educational PowerPoint.
2004 BMP Partnerships					
M03015E10	Menomonee Valley Bioretention Facility	City of Milwaukee	$ 682,500	$ 682,500	Bioretention facility. Tour, PowerPoint, brochure, signage.
M03015E06	Miller Brewing Co. Rain Garden and Bioretention Swale	Miller Brewing Co.	$ 131,080	$ 136,430	Education with signage and brewery tour.
M03015E07	Walnut Way Stormwater Management Initiative	Walnut Way Conservation Corp., City of Milwaukee, Milwaukee Public Schools, USEPA, United Water	$ 44,000	$ 17,972	School education. Cisterns, bioretention, designs. Design workshop. Brochure.
M03015E08	Milwaukee County Zoo Green Roof	Zoological Society of Milwaukee	$ 31,500	$ 31,500	Webcam, flow and temperature monitoring, educational kiosk.
M03015E09	Vineyard Terrace Residential Neighborhood Low Impact Development Designs	City of Milwaukee	$ 24,700	$ 98,800	Design. Educational brochures. Evidence of public education program. Monitoring, construction, and site plans. Status reports.
2005 BMP Partnerships					
M03015E21	Milwaukee School of Engineering Pervious Parking Project	Milwaukee School of Engineering, TEI Corporation	$ 331,800	$ 331,800	Magazine articles, project signage, student education.
M03015E23	University of Wisconsin - Milwaukee Green Parking Lot Design	University of Wisconsin - Milwaukee	$ 140,317	$ 140,317	Educational signage. Kinetic/functional sculpture installation in School of Architecture.
M03015E24	Mequon Nature Preserve PieperPower Education Center	Mequon Nature Preserve	$ 26,000	$ 26,222	Construction of bioretention/cistern system. Educational materials and performance observations.
M03015E25	Residential Action in Neighborhood	City of Milwaukee	$ 31,750	$ 46,250	Report on monitoring, participation, costs, and questionnaires.
M03015E26	Josey Heights Green Pavement - Phase I	City of Milwaukee, Walnut Way Conservation Corp., Coach House Development	$ 95,000	$ 95,000	Brochures and information for homeowners to education them on the values of methods and maintenance measures.
2006 BMP Partnerships					
M03015P01	Porous Pavement	General Mitchell Airport	$ 7,500	$ 7,500	Signage. Educational brochure.
M03015P02	Stormwater Park (paved playground conversion)	Brown Street Academy	$ 27,300	$ 36,780	Signange. Educational brochures, report.
M03015P03	Porous Pavement	Urban Ecology Center	$ 30,000	$ 103,716	Signage, brochures on values of methods and maintenance measures.
M03015P04	Green Roof--Department of Public Works	City of Milwaukee	$ 35,200	$ 277,800	Signage, brochures on values of methods and maintenance measures.
		TOTAL COST	**$ 2,077,555**	**$ 2,661,523**	

Source: MMSD, Application of Stormwater Runoff Reduction Best Management Practices in Metropolitan Milwaukee, February 28, 2007

The 2007 report describes successes and failures among these pilot projects. For example, some Auto Recycler rain gardens flourished but others were stunted due to inadequate water supply and small plantings. The Residential Action in Neighborhood (RAIN) had substantial success in motivating homeowners to disconnect downspouts and install rain gardens once initial concerns about aesthetics and possible overflow were addressed through a comprehensive education campaign. Challenges posed by maintenance and continuity issues were also described in the report. For example, the rain garden installed for the Zabest Group project died because the planned commercial tenant never occupied the site, thus the garden was not maintained. The Starbucks franchise that subsequently purchased the site removed the remains of the rain garden and planted conventional vegetation. The Milwaukee School of Engineering also experienced several problems with its porous pavement applications before finding a suitable solution.[205]

MMSD took the lead on a number of larger pilot projects in addition to the partnerships described above. The Shorewood Wet Weather Flow Volume and Peak Management Project was a joint project of MMSD and the Village of Shorewood aimed at alleviating basement flooding. The Shorewood project combines traditional stormwater management with green infrastructure alternatives in order to reduce flooding and CSO volumes. A public education campaign for downspout disconnection resulted in disconnection of 35% of all connected downspouts, or 126 roofs.[206] This represented an 8% reduction in imperviousness, or 5.64 impervious acres removed from the combined sewer system, with a volume reduction of 20,500 cubic feet of runoff per 1 inch of rain.[207] Fifty rain gardens and eighty rain barrels were also installed. Eighteen catch basins were disconnected from the combined sewer system and rerouted to separate storm sewers in coordination with the Village's street reconstruction program.

The Milwaukee Downtown Downspout Disconnection Project evaluated 137 public and institutional buildings in downtown Milwaukee for downspout disconnection feasibility. Many buildings could not be disconnected due to internal downspouts or inadequate pervious area for infiltration. The study concluded that 16 buildings were appropriate for downspout disconnection and several others could be partially disconnected.[208]

In 2005 the District awarded roughly $200,000 in grants for four projects that conducted tests to evaluate green stormwater practices for their risk of creating seepage into sanitary sewer lines. They found, for example, that rain gardens should be placed laterally at least 2 feet away from sewer lines to prevent seepage, and that the City's liner requirements for wet and dry detention basins had been sufficient to prevent infiltration around the systems.[209]

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

[205] Ibid., pp. 10-39.
[206] Ibid., pp. 10-39.
[207] Ibid., p. 46.
[208] Ibid., p. 46.
[209] Ibid., pp. 50-51.

effectiveness of the green stormwater alternatives.[210] Considerable performance differences are to be expected in different seasons and locations, and the effects of different materials and maintenance practices merit careful testing.

Local Ordinance Audit

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

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

Public Education

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

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

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

[210] Ibid., pp. 70 and 73.
[211] Ibid., pp. 61-68.
[212] Ibid., p. 69.
[213] Kevin Shafer, Executive Director, Milwaukee Metropolitan Sewerage District, presentation at the Center for Neighborhood Technology's "Stormwater Solutions that Hold Water" conference, Chicago IL, May 31 2007.

runoff reduction strategy. Public feedback also informs MMSD on the incentives required to generate widespread implementation of best practices.[214]

However, the Final Report of the Stormwater Runoff Reduction Program warned that public education is necessary but not sufficient to ensure the broad implementation that is required in order for green infrastructure to make a measurable contribution to stormwater runoff reduction. Regulations, incentives, and community-led grassroots implementation programs are critical to successful implementation.[215]

The MMSD web site is an important educational tool and provides extensive information on the District's various green infrastructure initiatives. In additional to explaining the traditional sewer systems and deep tunnel structures, it describes the problems caused by stormwater runoff from impervious surfaces. Detailed information about downspout disconnection, rain barrels, and rain gardens is provided in a manner that encourages their implementation.[216]

SUMMARY

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

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

The five stormwater agencies examined in this report have confronted these barriers to varying degrees and in different ways. Several of the agencies embarked on green infrastructure pilot projects despite a paucity of performance data. Seattle Public Utilities monitored its early pilot projects and collected performance data in order to guide decision-making about future projects. The Milwaukee Metropolitan Sewerage District also required some of its BMP partners to

[214] Milwaukee Metropolitan Sewerage District, *Stormwater Runoff Reduction Program: Final Report*, p. 69.
[215] Ibid., p. 77.
[216] See http://www.mmsd.com/index.cfm

collect performance data, but other pilot projects were allowed to proceed without monitoring. Monitoring adds costs to the projects and in some cases agencies may choose to forgo data collection in favor of funding additional projects. This is unfortunate, since pilot projects are part of a learning process in which both success and failure provide important information.

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

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

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

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

APPENDIX: EVALUATION AND COST EFFECTIVENESS OF STORMWATER BMPS

The charts on the following three pages are reprinted from the Milwaukee Metropolitan Sewerage District *Stormwater Runoff Reduction Program Final Report*, MMSD Contract W91004E03, February 28, 2007, with permission of the Milwaukee Metropolitan Sewerage District.