

# PHILADELPHIA, PENNSYLVANIA

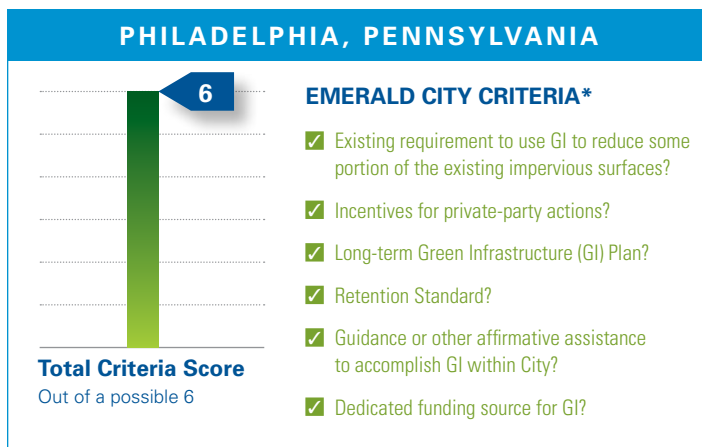
A CASE STUDY OF HOW GREEN INFRASTRUCTURE IS HELPING MANAGE URBAN STORMWATER CHALLENGES

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



Over the next 25 years, Philadelphia is committed to deploying the most comprehensive urban network of green infrastructure in the United States. Philadelphia's Green City, Clean Waters plan, recently approved by state regulators, requires the retrofit of nearly 10,000 acres (at least one-third of the impervious area served by a combined sewer system) to manage runoff on-site; relies on green infrastructure for a majority of the required CSO reductions; calls for the investment of more public funds in green infrastructure (at least \$1.67 billion) than in traditional gray approaches; and leverages substantial investments from the private

sector, primarily through application of a one-inch retention standard for new development and redevelopment projects citywide. The city will fund its share of the costs with a stormwater fee based on impervious area, supplemented by state and federal grants as available. To encourage retrofits on private property beyond that required by the retention standard, the city offers incentives such as reduced stormwater fees, free design assistance and low-interest loans to owners of large impervious properties, a green roof tax credit, rain barrel giveaways, and expedited permit reviews. Philadelphia also has installed dozens of green infrastructure demonstration projects, has published a technical design manual, and is developing a maintenance manual.



## BACKGROUND

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

Today, 60 percent of the city is served by combined sewers, and 40 percent by separate storm and sanitary sewers.<sup>2</sup> The Philadelphia Water Department (PWD) oversees approximately 3,000 miles of sewer piping, 79,000 stormwater

inlets, three sewage treatment plants, 164 CSO outfalls, and more than 450 stormwater outfalls.<sup>3</sup> The combined sewer system serves more than three-quarters of the city's residents, covers an area of about 40,000 acres (64 square miles), and discharges into the Delaware and Schuylkill rivers as well as the Cobbs, Pennypack, and Tacony-Frankford creeks.<sup>4</sup> Elsewhere, separate storm sewers discharge into additional water bodies, such as Wissahickon Creek and its tributaries.<sup>5</sup>

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

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

## PROMOTING GREEN INFRASTRUCTURE ON PRIVATE PROPERTY

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



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all new impervious surfaces and was the impetus for the development of a new stormwater rule.

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

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

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

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

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

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

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

## DEMONSTRATION PROJECTS IN PUBLIC SPACES

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

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

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

## GREEN CITY, CLEAN WATERS

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

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

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

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

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

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

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

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

Over the 25-year life of the program, the primary focus of PWD’s green infrastructure investments will be streets and sidewalks, since they account for 38 percent of impervious cover in the combined sewer areas. The agency will focus on streets slated for capital improvements or routine repaving by the city Streets Department or state Department of Transportation; streets slated for repair or replacement of PWD’s existing water and sewer infrastructure or flood-control-related construction; and streets where cable, gas, or phone infrastructure are being repaired and replaced. When such utility and road work is planned, PWD can also design and fund the installation of tree trenches and expanded tree pits, sidewalk planters and bump-outs, porous pavement, and other green infrastructure features to be installed

simultaneously. This will limit the project costs by avoiding the need to repeatedly dig up and replace portions of streets and sidewalks, making the stormwater improvements a small marginal cost of the overall capital improvement expenditure. It will also limit inconvenience to residents.<sup>44</sup>

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

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

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

PWD is developing an operation and maintenance manual for all types of green stormwater infrastructure included in the Green City, Clean Waters plan. The manual is intended for use both by city agencies and by private property owners with responsibility for maintenance of green stormwater infrastructure.<sup>51</sup> PWD plans to invest more

than \$200 million in operation and maintenance of green stormwater infrastructure on public property over the next 25 years and upwards of \$30 million each year thereafter.<sup>52</sup>

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

## \*EMERALD CITY RATING SYSTEM

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

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

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