MANAGING URBAN STORMWATER AND ITS INFLUENCE ON BUILDING A SUSTAINABLE, RESILIENT CITY PHILADELPHIA, PENNSYLVANIA

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Philadelphia Water has been working with other city agencies, urban planning organizations, developers, private and public land owners, community groups and politicians to successfully leverage new green stormwater infrastructure (GSI) solutions into new urban thinking, planning and construction to insure a sustainable and resilient city into the 21st century and beyond. The Green City, Clean Water (GCCW) program is part of a new "One Water" management approach to integrating the traditionally "separate" business sectors of drinking water, wastewater, stormwater and water resource management. The Philadelphia model is being adopted by cities throughout the US.

Figure 1: Green roof installed on Philadelphia's Central Public Library. Source: Philadelphia Water Department

BACKGROUND

There is urgent need in the US for a new generation of infrastructure to replace the current water and sewer pipe networks which were largely designed and built between the 1880s and the 1940s. These systems are wearing out and becoming obsolete. The grand problems they solved at the turn of the 20th century (typhoid, sanitation, delivery of water, etc.) do not address new 21st century threats (emerging pathogens, toxins from Cyanobacteria, heavy metals, sewer overflows, drought, floods, and more).

The costs to rebuild these systems in the US is estimated at over 1 trillion USD[1]. It come at a time when the economy cannot afford this outlay, much less the plethora of other challenges facing 21st century urban America, such as those attributed to changes in climate, economy, security, demographics, as well as societal responses to urban issues of environmental justice and economic inequity.

To alleviate this problem, one of the most critical elements of the United States Clean Water Act of 1972 was its massive construction grant programs for expanding and improving regional wastewater treatment. By the mid-1990s, this program, along with new rules governing the discharge of industrial wastes, dramatically reduced river and stream pollution in the US. In fact, only one major pollutant source, urban stormwater runoff, remained largely unchecked.

Stormwater runoff can affect almost all aspects of a water systems, including scarcity, flooding, pollution, infrastructure capacities, erosion, wildlife habitats; and stream temperatures. To manage this runoff, utilities began constructing large underground storage systems, often employing massive tunneling projects. This approach, used by urban water engineers for millennia, manages increased demand by increasing infrastructure capacity. With little to no jurisdiction over urban planning, development controls, or land management, the urban water engineer really had no choice *but* to design to manage, regardless of how much runoff was sent to its sewer inlets. Issues of climate change and increasingly extreme weather events seemed only to further justify this approach.

Indeed, among the most significant programmatic costs to US water utilities in the past two decades have been massive tunnel construction projects designed to reduce the overflows of raw sewage and stormwater into our rivers and streams. Up until the middle of the 20th century, major portions of the nation's water waste went largely untreated and directly into rivers. Since that time, the city has invested billions of dollars to build modern, state-of-the-art Water Pollution Control Plants (WPCPs) to treat the wastewater to levels cleaner than the river water itself. Today, cities like Philadelphia operate some of the most advanced, complex, and efficient wastewater facilities in the world.

But no matter how sophisticated the facilities, the overflow problem persists. The capacity of the sewer network and the pumping and treatment facilities proves insufficient to capture and treat all of the polluted rainwater that is generated nearly every time it rains. In fact, for Philadelphia, only about 67% of the combined sewage/rainfall is "captured" – the rest continues to pollute rivers and streams. This is not only disgusting, but also is legally unacceptable under the Clean Water Act. The cost of managing the rainfall is no longer a hidden fee or tax paid by direct discharge to our streams, but rather is a new cost to cities and suburbs for years of urbanization.

Today, the US water sector is moving toward a newer, softer, greener, more decentralized approach of managing runoff. Instead of increasing sewer capacities to meet runoff capture requirements, a new paradigm has been introduced to limit the demand on our infrastructure by managing rain water more locally, by allowing the rainwater to be captured and managed on-site. Put simpler, rainwater will no longer be treated as a waste product to be discharged as expediently as possible to a sewer drain. Instead, rainwater runoff has been recognized to have significant beneficial impacts on the environment and economy. More importantly, rainwater has a value that can be used to not only rejuvenate the environment, but also the city's economy and infrastructure.

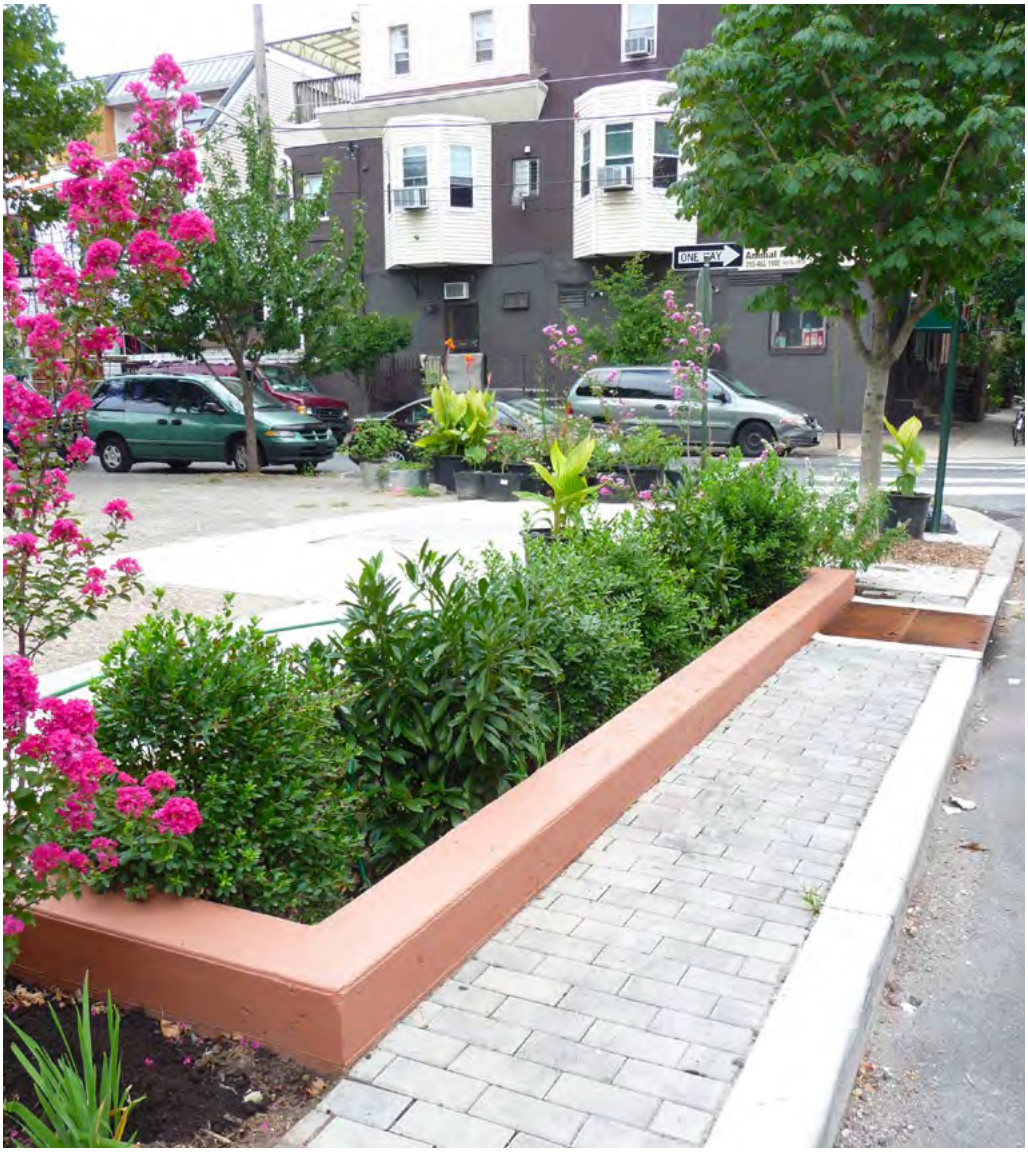

Figure 2: Rain garden corner bump out installed by Philadelphia Water.
Source: Philadelphia Water Department

Figure 3: Students playing on new GSI playground. Source: Philadelphia Water Department

CITY-FOCUSED SUSTAINABILITY INITIATIVES

The 2008 inauguration of Mayor Michael Nutter brought with it a revolution of green progressive thinking for Philadelphia. Fulfilling a campaign promise, he formed a Mayor's Office of Sustainability, which spent its first years developing a policy and benchmarking document for meeting new sustainability goals that addressed issues of energy, green space, and water.

This timing was extremely fortunate for Philadelphia Water, which was negotiating with the USEPA on the details of its stormwater program. Most importantly, the city's political emphasis on sustainability and the Department's focus on stormwater got the citizens of Philadelphia involved at all levels and all ages. From rain barrel programs and home-situated rain gardens, to science, engineering, and math lessons in water management in our schools, to community groups repairing vacant lots and protecting their new neighborhood parks, increased community involvement and engagement with sustainable water practices has greatly increased the capacity of the GCCW.

GREENER CITY, CLEANER WATER

"Green City, Clean Waters" (GCCW), created in 2009, aims to reduce the amount of polluted runoff that enters the city's water system. Unlike conventional stormwater management programs in the US and elsewhere, it does not rely solely on increasing sewer and treatment plant capacity to manage a seemingly ever-increasing load of rainwater[2]. GCCW aims to "conserve rainwater", meaning that we now value our rainwater as an urban asset and not as a wastewater product. Rather than discard the rainwater down a sewer drain as swiftly as possible, we now look to use it to improve the quality of urban life. We want to use water management techniques to balance nature, development, and people in the urban setting.

As America's first capital, the city of Philadelphia was among the world's great industrial cities at the turn of the 20th Century. Now, following a 25% loss of population over the past 50 years, Philadelphia is transforming again, this time into a beautiful, vibrant, green city, destination for tourists, and hub for innovation, healthcare, and education. However, because of its industrial history, the city remains marred with environmental challenges and has needed to place special focus on sustainable development as the city revitalizes.

Despite the positive changes Philadelphia has seen, the storm sewer system can surcharge during even small rain events, and result in sewage, trash, and flooding in our rivers and streams. Increasing sewer capacity (through the construction of bigger and bigger pipes, tunnels, and

Figure 4: Raingarden installed in Philadelphia's public school, Greenfield Elementary School. Source: Philadelphia Water Department

pumping stations) can no longer be considered affordable, justifiable, or sustainable.

In order to alleviate the demand on the city's sewer system, the GCCW program proposed a variety of "green stormwater infrastructure" (GSI) systems to intercept stormwater, using soil, water, and plant catchment systems to infiltrate water into the ground, evaporate and transpire water into the air, and, in some cases, slowly release a portion back into the sewer system. Through this new green infrastructure, the city seeks to not only improve water quality for residents, but also to improve the regional environment and create a more resilient, threat-resistant system.

In addition to increasing resilience and environmental quality, the city sought opportunities to use urban redevelopment to increase the integration of key system services so as to create a more sustainable, attractive and livable city. Philadelphia Water has started to partner, coordinate, and integrate its water infrastructure operations and capital improvements into the very fabric of the city. By doing this, it can use its water capital to improve not only the city's tunnels and sewage but also parks, school, businesses, homes, public facilities, universities, and much more.

CREATING 10,000 GREEN ACRES

In partnership with the US Environmental Protection Agency (USEPA), the GCCW program has agreed to build 10,000 Green Acres (GAs) over the next 25 years. One GA is defined as the conversion of one acre of impervious land to one acre that manages the first one-inch (2.5 cm) of each rainfall. Table 1 shows the five-year benchmarks for the program. As of this writing, the program has surpassed its first five-year goal of 750 acres by 130%.

These GAs, combined with certain improvements in wet weather capacity at the wastewater treatment plants and sewer systems, are intended to increase the efficiency of the sewer system from managing just 67% of overflows to 85%, or, said another way, more than a 33% increase in the working capacity of the system (9 billion gallons of additional runoff management).

Since this program called for the conversion of 10,000 acres of impervious land that was managed in an environmentally sensitive manner, everyone seemed to get on board, including: the Streets Department with litter control, "complete streets[3]" and bicycle lane projects; Parks and Recreation began a million tree planting campaign with its non-profit cohort, the Pennsylvania Horticultural Society; the school district became interested in our schemes to "green" asphalt schoolyards; and our City Planning department developed an environmentally friendly "Plan 2035".

METRIC	YEAR 0	YEAR 5	YEAR 10	YEAR 15	YEAR 20	YEAR 25
TOTAL GREENED ACRES	0	750	2100	3800	6500	10000

Table 1: Green Acre Goals by Year (year 0 began June, 2011)

Land management strategies used to achieve 1000 GAs during the first five years of the GCCW program are shown in Textbox 1 and will be discussed further in this document:

→ Green and/or porous pavement street improvements following water/sewer reconstruction projects
→ Improvements to schoolyards, parks, vacant land and other open space areas
→ Improvements to public facilities
→ Instituting a parcel-based stormwater fee system to encourage rainwater conservation
→ Creating a stormwater credits system for on-site stormwater management
→ Competitive grants to public and private entities to improve properties
→ Development regulations requiring private management of the first 1.5 inches (3.8 cm) rain

Textbox 1: Land Management Strategies for achieving Green Acres

FINANCIAL AND SOCIAL INCENTIVES TO CREATE CHANGE

Taking advantage of the spread of progressive green thinking in Philadelphia, the water utility institutionalized several important programs, regulations, and policies that not only supported its own goals of water quality, but also the city's goals to improve livability, jobs, and sustainability.

The most important driver for change began with new stormwater development regulations[4]. Under the new regulations, developers needed to provide measures to abate runoff on their properties.

These new regulations did add to the design and construction cost of new buildings and created some friction within the development community. Everyone accepted that they needed plumbing to run drinking water into the premises and wastewater out, but stormwater management was considered "free" - to be collected by the landowner and discharged to the sewer. It has taken careful talks, encouragement and cooperation to dispel the traditional philosophy on water management - that the sewer capacity was practically unlimited, since any overflow "just went to the river".

To support the development community, Philadelphia Water recognized that time equals money and worked to compensate for the new costs by issuing "expedited permits" for projects which included on- site stormwater abatement systems, such as green roofs and porous pavement projects. In addition, engineering support services were provided free of charge to developers and engineers early on in the conceptual project design phase which helped increase efficiency and ease costs. Though it was a long process to find reasonable procedures that allowed for stormwater management as well as development, it ultimately resulted in

Figure 5: Green roof installed on Golkin Hall of the University of Pennsylvania's Law School. Source: Philadelphia Water Department

Figure 6: Rendering of stormwater tree trenches created by Clean Water, Green Cities Plan. Source: Philadelphia Water Department

a new modern building designs that led to LEED certifications and increased market value and a city exporting its architectural and engineering prowess to other cities across the US.

In 2011, perhaps the most important element of a green stormwater program was put in place, a parcel based billing system for deriving revenues to pay for the Philadelphia Water US $150 million "stormwater utility". Philadelphia Water commoditized the rain in order to remediate this negative externality from the true cost of managing that rainfall. In effect, the impervious and gross areas of every property parcel in Philadelphia was analyzed and priced so that each property owner paid their "fair share" for managing the rainwater.

This created an incentive for private landowners and government agencies to reduce their stormwater fees by personally managing the runoff from their property. In effect the city created a credit incentives program for property owners to move off of the city stormwater system, thereby decentralizing stormwater management. In order to facilitate the conversion of land into green stormwater management systems, Philadelphia Water also created grant opportunities for landowners to further motivate them to retrofit their systems.

With these policies came a wave of community support that turned out to be the most rewarding and sustainable return on investment for the city. Community groups vocalized their desire to make changes – from school yards to vacant lots, so much so that Philadelphia Water

Figure 7: Philadelphia Water encourages residents to implement green infrastructure in their homes, like pervious surfaces for backyards and patios. Source: Philadelphia Water

was accused of "inciting the masses" despite the ability to execute the projects due to funding restraints. For example, controversy arose over the fact that the specific funding could only support water projects, but when picnic tables or play equipment are involved, other funding sources was required. This forced politicians and government agencies to collaborate and fundraise.

In 2015, Philadelphia Water worked with the development community in a very democratic process to revise the regulations, provide more management of runoff (1.5 inches (3.8 cm) of rainfall), and create new incentives for developers to use "green" alternatives for stormwater management. The city worked to be widely supportive throughout the change in regulation, from providing educational materials regarding the changes, to working with the community to make sure their viewpoints were heard. One stakeholder even described their experience as, "democracy the way it was intended to be."

The city has seen significant progress since the inception of GCCW. In 2006, Philadelphia had one green roof. By the end of 2015, the city boasted over 150 green roofs, creating a new industry; Design, construction, and maintenance of green roofs became a new business for Philadelphia and green jobs expanded across the city. At its core, the investment in Green City, Clean Waters has certainly met its triple bottom line goals of improving the environment while making Philadelphia a greener, more viable place to live and work.

RE-ENVISIONING INFRASTRUCTURE

As noted earlier, urban land management and control has remained an area largely outside the purview of the water industry. As Philadelphia Water learned more about the full impact of urban land use decisions on water quality and quantity, it is becoming increasingly more difficult to integrate water issues without addressing the complexity of the urban systems of land management. Questions arose such as, how do we integrate and coordinate the construction and rebuilding of public roads, public spaces, and private development in a manner that most efficiently and effectively manages our water resources, prevent pollution, and create a cohesive and leveraged and sustainable city system?

It will take vision and leadership to overcome the multiple barriers that confront the city to find local solutions for our global water problems, *and* to do so in a way that supports a livable, sustainable city. With urban water systems as a national focal point for reform and financial support, there is no better time to integrate environmental protection strategies, responsible land use, and dynamic zoning reform with infrastructure improvements through the use of integrated urban systems thinking.

As to the future, cities across the world must recognize that GSI is a very new field. Innovations are occurring daily. Regular analyses and modeling of these systems along with adaptive management at the water and city levels are essential to achieve the correct future balance of clean, abundant water and green, sustainable, and resilient cities. ◆

→ A recent study found that the new regulations helped catalyze a best-in-class GSI industry cluster in Philadelphia, with meaningful consequences for the local economy. The study found that the local GSI industry is experiencing double-digit annual growth and conservatively represents annual economic impact of almost US $60 million, supporting 430 local jobs and generating nearly $1 million in local tax revenues. The innovative solutions birthed for the GCCW program also produced export opportunities for the benefit of the local economy and established Philadelphia as a leader in stormwater management, positive media coverage, national awards, and emulation from such cities as New York City and Washington DC.

ENDNOTES

1 http://gsipartners.sbnphiladelphia.org/wp-content/uploads/2016/02/SBN_FINAL-REPORT.pdf

2 Like many global cities, Philadelphia is experiencing unusually heavy intensity, short duration but more frequent rain events over its highly impervious ground cover so the concern for rainwater runoff burden has increased significantly.

3 In June 2009, Mayor Nutter issued the Complete Streets Executive Order, requiring all City departments and agencies to balance the needs of pedestrians, bicyclists, public transit users, and motorists when making decisions regarding the transportation system and development projects. The Order places a high priority on increasing safety and convenience for those traveling in the public right-of-way, particularly children, the elderly, and persons with disabilities (City of Philadelphia Complete Streets Handbook)

4 In old, industrial cities like Philadelphia, most development is actually re-development of a previously purposed and built site; not the development of "green" (previously undisturbed) sites. (This has allowed Philadelphia to actually reduce impervious cover in the city by about 0.4% per year, just through the demolition and re-building of properties.)

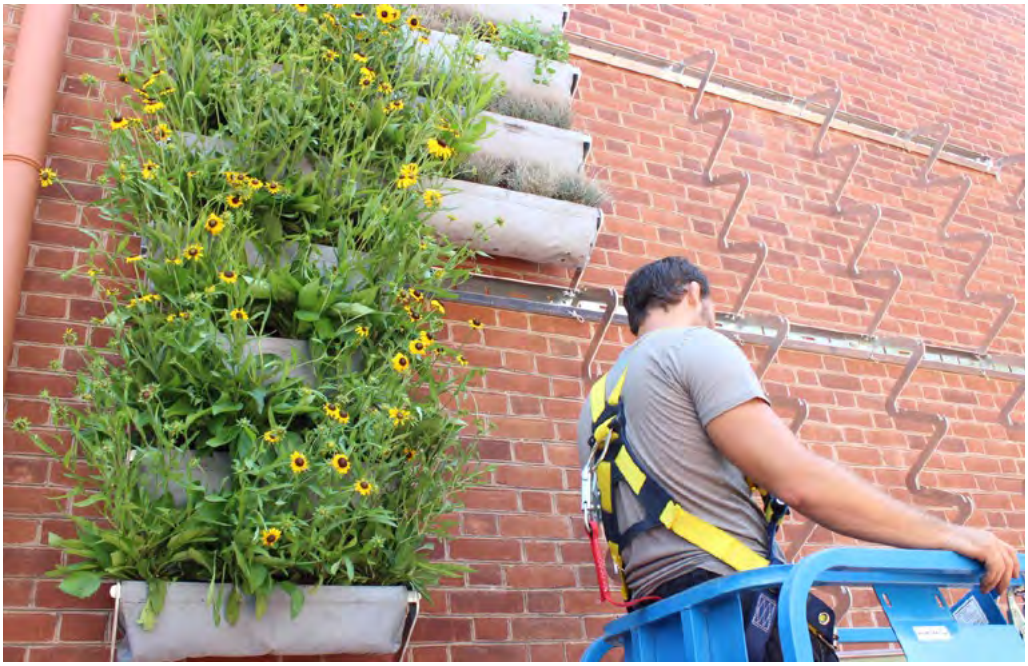

Figure 8: “Drainspotting” initiatives use temporary art work by Frank McShane to decorate storm drains in Schuylkill River Park and Vernon Park. Source: Philadelphia Water Department

Figure 9: Living wall installation on the Park Institute building. Source: Philadelphia Water