Making Governance Work for Green Stormwater Infrastructure on Vacant Land in Legacy Cities

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NEIGHBORHOOD, ENVIRONMENT, AND WATER RESEARCH
COLLABORATIONS FOR GREEN INFRASTRUCTURE
NEW-GI TECHNICAL REPORT NO. 2, September, 2018

ACKNOWLEDGEMENTS:

Our work was funded with a grant to the University of Michigan Water Center from the Erb Family Foundation. We thank Kelsea Dombrovski, Samantha Henstell, Libby Levy, Joan Nassauer, and Ceara O'Leary for very helpful comments on drafts of this report.

Editorial assistance from Rachel C. Leonard.

Graphic design by Marty Somberg / Somberg Design

Cite as:
Dewar, M., Cho, G., Labov, R., Egler, M., & Alvarez, A. (2018). *Making Governance Work for Green Stormwater Infrastructure on Vacant Land in Legacy Cities* (NEW-GI Technical Report No. 2). Ann Arbor, MI: University of Michigan Water Center.

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ACRONYMS RELATED TO STORMWATER QUALITY MANAGEMENT

CSO: combined sewer overflow or outflow
CSS: combined sewer system
LTCP: Long-Term Control Plan
MS4: Municipal Separate Storm Sewer System
NPDES: National Pollutant Discharge Elimination System
SSO: sanitary sewer overflow
TSS: total suspended solids

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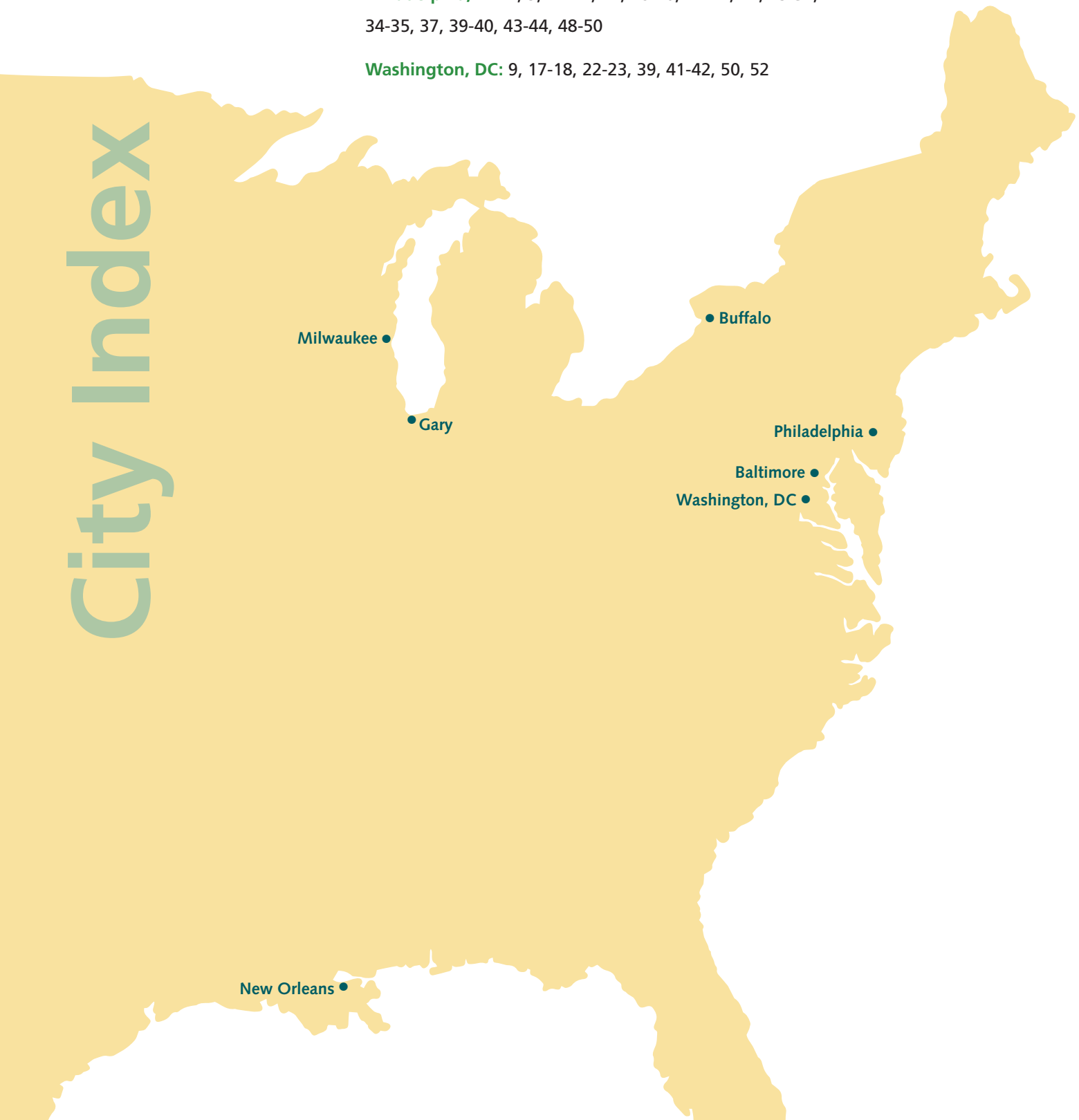

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Figure 1. Peace Park, a Growing Green Design Challenge grant recipient, improved vacant lots' stormwater retention in Baltimore using rain gardens and permeable pavers.

SOURCE: BEFORE IMAGE FROM J. GUILLAUME, AFTER IMAGE BY AUTHORS.

Introduction

MANY CITIES are using green stormwater infrastructure (GSI) to meet Environmental Protection Agency (EPA) and state environmental agency requirements under the Clean Water Act [33 U.S.C. §1251 et seq. (1972)]. The hope is that GSI will slow flows of urban stormwater into sewer systems and therefore reduce pollution of receiving waters. GSI designed in ways that enhance neighborhoods also offers the prospect of co-benefits including increased property values, reduced crime, property reinvestment, enhanced perceptions of safety, and residents' increased interaction with neighbors and satisfaction with neighborhoods. GSI may reduce stress and increase physical activity, thus improving health (Lichten et al., 2017).

To realize the potential benefits of GSI, city officials and others need to install and maintain GSI efficiently across areas that send substantial volumes of water to the sewer system. As cities' experiences and research show, the governance challenges to implementing and maintaining GSI are considerable (Brown, 2005; Keeley et al., 2013; Lichten et al., 2017; Pincetl, 2010; Young & McPherson, 2013). Within a municipality, agencies need to fulfill new roles in the implementation and maintenance of GSI but are not accustomed to working across departments for this purpose. Staff cannot readily assume new responsibilities for systems that may be unfamiliar to them; sewer departments and authorities are organized and staffed to build and maintain drains, pipes, and treatment plants, not green spaces that manage stormwater. Residents and small, community-based organizations usually lack capacity to maintain GSI in their neighborhoods. Even where installation or maintenance of GSI can benefit from the involvement of non-governmental entities, such involvement may not be well integrated into the city's overall plans for achieving stormwater management goals.

Implementation and maintenance of GSI in legacy cities differ from that in growing cities. The work poses opportunities as well as challenges. The water and sewerage infrastructure in legacy cities is old and often in poor repair, meaning it could benefit from GSI that manages stormwater and reduces use of drains and pipes. Plentiful vacant land offers many potential sites for GSI. City and county governments often own a substantial share of the vacant land and could potentially assemble it for GSI. At the same time, legacy cities experience little new construction in many neighborhoods and cannot rely as much on the approach of growing cities: post-construction requirements for stormwater management in new developments, which often lead to installation of GSI.

Consequently, city governments have limited resources for any investments in infrastructure for stormwater management, including GSI. Although water and sewer departments charge customers fees, a reduced customer base in legacy cities means that each customer bears more of the fixed cost of bonds issued to pay for capital investments. In cities where many residents live in poverty, fee increases impose considerable hardship on customers.

DEFINING GREEN STORMWATER INFRASTRUCTURE, GREENING, GREEN SPACE, GOVERNANCE AND LEGACY CITIES

The terms green stormwater infrastructure, greening, green space, governance and legacy cities are used throughout this report. These terms have different but sometimes overlapping meanings.

Green stormwater infrastructure (GSI), also known as green infrastructure (GI), refers to systems that use vegetation, soils and other natural processes to retain, detain, infiltrate, or evapotranspire stormwater at its source rather than removing it from the site through a municipal stormwater system (US Environmental Protection Agency, 2016a, 2016c). GSI may incorporate aspects of greening or green space, but it has a separate and distinct purpose: to manage stormwater.

Greening describes efforts to increase the amount or quality of green space in a neighborhood landscape by planting or maintaining trees, shrubs, grass or other vegetation. Vacant lot greening refers to planting or maintaining vegetation or structures (e.g. garden beds, fences or signs) on vacant lots.

Green space is land that is "partly or completely covered with… vegetation" (US Environmental Protection Agency, 2016b). While commonly-given examples of urban green spaces include parks, community gardens, cemeteries, and playgrounds, the term may also refer to residential yards and other vegetated areas. Green space can occur on private or public land.

Governance in this report refers to the laws, regulations, codes, political and bureaucratic relationships, and practices that determine whether and how governmental and non-governmental actors implement and sustain a policy or program (for varying definitions, see Pierre, 2005; Pierre and Peters, 2000; Stoker, 1998; Lynn et al., 2001).

Legacy cities have lost substantial portions of their peak population and employment and therefore have endured extensive property disinvestment. These cities now have high poverty rates, large amounts of vacant land, and weak property markets. As a result of reduced tax revenues and cutbacks in federal and state intergovernmental transfers, they also have few financial resources with which to address their challenges (Mallach, 2012).

Public officials in legacy cities are innovating in governance to improve implementation and maintenance of GSI. This report describes varied approaches in seven legacy cities. These cities have numerous plans for further changes, but this report focuses on practices that cities have implemented, not those in the planning stage. Officials can rarely, if ever, say exactly how much their changes have achieved improvements in water quality because measurements and monitoring are difficult and costly. Their innovations are promising because they tackle barriers that other cities also experience. This report synthesizes these experiences to offer ideas about GSI adoption and maintenance across legacy cities.

This report describes varied approaches to improve implementation and maintenance of GSI in seven legacy cities. It focuses on practices that have been implemented and not on cities' future plans.

CITY OVERVIEWS

This report looks at innovations in Baltimore, Buffalo, Gary, Milwaukee, New Orleans, Philadelphia, and Washington, DC, to identify ways that government officials, leaders of nonprofit organizations, grantmakers, and others interested in GSI have adapted governance to facilitate implementation and maintenance in legacy cities. All these cities had lost at least 20 percent of their peak population by the 2010 decennial census (US Census Bureau, 1930-2010). We chose to study these legacy cities because their experiences in addressing barriers to GSI adoption and maintenance can be useful to other legacy cities.

Some of the cities face requirements or recommendations for use of GSI to address stormwater runoff and combined sewer overflows (CSOs) (Table 1). The requirements vary and reflect the financial capacity of the city, the scale of the stormwater management problem, the type and condition of water and sewer infrastructure, and the progress the city has made in meeting past requirements. In several cities, officials have decided to try GSI though they face no requirement to do so.

Exactly what cities have accomplished in GSI remains difficult to determine. Legally binding documents, such as permits under the Clean Water Act and consent decrees, only began to require or recommend GSI within the last ten years. In five of the seven cities, either officials did not need to report on progress toward meeting agreed-upon goals using GSI since they faced no requirement, or they did not make their reports publicly available. Philadelphia and Milwaukee made strong commitments to GSI and did report progress to the public. In 2015, Milwaukee had exceeded its stormwater capture goal with GSI (an estimate based on what installations had been engineered to hold) and continued work to achieve a higher regional goal (City of Milwaukee Office of Environmental Sustainability, 2015). Philadelphia had made substantial investments but had not reached 20 percent of its goal for CSO volume reduction or impervious surface conversion though 20 percent of the time for achieving the goal had passed. However, substantial changes in governance in Philadelphia, discussed in the next chapters, could facilitate future GSI investments.

Table 1. U. S. Environmental Protection Agency's GSI requirements for selected legacy cities.

City	Type	Responsible department	EPA or state regulation	Stormwater improvement requirements	Requirements for GSI	Expected or required GSI expenditure	Progress toward GSI requirement or commitment
BALTIMORE, MD	MS4	Baltimore City Department of Public Works	2002: Consent Decree	Eliminate illegal wastewater discharge, all CSOs, and all SSOs.	No requirement	No requirement	No requirement
			2013: NPDES permit	Restore 4,291 acres of impervious surface (or 20% of total impervious area) to permeable surface by 2018.	No requirement	Expected FY 2016 expenditure on NPDES compliance: $25 million. No requirement specified.	20% of required reduction in impervious surface achieved through greening and GSI as of 2013; no tracking of GSI alone.
			2016: Modified Consent Decree	Eliminate unpermitted wastewater discharge and SSOs, and improve water quality. Complete regular inspections of major sewer lines. Reduce SSOs by 83% by 2021.	No requirement	No requirement	No requirement
BUFFALO, NY	CSS	Buffalo Sewer Authority	1999: Citation from New York Department of Environmental Conservation for violating NPDES permits	Comply with NPDES permits and produce revised LTCP to reduce discharges by 2001.	No requirement	No requirement	No requirement
			2012: EPA administrative order	Submit revised LTCP; found 2004 submission "late and inadequate."	No requirement	No requirement	No requirement
			2014: EPA approved final updated LTCP	Reduce annual CSO volume from 1,749 millon gallons (MG) to 504 MG	LTCP goal of controlling stormwater from 1,315 acres of impervious surface through greening and GSI over a 20-year implementation period.	$93 million on GSI, out of $278 million total LTCP project costs.	Progress not reported
GARY, IN	CSS	Gary Storm Water Management District	2003: Consent decree	Improve water treatment facilities' operations and maintenance to treat the maximum amount of stormwater; meet water quality requirements for TSS, bacteria, ammonia-nitrogen, and chloride.	No requirement	No requirement	No requirement
		City of Gary	2012: NPDES permit	Improve quality of stormwater discharge from CSOs. Develop LTCP to comply with Clean Water Act.	No requirement	No requirement	No requirement
		City of Gary, Gary Sanitary District	2016: Consent decree amended	Improve water treatment facilities' operations and maintenance to treat the maximum amount of stormwater; meet water quality requirements for TSS, bacteria, ammonia-nitrogen, and chloride.	Develop LTCP to control CSO discharge. Gary will evaluate the effectiveness of GSI as an alternative CSO control.	No requirement	No requirement. Progress not reported on evaluation of GSI.

City	Type of system	Responsible department	EPA or state regulation	Stormwater improvement requirements	Requirements for GSI	Expected or required GSI expenditure	Progress toward GSI requirement or commitment
MILWAUKEE, WI	CSS	Milwaukee Metropolitan Sewerage District (MMSD)	2003: Wisconsin Pollutant Discharge Elimination System permit	Ensure wastewater treatment plant effluents meet standard levels for TSS, ammonia, chlorine, and phosphorus.	No requirement	No requirement	No requirement
			2013: Wisconsin Pollutant Discharge Elimination System permit	Treat 85% or more of the combined sewage from storms per year OR have no more than six CSO events per year.	Install 3 MG of GSI storage and reach 12 MG total GSI stormwater capture in the greater Milwaukee region by 2017. MMSD has set higher targets than the permit: 173 MG of GSI storage by 2035.	Regional goal (not required by the permit) of $62 million for GSI storage by 2035.	14 MG of greening and GSI stormwater capture in the City of Milwaukee as of 2015.
NEW ORLEANS, LA	CSS and MS4	Sewerage & Water Board of New Orleans (SWBNO)	1998: Consent Decree	Repair water and sewer infrastructure to limit pollutant discharge into local bodies of water.	No requirement	No requirement	No requirement
			2010, 2013, 2014: Modified Consent Decree	Extended deadline for repairs.	Create a GSI plan within one year of the 2013 decree.	$2.5 million over 5 years by SWBNO; at least $27 million by US Dept. of Housing & Urban Development/FEMA.	Plan completed in 2014. Other progress not reported.
PHILADELPHIA, PA	CSS and MS4	Philadelphia Water Department (PWD)	June 2011: Consent Order & Agreement (CO&A) with Commonwealth of Pennsylvania	Implement updated LTCP (PWD's *Green City Clean Waters* plan). Reduce CSS discharge to comply with NPDES permits; reduce CSOs by 85% (7.9 billion gallons (BG)/ year) within CSS by 2036.	*Green City Clean Waters:* Convert 9,600 impervious acres in CSS area (34% of total) to "greened acres." *	*Green City Clean Waters:* $2.4 billion over 25 years.	As of 2017, 600 MG per year reduction in CSO volume (8% progress towards goal of 7.9 BG per year reduction by 2036). 10% progress towards conversion of 9,600 impervious acres in CSS area by 2036.
			2012: EPA Administrative order for compliance on consent	No ordered provisions for water quality; required submissions pursuant to 2011 PADEP CO&A.	Not specified	Not specified	
WASHINGTON, DC	CSS and MS4	DC Water and Sewer Authority	2005, 2016: Consent decree amended	Rock Creek Watershed: 90% CSO volume reduction; Potomac River Watershed: 93% CSO volume reduction; Anacostia River Watershed: 98% CSO volume reduction.	GSI to collect 1.2 inches of rainfall for impervious surface: 365 acres by 2030 in Rock Creek Watershed, and 133 acres by 2027 in Potomac River Watershed.	Install $3 million of GSI on DC Water facilities. Planned expenditure for pilot program: $10-30 million for 50 acres of GSI; $90 million for GSI by 2030.	Progress not reported
		District Department of Energy & Environment	2011: NPDES	Implement a program that promotes on-site retention through policies, regulations, ordinances, and incentives.	Develop an incentive program for "green landscaping" such as large trees, permeable pavement, green roofs. Install 350,000 sf of green roofs on District properties.	No requirement	Progress not reported

Sources: Baltimore: Maryland Department of the Environment, 2013; Baltimore City Department of Public Works, 2015; Buffalo: Buffalo Sewer Authority, 2014; Environmental News Service, 2012; U.S. Environmental Protection Agency Region 2, 2012; Gary: Indiana Department of Environmental Management, 2012; United States of America v. the City of Gary, Indiana, 2016; Milwaukee: City of Milwaukee Office of Environmental Sustainability, 2015; Milwaukee Metropolitan Sewerage District, 2007b; Wisconsin Department of Natural Resources, 2014; New Orleans: United States of America v. Sewerage & Water Board of New Orleans, 2013; ResilientNOLA, 2016; Philadelphia: Philadelphia Water Department, 2011a; U.S. Environmental Protection Agency Region 3, 2012; Philadelphia Water Department, 2010-2017: report for 2016; City of Philadelphia Office of Sustainability, 2016; Rademaekers, 2017b; Washington, DC: District of Columbia Water and Sewer Authority, 2015; US Environmental Protection Agency, 2011.

*Greened acre = an acre of impervious surface for which stormwater is managed through GSI; the formula for calculating greened acres is GA = Ic x Wd, where Ic = contributing impervious area managed in acres and Wd = depth of stormwater managed in inches.

PROMISING PRACTICES

No legacy city has yet made the installation and maintenance of GSI routine and widespread, but cities' experiences offer ideas for how to resolve barriers to the work. Their innovations reflect the need for specific changes in governance. Their experiences suggest ways to make city processes work better for GSI installation and maintenance, and to enable businesses, nonprofit organizations, and residents to make investments in GSI.

Figure 2. Fondy Park in Milwaukee captures stormwater from the adjacent farmers market.

OVERVIEW OF GOVERNANCE TOPICS

Chapter 1 looks at changes in city government approaches to strengthen systems for GSI installation and is organized as follows:

1. Leadership
    a. Mayoral leadership
    b. Leadership from city and county sewer department officials
2. Reorganization of water and sewer departments
3. Interdepartmental coordination
    a. Coordinating with street projects
    b. Creating an environmental affairs or sustainability office
    c. Connecting GSI installation to demolition
4. Revisions to codes
5. Systems for site plan approvals, permits, and inspections
6. A plan for locating GSI
7. Use of information systems
8. Engagement and education programs with residents, business owners, and others

Chapter 2 examines ways city governments have encouraged GSI installation by businesses, residents, and nonprofit organizations or partnered with these entities on GSI projects:

1. Incentives
2. Off-site ways to meet requirements or reduce fees, especially on vacant land
3. Use of information systems and electronic tools
4. Resources and services
5. Partnerships and initiatives with nonprofit organizations

Chapter 3 considers cities' innovations to maintain and preserve GSI:

1. Maintenance
2. Long-term land control

Figure 3. Green infrastructure in Kemble Park in Philadelphia resulted from a partnership between the Parks and Recreation Department and the Philadelphia Water Department.

Chapter 1: City government approaches to strengthening systems for installing GSI

IN EFFORTS TO INCREASE GSI in response to federal requirements, city and county officials - often with mayoral leadership - have reorganized water and sewer departments, established new ways of working across departments, revised codes, reformed permitting and inspection systems, become more specific about where GSI can help meet EPA requirements, improved information systems to identify and communicate appropriate locations for GSI, and worked to educate and engage residents and others.

1. LEADERSHIP

Local leadership makes a difference in how GSI is implemented. Mayors and the directors of water and sewerage agencies have been key leaders in the legacy cities that have adopted GSI most extensively.

A. MAYORAL LEADERSHIP

Mayoral priorities can encourage department heads and other senior staff to collaborate on specific issues to move GSI implementation forward. Mayors in legacy cities have many pressing priorities. Some mayors nevertheless make environmental sustainability and stormwater management, including GSI, a focus. Here are some instructive examples:

Coordination with the Mayor's Sustainability Plan (Philadelphia)

Mayor Michael Nutter's (in office 2008-2015) commitment to sustainability was a major factor in the successful launch and continued implementation of the Philadelphia Water Department's (PWD) 2011 *Green City Clean Waters plan*. In 2008, Mayor Nutter established the Office of Sustainability and charged the office with developing and implementing the 2009 *Greenworks* plan and its 15 sustainability targets, including an initial goal of 500 additional acres of permeable surface by 2015. *Greenworks* recommended a variety of GSI strategies on both public and private land, including the transformation of vacant land into GSI. In 2011, *Green City Clean Waters* integrated those strategies into PWD's broad plan for stormwater management (Philadelphia Water Department, 2011a). Mayor Nutter supported the recommendations in *Green City Clean Waters* and the use of GSI over investment in grey infrastructure to address CSOs (Freeh and Wu, 2015). The Pennsylvania Department of Environmental Protection (PADEP) accepted this plan as PWD's updated Long-Term Control Plan (LTCP) in a 2011 agreement,

referenced in the 2012 EPA administrative order for compliance on consent (US Environmental Protection Agency Region 3, 2012).

Within five months of taking office, Nutter promised to make Philadelphia the "greenest city" in the United States. "It really is about jobs," he told a reporter (John-Hall, 2008). In 2013, as president of the US Council of Mayors, Nutter thanked the EPA administrator for "working with local governments to figure out how we can maintain and improve our water systems in a manner that doesn't hurt our most vulnerable citizens," a reference to Philadelphia's commitment to meet EPA requirements through GSI instead of increased investment in grey infrastructure (National League of Cities, 2013). Nutter and EPA staff agreed that the lower initial GSI capital investment could mitigate fee increases for residents, many of whom live in poverty.

PROGRESS UNDER PHILADELPHIA'S GREEN CITY CLEAN WATERS PLAN

By 2016, efforts guided by Philadelphia's *Green City Clean Waters* plan had reduced CSO volume by 600 million gallons per year, with a goal of 7.9 billion gallons reduced by 2036 (City of Philadelphia Office of Sustainability, 2016, 23; Philadelphia Water Department, 2010-2017).

By October 2017, public and private projects under *Green City Clean Waters* had created 1,000 "greened acres," 10.4 percent of the 9,600 acre goal by 2036 (Philadelphia Water Department, 2017c).

Philadelphia's 2009 Greenworks plan was developed under Mayor Michael Nutter with a focus on metrics. It was updated in 2016 under newly elected Mayor Jim Kenney with a greater focus on equitable site selection.

In late 2016, following the election of Mayor Jim Kenney, the Office of Sustainability updated the *Greenworks* plan. While the early plan focused on metrics, the update placed a greater focus on site selection. The Office of Sustainability plans to use the Greenworks Equity Index to determine which neighborhoods have not yet benefited from *Greenworks* initiatives, such as increased access to parks or improved air quality, and to prioritize projects in those neighborhoods (Warren, 2017). One of the plan's eight visions for the city is for all Philadelphians to benefit from increased access to parks, increased tree cover, effective stormwater management, and healthy waterways (City of Philadelphia Office of Sustainability, 2016).

Mayor's Growing Green Initiative (Baltimore)

Baltimore Mayor Stephanie Rawlings-Blake (in office 2010-2016) championed sustainability and vacant lot improvement strategies as part of her focus on safer streets, stronger neighborhoods, and a cleaner, healthier city (Baltimore Department of Planning Office of Sustainability, 2015). Her administration created systems for residents to adopt lots for greening projects and GSI, developed processes for residents to lease publicly-owned lots from the city, and created resources on how to green lots (see chapter 2, section 4). The Office of Sustainability and the Mayor's Office collaborated on the Growing Green

Initiative, which promoted the re-use of vacant lots across the city for green uses, including GSI and urban agriculture (Baltimore Office of Sustainability, 2017b). The Initiative's Growing Green Design Challenge was directed toward reducing stormwater runoff. Launched in May 2014, this program aimed to "use sustainable, innovative, and cost-effective practices for stabilizing and holding land for redevelopment, and reusing vacant land to green neighborhoods, reduce stormwater runoff, grow food, and create community spaces that mitigate the negative impacts of vacant properties and set the stage for growing Baltimore" (Baltimore Office of Sustainability, 2017c). The Challenge encouraged the greening of vacant lots according to the *Green Pattern Book* (Baltimore Department of Planning Office of Sustainability, 2015) and Municipal Separate Storm Sewer System (MS4) requirements for GSI initiatives. Funding for the Challenge came from stormwater fees administered by the Department of Public Works and matching grants from Baltimore's Planning Department and the EPA. Six projects were selected to receive grants of $300,000 each. Three of the projects included GSI. Some of these projects were completed in 2016 (Baltimore City Department of Public Works, 2016).

Instead of continuing the Growing Green Design Challenge under the new mayor, the Department of Public Works and the Mayor's Office opted to contribute to funding two Chesapeake Bay Trust grant programs: the Outreach and Restoration Grant, and Green Streets, Green Jobs, Green Towns (G3) (J. Guillaume, Baltimore Office of Sustainability, phone interview, March 2017). Through the Trust, grants are available for local governments, nonprofit organizations, and neighborhood associations to implement their own plans and projects for stormwater runoff mitigation (Chesapeake Bay Trust, 2017) (see chapter 2, section 5).

Milwaukee Green Team and the Mayor's HOME GR/OWN Initiative

Elected in 2004, Milwaukee Mayor Tom Barrett's effort to understand environmental issues in Milwaukee promoted GSI implementation. He formed a "Green Team" around issues of sustainability. The initial members were eleven appointed environmental, business, and community leaders who developed recommendations related to the condition of local waterbodies, energy efficiency, and green jobs (City of Milwaukee, no date; Dobkin, 2008). The Green Team's 2005 report to the Mayor addressed the costs of relying solely on expensive grey infrastructure solutions to manage stormwater. The report's first objective was to reduce the quantity and improve the quality of stormwater runoff, as dictated by the Wisconsin Department of Natural Resources. Recommendations included implementing GSI strategies such as bioswales (trenches or channels that receive stormwater runoff and have vegetation that slows water for infiltration and filters out pollutants) and rain gardens and enacting a stormwater fee (Milwaukee Green Team, 2005).

Milwaukee mayor Tom Barrett formed a "Green Team" of appointed environmental, business, and community leaders to develop recommendations related to the condition of local waterbodies, energy efficiency, and green jobs.

Another result of the mayor's leadership is the HOME GR/OWN Initiative. This program primarily addresses vacancy and blight. The Initiative, administered by the City's Environmental Collaboration Office, focuses on repurposing vacant lots for urban farms and neighborhood beautification (City of Milwaukee Environmental

Collaboration Office, 2013). Since 2014, HOME GR/OWN has developed 30 pocket parks, orchards, and community gardens on 50 vacant lots. HOME GR/OWN frequently installs GSI as part of its vacant lot reuse projects. Projects that incorporate GSI include:

- **Fondy Park:** In 2017, HOME GROWN completed a neighborhood green space on a formerly vacant lot adjacent to the Fondy Farmers Market. The project includes bioswales, downspout disconnections, rain gardens, and an underground water channel to improve water quality and collect stormwater (Anderegg, 2017). The on-site GSI can store 88,000 gallons of water during a 24-hour rain event (City of Milwaukee Environmental Collaboration Office, 2017).

- **Cream City Farms:** This 1.3-acre urban farm was built on a brownfield site owned by the Redevelopment Authority of the City of Milwaukee. Site contamination was remediated by partial excavation and capping. This process allowed for re-grading to support on-site stormwater management facilities. Cream City Farms has large bioswales and a 40,000 gallon cistern that collects rainwater for irrigation. HOME GR/OWN, the Redevelopment Authority, the EPA, Milwaukee Metropolitan Sewerage District, and stormwater nonprofit organization Reflo collaborated to design and fund the project (City of Milwaukee Environmental Collaboration Office, 2016).

Mayor Byron Brown (Buffalo)

In 2018, Buffalo Mayor Brown advocated for an overhaul of the city's 60-year-old zoning code with a new Green Code that prioritizes GSI for stormwater management.

Elected in 2005, Buffalo Mayor Byron Brown has been a strong supporter of sustainability and GSI in particular. Under his leadership, the city received a $500,000 EPA grant in 2013 through the Great Lakes Restoration Initiative[1] to install GSI along a three-mile section of Niagara Street (Martin, 2014). As of August 2017, this project was in the bidding phase and is anticipated to be one of the largest green streets projects in the country (J. O'Neill, Buffalo Sewer Authority, phone interview, August 2017). The mayor's office also started a rain barrel and downspout disconnection program that provides free rain barrels and installation for city property owners. The Buffalo Sewer Authority expects to release reports on the progress of this program in 2018 (Rain Check Buffalo, 2017; J. O'Neill, August 2017). Mayor Brown has also been recognized for advocating an overhaul of the city's 60-year-old zoning code through the development of a new Green Code in 2018 (see chapter 1, section 4) that prioritizes GSI for stormwater management (Jedlicka, 2015). The mayor emphasizes that the reform is a key component of his place-based economic development strategy to promote investment and create jobs while restoring the environment and improving quality of life for residents (City of Buffalo Mayor's Office, 2015). While Mayor Brown supports GSI for economic development reasons, most of Buffalo's GSI efforts came after the 2012 EPA administrative order and responded to EPA requirements.

[1]The Great Lakes Restoration Initiative, led by the EPA, receives an appropriation to allocate to federal agencies for Great Lakes protection and restoration. Some of the funding provides grants for reducing the volume of untreated urban stormwater runoff (Great Lakes Restoration Initiative, 2017).

B. LEADERSHIP FROM CITY AND COUNTY SEWER DEPARTMENT OFFICIALS

Other municipal and regional leaders have made a difference in facilitating the use of GSI. Usually, the leadership comes from directors of water and sewer departments or new sustainability offices. Their work in changing governance related to GSI is critical to making the use of GSI more widespread.

Director of Office of Watersheds / Water Commissioner Howard Neukrug (Philadelphia)

As director of the Office of Watersheds, Howard Neukrug pushed for the implementation of GSI pilot projects, developed partnerships with city agencies and external organizations, and helped lay the groundwork for Mayor Nutter's commitment to prioritizing GSI (see chapter 1, section 1a). Neukrug went on to serve as Philadelphia Water Department (PWD) Commissioner from 2011 through 2016, advocating for the use of GSI throughout his tenure. He restructured PWD so that GSI-related activities were coordinated under one division, which has streamlined project coordination and made the department more effective in implementing GSI (see chapter 1, section 2) (Madden, 2010).

Milwaukee Metropolitan Sewerage District (MMSD) Director Kevin Shafer

Kevin Shafer, Executive Director of the MMSD since 2002, led the expansion of regional GSI efforts to include businesses, schools, parks, and real estate development projects. Under Shafer's leadership, Milwaukee was the first city nationally to have a GSI requirement in its National Pollutant Discharge Elimination System (NPDES) permit (Nusser, 2015). Shafer also spearheaded the creation of MMSD's Vision 2035 (Behm, 2014), which set regional goals for eliminating sewer overflows and basement backups and for collecting the first half-inch of rainfall with GSI by 2035 (Milwaukee Metropolitan Sewerage District, 2010a).

Milwaukee Metropolitan Sewerage District's Vision 2035 sets regional goals for eliminating sewer overflows and basement backups and for collecting the first half-inch of rainfall with GSI by 2035.

To encourage governance changes that could facilitate GSI, Shafer developed partnerships with municipal agencies, nonprofit organizations, and residents (Utility Infrastructure Management, 2015). He played an important role in creating the Southeast Wisconsin Watersheds Trust, a regional organization that encourages collaboration for stormwater management among diverse stakeholders (see chapter 2, section 5). The MMSD often collaborates with the City of Milwaukee's Department of Public Works on GSI projects (Nusser, 2015).

General Manager of DC Water and Sewer Authority George Hawkins (Washington, DC)

George Hawkins was General Manager of the DC Water and Sewer Authority (DC Water) from 2009 to 2017. Hawkins previously served as the head of the District Department of Energy & Environment where he began using GSI to manage polluted runoff. His tenure in leading DC Water included innovative efforts to support GSI implementation. In 2014, Hawkins announced a $100 million investment in GSI by DC Water (District of Columbia Water and Sewer Authority, 2014; Farr, 2017; Pipkin, 2017). Hawkins led efforts to evaluate the effectiveness of GSI in managing stormwater and providing economic and social benefits. Some

In 2016, DC Water issued a 30-year tax-exempt Environmental Impact Bond to finance GSI installations. The bond includes a payment after five years either to DC Water by investors or to investors by DC Water, depending on GSI performance.

of these studies demonstrated that GSI could be an effective and more affordable solution to flooding and CSOs than expanding grey infrastructure (District of Columbia Water and Sewer Authority, 2015; Hawkins, 2015). Hawkins played an important role in negotiating the 2016 revision to the EPA consent decree, which allows GSI installations in place of some of the District's planned sewerage tunnel expansions (Brainard, 2016; Farr, 2017). Under Hawkins's leadership, DC Water issued an Environmental Impact Bond to finance GSI installations in 2016. The bond is a 30-year tax-exempt municipal bond with a payment after five years either to DC Water by investors or to the investors by DC Water. The payment depends on GSI performance in reducing runoff. DC Water uses bond proceeds to pay installation costs, while performance risks are absorbed by both the public agency and private investors (Farr, 2017; US Environmental Protection Agency, 2017).

2. REORGANIZATION OF WATER AND SEWER DEPARTMENTS

Implementing GSI involves different roles and different kinds of work than building grey infrastructure. It therefore requires adjustments to water and sewer departments' organization and processes to facilitate new ways of working. Philadelphia provides an example.

Philadelphia Water Department's Green Stormwater Infrastructure office now leads all project-related programs addressing Long-Term Control Plan compliance and helps foster interdepartmental coordination.

Restructuring the Philadelphia Water Department (Philadelphia)

In 1998, the Philadelphia Water Department (PWD) was drafting its first Long-Term Control Plan (LTCP), an EPA requirement to address CSOs. PWD's then-Director of Planning and Technical Services Howard Neukrug raised concerns about insufficient coordination between departments to address EPA demands. Neukrug fostered internal support for a new department that would integrate source water protection and wastewater management. In January 1999, Commissioner Kumar Kishinchand approved the combination of three departments - Combined Sewer Overflow, Stormwater Management, and Source Water Protection - into the Office of Watersheds with Neukrug as its director (see chapter 1, section 1b) (Madden, 2010). The Office of Watersheds encouraged the use of GSI as part of a holistic approach to stormwater management and initiated the construction of PWD's early GSI projects (Madden, 2010).

After PWD's publication of the Green City Clean Waters stormwater management plan in 2011, the Office of Watersheds itself was reorganized, placing all project-related programs addressing LTCP compliance under one lead, the Green Stormwater Infrastructure office. This has helped foster interdepartmental coordination for implementing GSI. In 2017, the office was organized as follows:

- **Office of Watersheds:** Monitors LTCP compliance and houses three sub-units-Source Water, Stream Restoration, and Modeling.

- **Green Stormwater Infrastructure**: Identifies projects, coordinates with external partner organizations, pilots a variety of project types, and

coordinates design and construction oversight to meet compliance with the LTCP. This division's four units are:

- *Design:* Designs PWD GSI projects and ensures that planned projects comply with EPA stormwater regulations for design, monitoring, and inspection.

- *Planning:* Plans GSI using the Planning Study Area Analysis process to locate GSI strategically (see chapter 1, section 6). Within Planning, a Strategic Partnership group coordinates external partner organizations to support implementation of GSI on public property.

- *Stormwater Plan Review:* Facilitates timely stormwater plan review, required for private developments that disturb more than 15,000 square feet of earth. The process ensures compliance with city stormwater regulations, including managing the first 1.5 inches of rainwater on-site and completing Post Construction Stormwater Maintenance Plans (Philadelphia Water Department, 2016a).

- Incentives: Manages parcel-based billing and the implementation of credits and appeals programs for property owners who reduce runoff from their properties (J. Noon, Philadelphia Water Department, email communication, August 2017).

3. INTERDEPARTMENTAL COORDINATION

Implementing GSI involves coordination among many city departments. The water and sewer department overseeing the GSI installation may need to collaborate with planning, public works, parks, community development, and building departments as well as with land banks or other departments responsible for holding city-owned land. Coordination, often requiring new relationships and connections between departments, may be an unfamiliar way of operating for the departments involved. Several cities have worked on procedures to address this issue. Philadelphia and New Orleans are two of these.

Two types of interdepartmental coordination are most common: 1) connecting GSI installation to street reconstruction and 2) establishing offices of sustainability that advocate for approaches to improve environmental sustainability including GSI.

Two types of interdepartmental project coordination are most common: 1) connecting GSI installation to street reconstruction and 2) establishing offices of sustainability that advocate for approaches to improve environmental sustainability including GSI. A third approach, connecting GSI installation to ldemolition, is newer and still unusual. Following are examples of how some llegacy cities achieved coordination:

Memoranda of understanding (Philadelphia)

Philadelphia has used interdepartmental memoranda of understanding (MOUs) to coordinate work between city departments. The Philadelphia Water Department (PWD) works with numerous city departments and agencies to

implement GSI projects. Generally, PWD first implements a joint pilot project with a partner agency, and eventually both parties sign an MOU that transfers land use, construction, and maintenance responsibilities to PWD. These MOUs have helped to establish a partnership model that facilitates future joint projects (Philadelphia Water Department, 2011b).

As of August 2017, MOUs existed between PWD and the Streets Department, the Southeastern Pennsylvania Transportation Authority, the Philadelphia Redevelopment Authority, and the Philadelphia Land Bank. PWD also has an MOU template for establishing GSI on city-owned vacant lots under Department of Public Property jurisdiction, and is developing an MOU with Parks and Recreation.

As PWD has become more familiar with MOUs, it has modified the approach. The department found that working closely and having regular meetings with partner departments could be more fruitful than the longer legal process of creating an MOU. As a result, PWD has transitioned to using MOUs only in specific situations, as when maintenance procedures and guidelines are part of an agreement (J. Noon, Philadelphia Water Department, email communication, August 2017, and phone interview, December 2017) (see chapter 2 for more on agreements with nonprofit organizations and other non-governmental entities).

Resilience Design Review Committee (New Orleans)

New Orleans created an interdepartmental committee to coordinate GSI work. In 2016, the city received a grant from the US Department of Housing and Urban Development's National Disaster Resilience Competition (NDRC) for GSI projects to reduce major flooding. The Mayor's Office of Resilience and Sustainability and the Resilience Design Review Committee (RDRC) manage the grant (City of New Orleans, 2017a). The RDRC includes representatives from key agencies (Sewerage & Water Board of New Orleans, Planning Commission, Capital Projects Administration, and Department of Parks and Parkways) and reviews all construction projects using NDRC funds and all projects of any type that have stormwater management and GSI components (City of New Orleans, 2017b). RDRC reviews projects from an inter-agency perspective to ensure they meet the city's GSI and sustainability goals and are compliant with the *Resilient New Orleans* plan - a long-term plan outlining strategies for dealing with threats to the city from climate change. Projects are reviewed at the 30, 60, and 90 percent completion marks to ensure compliance during construction.

A. COORDINATING WITH STREET PROJECTS

Major street repair or reconstruction can offer an opportunity to coordinate with GSI installation. "Green streets" programs that include stormwater management depend on this type of coordination. Such "green streets" use GSI to capture and filter stormwater runoff from the street before it enters a sewer or a local waterway (Lukes & Kloss, 2008).[2] Examples from Philadelphia, Buffalo, and Washington, DC, follow.

Green Streets (Philadelphia)

The Philadelphia Water Department (PWD) has partnered with the Streets Department through the Green Streets program to couple GSI and street tree installation with street repair projects. The program uses a variety of GSI approaches including tree trenches, stormwater planters, planted bump-outs, and pervious pavement to capture runoff from streets and sidewalks. A number of plans and tools facilitate Green Streets projects:

- *Greenworks,* the city's sustainability plan (see chapter 1, section 1b), sets goals for the creation of green streets and sidewalks. The Office of Sustainability works with the Streets Department, PWD, and Parks and Recreation to coordinate the installation of GSI during street construction.

- PWD works with the Streets Department through an established Memorandum of Understanding (MOU) to coordinate GSI installation with street construction projects. PWD has also developed partnerships and MOUs with the Pennsylvania Department of Transportation and the Southeastern Pennsylvania Transportation Authority to facilitate Green Streets projects (see chapter 1, section 3).

PWD completed over 200 Green Streets projects by 2016, managing stormwater from 136 acres of impervious surface with $25.2 million of PWD funds. Green Streets projects completed since 2006 can store nearly 540,000 cubic feet of stormwater.

Figure 4. The Philadelphia Water Department has worked with transportation and public works departments to install GSI as part of Green Streets projects.

SOURCE: PHILADELPHIA WATER DEPARTMENT, 2018.

[2] The Federal Highway Administration and Metropolitan Planning Organizations fund roadway design, construction, and maintenance; some of these funds are designated for drainage from roadways and can be used for GSI (Federal Highway Administration, no date).

- In 2014, PWD released a *Green Streets Design Manual* to provide design standards that promote GSI as a stormwater management strategy (Philadelphia Water Department, 2014a).

- The Guaranteed Pavement Information System (GPIS) is an online system that helps departments coordinate utility work that affects the right-of-way, including GSI projects (see chapter 1, section 7).

By the end of 2016, PWD had completed over 200 Green Streets projects, managing stormwater from 136 acres of impervious surface at a cost to PWD of $25.2 million (City of Philadelphia Office of Sustainability, 2016). Green Streets projects completed since 2006 have a total storage capacity of nearly 540,000 cubic feet of stormwater; 209 additional Green Streets projects are in design or construction, to be completed by 2019 (Philadelphia Water Department, 2010-2017: 2016 report).

Buffalo's GI Master Plan identified five demonstration projects to capture runoff from 7.9 acres of streets. Completed in 2012, they are maintained by the Department of Public Works. Post-construction monitoring was conducted over a two-year period.

Complete Streets (Buffalo)

The Buffalo Sewer Authority (BSA) focused on green streets as a primary strategy for Phase I of the Green Infrastructure Master Plan, to be implemented from 2011 through 2018. This program incorporates many elements of the city's 2008 Complete Streets ordinance, which emphasizes safe access for pedestrians, bicyclists, motorists, and transit riders. Because many streets projects already had the commitment of local, state, and/or federal funding, BSA was able to piggyback on this investment to install GSI (Buffalo Sewer Authority, 2014). Major streets projects included the following:

- The GI Master Plan identified five demonstration projects in partnership with the nonprofit organization Buffalo Niagara Waterkeeper (formerly Riverkeeper) to capture runoff from 7.9 acres of streets. These projects use a combination of porous asphalt, rain garden cutouts, and bioretention planters and are maintained by the Department of Public Works (DPW) (Buffalo Sewer Authority, 2014). The program was funded in part by a $750,000 grant from the New York State Green Innovation Grant Program (New York State Environmental Facilities Corporation, 2010). The projects were completed in 2012, and BSA conducted post-construction monitoring on the performance of these sites over a two-year period. BSA expects to issue an official progress report in 2018.
- BSA worked with the DPW on the Fillmore Avenue Streetscape project, which incorporated GSI into both streetscaping and the redevelopment of three city-owned vacant lots. BSA also completed three other major projects in 2013 that involved full street reconstruction and incorporated porous asphalt, pedestrian bump-outs, and new drainage structures (Buffalo Sewer Authority, 2014).

District Department of Transportation's (DDOT) Green Infrastructure Standards (Washington, D.C.)

In 2013, the District Department of Energy & Environment (DOEE) revised its stormwater management regulations to help meet GSI retrofit requirements in

the MS4 permit (Brainard, 2016). Revisions included requirements for on-site stormwater retention for major construction projects, including those in the public right-of-way. This encourages infiltration in areas with high degrees of imperviousness. In response to these changes, in 2014, DDOT developed GSI standards to satisfy the requirements of DOEE stormwater regulations. Some important considerations in complying with DOEE requirements for streets projects include:

1. DDOT must submit a stormwater management plan for review by DOEE

2. Projects must adhere to DOEE requirements for GSI maintenance

3. Projects must be designed to preserve public safety and to avoid disturbing utility lines (District Department of Transportation, 2014a).

DDOT published its Green Infrastructure Standards and the "Greening DC Streets" guidebook to help inform GSI installation in public works projects. These documents provide recommendations, designs, and specifications for various streetscape installations (District Department of Transportation 2014a; District Department of Transportation 2014b). *Green Infrastructure Standards* acts as a detailed and technical supplement to DDOT's *Design and Engineering Manual*. It highlights important stormwater management requirements, as well as design, legal, topographic, hydrologic, drainage, and traffic concerns (District Department of Transportation, 2014a).

DDOT has installed GSI in streets, parking lanes, tree boxes, sidewalks, and public parking lots. DDOT is responsible for the maintenance of publicly installed GSI (District Department of Transportation, 2014b). From 2012 to 2016, DDOT retrofitted 30 acres of impervious surface in the public right-of-way (District Department of Energy & Environment, 2017a). For some installations, DDOT has partnered with other public agencies, such as DC Water and DOEE, or with business improvement districts, nonprofit organizations, and private developers. These projects have included bioretention basins and bump-outs, permeable pavement, bioswales, and stormwater planters (District Department of Transportation, 2013).

DC's District Department of Transportation is responsible for maintaining publicly installed GSI.

One of the major city programs for public right-of-way GSI retrofits is RiverSmart Washington, which combines stormwater management with infrastructure improvements. Administered primarily by the DOEE, RiverSmart has installed pilot GSI projects in the Rock Creek Watershed, with the potential for expanding into other neighborhoods if deemed successful. DOEE completed project planning and neighborhood outreach with the Rock Creek Conservancy, a local environmental nonprofit organization. As a part of this program, DDOT has installed bioretention basins, rain gardens, permeable pavement, and tree boxes on streets, sidewalks, and alleys. Funding for RiverSmart Washington comes from the National Fish and Wildlife Foundation,[3] DDOT, and DC Water (Rock Creek Conservancy, 2013).

[3] The National Fish and Wildlife Foundation makes grants for "projects that sustain, restore, and enhance our nation's fish, wildlife, and plants and their habitats" (National Fish and Wildlife Foundation, 2018).

B. CREATING AN ENVIRONMENTAL AFFAIRS OR SUSTAINABILITY OFFICE

Several cities have created a municipal department of environmental sustainability. Sustainability offices often work with other city agencies to facilitate GSI and with nonprofit organizations wishing to undertake their own GSI projects.

Office of Sustainability (Baltimore)

Baltimore's Office of Sustainability, a division of the Department of Planning, is charged with coordinating interdepartmental efforts to achieve goals in the *Baltimore Sustainability Plan*. The office defines sustainability as "meeting the environmental, social, and economic needs of Baltimore without compromising the ability of future generations to meet these needs" (Baltimore Office of Sustainability, 2017a). The office leads initiatives focused on improving food access, greening vacant spaces, and adapting to climate change. It managed the Growing Green Initiative that sponsored the greening of vacant lots, some incorporating the installation of GSI. In 2017 and 2018, the office updated the *Sustainability Plan* to reflect changing priorities, including a specific section on GSI implementation (J. Guillaume, Baltimore Office of Sustainability, phone interview, March 2017).

Office of Sustainability (Philadelphia)

Mayor Michael Nutter established Philadelphia's Office of Sustainability in 2008 to implement *Greenworks*, the city's comprehensive sustainability plan, which set specific sustainability goals to be achieved by 2015 (see chapter 1, section 1a). In 2014, the Philadelphia City Council approved an amendment to the city charter to make the Office of Sustainability permanent, and Philadelphia voters approved the amendment in November 2014 (Hancher, 2014). Under the leadership of former Director Katherine Gajewski, the city exceeded its stormwater management goal of 500 "greened acres" by 2015 (Freeh and Wu, 2015) (see Table 1 for a definition of "greened acres"). By the end of October 2017, Philadelphia had greened 1,000 acres (Rademaekers, 2017b). An updated *Greenworks* plan released in 2016 aligned targets for GSI with the Philadelphia Water Department's *Green City Clean Waters* plan and emphasized that all Philadelphians should benefit from stormwater management that creates and enhances green spaces (City of Philadelphia Office of Sustainability, 2016). While both the mayor and the director of the Office of Sustainability are new, the commitment to sustainability goals sets a strong precedent for support of GSI initiatives moving forward.

C. CONNECTING GSI INSTALLATION TO DEMOLITION

Thus far, few cities have found ways to connect the complicated requirements for demolition to the still-evolving processes for installing GSI, but Buffalo and Gary offer examples of connected practices that may lead to efficiencies in the future.

Specifications for reducing stormwater runoff following demolition (Buffalo)

The Buffalo Department of Public Works (DPW) has a well-developed demolition program funded through state and federal grants, the city capital fund, and DPW's general operating fund. The Buffalo Sewer Authority (BSA) connected with this program to reduce stormwater runoff from vacant lots. In 2013, the BSA partnered with the Office of Strategic Planning, the Office of Permits and Inspections, and DPW to pilot an alternative demolition finishing process on ten scheduled demolition sites. The pilot sites were selected by their location within a priority sewershed to reduce impervious surface and CSOs. The goals of the program were to reduce maintenance costs associated with mowing on-site vegetation and to reduce stormwater runoff compared to traditional demolition methods, which involved backfilling with clay soil and grading towards sidewalks to minimize runoff to adjacent properties (Buffalo Sewer Authority, 2014). BSA revised DPW's demolition specifications, using the EPA's draft green demolition specifications as a model, and adopted EPA's recommendations for soil, planting and site grading (Furio et al., 2013). At the pilot sites, demolition contractors prepared soils at four inches below grade with close to zero percent slope and raked to remove stones and debris. BSA then contracted for landscaping services to:

1. Remove remaining debris
2. Fill to grade with a mix of 50 percent sand, 25 percent topsoil, and 25 percent compost
3. Grade to minimize off-site flow
4. Seed with low or no-mow, deep-rooted, grass seed mixture
5. Maintain the site for 18 months with regular mowing

The estimated cost for this treatment was $2,000 for a typical 30 by 100 foot lot, which was added to demolition costs (Buffalo Sewer Authority, 2014). The Department of Permits and Inspections inspected these projects after initial demolition, and BSA re-inspected them after grading and planting (J. O'Neill, Green Program Director, phone interview, August 2017). Thus far, BSA has not integrated landscape design into the process.

By August 2017, BSA had completed the pilot program and preliminary evidence showed reduced runoff from the sites. A challenge in some cases was the timing of seeding; because site work followed demolition schedules, seeding often occurred when grass had to compete with weeds. A report on the program's outcomes is expected by the end of 2018. Assuming the report will show a reduction in stormwater runoff and maintenance costs, Buffalo's Green Stormwater Master Plan calls for more demolitions using these practices through 2018 (Buffalo Sewer Authority, 2014). The pace of demolitions has slowed citywide, however, which may affect this component of the plan (J. O'Neill, Green Program Director, phone interview, August 2017).

Few cities have found ways to connect demolition requirements to GSI installation, but Buffalo and Gary offer examples of connected practices that may lead to efficiencies in the future.

Supported by the Great Lakes Restoration Initiative, the Cleveland Botanical Garden formed partnerships in Gary, Buffalo, and Cleveland to explore the use of vacant lots for GSI installation

Vacant to Vibrant Initiative (Gary)

Using funds from the Great Lakes Restoration Initiative,[4] the Great Lakes Protection Fund made a grant to the Cleveland Botanical Garden to study regional ecological health. In 2010, the Botanical Garden staff began the Vacant to Vibrant Initiative to address stormwater management as a key environmental issue (S. Albro, Cleveland Botanical Garden, interview, September 2017). The Cleveland Botanical Garden formed partnerships in Gary, Indiana; Buffalo, New York; and Cleveland, Ohio, to explore the use of vacant lots for GSI installation.

In Gary, the city's Department of Green Urbanism and Department of Redevelopment and the Stormwater Management District (a separate entity) worked with the Cleveland Botanical Garden to complete demonstration projects that transformed vacant, blighted land into GSI (Cleveland Botanical Garden, 2014a). The initiative installed bioretention, rain gardens, berms, and trees on three residential lots in the Aetna neighborhood, one that had long been vacant and two others that were cleared just prior to GSI installation (Mackin, 2015). The latter two sites used federal Hardest Hit funding[5] to pay for demolition costs and two to three years of site maintenance. City officials chose sites near the Northside neighborhood, which had benefited from other stabilization efforts (B. Scott-Henry, City of Gary Department of Green Urbanism and Environmental Affairs, phone interview, September 2017).

4. REVISIONS TO CODES

The requirements of city codes often increase impervious area or interfere with the installation of GSI and therefore need revision (Wisconsin Sea Grant, 2017). For example, city codes that require a minimum number of off-street parking spaces per unit of a multifamily structure can result in large paved surfaces that drain directly to grey infrastructure if GSI is not employed. Numerous legacy cities have developed requirements for stormwater management when development or redevelopment occurs, but extensive revision of codes to enable widespread GSI or to preserve vacant or undeveloped land for GSI is less common. Buffalo and Milwaukee offer promising examples of code revisions that may facilitate the implementation of GSI, although the regulations apply mainly to sites where development occurs and do not offer much guidance for the use of vacant land for GSI.

Buffalo Green Code

In January 2017, Buffalo adopted a "Green Code," a new unified development code that prioritizes sustainability. The Green Code is form-based, a type of land use regulation organized by physical form rather than by use. It builds on the

[4] See note 1 regarding the Great Lakes Restoration Initiative.

[5] President Obama established the Hardest Hit Fund in 2010 to provide mortgage foreclosure prevention solutions in areas with steep home price declines and high unemployment rates. In some states, Hardest Hit Funds could be used for demolition of blighted houses and maintenance of lots following the demolition (US Department of the Treasury, 2018).

Figure 5. Cleveland Botanical Garden's Vacant to Vibrant program coordinated with demolitions to install GSI on neighborhood lots in Gary. Shown here is a project at 1200 Oklahoma Street.

SOURCE: CLEVELAND BOTANICAL GARDEN, 2014B

sustainability principle outlined in Buffalo's comprehensive plan, *Queen City in the 21st Century,* and prioritizes GSI for stormwater management. A citizen's advisory committee, a technical advisory committee, and a consultant team assisted with preparing the Green Code (Office of Strategic Planning, 2016b). The Green Code applies to all land uses and governs the alteration or construction of all structures and changes in land use across the city. Property owners can apply for variances that allow exceptions to the Code, but generally, all land uses and structures must comply with the standards in the Green Code (Office of Strategic Planning, 2016b).

Buffalo's land use plan reserves substantial areas of vacant land. New land use policies allow interim and permanent reuse for vacant land, including for stormwater management.

The Green Code specifies guidelines for implementing stormwater best management practices (BMPs) that conserve natural areas, promote on-site stormwater infiltration, and capture and reuse runoff. It specifies a hierarchy of preference based on type of stormwater management, with discharge to combined sewers as the last resort. If BMPs are not feasible on a particular site, off-site GSI installations within the sewershed may be allowed on a case-by-case basis, although, as of August 2017, no developers had taken advantage of this clause (Office of Strategic Planning, 2016b; J. O'Neill, Green Program Director, phone interview, August 2017).

The city's comprehensive land use plan informs the implementation of the code and guides the city's physical development. The land use plan indicates that substantial areas of publicly held vacant land will remain vacant as new development is directed to areas with the strongest growth potential. The plan also highlights new land use policies that allow interim and permanent reuse for vacant land, including for stormwater management. For areas slated for redevelopment, land use policies include compact, mixed-use development, reduction of impervious areas and building footprints, street-oriented development, removal of minimum parking requirements, use of innovative paving materials, and on-site stormwater management for large projects. The plan also creates districts zoned specifically for open space (Office of Strategic Planning, 2016a). These districts are primarily located along the Niagara riverfront, however, and do not overlap with areas of highest residential vacancy where vacant land could potentially be adapted for GSI.

Comprehensive amendments to codes (Milwaukee)

In a regional audit of 28 municipalities' local codes, the City of Milwaukee was the only municipality to implement comprehensive amendments to its code to enable GSI installation.

In 2005, the Milwaukee Metropolitan Sewerage District (MMSD) established a stormwater ordinance review committee to audit local codes for runoff reduction BMPs. The City of Milwaukee participated in this audit. The review pointed to Milwaukee's poor performance compared to other cities in the MMSD service area with regard to rules and policies that would enable stormwater runoff reduction interventions.

The City of Milwaukee responded to the audit's recommendations and has made progress in amending its code to allow GSI installations. For example, in 2007, city officials revised the "Plumbing and Drainage" chapter of the code to allow downspout disconnections on non-residential structures so that stormwater runoff

from roofs did not go directly into the sewers (Milwaukee Metropolitan Sewerage District, 2007a). In 2017, city elected officials passed an ordinance to allow permeable pavement systems in lieu of catch basins to manage stormwater in parking lots, thus enlarging the area that infiltrates or retains stormwater (E. Shambarger, Environmental Collaboration Office, phone interview, October 2017).

Milwaukee has made noteworthy progress in revising its code to encourage GSI implementation. In 2016, an environmental nonprofit organization, 1,000 Friends of Wisconsin, led a regional audit of local codes that presented barriers to GSI. The audit found that, of all 28 municipalities in the MMSD service area, the City of Milwaukee was the only one to implement comprehensive amendments to its code to enable GSI installation. In addition, the audit found that the city is a regional leader in permeable pavement installation (1,000 Friends of Wisconsin, 2014).

5. SYSTEMS FOR SITE PLAN APPROVALS, PERMITS, AND INSPECTIONS

City systems for site plan approvals, permits, and site and building inspections are not necessarily applicable to the installation of GSI. Stormwater management ordinances often neglect to establish procedures for installing of GSI on vacant lots with no new development, a common issue for legacy cities.

GSI often involves excavation, grading, modification of sewers, and installation of soil medium and plants to absorb water (Wible, McDaniels, & Rominger, 2014). Miscalculations and oversights in installation could have implications for localized flooding or early deterioration of new sewers. Design and installation of GSI benefit from clear standards for approvals, permits, and inspections. Although none of the cities we studied provided such an example for GSI on vacant land, Philadelphia has created a stormwater plan review process that could potentially be adapted for this purpose.

Stormwater Plan Review (Philadelphia)

Philadelphia has a well-developed, clear process for approval of GSI installation in connection with development, although no specific process exists for GSI projects on vacant land. Stormwater Plan Review (SPR) is a unit within the Philadelphia Water Department (PWD) that reviews projects that disturb more than 15,000 square feet of earth for compliance with stormwater management regulations. The unit was created in 2011 as part of the restructuring of PWD (see chapter 1, section 2). Applicants must receive an SPR permit before proceeding to a zoning or building permit. Applications include site photographs, existing conditions, and a conceptual review phase submission package. Depending on the project, SPR may include a conceptual review, an erosion and sediment control review, and a post-construction stormwater management plan review. PWD completes post-construction inspections. The SPR process provides an opportunity for a five-day expedited review for projects that will be 95 percent disconnected from the sewer system (Philadelphia Water Department, 2015b).

PWD uses inspections to verify which completed projects can be counted towards the city's "greened acre" total (see Table 1 for a definition of "greened acres"). Newly constructed projects submit drawings of as-built conditions. By 2016, 115 projects managing stormwater from 157 acres had been inspected and verified (Philadelphia Water Department, 2010-2017).

6. A PLAN FOR LOCATING GSI

Philadelphia introduced ways to develop detailed plans for locating GSI within the broad geography of priority areas.

The plans that water and sewer departments prepare in connection with permits or consent agreements generally prioritize large areas for GSI. Such plans offer little detail about how to select appropriate locations within selected sewersheds. Philadelphia introduced ways to develop detailed plans within the broad geography of priority areas.

Planning Study Area Analysis (Philadelphia)

The Philadelphia Water Department (PWD) significantly revised its GSI planning approach between 2011 and 2016, shifting away from planning by land use or partner type to a geographic approach. PWD created four stormwater districts,

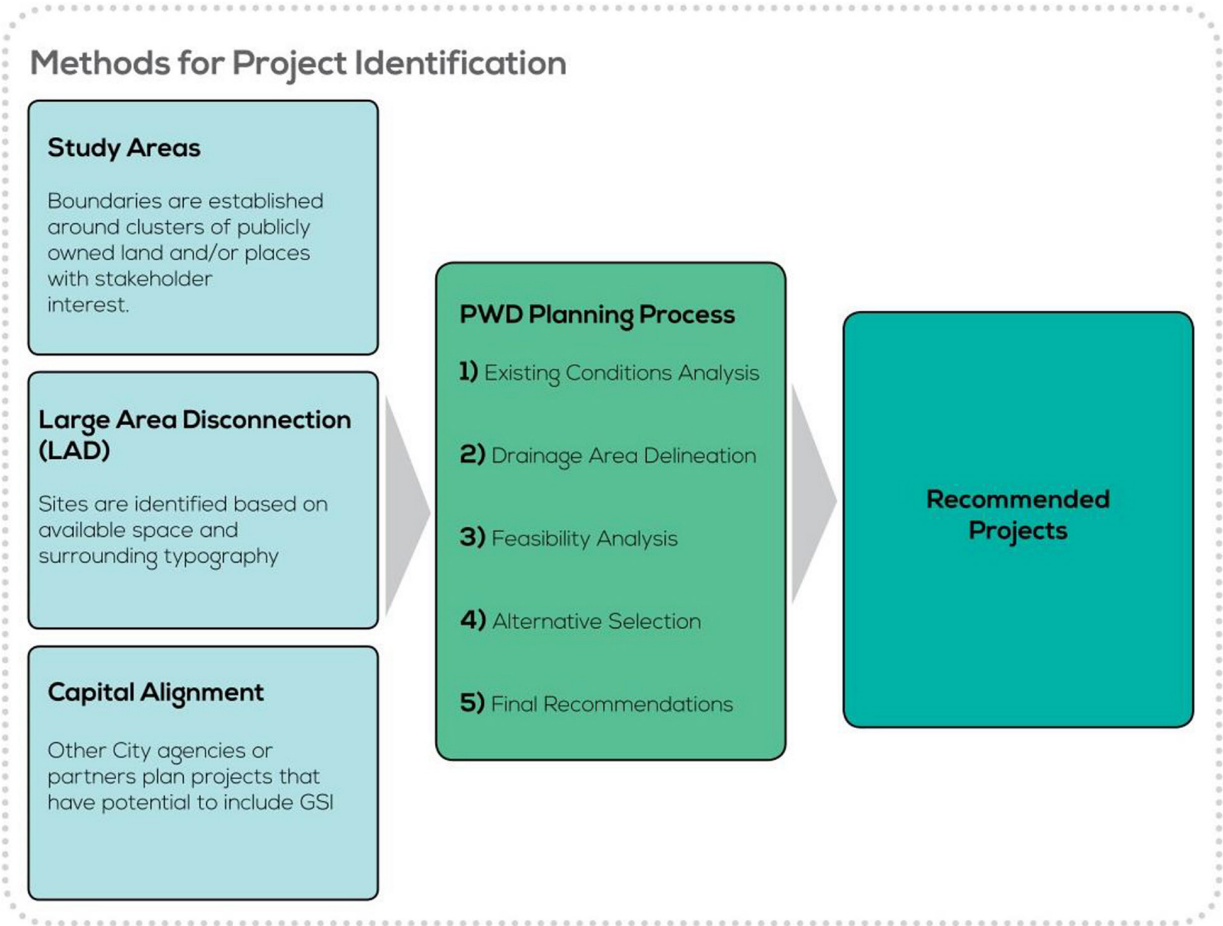

Figure 6. The Philadelphia Water Department creates plans for small areas of the city to help identify GSI projects that can manage stormwater from streets.

SOURCE: PHILADELPHIA WATER DEPARTMENT, 2010-2017, REPORT FOR 2016, FIGURE 3.1.

each with a multidisciplinary planning staff, and delineated them further into small planning study areas. PWD analyzes every street in a planning study area to look for ways stormwater runoff can be kept out of the sewers. PWD works with consultants to conduct study area analyses to identify potential GSI projects. The process uses geographic information systems to analyze existing conditions, drainage area delineation, and stormwater management potential for particular sites (Philadelphia Water Department 2016a). Figure 6 illustrates the approach.

This approach has helped connect neighborhood groups with leaders of PWD and has increased coordination and cost sharing within geographies. PWD and Planning Commission staff are involved in the same meetings for specific areas (J. Noon, Philadelphia Water Department, phone interview, December 2017). PWD also identifies opportunities for coordination with Philadelphia Parks and Recreation (Philadelphia Water Department, 2016a).

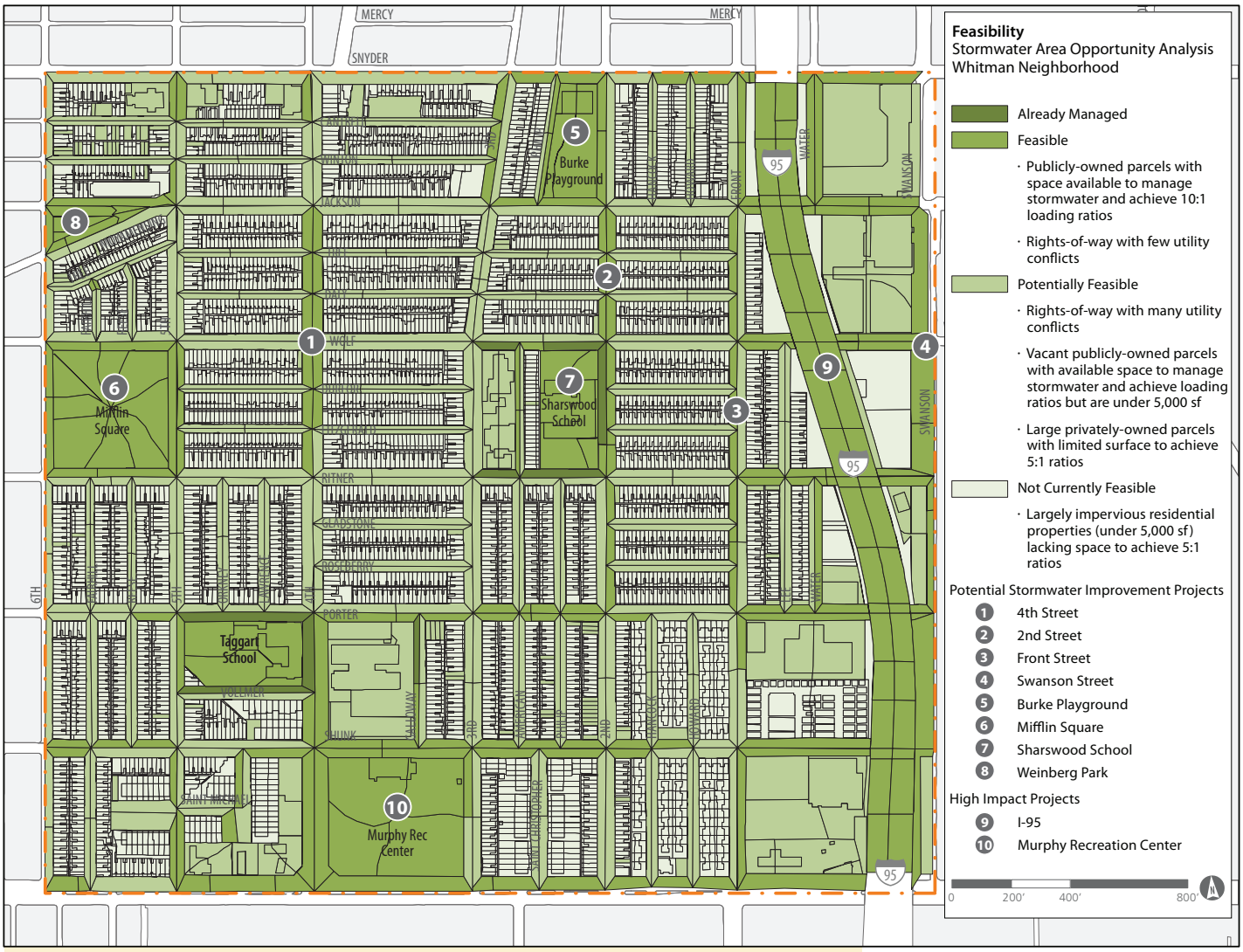

Figure 7. Philadelphia's Study Area Analysis results in a small area plan for diverting stormwater from streets to GSI.

SOURCE: WRT, F.X. BROWNE, AND RODRIGUEZ CONSULTING, 2014.

The Whitman Neighborhood Area of Opportunity Analysis (Figure 7) is an example of a Planning Study Area Analysis that PWD used to inform future GSI projects. The report mapped property ownership; environmental conditions such as topography, ground cover, and surface water flow; the location of utilities; stormwater management initiatives already planned; and travel routes and activity hubs. The report also analyzed drainage and considered the feasibility of managing drainage areas with GSI based on space available for receiving stormwater, utility conflicts, fragmentation of ownership, and cost effectiveness (determined by PWD to mean that a project can manage stormwater from at least an area of 5000 square feet, about .115 acres). Based on this analysis, the report identified potential projects on publicly owned sites and in the right-of-way that could serve a large, unmanaged drainage area (WRT, F.X. Browne, and Rodriguez Consulting, 2014).

7. USE OF INFORMATION SYSTEMS

GSI siting and design require different types of information and information sharing than grey infrastructure. Some cities have instituted site assessment and project management information systems to address these needs.

GSI siting and design require different types of information and information sharing than does grey infrastructure planning. Philadelphia, Gary, and Baltimore have instituted site assessment and project management information systems to address these needs.

Guaranteed Pavement Information System (Philadelphia)

Projects affecting the right-of-way require a Guaranteed Pavement Information System (GPIS) permit from the city of Philadelphia prior to construction. GPIS is a web-based application that supports the coordination of utility work for all projects. It indicates time conflicts (start and end dates) and helps agencies coordinate and minimize degradation fees (fees charged for infringement on right-of-way during construction). The Office of Watersheds manages information from the GreenIT database to track GSI project metrics such as "greened acres," drainage area, and stormwater management practice type. This information is integrated with GPIS (Philadelphia Water Department, 2015a).

Data collection and analytics (Gary)

Dynamo Metrics (a data analysis firm) and the Delta Institute (a nonprofit environmental consulting firm) developed the Gary Green Infrastructure Tool (GGIT) to analyze land in the city for reuse as GSI (Dynamo Metrics & Delta Institute, 2017). This tool identifies sites with high potential for GSI and allows users to search for suitable GSI locations using three different indices: conservation, beautification, and stormwater management. Each index uses different criteria to evaluate the suitability of a property for a given type of GSI. Community and conservation organizations and city and sanitary district staff chose the criteria (M. Brown, Delta Institute, phone interview, November 2017). The "Stormwater Index" provides a score between 1 and 100 for each property based on flooding, imperviousness, soil drainage, and proximity to tax delinquent or publicly owned properties. A site's score is determined by its "readiness" (public or private ownership and presence of structures) and index-specific

variables. A higher score indicates stronger potential for use for GSI. City officials use spatial data from the GGIT to develop plans for GSI implementation that take location, condition, and feasibility of the site into account (B. Scott-Henry, City of Gary Department of Green Urbanism and Environmental Affairs, phone interview, September 2017). This expands the GGIT analysis of specific sites to the development of GSI plans for larger areas of the city (see chapter 1, section 6).

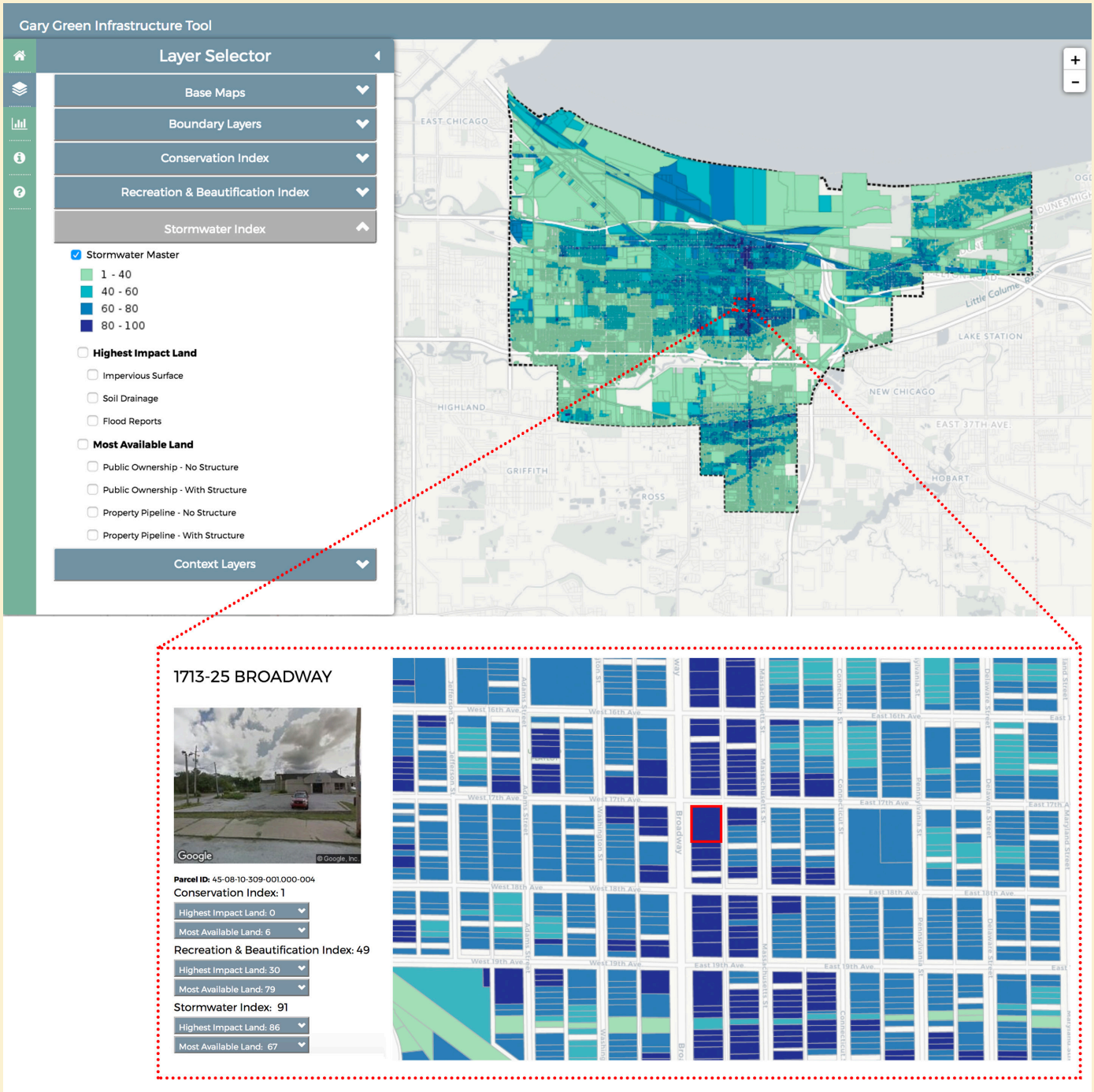

Figure 8. The Gary Green Infrastructure Tool allows anyone to see how a specific property ranks as desirable for GSI.

SOURCE: DYNAMO METRICS & DELTA INSTITUTE, 2017.

Vacant Lot Opportunities Analyst (Baltimore)

Created by the Chesapeake Conservancy, a statewide nonprofit organization, the Vacant Lot Opportunities Analyst is a geographic information system tool that allows city employees to search for vacant, city-owned parcels suitable for implementing GSI (Chesapeake Conservancy, 2015). Users can search for parcels with specific criteria such as size, tree coverage, and slope. The criteria in the *Green Pattern Book* help identify lots that are suitable for a specific green use (Baltimore Department of Planning Office of Sustainability, 2015). Ideal lots for GSI are greater than 0.125 acres and surrounded by properties with more than 25 percent impervious surface (Chesapeake Conservancy, 2015). Baltimore's Office of Sustainability uses this tool to assess the most suitable uses for 17,000 vacant lots in the city and has identified 1,497 lots as appropriate for GSI implementation. As of August 2017, the public did not have access to this tool (Chesapeake Conservancy, 2015).

8. ENGAGEMENT AND EDUCATION PROGRAMS WITH RESIDENTS, BUSINESS OWNERS, AND OTHERS

As cities began to invest in GSI to meet EPA requirements, officials needed to communicate with constituencies about how GSI functions and how it can help solve stormwater management problems. While some city residents have been enthusiastic about GSI, unfavorable experiences with unmaintained or unattractive installations made others leery about having GSI in their neighborhoods. Examples of local officials' efforts to engage residents in considering GSI are below.

Sewerage & Water Board of New Orleans (SWBNO) community outreach efforts

As part of the Third Modified Consent Decree with the EPA in 2013, SWBNO was required to create a plan for the implementation of GSI in New Orleans. The SWBNO Green Infrastructure plan, created in 2014, has several goals for implementing GSI, including "developing community outreach programs to provide education on GSI practices and include the community in the decision making to ensure sustainable projects" (SWBNO, 2014: 1). The plan suggests creating outreach programs tailored to school children, residents, and businesses owners. SWBNO has been doing extensive outreach to these groups since 2014 (SWBNO, 2017).

Outreach in partnership with nonprofit organizations (Philadelphia)

The Philadelphia Water Department's (PWD) Public Engagement team works with residents in the neighborhoods of any planned GSI installation because residents will be affected by the site and can play a vital role in reporting problems with GSI (Philadelphia Water Department, 2012). For example, PWD worked with Public Workshop, an organization specializing in creative, hands-on events, to engage residents of the Point Breeze neighborhood in cleaning a lot and building art installations on the site. As of 2017, the lot is planned as a rain garden and will include tree trenches, a bump-out (an extension from the curb into a parking space or traffic lane to receive and infiltrate stormwater runoff from the street), and an infiltration trench that together will absorb up to 23,300 gallons of stormwater (Rademaekers, 2017a).

Figure 9. Residents of Philadelphia's Point Breeze neighborhood worked with the Philadelphia Water Department and Public Workshop to clean up a vacant lot and create an art installation to accompany planned GSI on the site.

SOURCE: IMAGE FROM PHILADELPHIA WATER DEPARTMENT.

Figure 10. PUSH Buffalo created a rain garden to receive stormwater from the parking lot of a renovated apartment building in the PUSH Green Development Zone. SOURCE: CHUCK LACHIUSA

Chapter 2: Changes to encourage businesses, nonprofit organizations, and residents to install GSI

BUSINESSES, NONPROFIT ORGANIZATIONS, AND RESIDENTS often participate in greening efforts, some of which may contribute to GSI functions. Greening of the code and establishing routines for site plan approvals, permits, and inspections (see chapter 1) can reduce uncertainties facing those outside government as they make decisions about installing GSI. Governments can also encourage non-governmental actors to install GSI by providing financial incentives and opportunities to meet stormwater management requirements off-site, creating online tools to show the potential effects of projects on stormwater management, and partnering with other organizations in the planning and installation of GSI.

1. INCENTIVES

Many cities have instituted charges for property owners whose impervious land cover contributes to stormwater entering the sewer system. To encourage the implementation of practices that manage stormwater, including GSI, some cities have offered credits that reduce fees if property owners remove impervious surfaces or implement GSI to reduce the amount of stormwater entering sewers. The options water and sewer officials have with respect to fees and credits vary by state due to differing state laws and state court decisions. Table 2 shows the fees and credits in place in the cities discussed in this report.

From a financial perspective, credits rarely justify landowners' investment in GSI. Costs of installation and long-term maintenance of GSI dwarf the credits received. In Baltimore, for instance, commercial property owners would not see a return on investment for several decades. Commercial property owners who install GSI do so because it fits their mission, not because of money saved (M. Cameron, Baltimore Department of Public Works, phone interview, February 2017). A few cities have offered larger grants to help make such investments feasible. The Philadelphia example shows two types of initiatives.

Stormwater management grant programs (Philadelphia)

Philadelphia has two grant programs for property owners seeking to offset their stormwater fees with GSI installations. The Stormwater Management Incentives Program (SMIP) provides grants in partnership with the Philadelphia Industrial Development Corporation (PIDC), a public-private economic development corporation. Between 2011 and 2016, SMIP provided grants to non-residential

Table 2. Stormwater fees and credits for reduction in stormwater runoff for selected legacy cities.

City	Stormwater fee	Credit
BALTIMORE, MD	Single-family properties: Flat monthly fee based on impervious surface area: • < 820 square feet (SF): $3.33/month • 820 - 1,500 SF: $5/month • > 1,500 SF: $10/month Other properties: Charged based on impervious surface area: $5/ERU/month. Religious nonprofits: $1/ERU/month. 1 ERU (equivalent residential unit) = 1,050 SF of impervious surface.	Single-family properties: • Participation credit: participation in eligible city event such as stream clean-up, tree planting, depaving. $10 for 4 hours of participation, not more than 12 hours, or $30/year. • Simple residential Best Management Practices (BMPs) each have their own credit: • Small rain garden: $8/year • Large rain garden: $16/year • Tree: $5/year/tree • Rain barrel: $25/rain barrel 50 gallons or larger, one time • Other residential BMPs: 45% fee reduction for 100% on-site treatment Other properties: • Participation: same as single-family • Treatment: installation and maintenance of structural and environmental site design BMPs, 45% fee reduction for 100% on-site treatment • Activity-based BMP for recurring activity such as inlet cleaning, 45% fee reduction for 100% on-site treatment
BUFFALO, NY	No stormwater fee.	No credits applied to a stormwater fee.
GARY, IN	Monthly fees vary by property class: • Residential: $5/month • Residential vacant land 0.25 acres or less: $0.50/month • Residential vacant land, 0.251 acres to 20 acres: $2.50/month • Residential vacant land, more than 20 acres: $0.125/acre/month • Industrial: $35.00/month • Industrial vacant land, 20 acres or less: $2.50/month • Industrial vacant land, more than 20 acres: $0.125/acre/month • Charitable or religious: $15.00/month	No credits applied to a stormwater fee.
MILWAUKEE, WI	Quarterly fees: Residential properties: $20.18 per ERU (1 ERU = 1,610 SF of impervious surface) Non-residential or vacant improved properties: charge will be administered as total impervious surface area divided by ERU multiplied by the ERU rate.	Reductions are capped at 60% of the stormwater fee. The percent credit is based on the amount and type of Total Suspended Solids (TSS) removed and specifications of the GSI facility. For example, credits are awarded for green roofs as follows: • 1 inch engineered soil depth: 12% credit • 2 inch engineered soil depth: 24% • 3 inch engineered soil depth: 36% • 4 inch engineered soil depth: 48% • 5 inches or more engineered soil depth: 60% For bioretention basins, credits are awarded based on the size of the treatment compared to the contributing area: • Bioretention area/contributing area: 0-.05 leads to a 0-20% credit, .05-.10 leads to a 20-40% credit, .10-.15 leads to a 40-60% credit

City	Stormwater fee	Credit
NEW ORLEANS, LA	No stormwater fee.	No credits applied to a stormwater fee.
PHILADELPHIA, PA	Monthly fees: Residential: $14.12 Nonresidential: Sum of: • Gross Area (GA): $0.63/500 SF, and • Impervious Area (IA): $4.91/500 SF, but not less than $14.79 total.	Stormwater credits are offered to nonresidential and condominium customers. Three types of credits exist, with total credits typically capped at 80% of fees: • **GA Credits** apply if the open space area (GA - IA) is at or below the "Natural Resource Conservation Service Curve Number," requiring a complex calculation. • **NPDES Credits** apply to property owners who demonstrate that property is subject to and in compliance with a NPDES permit for industrial stormwater discharge activities. • **IA Credits** can be earned by implementing IARs (impervious area reductions) such as detention, infiltration, slow release, or volume reduction. Options for IARs are: • Rooftop disconnection • Pavement disconnection • Tree canopy coverage • Green roof • Porous pavement
WASHINGTON, DC	Monthly fees: $2.67 per ERU (1 ERU = 1,000 SF of impervious surface), administered by DC Water. Revenue from the fee supports MS4 permit compliance activities and DC Water's Clean Rivers Project.	Large construction projects that trigger stormwater management regulations can purchase stormwater credits from sites with excess storage capacity. The rate as of November 2017 is $3.61/gallon of storage (see chapter 2, section 2).

Sources: Baltimore City Department of Public Works, 2017a, 2017b; Gary Storm Water Management District, 2011; City of Milwaukee, 2016; City of Milwaukee, 2018; Milwaukee Metropolitan Sewerage District, 2010b; Philadelphia Water Department, no date; District Department of Energy & Environment, 2017d; M. Epsie, District Department of Energy & Environment, phone interview, November 2017.

property owners wanting to construct stormwater retrofit projects. Funded projects manage stormwater for 163.7 "greened acres" (Philadelphia Water Department, 2016a) (see Table 1 for a definition of "greened acres").

The Philadelphia Water Department (PWD) found that few owners of large industrial and commercial properties applied for the program, and this sparked the launch of the Greened Acre Retrofit Program (GARP) in 2014 for non-residential properties. Also a joint venture between PWD and PIDC, GARP provides grants to contractors and companies that act as "project aggregators" to build large-scale stormwater retrofit projects across multiple properties. Aggregators design and build proposed projects and must submit signed contracts or letters of intent to this effect with their applications. PWD's selection criteria for

Philadelphia's Greened Acre Retrofit Program provides grants to contractors and companies that act as "project aggregators" to build large-scale stormwater retrofit projects across multiple properties.

grant awards include total area managed, cost to PWD, quality of long-term maintenance plans, and availability of matching funds. In evaluating potential projects, PWD assigns the most weight to the cost effective management of stormwater from impervious acreage. The maximum grant is $90,000 per impervious acre managed, and at least 1.5 inches of stormwater for a minimum 10 impervious acres must be managed on each site. Stormwater management sites do not need to be adjacent to the impervious area (Philadelphia Water Department, 2014c). Although PWD provides substantial subsidies, installations on private property still cost PWD less than installations in the right-of-way (Valderrama & Davis, 2015).

When PWD reviews and approves a project design, property owners must execute an operations and maintenance agreement with PWD, and project aggregators must execute an Economic Opportunity Plan.

PWD grants money to the Industrial Development Corporation, which in turn makes grants to recipients based on a subgrant agreement. Grants are disbursed during design and construction based on a milestone schedule and may be issued as reimbursements or dual party checks; the final 10 percent is not disbursed until after PWD approves stormwater credits. Private property owners enter into a contract with the project aggregator, who manages the design, construction and maintenance of the GSI installation. PWD reviews and approves designs. After PWD has approved engineering drawings, property owners must execute an operations and maintenance agreement with PWD, and the project aggregator must execute an Economic Opportunity Plan (Philadelphia Water Department, 2014b, 2014c). This plan serves as a written commitment that the project aggregator will use "best and good faith efforts" to provide opportunities for minority-owned, women-owned, and disabled-owned businesses throughout the project (City of Philadelphia, 2017). Building permits are not required. PWD completes inspection throughout construction, after construction, and every four years afterwards to assure projects have been constructed and maintained according to the agreement between the property owners and PWD (E. Williams, Philadelphia Water Department, phone interview, August 2017). Property owners may then apply for stormwater credits on their bills. Project aggregators typically conduct ongoing maintenance themselves or work closely with an external maintenance service provider.

PWD saw significant interest in GARP in the first two years, with projects totaling 62.8 "greened acres" by 2016 (Philadelphia Water Department, 2010-2017, 2016 report). By 2017, PWD had a combined operating budget of $15 million for SMIP and GARP (E. Williams, Philadelphia Water Department, phone interview, August 2017).

2. OFF-SITE WAYS TO MEET REQUIREMENTS OR REDUCE FEES, ESPECIALLY ON VACANT LAND

In some cities, development projects that trigger requirements to manage stormwater can meet these requirements off-site, potentially by directing stormwater to vacant land or by paying for GSI elsewhere in the city. In addition, community development organizations and residents can install GSI on vacant

lots to receive stormwater from nearby residential properties and reduce residents' drainage fees. Washington, DC, and Milwaukee have set up systems to enable these kinds of GSI investments, but the programs have not attracted much interest.

Off-site retention volume (Washington, DC)

For large-scale construction projects, the District Department of Energy & Environment (DOEE) requires that at least 50 percent of required stormwater retention volume be met on site. Up to 50 percent of required stormwater retention can be met off site. Some properties may not be able to meet the 50 percent on-site requirement because of "extraordinarily difficult site conditions" (District Department of the Environment, 2013a: 37) such as the presence of utility lines, soil or groundwater contamination, or legal constraints. If conditions make on-site stormwater management difficult, property owners can apply for relief from the requirements (District Department of the Environment, 2013a; 2013c).

Washington, DC's DOEE requires at least 50% of required stormwater retention volume to be met on site, with the option of managing up to 50% off site.

A property owner may achieve off-site retention volume by paying an in-lieu fee and/or purchasing Stormwater Retention Credits (SRCs). Property owners can also create off-site storage that is certified for SRCs to meet their own requirements or to sell to others (Johnston, 2013; Branosky, 2016).

- *Paying an annual in-lieu fee* to DOEE costs $3.58 per gallon of capacity per year (in 2016 dollars, not adjusted for inflation). DOEE uses revenue from in-lieu fees to increase stormwater retention in other parts of the city (Branosky, 2016).

- *Purchasing Stormwater Retention Credits* (SRC) from a property owner who has excess stormwater storage capacity is another option. One credit is equivalent to one gallon of storage for one year. DOEE assigns a serial number to each credit and tracks it. Credit owners can use, sell, or withdraw their credits from the credit market (District Department of the Environment, 2013a).

To certify off-site capacity in SRCs, DOEE requires that GSI storage owners have a maintenance contract with a landscaping company or a maintenance plan for groundskeeping staff. DOEE certifies credits for up to three years at a time. After three years, the GSI site is subject to DOEE inspection. The program does not use easements or require permanent obligations; rather, credits can be retired from the market at the discretion of the owner or if DOEE decides the facility is no longer performing its storage function.

While DOEE aims to increase GSI storage capacity throughout the city, the agency is most interested in increasing GSI in the municipal separate storm sewer system (MS4) area to generate credits for construction projects in the combined sewer system (CSS) area. Since stormwater runoff is not treated by the MS4 system before entering waterways, DOEE wants to encourage GSI implementation in the MS4 area. DC Water's Clean Rivers Project is expanding the grey infrastructure system to solve problems in the part of the city served by combined sewers, but

not in the MS4 area. These two efforts could reduce the volume of untreated stormwater entering rivers. By 2017, 24 projects had been built with an off-site retention volume totaling 136,000 gallons per year. Around two-thirds of this volume is generated by GSI in the MS4 area for project compliance in the CSS area; 30 percent is from trades within sewersheds; and 4 percent is from MS4 projects using credits generated in the combined sewer area (M. Epsie, District Department of Energy & Environment, phone interview, November 2017). As of January 2018, 30 sites had been approved for construction with a combined off-site retention volume of approximately 209,000 gallons per year (M. Epsie, District Department of Energy & Environment, email communication, January 2018). The DOEE keeps track of these data through its in-house web system that updates in real time. The database records where and when a credit is generated and where and when it is used. Italso sends reminders to individuals and organizations to manage SRC portfolios (M. Epsie, District Department of Energy & Environment, phone interview, November 2017).

DC's Price Lock program helped to grow the market for SRCs: participants wishing to construct an SRC project could receive a confirmed SRC selling price, allowing DOEE to create a price floor and encouraging people to generate credits by investing in GSI.

Initially, use of the SRC market by developers and property owners was slow, with only 13 trades from 2013 through 2017 (Fenston, 2017). DOEE attributes long construction timetables to this delay in the growth of the market. The market for SRCs in the District began to grow substantially in early 2016 with the Price Lock program, through which participants wishing to construct an SRC project receive a confirmed SRC selling price from DOEE. This program allows DOEE to create a price floor for SRCs, encouraging people considering investment in GSI to generate credits for purchase. DOEE has committed $11.5 million in funding to the Price Lock program. Purchase agreements with a fixed price per credit between DOEE and credit generators can last up to 12 years. This arrangement aims to ensure that GSI facilities remain functional over the long term (M. Epsie, District Department of Energy & Environment, phone interview, November 2017; District Department of Energy & Environment, 2017c).

The Anacostia Waterfront Trust, a local nonprofit organization, used the SRC program to construct GSI at the Progressive National Baptist Convention's headquarters. The Trust leases land from the organization for a rain garden. The SRC program provides the Trust revenue for lease payments. In addition, the Convention receives a discount on its water bill through RiverSmart Rewards, a DOEE program that encourages stormwater management through GSI (District Department of Energy & Environment, 2017b).

The success of the SRC market depends in part on sufficient demand for development in the District's CSS area and developers' willingness to continue projects despite high costs of on-site stormwater retention or off-site SRCs. In cities with weaker demand for property, these costs could deter development. The price of SRCs needs to be high enough to encourage property owners to create off-site stormwater retention. In a city with weaker demand, this depends on continued subsidy to property owners through a program like the District's Price Lock.

Off-site drainage facilities (Milwaukee)

The City of Milwaukee's code allows property owners to discharge stormwater to off-site drainage facilities if runoff cannot be managed on site. Development and redevelopment projects that exceed one acre in size may use off-site drainage facilities if runoff reduction requirements prove difficult to meet on-site. The developer must design, construct, and maintain facilities leading to the drainage site, as well as the site itself (City of Milwaukee, 2018). The city engineer must receive a copy of a deed restriction that includes the requirements of agreements among owners about costs and shared use of a site. The city engineer must also receive an easement for access to the drainage facility. No developer had taken advantage of this provision as of mid-2018 (D. Misky, Redevelopment Authority of the City of Milwaukee, email communication, May 2018).

3. USE OF INFORMATION SYSTEMS AND ELECTRONIC TOOLS

Information systems can help those outside government learn about measures to reduce their water and sewer fees and ways to implement GSI projects to accomplish them. Philadelphia has created one such system.

Stormwater Credits Explorer (Philadelphia)

To assist non-residential property owners in determining whether a GSI installation will benefit them, the Philadelphia Water Department created the Stormwater Credits Explorer, an interactive website that provides a rough estimate of cost savings in stormwater fees for potential GSI installations. The cost savings estimates are based on total area and impervious area of a given lot, as well as the type of GSI intervention. The Explorer shows reductions to water bills for one month and up to ten years that could result from a GSI installation. The tool is designed to work in conjunction with the *Stormwater Retrofit Guidance Manual*, which provides property owners with information on planning and designing GSI projects (Philadelphia Water Department, 2015c, 2017b).

4. RESOURCES AND SERVICES

Some cities provide GSI installation and maintenance guidance manuals for businesses, nonprofit organizations, and residents. Philadelphia and Baltimore, for example, have provided such guidance, although they offer no advice on which sites would most advance stormwater management.

Design, installation and maintenance manuals for GSI (Philadelphia)

The Philadelphia Water Department (PWD) has published a technical design manual, a maintenance manual, and a range of other resources to assist those outside city government in the design, implementation, and maintenance of GSI. The Stormwater Plan Review (SPR) office of PWD created a *Stormwater Management Guidance Manual* for developers. It outlines regulations for managing the first 1.5 inches of rainfall on impervious surfaces. It also outlines the SPR

process, including how to qualify for expedited SPR review and guidelines for construction and post-construction maintenance (see chapter 1, section 5) (Philadelphia Water Department, 2015c). The Green Stormwater Infrastructure Planning and Design group also published a manual for developers wishing to implement GSI; the manual includes workflow packets, planning guidelines, drawing requirements, standard details, contacts, and other information (Philadelphia Water Department, 2016c).

Baltimore's *Green Pattern Book,* outlines ways to transform vacant lots into GSI, and provides guidelines for GSI site selection, such as minimum size, nearby impervious surfaces that can drain to the site, and a low point within 20 feet of a stormwater inlet.

Green Pattern Book (Baltimore)

The *Green Pattern Book* offers planning and implementation guidance in connection with the Mayor's Growing Green Initiative with the aim of encouraging non-governmental entities to reuse lots for green purposes. The book is the result of a collaboration between the USDA Forest Service, the City Planning, Public Works, Housing and Community Development, Transportation, and Parks & Recreation departments, several neighborhood community development corporations, and other nonprofit organizations (Baltimore Department of Planning & Office of Sustainability, 2015). *The Green Pattern Book* outlines methods for transforming vacant lots for stormwater management through bioretention, rain gardens, vegetated swales, and landscape infiltration. It also provides guidelines for site selection for GSI, such as minimum size, nearby impervious surfaces that can drain to the site, and a low point within 20 feet of a stormwater inlet. The guidelines do not prioritize some areas of the city over others. *The Green Pattern Book* provides a single, consolidated resource for permitting, design, and site selection for residents and nonprofit organizations looking to convert a lot in their neighborhood to a green use (Baltimore Department of Planning Office of Sustainability, 2015) (see chapter 1, section 1a).

5. PARTNERSHIPS AND INITIATIVES WITH NONPROFIT ORGANIZATIONS

Numerous cities have worked with nonprofit organizations that are interested in installing GSI and using greening strategies to strengthen neighborhoods. Nonprofit organizations may act as consultants or contractors for the city, or they may take initiative to install GSI on their own. Experiences in Buffalo, Baltimore, Milwaukee, and Gary illustrate such partnerships.

PUSH Buffalo

In 2005, the nonprofit organization People United for Sustainable Housing (PUSH) Buffalo created a neighborhood Green Development Zone (GDZ) in the city's west side that includes 14 stormwater management projects. While the Massachusetts Avenue Park at the center of the GDZ is zoned as Open Space in Buffalo's updated land use plan, most of the GDZ is residential and remains zoned as General Residential or Neighborhood Center (Office of Strategic Planning, 2016a).

Recently, the organization started the PUSH Blue initiative, with the goals of promoting GSI and creating entry-level jobs to spur economic revitalization (Magavern et al., 2015). In some cases, PUSH acts as a contractor for the Buffalo Sewer Authority. Because of the organization's experience with GSI installation, the city hired PUSH to install GSI in conjunction with demolition during its demolition pilot program (J. O'Neill, Buffalo Sewer Authority, phone interview, August 2017) (see chapter 1, section 3c).

Buffalo Niagara Waterkeeper (previously Riverkeeper)

Buffalo Niagara Waterkeeper, a community-based nonprofit organization, created a *Green Infrastructure Solutions* feasibility study in 2011 to inform the city's GI Master Plan. This study helped the Buffalo Sewer Authority (BSA) secure state funding to incorporate GSI into the city's Long Term Control Plan (Buffalo Niagara Riverkeeper, 2011). Waterkeeper has also championed a "Blue Economy Initiative" to highlight the connection between environmental and economic health in the region (Buffalo Niagara Riverkeeper, 2017). Through this initiative, Waterkeeper has contributed to the revitalization of the riverfront by securing funding for the restoration of waterways, installation of GSI, and citizen engagement.

Waterkeeper has also partnered with the city on the first phase of projects outlined in the GI Master Plan for 2011 through 2018. In one instance, Waterkeeper acted as a contractor to conduct outreach and distribution for the city's down-spout disconnection and rain barrel programs, while BSA maintained metrics on the project. Waterkeeper is also working with BSA and the Army Corps of Engineers on a major project in a privately owned cemetery to restore wetlands and reconnect an existing stream adjacent to the property. Waterkeeper's planning and engineering studies helped BSA apply for needed state funding for the GSI components of the project (K. Gallo, Buffalo Niagara Waterkeeper, phone interview, July 2017).

Chesapeake Bay Trust (Baltimore)

The Chesapeake Bay Trust is a statewide organization focused on conserving the Chesapeake Bay Watershed. The Trust provided funding for the Growing Green Design Challenge managed by the Mayor's Office (see chapter 1, section 1a). The Trust manages a grant program called Green Streets, Green Jobs, Green Towns (G3) with funding from several public agencies at the federal, state, and local levels (Chesapeake Bay Trust, 2017). G3 assists in the development and implementation of plans that reduce stormwater runoff, increase green space in urban areas, improve the health of local streams and the Chesapeake Bay, and enhance quality of life for residents. Grants up to $30,000 are available for engineered design projects and up to $75,000 for implementation and construction (Chesapeake Bay Trust, 2017).

Walnut Way Conservation Corporation (Milwaukee)

The Walnut Way Conservation Corporation began as a grassroots effort to stabilize and revitalize the Lindsay Heights neighborhood. In 2004, the organization began to install stormwater management facilities to mitigate basement flooding from

sewer backups. Strategies have included both greening and GSI, such as installing orchards, rain barrels, and rain gardens (Walnut Way Conservation Corporation, 2016). Walnut Way's Residential Action in Neighborhoods - Minimizing Stormwater Program focused on community education and outreach specifically around GSI. The City of Milwaukee supported this effort by providing technical assistance and funding for 38 homeowners to disconnect their downspouts from the sewer system and install rain gardens. The program installed around 552,000 gallons of GSI storage capacity on residential properties. In addition, Walnut Way maintains a bioretention basin at a local school during the summer and has three 500-gallon cisterns that collect roof runoff from its neighborhood center building (Milwaukee Metropolitan Sewerage District, 2007a).

In January 2018, Walnut Way received $150,000 in funding from the Institute for Sustainable Communities' Partnership for Resilient Communities.[6] Walnut Way plans to use a portion of this funding to design, install, and maintain GSI to reduce flooding in Milwaukee neighborhoods (Institute for Sustainable Communities, 2018). The organization partnered with the City of Milwaukee's Environmental Collaboration Office to apply for this funding and will continue to work with that office to implement GSI projects (Walnut Way Conservation Corporation, 2018).

Southeastern Wisconsin Watersheds Trust (Milwaukee)

Known as Sweet Water, the Southeastern Wisconsin Watersheds Trust encourages regional collaboration for a watershed approach to stormwater management (Behm, 2014). Sweet Water involves a diverse group of public and private organizations that work together to administer stormwater education and outreach programs (City of Milwaukee Office of Environmental Sustainability, 2014). Sweet Water has worked with the City of Milwaukee and the Milwaukee Metropolitan Sewerage District to develop pollutant reduction plans for all watersheds within city limits. In addition, the city government has contributed funding to Sweet Water's annual Water Quality Mini-Grant Program to support neighborhood GSI and greening projects (City of Milwaukee, 2013; Southeast Wisconsin Watersheds Trust, 2017). Some 2018 recipients of the mini-grants have planned GSI approaches such as rain gardens, while others have focused on greening approaches to stormwater management such as restoring wetlands (Herriges, 2018). Sweet Water has also hosted GSI roundtables with regional stakeholders to discuss challenges and strategies for effective implementation (Southeast Wisconsin Watersheds Trust, 2016).

Cleveland Botanical Garden's Vacant to Vibrant Initiative (Buffalo and Gary)

The Cleveland Botanical Garden received a grant from the Great Lakes Protection Fund[7] to install GSI on vacant land in Cleveland and two other cities with high levels of vacancy, blight, and aging infrastructure--Gary and Buffalo.

[6] The Institute for Sustainable Communities' Partnership for Resilient Communities selects partners through a competitive proposal process. The partners receive technical assistance, connections to others doing similar work, and funding (Institute for Sustainable Communities, 2018).

[7] The Great Lakes Protection Fund makes grants to protect and improve the health of the Great Lakes (Great Lakes Protection Fund, 2018).

In Gary, the Vacant to Vibrant Initiative partnered with city government to encourage GSI installation on vacant lots (Cleveland Botanical Garden, 2014a). Gary was one of the first municipalities to use sustainability as an economic development approach. Small municipal government in Gary made communication and decision making easier than in other larger cities (S. Albro, Cleveland Botanical Garden, interview, September 2017). In 2015, the Initiative used funding from the EPA and a matching grant from the city to install GSI on 15 vacant lots (Tejeda, 2015). In addition, the city demolished three blighted residential buildings in the Aetna neighborhood and coordinated with the Initiative to develop rain gardens, bioretention, and berms (Cleveland Botanical Garden, 2014a; Van der Kloot and Scott-Henry, 2017) (see chapter 1, section 3c).

In Gary, the Vacant to Vibrant Initiative used EPA and city funding to install GSI on 15 vacant lots, and coordinated with city officials to develop GSI on the demolition sites of three blighted residential buildings.

In Buffalo, the Cleveland Botanical Garden partnered with PUSH Buffalo, a community development corporation, to install GSI on vacant lots owned by PUSH. The Botanical Garden provided guidance for GSI implementation, while PUSH Buffalo completed vital community engagement functions. The partnership succeeded in installing GSI because of PUSH Buffalo's strong presence in the neighborhood, its ownership of the lots, and its commitment to creating social enterprises that support GSI maintenance (S. Albro, Cleveland Botanical Garden, interview, September 2017).

Figure 11. Volunteers cleaned and replanted a bump-out in Philadelphia as part of the Soak It Up Adoption Program.

SOURCE: PHILADELPHIA WATER DEPARTMENT

Chapter 3: Long-term function of GSI

THE ATTENTION OF MOST CITIES has principally been on installing GSI and much less on ensuring its continued function. Maintenance is critical to making sure GSI serves its stormwater management function, continues to look attractive, and sustains the support of residents. In addition, assurance that GSI installations will be protected as a land use over time is important for encouraging private investment in GSI. Cities have developed some ways to facilitate maintenance and to protect GSI installations from redevelopment.

1. MAINTENANCE

Maintenance of GSI remains difficult. Although public officials and leaders of nonprofit organizations often suggest that residents can and should be responsible for maintenance, residents usually lack the capacity and the knowledge to do so. For instance, long-term maintenance of GSI has been an obstacle for Buffalo. While nonprofit organizations such as PUSH Buffalo have dedicated resources to job training for GSI installation and maintenance, no revenue stream for maintenance exists. Some city officials are considering a public trust or stewardship fund dedicated to ongoing maintenance (K. Gallo, Buffalo Niagara Riverkeeper, phone interview, July 2017). The Milwaukee Metropolitan Sewer District commissioned a plan to address GSI owners' lack of resources and training for long-term maintenance (US Environmental Protection Agency, 2015). Philadelphia, Washington, DC, and Gary have programs that have achieved some success.

Blue Skies Landscaping Program (Milwaukee)

The Blue Skies Landscaping Program offers green job training and employment for individuals who have faced barriers to entering the workforce. It is a Walnut Way Conservation Corporation program, a neighborhood-based nonprofit organization in the Lindsay Heights neighborhood (see chapter 2, section 5). Blue Skies Landscaping provides GSI-specific and traditional landscaping services throughout the Milwaukee region, supplying employment to individuals and funding for the organization (Walnut Way Conservation Corporation, 2017).

Maintenance initiatives (Philadelphia)

Philadelphia has addressed maintenance of GSI through public and private initiatives:

- P*ublic GSI maintenance:* The operation and maintenance of new Philadelphia Water Department (PWD)-owned GSI facilities is the responsibility of the Planning & Environmental Services Division, using contract maintenance according to the standards in the Green Stormwater Infrastructure Maintenance Manual (Philadelphia Water Department, 2016b). For city-owned vacant lots,

Philadelphia Water Department uses contract maintenance for PWD-owned GSI facilities, and the Department of Public Property transfers maintenance responsibilities to PWD for city-owned lots.

PWD signs agreements with the Department of Public Property to transfer maintenance responsibility to PWD. Philadelphia Parks and Recreation generally maintains GSI in parks (see chapter 1, section 3).

• *Soak It Up Adoption Program:* PWD manages the Soak It Up Adoption Program in coordination with the Pennsylvania Environmental Council and Philadelphia Industrial Development Corporation. The program provides grants up to $5,000 annually to civic organizations to maintain GSI sites. Fourteen organizations managed 38 sites as of spring 2017. Services consist of aesthetic maintenance, which includes trash clean-up, watering, and mowing, reporting structure conditions to PWD, and keeping inlets free of debris. Organizations also make a commitment to engage with others to inform them about the adopted GSI. PWD expects organizations to report on weekly maintenance visits (Philadelphia Water Department, 2016a, 2017a).

• *LandCare maintenance partnerships:* The Pennsylvania Horticultural Society (PHS) partners with PWD to conduct aesthetic maintenance on approximately ten lots with GSI installations, at a rate of approximately $175 per parcel per year (A. Knee, Philadelphia LandCare, email communication, August 2017). This partnership is part of the PHS LandCare program, best known for its work with 18 community organizations to provide interim landscaping treatments on over 12,000 vacant lots, one-fourth of which are publicly owned (Pennsylvania Horticultural Society, 2017).

Maintenance requirements (Washington, D.C.)

Projects seeking to generate Stormwater Retention Credit (see chapter 2, section 2), requesting a stormwater fee discount, and/or falling under District stormwater regulations must submit a Stormwater Management Plan that includes details about routine and long-term maintenance needs and a maintenance schedule. A declaration of covenants stating the owner's specific maintenance responsibilities for the future must be recorded with the deed at the Recorder of Deeds. The District Department of Energy and Environment (DOEE) inspects the condition of an installation every three years. DOEE recommends specific maintenance strategies for varied types of GSI installations such as permeable pavement, green roofs, rain gardens, and bioretention (District Department of the Environment, 2013b). DC Water maintains or contracts maintenance for GSI projects that focus on the control of combined sewer overflows in the combined sewer system area (District of Columbia Water and Sewer Authority, 2015).

As part of the Department of Green Urbanism, Gary's urban conservation team performs maintenance on vacant land, natural areas, open space, and GSI sites owned by the city .

Urban conservation team (Gary)

As part of the Department of Green Urbanism, the urban conservation team performs maintenance on vacant land, natural areas, open space, and GSI sites owned by the city (Business View Magazine, 2016). The team is usually present on-site during GSI installation, provides education about GSI, and completes maintenance tasks (S. Albro, Cleveland Botanical Garden, interview, September 2017). The team also evaluates site conditions and GSI performance and may consult with experts to determine how to improve stormwater management outcomes

(B. Scott-Henry, City of Gary Department of Green Urbanism and Environmental Affairs, phone interview, September 2017).

2. LONG-TERM LAND CONTROL

City officials have been reluctant in some legacy cities to guarantee that GSI installed by non-governmental entities on city-owned vacant land will remain GSI for the life of the project. Providing assurance about the future of GSI can help encourage private investment in GSI and protect public investment on land that is not publicly owned or that is not under the control of a water and sewer department. Properties where GSI has been installed need to continue to serve that purpose for the life of the installation, perhaps 25 years. Land trusts set up for the purpose of continuing the use of GSI, deed restrictions requiring land be used for GSI, and easements conveying rights to use for specific purposes can help to protect GSI (Lewinski et al., 2015).

Properties with GSI need to continue to serve their purpose for the life of the installation, perhaps 25 years.

Nonprofit organizations, associations of small businesses along city commercial corridors, and residents who want to install GSI may not be able to assume ownership of property because of uncertainty about the future of an organization, concern about liability, or worries about property taxes. Few cities have developed legal arrangements that address these issues and assure long-term GSI continuity. New Orleans offers one model that has not yet achieved scale.

Growing Green (New Orleans)

The New Orleans Redevelopment Authority (NORA) administers the Growing Green program, which allows long-term leasing of the authority's vacant lots for green use. Nonprofit organizations, businesses, and individuals who want to use NORA-owned lots for a project may lease lots annually for $250 each and purchase them after three years of a successful project (New Orleans Redevelopment Authority, 2017a). Projects must fall under the categories of greening, gardening, or urban agriculture to be considered for the program; "greening" includes GSI. As of 2017, NORA was leasing 35 lots and had sold 22 lots as part of this program (New Orleans Redevelopment Authority, 2017b). NORA itself completed seven pilot projects; four of these were rain gardens with a combined storage capacity of 157,500 gallons (New Orleans Redevelopment Authority, 2016).

Figure 12. GSI was installed on this vacant lot in Buffalo through a partnership between the Vacant to Vibrant Initiative and PUSH Buffalo, a community development corporation with a strong presence in the neighborhood.

SOURCE: MARÍA ARQUERO DE ALARCÓN

Conclusion

OFFICIALS IN LEGACY CITIES are employing GSI in their efforts to meet EPA and state requirements for improving water quality. The water and sewer departments in the cities discussed here have invested in GSI through partnerships with parks departments and other property-owning departments. Federal funding for transportation and redevelopment have also supported GSI investments. Nevertheless, no cities have solved all challenges of employing GSI in stormwater management systems. Their efforts thus far have shown that doing so will involve extensive changes in the way city governments operate.

The experiences of these cities offer insights into changes that can help make GSI adoption and maintenance business-as-usual. The leadership of mayors and water and sewer directors is critical to bringing about the needed changes in the way government systems deal with GSI. Mayors' visions of what GSI can accomplish and their commitments to implementation can encourage city officials to make needed reforms. Water and sewer departments were originally organized to build and maintain grey infrastructure. They therefore need to operate differently internally and with other city departments to advance GSI. Directors of those departments, with the authority to make changes, can advance GSI implementation considerably. City codes and permitting and approval processes, created to establish standards for building, need to adapt to enable and encourage GSI. In most cities, plans for locating GSI require more detail to show priority project areas and eligible sites for installation, especially if the hope is to engage customers and nonprofit organizations in helping to meet stormwater management goals. Enhanced information systems can strengthen project management when numerous city departments are involved and can aid in prioritizing sites for GSI installation. In addition, city officials need to engage with and educate residents and others about GSI to encourage public support.

Businesses, nonprofit organizations, and residents show interest in installing GSI to reduce stormwater fees and to strengthen neighborhoods. City officials can encourage this interest through the governance innovations above, but also by offering incentives, providing opportunities to meet stormwater management requirements off site, creating online information systems that show how property owners can reduce fees, providing guides for GSI installation, and partnering with nonprofit organizations.

Most governance innovations have facilitated GSI installation; few have ensured functioning of GSI over the long term. Some issues have proven especially challenging. For one, city officials have not necessarily identified how to ensure long-term maintenance, and they almost never institute legal arrangements that protect GSI from changes in land use over the life of the investment. Over time, the need to find solutions to these issues will become more urgent, or GSI will cease to serve its purpose.

For another, analyses of how well GSI achieves stormwater management goals are rare and may not yet provide adequate evidence to help officials plan for the future, even when the capacity of a specific project is known (Burton et al., 2018). Monitoring of the effectiveness of each project in the context of each city's broader stormwater management goals is needed. Evidence about how well GSI achieves water quality goals, as well as broader goals for residents' quality of life, would be useful to many local governments.

This would help officials in legacy cities take more complete advantage of the ways GSI can address issues other than stormwater management, including enhancing the well-being of city residents (Lichten et al, 2017) and the long term development potential of vacant land (Nassauer and Feng, 2018). The emphasis in GSI installation remains on post-construction requirements despite the fact that legacy cities have plentiful vacant land, often publicly owned, and they experience little development pressure across large sections of their jurisdictions. These cities also have high poverty rates and considerable property disinvestment. Some city efforts and nonprofit organizations' initiatives have focused on generating jobs in maintenance for greening and GSI. GSI that uses vacant land, designed in ways that enhance neighborhoods, can provide stormwater management plus quality-of-life improvements. To achieve this, GSI needs to be attractive to residents as well as functional for stormwater management. This means city officials and others need to consider landscape design and residents' opinions.

Water and sewerage departments could find more ways to facilitate projects that bring numerous benefits to neighborhoods. For instance, grant-making organizations and property owners want more GSI that can lower stormwater fees, reduce flooding, and make neighborhoods more attractive. City officials and others have responded with resources for installing and maintaining GSI and have partnered with neighborhood-based nonprofit organizations to undertake projects, many of which have received considerable praise. These efforts could be more fully integrated and consistent with plans for strengthening a city's neighborhoods and plans for achieving stormwater goals.

Legacy cities have many additional opportunities for GSI to reach its full potential for managing stormwater, enhancing neighborhoods, and improving health. As this report shows, legacy cities are making substantial strides in that direction. These efforts offer ideas to other cities facing similar conditions and may encourage additional progress in legacy cities elsewhere in the nation.

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About NEW-GI

NEW-GI *(Neighborhood, Environment, and Water research collaborations for Green Infrastructure)* contributes to knowledge about green infrastructure in legacy cities by integrating research about water quality, community well-being, governance and ecological design. Involving community, government and academic collaborators, it produces evidence-based guidance for sustainably managing stormwater in ways that enhance landscapes and the lives of residents in Detroit and other legacy cities.

NEW-GI ecological designs link Detroit's vacant property demolition process with new forms of green stormwater infrastructure (GSI) that aim to manage stormwater as well as increase nearby residents' well-being. This research uses a transdisciplinary design-in-science approach, in which researchers, practitioners and community members work together to contribute knowledge addressing social and ecological objectives. NEW-GI researchers assess the performance of different GSI designs and governance approaches. This assessment provides evidence for making decisions about how GSI can better achieve objectives.