Green Infrastructure Policy Options for the Capital Region

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1 Introduction

1.1 Definition of Green Infrastructure

Green Infrastructure (GI) refers to practices or strategies to capture and slow stormwater runoff, water from rainfall or snowmelt that runoffs off into a stream channel or storm pipe. When GI captures runoff, it allows the water soak into the ground rather than immediately entering a stream channel. The term GI is sometimes used interchangeably with the terms Low Impact Development (LID) and Best Management Practices (BMP), which have similar definitions.

The U.S. Environmental Protection Agency's (EPA's) definition of GI emphasizes the multiple benefits of GI and the different scales at which it can be implemented:

> "Green infrastructure is a cost-effective, resilient approach to managing wet weather impacts that provides many community benefits. While single-purpose gray stormwater infrastructure - conventional piped drainage and water treatment systems - is designed to move urban stormwater away from the built environment, green infrastructure reduces and treats stormwater at its source while delivering environmental, social, and economic benefits.... Green infrastructure uses vegetation, soils, and other elements and practices to restore some of the natural processes required to manage water and create healthier urban environments. At the city or county scale, green infrastructure is a patchwork of natural areas that provides habitat, flood protection, cleaner air, and cleaner water. At the neighborhood or site scale, [GI] stormwater management systems... mimic nature [to] soak up and store water."[1]

The New York State Department of Environmental Conservation (NYSDEC) similarly defines GI as, "a variety of site design techniques and structural practices used by communities, businesses, homeowners and others for managing stormwater. On a larger scale, green infrastructure includes preserving and restoring natural landscape features (such as forests, floodplains and wetlands), and reducing the amount of land covered by impervious surfaces [roads, buildings, and parking lots]. On a smaller scale, GI practices include green roofs, pervious pavement, rain gardens, vegetated swales, planters and stream buffers."[2] The NYSDEC Stormwater Management Design Manual emphasizes the important functions of GI in its description of GI: "Green infrastructure planning includes measures for preservation of natural features of the site and reduction of proposed impervious cover. The green infrastructure techniques include practices that enable reductions in the calculated runoff from contributing areas and the required water quality volume."[3]

[1] https://www.epa.gov/green-infrastructure/what-green-infrastructure
[2] http://www.dec.ny.gov/chemical/68199.html
[3] http://www.dec.ny.gov/chemical/29072.html

1.2 Benefits of Green Infrastructure

GI is often used in conjunction with or as an alternative to gray infrastructure, traditional stormwater management techniques (such as storm drain pipes) that are designed to move stormwater runoff away from towns and cities quickly. In addition to providing some of the stormwater management functions of gray infrastructure such as flood reduction, GI provides many additional benefits that gray infrastructure does not. These benefits have been identified through rigorous scientific and academic research.

1.2.1 Environmental and Ecosystem Benefits

When it rains or snow melts, stormwater runoff can flood neighborhoods and river channels. In addition, stormwater runoff can pick up pollutants such as trash and oil from urban and suburban surfaces and deliver it to stream channels. GI does a good job at mitigating these impacts and restoring natural hydrologic functioning to urban watersheds by slowing down runoff and allowing it to soak, or infiltrate, into the ground and by retaining contaminants (Dietz [2007], Ahiablame et al. [2012]). Although some studies show that the effectiveness of GI can vary by type, location, and type of pollution examined (Center for Watershed Protection (CWP) [2007], Leisenring et al. [2014], Koch et al. [2014]), generally GI performs well as long as it is properly designed, constructed, and maintained (Dietz [2007], Ahiablame et al. [2012]).

Furthermore, in urban environments, natural habitats can be destroyed, reducing the amount of native vegetation on the landscape and the amount of space for animals to live. GI provides habit for urban wildlife (such as birds, mammals, amphibians, reptiles, and insects) and can improve urban biodiversity (the variety of animal and plant species) (Tzoulas et al. [2007], Mullaney et al. [2015]).

1.2.2 Human Benefits

In addition to these environmental benefits, GI provides a number of “ecosystem services". Ecosystem services are the benefits that the natural world provides to humans (such as logs from forests). Urban green spaces can reduce urban air temperatures (Bowler et al. [2010], Mullaney et al. [2015]) as well as reduce noise and improve air quality in outdoor and indoor environments (Wang et al. [2010], Mullaney et al. [2015]) leading to improved mental and physical health (Tzoulas et al. [2007]). All of these ecosystem services provide economic benefits such as reducing heating and cooling costs, improving property values, reducing stormwater management costs, and providing energy savings (Wang et al. [2010], Mullaney et al. [2015]).

2 Green Infrastructure in the Capital Region

Like many urban areas, the Capital Region (defined as Albany, Columbia, Greene, Warren, Washington, Saratoga, Schenectady, and Rensselaer counties) is facing several challenges that are being addressed using GI. This section discusses these challenges and many of the GI projects, initiatives, and plans that address the challenges.

2.1 Relevance of Green Infrastructure to the Capital Region

2.1.1 Reducing Runoff and Improving Water Quality

Since the Clean Water Act of 1972, the NYSDEC has been collecting water quality data in New York streams through biomonitoring. Biomonitoring involves identifying species of aquatic insects, called macroinvertebrates; the types of macroinvertebrate species found in a stream channel can indicate whether the stream channel is non-impacted (the cleanest and healthiest designation) or slightly-, moderately-, or severely-impacted. A 30-year trend report (1972-2002) based on these biomonitoring data shows that while water quality throughout New York is improving, there are several impacted streams in urbanized areas, including in the Capital Region (Bode et al. [2004], Figs. 1 and 2). More recently, data from the 2014 New York State Waterbody Inventory/Priority Waterbodies List (WI/PWL) indicates similar trends. The WI/PWL, "provides waterbody-specific summaries of water quality conditions, tracks the degree to which the waterbodies support (or do not support) a range of uses, and monitors progress toward the identification and resolution of water quality problems, pollutants and sources."[4] According to WI/PWL data, 14% of the stream channels in the Capital Region (including the Hudson River) are at least partially impaired, while 13% (including the Mohawk River) have minor impacts. 9% of the Capital Region's lakes and ponds are impaired (including Lake Champlain and Lake George) and 4% have minor impacts. GI can help to improve water quality in the Capital Region by reducing stormwater runoff and the amount of pollutants entering these streams, rivers, lakes and ponds.

Several neighborhoods in the Capital Region are prone to flooding during large rain storms. By slowing and reducing runoff, GI can help to mitigate some of this flooding. Although annual runoff is relatively modest in the Capital Region (Fig 3, Lumia et al. [2006]), climate projections suggest that the frequency of extreme events (both floods and droughts) is likely to increase in the future (Horton et al. [2014]).

2.1.2 Combined Sewer Overflow (CSO) Abatement

In New York State, the most common sources of water pollution include excess nutrients such as fertilizers, industrial wastes, and organic wastes such sewage and animal wastes (Bode et al. [2004]). Sewage waste most often enters waterbodies in the Capital Region through Combined Sewer Overflows (CSOs). In parts of the Cities of Albany, Troy, Cohoes, Rensselaer, Watervliet, and the Village of Green Island, rainfall runoff and sewage collect in the same pipe. During dry weather, sewage is routed to and treated in publicly-owned treatment (POTW) facilities. However, during large storms, runoff enters the combined sewer and overwhelms the combined sewer systems (CSSs), resulting in untreated sewage overflowing directly to the Hudson River (CDRPC [2011]). Water quality data collected in 2008 and 2009 show that while some stream channels do sometimes exceed bacteria (fecal coliform and E. coli) water quality standards set by the NYSDEC, the concentration of bacteria during CSO events is comparable to other urban areas with CSSs (CDRPC [2011]). Water quality data collected by Riverkeeper from 2006-2011 found that bacteria levels (Enterococcus) do often fail the EPA's recommended criteria for safe swimming (Fig. 5, Riverkeeper [2015]).

[4] `http://www.dec.ny.gov/chemical/66532.html`

The municipalities in the Capital Region with CSSs that experience CSOs are referred to collectively as the Albany Pool communities. The Pool communities have 92 outfalls where combined sewers can outflow to surface water bodies and currently discharge 1,236 million gallons of untreated CSOs annually into Capital Region waterways. CSSs from Cohoes, Watervliet and Green Island contribute 30 million gallons of CSOs annually to the Hudson River, CSSs from the City of Albany contribute 739 million gallons of CSOs annually, CSSs from Troy contribute 447 million gallons of CSOs annually, and CSSs from Rensselaer contribute 20 million gallons of CSOs annually. Located just north of the Port of Albany, the “Big C" is the largest CSO outfall and accounts for 40-45% of this annual pool-wide CSO volume (CDRPC [2011]).

The Pool communities have worked together to form the Long Term Control Plan (LTCP) with the goals of better understanding the impact of CSOs on water quality in the region and developing plans and programs to mitigate the impact of CSOs. The LTCP is required by the State to meet the requirements of the national Wet Weather Water Quality Act. Among the goals of the Albany Pool CSO LTCP is to decrease the volume of untreated CSOs from the current amount of 1,236 million gallons to 610 million gallons and to decrease the number of fecal coliform water quality violations (when the concentration of sewage exceeds state-regulated limits) from the current number of violations of 30 over 5 years to 0 (CDRPC [2011]). The Albany Pool CSO LTCP includes several strategies to reduce CSOs. Among these strategies are gray infrastructure improvements such as sewer separation and increasing runoff storage, design and construction of a “Big C" disinfection facility that will treat an estimated 285 million gallons of CSOs annually, and several GI projects (described in Section 2.2). Of the $136 million it will cost to implement the Albany Pool CSO LTCP over 15 years, $5 million is set to be spent on these GI projects.

Although the total volume of CSO reduction will not be measured directly, runoff reductions from individual GI projects will be quantified and reported to the State. In addition, water quality monitoring will continue throughout the LTCP project period. If water quality monitoring data indicate that water quality improvement goals are not being met, the State will require additional projects be implemented to further reduce CSO volumes.

2.1.3 Urban Revitalization

The Capital Region is actively working to improve the local economy through economic development projects. One of the goals of the Capital Region Economic Development Council (CREDC) 2011 Strategic Plan, is to “capitalize on our urban centers within the Capital Region that have a history rich in vibrancy and return them to centers of influence that are alive with business, residential, and cultural programs that will revitalize them as active neighborhoods" (Capital Region Economic Development Council [2011]). A 2015 update to the strategic plan identifies the Cities of Albany, Schenectady, and Troy (Fig 4) as “Opportunity Zones", that is, areas in the Capital Region with targeted urban revitalization and economic development initiatives (Capital Region Economic Development Council [2015]). GI projects can support urban revitalization efforts by improving aesthetics and increasing property values. A 2015 report by Brian Davis of Cornell University proposes a redevelopment plan for the Troy waterfront that not only reduces runoff and improves water quality, but is designed to connect the community to the Hudson River (Davis [2015]). Several of the GI projects described in Section 2.2 are already underway or are planned for the Capital Region’s “Opportunity Zones".

2.2 Green Infrastructure Plans and Projects in the Capital Region

The following section highlights some of the GI projects, programs, and studies that have been implemented and are planned for the Capital Region. This list is in no way meant to be exhaustive, but instead highlights the diversity of projects in the Capital Region as well as the successes and challenges of, and lessons learned from these projects. Projects are organized as regional projects and local or site-specific projects. Regional projects are studies and plans to evaluate, adopt, and implement GI widely throughout the Capital Region (such as in the Albany Pool communities) while site-specific projects are GI projects at one site or neighborhood.

2.2.1 Regional Projects

Albany and Saratoga Counties as well as the Albany Pool CSO LTCP (CDRPC [2013] and CDRPC [2015]) propose several strategies for expanding GI in the region:

- **Local Law Review.** A review of codes and local law in New York State involves assessing how well these codes and local law are in line with State stormwater regulations and whether they present any barriers to implementing GI locally. A local law review was completed in 2013 by the Albany County Stormwater Coalition. This project inventoried existing comprehensive plans and local laws for GI strategies, identified GI local law “gaps", researched other GI local laws, and developed a Model Local Law beneficial to the unique needs of Coalition members (Stormwater Coalition of Albany County [2013]). A similar review is underway for the Albany Pool communities through the Albany Pool CSO LTCP. (Task completion date: 8/1/16)

- **Green Infrastructure Technical Design Guidance.** The scope of the GI Technical Design Guidance is still being developed, but will provide the Albany Pool communities with consistent standards and details for implementing GI practices that meet the specific needs of these communities. Having local technical design guidance documentation can help communities overcome technical barriers to implementing GI described below and ensure they are implementing the most appropriate GI practices for the local area. (Projected task completion date: 8/1/17)

- **Documentation and Reporting of New Public and Private Green Projects.** The purpose of reporting green projects within the Albany Pool communities is to document the implementation and acceptance of these projects as well as allow the estimation of the total reduction in annual runoff volume. The reporting of design criteria for these GI projects, along with continued water quality monitoring, will help to estimate the total reduction of CSOs in the Capital Region as a result of installed and planned GI projects. (Projected task completion date: 3/1/19)

- **Completion of a Feasibility Assessment for a “Green Infrastructure Banking System".** This project is evaluating “green banking" through a stormwater in-lieu fees and credit banking feasibility study. This project examines, as an alternative to traditional on-site stormwater mitigation, stormwater in-lieu fees (a developer can pay an in-lieu fee instead of on-site stormwater mitigation and then a sponsor can accumulate fee revenues and implement other stormwater projects in other desirable areas) and stormwater credit banking (a private property owner can install stormwater best management practices on private lands and sell excess retention credits to permitted entities).

As part of this feasibility study, Martin Daley, Environmental Planner for the Capital District Regional Planning Commission, Ryan Waldron, P.E., NYSDEC Division of Water, and Michele Golden, Hudson River Estuary Program GIS Coordinator are performing a GI modeling study within the City of Albany. According to Golden, "Our goal for this modeling project is to determine if the location of GI practices in a CSO community would make a difference in the flow, or in reducing the number of CSOs, at a CSO outfall. The overall result would better help shape a Green Infrastructure Credit and Banking System." (Projected task completion date: 8/1/17)

- **Saratoga County Green Infrastructure Plan.** Saratoga County has more undeveloped land and open space than the Albany Pool communities. Thus while GI projects in the Albany Pool communities often focus on redevelopment and retrofits, which tend to be site-scale, Saratoga County can also promote preservation of open space and limiting low-density development. The Green Infrastructure Plan for Saratoga County, adopted in 2006, includes the following action items: (1) expand and modify the existing county farmland/open space grant program, (2) link GI planning with gray infrastructure planning, and (3) help to build local capacity for GI by creating a County GI Assistance Program. The Saratoga GI plan envisions a Saratoga County with interconnected and linked GI networks and could inform large-scale GI planning in more rural areas throughout the Capital Region.[5]

- **Demonstration Projects.** Demonstration and pilot projects are a common way to introduce GI to the general public as well as local governments. They can also be helpful for figuring out the logistics of implementing GI and through trial and error, identify what works well and what doesn't in a certain region. It is important for demonstration projects to be correctly designed, constructed, and maintained to build trust in the process of GI implementation. If a GI demonstration project does not function as planned, lessons learned should be documented to help ensure the next project will be more successful. As part of the Albany Pool CSO LTCP, several demonstration GI projects are being implemented in the Pool communities. These, along with projects throughout the Capital Region, are described below.

2.2.2 Site Projects

While regional projects like those described above are important for understanding and promoting widespread GI implementation, individual or site-scale projects are important for building acceptance for GI and identifying what types of projects work well in a specific area.

- **North Swan Street Park Revitalization (City of Albany).** Prior to 2013 this neighborhood park was in a state of disrepair. Starting in 2003, community members came together to create a vision for a revitalized, multi-generational, recreational park with a new half-court basketball court, playground, ADA-accessible walkway, amphitheater, and play-fountain. GI elements of the park include bioretention and dry swales, a rain garden, porous pavements, vegetated swales, tree plantings, and soil restoration. In addition to reducing runoff volumes, and therefore the frequency and magnitude of CSO events, the project is estimated to result in significant water quality benefits. It is estimated that the following volume of pollutants will be reduced as a result of this project: Total Suspended Solids (TSS) by approximately 11 tons/yr, Total Phosphorus (TP) by 82 lbs/yr, and Total Nitrogen (TN) by 524 lbs/yr. These are pollutants that will no longer be entering the Hudson River. In September 2014, the American Planning Association announced that the neighborhood was

[5] http://www.saratogaplan.org/www/wp-content/uploads/2014/12/Sco-GIP.pdf

chosen as one of the 10 great neighborhoods in America for 2014. (Operational start-up date: 11/20/2015) (CDRPC [2015])

- **Quail Street Green Infrastructure Project (City of Albany).** Quail Street is a major transportation corridor through the City of Albany and passes through several diverse neighborhoods. In addition, Beaver Creek, once a natural river channel, was diverted to underground pipes several decades ago and now floods the neighborhoods around Quail Street. The Quail Street GI project, which is located between the Madison Avenue and Central Avenue cross streets, addresses this flooding issue as well as the frequency and magnitude of CSO events by reducing runoff volumes. Additional goals of the project include improving the aesthetics and walkability of Quail Street. The plan for the project was originally to use street trees to expand urban canopy and reduce runoff and to retrofit the roadway to include pervious pavers and bioretention areas to increase infiltration. However, it was found that some soils in the area are not appropriate for these types of infiltration practices. This and right-of-way restrictions and limiting funding forced the City to modify the plan. The new plan includes porous pavement with constructed underground storage, street trees, and sewer separation. (Projected operational start-up date: 12/15/16) (CDRPC [2015])

- **Monument Square Green Infrastructure Project (City of Troy).** This project is underway in the highly visible area of Downtown Troy, Monument Square. Beginning in 2009, a series of public meetings were held to identify a vision for Monument Square and vicinity. The community expressed the desire for improved walkability and streetscape amenities (bike racks and benches, for example) in the area around the square. GI elements of the redevelopment project include porous pavement and pavers as well as an educational component that will help the community better understand GI. When completed, the project is designed to capture all of the water from a storm producing 1 inch of rainfall. This will result in the reduction of approximately 760,000 gallons of runoff annually, reducing the frequency and magnitude of CSO events and improving water quality. (Projected operational start-up date: 12/15/16) (CDRPC [2015])

- **Route 32 Green Street Project (City of Watervliet).** This project involves the redevelopment of approximately 3/4-miles of the Rt. 32 corridor in the City of Watervliet. GI elements include porous pavement, underground infiltration storage, new street trees, two rain gardens, a bioretention area, and areas designed for future bioretention. Once completed, the project will reduce the frequency and magnitude of CSOs and improve water quality. (Projected operational start-up date: 12/15/17) (CDRPC [2015])

- **Capital Roots Urban Grow Center (City of Troy).** Capital Roots is a not-for-profit organization whose vision is to provide access to fresh, affordable, and healthy food to Capital Region communities. Their Urban Grow Center, located in a former industrial building within a low-resource, urban neighborhood of Troy, serves as a regional hub for their activities such as providing fresh food through their produce market and distributing fresh foods throughout the region using the “Veggie Mobile". With funding from the Environmental Facilities Corporation (EFC) Green Innovation Grant Program (GIGP),[6] Capital Roots included a number of GI elements when constructing their Urban Grow Center. In total, the Urban Grow Center is designed to capture 144,000 gallons of runoff/yr (15,000 gallons/yr of this runoff is reused to water plants and flush toilets), reducing the frequency and magnitude of CSO events. It is estimated that the following pollutants will be reduced: 7 lbs/yr Nitrogen and 56.25 lbs/yr road salt, improving water quality.

  The GI elements of the Urban Grow Center as well as a number of lessons learned is reported in CDRPC [2015]:

[6] http://www.efc.ny.gov/Default.aspx?tabid=461

"*Green Roof:* The Green Roof for the Center's 1,600 sqft. addition also accepts drainage from the adjacent building's flat roof. Durable, native, low maintenance grasses were planted to ensure survival and to require little to no pruning. The green roof helps insulate the building below and doubles as a community space for outdoor gatherings. Runoff that isn't absorbed and evaporated by the green roof is piped to a large cistern.

"*Cistern:* The insulated cistern holds 5,200 gallons of stormwater. The water is used year round for flushing toilets and landscaping. This has resulted in a 50% reduction in water needs at the facility. An aerator prevents the cistern from freezing and [an] automatic valve ensures that there is a back-up municipal water supply on hand in the event of the system runs dry or there is a power outage. After several months of use, the system is reportedly working well with only a few small modifications. Small particles of organic material do collect in the rainwater creating a tan, greyish color. There was some alarm about the color of water in the toilets, as folks unfamiliar with the rainwater system believed something was amiss with the water supply. Although the discoloration from organic material in the harvested rainwater is normal, the project manager thought this could easily be rectified by posting a sign and switching out the system filter to a smaller micron rating. Only rarely has the cistern ever filled beyond capacity. An overflow is built in and this drains to a bioretention practice.

"*Porous Pavement:* The parking lot for the facility was constructed from porous asphalt. The lot was the toughest and most expensive part of the project, according to Matt Schuler, the project manager for Capital Roots. It required excavation of compacted fill and refilling of sub-base to support the porous pavement. The lot was sloped into a bioretention practice with an overflow and clean out. Capital Roots staff has been impressed by the lot's ability to soak up rainwater quickly. During several recent storms the lot was dry several minutes after the end of the rain, but local streets remained partially flooded. Despite having a contract for plowing and basic maintenance, there's been little need for it. The lot doesn't refreeze once cleared like regular lots, and thus less salt has been needed. The porous pavement vacuumed twice yearly by Canaday Sweepers, under contract for an annual cost of $600.

"*Rain garden:* The rain garden is an integral component of the treatment train approach at the Grow Center. This practice is the last stop in the green roof-cistern system and absorbs some flow from the porous lot. It features native, resilient plants. Center staff would like to cut down on mulch use moving forward, believing it may be hampering plant growth. An overflow and cleanout were built in, but to staff's best recollection, all of the flow that's entered the rain garden has infiltrated and not reached the storm drain overflow - thus it's believed that 100% of the precipitation to date has been captured, reused, or/and infiltrated by the practices employed on site" (CDRPC [2015]).

- **Antoinette Estates Residential Development (Town of Colonie).** This GI project provides an example of how GI can be utilized at a private, residential development site. The Antoinette Estates project was constructed with pervious pavement, downspout disconnections, reduced impervious surfaces, and soil restoration practices. All of these practices are meant to facilitate infiltration and reduce the amount of runoff directly entering the storm drain system. Although not part of the Albany Pool communities, these improvements will reduce flooding and also improve water quality within the Town of Colonie and Hudson River.[7]

- **Rapp Road Landfill Stream Daylighting and Restoration (City of Albany).** Another type of GI project being implemented in the Capital Region is stream daylighting. Several decades ago, it was common practice in the Capital Region, like many urbanized areas, to divert natural stream channels into underground pipes. Stream daylighting restores streams that were previously in underground pipes back to a natural river system. The Rapp Road Landfill project restored 20 acres of wetlands, 3200 feet of stream, and a native plant nursery in the Landfill and adjacent Albany Pine Bush preserve.

While many of the projects described above are located in dense city centers, several projects have been installed in more rural settings in the Capital Region such as a porous pavement retrofit on Beach Road in Lake George. According to the Environmental Facilities Corporation (EFC) Green Innovation Grant Program (GIGP), "[a]s the first large-scale porous asphalt installation located in the Northeast, the installation will help demonstrate the performance of this green technology under high-traffic and cold climatic conditions." The Roeliff Jansen Community Library in Copake is another example of a GI project in a more rural setting and inlcudes a number of GI practices such porous concrete, bioretention, and vegetated swales. The NYSDEC[8] and EFC GIGP[9] describe these and a number of additional GI projects being implemented in the Capital Region and throughout New York State.

2.2.3 Lessons Learned

In addition to the project-specific lessons learned described above, local stormwater professionals have shared their experiences working on GI projects throughout the Capital Region.

- *Design and construction.* Several local stormwater professionals stated the importance of proper design, construction, and maintenance of GI projects. This is especially important for demonstration projects, which often have the added goal of helping to build trust in and acceptance in GI. These same stormwater professionals commented that they faced resistance to new GI strategies at first, especially from contractors and maintenance crews, but after seeing GI functioning properly, the resistance faded. Furthermore, Frank Fazio, University at Albany Stormwater Management Program Coordinator, adds that the design of GI practices such as porous asphalt has improved greatly over the years. The University's first installment of porous pavement would have some surface deterioration, especially in the winter, but the newer designs hold up much better.

- *Maintenance.* Nancy Heinzen, Albany County Stormwater Management Coordinator, notes that when working on collaborative projects with many partners, it is important to establish who will take the lead and be responsible for maintaining the GI project once it is constructed. Some GI practices can require more maintenance than traditional stormwater management, yet some require less. John Dzialo, Town of Colonie Stormwater Management Program Coordinator, notes that surface sand filters (used in many infiltration-based GI practices) require more maintenance. However, Fazio

[7] For more information on and pictures of this project see the Albany County Stormwater Coalition Green Infrastructure webpage, http://www.stormwateralbanycounty.org/green-infrastructure/

[8] http://www.dec.ny.gov/lands/58930.html

[9] http://www.efc.ny.gov/Default.aspx?tabid=461

notes that porous pavement requires less winter maintenance than traditional asphalt and concrete because it can't be salted as often and can't be sanded at all. Furthermore, the porous asphalt used for sidewalks and walkways doesn't generate puddles during warm weather and eliminates black ice during the winter. Fazio adds that the University maintenance crews were initially skeptical of the GI practices, but quickly warmed to the reduced maintenance required. A University at Albany green roof requires very little care because it is planted with low-maintenance vegetation that is both flood and drought resistant.

- *Post-construction monitoring.* Several stormwater professionals mentioned the need to continue to monitor GI projects after construction to ensure they are meeting the goals for which they are designed.

3 Opportunities and Challenges for Green Infrastructure

Recent surveys of GI professionals describe the barriers toward implementing GI projects. Despite these challenges, there is a lot of work being done in the Capital Region to overcome these barriers. Yet, as a community, there is more work that needs to be done toward realizing the full potential of GI in the Capital Region.

3.1 Barriers to Implementing Green Infrastructure

The EPA lists several potential barriers for communities adopting GI practices. These include the perception that performance is unknown, perception of higher costs, perception of resistance within the regulatory community, perception of conflict with principles of smart growth, perception of conflict with water rights law, unfamiliarity with maintenance requirements and costs, conflicting codes and ordinances, lack of government staff capacity and resources, and skepticism about long-term performance.[10]

[10] https://www.epa.gov/green-infrastructure/overcoming-barriers-green-infrastructure

Locally, in 2012, Emily Vail and Andrew Meyer from the NYSDEC Hudson River Estuary Program asked GI professionals and implementers in the Hudson Valley what they saw as the largest barriers to implementing GI in their communities. 30% cited cost as the primary barrier, 25% cited lack of technical knowledge about GI, and 22% cited unfamiliarity and resistance from local governments. The least cited barrier was concerns about GI aesthetics. Within the Capital Region, the most cited barrier was cost. To overcome the cost barrier, there are several mechanisms to fund GI projects described in Section 4.4. In addition, recognizing the avoided costs of not having to construct large, gray infrastructure projects as well as the potential to add value to property and the many additional economic benefits of GI cited above can help to overcome the cost barrier. The Green Infrastructure Technical Design Guidance document planned as part of the Albany Pool CSO LTCP, and other guidance documents like it available through the EPA,[11] can help to overcome the technical knowledge barrier. Projects like the Local Law review, the ever expanding demonstration projects, knowledge sharing such as the Documentation and Reporting of New Public and Private Green Projects plan, and GI tours and workshops like those held by the Albany County Stormwater Coalition can help local governments overcome unfamiliarity and resistance to GI.

3.2 Opportunities for Green Infrastructure in the Capital Region

Despite the above described barriers, GI is widely being adopted and implemented throughout the Capital Region, as evidenced by the numerous GI projects described above. Yet, even with growing adoption of the GI, there are several opportunities to expand our understanding and acceptance of GI.

While GI is widely accepted amongst the stormwater community, several local stormwater professionals have stated the need to better educate and communicate the benefits of GI to the general public. Outreach and education is important for wide-scale adoption of GI on private residential property. Popular approaches to GI education and outreach include using signage, brochures, and websites. Nancy Heinzen of the Albany County Stormwater Coalition also cited the need for better training and the importance of sharing technical knowledge amongst the stormwater community and planning professionals. The Documentation and Reporting of New Public and Private Green Projects that is part of the Albany Pool CSO LTCP is one way to achieve this.

[11] https://www.epa.gov/water-research/technical-assistance-green-infrastructure, https://www.epa.gov/green-infrastructure/green-infrastructure-design-and-implementation

While GI undoubtedly has many environmental and social benefits (as described in Section 1.2) there are still steps we could take to better understand some of the science of GI to maximize its economic efficiency and environmental effectiveness. Emily Vail, Watershed Outreach Specialist, NYSDEC Hudson River Estuary Program, stresses that GI projects that work well in some places might not work well in others for a number of reasons and it's therefore important to understand the environment and social context in which we are implementing our GI projects. For example, Frank Fazio points out that the University at Albany campus is constructed on sandy soils that are well-suited to the infiltration GI practices such as porous pavement the University has implemented. Other locations with more clay may need to use practices with built storage such as tree boxes. To this end, Brian Davis of Cornell University points out in his redevelopment plan for the Troy waterfront that in the Capital Region, "it is still unclear where the most effective use of green infrastructure would be, what form it should take, and what its specific role would take" (Davis [2015]). And still, the broader research community needs to do more work to understand how well GI functions over very large or regional scales, over long time-periods, in different climatic conditions, and for poorly understand contaminants (Ahiablame et al. [2012]).

A number of stormwater professionals stated the need for new and innovative approaches and types of GI. To identify new approaches, we may have to look beyond the Capital Region and even New York State to learn lessons from innovative GI projects being implemented nationally, throughout Europe, and at stormwater research facilities at institutions such as Villanova University and the University of New Hampshire Durham.[12] When innovative approaches are identified, it is important to convince the community that implementing these new types of GI projects in the Capital Region is feasible.

4 Policy Options and Funding Mechanisms for Green Infrastructure in the Capital Region

To overcome the above described challenges, take advantage of the many opportunities for GI, and fully realize the benefits to GI, there are several policy options available for GI implementation. This section discusses policy options and implementation strategies recommended by the EPA that address the needs and specific challenges of the Capital Region.

4.1 The Planning Process for Green Infrastructure Implementation

The EPA provides many guidance documents for government, private, and not-for-profit agencies wishing to implement GI in their communities. They describe the process for implementing GI projects as multi-step (USEPA [2014a], USEPA [2015]):

1. *Review Planning Documents and Codes.* New York State requires new and redevelopment projects to utilize GI to manage stormwater to the greatest extent possible. Furthermore, local laws can ensure that development projects are meeting the State stormwater requirements and also further require GI be used in areas and situations not covered by State regulations or that specific GI strategies be used that are best suited to the specific area (for example, rural areas might favor open space protection

12 http://www1.villanova.edu/villanova/engineering/research/centers/vcase/vusp1.html, http://www.unh.edu/unhsc/

while more urban areas might promote street greening). In the Capital Region, both the Albany County Stormwater Coalition and Albany Pool communities have or plan to review local codes to ensure the barriers to implementing GI have been removed. However, other municipalities will want to check local codes, design standards, and planning documents to be sure they do not pose any barriers to implementing GI projects.

2. *Engage Stakeholders.* Stakeholders are individuals, organizations, or entities that live, work, or are in some other way connected to the community in which the GI project will be implemented. Engaging stakeholders early in the planning process is important for building trust and can often lead to more successful projects. The lead on the GI project, who is in charge of planning and implementing the GI project, can also organize stakeholders, which often include government officials, not-for-profits, community groups, and academic and health institutions.

3. *Set Goals.* Stakeholders can help to develop a vision and goals for the GI project (ex. flood reduction, creation of recreational space, restoring native habitat, increasing property values).

4. *Identify GI Projects.* Demonstration projects, those recommended in the NYS Stormwater Design Manual, local laws, and technical guidance documents can be used to identify GI projects that are in line with the vision and goals. Implementing one or more of the strategies described in Section 4.2 may help to increase acceptance of the project.

5. *Identify Funding to Implement and Maintain Projects.* A variety of mechanisms and sources are available to fund GI projects. These are described in more detail in Section 4.4.

6. *Plan for Long-term Operations Maintenance.* Long-term maintenance is essential for ensuring the GI project perform as designed. Funding mechanisms should be identified to cover the operations and maintenance of the GI project.

7. *Plan for Monitoring and Measuring Success.* A process should be developed to monitor the GI project after implementation to ensure it is functioning as designed (ex. removing the volume of runoff for which it was designed) and to measure how well the GI project helps the community achieve its environmental, social, and economic goals.

4.2 Strategies

Communities can adopt a number of strategies to promote, build, and increase acceptance of GI locally including encouraging retrofits, developing green streets programs, and promoting rainwater harvesting (USEPA [2008]).

- **Retrofits.** GI can be used in new and redevelopment projects, but also part as retrofits. Examples of GI retrofits include installing a green roof on a existing building or removing parking lot asphalt and adding porous pavement. Often these retrofits can be used as an alternative for needed expansion or replacement of existing gray infrastructure. Reviewing and revising local laws can help to remove barriers to implementing GI retrofits. Local governments can also provide economic incentives for private landowners to encourage GI retrofits.

- **Green Streets.** The Capital Region Department of Transportation (DOT) spends a large portion of its annual budget on road and sidewalk repairs, maintenance, and improvements. Some of these funds could be leveraged to integrate GI into surface transportation redevelopment and retrofits. These “Green Streets" practices include bioswales, bioretention curb extensions and sidewalk planters, rain gardens and infiltration practices, street trees and tree boxes, and porous paving material. Several of the site projects described in Section 2.2 are examples of Green Streets GI projects.

- **Rainwater Harvesting.** Extreme dry conditions this summer and fall in western New York and Massachusetts that have led to water use restrictions and drought relief for farmers should remind us that the Northeast United States is not immune to drought. Rainwater harvesting, a GI strategy that can help to alleviate some of the consequences of drought, involves capturing rainfall and snowmelt in cisterns and rain barrels so that it can be used to water gardens and lawns. With retrofits to indoor plumbing, captured (or reclaimed) rainwater can also be used for indoor uses such as flushing toilets (as in the Capital Roots Urban Grow Center). Local codes should address public health concerns by establishing acceptable use and treatment standards for harvested rainwater. Rainwater harvesting can be encouraged through economic incentives or when water rates increase to the point where the construction of rainwater harvesting systems make economic sense.

4.3 Policy Options

In addition to promoting the strategies described above and reviewing local laws as was done in Albany County, a specific policy option for the Capital Region that has been mentioned by several local stormwater professionals is the formation of a Stormwater Utility District and the development of a stormwater fee. Currently much of the cost of stormwater management in the Capital Region is paid for with general funds from taxes. Alternatively, a Stormwater Utility would calculate user fees for commercial, multi-family residential, and industrial properties based on the total lot size and percentage of imperviousness of the property. Thus property owners are directly covering the costs to manage the stormwater they are generating. When stormwater management is paid for with general funds, some entities might generate relatively more stormwater, but pay less taxes (such as a not-for-profit organization with a large campus with many roads, buildings, and parking lots). Along with the fee, the Stormwater Utility District could establish a stormwater fee discount if property owners reduced the need for stormwater management by reducing impervious area through stormwater management strategies such as GI. (Even without a Stormwater Utility District, the same practices could be incentivized through tax credits or reimbursements to property owners who install specific GI practices.) Stormwater user fees have been implemented in the City of Ithaca.[13] According to Emily Vail of the NYSDEC Hudson River Estuary Program, the program in Ithaca, while relatively new, has been successful so far, and similar types of programs could be implemented in other parts of the State, including the Capital Region.

If it is determined that it is feasible, the GI Credit and Banking System currently being examined in the City of Albany as part of the Albany Pool CSO LTCP could complement the Stormwater Utility District. As described above, the “green banking" system would require stormwater in-lieu fees (a developer can pay an in-lieu fee instead of on-site stormwater mitigation and then a sponsor can accumulate fee revenues and implement other stormwater projects in other desirable areas) and stormwater credit banking (a private property owner can install stormwater best management practices on private lands and sell excess retention credits to permitted entities). Both the stormwater user fees and credit banking system could be ways to generate funds to cover the cost of stormwater management, promote GI, reduce flooding, and improve water quality in the Capital Region.

[13] http://www.cityofithaca.org/520/Stormwater-User-Fee-FAQs

4.4 Funding Mechanisms

USEPA [2014b] provides a description of funding mechanisms that support GI projects or programs including raising funds through taxes or fees, applying for grants, borrowing money through bonds or loans, and establishing public-private partnerships. These mechanisms along with the advantages and disadvantages of each are shown in Fig. 6. USEPA [2008] provides additional guidance to local governments for implementing stormwater fees and loan programs to fund GI. Federal funding sources are listed on the EPA's GI funding opportunities webpage[14] and the Partnership for Sustainable Communities webpage.[15] State sources that fund GI projects include the NYSDEC [16] and the EFC GIGP.[17]

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[14] https://www.epa.gov/green-infrastructure/green-infrastructure-funding-opportunities

[15] https://www.sustainablecommunities.gov/partnership-resources

[16] http://www.dec.ny.gov/pubs/grants.html

[17] http://www.efc.ny.gov/Default.aspx?tabid=461

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6 Tables and Figures

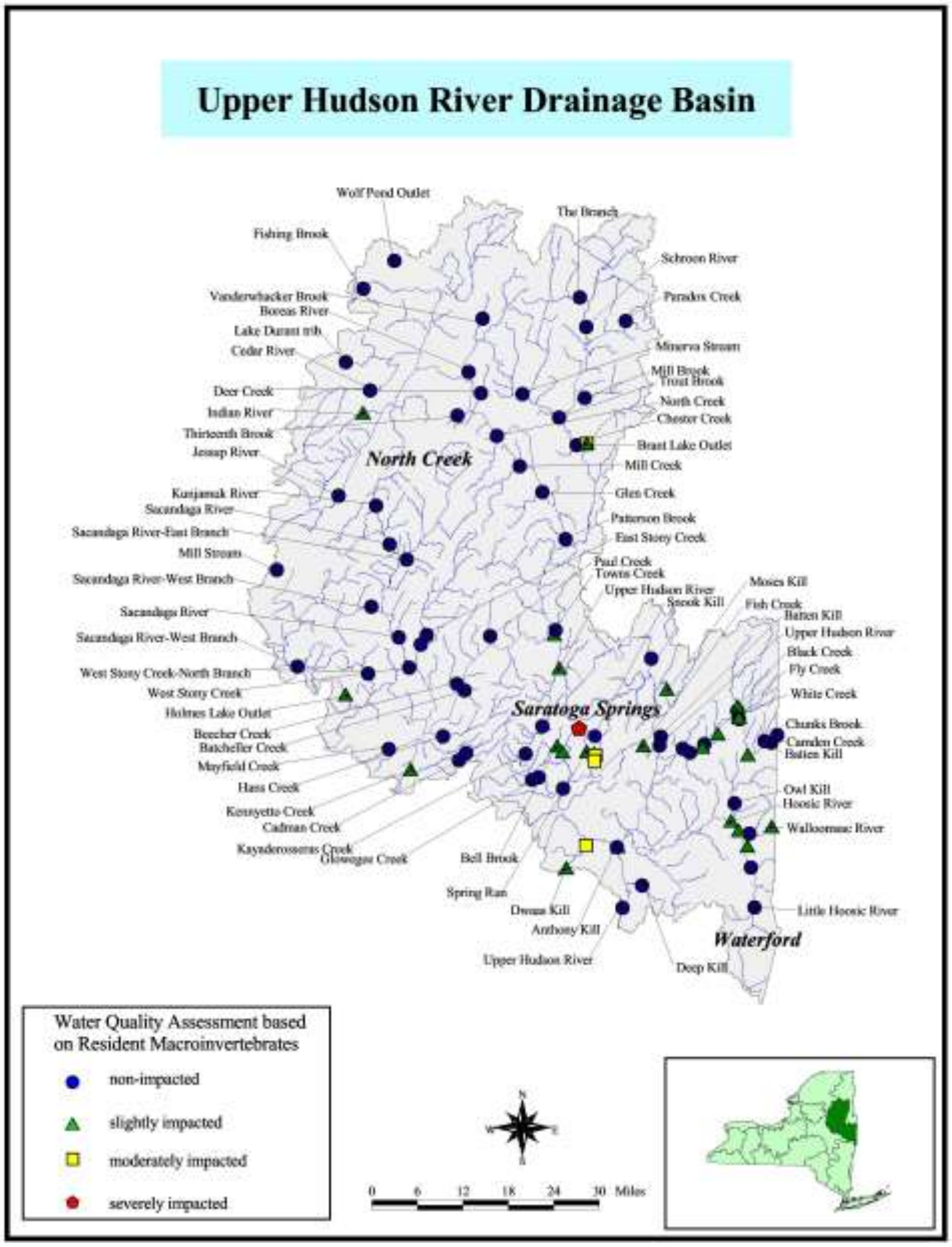

Figure 1: Macoinvertebrate sampling sites in the Upper Hudson Drainage Basin. Sites in red have the poorest water quality according to the results of a 30-year (1972-2002) biomonitoring trend report (Bode et al. [2004]).

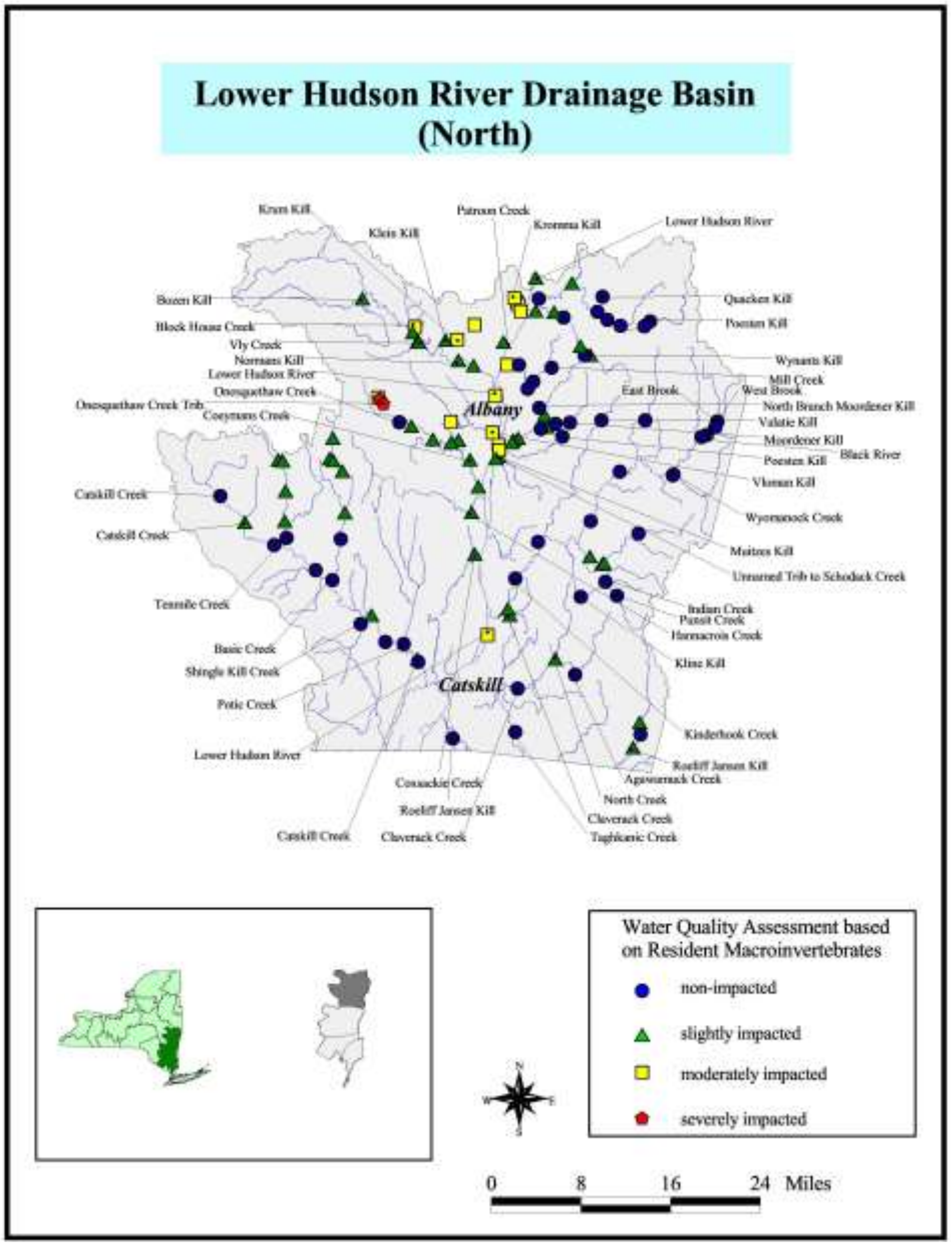

Figure 2: Macoinvertebrate sampling sites in the Lower Hudson Drainage Basin (North). Sites in red have the poorest water quality according to the results of a 30-year (1972-2002) biomonitoring trend report (Bode et al. [2004]).

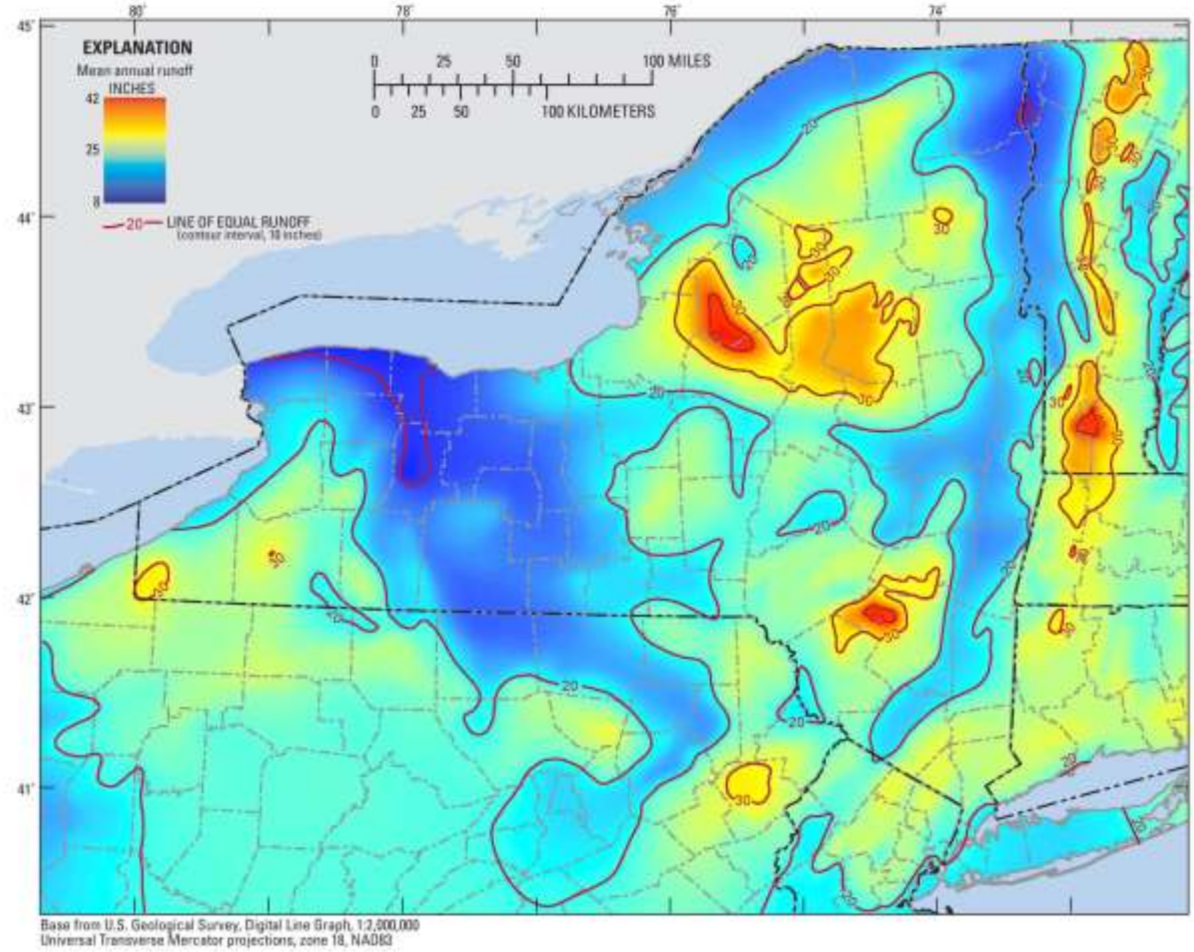

Figure 3: Mean annual runoff in areas in and adjacent to New York (as interpreted from Randall [1996] and cited in Lumia et al. [2006]). Though runoff volumes are modest in the Capital Region, climate change is likely to increase the frequency of extreme events.

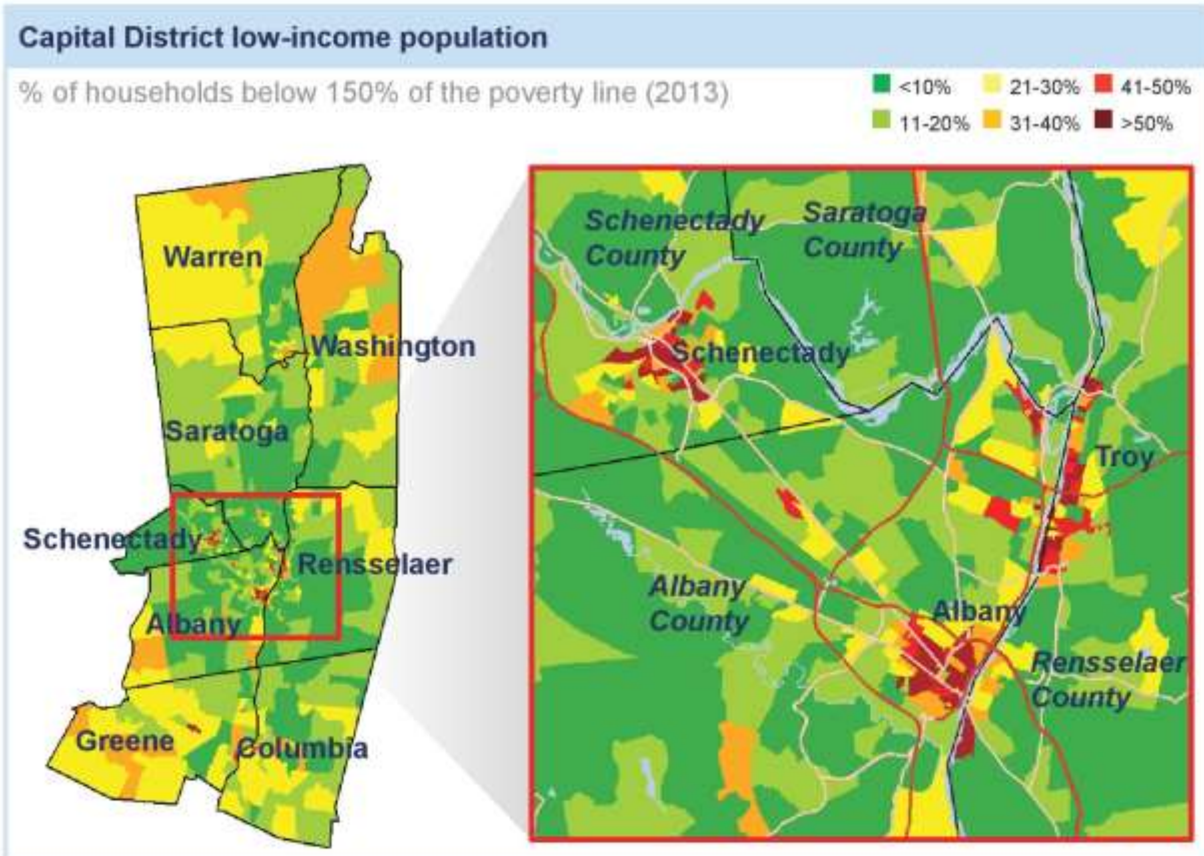

Figure 4: Areas in red are low-resource areas within the Capital Region designated as "Opportunity Zones" for economic development (Capital Region Economic Development Council [2015]). These areas could benefit from the improved aesthetics and increase in property values resulting from GI implementation.

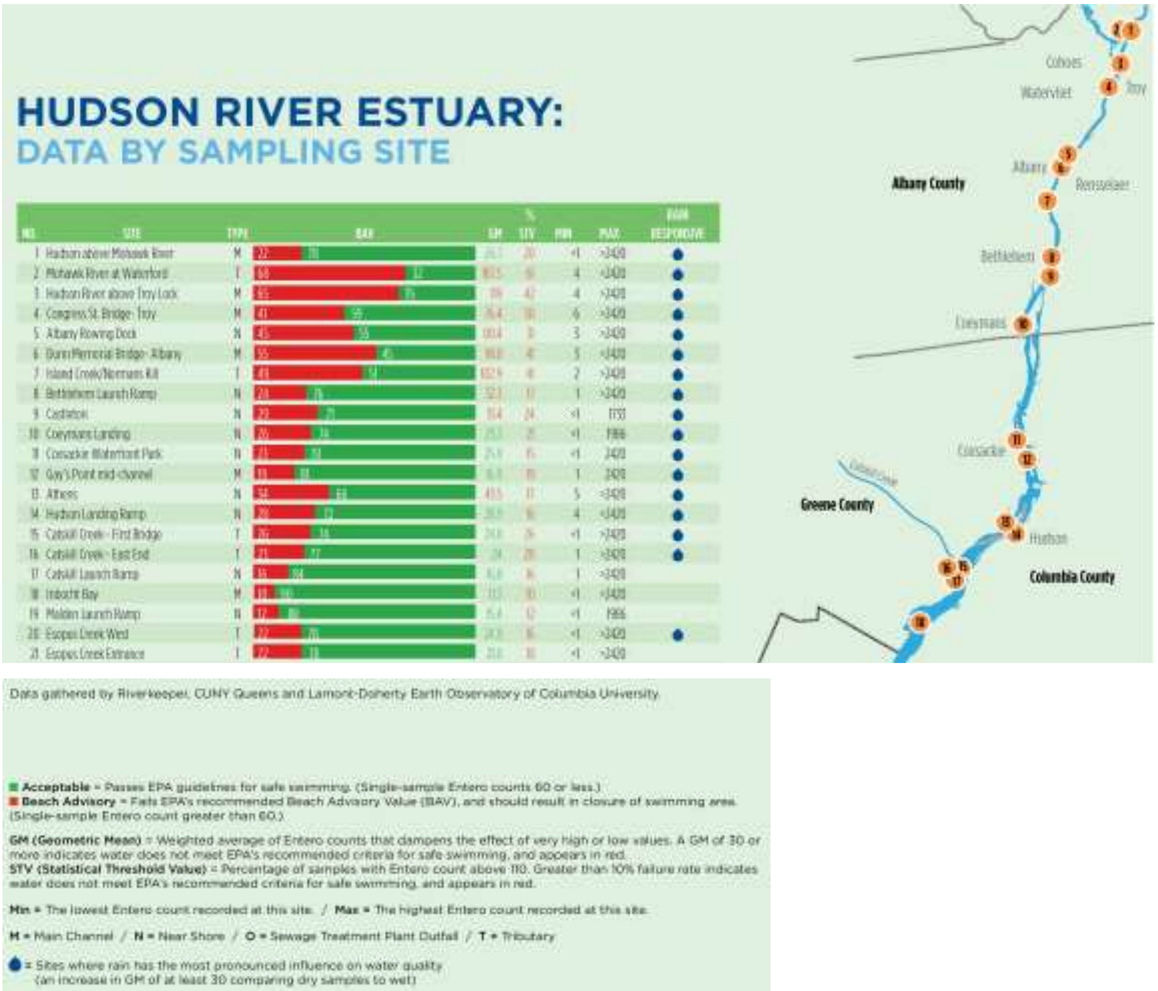

Figure 5: The results of Riverkeeper water quality monitoring, 2008-2014 (Riverkeeper [2015]). Several sites within the Capital Region fail US EPA standards for safe swimming due to excess bacteria from sources such as CSOs.

Funding Source	Description	Advantages	Disadvantages
Taxes/General Funds	Funds raised through taxes such as, property, income, and sales that are paid into a general fund.	• Consistent from year-to-year • Utilizes an existing funding system	• Competition for funds; • Tax-exempt properties do not contribute; • System is not equitable (does not fully reflect contribution of stormwater runoff)
Fees	Funds raised through charges for services such as inspections and permits. Funds raised through developer impact fees are one-time charges linked with new development.	• Specific permit and inspection fees allow for more direct allocation of costs for services provided • Addresses potential stormwater impacts related to new construction	• Funding not available for larger projects or system-wide improvements • Developer impact fees may be an unreliable source when development slows (due to market downturns/contractions) • Requires administrative framework to assess and manage
Stormwater Utility	A stormwater utility generates its revenue through user fees and the revenues from the stormwater charges will go into a separate fund that might be used only for stormwater services.	• Dedicated funding source • Directly related to stormwater impacts • Sustainable, stable revenue • Shared cost • Improved watershed stewardship • Addresses existing stormwater issues	• Feasibility study required for implementation, fee structure, and administration of utility • Approval by vote of the local legislative body • Perception by the public of a "tax on rain"
Grants	State and federal grants provide additional funding for water quality improvements.	• Existing sources available for stormwater-related funding • Does not require repayment	• Competitive • Typically one-time, project-specific, or time-constrained funds • Often requires a funding match
Bonds	Bonds are not a true revenue source, but are a means of borrowing money. "Green" bonds are a new source of funding dedicated to environmentally friendly projects, including clean water projects.	• Existing sources available for stormwater-related funding • Can support construction-ready projects • Can provide steady funding stream over the period of the bond	• One-time source of funds • Requires individual approval for each issuance • Requires full repayment • Possible interest charges • Requires dedicated repayment revenue stream • May require design-level documents to be prepared in advance • Likely requires voter approval • Can have high transaction costs relative to requested amount • May require significant administrative preparation to issue
Loans	Low-interest loans may be secured, but are generally used for planning and capital projects.	• Existing sources available for stormwater-related funding • Offers low- or no-interest financing	• One-time source of funds • Requires full repayment
Public-Private Partnerships	Contractual agreement between a public agency and a private sector entity that allows for the private sector participation in the financing, planning, design, construction, and maintenance of stormwater facilities.	• Can reduce costs to government • Significantly leverages public funding and government resources • Ensures adequate, dedicated funding • Improved O&M • Shared risk	• Perceived loss of public control • Assumption that private financing is more expensive and belief that contract negotiations are difficult

Figure 6: Potential funding mechanisms for GI with the advantages and disadvantages of each (USEPA [2014a]).

A

Glossary of GI Terms

All GI definitions are quoted from the National Green Infrastructure Certification Program.[18]

- **Bioretention.** Bioretention is a type of green infrastructure practice where shallow basins (such as rain gardens) or structures (such as stormwater tree planters) collect stormwater and use vegetation and layers of soil and aggregates to filter, store and infiltrate the water. The vegetation also uses (transpires) the water. Bioretention is commonly installed in parks and wide road medians or sidewalks.
- **Bioswale.** A bioswale is a bioretention practice that uses a shallow, open-channel flow pathway. Bioswales use a dense growth of vegetation, generally tall grass, along with layers of soil and aggregate to treat, store and infiltrate stormwater runoff.
- **Cistern.** A cistern is a structure built in a basement or near a house or building that collects and stores hundreds or thousands of gallons of rainwater from downspouts and nearby impervious surfaces so that the water can be used for non-potable uses such as irrigation, toilet flushing or car washing.
- **Evapotranspiration.** Evapotranspiration is the combined loss of water from a given area and during a specific period of time, by evaporation from the soil and by transpiration from plants. This is the step in the hydrologic or water cycle where moisture returns to the air (atmosphere) as humidity and begins to collect again as clouds.
- **Green roof.** A green roof is a roof of a building that is partially or completely covered with growing media and vegetation on top of a waterproof roof membrane. Rainwater falling on the rooftop is captured and stored in the media until it is used by the plants or it evaporates.
- **Impervious surface.** Impervious surfaces refer to surfaces that do not allow water to pass through the material, such as paved roadways, concrete sidewalks, rooftops, etc.
- **Infiltration.** Infiltration occurs when precipitation (rain, melting snow/ice) falls on pervious areas such as forests, prairies, mulch, grassed areas, and it soaks down through the soil layers and eventually recharges the underground aquifers (groundwater).
- **Permeable pavement.** Permeable pavement refers to a pavement system that includes a porous, load-bearing surface with an open-graded aggregate base below it that temporarily stores stormwater until it infiltrates into the underlying soils or drains to a controlled outlet.
- **Pervious concrete.** Pervious concrete is a type of permeable pavement where tiny interconnected holes are allowed to form in the concrete during the installation process to allow the water to pass through the concrete and infiltrate through the base layers and soil below.
- **Pervious pavers.** Pervious pavers are a type of permeable pavement that consists of individual concrete or stone shapes that are placed with a small gap between each other over a permeable sub-base. Stormwater passes between the individual pavers and then infiltrates down through the sub-base and the soil layers below.

[18] `http://ngicp.org/project/ngicp-glossary/`

- **Porous asphalt.** Porous asphalt is a type of asphalt pavement that uses uniform, larger aggregate than regular asphalt, which creates small, interconnected pathways through the asphalt pavement. Stormwater passes through the pavement surface and into stone sub-base where it is stored until it can infiltrate into the soil below.
- **Precipitation.** Precipitation is liquid or frozen moisture that falls from the sky. It includes drizzle, rain, sleet, snow and hail.
- **Rain barrel.** A rain barrel is a structure that collects and stores stormwater runoff from rooftops. They are typically stand-alone containers that hold 55 or 90 gallons of water. The stored water is often used to water lawns, gardens, window boxes, and/or street trees.
- **Rain garden.** A rain garden is a bioretention stormwater management practice where a shallow basin is used to capture stormwater runoff. Vegetation and layers of different mulch, soils and aggregates are used to mimic the ecological functions of a natural landscape. Rain gardens capture, filter, treat and infiltrate or transpire stormwater.
- **Rainwater harvesting.** Rainwater harvesting is the practice of collecting and temporarily storing rainwater in rain barrels or cisterns until it can be beneficially used for irrigation or some other non-potable use.
- **Stormwater.** Stormwater is precipitation that runs off surfaces such as rooftops, paved streets, highways, and parking lots. It also can come from hard grassy surfaces like lawns, play fields, and from graveled roads and parking lots.
- **Stormwater planter.** A stormwater planter is a type of bioretention. It is a specialized planter installed in the sidewalk area that is designed to manage stormwater runoff from streets and sidewalks. It is normally rectangular, with four concrete sides providing structure and curbs for the planter. The planter is lined with a permeable filter fabric, filled with gravel or stone, and topped off with soil, plants, and sometimes trees. The top of the soil in the planter is lower in elevation than the nearby street or sidewalk, allowing for runoff to flow into the planter through an inlet at street level. These planters manage stormwater by providing filtration, storage, infiltration, and evapotranspiration.
- **Tree box.** A tree box is a specific type of bioretention stormwater planter box that uses trees and bushes with deeper roots. Stormwater is captured, filtered, and temporarily stored until it is used by the trees and tall bushes or it infiltrates into the ground.
- **Tree trenches.** A stormwater tree trench is another type of bioretention practice where a collection of trees are planted along an underground infiltration structure. On the surface, a stormwater tree trench looks just like a series of street tree pits. However, under the sidewalk, there is an engineered system to manage the incoming runoff. This system is composed of a trench dug along the sidewalk, lined with a permeable geotextile fabric, filled with stone or gravel, and topped off with soil, trees and mulch. Stormwater runoff flows through a special inlet (storm drain) leading to the stormwater tree trench. The runoff is stored in the empty spaces between the stones, watering the trees and slowly infiltrating through the bottom of the trench. Once the capacity of this system is exceeded, stormwater will overflow to a stormwater sewer system.