TWO

PLACE

Green infrastructure can solve stormwater challenges while improving public spaces, streets, and parks and create places that make Buffalo's neighborhoods unique and livable.

This chapter presents the types of green infrastructure and how they function within a green stormwater network.

The Buffalo Sewer System and Green Infrastructure

Buffalo's sewer system is a combined sewer system (CSS) — combining sanitary sewage and stormwater in the same pipe. The CSS was constructed with 65 permitted combined sewer overflow (CSOs) outfalls to relieve the system during wet weather events in order to protect downstream treatment facilities and prevent basement flooding. Buffalo Sewer has completed numerous improvement projects resulting in the reduction of CSO outfalls. Currently, the system consists of 52 permitted CSO outfalls. The United States Environmental Protection Agency (USEPA) issued a national CSO Control Policy in 1994, requiring communities with CSSs to develop Long Term Control Plans (LTCPs) that comply with the requirements of the Clean Water Act, including attainment of current or revised water quality standards to reflect wet weather in-stream conditions.

While this LTCP program focuses primarily on the collection system, the Bird Island Wastewater Treatment Plant (WWTP) is also an integral part of the CSS. Immediately after the establishment of Buffalo Sewer in 1935, a primary wastewater treatment plant, focused on disinfection and removal of solids from wastewater, was constructed and began operation on July 1, 1938. Secondary treatment facilities, which provided for additional treatment and disinfection of wastewater, were added at the plant between 1975 and 1979.

Completed and current upgrades to the facility will allow for improved treatment for up to 320 million gallons per day (MGD) of flow through the secondary treatment system and following completion of the additional future upgrades, up to 400 MGD through the secondary treatment system. All treated flows are discharged to the Niagara River via two permitted outfalls. The WWTP is also equipped with a third emergency outfall which is used to protect the WWTP in the event of extreme wet weather or equipment malfunction to prevent the plant influent flow from exceeding the plant's treatment capacity.

LTCP Development Process

Buffalo Sewer originally submitted its LTCP for CSO abatement to the New York State Department of Environmental Conservation (NYSDEC) in July 2004 (2004 LTCP). Buffalo Sewer began additional work in 2008 to update the LTCP based on comments received from NYSDEC and additional evaluations conducted at the request of NYSDEC and USEPA (the Agencies).

From 2008 through early 2012, Buffalo Sewer and the Agencies discussed revisions to the LTCP. On March 15, 2012, the USEPA ordered Buffalo Sewer to submit an updated LTCP to the Agencies no later than April 30, 2012. Following submission of the April 2012 LTCP, the Agencies provided comments. A major effort in addressing this set of comments was the development of a Green Infrastructure Master Plan (GI Master Plan). Based on the comments provided by the Agencies, the LTCP has been revised to incorporate the findings of the GI Master Plan.

In addition to developing this LTCP update, Buffalo Sewer has continued to work diligently to reduce CSO overflow volumes and frequencies. Along the way, Buffalo Sewer has invested tens of millions of dollars in capital improvements both at the WWTP and in the collection system.

Green Infrastructure Master Plan

In determining how best to address the CSO overflow challenge and respond to the Agencies' comments, Buffalo Sewer looked at implementing real time controls (RTC) to maximize the efficient use of the existing infrastructure, in conjunction with green infrastructure to reduce the amount of stormwater entering the sewer system. In response to Agencies' comments on the April 2012 LTCP, Buffalo Sewer provided additional detail on their green infrastructure program by developing a GI Master Plan.

The GI Master Plan includes further refinement of the green infrastructure impervious surface control targets presented in the April 2012 LTCP to

Figure 2.1: Buffalo's Wastewater Treatment Plant on Bird Island.

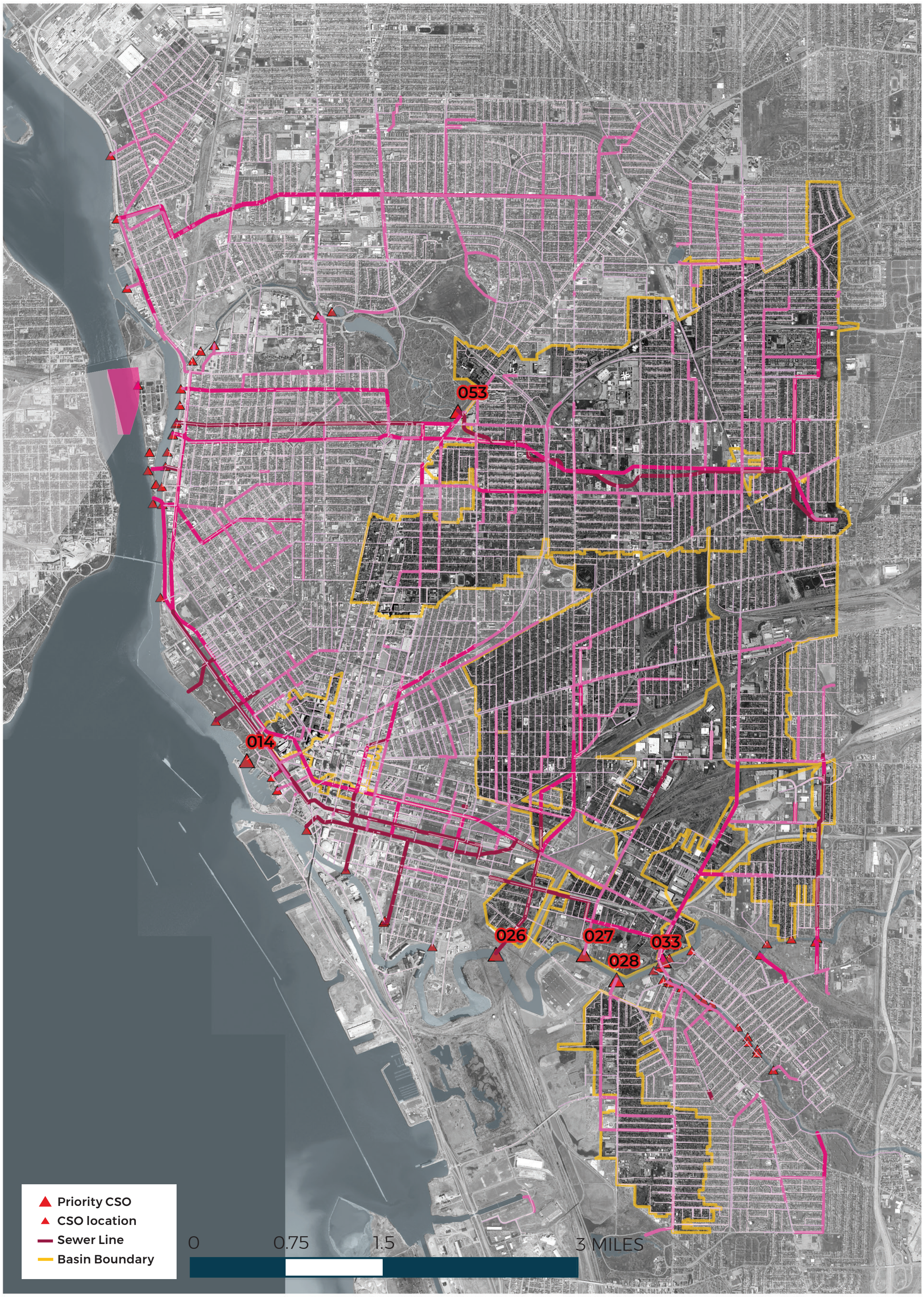


Figure 2.2: Map of Buffalo's Sewer System with the priority CSO basins outlined.

determine, on a more localized level, where the system would most benefit from green infrastructure technologies. It also provides requested detail on the Phase 1 green infrastructure projects to be implemented over the first five-year period. It does this by further dividing CSO basins into sub-basins. By focusing on the sub-basin level, the GI Master Plan could closely identify which portions of the larger CSO basins were contributing the most to the CSO challenge and where green infrastructure would provide the greatest benefit.

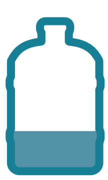
Refining the impervious control acreage to the sub-basin level allowed for better identification of CSO basins (and by extension CSO outfalls) that would benefit most from implementing green infrastructure technologies, and also for determining which basins would not benefit because they were already at or below the recommended level of control or do not discharge directly to receiving waters. Recommended acreages increased in the Black Rock Canal and Erie Basin, and decreased in the Cazenovia Creek, Buffalo River, Niagara River, and Scajaquada Creek Basins. Because the sub-basin-level green infrastructure allocation provides a more refined and cost-effective approach, Buffalo Sewer is working towards a 1,315-acre total green infrastructure program effort.

Buffalo Sewer remains committed to evaluating opportunities to maximize the use of cost-effective green infrastructure approaches. The target acreage above is a minimum program commitment. Additional green infrastructure acreage may go beyond this minimum and can be used in conjunction with the optimization of gray projects. This approach allows Buffalo Sewer to adaptively manage the green infrastructure program to incorporate lessons learned and take advantage of land use and infrastructure investments to deliver the maximum public benefits at the lowest cost.

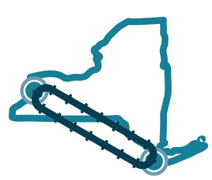
Green Infrastructure Planning Efforts History

Figure 2.3: Key Buffalo stormwater planning documents. Top to bottom: Long-Term Control Plan and GI Master Plan; Buffalo Green Code and LWRP; Rain Check 1.0 Report; Rain Check 2.0 Opportunity Report.

Citywide Statistics



The maximum daily capacity of the WWTP is **560** million gallons, of which usually **144** million gallons are treated each day.

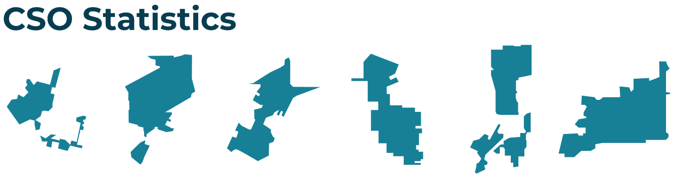


The length of sewer main pipes in the system is **854** miles—long enough to reach from Buffalo to NYC and back.

110 SQUARE MILES OF COLLECTION SYSTEM

92% OF BUFFALO'S SEWER SYSTEM IS COMBINED

CSO Statistics



6 TARGET CSO OUTFALLS

52 PERMITTED CSO OUTFALLS

GREEN INFRASTRUCTURE: SOLUTIONS AND NETWORKS

Practices and Technologies

Green infrastructure practices keep the stormwater challenge in check by reducing and managing the impervious surfaces of the City that produce stormwater runoff, particularly runoff from streets, buildings, and parking lots. While traditional gray infrastructure and other "smart" approaches are still needed, especially in extreme events, green infrastructure is a powerful, cost-effective way to reduce sewer overflows. This section identifies the green infrastructure practices and technologies that Buffalo Sewer has identified as the most appropriate for Buffalo and includes maintenance considerations.

As discussed in **Chapter 1 | Opportunity**, green infrastructure has the capacity to provide co-benefits in addition to reducing the amount of stormwater entering the sewer system. This section will discuss how different network configurations can contribute to increasing these co-benefits, helping to address equity and environmental goals.

Finally, planning and implementation will be key to a successful green infrastructure program, including the ability to provide larger, more networked systems. This chapter also discusses programs that create incentives for implementing green infrastructure and the planning process.

Green infrastructure captures stormwater before it goes into the combined sewer system and reduces combined sewer overflows.

Green Infrastructure Practices, Configuration, and Planning

There are many types of green infrastructure. The basic goal of all green infrastructure is to remove stormwater from the sewer system by storing, diverting, or infiltrating it on site. Green infrastructure mimics the way water moves in a natural system by allowing stormwater to be absorbed by soil and plants. Green Infrastructure is a way to let the landscape do the work of managing stormwater, rather than relying solely on the sewer system and treatment plant to do this work.

Green Infrastructure practices can be considered on one end of a sliding scale of stormwater technologies with the most 'green' consisting of vegetation and living systems and the other end being more traditional gray infrastructure technologies utilizing underground storage without living systems. Green infrastructure is also implemented in a decentralized and distributed network of stormwater management where stormwater does not travel to a central facility for treatment.

In addition to the green infrastructure itself, the way that green infrastructure is placed on the site and its relationship to other green infrastructure interventions also impact how effectively green infrastructure reduces the quantity of stormwater entering the combined sewer system. Green infrastructure practices that are networked can provide additional stormwater benefits and opportunities for shared costs and streamlined maintenance.

Figure 2.4: Rain Garden on Penn Avenue in Pittsburgh, PA.

Vegetated Practices

Vegetated practices provide many important benefits in addition to stormwater management. Stormwater planters, tree pits, rain gardens, bioswales and green roofs have the potential to increase property values, reduce urban heat island effect, and mitigate pollution.

Stormwater Planters and Tree Pits

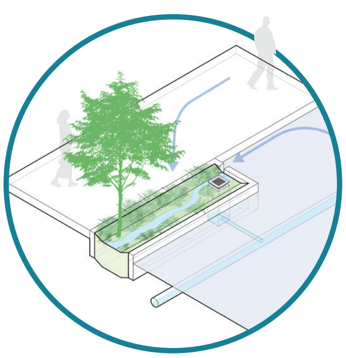
Tree pits and sidewalk planters can be used to capture stormwater in urban areas. These small landscaped installations can infiltrate or filter water and can also convey or store water if designed with the appropriate infrastructure. Stormwater planters and tree pits are usually structured and may have curbs, sidewalks, inflow, and overflow devices. According the New York State Stormwater Management Design Manual, the soil in a stormwater planter uses biogeochemical processes and soil infiltration to decrease stormwater quantity and improve water quality. Soil for urban planters and pits should be carefully selected to deal with the structural conditions and salt or contaminant inflow.

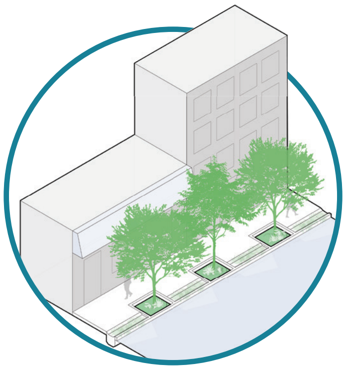
Rain Gardens

Rain gardens (sometimes called bioretention) are depressed landscape features. They contain plants that tolerate alternating wet and dry periods. They are designed to hold stormwater and allow it to infiltrate into the soil. The size of rain gardens can vary depending on how much water they will receive. A small rain garden at a private home may be able to receive water from a disconnected downspout while a rain garden that captures run off from a large parking area will be significantly larger. Rain gardens usually use a special, highly porous planting soil to promote infiltration. Rain gardens are typically sized to handle runoff from a small event and have an overflow mechanism to convey water from a large event. Depending on the porosity of the underlying soils, rain gardens may also be equipped with an underdrain.

Bioswales

Bioswales (sometimes called vegetated swales) are gently sloped and vegetated landscape features. Bioswales reduce the quantity of stormwater by promoting infiltration and help to improve water quality by slowing and filtering stormwater, allowing sediment and some pollutants to settle out. They are often used along roadways, driveways, and parking lots. They will typically use a specialized, very porous planting soil.





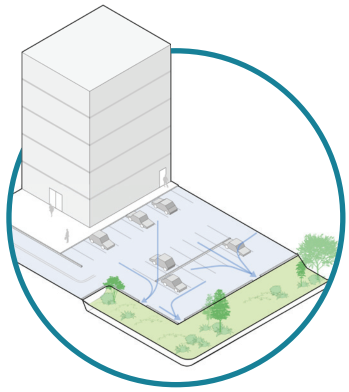


Figure 2.5: Buffalo Sewer Rain Garden on Windsor Avenue.

Considerations

For all these practices, plants should be selected for the planter or pit size, location and exposure to light, and their salt and pollutant tolerance.

- Weeding and regular maintenance will be required.
- Trash will need to be removed, especially after large events or where planters and pits are receiving water from streets or parking lots.
- Plants will need to be regularly pruned and may need to be periodically replaced.
- Soil should be selected to maximize infiltration, storage, or other site-specific and plant-specific requirements.

Pollution Mitigation Benefits

Rain gardens, bioswales, and wetlands remove pollutants from air and water. The pollution removal increases if tree area is added at a density of 5 trees per 1,000 square feet.

Benefit	No Trees	Trees
Carbon Dioxide sequestered	581 lbs/year	728 lbs/year
Ozone Removed	0.49 lbs/year	1.1 lbs/year
Particulates Removed	0.43 lbs/year	0.84 lbs/year
Nitrogen Dioxide Removed	0.39 lbs/year	0.81 lbs/year
Sulfur Dioxide Removed	0.23 lbs/year	0.46 lbs/year
Carbon Monoxide Removed	0.12 lbs/year	0.2 lbs/year

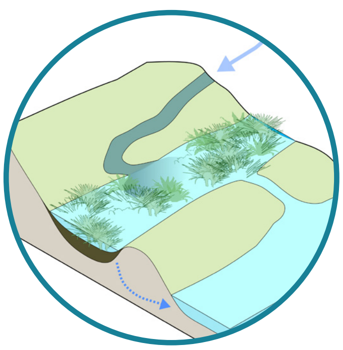
Numbers are for 1,000 s.f. installation and are based on NYC Green Infrastructure Co-Benefits Calculator.

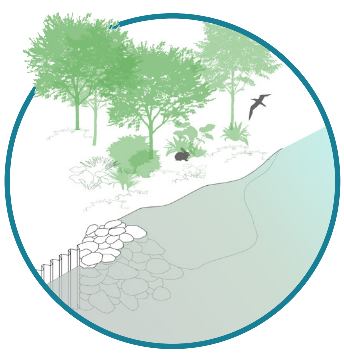
Wetlands

Both natural and constructed wetlands provide significant stormwater quality improvement. Constructed wetlands are designed to maximize pollutant removal by settling out sediment and through uptake and filtering of pollutants by wetland vegetation. To function properly, constructed wetlands must have a sufficient drainage area and receive enough water during dry weather, in order to maintain a minimum pool level. Wetlands can also reduce urban heat island effect, increase property values, and sequester carbon dioxide.

In-stream Restoration

In addition to working inland on point source practices and prevention strategies, implementing projects within waterways addresses water quality more directly. Floating wetlands reduce nitrogen and phosphorus nutrient concentrations; root wads, pools and riffles provide habitat enhancements; and flow deflectors recreate natural stream meanders. In-stream restoration practices provide an excellent opportunity to improve water quality continuously throughout the year and not just in preventing pollution during wet weather events.





Riparian Restoration

Recreating the natural vegetated edge—or buffer—along streams and rivers assists with slowing, filtering, and infiltrating stormwater runoff before it reaches those water bodies. Combining it with a level spreader, which distributes the stormwater as sheet flow, rather than in a concentrated stream, helps to minimize erosion and increases the effectiveness of riparian buffers at filtering and infiltrating stormwater.

Tree Planting / Preservation

Trees are important allies in managing stormwater. Adding trees increases the absorption of stormwater into the soil (infiltration). Trees use stormwater (evapotranspiration), which reduces the amount of stormwater runoff. Tree canopies also intercept water, slowing stormwater flows. Trees can reduce urban heat island effect, increase property values, and sequester carbon dioxide.

Open Space Preservation

Open space—such as a park—is an important component of permeable, vegetated space, particularly in urban areas. Preserving open space and, in some cases enhancing it with the addition of planting, especially trees, reduces the amount of stormwater runoff that eventually enters the storm system. In some cases open space also provides an opportunity for incorporating other green infrastructure practices, such as riparian buffer restoration, rain gardens, tree planting, and bioswales. Open spaces can also be important nodes in a networked system of green infrastructure.

Tree Benefits

Buffalo's 3,830 acres of tree canopy provides the following benefits on an annual basis

Benefit	Buffalo Canopy
Carbon dioxide sequestered	2,523,374 lbs
Water Saved	40,882,251 gallons
Energy Saved	271 Kwh
Energy Saved	80 Therms

Based on City of Buffalo Open Data Portal

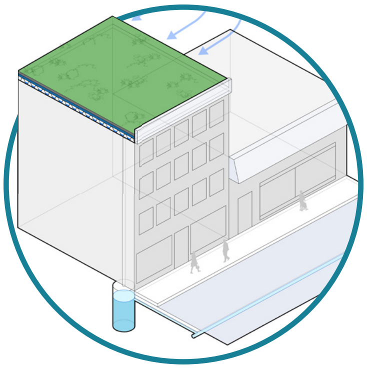
Focus on
Green Roofs

Green roofs are planted areas on building roofs that use a special lightweight planting soil and plants to store and use (evapotranspire) stormwater. Green roofs can add value to large buildings with flat roofs, such as offices and apartment buildings, by decreasing temperature swings in the buildings, extending the life of roofing, and by providing an amenity for occupants. Studies have shown that people prefer views of living habitat, and green roofs bring plants, birds, and insects into the urban environment.

Green Roofs may require significant structural support which may increase cost. Existing buildings may be difficult to retrofit. Depending on the location and height of the building, getting planting media and plants onto the roof can be a logistical challenge. Egress and access that complies with the Americans with Disabilities Act is required for occupiable green roofs.

Nearly 7,000 acres of Buffalo's impervious surface is rooftop!

Figure 2.6: Green roof at Kensington High School in Philadelphia, PA (image ROOFMEADOW).



Pollution Mitigation Benefits

Green roofs help remove pollutants from air and water.

Benefit	Green Roof
Carbon Dioxide sequestered	244 lbs/year
Ozone Removed	0.55 lbs/year
Particulates Removed	0.21 lbs/year
Nitrogen Dioxide Removed	0.08 lbs/year
Sulfur Dioxide Removed	0.54 lbs/year
Carbon Monoxide Removed	0.21 lbs/year

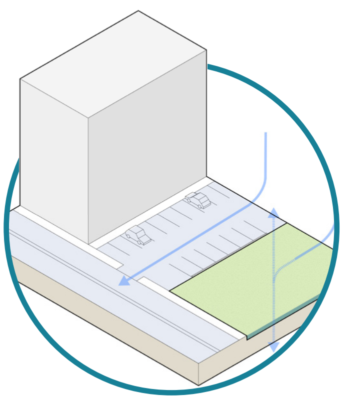
For a 1,000 s.f. green roof with 3" of planting medium and 2" drainage layer. Based on NYC Green Infrastructure Co-Benefits Calculator

Non-Vegetated Practices

Non-vegetated practices, such as porous paving and rain barrels or cisterns, are essential in urban areas where space is constrained or where water can be captured for reuse.

Impervious Surface Reduction

Impervious surface reduction is a key strategy for managing stormwater. Impervious surfaces - such as parking lots, driveways, roadways and sidewalks - generate a much higher level of stormwater runoff than landscaped areas. Rainfall on or snowmelt from impervious surfaces runs off more quickly and carries more pollutants. By reducing the amount of impervious surface - for example using porous pavement in parking lots, incorporating landscaped areas into parking lots, putting green roofs on buildings, or simply making impervious components of the lot as small as possible - the amount of stormwater runoff is reduced.

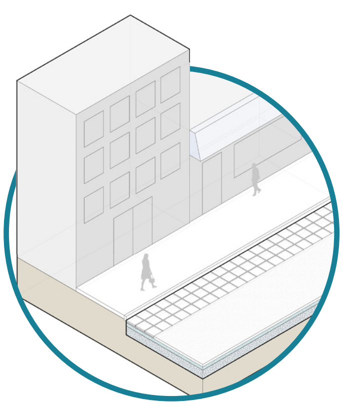


Porous Paving

Porous or permeable pavement can include pavers with small gravel in the joints, or special concrete or asphalt with pore spaces that allow stormwater to move through the pavement into a gravel bed below, where it is held while it infiltrates into the soil. Depending on the permeability of the underlying soil, the gravel bed may be equipped with a perforated pipe to convey overflow.

The effectiveness of porous paving is reduced if the pore spaces become clogged with dirt or debris. Regular maintenance is required to vacuum out pore spaces. Consideration should be given to the type of runoff that will be reaching the porous paving. If an area receives silty runoff, for example, it may not be a suitable location for porous paving. Porous paving is appropriate for driveways, parking lanes, parking lots, sidewalks, and other low traffic applications.

Winter maintenance is important and while deicing materials such as road salt can be used, materials to reduce slipperiness, such as sand, will clog porous paving. Proper installation of the pavement is required to avoid damage from plows and porous paving should not be used in areas that require heavy duty pavement.



Sand Filtration

Sand filters are designed to remove pollutants from stormwater. Stormwater is directed to a sand bed with an underdrain. As stormwater moves through the filter, pollutants are treated by settling and absorbing into the sand bed. Sand filters are particularly effective at removing nutrients and total suspended solids, which are significant pollutants in stormwater.

Rain Barrels

Rain Barrels capture water from roofs. The water is stored and can be used by homeowners for gardening or other nonpotable uses. Rainwater should be used before the barrel overflows to ensure that the rain barrel is empty and ready to receive runoff from the next storm. Homeowners use rainwater instead of drinking water, reducing their water use and cost.

Rain barrels are low maintenance, however, they work best when owners are committed to maintaining them. Rain barrels have an overflow and need a place to divert overflow, such as a lawn or a rain garden, that is away from house foundations. Leaves and debris needs to be cleaned and rain barrels must be disconnected in winter.

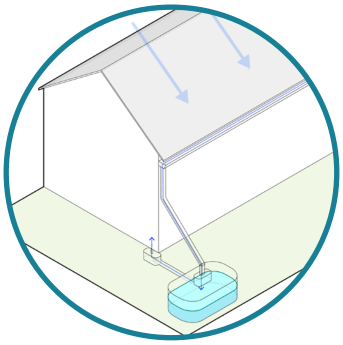
Cisterns

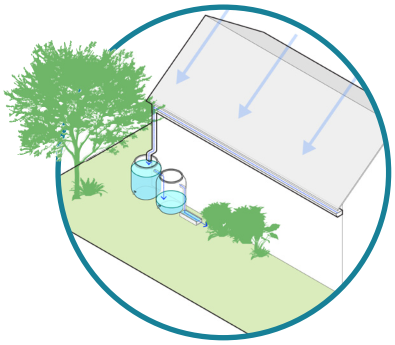
Rainwater cisterns are larger storage tanks for holding stormwater. These tanks can be either above or below grade. They collect stormwater from impervious surfaces, such as roofs and pavement, and store the water either for reuse for non-potable uses, such as irrigation or toilet flushing, or for slow release after wet weather has passed.

Downspout Disconnection

Roof downspouts are typically connected to the sewer system, contributing significantly to the volume of stormwater entering the system. Downspout disconnection is the process of separating roof downspouts from the sewer and redirecting roof runoff away from impervious surfaces to landscaped areas, most commonly a lawn, reducing the volume of stormwater entering the sewer system during wet weather. Directing stormwater to a vegetated area also helps to remove sediment and pollutants.

Figure 2.7: Porous paving next to bioswale along Living Place in Pittsburgh PA.



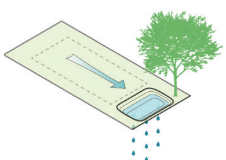


Source & Configuration

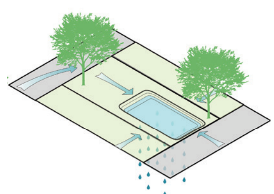
Source & Configuration describes how a system works. Planning & Decision-Making describes how it is implemented at scale.

Green infrastructure can either be stand alone or combined into systems at scale. These systems are arrayed along a continuum from the individual parcel to a network encompassing an entire CSO basin. The larger the scale of the system, the greater the quantity of stormwater that is managed, and the more effective it is at achieving green infrastructure compliance goals under the Long-Term Control Plan. Larger systems also have a greater ability to provide a broader array of benefits in addition to reducing stormwater, including equity, economic and environmental benefits, sometimes referred to as the triple bottom line. The triple bottom line benefits are discussed more later in this chapter.

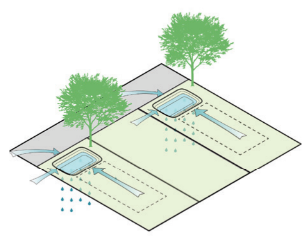
Green Infrastructure Scale Continuum



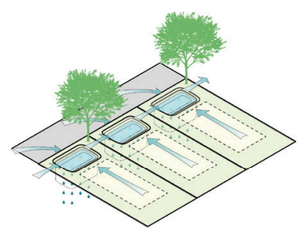
PARCEL



AGGREGATED



DISTRIBUTED



NETWORKED

Figure 2.8: Stormwater planter in Buffalo.

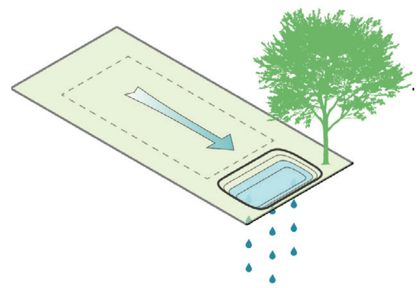
Figure 2.9: Rain garden along Windsor Avenue.

Figure 2.10: Porous paving alongside a bioswale.

Figure 2.11: Rain garden along Elmwood Avenue.

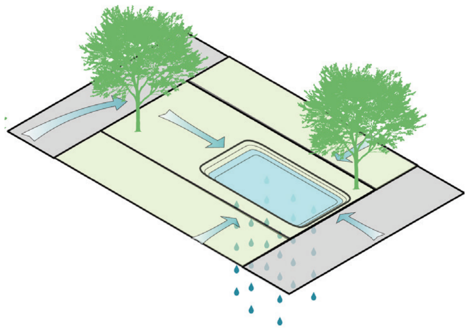
The configuration on any given parcel and how it connects into a larger green infrastructure system depends on factors such as available land, land use, and the cooperation of the property owner.

Parcel based / Single Source



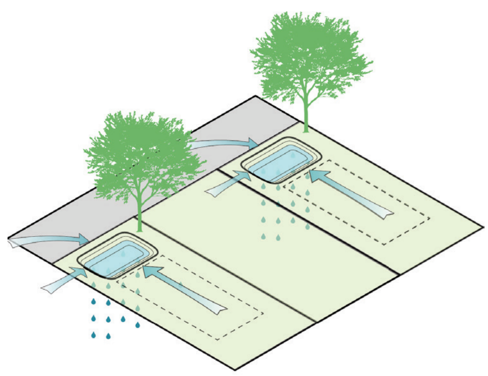
The parcel level is the simplest type of configuration. In this case green infrastructure on a parcel is used to manage stormwater on that parcel. An example would be a roof downspout that flows into a rain garden. By managing water from impervious surfaces in the rain garden, a parcel-based approach helps to keep stormwater out of the sewers. The parcel is also the building block for other, more complex networks.

Aggregated / Multi-Source



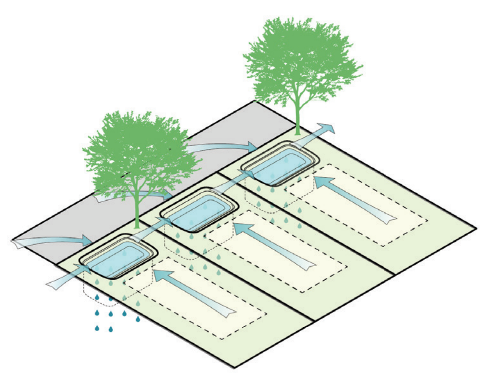
An aggregated system uses green infrastructure to manage stormwater runoff from a variety of sources. A rain garden that manages roof and driveway runoff from multiple parcels is an example of an aggregated system. Aggregated systems may also involve a treatment train — where stormwater passes through multiple green infrastructure interventions. For example, porous pavement may be used in a driveway or parking lot to manage stormwater. If a rain garden were present on the same parcel, it would manage rainfall from larger events that is not able to be handled by the porous paving alone. By combining green infrastructure strategies, more stormwater is managed.

Distributed



A distributed system is where multiple aggregated systems are managing stormwater. Because there is more green infrastructure, more stormwater is being managed. While more effective than an aggregated system alone, a distributed system is smaller and less effective than a more networked system. A distributed system or systems can be a step toward a more networked system.

Networked / Multi-Part System



A networked system is the largest, most complex and ultimately the most effective network type at reducing the amount of stormwater entering the sewer system. A networked system combines distributed systems, increasing the treatment train. For example, a networked system might include a streetscape with a bioswale. The bioswale would manage stormwater from the roadway and convey it to a larger rain garden or wetland. That same bioswale could also pick up water that overflows from private parcels, or from aggregated or distributed systems, networking them together into a larger system. In addition to lengthening the treatment train and allowing more water to infiltrate into the ground or be absorbed by plants, a networked system also creates the highest amount of redundancy in the stormwater management system which allows water from larger storm events to be managed while increasing resiliency.

Planning & Decision-Making

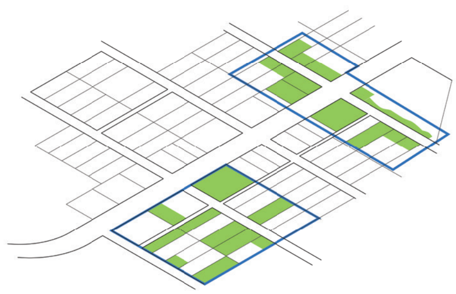
To meet the scale of implementation needed to meet compliance goals, Buffalo can bring green infrastructure to scale with different distribution typologies.

Green infrastructure can be deployed with an opportunistic approach that is typically distributed and parcel-based, responding to available opportunities. Green infrastructure can also be implemented with a strategic approach where that creates larger or more effective networks. Each typology has benefits and drawbacks.

Opportunistic sites are easier to implement and require less planning, but may come at the cost of being less effective at stormwater removal. Strategic approaches may require more time, planning, engineering, coordination among partners, and cost, but handle much larger quantities of stormwater. They also provide greater triple bottom line benefits. Strategic approaches may be based on physical proximity, or they may be more programmatic, focusing on a neighborhood or region or targeted by land use or ownership. The co-benefits of more networked approaches will be discussed in more detail later in this chapter.

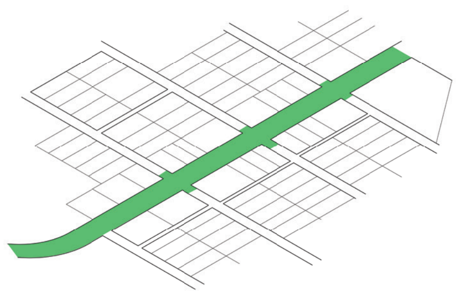
Opportunistic Sites

Green infrastructure is implemented on a parcel basis where there is an opportunity and a willing property owner. This approach is an important step in developing a larger more networked system. The approach is the simplest to implement, but has limited effectiveness in how much stormwater can be removed from the system.



Clusters

A clustered approach is where there are a number of opportunities in a common geographic location. A cluster could be a college campus, or group of institutions, an industrial park, or simply a series of green infrastructure opportunities close to one another. The power of clusters is that it allows for a more networked system, creates greater visibility for green infrastructure, and utilizes green infrastructure as a place-making opportunity.

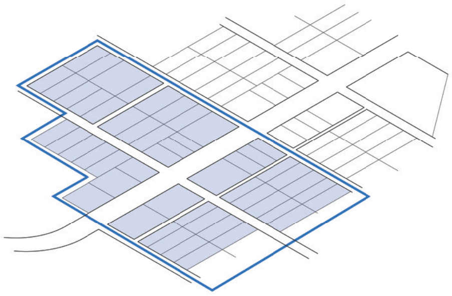


Corridors

Corridors are linearly connected systems of green infrastructure, typically within or along the public right of way. Corridor approaches can provide the armature for more networked systems. Green infrastructure in corridors also provides many other co-benefits, including traffic calming, reduction of urban heat island effect, improved walkability, and access to green space to city residents.

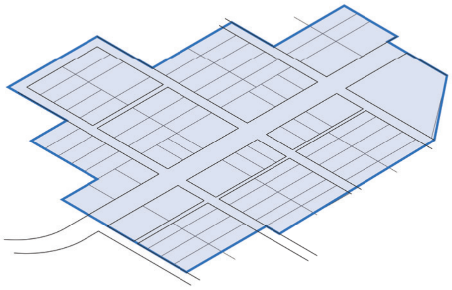
Neighborhoods

Neighborhood programs focus on systematically providing green infrastructure within a neighborhood. Neighborhood programs are most appropriate where there are strong community partners to implement the program. Neighborhood programs might include green streets and street trees along neighborhood commercial districts, working with homeowners to install rain barrels, building rain gardens, and disconnecting downspouts. Neighborhood programs can also provide other co-benefits such as workforce development and economic revitalization. Neighborhoods are also a traditional basis for planning and so planning at the neighborhood level will feel familiar to many partners.



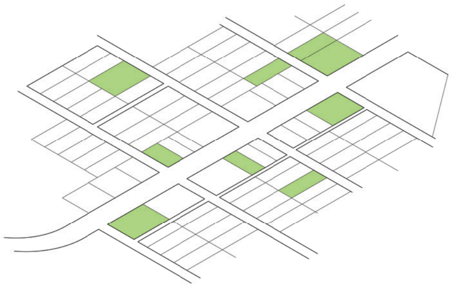
Regional Systems

Regions are where multiple zones, neighborhoods, or clusters are aggregated and large-scale investments can be made to enable localized projects upstream. By working across larger regions, project scale can increase and greater levels of stormwater performance become possible. Regional systems could include larger planning projects or corridors. In the stormwater context, the most effective regional system will be one that encompasses the entire CSO basin and larger watershed.



Targeted Land Use or Ownership

Targeting a particular type of land use — such as parking lots — or a particular type of ownership — such as schools — can be a strategy for demonstrating green infrastructure, for building communities of action, and for providing benefits such as workforce training. Since similar land uses will have similar challenges and opportunities, targeting particular land uses can provide efficiencies and economies of scale with regard to planning and design. In addition, since land uses are often grouped together, targeting specific land uses also facilitates the creation of clusters, neighborhoods, and regional systems.



Programmatic Co-Benefits

Green infrastructure can help neighborhoods feel vibrant and livable with social, economic, and environmental benefits...while managing stormwater more effectively.

Corridors

Buffalo has very prominent avenues and streets. Green corridors and complete streets were envisioned by Olmsted in his plan for Buffalo. Green corridors can help connect neighborhoods, improve the viability of commercial districts, and create public-right-of-way systems that demonstrate green infrastructure viability to private landowners.

Corridors are an opportunity to integrate green infrastructure into complete street concepts. Complete streets integrate people and neighborhoods into the planning and design process for roadways that are safe, convenient, and comfortable for all users, including pedestrians, cyclists, and drivers. Complete streets improve walkability by creating person-scaled sidewalks. Green infrastructure's street trees, porous paving, rain gardens, and bioswales are part of the complete street design toolkit but require maintenance that the City does not have the capacity to provide. Buffalo Sewer will explore opportunities for shared maintenance responsibility with local community groups and landowners.

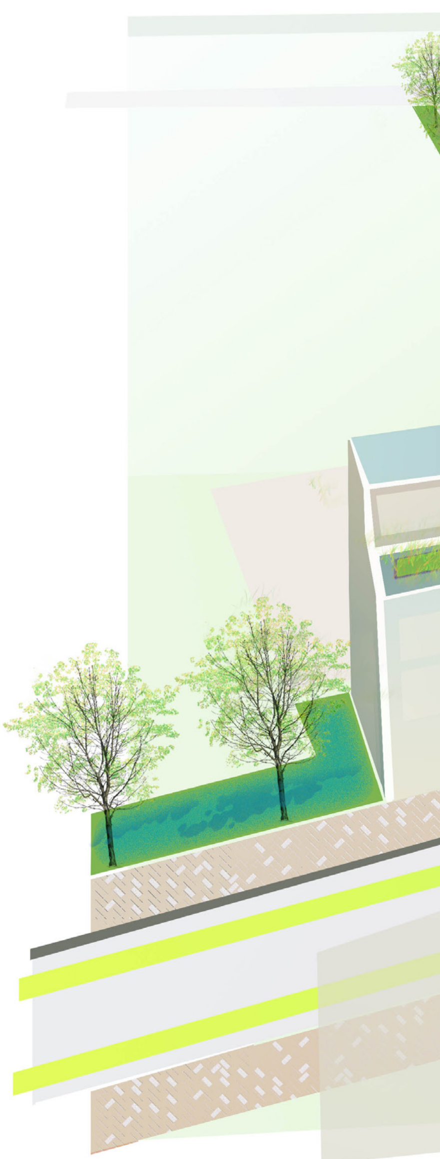
Commercial Property

Commercial properties have large impervious areas that contribute significant amounts of stormwater to the combined sewer system and contribute to urban heat island effect, including parking lots and rooftops. By incorporating green infrastructure technologies such as green roofs, rain gardens, porous paving and tree planting onto commercial properties, the quantity of stormwater runoff can be reduced.

Converting from traditional landscape maintenance to green infrastructure landscape maintenance requires some additional training but most commercial owners already have a maintenance regimen. Incorporating green infrastructure is essentially a modification of tasks already being performed and paid for, rather than entirely new tasks.

Parking Lots

Parking lots make up a large area of impervious pavement across Buffalo and are therefore major contributors of stormwater runoff to the combined sewer. By targeting parking lots for green infrastructure, the amount of stormwater entering the combined sewer system can be reduced. The addition of green infrastructure to parking lots can create "outdoor rooms," with trees and plants breaking up otherwise monotonous parking areas.



Green infrastructure can improve Buffalo's corridors:

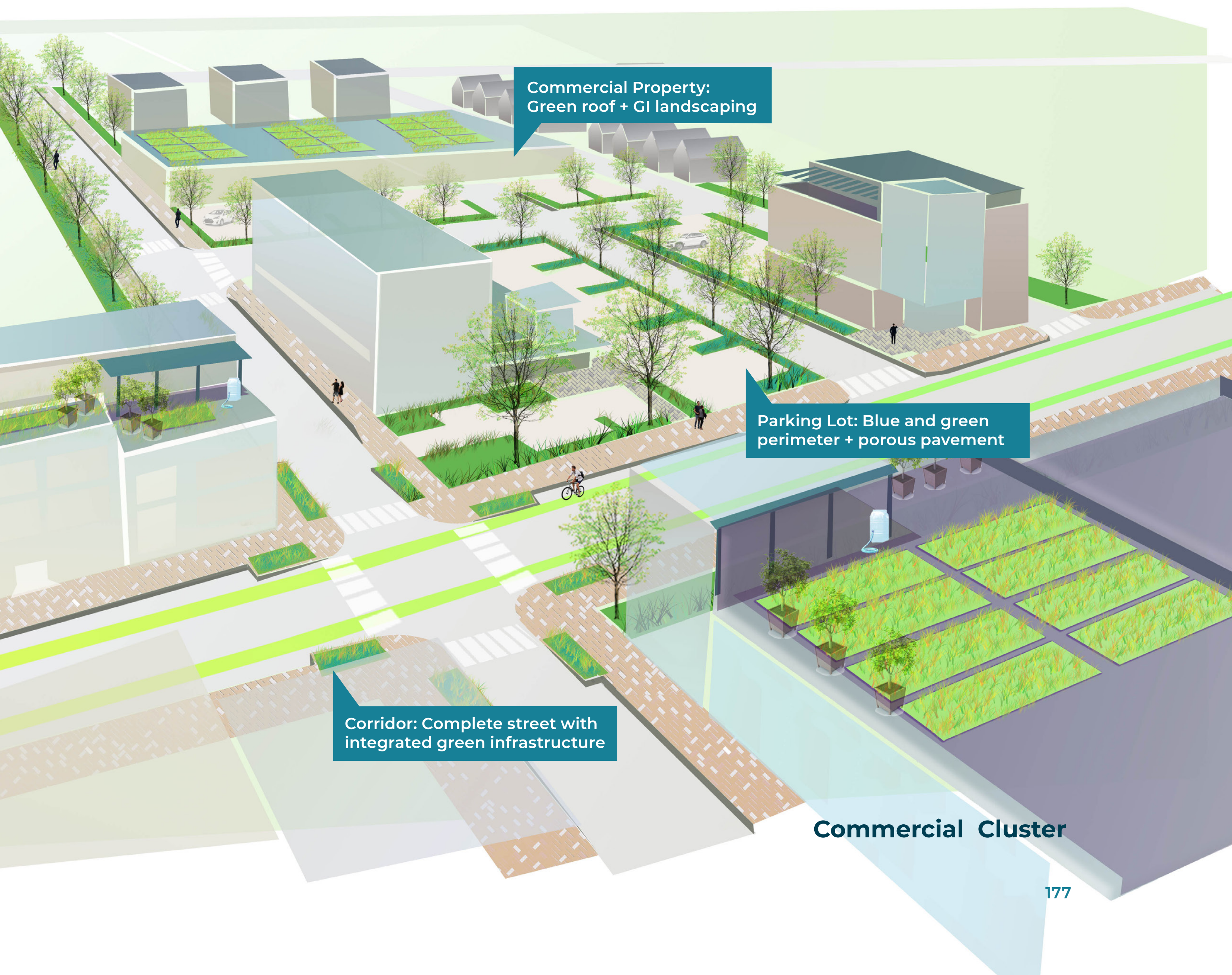
- Improves walkability, can incorporate complete street infrastructure, and can help calm traffic.
- Reduces extreme microclimate conditions due to the urban heat island effect.
- Improves habitat connectivity and usable green space.

Green infrastructure can benefit commercial properties:

- Can serve as an amenity for building occupants and increase lease values.
- Creates natural habitat that improves aesthetics and increases property values.
- Improves the public realm when visible from the public right of way.

Green infrastructure can reshape barren parking lots:

- Saves energy for adjacent buildings as it reduces the urban heat island effect.
- Serves as a visual buffer that improves the appearance of parking lots.
- Creates more walkable streets and sidewalks and provides shade for people and vehicles.



Commercial Cluster

Institutional Property

Institutions, such as schools, churches and community centers, often have large properties where green infrastructure can be implemented. Like commercial properties, institutions typically have maintenance staff that could care for green infrastructure or procure professional services. In addition, they often have a civic or charitable mission and are good partners with the community. Their implementation of green infrastructure can influence others to adopt similar practices. Institutions can implement green infrastructure, such as porous paving, street trees, and rain gardens, on campuses or across a portfolio of buildings. Implementation can range in scale from parcel based to aggregated or distributed networks.

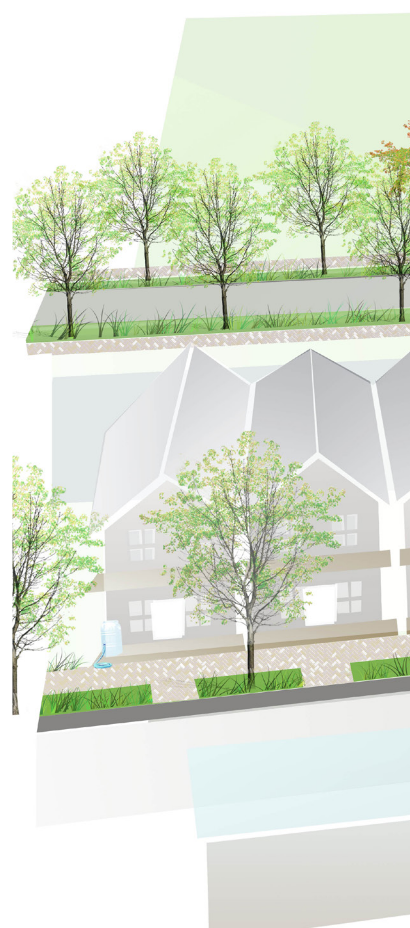
Parks & Open Space

Parks are important pieces of the urban fabric. They provide social benefits, such as access to green spaces for city residents and places for recreation and physical activity. They provide economic benefits by increasing adjacent property values. They provide environmental benefits, including habitat patches, that reduce air pollution and urban heat island effect. Parks are also highly visible and public and are often neighborhood destinations. While parks often already contain less impervious surface than other uses, their stormwater function can be enhanced through increased tree planting and the use of green infrastructure technologies, such as rain gardens and porous paving, to manage stormwater from impervious areas, such as paved playing courts, sidewalks, and parking areas. They can also be the end point for larger green infrastructure networks (for example, along corridors), providing potential sinks for stormwater.

Vacant Lots

Rain Check 1.0 addressed demolition of vacant properties and greening of vacant lots extensively. Vacant lots continue to be an important strategy as Rain Check moves into its next phase.

While vacant lots are often permeable, they can be modified to include green infrastructure and increase their effectiveness with rain gardens, tree plantings, and other practices. Green infrastructure on vacant lots needs to be protected or owned by individuals or entities who can maintain the green infrastructure. Vacant land can also be part of an aggregated stormwater network. For example, a vacant lot in a residential area could contain a rain garden that receives stormwater from disconnected downspouts from several adjacent properties. If the vacant lot is along a complete street corridor, it could be a receiving site for a larger networked public-right-of-way system.



Green infrastructure is aligned with institutions:

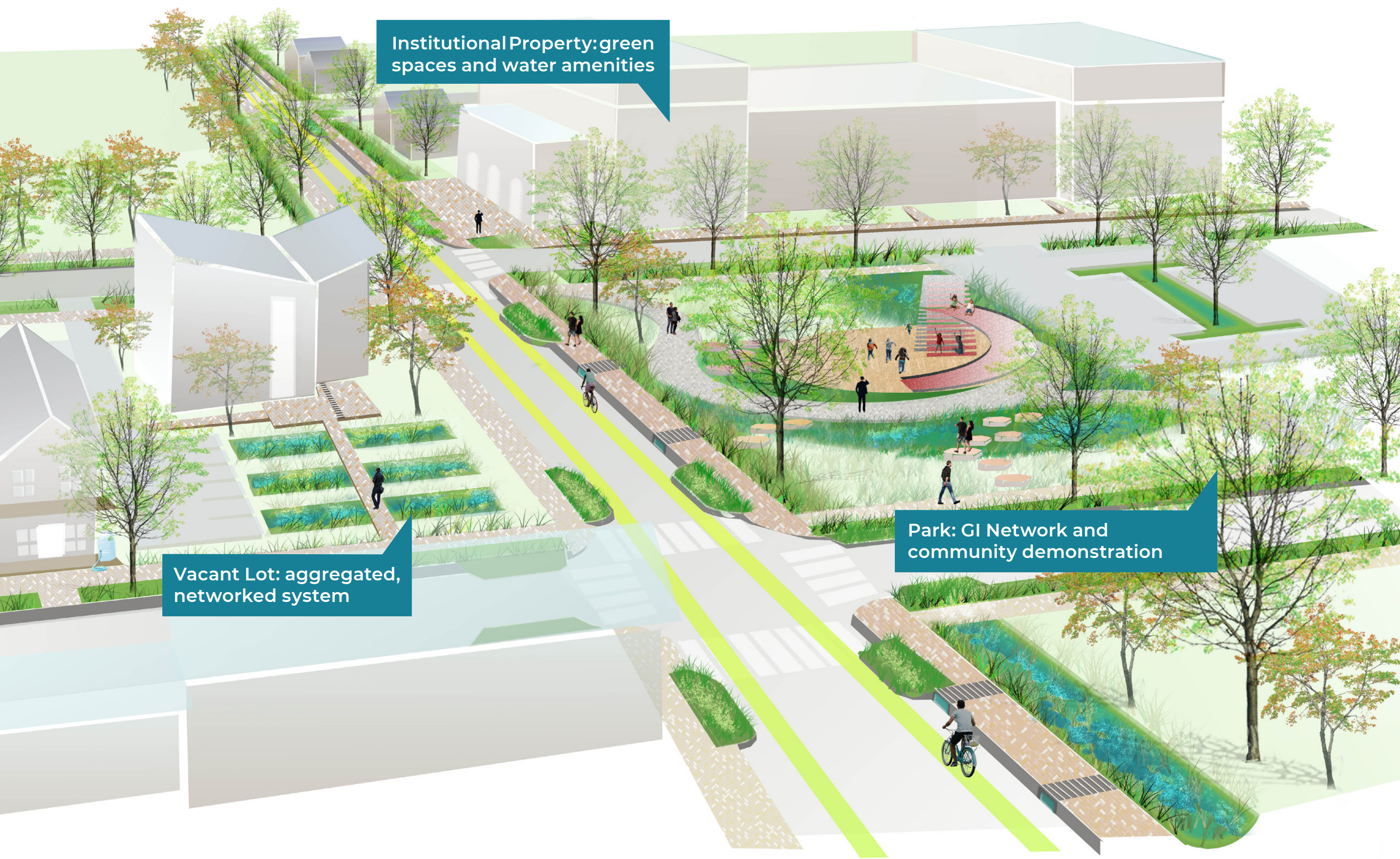
- Can provide workforce development opportunities or can align with other institutional missions.
- Can demonstrate best practices for other community members to adopt.
- Can be incorporated into existing planning, construction, and maintenance practices to ensure viability over time.

Green infrastructure can benefit parks & open space:

- Improves habitat, especially in highly urbanized parks.
- Can mitigate heat island effect and make more pleasant places, especially in areas of pavement such as courts and parking lots.
- Creates amenities for neighborhoods and provides opportunities for community care and participation.

Green infrastructure can reinvent Buffalo's vacant lots by:

- Decreasing blight.
- Functioning within a green infrastructure network.



Institutional Cluster

Review of Implementation Programs

To achieve the benefits and network efficiencies of green infrastructure, Buffalo Sewer will develop programs to support and promote implementation. Despite a recent surge in new development activity, the pace is insufficient for Buffalo Sewer to depend solely on new development stormwater regulations, such as the Green Code, for its green infrastructure compliance program.

Buffalo Sewer is required to manage runoff from 1,315 acres of impervious surfaces through green infrastructure as part of its combined sewer overflow LTCP. To date, the existing Green Infrastructure Program has focused primarily on streets, sidewalks, and other public property. Recognizing the logistical and cost challenges to meeting goals by focusing exclusively on public property, Buffalo Sewer is encouraging the installation of green infrastructure on private property. Landowners may have existing site maintenance programs that can readily incorporate green infrastructure sites and therefore implementation programs that focus on improving existing developments are key.

This section summarizes implementation programs deployed elsewhere, providing potential implementation models for Buffalo.

Typical Incentives for Green Infrastructure

Many communities, including Portland, Oregon and Howard County, Maryland, have enacted stormwater fees based on the impervious area on each property with higher fees associated with properties with larger impervious areas. Therefore, implementing green infrastructure decreases the impervious area, reducing the fee. The resulting stormwater fee discount would continue in subsequent years, if the total impervious area is retained at post-green infrastructure implementation levels. Buffalo Sewer does not currently have a stormwater fee, making this a more ambitious option.

Grant or rebate programs offer reimbursement of installation costs associated with green infrastructure implementation. Requirements for receiving the grant are dictated by the utility and may restrict funds to a certain type of project, a maximum grant amount, and require specific procedures to be followed for receipt of grant funding. Such funding may be issued in the form of a rebate once construction is finished and inspection verifies design goals are met. Examples of such programs include:

- Philadelphia's Stormwater Management Incentives and Greened Acre Retrofit Programs
- Syracuse's Green Improvement Fund, New York City's Green Infrastructure (Competitive) Grant Program
- Pittsburgh Water and Sewer Authority's Green Infrastructure Grant Program
- Allegheny County Sanitary Authority's Green Revitalization of our Waterways Program

Grant programs allow for equitable distribution and allocation of resources to those who have a demand for green infrastructure and provide a cost-effective way to meet stormwater goals.

Other incentive programs encourage developers to implement green infrastructure as they develop or redevelop projects. Such incentives can take the form of expedited permit application review processes, reduced permitting fees, zoning upgrades, and reduced stormwater requirements.

Other programs targeted towards developers also include payments in-lieu of a portion of the stormwater requirements and/or trading stormwater credits (i.e., where a project is implemented with more stormwater retention than required, the additional credit can be sold or traded to developers of more constrained sites).

Incentives for Implementing Green Infrastructure

Figure 2.12: Examples of green infrastructure from Pittsburgh and Buffalo.

Tax Credits

Some communities charge a stormwater fee as part of their sanitary sewer fees and/or property taxes based on the amount of impervious area on a given property. A credit is then extended to the property owner for the inclusion of green infrastructure technologies on the property that either captures and/or treats a given amount of flow. The amount of credit typically is determined by how much impervious area is removed or how much stormwater is captured using the green infrastructure technology.

Stormwater Permitting Fee Credits

Other incentive programs allow for a one-time reduction in stormwater fees paid during the project permitting process.

Rebates/Grants

Reimbursements may be made either during or upon completion of construction of a green infrastructure project for either the full or partial costs (design and construction). Some communities fund these programs from existing wastewater collection and/or treatment budgets, while others use the stormwater fees collected to provide such reimbursements.

New Development Incentives

Non-monetary incentives, which may include fast-track review of permit application, density and/or height bonuses, flexibility on setbacks, etc., may be offered to developers who would then apply those incentives to larger developments, such as multi-family or commercial/industrial/institutional developments.

Downspout Disconnection Program

Downspout disconnection programs encourage homeowners to have their downspouts disconnected and the standpipe to the sewer capped.

Credit Trading

When green infrastructure technologies implemented on-site do not offer sufficient incentives on their own to prove cost-effective, developers may choose to buy credits from other developers that may have excess credits from green infrastructure installations that provide more benefit than required at another site in the same watershed.

Watershed Improvement District

Watershed Improvement Districts (WID) are entities created by local government and landowners. The purpose of a WID is to address water needs, including stormwater, on a system-wide basis, in order to protect water quality and address drainage issues. The WID structures allows local government entities and property owners to collaborate on projects, generate funds needed for projects, and secure grants.

Tree Planting Program

Tree planting programs can include giving away trees, providing assistance with tree planting, or sharing long-term tree maintenance with citizens to expand the tree canopy throughout the City.

Examples of trading programs include Washington DC's stormwater retention credit (SRC) program, which allows a portion of the stormwater requirements to be met by purchasing privately traded SRC credits or paying an in-lieu of fee, and Chattanooga, Tennessee's program, which allows a portion of the stormwater requirements to be met with an in-lieu fee. In both programs, any rainfall retained on site in addition to the first inch can be sold as a credit to other developers working on sites where stormwater retention is more challenging.

Such programs can maximize green infrastructure on sites where implementation is easier and generate funds to encourage implementation by other property owners. This type of program requires significant participation from developers and land owners to be successful and Buffalo Sewer's pipe network is such that credits would need to be provided within a specific geographic area to impact CSO events associated with the particular site. This type of program would be challenging to implement in a timely manner and may not be feasible for the Buffalo market in order to meet LTCP goals.

Other programs offer non-monetary incentives in the form of recognition of the property owner, either formally or informally, in implementing "green" technologies. However, these programs are utilized less frequently than the monetary-based programs. Property owners within Buffalo Sewer's service area are not currently assessed a stormwater fee; the fee paid to Buffalo Sewer is currently based on assessed value of the property and not on impervious area. Therefore, there is no incentive under the existing fee structure to encourage green infrastructure implementation.

Grant or rebate programs seem most suitable for implementation in Buffalo. These offer direct incentives through reimbursement of installation costs associated with green infrastructure implementation. Buffalo Sewer is in the process of creating a green infrastructure grant program to encourage private partners and help realize additional co-benefits.

Programs to Encourage Tree Planting

The City of Buffalo is also researching other ways to encourage tree planting. A review of other programs nationwide highlighted some successful programs where government agencies or non-profit organizations work with citizens to encourage tree planting on private property, or better upkeep of trees planted on public lands. Some examples include giving away trees, providing assistance with tree planting, or sharing long-term tree maintenance with citizens. City of Buffalo Forestry does not currently have the capacity for a major tree planting program on streets, in parks, or within other public properties and Buffalo Sewer will explore alternative options for increasing the tree canopy throughout the City.

Programs for Residential Properties

While commercial properties typically generate larger quantities of stormwater runoff, residential properties also contain impervious surfaces that contribute runoff to the combined sewer system and programs targeted at residential properties can engage homeowners in addressing stormwater challenges.

In addition to tree planting programs that could benefit residential properties as well, downspout disconnection programs are another way to reduce stormwater runoff from residential properties. Downspout disconnection programs encourage homeowners to have their downspouts disconnected and the standpipe to the sewer capped. The disconnected downspout is directed either to a rain barrel or to a vegetated area such as a lawn, rain garden or other landscaped area. In addition to removing stormwater from the sewer system, downspout disconnection programs are a way of making stormwater management visible and connecting residents to the environment. In addition to the stormwater benefit these programs are also important as part of larger outreach efforts. They provide the opportunity to partner with local organizations to do the work and can be part of workforce development programs as well.

Tree Canopy Crediting and Modeling

Trees provide a major benefit of reducing stormwater runoff, potentially reducing the volume and frequency of Combined Sewer Overflows. Although this benefit is widely accepted among the scientific community, the modeling that is used to estimate CSO volumes in the City of Buffalo currently does not have the granularity to consider the impact of tree planting on stormwater reduction. A panel of urban tree experts (the Tree Technical Advisory Committee), led by Buffalo Sewer, developed a system for estimating the stormwater benefit of urban trees over time. The system was developed using data about the typical trees planted in the City of Buffalo, along with a "water balance" model that accounts for the benefits of trees, including:

1. Intercepting runoff in leaves
2. Improving soil conditions to encourage soil infiltration, and
3. Increasing Evaporation and Transpiration, thus allowing more runoff to infiltrate the soil.

The resulting system equates each tree planted (or each area of tree canopy) with a volume of stormwater runoff reduction. One advantage of this system, is that it accounts for specific traits of trees, such as the age, type of tree and where it is planted.

As a next step, this system can be used to track and estimate the benefits of trees over time, with the goal of integrating trees into Buffalo Sewer's stormwater modeling in the future. Some next steps will involve determining the specific techniques to represent trees within the City's model. Some techniques might include:

1. Reflecting a tree as reducing impervious cover (using the crediting system);
2. Treating trees similar to green infrastructure practices, that reduce the volume of stormwater; or
3. Treating trees as stormwater storage throughout the landscape.

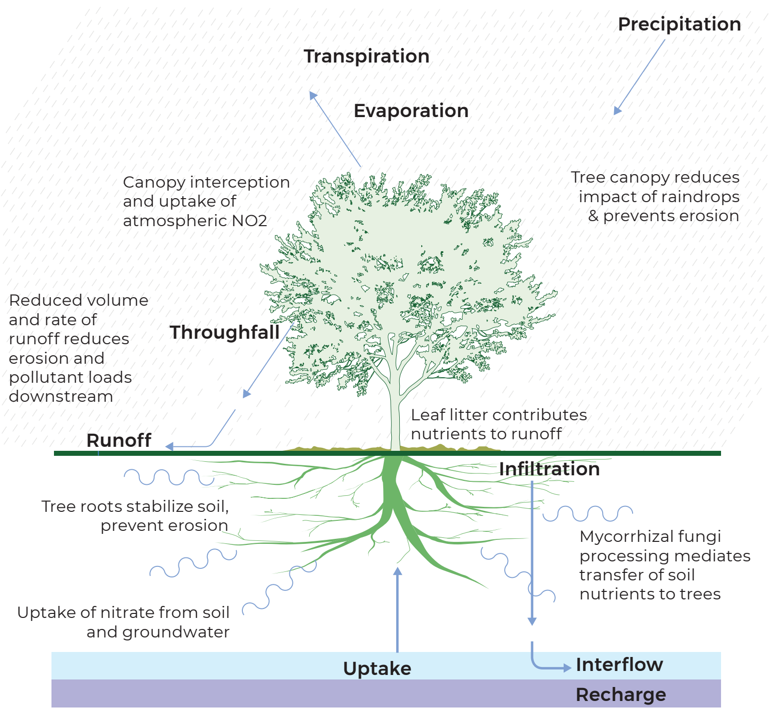


Figure 2.13: Trees reduce the volume and rate of stormwater runoff, which reduces the amount of stormwater and pollutants entering the sewer system