CREATING GREEN BUFFERS IN THE GREENPOINT INDUSTRIAL AREA

FUNDED BY:

NYS ATTORNEY GENERAL'S OFFICE | NYS DEPT OF ENVIRONMENTAL CONSERVATION | NATIONAL FISH AND WILDLIFE FOUNDATION

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BROOKLYN, NY

MARCH 2018

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Purpose

The purpose of the "Creating Green Buffers in the Greenpoint Industrial Area" (Green Buffers) project is to generate a green infrastructure (GI) plan for a five-block industrial area in the Greenpoint neighborhood of Brooklyn. The GI plan is to be developed through a collaborative and community-driven process and to identify potential sites for GI installations with the intent that property owners and/or public agencies will implement the GI plan in the future.

This document is the resultant GI Plan that discusses the green infrastructure practices considered for the Green Buffers project (Part 1) and proposes GI practices for the project area (Part 2). This GI Plan contains background information and desktop assessments that explore the various GI alternatives and their feasibility in the project area. This document informs future actions for the project, including outreach and field work, which will help make Green Buffers in the Greenpoint industrial area a reality.

Background

Industrial areas in a dense urban center are often perceived negatively by residents immediately outside of the area even if industrial areas provide economic benefits to the neighborhood as well as to the entire city. One of the reasons for the negative perception is the physical environment found in many industrial areas. Large industrial buildings, machineries, noisy or dusty activities, truck traffic, and lack of greeneries are common features that are not particularly inviting for local residents. However, preserving industrial activities is important to many urban residents for jobs and related economic activities. Although seemingly contradictory, preserving industrial activities may also preserve the neighborhood character of the surrounding areas by stemming the tide of gentrification. The tension between the need to preserve an industrial area and the desire for a "green" neighborhood is nothing new. However, with the establishment of green infrastructure in urban planning as well as stormwater management, there are now opportunities to create a green industrial area that serves the businesses as well as the residents.

McGolrick Park Neighborhood Alliance (MPNA) is a grassroots volunteer organization, which saw an opportunity to transform the industrial area of Greenpoint through green infrastructure. On behalf of the MPNA, New York City Soil & Water Conservation District (SWCD) received grant funding from the Office of New York State Attorney General and the New York State Department of Environmental Conservation through the Greenpoint Community Environmental Fund to engage the community in developing a greening plan for the industrial area. As part of the greening plan development, SWCD issued a request for proposals (RFP) from consultant teams to complete the technical aspects of the project. The contract was awarded to the Evergreen Exchange team that included eDesign Dynamics, LLC, in partnership with NYC Audubon, and MPCA. In May 2016, SWCD with assistance from the Evergreen Exchange team initiated a community-driven

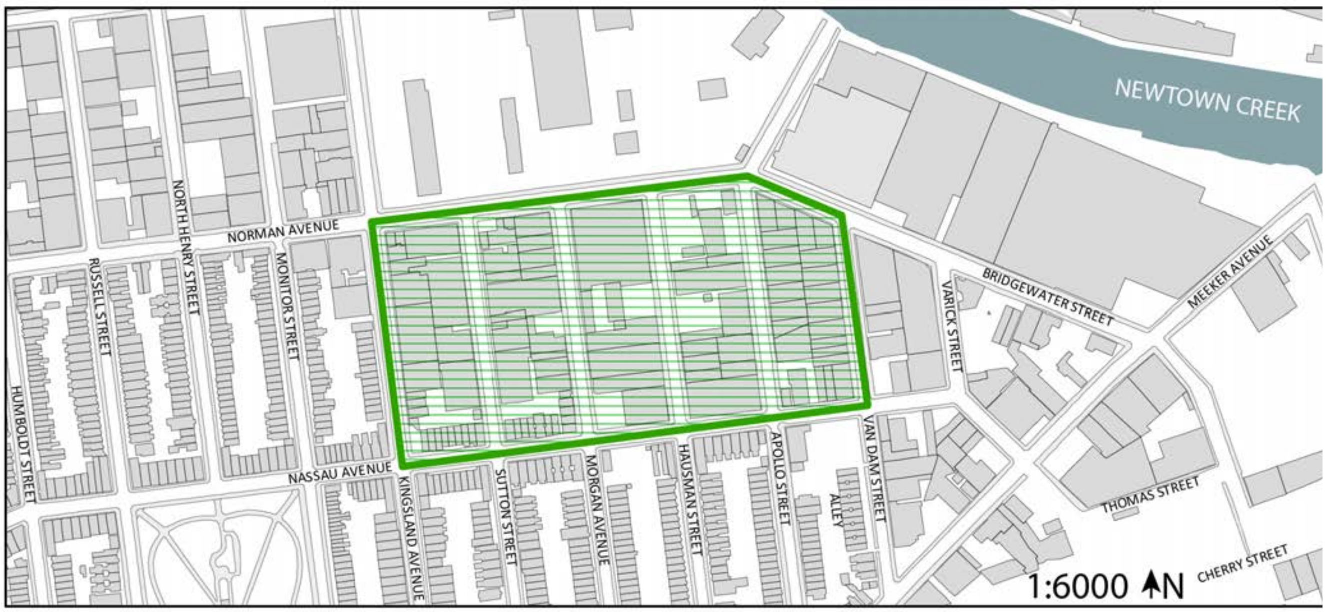


FIGURE 1 - PROJECT AREA MAP
Location of 'Green Buffers' Project area in Greenpoint, Brooklyn, NY.

planning process with the goal of enhancing its stormwater management, reducing its thermal pollution, improving its aesthetics, uniting its commercial and residential sectors, and acting as a model for other mixed industrial and residential communities.

The project area consists of five blocks in the Greenpoint neighborhood of Brooklyn, bounded by Norman Ave. and Bridgewater St. to the north, Nassau Ave. to the south, Kingsland Ave. to the west, and Van Dam St. to the east. (See Figure 1.) The area is primarily zoned as industrial with a small portion being commercial, residential, and mixed-use. However, the west and south borders of the project area abuts predominantly residential areas. The majority of the project area is privately owned. The total project area is approximately 875,500 square feet. From GIS data, it is estimated that 57% of the project area is covered by buildings, 17% by roadways, 15% by sidewalks, and 11% by trees and courtyards. The prevalence of existing infrastructure was an important factor in evaluating the feasibility of installing green infrastructure practices in the project area; another important factor was the presence of the contamination plume (described below) underlying the project area.

The project area falls within the Combined Sewer Overflow (CSO) Drainage Area NCB-027. Combined sewer overflow in New York City has been an environmental concern for decades. During a combined sewer overflow event, the sewer system receives high flows from heavy rain or snow melt which lead to a mixture of stormwater and untreated sewage being discharged into the city's waterways. New York City has invested over $2 billion in reducing CSO discharges to date and has committed to spending $1.5 billion in public funds to utilize green infrastructure (NYC DEP, 2016) to further reduce CSOs. The green infrastructure projects discussed within this report reduce stress on downstream combined sewer systems by capturing stormwater runoff and thereby reduce the volume of overflows within NCB-027.

The project area sits directly above an ExxonMobil oil spill, which originated from the oil refineries that extended between present-day North Henry St., Greenpoint Ave., Norman Ave., Apollo St., and Newtown Creek. The oil spill was first detected in 1978 by a film that appeared on the surface of Newtown Creek. Seventeen to thirty million gallons of petroleum product is estimated to have spilled along the 52 acres of shorefront property between the Greenpoint Avenue Bridge and Kosciusko Bridge. Although remediation efforts commenced after discovery of the spill, they are still ongoing and a plume remains under and around the area near the refineries, which includes the project area for Green Buffers (see Appendix 1 for a map of the plume.)

This plan assesses the feasibility of installing the following green infrastructure practices for the Green Buffers project area: Bioswales, stormwater greenstreets, porous paving systems, green walls, green roofs, and rainwater harvesting/reuse systems. Retention-based GI practices, such as bioswales and porous paving systems, are designed to manage stormwater runoff by promoting infiltration and evapotranspiration. Infiltration contributes to groundwater recharge and has the potential to improve the stormwater quality via biogeochemical processes. Storage and detention based GI reduce contributions to combined sewer systems by detaining rainwater temporarily and releasing it slowly. Water harvesting systems, such as cisterns and rain barrels, also reduce contribution to combined sewer systems by diverting rainwater that falls on rooftops and other exposed surfaces into storage containers. The harvested water can be reused in numerous ways, such as for watering plants or other landscaping purposes, or if the water is configured for reuse inside a building, the harvested water can be used for flushing toilets, laundering clothes, or other grey water uses. Alternatively, storage containers or cisterns can be configured to detain the runoff for slow release over several days, thus helping to reduce wet weather contributions to the combined sewers.

This conceptual plan expands on the GI practices being considered for the Green Buffers project and discusses the New York City technical and regulatory considerations that need to be taken into account prior to their installation in the Green Buffers project area. The plan recommends the green infrastructure technologies most suited to the project area, sites potential installation locations, and outlines the next steps needed for implementation.

SECTION ONE

GENERAL GREEN INFRASTRUCTURE FRAMEWORK & CONSIDERATIONS

1.1 Bioswales and Stormwater Greenstreets

1.1.1 Introduction to Bioswales and Stormwater Greenstreets

One of the most standardized and common forms of green infrastructure in New York City is the right-of-way bioswale (ROWB). Right-of-way bioswales are designed to capture and manage stormwater runoff from upstream impervious areas. ROWBs look much like a standard sidewalk planted area or tree pit, but lie below the roadway grade and include layers of soil and gravel that allow for storage and infiltration of stormwater. ROWBs are located on the sidewalk, and stormwater is conveyed through an engineered curb-cut inlet. Rainwater flowing along the curb enters the ROWB basin through the curb-cut inlet. After entering the ROWB, stormwater accumulates in a depressed, vegetated area to allow for infiltration into engineered soil and coarse gravel layers within the ROWB. The collected water stored in the soil and gravel layers infiltrates vertically and laterally into in-situ soils. Any runoff that surpasses the collection capacity of the bioswale bypasses the bioswale and is subsequently captured at a conventional stormwater inlet and directed to the sewer system. A typical New York City bioswale can be seen in Figure 2.

Like ROWBs, stormwater greenstreets ("greenstreets") are designed to capture and manage stormwater runoff from upstream impervious areas. Rather than being located on the sidewalks, however, greenstreets are located in "bump outs" adjacent to the sidewalk on the roadway or at traffic triangles and are typically larger in size than ROWB. Greenstreets may or may not contain trees, but are vegetated to maintain infiltration rates and provide water quality improvements and habitat value. An example of a greenstreet can be seen in Figure 3. (next page)

FIGURE 2 - NYC DEP BIOSWALE DIAGRAM
Typical NYC Bioswale (NYC DEP, 2017)

FIGURE 3 - NYC GREENSTREET
Typical NYC Greenstreet extending from sidewalk into the right of way as a bump-out. (NYC Parks/ localecology.org, 2017)

1.1.2 Technical and Regulatory Considerations for Bioswales and Stormwater Greenstreets

The NYC Department of Environmental Protection (DEP), the NYC Department of Transportation (DOT), and the NYC Department of Parks and Recreation (DPR), have developed design standards, procedures, and guidelines for GI within the public right-of-way. Any right-of-way installation of bioswales and stormwater greenstreets follow these guidelines. The site selection and design procedure, published by NYC DEP, includes a tributary drainage area analysis, agency walkthroughs, and geotechnical evaluations. Both city agencies and contractors are required to strictly adhere to these standards.

Along with NYC DEP's siting and design standards, DOT has issued siting guidelines outlining where ROWBs can be placed on the sidewalk and where greenstreets can be placed within the roadway. DOT's siting guidelines can be found in Appendix 2. The stormwater management capacity for each potential ROWB and greenstreet is determined through NYC DEP's tributary drainage area analysis (TDA). The TDA process prioritizes GI sites based on rainfall captured and provides a criterion for preliminary sites to move on to the geotechnical investigation. Once preliminary sites have been selected through the TDA analysis, representatives from DOT and DEP conduct a walkthrough to ensure that all siting guidelines are satisfied including: distances from building foundations, trees, hydrants, curb cuts, entrances, stop signs, light and electrical poles, and other street features.

After the preliminary sites have been approved, the sites undergo a geotechnical investigation to determine the soil characteristics and permeability rates at the preliminary sites. A geotechnical investigation is required to determine if a proposed GI location has adequate soil characteristics for an infiltration-based GI practice. Upon completion of the geotechnical investigation, and acceptance of the geotechnical results by DEP, sites proposed for ROWBs and greenstreets will undergo a limited survey to document the topography, surface/subsurface features, trees, utilities, and vaults within the defined survey area for the project.

1.2 Permeable Pavement and Paver Systems

1.2.1 Introduction to Permeable Pavement and Paver Systems

Permeable paving systems allow water to infiltrate through engineered macropores, thereby reducing flooding, excess runoff, and pooling. Permeable paving alternatives include asphalt and concrete with large void spaces and are pre-mixed but poured/installed in place. Permeable pavers are pre-fabricated and installed in interlocking patterns. All permeable paving technologies are placed above sand and/or gravel subsurface storage layers. Examples of permeable pavement and permeable pavers can be seen in Figure 4 and Figure 5 respectively.

FIGURE 4 - PERMEABLE PAVEMENT
Permeable surfaces, like this pervious concrete, allow for stormwater to easily drain into a stormwater management system. (CivilTech, 2016)

FIGURE 5 - PERMEABLE PAVERS
Permeable Pavers used for public walkways and plaza space. (NYC DEP, 2017)

1.2.2 Technical and Regulatory Considerations for Permeable Pavement and Pavers

Permeable pavements and pavers are typically installed over porous sand/gravel beds that provide storage for the water passing through the pavement. A review of site conditions is necessary to determine the permeable pavement design options and preliminary features. The soil conditions and infiltration should be determined by a geotechnical evaluation as described in the above sections. The soil test should be completed at the elevation for which natural soil subgrade infiltration is being proposed. Permeable pavements can be used over low permeability soils, but alternative design features such as underdrains or a raised drain/outlet structure with greater reservoir storage would need to be included for proper system functionality (Eisenberg et al., 2013).

In addition to soil conditions and other geotechnical factors, existing and proposed slopes of the project should be evaluated when considering a permeable pavement system.

Contributing area run-on and land use will factor into the design of the permeable pavement system. Existing, proposed, and neighboring land use may create an increased risk for surface clogging and soil and groundwater contamination. Permeable pavement should not be used to treat stormwater hotspot areas where concentration of pollutants such as oils and grease, heavy metals, and toxic chemicals are likely to be significantly higher than in typical stormwater runoff (NCDENR, 2012). Generally, permeable pavements are intended for capture of precipitation falling directly on the surface only, avoiding run-on carrying fine sediments that will clog pores and reduce overall infiltration capacity.

1.3 Street Trees and Street Planters

1.3.1 Introduction to Street Trees and Street Planters

Street trees are planted by the New York City Department of Parks and Recreation (DPR) and are located in the public right-of-way. Tree species are determined based on sidewalk width, soil conditions, surrounding tree canopy, flood/drought vulnerabilities, nearby infrastructure, and sewers. Street planters are large potted plants (usually a total planter footprint of over four square feet) planted by property owners and placed within the right-of-way. Street trees and street planters reduce stormwater runoff by leaf interception and direct capture.

FIGURE 6 - STREET TREES
Street Trees along a sidewalk in residential blocks (Welcome2TheBronx)

FIGURE 7 - STREET PLANTERS
Street Planters used in a street median to create public space and provide safety from road traffic. (TerraCast, 2014)

1.3.2 Technical and Regulatory Considerations for Street Trees and Street Planters

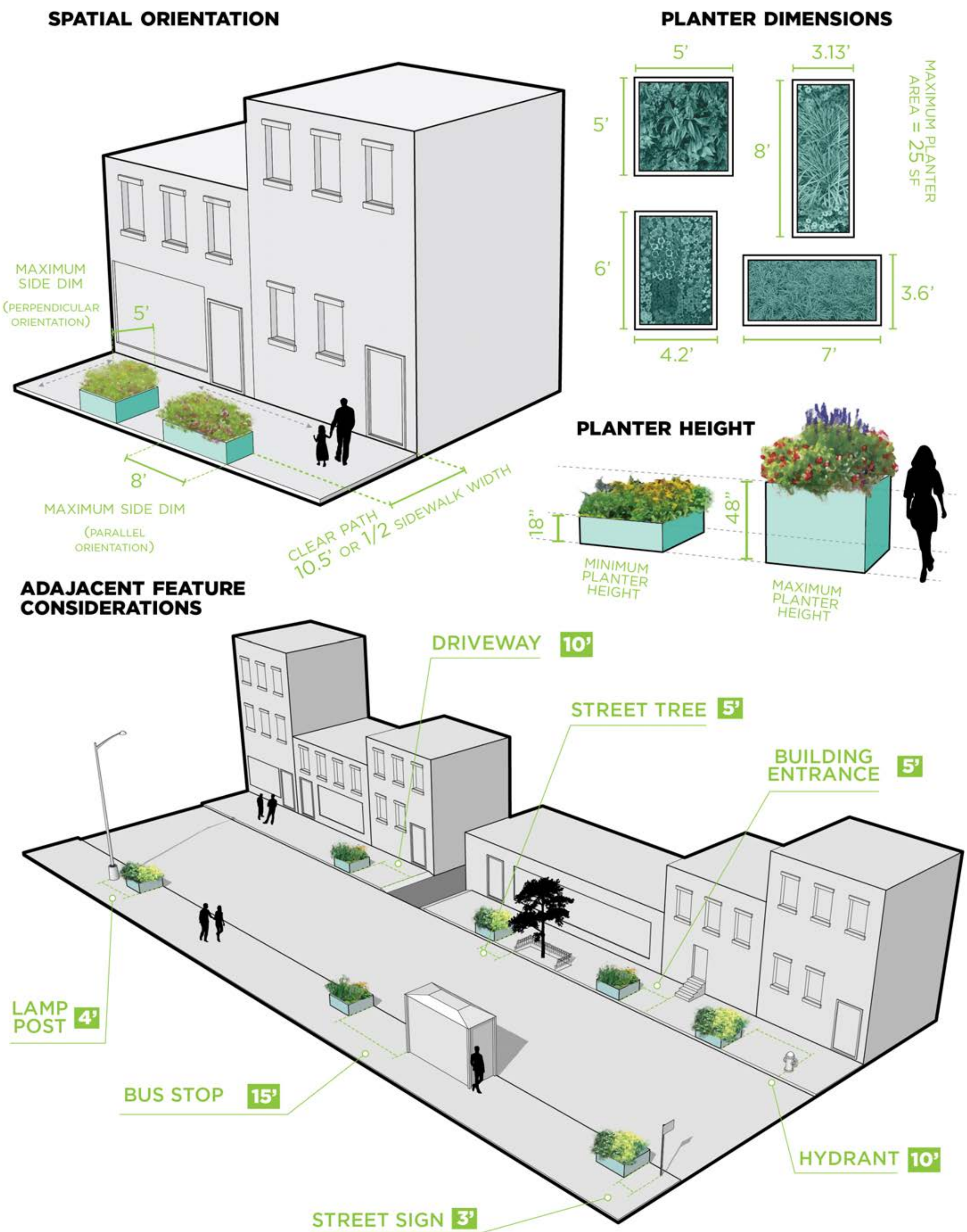
Street tree and street planter locations are determined by the clearances and dimensions regulated by the New York City Department of Parks and Recreation (DPR). DPR lays out its requirements for planting street trees in its Tree Planting Standards (2016). DPR's Tree Planting Standards outline the spacing requirements, tree pit dimensions, tree species and group plantings selection, planting and materials specifications, seasonal maintenance, guarantee period, and finishing requirements. To illustrate the spacing requirements between a proposed street planting location and existing utilities, structures, or other trees, DPR has also generated a Street Tree Planting Standard which follows regulations of other agencies with street jurisdiction such as Fire, DOT, and MTA. DPR's Tree Planting Standard is shown in Appendix 3 and DPR's Street Tree Planting Guidelines are shown in Appendix 4.

In addition to the DPR Tree Planting Standards, DOT outlines rules for where larger planter boxes can be placed on city sidewalks. The specific allowable clearances for street planters can be found in DOT's "Revocable Consent Rules," which can be viewed in Appendix 5. DOT states that street planters, along with benches, information kiosks, litter receptacles, mail boxes, and public telephones may be aligned with a minimum of three feet clearance between them for up to 30 feet, or may be grouped together without separation but extend no more than 15 feet long (NYC DOT, 2016). Also, in the "Revocable Consent Rules," DOT specifies dimensions for street planters.

Sizing for the street planters is also outlined in the DOT rules; they can be 18 to 48 inches high and must be maximum five feet along the side that is perpendicular to the curb, or maximum eight feet along the side that is parallel to the curb. If a street planter is located against a building, it may be continuous. Street planters can have a maximum area of 25 square feet, with dimensions measured at the planter's widest point. Community Board and Public Design Commission (PDC) approval for street planters may also be required at DOT's discretion.

FIGURE 8 - STREET PLANTER DESIGN GUIDELINES

Various selected clearances and dimensions for street planter design, complete list found in the DOT "Revocable Consent Rules," which can be viewed in Appendix 5.



1.4 Green Walls

1.4.1 Introduction to Green Walls

Located on the sides of buildings, green walls add green space at eye-level to communities. Green walls include two categories: living walls and green facades. Green facades are created by planting climbing plants at ground level in garden beds or containers. Climbing plants can attach directly to the surface of the building or they can be supported on a structure, such as a modular trellis, independent of the building.

Living walls are vertical gardens that are attached to the exterior of a building. They differ from green facades in that planting substrate is fastened to the wall itself. The plants receive water and nutrients from within the vertical support instead of from the ground. Living walls typically include a modular panel system to support roots and growing medium, a drip irrigation system, and a catch basin to capture runoff.

Green walls provide retention of stormwater through percolation of rainfall and direct interception (Loh, 2008). Examples of living walls and green facades can be seen in Figure 9 and Figure 10, respectively.

FIGURE 9 - LIVING WALL
Living Walls allow for vegetation to grow directly on the exterior of the building. (BlueBrick, 2017)

FIGURE 10 - GREEN FACADE
Example of a Green Facade with climbing plants which grow up the trellis structure. (Greenscreen)

1.4.2 Technical and Regulatory Considerations for Green Walls

Architectural, engineering, and structural considerations should be evaluated when designing a living wall or green facade.

Attachment to the building and how the system will be secured to the building or freestanding structure are key in determining the suitability of a green wall. A structural engineer should be included in the siting and design of living walls and green facades to verify the required loads and that the system is compatible with the building construction and materials.

NYC building codes regarding right-of-way, landscape ordinances and easements need to be consulted when locating a green wall. Depending on building placement, a green wall may protrude from the building and extend into public space. If not approved by City agencies, planter type and size may need to be reduced to remain on private property.

When designing a green wall, selection of plant species that will thrive under the given conditions is key. Preference should be given to native plants, as they are more suited for the site environment and more likely to thrive. Plant selection should be based on wind and light exposure, hardiness zones, moisture needs and amenity context.

Living wall systems have recently become available as modular kits that can be installed inside or out. Because planting medium is limited, irrigation is typically a required component to maintain good plant health. Generally, the living walls are fitted with drip irrigation systems with an emitter placed in each cell or plant box. Drip irrigation is efficient and effective, but requires pumping and a reliable source of irrigation water. Sometimes the water source can be a tank or cistern filled with stormwater, but it is more common to use potable water because of its ease of use. According to one manufacturer, approximately 20 square feet of living wall receives on the order of one gallon per day of irrigation water.

Green facades, which consist of climbing plants with roots in the ground, do not generally require irrigation but may need supplemental moisture during dry spells. Perennial plants will endure longer dry periods than annuals because of root depth. Irrigation water is typically added to the planting area by garden hose.

1.5 Green Roofs

1.5.1 Introduction to Green Roofs

Green roofs are planted areas constructed on building rooftops that are designed to have a vegetated, light-weight soil medium lying above a drainage and water storage layer and roofing membrane. The rainwater absorbed and stored by the green roof system helps prevent stormwater runoff from entering combined sewers and the occurrence of flooding after major rain events. Because of the additional burden on the roof structure from green roofs, it is necessary to employ a structural engineer to inspect and assess the condition of the roof below the membrane, and confirm that it is capable of bearing the additional load.

Green roofs can be categorized into three typologies: Extensive, intensive, or semi-intensive. Selection of a particular typology depends both on the structural capacity of the roof and the costs for installation. Extensive green roofs consist of a shallow planting medium and short vegetation (often sedum). Primarily installed for environmental and visual benefits, extensive green roofs are lightweight and often require little maintenance. Intensive green roofs are often designed for human use and/or enjoyment and typically incorporate a variety of plants, including shrubs and trees. These more complex roofing systems typically require landscape maintenance and/or fertilization, water collection systems, and enhanced roofing structure, and are therefore significantly more expensive than extensive rooftops. Semi-intensive green roofs are a mixture of extensive and intensive green roofs. They have a greater diversity of plants than extensive green roofs, incorporating plants such as perennials or small shrubs, but cannot support deep root systems due to its shallower growing medium depth. The cost of semi-intensive rooftops are in-between extensive and intensive green roofs. Generally speaking, deeper the growing medium, the greater the environmental benefits. In addition to conventional benefits of green infrastructure, such as air quality improvement and habitat enhancement, green roofs can reduce the cooling costs for buildings.

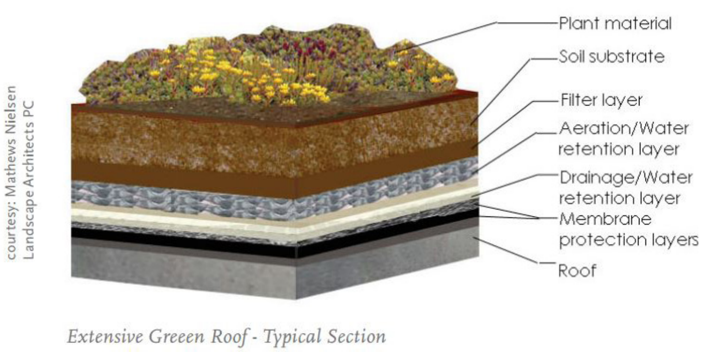
Where there are multiple roof levels, green roof systems can be organized in a manner that allows for conventional roof areas to drain to lower green roof areas, thus reducing the total area required for green roof installation. The green roof design provides for some retention of moisture held in the planting medium and gradual release of the detained volume as the planting medium drains to its field capacity. Green roofs can be designed to retain 1” of rainfall depending on the structural capacity of the roof.

1.5.2 Technical and Regulatory Considerations for Green Roofs

The building's structure, existing use of the rooftop, and rooftop accessibility must be evaluated when considering green roofs. The saturated weight of the green roof adds a significant load to the roof structure. In a retrofit scenario, the loading capacity of the roof may be limited, and structural reinforcements are generally costly and difficult. New structures can be designed to bear the additional load at a more reasonable cost.

Green roofs are typically discussed in terms of the depth of the planting medium. Extensive rooftops have a growing medium depth of 2-6 inches with a saturated weight of 16-35 pounds per square foot; and, extensive rooftops can be installed on surfaces with slopes up to 30%. Intensive rooftops have a growing medium depth greater than 12 inches with a saturated weight load of 60-200 pounds per square foot, and can be installed on surfaces with slopes up to approximately 3%. Use of large woody plants like trees and shrubs can add substantial weight over time, and must be evaluated structurally. Semi-intensive rooftops have a growing medium depth of 6-12 inches with a saturated weight load of 35-60 pounds per square foot (NYC DDC, 2007).

Regardless of the type of green roof selected, five layers should be incorporated in a green roof's design: the waterproof membrane (which may already be installed over the roof), the drainage layer, the filter cloth, the growing medium, and the plants. Below, the typical sections for extensive and intensive green roofs are shown. Green roofs add significant weight on top of a building, and property owners looking to add a green roof to their building are required by New York City Department of Buildings (DOB) to hire a professional engineer (P.E.), a registered architect (R.A.), or a registered landscape architect (R.L.A.) to perform a structural analysis.



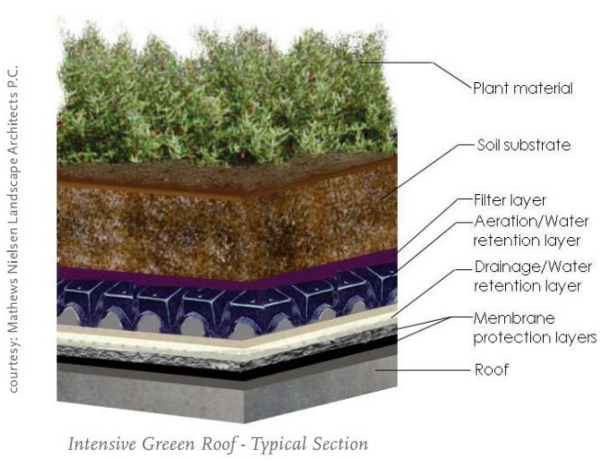


FIGURE 11 - EXTENSIVE VERSUS INTENSIVE GREEN ROOFS
Typical Green Roof Sections (NYC DDC, 2007/MNLA)

The analysis will determine if the existing roof will be able to support the proposed green roof system along with existing loading. After verifying the structural integrity of the roof, the P.E. or R.A. can apply for the construction permit. The P.E. or R.A. will need to certify specific technical elements, submit the structural analysis, and confirm that the existing roof will support the green roof when saturated by providing additional drawings, calculations, and construction documents if necessary. The P.E., R.A., or R.L.A. must also ensure that the green roof is in compliance with the New York State law and the New York City Department of Buildings implementation rule (NYC DOB, 2010). These procedures, however, are only required if the green roof installation is greater than four inches in depth. DOB states that "green roof systems, not more than four inches in depth measured from the upper surface of the roof covering to the top of the growth medium, located on buildings of noncombustible construction or buildings greater than 100 feet in height" do not require permits (NYC DOB, 2010).

1.6 Detention Bioswales

1.6.1 Introduction to Detention Bioswales

At the surface, detention bioswales operate similarly to the standard retention-based ROWB discussed previously. Detention bioswales capture and manage stormwater runoff from upland areas through a depressed planted area with curb-cut (or catch basin) inlet. Beneath the surface, detention bioswales have a soil and gravel layer, like those found in the retention-based bioswales, however, the detention-based bioswales are lined to prevent infiltration into the surrounding earth. Detention bioswales typically possess an underdrain that connects to the sewer system which allows the stored volume to slowly discharge to the sewer system.

Detention bioswales are best suited for areas where a standard (retention-based) bioswale is not possible due to low infiltration rates, contaminated soils, or proximity to other limiting structures such as building foundations or shallow bedrock.

1.6.2 Technical and Regulatory Considerations for Detention Bioswales

Currently, NYC DEP does not allow detention bioswales to be constructed within the right-of-way, thus there is no governing procedure or technical guidance for this technology. However, this practice is currently being used in other cities and on private land. It is expected that in the future, NYC DEP will adopt this technology for areas that are otherwise unsuitable for infiltration, and publish governing documents to guide the process. Likely, the construction of detention-based bioswales will follow a similar process to that outlined previously for detention-based bioswales.

1.7 Rainwater Harvesting

1.7.1 Introduction to Rainwater Harvesting

Water harvesting GI practices capture and store rainwater from roofs or other raised surfaces for later use. The captured rainwater can be used by property owners for irrigation or other greywater purposes, such as cooling water, toilet flushing, or cleaning. The use of harvested water reduces the property's dependence on municipal water and its utility bills.

1.7.2 Technical and Regulatory Considerations for Rainwater Harvesting

Water quality plays a large role in rainwater harvesting systems. In less urban environments or where there is irrigation demand, it is technically straightforward to store and redistribute stormwater to green areas. Other uses, such as toilet flushing or cleaning, require treatment to prevent the potential spread of pathogens and to limit the growth of bacteria in storage tanks. Green roofs can provide effective pre-treatment of runoff and supply a cleaner source of harvested water than standard roof areas. A number of mechanical, biological and chemical treatment options exist to meet the water quality goals of the specific uses.

The first condition to consider when evaluating a rainwater harvesting system is potential demand. If there is no irrigation demand, potential uses are limited to toilets, cleaning, cooling water or other industrial processing (e.g., dust control). If the average daily demand is low (compared to the proposed management area), then a rainwater harvesting system will likely not be cost effective. Other factors influencing use decisions include ease of routing and collecting from multiple sources and storage availability, as well as public perception and acceptance.

According to the Rainwater Harvesting State Regulations and Technical Resources report prepared by the United States Department of Energy (DOE) in June 2015, there are no statewide rainwater harvesting regulations for New York. The DOE advises that reuse scenarios follow the New York State Rainwater Harvesting Guide developed by the Environmental Finance Center of Syracuse University in 2015 and the Rainwater Harvesting 101 report prepared by GrowNYC in August 2008. The New York State Rainwater Harvesting Guide can be viewed in Appendix 6 and the Rainwater Harvesting 101 report can be viewed in Appendix 7. Both documents provide useful background information on rainwater harvesting systems, but the Rainwater Harvesting 101 report provides a more in-depth description for installing a system for a given location. The Rainwater Harvesting 101 report outlines the typical materials and devices needed for rainwater harvesting systems and where they can be obtained, cost estimates, and formulas for calculating the potential rainwater capture volume as well as the size and quantity of pipes and tanks needed. There may also be additional water quality requirements from NYC Department of Health and Mental Hygiene when stormwater is used within a building's interior.

SECTION TWO

GREEN INFRASTRUCTURE PROPOSED FOR THE GREEN BUFFERS PROJECT AREA

2.1 Bioswales and Stormwater Greenstreets

After assessing the existing conditions of the project area, infiltration-based GI practices are not suitable for the Green Buffers project area because of the known ExxonMobil petroleum-based contaminant plume underlying the project area. Installing infiltration-based GI in areas of known contamination presents environmental and health risks, and is thereby prohibited by DEP. DEP's Procedure Governing Limited Geotechnical Investigation for Green Infrastructure Practices states that "if soil and/or groundwater contamination is observed or suspected during the investigation, drilling shall be terminated immediately. The borehole shall be filled and the proposed location shall be abandoned." Therefore, no infiltration-based GI practices are recommended for the Green Buffers project.

2.2 Permeable Pavement and Paver Systems

Permeable pavement systems function by allowing stormwater to infiltrate through the underlying soil. As described above, infiltration within the ExxonMobil plume presents an environmental and human health risk. For this reason, permeable pavement systems are not recommended for the Green Buffers project area.

2.3 Street Trees and Street Planters

With long stretches of sidewalk and numerous lengths of fences, the Green Buffers project area is well suited for street trees and planters. There are currently a few stretches that include a grouping of street trees most notably on Nassau Avenue, Kingsland Avenue, and Apollo Street. Street trees and planters are a very visible and aesthetically pleasing GI option. Installation of street trees would be lead and facilitated by NYC DPR. Street planters are low cost and easily installed while still providing visible greening to the community. A desktop assessment, described in the following section, determined approximately 34 street trees and 19 planters are feasible for the Green Buffers project area.

2.3.1 Siting and Proposed Locations for Street Trees and Street Planters

Using Google Earth, a desktop assessment was performed to site street trees and planters in the project area. As outlined previously, street trees sites are selected according to the clearances and dimensions regulated by the New York City DPR and DOT. When a location was deemed unsuitable for a street tree, the location was evaluated for a street planter using the "Revocable Consent Rules" from DOT.

The proposed locations for street trees and street planters are shown in Figure 12. Within the Green Buffers project site there are 34 potential street tree locations and 19 street planter locations. One of the 34 potential street tree locations is an already constructed, empty tree pit.

FIGURE 12 - SITING MAP: STREET TREES & STREET PLANTERS
Potential Street Tree and Planter Locations in the Project Area, chosen based on various design guidelines and limitations

2.3.2 Value and Co-benefits of Street Trees and Street Planters

Street trees and planters act as stormwater management practices by reducing the amount of runoff that enters the combined sewer system. Trees and planters, acting as mini-reservoirs, control stormwater at the source. Street trees reduce runoff through evapotranspiration, interception, reduced throughfall, and increased infiltration (US EPA, 2013). Unlike ROWBs and greenstreets, street tree pits are not generally designed to capture large volumes of runoff from adjacent impervious areas. The volume of water entering the tree pit and subsequent infiltration is at a much smaller scale than ROWBs or greenstreets, which typically receive runoff directed from a minimum of 20 times the surface area of the ROWB or greenstreet itself. The stormwater that reaches the tree pit is either direct rainfall or incidental runoff from adjacent sidewalk areas; street trees achieve much of their runoff reduction through interception, rainfall that lands on tree leaves and is stored or evaporated back into the atmosphere and never reaches the ground. Estimates for water a typical tree can intercept in its crown range from 760 to 4,000 gallon/tree/year (CRWA, 2009). Similarly, street planters control stormwater runoff through direct interception alone because no vegetation is rooted in the ground. Street trees are recommended for the study area because the benefits (stormwater management, air quality improvements, head island reduction, habitat, shade and beautification) are assumed to well exceed the risks associated with soil contamination. Currently, New York street trees are estimated to reduce runoff by 890.6 million gallons annually (NYC Parks, 2016).

The number of trees and planters sited in the project area was used to determine the potential annual capture of stormwater. The capture was analyzed from the year of planting to year 30, when the trees are expected to reach maturity. As street trees mature, the canopy width increases thereby increasing the amount of stormwater captured through interception. The planters were assumed to have the maximum allowable surface are of 25 square feet. The analysis assumed average New York City annual rainfall. According to the analysis, if all sited planters (19) and street trees (34) were planted in the project area, total annual capture of stormwater would exceed 43,000 gallons.

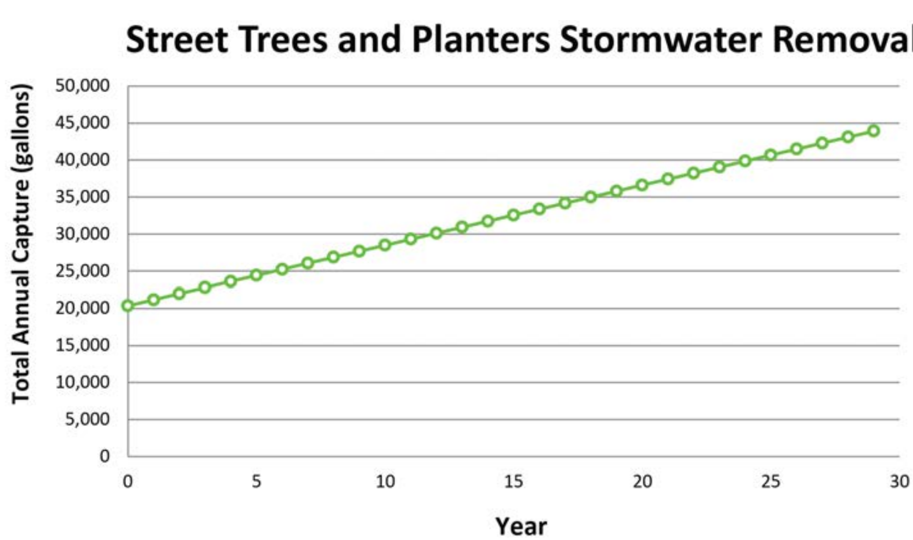


FIGURE 13 - GI TECHNOLOGY PERFORMANCE: STREET TREES & STREET PLANTERS
Stormwater Removal by Street Trees and Street Planters

Street trees and planters provide other numerous social and environmental benefits apart from stormwater management. Urban trees and plantings help offset climate change by capturing atmospheric carbon dioxide through photosynthesis, and decreasing energy used by buildings through evapotranspirative cooling. Trees remove gaseous air pollution by uptake via leaf stomata and also intercept airborne particles. Pollution removal rates differ among cities according to the amount of air pollution, length of in-leaf season, precipitation, and other meteorological variables. In 1994, trees in New York City removed an estimated 1,821 metric tons of air pollution (Nowak, 2002).

The discussed benefits of street trees are quantified in the table below. Numerical values for urban planters are not well defined in the literature.

A further stormwater benefit of street trees, particularly when planted within properly constructed tree pits, is their ability to improve and sustain soil permeability and the infiltration of captured runoff through the soil profile. The extensive root area of mature trees helps to assure that infiltration zones do not become clogged or compacted over time.

Urban heat island effect, defined as the increase in ambient temperature in cities due to modification of land surfaces and waste heat generated, can be decreased through street tree plantings. Leaves and branches reduce the amount of solar radiation that reaches below the tree canopy or plant. Trees also cool through evapotranspiration, which uses the heat from the air to evaporate water. Studies have found that evapotranspiration and shading effects can reduce air temperature by 1°C to 5°C (Brown et al. 2013). Street trees and plants help create New York City's urban forest that provides habitat- including food and shelter for many species of birds, insects, and other wildlife.

The environmental benefits of street trees and plantings lead to human health and social benefits as well. Street trees have been found to increase property values, reduce crime, and enhance quality of life. (US EPA, 2014). By reducing air pollution, trees and vegetation lower the negative health consequences of poor air quality. Shade from trees can reduce heat gain in buildings, which can lower indoor air temperatures and minimize the health impacts of heat waves. The shade provided by tree's canopies can help lower UV exposure. Trees also act as wind breakers, including during winter months, thus helping to reduce the cost of winter heating.

STREET TREE ENVIRONMENTAL BENEFITS

	PER MATURE TREE	WITH 34 TREES PLANTED IN PROJECT AREA
CARBON REDUCTION (TONS/YR) *(NOWAK, 1992)*	3.63	123.42
AIR POLLUTION REMOVAL (KG/YR) *(NOWAK, 2002)*	0.71	24.14

2.3.3 Maintenance of Street Trees and Street Planters

Maintenance for street trees and planters is minimal. NYC DPR provides all maintenance and pruning for street trees. Every year, DPR conducts a routine pruning on a portion of the city trees in each community board to keep the mature trees healthy. Residents and property owners can contribute to the health of the street trees by keeping the tree pits free of garbage, road and sidewalk salt and dog waste, which can contaminate the soil. Residents and property owners can also request maintenance for a tree that is dead, blocking streets signs, or other hazards by contacting DPR.

Street planters are owned, and therefore maintained, by property owners. Property owners agree to maintain the structure and indemnify the City for any resulting damages. Street planter maintenance is that of any outdoor potted plant. During times of drought, watering may be necessary. If overgrowth occurs, the plants may need to be pruned. To retain the aesthetics of the planter, weeds and trash should be removed, if found.

2.3.4 Data Gaps and Next Steps for Street Trees and Street Planters

A walkthrough of the project area should be conducted to investigate the proposed street tree and street planter locations shown in Figure 12 and listed in Appendix 4. While conducting the walkthrough, DPR's Tree Planting Standards and Street Tree Planting Guidelines as well as DOT's clearances for street planters should be kept in mind to ensure spacing and setback requirements are met. Sites in front of commercial properties warrant communication with the business owner or manager to ensure placement of a tree or a planter does not interfere with the operation of the business.

If proposed street tree locations are confirmed during the site walkthrough, planting requests should be made through DPR.

For all planter locations that are confirmed, property owners should initiate the DOT approval process through a revocable consent. The application process begins with the Petition Form for a New Revocable Consent Petition, available on the NYCDOT website. The application process requires a plan prepared by a licensed architect or engineer that conforms to DOT standards. A pre-submission conference can be scheduled to ensure all application requirements are fulfilled and in order.

Upon receiving a complete petition for revocable consent, DOT distributes the material to the appropriate City agencies for review. Upon review, DOT will make a determination on whether the designs must by reviewed by the Public Design Commission (PDC) or the local Community Board.

2.4 Green Walls

The Green Buffers Project Area provides a great opportunity for green walls due to the prevalence of non-residential buildings with large, plain facades that have minimal windows and other adornments. Green walls offer a street-level greening opportunity that is visible and aesthetically pleasing to the public.

2.4.1 Siting and Proposed Locations for Green Walls

Since green walls are on building facades or private property fences, no New York City agency has siting guidelines and the choice of installation and location is up to the property owner. However, if the planter is placed on the ground (as opposed to fastened to the wall), street planter permit may be necessary even if the planter is placed inside the property line. The green wall locations that were sited in the Green Buffers project area were sited in a desktop assessment based on building facade surface area, prevalence of windows, and entry ways.

There are two general types of green walls: planting medium in a planter on the ground with a trellis or fence for climbing plants or panting medium in containers fastened to the walls at various heights. The former is minimally invasive to the building structure while the latter requires an engineering analysis . Siting locations should be conducive to sunlight and rainfall for the health of the plants. Local community members should be able to see the green walls easily to obtain all the benefits of the added green space. When green walls are planted directly in soils below grade, the designer/installer should consider the volume (depth and area) for planting bed so as to assure that the root structure can fully develop. Designers should also make an effort to assure that some runoff from adjacent impervious areas is directed toward the planting bed for irrigation and for greater stormwater volume benefits.

The proposed green wall locations for the project area are shown in Figure 14.

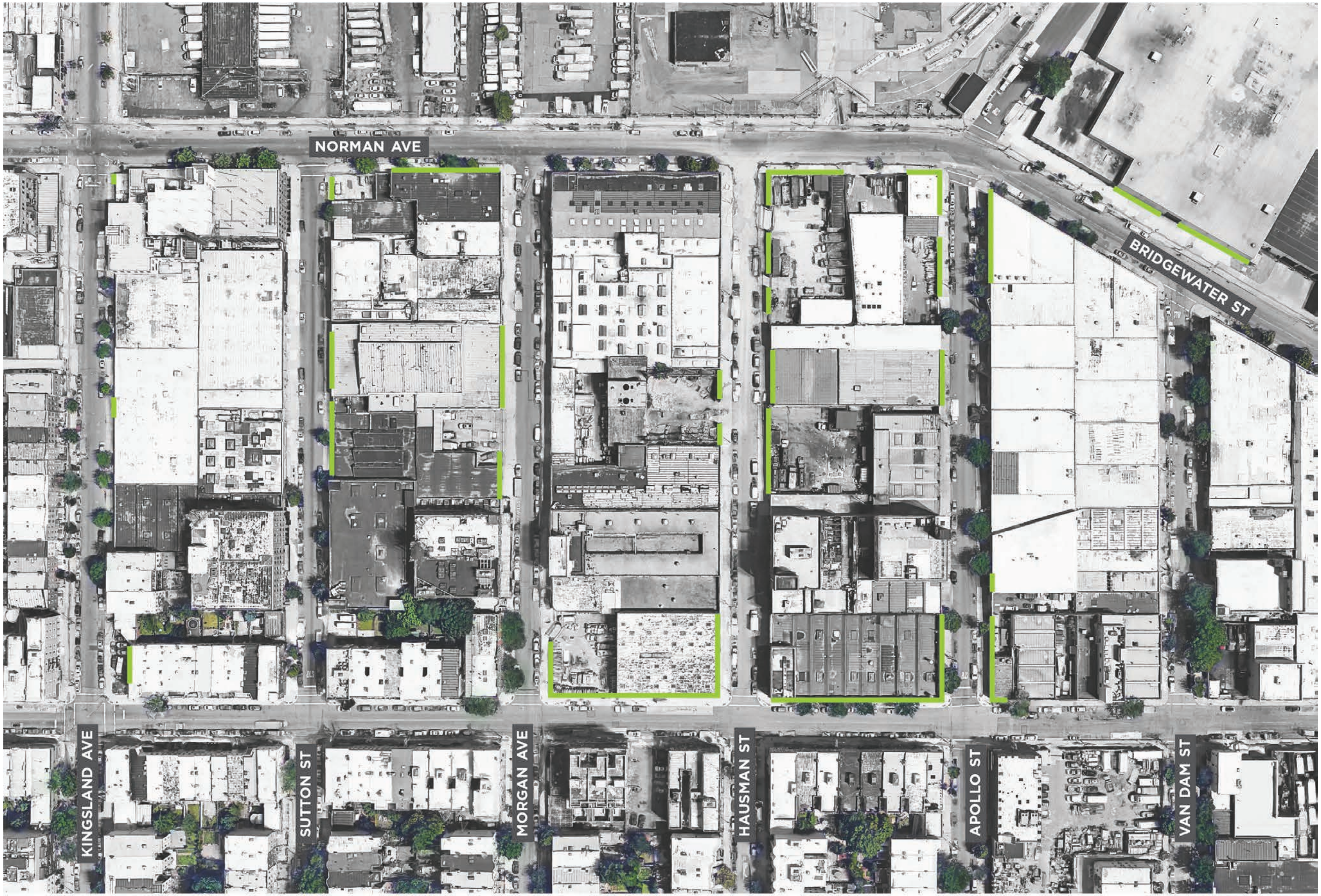


FIGURE 14 - SITING MAP: GREEN WALLS
Potential Green Wall Locations in the Project Area, chosen based on various design guidelines and limitations

2.4.2 Value and Co-Benefits of Green Walls

Green walls create a small, but measurable reduction of runoff to combined sewers. The plants and media in green wall systems promote interception, infiltration and evapotranspiration. Some green walls use collected rain water or recycled grey water for irrigation, further reducing the building's contribution to the combined sewer system. An analysis was conducted to determine the removal from the system with non-irrigated green wall systems. For the purpose of the analysis, green wall systems were assumed to possess a planting bed of 10 square feet and cover a wall area of 200 square feet after 9 years of maturation. The model used historical annual precipitation of New York City.

In addition to stormwater management, green walls provide other environmental benefits including urban temperature reduction and decreased energy usage. Studies have shown that a vine sunscreen such as ivy, growing directly on a west wall, provides effective shading of the wall - thus contributing to lower heat absorption of the wall and therefore lower indoor temperatures (Hoyano, 1988). Temperature differences up to 10°C was recorded between exposed wall surfaces with and without the plant screening. The effect of air movement increasing convective heat gain/loss through building facades can also be mitigated by green walls, thus helping in the lowering of building energy usage. The increased thermal performance can lower energy requirements for the heating or cooling of a building, and thus lower greenhouse gas emissions (Loh, 2008). The evapotranspiration from green walls also contributes to the lowering of temperatures around the planting, an affect that can help lower the urban heat island effect.

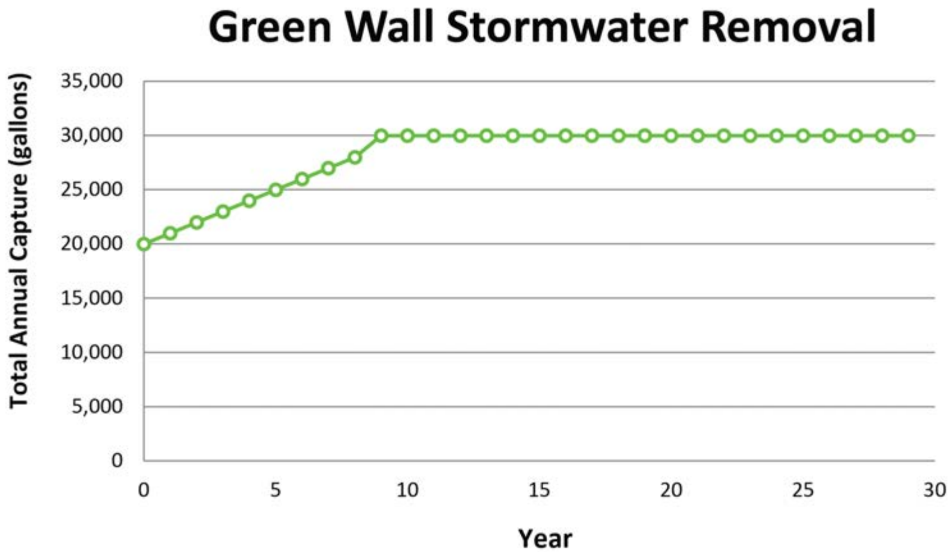


FIGURE 15 - GI TECHNOLOGY PERFORMANCE: GREEN WALLS
Stormwater Removal by Green Walls

Green wall systems can be of benefit to reduce sound reflection from the hard surfaces of roads and buildings. Studies have shown that green walls show better acoustic absorption than other common building materials (Azkorra et al., 2015). Green walls can be a means to increasing biodiversity in urban environments where much ecology has been lost to development. Increased native flora and fauna species have been documented by green roof projects and it is not unreasonable to expect similar results for vertical landscapes.

2.4.3 Maintenance of Green Walls

Maintenance needs of green walls are similar to that of regular landscape plants. Plant growth must be maintained through routine weeding, pruning, and mulching. The substrate must be maintained if it is disturbed by wind, rain, or animal activity. If being used, waterproofing membranes need to be inspected for any damage from water or plants.

If the wall uses an irrigation or pumping system, they must be tested and inspected. Most walls are dormant in the winter when irrigation systems should be shut down. Plant selection will determine the extent of any annual pruning or plant replacement needed, which will be described by the green wall vendor or designer. If drainage features are a part of the system, ensure that they are clear and functioning by removing dirt and litter.

2.4.4 Data Gaps and Next Steps for Green Walls

Little research has been done to quantify the potential for green walls to capture rainfall through leaf interception. Better analysis could demonstrate a marked increase in the expected management volume for the installation. Additionally, irrigation of green or living walls using stored rain water would similarly increase the management volume through evapotranspiration. The research on this practice is also lacking.

2.5 Green Roofs

The Green Buffers project area is well suited for green roofs due to the large number of industrial buildings that have flat, open roofs with expansive surface areas. The popularity of green roofs in industrial areas is growing in New York City. Green roofs are a desirable option for industrial properties because these sites often maximize their property footprint with built structures and, the remaining ground-level space is heavily used for their business practices, making it unsuitable for grade-level green infrastructure installation. A green roof is an option that does not interfere with any daily operations. Green roof systems, because they protect the roofing membrane from exposure to sun and climate, are expected to increase the life-expectancy of the roofing membrane by two to four times (NPS, 2017). Some green roof installations in Germany have been operating for over a hundred years without roof replacement. These features, coupled with the tax abatements from green roof installation, make green roofs a good choice for the project area.

2.5.1 Siting and Proposed Locations of Green Roofs

As mentioned in previous sections, the most important factor in siting a green roof is ensuring the building can support the additional weight added by the green roof. A structural assessment must be conducted by a licensed engineer to verify that the roof and its support system are adequate. A structural assessment of each building within the project area was not plausible; thus other factors, such as roof slope, sizes, and complexity, were considered during the desktop assessment of potential green roof locations within the project area.

Green roofs siting must consider roof slope. Roof slopes under 10 degrees are best suited for green roofs although it is possible to install a green roof on a slope up to 30 degrees. Size is also a factor in green roof siting. A smaller green roof will be less cost efficient, since they require more detailed work per square foot when installing the membrane. Similarly, roofs with many protrusions, such as skylights, vents, or mechanical systems can become more costly. Naturally, cost structures change when green roofs are installed as part of a needed roof replacement, or when new buildings are constructed. Structurally enhancing existing roofs so that they can bear the additional load is generally not a cost-effective measure. In some instances, it may be possible to provide an intensive (deep) green roof that receives runoff directed from a higher roof area.

Using Google Earth, a desktop assessment was performed to determine potential green roofs within the project area. Roofs were chosen based on the guidelines above, but with no actual inspection or field verification. All potential green roof locations are shown in Figure 16.

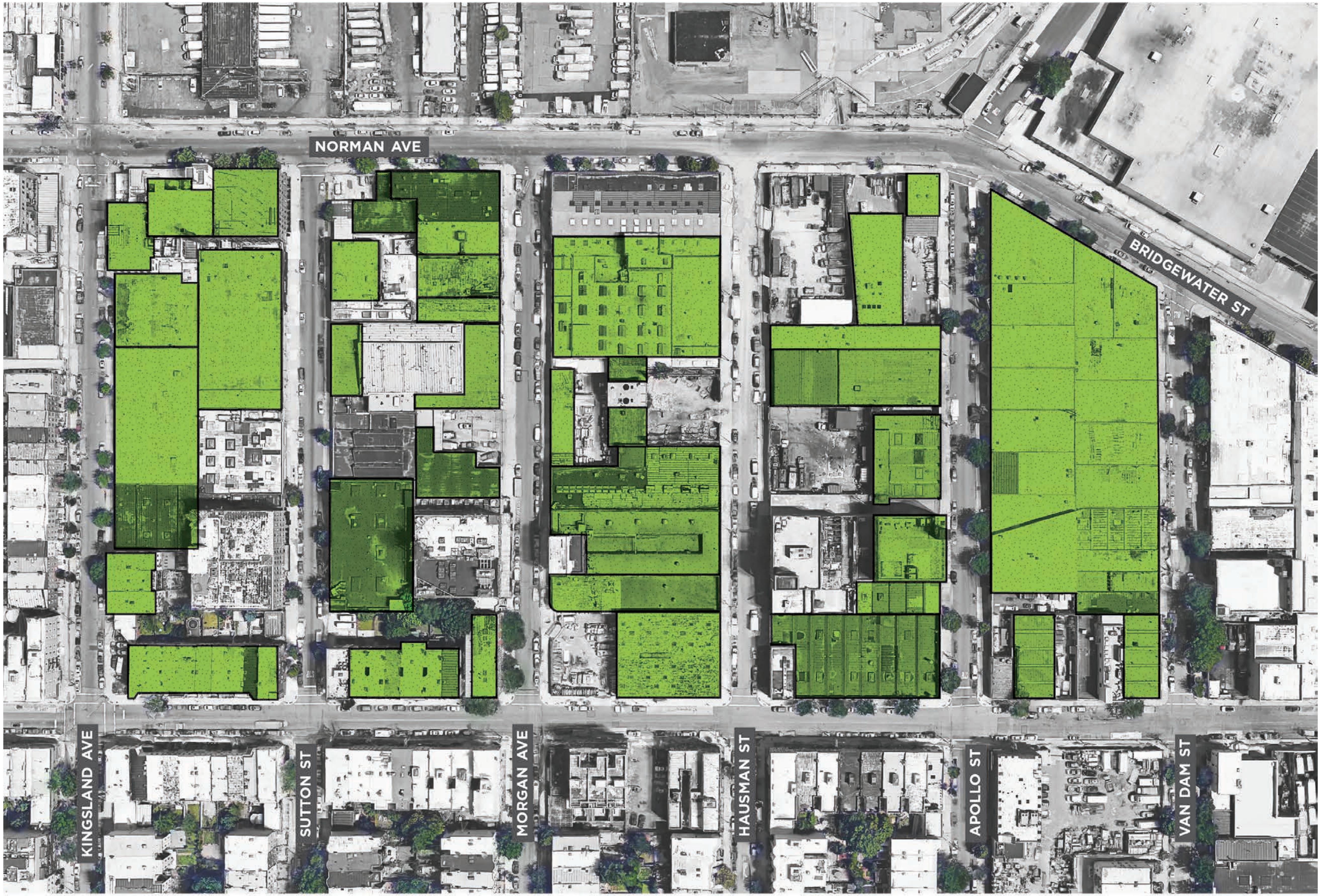


FIGURE 16 - SITING MAP: GREEN ROOFS
Potential Green Roof Locations in the Project Area, chosen based on various design guidelines and limitations

2.5.2 Value and Co-Benefits of Green Roofs

Green roofs help reduce stress on New York City's aging wastewater infrastructure by diverting rainwater from directly entering the storm sewer networks. Using green roof vendor publications and research papers, a model was created to determine the total annual capture of stormwater within the Green Buffers project area as a function of the adoption of the green roof locations proposed in Figure 16. The model used historical annual precipitation of New York City, an average capture depth, and a conservative porosity value (35%). For extensive green roofs, a 3-inch growing medium was used and for intensive, a 6-inch growing medium was used (Young, 2008).

Green roofs also provide additional benefits, such as energy conservation, noise reduction, urban heat island effect reduction, a potential for urban agriculture expansion, economic growth, and an overall improvement in a building's aesthetics. The insulation value and thermal mass of the green roof reduces heating/cooling loads by insulating the building during winter and reducing the building's surface temperature during summer. The insulated nature of the green roof also aids in dampening surrounding city noise, which creates a better living/working environment for the building's occupants.

The plantings on green roofs also aid in lowering the urban heat island effect by deflecting the sun's radiation, absorbing carbon dioxide, and releasing moisture into the atmosphere. Green roofs typically incorporate low-maintenance plants with high water holding capacity, such as sedums, into their design, but additional planting should be considered to promote biodiversity. One possibility is to incorporate vegetables and/or other produce on the rooftops. The produce could be used by the building's tenants or donated to those in need.

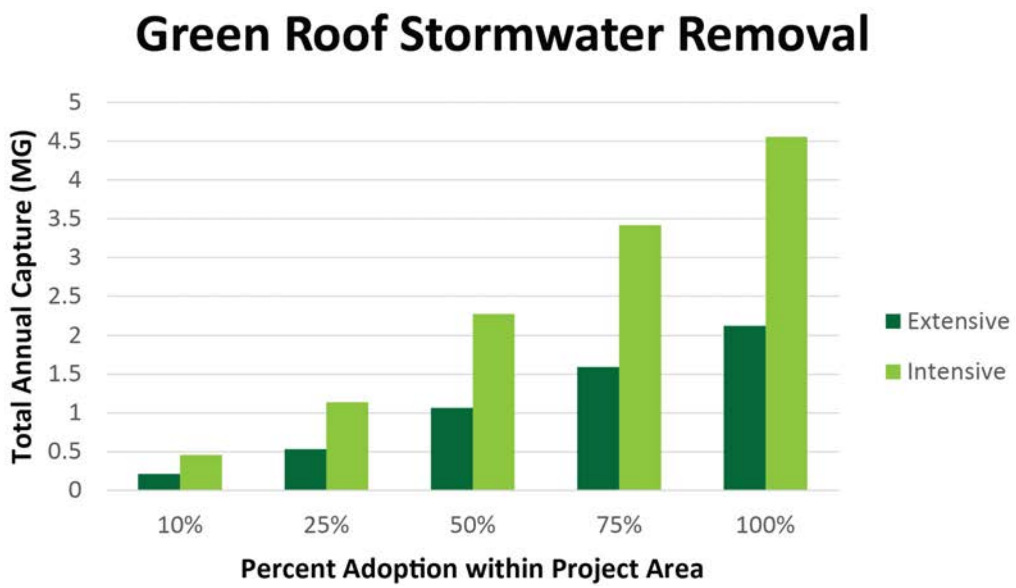


FIGURE 17 - GI TECHNOLOGY PERFORMANCE: GREEN ROOFS
Stormwater Reduction by Green Roofs

In addition to the potential revenue, the local economy is improved by new job opportunities generated from the construction and maintenance of the green roof. The increase of green space may also lead to increased property value of the building.

2.5.3 Maintenance of Green Roofs

The primary maintenance requirements for green roofs have to do with plant maintenance and debris removal to prevent clogging. De-clogging of overflows or drainage outlets may sometimes be required after a large storm, but periodic inspection should be performed several times annually, especially during the first years after installation and until the specific behavior of the green roof system is better understood.

Plant maintenance requirements will depend on whether the green roof is intensive or extensive as well as the planting regime chosen. Extensive green roofs typically support only a small variety of plants, mostly sedums, which are well adapted to the wet/dry environment, although they require irrigation during summer dry spells, especially during the establishment period. Intensive systems generally retain more moisture and require less (or no) irrigation. Due to the larger variety of plant species, intensive green roofs may require greater attention to assure that the plant communities are able to remain healthy and to prevent a flush of undesirable weeds. Plant care on any green roof is most critical during establishment, which lasts 18 to 24 months (Tolderlund, 2010). The general plant maintenance tasks include weeding, watering, thinning, pruning, fertilizing and occasional plant replacement, instructions for which are customarily provided by the installer. Most plant maintenance can be performed by the roof owners or interested tenants. Maintenance contracts are often negotiated with the green roof installer for the first one to three years after installation.

Maintenance and visual inspection of the waterproofing membrane is necessary as leaks can occur at joints, penetrations, and flashings due to poor installation or material failure. Alternatively, electronic leak detection systems between or underneath the membranes can pinpoint exact locations of water leaks. In addition, any areas or joints where the roof is penetrated, such as vents, ducts, drains, and expansion joints should be regularly inspected and kept free of roots, leaves, and debris.

2.5.4 Data Gaps and Next Steps for Green Roofs

Rooftops that have large catchment areas and maximum rainfall exposure should be investigated in the Green Buffers project area for green roof installations. While surveying the rooftops in the project area, the rooftop gradients should also be investigated to assess the type of green roof that can be proposed on the rooftop.

The structural analysis of a rooftop determines if the existing rooftop can support the installation of a green roof. The structural analysis for a green roof is critical because of the additional loading from the stored water, growing medium and planting layers. A structural analysis must be carried out by a P.E. or R.A. in order to file for a construction permit from the DOB; however, even before the structural analysis is conducted the rooftop's exposure to rainfall, as well as its size, should be assessed. The assessment should also include consideration of combining roof areas into a single "catchment" that is managed by one or more intensive green roof areas, allowing higher roofs to drain freely to lower green roofs, thus reducing the overall cost of installation on a per square foot of catchment basis. Additionally, since green roofs offer substantial cooling benefits during summer months, roof areas should be selected that cover interior spaces that require cooling for maximum energy benefit.

2.6 Detention Bioswales

2.6.1 Siting and Proposed Locations of Detention Bioswales

Detention bioswales could prove to be a promising practice for the project area in the future. Currently, detention bioswales are not being sited or constructed in the right-of-way in New York City. Detention bioswales should be considered for the project area if they are adopted by the City.

Due to the fact that the detention bioswale is not currently an accepted technology for the right-of-way in NYC, exact bioswale locations were not determined. New York City Economic Development Corporation (NYC EDC) and DEP estimate future construction of bioswales at one bioswale per acre (NYC EDC, 2017). Applying this estimation to the project area, which is approximately 23 acres, 23 bioswales could potentially be sited. If this technology is approved, the siting process will follow any published NYC DEP site selection and guidelines.

2.6.2 Value and Co-Benefits of Detention Bioswales

Based on an assumed adoption of 23 bioswales, and the average annual rain events in New York City, an analysis was performed to determine the average annual capture for the project area. The annual capture is shown as a function of adoption rate. In addition, annual capture for two bioswale configurations, with and without a stormwater chamber is shown.

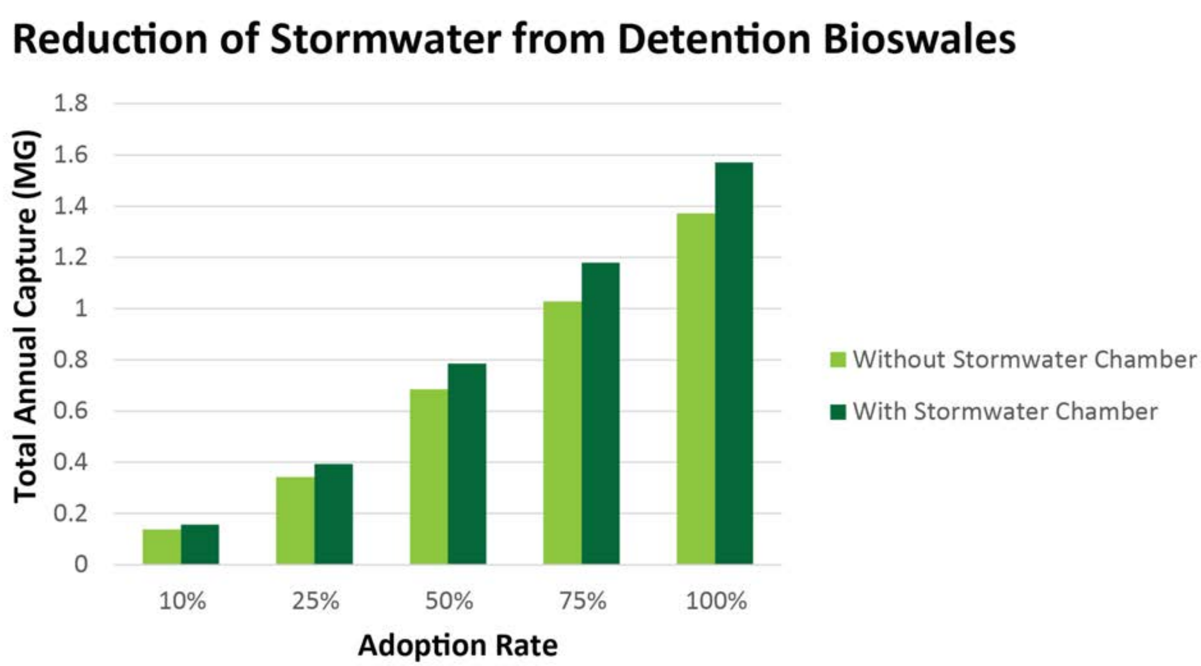


FIGURE 18 - GI TECHNOLOGY PERFORMANCE: DETENTION BIOSWALES
Stormwater Reduction by Detention Bioswales

Along with stormwater management, bioswales provide numerous public health benefits including reduction in urban heat island effect and improvement in air quality. According to a study conducted by NYC DEP, an individual bioswale can remove 0.15 lbs of ozone, 0.1 lbs of PM10 and nitrogen dioxide, and 0.06 lbs of sulfur dioxide annually. In this study, individual bioswales showed temperatures 15% lower than the average sidewalk or street temperature (NYC DEP, 2016).

Bioswales also improve ecosystems in the urban area. The increase in green space adds to the wellbeing for residents and desirability of the neighborhood. Construction of bioswales in right-of-way support green jobs in the metropolitan region through design, construction, and maintenance.

2.6.3 Maintenance of Detention Bioswales

New York City has an established Green Infrastructure Task Force, formed by all relevant City agencies, with the goal of efficient maintenance to upkeep all green infrastructure in the right-of-way. Crews manage the vegetation within the bioswale, including weeding and trash removal. If detention bioswales were approved and constructed in the project area, following all City guidelines, the maintenance would be performed by the Green Infrastructure Task Force, relieving the property owner of any effort or responsibility.

2.6.4 Data Gaps and Next Steps for Detention Bioswales

Detention bioswales are not an accepted form of green infrastructure in the New York City right-of-way. Prior to any siting or construction of detention bioswales, NYC DEP must approve this technology. If the detention bioswale becomes a standard practice in New York City, NYC DEP will publish siting guidelines and design standards.

2.7 Rainwater Harvesting

Rainwater harvesting is difficult to site in a largely industrial urban area. Due to the overwhelmingly industrial land-use within the project area, many of the properties do not have a needed end use for harvested rainwater. Those businesses that do use water in their operations have stringent quality standards that may require filtration and treatment. Rainwater harvesting is not recommended for the project area, except in conjunction with a green wall project.

Financial Feasibility

When assessing the financial feasibility of a GI practice, the cost of installation should be compared to the volume of stormwater managed and co-benefits to determine if the environmental benefits are significant enough to justify the cost of the project. One way to assess GI projects is through the "dollar per gallon" metric, assessing the cost of installation versus the number of gallons removed from the combined sewer system on an annual basis. The dollar per gallon of stormwater managed metric ($/gallon) standardizes projects to help evaluate a project's financial feasibility. By evaluating GI projects in a single metric, various GI installations can be compared and ranked according to which project manages a gallon of stormwater at a lower cost. However it is important to note that this metric only evaluates the cost effectiveness with respect to stormwater management and does not take into consideration any of the co-benefits.

A model was created to evaluate the proposed green infrastructure practices that determined the cost per gallon of stormwater managed annually. Below is a graph depicting these costs for the GI practices proposed for the Green Buffers project. The results are shown as a high and low estimate as the cost of each practice can range based on local conditions, materials and other factors. Each practice was sized to manage the one-inch rainfall event from its contributing area. The calculations assume the events of one-inch or less represent 85% of annual rainfall in New York City and that 44 inches of rainfall is received annually.

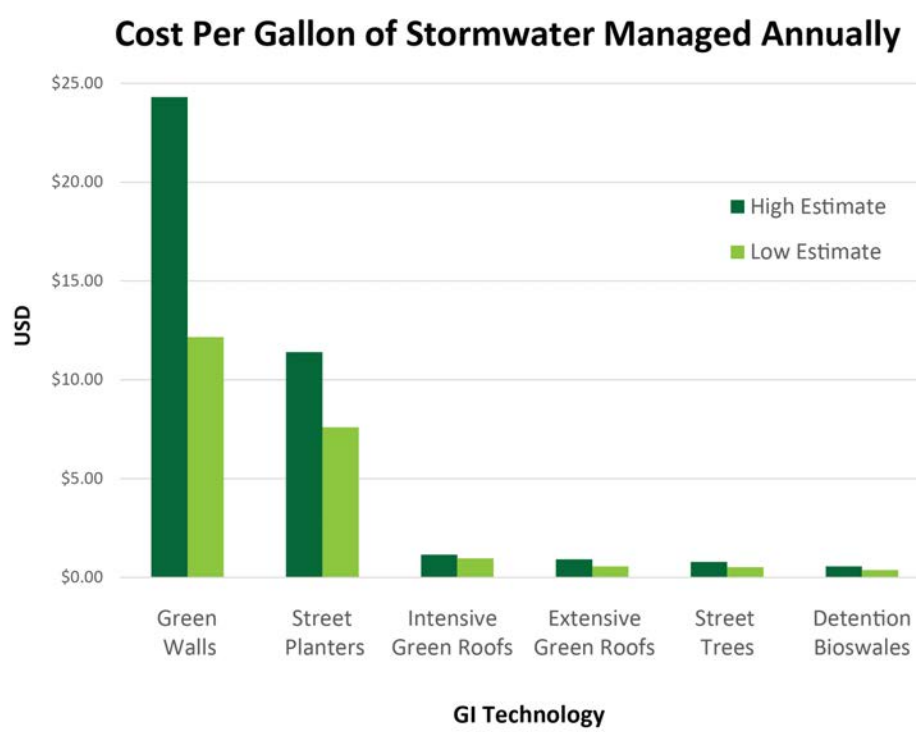


FIGURE 19 - GI TECHNOLOGY PERFORMANCE: TECHNOLOGY COMPARISON
Cost for proposed GI Practices for the project area shown as a function of their ability to manage stormwater

Although the dollar per gallon value helps maximize stormwater management while being cognizant of funds, these values should be evaluated in conjunction with the technical feasibility and co-benefits. The relative value of co-benefits for the proposed GI practices is summarized in the following table.

The annual dollar per gallon values, technical feasibility, and co-benefits are useful for making an informed decision about which GI practices to install and at what locations; additionally, some GI practices qualify for DEP's green infrastructure grant program or DOB's tax abatement for green roofs.

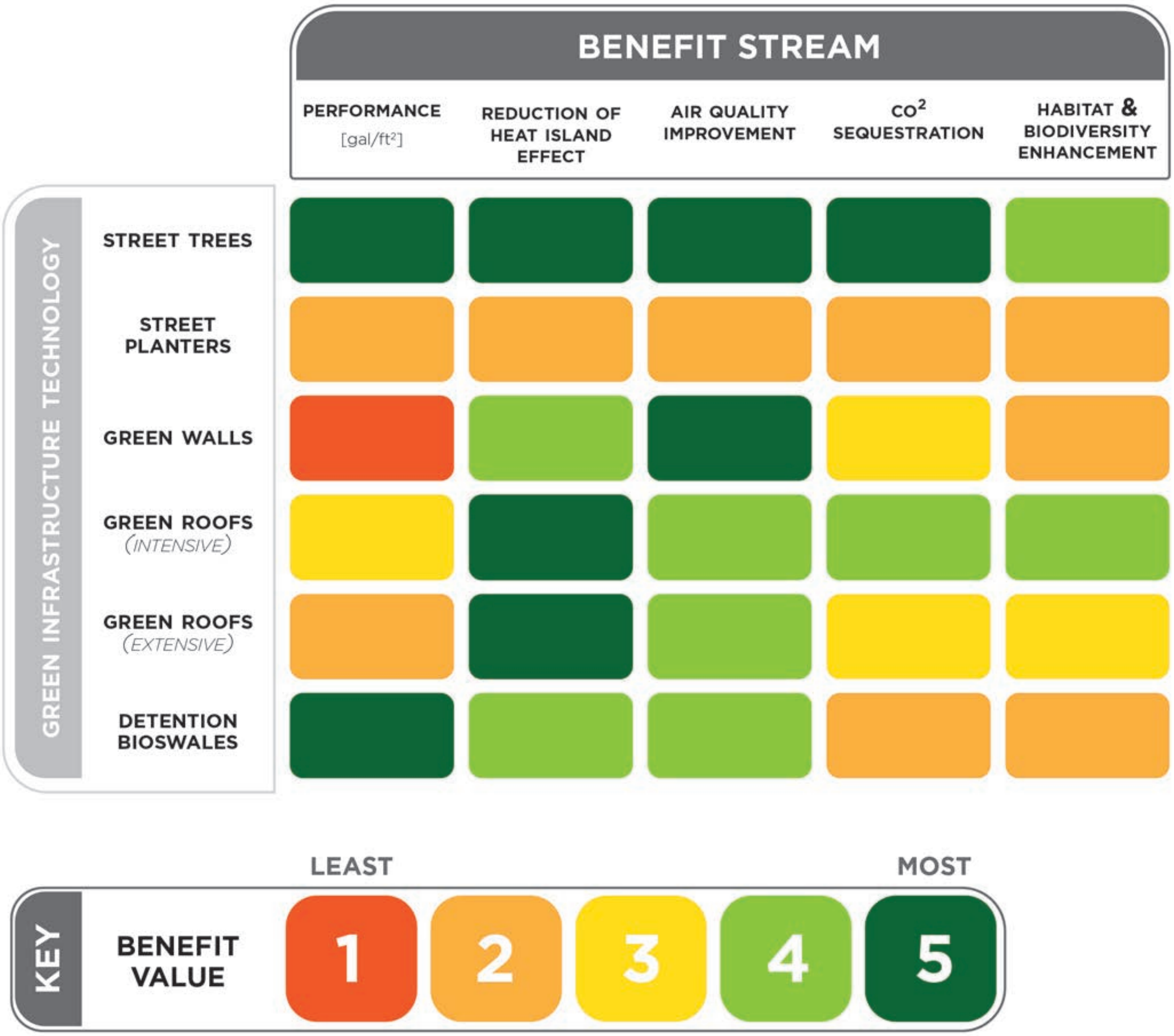


FIGURE 19 - GI TECHNOLOGY COMPARISON: CO-BENEFITS
Comparison of positive secondary effects, or co-benefits, among various proposed GI technologies for the project area

DEP GI Grant Program

To meet the goals of the CSO Consent Order, DEP developed a GI Grant Program to provide funding for the design and construction of GI projects on non-City owned properties. GI projects eligible for the program include: Rooftops (green roofs, blue roofs, or roof leader diversion to rain gardens), infiltration (rain gardens or vegetated swales), rainwater harvesting (cisterns or rainwater reuse systems), subsurface systems with infiltration capacities, and porous paving systems. For a property to be eligible for the program, it must lie within a combined sewer area of New York City, be privately owned (City-owned properties leased to private parties or other government entities are reviewed on a case-by-case basis), and property owners must execute a Declaration of Restrictive Covenant, Funding Agreement, and a Statement of Agreement. The Declaration of Restrictive Covenant ensures the project will be kept in place and maintained for a period of at least 20 years.

The Green Buffers project area falls within the NCB-027 combined sewer area and does not contain any City-owned properties. Appendix 8 has a map of the combined sewer areas in and near the project area, and Appendix 9 shows the land use in and around the project area as well as the properties near the project area that are City-owned.

To receive funding, GI practices are required to manage the volume of stormwater equivalent to one inch of rainfall over the total impervious area that is contributing to the proposed GI practice. Additionally, the funds requested for the proposed design must exceed $35,000. For rooftop projects, applicants are also required to have a P.E. or R.A. inspect the loading capacity of the roof and verify it can support the proposed rooftop project. A P.E. or R.A.-stamped structural analysis will have to be submitted with the Grant application.

The Grant program evaluates GI projects based on a cost/benefit ratio, feasibility, application completeness, and other factors that have to do with community engagement, monitoring, projected timeline, and if applicants are willing to pay in-kind costs. The Grant program looks favorably on projects that can be completed in shorter time frames, are innovative, submit monitoring plans, aid community involvement, support economic/workforce development, and/or match the funding request with in-kind or cash costs.

DOB Tax Abatement: Green Roofs

DOB provides a one-year tax abatement of $5.23 per square foot of green roof to buildings that have at least 50% of their eligible roof space coved by a green roof. The tax abatement is capped at $200,000 for a single property. To qualify for the tax abatement, the green roof must have a vegetated layer, a growing medium layer, a weather and waterproof roofing membrane, a root barrier layer, an insulation layer, and a drainage layer. The vegetated layer must have at least 80% of live plants, either native and agricultural plant species or plants that have high water storage capacity, such as *sedums*, and should be spaced out to cover 80% of the layer. The growing medium should be a mixture of natural or engineered soil that is at least two inches in depth. If the growing medium layer is less than three inches, a layer for water storage should be included to prevent the growth medium layer from drying out (NYC DOB, 2010).

Stakeholder Engagement

One of the main tenets of green infrastructure planning is stakeholder and community engagement. The goal of this engagement is to build community awareness of and support for green infrastructure projects and initiatives that can result in the implementation of proposed projects and initiatives. The previously outlined feasibility analysis was intended to engage diverse stakeholders in the process of siting, designing, and evaluating the potential of GI typologies to become integrated within the project area's existing infrastructure, function, and community. The project team has performed community and business owner outreach through open community meetings and individual meetings.

Community Meeting

A community meeting was held on May 15, 2017 to present the types of GI practices feasible for the Green Buffers area and engage stakeholders in identifying potential locations for those practices. Maps of the project area, depicting parcel building footprints and land use, were distributed to groups of community members along with stickers depicting GI practices. Each group indicated where they would like to see different practices sited and investigated. This exercise resulted in several projects and locations for the project team to further investigate:

•Install a green roof on Broadway Stages building (located at 359 Kingsland Avenue). Broadway Stages is a good community partner and has installed a green roof on another of its property.

•Use the private properties and empty tree pits on Norman Avenue to create a "landscape buffer."

•Determine if a repair is scheduled for the flooding at Kingsland Ave and tack on a greening element to a capital project.

•Consider green roofs on bus stops along Nassau Avenue

•Approach the business located in Empire Merchant Building (16 Bridgewater Street) for a potential green roof.

•Create a “green corridor” from McGolrick Park to 520 Kingsland using green walls, street trees, and planters.

•Strategically plan green infrastructure downstream of the Nassau Avenue and Apollo Avenue corner (the highest point in the project area).

Business Outreach

Based on the technical and regulatory feasibility and integrating the stakeholders’ feedback from the community meetings, an outreach plan was developed for businesses within the project area. The goals for the business outreach were: 1) to inform and engage the business owners in the project area and 2) to notate any concerns, restrictions or considerations for siting a GI practice in the vicinity of their facilities. The outreach plan involved initiating contact with all businesses in the area and focusing on those whose location was chosen as a potential site for green infrastructure. Every effort was made to reach the business owner or operator to explain the green infrastructure projects and the steps necessary for implementation.

There are more than 100 businesses within the 5 block project area and the immediately adjacent area. Of the total 119 businesses, the outreach coordinator called 81 businesses and met or spoke with representatives from 41 businesses. Priority for further consideration was given to the 41 businesses that responded to the initial outreach effort. Out of this cohort of businesses, the outreach coordinator was able to engage in in-person meetings with 18 businesses, some with multiple visits, to solicit their concerns and gauge their interest level.

The 18 businesses were generally categorized as “high priority,” “medium priority,” and “low priority” based on a combination of factors, such as the business representative who met with the outreach coordinator (business owner vs manager); expression of interest and/or enthusiasm; nature of the site and the business; and other factors. The table on the following page summarizes the meetings with the 18 businesses.

In general even those businesses with an interest in the project want participation to be convenient with minimal commitment of time and human resources. They will not send a representative to a community meeting but are willing to meet with the project team at their convenience. Many were also reluctant to engage until there is a more specific plan for them to review. Those identified as high priority also shared useful information regarding their operation and potential concerns in siting GI practices in the vicinity of their businesses.

In addition to business outreach, property ownership was researched. Letters were sent to all 65 property owners in the project area informing them of the project. Because telephone numbers were not readily available, no property owner was contacted by telephone. Most of the properties are owned by companies (e.g., LLCs) rather than individuals, making it difficult to establish a personal connection.

Priority	Business Name	Level of Engagement	Steet Trees	Street Planters	Green Walls	Green Roof	Detention Bioswale
			POTENTIAL GI PRACTICES AT SITE				
HIGH PRIORITY	AF & JR TRUCK REPAIR INC	4 (Expressed interest)	✓	✓		✓	
HIGH PRIORITY	PICOLIN AUTO REPAIR	4 (Expressed interest)				✓	
HIGH PRIORITY	SMC STONE	4 (Expressed interest)				✓	
HIGH PRIORITY	AIA SHEET METAL	4 (Expressed interest)			✓	✓	
HIGH PRIORITY	READY SET	3 (Potentially deeper involvement)	✓		✓	✓	
HIGH PRIORITY	COBRA KITCHEN	4 (Expressed interest)				✓	
HIGH PRIORITY	ALL SORTS INC	4 (Expressed interest)				✓	
HIGH PRIORITY	CENTRAL TRANSPORT	4 (Expressed interest)			✓		
MEDIUM PRIORITY	60 VAN DAM STREET	2 (Limited engagement)					
MEDIUM PRIORITY	SABRA STONE	4 (Expressed interest)				✓	
MEDIUM PRIORITY	DESCIENCE LAB	3 (Potentially deeper involvement)				✓	
MEDIUM PRIORITY	WINDMILL STUDIOS	3 (Potentially deeper involvement)			✓	✓	
LOW PRIORITY	RITE PAC	3 (Potentially deeper involvement)				✓	
LOW PRIORITY	K-O AUTO SERVICE	3 (Potentially deeper involvement)					
LOW PRIORITY	RELIANT TRANSPORTATION	2 (Limited engagement)					
LOW PRIORITY	POINT RECYCLING	2 (Limited engagement)					
LOW PRIORITY	UPGRADE CONTRACTING	1 (Potential future outreach target)				✓	
LOW PRIORITY	CADOGAN TATE	1 (Potential future outreach target)	✓				

KEY — LEVEL OF ENGAGEMENT

4	3	2	1
EXPRESSED INTEREST	POTENTIALLY DEEPER INVOLVEMENT WHEN A SPECIFIC PLAN IS DEVELOPED	LIMITED ENGAGEMENT	POTENTIAL FUTURE OUTREACH TARGET BECAUSE OF THE NATURE OF THE SITE

FIGURE 20 - BUSINESS OUTREACH COMPARISON TABLE

Prioritized list of businesses within the project area, their level of engagement, and possible GI technologies to be installed

Community Feedback

After the initial community workshop in which residents identified some potential sites for green infrastructure practices that are feasible in the project area (see page XX), a walkthrough of the project area was organized as a public event on October 14th, 2017. The goal of the event was to evaluate locations for street trees, street planters, green roofs and green walls based on the maps shown in Figures 12, 14 and 16.

Although the turnout was low, some sites were identified as desirable from a resident's perspective. A more technical walkthrough is needed to determine what is theoretically feasible due to spacing and set back requirements. In addition, a second community workshop was held on January 30th, 2018, to develop strategies for moving this project to the implementation phase. Representatives from the NYC Department of Transportation and DPR participated as well as members of the community. There was a strong desire to focus on Norman Avenue as a green corridor. DPR is interested in planting trees in existing tree pits that are empty. Newtown Creek Alliance, a community-based organization, is interested in supporting efforts to build stormwater planters along Norman Avenue. The NCA is currently working on creating a street-end planters at the end of Apollo Street, which merges Norman Avenue. Focusing on Norman Avenue will serve as an extension of the NCA's existing greening efforts, and thus improves the potential for implementation.

Next Steps/Conclusions

The next phase of the project requires a local organization which can serve as the project lead. Additional financial resources are also warranted. Another walkthrough with members of the community would be beneficial in identifying additional potential sites for GI practices. Such a walkthrough should be followed by a more technical walkthrough for preliminary feasibility assessment.

Following the preliminary feasibility assessment, rough conceptual design for each potential site for a green roof, a green wall or street planters would be useful in approaching the business and property owners. In addition to the conceptual designs, potential financing resources should be prepared, particularly for structural analysis needed to fully evaluate each project site. Aggregating multiple sites for structural analysis should be considered for applying for potential funding.

For tree pits that are currently empty, businesses that front the tree pit should be contacted to evaluate whether a tree would interfere with their operation. If a tree does not pose a nuisance for the business, a request for a tree should be placed with DPR. If a tree is a concern for the operation of the business, replanting the tree pit with herbaceous native plants might be investigated.

For potential funding, New York City Council Resolution A Capital Funding should be pursued for installing new tree pits. The project area is within the City Council District 33 (Councilman Stephen T. Levin), which currently offers participatory budgeting. In addition to new tree pits along Norman Avenue, the Reso A funding might be appropriate for other potential projects such as a bus stop green roof on Nassau Avenue. For green roofs, outreach to business and property owners to inform them of the DEP Green Infrastructure Grants Program and the Green Roof Tax Abatement Program is warranted.

Continued community engagement is also needed to sustain the project. One of the goals of this project is to make the industrial area of Greenpoint a more pleasant environment for area residents and the workers. By doing so, the rift between residents and businesses can be narrowed and the support for local businesses in the project area, many of them small businesses, can be nurtured. A leadership by a local organization is thus critical to move the project into the implementation phase.

GLOSSARY
OF TERMS

Glossary of Terms

Blue Roof
Blue roofs are designed without vegetation for the primary purpose of temporarily detaining stormwater. Weirs at the roof drain inlets create temporary ponding and gradual release of stormwater.

Co-Benefits
(In reference to Green Infrastructure) The subsequent positive effects of installing Green Infrastructure in urban settings, including but not limited to the secondary improvements to urban life such as recreational benefits, community benefits, educational opportunities, stewardship possibilities, and reduction in Urban Heat Island Effect.

Combined Sewer Overflow (CSO)
Discharge of untreated wastewater, mixture of stormwater and domestic waste, when the flow capacity of a sewer system is exceeded during rainstorms.

Detention
The act of holding stormwater temporarily and discharging the stormwater over an extended period of time (hours to days), generally by controlling the size of the discharge volume and flow rate.

Direct Capture
In hydrology, the component of the water cycle which has been directly absorbed by vegetation, including plant and tree leaves.

Evapotranspiration
The release of water vapor into the atmosphere by the combination of direct evaporation from soil media and transpiration by plants.

Extensive Green Roof
Vegetated Roof system with a typical soil depth of 3-6 in, with lightweight soil containing relatively low organic matter. Extensive Green Roof systems typically have a limited variety of plant species and have, on average, lower maintenance, nutrition and irrigation requirements. (Compare to Intensive Green Roofs)

Green Infrastructure (GI)
Infrastructure associated with stormwater management and low impact development that encompasses approaches and technologies to infiltrate, evapotranspire, capture, and reuse stormwater to maintain or restore natural hydrologies.

Hardiness Zones
Zones based on the average annual minimum winter temperature, divided into 10-degree F zones.

Infiltration
The movement of water through the ground surface into the unsaturated zone.

Intensive Green Roof
Vegetated Roof system with a typical soil depth of 6 in or greater, with heavier weight soil (up to 150 lbs/in2). Intensive Green Roof systems typically have a greater diversity of plant species including shrubs and small trees, and typically require more maintenance, nutrition and irrigation regimes. (Compare to Extensive Green Roofs)

Interception
In hydrology, the accumulation of precipitation on vegetation and other above-ground surfaces and its evaporation during and after a storm event.

Macropores
Macropores are large soil pores, usually between aggregates, that are generally greater than 0.08 mm in diameter. Macropores drain freely by gravity and allow easy movement of water and air. They provide habitat for soil organisms and plant roots can grow into them.

MPNA
McGolrick Park Neighborhood Alliance, a group of organized community leaders and residents working to improve McGolrick Park and surrounding neighborhood.

NYC DEP
New York City Department of Environmental Protection, , the department of the government of New York City which protects public health and the environment by supplying clean drinking water, collecting and treating wastewater, and reducing air, noise, and hazardous materials pollution.

NYS DEC
New York State Department of Environmental Conservation, department of the New York state government which guides and regulates the conservation, improvement, and protection of New York's natural resources; manages Forest Preserve lands in the Adirondack and Catskill parks, state forest lands, and wildlife management areas; regulates sport fishing, hunting and trapping; and enforces the state's environmental laws and regulations.

NYC DOB
NYC Department of Buildings, the department of the government of New York City which promotes the safety of all people that build, work, and live in New York City by regulating the lawful use of over one million buildings and construction sites across the five boroughs.

NYC DPR
NYC Department of Parks & Recreation, the department of the government of New York City responsible for maintaining the city's parks system, preserving and maintaining the ecological diversity of the city's natural areas, and furnishing recreational opportunities for city's residents and visitors.

NYC DOT
NYC Department of Transportation, the department of New York City which provides for the safe, efficient, and environmentally responsible movement of people and goods in the City of New York and maintains and enhances the transportation infrastructure crucial to the economic vitality and quality of life of City residents.

NYC SWCD
New York City Soil & Water Conservation District, subdivision of the state government, is part of a nationwide system of 3000 districts, assists New Yorkers and local decision-makers in making wise use of the City's soil, water and related resources.

Photosynthesis
The manufacture by plants of carbohydrates and oxygen from carbon dioxide mediated by chlorophyll in the presence of sunlight.

PM10
Inhalable particles, with diameters that are 10 micrometers and smaller; an air pollutant.

Porosity
The volume fraction of a rock or unconsolidated sediment not occupied by solid material but usually occupied by water and/or air.

Retention
The act of managing stormwater by maintaining a permanent pool of water between storm events. A retention system differs from a detention system, which is designed to empty between storm events and does not maintain a permanent pool.

Right-Of-Way Bioswales (ROWBS)
Planted areas in the sidewalk that are designed to collect and manage stormwater.

Semi-Intensive
A combination of an extensive greenroof with areas of higher plant depths, the semi-intensive living roof will have both areas of lower than 6" of growing media and higher, ranging from 8-12" or 20 – 30 cm.

Stormwater Greenstreets
Stormwater Greenstreets, like Right-of-way Bioswales (ROWB), are planted areas designed to collect and manage stormwater that runs off the streets and sidewalks. However Stormwater Greenstreets are typically constructed in the roadway as a "bump out", are usually larger than ROW Bioswales, and have varying lengths, widths and soil depths based on the characteristics of the existing roadway.

Substrate
The material on which another material is coated or fabricated; in a natural water system, the bottom sediment material or the rock underlying surface soils.

Thermal Pollution
A reduction in water quality caused by increasing its temperature, often due to disposal of waste heat from industrial or power generation processes. Thermally polluted water can harm the environment because it has less dissolved oxygen holding capacity, and plants and animals can have a hard time adapting to it.

Throughfall
The precipitation that penetrates through the canopy and reaches the soil surface by canopy drip.

Transpiration
A part of the hydrologic cycle in which water vapor passes out of living organisms through a membrane or pores.

Tributary Drainage Area (TDA)
The total impervious surfaces that drain downhill and transport stormwater towards a specific point or feature.

USDOE
United States Department of Energy

Urban Heat Island Effect
The measurable increase in ambient urban air temperatures resulting primarily from the replacement of vegetation with buildings, roads, and other heat-absorbing infrastructure. The heat island effect can result in significant temperature differences between rural and urban areas.

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