In November 2011, the U.S. Department of Housing and Urban Development (HUD) awarded TOGETHER NORTH JERSEY (aka, North Jersey Sustainable Communities Consortium) a $5 million Sustainable Communities Regional Planning Grant. The grant is matched with an additional $5 million in leveraged funds from project partners. Grant funds have been used to implement the Local Demonstration Project (LDP) Program, develop a Regional Plan for Sustainable Development (RPSD) for the 13-county planning region (pictured to the right), and provide technical assistance and offer education opportunities that build the capacity of jurisdictions, organizations and the public to advance sustainability projects and initiatives.

The RPSD plan is both “place-based” and “issue-based” and uses sustainability, transit system connectivity and Transit-Oriented Development (TOD) as the central framework for integrating plans, regulations, investments, and incentive programs at all levels of government to improve economic and environmental conditions, while promoting regional equity and resource efficiency. For more information, please visit togethernorthjersey.com

ACKNOWLEDGEMENTS

- 13 County Governments in the NJTPA Region
- Edward J. Bloustein School for Planning and Public Policy at Rutgers University
- North Jersey Transportation Planning Authority (NJTPA)
- NJ TRANSIT
- NJ Office of Planning Advocacy (NJOPA)
- Housing and Community Development Network of New Jersey (HCDN-NJ)
- Sustainability Institute/Sustainable Jersey at The College of New Jersey
- NJ Future
- Building One New Jersey
- PlanSmart NJ
- Regional Plan Association (RPA)

DISCLAIMER

The work that provided the basis for this report was supported by funding under an award from the U.S. Department of Housing and Urban Development. The substance and findings of the work are dedicated to the public. The authors of the report are solely responsible for the accuracy of the data, statements and interpretations contained in this document. Such statements and interpretations do not necessarily reflect the views the Together North Jersey Steering Committee or its individual members or any other agency or instrumentality of Government.
ABOUT THE LOCAL DEMONSTRATION PROJECT PROGRAM

The Local Demonstration Project (LDP) Program seeks to advance specific projects, initiatives, and other investments for local communities to achieve short-term, implementable projects which are consistent with the RPSD goals and program outcomes.

The LDP Program provides technical assistance for strategic planning studies focused on designated areas or corridors associated with established or anticipated transit services and/or facilities. Eligible LDP projects will be sponsored by municipalities, counties, non-governmental organizations, community development corporations, and other interested organizations.

These demonstration projects help to identify partnering opportunities, milestones, and potential funding sources and serve as a model for future initiatives.

Please visit togethernorthjersey.com to learn more.

12 KEY ISSUES

The range of issues faced by the communities within the Region in positioning themselves for a more sustainable future is broad. The Local Demonstration Project program as a whole will attempt to engage all of the major policy issues that have been identified in recent years, as seen in the adjacent diagram. Each project of the LDP program will address Land Use and Transportation at its core and will identify several primary issues as the project’s focus.
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The increasing intensity and frequency of severe weather and flooding occurrences has created significant challenges to Hoboken’s antiquated stormwater management infrastructure. Between July 2002 and July 2012 the City recorded 26 dates with greater than 2 inches of precipitation and tides of 4 feet or higher. During storm events, Hoboken’s sewer infrastructure is overtaxed resulting in system backups that produce flooding in the lowest-lying areas. Stormwater that flows into the combined sewer system in Hoboken is exacerbated by the high percentage of impervious coverage in the City. Currently, the Hoboken waste water treatment plant is overtaxed by storm flows, on average, five times per month leading to combined sewer overflows. Future federal regulations may require the North Hudson Sewerage Authority to reduce this number to four per year.

The impacts associated with this situation were most dramatically seen in the aftermath of Hurricane Irene and Superstorm Sandy when unprecedented flood levels crippled Hoboken’s heavily-trafficked transportation infrastructure, stranded residents in their homes for extended periods of time, destroyed personal and public property and intensified public health hazards. The storms also brought commercial activity to an abrupt halt, collectively costing business owners millions of dollars in revenue.
In Spring 2013, NJ TRANSIT, as part of Together North Jersey (TNJ), the USHUD funded regional planning effort for the 13-county northern NJ region, began the Hoboken Green Infrastructure Strategic Plan as part of the Regional Plan for Sustainable Development. This project, one of 18 competitively-selected Local Demonstration Projects sponsored by TNJ, focused on:

- Creating a framework for green infrastructure on both a city-wide and district by district basis;
- Identifying the most cost-effective place-based best management practices (BMP) the City can employ to address stormwater management and the anticipated increase in frequency of flooding events;
- Understanding how these measures can improve the resilience of Hoboken’s transit infrastructure.
- Locating and prioritizing the assets and priorities most in need of protection;
- Developing a set of strategies the City can employ to implement the Plan.

Other parallel efforts include collaboration with Re.InvestInitiative.org, Global Green, and 100 Resilient Cities to develop the necessary tools to make the City resilient to future storm events. The City is also the focus of a potential design opportunity through the Rebuild by Design program for a comprehensive flood defense strategy, which is scheduled to enter the design development phase as of November 2013. Please also note that Appendix H in the back of this document is the RFP for the Post-Sandy Planning & Discovery Plan, which will serve as a legislative follow-up to this plan.
PART 1: CONCEPTUAL FRAMEWORK
The City of Hoboken sought a strategic and place-based approach to green infrastructure, which maximizes the benefit of capital investment for stormwater management. The Plan employed a sewershed level analysis to achieve this objective, as described below.

**METHODOLOGY**

**SEWERSHED LEVEL ANALYSIS**

Based on its analysis of the carrying capacity of the underlying land forms, the Plan proposed a Conceptual Framework that organizes the City into three zones:

- **The Gray Zone**, which contains a shallow depth to bedrock and therefore cannot infiltrate stormwater efficiently, is most appropriate for above-ground BMPs such as rainwater harvesting and green roofs.

- **The Green Zone**, which has a greater depth to bedrock and soils that are capable of accepting and infiltrating stormwater and as such is most appropriate for vegetated BMPs like rain gardens, swales, and stormwater trees.

- **The Blue Zone**, which contains the lowest elevations in the City and therefore may be available for the detention of stormwater.

On the district level, the Plan identified sewersheds H1, H4, H5, and H7 (as identified by the North Hudson Sewerage Authority) as areas where green infrastructure would produce the most cost-effective results. The Team determined the most appropriate BMPs for each sewershed based on an analysis of Hoboken’s existing stormwater management system, land use context for each sewershed, and siting considerations. To help identify which BMPs would have the most cost-effective impact, the Team conducted a literature review (which can be found in the appendix) of green infrastructure measures successfully employed in other cities.
Green Infrastructure has the potential to address many issues. For example, recurring flooding is one of the most significant barriers to accessing the City’s two Hudson Bergen Light Rail stations. Addressing flooding through green infrastructure will be essential in making critical infrastructure assets more resilient and will improve accessibility to transit. Because the City’s most vulnerable populations are concentrated in its most flood prone areas, implementation of green infrastructure in these areas will be an important element in improving the quality of life for those most in need of protection.

The Plan puts forth a bold but pragmatic implementation strategy to implement these recommendations. This strategy is based on:

- Leveraging opportunities for the City to take early and significant action, including the relatively large concentration of land controlled by the public sector. Also, it is largely concentrated within the sewersheds H1, H3, H4, and H7; and designated Redevelopment Areas, which presents opportunities to implement green infrastructure in a more comprehensive manner potentially engaging public private partnerships.

- Innovative regulatory measures such as performance-based zoning and establishment of a Stormwater Trust Fund to allow the City to address the issues.

<table>
<thead>
<tr>
<th>Best Management Practices (BMPs)</th>
</tr>
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</table>

Determined the most beneficial BMPs and ideal distribution

**Siting Considerations**

- Size: Drainage area, Physical Sq. Ft.
- Vertical Constraints: Groundwater Table, Bedrock Depth
- Topography: Slope, Contours
- Soils: Permeability, Infiltration Rate
- Pros / Cons

Identified the ‘gray zone,’ modified distribution based on siting

**Sewershed Characteristics**

- Analysis of Hoboken’s stormwater management system
- Land Use Context
- Constraints
- Opportunities
- Impervious Coverage

Recommended specific BMPs for each sewershed based on siting and sewershed characteristics

**Benefits of Green Infrastructure by Sewershed**

- Impervious Area outside of the ‘gray zone’ (sq. ft.)
- Goal of Impervious Area Captured/Stored by Green Infrastructure (15 %)
- Distribution of Impervious Area per BMP (sq. ft.)
- Calculate Potential Stormwater Captured/Stored by Green Infrastructure (cu. ft.)
The Team’s initial analysis of Hoboken’s sewer system revealed that sewershed interconnections allow stormwater to flow from one sewershed to another. Stormwater captured in one sewershed may be exacerbating flooding in another sewershed. Key interconnections between Hoboken’s sewersheds, particularly between H1 and H3/H4, may cause increased localized flooding in the lowest areas. Therefore, the Plan recommends focused implementation of Green Infrastructure BMPs within sewersheds H1, H3, H4, and H5. In addition, interconnections between sewersheds were recommended as an area for future study.

Subsequent analysis of the subsurface conditions revealed that while sewershed H3 plays a key role in Hoboken’s interconnected sewer system, its subsurface geology and land use context are not conducive to installation of vegetated BMPs (e.g., rain gardens, infiltration planters). Conversely, sewershed H7 has ideal subsurface geology as well as the presence of the North End Rehabilitation Area, presenting the City’s most significant opportunity for targeted green infrastructure installation throughout an entire sewershed. As such, the Plan recommends H1, H4, H5 and H7 for strategic green infrastructure implementation.
DEMOGRAPHICS

PUBLIC HOUSING

Hoboken is home to a disproportionate quantity of subsidized and low-income housing. The city has more than three times the number of HUD-subsidized Housing Units (46 per 1,000 population compared to 13 in the North Jersey NJTPA region), more than five times the number of Public Housing Units (27 compared to 5), and almost three times the number of Multi-Family Housing Units (16 compared to 6) compared to the region.

POVERTY RATES

Hoboken has slightly higher rates of poverty (10.1%) than the North Jersey region (8.6%). This trend extends to families with children, which have higher rates of poverty (6.3%) compared with the region (5%) as a whole.

ACCESS TO TRANSPORTATION

Transit is important to the mobility needs of residents in Hoboken, who have a higher percentage of carless households (15.7%) than Hudson County (13.7%) and the North Jersey region (12.5%).

One of the Plan’s most significant concerns is identifying the people and assets that are most in need of protection. With the presence of Hoboken Housing Authority’s Andrew Jackson Gardens and the Columbian Arms Senior Living Community in sewershed H1 and the Hoboken Housing Authority in sewershed H4, the City’s most vulnerable populations are concentrated in the City’s most flood prone areas. As such, implementation of green infrastructure in these areas has the greatest potential to address the areas frequently impacted by flooding. This will also have the potential to significantly improve the quality of life for Hoboken’s most vulnerable residents.

“HOPES applauds the city’s focus on positively affecting the Blue Zone; the most heavily impacted areas for flooding with most vulnerable populations, as cited in the report and looks forward to the continued growth of the city and its residents.”
OUTREACH

On April 18, 2013 the Team hosted an outreach event in the Hoboken Public Library in order to build awareness about the project and to gain input about local flooding. A community survey was made available on the City of Hoboken website from July 16th to August 5th, 2013. On-the-ground outreach was also conducted on July 24th in conjunction with HOPES and was based in their location at 532 Jackson Street in the Family Resource Center complex of the Hoboken Housing Authority. In addition to the online survey and door-to-door outreach, the survey was also made available in Hoboken public buildings such as the Public Library, Senior Building and City Hall. The City of Hoboken advertised these events via the City website, flyers were posted in public buildings prior to the events, and the events were publicized in the Together North Jersey newsletter, on the website and via social media outlets. Event locations were chosen based on centrality, presence in the community, and location in relation to the areas that flood frequently.

IDENTIFICATION OF ISSUES AND CHALLENGES

The survey had a total of 196 respondents, and confirmed that the worst flooding typically occurs in sewersheds H1, H4 and H5, the southern and western portions of the city. 57% of respondents claimed that flooding has “some” or “strong” impact on their lives. Most residents were in favor of paying for stormwater management with either bonds or local taxes and stormwater fees.

The survey confirmed city-identified problem areas of minor localized flooding, which were considered when recommending locations for siting green infrastructure BMPs.

TRANSPORTATION

FLOODING IMPACT

HOW WILL WE PAY FOR IT?

Survey results showing primary mode of transportation for respondents, flooding impact, and how respondents propose to pay for stormwater management improvements.
SERVICE ORGANIZATIONS

These organizations participated as members of the project’s Steering Committee and were integral to informing the community engagement process.

**HOPES Community Action Partnership Incorporated** is a Hoboken-based organization which is part of a larger, nationwide network of community action agencies dedicated to fighting poverty through encouragement of self-sufficiency. Their mission is to provide community services that respond to the social, educational and training needs of individuals in an effort to overcome barriers and fight the causes of poverty. They operate from five different Hoboken locations, including the Family Resource Center in the Jackson Gardens community of the Hoboken Housing Authority.

**Hoboken Quality of Life Coalition (QLC)** is a community-based organization concerned about the air, earth and water of Hoboken, especially as it relates to issues such as development, open space, parking and flooding in the city. Their continuing efforts revolve around preserving the streetscape and the city’s old and historic buildings.

The survey confirmed that the worst flooding occurs in sewersheds H1, H4, and H5.
FLOODING CONCERNS

PROBLEM LOCATIONS AND IMPACTS

Much of Hoboken’s west side was built on filled wetlands, and a river was located on the City’s western perimeter. The lowest areas of the City are located in the southwest, which is less than three feet above sea level. The high point in the City is located along the eastern cliff face at Castle Point. Surface stormwater flows generally follow the topography, leading to the west and southwest parts of the city with additional flows coming from the higher elevations of the surrounding communities such as Jersey City and Union City in the Palisades.

The City’s flooding problems can be attributed to multiple sources: high tides, low topography, surface runoff, a prevalence of impervious surfaces, antiquated sewer infrastructure, interconnections between sewer sheds, and insufficient pumping capability.

These factors combine to pose the highest flood risk in the southwest portion of the city. Specifically, flooding occurs most often at catch basin flood points and around certain intersections:

1. Paterson Avenue and First Street
2. Jackson Street and Fourth Street
3. Ninth Street between Monroe Street and Madison Street
4. Clinton Street between First and Second Streets
5. Thirteenth Street between Jefferson and Grand Streets.

Surface Stormwater Flows

Stormwater Management Problem Areas
KEY ASSETS TO BE PROTECTED

• Critical facilities are concentrated in H1, H3 and H4
• Transit infrastructure is concentrated at the borders of H1, H2, H4, H5, and H7
There are a wide range of actions that the City can take to reduce stormwater on a lot-by-lot basis through the implementation of best management practices (BMPs). Designs that utilize BMPs help to minimize impervious surfaces, absorb stormwater and mimic the natural water cycle through the processes of infiltration, evaporation and reuse. BMPs can help reduce the overall volume of stormwater generated on-site and recharge groundwater supply. BMPs that were considered for use in the City include:

- Constructed wetlands
- Permeable pavements
- Stormwater street trees
- Vegetated swales
- Rainwater harvest and reuse
- Basins or ponds
- Rain gardens
- Stormwater infiltration planters
- Subsurface storage
- Green roofs
The primary sewersheds where green infrastructure installations would appear to be most beneficial include the H1, H4, H5 and H7. Public sector entities control 29.1 acres in Hoboken, which is largely concentrated within the four key sewersheds (H1, H2, H4 and H5). Designated Redevelopment Areas offer larger-scale opportunities to implement green infrastructure, among which is the BASF site located in the Northwest Redevelopment area.
Part 1: Conceptual Framework

OPPORTUNITIES

Existing open space and recreation areas, as well as schools, roadways and other public property provide significant opportunities for the integration of green infrastructure Best Management Practices (BMPs). Hoboken’s three proposed parks (located within the BASF, Pino, and Block 12 sites, shown in the map on page 18) are also ideal locations for the implementation of BMPs.

New development and redevelopment can incorporate source controls (BMPs that absorb water before it can enter the stormwater system) such as green roofs, infiltration technologies and subsurface detention. The most effective BMPs include constructed wetlands, permeable pavements and stormwater tree pits. When factoring capital cost as well as operation and maintenance, swales and rainwater harvest/reuse tend to be highly effective over their useful lifetime.

Implementation of green infrastructure best management practices can help mitigate the significant costs involved in improving the gray infrastructure system to reduce the frequency of future CSO events.
PART 2: CITY WIDE STRATEGY
THE PLAN

Based on analysis of the carrying capacity of the underlying land forms, and contingent upon watertable data which will have to be part of a follow-up study, the Plan proposed a Conceptual Framework that organizes the City into three zones:

- **The Gray Zone**, which contains a shallow depth to bedrock and therefore cannot infiltrate stormwater efficiently, is most appropriate for above-ground BMPs such as rainwater harvesting and green roofs.

- **The Green Zone**, which has a greater depth to bedrock and soils that are capable of accepting and infiltrating stormwater and as such is most appropriate for vegetated BMPs like rain gardens, swales, and stormwater trees.

- **The Blue Zone**, which contains the lowest elevations in the City and therefore may be available for the detention of stormwater.

This framework provides an overarching conceptual construct that can be used to educate residents, business owners and developers as Hoboken advances its green infrastructure program. It can also be used to help guide strategies for the individual sewersheds and future redevelopment of the areas in the northwestern part of the city.

Almost all of the sewersheds H2, H3 and H6 are on shallow bedrock (“Gray Zone”), preventing stormwater from infiltrating effectively and therefore not ideal for certain infiltrating green infrastructure BMPs. Because of its geological features and potential redevelopment opportunities in the north end of the City, H7 presents the greatest opportunity for targeted green infrastructure installation. However, H1, H4 and H5 are also recommended for strategic Best Management Practice (BMP) implementation.
GRAY ZONE: DETENTION STRATEGIES

Although the Gray Zone limits certain BMPs due to the shallow bedrock, the detention of stormwater through above-ground BMPs (rainwater harvesting and green/blue roofs) and subsurface storage creates a real opportunity to reduce runoff during storm events.
The Green Zone provides the best opportunity to infiltrate stormwater using vegetated BMPs, such as rain gardens, swales, stormwater trees, infiltration planters and permeable pavement. Gradual implementation of these BMPs will provide an incremental, cumulative benefit for stormwater management.

The use of large-scale BMPs for a more immediate impact includes:
- Subsurface Storage under the BASF Site;
- Constructed wetlands or basin, and mass implementation of BMPs through redevelopment in the North End Rehabilitation Area.
Because of Hoboken’s unique topography (i.e. surface stormwater runs toward the west), stormwater retention is focused on the western and northern edge. The use of basins or ponds, constructed wetlands and subsurface storage is recommended in these areas.

This blue corridor could utilize existing public property along the NJ Transit Hudson-Bergen Light Rail and potential redevelopment sites to form a contiguous corridor for stormwater management, without affecting the transit system.
Recurring flooding is one of the most significant barriers to accessing the City’s two Hudson Bergen Light Rail stations. Addressing flooding through green infrastructure has the potential to improve accessibility to transit. In addition, because the HBLR right-of-way runs through sewersheds H1, H2, H4, H5 and H7, along the “blue zone”, it presents a significant opportunity to implement several green infrastructure BMPs.
CONNECTING THE DOTS
Although each zone is identified by its ability to process stormwater, they are all interconnected. This strategic approach allows detention, infiltration and retention to work together, increasing stormwater management benefits by employing specific green infrastructure BMPs in their most suitable locations.

Gray infrastructure improvements should work cooperatively with this green infrastructure strategy. Separate sewer lines could be constructed to convey stormwater from localized flooding problem areas to green infrastructure retention systems in the blue zone. Further analysis of how the sewersheds affect each other should be a priority.
PART 3:
SEWERSHED STRATEGIES
POTENTIAL STORMWATER THAT CAN BE CAPTURED USING GREEN INFRASTRUCTURE

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<th>H3</th>
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<th>H5</th>
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<td>20,029</td>
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<td>10,994</td>
<td>1,011,581</td>
</tr>
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</table>

Estimated Potential Amount of Stormwater (cu. ft.) captured or treated by BMPs by Sewershed during a 1-year storm event

Gray signifies that a BMP is not recommended in a given Sewershed due to siting considerations or sewershed characteristics.

OVERVIEW

Sewersheds H1, H4, H5 and H7 present the biggest potential opportunities to capture the largest quantity of stormwater using green infrastructure BMPs. The chart highlights the BMPs best suited for each sewershed. A blank area in the chart signifies that a BMP is not recommended in a given sewershed.

It is important to note that all recommendations and calculations within this plan are based on a review of the best data available. Proper site evaluation, site-specific investigation and testing will be necessary during engineering design for individual BMPs at selected locations.
H1: SOUTHWEST SEWERSHED

The H1- Southwest Sewershed contains residential neighborhoods, business districts concentrated on Observer Highway and Washington Street, redevelopment areas, park sites and City facilities including City Hall. Because this area is the low point in the City, stormwater concentrates in the H1 sewershed making the southwest section of the city very flood prone.

The total potential amount of stormwater that can be captured using green infrastructure in the H1 sewershed is approximately 2.3 million cu.ft. Basins, infiltration planters and rain gardens have the highest potential to capture the most amount of rainfall.
The City has identified Southwest Park, also known as Block 12, as a future site for a new park in Western Hoboken. With Hoboken’s growing population of young families and senior community, additional park space is viewed as essential to accommodate an increasingly active community. Block 12 Site not only represents a significant open space resource but also provides an excellent opportunity to increase the capture and treatment of rainfall.

Due to shallow slopes, deeper bedrock and high groundwater table, the amount of rainfall retained can be increased by 30% through the use of infiltration planters and rain gardens and reducing impervious coverage to 50% of the lot area.
H4: MIDTOWN SEWERSHED

Residential units are concentrated in the H4-Midtown Sewershed including a Hoboken Housing Authority facility. The 9th Street NJ TRANSIT Hudson Bergen Light Rail Station is also located on the boundary between the H4 and H5 Sewershed. The eastern part of this sewershed contains shallow bedrock and poorly drained soils. However, there still exists a potential to capture stormwater using green infrastructure along the western end of the H4 sewershed.

The total potential amount of stormwater that can be captured using green infrastructure in the H4 sewershed is approximately 440,000 cu.ft. with rain gardens, infiltration planters and subsurface infiltration or storage devices having the highest potential for stormwater capture.
The City is interested in acquiring this one acre property (known as Pino Site) for a park in Western Hoboken as part of an agreement to continue the redevelopment of the Monroe Center site. This potential park site near the Jubilee Center, Monroe Center for the Arts, and a growing residential neighborhood would bring much needed open space and transform unused land into a community gathering focal point.

Pino Site provides a great opportunity to increase the capture and treatment of rainfall. Due to shallow slopes, the amount of rainfall retained can be increased by 46% through the use of BMP’s such as subsurface storage and tree planters and reducing impervious coverage to 50% of the lot area.
H5: NORTHWEST SEWERSHED

Residential neighborhoods, business districts and the Western Edge and Northwest Redevelopment Area make up the H5-Northwest sewershed. Although there is little publicly owned land in this sewershed, there is an extensive amount of land area within the identified redevelopment areas that provide ripe opportunities to retain vast amounts of stormwater. Rain gardens and stormwater basins/ponds have the potential to capture the most amount of rainfall.

The total potential amount of stormwater that can be captured using green infrastructure in the H5 sewershed is approximately 350,000 cu.ft. with basins or ponds, rain gardens, stormwater infiltration planters and subsurface infiltration or storage devices potentially capturing the highest volumes of stormwater.

Opportunities:
1. BASF / Cogins Site
2. Northwest Redevelopment Area
3. Western Edge Redevelopment Area
4. Hoboken Housing Authority
5. HBLR
The City is focused on acquiring land to provide large active space for residents at a fair market price. The BASF Site, a six acre site in Western Hoboken, is a unique opportunity to provide much needed large open space swaths for active recreation while also addressing the need to manage stormwater efficiently.

BASF Site provides a great opportunity to increase the capture and treatment of rainfall. Due to well drained soils and deeper bedrock, the amount of rainfall retained can be increased by 31% (after capping the contaminated site) or 47% (after remediating the contaminated site) through the use of BMP’s such as wet ponds, rainwater harvesting and reuse, green roofs and subsurface storage and reducing impervious coverage to 30-50% of the lot area.
**H7: NORTHWEST SEwershed**

Industrial uses, surface parking lots and the North End Rehabilitation Area make up the H7-Northwest sewershed. Although there are marginal well-drained soils in this sewershed, there is an extensive amount of impervious area within the identified redevelopment areas, which should be reduced, that provide opportunities to implement large scale BMP’s. Rain gardens and stormwater basins/ponds have the potential to capture the most amount of rainfall.

The total potential amount of stormwater that can be captured using green infrastructure in the H7 sewershed is approximately 1 million cu.ft. with basins or ponds, rain gardens, constructed wetlands, infiltration planters and subsurface infiltration or storage contributing highest to stormwater capture.

*View of 14th Street which is appropriate for large scale best management practices.*
PART 4: RECOMMENDATIONS BY BMP
CONSTRUCTED WETLANDS

Constructed wetlands are recommended in the H1, H5 and H7 Sewersheds. Although these BMPs require a large amount of surface area, they also provide opportunities for passive recreation and wildlife habitat. Constructed wetlands require minimally upstream slopes from which to direct stormwater, making H1 and H7 ideal candidates due to their lower elevation.

Constructed wetlands are one of the most effective BMPs with a capital cost of 0.45 cents per cubic foot.
Permeable pavements are recommended in the H2, H4, H5 & H7 sewersheds and serve as an alternative to pervious material used for sidewalks, driveways, parking lots and bicycle lanes. Snow removal is generally easier on permeable pavement surfaces due to a faster freeze-thaw cycle. Because the integrity of the permeable pavement structure may be harmed by standing water, it is not suitable for high-volume roadways.

Permeable pavements are one of the more effective BMP’s with a capital cost of $2.62 per cubic foot and a useful life of 20 to 40 years.

**COST EFFECTIVENESS**

<table>
<thead>
<tr>
<th>Feature</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Useful Life</td>
<td>20-40 years</td>
</tr>
<tr>
<td>Capital Cost</td>
<td>$2.62/cu.ft.</td>
</tr>
<tr>
<td>Annual Operations &amp; Maintenance Cost (as percentage of capital cost)</td>
<td>3%</td>
</tr>
</tbody>
</table>

Permeable Asphalt

Permeable Paver Alley, Chicago, Il
STORMWATER STREET TREES

Stormwater Tree Pits are recommended in all the Sewersheds except for the H1 sewershed. Although stormwater tree pits may interfere with utility infrastructure, they can fit nicely into the design fabric of the City sidewalk and bicycle network. Species, site selection and design may increase infiltration by allowing trees to penetrate through impervious zones in soils.

Stormwater tree pits are one of the more effective BMPs with a capital cost of $5.98 per cubic foot and a useful life of 13 to 37 years.

COST EFFECTIVENESS

<table>
<thead>
<tr>
<th>Useful Life</th>
<th>13-37 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital Cost</td>
<td>$5.98/cu.ft.</td>
</tr>
<tr>
<td>Annual Operations &amp; Maintenance Cost (as percentage of capital cost)</td>
<td>8%</td>
</tr>
</tbody>
</table>
Vegetated Swales are recommended in the H1, H2, H4, H5 and H7 Sewersheds. Although these BMPs do not treat large drainage areas due to the small surface area they cover, they are well suited for treating road runoff because of their linear design.

Swales and rain gardens can also serve as facilities for snow storage and treatment. Swales are one of the more cost-effective BMPs with a capital cost of $9.72 per cubic foot.

**VEGETATED SWALES**

Right-of-Way Swale

Parking Lot Swale

**COST EFFECTIVENESS**

<table>
<thead>
<tr>
<th>Useful Life</th>
<th>20-50 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital Cost</td>
<td>$9.72/cu.ft.</td>
</tr>
<tr>
<td>Annual Operations &amp; Maintenance Cost (as percentage of capital cost)</td>
<td>6%</td>
</tr>
</tbody>
</table>
Rainwater harvest and reuse is recommended in all swersheds. Rainwater harvest works well on sites that have limited space, that are entirely impervious or were brownfields (contaminated). Green roofs have the ability to provide additional insulation and wildlife habitat. Rainwater harvesting can serve as an irrigation source and subsurface storage areas can be installed below many flat surfaces such as parking lots, parks and sidewalks.

Rainwater harvesting is one of the more cost effective BMPs due to its low maintenance cost, and is very accessible to the public at large.

**COST EFFECTIVENESS**

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>Useful Life</td>
<td>20-50 years</td>
</tr>
<tr>
<td>Capital Cost</td>
<td>$11.03/cu.ft.</td>
</tr>
<tr>
<td>Annual Operations &amp; Maintenance Cost (as percentage of capital cost)</td>
<td>5%</td>
</tr>
</tbody>
</table>
Basins or ponds are recommended in the H1, H5 and H7 Sewersheds. They require a large surface area, as well as shallow slopes upstream to provide for stormwater flows into the basins or ponds. Basins can also serve as facilities for snow storage and treatment.

Basins have the capacity to treat a large drainage area, up to 25 acres. However, given their construction and maintenance costs, basins are not very cost-effective.

**Basins or Ponds**

<table>
<thead>
<tr>
<th>Cost Effectiveness</th>
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</thead>
<tbody>
<tr>
<td>Useful Life</td>
<td>&gt;20 years</td>
</tr>
<tr>
<td>Capital Cost</td>
<td>$15.00/cu.ft.</td>
</tr>
<tr>
<td>Annual Operations &amp; Maintenance Cost</td>
<td>12%</td>
</tr>
<tr>
<td>(as percentage of capital cost)</td>
<td></td>
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</tbody>
</table>
Swales, rain gardens and stormwater planters are recommended in the H1, H2, H4, H5 and H7 Sewersheds. Although these BMPs do not treat large drainage areas due to the small surface area they cover, they are well suited to treat runoff from sidewalks and the public right-of-way as curb bump-outs, and fit well within an urban context.

Rain gardens can also serve as facilities for snow storage and treatment. However, they are on the higher end of capital costs among other BMPs because of potential excavation costs.

**COST EFFECTIVENESS**

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>Useful Life</td>
<td>20-50 years</td>
</tr>
<tr>
<td>Capital Cost</td>
<td>$28.05/cu.ft.</td>
</tr>
<tr>
<td>Annual Operations &amp; Maintenance</td>
<td>8%</td>
</tr>
</tbody>
</table>

**Examples of Rain Gardens**

**HUDSON RIVER**

**1440**

**H3**

**H5**

**H7**

**H6**
Stormwater infiltration planters are recommended in the H1, H2, H4, H5 and H7 Sewersheds. Like rain gardens, they do not treat large drainage areas because of their small surface area, however they are uniquely suited for Hoboken’s urban fabric, and can easily be connected to downspouts alongside apartment buildings or commercial businesses.

Stormwater planters have a lower maintenance cost than rain gardens, given their size, with average maintenance costs of only 5 percent.

**COST EFFECTIVENESS**

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Useful Life</td>
<td>20-50 years</td>
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<tr>
<td>Capital Cost</td>
<td>$29.92/cu.ft.</td>
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<tr>
<td>Annual Operations &amp; Maintenance Cost</td>
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</tbody>
</table>

**STORMWATER INFILTRATION PLANTERS**
Subsurface storage or detention is recommended in all the City Sewersheds. These BMPs work well on sites that have limited space, that are entirely impervious or were brownfields (contaminated). Subsurface storage is ideal for flat surfaces, such as parking lots, parks and sidewalks, especially in the case of redevelopment areas.

Capital costs are relatively high for subsurface storage, at $34.52 per cubic foot, and can grow exponentially depending on bedrock excavation or utility relocation.

**COST EFFECTIVENESS**

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</thead>
<tbody>
<tr>
<td><strong>Useful Life</strong></td>
<td>20-50 years</td>
</tr>
<tr>
<td><strong>Capital Cost</strong></td>
<td>$34.52/cu.ft.</td>
</tr>
<tr>
<td><strong>Annual Operations &amp; Maintenance Cost</strong></td>
<td>12%</td>
</tr>
</tbody>
</table>

(use as percentage of capital cost)
Green roofs are recommended in all the City Sewersheds, but are especially recommended for the “gray zone” where other BMPs are limited. Like subsurface storage and rainwater harvest or reuse, green roofs work well on sites that have limited space, that are entirely impervious or were brownfields (contaminated). Green roofs also have the ability to provide additional insulation and wildlife habitat. Green roofs vary in design, with modular construction suitable for a wide variety of roof conditions. However, their implementation is limited by the strength of the building, size and slope of the roof.

While green roofs have the most expensive capital of the BMPs evaluated, they also have one of the lowest maintenance costs, at only two percent.

**COST EFFECTIVENESS**

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Useful Life</td>
<td>20-50 years</td>
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<tr>
<td>Capital Cost</td>
<td>$41.14/cu.ft.</td>
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<tr>
<td>Annual Operations &amp; Maintenance Cost</td>
<td>2%</td>
</tr>
<tr>
<td>(as percentage of capital cost)</td>
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</table>
PART 5: POLICY RECOMMENDATIONS
Performance-based standards require a site to function in a particular way, regardless of the design. Performance-based standards allow for greater function at lower costs than prescriptive standards because they accommodate more creative and integrated designs. For stormwater management, one example of a successful strategy is the adoption of a performance goal related to the amount of rainfall retained on site, which allows the developer to implement whichever BMP or BMPs are best suited to the site. Whereas incentive zoning provides bonuses in terms of increased density, floor area ratio and/or height based on the amount of rainfall retained on site, the performance based zoning can be a flexible, site specific regulating tool. The City of Philadelphia has developed a new ordinance that is a performance-based approach to manage the quantity of stormwater entering the combined sewer system which is a good model to study for future policy regulations.

**PERFORMANCE/INCENTIVE ZONING**

<table>
<thead>
<tr>
<th>Regulation</th>
<th>Rainfall Retained</th>
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<tbody>
<tr>
<td></td>
<td>1-25%</td>
</tr>
<tr>
<td>FAR</td>
<td>1.0</td>
</tr>
<tr>
<td>Height</td>
<td>2 story</td>
</tr>
<tr>
<td>Density</td>
<td>28 DU/ Acre</td>
</tr>
</tbody>
</table>

Philadelphia has adopted an ordinance that rewards developers with height and density bonuses for greater rainfall retention.
A Stormwater Trust Fund may be a valuable tool for sites where BMPs cannot be implemented based on specific site conditions or excessive costs. A trust fund is a mechanism that allows a developer to provide a contribution in lieu of meeting a required standard. Municipalities have implemented parking and street tree trust funds for situations in which developers may not be able to meet the requirement because of site specific constraints. Instead, they provide funds equal to a pre-determined amount per parking space or tree.

A Stormwater Trust Fund would employ a similar approach. Developers would be required to retain a certain amount of rainfall on site. If, for specific site constraints (carrying capacity of the land), the Developer cannot meet the requirement, they would have the option to provide an in-lieu contribution equal to a pre-determined amount based upon the cost of an adequate BMP mechanism. The municipality can utilize the funds to implement BMP’s in strategic locations that benefit an entire sewershed and/or City at large. In the case of sewershed H5, these funds may be used to develop a new park with parking and stormwater storage capacity.
The Plan identified the Western Edge Redevelopment Area to test the recommended performance and incentive based zoning. The Western Edge Redevelopment Area contains several conditions that make it particularly effective for this analysis, including the fact that it is:

- located in the H5 sewershed which generates the second highest volume of stormwater;
- identified as highly flood prone;
- located adjacent to the 9th street NJ Transit Station;
- identified as a redevelopment area with a adopted plan;
- able to retain a significant amount of rainfall; and
- located adjacent to the BASF Site.

WESTERN EDGE REDEVELOPMENT AREA
POTENTIAL DEVELOPMENT SCENARIOS

Three different scenarios were analyzed based on the performance goal of increasing the amount of rainfall retained on site compared to the existing condition. Incentive zoning was used to analyze the effect of increased height, residential density and floor area ratio.

While decreasing impervious coverage is important, implementation of specific BMPs is equally important to the overall objective of retaining and treating the most amount of rainfall on site.

- In Scenario A, with no BMPs, FAR of 1.0 and impervious coverage of 80%, there is a 7% increase of rainfall retained compared to the existing condition.
- In Scenario B, with 50% of the impervious area treated with BMPs, FAR of 3.1 and 70% impervious coverage, there is a 33% increase in rainfall retained compared to the existing condition.
- In Scenario C, with 90% of the impervious area treated by BMPs, FAR of 4.0 and 60% impervious coverage, there is a 40% increase in rainfall retained compared to the existing condition.
Philadelphia, PA requires sites to manage the first inch of runoff from all directly connected impervious areas. The requirement must be met by “infiltrating” the water volume unless infiltration is determined to be infeasible (due to contamination, high groundwater table, shallow bed rock, poor infiltration rates, etc) or where it can be demonstrated that infiltration would cause property or environmental damage. The newly adopted performance based ordinance does not dictate how to manage the first inch of stormwater on-site. It does however, provide guidance on a variety of innovative BMPs that can be used to meet the requirement. Approximately 500 developments over the past year have adopted the new performance based requirement. One such effort underway in north Philadelphia is the William Dick Elementary School. Six acres of asphalt will be transformed into an artificial turf field with underground storage for excess rainfall to be absorbed for reuse as irrigation in nearby gardens.

Plans for William Dick schoolyard renovation incorporating subsurface rainwater storage under the turf field

Source: Philadelphia Water Department
PART 6:
NEXT STEPS AND IMPLEMENTATION
The outcome of this project includes the creation of a strategic city-wide framework to reduce flooding through the implementation of best management practices, which will structure future implementation of actions in the public realm, development community and for City residents and business owners. In order to organize future implementation efforts, the Project Team developed an Action Agenda. The issues and challenges raised by the residents of Hoboken during the engagement process were integrated into a set of priorities created by the Project Team and the Steering Committee. They include:

**Develop new regulatory mechanisms.**
By controlling what is allowed to be built and where development can occur, development can improve the city’s stormwater management.

**Implement gray and green infrastructure solutions.** Different levels of flooding and other factors such as topography, soil type and bedrock depth will determine which strategy is most effective at a given location.

**Strengthen communication and local partnerships.** Get the word out to the local community about how to improve the “water footprint” of residents.

### PROJECT OUTCOMES AND NEXT STEPS

<table>
<thead>
<tr>
<th>Priority 1</th>
<th>Develop new regulatory mechanisms</th>
<th>Short Term</th>
<th>Medium Term</th>
<th>Long Term</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Zoning Ordinances - Changes to existing zoning</strong></td>
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<td></td>
<td></td>
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<tr>
<td>• Decrease impervious coverage</td>
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<tr>
<td>• Amount of stormwater captured on-site</td>
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<tr>
<td><strong>Redevelopment Areas</strong></td>
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<td></td>
</tr>
<tr>
<td>• Performance-based ordinances</td>
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<tr>
<td>• Stormwater Infrastructure Trust Fund</td>
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<td><strong>Financial Incentives</strong></td>
<td></td>
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<tr>
<td>• Stormwater Management Tax Credit</td>
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<table>
<thead>
<tr>
<th>Priority 2</th>
<th>Implement gray and green infrastructure solutions</th>
<th>Short Term</th>
<th>Medium Term</th>
<th>Long Term</th>
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</thead>
<tbody>
<tr>
<td><strong>Develop Green Infrastructure plans for major public spaces</strong></td>
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<tr>
<td>• Road Right-of-Ways</td>
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<tr>
<td>• Parks</td>
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<tr>
<td>• Housing Authority property and facilities</td>
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<tr>
<td>• Board of Education property and facilities</td>
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<tr>
<td>• Other City-owned property and facilities</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>• NJTRANSIT owned property and facilities</td>
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<tr>
<td><strong>Gray Infrastructure</strong></td>
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<tr>
<td>• Implement new pumps at strategic locations</td>
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<td></td>
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<tr>
<td>• Replace Combined Sewer Overflow system</td>
<td></td>
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<table>
<thead>
<tr>
<th>Priority 3</th>
<th>Strengthen communication and local partnerships</th>
<th>Short Term</th>
<th>Medium Term</th>
<th>Long Term</th>
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</thead>
<tbody>
<tr>
<td><strong>Partnerships</strong></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>• Establish Partnership between TNJ and Stevens Tech</td>
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<tr>
<td><strong>Public Communication</strong></td>
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<tr>
<td>• Create guidebook for Business Owners and Homeowners</td>
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</table>

**NOTE:** priorities and proposed funding mechanisms can be found in greater detail in Appendix A
STATE AGENCY
ROUNDTABLE DISCUSSION

The Project concluded with a Roundtable Discussion on March 5, 2014. The discussion presented an opportunity for project partners to share key challenges and recommendations with representatives from key state agencies.

Apart from the Project Team and Steering Committee participants, other notable attendees included John Hansbury from NJEIT, Mathew Abraham from NJEDA, Jennifer Cribbs from HUD, and Dan Kennedy and Kate Meade from NJOPA.

Although the Roundtable Discussion marked the conclusion of the Local Demonstration Project, it set the stage for the next stage of the project’s evolution: the creation of regulatory mechanisms that assist in stormwater management and the incorporation of green infrastructure BMPs into redevelopment plans.

The Project Team leads a discussion on the implementation, next steps and priorities on March 5.
CONNECTING PEOPLE, PLACES, AND POTENTIAL.