CHAPTER FIVE

CATEGORY 3, STORMWATER MANAGEMENT THROUGH SOUND LAND USE

INTRODUCTION AND ISSUES IDENTIFICATION

The vision of the *Jamaica Bay Watershed Protection Plan* describes the future watershed as an urban environment that harbors healthy estuarine and land-based habitats in which "*New Yorkers and visitors co-exist with natural areas and clean water*." The attainment of this vision is dependent upon the human uses and management of land within the watershed, which has a direct impact on the water quality of the Bay and the natural resources in and around the Bay. Sound, environmentally-sensitive land use initiatives, ranging from the modification of an individual's landscaping practices to comprehensive planning and management measures, will enable human populations in the Jamaica Bay watershed to live in a more environmentally sustainable manner, and can offset the added stressors of future population growth on the ecological integrity of the Bay.

The transport of pollutants from developed land to water starts with an increase in volume and rate of stormwater runoff from a watershed's impervious areas, which enters the combined sewer system and triggers CSO events when the wastewater treatment plants cannot handle the excess water. Much of the urban landscape is impervious including building rooftops, parking lots, and roads. Instead of infiltrating water to the ground, these hard surfaces direct stormwater into the nearest storm drain or combined sewer system. They are so efficient at moving water that the time for stormwater to arrive at any given point in the watershed is very short, translating into a large volume of runoff occurring in a short amount of time in the combined sewer or storm drain network. CSO events in New York City can occur during rainfall events as small as 0.05 to 0.1 inches per hour.

Stormwater BMPs effectively reduce stormwater runoff volumes entering the storm drain and combined sewer system, thereby reducing the pollutant load and the volume of water that discharges directly to Jamaica Bay through storm sewers, CSOs or the WPCPs during a rainfall event. Stormwater BMPs are designed to improve infiltration, retention, and detention of stormwater runoff. In addition, reducing the amount of impervious surface, increasing interception of rainfall, and promoting the development of pervious media (including landscaped areas) can help to reduce the impact of urban stormwater on water quality in Jamaica Bay. BMPs have the potential to reduce the volume of stormwater runoff that makes its way into the sewer system, thus reducing the quantity of pollutants that occur on the streets or sidewalks to be directed into the tributaries and the Bay. Furthermore, by reducing the volume of stormwater runoff, more sewage in the combined sewer system can be treated in the WPCPs.

In dense urban environments, controlling stormwater at the source before it enters the sewer system is appealing because end of pipe controls can be very expensive and land availability for off-site BMPs can be scarce. Control of stormwater runoff at the parcel level may under certain instances lead to some reduced public costs for larger, more expensive stormwater management facilities. These source controls are gaining wider acceptance and play a role in stormwater management in municipalities around the country including Portland, Chicago, Seattle, Philadelphia, and Washington, DC.

The passage of LL 71 requires the NYCDEP to create a *Jamaica Bay Watershed Protection Plan* to address the long-term ecological sustainability of the Jamaica Bay watershed. With respect to land use practices, the law requires NYCDEP to assess the feasibility of a variety of land use and development practices including, but not limited to, stormwater BMPs, the minimization of impervious surfaces and creation of natural systems to control and minimize stormwater runoff; incentives for environmentally beneficial development, and disincentives, such as stricter development guidelines, for development that may adversely impact Jamaica Bay.

The Mayor issued PLANYC 2030 to meet the challenges faced by the City and its anticipated one million new residents over the next three decades. PLANYC 2030 includes ten goals as drivers in the development of citywide sustainability initiatives; one of these goals is to open 90% of the City's waterbodies for recreation. In order to achieve this goal, the Mayor's Office is specifically considering strategies for implementing a comprehensive stormwater BMP approach using information and strategies generated as part NYCDEP's watershed protection planning process for Jamaica Bay and long-term control planning for CSOs citywide. According to PLANYC 2030:

> "We cannot rely solely on hard and centralized infrastructure upgrades to improve the quality of our waterways. In addition to working to capture more CSOs at the "end of the pipe," after it has already entered our system, we have also begun pursuing a range of proven strategies to keep stormwater from entering our combined system at all."
>
> "…a range of emerging strategies that enhance the ecological environment while naturally cleansing our waterways have begun to be tested and installed across the United States. Cities from Seattle to Chicago have begun integrating these softer solutions on a broad scale into their planning and development, with exceptional results. Within New York City, financial, informational, and institutional barriers have hindered our ability to experiment with these best practices. Our dense environment has also made spaces difficult to identify. But the opportunities are there."

These efforts are discussed below. In addition, the Mayor's Office has created an interagency task force for BMP implementation to bring together all the relevant City agencies to analyze ways to incorporate BMPs into the design and construction of both public and private development projects. NYCDEP has been working with the Mayor's Office to develop BMP strategies and pilot projects specific to New York City's urban environment.

This *Jamaica Bay Watershed Protection Plan* addresses two different types of stormwater BMPs:

- "on-site" source control, at individual development parcels such as a residential lot whereby runoff would be captured, attenuated, and/or infiltrated at the source (see Objective 3A below); and
- "off-site" control, which typically involves capturing runoff from streets and sidewalks. It also includes use of vacant lands or open space to capture stormwater from multiple parcels (usually at a neighborhood or community scale) and store it in a stormwater pond, underground detention tank, or other structure (see Objective 3B below).

The Objectives and Management Strategies discussed in this chapter identify measures and programs that would change the way people develop and use watershed land with the goal of restoring and preserving Jamaica Bay's unique ecological resources. To be successful, these strategies will require widespread participation from watershed residents and businesses. They will require people to change old habits. They will require coordination between multiple New York City regulatory agencies, as well as the engagement of those who directly affect land use and whose actions are inextricable from environmental effects — the citizens who live within the watershed. When the relationships between human actions and ecosystem effects are addressed in a holistic and coordinated way, we will begin to reverse the current trend of environmental degradation.

OBJECTIVE 3A: PROMOTE THE USE OF ON-SITE BEST MANAGEMENT PRACTICES IN NEW AND EXISTING DEVELOPMENT

Current Programs

The current Administrative Code and City practices are directed to controlling the flow of stormwater away from lots and into sewers with the primary purpose of controlling flooding and standing water and protecting against public health concerns associated with these conditions. While they have ancillary benefits for control of CSOs, they do not specifically require or promote the use of stormwater detention or retention BMPs with the goal of minimizing CSOs.

Currently, both NYCDEP and the Mayor's interagency BMP Task Force are evaluating potential strategies for expanding the use of stormwater BMPs to reduce stormwater runoff throughout New York City. PLANYC 2030, using information generated by NYCDEP, recommends a number of different pilot projects and incentive programs to evaluate the uncertainties associated with BMPs and to promote their use including new parking lot design standards and a green roof incentive program (see *Implementation Strategies* below).

Other recent "green initiatives" include passage of Local Law 86 which requires all new public construction to be designed and constructed to comply with green building standards to achieve a Leadership in Energy and Environmental Design (LEED) silver or higher rating and, in many cases, to use energy and water more efficiently than current codes mandate; LEED is a program of the U.S. Green Building Council. Sustainability concepts have been incorporated into the policies and projects of different city agencies through the formation of specific offices such as the Office of Sustainable Design (OSD), a branch of the NYCDDC, which has established green-building principles for New York City. Two documents released by OSD, *High Performance Building Guidelines* (1999) and *High Performance Infrastructure Guidelines* (2005) introduce sustainable design guidance for New York City buildings. HPD and the New York City School Construction Authority (SCA) are also incorporating green design into their design guidelines. For recent projects, HPD has been adding a sustainability requirements checklist. The checklists have 30 prerequisites that are required for new construction projects, dependent on the size of the project, and 11 optional credits. The below list highlights the required and optional credits related to wastewater and stormwater:

- *Required:* Choosing an environmentally aware site plan that maximizes permeable space would offer an indirect benefit; required water conservation.

- *Optional:* On-site stormwater capture, use retained rainwater for irrigation and non-potable uses, increased permeable surfaces and water containment features, install an extensive green roof; additional water conservation.

SCA has created a NYC Green Schools Guide (SCA 2007) that adapts the LEED credit system to New York City Schools per Local Law 86. The list below highlights the required and optional credits related to wastewater and stormwater:

- *Required non-point credit:* Develop an Erosion and Sedimentation Control Plan for all projects that will include earth disturbance activities (*i.e*., excavation, trenching, etc).

- *Required with credit:* Avoid using undeveloped lands within 50 feet of a water body, 100 feet of wetlands and any land that was previously parkland; Promote biodiversity through conserving natural areas and restoring damaged areas; Maintain a high percentage of open space that is vegetated with adapted or native plants; Reduce or eliminate water pollution by reducing impervious cover, increasing on-site infiltration, eliminating contaminants and suspended solids from stormwater runoff.

- *Additional credit option with SCA approval:* Install a vegetated roof on at least 50% of the roof surface; Limit disruption of the site's natural hydrology by reducing impervious cover through either equalizing post-development stormwater volume and discharge rate to pre-development rates or by decreasing runoff volume by 25%.

- *Water Conservation:* three requirements for one credit each to conserve water.

In addition to these guidelines, the adoption of the *New York State Stormwater Management Design Manual* (CWP, 2003) marked a significant step in facilitating the design and implementation of stormwater BMPs.

NYCDEP is embarking on a new water conservation program to achieve a five percent reduction in water demand over a five year period. Such a program has the potential to free up capacity at the wastewater treatment plants to treat additional wet weather flow.

Three management strategies to reduce stormwater discharges and address them at the individual lot level are discussed below:

- Promote low impact development and BMPs for new and existing development (Strategy 3a1).
- Reduce the imperviousness of new and existing development (Strategy 3a2).
- Expand water conservation program to achieve a greater reduction in water use (Strategy 3a3).

Management Strategy 3a1: Promote low impact development and Best Management for new and existing development (residential and non-residential).

STRATEGY DESCRIPTION

On-site stormwater BMPs at the parcel or lot level can provide significant stormwater runoff volume and pollutant load reduction benefits for a wide range of land uses. BMPs control runoff at the source, intercepting, infiltrating, and/or storing runoff before it enters the combined or separate sewer system.

Treating stormwater on-site involves the integration of detention or retention measures onto a discrete parcel (Table 5.1). Typical detention measures include underground detention tanks or rooftop detention to detain certain storm intensities. Retention measures include a wide range of low impact development techniques, many of which infiltrate stormwater into the soils.

TABLE 5.1. Examples of Stormwater BMPs

LOW DENSITY RESIDENTIAL	
Infiltration/Retention	**Detention**
Bioinfiltration Practices (Rain Gardens and Swales)	Rain Barrels/Cisterns
Porous Paving	
Trees	
Driveway Infiltration	
Rain Planters	
Infiltration Basin	
MEDIUM TO HIGH DENSITY RESIDENTIAL/COMMERCIAL/INDUSTRIAL	
Infiltration/Retention	**Detention**
Bioinfiltration Practices (Rain Gardens and Swales)	Rain Barrels/Cisterns
Porous Paving	Green Roofs
Trees	Rooftop Detention
Parking Lot Infiltration Islands	Subsurface Detention
Rain Planters	
Sand/Peat Filter	

Source: Milwaukee Metropolitan Sewer District

Low density residential developments, especially those that include some vegetation, can incorporate a wide range of BMPs including downspout disconnection, rain barrels, rain gardens, rain planters, bioinfiltration practices, and cisterns.

Stormwater BMPs can also be sited on high density residential, commercial, manufacturing, and industrial developments. These uses generally have little vegetation and often contain large rooftops. Under the existing Sewer Code, these developments are typically required to provide subsurface detention or rooftop detention when there is not adequate capacity in the sewer system.

Green roofs are another option for these high density urban land uses. A green roof can either be a tended roof garden that adds open space or a more low-maintenance rooftop feature. In addition to providing stormwater management benefits, a green roof reduces the urban heat island effect caused by a concentration of dark impervious rooftops and other hard surfaces and can provide carbon sequestration to mitigate greenhouse gases.

Rooftop Detention

Rooftop detention, also known as *Blue Roofs*, is a promising BMP for a densely developed urban landscape filled with flat roofs. By using already available rooftop area, smaller storms that cause CSOs can be detained at the source and more slowly released to the sewer system reducing peak surges, thus allowing more of the flows to be directed to the WPCP for treatment. Collars – as shown in the picture to the lower left – capture the smaller storms by detaining flow of about 1.5 inches. Rooftop detention, an acceptable option for controlling flows under the Sewer Code (the other being subsurface detention), is used on a number of developments in New York City, particularly where land is scarce. Subsurface detention cannot be designed to accommodate the smaller storms addressed by rooftop detention.

Not only is rooftop detention less expensive than subsurface detention, but it also is much less expensive, and likely just as effective in reducing CSOs, as green roofs. They also have fewer load bearing issues than green roofs. While effective at reducing CSOs, they have limited applicability in areas that discharge to storm sewers. They may also be somewhat useful in reducing localized flooding.

Despite its significantly lower costs, rooftop detention is only being implemented on a small number of developments. One reason is that developers may not be aware that it is an option until later in the process when their designs, including subsurface detention, are well underway. Another reason is that there are concerns that rooftop detention will result in leaks. However, rooftop detention has been successfully used in New York City and is expected to be used more frequently, especially in high density areas where use of subsurface detention is limited due to lack of available land. If designed properly, rooftop detention can be very reliable.

To make a real impact on CSOs, measures to incorporate into existing development should be investigated. Existing development would need to be evaluated to determine the structural integrity of buildings and may require some structural support and resurfacing to prevent leakage. Roofs are built to support snow pack, and therefore load bearing may not be a significant issue. NYCDEP will work to develop opportunities to promote the use of rooftop detention more widely as discussed below.

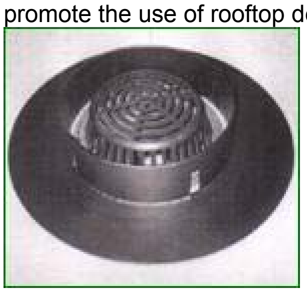

FIGURE 5.1 Rooftop Detection Collar; Source: Milwaukee Sewer District

In addition to the building footprint, parking lots found on many of these high density land uses are also a major source of stormwater runoff due to their large impervious areas. NYCDEP worked with New York City Department of City Planning (NYCDCP) to incorporate BMPs into proposed new parking lot design standards in the Zoning Resolution for commercial and community facility developments. The new standards would not only address aesthetic issues of vast expanses of pavement, but also increase permeability to mitigate stormwater runoff and increase tree canopy to reduce the heat island effect. The standards include adding street trees and perimeter and interior landscaping combined with BMPs that would provide infiltration to the soils.

EVALUATION OF MANAGEMENT STRATEGY

Environmental

Approach

Analyses were performed to estimate the stormwater runoff and CSO reductions associated with various stormwater BMPs applied to residential, commercial and manufacturing development. Six land use prototypes were identified to develop potential BMP conceptual site plans for what might be achievable on individual parcels:

- low density residential,
- medium density residential/commercial,
- high density residential/commercial,
- big box commercial and industrial (small)
- big box commercial and industrial (large)
- schools and other institutional uses

Attractive examples of residential BMPs including a rain garden on left and porous paver blocks on right. Source: Amy S. Greene Environmental Consultants

Land use prototypes were based on NYCDCP's Zoning Handbook, including specific zoning regulations (*e.g.*, lot area, floor area ratio (FAR), open space ratio, etc.) for the prevalent zoning district represented by each prototype.

For each prototype, BMP applications were developed to address existing development and new development. For existing development, "low capture," "medium capture," and "high capture" measures were developed, while for new development, "medium capture," and "high capture" measures were developed. Note that for new development, green roofs appear in both medium and high capture scenarios. The high capture scenario represents a more intensive green roof design for several of the prototypes.

FIGURE 5.2. High Capture for Existing Development: Single Family Residential Prototype w/Tree & Bioinfiltration, 120 sf. Source: Biohabitats, Inc.

The BMP applications provide a range of stormwater benefits as shown for each prototype on Table 5.2. As reflected in the capture rates, it is expected that it would be easier to install BMPs on new development and more difficult to retrofit existing development.

TABLE 5.2. Stormwater Capture Benefits By Land Use Prototype

	Existing Development			New Development	
	Low Capture	**Medium Capture**	**High Capture**	**Medium Capture**	**High Capture**
LOW DENSITY RESIDENTIAL					
3,500 Square feet					
Zoning: R1					
	Rain barrels (4-55 gal), downspout disconnection	Porous paving (300 sf)	NA	NA	Infiltration basin (1140 gal) + porous paving (750 sf)
Example BMPs	Rain planter (60 sf)	Infiltration basin (450 gal)	NA	NA	Cistern (448 gal) + infiltration basin (510 gal) + porous pavement (750sf)
BMP Capture Volume (gal)	224	449	NA	NA	2304
Average rainfall event 0.4 inches	30%	60%	NA	NA	100%
90%ile rainfall 1.2 inches	10%	20%	NA	NA	100%
100%ile rainfall 2.5 inches	5%	10%	NA	NA	50%
MEDIUM DENSITY RESIDENTIAL/COMMERCIAL					
2,178 Square feet					
Zoning: R5, 6, 7, c1, 2, 4, 6					
	Rain barrels (4-55 gal), downspout disconnection	Plumbing retrofit, rain barrels (6-55 gal) or equiv cistern	Green roof (3 in. soil, 2178 sf)	Green roof (3 in. soil, 2178 sf)	Green roof (3 in. soil, 2178 sf)
Example BMPs	Rain planter (45 sf)	Infiltration basin (340 gal)	Rooftop Detention	Rooftop Detention	
BMP Capture Volume (gal)	170	340	1698	1698	1698
Average rainfall event 0.4 inches	31%	63%	100%	100%	100%
90%ile rainfall 1.2 inches	10%	21%	100%	100%	100%
100%ile rainfall 2.5 inches	5%	10%	50%	50%	50%
HIGH DENSITY RESIDENTIAL/COMMERCIAL					
17,000 Square feet					
Zoning: R8, 9, 10, C1, 2, 4, 5, 6					
	NA*	NA	Green Roof (3"' soil, 17000 sf)	Green Roof (3" soil, 17000 sf)	Green Roof (3"' soil, 17000 sf)
Example BMPs	NA	NA	Rooftop Detention	Rooftop Detention	
BMP Capture Volume (gal)	NA	NA	13246	13246	13246
Average rainfall event 0.4 inches	NA	NA	100%	100%	100%
90%ile rainfall 1.2 inches	NA	NA	100%	100%	100%
100%ile rainfall 2.5 inches	NA	NA	50%	50%	50%

TABLE 5.2. Stormwater Capture Benefits By Land Use Prototype					
	Existing Development			New Development	
	Low Capture	Medium Capture	High Capture	Medium Capture	High Capture
INDUSTRIAL AND BIG BOX COMMERCIAL (SMALL)					
0.5 Acres					
Zoning: M1					
Example BMPs*	Bioinfiltration/trees (390 sf) Porous paving (1150 sf)	Bioinfiltration/trees (780 sf) Porous paving (2300 sf)	Green roof (3" soil, 12795 sf) Rooftop Detention	Green roof (3" soil, 12795 sf) Rooftop Detention	Green roof 3" soil, 12,795 sf) + bioinfiltration/trees (1,560 sf)
BMP Capture Volume (gal)	1698	3396	9969	9969	16980
Average rainfall event 0.4 inches	31%	63%	100%	100%	100%
90%ile rainfall 1.2 inches	10%	21%	60%	60%	100%
100%ile rainfall 2.5 inches	5%	10%	29%	29%	50%
INDUSTRIAL AND BIG BOX COMMERCIAL (LARGE)					
1 Acre					
Zoning: M2, 3, C4					
Example BMPs*	Bioinfiltration/trees (780 sf) Porous paving (12300 sf)	Bioinfiltration/trees (1560 sf) Porous paving (4600 sf)	Green roof (3" soil, 18150 sf) Rooftop Detention	Green roof (3" soil, 18150 sf) Rooftop Detention	Green roof 3.1" soil, 18150 sf) +, bioinfiltration/trees (4440 sf)
BMP Capture Volume (gal)	3396	6792	14142	14142	33959
Average rainfall event 0.4 inches	31%	63%	100%	100%	100%
90%ile rainfall 1.2 inches	10%	21%	43%	43%	100%
100%ile rainfall 2.5 inches	5%	10%	21%	21%	50%
PUBLIC FACILITIES, SCHOOLS AND INSTITUTIONAL USES					
1.5 Acres					
Zoning: NA					
Example BMPs*	Bioinfiltration/trees (1170 sf) Porous paving (3400 sf)	Bioinfiltration/trees (2340 sf) Porous paving (6800 sf)	Green roof (3.1" soil, 19900 sf) Rooftop Detention	Green roof (3.1" soil, 19900 sf) Rooftop Detention	Green roof +, bioinfiltration/trees (7906 sf)
BMP Capture Volume (gal)	9500	18999	15505	15505	47498
Average rainfall event 0.4 inches	31%	62%	95%	95%	100%
90%ile rainfall 1.2 inches	10%	21%	32%	32%	100%
100%ile rainfall 2.5 inches	5%	10%	15%	15%	50%

* "NA" = It was assumed that physical space is limited for several of the land use prototypes.

Once it was determined what was achievable on an individual parcel, these benefits were evaluated on a watershed scale. A ten-year snapshot (2000-2010) of BMP implementation was developed to estimate the effects on CSO reductions if development that occurred or will occur during this period had installed BMPs. This ten-year snapshot could be carried into future years to estimate additional benefits with new development over time.

To develop the ten-year snapshot of the watershed, the following assumptions were made:

- Existing development: For the low and medium capture scenarios, it was assumed that 1% per year of existing development would install BMPs for a total of 10% over the ten year period. For the high capture scenario, it was assumed that large rooftops over 5,000 square feet would install BMPs.

- New Development: It was assumed that both new development and major alterations of existing development would install BMPs. All development that occurred in the watershed between 2000 and 2007 and all that is projected to occur through 2010 was estimated using the following sources of information (Figure 5.3):

  - New York City Department of Buildings (NYCDOB): new and major reconstruction permits (2000-2010)
  - NYCDCP: projected redevelopment sites - ten year period
  - Economic Development Corporation: recent and proposed development projects
  - HPD recent and proposed housing projects
  - SCA: recent and proposed school projects.

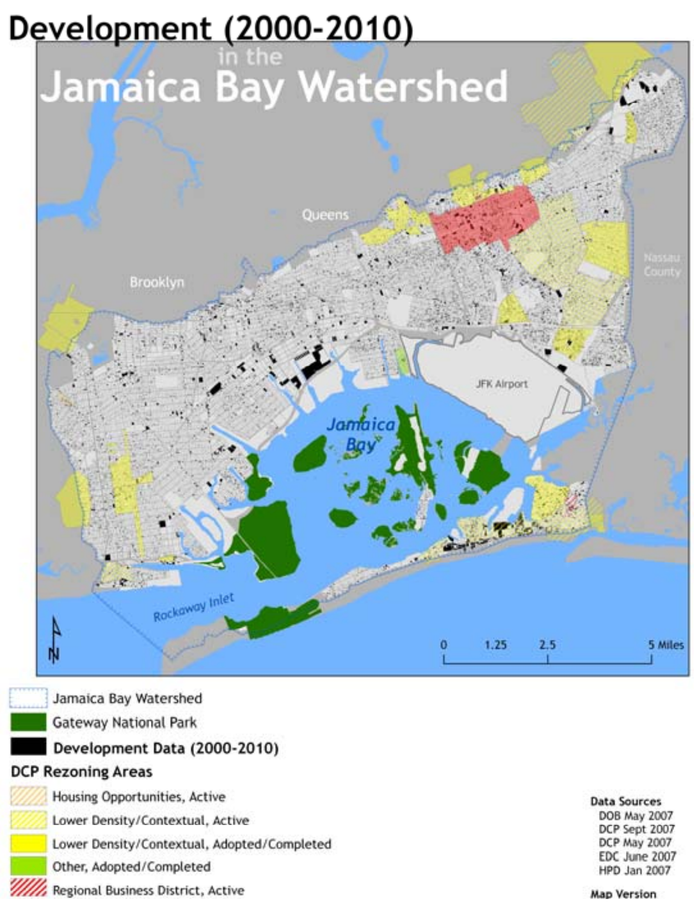

Figure 5.3 Development data used to model BMP penetration in the Jamaica Bay watershed; Source: NYCDEP

The total amount of runoff that could be captured through implementation of these BMPs throughout the watershed was calculated for each of the application scenarios, (existing low, medium, and high capture; and new medium and high capture) and the accumulated annual reduction of discharges to the Bay including CSOs, storm sewer discharges and direct runoff was modeled using the INFOWORKS model for each WPCP drainage area. Precipitation data were used for the year 1988, which represents a typical year.

The results were compared to baseline conditions which included 2020 dry weather flows (*i.e.*, 55 MGD at 26th Ward WPCP, 82 MGD at Jamaica WPCP, 21 MGD at Rockaway WPCP, and 90 MGD at Coney Island WPCP), and specific CSO-related infrastructure projects in progress or recently completed (*i.e.*, Paerdegat Basin storage tank, sewer cleaning within 26th Ward WPCP drainage area, and the Spring Creek AWPCP Upgrade).

As discussed above, for low and medium capture scenarios for existing development, it was assumed that 1% per year of existing development would install BMPs for a total of 10% over the ten year period. For the high capture scenario for existing development, it was assumed that large rooftops over 5,000 square feet would install BMPs including rooftop detention or green roofs. It was determined that within the watershed large roofs (over 5,000 square feet) account for 2.5% of the buildings, but 29% of the roof area, for a total of 109 million square feet of rooftop area. (See also *Existing Development* section under *Technical* below for more information on targeting large rooftops.)

Lastly, a separate analysis was performed to measure the effects of the proposed Zoning Resolution parking lot standards. The parking design regulations are expected to achieve the following benefits for different rainfall events:

- Average from a 2.5 inch rainfall (typically largest event in a year): 47% capture
- Average from a 1.2 inch rainfall (90th percentile event): 76% capture
- Average from a 0.4 inch rainfall (average event): 100% capture.

RESULTS

Results of the modeling for the ten-year period for new and existing development are shown on Table 5.3. The results are summarized to include reductions due to BMPs of untreated discharges to the Bay including CSOs, storm sewer, and direct runoff discharge volumes. The results also include reductions in treated overflows from Paerdegat CSO facility (for Coney Island WPCP drainage area) and Spring Creek AWPCP (for 26th Ward WPCP and Jamaica WPCP drainage areas).

TABLE 5.3. Stormwater Capture Benefits Of On-Site BMPs By Drainage Area						
Condition	**Baseline Conditions**	**Existing Development Low Capture BMPs**	**Existing Development Medium Capture BMPs**	**Existing Development High Capture BMPs (Large Roofs)**	**New Development Medium Capture BMPs**	**New Development High Capture BMPs**
Coney Island WPCP Drainage Area						
Portion of Drainage Area Impacted (%)	N.A.	3.4%	3.4%	5.4%	2.2%	3.8%
Total BMP Storage Volume (MG)	N.A.	2.5	5.1	22.1	9.2	14.9
Total CSO, treated CSO, storm sewer, and Direct (surface) Discharge (MG)	455.5	449.3	441.0	341.5	414.3	409.3
Reduction with BMPs (MG/yr)	0.0	6.2	14.5	114.0	41.2	46.2
Reduction with BMPs (%)		1.4%	3.2%	25.0%	9.0%	10.2%
26th Ward WPCP Drainage Area						
Portion of Drainage Area Impacted (%)	N.A.	5.4%	5.4%	9.3%	6.5%	7.7%
Total BMP Storage Volume (MG)	N.A.	1.4	2.8	19.1	13.5	15.7
Total CSO, treated CSO, storm sewer, and Direct (surface) Discharge (MG)	822.4	798.8	771.3	587.3	652.5	648.9
Reduction with BMPs (MG/yr)	0.0	23.7	51.1	235.1	169.9	173.5
Reduction with BMPs (%)		2.9%	6.2%	28.6%	20.7%	21.1%
Jamaica WPCP Drainage Area						
Portion of Drainage Area Impacted (%)	N.A.	4.1%	4.1%	4.4%	1.8%	5.7%
Total BMP Storage Volume (MG)	N.A.	5.8	11.6	39.2	15.8	46.7
Total CSO, treated CSO, storm sewer, and Direct (surface) Discharge (MG)	11,947.3	11,661.1	11,350.5	11,179.5	11,605.7	10,487.9
Reduction with BMPs (MG/yr)	0.0	286.2	596.8	767.8	341.6	1459.5
Reduction with BMPs (%)		2.4%	5.0%	6.4%	2.9%	12.2%
Rockaway WPCP Drainage Area						
Portion of Drainage Area Impacted (%)	N.A.	5.0%	5.0%	2.6%	4.0%	15.0%
Total BMP Storage Volume (MG)	N.A.	1.4	2.8	4.9	7.6	25.4
Total storm sewer and Direct (surface) Discharge (MG)	2,605.6	2,478.6	2,367.1	2,474.7	2,412.6	1,848.3
Reduction with BMPs (MG/yr)	0.0	127.0	238.5	130.9	193.0	757.3
Reduction with BMPs (%)		4.9%	9.2%	5.0%	7.4%	29.1%
Jamaica Bay Watershed Totals						
Portion of Drainage Area Impacted (%)	N.A.	4.2%	4.2%	5.0%	2.7%	6.5%
Total BMP Storage Volume (MG)	N.A.	11.1	22.3	85.3	46.1	102.7
Total CSO, treated CSO, storm sewer, and Direct (surface) Discharge (MG)	15,479.8	15,040.5	14,590.8	14,253.2	15,085.1	13,075.7
Reduction with BMPs (MG/yr) (of Untreated Discharges)	0.0	439.3	888.9	1,226.6	745.8	2,404.1
Reduction with BMPs (%) (of Untreated Discharges)		2.8%	5.7%	7.9%	4.8%	15.5%

Key findings are:

- Across the watershed, implementation of BMPs on new development would reduce *untreated discharges to the Bay* including CSO, partially treated CSO, storm sewer, and direct runoff volumes by 4.8% (medium capture) to 15.5% (high capture).

- Installing BMPs on 10% of existing development would reduce *untreated discharges to the Bay* including CSO, partially treated CSO, storm sewer, and direct runoff volumes by 2.8% (low capture) to 5.7% (medium capture).

- Installing BMPs on existing large rooftops would reduce *untreated discharges to the Bay* including CSO, partially treated CSO, storm sewer, and direct runoff volumes by 8% (high capture).

- Pollutant load reductions are comparable to volume reductions. For example, a high capture/new development BMP scenario could achieve a 15% reduction in *untreated discharge* volumes and a similar percent reduction in total nitrogen, BOD, fecal coliforms and toxins. A low capture BMP scenario for existing development could achieve a 6% reduction in volume and a similar pollutant load reduction.

The results provided above are presented as reductions with BMPs of *untreated discharges to the Bay.* Stormwater runoff from a site can travel many different pathways to reach a waterbody. And the Jamaica Bay watershed offers more pathways than are typically found in other parts of the City. A large percentage of the runoff in combined sewer areas makes its way directly to the WPCPs (the WPCPs accommodate wet weather flow at a capacity of approximately two times design dry weather flow) or it is sent to the WPCP indirectly – being first detained at the Spring Creek AWPCP wet weather retention facility or, soon to be completed, Paerdegat Basin CSO retention facility and then pumped back to the WPCP when capacity is freed up after the rain event. Some of the stormwater infiltrates into soils to groundwater, which slowly makes its way to the Bay. The remainder of the runoff is discharged to the Bay as CSOs, partially treated CSOs (overflows from Spring Creek and planned Paerdegat Basin CSO facilities), storm sewer discharges, and direct surface runoff, which are cumulatively summarized as *untreated discharges to the Bay*.

As shown in Table 5.4 below, in the Jamaica Bay watershed, the majority of untreated discharges to the Bay, as measured by volume, are storm sewer discharges (62%), as compared to CSOs which make up only 12% of the discharges. This balance is highly influenced by the amount of stormwater introduced into the eastern section of Jamaica Bay in the Jamaica WPCP sewershed. In most other areas of the City, CSOs make up the predominant source of untreated discharges.

TABLE 5.4 Baseline Untreated Discharges To Bay

Discharge	Volume (MG)	Volume (%)
CSO	1841	12%
Partially Treated CSO (overflows from CSO facilities)	514	3%
Storm Sewer	9572	62%
Direct Runoff	3615	23%
Total	15480	100%

So, for example, the 15.5 percent reduction in *untreated discharges to the Bay* with high capture BMPs (see Table 5.4) includes not only reductions in CSO discharges, but large reductions in storm sewer discharges. Watershed-wide, the percent reduction for each type of discharge is based on where the BMPs are located in the watershed (*e.g.* a combined sewered or separately sewered area). If the development where the BMPs are located is primarily in the combined sewer area of the watershed, then much of the reduction will be in CSOs.

However, most of the discharges that will be addressed by BMPs in the Jamaica Bay watershed are likely to be discharged from storm sewers as the storm sewered areas represent a large portion of the drainage area tributary to the Bay. While storm sewer discharges contain significantly lower levels of solids and pathogens than are present in CSOs, they still contain significant pollutant loads from street runoff (oil, grease), lawn areas (pesticides and fertilizers), and numerous other pollutants. For example, stormwater is estimated to contribute about 45 to 50 percent of the total nitrogen discharged to the Bay from wet weather sources while only contributing about 10 percent of the pathogen loads to the Bay. This clearly indicates that the effectiveness of any BMP program will depend on the location within the watershed where the BMPs are applied. Currently, a major focus of NYCDEP's wet weather flow reduction program is focused on CSOs. However, it is expected that storm sewer discharges will be receiving increasing attention as a source of pollution.

It should be noted that not all BMPs are applicable across all systems, thus a menu of options is offered. In a combined sewer area, rooftop detention and other detention BMPs could be very effective in detaining stormwater that would be slowly released and ultimately make its way to a WPCP for treatment. On the other hand, in a separately sewered area, rooftop detention and other detention BMPs would not be effective in reducing stormwater volumes or pollutants. They would merely detain the stormwater for release a few hours later, having no effect on discharges. However, with a large enough penetration rate, they could be effective in reducing some of the effects of flooding. In areas with storm sewers, infiltration BMPs or green roofs would be most effective; however, in many of these areas in the watershed, there are high groundwater tables that would preclude the use of infiltration BMPs.

It is also important to understand that the results presented are reductions with BMPs in *untreated* discharges to the Bay. This does not mean that BMPs reduce discharges to the Bay. All stormwater would ultimately discharge to the Bay, whether it be very slowly via infiltration and groundwater or more rapidly through WPCP discharges, thereby maintaining salinity levels similar to those there now. However, with BMPs, the stormwater is "treated" in some manner prior to discharge to reduce CSO and stormwater pollutants that negatively influence the Bay.

In addition to reducing untreated discharges to the Bay, including CSOs and other discharges, BMPs also provide aesthetic resources, open space, and other environmental benefits. See the *BMP Conclusions* section at the end of this Chapter for a discussion of these benefits.

Technical

There are a number of challenges to ensuring more widespread implementation of BMPs, particularly those that rely on infiltration as compared to detention. BMPs require substantial maintenance to ensure their effectiveness over time. In addition, in areas with high groundwater tables, infiltration practices could lead to more flooding. However, BMPs can provide effective stormwater management over a wide range of rainfall conditions. Specific BMPs such as green roofs and rain barrels also have their own set of technical concerns. Finally, it may be considerably more feasible to implement BMPs for new development than for existing development. These issues are discussed below.

Maintenance
Infiltration BMPs require maintenance to ensure that they function over time. A common problem is that they collect sediments and can clog. For example, dry wells are sometimes used in New York City where access to sewers is inadequate; they are susceptible to clogging, causing street flooding problems. Because infiltration devices would be located on private property, the property owner would be responsible for their ongoing maintenance.

Site Conditions
Stormwater infiltration measures require certain soil types; in general, sandier soils that drain well are preferable to clay soils. However, infiltration BMPs can be engineered with porous materials to allow for increased drainage.

In addition, depth to groundwater is an important factor to consider. In areas such as Southeast Queens with high groundwater tables, installation of infiltration BMPs are not recommended because they could exacerbate flooding problems.

Infiltration issues can also be addressed through installing overflow devices that would direct excess stormwater to the sewers. Site conditions that may best lend themselves to BMP implementation include:

a. The soil texture is primarily sand, loamy sand, sandy loam, loam, or silt loam and, therefore, in a class with an infiltration rate that will permit adequate percolation of collected water through the soil.

b. There is adequate depth to provide a vertical depth of five feet, minimum, between the infiltration bed and bedrock.

c. There is adequate depth to provide a vertical depth of five feet, minimum, between the infiltration bed and the seasonal high water table.

d. The site topography is mildly sloped (between 5-8 percent), appropriate to the proposed infiltration system and would not cause flooding to occur (NYCDEP, 2004).

Permeable gravel parking strip in residential neighborhood of the Jamaica Bay Watershed; Source: Biohabitats

e. The location of foundations, utilities, wells, subways, and similar features is appropriate to the proposed infiltration system and would not cause flooding to occur.

Climate Conditions

Climate conditions, particularly in areas that commonly experience intense rainfalls during short periods of time, cold temperatures, deep frost lines, short growing seasons, or significant snowfalls may impact the performance of BMPs, which should be selected or designed accordingly (CWP, 1997). Most BMPs rely on pipes for controlled releases of water or for overflows; in order to prevent pipes from freezing, pipes should be located at a depth of three feet or more below the surface where the ground is less likely to freeze. BMP inlets and outlets closer to the surface may freeze and result in flooding. Detention ponds and constructed wetlands could also freeze over creating increased impervious surface and reduced storage volumes. Detention facilities with shorter detention times are less likely to be problematic. Infiltration BMPs would become ineffective if the soil were to freeze and prevent stormwater runoff from percolating into the ground which would, in turn, increase the runoff rate. Despite this limitation, infiltration BMPs such as swales and filter strips can be used to store packed or melted snow for infiltration upon the warming of the ground cover and surface soils. BMPs can be effective throughout the year in climate conditions such as in New York City, if designed properly.

Specific BMPs

Green roofs have been extensively studied and are being installed at sites in New York City and other major metropolitan areas. While green roofs provide a number of stormwater and heat island effect benefits especially in urban environments, their application may be limited for existing developments. The saturated soils that make up green roofs are heavy and require rooftops with adequate internal structural support. Existing rooftops would need to be evaluated to determine if they can accommodate the load. New lighter-weight substrate materials are being produced that may make it easier to install green roofs on a wider range of existing rooftops. However, even with lighter weight substrates the weight of the saturated substrate needs to be balanced against the structural support system. Rooftop detention, while not having as significant load bearing issues as green roofs, would also require evaluations of a roof's structural integrity and upgrades with leakproof membranes.

Rain barrels are a far simpler and cheaper alternative. However, they depend on active attention by the homeowner. They require disconnecting the rain barrel from the roof leader in the fall/winter and reinstalling it in the spring/summer. Rain barrels also require the homeowner to empty them between rainfall events using the contents for watering gardens, lawns and houseplants. In New York City, the rain barrels need to be fitted with an overflow device that connects them to the sewer when the capacity of the rain barrel is reached. In addition, they are only appropriate for low density settings that contain vegetation requiring watering. Even for these applications, numerous rain barrels would be required and they would need to be emptied between rain events to achieve a substantial percentage of stormwater capture.

Rain barrels and downspout disconnection;
Source: Biohabitats

Existing Development

Incorporating BMPs on a built lot can mean expensive alterations. It may mean removing paved areas and replacing them with infiltration measures. Or installing additional plumbing, drainage controls, or waterproofing on an already built structure. To encourage the use of BMPs on existing lots, financial incentives will likely be needed. It may also be feasible to target existing developments that are undergoing substantial renovations (see *Implementation Strategies* below).

One way to achieve cost-effective implementation for existing development can be to target large roofs. This is an approach suggested in a USEPA-funded study; by targeting large roofs, a significant percentage of the total building footprint can be addressed with a smaller number of buildings involved (Casey Trees and LimnoTech, 2007). A similar assessment was undertaken for the Jamaica Bay watershed to determine the number of buildings with a rooftop area over 5,000 square feet. The assessment found that:

- 2.5% of the buildings in Jamaica Bay watershed have rooftops over 5,000 square feet. These buildings make up approximately 29% of the rooftop area in the watershed.

Therefore, targeting this smaller number of buildings, 7,116 of 285,937 in the Jamaica Bay watershed, for rooftop detention or green roofs could be beneficial (see *Implementation Strategies*" below).

Cost

Average construction costs for each of the low, medium and high capture prototypes are shown in Table 5.5. Operation and maintenance costs are under development.

As can be seen from the table, rooftop detention is shown as a no-cost alternative for new development. This is because under the Administrative Code, in areas such as the watershed where there is inadequate capacity of the sewer system, higher density new development is required to provide stormwater detention, either subsurface or rooftop, or sewer reconstruction. Rooftop detention is considerably less expensive than subsurface detention and can detain smaller flows that cause CSOs. Rooftop detention also compares very favorably to green roofs. Green roofs estimated for these prototypes cost approximately \$30/square foot, depending on the depth and type of green roof system, compared to approximately \$5/square foot for rooftop detention. These costs do not include structural upgrades; however, green roofs are more likely to require additional structural support than rooftop detention.

Because BMPs have not been widely used in New York City, these costs are based largely on estimates developed in other areas and adjusted to account for New York City construction costs, and there are uncertainties associated with them. More accurate costs will be developed as part of the proposed pilot projects (see *Implementation Strategies* below), which will also provide information needed to determine which BMPs provide the most cost-effective results under New York City conditions. In addition, BMP costs are expected to drop as they are more widely implemented and economies of scale are realized.

TABLE 5.5. Stormwater BMP Costs By Land Use Prototype					
	Existing Development			**New Development**	
	Low Capture	**Medium Capture**	**High Capture**	**Medium Capture**	**High Capture**
LOW DENSITY RESIDENTIAL 3,500 Square feet					
Zoning: R1					
Example BMPs	Rain barrels (4-55 gal), downspout disconnection	Porous paving (300 sf)	NA	NA	Infiltration basin (1140 gal) + porous paving (750 sf)
	Rain planter (60 sf)	Infiltration basin (450 gal)	NA	NA	Cistern (448 gal) + infiltration basin (510 gal) + porous pavement (750 sf)
BMP Capture Volume (gal)	224	449	NA	NA	2304
Average BMP Scenario Costs	$4,700	$7,250	NA	NA	$27,650
MEDIUM DENSITY RESIDENTIAL/COMMERCIAL 2,178 Square feet					
Zoning: R5, 6, 7, c1, 2, 4, 6					
Example BMPs	Rain barrels (3-55 gal), downspout disconnection	Plumbing retrofit, rain barrels (6-55 gal) or equiv cistern	Green roof (3 in. soil, 2178 sf)	Green roof (3 in. soil, 2178 sf)	Green roof (3 in. soil, 2178 sf)
	Rain planter (45 sf)	Infiltration basin (340 gal)	Rooftop Detention	Rooftop Detention	
BMP Capture Volume (gal)	170	340	1698	1698	1698
Average BMP Scenario Costs	$3,500	$6,350	$ 10,700 (rooftop detention)-$63,050 (green roofs)	$0 (rooftop detention)-$63,050 (green roofs)	$63,050
HIGH DENSITY RESIDENTIAL/COMMERCIAL 17,000 Square feet					
Zoning: R8, 9, 10, C1, 2, 4, 5, 6					
Example BMPs	NA	NA	Green Roof (3'" soil, 17000 sf)	Green Roof (3" soil, 17000 sf)	Green Roof (3 in. soil, 17000 sf)
	NA	NA	Rooftop Detention	Rooftop Detention	
BMP Capture Volume (gal)	NA	NA	13246	13246	13246
Average BMP Scenario Costs	NA	NA	$58,300 (rooftop detention)-$492,000 (green roofs)	$0 (rooftop detention)-$492,000 (green roofs)	$492,000

TABLE 5.5. Stormwater BMP Costs By Land Use Prototype					
	Existing Development			New Development	
INDUSTRIAL AND BIG BOX COMMERCIAL (SMALL) 0.5 Acres					
Zoning: M1					
Example BMPs	Bioinfiltration/trees (390 sf)	Bioinfiltration/trees (780 sf)	Green roof (3" soil, 12795 sf)	Green roof (3" soil, 12795 sf)	
	Porous paving (1150 sf)	Porous paving (2300 sf)	Rooftop Detention	Rooftop Detention	Green roof (3" soil, 12795 sf) +, bioinfiltration/trees (1560 sf)
BMP Capture Volume (gal)	1698	3396	9969	9969	16980
Average BMP Scenario Costs	$22,500	$36,000	$46,100 (rooftop detention)-$370,400 (green roofs)	$0 (rooftop detention)-$370,400 (green roofs)	$453,000
INDUSTRIAL AND BIG BOX COMMERCIAL (LARGE) 1 Acre					
Zoning: M2, 3, C4					
Example BMPs	Bioinfiltration/trees (780 sf)	Bioinfiltration/trees (1,560 sf)	Green roof (3" soil, 18,150 sf)	Green roof (3" soil, 18,150 sf)	
	Porous paving (2,300 sf)	Porous paving (4,600 sf)	Rooftop Detention	Rooftop Detention	Green roof 3" soil, 18150 sf) +, bioinfiltration/trees (4,440 sf)
BMP Capture Volume (gal)	3,396	6,792	14,142	14,142	33,959
Average BMP Scenario Costs	$36,000	$58,000	$61,500 (rooftop detention)-$525,417 (green roofs)	$0 (rooftop detention)-$525,417 (green roofs)	$677,900
PUBLIC FACILITIES, SCHOOLS AND INSTITUTIONAL USES 1.5 Acres					
Zoning: NA					
Example BMPs	Bioinfiltration/trees (1170 sf)	Bioinfiltration/trees (2340 sf)	Green roof (3" soil, 19900 sf)	Green roof (3" soil, 19900 sf)	
	Porous paving (3,400 sf)	Porous paving (6,800 sf)	Rooftop Detention	Rooftop Detention	Green roof (3 in. soil,19,900 sf) +bioinfiltration/trees (7,906 sf)
BMP Capture Volume (gal)	5,086	10,173	15,505	15,505	50,864
Average BMP Scenario Costs	$47,500	$76,500	$66,400 (rooftop detention)-$576,100 (green roofs)	$0 (rooftop detention)-$576,100 (green roofs)	$789,700

Table 5.6 summarizes costs for implementing BMPs across the watershed for each of the scenarios. Costs range from $231 million to $3 billion depending on the scale of implementation. For new development, these costs range from $0 (if rooftop detention is already required) to $2.4 billion.

TABLE 5.6. Watershed Wide Costs For Implementing BMP Scenarios

Existing Development Low Capture BMPs	Existing Development Medium Capture BMPs	Existing Development High Capture BMPs	New Development Medium Capture BMPs	New Development High Capture BMPs
$231 million	$346 million	$ 469 million (rooftop detention) - $3 billion (green roofs)	$0 (rooftop detention) - $1.7 billion (green roofs)	$2.4 billion

Legal

The authority for various functions to control drainage of stormwater from private and public lots, to City streets and sewers, and eventually to waterbodies is a shared responsibility that crosses five major City agencies (see Table 5.7 below). As such, implementation of stormwater control practices, whether to reduce stormwater runoff or to improve stormwater quality, is a multi-agency responsibility. The agencies that have the greatest ability to promote change are the NYCDEP, because of its role in permitting connections to the sewers, NYCDOB for its responsibility in enforcing the Building Code, and the NYCDCP, because of its control over zoning in the form of property development requirements.

TABLE 5.7. Regulatory Authority For Controlling Stormwater Runoff

NYC Agency	Authority as Related to Disposal of Stormwater	Legislative Authority
New York City Department of Environmental Protection (NYCDEP)	• Establish Drainage Plan - sets sewer sizes in relation to zoning • Assess the capacity of the sewer system to accept sanitary and stormwater from new development or altered development and certifies sewer connection applications • Issues permits and inspects for the connection of the building or house sewer to the sewer system	• Administrative Code, Title 24 (24-503) • Administrative Code, Title 24 (24-526) and Reference Standard 16 (P110.0) • Administrative Code, Title 24 (24-507)
New York City Department of Buildings (NYCDOB)	• Develops Building Code – sets standards for construction practices on individual lots in accordance with land uses and zoning • Reviews new building or alteration applications including associated plumbing. Can accept and may certify applications for connection of building or house sewer in conjunction with a permit for construction or alteration of a structure • Authority for Building Code which allows retention and recycling of stormwater	• Administrative Code, Title 27 (27-102) • Administrative Code, Title 27 (27-896, 27-901, 27-909, 27-916 and 27-2027) • Administrative Code, Title 28 (PC 28-1101.2, PC 1110.1, PC C101.1)

TABLE 5.7. Regulatory Authority For Controlling Stormwater Runoff (continued)		
New York City Department of City Planning (NYCDCP)	• Establish City Map – establishes land uses and population densities in districts (zones) around City • Develop Zoning Resolution - controls open space on lots and other factors such as floor area ratios that impact use of individual lots • Review and approve NYCDEP drainage plans	• City Charter (Section 198) • City Charter (Section 200)
New York City Department of Transportation (NYCDOT)	• Responsible for roadways and sidewalks and associated storm drainage • Can become involved with site grading	• Administrative Code, Title 17 • Administrative Code, Title 19 (19-137)
New York City Department of Health and Mental Hygiene	• Enforces drainage on property when poor drainage impacts public health • Review and approve NYCDEP drainage plans • Reviews and approves water reuse systems	• Administrative Code, Title 17 (17-119) • Administrative Code, Title 24 (24-143 and 24-145)

Currently, City codes and stormwater management regulations do not routinely require or promote the use of stormwater detention or retention BMPs for the purpose of minimizing CSOs. However, stormwater detention to address flooding and capacity limitations in the built infrastructure is routinely required. The current Administrative Codes, Building Codes and City practices are directed to controlling the flow of stormwater away from lots and into sewers with the primary purpose of avoiding flooding and standing water and the public health concerns associated with these conditions. They also are intended to prevent disputes between homeowners created by storm drainage being routed across property boundaries.

The Building Code requires that all stormwater falling on a property shall be discharged into a street storm or combined sewer by:

- a house connection where there is a street storm or combined sewer in front of the property; or
- construction of a new sewer to the storm or combined sewer located within 200 feet of the property (for residential exceeding 20,000 square feet impervious) to 500 feet of the property (for commercial lots), where feasible.

When a new or expanded development applies for a sewer connection permit, an assessment is performed to assess the capacity of the sewer to demonstrate whether the impervious surfaces on the property will generate stormwater runoff that can be accommodated by the existing street storm or combined sewer. That generally requires the developer to perform step-by-step calculations assessing the flow (sanitary and storm drainage) being added to every sewer pipe in the area as well as those draining from the immediate area of the project site. Typically one of the following three outcomes are identified:

- If the subject sewer has adequate capacity, then it is a matter of demonstrating capacity to NYCDEP for a site connection approval to the sewer.

- When the sewer does not have adequate capacity, the developer must work with NYCDEP to redesign the sewers and develop a modified drainage plan or provide for on-site detention of stormwater so the sewers can convey the storm drainage without adversely impacting the system.
- When no sewer exists within 200-500 feet of the property, the developer must design and construct on-site retention using a drywell sized in accordance with design standards.

If on-site detention is proposed, the developer can provide either a subsurface detention tank, rooftop detention, or can apply for an alternative method of control. The detention required is not intended, as a goal, to address CSOs. NYCDEP requirements for on-site detention primarily address large rainfall intensities, for example 3 or 5 year storms. However, smaller storms that can result in CSO events are also detained to some extent. Rooftop detention is more effective in controlling smaller storms than subsurface detention due to design limitations associated with subsurface detention systems.

Adequate design capacity is established in NYCDEP's current drainage plans and has been the practice for many years in development of the drainage plans for most areas of New York City. The current practice is to design storm or combined sewers to convey stormwater drainage from parcels based on rainfall intensities of 5.95 inches per hour, is about a 5-year return rainfall intensity. Older sewers in the City were designed to lesser levels of protection (1, 2 and 3 year intensities) and thus could incur flooding on a more frequent basis.

As discussed, the codes are quite specific in how stormwater from impervious surfaces needs to be controlled and where it should go. It does not appear that mandatory stormwater BMPs that allow for increased detention and retention to address CSOs could be implemented without changes to the Administrative Code and other regulations. However, there are a number of situations where they could be installed under the current Sewer Code and Building Code and the soon to be effective revised Building Code:

- If no street storm or street combined sewer is located within 200-500 feet, NYCDEP will determine the appropriate means by which stormwater is to be managed. On-site drywells (in accordance with Reference Standard (RS) P110.13) are specifically referenced as an alternative measure. According to Reference Standard RS-16 (P110.2) where there is no sewer within 200 feet (or 500 feet for commercial lots) the owner may provide for on-site disposal of stormwater using a dry well designed to contain and dispose of 2 inches of rainfall within a 24 hour period with approval from NYCDEP (RS-16, P110.13).
- Stormwater falling onto pervious surfaces can be disposed of on-site through surface infiltration providing that the stormwater does not drain to the street across a sidewalk or drain onto an adjacent property (27-901, 27-2027) and without ponding on the site.
- Stormwater falling onto areaways 25 square feet or less can be leached into the ground through pervious surfaces where groundwater is at least 2 feet below the ground surface (RS-16, P110.13 (a) and (b)). An areaway is a sunken space that affords below grade access, air, and light to the first basement or cellar story below grade. This regulation applies only to a very small and specific area immediately adjacent to a building.
- Disconnection of roof leaders from the sewers could be connected to a BMP if it is provided with a connection to the sewer for any overflow (27-2027, RS-16, P110.2). For example, downspouts could be directed into a rain planter, rain garden, or rain barrel as long as a means is provided

from the BMP to capture and divert flow back into the property storm sewer and then to the street sewer at an allowable rate before it overflows the BMP.

- Green roofs and rooftop gardens could be installed provided that the roof is designed to carry the load of the garden and the landscaped portions in accordance with Administrative Code 27-561, and a means is provided from the BMP to capture and divert flow back into the property storm sewer and then to the street sewer at an allowable rate before it overflows the BMP.
- Property could be recontoured to encourage rainwater to infiltrate if the re-contouring did not result in either ponding of the water on-site without rapid percolation into the ground or in water flow off the property across a sidewalk or onto an adjacent lot (27-901). By directing the runoff to a BMP technology such as bioinfiltration, it would be possible to manage stormwater on-site without ponding of the water on-site or water flow off the property across a sidewalk or onto an adjacent lot, provided an underdrain and a control structure to discharge at an allowable rate are connected to the sewer system.
- Other types of BMPs that reduce impervious surfaces are likely to be allowable under the current codes (see also Management Strategy 3a2 below). These include planting of additional trees or other landscaping practices, converting impervious areas to pervious areas or porous pavers, where groundwater is at least two feet below ground surface.
- The new plumbing code, soon to be effective under the revised Building Code, allows for approved systems for the beneficial collection for recycling of stormwater (Section PC 1101.2): "Where required. All roofs, paved areas, yards, courts and courtyards shall drain into a separate storm sewer system, or a combined sewer system, or to an approved place of disposal. In accordance with city department of environmental protection requirements, an approved system for beneficial collection and use of stormwater may be installed in which case overflow from such a system shall be discharged to street storm sewer or street combined sewer." Note that NYCDEP will be developing the requirements referenced above.

Possible changes to rules and regulations to encourage BMPs. As discussed above, the objectives of the current City Codes promote the removal of stormwater drainage away from public and private parcels of land to the sewer system. NYCDEP regularly requires detention, with the primary goal of addressing flooding due to large storms. These detention facilities do not specifically address the goal of reducing combined sewer or storm sewer flows and related pollution in waterbodies. However, rooftop detention and, to a lesser extent, subsurface detention are typically designed in a manner that would address CSOs due to smaller storms. To better encourage BMPs, changes to the City codes may be needed to balance the need for public health protection with the need to reduce environmental pollution from urban runoff and from CSOs.

Possible changes to existing codes to encourage BMPs, which appear to be implementable within the constructed New York City environment, are discussed below. Code changes related to detention and retention are addressed. Some of these concepts are based on practices currently permitted in other large cities. ***All potential revisions discussed below are not recommendations at this point in time, but rather preliminary concepts for further evaluation. As a next step, NYCDEP will undertake a study to identify specific provisions of the Sewer Code and other applicable codes that might be recommended for revision while meeting the goals of addressing flooding, ponding, and other potential health effects.***

Potential New Applicability Triggers for On-Site BMPs. The current practice is to require on-site detention when proposed zoning changes or impervious cover changes would cause the sewers to exceed their flow capacity based on large rainfall intensities. Where the street sewer does not have adequate capacity to convey intense rainfalls, the City can mandate on-site detention or retention and controlled release of the stormwater. When adequate capacity is available to handle large rainfall intensities, no detention measures are required.

Rather than requiring detention or retention when allowable flow capacity of the sewer is exceeded, alternative triggers for requiring on-site detention or retention could include:

1. require BMPs when additional CSOs beyond some selected baseline are created; OR
2. require all new construction or enlargements over a certain size (*e.g.*, ¼ acre impervious) to require on-site detention or retention sufficient to not increase the total volume or peak discharge rate of stormwater over that presently leaving the site. This would result in no increase in stormwater entering the sewer. However, since most development sites in the city are largely covered with impervious surfaces that may not be controlled, this would do little to reduce uncontrolled stormwater from the site; OR
3. require all new construction or enlargements over a certain size (*e.g.*, ¼ acre impervious) to require on-site detention or retention sufficient to not increase the total volume or peak discharge rate of stormwater over pre-development conditions. This would typically reduce the stormwater entering the sewer and would not allow the developer to take credit for existing impervious surfaces.

Temporary Storage of Stormwater on Lots (On-site Detention). The Code and Reference Standards could be revised to provide specific design guidelines and requirements to support higher levels of detention to address CSOs. Specifically, guidance to determine storage volumes and design overflow control structures that can detain on-site stormwater flows for smaller storms with intensities that cause or contribute to CSOs could be developed.

In addition, the rules can be modified to promote detention systems other than subsurface or rooftop detention. While the rules do not necessarily preclude diversion of roof leaders into a rain barrel or cistern with reconnection of the overflow from these detention devices at an allowable rate to the storm or combined sewer, the code could be revised to specifically permit these types of storage practices. Alternatively, they could be allowed to infiltrate without reconnection to a sewer (see below).

Infiltration of Stormwater on Lots (On-site Retention). While the rules do not preclude diversion of stormwater from impervious areas into a rain garden, rain planter, bioinfiltration basin, or other infiltration device, the device must include a reconnection of the overflow to discharge at an allowable rate through these devices to the storm or combined sewer. Changes to the code to better support infiltration practices could include:

- Removing the mandate of needing to make a direct connection of impervious surfaces to street storm or combined sewers in certain situations.
- Providing allowances for and conditions under which certain infiltration BMPs either could or must be employed.

- Discourage ponding of water on-site.

To ensure that infiltration practices continued to meet the objectives of avoiding flooding and ponding of water, the Codes and Reference Standards would need to be revised to provide specific design guidelines and requirements related to the following:

- Define soils that can be used for on-site retention.
- Infiltration or permeability testing requirements for acceptable on-site retention infiltration practices.
- Minimum depths to groundwater.
- Minimum depths to bedrock.
- Mandated overflow connections to discharge at an allowable rate to storm or combined sewers from certain subsurface drainage systems to protect against surface ponding during extreme rainfall events or when peak stormwater flows exceed infiltration rates.
- Provisions for freezing temperatures.
- Maintenance requirements and responsibilities to ensure the ongoing performance of the installed methods.

If any of the changes discussed in this section were to be proposed, they would require revisions to the Administrative Code by an action of the City Council. The City Council would need to pass a local law to introduce any changes to the Code or Reference Standards.

In addition, enforcement is an issue with allowing BMPs under sewer permits. Because they do not function well without regular maintenance, widespread use of BMPs would require an inspection program. NYCDEP does not inspect individual properties and this may be an effort that would require support from the NYCDOB.

RECOMMENDATION

It is recommended that the City further pursue and encourage the use of on-site stormwater BMPs in the Jamaica Bay watershed. This would be done through the Implementation Strategies listed below. Many of these Implementation Strategies address the uncertainties discussed above under environmental, technical, cost, and legal issues.

IMPLEMENTATION STRATEGIES

The integration of stormwater BMPs into new and existing development will occur over time. Currently, BMPs are the exception in New York City, and developing more widespread use will involve technical assistance and education for developers and building owners, economic incentives, and regulatory and design standard changes. BMP technologies have not been widely accepted by the development community, including engineers and architects, due to a lack of familiarity with the available technologies, maintenance issues, costs, and the fact that existing regulations do not encourage their use. Pilot projects and demonstration projects will be needed to determine the effectiveness and address uncertainties of the measures in conditions unique to New York City.

Monitoring programs will be needed to track their effectiveness over time. These *Implementation Strategies* are discussed below.

Pilot Projects and Demonstration Projects

To address uncertainties related to costs, benefits, public acceptance, maintenance requirements, and site conditions, NYCDEP will pursue several pilot studies. In addition, New York City government can be a leader by example in pursuing these technologies; there are potential opportunities to incorporate BMPs into the design of city government buildings and construction projects.

<u>Green Roof/Blue Roof Pilot Study</u>

One of Gaia Institute's green roof projects in the New York City area; Source: Gaia Institute

NYCDEP, working with the Gaia Institute, will design, construct and monitor a green roof and a blue roof (rooftop detention) on two existing commercial developments in the Jamaica Bay watershed. Although green roofs have been investigated in various cities, their widest applications have been in the Pacific Northwest and in Germany whose temperate climates are not similar to New York City's. In addition to comparing the stormwater benefits of the two approaches, addressing uncertainties with installation on existing development and costs will be the objectives of the study.

Schedule: Pilot to begin in late 2007. Nine months to select site, design and install. Monitoring over a three year period to evaluate the effectiveness over time and under various environmental conditions.

Cost: $352,500 for design and construction. Additional funding will be provided for monitoring and reporting over three years.

<u>Rain Barrel Give-Away Pilot Study</u>

Rain barrels have been installed in low density areas both in New York City and other American and European cities. Rain barrels have been shown to be effective particularly in the Pacific Northwest, whose milder weather and less intense rainfall patterns are more conducive to rain barrel use. One goal of the pilot study would be to test the effectiveness in climate patterns experienced in New York City.

In addition, to make a noticeable change in stormwater capture rates, rain barrels would require wide-scale market penetration and buy-in from homeowners. To function properly, they require dedicated involvement. They need to be emptied between rainfall events with the water being used for garden, lawn and houseplant watering. In addition, rain barrels need to be disconnected from the roof leader each fall and reinstalled each spring. Therefore, a second goal of the pilot study would be to gauge public acceptance and interest in using rain barrels and their willingness and ability to maintain them. Approximately 1,000 rain barrels would be distributed.

Schedule: Pilot study will be developed through a proposed contract that will implement CSO strategies. Pilot to be initiated in Summer 2008. Program to be monitored over two years. Depending on public participation, program can be expanded.

Cost: $138,000.

Parking Lot Pilot Study

To serve as a model for the proposed Zoning Resolution parking lot design requirements, NYCDEP will develop a model parking lot pilot study in the Jamaica Bay watershed. Two 1.5 acre parking lots will be retrofitted for stormwater capture with edging and median bioretention and storage systems in accordance with proposed design requirements under the Zoning Resolution.

Schedule: Pilot study to begin in late 2007. Nine months to select sites, design and install. Monitoring over a three year period to evaluate the effectiveness over time and under various environmental conditions.

Cost: $290,000 for design and construction. Additional funding will be provided for monitoring and reporting over three years.

NYCHA or HPD Pilot Study

NYCDEP will retrofit an existing affordable housing site under the jurisdiction of New York City Housing Authority (NYCHA) or HPD. The pilot study will include retrofitting the existing site with infiltration and detention BMPs and redirecting runoff to existing pervious areas. The study will examine the uncertainties involved in retrofitting existing development.

Schedule: Pilot study will be developed through a proposed contract that will implement CSO strategies. Pilot to be initiated in Summer 2009. Program to be monitored over two years.

Cost: $550,000 including design, construction and monitoring.

New York City Agency Demonstration Projects

Because BMPs do not have wide-scale application in New York City, City projects and lands can provide a testing ground that can highlight the benefits and work out the logistics to provide for wider scale implementation. Implementing BMPs on public properties would provide a real life evaluation of the performance of these BMPs and the costs for implementation. Such an approach by the City of "leading by example" would expand practice in the construction of BMPs within New York City, help to standardize BMP construction costs, and encourage private developers to pursue these options. Through an on-going monitoring program and campaign to determine accurate costs and benefits of BMPs on public properties, on-site BMP implementation could be scaled up to include more City-owned properties and extend to private developments.

Through the Mayor's interagency BMP Task Force, strategies for incorporating BMPs into the design and construction of City capital projects will be developed. The interagency task force includes HPD, New York City Economic Development Corporation (NYCEDC), SCA, NYCDDC and DCAS which are directly responsible for managing, designing, and constructing City housing projects, schools, courthouses, City-funded commercial development, and other City development projects as well as NYCDEP and NYCDOB which grant permits and approvals for these projects. (See "Off-site BMPs" below for NYCDPR and NYCDDC roles on the BMP Task Force). The Task Force members are evaluating their built and planned projects to determine where BMPs can be incorporated. Interagency communications and coordination is particularly helpful to share lessons learned about BMP implementation and provide case studies of information for both public and private developers.

In addition, NYCDEP has met with HPD, NYCDDC and SCA, to determine how BMPs can be incorporated into current design projects. These agencies are eager to work with NYCDEP to determine how to add BMP requirements to their Requests for Proposals and/or contracts with private developers. All of these agencies have developed green design standards for their projects.

In addition to measures encouraged by individual agencies, Local Law 86 can be expanded to more prominently encourage stormwater BMPs in addition to its current focus on reducing energy and water usage. Under Local Law 86, all new public construction is required to be designed and constructed to comply with green building standards to achieve a LEED silver or higher rating for the infrastructure.

Schedule: Mayor's Office Interagency BMP Task Force Plan to be delivered in Fall 2008.

Evaluate Rooftop Detention

Despite its considerably lower cost, as discussed above, only a small number of developers now choose rooftop detention over subsurface detention when required to provide detention as part of their projects. NYCDEP will work with the NYCDOB to better promote the advantages of rooftop detention earlier in the approval process. Information will be provided on costs as compared to subsurface detention and case studies of where it has been implemented will be highlighted.

In addition, NYCDEP will investigate a program to target the implementation of rooftop detention on existing large roofs in the Jamaica Bay watershed. As noted above, 2.5% of the rooftops are over 5,000 square feet representing approximately 29% of the rooftop area within the watershed. NYCDEP will identify the associated buildings and inventory the extent to which they already include detention or retention measures, and the ability of the rooftops to be retrofitted to accommodate rooftop detention. A pilot study comparing a green roof and blue roof will be undertaken (see "Pilot Projects and Demonstration Projects" above).

NYCDEP will work with the New York City Soil and Water Conservation District (NYCSWCD) (see *Economic Incentives* below) to investigate and incentive program to encourage the installation of rooftop detention and other BMPs on these buildings. In addition, as part of the Code Review, NYCDEP will explore whether rooftop detention can be included as an option for major roof renovations.

Schedule: To be initiated late 2007.

Cost: See Cost Sharing Programs below.

Economic Incentives

Economic incentives such as water and sewer rate discounts and public/private cost-sharing may be needed to encourage the implementation of BMPs, particularly for existing development. New York City already has engaged in several incentive-based initiatives, including a toilet rebate program, where residents can obtain a rebate if they have a new water-conserving toilet installed by a licensed plumbing company.

<u>Stormwater Rates and Credits</u>

Stormwater rates and water conservation rates are currently being used by municipalities across the country to achieve local and regional goals of reducing water demand and stormwater generation and addressing infrastructure needs to meet more stringent regulatory requirements. Rates to achieve higher levels of water conservation send price signals to encourage users to consume less water. Stormwater rates establish a separate pricing structure for stormwater discharges to reflect the stormwater generation characteristics of specific land uses. This revenue can then be applied to a large array of stormwater-related investments from infrastructure to BMPs.

In New York City, the New York City Water Board uses a metered and flat rate system to bill customers for water service and sewer service. The wastewater charge for any property is 159% of the charges for water supplied to that property. Rates for expenditures related to both wastewater and stormwater are incorporated into one wastewater rate.

New York City's rate schedule also provides limited incentives for buildings which meet the criteria for either "Blackwater Systems" or "Greywater/Recycled Water Systems." The building must demonstrate a 25% aggregate annual reduction in demand for potable water compared to other similar buildings. Reduction in potable water can be through water conservation, reuse, or stormwater reuse.

Under the current structure, ratepayers are charged for service in a manner that assigns stormwater costs to the quantity of water that is used. This structure does not reflect stormwater generation. For example, customers that do not use water (*e.g.,* parking lots) are receiving stormwater service but are not assessed a rate. On the other hand, high density housing developments can have high water usage and wastewater volumes, but from a stormwater perspective, they generate less stormwater per capita due to their compact land area.

NYCDEP will undertake a study to evaluate alternative water, sewer, and stormwater rate structures. Among other issues, the study will assess revenue and ratepayer impacts of different stormwater rate structures, as well as the costs to the City of new development on water, wastewater and stormwater infrastructure. There are both advantages and disadvantages associated with stormwater rate structures that will be explored as part of this study.

Stormwater rate structures can be defined by a number of variables such as imperviousness, land area, and property classifications. The study will assess the extent to which a variety of stormwater rate structures can provide additional revenue and equity, while encouraging BMPs. The study will evaluate impacts on ratepayers and revenues. Administrative, billing, and enforcement requirements associated with the different rate structures will also be explored.

Stormwater rate structures in and of themselves do not encourage the use of BMPs without a credit program. This is because administratively it is not possible to measure the imperviousness of each lot and charge based on actual imperviousness. If such a rate were possible, stormwater charges would be lower for those who install pervious areas. Instead, these rates are typically based on lot size and average impervious surface coverage for each land use such as residential, commercial, and industrial. Because consumers are paying an average rate, their rate is not reduced if they install BMPs. Therefore, the study will review appropriate credit programs that could be developed to encourage BMPs, without substantial loss of revenues. Seattle and Kings County, Washington have included a sophisticated credit program as part of their stormwater rate structure.

Schedule: The study is expected to begin in late 2007 and take 18 months, to be concluded in mid-2009.

Cost: To be determined.

Cost-Sharing Programs

As noted below, New York City provides rebates for installing low flow toilets citywide. Several other economic incentive programs are offered within the City for energy and other environmental initiatives for private developers. The Bronx Overall Economic Development Corporation (BOEDC), a federally designated agency for economic development in the county, offers several incentive programs as part of its Bronx Initiative for Energy and the Environment. The first is the Empowerment Zone Environmental Fund applicable for businesses located in the Empowerment Zone that receive an Empowerment Zone loan. The Environmental Fund funds up to $100,000 per grant to cover the incremental costs associated with the installation of a green roof or photovoltaic cells/solar panels.

To expedite the implementation of BMPs on existing development, particularly development with large rooftops and impervious areas, NYCDEP will investigate the establishment of an incentive program with the NYCSWCD. The program could be modeled after a program currently in place through Washington D.C.'s Department of the Environment. Under the program, the NRCS partners with the Washington D.C. Department of the Environment to offer design/build services instead of cash awards; BMPs are fully designed and installed by a list of pre-qualified contractors.

PLANYC 2030 includes an incentive program for green roofs. Under PLANYC 2030, the City has proposed providing incentives for green roofs beginning in 2007. A key role of the Mayor's Office Interagency BMP Task Force is to investigate incentives that can be used to encourage BMP implementation. These incentives will be included in the Task Force's Plan to be completed in late 2008.

Schedule: NYCDEP and NYCSWCD will investigate cost-sharing programs beginning in Fall 2007. The PLANYC 2030 green roof incentive program is awaiting approval from the state legislature and is scheduled to last five years upon state approval. The Mayor's Office Interagency BMP Task Force Plan will be completed in late 2008.

Cost: The NYCDEP/NYCSWCD program is currently funded for $40,000 to do exploratory work to investigate the establishment of a framework and identify funding sources for the incentive program. Monetary incentives are not included and funding would need to be identified.

Other Incentives

Streamlining development processes such as expediting or fast-tracking building permit applications could be implemented for developments that include green buildings and low impact development, or developers utilizing the NYCDDC high performance guidelines.

Potential Regulatory Code Changes

Zoning Resolution Parking Lot Design Requirements

As discussed above, NYCDEP worked with NYCDCP to develop proposed parking lot design standards in the Zoning Resolution. The standards apply to commercial and community facilities with parking lots that contain 18 or more parking stalls or are 6,000 sq ft or more in size. The standards include adding stormwater BMPs such as street trees and perimeter and interior landscaping that would provide infiltration to the soils. To be implemented, the standards require a zoning text change through a process similar to the City's Uniform Land Use Review Process (ULURP).

Schedule: The proposed text amendment approval and public review process began on June 18, 2007 and involves the City Planning Commission, Community Boards, Borough Presidents, and City Council. If approved, the requirements would take effect on the date it is approved by the City Council.

Code Review

Based on the above summary of potential legal issues associated with installing BMPs for new and existing development, the Sewer Code and Building Code may need to be revised to better facilitate installation of BMPs on a wider scale. NYCDEP will conduct a review and study of the Sewer Code and closely coordinate with NYCDOB and other agencies on related codes to evaluate whether code changes would be needed.

Schedule: The Sewer Code review will be developed through a contract that will implement CSO strategies. A contractor is anticipated to be retained by mid-2008. The review will be conducted in conjunction with the development of a BMP Design Manual (see below). The pilot studies will also be used to inform potential revisions. If revisions are proposed, they will be required to be adopted pursuant to the City's Administrative Procedures Act (CAPA) process.

Cost: $250,000 (includes BMP Design Manual below).

Technical Assistance

Companion BMP Design Manual

A BMP Design Manual will be developed as a companion to the Sewer Code. A number of existing manuals including the *New York State Stormwater Management Design Manual* (CWP 2003) currently provide a wealth of information related to the design of BMPs. However, a manual specific to New York City's unique conditions and urban environment would further facilitate the implementation of BMPs in New York City. The manual would specifically address high density development patterns, drainage issues, Sewer Code and permitting process interface, soil, bedrock and groundwater conditions, and climate conditions specific to New York City. The manual would include detailed design requirements for public and private development projects and would be developed with input from multiple city agencies.

Schedule: The BMP Design Manual will be developed through a contract that will implement CSO strategies. NYCDEP will issue a Request for Proposals for the study in early 2008 and a contractor is anticipated to be retained by mid-2008. Proposed revisions will take 18 months, to be concluded by late-2009, and will be done in conjunction with Sewer Code revisions (see above). The pilot studies will also be used to inform the manual.

Cost: See Code Review above.

CEQR Technical Manual

Revisions to the New York City Environmental Quality Review (CEQR) Technical Manual will be proposed to include a specific section addressing proposed developments in the Jamaica Bay watershed that are subject to CEQR. For example, applicable developments in the Jamaica Bay watershed that exceed certain size thresholds could trigger a detailed CEQR review. The applicant would need to document measures to capture, store, and/or treat stormwater from the site.

Schedule: Next CEQR Technical Manual revision is scheduled for Summer 2008.

Monitor Benefits

Currently, benefits provided by BMPs can only be predicted by modeling. To determine actual benefits, field indicators need to be developed to track the success of BMP implementation over time. The City will maintain a database of public and private projects that incorporate BMPs. Improvements at the CSO outfalls for the drainage areas where these BMPs are installed will also be tracked to assess the effectiveness in reducing CSOs.

In addition, the pilot studies, which include a substantial monitoring and evaluation component to track performance and effectiveness over time, will provide data to inform and improve BMPs and make them easier to implement in the future in a manner that is specific to conditions found on the ground in New York City.

Schedule: To be determined. The tracking program will be expanded as Implementation Strategies are undertaken.

Management Strategy 3a2: Reduce the imperviousness of new and existing development.

STRATEGY DESCRIPTION

Despite its low density land uses compared to other parts of the City, the Jamaica Bay watershed is densely developed and largely covered with impervious surfaces. Based on recently analyzed multi-spectral satellite imagery being performed by the Lamont Doherty Earth Observatory, the land area in the Jamaica Bay watershed is approximately 65-70% impervious surfaces. As indicated in Table 5.8, the 26th Ward sewershed has the greatest percent impervious cover (83%), while Rockaway has the least (59%).

TABLE 5.8. Impervious Cover By Sewershed

WPCP Sewershed	Impervious cover %
Coney Island (Paerdegat area)	66
26th Ward	83
Jamaica	68
Rockaway	59

A trend toward increased impervious cover is occurring. According to PLANYC 2030, over the last 25 years, the City has lost more than 9,000 acres of pervious surfaces. Another trend observed in low density areas is that homeowners are paving over front lawns to allow for additional parking.

Standard Pavement

Porous Pavement

FIGURE 5.4 Comparison of asphalt types; Source: University of New Hampshire Stormwater Center and Biohabitats, Inc.

Creating pervious areas on a site with adequate subsoil strata reduces runoff and allows for infiltration to the soils. Currently, there are no rules within New York City that limit the amount of impervious area or require that a portion of the lot remain pervious. The Zoning Resolution does have open space requirements for various zoning categories, but these areas are allowed to be paved. However, City

Planning is currently considering changes to the Zoning Resolution to require pervious areas on low density residential lots (see *Implementation Strategies* below for more information). In addition, implementing certain of the BMPs discussed above for on-site stormwater control, including trees and rain gardens would create both pervious areas and infiltration capabilities. Under the Zoning Resolution's new parking lot design standards, it is estimated that about 10% of the area of regulated parking lots will be pervious.

FIGURE 5.5 ***Porous concrete*** – Like porous asphalt, porous concrete is produced by substantially reducing the number of fines in the mix in order to establish voids for drainage. The pavement will support traffic and allow water to pass through to a gravel layer underneath. The strength of pervious concrete is about 85 percent of conventional concrete, making it suitable for sidewalks, driveways, alleys, parking lots and residential streets. In northern and mid-Atlantic climates, porous concrete should always be underlain by a stone subbase designed for stormwater management and should never be placed directly onto soil; *Source: Draft Pennsylvania Stormwater Management Manual. 2005*

FIGURE 5.6 ***Porous bituminous asphalt*** - consists of standard bituminous asphalt in which the fines have been screened and reduced, allowing water to pass through very small voids. Porous asphalt is suitable for use in any climate where standard asphalt is appropriate and its compressive strength is similar to conventional asphalt pavements; *Source: Draft Pennsylvania Stormwater Management Manual. 2005*

A second strategy for reducing imperviousness is the use of porous pavement for driveways, sidewalks, walkways, patios, parking lots, and playgrounds, among other uses. Porous paving, also known as permeable paving, allows the passage of water through voids within the pavement media. Porous paving materials include pervious concrete, porous asphalt, pervious interlocking concrete paving blocks, concrete grid pavers, perforated brick pavers, and compacted gravel

Porous pavement consists of a permeable surface underlain by a uniformly-graded stone bed with a void space of at least 40% which provides stormwater management. Stormwater drains through the surface, is temporarily held in the voids of the stone bed, and then slowly exfiltrates into the underlying, uncompacted soil substrate. The stone bed is designed with an overflow control structure so that during large storm events peak rates are controlled, and at no time does the water rise to the pavement level. A layer of nonwoven geotextile filter fabric separates the aggregate from the underlying soil, preventing the migration of fines into the bed.

EVALUATION OF MANAGEMENT STRATEGY

FIGURE 5.7 ***Porous paver blocks*** - Porous paver blocks consist of interlocking units (often concrete) that provide some portion of surface area that may be filled with a pervious material such as gravel. These units are often very attractive and are especially well suited to plazas, patios, small parking areas, etc. The compressive strength of pavers varies depending on the product, but tends to be high (up to 8,000 psi); *Source: Draft Pennsylvania Stormwater Management Manual. 2005*

Keeping areas pervious allows stormwater to infiltrate, thus reducing stormwater runoff. It also provides attenuation of pollutant loading through the absorptive capacity of the soils. Porous pavement can also provide runoff volume and pollutant load reductions. Long-term studies show removal efficiencies of:

- 82-95% of sediments
- 65% total phosphorus
- 80-85% total nitrogen
- high removal rates are also reported for zinc, lead and chemical oxygen demand (COD) (Adams, 2003; USDOT, 2002; Stotz and Krauth, 1994).

Porous pavements have not been found to effectively treat fuel leaks from automobiles.

Porous paving has other environmental benefits it can reduce thermal pollution; glare and automobile hydroplaning (skidding) accidents; pavement ice buildup; and tire noise (for asphaltic porous pavements). In playgrounds it also can reduce noise of bouncing balls. Porous pavement also benefits nearby trees which have greater access to water, since water infiltrates rather than running off.

Technical

A review of what is required or allowable within zoning districts such as maximum building coverage, FAR, open space ratio, driveways and parking areas was conducted. Based on this assessment, low density districts could most readily accommodate areas to be set aside as pervious.

While use of porous pavement cannot replace asphalt and concrete, there are many opportunities for its wider use in New York City. However, there are a number of technical issues to be addressed including maintenance issues, site and climate conditions, and determining the types of applications that would be most appropriate.

Maintenance

Porous pavements require regular maintenance to ensure that pavements remain free of fine materials which can clog the pores. Quarterly maintenance (four times per year) includes vacuum sweeping followed by high-pressure hosing. Potholes and cracks can be filled with patching mixes unless more than ten percent of the surface area needs repair. Spot-clogging may be fixed by drilling 1.3 centimeter (half-inch) holes through the porous pavement layer every few feet (USEPA, 1999). With the proper care, porous pavements can last 15-20 years or more with moderate to heavy use, equivalent to the lifetimes of most standard pavements. The property owner would be responsible for their ongoing maintenance; if not properly maintained they lose their effectiveness.

Site Conditions
As discussed above for BMPs, porous pavement which infiltrates stormwater requires soil types that drain well. However, porous pavement is typically underlain with a porous substrate to enhance infiltration and storage. In addition, as with any infiltration practice, depth to groundwater is an important factor that needs to be considered to avoid ponding and flooding.

Climate Conditions
As discussed above, the effectiveness of specific BMPs can be impacted by climate conditions including frost, snowfall and heavy, intense rainfall in a short period of time. The effectiveness of porous pavement may be limited in cold climate conditions. Besides limitations related to infiltration and frozen ground cover, sand or salts to deice pavement clog the porous pavement. However, new technologies for porous materials are in development and should undergo pilot studies to determine effectiveness in New York City.

Appropriate Applications
Porous pavement is well suited for parking lots, driveways, walking paths, sidewalks, playgrounds, plazas, tennis courts, and other similar uses. While it has been shown that porous pavements are more efficient than conventional materials at filtering out pollutants, it is recommended that they not be applied in heavy industrial use areas. Also, they may not meet specifications for traffic-bearing roadways. Table 5.9 below illustrates areas in New York City that would be optimal for porous pavement application and others where it would not be recommended.

TABLE 5.9. Appropriate Locations For Application Of Porous Pavement

Porous Pavement *Not* Recommended for Use on:	Porous Pavement Recommended for Use on:
Commercial nurseries	On-street parking lanes in residential neighborhoods
Auto recycle facilities	Sidewalks in residential neighborhoods
Vehicle service and maintenance areas	Patios and plazas
Vehicle and equipment washing/steam cleaning facilities	Residential driveways
Fueling stations	Residential and commercial parking lots
Industrial parking lots	Playing, basketball fields
Marinas (service and maintenance)	Parks and bicycle lanes
Hazardous material generators (if the containers are exposed to rainfall)	Cemeteries
Outdoor loading and unloading facilities	
Public works storage areas	

Cost
Materials costs are often higher for porous pavement applications that require underlying stone bed than for conventional pavement, but these added expenses can be somewhat offset when soil is favorable by the need for less piping and other materials that would otherwise be required for traditional stormwater management practices.

Maintenance involves vacuum sweeping followed by high-pressure hosing to be performed four times per year. Annual maintenance costs are in the process of being developed by NYCDEP. Potholes and cracks may on occasion need to be filled with patching mixes unless more than 10 percent of the surface area needs repair.

Legal
The Building Code does contain specifications for porous pavement on parking lots. However, the Building Code and potentially the Sewer Code may need to be revised to better facilitate installation of porous pavement.

In addition, the Zoning Resolution currently provides density, bulk, and setback requirements for development within each zoning district which contain maximum building and other coverage requirements per lot. Although not all of the area of a parcel is accounted for by structures, driveways, and other impervious surfaces, there is no impervious surfaces requirement that restricts paving the entire lot. NYCDCP is addressing this through proposed text changes (see *Implementation Strategies* below).

RECOMMENDATION

It is recommended that the City further pursue and encourage the use of porous pavement and setting aside areas as pervious surfaces for appropriate applications. This would be done through the *Implementation Strategies* listed below. Many of these Implementation Strategies address the uncertainties discussed above under environmental, technical, cost, and legal issues.

IMPLEMENTATION STRATEGIES

Porous pavement technologies have not been widely used in New York City due to a lack of familiarity with the available technologies, maintenance issues, and costs, and existing regulations do not provide for their use. Pilot projects will be conducted to determine their effectiveness and address uncertainties due to conditions unique to New York City. Code changes may be required to promote both setting aside pervious areas and the use of pervious technologies and to define appropriate areas for their use. As discussed above under BMP Implementation Strategies, financial incentives may also be needed to facilitate their acceptance.

Pilot Projects
To address uncertainties related to costs, benefits, maintenance requirements, and site conditions, NYCDEP will pursue several pilot studies. In addition, New York City government can be a leader by example in pursuing these technologies and incorporate them into the design of City buildings and construction projects.

<u>Parking Lot Pilot Study</u>
As discussed above under on-site BMP Implementation Strategies, NYCDEP is proposing a pilot study to serve as a model for the new Zoning Resolution parking lot design requirements. This pilot study can also be used to test the effectiveness and maintenance requirements for porous pavement technologies.

Porous Pavement on NYCDEP Property

NYCDEP will install and monitor the effectiveness of porous pavement on several of its properties.

Schedule: Pilot study will be developed through a proposed contract that will implement CSO strategies. Pilot study to be initiated in Summer 2008. Monitoring will be performed over two years.

Cost: $442,000.

Potential Regulatory Code Changes

Zoning Resolution Pervious Area Requirements

NYCDCP is developing front yard landscaping requirements for low density zoning districts (R1-R5), which will ensure that a certain portion of the lot remains pervious. The proposal calls for planting a minimum percentage of the area of a front yard ranging from 20% for narrow lots (less than 20 feet), to 50% for lots 60 feet wide or more. The proposal would apply to new and existing residential developments. To be implemented, the standards require a zoning text change through a process similar to ULURP.

NYCDCP is also planning a citywide text change to require that new developments and enlargements provide street trees except for certain light and heavy industrial uses. This would also provide more permeability (see Off-Site BMPs below for more information on this proposal.)

Revising the Zoning Resolution to require more pervious areas would begin to change the surfaces of New York City, thereby reducing the environmental impacts of stormwater runoff. Such a requirement would have aesthetic benefits in addition to reductions in stormwater runoff.

Schedule: The proposed text amendment approval and public review process began on September 17, 2007 and involves the City Planning Commission, Community Boards, Borough Presidents, and City Council. If approved, the requirements would take effect on the date it is approved by the City Council.

Code Review

The Building Code includes some specifications for porous paving materials. Currently, the American Society for Testing and Materials (ASTM) is developing standards for pervious concrete and asphalt. Many municipalities have developed their own specifications for the application of porous paving materials.

It is recommended that additional standards and specifications be developed for New York City to allow porous paving in qualified areas. As discussed above under BMPs Implementation Strategies, the BMP manual that will be developed could address specifications for porous pavements.

Schedule: To be determined.

Cost: To be determined.

Management Strategy 3a3: Expand water conservation program to achieve a greater reduction in water use.

STRATEGY DESCRIPTION

The City uses 1.1 billion gallons of water each day. Water use and wastewater flows have consistently declined over the last decade (see Figure 5.10) due to enormous strides the City has made in water conservation. In the 1990s, the City spent $290 million for a toilet rebate program that provided incentives to all property owners to replace older toilets and shower heads with modern, more efficient models. The program achieved 70-90 MGD of water conservation savings.

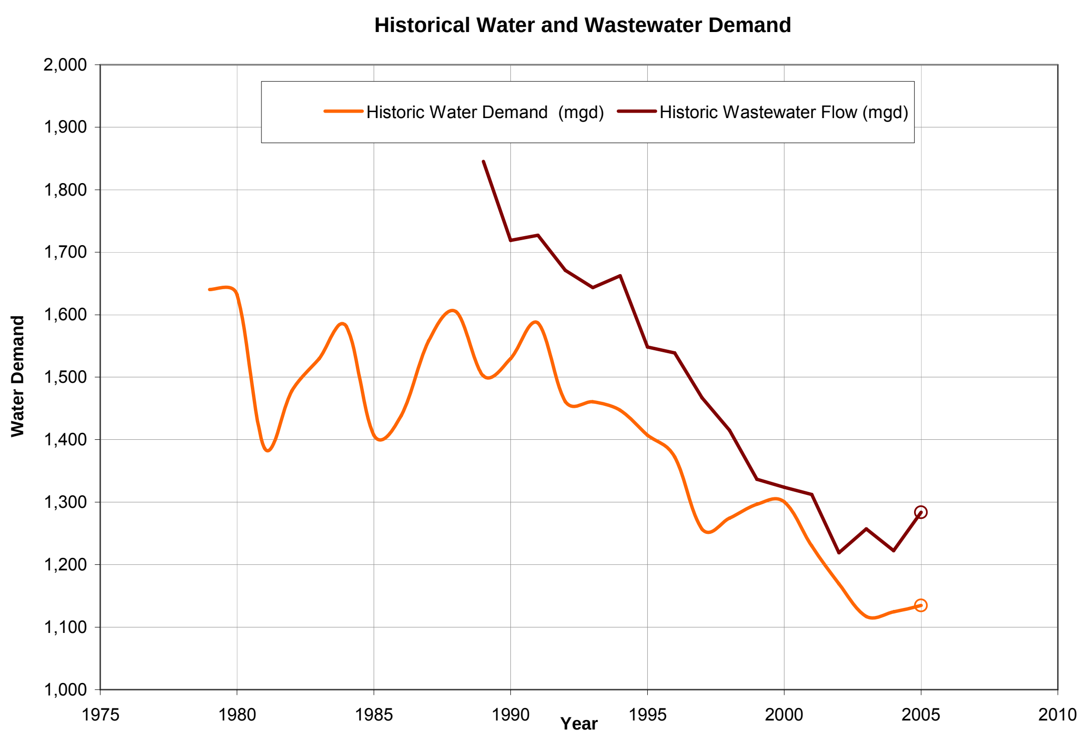

FIGURE 5.10 Historical water and wastewater demand; Source: NYCDEP

Starting in 2008, NYCDEP will launch additional rebate programs for toilets, urinals, and high-efficiency washing machines to lower water use in the City by 5%. This program will save approximately 60 MGD.

Water conservation not only reduces demands for potable water, but it also provides enormous benefits for reducing the flows to the wastewater treatment plants. As part of the Jamaica Bay planning effort, an assessment was performed to determine potential benefits from water conservation on reducing CSOs. By reducing sanitary flows, more room would be available at the plants to treat CSOs. This strategy examines the effects of the new 5% program. The effects of an additional 5%

water conservation savings within Jamaica Bay, for a total of 10% in water savings, was also analyzed.

EVALUATION OF MANAGEMENT STRATEGY

Environmental

Modeling, using INFOWORKS, was performed to estimate CSO reductions associated with 5 percent and 10 percent water conservation in Jamaica Bay.

Results of the modeling by sewersheds are shown on Table 5.10. Key findings are:

- The Coney Island WPCP drainage area has the largest reductions with 2.7% and 5.1% reductions in *untreated discharges to the Bay* of CSO, treated CSO, storm sewer, and direct runoff for the 5 and 10 percent water conservation scenarios, respectively. See On-Site BMPs (Management Strategy 3a1) above for a definition of *untreated discharges to the Bay.*

- Implementing the 5 and 10 percent water conservation scenarios in the 26th Ward Island WPCP drainage area would reduce *untreated discharges to the Bay* of CSO, treated CSO, storm sewer, and direct runoff by 1.7% and 3.3%, respectively.

- Water conservation programs in the Rockaway and Jamaica WPCP drainage areas would not result in significant reductions in *untreated discharges to the Bay* since both drainage areas are primarily separately sewered areas.

TABLE 5.10. Stormwater Benefits Of Water Conservation Savings By Drainage Area (Average Year 1988)

Condition	Baseline Conditions	10% Water Conservation	5% Water Conservation
Coney Island WPCP Drainage Area			
Reduction in dry weather flows in 2020 (MGD)	N.A.	9	4.5
Total CSO, treated CSO, storm sewer and Direct Discharge (MG)	455.5	432.4	443.3
Reduction with BMPs (MG/yr)	0.0	23.1	12.2
Reduction with BMPs (%)	0.0%	5.1%	2.7%
26th Ward WPCP Drainage Area			
Reduction in dry weather flows in 2020 (MGD)	N.A.	5.5	2.8
Total CSO, treated CSO, storm sewer, and Direct Discharge (MG)	822.4	795.1	808.8
Reduction with BMPs (MG/yr)	0.0	27.4	13.7
Reduction with BMPs (%)	0.0%	3.3%	1.7%

Technical

Water conservation is a proven program. However, it is more difficult to obtain conservation savings as higher goals for water savings are set (see *Costs* below).

Cost

The costs for the 60 MGD water conservation program are estimated to be $186 million over five years, amounting to $3.11/gallon of water savings. Additional conservation efforts would have higher costs of $10.35/gallon due to the increasing difficulty of identifying water saving opportunities.

Legal

There are no legal issues associated with the water conservation program.

RECOMMENDATION

It is recommended that the City further pursue and encourage water conservation. The current goal is to reduce water use by 5%. Once this level has been achieved, the City may pursue additional measures. The Implementation Strategies to achieve a 5% reduction are listed below.

IMPLEMENTATION STRATEGIES

Listed below are planned programs to achieve a 5%, or 60 MGD, reduction in citywide water use. In addition to these strategies, NYCDEP is planning to conduct a study of water conservation and stormwater rate structures to encourage water conservation (see BMP Implementation Strategies above).

Toilet, Urinal, and Clothes Washer Rebate Program

Preparations for a new series of conservation incentive programs are underway. An incentive program for toilets and possibly clothes washers for apartment building laundry rooms will be opened for high-density buildings currently on flat-rate billing during the first quarter of 2008. The program is scheduled to open citywide and be expanded to include urinals in 2009. The program is expected to result in water savings of 50 MGD.

Schedule: Five years - 2008-2012.

Cost: $154 million. Partially funded.

Fixture Replacements in Public Buildings

NYCDEP will be working with other city agencies to replace plumbing fixtures in public buildings. The program is expected to result in water savings of 5 MGD.

Schedule: Five years - 2008-2012.

Cost: $16 million. Partially funded.

Performance-Based Efficiency Projects to be Issued

Water efficiency opportunities exist well beyond fixture replacements. Replacement of once-through water-cooled equipment, steam condensate reuse, water reuse and irrigation-based measures are only a few examples. NYCDEP will be pursuing cost-sharing opportunities with the private sector for incentives for these water efficiency measures. The program is expected to result in water savings of 5 MGD.

Schedule: Five years - 2008-2012. NYCDEP issued a Request for Expressions of Interest to potential applicants as a first step in the process in June 2007.

Cost: $16 million. Funding not yet available.

OBJECTIVE 3B: PROMOTE THE USE OF OFF-SITE STORMWATER BEST MANAGEMENT PRACTICES

Current Programs

Off-site BMPs involve the capture and infiltration of runoff from roadways and sidewalks and use of vacant parcels and parks for stormwater management. With respect to roadways and streets, NYCDDC works closely with the NYCDOT and NYCDEP to construct or reconstruct streets and sewer lines within the street right-of-way. NYCDDC recently introduced sustainable design standards, entitled *High Performance Infrastructure Guidelines* (NYCDDC, 1999) which include stormwater BMPs for New York City infrastructure. This guidance document provides a road map for incorporating various types of BMPs into the City's right-of-way infrastructure capital program, including vegetated filter and buffer strips, catch basin inserts, detention structures, infiltration structures, bioretention and constructed wetlands among others. In addition, the NYCDPR will be responsible for planting and monitoring over one million street trees under the Mayor's PLANYC 2030 program.

Open space also provides opportunities for stormwater capture. The Council on the Environment of New York City (CENYC) utilizes stormwater BMPs for their citywide community gardens projects at certain sites. For example, using rain barrels and cisterns to retain stormwater during high rainfall events reduces runoff and provides water storage for use in community gardens during periods of water scarcity.

The Mayor's BMP Task Force is meeting regularly with NYCDEP, NYCDDC, and NYCDPR to coordinate the implementation of many of the strategies discussed in this section. Some of these strategies are highlighted in PLANYC 2030.

Three management strategies are discussed below:

- Promote the use of BMPs on highway rights-of-way and adjacent lands, streets, and sidewalks.
- Promote the use of vacant public lands for their potential conversion to stormwater parks.
- Promote the use of existing open space (such as parks, plazas, community gardens, etc.) for their potential to accommodate stormwater BMPs.

Management Strategy 3b1: Promote the use of BMPs along streets and sidewalks and highway rights-of-way.

STRATEGY DESCRIPTION

Impervious surface analyses of the watershed estimate that approximately 30% of the Jamaica Bay watershed is covered by streets and sidewalks alone. Locating off-site BMPs along roadways would help to capture runoff that contains high levels of pollutants that collect on the City's streets and sidewalks.

Several major and intermediate roadways and transportation corridors intersect the Jamaica Bay watershed throughout Brooklyn and Queens. The volume of stormwater runoff and pollutant loading from these surfaces could be reduced through the integration of stormwater BMPs. Specific BMPs suitable for roadways and sidewalks include use of infiltration swales in medians and along curbs, infiltration basins within streets and sidewalks, adjacent land areas for detention/retention or constructed wetlands, increased street-side planting, and enhanced tree pits which are larger than traditional tree pits and designed to store stormwater.

With these types of BMPs, there is a combined opportunity to increase habitat, green spaces, and tree plantings throughout the watershed. Vegetation and trees provide a myriad of ecological benefits, including shade, oxygen generation, temperature regulation, habitat for birds and insects, aesthetic benefits, and carbon sequestration. The key is to integrate these concepts into roadway construction, reconstruction, retrofit, and maintenance projects early in the design process.

EVALUATION OF MANAGEMENT STRATEGY

Environmental

Approach

Modeling was performed to estimate the stormwater runoff and CSO reductions associated with various stormwater BMPs applied to streets and sidewalks. To estimate the effects on individual streets and sidewalks, two street and sidewalk prototypes were developed based on street width since this is a major determinant of BMP type and size that can be feasibly constructed within a street right-of-way. For each street and sidewalk prototype, two sets of BMP applications were developed to address "low capture" and "high capture" measures that could be implemented as part of proposed infrastructure projects. The two applications provide a range of stormwater benefits and costs as shown on Table 5.11.

TABLE 5.11. Stormwater Capture Benefits Street And Sidewalk Prototype		
Land Use Prototypes	**Low Capture**	**High Capture**
STREETS AND SIDEWALK 25 TO 65 feet wide; 500 feet long		
Example BMPs	Sidewalk Reservoir (580 sf, 22 inch gravel)	Sidewalk Reservoir (1160 sf, 22 inch gravel)
	Bioinfiltration (1825 sf)/trees	Bioinfiltration (3650 sf)/trees
BMP Capture Volume (gal)	6,807	13,614
Average rainfall event 0.4 inches	100%	100%
90%ile rainfall 1.2 inches	52%	100%
100%ile rainfall 2.5 inches	25%	50%
STREETS AND SIDEWALK 65 feet wide and greater; 500 feet long		
Example BMPs	Sidewalk Reservoir (750 sf, 22) inch gravel)	Sidewalk Reservoir (1500 sf, 22 inch gravel)
	Bioinfiltration (2604 sf)/trees	Bioinfiltration (5208 sf)/trees
BMP Capture Volume (gal)	9,724	19,448
Average rainfall event 0.4 inches	100%	100%
90%ile rainfall 1.2 inches	52%	100%
100%ile rainfall 2.5 inches	25%	50%

Once it was determined what was achievable on an individual street level, a ten-year snapshot of road reconstruction projects based on NYCDDC's capital improvement program was used to determine what would be achievable at a watershed level. A total volume of runoff capture was calculated for each of the two application scenarios (low and high capture) and the accumulated annual storage volumes were modeled using the INFOWORKS model to calculate the decrease in annual CSO volumes and overflow events for each WPCP drainage area.

Results

Results of the modeling for the ten year period for streets and sidewalks reconstruction are shown on Table 5.12 for individual drainage areas. Key findings are:

- Across the watershed, implementation of BMPs would reduce *untreated discharges to the Bay* including CSO, treated CSO, storm sewer and direct runoff of 3.4% (low capture) to 5.8% (high capture). See On-Site BMPs (Management Strategy 3a1) above for a definition of *untreated discharges to the Bay.*

TABLE 5.12. Benefits Of Street And Sidewalk BMPs By Drainage Area			
Condition	**Baseline Conditions**	**Streets & Sidewalks Low**	**Streets & Sidewalks High**
Coney Island WPCP Drainage Area			
Portion of Drainage Area Impacted (%)	N.A.	0.6%	0.6%
Total BMP Storage Volume (MG)	N.A.	1.3	2.6
Total CSO, treated CSO, storm sewer, and Direct Runoff (MG)	455.5	433.5	404.1
Reduction with BMPs (MG/yr)	0.0	22.0	51.4
Reduction with BMPs (%)		4.8%	11.3%
26th Ward WPCP Drainage Area			
Portion of Drainage Area Impacted (%)	N.A.	1.1%	1.1%
Total BMP Storage Volume (MG)	N.A.	1.1	2.2
Total CSO, treated CSO, storm sewer, and Direct Runoff (MG)	822.4	801.8	779.7
Reduction with BMPs (MG/yr)	0.0	20.6	42.7
Reduction with BMPs (%)		2.5%	5.2%
Jamaica WPCP Drainage Area			
Portion of Drainage Area Impacted (%)	N.A.	2.0%	2.0%
Total BMP Storage Volume (MG)	N.A.	9.1	18.2
Total CSO, treated CSO, storm sewer, and Direct Runoff (MG)	11,947.3	11,539.4	11,246.8
Reduction with BMPs (MG/yr)	0.0	407.9	700.6
Reduction with BMPs (%)		3.4%	5.9%
Rockaway WPCP Drainage Area			
Portion of Drainage Area Impacted (%)	N.A.	2.5%	2.5%
Total BMP Storage Volume (MG)	N.A.	2.4	4.8
Total storm sewer and Direct (surface) Runoff (MG)	2,605.6	2,516.5	2,486.7
Reduction with BMPs (MG/yr)	0.0	89.1	118.9
Reduction with BMPs (%)		3.4%	4.6%
Jamaica Bay Watershed Totals			
Portion of Drainage Area Impacted (%)	N.A.	1.6%	1.6%
Total BMP Storage Volume (MG)	N.A.	13.9	27.8
Total CSO, treated CSO, storm sewer, and Direct Runoff (MG)	15,830.9	15,291.2	14,917.2
Reduction with BMPs (MG/yr) (of untreated discharges)	0.0	539.6	913.6
Reduction with BMPs (%) (of untreated discharges)		3.4%	5.8%

Similar to on-site BMPs, off-site BMPs provide significant pollutant removal benefits in addition to reductions of untreated discharges. BMPs along streets and sidewalks and highway right-of-ways can also be instrumental in the capture of what is commonly referred to as the "first flush," highly concentrated pollutant loading that occurs during the early stages of a storm due to the washing effect of runoff on pollutants that have accumulated on impervious areas. Generally, it is the stormwater runoff draining the streets and sidewalks that contains the highest pollutant load, carrying automobile byproducts, road salt and sediment, and urban litter and debris.

Trees provide multiple pathways that alter the patterns of stormwater runoff, through the processes of rainfall interception on the leaves, trunk and branches, and the combined processes of runoff attenuation, infiltration, and vegetative uptake. Thus, an increase in vegetation and the number of street trees in the watershed would positively influence runoff processes by decreasing the volume and pollutant load of stormwater runoff entering the storm drain or combined sewer system.

Technical

As with on-site BMPs, there are a number of challenges to ensuring more widespread implementation of off-site BMPs, including maintenance, site conditions, and climate. These challenges are generally described under the summary of technical issues associated with on-site BMPs (see Management Strategy 3a1).

Costs

According to NYCDPR, Mayor Bloomberg has dedicated $391 million over ten years for greening initiatives (*e.g.*, planting street trees in all possible locations, creating 800 new greenstreets, and reforesting 2,000 acres of parkland), with the first year's funding becoming available starting July 1, 2007. In addition, the Mayor has funded an additional 156 staff and $4.6 million in new forestry and horticulture maintenance funds to support these greening efforts.

Table 5.13 below illustrates the average costs associated with other street and sidewalk BMPs including bioinfiltration and sidewalk reservoirs.

TABLE 5.13. Stormwater Capture Benefits Street And Sidewalk Prototype

Land Use Prototypes	Low Capture	High Capture
STREETS AND SIDEWALK 25 TO 65 feet wide; 500 feet long		
Example BMPs	Sidewalk Reservoir (580 sf, 22 inch gravel)	Sidewalk Reservoir (1160 sf, 22 inch gravel)
	Bioinfiltration (1825 sf)/trees	Bioinfiltration (3650 sf)/trees
BMP Capture Volume (gal)	6,807	13,614
Average BMP Scenario Cost	$102,900	$183,000
STREETS AND SIDEWALK 65 feet wide and greater; 500 feet long		
Example BMPs	Sidewalk Reservoir (750 sf, 22 inch gravel)	Sidewalk Reservoir (1500 sf, 22 inch gravel)
	Bioinfiltration (2604 sf)/trees	Bioinfiltration (5208 sf)/trees
BMP Capture Volume (gal)	9,724	19,448
Average BMP Scenario Cost	$130,200	$232,400

Legal

As with on-site BMPS, the Sewer Codes and potentially other codes may need to be revised to better facilitate installation of BMPs on a wider scale.

RECOMMENDATION

It is recommended that the City further pursue and encourage the use of BMPs on streets and sidewalks and highway rights-of-way in the Jamaica Bay watershed. This would be done through the *Implementation Strategies* listed below. Many of these Implementation Strategies address the uncertainties discussed above under environmental, technical, cost, and legal issues.

IMPLEMENTATION STRATEGIES

The integration of stormwater BMPs into the City's roadways, streets and sidewalks will occur over time as the City replaces and reconstructs its infrastructure. Developing more widespread use will require pilot projects and demonstration projects to determine the effectiveness of some of the measures and conditions unique to New York City along with monitoring programs to track the effectiveness over time. These Implementation Strategies are discussed below. See also on-site BMPs above for information about possible Sewer Code revisions and a companion BMP Design Manual that would also be needed to further encourage the installation of BMPs along streets and sidewalks.

In addition to the initiatives outlined below, the NYCDOT will be embarking on a *Streetscape NYC: Materials and Designs for the 21st Century* project to review and update street materials being used in New York City to include more sustainable designs. They will be leading an interagency task force to review performance and costs and develop recommendations.

Pilot Projects and Demonstration Projects

Belt Parkway Bridges Demonstration Project

NYCDEP and NYCDOT in consultation with NYCDPR and the NPS have developed designs for stormwater BMPs for the reconstruction of the Fresh Creek, Paerdegat and Rockaway Bridges along the Belt Parkway. This roadway improvement project provides an opportunity to incorporate stormwater BMPs that concurrently treat roadway runoff, attenuate direct discharges and provide freshwater habitat in the watershed. These initial bridges and their BMPs will serve as demonstration projects that could be expanded to other bridges.

FIGURE 5.9 Location of BMPs for the reconstruction of Rockaway and Paerdegat Bridges adjacent to the Belt Parkway; Source: NYCDEP

Preliminary concepts including linear bioinfiltration and bioswales have already been created, and are in the process of being reviewed for two of the three bridge crossings, Paerdegat and Rockaway (see Figure 5.9 for locations of BMPs). Drainage areas were determined for each site location and design option. Each site location includes unique hydraulic conditions that needed to be considered during the design process related to slopes, groundwater, overflow and potential for erosion.

Schedule: Final designs to be completed in three months.

Cost: The BMP designs for both bridges cost $95,000. Construction of BMPs for the Rockaway Bridge will cost $1,200,000. The total BMP construction cost for the Paerdegat Bridge has yet to be determined.

Vegetated swale installed in road median;
Source: USDA Natural Resources
Conservation Service

Streetside Infiltration Swales Pilot Study

NYCDEP, working with the Gaia Institute, will pilot test different infiltration and detention BMPs along streets and sidewalks within the Jamaica Bay watershed. This pilot study is designed to demonstrate the cost-effectiveness of streetside infiltration swales for a four lane, 500 linear foot street. Three swales would be installed along the roadway.

Schedule: Pilot study to begin in late 2007. Nine months to select site, design and install. Monitoring over a three year period to evaluate the effectiveness over time and under different environmental conditions.

Cost: $510,000 for design and construction. Additional funding will be provided for monitoring and reporting over three years.

Constructed Wetlands Pilot Study

NYCDEP, working with the Gaia Institute, will pilot test a constructed wetland to detain stormwater runoff from a roadway. The constructed wetland would be designed to capture runoff from 1.5 acres of impervious surface.

Schedule: Pilot study to begin in late 2007. Nine months to select site, design and install. Monitoring will be performed over a three year period to evaluate the effectiveness over time and under different environmental conditions.

Cost: $510,000 for design and construction. Additional funding will be provided for monitoring and reporting over three years.

Tree Pit Pilot Study

A pilot test to study the effectiveness of enhanced tree pits will be performed. Five enhanced tree pits would be designed to incorporate infiltration, retention and water harvesting practices as well as larger spaces for trees (4 feet wide by 20 feet long) than traditional tree pits (4 feet by 4 feet) (see Figure 5.10). The enhanced tree pits will be installed along a street. The enhanced tree pits would be designed to store stormwater in a subsurface cistern that can hold approximately 1,200 gallons of stormwater. Capture rates for an enhanced tree pit over a 24-hour period could be as high as 7,800 gallons. Water captured in the cistern could be stored and released slowly via gravity feed to a subsurface irrigation system. This pilot project will monitor additional benefits potentially provided by enhanced tree pits including improved chances for tree survival given a larger pit size and ability of the cistern to irrigate plantings during periods of reduced precipitation. The pilot projects could also test the use of "structural soils." These manmade "soils" consist of angular stone with some clayey topsoil and organic matter mixed in to increase the rooting zone area beneath pavements and thereby improve tree longevity.

Schedule: Pilot to begin in late 2007. Nine months to select site, design and install. Monitoring over a three year period to evaluate the effectiveness over time and under different environmental conditions.

Cost: $112,500 for five enhanced tree pit retrofits. Additional funding will be provided for monitoring and reporting over three years.

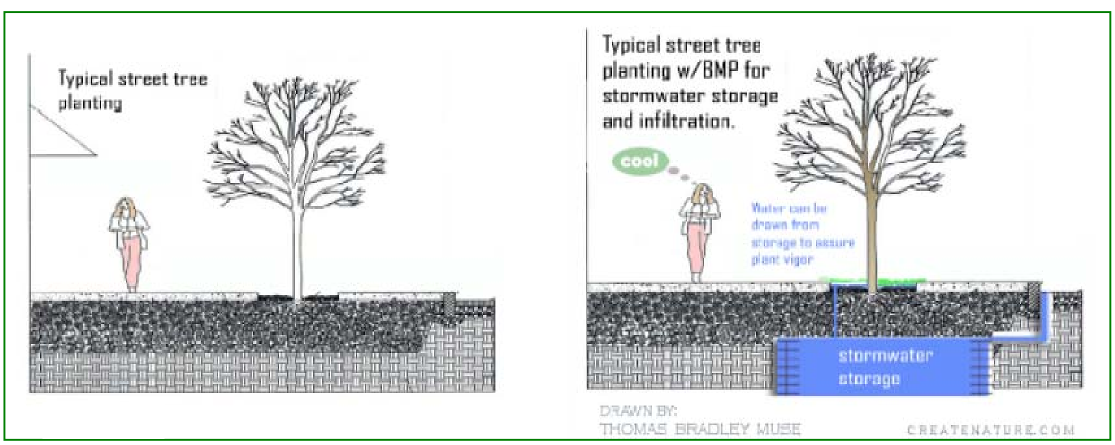

FIGURE 5.10 Comparison of typical street tree planting and street tree planting with BMP for stormwater storage and infiltration; Source: Gaia Institute

Greening Initiatives

PLANYC 2030 Street Tree Plantings

As discussed above, PLANYC 2030 has committed to planting one million street trees throughout the City. According to the NYCDPR 2000 Tree Census Survey, there are 74,138 street trees within the Brooklyn portion of the watershed and 105,931 street trees within the Queens portion of the watershed (Figure 5.11 provides street tree stocking levels within the Jamaica Bay watershed).. The Mayor's PLANYC 2030 includes an initiative to green the cityscape and specifically to increase the number of street trees in New York City by filling every available street tree opportunity in New York City. Current plantings citywide fill 74% of the existing space for street trees. The Mayor's goal is to raise the street stocking level to 100% as part of the overall goal of planting one million more trees by 2030. To achieve this, the City will plant approximately 23,000 additional trees annually citywide.

Schedule: 23,000 additional trees to be planted annually citywide.

Cost: $391 million including Greenstreets projects (see discussion below) over the next ten years.

PLANYC 2030 Greenstreets Initiative

PLANYC 2030 includes a strategy to undertake 40 new Greenstreets projects every planting season, bringing the total number of Greenstreets projects to 3,000 by 2017. The Jamaica Bay watershed is targeted for 14 new Greenstreets to be planted in Fall 2007 (see Figure 5.12). NYCDPR is interested in working with NYCDEP and NYCDDC to ensure that Greenstreets capture stormwater flows to the extent feasible.

Schedule: Fourteen new Greenstreets to be planted in the Jamaica Bay watershed in Fall 2007; 3,000 new Greenstreets citywide by 2017.

Cost: See Street Tree Plantings above.

East New York Community Forestry Management Plan

NYCDPR, together with community residents, developed a strategy for increasing the tree cover in East New York. The overall vision of the East New York Community Forestry Management Plan is to increase the health and extent of East New York's urban forest in order to improve the health and well-being of their residents. The primary goal of the plan is to increase the street tree stocking level of the East New York community from 52 to 100 percent in the next ten years. In addition, the plan seeks to establish a Friends of Trees Group. East New York was one of five City neighborhoods selected for the Trees for Public Health program based on two variables: street tree stocking level; and asthma hospitalization rates among children since trees are noted for their potential to improve air quality.

Cost: Implementation will be funded through PLANYC 2030 Street Tree Plantings (see above). An additional $425,000 in outside funding is needed each year to protect at least half of all new trees planted with tree guards (Figure 5.12).

Schedule: NYCDPR will plant 850 trees in East New York (Community Board 5) each year for the next ten years.

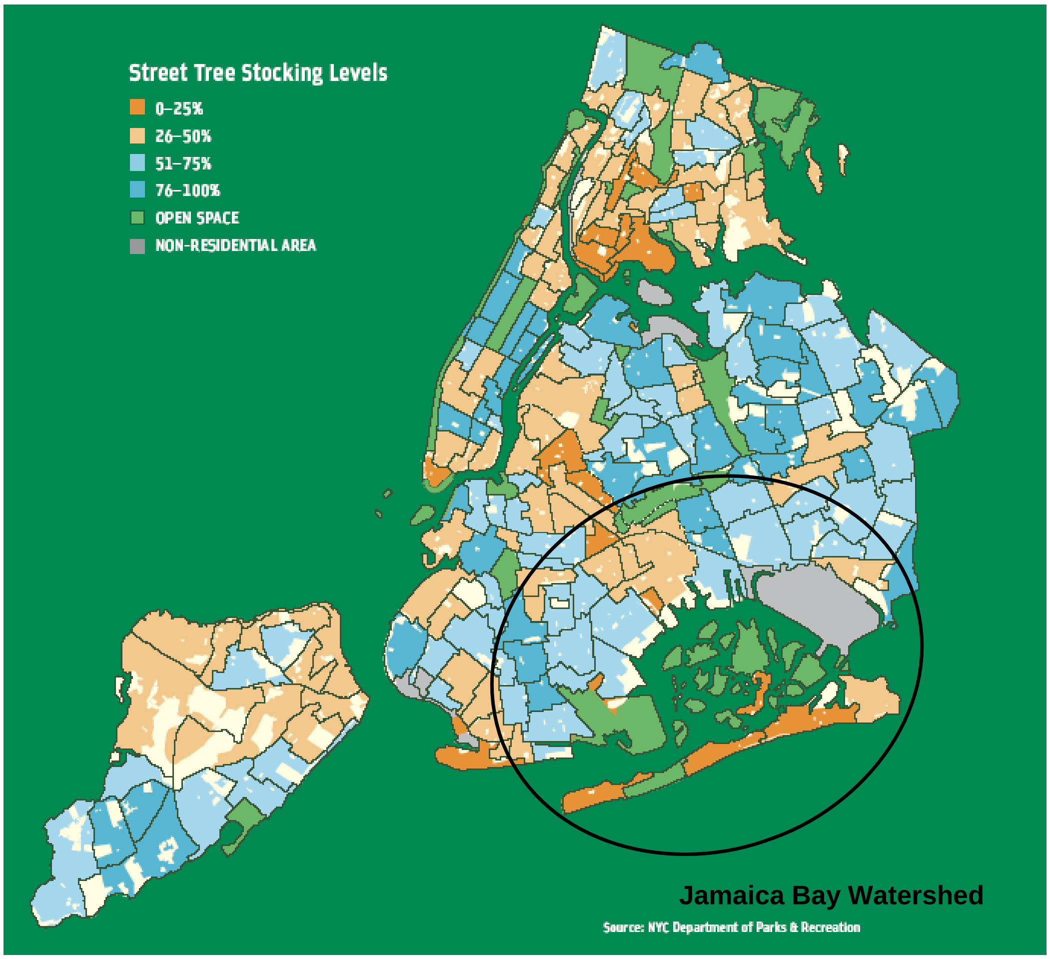

FIGURE 5.11 Street stocking levels in the Jamaica Bay Watershed;
Source: NYCDPR

Regulatory and Design Code Changes

Zoning Resolution Street Trees Requirements

NYCDCP is developing citywide street tree requirements for all zoning districts except for certain light and heavy industrial uses, to ensure that new developments and enlargements provide street trees (above a required baseline) and, as a result, increase permeability in the public right-of-way. The proposal calls for NYCDPR standards for tree pit design to be applied. To be implemented, the standards require a zoning text change through a process similar to ULURP.

Revising the Zoning Resolution to require more street trees would begin to change the surfaces of New York City, thereby reducing the environmental impacts of stormwater runoff. Such a requirement would have aesthetic benefits in addition to reductions in stormwater runoff.

Schedule: The proposed text amendment approval and public review process began on September 17, 2007 and involves the City Planning Commission, Community Boards, Borough Presidents, and City Council. If approved, the requirements would take effect on the date the proposed amendment is approved by the City Council.

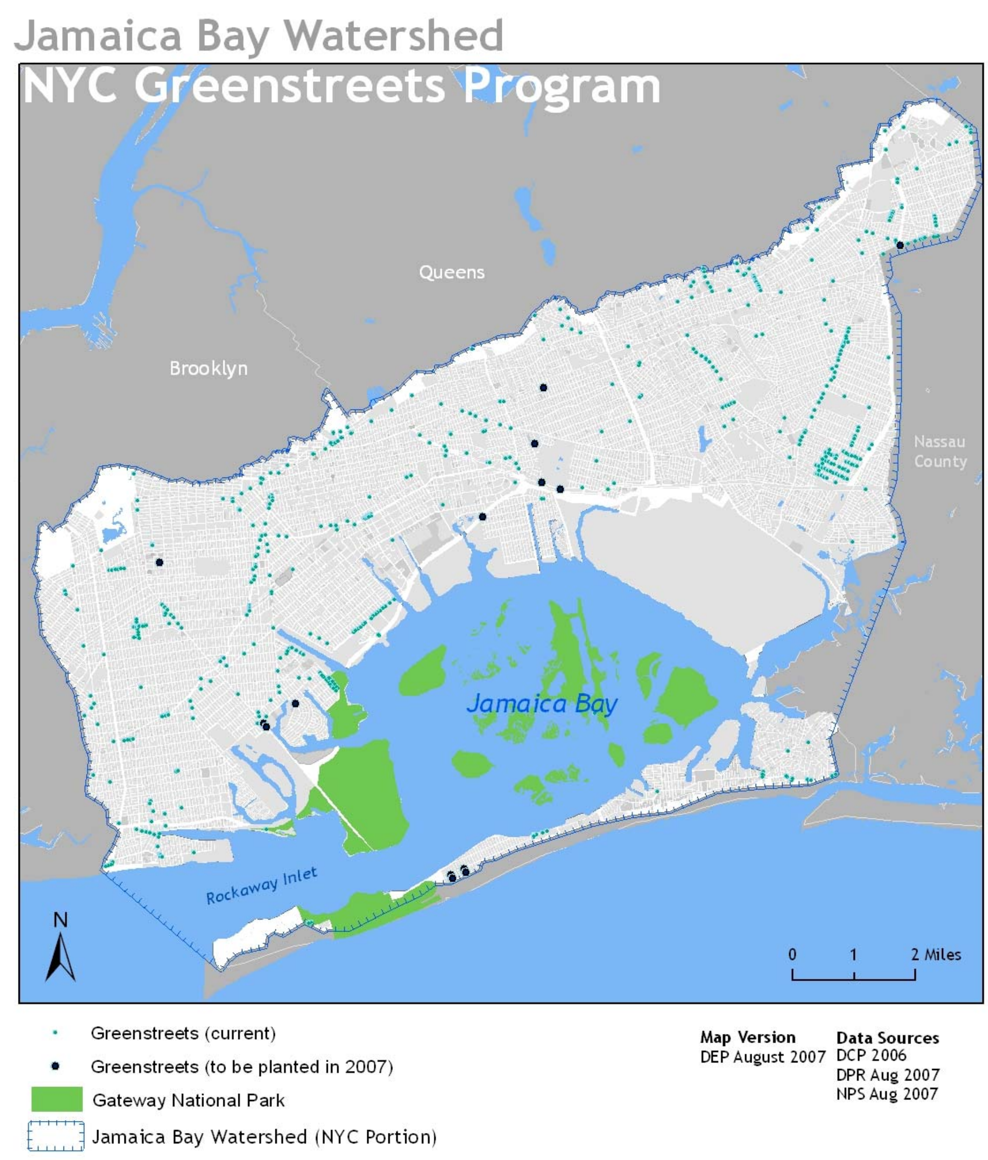

FIGURE 5.12 Jamaica Bay Watershed Greenstreets Program; Source: NYCDEP

Management Strategy 3b3: Promote the use of vacant public lands for their potential conversion to stormwater parks.

STRATEGY DESCRIPTION

Constructing off-site BMPs on existing publicly-owned vacant parcels and open spaces would allow BMPs to detain or infiltrate larger stormwater volumes from multiple adjacent parcels. This strategy would provide stormwater runoff benefits and establish "pocket parks" within the watershed. The design of these stormwater facilities can incorporate palustrine woodlands, gardens, vegetated swales, bio-infiltration areas, constructed wetlands, detention/retention ponds, and other stormwater capture and treatment features designed to attenuate urban stormwater runoff as well as provide some level of urban habitat and/or public use. The greatest opportunities lie in capturing runoff from adjacent developed lots by disconnecting roof leaders and rerouting the runoff from impervious surfaces into the off-site stormwater facility.

EVALUATION OF MANAGEMENT STRATEGY

Environmental

Approach

Modeling was performed to estimate the potential for publicly-owned vacant parcels to be used to capture and infiltrate stormwater runoff from a specified area surrounding the parcel. An inventory of publicly-owned vacant parcels was completed to identify vacant parcels that could be available for use as "stormwater parks." Recognizing that small parcels would not be able to store sufficient volumes of runoff, only vacant, city-owned parcels or adjacent parcels totaling 5,000 square feet (0.11 acres) or greater were selected.

TABLE 5.14 Runoff And Capture Volumes	
RUNOFF STORAGE POTENTIAL	
Lot size:	10,000 sq ft
Usable area:	80%
Usable area:	8,000 sq ft
Average storage depth:	2 ft
Average storage volume:	16,000 cu ft
Average storage volume:	120,000 gallons
AVERAGE RUNOFF PER BLOCK	
Average block area:	150,000 sq ft
Assume 90% impervious area	
2.5 inch event:	281,125 cu ft <-~50% runoff captured
1.2 inch event:	13,500 cu ft <-all runoff captured
0.4 inch event	4,500 cu ft <-all runoff captured

The results from the above analysis illustrated that 607 vacant public sites totaling 306 acres could potentially be used to implement public stormwater parks. These sites were then used to model the potential effects of constructing BMPs such as constructed wetlands and detention ponds. Table 5.14 presents the information used for runoff and capture volumes for a prototypical lot size of 10,000 square feet. In the model, these volumes were scaled based on the actual size of the lot in which BMPs were applied. (The determination of existing public vacant lots for potential use as "stormwater parks" consisted of a GIS desktop analysis only; the data used were not field verified to determine whether the lots identified remain vacant and publicly-owned at the time of modeling or publication of this report.)

RESULTS

The results of the modeling for constructing BMPs on vacant parcels for individual drainage areas are shown on Table 5.15. Key findings are:

- Installing BMPs on 306 acres of vacant land across the Jamaica Bay watershed would reduce *untreated discharges to the Bay* including CSO, treated CSO, storm sewer, and direct runoff by 6.8%. See On-Site BMPs (Management Strategy 3a1) above for a definition of *untreated discharges to the Bay.*

TABLE 5.15. Benefits Of Vacant Parcel BMPs By Drainage Area		
Condition	**Baseline Conditions**	**Vacant Parcels – Off-site Scenario**
Coney Island WPCP Drainage Area		
Portion of Drainage Area Impacted (%)	N.A.	0.3%
Total BMP Storage Volume (MG)	N.A.	16.6
Total CSO, treated CSO, storm sewer and Direct Runoff (MG)	455.5	443.1
Reduction with BMPs (MG/yr)	0.0	12.4
Reduction with BMPs (%)		2.7%
26th Ward WPCP Drainage Area		
Portion of Drainage Area Impacted (%)	N.A.	1.3%
Total BMP Storage Volume (MG)	N.A.	40.1
Total volume CSO, treated CSO, Direct Runoff (MG)	822.4	716.4
Reduction with BMPs (MG/yr)	0.0	106.1
Reduction with BMPs (%)		12.9%
Jamaica WPCP Drainage Area		
Portion of Drainage Area Impacted (%)	N.A.	0.3%
Total BMP Storage Volume (MG)	N.A.	48.1
Total CSO, storm sewer and Direct (surface) Runoff (MG)	11,947.3	11,258.4
Reduction with BMPs (MG/yr)	0.0	689.0
Reduction with BMPs (%)		5.8%
Rockaway WPCP Drainage Area		
Portion of Drainage Area Impacted (%)	N.A.	2.8%
Total BMP Storage Volume (MG)	N.A.	82.7
Total CSO, storm sewer and Direct (surface) Runoff (MG)	2,605.6	2,330.6
Reduction with BMPs (MG/yr)	0.0	275.0
Reduction with BMPs (%)		10.6%

TABLE 5.15. Benefits Of Vacant Parcel BMPs By Drainage Area		
Condition	**Baseline Conditions**	**Vacant Parcels – Off-site Scenario**
Jamaica Bay Watershed Totals		
Portion of Drainage Area Impacted (%)	N.A.	0.7%
Total BMP Storage Volume (MG)	N.A.	187.5
Total CSO, treated CSO, storm sewer and Direct (surface) Runoff (MG)	15,830.9	14,748.5
Reduction with BMPs (MG/yr)	0.0	1,082.4
Reduction with BMPs (%)		6.8%

Technical

Utilizing vacant parcels to construct BMPs designed to capture and infiltrate runoff presents similar maintenance issues as other BMPs previously described. Capture of roof runoff from adjacent parcels would require installing a "feeder pipe" from the roof leaders of each house to direct flow into stormwater parcel and could present potential conflicts with existing utilities or neighboring property uses. Finally, ponded water may be considered a health hazard that may require use of facilities that encourage infiltration or use sub-surface storage.

Cost

The cost of achieving the stormwater capture benefits above and installing BMPs on 607 vacant public sites within the Jamaica Bay watershed has not been estimated. It would depend on site specific conditions.

Legal

The Sewer Codes may need to be revised to better facilitate installation of off-site BMPs on a wider scale (see *Implementation Strategies* above for on-site BMPs). Currently, NYCDEP requires on-site detention storage when the capacity of the sewer is not adequate. However, the use of infiltration and retention measures is not typically encouraged under the current Administrative Codes. In addition, the Sewer Code does not permit stormwater to flow across property boundaries.

RECOMMENDATIONS

It is recommended that the City further pursue and encourage the use of vacant lots for off-site stormwater BMPs (stormwater parks) in the Jamaica Bay watershed. This would be done through the *Implementation Strategies* listed below. These Implementation Strategies address some of the uncertainties discussed above under environmental, technical, cost, and legal issues.

IMPLEMENTATION STRATEGIES

The development of stormwater parks will also require pilot projects and demonstration projects to determine the effectiveness of some of the measures and conditions unique to the drainage characteristics of the study area and the impacts on the existing sewer system. Similar to the other BMPs to be piloted, monitoring programs would be implemented to track the effectiveness related to stormwater runoff reductions over time as well as additional benefits provided such as opportunities for multi-use, pocket parks, green spaces, and urban habitat. These Implementation Strategies are further discussed below. See also on-site BMPs above for information about Sewer Code revisions and the companion BMP Design Manual that would be needed to further encourage the installation of BMPs on publicly-owned vacant parcels.

Pilot Projects and Demonstration Projects

Vacant Parcels Pilot Study

NYCDEP, working with the Gaia Institute, will implement a pilot project for a constructed wetland on a publicly-owned vacant parcel to capture runoff from a roadway (see the "Streetside Infiltration Swales Pilot Study" described above). The pilot project will be used to demonstrate the costs and benefits of BMP installation on publicly-owned vacant parcels. Based on these results, additional publicly-owned vacant parcels that show the most promise to reduce stormwater runoff entering the combined sewer system may be identified for future installation of BMPs. The inventory of city-owned vacant properties in the Jamaica Bay watershed, completed for the modeling exercise described above, and the sites identified for land acquisition in Chapter 4, *Ecological Restoration,* can be used to select parcels for the development of future stormwater park pilot projects. In addition, abandoned railroad corridors may provide a potential opportunity for implementing a BMP pilot.

Schedule: To be determined based on results of Streetside Infiltration Swales Pilot Study.

Cost: To be determined based on results of Streetside Infiltration Swales Pilot Study.

Management Strategy 3b4: Promote the use of existing open space (such as parks, plazas, community gardens, etc.) for their potential to accommodate stormwater BMPs.

STRATEGY DESCRIPTION

Existing open space can offer additional opportunities to attenuate, store, and infiltrate stormwater runoff in the Jamaica Bay watershed. Existing landscaped areas can be retrofitted to accommodate stormwater detention, retention, and infiltration capabilities, including bioretention, vegetated swales, rain gardens, etc., while improving the ecology of these same areas. An ancillary benefit associated with BMPs in active and passive open spaces is the educational information provided to park and open space users. Opportunities to provide interpretative or descriptive information about stormwater runoff and the benefits of BMPs for the City's surrounding waterbodies may increase awareness and encourage BMPs on private properties.

EVALUATION OF MANAGEMENT STRATEGY

Environmental
While the environmental impacts of applying BMPs to existing open space within the Jamaica Bay watershed were not modeled, the information developed for the analysis of vacant parcels could be directly applied to existing open space.

Technical
Fencing may be needed to prohibit access to retention ponds or constructed wetlands and swales may need to be clearly marked to prevent accidents and injuries.

Cost
See individual *Implementation Strategies* below for cost information.

Legal
As with on-site BMPS, the Sewer Codes may need to be revised and the BMP Design Manual will be developed to facilitate installation of BMPs on a wider scale.

RECOMMENDATION

It is recommended that the City further pursue and encourage the evaluation of existing publicly-owned open space for off-site stormwater BMPs in the Jamaica Bay watershed. This would be done through the *Implementation Strategies* listed below.

IMPLEMENTATION STRATEGIES

<u>Baisley Pond Park Project</u>

Baisley Pond is a 30-acre pond within the 110-acre Baisley Pond Park, located north of the Belt Parkway and west of Baisley Boulevard in Queens (Figure 5.13). The neighborhood directly adjacent to the eastern side of Baisley Pond experiences periodic flooding due to the absence of storm sewers. NYCDEP has developed a plan to discharge the stormwater from this neighborhood into Baisley Pond. The project will involve connecting traditional sewers within the neighborhood to a non-traditional stilling basin to reduce the water's velocity and allow the release of suspended sediment to the bottom of the basin where it will be periodically removed by NYCDEP. The water will then continue on its normal path to Jamaica Bay. To increase the pond's filtering abilities, the outlet will be planted with vegetation that can further remove stormwater pollutants as well as improve the pond aesthetics.

FIGURE 5.13 Baisley Pond Project area map
Source: NYCDEP

Schedule: Since the Baisley Pond stormwater upgrade will require street reconstruction, this project will be constructed by NYCDDC in coordination with NYCDOT and is slated to begin construction in 2010.

Cost: The estimated cost of constructing the project is $3 million to $4 million dollars.

Springfield Park Project

NYCDEP is currently designing a project to implement non-traditional stormwater management into Springfield Gardens, which drains in Springfield Lake, located in Springfield Park in Southeast Queens just north of JFK Airport (Figure 5.14). This area has recurrent flooding from insufficient storm sewers and poor roadway conditions.

To alleviate the community's flooding issues and improve water quality of Springfield Lake, new storm and sanitary sewers are proposed for the neighborhood south of South Conduit Avenue, west of Springfield Boulevard, and north of 149th Avenue. The current design moves stormwater through a freshwater wetland, a tidal wetland with a low marsh and elevated wooded buffer, and a stream with a wetland buffer on its way to Jamaica Bay. The construction of fresh water and tidal wetlands with stilling basins by each outfall would allow stormwater to decrease its velocity, giving time for sediments to sink to the bottom. Removing sediments from the water in stilling basins would reduce algal blooms in the lake and improve water quality throughout the system as well as downstream in Jamaica Bay. The accumulated sediments will be removed periodically by NYCDEP with Vactor trucks.

The current design would include dredging the lake of accumulated sediments and re-grading the lake bottom to create a more hospitable environment for diverse native vegetation. Along with flooding relief and water quality improvement, NYCDEP plans to maintain the water elevation and return the lake to its historic footprint while improving its aesthetic value to the community.

Schedule: The sewer and roadway reconstruction for Springfield Gardens has been implemented in phases: Phase C has been completed, Phases A and B are in progress, and Phase D, which includes the work discussed above, is slated to begin construction in 2009.

Cost: The estimated cost to construct the project is $15 million.

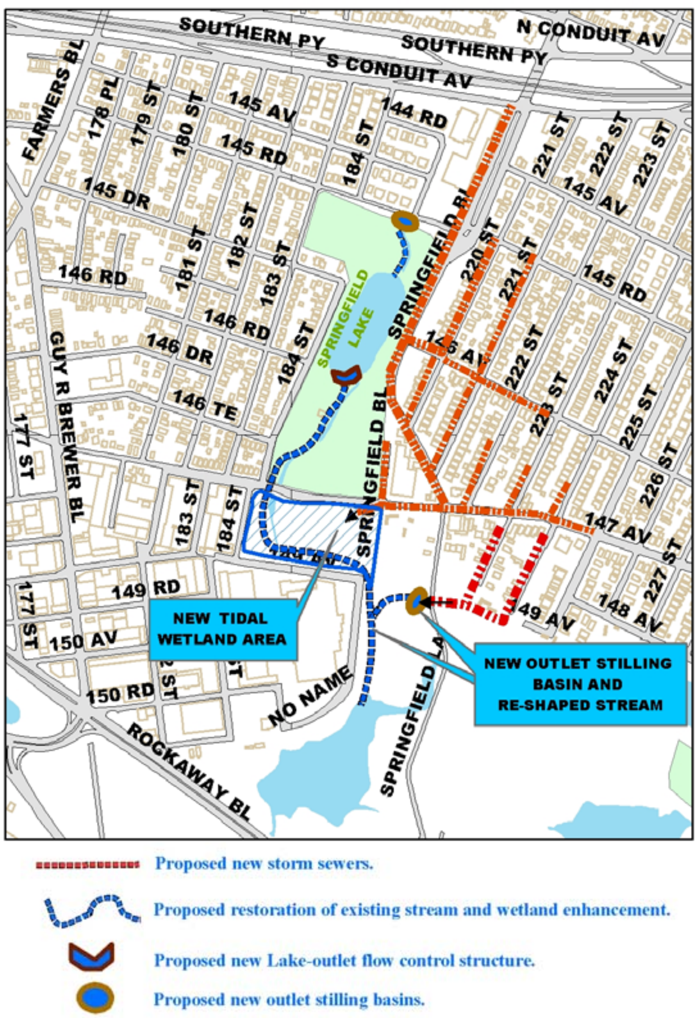

FIGURE 5.14 Proposed Springfield Gardens Stormwater Plan; Source: NYCDEP

BMP CONCLUSIONS

BMPs can effectively achieve substantial reductions in stormwater runoff generated by impervious surfaces. Table 5.16 presents four different scenarios that address new development, existing development, and streets and sidewalks. After a ten-year period, BMP implementation efforts in the Jamaica Bay watershed could yield:

- *Scenario 1*: Lower capture BMPs, such as rain barrels, rain gardens, and swales for existing development and streets and sidewalks, could reduce CSOs by 5% and achieve a 6% reduction in *untreated discharges to the Bay* including CSO, treated CSO, storm sewer, and direct runoff annually.

- *Scenario 2*: A scenario that includes rooftop detention or green roofs on new development and existing large rooftops could reduce CSOs by 17% and achieve a 13% reduction in *untreated discharges to the Bay* including CSO, treated CSO, storm sewer, and direct runoff annually.

- *Scenario 3:* A scenario that includes rooftop detention or green roofs on new development and existing large rooftops, and high capture BMPs on streets and sidewalks could reduce CSOs by 15% and achieve an 18% reduction in *untreated discharges to the Bay* including CSO, treated CSO, storm sewer, and direct runoff annually.

- *Scenario 4:* A scenario that includes medium capture BMPs on existing development and high capture BMPs on new development and streets and sidewalks could reduce CSOs by 25% and achieve a 24% reduction in *untreated discharges to the Bay* including CSO, treated CSO, storm sewer, and direct runoff annually.

Pollutant reductions from BMPs for the Jamaica Bay watershed include pathogens, nutrients and toxins. Pollutant load reductions are comparable to volume reductions. For example, an aggressive BMP implementation effort (Scenario 4) would achieve a 24% loadings reduction in total nitrogen, BOD, and fecal coliforms, while a low capture scenario (Scenario 1) would achieve a 6% loadings reduction in total nitrogen and BOD, and a 5% loading reduction in fecal coliforms.

As discussed in On-Site BMPs (Management Strategy 3a1) above, the results are presented as reductions with BMPs of *untreated discharges to the Bay.* Stormwater runoff from a site can travel many different pathways to reach a waterbody. And the Jamaica Bay watershed offers more pathways than are typically found in other parts of the City. Stormwater runoff that does not get treated by the WPCPs in CSO sewersheds (directly or indirectly passing first through CSO retention facilities) is discharged to the Bay as CSOs, partially treated CSOs (overflows from Spring Creek and planned Paerdegat Basin CSO facilities), storm sewer discharges, and direct surface runoff, which are cumulatively summarized as *untreated discharges to the Bay.* In the Jamaica Bay watershed, the majority of *untreated discharges to the Bay*, as measured by volume, are storm sewer discharges (62%), as compared to CSOs which make up only 12% of the discharges. This balance is highly influenced by the amount of stormwater introduced into the eastern section of Jamaica Bay in the Jamaica WPCP sewershed. In most other areas of the City, CSOs make up the predominant source of untreated discharges.

TABLE 5.16 Summary Of BMP Runoff Reductions and Costs					
Scenario #		1	2	3	4
Condition	Baseline Conditions	LOW CAPTURE BMPS (Existing Development, Streets/Sidewalks)	HIGH CAPTURE BMPS (Existing Development) PLUS MEDIUM CAPTURE BMPS (New Development)	HIGH CAPTURE BMPS (Existing Development, Streets/Sidewalks) PLUS MEDIUM CAPTURE BMPS (New Development)	MEDIUM CAPTURE BMPS (Existing Development) PLUS HIGH CAPTURE BMPS (New Development & Streets/Sidewalks)
Jamaica Bay Watershed Totals					
Portion of Drainage Area Impacted (%)	NA	6%	11%	12%	12%
Total BMP Storage Volume (MG)	NA	25	131	159	153
Total CSO, stormwater and direct (surface) Discharges (MG)	15,480	14,531	13,516	12,963	11,726
Reduction with BMPs (of untreated discharges) (MG)	NA	949	1,963	2,517	3,754
Reduction with BMPs (of untreated discharges) (%)	NA	6%	13%	18%	24%
Partially Treated CSO (MG)	514	497	285	357	402
Untreated CSO (MG)	1,841	1,752	1,529	1,572	1,381
Reduction with BMPs of CSO only (MG)	NA	106	541	426	572
Reduction with BMPs of CSO only (%)	NA	5%	17%	15%	25%
Cost ($)*	NA	$400 million	$470 million- $4.9 billion	$825 million - $5.2 billion	$3.2 billion
*Low end of cost ranges is for rooftop detention and high end is for green roofs.					

Example, the 25 percent reduction in *untreated discharges to the Bay* with high capture BMPs (see Table 5.16) includes not only reductions in CSO discharges, but large reductions in storm sewer discharges. Watershed-wide, the percent reduction for each type of discharge is based on where the BMPs are located in the watershed (*e.g.* a combined sewered or separately sewered area). If the development where the BMPs are located is primarily in the combined sewer area of the watershed, then much of the reduction will be in CSOs.

However, most of the discharges that will be addressed by BMPs in the Jamaica Bay watershed are likely to be discharges from storm sewers as the storm sewered areas represent a large portion of the drainage area tributary to the Bay. While storm sewer discharges contain significantly lower levels of solids and pathogens than are present in CSOs, they still contain significant pollutant loads from street runoff (oil, grease), lawn areas (pesticides and fertilizers), and numerous other pollutants. For example, stormwater is estimated to contribute about 45 to 50 percent of the total nitrogen discharged to the Bay from wet weather sources while only contributing about 10 percent of the pathogen loads to the Bay. This clearly indicates that the effectiveness of any BMP program will depend on the location within the watershed where the BMPs are applied. Currently, a major focus of NYCDEP's wet weather flow reduction program is focused on CSOs. However, it is expected that storm sewer discharges will be receiving increasing attention as a source of pollution.

It should be noted that not all BMPs are applicable across all systems, thus a menu of options is offered. In a combined sewer area, rooftop detention and other detention BMPs could be very effective in detaining stormwater that would be slowly released and ultimately make its way to a WPCP for treatment. On the other hand, in a separately sewered area, rooftop detention and other detention BMPs would not be effective in reducing stormwater volumes or pollutants. They would merely detain the stormwater for release a few hours later, having no effect on discharges. However, with a large enough penetration rate, they could be effective in reducing some of the effects of flooding. In areas with storm sewers, infiltration BMPs or green roofs would be most effective; however, in many of these areas in the watershed, there are high groundwater tables that would preclude the use of infiltration BMPs.

It is also important to understand that the results presented are reductions with BMPs in *untreated* discharges to the Bay. This does not mean that BMPs reduce discharges to the Bay. All stormwater would ultimately discharge to the Bay, whether it be very slowly via infiltration and groundwater or more rapidly through WPCP discharges, thereby maintaining salinity levels similar to those there now. However, with BMPs, the stormwater is "treated" in some manner prior to discharge to reduce CSO and stormwater pollutants that negatively influence the Bay.

These environmental benefits need to be understood in the context of what is achievable. For purposes of this Plan a number of what-if scenarios were developed. *What if* all new development and 10% of existing development were to implement BMPs? *What if* all existing large rooftops were to implement BMPs? While the Plan answers these questions to a certain degree, a much more difficult question is: "How much can be implemented?" The answer to this question will depend on the development of a comprehensive program that will potentially include regulatory measures, incentive programs, and public outreach. This effort, being orchestrated through the Mayor's Interagency BMP Task Force, will require the coordination of the resources of many City agencies, private interests, and other stakeholders.

As positive as the potential benefits are, they come at a hefty price. The scenarios outlined above for the Jamaica Bay watershed result in a wide range of costs:

- Scenario 1: $400 million for a program achieving a 6% reduction in untreated discharges to the Bay.
- Scenario 2: $470 million – $4.9 billion for a program achieving a 13% reduction in discharges to the Bay.
- Scenario 3: $825 million – $5.2 billion for a program achieving a 18% reduction in discharges to the Bay.
- Scenario 4: $3.1 billion for a program achieving a 24% reduction in discharges to the Bay.

Note that ranges are provided for Scenarios 2 and 3. The low end of the range assumes rooftop detention for new and existing development (no costs are assumed for rooftop detention for new development, since these new developments would likely require either subsurface or rooftop detention under the current provisions of the Administrative Code). The high end of the range assumes green roofs for new and existing development.

These cost estimates are substantially higher and would capture a significantly smaller percentage of CSOs than that which is currently proposed under NYCDEP's CSO Long Term Control Program. That program focuses on hard infrastructure including the installation of storage tanks, additional treatment capacity and the construction of high level storm sewers.

However, there is still much to be resolved on the costing side of BMPs. *The Jamaica Bay Watershed Protection Plan* utilizes the best available information on the cost of BMP installation in New York City. However, there is little information to draw from that is specific to New York City implementation, and there are many uncertainties associated with these costs. One of the key purposes of the pilot studies proposed in this Plan is to develop better cost estimates for both capital and maintenance costs and to determine which BMPs provide the most cost-effective results under New York City conditions.

The cost-benefit equation will also differ from area to area in the City. In Jamaica Bay, large CSO storage tanks are cost-effective because there is typically one CSO outfall per tributary basin and a storage facility can be located so as to capture CSOs in one location. In other areas of the City, CSOs are more diffuse. Either more smaller tanks would need to be built, or sewer construction would be needed to reroute and concentrate flows at a tank location. In addition, much of the Jamaica Bay watershed discharges to separate storm sewers, therefore effects of BMPs on CSOs in this watershed are not as significant as they would be in largely combined sewered areas.

Another key consideration is: *who pays*? While NYCDEP, and ultimately the City's water and sewer ratepayers, will bear the burden of expenditures for new CSO tanks and other hard infrastructure costs, the costs for BMPs can be allocated differently. One approach could be to mandate BMPs for new development, thereby placing greater responsibility on new development to offset the additional burdens it would place on the City's already taxed infrastructure. Credit programs could be offered to partially offset some of these costs.

In addition, large-scale infrastructure projects do not necessarily provide greater benefits than do low-impact small-scale technologies. When a large-scale infrastructure element has a problem or needs repair, large geographic areas can be affected. Diffusely located BMPs would not subject any area to large-scale disruptions.

Further, the benefits of BMPs should not be compared only to the NYCDEP's CSO program. In fact, BMPs are embraced by many municipalities around the country that do not have CSOs. By addressing stormwater generation at its source and fostering low-impact development, BMPs can provide many benefits that end-of-pipe treatments cannot.

In addition to controlling stormwater runoff and CSO volumes and pollutant loads, some of the many benefits BMPs and source controls provide include:

- Reducing urban heat island effect: Impervious surfaces, prevalent in urban areas, increase urban temperatures as compared to suburban and rural temperatures. Many BMPs that reduce impervious areas and increase vegetative and tree canopy reduce the urban heat island effect, thus reducing ambient temperatures and energy needs.

- Greenhouse gas reductions: Reductions due to reduced energy use and carbon sequestration, reducing carbon dioxide through plant uptake.

- Flood mitigation: Because BMPs reduce the rate and/or volume of stormwater runoff, they can alleviate localized street flooding by detaining water so it does not reach the street during peak stormwater generation. However, in areas that are prone to flooding due to high groundwater tables, infiltration BMPs cannot be used.

- Habitat: Trees and other BMPs provide habitat for wildlife.

- Erosion control: BMPs reduce sediment loadings from construction sites and other exposed areas.

- Aesthetic amenities: BMPs add greenery and, at times, open space to private properties and public areas. These amenities have been documented to increase property values. In fact, many tenants are attracted to, and willing to pay a premium for, apartments and office space in LEED-certified buildings.

While these benefits are difficult to quantify in dollars, Columbia University recently undertook a study for green roofs with assumptions specific to New York City (Acks, 2006). Columbia University modeled a green roof installation on a single building (green roof of 1,968 sq ft) and a wide-scale installation of 7,698 acres of green roofs (equivalent to 4% of the City total land area, or greening 50% of the City's flat roofs) (see Table 5.17 below for estimated benefits). The Columbia Study concludes that green roof infrastructure is cost-effective when all of these benefits are incorporated.

TABLE 5.17. Quantified Green Roof Benefits		
1 GREEN ROOF (1,968 SQ FT)		
Benefits and Costs	**Modeled Benefit**	**Additional Information**
Energy used for cooling	15% reduction	Difficult to estimate given that each building has different and cooling demands that depend on a variety of parameters associated with a building
Sound reduction	3 decibels	Figure used to estimate change in property value; based on data from German green roof company
Private aesthetic benefits	$10-50 per person benefiting	Based on willingness-to-pay for building amenity; based on Toronto study
7,698 ACRES OF GREEN ROOFS (4% of the City total land area)		
Benefits and Costs	**Modeled Benefit**	**Additional Information**
Urban heat island	$213 million (total savings resulting from energy reduction)	0.8˚F temperature reduction results in 5% reduction in energy demand for cooling
Stormwater runoff	1.9% reduction in capital expenditures	Resulting from retention of 50% of rainwater that falls directly on roof
Greenhouse gases	$0.18 per square foot in savings	Based on Toronto study
Air Pollution	$2.2 per pound	Assumed 20% reduction in airborne particulates; based on US Forest Service model
Health	Mean willingness to pay for longer/healthier life	Based on USEPA numbers
Public aesthetic	1.7 million people benefiting	Assumes 12 people per green roof would enjoy

As BMPs become more widely used and as contractors and developers incorporate more BMPs into their developments, lessons will be learned, cost efficiencies will be identified, and economies of scale will be accrued. Installing BMPs at City-owned facilities, an approach being pursued through the Mayor's Interagency BMP Task Force, will also set an example and help to establish the market. It is NYCDEP's hope that the implementation strategies suggested in this Plan, from the many pilot studies that will be conducted to the code reviews and the incentive programs that will be explored, will help lay the groundwork for more widespread acceptance of BMPs in New York City.

The future for BMPs is encouraging, but it will take time to see the benefits. It will involve harnessing the resources of many city agencies, private developers, homeowners and environmental organizations. End-of-pipe solutions also take long periods of time to become facts on the ground, involving very lengthy design and construction processes. The City has patiently awaited these facilities to be built and their effects to be made known; it is now time to pursue BMPs with the same patience and commitment.

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