SUSTAINABLE RAINDROPS

Cleaning New York Harbor by Greening The Urban Landscape

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About Riverkeeper: Riverkeeper's mission is to safeguard the ecological integrity of the Hudson River, its tributaries and New York City's drinking water supply by prosecuting polluters and promoting effective environmental policies. Since 1966, Riverkeeper has investigated and brought to justice thousands of environmental lawbreakers. Along with sister groups New York-New Jersey Baykeeper and Long Island Soundkeeper, Riverkeeper has been working on combined sewage overflow issues in New York City for nearly two decades. Riverkeeper and its local sister groups are part of the international Waterkeeper Alliance, now comprised of more than 156 individual "keepers" around the world. For more about Riverkeeper, visit **www.riverkeeper.org**. For more about the Waterkeeper Alliance, visit www.waterkeeper.org.

Riverkeeper is a founding member of S.W.I.M (Storm Water Infrastructure Matters), a coalition dedicated to ensuring swimmable waters around New York City through natural, sustainable storm water management practices in our neighborhoods. For more about S.W.I.M., visit www.swimmablenyc.org.

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TABLE OF CONTENTS

EXECUTIVE SUMMARY

More than 27 billion gallons of raw sewage and polluted stormwater discharge out of 460 combined sewage overflows ("CSOs") into New York Harbor each year. Although water quality in the Harbor has improved significantly over the last few decades, most parts of the waterfront and its beaches are still unsafe for recreation after it rains. As little as one-twentieth of an inch of rain can overload the system. The main culprit is New York City's outmoded sewer system, which combines sewage from buildings with dirty stormwater from streets.

This extraordinary degree of pollution imposes steep environmental, human health, and economic costs on the City and its residents. CSO discharges, in addition to preventing safe recreation, impair navigation and damage fish habitat. Sadly, the New York City Department of Environmental Protection ("DEP") may be understating the severity of the CSO pollution in the Harbor due to sampling inadequacies.

Federal and state law requires New York City to bring its CSO discharges into compliance with water quality standards. The DEP must submit the initial outline for its long-term CSO control plan to the New York State Department of Environmental Conservation ("DEC") in June 2007.

The DEP is Investing in Obsolete Infrastructure.

The DEP's June 2007 plan will likely favor a $2.1 billion investment in end-of-pipe tanks and in-line storage for CSO pollution. This approach ignores meaningful and economical alternatives that reduce the volume of stormwater entering the system. Furthermore, these end-of-pipe investments will fail to bring the City into compliance with water quality standards. After the proposed end-of-pipe projects are completed in the next two decades, the City will continue to discharge 22 billion gallons or more of CSOs each year. Acknowledging that its plan is likely to fail, the DEP has already applied for variances in anticipation of its inability to meet water quality standards.

The burden of fixing the CSO problem falls on all the agencies that manage the urban environment, including the Departments of Buildings, Transportation, and Parks. The state DEC recognized as much, naming the "City of New York" and the DEP as parties to a recent CSO enforcement action. Yet, no other City agency was brought to the table by the DEC. As a consequence, the DEP is going it alone, driven by a mindset that regards stormwater as a waste that must be disposed of rather than a resource to be utilized at the source, where the rains hit the ground. For a long time, this mindset has ignored the state-of-the-art source control technologies and practices described in this report. A DEP study now underway in Jamaica Bay is encouraging, but the report will not be complete for the June deadline.

Source Control is the Economical and Sustainable Alternative.

New York City needs to adopt a sustainable approach to CSOs that gives appropriate consideration to stormwater source controls that keep stormwater from ever entering the sewage system in the first place. Source controls include street trees, "Greenstreets" parks (smaller vegetated areas on streets), green roofs, rain barrels, and direct injection into groundwater. Any excess stormwater that is not captured by source controls would then enter the sewage system for eventual treatment. Source controls must be viewed as a long-term, economically viable alternative to be used in concert with end-of-pipe controls, not just as convenient gap-fillers.

This report demonstrates that source controls may be significantly more cost effective than end-of-pipe controls, even when favoring conservative assumptions. The gallon-removal benefits of source controls can be measured. For $1,000 invested in the DEP's end-of-pipe projects, CSOs might decrease by 2,400 gallons per year. By comparison, the same $1,000 investment in:

- Greenstreets could decrease CSOs by 14,800 gallons;
- Street trees could decrease CSOs by 13,170 gallons;

- New green roofs could decrease CSOs by 810 gallons; retrofitted green roofs could decrease CSOs by 865 gallons; and incentivized green roofs could decrease CSOs by 12,000 gallons; and

- Rain barrels could decrease CSOs by 9,000 gallons.

The EPA Endorses Source Control.

Source control systems work. The EPA recognizes the effectiveness of source control, as noted in guidance by the Assistant Adminstrator on March 5, 2007 (attached as an appendix). Cities across the country, including Chicago, Milwaukee, Pittsburgh, Portland, Seattle, and Washington D.C. have recognized the effectiveness of source control and have implemented programs in an effort to control CSOs. And while source control is only done in New York City on a haphazard basis, the City Office of Environmental Coordination has itself recognized its effectiveness. The DEP is well behind the curve in embracing the obvious benefits of keeping stormwater out of the sewer system.

A recent and ongoing DEP source control study by the company Biohabitats is somewhat encouraging. However, a draft of that study was slated to be released in October 2006 but was instead inexplicably delayed until *after* the June 2007 deadline. Further, the DEP cancelled the only two prior source control studies that might have informed the CSO long-term planning process in time for the June 2007 submission deadline to the state DEC.

Stormwater Can Make the City More Sustainable.

Source control regards stormwater as a resource to be utilized for much broader sustainability purposes, rather than a waste that must be disposed. By giving life to vegetation, stormwater can help prepare the City for the effects of climate change, decrease summer temperatures, promote energy efficiency, improve air quality, and make communities more livable. A major commitment to source control would help advance a number of ambitious and laudable goals that Mayor Michael Bloomberg wants the City to attain by the year 2030. The following findings illustrate the wisdom of an ambitious source control commitment, over and above its effectiveness in reducing CSO discharges:

- In twenty years, additional unsustainable growth could add to the urban heat island beyond the 2 to 3°F temperature increase that will accompany global warming. Surface temperatures in the City could be reduced by 1.4°F if 50 percent of the flat roofs in the City were converted to green roofs. This decrease in temperatures correlates to energy savings of $70 million dollars per year;

- By adding another 300,000 street trees to the 500,000 existing street trees, over 60 tons of air pollution can be removed from the City's air every year;

- By decreasing the city temperature 1.4 degrees, ozone concentration could be decreased over 10% on summer days. Ozone removed by biological processes in trees would annually remove an additional 12,000 pounds of ozone per 100,000 trees;

- Comprehensive City greening could decrease citywide temperatures by 1.4°F. The resulting energy conservation would remove 85,000 tons of air pollution, including carbon dioxide emissions. Decreased energy consumption from dirty power plants would decrease the City's contribution to global warming and dependence on foreign oil. In contrast, simply treating the 5 billion gallons of captured stormwater with the proposed end-of-pipe controls will create nearly 5,000 tons of air pollution via energy consumption at the sewage plants; and

- Rain barrels and stormwater capture would conserve residential and commercial water usage, putting stormwater to use for irrigation, sidewalk cleaning, cooling, industrial use, and sanitary needs.

End-of-pipe controls confer <u>none</u> of these benefits.

The City has demonstrated the capacity to manage distributed systems. Programs at such as the DEP's catchment basin cleaning and at the Department of Parks and Recreation's street trees and Greenstreets programs suggest the City already has the competence to manage a distributed stormwater source control system.

Visionary Leadership is Needed.

The Mayor's Office of Long Term Planning and Sustainability is set to release its sustainability plan in early Spring 2007. The sustainability plan will hopefully include, among many things, the specific ways in which stormwater can be controlled at the source. Yet in December, the Mayor was unwilling to commit the New York City to a goal of making the Harbor safe for swimming by 2030. This reluctance stems from DEP's reluctance to fully address CSOs. Based on DEP's most recent statements, few meaningful source control initiatives will be incorporated into the June 2007 DEP plan, which will chart the City's approach to CSOs for the next generation.

The DEP's long term CSO planning is part of a binding, legal construct, driven by a matrix and federal and state laws, enforcement actions, and legally required citizen participation. To implement a sustainable and effective CSO solution, the Mayor's likely initiatives must be merged into the binding long-term planning process. Provision must me made for continued public participation until the planning process is complete.

Mayor Bloomberg has consistently demonstrated that the impossible is within reach. Despite the great challenges ahead, the creation of the new Office of Long Term Planning and Sustainability and the level of public involvement to date present reasons for optimism.

Eliminating the combined sewage overflow problem—and greening the City—will require the vision, toughness and endurance necessary to wrestle an entrenched bureaucracy. The Mayor should set a goal of a swimmable and fishable Harbor. While this would mean taking on the DEP, the Mayor can take inspiration from precedent. In 1997, the historic Watershed Agreement ensured for the protection of the City's upstate reservoir system *at the source* rather than building a multi-billion dollar filtration plant at the *end-of pipe.* The Agreement was hailed as an international model for drinking watershed management. Mayor Bloomberg could implement a similarly groundbreaking plan for stormwater source control within the five boroughs, and use it to advance a more sustainable urban environment.

This report does not purport to be the final answer on the benefits and costs of stormwater source control in New York City. Rather, the preliminary findings in this report demand the need for a robust discussion and further in-depth technical analysis of source control.

Section I of this report discusses the environmental and economic costs of combined sewage overflows on the City and demonstrates how the DEP's likely plan will fail to achieve water quality standards.

Section II reveals that source control technologies can be more cost effective than end-of-pipe controls at reducing CSOs.

Section III describes the substantial sustainability benefits of source controls.

Section IV provides three examples of CSO control scenarios, spreading $2.1 billion across source control and end-of-pipe alternatives.

Section V concludes the report with a series of recommendations.

I. COMBINED SEWAGE OVERFLOWS IMPOSE STEEP ENVIRONMENTAL AND ECONOMIC COSTS ON NEW YORK CITY.

Although water quality in New York Harbor has significantly improved over the last few decades, the waterfront and its beaches are still too dirty for safe recreation after it rains. New York City Mayor Michael Bloomberg recognized as much in a recent speech when he announced a goal to make 90 percent of the Harbor safe enough for boating by 2030.[1] This goal falls far short of making waters safe for swimming, demonstrates a reluctance to meaningfully address the sheer levels of pollution currently inundating the Harbor, and shows an unwillingness to take on a bureaucracy that seeks to maintain the status quo.

This map of New York Harbor shows the locations of <u>some</u> of the 460 CSOs citywide, indicated by red dots. Image: Sustainable South Bronx. For a more detailed map, see <u>http://www.nyc.gov/html/dep/pdf/hsurvey97.pdf</u>

The main culprit for Harbor pollution is the City's outmoded sewer system. The City combines sewage from buildings with dirty storm water runoff from streets. As little as a twentieth of an inch of rain can overload sewer lines and the City's fourteen sewage treatment plants. As a result, more than 27 billion gallons of the combined flow of sewage and dirty stormwater is diverted into the harbor each year at more than 460 combined sewage overflow ("CSO") locations around the City (map at left). That is more than 520 million gallons each week.[2] These diversions severely impact water quality with toxins, bacteria and pathogens, placing the public at risk.

Federal and state law requires the City to meet water quality standards by controlling CSOs. In 2004, the City of New York and the City Department of Environmental Protection ("DEP") entered into an administrative consent order with the State Department of Environmental Conservation ("DEC"), requiring a variety of end-of-pipe CSO abatement projects. In June, the City Department of Environmental Protection ("DEP") must submit to the state Department of Environmental Conservation ("DEC") its proposal for exactly how it will reduce CSO discharges. While the 2004 consent order[3] named the DEP *and* the City of New York—and by extension all of its agencies—the DEP is the only agency charged with devising a solution.

A logical approach for the DEP to pursue would begin with preventing as much stormwater as possible from entering the system in the first place, i.e. "source control,"[4] while simultaneously expanding the inline capacity of the sewer system and treating any remaining overflows at the end of the pipe. This would require collaboration between the DEP, which manages the City's wastewater infrastructure, and the many other agencies managing the urban landscape, such as the Departments of Buildings, Parks and Recreation, and Transportation.

Unfortunately, the DEP's go-it-alone proposal is likely to exclusively rely on end-of-pipe controls. The controls currently planned and under construction by the DEP will cost more than $2.1 billion over the next two decades but will *not* result in the attainment of water quality standards, as the DEP itself admits.[5] If the DEP succeeds in convincing the state DEC that it cannot meet water quality standards, it will seek to lower them. This is terrible public policy and should not be allowed.

Combined Sewage Discharges and Polluted Stormwater Runoff Severely Affect New York Harbor.

Overflow pipes like this one on Newtown Creek discharge raw sewage and dirty stormwater into New York Harbor. Image: Giles Ashford © 2004.

The 27 billion gallons of CSO discharges into the Harbor severely impact water quality and threaten public health. In addition to discharging bacteria and pathogens associated with raw sewage, CSOs also contribute toxins such as PCBs, dioxins, mercury and other metals, pesticides and petroleum products.[6] New York State classifies 18 of the City's waterbody segments as substantially "impaired" for human uses or aquatic life as a result of pathogens, oxygen demand, nitrogen or trash discharged in CSOs.[7]

Combined sewage overflows prevent safe recreation on the Harbor. Because of the hazards posed by bacteria and pathogens in raw sewage, beaches around the City must be closed after rains because of health hazards associated with CSOs.[8] In 2006, CSOs forced the closing of Orchard Beach for 3 days and nine private beaches for a total of 66 days.[9] In 2005, CSOs forced the closing of Wolfe's Pond for 9 days and two private beaches for 34 days.[10] In 2003, race officials cancelled the swimming portion of the New York City triathlon because CSOs made the Hudson River too polluted for swimming.[11]

New Yorkers are rediscovering the waterfront, drawn there in part by major, public investments in parks and promenades. People want more than vistas, however, they want access to swimmable waters and clean beaches. In increasing numbers, New Yorkers are using the Harbor for kayaking, swimming, and fishing. People want the City to commit to making waters fit for swimming by 2030, not just for boating and sailing—an uninspiring goal set by the Mayor. One swimming coalition called S.W.I.M. (Storm Water Infrastructure Matters) is calling for a greener urban landscape as a solution to the CSO problem.[12]

Combined sewage overflows impair navigation in the Harbor by contributing polluted sediment to the Harbor seafloor. Over 11 percent of the toxic sediment entering the Harbor comes from CSOs in New York and New Jersey, increasing the frequency and cost of dredging.[13] For example, long stretches of Newtown Creek (which is classified a Significant Maritime Industrial Area[14]) are unnavigable because of this sedimentation, a situation that virtually eliminates barging opportunities for many waterfront businesses along this waterway that cannot afford the cost of periodic dredging.

Combined sewage overflows contaminate shellfish beds and aquatic life. In the Harbor, these shellfish beds must be closed after storms because disease causing organisms[15] in untreated sewage collect in the shell fish and can lead to gastroenteritis, hepatitis, typhoid fever, and cholera.[16]

Of major concern are the thousands of New Yorkers and their families who subsist off of fish and shellfish caught within yards of CSO outfalls. Many of these subsistence anglers favor the certainty of a meal over the prospect of an eventual sickness caused by toxins in fish.[17] An EPA study of 200 subsistence anglers in the Greenpoint-Williamsburg section of Brooklyn found that fish caught in the East River and Newtown Creek fed an average of six family members per angler. [18] The study also emphasized that for many of the poor, immigrant anglers, fishing is a way of life rooted in cultural heritage.[19]

Combined sewage overflows are also the main source of floatable debris in the Harbor,[20] *contribute to decreased dissolved oxygen levels that suffocate or stress fish*, and *dump over 300,000 tons (about 20,000 dump truck loads) of nitrogen, phosphorous and organic carbon into the harbor every year* – the three key ingredients for harmful algal blooms.[21]

Polluted stormwater discharges severely affect certain parts of the Harbor. Some parts of the City, particularly in the outer boroughs, are separately sewered but have few source controls or best management practices to prevent polluted stormwater runoff. Stormwater from these areas runs off dirty streets, picking up oils, toxins, and debris and then discharges, untreated, into the Harbor. For example, untreated stormwater seriously impacts Jamaica Bay's tributaries.[22]

The DEP May Be Understating the Severity of Sewage Pollution in the Harbor.

Harbor water quality is undeniably impacted by CSOs. Yet, the DEP's existing data and studies on the effects of CSOs may actually understate the problem. The DEP samples water quality far less frequently than the minimum required by law to assess water quality compliance.[23] Furthermore, New York State's coastal recreation water quality pathogen criteria[24] are not sufficiently protective of human health to comply with the Clean Water Act. [25]

In fact, even if DEP sampled frequently enough to determine compliance, the data would still fail to assess the full effects of CSOs discharges. The DEP's sampling stations are often located in the center of waterways. Because bacterial effects of CSOs are greatest near combined sewer outfalls during and after storms, monitoring performed away from the shore without regard for rain events distorts results. Recreational uses like swimming, fishing and boating often occur near the shoreline, and thus closer to the CSOs outfalls, where higher pollutant levels would be expected.[26]

The City's waterfront is undergoing a renaissance. Yet, until conditions are fully addressed, adequately sampled, and properly disclosed, CSO will prevent New Yorkers from fully using and enjoying the Harbor.

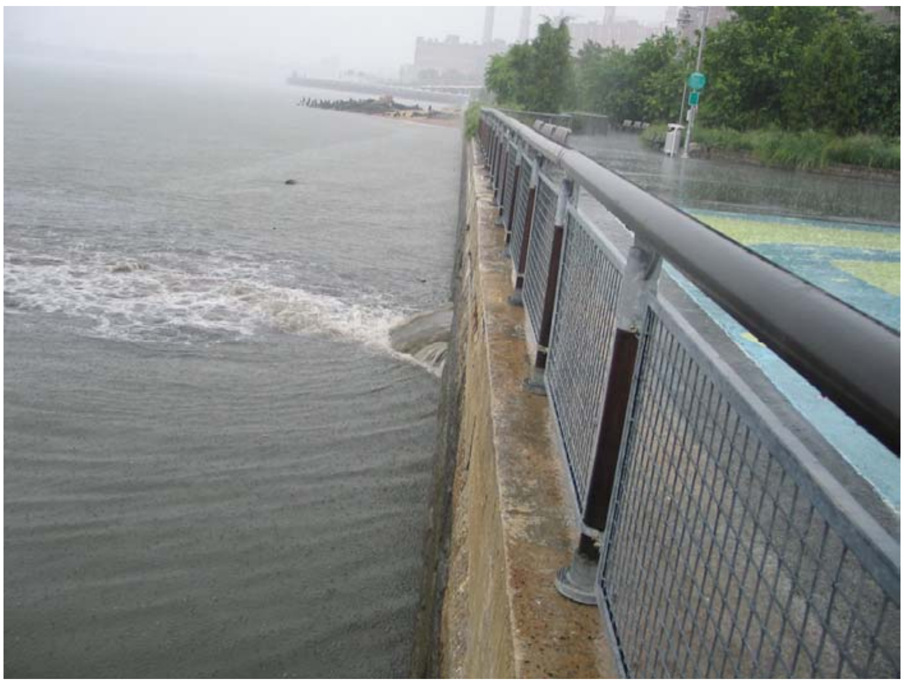
The Root of the Problem: Too Much Stormwater in the Sewer System.

The cause of CSO discharges has less to do with sewage flows from buildings than with the huge amount of stormwater that gets into the sewer system. Stormwater gets into the sewer system because the City has long regarded stormwater as a waste that must be channelized, captured, and disposed of. For years, this philosophy has discouraged progressive thinking within the DEP that would regard stormwater as a resource to be kept out of the system and utilized for much broader sustainability purposes.

Over 80 percent of municipalities in the United States have separate sewer systems, with one set of sewer pipes that direct sewage to treatment plants and a separate set of drainage pipes that direct stormwater runoff to adjacent surface waters. [27] Some municipalities with very old sewers, such as New York, have a combined sewer system that collects stormwater in the same pipes used to collect sewage.

The introduction of piped water to 19th century cities greatly increased domestic water consumption. This increased consumption often exceeded the treatment capacity of the backyard cesspools that served as the earliest form of wastewater treatment in the City. In response, many property owners connected their individual sewer pipes directly to existing street sewers, which, until then, had been used only for urban drainage. With the innovation of new economical forms of water treatment, this new infrastructure became ubiquitous – thousands of miles of combined sewer pipes were built in cities throughout the country.[28]

Today, sewage is treated at the City's fourteen sewage treatment plants. Most of the City's storm drains are connected to the same sewage lines. Each plant can treat about twice the average daily dry weather flow-rate of combined sewers. During wet weather, stormwater quickly consumes this capacity and CSOs occur. The EPA has found that in New York City approximately 60 percent of urban stormwater runoff originates on roads and sidewalks, 20 percent originates on roofs, and the remaining 20 percent originates on private driveways.[29] In some parts of the City, as little as one twentieth of an inch of rain can trigger and overflow, discharging a mixture of polluted stormwater and untreated sewage into New York Harbor.[30]



With nowhere else to go, stormwater runs off tar roofs, concrete sidewalks, and asphalt into nearby storm drains, where it mixes with sewage. As little as 1/20 of an inch of rain can overload the system, triggering a release at a CSO outfall. This one is spewing into the East River at Stuyvesant Cove, just below 34th Street in Manhattan. Image: Jamie Paquette, Solar One.

The City's Current Approach to CSOs Will Not Work.

In June 2007, the DEP must submit to state regulators its proposal for controlling CSO discharges over the long term. When approved by the state, this proposal—known as a long term control plan ("LTCP")—will chart the City's approach to CSOs for the next generation.[31]

From participation in the DEP's LTCP citizen advisory committee meetings, it is becoming apparent that the proposed LTCP will focus almost exclusively on building end-of-pipe storage tanks and expanded in-line storage. Recent DEP presentations on source control studies that are currently underway are encouraging but they are late in coming—too late to influence DEP's June 2007 to the state. Combined sewage overflows are a citywide problem that demands the attention of the Mayor's office and the many City agencies that manage sewage and stormwater flows.

In the DEP's go-it-alone, stormwater-as-waste mindset, the agency is planning to address CSOs by focusing alone on the combined flow *after* stormwater gets into the system—*at the end of the pipe*. The DEP's likely plan will be to collect and temporarily store portions of each overflow. Then, after each storm, the fraction of stored overflow that did not discharge into the Harbor will be sent to sewage treatment plants. For example, at Paerdegat Basin, a tank and in-line storage will add 50 million gallons of CSO storage capacity to the sewer system for $311 million.[32] The recently completed Flushing Bay Facility, a tank and in-line storage, will add 43 million gallons of CSO storage capacity to the sewer system for $291 million.[33]

The federal Clean Water Act prohibits the discharge of pollutants into surface waters without a permit and applicable controls.[34] The federal Wet Weather Water Quality Act of 2000 requires all municipalities with combined sewer systems to implement LTCPs.[35] EPA guidance specifically includes source controls as one of the alternatives that must be considered in the creation of a LTCP.[36] As chronicled by the Natural Resources Defense Council's excellent report, "Rooftops to Rivers," many forward-looking municipalities around the United States have adopted innovative source control measures as part of their LTCPs to reduce CSO discharges.[37]

New York City is not one of those municipalities. Within the formal, binding process of the LTCP, the DEP is committing (via the consent order) to $2.1 billion in construction costs alone on a series end-of-pipe projects with no meaningful commitments to source control.[38]

These end-of-pipe projects cannot and are not intended or designed to eliminate combined sewer overflows or allow the City to meet water quality standards. The likely end-of-pipe plan is projected to reduce CSO discharges only about 5 billion gallons, getting the City to 75 percent of CSOs captured.[39] Put differently, 22 billion gallons or more of CSOs will still be discharged into the Harbor.

Billions of gallons of raw sewage and polluted stormwater will continue to be discharged into the Harbor—*by design*. End-of-pipe control designs are engineered using "knee-of-curve" cost analysis. The "knee" is the point on a cost-benefit curve beyond which incremental increases in cost yield negligible benefits, or diminishing returns. Under this analysis, additional decreases in CSOs beyond the knee cost significantly more per gallon than the designed knee-of-the-curve cost per gallon.

In the DEP's end-of-pipe mindset, additional gains in capture rates introduce enormous costs. The DEP says that achieving the Clean Water Act target of 85 percent CSO capture would cost $6 billion in in-line storage projects.[40] One hundred percent capture would cost $39.3 billion in in-line storage projects.[41]

Yet, knee of curve economics as applied here is riddled with problems. First, the knee of the curve only evaluates a single benefit – CSO reduction. The full array of potential source control alternatives that green the urban landscape confer numerous benefits (as described more thoroughly in Section III), over and above reductions in CSO discharges. By only considering a single benefit, the analysis is so flawed that it becomes useless.

Second, the knee of the curve does not logically relate to water quality improvements. The knee of the curve simply reflects additional costs of a larger tank at a given location. Tanks are built at the knee of the curve regardless of whether an end-of-pipe control will attain water quality standards.[42]

Third, knee-of-the-curve analysis says nothing about whether the costs are affordable given the resources available to fund them or whether the costs are justified by the benefits.[43]

Lastly, knee-of-the-curve analysis as applied by the DEP here is of limited value because the analysis has only included the costs of end-of-pipe technologies. When source controls are considered, knee of the curve calculations become meaningless. Source controls are cost competitive with end-of-pipe controls (as described more thoroughly in Section II). Source control CSO reductions increase linearly with cost. Source control benefits continue to increase with increased installation (as described more thoroughly in Section III). Therefore, there is little use for knee of the curve here. Source controls allow additional gains in CSO reduction at the same or better rates than end-of-pipe controls, regardless of scale. Source controls, used in concert with end-of-pipe, could help the City meet or exceed 85 percent CSO capture.

The DEP raises the $39.5 billion alarm bell to convey a sense of economic hardship. Dressed in complex knee-of-the-curve economics, this figure is little more than a diversionary red herring. But it has a purpose. If the DEP can convince the state that capture rates above 75 percent would be too costly, it might be able to avoid further obligations to meet existing water quality standards. This alleged proof of economic hardship would then be used to petition the state to lower water quality standards to levels achievable through the end-of-pipe approach.[44]

In fact, the DEP has already applied for water quality variances and has drafted applications to decrease water quality standards in anticipation of the proposed LTCP failing to cure water quality standard violations.[45] This terrible public policy could be avoided were the City to commit to widespread implementation of source control.

A Sustainable CSO Plan: Incorporating Source Control Systems.

New York City needs to adopt a sustainable, hybrid approach to CSOs that gives appropriate weight to site-specific source controls that prevent stormwater runoff as to end of pipe controls that capture wastewater flows in the combined system.[46]

The state DEC and the City must act now and force the DEP to meaningfully build source control into the LTCP process. If the DEP's June 2007 submission to the state fails to substantially include source control commitments, the state should reject the submission and send it back to the City with explicit instructions to do so. The idea of a source control "placeholder" was recently discussed as a possible element of the June 2007 submission, the idea being that DEP would eventually merge source control into the plan. It is risky to put off what should be incorporated now. But such a placeholder might be warranted only if the eventual submission is binding, enforceable, and subject to public input.

Source control systems, such as street trees, Greenstreets, porous sidewalks and pavement, rain barrels, groundwater injection and green roofs can significantly reduce stormwater runoff into sewers. Even in areas with separate sewers, source controls would help prevent polluted stormwater from being directly discharged into the Harbor. Progressive DEP projects like the Staten Island Bluebelt should be encouraged where space is available.[47] Source controls would significantly further the goal of meeting applicable water quality standards and would confer substantial benefits to all New Yorkers.

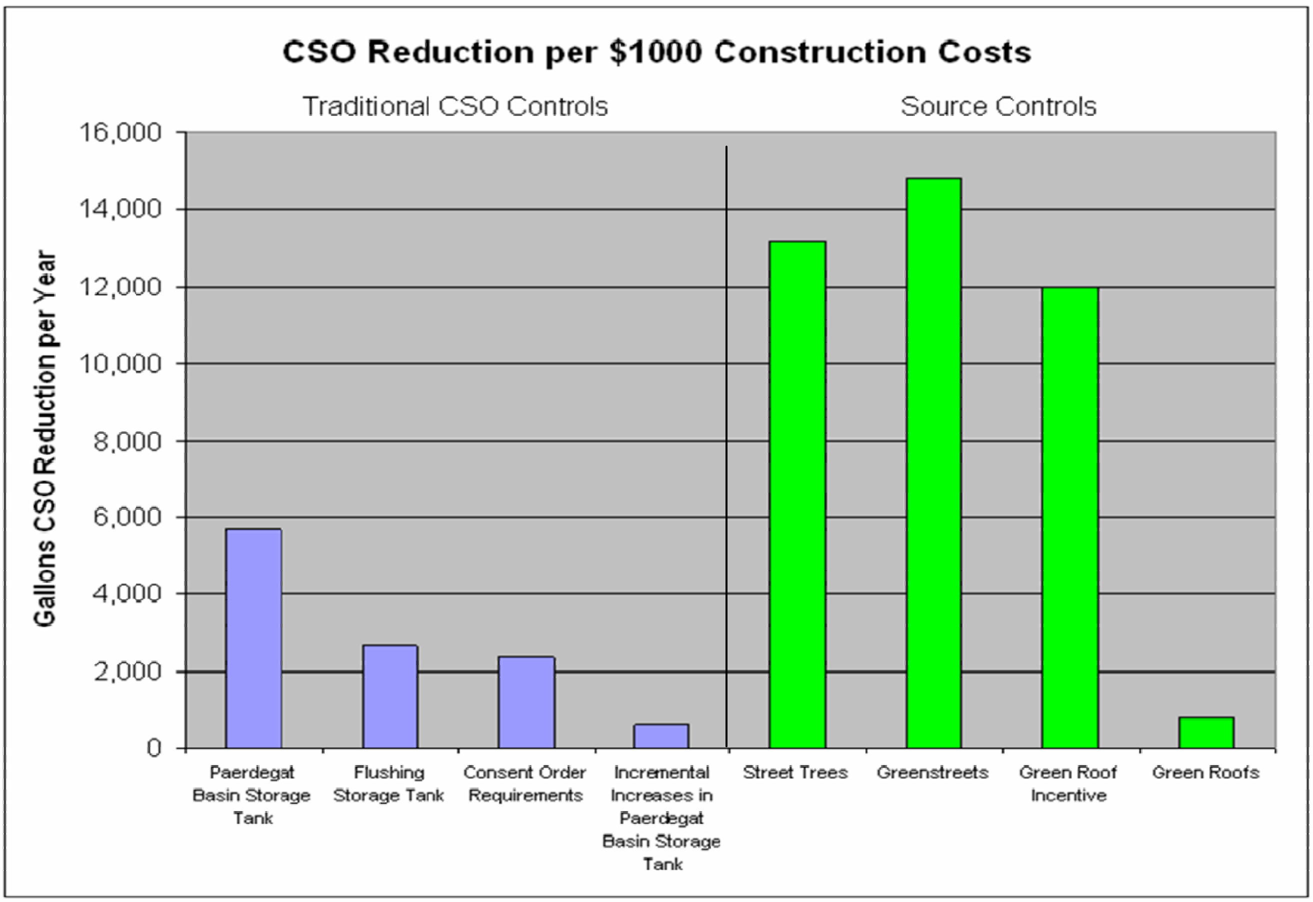
As described in Section II, these source control systems on a per-gallon cost basis are comparable to, if not more effective than, end-of-pipe controls. Each green roof or street tree collects the same amount of stormwater at the same cost. Incremental increases in stormwater source control capture relate linearly to cost. So, the last billion gallons of CSOs will be collected at the same cost as the first billion gallons. And when broader benefits of a greener City are added to CSO benefits (as described more fully in Section III), source control is revealed as a key tool for much broader sustainability purposes.

The ideas behind source control are likely endorsed by the Mayor's new Office of Long Term Planning and Sustainability.[48] In fact, source control was championed by the City Office of Environmental Coordination back in 2004, when it reported that "[r]educing stormwater entering the system would eliminate the potential overflow of untreated wastewater into the harbor, minimizing the need to carry out expensive retrofitting of the City's sewer system."[49] Statements by DEP Commissioner Lloyd suggest she believes in the benefits of source control. However, not until the very late stages of the planning process has source control been considered by the DEP.[50]

The DEP is entrenched in an end-of-pipe mindset when it comes to meeting its CSO abatement obligations under state and federal law. This mindset must be broken and source control must become an integral part of the CSO solution. Source control will save the City money, improve water quality, and elevate the quality of life of all New Yorkers.

II. SOURCE CONTROLS CAN BE MORE COST EFFECTIVE THAN END-OF-PIPE CONTROLS AT CONTROLLING CSOs.

In this section, a simple, preliminary cost comparison demonstrates that source control may be competitive with, if not more cost effective than, end-of-pipe controls, even with conservative assumptions.[51] As discussed below and depicted on the graph, street trees, Greenstreets, and green roofs can each be more cost effective than end-of-pipe controls. Source controls are revealed to be effective CSO mitigation tools that should be a substantial element in the City's CSO control strategy. The significant additional sustainability benefits of source control, beyond stormwater management, are discussed in Section III.



The chart compares end-of-pipe and source control CSO decreases per $1,000 in construction costs. The chart demonstrates the obvious cost competitiveness of source control. Even when applying the most conservative estimates, street trees with porous pavement, Greenstreets and incentivized green roofs are more cost effective than the Flushing Storage Tank, full build-out of the consent order-required projects and increases in tank size at Paerdegat Basin.

This section also demonstrates that source control costs and stormwater capture rates can be measured and unitized. This is a crucial point, as the City is under an obligation to reduce CSO discharges and must demonstrate to the state precisely how it can be done.

The prevailing perception at the DEP and at the DEC is one of uncertainty as to the effectiveness of source controls,[52] including how well they will work when installed, how widely they can be installed, whether broad adoption of source control will allow the City to meet legal obligations within a certain timeframe, and how well source control sites would be maintained.

Of course, these are important concerns. But the purposes of the demonstration in this section are to facilitate a robust discussion and encourage a thorough evaluation of source control and end-of-pipe control benefits and costs.

End-of-Pipe Controls: Storage Tanks and Expanded In-Line Capacity.

The end-of-pipe storage tanks at Paerdegat Basin and Flushing Creek will each cost the City approximately $300 million.[53] The Paerdegat Basin storage tank and upgrades include 50 million gallons of CSO storage capacity and are projected to reduce CSO volumes by up to 1.3 billion gallons per year.[54] The Flushing Creek storage tank and upgrades include 43 million gallons of CSO storage capacity and are projected to reduce CSO volumes by up to 800 million gallons per year.[55] As shown in the graph, these two end-of-pipe storage tanks may decrease annual CSO volumes by 2,660 for Paerdegat Basin and 4,330 gallons for Flushing Creek per year for every $1,000 spent on construction.

Under the City's flawed "knee-of-curve" economics, additional sizing at these tanks would have diminishing benefits. For example, an additional 20 million gallons of storage at Paerdegat Basin would cost an additional $490 million[56] and decrease CSOs an additional 309 million gallons per year.[57] (Recall that the first 1.3 billion gallons would be captured at a cost of $300 million). This additional decrease in CSOs would treat only 630 gallons per year for every $1,000 spent, as shown in the graph (see "Incremental Increases in Paerdegat Basin").

The end-of-pipe projects required by the administrative consent order include both storage tanks and expanded in-line capacity. [58] The LTCP appears to be adopting this approach. The full breadth of proposed consent order projects have a construction cost of $2.1 billion and are projected to decrease annual CSO volumes by about 5 billion gallons. [59] Put differently, the consent order requirements decrease CSOs by about 2,400 gallons per year for every $1,000 spent on construction,[60] as shown in the graph (see "Consent Order Requirements").

Source Controls: Greenstreets.

Greenstreets are pocket parks created on formerly paved or hardened areas, such as traffic triangles, roundabouts, and street medians. In 1994, former New York City Mayor Rudolph Giuliani set a goal of creating 2,000 Greenstreets by the year 2000. Today, there are 2,050 of these Greenstreets citywide.[61]

This Greenstreet at 110th Street and Amsterdam Avenue in Manhattan was designed to capture surrounding stormwater. The formerly paved site now provides substantial community benefits. Design by Jeff Kieter, NYC Parks Department.

The Greenstreets program was not originally envisioned as a stormwater control measure. Indeed, Mayor Giuliani's 2,000 Greenstreets were not designed to capture surrounding stormwater and must be watered manually during the summer months. (Older Greenstreets are not alone in the regard. For example, the Park Avenue median and West Side Highway Bike Path median must also be watered manually).[62]

Greenstreets can reduce the volume of stormwater that reaches the sewers by up to 14,800 gallons per $1,000 in construction costs, as shown in the graph.[63] When stormwater enters a Greenstreet, pollutants from the street are intercepted by the organic mulch and digested by microbes that feast on petroleum and nitrogen-rich street pollution. The cleansed water seeps into the soil to be taken up by the tree and other plant roots. Excess water infiltrating the soil then recharges the aquifer (aquifer recharge is a source control alternative described below on page 19).

Considering that approximately 60 percent of the City's stormwater runoff originates on streets and sidewalks,[64] a sizable percentage of the CSO problem could likely be resolved through a comprehensive program of installing and retrofitting Greenstreets. Water-retaining Greenstreets can efficiently collect and treat rainwater runoff from an area 10 or more times greater than the vegetated surface area.[65]

The City Department of Parks and Recreation has set out to retrofit Greenstreets into stormwater capture devices on a pilot basis. The Department is currently in the early stages of an effort to retrofit 10 to 20 Greenstreets into stormwater capture islands per year.[66] These 10 to 20 water-retaining Greenstreets could remove 1.2 million to 2.4 million gallons of stormwater from the sewer system every year.[67] If all 2,000 existing Greenstreets were redesigned to capture stormwater, as much as 247 million gallons of stormwater could be removed from the sewer system every year, potentially reducing the frequency or duration of CSO events. It is worth noting that if those 247 million gallons were to go into storage tanks rather than Greenstreets, the cost alone to the City for treating that combined sewage stormwater would exceed $65,000 per year.[68]

The Greenstreets retrofit program is not part of the City's long-term control planning for CSOs, which is being led exclusively by the Department of Environmental Protection. It should be. The City has already developed contracting procedures and attracted experienced contractors who are ready for a rapid increase in Greenstreets construction and retrofits.[69] This example of sustainable thinking on the part of the Parks Department is commendable and demonstrates the need for aggressive inter-agency CSO planning.

Source Controls: Street Trees.

Street Trees cost approximately $1,000 to install.[70] Therefore, for every $1,000 invested in street trees, stormwater runoff to the sewers can be reduced by approximately 13,170 gallons per year.[71] Today, there are about 500,000 street trees in the City.[72] The combined effect of 500,000 street trees therefore is a total reduction of runoff to the sewers of about 6.5 billion gallons per year. An additional 300,000 street trees could further reduce runoff to the sewers by about 3.9 billion gallons per year.[73]

Street trees at Carmansville Playground in Washington Heights. Image: NYC Parks Department.

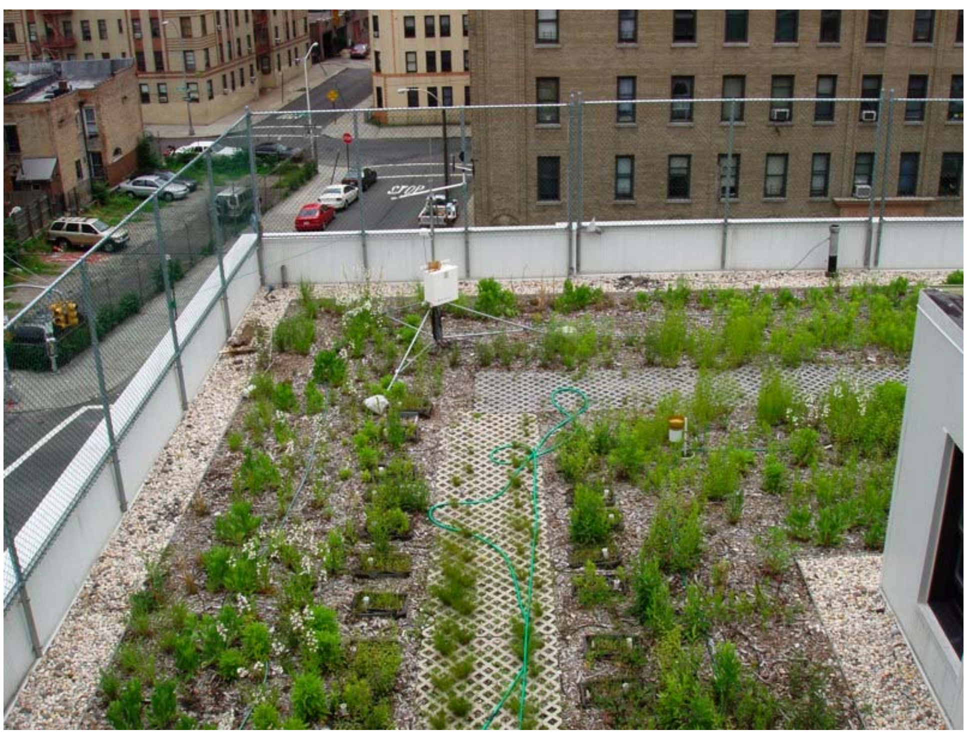
Each street tree needs about 20 gallons of water per day during the growing season to survive.[74] Currently, many trees citywide need to be irrigated and many of those trees that are not irrigated die shortly after planting from dehydration.[75] Many others die before making it to maturity.[76] By increasing the effective permeable area around street trees from 25 to 300 square feet (achieved by installing 275 square feet of porous sidewalk pavement around each 25 square foot tree pit), street trees would be sufficiently irrigated and runoff to the sewer system would be decreased by an additional 4,075 gallons of stormwater per year. [77] If porous pavement were installed around all 500,000 existing street trees, stormwater runoff to sewers would be decreased by an additional 2 billion gallons per year. Installing porous pavement around existing street trees could reduce stormwater runoff to sewers by about 1,780 gallons per $1,000 spent on construction.[78]

By increasing the number of street trees in the City, a proportional volume of stormwater could be diverted from the sewer systems. A $300 million investment in street trees and associated porous pavement, an investment equivalent to a single end-of-pipe storage tank, could plant over 90,000 street trees and decrease stormwater runoff to sewers by over 1.5 billion gallons.[79]

Healthier trees do not need to be replaced as often as the City's trees do today. By installing porous sidewalk pavement, maintenance costs will be decreased because trees will live longer and be replaced less often. As with Greenstreets, contracting procedures are in place and experienced contractors are ready to ramp up installations today. While porous pavement contractors may not yet be readily available, a commitment by the City to porous pavement contracts would likely result in a rapid expansion of qualified contractors.[80]

Source Controls: Green Roofs.

A green roof is the roof of a building that is partially or completely covered with vegetation and soil planted over a waterproofing membrane. Green roofs cost from $6.40 to $25.50 per square foot to install.[81] Costs vary widely based on the whether the roof is new (less expensive) or a retrofit of a traditional roof (more expensive). Costs also depend on whether the construction is intensive, with soil deeper than 6 inches (more expensive), or extensive with soil up to six inches deep (less expensive).[82]



This green roof was constructed atop St. Simon Stock School in the Bronx by Dr. Paul Mankiewicz of The Gaia Institute. Green roofs help control stormwater, reduce surface temperatures, and, here, provide a living laboratory for school children. Image: Mary Burge © 2006.

For every $1,000 invested in new green roof construction, up to 810 gallons of stormwater can be removed from the sewer system every year,[83] as shown in the graph. For every $1,000 invested in retrofit green roof construction, up to 575 gallons of stormwater can be removed from the sewer system every year.[84] These lower numbers need not eliminate green roofs from CSO source control analysis. To begin with, the chart shows that green roofs could be more cost effective at controlling CSOs than increasing the size of the Paerdegat Basin tank. Further, green roofs would confer many other benefits to building owners and the City (discussed in section III), none of which are included in this evaluation. Lastly, as traditional roofs *must* be replaced every few decades, this presents an ideal opportunity for a public-private cost sharing, as discussed further below.

Flat roofs potentially eligible for green roof construction cover nearly 16,000 acres in the City,[85] a land area approximately 19 times larger than Central Park.[86] To be sure, any effective control of CSOs in the City must address rooftops and the complicated issues associated with capturing stormwater from the predominantly privately owned roofs. Yet if every potentially eligible flat roof in the City were made into a green roof, those roofs would capture over 13 billion gallons of stormwater that would otherwise end up in the sewers.[87]

Traditional roofs in New York City cost between $4.00 and $6.00 per square foot.[88] Because initial installation costs of green roofs are more than conventional roofs, most building owners will balk at investing the additional costs, despite the demonstrated long term advantages to the building owner. However, on average, green roofs lasts two to three times as long as traditional roofs.[89] Considering decreased replacement costs, as well as potential energy savings, green roofs will pay for themselves within a 20 year roof life.[90] The additional advantages of green roofs extend beyond the building owner. Green roofs also provide the City with significant advantages including decreased surface temperatures, air quality improvements, and aesthetically pleasing views from other buildings.

To make green roofs (and other source control technologies) more appealing to private property owners, the City could consider a cost sharing program that would subsidize the installation of these technologies on private property. Described in detail in a paper in the *Journal of Landscape and Urban Planning* by Dr. Franco Montalto of eDesign Dynamics LLC and Columbia University and co-authors, such a scheme (referred to in this report as "the Green Roof Incentive Program") would set the amount of the public subsidy so that private property owners who took advantage of the program would see no difference in cost between a green roof and a conventional roof.

A 2006 Columbia University study performed for Sustainable South Bronx found that if 155 acres of green roofs were constructed in Hunts Point, stormwater runoff would be reduced by over 50 percent on new green spaces, capturing 1.1 million gallons of stormwater annually. The image above shows a what Lafayette Avenue would look like under this program. Image: Jin Jo (2006).

For example, traditional non-green roof retrofit costs can vary from $1.25[91] to $3.00[92] per square foot. By contributing the difference in cost between the traditional roof retrofit and a green roof *retrofit*, the City could reduce stormwater runoff to sewers by up to 865 gallons per $1,000.[93] As stated, *new* roofs in the City can cost between $4.00 and $6.00 per square foot to install. For every $1,000 invested by the City on new construction toward the additional expense of *new* green roofs, up to 12,000 gallons of stormwater could be removed from the sewer system,[94] as shown in the graph. As the number of available green roof contractors increases with demand, the price of green roofs will likely decrease and stormwater treatment efficiencies will increase.[95]

In a recent survey of 300 Brooklyn property owners conducted by Dr. Montalto and Professor Patricia Culligan of Columbia University, 77 percent of respondents stated that they would be willing to house a green roof on their property if it cost them no more than an ordinary roof. Similar percentages of respondents indicated their willingness to host porous pavement, and rain barrels if a public subsidy made these technologies cost neutral to them. If the same subsidy were offered to all property owners in a particular CSO-shed, this policy could make source control technologies a cost-effective reductions means of reducing the City's CSOs.

Source Controls: Aquifer Recharge.

Most of the City sits atop glacial till, a porous mixture of gravel and sand with enormous water storage capacities and high flow rates.[96] In addition, most of the City does not use groundwater for drinking water. These are ideal conditions for introducing aquifer recharge systems.[97] Where subsurface conditions are appropriate, Greenstreets and street trees pits, parking lots, and roofs could drain through sand filters, or other engineered controls, directly into the subsurface aquifer.

The current City building code does not allow for aquifer recharge. City Council Introduction 321-2006 would allow the use of drywells for on-site disposal of stormwater runoff subject to appropriate site conditions.[98] Passing Introduction 321 is the necessary precursor to experiencing the significant economic and environmental advantages of aquifer recharge.

Source Controls: Rain Barrels.

Rain barrels are on-site rainwater collection systems, usually designed to collect roof stormwater runoff for reuse. Captured water can be used for irrigation or, in more elaborate systems, connected to the buildings cooling towers or plumbing for use in toilets. While the comparatively small roof area of tall urban buildings presents some challenges for rain barrel application,[99] rain barrels could be used on many of the 41,000 acres of one and two family residences throughout the City.[100] A typical rain barrel consists of a 55-gallon barrel attached to a gutter downspout with a hose connection for irrigation water reuse.[101]

While the City has not yet researched the applicability of rain barrels, a recent study in the City of Milwaukee found that attaching rain barrels to 40,000 houses could decrease runoff by 273 million gallons per year and decrease water treatment plant operation costs during light rainfall.[102] At a cost of $4.00 per gallon for rain barrel installation,[103] such a system would decrease stormwater runoff by over 9,000 gallons for every $1,000 in installation costs.[104]

Source Controls Can Be More Protective of Water Quality.

Source control systems, in and of themselves, contribute no pollution to the Harbor. By contrast, end-of-pipe controls not only allow for untreated sewage overflows into the Harbor (because of incomplete knee of the curve analysis) but even the fraction of captured water eventually treated and discharged into the Harbor is *not* clean stormwater. Rather, the treated and discharged sewage-stormwater mixture is still laden with chemicals, bacteria, and nitrogen, though within treatment plant permit levels.

For example, treated effluent from sewage plants contains excess nitrogen which harms the City's water bodies. In contrast, by allowing stormwater to be taken up by vegetation or infiltrate the ground at the site of the source control, no excess nitrogen is transferred to the Harbor. The total amount of pollution entering the Harbor increases further when considering the efficiency losses caused by diluting treatment plant influent with captured stormwater. The additional pollution in both circumstances is avoided by using source control systems.

Likewise, in those parts of the City with separate sewers, the stormwater runoff to the Harbor is contaminated with bird and pet waste, fertilizer, pesticides, and oil and fuel from the street. Source control flushes these contaminants through the soil where they degrade. The separate sewer flushes these contaminants into the Harbor where they further deteriorate surface water quality.

Source Controls Work.

According to the US Environmental Protection Agency, "[g]reen infrastructure [source controls] can be both a cost effective and environmentally preferable approach to reduce stormwater and other excess flows entering combined or separate sewer systems in combination with, or in lieu of, centralized hard infrastructure solutions"[105] (see attached as Appendix).

EPA's management plans for CSOs include low-impact developments.[106] Other cities are proving that source control works. Chicago, Philadelphia, Milwaukee, Pittsburgh, Seattle and Portland have already realized that end-of-pipe systems will not alone solve their CSO crisis. As discussed thoroughly by the Natural Resources Defense Council in "Rooftops to Rivers," these cities have adopted source control as part of the solution.[107]

The City Office of Environmental Coordination recognizes that source controls work, reporting, as noted earlier, that "[r]educing stormwater entering the system would eliminate the potential overflow of untreated wastewater into the harbor, minimizing the need to carry out expensive retrofitting of the City's sewer system."[108] Yet, as source control has yet to be institutionalized, it is only being done in the City on an ad hoc basis. Some of the many examples include:

- *Battery Park City*: The new low impact development, including source controls, in Battery Park City is widely admired for its green construction[109] and apartment rental prices comparable with new buildings elsewhere in Manhattan.[110]

- *Lower East Side*: ConEd settlement funds are being used to create a green street on Lower East Side. While the focus of the Lower East Side green street is the electricity and water conservation, the green roofs and street trees will also act as source control for stormwater.[111]

- *Atlantic Yards*: The Atlantic Yards project recently approved by the City includes green roofs, permeable pavement, stormwater capture for cooling tower consumption, and landscaping features. By employing these source control measures, the 22-acre project decreased potential CSO volumes by 10.8 million gallons per year.[112]

With a citywide approach to source control systems, rain events would look much different. Drought-tolerant plants would use much of the water that fell on green roofs. Porous sidewalks would allow water to pass through to the underlying tree roots and aquifer. Street runoff would be directed to green street gardens, where the runoff would soak into the soil to be used by the trees and other plants. Any rainfall beyond the storage capacity of the source control systems would run into the sewer system and, if the in-line storage reached capacity, into the end-of-pipe storage tanks. Without compromising the safety elements of traditional stormwater management, costs can be minimized while experiencing benefits far beyond those realized by a single function end-of-pipe system.

The City has already demonstrated the capacity to manage distributed systems. Such capacity would be a crucial factor in evaluating whether the City could manage an effective distributed stormwater source control system. Distributed management programs include:

- *Catchment basin cleaning*: the DEP routinely cleans out 100,000 catchment basins citywide to decrease litter floating in the Harbor;

- *Street trees*: the Parks Department maintains a street trees program citywide.

- *Greenstreets*: the Parks Department also maintains more than 2,000 Greenstreets citywide.

There are many more examples. The difficulty of managing a distributed, source control system is well within the demonstrated capabilities and past performance of City agencies.

The DEP Has No Basis to Ignore Source Control As a Viable CSO Control Alternative.

During citizen advisory committee meetings on the CSO long term plan, the DEP regularly discounted the effectiveness of source control as a broad solution. For example, at a City Council hearing in October 2006, the DEP asserted that source controls have a "limited value for large scale CSO mitigation."[113] This conclusion is contradicted by a substantial body of EPA findings, by experiences in other cities, and by statements by the City's own Office of Environmental Coordination, as noted above.

Responding slowly to public pressure, the DEP is now beginning to study its potential effectiveness of source control as a CSO management tool within the five boroughs. Prior to the recent study described below, the DEP had squelched the only two studies which could have informed the DEP's long term planning process—two studies that were contracted out but subsequently canceled by the DEP.[114]

The company Biohabitats was commissioned in summer 2006 to conduct a study of source control. A draft of that study was due to be submitted to the public in the fall of 2006 but is inexplicably being delayed until *after* the June 2007 deadline for DEP's submittal of its CSO abatement plans to the state. There has been a dramatic disparity between the spending on the study on end-of-pipe controls versus source controls—study which is directly informing policy.

A dichotomy exists within City government. As with the Office of Environmental Coordination, the Mayor's Office of Long Term Planning and Sustainability likely understands the importance of a greener City. In early spring, it will release its sustainability plan, which is expected to include, among many things, the specific ways in which stormwater can be controlled at the source.

At the same time, the DEP, which has long viewed stormwater as a waste, is preparing on its own a CSO control plan that will fail to contain many of the Mayor's initiatives. To compound the disconnect, LTCP citizen advisory committee meetings are attended neither by representatives of the Mayor's sustainability office nor the other City agencies with a stake in stormwater. Based on DEP's most recent statements, none of the Mayor's likely source control initiatives will be incorporated into the June 2007 DEP plan, which will chart the City's approach to CSOs for the next generation.

Here is the key distinction: the Mayor's laudable initiatives at this stage depend on the will and tenure of the Mayor himself, whereas the DEP's CSO long term planning is part of a binding, legal construct, driven by a matrix and federal and state laws, enforcement actions, and legally required citizen participation. To implement a sustainable and effective CSO solution, the Mayor's initiatives must be merged into the binding long-term planning process.

The preliminary findings in this section suggest that source control may well be a viable stormwater and CSO control measure in the City. In the following section, the additional sustainability benefits of source control systems, beyond functioning as effective CSO controls, are explored.

III. SOURCE CONTROLS CONFER SUBSTANTIAL SUSTAINABILITY BENEFITS.

The benefits of stormwater source control extend far beyond reducing CSO discharges. Source control regards stormwater as a resource to be utilized, rather than a waste that must be disposed of. By giving life to vegetation, stormwater can help prepare the City for the effects of climate change, decrease summer temperatures, promote energy efficiency, improve air quality, and make communities more livable. End-of-pipe controls confer none of these benefits. In fact, end-of-pipe controls may make things worse by hardening the landscape around the tanks, consuming energy, and removing a powerful incentive to construct a green landscape. End-of-pipe controls are single purpose systems. Their sole function is to dispose of stormwater, whether treated or untreated.[115]

The mayor recently proposed "greening" the City and using "sustainable solutions" to decrease CSOs.[116] Source control embodies that proposal. Source control can help the City address the following mayoral sustainability goals: (1) opening waterways for recreation by reducing water pollution; (2) achieving the cleanest air of any big city in America; (3) reducing global warming emissions; (4) creating more sustainable housing; and (5) ensuring that every New Yorker lives within a ten minute walk of a park.[117]

A complete evaluation of cost effectiveness in comparing source controls with end-of-pipe controls must include consideration of the additional benefits provided by source controls. Specifically, source controls improve air quality, cool the City, decrease electricity demand, decrease water demand, and make the City more livable. These additional functions create real economic and public health benefits.

By relying exclusively on end-of-pipe CSO controls, negative environmental and economic consequences will increase over time as population and economic activity increases.[118] Fixed sizing of end-of-pipe systems precludes timely adjustments as wastewater loading increases. Source controls, on the other hand, can be installed in real time. If a developer produces an environmental impact statement that identifies an increase in dry weather sewage flows, the City could require that construction design includes source controls that offset the corresponding increase in wet weather CSOs.[119]

Source Controls Can Help Prepare the City for the Effects of Climate Change.

In twenty years, the City is projected to be 2 to 3°F warmer as a result of climate change.[120] A warmer City will require more electricity to stay cool. Additional electricity will be produced predominantly by burning coal and oil—further reinforcing the tragic consequences of both adding heat trapping carbon dioxide to the atmosphere and relying on foreign oil. Source control can help mitigate the localized warming effects of climate change and help reduce the City's contribution to this global crisis.

New York City is already warmer than nearby rural areas, a phenomenon scientists call the urban heat island effect. Exposed concrete, asphalt, and rooftops absorb heat from the sun during the day and radiate the heat to the City at night. The heat released by these surfaces increases citywide temperatures by an average of 7.2°F,[121] with localized temperature increases sometimes exceeding 10°F.[122] The warmer temperatures result in steep increases in electricity demand as New Yorkers try to cool off.[123]

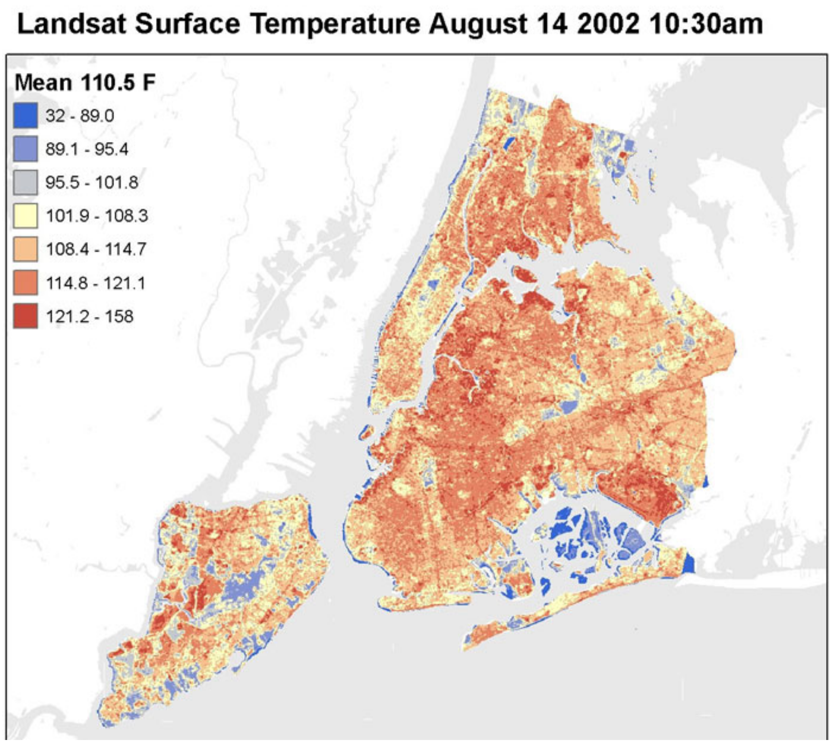
Heat waves take a human toll. Every year, 840 New Yorkers die from heat related complications.[124] In twenty years, additional unsustainable growth could add to the urban heat island beyond the 2 to 3°F temperature increase that will accompany global warming. By 2025, the number of heat related fatalities is projected to increase to over 1,300 New Yorkers per year, an increase of more than 400.[125] (A 35 percent per capita increase, corrected for projected population increase.)

Stormwater source controls can help counter the localized impacts of the urban heat island effect. Because the City is already warmer than surrounding areas due to the urban heat island effect, source control can help mitigate the anticipated climate change temperature increases over the next twenty years.

By planting trees and green roofs, solar energy is intercepted and used by the plants rather than absorbed by exposed roofs, brick, and concrete. While solar energy absorbed by buildings and streets heat the City, the solar energy absorbed by plants actually helps cool the City by using the energy for biological processes and providing shade for direct cooling. In addition, the stormwater that evaporates and transpires from trees and green roofs actually cools the surrounding air much like an air conditioner. In fact, one tree has the cooling power of about 5 average sized air conditioners.[126] Trees and green roofs cool the City by shading windows, keeping building walls and the nearby ground cool, and by transpiring cool air.[127]

Recent research conducted by the Columbia University Center for Climate Systems Research and the NASA Goddard Institute for Space Studies reports that surface temperatures in the City could be reduced by 1.4°F if 50 percent of the flat roofs in the City were converted to green roofs.[128]

Converting 50 percent, or 347 million square feet of the City's flat roofs to green roofs would reduce the volume of stormwater entering the sewers by over 6.7 billion gallons per year and save millions of dollars in summer cooling costs.[129] The City's electrical demand increases with average daily temperature. Installing green roofs on just 50 percent of the flat roofs in the City could decrease citywide electricity costs by approximately $70 million dollars per year.[130]



This thermal satellite image of New York City shows pockets of elevated surface temperatures, in red. These "heat islands" occur in areas of hardened surfaces and limited vegetation. Source: http://www.giss.nasa.gov/research/news/20060130/,

Comprehensive citywide greening is a worthwhile, achievable goal. In the short term, targeted greening may be able to locally cool some of the hottest areas in the City. By greening roofs that act as local hot-spots, stormwater goals are furthered while visibly addressing City standard of living improvements.

Source Controls Improve Air Quality.

There are only 15 cities in America with worse air pollution than New York City[131] and projections anticipate future declines in air quality given the impact of climate change.[132] Air pollution directly affects public health. Approximately 1,300 New Yorkers die every year from causes related to ozone air pollution and by 2050 that number is projected to increase by 5 percent.[133]

Source controls would improve City's air quality by removing pollutants from the air. A recent study suggests that every tree in the City can remove approximately 0.44 pounds of air pollution per year.[134] By adding another 300,000 street trees to the 500,000 existing street trees, over 60 tons of air pollution can be removed from the City's air every year.

Source controls in the City will decrease smog - directly decreasing the ozone mortality rate. A greener City reduces ozone (the pollutant responsible for smog) through biological processes[135] but also produces less ozone because of cooling.[136] For example, ozone concentrations in the City are about 120 parts per billion on an 86°F summer day. [137] By decreasing the temperature just 1.4°F, the City's ozone concentrations drop by almost 12 percent to around 105 parts per billion. Ozone removed by tree biological processes would annually remove an additional 12,000 pounds of ozone per 100,000 trees.[138]

Source controls will also help the City improve air quality by reducing energy demand from dirty power plants. By decreasing citywide temperatures by 1.4°F, energy conservation would remove 90,000 tons of air pollution, including carbon dioxide emissions.[139] Consuming energy means reducing the City's contribution to global warming and our dependence on foreign oil. In contrast, simply treating the 5.1 billion gallons of captured stormwater with the proposed end-of-pipe controls will create nearly 5,000 tons of air pollution via energy consumption.[140]

Source Controls Can Make Neighborhoods More Livable.

By ambitiously and uniformly greening our streets, buildings, and communities, New York City would become a more livable place for all New Yorkers. A commitment to build more natural spaces and Greenstreets would help fulfill the Mayor's goal of ensuring that all New Yorkers live within a ten minute walk of a park.

Streets with trees and properties with gardens are more desirable than their barren counterparts. The EPA has found that trees and green space can increase property values by 3 to 20 percent,[141] particularly in urban areas with an inconsistent green cover like the City. The market economics here underscore the desirability of greener streets. If implemented uniformly, the City would improve the livability of all neighborhoods since all properties would benefit from the greening.

The green roof at St. Simon Stock School in the Bronx will help reduce roof temperatures and conserve energy. This example of source control also improves the quality of life for school children and neighbors. Designed by: The Gaia Institute. Credit: Mary Burge (2006).

Trees have also been shown to be good for business by reducing stress, enhancing productivity, and attracting customers.[142] In blighted communities, additional benefits of urban trees include decreased violent crime, decreased property crime, increased social interaction and increased parental supervision of children.[143]

The garden-like green roof atop The Solaire, a residential apartment building in Battery Park City, Manhattan. Credit: © birdwOrks/Simon Bird and the Albanese Org. http://www.flickr.com/ photos/ birdw0rks/180089281/

Source Controls Reduce Water Usage.

Source controls would also decrease the amount of tap water consumed by New Yorkers. Every day, New Yorkers use an average of 1.1 billion gallons of water for domestic and commercial uses or more than 400 billion gallons per year, from the pristine, unfiltered upstate reservoir system.[144] By contrast, more than 236 billion gallons of rainwater falls on the five boroughs in an average year.[145] Without question, some of this stormwater—much of which is currently discarded—could be captured and put to use for supplementary or complementary domestic and commercial uses, allowing the City to conserve reservoir water.

For example, homeowners that connect their roof drains to rain barrels could use captured stormwater to irrigate their lawns or wash sidewalks or automobiles. Larger buildings could put captured stormwater to use for irrigation, cooling, or sanitary water needs. Businesses, too, could use stormwater for industrial cooling. Each of these stakeholders would need to make up-front investments in stormwater capture devices but would save money over time on water billing. The City itself would experience decreases in demand from its reservoir system, providing added security during periods of drought.

End-of-Pipe Controls Confer None of These Benefits.

The consideration of end-of-pipe controls alone precludes consideration of the many benefits made possible by source controls. But end-of-pipe controls also introduce opportunity costs for sustainability gains forgone and for additional direct costs. End-of-pipe controls, such as large tanks, occupy large areas of shoreline. Energy is consumed pumping stormwater out of the tanks. Sewer odors may affect the local community. Additional exposed concrete further warms the City. Perhaps most significantly, the existence of a tank allows property developers to disregard the important landscape features that help beautify the City.

IV. EXAMPLES OF ALTERNATIVE CSO CONTROL SCENARIOS.

In its June 2007 long term plan submission to the DEC, the DEP is likely to propose $2.1 billion in end-of-pipe projects to control CSOs (some of these projects are already contracted and under construction). In this section, we compare how $2.1 billion could be spread across three alternatives: (1) 100 percent end-of-pipe; (2) 50 percent end-of-pipe/50 percent source control; and (3) 100 percent source control. The exercise, while basic, explores the potential costs and benefits of variations in end-of-pipe and source control commitments. Each example corresponds with a column in the chart below.

	Example 1: Proposed LTCP (100% End-of-Pipe)	Example 2: 50% End-of-Pipe and 50% Source Control	Example 3: 100% Source Control
Installation Cost	$2.1 billion	$2.1 billion	$2.1 billion
Gallons Captured per Year	5.1 billion gallons	6.1 billion gallons	7.2 billion gallons
Cost of Treating Captured Stormwater per Year[146]	$1.41 million	$0.68 million	None
Air Quality Effects (Not including CO_2.)[147]	Water treatment adds 37.8 tons of air pollution via energy consumption per year	Water treatment adds 18.9 tons. Trees remove 25 tons. (Net reduction 6.1 tons.)	Trees remove 60 tons of air pollution. Cooling decreases summer smog.
Carbon Dioxide Effects[148]	6,481 tons created by water treatment energy consumption	3,240 tons created by water treatment energy consumption. Trees remove 145 tons. (Net addition of 3,095 tons)	Trees remove 340 tons.
Additional Street Trees[149]	None.	150,000	300,000
Additional Water Collecting Greenstreets[150]	None.	2,133	4,266
Additional Green Roofs[151]	None.	175 million square feet	350 million square feet
Electricity Cost Savings	None.	Hundreds of thousands to millions of dollars.	$67 million per year[152]
Property Value Benefits	None.	3% - 20% increase in property values.	
Other Benefits	None.	Reducing stress, enhancing productivity, and attracting customer, decreased violent crime, decreased property crime, and increased social interaction.	

Example 1: 100% End-Of-Pipe

The end-of-pipe projects at the core of the DEP's plans would capture and treat 5.1 billion gallons of CSO at a total cost of about $2.1 billion dollars. This end-of-pipe approach will produce no ancillary benefits.

Example 2: 50% End-Of-Pipe, 50% Source Control

Alternatively, the City could halve the scope of the end-of-pipe controls and invest the other half ($1.05 billion) in source controls. This alternative could capture and treat over 6.1 billion gallons of stormwater by installing 2,133 Greenstreets, 87.5 million square feet of new green roof, 87.5 million square feet of retrofit green roof, planting 150,000 street trees and installing 275 square feet of permeable pavement sidewalk around 105,148 street trees. This alternative would also include significant additional benefits for the City beyond stormwater control.

Example 3: 100% Source Control

Another alternative might be to invest the entire $2.1 billion in source controls. This alternative could capture and treat over 7.2 billion gallons of stormwater. This alternative would include 4,266 Greenstreets, 175 million square feet of new green roof, 175 million square feet of retrofit green roof, planting 300,000 street trees and installing 275 square feet of permeable pavement sidewalk around 210,296 street trees.

V. RECOMMENDATIONS

POLITICAL WILL TO ACHIEVE SOURCE CONTROL

Immediate Actions

Mayor's Sustainability Initiative & LTCP Process

- Incorporate the source control portions of the sustainability plan into the LTCP process. DEC should reject LTCP unless source control is substantially incorporated. (*OLTP&S; DEC; DEP*)
- Commit to a goal of a swimmable and fishable Harbor by 2030.
- Require all agencies to participate in LTCP process. (*OLTP&S; DEC; DEP)*.
- Commit to public participation through life of LTCP process. (*DEC; DEP*)
- Form Source Control Task Force:
  - Create public-private task force to study source control barriers, incl. legal changes outlined below. (*OLTP&S; multiple agencies; City Council; NGOs; developers and building owners*)
  - Develop public outreach and education program. Provide funding for private source control pilot projects and studies. (*OLTP&S*)
  - Conduct Task Force study on legal and regulatory barriers.
  - Provide funding to NGOs/academics for pilot programs.

City Agency Commitments

- By 2015, double number of Greenstreets to 4,000; ensure all capture stormwater. .(*OLTP&S; DEP; Parks*)
- By 2015, add 300,000 street trees to existing 500,000; ensure all capture maximum stormwater. (*OLTP&S; DEP; Parks*)
- By 2015, eliminate stormwater runoff from City properties and parking lots. (*OLTP&S; multiple agencies*)
- Direct DOB to encourage onsite stormwater management. (*OLTP&S; DOB*)

Legislative & Agency Action

- Pass resolution supporting source control. (*Assembly./Senate.; Council*)
- EPA directive to DEC & DEP to consider source control. (*EPA*)

Legal Changes

City Council Legislation

- Introduce legislation permitting separate water & stormwater billing, enabling a source of revenue for source control commitments.
- Pass Council Intro. 506-2007 comprehensive wetland policy.
- Pass Council Intro. 321-2006 groundwater injection bill.
- Duplicate Jamaica Bay Watershed Protection Plan legislation for other watersheds.

State Legislation

- Change SEQRA and CEQR Manuals to require site-specific and cumulative analysis of CSO impacts. (*with Council*)
- Establish a stormwater trading system (*with Council*)
- Create incentives for private use of source control measures. (*with Council*)

Further Study

Intensive Technical Studies

(*Seek funding from EPA; DEC; state legislature; DEP; Foundations*)

- GIS study for representative sections of City to determine source control opportunities.
- Determine expected levels of public acceptance of source control and necessary incentives to maximize participation in source control programs.
- Determine effectiveness of existing source control infrastructure.
- Develop hydrological model to measure source control at various scales.
- Quantify / unitize source control CSO and overall sustainability benefits. Formula should be adjustable based on variations in site conditions.

APPENDIX—USEPA SOURCE CONTROL MEMORANDUM

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

MAR 5 2007

OFFICE OF
WATER

MEMORANDUM

SUBJECT: Using Green Infrastructure to Protect Water Quality in Stormwater, CSO, Nonpoint Source and other Water Programs

FROM: Benjamin H. Grumbles
Assistant Administrator

TO: EPA Regional Administrators

Green infrastructure can be both a cost effective and an environmentally preferable approach to reduce stormwater and other excess flows entering combined or separate sewer systems in combination with, or in lieu of, centralized hard infrastructure solutions. EPA Water Programs are in a pivotal position to exert leadership in the consistent and reliable implementation of green infrastructure approaches. This memo is to highlight opportunities for the Regions, States, and Headquarters efforts to increase the development and use of green infrastructure in water program implementation.

Several cities, searching for alternatives to traditional hardscape solutions to wet weather discharge problems, have initiated some green infrastructure approaches. The Natural Resources Defense Council (NRDC) has recently published a document with information and case studies on these efforts. I strongly support the use of green infrastructure approaches described in the NRDC report and I suggest you share the report with States and promote other tools for green infrastructure. *Rooftops to Rivers: Green strategies for controlling stormwater and combined sewer overflows* (NRDC, June 2006) is available at:
http://www.nrdc.org/water/pollution/rooftops/contents.asp

Green infrastructure approaches essentially infiltrate, evapotranspirate or reuse stormwater, with significant utilization of soils and vegetation rather than traditional hardscape collection, conveyance and storage structures. Common green infrastructure approaches include green roofs, trees and tree boxes, rain gardens, vegetated swales, pocket wetlands, infiltration planters, vegetated median strips, reforestation, and protection and enhancement of riparian buffers and floodplains. Green infrastructure can be used where soil and vegetation can be worked into the landscape. It is most effective when supplemented with other decentralized storage and infiltration approaches, such as the use of permeable pavement, and rain barrels and cisterns to capture and re-use rainfall for watering plants or flushing toilets. These approaches can be used to keep rainwater out of the sewer system to reduce sewer overflows and to reduce the amount of untreated stormwater discharging to surface waters. Green infrastructure

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facilitates or mimics natural processes that also recharge groundwater, preserve baseflows, moderate temperature impacts, and protect hydrologic and hydraulic stability.

Green infrastructure has a number of benefits:

- *Cleaner Water* – Vegetation and green space reduce the amount of stormwater runoff and, in combined systems, the volume of combined sewer overflows.
- *Enhanced Water Supplies* – Most green infiltration approaches result in stormwater percolation through the soil to recharge the groundwater and the base flow for streams.
- *Cleaner Air* – Trees and vegetation improve air quality by filtering many airborne pollutants and can help reduce the amount of respiratory illness.
- *Reduced Urban Temperatures* – Summer city temperatures can average 10°F higher than nearby suburban temperatures. High temperatures are linked to higher ground level ozone concentrations. Vegetation creates shade, reduces the amount of heat absorbing materials and emits water vapor – all of which cool hot air.
- *Increased Energy Efficiency* – Green space helps lower ambient temperatures and helps shade and insulate buildings, decreasing energy needed for heating and cooling.
- *Community Benefits* – Trees and plants improve urban aesthetics and community livability by providing recreational and wildlife areas and can raise property values.
- *Cost Savings* - Green infrastructure may save capital costs on digging big tunnels and stormwater ponds, operations and maintenance expenses for treatment plants, pipes, and other hard infrastructure; energy costs for pumping water; and costs of wet weather treatment and of repairing stormwater and sewage pollution impacts, such as streambank restoration.

The Office of Water is working with a coalition of organizations, including the Natural Resources Defense Council, the National Association of Clean Water Agencies, and the Low Impact Development Center, to develop additional strategies for green infrastructure approaches to water quality challenges. As those strategies take shape, we will send you additional tools and information on implementing green infrastructure in our water programs.

I am pleased that EPA Regions and States are looking for opportunities to incorporate green infrastructure. We would be very interested in hearing about your efforts, and to the extent they can be applied elsewhere, assist in disseminating information and tools. If you have any questions, please contact me or have your staff call Jenny Molloy at (202) 564-1939 with any questions, comments, ideas or information on green infrastructure approaches.

cc: Water Division Directors
OW Office Directors

ENDNOTES

[1] Mayor Bloomberg Delivers Sustainability Challenges and Goals for New York City Through 2030, Press Release 432-06, available at http://www.nyc.gov/portal/site/nycgov/menuitem.c0935b9a57bb4ef3daf2f1c701c789a0/index.jsp?pageID=mayor_press_release&catID=1194&doc_name=http%3A%2F%2Fwww.nyc.gov%2Fhtml%2Fom%2Fhtml%2F2006b%2Fpr432-06.html&cc=unused1978&rc=1194&ndi=1 The mayor set the goal of "recreation," meaning secondary contact recreation, a level of water quality that safely supports partial body contact during power boating, sailing, and some types of fishing.

[2] HydroQual, Combined Sewer Overflows to New York Harbor Waters from New York City Watersheds for an Average Precipitation Year (JFK, 1988) Current Conditions (2003 Dry Weather Flow, 2003 Operations), September 29, 2004.

[3] 2004 CSO Consent Order ACO# C02-20000107-8 (Effective January 14, 2005) commits DEP to planning designing and implementing a number of CSO abatement projects.

[4] Source control can be defined as a land development and retrofit strategy that emphasizes the protection and use of distributed interventions to reduce the volume and rate of stormwater runoff from a developed landscape. Source control is also referred to as low impact development ("LID"), green design, and technologies known as best management practices ("BMPs").

[5] *See* 2004 Administrative Consent Order for Implementation of the Combined Sewer Overflow Abatement Program in New York City, section III.A.2; Memorandum of Understanding between the New York State Department of Environmental Conservation and the New York City Department of Environmental Protection, referenced in the 2004 Administrative Consent Order, paragraphs 20 and 22. *See also* Bruce Bell, PhD, PE, DEE President, Comments on Draft State Pollutant Discharge Elimination System Permits and Associated Administrative Consent Order and Memorandum of Agreement for Fourteen New York City Water Pollution Control Plants, March 31, 2005, p. 7.

[6] Steinberg, N. D.J. Suszkowski, L. Clark and J. Way. 2004. Health of the Harbor: The First Comprehensive Look at the State of the NY/NJ Harbor Estuary. A Report to the NY/NJ Estuary Program. Hudson River Foundation, New York, NY. 82 pp. p29. Available at http://www.hudsonriver.org/docs/harborheath.pdf (hereinafter "Health of the Harbor Report")

[7] See New York State 2004 Section 303(d) List of Impaired Waters Requiring TMDL, Part 1 (September 24, 2004) available at http://www.dec.state.ny.us/website/dow/part1.pdf.

[8] Natural Resources Defense Council and Environmental Integrity Project, Swimming in Sewage: The Growing Problem of Sewage Pollution and How the Bush Administration is Putting Our Health and Environment at Risk, February 2004.

[9] 2006 Beach Surveillance and Monitoring Program Summary, Department of Health and Mental Hygiene, Office of Public Health Engineering, Oct. 2006, available at http://home2.nyc.gov/html/doh/downloads/pdf/beach/beach-report-2006.pdf.

[10] Id.

[11] Rodriguez, G. N.Y. Times. Strong Runners Catch a Break in a Dry Race. Aug 11, 2003. D7.

[12] Riverkeeper is a member of S.W.I.M. Visit www.swimmablenyc.org. Other members include: Bronx Initiative for Energy and the Environment; the Bronx River Alliance; Friends of Brook Park; the Gaia Institute; the Gowanus Dredgers; Green Apple Corps; League of Conservation Voters; Long Island City Community Boathouse; Lower East Side Ecology Center; Metropolitan Waterfront Alliance; Mosholu Preservation Coalition; Natural Resources Defense Council; New York City Parks Natural Resources Group; New York City Soil and Water Conservation District; NYPIRG; New York Restoration Project; the Newtown Creek Alliance; Pratt Center for Community Development; Rocking the Boat; Sustainable South Bronx; the Urban Divers Estuary Conservancy; Water Resources Group; and Youth Ministries for Peace and Justice.

[13] Health of the Harbor Report, p. 27-28.

[14] Significant Maritime Industrial Areas ("SMIAs") are a program of the City of New York and the New York State Department of State. Waterfront activities which furthers the industrial or maritime character of these areas would be consistent with the State of New York's coastal policies for these waterfront properties. The SMIAs were determined by identifying concentrations of existing water-dependent uses and areas where the physical capacity of the lands, water, and infrastructure, and zoning accommodated these uses. See http://www.nyswaterfronts.com/initiatives_NYC.asp

[15] Coliform bacteria can be counted to determine the influence of fecal waste in the water – CSOs are the main source of coliform bacteria in NYC waters. Health of the Harbor Report, p. 52.

[16] Health of the Harbor Report, p. 50.

[17] The New York State Department of Health issues fish consumption advisories for the state's waters. Advisories on fish consumption for Harbor waters are not explicitly tied to CSO discharges but for chemicals of concern such as mercury, dioxins, cadmium, and PCBs. See http://www.health.state.ny.us/environmental/outdoors/fish/fish.htm.

[18] Corburn, J., Street Science: Community Knowledge and Environmental Health Justice, MIT Press, 2005, p. 99-101. Discussing an EPA study of Greenpoint Williamsburg (U.S. EPA Community Specific Cumulative Exposure Assessment for Greenpoint/Williamsburg, New York. Office of Policy, Planning and Evaluation. Washington D.C.: U.S. EPA, 1999). See also USEPA, Fish Consumption and Environmental Justice 2002, available online at http://www.epa.gov/compliance/resources/publications/ej/fish_consump_report_1102.pdf.

[19] *Id*.

[20] Health of the Harbor Report, p. 58.

[21] Id., p. 62.

[22] See Jamaica Bay Watershed Protection Plan, Interim Report, September 1, 2006 at http://nbii-nin.ciesin.columbia.edu/jamaicabay/jbwppac/JBAC_DEP_Interim_Report_082406.pdf.

[23] Testimony of Reed Super, October 17, 2006 City Counsel DEP Long Term Control Plan Oversight Hearing, Transcript, p. 105. *See* 6 NYCRR § 703.4, requiring a minimum of five samples per month.

[24] EPA's 1986 bacteria indicator criteria for designated bathing areas in saline waters was set at 104 *Enterococci* colonies per 100 ml at a 75% (most protective) confidence level. These 1986 criteria also set *Enterococci* levels at 158 colonies per 100 ml (82% confidence level) for moderate full body contact recreation), 158 colonies per 100 ml (90% confidence level) for lightly used full body contact recreation, and 501 colonies per 100 ml (95% confidence level) for infrequently used full body contact recreation). The geometric mean indicator standard is 35 colonies per 100 ml. *See* US EPA, *Ambient Water Quality Criteria for Bacteria,* 1986. On November 8, 2004, the EPA Administrator signed a new final rule setting Water Quality Standards for Coastal and Great Lakes Recreation Waters, which codified the 1986 standards at 40 CFR § 131.41(c)(2). *See* http://www.epa.gov/OST/beaches/final-bacteria-rule-pre-pub.pdf.

[25] Undated letter from EPA's Acting Assistant Administrator for Water Benjamin H. Grumbles to NYS DEC Commissioner Erin Crotty, regarding New York's lack of compliance with the BEACH Act (CWA § 303(i)) as of February 27, 2004, available at http://www.epa.gov/OST/beaches/letters/new-york.pdf. (New York State "has not adopted water quality criteria for coastal recreation waters for pathogens and pathogen indicators that are as protective of human health as EPA's 1986 bacteria criteria as required by [Clean Water Act] Section 303(i)."

[26] Testimony of Reed Super, October 17, 2006 City Counsel DEP Long Term Control Plan Oversight Hearing, Transcript, p. 105.

[27] EPA, Combined Sewer Overflow Demographics, at http://cfpub.epa.gov/npdes/cso/demo.cfm?-program_id=5. The 772 combined sewer systems service approximately 40 million people. The US has 15,582 municipal sanitary sewers systems and an additional 4,846 satellite systems. USEPA, Report to Congress on the Impacts and Control of CSOs and SSOs. August 26, 2004. ES-5.

[28] The Evolution of Sewage Treatment, 1.4 The Development of Wastewater Treatment in New York City, Onsite Wastewater Demonstration Project, directed by Northern Arizona University College of Civil Engineering and funded by the Arizona Department of Environmental Quality and USEPA, at http://www.cet.nau.edu/Projects/WDP/resources/History/History.htm

[29] Heaney, JP; Pitt, R and R. Field. 1999. Innovative Urban Wet-Weather Flow Management Systems. EPA/600/R-99/029, available at http://www.epa.gov/nrmrl/pubs/600r99029/600R99029prelim.pdf.

[30] NYS DEC, Hudson River Estuary Action Plan 2001, The Hudson River Estuary Program, February 2002, p.119 at http://www.dec.state.ny.us/website/hudson/actionplan2001.pdf.

[31] EPA CSO control policy requires that a CSO long term control plan be developed in coordination with water quality standards review and potential use attainability analysis. *See* Combined Sewer Overflow (CSO) Control Policy*,* 59 Fed. Reg. 18688 (April 19, 1994). The DEP is currently in the preliminary design stages of the long term plan, with a draft of the waterbody-watershed facility plans due to be submitted to the state DEC in June 2007. Public

participation is a required element of the long term plan process. The DEP has created citizen advisory committees ("CACs") for the open waters section of the harbor and for many of its most impacted tributaries. Public participation is currently slated to expire at the submission of the June plan.

[32] NYC DEP Long Term Control Plan Data Sharing Website, Peter Young Presentation, July 12, 2006.

[33] Id.

[34] 33 U.S.C. §1251 et seq. The Clean Water Act has the goal of making all surface waters fishable and swimmable. Water quality standards require specific ambient water quality levels for each waterway based on the highest achievable use. The NYC water treatment plant state permits currently allow for CSOs. However, NYC is required to adopt a long term control plan that meets the Clean Water Act fishable/swimmable goals and NYC should be designing a plan to meet the current water quality standards.

[35] 33 U.S.C. §1342, §402(q)(1)

[36] See Combined Sewer Overflows Guidance For Long Term Control Plan, EPA 832-B-95-00, at p. 3-31. Avail. at http://cfpub.epa.gov/npdes/cso/guidedocs.cfm).

[37] Rooftops to Rivers: Green Strategies for Controlling Stormwater and Combined Sewer Overflows, Natural Resources Defense Council, June 2006, available at www.nrdc.org.

[38] Response to Comments on the 2004 Administrative Consent Order for Implementation of the Combined Sewer Overflow Abatement Program in New York City. Jan. 14, 2005.

[39] DEP testimony of City Council Oversight Hearing on PLANYC Water Quality Goal, Feb. 14, 2007. See also, Response to Comments on the 2004 Administrative Consent Order for Implementation of the Combined Sewer Overflow Abatement Program in New York City. Jan. 14, 2005. The 75% target is determined using the 1988 rain year, a projected 2045 population and 2003 plant operations. Currently, using these numbers, the city captures approximately 70% wet weather in-system volumes. However, using modeling and real rainfall and population data, NYC estimates that the system achieved 76% capture in 2005.

[40] January 10, 2007 CAC Open Water Meeting, DEP PowerPoint presentation, Update on Tributary Stakeholder Group Activities, Slide 50, 88.9% CSO capture for the East River and Open Waters using 26-40 foot diameter tunnels would cost $6.3 billion.

[41] Id. 100% CSO capture for the East River and Open Waters using 26-40 foot diameter tunnels would cost $39.3 billion. Also, see July 12 CAC Open Water DEP PowerPoint presentation, NYC CSO Long Term Control Plan, Slide 32, For the entire city, "even marginal increase in capture would cost in the range of $20 to $30 billion."

[42] Bruce Bell, PhD, PE, DEE President, Comments on Draft State Pollutant Discharge Elimination System Permits and Associated Administrative Consent Order and Memorandum of Agreement for Fourteen New York City Water Pollution Control Plants, March 31, 2005, p8.

[43] Id.

[44] Id, pp. 8-9.

[45] CAC Open Water Meeting Summary Nov. 8, 2006, pp. 5-9

[46] Source control can be defined as a land development and retrofit strategy that emphasizes the protection and use of distributed interventions to reduce the volume and rate of stormwater runoff from a developed landscape.

[47] See http://www.nyc.gov/html/dep/html/news/bluebelt.html.

[48] "We need to explore innovative best practices that will prevent stormwater that isn't polluted from entering the sewage system." PLANYC 2030, at http://www.nyc.gov/html/planyc2030/html/about/faq.shtml

[49] Sustainable New York City, January 2006, p. 22. A project of the Design Trust for Public Space and the New York City Office of Environmental Coordination. Available at http://www.nyc.gov/html/oec/downloads/pdf/sustainable_nyc_final.pdf.

[50] DEP has a single contract with Biohabitats to evaluate applicability of source controls. Completion of the study has been pushed off until after the due date of the waterbody/watershed plans that will become the foundation of the citywide LTCP.

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[51] This report intends to illustrate the potential cost effectiveness of source controls, assuming uniform costs and effectiveness. The potential benefits of source control are evaluated using similarly uniform assumptions. Source control costs and effectiveness vary with site conditions.

[52] Statements of G. Kline, NYSDEC, and K. Mahoney, NYCDEP, at Gowanus Canal Water Quality Summit, March 6, 2007.

[53] July 12, 2006 CAC Open Water Meeting, DEP PowerPoint presentation, NYC CSO Long Term Control Plan

[54] Paerdegat Basin Long Term Control Plan, NYC DEP, November 2005, Revised June 2006.

[55] Queens Community Board, Flushing Bay Committee ("Annual CSO capture will be approximately 800MG.") at http://www.cb3qn.nyc.gov/page/flushing-bay/.

[56] Paerdegat Basin LTCP p. 7-18, Table 7-4

[57] Id, p. 7-19, (309 MG = 1,046 MG – 737 MG)

[58] 2004 CSO Consent Order ACO# C02-20000107-8 (Effective January 14, 2005) commits DEP to planning designing and implementing a number of CSO abatement projects.

[59] NYC DEP, Response to Comments on the 2004 Administrative Consent Order for Implementation of the Combined Sewer Overflow Abatement Program in New York City, January 14, 2005, Final Version, Costs in Table 1, p. 14; CSO decrease estimate, p.17. There is considerable debate regarding the accuracy of DEP's CSO costs. Future costs of end-of-pipe and in-line CSO abatement, through 2015, are expected to be $581.3 million. DEP seems to conflate these costs with $955 million projected to be spent on water pollution control plant upgrades and prior investments in CSO abatement. *See* NYC Independent Budget Office, *Analysis of the Mayor's Preliminary Budget for 2006*, p. 105 (Mar. 2005).

[60] The effectiveness of the end-of-pipe and in-line storage is likely overstated. See, Bent Flyvbjerg, Policy and Planning for Large Infrastructure Projects: Problems, Causes, Cures, World Bank Policy Research Working Paper 3781, December 2005. ("[A] major problem in the planning of large infrastructure projects is the high level of misinformation about costs and benefits… [t]he result is cost overruns and/or benefit shortfalls with a majority of projects," pp. 1-2.).

[61] NYC Department of Parks & Recreation, 2002-2003 Biennial Report, Eight Seasons of Progress, http://www.nycgovparks.org/sub_newsroom/biennial_report/biennial_02_03/html/greening.html.

[62] Paul Mankiewicz, Ph.D., Founder and Executive Director of the Gaia Institute. The Gaia Institute couples ecological engineering and restoration with the integration of human communities in natural systems. Paul Mankiewicz designs NYC's green streets that collect stormwater runoff. Visit http://www.gaia-inst.org/.

[63] "The Curve Number Method and a water budget analysis were used to estimate the volume of runoff generated by a 500 sf green street receiving runoff from an impervious catchment area ten times larger than the vegetated area. Such an installation might resemble a 200 ft x 25 ft street surface hydrologically coupled to a 50ft x 10ft green street feature. It was assumed that stormwater discharge from the green street feature only occurred when the volume of water in the green street overtopped a 4-inch high perimeter wall (such as might be constructed with Belgian blocks), and that water ponded in the green street feature could infiltrate into the ground at a conservative rate of 0.02 in/hr. 1988 hourly rainfall data from JFK airport were used in the analysis. The curve numbers used to represent hydrologic performance of the green street were based on average to fair grade open space, (USDA-SCS 1968). No tree canopy interception is assumed during either the dormant or growing seasons. Covered with impervious pavement, the 5500 sf area would have generated 17,704 cubic feet of stormwater runoff on an annual basis (assumes a volumetric runoff coefficient of the entire area of 0.95). The retrofitting of a 500 sf green street feature into this area would result in annual runoff amounting to only about 6% of this volume (or 1,131 cubic feet)." eDesign Dynamics Report to Riverkeeper, January 30, 2007. Cost estimate of 2,650 gallons per $1,000 construction costs based on $75,000 construction cost of approximately 800 sf green street at W. 110th St and Amsterdam in Manhattan. Cost estimate of 14,800 gallons per $1,000 construction costs based on $15 per sf for a rain garden (Bannerman, Roger. 2003. Rain Gardens, A How-to Manual for Homeowners. University of Wisconsin. PUB-WT-776) and 120 linear feet of curb at $6.95 per linear foot (Costs of Urban Stormwater Control, EPA, Heaney and Wright, January 2002, EPA-600/R-02/021).

[64] Heaney, JP; Pitt, R and R. Field. 1999. Innovative Urban Wet-Weather Flow Management Systems. EPA/600/R-99/029, available at http://www.epa.gov/nrmrl/pubs/600r99029/600R99029prelim.pdf.

[65] As discussed in note 63, these calculations employed a collection area 10 times greater than the vegetated surface. Infiltration rates capable of supporting collection areas larger than 10 times the vegetated area have been observed at the green street being installed at Cozine and Crescent in East New York, Brooklyn.

[66] Paul Mankiewicz, phone conversation, March 2, 2007.

[67] See note 71 for detailed explanation of calculations to determine street trees effect on decreasing runoff to sewers.

[68] The DEP uses 640,900 MWh per year. New York City Energy Policy: An Electricity Resource Roadmap, Prepared by the New York City Energy Policy Task Force, January 2004., p48. Assume 100% of power is used in wastewater treatment. Mean 2002 total daily flow to plants of 1,220 MGD. NYC DEP Water Pollution Control Plants, available at http://home2.nyc.gov/html/dep/hqws/html/plant.html. Annual flow therefore is 1,220 million gallons *365 days = 445.3 billion gallons per year. Dividing total energy consumption by total water treated gives us 1.439 * 10^-6 MWh / gallon. Assume $0.186 per kWhr. (1.439*10-6 MWh/gallon * $0.186/kWh * 1000 kWh/MWh * 247,000,000 gallons = $66,122.)

[69] Paul Mankiewicz, phone conversation, March 2, 2007.

[70] Get That Oak An Accountant; Study Puts a Dollar Value on Work Done by City Trees, The New York Times, May 12, 2003. The city values a street tree at $1,000. “The average cost of putting a tree in the sidewalk is $590.” Queens Forestry values a 3” diameter tree at $750.

[71] “The Curve Number Method and literature sources documenting tree canopy rainfall interception (Gash et al 1995) were used to calculate the difference in annual volume of runoff from a 25 square foot tree pit housing a tree with 20 ft radius canopy, compared to a 1,256 square feet (3.14*20^2) patch of paved land with a volumetric runoff coefficient of 0.95. Hourly precipitation data from 1988 (JFK Airport gage# 94789) were used in the analysis. This rainfall record is used routinely by NYCDEP for facility planning purposes. The curve numbers used to represent street trees were comparable to those used to describe poor to fair grade woods (USDA-SCS 1968). The results of the analysis indicate that, if covered with impervious pavement, this area would produce about 4,043 cubic feet of runoff annually. The combined effect of the tree canopy and tree pit is to reduce annual runoff from the area by approximately 44% (or to approximately 2,282 cubic feet per year).” eDesign Dynamics Report to Riverkeeper, March 5, 2007.

[72] New York City Department of Parks and Recreation, Street Tree Census: Volunteers Count, May 9, 2006, at http://www.nycgovparks.org/sub_newsroom/daily_plants/daily_plant_main.php?id=19848.

[73] See note 63 for detailed explanation of calculations to determine decrease in runoff to sewers.

[74] New York City Department of Parks and Recreation, Caring for Street Trees and Greenstreets, at http://www.nycgovparks.org/sub_your_park/trees_greenstreets/tree_care_tips/water.html.

[75] Karen Doherty, D. Bloniarz, H. Ryan, “Positively the Pits! Successful Strategies for Sustainable Streetscapes,” Tree Care Industry, Nov. 2003.

[76] Id.

[77] “EPA guidelines (1999) specify that the porous reservoir underlying a porous pavement surface should be designed to hold the 2yr, 24-hour storm, (corresponding to 3.5 inches of precipitation in Manhattan). This depth of rainfall can be stored in 17.5-inch deep volume of crushed stone (porosity=20%), the assumed depth of the reservoir in this modeling exercise. The water table position in the 17.5” deep crushed stone reservoir underlying a porous pavement was simulated with a water budget analysis, assuming that the invert of an overflow pipe discharging to the sewer was 15” above the bottom of the reservoir, and utilizing the 1988 hourly rainfall record from JFK Airport. The results indicate that for assumed conservative infiltration rates to the sub-grade of 0.02 in/hr and above, there would be no annual runoff from this configuration porous pavement, i.e. there would be 100% reduction in annual runoff, over the imperviously paved condition. If this configuration of porous pavement were placed underneath the canopy of a street tree, there would be 100% reduction in annual runoff from the tree pit area as well. Note that near 100% runoff capture is commonly reported for porous pavement installations (Dreelin et al 2006, Ferguson 2005, Brattebo and Booth 2003, Booth and Leavitt 1999, Legret and Collandini 1999, Legret et al 1996).” eDesign Dynamics Report to Riverkeeper, March 5, 2007. 100% reduction in runoff from 275 sq ft porous pavement and 25 sq ft tree pit: 2282 cubic feet per gallon * 7.4805 gallons per cubic foot * 300 sq ft /1256 sq ft = 4,077 gallons. Stormwater volumes drawn from note 71. Adding porous pavement to 500,000 existing trees (500,000 trees * 4,077 gallons per tree) reduces stormwater runoff by 2,038,674,000 gallons.

[78] Porous pavement costs between $2.50 and $8.30 per square foot. (USEPA. 1999. “Stormwater Technology Fact Sheet: Porous Pavement.” September 1999. available at http://www.epa.gov/owm/mtb/porouspa.pdf) Assume $8.30

per square foot, installing 275 sq ft of porous pavement, resulting in 100% reduction in runoff from 300 sq ft, including porous pavement and 25 sq ft tree pit (see note 71).

[79] See note 71. (13,173 gallons per tree + 4,077 gallons per 275 sq ft of porous concrete = 17,250 gallons; $8.30 per square foot *275 sq ft + $1000/tree = 3,282.50; $300,000,000 tank cost / $3,282.50 tree and porous pavement cost = 91,393 trees with porous pavement; 91,393 trees with porous pavement * 17,250 gallons per tree with porous pavement = 1,576,000,000 gallons)

[80] Paul Mankiewicz, phone conversation, March 2, 2007.

[81] New Green Roofs cost between $6.40 and $15.30 per square foot. Retrofit Green Roofs cost between $9.00 and $25.50 per square foot. Peck, S. and M. Kuhn. Accessed 2003. Design Guidelines for Green Roofs. See http://www.cmhc-schl.gc.ca/en/imquaf/himu/himu_002.cfm.

[82] Id.

[83] "Green roof hydrologic performance was modeled based on a set of laboratory experiments. In those experiments, green roofs with substrate depths varying from 1-4 inches were subjected to uniform rainfall intensity of 0.9 in/hr. During two different trials of the experiment, runoff from the green roof began after about 10 minutes of rainfall (or after a total of 0.15 inches of rainfall fell on the green roof). This data was used to develop a simple green roof runoff model that assumes that a) runoff occurs if the depth of rainfall exceeds 0.15 inches in any one hour and/or b) the relationship of precipitation to runoff is 1:1 if more than 0.15 inches of precipitation fell during the previous 24 hours. To be conservative, no evapotranspiration is assumed. The results suggest that green roofs can reduce the total annual amount of runoff by about 23% over a comparable impervious roof. This value is on the low end of literature values such as those compiled by Dunnett and Kingsbury (2004) and Mentens et al (2006)." The average non-green roof runoff of the experiment was 81% of rainfall volume." eDesign Dynamics Report to Riverkeeper, January 30, 2007. A 23% reduction in runoff, decreases the total runoff to 62% of rainfall volume. A 1988 rain year was used. At $15.30 per square foot, $1000 can install about 65 square feet, decreasing annual runoff by approximately 340 gallons. At $6.40 per square foot, $1000 can install about 156 square feet, decreasing annual runoff by approximately 812 gallons per year.

[84] At $25.50 per square foot, about 40 square feet of traditional roof can be retrofit with green roof for $1000, decreasing annual runoff by approximately 203 gallons per year. At $9.00 per square foot, about 111 square feet of traditional roof can be retrofit with green roof for $1000, decreasing annual runoff by approximately 577 gallons per year.

[85] Rosenzweig, C., S. Gaffi n, and L. Parshall (Eds.) 2006. Green Roofs in the New York Metropolitan Region: Research Report. Columbia University Center for Climate Systems Research and NASA Goddard Institute for Space Studies. New York. 59 pages. p. 5.

[86] The Official Website for Central Park, Frequently Asked Questions, http://www.centralparknyc.org/centralparkhistory/faqs.

[87] Using the calculations explained in detail in note 83 and assuming 100% eligibility of flat roofs as green roofs. Further analysis must determine the eligibility of flat roofs for green roof construction.

[88] Lisa Chamberlain, "A Roof Garden? Its Much More than That," NY Times, Aug. 10, 2005.

[89] Penn State Green Roof Research, About Green Roof Research, http://hortweb.cas.psu.edu/research/greenroofcenter/history.html. Also, see US EPA, Greeen Roofs at http://www.epa.gov/heatisland/strategies/greenroofs.html ("Another factor reducing the cost of a green roof is that vegetation can extend the life of a roof.")

[90] Built up roofs are expected to last 20 years. Drew Ballensky, Roofing Life-Cycle Costs Emerge, Buildings, July 2006. Available at http://www.buildings.com/Articles/detail.asp?ArticleID=3187

[91] See http://www.epa.gov/heatisland/strategies/greenroofs.html.

[92] Jay Romano, "Your House: Fiddling on the Roof," NY Times, June 4, 1995

[93] Retrofit green roofs cost between $9.00 and $25.50 per square foot. By subtracting the $1.25 to $3.00 that the property owner would have had to pay for a traditional retrofit, the resulting cost for source control would range from $6.00 to $24.25 per square foot. Using the calculations explained in detail in note 83, we find that at $6.00 per square foot, stormwater runoff could be reduced by 866 gallons per year for every $1000 invested. Note that the more inexpensive, extensive green roofs reflect the conditions used in the experiment used to determine decreased runoff for this report. The more expensive intensive green roofs decrease runoff by higher percentages.

[94] New green roofs cost between $6.40 and $15.30 per square foot to install. By subtracting the $4.00 to $6.00 that the property owner would have had to pay for a traditional new roof, the resulting cost for source control would range from $0.40 to $11.30 per square foot. Using the calculations explained in detail in note 83, we find that at $0.40 per square foot, stormwater runoff could be reduced by 12,995 gallons per year for every $1000 invested.

[95] Paul Mankiewicz, phone conversation, March 2, 2007.

[96] US Geological Survey, Geology of the New York City Region: A Preliminary Regional Field-Trip Guidebook, 2003. Available at http://3dparks.wr.usgs.gov/nyc/

[97] Not all areas of NYC are ideal for aquifer recharge. Stormwater generated above shallow bedrock and aquitards in some areas may need to be transferred to areas more suitable for aquifer recharge.

[98] Available at http://webdocs.nyccouncil.info/textfiles/Int%200321-2006.htm?CFID=1349710&CFTOKEN=27613211

[99] City of Portland Oregan, Office of Sustainable Development, Rainwater Harvesting, at http://www.portlandonline.com/osd/index.cfm?a=bbehfa&c=ecbbd

[100] NYC Department of City Planning, 2002 Primary Land Use: NYC By Borough at http://www.nyc.gov/html/dcp/pdf/landusefacts/landuse_tables.pdf

[101] See, for example, Water Use and Conservation Bureau, New Mexico Office of the State Engineer, A Waterwise Guide to Rainwater Harvesting, at http://www.ose.state.nm.us/water-info/conservation/rainwater-harvesting.pdf

[102] Karen Sands and T. Chapman, Milwaukee Metropolitan Sewerage District, Milwaukee, Wisconsin, Rain Barrels – Truth or Consequences, presented at USEPA National Conference on Urban Stormwater: Enhancing Programs at the Local Level, February 17-20, 2003, p. 390-395. Available at http://www.epa.gov/owow/nps/natlstormwater03/fullreport.pdf. Study assumed two 90 gallon barrels attached to each roof and emptied between storms. Because of extensive stormwater infrastructure, Milwaukee only experiences 2.5 CSO events per year. The study did not demonstrate a decrease in these already rare CSO events.

[103] Texas Water Development Board (TWDB). 2005. The Texas Manual on Rainwater Harvesting 3rd Edition. See http://www.twdb.state.tx.us/publications/reports/RainwaterHarvestingManual_3rdedition.pdf. Rain barrels cost between $0.50 and $4.00 per gallon. Assume $4.00.

[104] Calculation: (273 million gallons / (40,000 homes * 180 gallons/home * $4.00/gallon))*1000 = 9,479 gallons per $1000.

[105] US EPA Memorandum, Using Green Infrastructure to Protect Water Quality in Stormwater, CSO, Nonpoint Source and other Water Programs, Benjamin Grumbles, Assistant Administrator, Washington, D.C., March 5, 2007.

[106] For a detailed discussion of how other cities have adopted source control, see Rooftops to Rivers: Green Strategies for Controlling Stormwater and Combined Sewer Overflows, Natural Resources Defense Council, June 2006, available at www.nrdc.org.

[107] Id.

[108] "Reducing stormwater entering the system would eliminate the potential overflow of untreated wastewater into the harbor, minimizing the need to carry out expensive retrofitting of the City's sewer system." Sustainable New York City, January 2006, p. 22. A project of the Design Trust for Public Space and the New York City Office of Environmental Coordination. Available at http://www.nyc.gov/html/oec/downloads/pdf/sustainable_nyc_final.pdf.

[109] Hugh L. Carey Battery Park City Authority Residential Environmental Guidelines at http://www.batteryparkcity.org/pdf/BPCA_GreenGuidelines.pdf (Section 5.1, p 42, Requirements, "Provide for 2.4 in. of rainwater falling on all building roofs and setbacks to be collected, treated, and stored on-site for reuse." Section 5.4.3, p46, Requirements "Develop a landscape maintenance plan of sustainable landscape practices for all landscaped areas.)

[110] Manhattan Rental Market Overview, 1st Half 2006, Prudential Douglas Elliman Real Estate, p.2 (Average and Median Rental Prices by Neighborhood Year End 2005 vs. June 2006) at http://www.prudentialelliman.com/images/reports/insert%202006.pdf.

[111] See http://www.greeningablock.org.

[112] Atlantic Yards FEIS, November 2006, Table 11-12, p. 11-35, at http://www.empire.state.ny.us/AtlanticYards/.

[113] Oct 17, 2006, City Council LTCP Oversight Hearing Transcript, First Deputy Commission Lawitts, "…many of these [source controls] have limited value for large scale CSO mitigation…" p26 L11-13; Deputy Commissioner Licata, "…these types of source controls may have a limited ability to affect the CSO problem…" p. 32 L14-16.

[114] eDesign Dynamics contract (An Assessment of the Cost-effectiveness of Low Impact Development for Reducing Combined Sewer Overflows in NYC) was with the Division of Water Quality Improvement, Bureau of Engineering, Design, and Construction Joint Venture Team. The goal of the study was to determine realistic low impact development [source control] implementation levels, costs, and impacts within a small representative study area. No reason was given for cancellation of the contract in 2005. The Gaia Institute's Green Corridor Project was a demonstration project meant to install source controls on six blocks of Lafayette Street in the Bronx and measure the resulting reduction in stormwater runoff to sewers. The Green Corridor Project was cancelled in 2004.

[115] To be sure, some flow of unpolluted stormwater into the Harbor is necessary for a balanced and healthy tidal estuary.

[116] Mayor's Sustainability Speech, Dec 12, 2006. Available at http://www.nyc.gov/portal/site/nycgov/menuitem.c0935b9a57bb4ef3daf2f1c701c789a0/index.jsp?pageID=mayor_press_release&catID=1194&doc_name=http%3A%2F%2Fwww.nyc.gov%2Fhtml%2Fom%2Fhtml%2F2006b%2Fpr432-06.html&cc=unused1978&rc=1194&ndi=1.

[117] PLANYC2030 – About PLANYC – 10 Goals for 2030. Available at http://www.nyc.gov/html/planyc2030/html/about/10-goals.shtml.

[118] NYC population is projected to increase by 1.2M in 20 years. The additional 150 million gallons of daily sewage will ensure CSOs occur sooner and last longer than they do today.

[119] For more discussion see The Next Step in Green?, NY Academy of Science, Montalto and Culligan, 2006.

[120] Cubasch, U., Meehl, G.A., Boer, G.J., Stouffer, R.J., Dix, M., Noda, A., Senior, C.A., Raper, S., Yap, K.S., 2001: Projections of Future Climate Change. In: Climate Change 2001: The Scientific Basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change [Houghton, J.T., Y. Ding, D.J. Griggs, M. Noguer, P.J. van der Linden, X. Dai. K. Maskell, and C.A. Johnson (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 881pp.

[121] Rosenzweig, C., S. Gaffi n, and L. Parshall (Eds.) 2006. Green Roofs in the New York Metropolitan Region: Research Report. Columbia University Center for Climate Systems Research and NASA Goddard Institute for Space Studies. New York. 59 pp. p. 15.

[122] Akbari, H., Cooling Our Communities: A Guidebook on Tree Planting and Light-Colored Surfacing, U.S. Environmental Protection Agency, Office of Policy Analysis, Climate Change Division, 1992, 217 pp.

[123] Rosenzweig, C. and W.D. Solecki (Eds.). 2001. Climate Change and a Global City: The Potential Consequences of Climate Variability and Change—Metro East Coast. Report for the U.S. Global Change Research Program, National Assessment of the Potential Consequences of Climate Variability and Change for the United States, Columbia Earth Institute, New York. 224 pp., p. 133, Figure 8-11.

[124] Assessing Potential Public Health and Air Quality Impacts of Changing Climate and Land Use in Metropolitan New York, A Study by the New York Climate & Health Project, http://www.earthinstitute.columbia.edu/events/2004/images/NYCHP_Briefing_Paper_June04.pdf

[125] Id.

[126] Akbari, H., Cooling Our Communities: A Guidebook on Tree Planting and Light-Colored Surfacing, U.S. Environmental Protection Agency, Office of Policy Analysis, Climate Change Division, 1992, 217 pp., p. 32.

[127] A green roof is most effective at cooling when plant height is approximately 108 times the diameter. This equates to about 3 feet tall meadow plants.

[128] Rosenzweig, C., S. Gaffi n, and L. Parshall (Eds.) 2006. Green Roofs in the New York Metropolitan Region: Research Report. Columbia University Center for Climate Systems Research and NASA Goddard Institute for Space Studies. New York. 59 pages.

[129] See note 83 for detailed explanation of green roof stormwater runoff calculations.

[130] Installing green roofs on 50% of eligible flat roofs could decrease city temperatures by 1.4°F. See note 128. NYS energy consumption in the summer correlates linearly with temperature at approximately 7.7gWhr/deg/day. NYC uses 28% of NYS Energy Consumption. Assume 120 days of summer cooling. Electricity in NYC costs $0.186 per

kWhr. (1.4°F * 7.7gWhr/deg/day * 0.28 * $0.186/kWhr * 120 days = $67,000,000). NYC uses approximately 28% of New York State Energy Consumption See Resource Insight, Inc., Energy Plan for the City of New York, prepared for The New York City Economic Development Corporation, Dec. 23, 2003. 89 pages. p 4. NYS energy consumption correlates linearly to temperature. See Rosenzweig, C. and W.D. Solecki (Eds.). 2001. Climate Change and a Global City: The Potential Consequences of Climate Variability and Change—Metro East Coast. Report for the U.S. Global Change Research Program, National Assessment of the Potential Consequences of Climate Variability and Change for the United States, Columbia Earth Institute, New York. 224 pp., p 133, Figure 8-11. Assume four months of summer cooling (120 days).

[131] American Lung Association, State of the Air: 2006. Of the 3 categories evaluated, NYC ranked 15th, 16th and 9th respectively for worst Short Term Particle Pollution, Long Term Particle Pollution and Ozone Pollution. http://lungaction.org/reports/sota06_cities.html.

132 Assessing Potential Public Health and Air Quality Impacts of Changing Climate and Land Use in Metropolitan New York: A Study by the New York Climate & Health Project. Project Briefing Paper. June 28, 2004. Available at http://www.earth.columbia.edu/news/2004/story06-11-04.html.

[133] Id.

[134] Greening New York's Cities: A Guide to How Trees Can Clean Our Water, Improve Our Air, and Save Money; May 2004. 0.44 lbs/tree is an average number extrapolated from Greening New York's Cities. Actual pollutant removal varies with the size and species of trees. For example, see Becket et al., Effective Tree Species for Local Air-Quality Management, Journal of Arboriculture 26(1): January 2000.

[135] See, for example T.S. Frederickson, et al., Light Environment Alters Ozone Uptake Per Net Photosynthetic Rate in Black Cherry Trees, 16 Tree Physiology 1996, pp. 485-90. ("Ozone uptake can be calculated as the product of stomatal conductance and ozone concentrations." Note, however that "Factors that lead to high ozone uptake rates result in greater exposure of leaf mesophyll cells to ozone which may increase… injury." p. 485) Also, see Greening New York's Cities (note 134), estimating 0.1277 lbs of ozone uptake per tree per year.

[136] J. Patz, New York Climate and Health Project, Climate Change and Public Health: Multiple Pathways for Exposure, June 25, 2004. Slide 9. (Graph illustrating NYC ozone concentrations changing with temperature. Because ozone production increases exponentially with temperature, the first few degrees of cooling are the most effective for ozone reduction.) Available at http://www.earthinstitute.columbia.edu/events/2004/nycch_documents/25June04_J_Patz_AM.pdf.

[137] Parts per billion by volume.

[138] Greening New York's Cities: A Guide to How Trees Can Clean Our Water, Improve Our Air, and Save Money; May 2004.

[139] Using the numbers from note 130, we can derive decreased air pollution from decreased energy demand. (7.7 gWhr/deg/day * 0.28 *1.4°F *120 days/summer = 362,208 MWhrs/summer). According to the EPA: production of 1 megawatt hour (MWh) by burning oil produces 1,672 lbs of CO2, 12 lbs of SO2, and 4 lbs of NOx; production of 1 MWh by burning coal produces 2,249 lbs of CO2, 13 lbs of SO2, and 6 lbs of NOx; and production of 1 MWh by burning natural gas produces 1135 lbs of CO2, 0.1 lbs of SO2, and 1.7 lbs of NOx. EPA Clean Energy http://www.epa.gov/cleanenergy/oil.htm. Energy in NYC comes from several sources including: 50% coal, 3% oil 18% natural gas – Atomic Balm, NY Times Magazine, July 16, 2006. (Assume no emissions from nuclear and hydroelectric power production.) Thus, the decreased air pollution from a 3°F decrease in summer temperatures can be calculated as follows: 362,208 MWh * ((0.5 * (2,249 lbs CO2 + 13 lbs SO2 + 6 lbs NOx)) + (0.03 * (1,672 lbs CO2 + 12 lbs SO2 + 4 lbs NOx)) + (0.18* (1,135 lbs CO2 + 0.1 lbs SO2 + 1.7 lbs NOx)) = 503,202,535 lbs of air pollution (or 251,601 tons).

[140] The DEP uses 640,900 MWh per year. New York City Energy Policy: An Electricity Resource Roadmap, Prepared by the New York City Energy Policy Task Force, January 2004., p. 48. Assume 100% of power is used in wastewater treatment. Mean 2002 total daily flow to plants of 1,220 MGD. NYC DEP Water Pollution Control Plants, available at http://home2.nyc.gov/html/dep/hqws/html/plant.html. Annual flow therefore is 1,220 million gallons *365 days = 445.3 billion gallons per year. Dividing total energy consumption by total water treated gives us 1.439 * 10^-6 MWh / gallon. Treating an additional 5.1 billion gallons of captured water would consume an additional 7,340 MWh of electricity. (Arrived by: 5.1 billion * 1.439 * 10-6.) Using the energy production pollution calculations explained in note 141 we find that 7,340 MWh creates 5,098 tons of air pollution.

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[141] Akbari, H., Cooling Our Communities: A Guidebook on Tree Planting and Light-Colored Surfacing, U.S. Environmental Protection Agency, Office of Policy Analysis, Climate Change Division, 1992, 217 pp.

[142] Wolf, 2003 Public Response to the Urban Forest in Inner-City Business Districts, Journal of Arboriculture 29

[143] Human-Environment Research Laboratory, Department of Natural Resources and Environmental Sciences, University of Illinois http://web.aces.uiuc.edu/herl/submit.cfm.

[144] NYCDEP, 2005 Drinking Water Supply and Quality Report, p. 1. Available at http://www.nyc.gov/html/dep/pdf/wsstat05.pdf.

[145] JFK 1988 Rainfall was 45 inches. NYC land area is 303 square miles. U.S. Census Bureau, 2000 Census. 303 square miles * 45 inches * 7.48 gallons per cubic foot = 236 billion gallons per year.

[146] The cost only reflects electricity costs as explained in detail in Note 130. (5.1 billion gallons * 1.49 * 10-6 MWh/gallon * 1000kWh/MWh * $0.186 per kWhr = $1.41 million)

[147] Air pollution from electricity production for water treatment. Air pollution from electricity production is detailed in note 141. Tree air pollution reductions are detailed in note 134. Note that while energy production pollution is widely distributed, air quality improvements are localized to NYC.

[148] 25 year-old northeast maple-beech-birch average 2.52 lbs of CO2 uptake per year. 25 year-old northeast white and red pines average 14 lbs of CO2 uptake per year. Tufts Climate Initiative at http://www.tufts.edu/tie/tci/sequestration.htm. Calculations assume: 2.52 lbs of CO2 per tree per year; no CO2 benefits from greenstreets or green roofs.

[149] Assume $1,000 per street tree (see note 70). 50% solution includes 150,000 street trees ($150 million; 1.9 billion gallons per year) and 275 sq. ft. of porous pavement surrounding 105,148 street trees ($240 million; 428 million gallons per year; assuming $8.30 per square foot – see note 78). 100% solution includes 300,000 stree trees ($300 million; 3.9 billion gallons per year) and 275 sq ft of porous pavement surrounding 210,296 street trees ($480 million; 857 million gallons per year). $8.30 per sq ft is a conservative cost for porous concrete sidewalk, which can cost as little as $2.50 per sq ft. Stormwater estimate conservatively assumes no additional street trees in Greenstreets. However, most existing Greenstreets include street trees.

[150] Assume 500 sq ft Greenstreets built at the same cost per square foot as the $75,000 Greenstreet on W 110 and Amsterdam (or $46,875 per Greenstreet). 50% solution of 2,133 stormwater collecting Greenstreets would reduce runoff by 264 million gallons per year. 100% solution of 4,266 stormwater collecting Greenstreets would reduce runoff by 528 million gallons per year. Most Greenstreets can be built for less. Using the assumptions explained in note 63, a 500 sq ft Greenstreet would cost $8,334. Also, assume all Greenstreets are new. This conservative estimate does not include the significant cost savings available by simply retrofitting the over 2,000 existing Greenstreets to collect stormwater.

[151] Assume new green roof incentive cost $0.40 per square foot ($6.40 for a new green roof - $6.00 for a new non-green roof). Assume traditional roof retrofit as green roof incentive cost $6.00 per square foot ($9.00 green roof retrofit - $3.00 traditional roof retrofit). Using the low end of the green roof cost scale is consistent with the extensive green roofs used to determine 23% reduction in runoff. 50% solution includes $35 million of incentive toward 87.5 million sq ft of new green roof and $525 million of incentive toward retrofit of 87.5 million sq ft of traditional roof to new green roof. The resulting 175 million sq ft of green roof will reduce runoff by 909 million gallons per year. 100% solution includes $70 million of incentive toward 175 million sq ft of new green roof and $1050 million of incentive toward retrofit of 175 million sq ft of traditional roof to new green roof. The resulting 350 million sq ft of green roof will reduce runoff by 1.8 billion gallons per year.

[152] See note 130 for detailed explanation of savings.