

STORMWATER MANAGEMENT METHODS and Opportunities for Compost Use

An inventory of where compost is used in stormwater management plans
and an assessment of where it could fit in plans of target cities relative to
larger green infrastructure and climate resilience strategies



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STORMWATER MANAGEMENT METHODS and Opportunities for Compost Use

By Joseph Lim

OBJECTIVE: To take an inventory of where compost is used in stormwater management plans, as well as to assess where it could fit as a part of city planning in target cities, and as a part of larger green infrastructure and climate resilience strategies

STORMWATER MANAGEMENT IS AN ISSUE FACING many communities across the country. Stormwater runoff causes flooding, pollution of water, contamination of drinking water supplies and a danger to public health. Many cities in the United States have combined sewer systems which are designed to collect stormwater runoff, sewage, and industrial wastewater. Stormwater is then transported to a sewage treatment plant to be treated and discharged to a nearby water body such as rivers or lakes. If due to stormwater, the volume exceeds the plant's capacity these combined sewer system overflows are discharged directly to the nearby water body without treatment, introducing untreated waste, pollutants, debris and toxic materials to the water.²

As development is constructed in major cities, the natural hydrology of an area is negatively affected due to an increase in impervious surface area, thus, decreasing the amount of stormwater that can be naturally infiltrated.

Rather than using grey infrastructure (i.e. water treatment plants), green infrastructure is a method to manage stormwater by mimicking the natural environment through strategies such as planting trees, creating rain gardens, etc.

Green Infrastructure strategies often involve soil that can benefit from compost use as compost can significantly reduce the amount of stormwater runoff, as well as absorb and retain pollutants.¹ Compost also helps improve soil structure, sequesters carbon, helps to divert organic materials from landfills, and listed as a best management practice (BMPs) for stormwater management by the EPA.³

This document provides examples of different stormwater management methods applied in cities all over the US, as well as different green infrastructure plans cities implemented and emerging opportunities for compost.

Green infrastructure is a method to manage stormwater that mimics the natural environment

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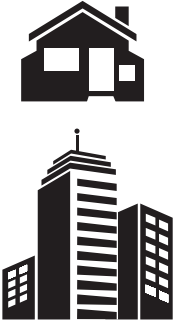



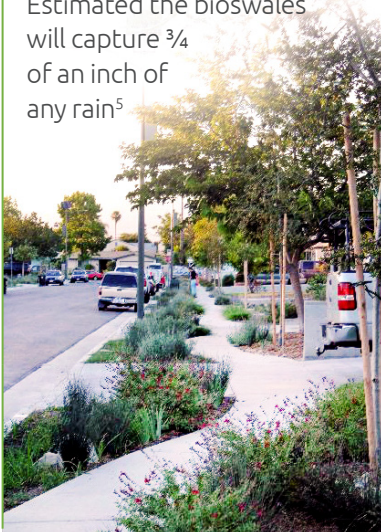
2. "What Are Combined Sewer Overflows (CSOs)? Urban Environmental Program in New England." EPA, Environmental Protection Agency, 10 Apr. 2017, www3.epa.gov/region1/eco/uep/cso.html.

3. Newman, Chris. "Compost-Based Stormwater Best Management Practices." EPA, archive.epa.gov/region5/waste/solidwaste/compost/web/pdf/compost_bmp_presentation_wisconsin.pdf.

TABLE 1

Description of Different Stormwater Management Techniques

Distinguishes between which techniques use soil. The table includes examples of where these techniques are being implemented

Types of Stormwater Management	What Does It Do?	Goals	Applications that Use Soil	Applications	Where its Implemented
<p>Downspout Disconnection (to areas of land with soil)</p> 	<p>Reroutes drainage pipes from draining stormwater into storm sewer. Drains it into permeable areas. Can store stormwater and/or allow stormwater to infiltrate into the soil</p> 	<p>Reduce runoff volume</p>	<p>Use soil</p> 	<p>Residential and commercial zone</p> 	<p>“Between 1993 and 2011, Portland’s Downspout Disconnection Program disconnected over 56,000 downspouts from the city’s combined sewer system”⁴</p>
<p>Stormwater Greenstreets</p> 	<p>Planted areas designed to collect and infiltrate stormwater that run off streets and sidewalks. Usually permeable pavements, planter boxes and trees</p>	<p>Reduce runoff volume</p>	<p>Use soil</p> 	<p>Commercial and residential zone</p> 	<p>Elmer Avenue in Los Angeles becomes a green street. Estimated the bioswales will capture ¾ of an inch of any rain⁵</p> 

4. “Downspout Disconnection Program.” Reusable vs Disposable Dishware RSS, www.portlandoregon.gov/bes/54651.

5. “The Dry Garden: Elmer Avenue Becomes Green Street, a Water-Wise and Solar-Lighted Community Effort.” Los Angeles Times, latimesblogs.latimes.com/home_blog/2010/07/elmer-avenue-sun-valley.html.

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Types of Stormwater Management	What Does It Do?	Goals	Applications that Use Soil	Applications	Where its Implemented
<p>Bioswales</p> 	<p>Planted areas in the sidewalk that are designed to collect and manage stormwater</p>	<p>Reduce runoff volume/ Absorb by Infiltration</p>	<p>Use soil</p> 	<p>Commercial and residential zone</p> 	<p>Implemented all over NYC⁶</p> <p>Implemented in Broadview Green Grid, Seattle. Uses compost-amended soil and erosion is controlled with compost blankets⁷</p>
<p>Green Roofs</p>  <p><small>Colin Lacy</small></p>	<ul style="list-style-type: none"> • Top vegetative layer that grows on engineered soil • Saves space in dense urban areas because ability to grow on top of buildings • Can reduce energy costs for cooling 	<p>Rainfall infiltration and evapo-transpiration</p>	<p>Use soil</p> 	<p>Commercial zone</p> 	<p>Implemented all around the USA⁸</p>
<p>Blue Roofs</p> 	<ul style="list-style-type: none"> • Weirs at the roof drain inlets create temporary ponds and gradual release of stormwater • Designed to slowly release stormwater 	<p>Detain water</p>	<p>Do not use soil</p> 	<p>Commercial zone</p> 	<p>Blue and Green roofs were tested in an pilot program in NYC elementary school⁹</p>

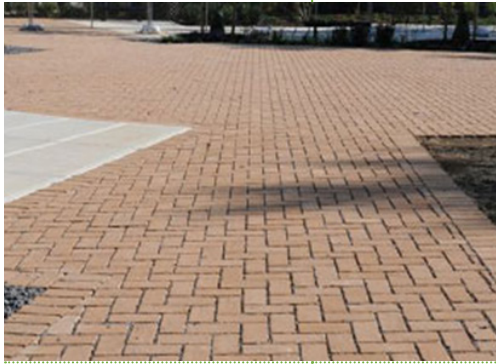







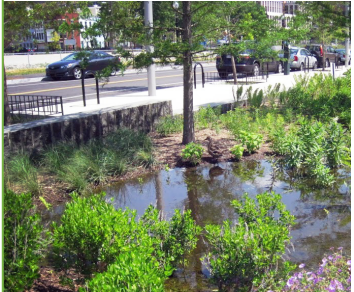
6. "New York Lets a Thousand Bioswales Bloom." State of the Planet, 22 Nov. 2016, blogs.ei.columbia.edu/2016/11/22/new-york-lets-a-thousand-bioswales-bloom/.

7. Horner, Richard, and Jennifer Reiners. BROADVIEW GREEN GRID NATURAL DRAINAGE SYSTEM PERFORMANCE MONITORING. Seattle Public Utilities, 2009, pp. 1–17, BROADVIEW GREEN GRID NATURAL DRAINAGE SYSTEM PERFORMANCE MONITORING

8. "The Greenroof & Greenwall Projects List." SOLARIS at Fusionopolis (Phase 2B): From Military Base to Bioclimatic Eco-Architecture, By T. R. Hamzah & Yeang Sdn. Bhd., <http://www.greenroofs.com/projects/plist.php>

9. "Blue Roof and Green Roof." Gowanus Canal – History, www.nyc.gov/html/dep/html/stormwater/green_pilot_project_ps118.shtml.

TABLE 1 Description of Different Stormwater Management Techniques

Types of Stormwater Management	What Does It Do?	Goals	Applications that Use Soil	Applications	Where its Implemented
<p>Permeable Surfaces</p> 	<p>Uses a range of materials like permeable pavers or porous concrete. Allows water to seep in through the material and be absorbed into the soil underneath</p>	<p>Detain Water</p>	<p>Use soil</p> 	<p>Commercial and residential zone</p>  	<p>Low traffic areas (e.g Parking Lots)</p> <p>Concrete paving stones were set at the Garrison Institute with grass. It allowed water to infiltrate into the ground in the spaces between¹⁰</p>
<p>Rain Gardens</p> 	<p>Vegetated or landscaped depressions with an engineered soil layer</p>	<p>Infiltration of water</p>	<p>Use soil</p> 	<p>Residential and industrial zone</p>  	<p>NYC is building 321 curbside rain gardens in Queens to improve the health of Newtown Creek¹¹</p> 

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10. "Garrison Institute Permeable Paving." Freshwater Wetlands Program - NYS Dept. of Environmental Conservation, www.dec.ny.gov/lands/59329.html.

11. "City Begins Construction of 321 Curbside Rain Gardens in Sunnyside, Maspeth and Ridgewood to Improve the Health of Newtown Creek." Gowanus Canal – History, www.nyc.gov/html/dep/html/press_releases/16-047pr.shtml#.Wz-ktNIzpPY.

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<p>Subsurface Detention Systems</p> 	<ul style="list-style-type: none"> Provides temporary storage of stormwater runoff underground Primarily designed with a gravel bed that stores water 	Storage of water	Do not use soil 	Residential and industrial zone 	Most subsurface detention systems are used in newly developed areas where land cost are a concern. Usually under parking lots or newly paved surface in commercial, residential and industrial ¹²
<p>Rain Barrels and Cisterns</p> 	<ul style="list-style-type: none"> Designed to catch water from rooftops and other impervious surfaces Can be stored underground 	Storage of water	Do not use soil 	Residential zone 	Commonly used in houses or apartment buildings. The water collected can be used to wash cars or water plants
<p>Wet Detention Basin</p> 	<ul style="list-style-type: none"> Wet detention basin treats stormwater through sedimentation and biological uptake by using plants, algae and bacteria Shaped like ponds or channels¹³ 	Temporary storage of water	Use soil 	Industrial zone 	Usually located in less dense areas to minimize space consumption. Low maintenance and promotes wildlife

12. Storm Water Technology Fact Sheet On-Site Underground Retention/Detention. United States Environmental Protection Agency, 2001, pp. 1-11, Storm Water Technology Fact Sheet On-Site Underground Retention/Detention

13. ACTIVITY: Wet Detention Basin. Knoxville BMP Manual / Stormwater Treatment, 2007, pp. 1-11, ACTIVITY: Wet Detention Basin. http://www.knoxvilletn.gov/UserFiles/Servers/Server_109478/File/Engineering/BMPManual/ST-02.pdf

TABLE 1 Description of Different Stormwater Management Techniques

Types of Stormwater Management	What Does It Do?	Goals	Applications that Use Soil	Applications	Where its Implemented
<p>Filter Strip</p> 	<p>A linear section of land, grassed or forested that physically filters and infiltrates stormwater¹⁶</p>	<p>Filter and Infiltration</p>	<p>Use soil</p> 	<p>Commercial, residential and industrial zone (highways)</p> 	<p>Can be placed near highways to reduce runoff volume</p>
<p>Planter Boxes</p> 	<ul style="list-style-type: none"> • Urban rain gardens with vertical walls and either closed or open bottoms • Collect off sidewalks and ideal for dense areas 	<p>Infiltration of water</p>	<p>Use soil</p> 	<p>Commercial and residential zone</p> 	<p>Used in dense cities to save space</p>
<p>Urban Tree Canopy</p> 	<p>Trees are able to slow down and reduce rainfall onto the streets</p>	<p>Reduction of waterfall</p>	<p>Use soil</p> 	<p>Residential zone</p> 	<p>City of Chicago has a tree initiative to help improve quality of life. Chicago has more than 500,000 parkway trees¹⁴</p>

14. "Streets and Sanitation (DSS)." City of Chicago :: Chicago History, www.cityofchicago.org/city/en/depts/streets/provdrs/forestry.html.

15. "Types of Green Infrastructure." Gowanus Canal – History, www.nyc.gov/html/dep/html/stormwater/combined_sewer_overflow_bmps.shtml.

16. "Chesapeake Stormwater Network." Index of /Wp-Content/Uploads/dlm_uploads/2013/10, chesapeakestormwater.net/bmp-resources/urban-filter-strips/.

Examples of Compost in Stormwater Management

THE USE OF COMPOST IN STORMWATER MANAGEMENT IMPROVES THE WATER holding ability of soil, reduces runoff, and increases nutrients within the soil for plants. In a Butler and Muir (2006) study the water infiltration rate was improved by 55 percent when compost was applied to stormwater management techniques. Applying compost also reduced nitrate by up to 80 percent when compared with plots that had not applied compost to soil thus improving plots that had not applied compost to soil.¹⁸

Water infiltration rate was improved by 55 percent when compost was applied to stormwater management techniques



Examples of EPA Best Management Practices of Using Compost to Reduce the Amount of Stormwater Runoff¹⁷

Compost Blanket



A loose layer of compost applied to the soil in disturbed areas

Compost Filter Socks



A tube filled with compost placed perpendicular to runoff

Compost Filter Berm



A dike of compost that is applied perpendicular to runoff


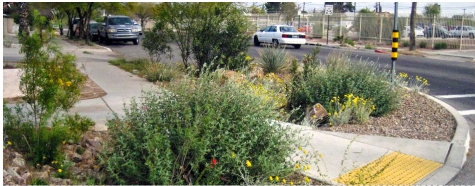




¹⁷“Reducing the Impact of Wasted Food by Feeding the Soil and Composting.” EPA, Environmental Protection Agency, 20 Mar. 2017, www.epa.gov/sustainable-management-food/reducing-impact-wasted-food-feeding-soil-and-composting#Stormwater Best Management Practices.

¹⁸“Impact of Compost Application On Soil Erosion and Water Quality.” California Department of Resources Recycling and Recovery, Mar. 2011. <https://www2.calrecycle.ca.gov/Publications/Documents/1377/2011013.pdf>

TABLE 2

Represents Uses of Compost in Different Types of Stormwater Management

This table demonstrates different green and gray stormwater management approaches from table 1 and their uses with compost.

Types of Stormwater Management	Stormwater Management Technique has Compost Use	Example
<p>Downspout Disconnection</p> 	<p>Has compost use</p> 	<p>Nashville released a design criteria for compost use in downspout disconnection. The use of 2-4 inches of compost and till a depth of 6 to 10 inches within the filter path. Specifications can be viewed here. This is not mandated but a best case use¹⁹</p>
<p>Stormwater Greenstreets</p> 	<p>Has compost use</p> 	<p>Biotreatment soil mix is a special mix of 30-40 percent compost and 60-70 percent sand in some cases. Can also be used in sediment and erosion control.</p> <p>City of Emeryville requires 6 cubic yards of compost per thousand feet of landscape²⁰</p>
<p>Bioswales</p> 	<p>Has compost use</p> 	<p>Subsoil can contain compost or compost biosolids. Compost can help to fertilize the plants but the excess chemicals can seep into the ground with the rainfall and pollute groundwater. Oregon permits the use of compost in bioswales²¹</p>
<p>Green Roofs</p> 	<p>Has compost use</p> 	<p>Higher amount of compost on green roofs release more nutrients. Concentration of nitrogen and phosphorus runoff are so high that it offsets water retention²²</p>
<p>Permeable Surfaces</p> 	<p>Has compost use</p> 	<p>Any paver or stone can be laid with 1/4-1 joint spaces that can use a sand/compost mix in which a plant low growing species can be planted.²³</p> <p>Open-celled grids are concrete grids. These grids can be filled with gravel or mixture of permeable soil/compost and grass to allow water to pass through²⁴</p>

Alisha Goldstein, EPA

19. *Downspout Disconnection*. Volume 5 – Green Infrastructure Practices , 2016, *Downspout Disconnection*, www.nashville.gov/Portals/0/SiteContent/WaterServices/Stormwater/docs/SWMM/2016/Vol5LID/GIP07_Downspout_2016.pdf.

20. Schultze Allen, Peter. Bay Friendly Green Stormwater Infrastructure & Compost Usage. Santa Clara County Master Composter Training, 2016, *Bay Friendly Green Stormwater Infrastructure & Compost Usage*, <http://cesantaclara.ucanr.edu/files/240554.pdf>.










21. Jurries , Dennis. *Biofilters For Stormwater Discharge Pollution Removal Bioswales, Vegetative Buffers, and Constructed Wetlands For Stormwater Discharge Pollution Removal*. State of Oregon Department of Environmental Quality , 2003, www.oregon.gov/deq/FilterPermitsDocs/biofiltersV2.pdf.

22. "Green Roofs Take Compost To New Heights." *BioCycle*, 24 Feb. 2012, www.biocycle.net/2009/05/27/green-roofs-take-compost-to-new-heights/.

23. "Permeable Paving." *Snohomish Conservation District*, snohomishcd.org/sound-homes-resources/2018/2/16/permeable-paving.

24. *Permeable Pavement*. www.mercergov.org/files/Permeable%20Pavement%20Brochure.pdf

TABLE 2 Represents Uses of Compost in Different Types of Stormwater Management

Types of Stormwater Management	Stormwater Management Technique has Compost Use	Example
<p>Rain Gardens</p> 	<p>Has compost use</p> 	<p>Old Woman Creek Reserve in Ohio installed a rain garden at the Visitor's Center using soil composed of 40 percent compost, 30 percent sandy loam topsoil and 30 percent sand. Barnes Nursery created several compost mixes for rain gardens²⁵</p>
<p>Wet Detention Basins</p> 	<p>Has compost use</p> 	<p>Wet detention basins can include a soil additives consisting of two inches of compost mixed into two inches of topsoil²⁶</p>
<p>Filter Strip</p> 	<p>Has compost use</p> 	<p>Compost can be added to filter strips to have a level of soil organic matter that can assure sustainability if the area is vegetated²⁷</p>
<p>Planter Boxes</p> 	<p>Has compost use</p> 	<p>Compost Mulch can be used in replacement to sand, gravel, and topsoil. Compost with organics will aid in pollutant removal but will remove nitrogen as it breaks down. In this case a fertilizer may be added to counter it²⁸</p>
<p>Urban Tree Canopy</p> 	<p>Has compost use</p> 	<p>The use of compost can increase tree growth, but may take multiple years for compost effects to manifest²⁹</p>

25. "Compost In The Rain Garden Mix." BioCycle, 27 Feb. 2012, www.biocycle.net/2008/11/24/compost-in-the-rain-garden-mix/.

26. *Infiltration Basin*. Wisconsin Department of Natural Resources Conservation Practice Standard, 2004, *Infiltration Basin*, dnr.wi.gov/topic/stormwater/documents/InfiltrationBasin_1003.pdf.

27. *USCC: Using Compost in Stormwater Management*. US Composting Council, 2008, compostingcouncil.org/wp-content/uploads/2015/06/Compost-Use-for-Stormwater-Management.pdf

28. *2.2.14 Planter Boxes*. City of Murfreesboro, *2.2.14 Planter Boxes*, www.murfreesborotn.gov/DocumentCenter/View/2748/Planter-Boxes-2214-?bidId=

29. Oldfield, E. E., Felson, A. J., Auyeung, D. S., Crowther, T. W., Sonti, N. F., Harada, Y., Maynard, D. S., Sokol, N. W., Ashton, M. S., Warren, R. J., Hallett, R. A. and Bradford, M. A. (2015), Growing the urban forest: tree performance in response to biotic and abiotic land management. https://www.fs.fed.us/nrs/pubs/jrnl/2015/nrs_2015_oldfield_001.pdf

Stormwater Specifications in 18 Sample Cities

TABLE 3 Demonstrates Different Sample Cities and Green Infrastructure Plans

THIS TABLE DISPLAYS VARIOUS EXAMPLES OF MUNICIPAL GREEN INFRASTRUCTURE STORMWATER MANAGEMENT plans that cities across the US have implemented. Providing a more affordable alternative to grey infrastructure, green infrastructure techniques also provide more community benefit. In a case study conducted in Lancaster, PA by the US EPA it was estimated

that by implementing a 25 year green infrastructure program, the city of Lancaster could avoid capital costs of up to \$210 million in grey infrastructure.³¹ Green infrastructure techniques would also save the community by reducing energy use by nearly \$2.4 million per year. Another example of green infrastructure cost savings and community

benefit is New York City's green infrastructure program, which has performed better than expected by, helping reduced discharge in sewers by more than 20%.³⁰ Opportunities to add green infrastructure should be considered to reduce grey infrastructure improvements and promote cost-effective solutions.³¹

City	Green Infrastructure Plan	Specific Specifications	Agencies Responsible for Stormwater Management
<p>Houston, TX</p>	<p>Houston has no green infrastructure plan. Plan Houston is a plan established that is intended to improve flood management through stormwater management but not green infrastructure³²</p>		<p>Flood Control District and Joint Task Force</p>
<p>San Antonio, TX</p>  <p style="writing-mode: vertical-rl; transform: rotate(180deg); font-size: small;">Mark Reagan</p>	<p>San Antonio will be a leader in high performance and resilient buildings/ infrastructure. Use water management to allow natural features to manage water</p>	<ul style="list-style-type: none"> • Update city facility design guidelines to meet EPA Energy Star Certification within the 80th percentile • Assess city owned buildings to install green or cool roofs to reduce building energy consumption • Require all city infrastructure projects be designed to be no net runoff/or providing an increase in net natural areas³³ 	<p>Regional Stormwater Management Program</p>


30. "Data Analysis Shows That Green Infrastructure Can Play an Important Role in Improving the Health and Cleanliness of Local Waterways." *Gowanus Canal – History*, www.nyc.gov/html/dep/html/press_releases/15-015pr.shtml#.W2IV4NlzpPb.

31. *The Economic Benefits of Green Infrastructure: A Case Study of Lancaster, PA*. United States Environmental Protection Agency, 2014, *The Economic Benefits of Green Infrastructure: A Case Study of Lancaster, PA*, www.epa.gov/sites/production/files/2015-10/documents/cnt-lancaster-report-508_1.pdf.

32. Carolina Planning Journal Board. "Piecing the Fragments Together: Approaches to Green Infrastructure Implementation In Cities." *Angles from the CPJ*, 12 Dec. 2017, carolinaangles.com/2017/12/12/piecing-the-fragments-together-approaches-to-green-infrastructure-implementation-in-cities

33. "City of San Antonio Sustainability Plan." City of San Antonio City Council, 11 Aug. 2016.

TABLE 3 Demonstrates Different Sample Cities And Green Infrastructure Plans

City	Green Infrastructure Plan	Specific Specifications	Agencies Responsible for Stormwater Management
Corpus Christi, TX	Mention of green infrastructure in sustainability plan, did not find further information	Mention of community gardens that can be designed to manage stormwater runoff ³⁴	Storm Water Department
Brownsville, TX	EPA helps Brownsville by providing a technical assistance grant to add green infrastructure along US-Mexico border to manage stormwater and cooling of areas experiencing high temperatures ³⁵	Design of wider sidewalks, stormwater parks, rain gardens and tree cells to help with stormwater management	<ul style="list-style-type: none"> • Rio Grande Valley Stormwater Task Force (SWMP) • http://rgvstormwater.org/ • Drainage Stormwater Division
Galveston, TX	<ul style="list-style-type: none"> • Develop a bay restoration plan • Development of a tree management plan and program • City is continuing to implement its Stormwater Master Plan³⁶ 	<ul style="list-style-type: none"> • The use of healthy marsh and wetland systems to serve as a buffer from wave action and absorb stormwater runoff • The use of a tree canopy to lessen the impact of stormwater • Promote the community to use green roofs 	<p>City of Galveston</p> 
Fort Worth, TX	The city has not yet developed a full green infrastructure plan. The floodplain management plan incorporates actions to potentially add green infrastructure to city facilities and projects (2015) ³⁸	BGE is working with Fort Worth to identify locations where green infrastructure could be implemented ³⁷	Stormwater Management Division
Port Aransas, TX	No Green Infrastructure plan found		Nueces County Water Control and Improvement District 4

Harrison Tran

34. "Corpus Christi Integrated Sustainability Plan ." City of Corpus Christi, Aug. 2011.

35. "GREENING AMERICA'S COMMUNITIES BROWNSVILLE, TX." United States Environmental Protection Agency , Nov. 2017.https://www.epa.gov/sites/production/files/2018-04/documents/17_12_11_epa_final_report_brownsville.pdf

36. "City of Galveston Comprehensive Plan." City of Galveston , 27 Oct. 2011. https://galvestontx.gov/DocumentCenter/View/1711/GALV_Comp_Plan_Adopted_Final_11_1027_webres

37. "City of Fort Worth LID." BGE - Brown & Gay Engineers, www.bgeinc.com/city-of-fort-worth-lid.html.

38. "FLOODPLAIN MANAGEMENT PLAN DRAFT." FREESE AND NICHOLS, INC., Sept. 2015.<http://fortworthtexas.gov/files/2015-09-28-draft-FMP.pdf>

TABLE 3 Demonstrates Different Sample Cities And Green Infrastructure Plans

City	Green Infrastructure Plan	Specific Specifications	Agencies Responsible for Stormwater Management
<p>Kingston, NY</p>	<p>The city of Kingston is actively working on controlling stormwater runoff from nearby waterways such as the Hudson River, Esopus Creek and Rondout Creek³⁹</p> <ul style="list-style-type: none"> • Follows NYS Stormwater Management Design Manual 	<ul style="list-style-type: none"> • Encouragement of green infrastructure in new development and redevelopment plans • Green infrastructure can include swales, green roofs, reduction of impervious areas, rain gardens and more 	<p>Ulster County Department of the Environment Stormwater Management Program</p>
<p>Philadelphia, PA</p> 	<p>Philadelphia has a plan called “Green City, Clean Waters.” This plan will use green infrastructure to reduce 85 percent of Philadelphia’s combined sewer overflow⁴⁰</p>	<p>Investing over 2.4 billion dollars into green infrastructure. This includes downspout planters, complex bioretention swales, rain gardens, tree trenches, green roofs and urban wetlands⁴⁰</p>	<p>Philadelphia Water Department and EPA</p>
<p>New York City, NY</p> 	<p>In 2010, NYC created their NYC Green Infrastructure Plan to continue the implementation of PlaNYC⁴¹</p> <ol style="list-style-type: none"> 1. Build cost-effective grey infrastructure 2. Optimize the existing wastewater system 3. Control runoff from 10% of impervious surfaces through green infrastructure 4. Institutionalize adaptive management, model impacts, measure CSOs, and monitor water quality 5. Engage and enlist stakeholders 	<p>NYC integrates green infrastructure such as green roofs and swales. Examples include: right-of-way bioswales can be seen on the streets. Porous pavements for parking lots, green streets, and rain barrels</p> 	<p>NYC Department of Environmental Protection</p>

U.S. Department of Agriculture



U.S. Department of Agriculture

39. “Ulster County Stormwater Management Program Plan.” Ulster County, Dec. 2013. <http://ulstercountyny.gov/sites/default/files/Ulster-County-Stormwater-Management-Program-Plan.pdf>

40. “Philadelphia Turns Massive Stormwater Runoff Problem Into Economic Boost.” Living Architecture Monitor, livingarchitecturemonitor.com/news/2018/4/3/philadelphia-turns-massive-stormwater-runoff-problem-into-economic-boost

41. “NYC Green Infrastructure Plan.” THE CITY OF NEW YORK OFFICE OF THE MAYOR, 2010. http://www.nyc.gov/html/dep/pdf/green_infrastructure/NYCGreenInfrastructurePlan_LowRes.pdf

TABLE 3 Demonstrates Different Sample Cities And Green Infrastructure Plans

City	Green Infrastructure Plan	Specific Specifications	Agencies Responsible for Stormwater Management
<p>San Leandro, CA</p>	<p>San Leandro was awarded a \$539,000 for green infrastructure project. The project includes a wetland restoration and a nutrient removal project. This will also help provide financial support to begin engaging the public on development of a local Climate Resilience and Adaptation Plan⁴²</p>	<p>Nature-based green infrastructure will be used to reduce community long-term water treatment costs</p>	<p>State Water Resources Control Board</p> 
<p>Washington DC</p>	<ul style="list-style-type: none"> • DC water has developed a plan to use green infrastructure to reduce the amount of stormwater runoff. • The DC Clean Rivers Project is DC Water infrastructure program to reduce combined sewer overflows into the waterways. There are more than 13 miles of tunnels 	<p>DC Water is developing bioretention facilities, implementing green roofs, porous pavements, and using downspout disconnection/ rain barrels. This is all part of their long term plan to implement green infrastructure as part of their Combined Sewer Overflows⁴³</p>	<p>Department of Energy and Environment</p>
<p>Mexico City</p>  <p><i>A view of Reforma avenue skyline and Chapultepec park</i></p>	<p>Mexico City has a 15 year course of action and guidelines to be establish for green infrastructure⁴⁴</p>	<ul style="list-style-type: none"> • Greening of flat roofs and facades at a rate of 30,000 square meters per year • Greening of roundabouts and traffic islands • Build new infrastructure such as rainwater collectors and bike lanes • Create new parks and gardens • Overall increase green areas 	<p>Secretariat of Environment and Natural Resources</p>

42. San Leandro Granted \$539,000 for Design and Permitting of a Treatment Wetland. " City Of San Leandro, 12 Apr. 2018, www.sanleandro.org/civica/press/display.asp?layout=1&Entry=935

43. "Long Term Control Plan Modification for Green Infrastructure." District of Columbia Water and Sewer Authority , May 2015. https://www.dcwater.com/sites/default/files/green-infrastructure-ltcp-modificaitons.pdf

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TABLE 3 Demonstrates Different Sample Cities And Green Infrastructure Plans

City	Green Infrastructure Plan	Specific Specifications	Agencies Responsible for Stormwater Management
<p>New Orleans, LA</p> 	<ul style="list-style-type: none"> In 2016, New Orleans was awarded \$141 million dollars by US HUD to implement a wide range of green infrastructure projects. The Gentilly Resilience District project will transform grey infrastructure into green infrastructure with benefits to the community⁴⁵ The City of New Orleans also adopted a master plan called “Plan for the 21st Century: New Orleans 2030.” This created a stormwater management unit within the city⁴⁶ 	<p>The Master plan calls for:⁴⁵</p> <ul style="list-style-type: none"> Replacing most lawn areas with shrubs and groundcover Creating rain gardens throughout the city Planting shrubs and trees in neutral grounds to help the city manage water Planting in drainage ditches also known as swales to improve stormwater management Retrofitting old buildings and designing new buildings to include stormwater management techniques like green roofs Encouraging the use of porous paving materials 	<p>City of New Orleans</p>  <p><i>Rain gardens and planter boxes built by community champions in New Orleans as a part of the Water Wise Gulf South program with Dana Brown & Associates, Global Green and Recharge NOLA.</i></p>
<p>Los Angeles, CA</p>	<p>Los Angeles is currently developing the Safe, Clean Water Program. This program is designed to capture and store a large untapped resource for the county. Plans to store as much as 100 billion gallons. Voting begins of July 18th, 2018⁴⁷</p>	<p>Funds would go to the construction of cisterns, rain gardens, and other infrastructure⁴⁸</p>	 <p>Los Angeles Regional Water Quality Control Board</p> <p><small>http://josemtephotos.net/</small></p>



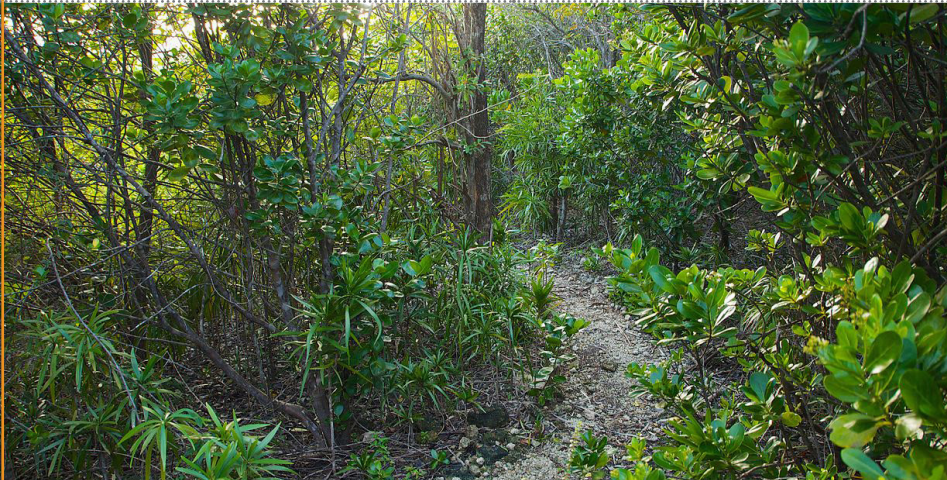
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TABLE 3 Demonstrates Different Sample Cities And Green Infrastructure Plans

City	Green Infrastructure Plan	Specific Specifications	Agencies Responsible for Stormwater Management
<p>Dallas, TX</p>	<p>EPA has helped Dallas to establish following codes, regulations, and standards that could have bearing on green infrastructure.</p> <p>Many barriers came across when implementing green infrastructure such as lack of incentives, and inconsistent/ inadequately addressed green infrastructure elements</p> 	<p>Dallas has established the following goals for stormwater management⁴⁸</p> <ol style="list-style-type: none"> 1. Minimize effective or connected impervious areas (e.g reducing sidewalk size) 2. Harvest rainwaters which can be done in rain barrels or cisterns 3. Allow and encourage use of stormwater control such as creating a urban tree canopy/ green roofs 4. Manage stormwater through monitoring and tracking measures 	<p>City of Dallas</p> 
<p>San Juan, Puerto Rico</p>	<p>EPA collaborated with ENLACE and the community to design green infrastructure options for San Juan. They designed it specifically for six sites, where each site is intended to look like an open space⁴⁸</p>	<p>The proposed plan is to use bioswales, detention ponds, soil cells, permeable paving, water plazas, and underground stormwater detention</p>	<p>Municipality of San Juan Corporación del Proyecto ENLACE del Caño Martín Peña</p>
<p>Vieques, Puerto Rico</p>	<p>Vieques does not have a green infrastructure plan for stormwater management, but Vieques is working towards sewer system labeling to reduce amount of pollutants entering the system⁴⁹</p>		

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49. "Mitigating Pollution Through Green Infrastructure and Sustainable Materials Management Mini-Grants: Community Education and Integration Projects Throughout EPA Region 2." Environmental Finance Center. http://efc.syr.edu/wp-content/uploads/2015/04/EPA_EE_DecUpdate_reduced.pdf

Jan-Willem Reusink

Courtesy Kevin Sloan Studio

Edgar Torres

ADDENDUM



NYC Stormwater Management

NYC DEP and DDC will launch project for stormwater management in Rochdale in a 62 million dollar project.³

- Part of the city 1.9 billion dollar project to improve flooding and street conditions in Southeast Queens
- Expected to complete in 2020 Summer

The blue belt program in staten island is a natural solution to stormwater management. It is implemented in staten island. “The program preserves natural drainage corridors called “Bluebelts,” including streams, ponds, and wetlands, and enhances them to perform their functions of conveying, storing, and filtering runoff precipitation or “stormwater.” 16 individual watersheds that cover over 10,000 acres of land.¹

City of Washington DC Stormwater Management

Washington DC adopted their sustainable DC plan in 2013. In their plans they included green infrastructure practices for streets to make DC the greenest city in the nation. Their stormwater management plans include the installation of rain gardens, street trees, landscape areas, permeable pavements and the removal of unnecessary paving.



City of Houston Stormwater Management

A report has urged Houston from Environment Texas to place priority on green infrastructure. It has ranked Houston as fourth out of five cities based on their usage of green infrastructure.²

The program preserves natural drainage corridors called “Bluebelts”

1. “The Bluebelt Program: A Natural Solution to Stormwater Management.” Gowanus Canal – History, www.nyc.gov/html/dep/html/stormwater/bluebelt.shtml
2. “Texas Stormwater Scorecard.” Environment Texas Research and Policy Center, 12 Sept. 2017, environmenttexascenter.org/reports/txe/texas-stormwater-scorecard.
3. “DDC, DEP Launch Project to Improve Stormwater Drainage and Street Conditions in Rochdale.” Zoning Districts & Tools : C6 - DCP, Liquor Authority, June 2018, www1.nyc.gov/site/ddc/about/press-releases/improving-stormwater-condition-rochdale.page

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