



Green Infrastructure in New York City:



Three Years of Pilot Implementation and Post-Construction Monitoring

Matthew Jones, PhD, PE mjones@hazenandsawyer.com

John McLaughlin, NYCDEP; Sandeep Mehrotra, PE, Hazen; Bill Leo, PE, HDR; Julie Stein, HDR

Acknowledgements

NYC Department of Environmental Protection

HDR

Biohabitats

Horsley Witten Group

Geosyntec

Brooklyn College



Stormwater Pilot Study

Develop Stormwater Pilot Designs

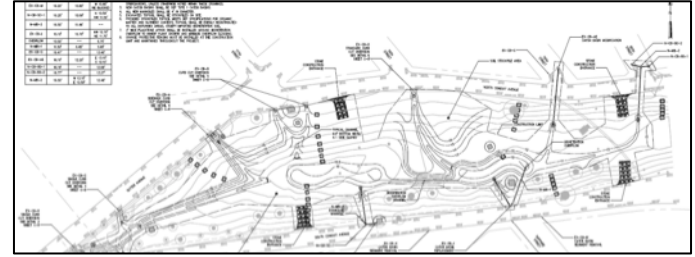
- Find locations suitable for GI retrofits
- Develop designs feasible as retrofits within the dense urban environment

Construct and Maintain Pilots

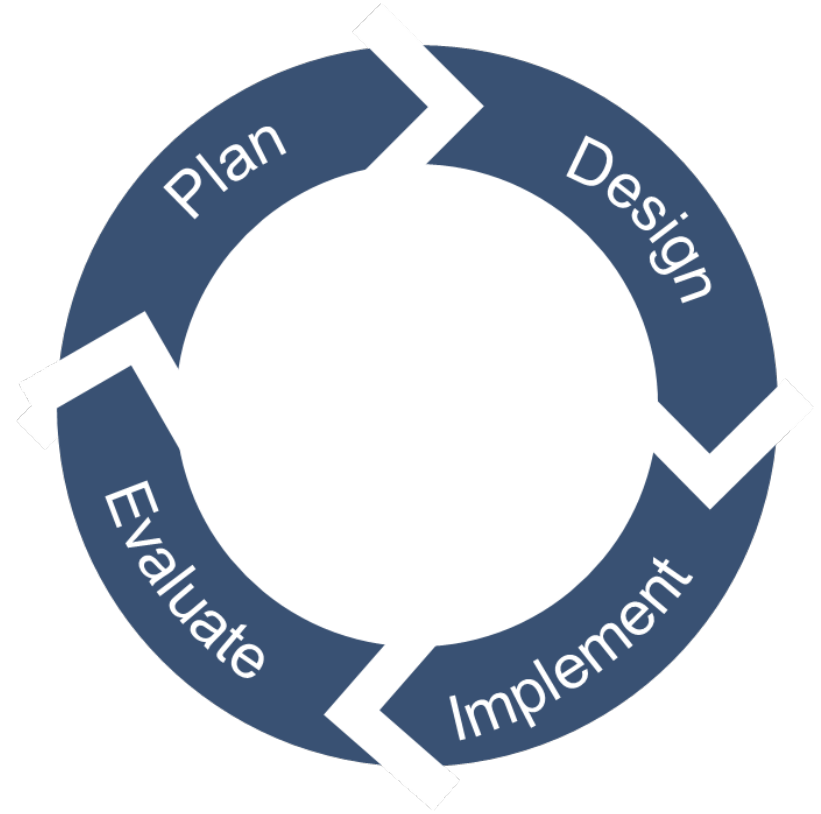
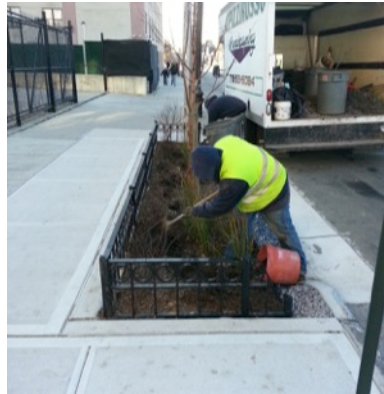
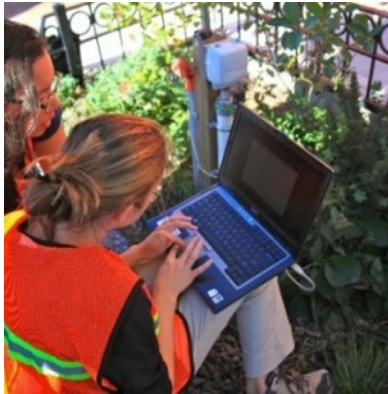
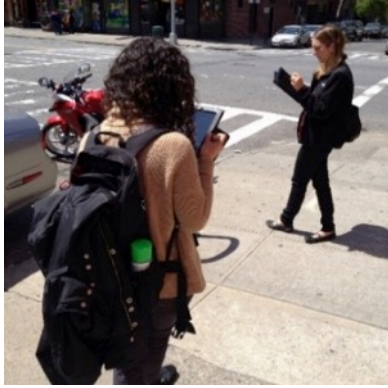
- Evaluate local logistics of implementation
- Characterize the type and frequency of maintenance needs

Evaluate Pilot Performance

- Qualitative performance
- Quantitative performance



Full Life Cycle Evaluation



Green Infrastructure Toolbox

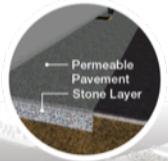
Subsurface Retention



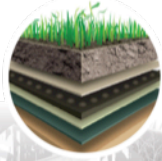
ROW Bioswale



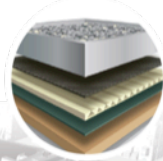
Permeable Pavement



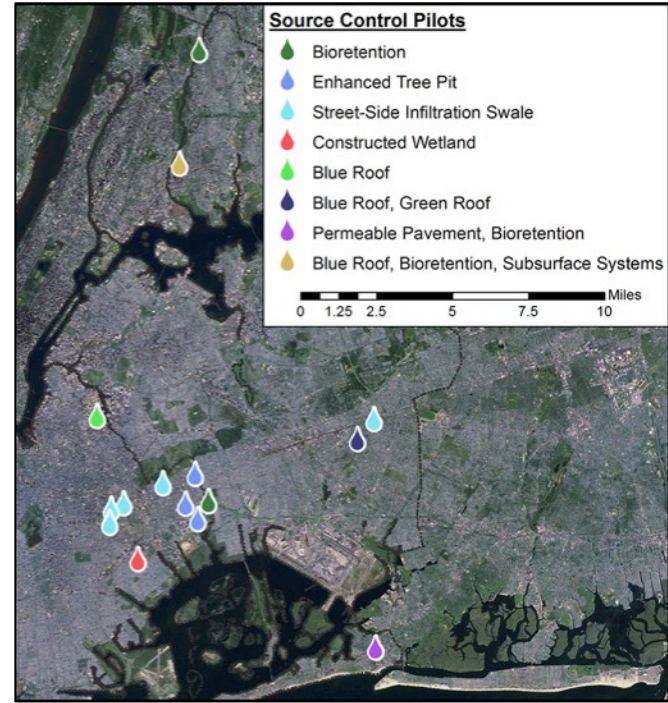
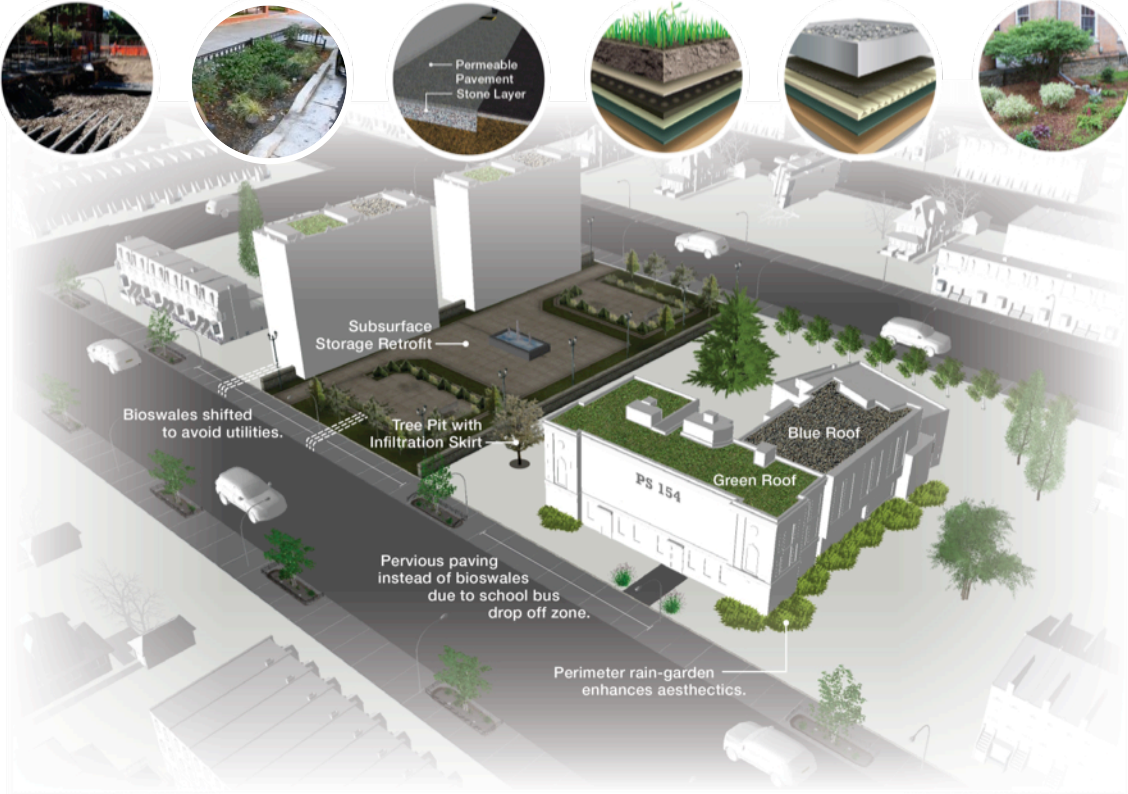
Green Roof



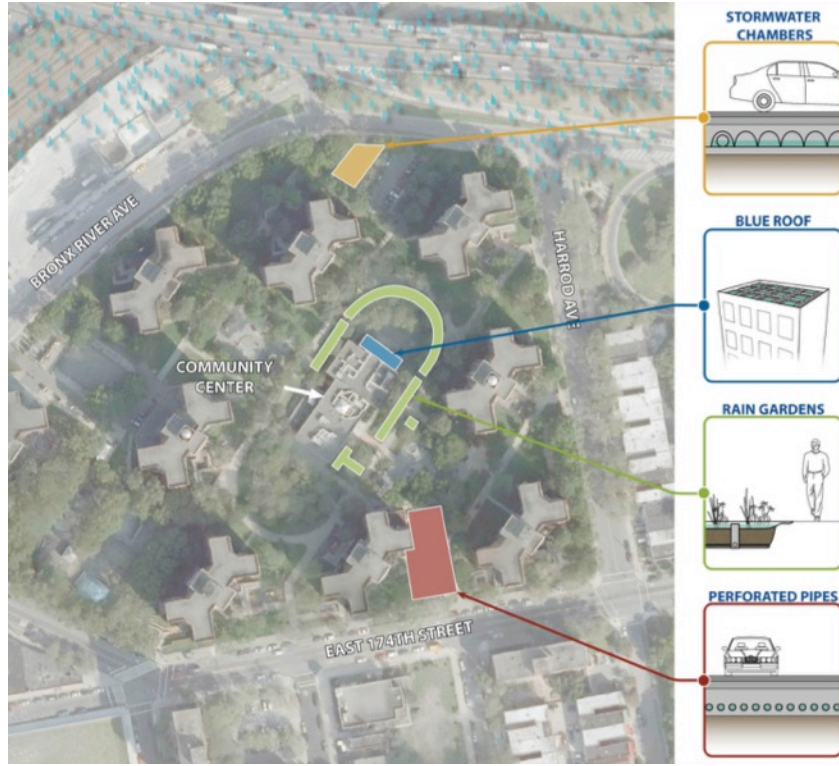
Blue Roof



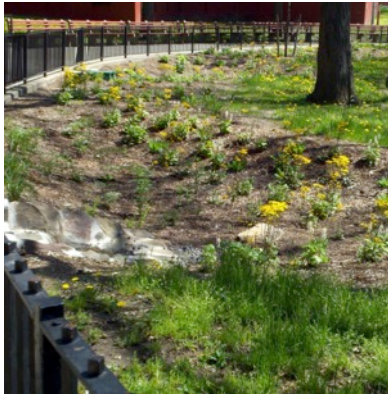
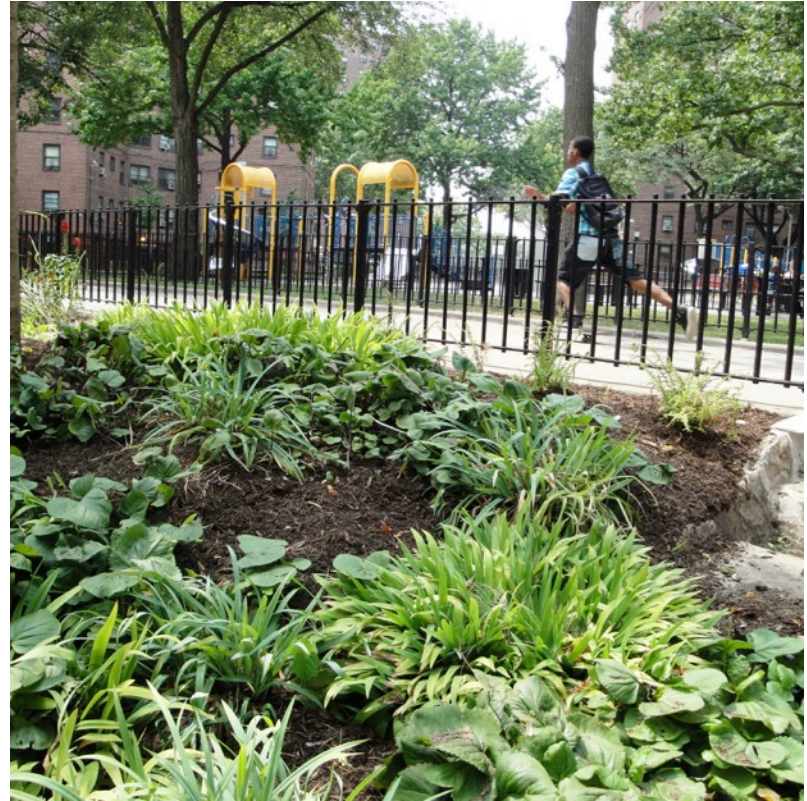
Rain Garden



Distributed Green Infrastructure at Public Housing



Completed Bioretention



Monitoring Toolbox



Off-the-Shelf
Weirs, Flumes,
and Loggers



Tested Custom
Equipment



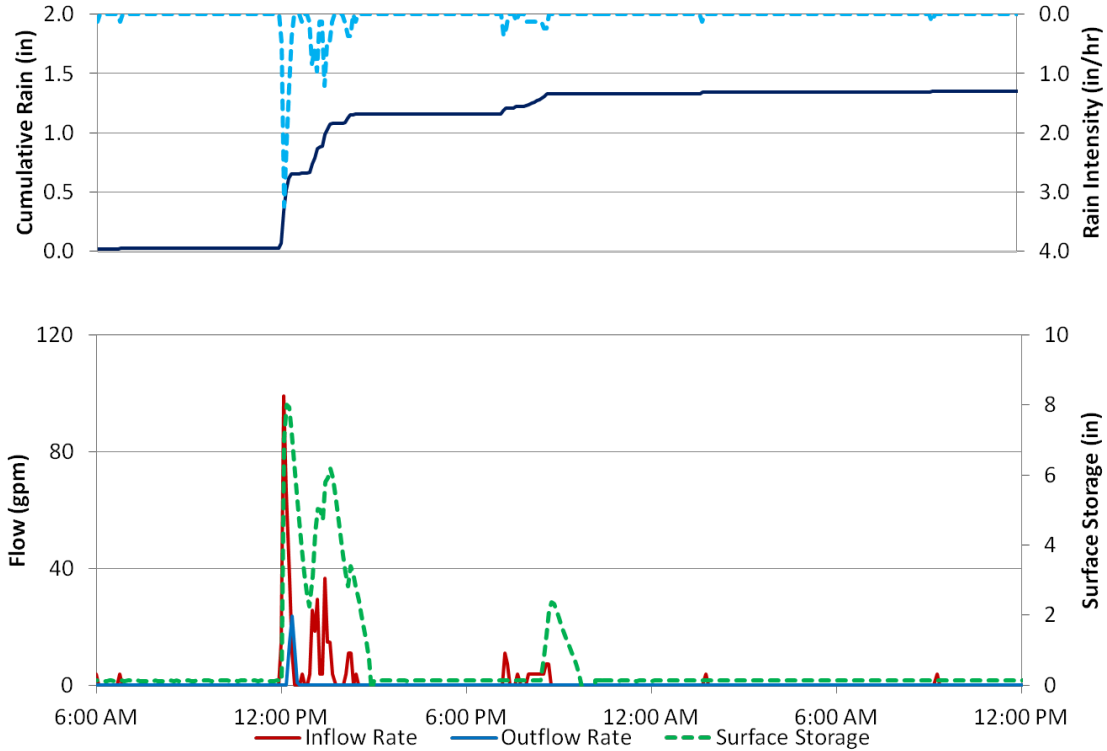
Time Lapse
Cameras



Water Quality
Sampling

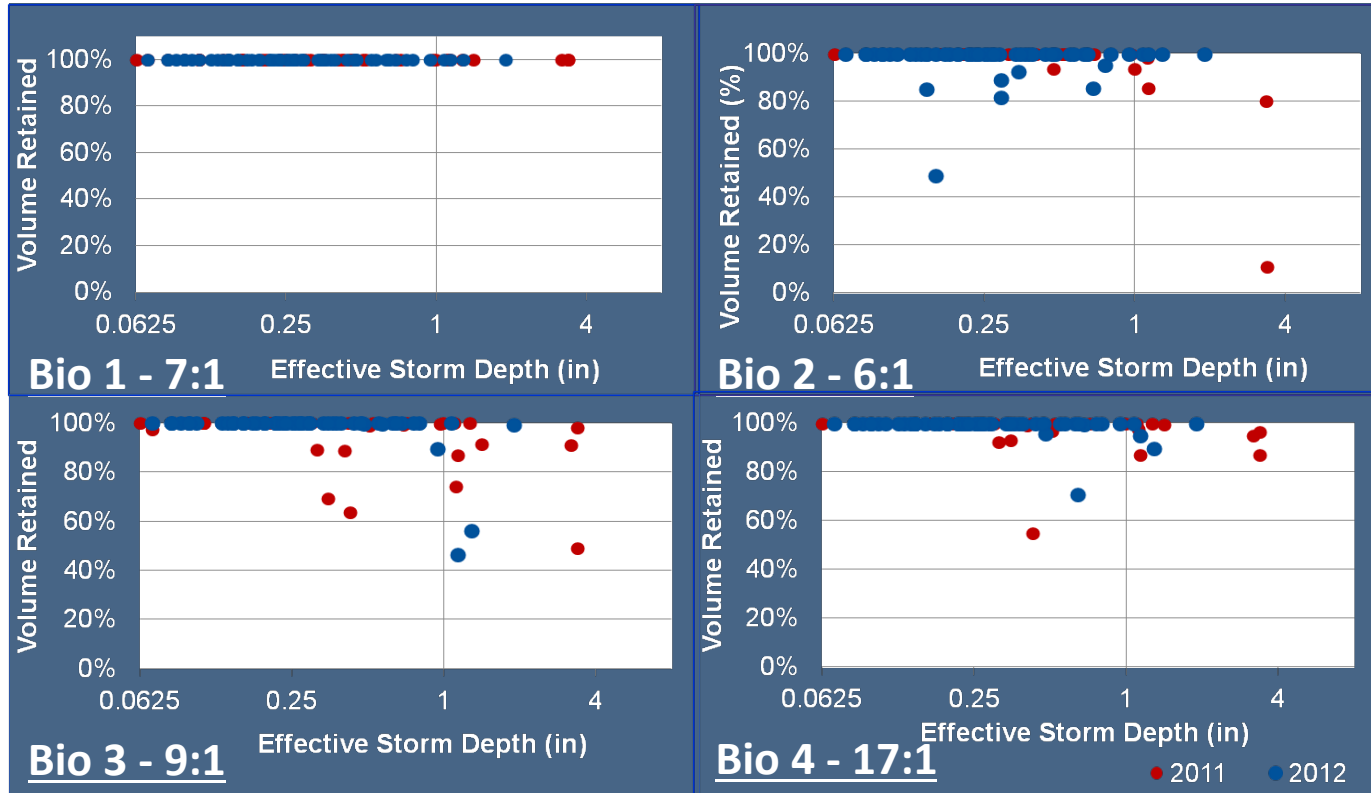
Bioretention Performance

Example 1.4" Storm



Bioretention Performance

Volume Retained



Bioretention Performance Summary



Retained most runoff they received

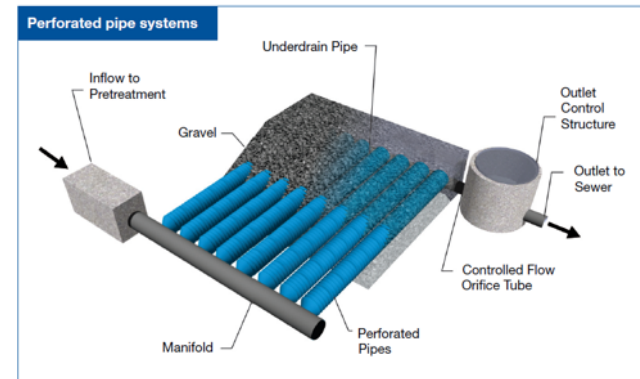
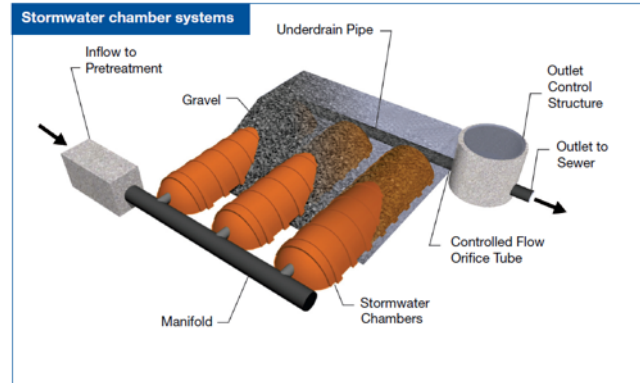
Simple curb cuts without depressed apron allow bypass

Curb cut sumps effective at capturing litter and debris

Most plants have performed well

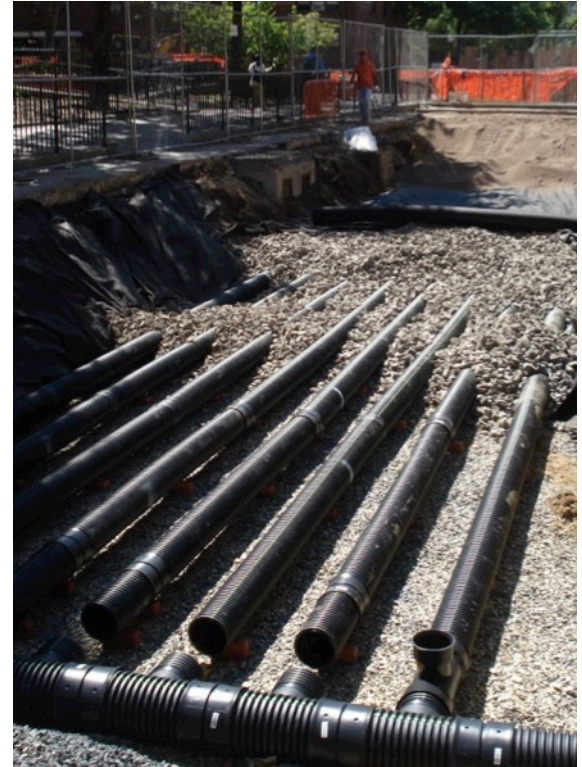
Positive community reception

Subsurface Detention and Infiltration



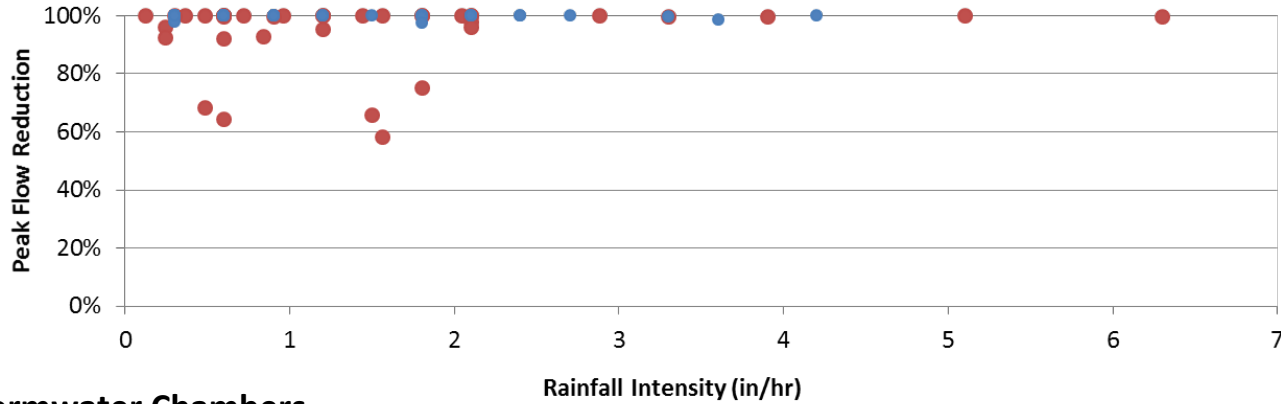
Subsurface Detention and Infiltration

Construction Photos

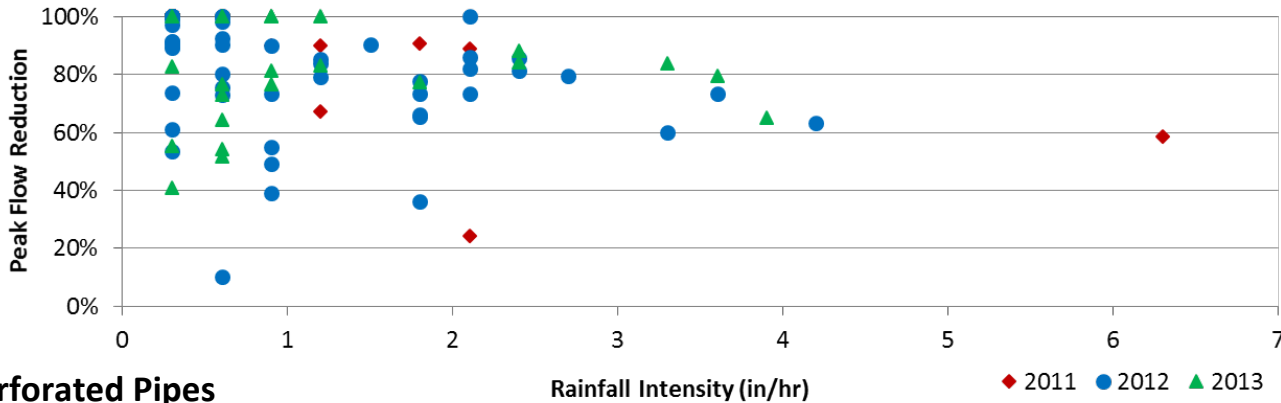


Subsurface Detention and Infiltration

Peak Flow Reduction



Stormwater Chambers

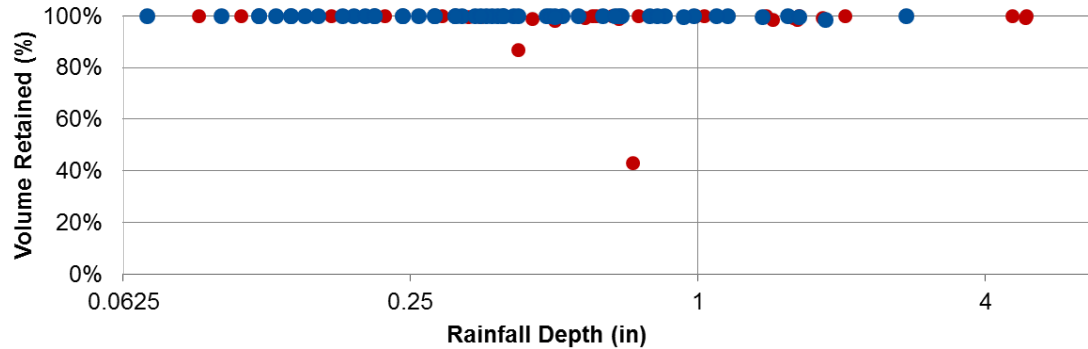


Perforated Pipes

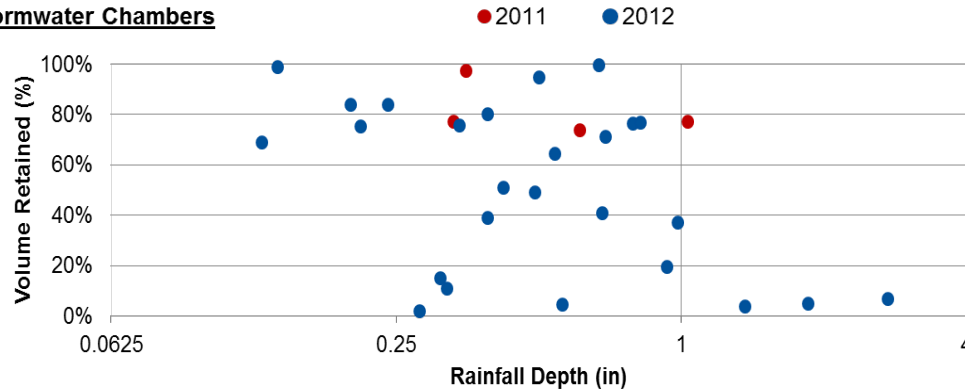
◆ 2011 ● 2012 ▲ 2013

Subsurface Detention and Infiltration

Retention Performance Variability



Stormwater Chambers



Perforated Pipes

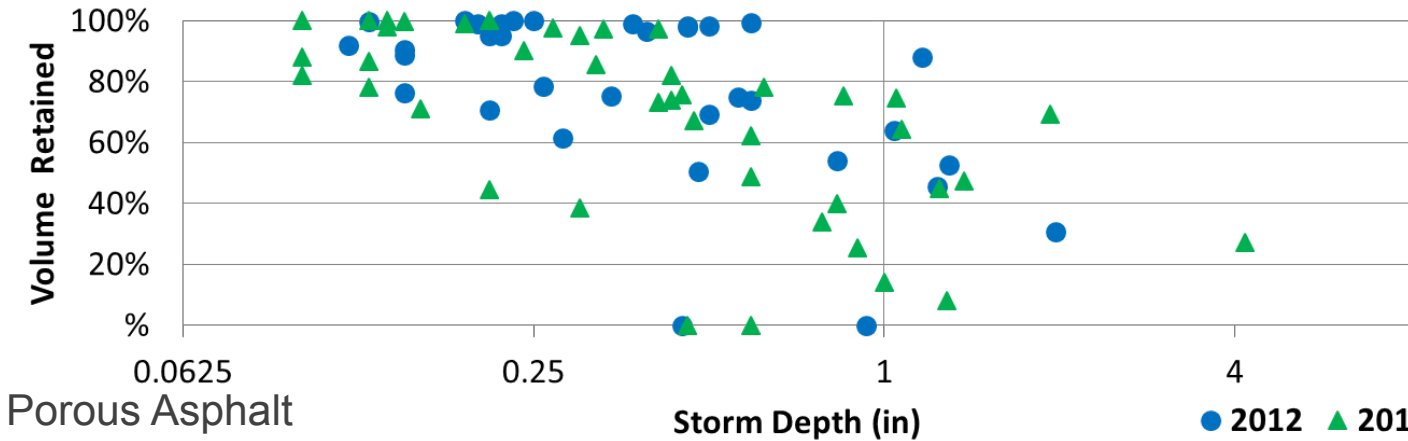
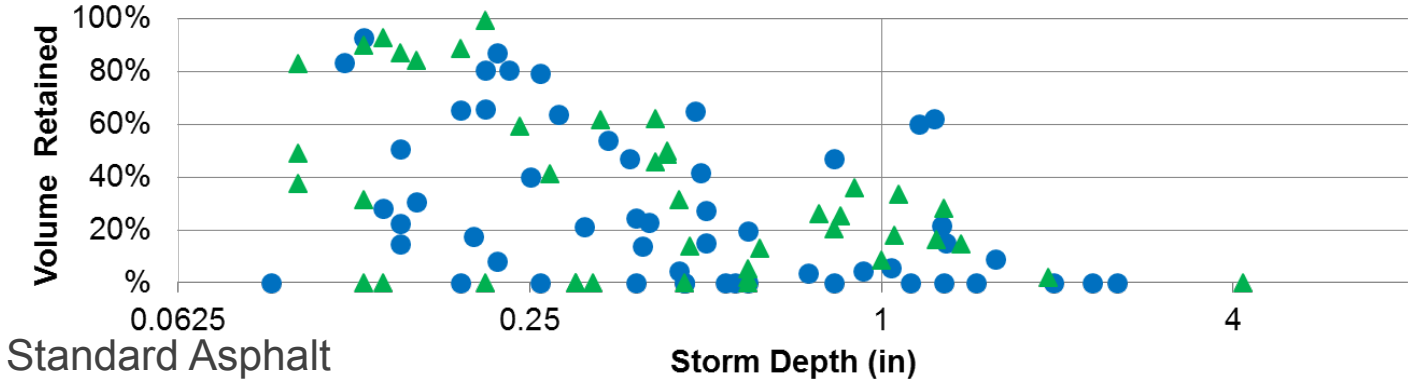
● 2011 ● 2012

Permeable Pavement



Permeable Pavement

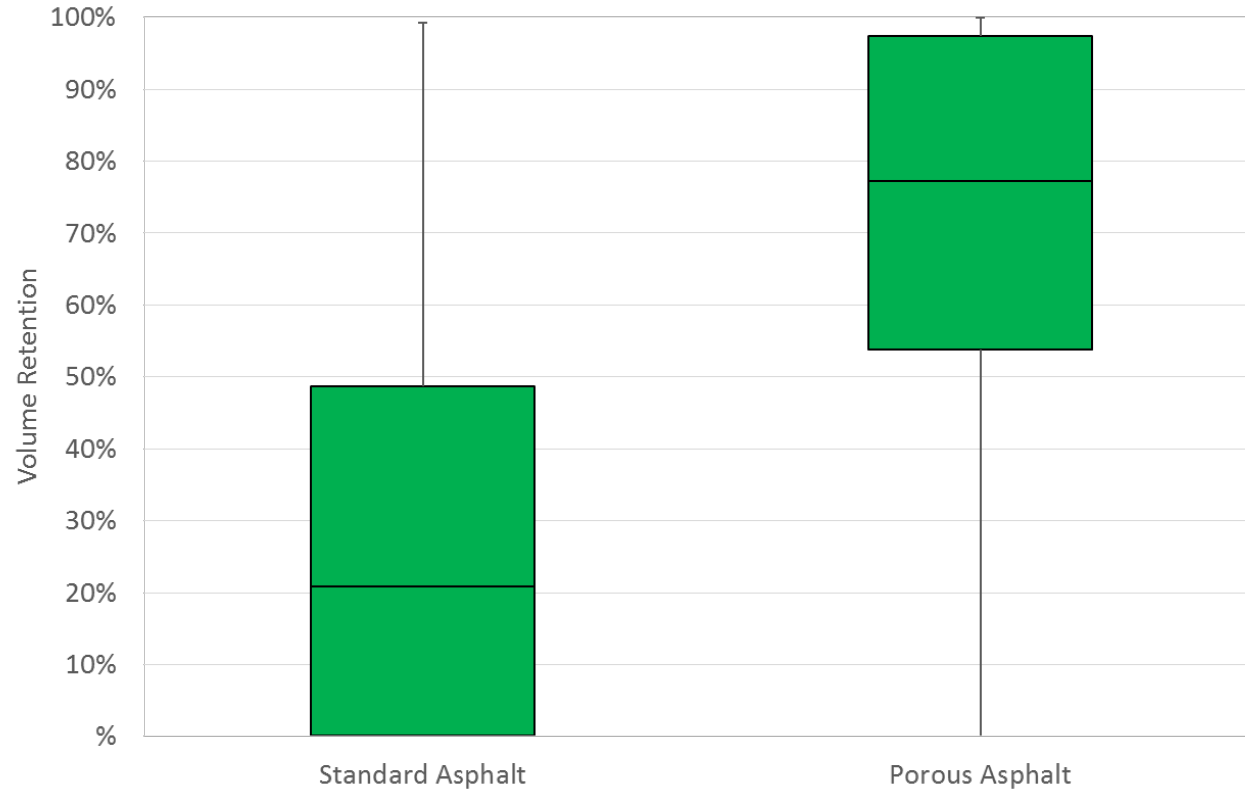
Monitored Performance



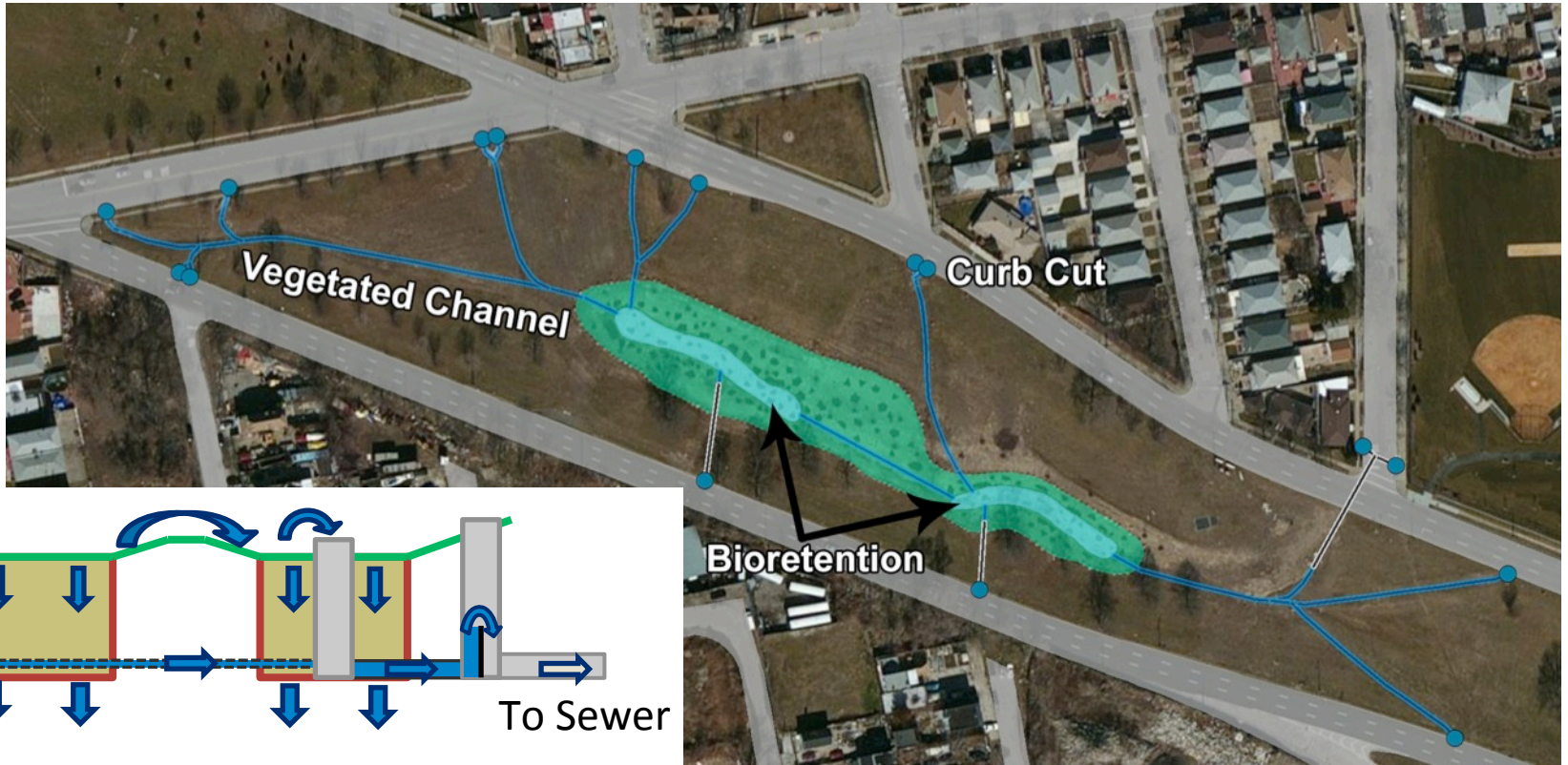
● 2012 ▲ 2013

Permeable Pavement

Monitored Performance



Roadway Median Bioretention

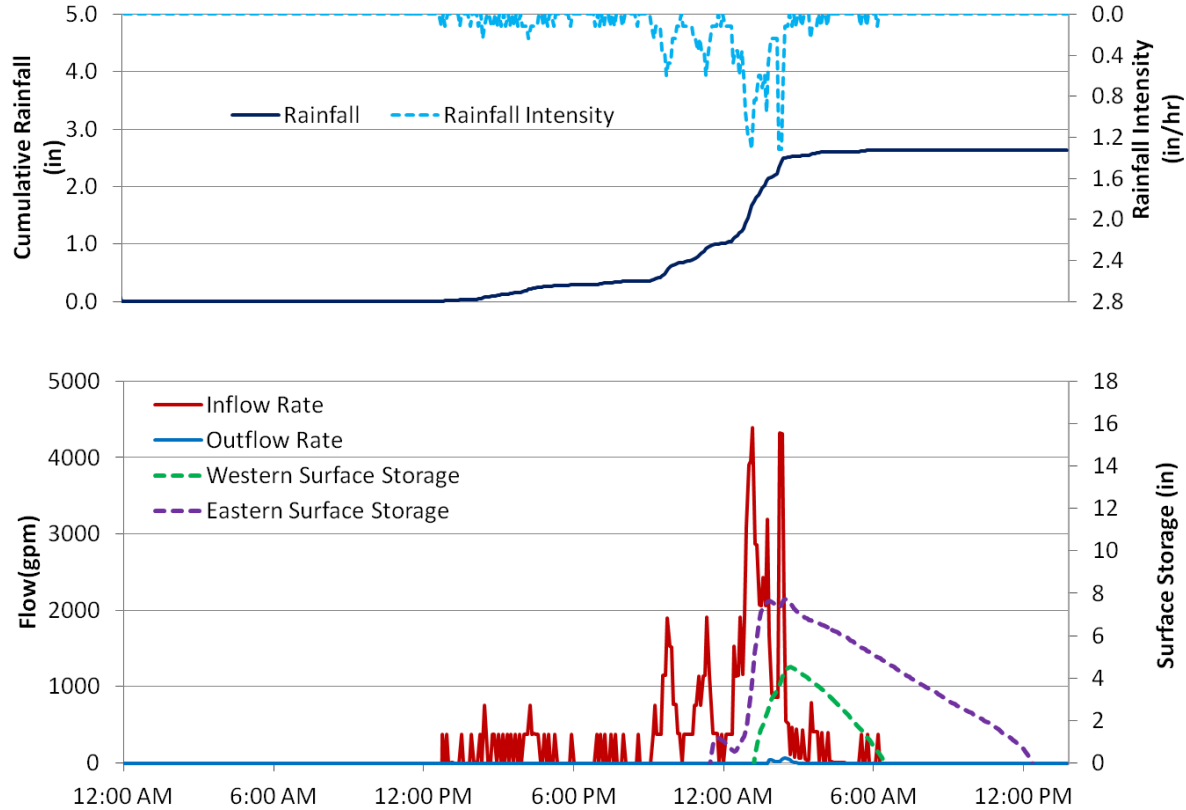


Roadway Median Bioretention



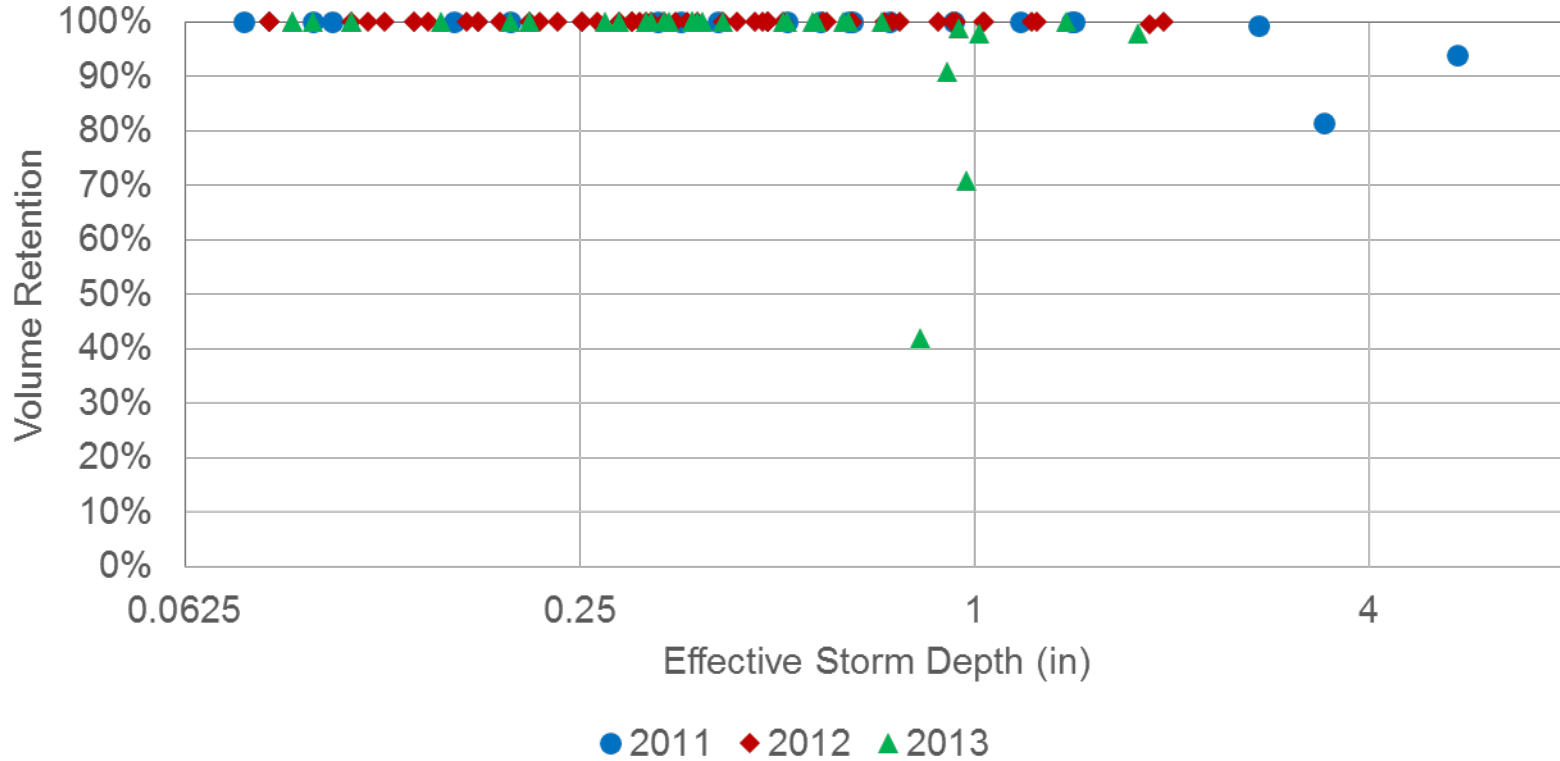
Median Bioretention

Example 2.6" Storm



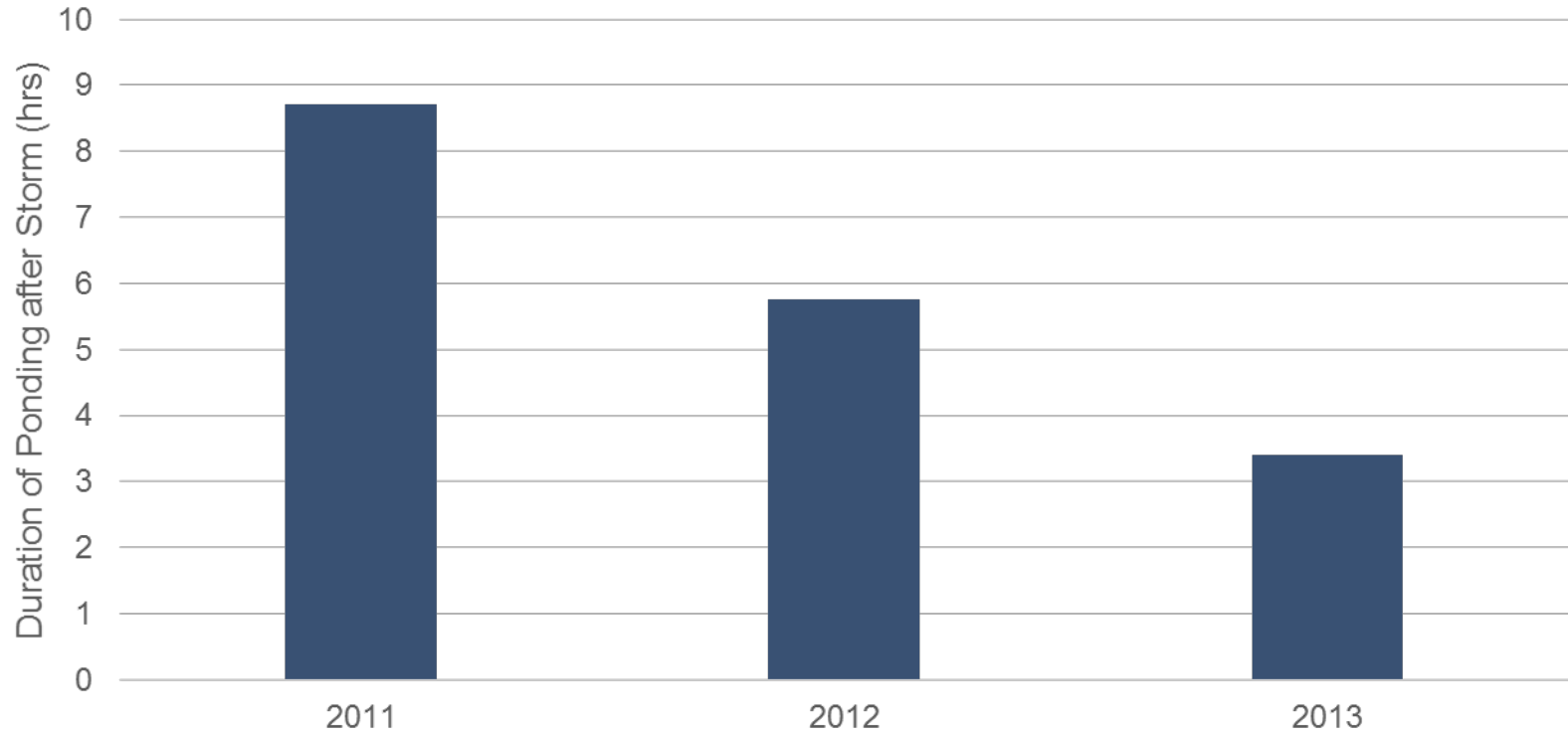
Roadway Median Bioretention

Retention Performance



Roadway Median Bioretention

Drawdown Performance



Co-Benefits Study Goals

Identify and quantify green infrastructure co-benefits

Conduct monitoring for co-benefits validation

Develop a tool to calculate, compare, and track co-benefits and triple bottom line costs



Field Monitoring

Temperature differences between control and green infrastructure

Pollinators, animal species, and bloom periods

Vegetative coverage and success of planting schemes

Soil investigations (nutrients, respiration, gasoline)



Field Monitoring Results

Temperature

GI surfaces generally cooler than nearby pavement

Cooler surfaces don't directly translate to cooler air temperatures

Vegetation

Substantial differences in vegetation performance

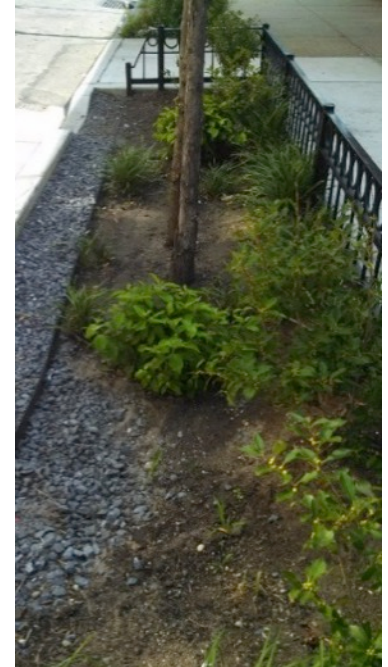
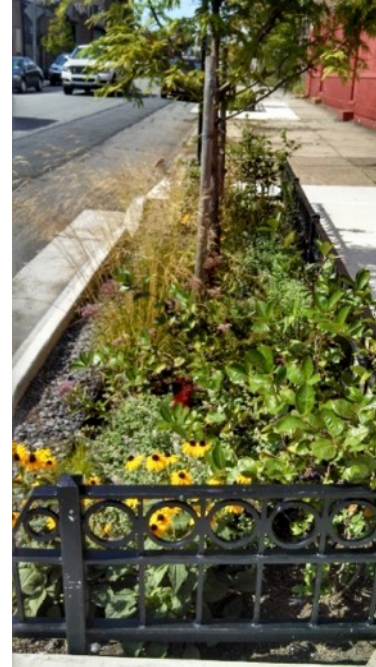
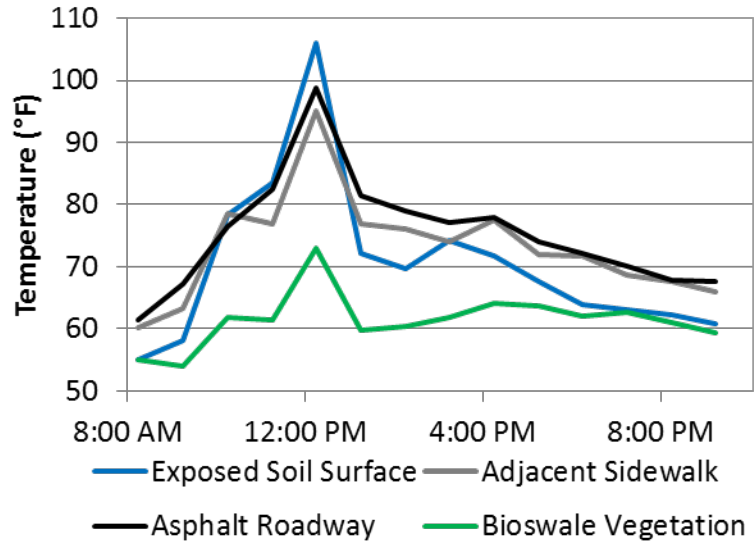
Pollinators

Confirmed presence even within isolated, highly urbanized areas

Green Infrastructure Soils

Higher levels of biological activity and some pollutant accumulation

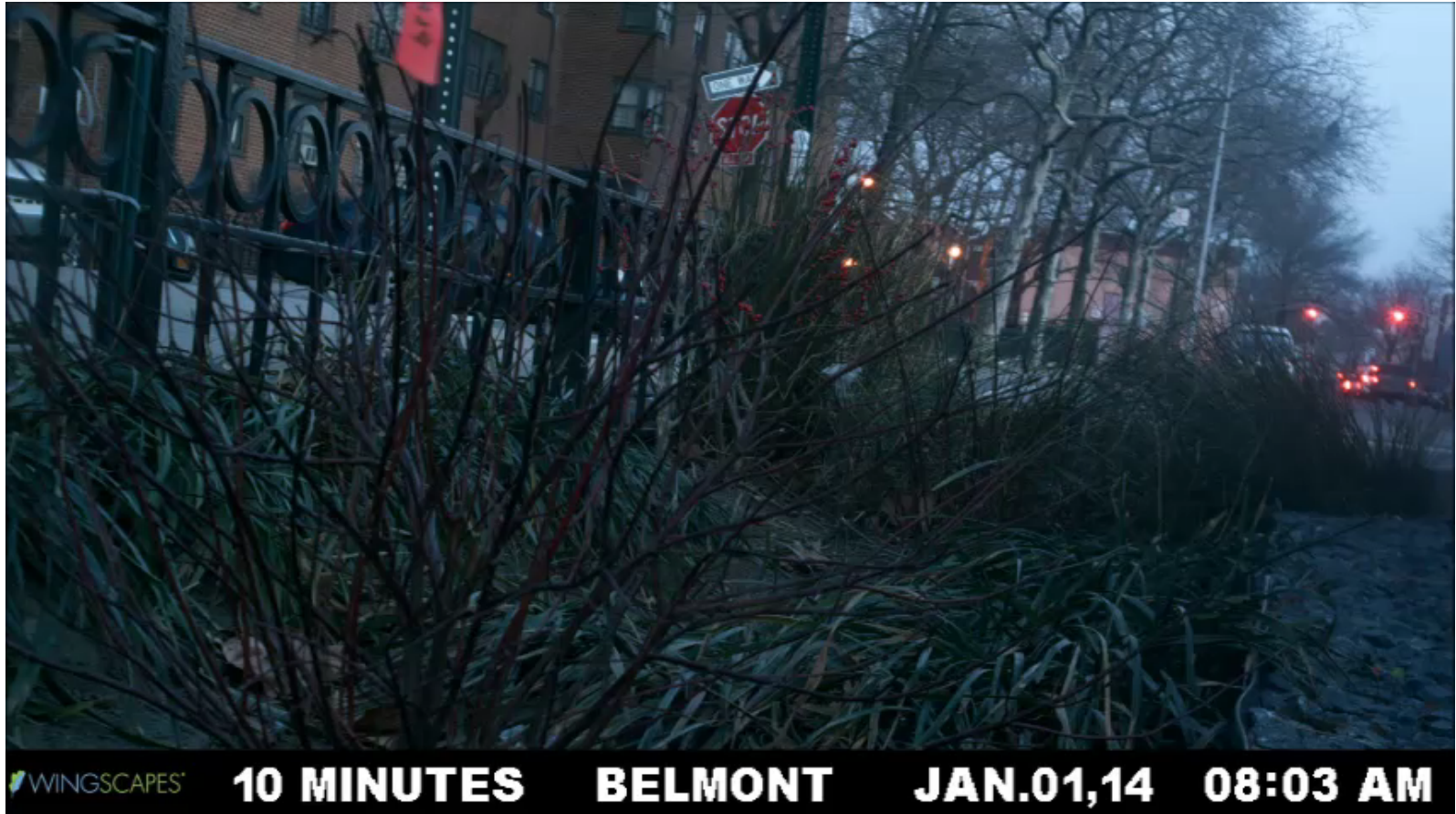
Monitoring Results



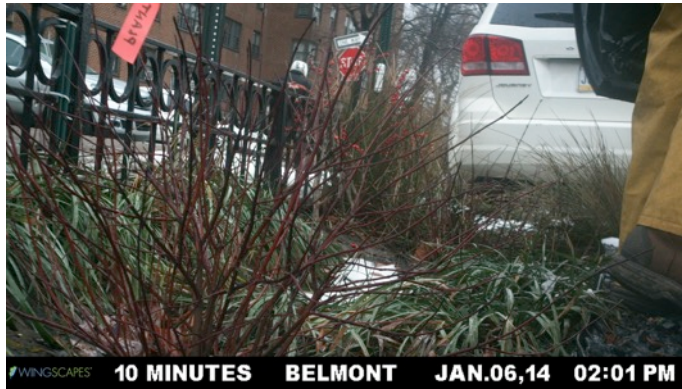
Bioswale Time Lapse



Bioretention and Snow



Bioretention and Snow



Co-Benefits Calculator

The screenshot shows the NYC Green Infrastructure Co-Benefits Calculator web application. The browser window title is "NYC Green Infrastructure Co-Benefits Calculator". The interface features a green header bar with navigation buttons: "Save/Open Mode", "Compare Mode", "File", "Load Control", "Store Control", and "View Comparison". On the right side of the header, there is a "Help Enabled" checkbox and a "Start Tutorial" button. Below the header, a "Save Location" section contains radio buttons for "ROWB 1", "ROWB 2", "PP Parking Lane", "School Green Ro", "Slot 5", "Slot 6", "Slot 7", "Slot 8", "Slot 9", and "Slot 10". A breadcrumb trail at the top of the main content area includes: "-Introduction-", "ROW Bioswale", "Greenstreet", "Large Bioretention", "Porous Pavement", "Constructed Wetland", "Green Roof", "Blue Roof", "-Combined Controls-", and "-Tool Setup-". The main content area is titled "NYC Green Infrastructure Co-Benefits Calculator" and contains two buttons: "Start Using the Calculator" and "Start the Tutorial".

Calculator Overview

The NYC Green Infrastructure Co-Benefits Calculator allows a user to identify and quantify the costs and benefits of green infrastructure in a comprehensive manner, considering costs like CO2 emissions associated with GI construction and benefits like urban heat island reduction.

Given basic information about the design of a green infrastructure control, the tool displays a range of environmental, economic, or social cost and benefit metrics. Results from a single green infrastructure control can be saved for extrapolation to a neighborhood scale or displayed in a head to head comparison with another green infrastructure control.

Links to Supporting Information

[NYCDEP Green Infrastructure Program](#)

Green Infrastructure Control Types

ROW Bioswale | Greenstreet | Large Bioretention | Porous Pavement | Constructed Wetland | Green Roof | Blue Roof

Right-of-Way Bioswale

A right-of-way bioswale refers to small planted area that is designed to capture and manage stormwater runoff within the sidewalk.

www.nycgicobenefits.net

Co-Benefits Calcul

Calculator Inputs

Save Name: ROWB 1

100 ROWB Footprint (ft²)

3000 Managed Impervious Area (ft²)

25 Anticipated Lifespan (yrs)

70 Shrub and Herbaceous Cover (%)

1 Number of Trees

Flowering Vegetation: 50%

Native Vegetation: 50%

Plant Species: 2-10

Visible Greenspace: Tree Pit(s)

GI Accessibility: Accessible

Calculator Outputs

Total Per ft² GI Per ft² Man. Per Gal.

Environmental

107,712	Gallons Managed (gal/yr)
294	Net CO2 Produced (lb/yr)
380	CO2 Produced (lb/yr)
85	CO2 Sequestered (lb/yr)
14 %	Urban Heat Island Reduction
0.16	Ozone Removed (lb/yr)
0.11	PM10 Removed (lb/yr)
0.11	NO2 Removed (lb/yr)
0.06	SO2 Removed (lb/yr)
0.02	CO Removed (lb/yr)
48 %	Ecosystem Services Score

Ecosystem Score Detail

Low	Pollinator Support
Medium	Native Habitat Support
Medium	Biodiversity Support
Med-Low	Green Corridor Support

Economic

\$25,000	Construction Cost
\$627	Maintenance Cost (\$/yr)
\$19.39	Treatment Savings (\$/yr)
\$1.63	Inferred Economic Benefit (\$/yr)
9 %	Potential Property Value Increase

Calculator Outputs

Social

0.69	Jobs Supported (job-yr)
76 %	Social Benefits Score

Social Score Detail

Medium	Aesthetic Potential
Med-High	Impact of New Greenspace
High	Educational Opportunity

Community Based Needs

Community District: Brooklyn-06

Park Slope, Carroll Gardens

Location Based Need Ratings:

0 100%

29 %	Ozone Levels
47 %	Asthma Incidents
62 %	Heat Stress Incidents
38 %	Lack of Greenspace
28 %	School Aged Population

Click on the bar to see description and rating details.

Co-Benefits Calculator

NYC Green Infrastructure Co-Benefits Calculator

 Help Enabled

Save Location:
 ROWB 1
 ROWB 2
 PP Parking Lane
 School Green Ro
 Slot 5
 Slot 6
 Slot 7
 Slot 8
 Slot 9
 Slot 10

Introduction
ROW Bioswale
Greenstreet
Large Bioretention
Porous Pavement
Constructed Wetland
Green Roof
Blue Roof
-Combined Controls-
-Tool Setup-

Co-Benefits Provided


- Carbon Sequestration
- Urban Heat Island Mitigation
- Reduced Energy Demand
- Improved Ecosystem Services
- Improved Air Quality
- Improved Quality of Life
- Increased Property Value
- Reduced Treatment Needs
- Green Jobs

Co-Benefit Details

Carbon Sequestration

Description:

By supporting plant growth, green infrastructure can provide carbon sequestration. Carbon is taken from the atmosphere and integrated into above and below ground biomass. When plant material is decomposed, some of this carbon can return to the atmosphere. Soil within the green infrastructure control also serves as a



Calculator Inputs

Save Name: ROWB 1

100 ROWB Footprint (ft²)

3000 Managed Impervious Area (ft²)

25 Anticipated Lifespan (yrs)

70 Shrub and Herbaceous Cover (%)

1 Number of Trees

Flowering Vegetation: 50%

Native Vegetation: 50%

Plant Species: 2-10

Visible Greenspace: Tree Pit(s)

GI Accessibility: Accessible

Calculator

Total

Environment

107,712 G

294 N

380

85

14% U

0.16 O

0.11 P

0.11 N

0.06 S

0.02 C

48% E

Ecosy

Low

Medium

Medium

Med-Low

Economic

\$25,000 Construction Cost

\$627 Maintenance Cost (\$/yr)

\$19.39 Treatment Savings (\$/yr)

\$1.63 Inferred Economic Benefit (\$/yr)

9% Potential Property Value Increase

Carbon Sequestered

The average annual amount of carbon sequestered from biological activity of trees, shrubs, herbaceous cover, and soil.

Calculation

Carbon Sequestered (lb/yr) = (Soil Sequestration Rate (lb/yr/ft²) * GI Footprint (ft²) + Shrub and Herbaceous Sequestration Rate (lb/yr/ft²) * Shrub and Herbaceous Coverage (%) * GI Footprint (ft²) + Tree Sequestration Rate (lb/yr/tree) * Number of Trees) * 3.67 (lbs CO₂/lbs C)

Carbon Sequestered lb/yr = (0.1402 lb/yr/ft² * 100 ft² + 0.0181 lb/yr/ft² * 70% * 100 ft² + 8 lb/yr/tree * 1 trees) * 3.67 lb CO₂/lb C = 85.46 lb/yr

Sequestration Rates for Soil, Shrub, and Herbaceous Cover

Jo, H. K., and McPherson, G. E. 1995. Carbon storage and flux in urban residential greenspace. Journal of Environmental Management, 45(2), 109-133.

Tree Sequestration Rate

Nowak, D. J., Hoehn III, R. E., Crane, D. E., Stevens, J. C., Walton, J. T. 2007. Assessing Urban Forest Effects and Values New York City's Urban Forest.

Click outside help box to close

Green Infrastructure Implementation and Performance

Green infrastructure provides an array of tools to overcome stormwater challenges

Retention can be significant within the ultra-urban environment

Evidence that co-benefits are being realized

Matthew Jones, PhD, PE
mjones@hazenandsawyer.com

