



Benefits of Green Infrastructure

Multiple Benefits

- Reduced hydrological impacts on streams and streambanks
- Reduced pollutant discharges
- Reduced flooding
- Increased groundwater recharge and baseflow
- Reduced energy consumption
- Improved air quality
- Reduced urban heat island impacts
- Enhanced property values
- Community benefits of green space
- Green roofs last longer than traditional roofs, thereby conserving resources
- Carbon sequestering
- Aesthetic benefits

Clean Water State Revolving Fund

Green Project Reserve (GPR)

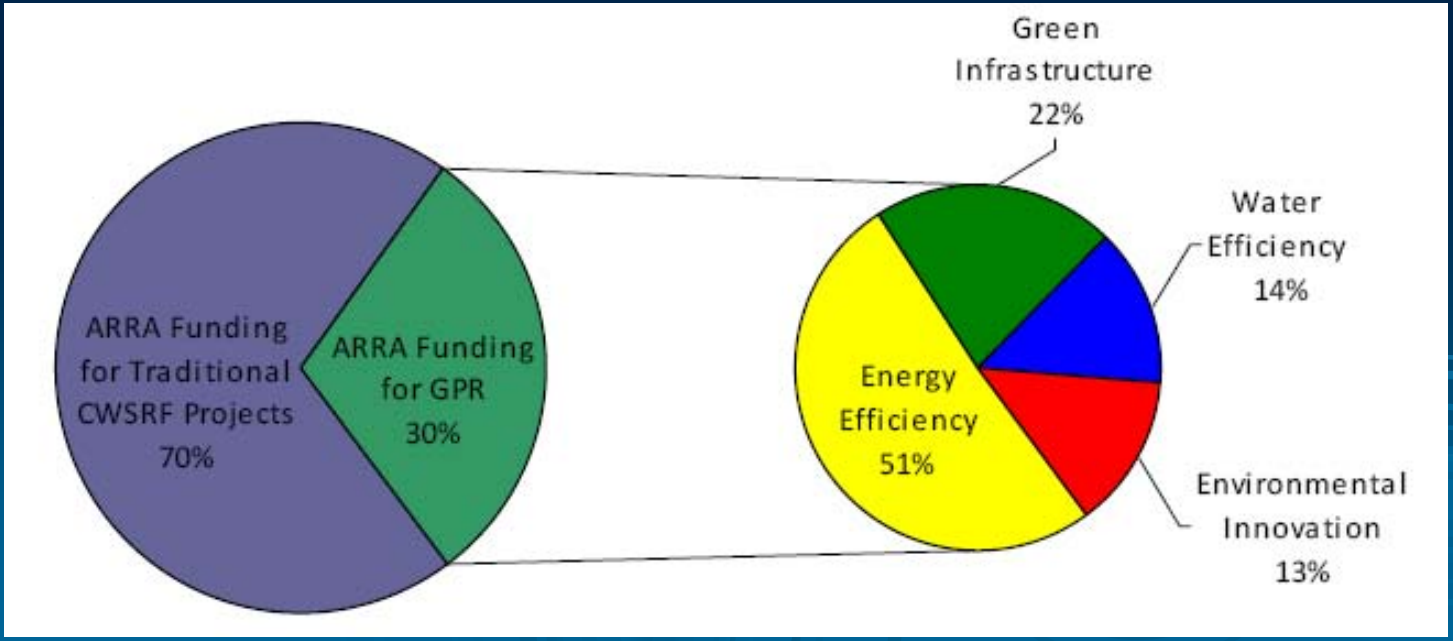
- Required 20% set aside for "green reserve"
  - Green stormwater infrastructure
  - Energy efficiency
  - Water efficiency
  - Other environmental innovations
- GPR was first seen in ARRA ~ $800 Million
- Continued in FY2010 Budget ~ $420 Million
- Proposed in FY2011 Budget ~ $400 Million

Clean Water State Revolving Fund

Future of GPR

- States made remarkable efforts under ARRA.
- Efforts now underway to augment state eligibilities, change priority systems, conduct outreach to borrowers, and form partnerships.
- States may have funded the 'low hanging fruit' with ARRA. States may now need to solicit more green projects in 2010.
- FY2010 Guidance was released on April 21, 2010.

Percentage of GPR Funding Allocated to the 4 Categories (as of 6/8/10)



Clean Water State Revolving Fund

Green Infrastructure Category of GPR

Categorically Eligible GI Projects

- Implementation of Green Streets
- Wet weather management systems for parking areas
- Implementation of comprehensive street tree / urban forestry programs
- Stormwater harvesting and reuse projects
- Comprehensive retrofits designed to keep stormwater out of sewers
- Establishment or restoration of permanent riparian buffers, floodplains, and wetlands
- Water quality portion of projects that preserve/restore hydrologic processes through sustainable landscaping and site design
- Fee simple purchase of land / easements that demonstrate direct water quality benefit

Clean Water State Revolving Fund

Alternative Funding Opportunities

Additional Subsidization

- For FY2010, states can provide additional subsidization in the form of grant, negative interest, or principle forgiveness.
- Up to 30% of the state's capitalization grant can be provided in the form of additional subsidization.
- States are encouraged to use the additional subsidization for disadvantages, green and sustainability projects.

Clean Water State Revolving Fund

Alternative Funding Opportunities

Sponsorships

- A growing number of CWSRF programs choose to tackle nonpoint source (NPS) pollution with POTW sponsorships
- POTWs can sponsor a NPS project in their community in exchange for a reduced interest rate on their CWSRF loan

Project	POTW Project Only	POTW Project + NPS Project (Sponsorship)
Project Size	$1,000,000	$1,200,000
Interest Rate	2.98%	1.06%
Repayment Amount	$33,366 (2x / year)	$33,366 (2x / year)

Interest rate is set so that repayments remain the same

- No financial impact to the POTW
- Projects without an easily identifiable repayment source get implemented
- States need to judiciously use this tool because it does impact the buying power of the CWSRF

Clean Water State Revolving Fund

Alternative Funding Opportunities

In-Lieu of Fee

- CWSRF loans can be used to supply capital for in-lieu of fee program activities
- This, in turn, generates compensatory mitigation credits
- Compensatory mitigation credits are acquired by the Clean Water Act §404 permit recipients to satisfy their compensatory mitigation requirements
- Using CSRF money to supply capital for in-lieu of fee program activities is an attractive option because:

  (1) It enables States to take a watershed approach to wetland and stream compensation projects under Clean Water Act §404

  (2) It may help States pay for up-front costs associated with establishing or modifying an in-lieu fee program (including planning and design costs, land acquisition, construction/restoration of resource)

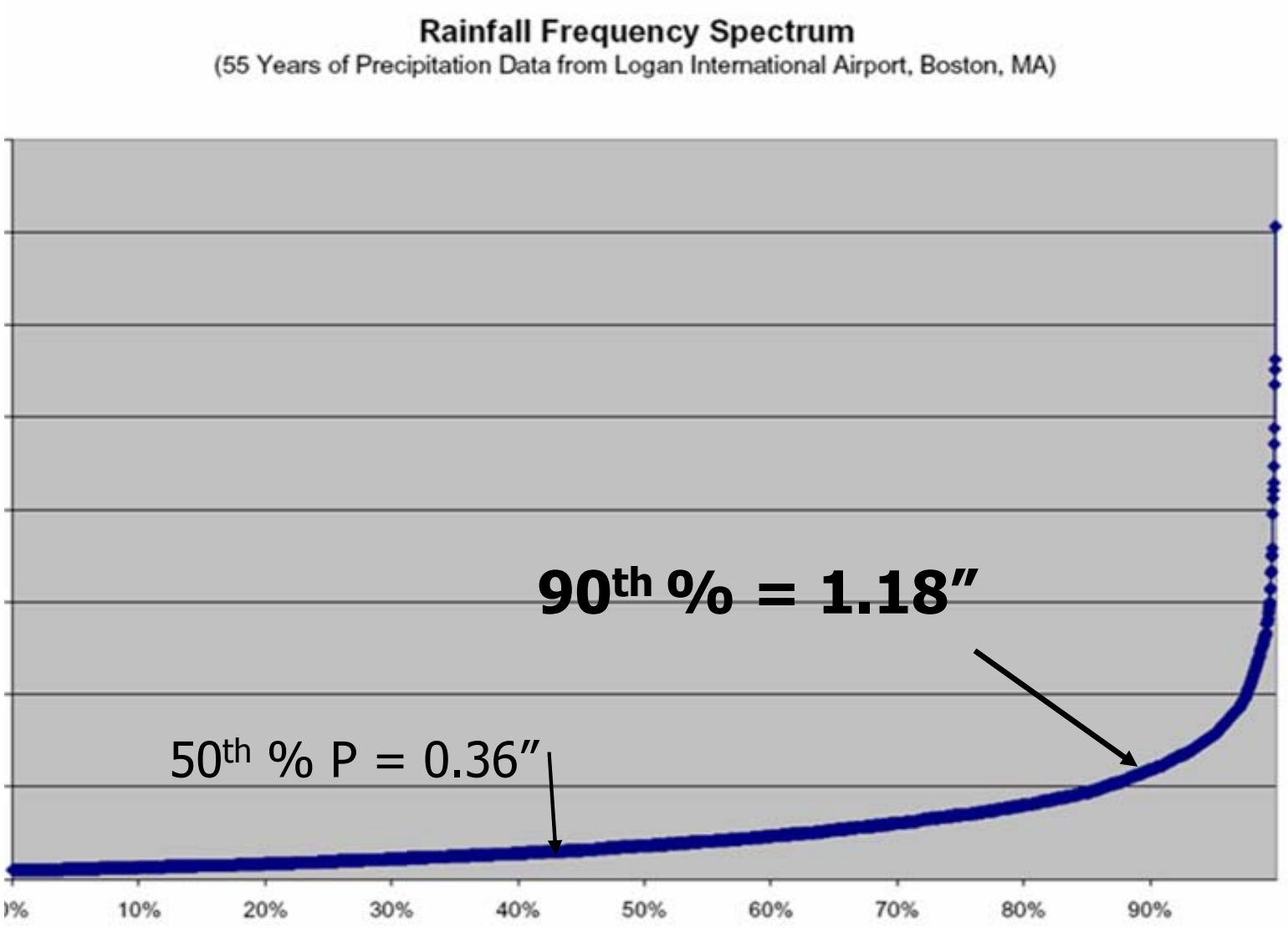
  (3) Ensures that the required amount and type of credits will be constructed prior to impact and be available to permit applicants in a timely way

  (4) Ensure that in a landscape configuration that augments watershed planning goals

Why Green Infrastructure?

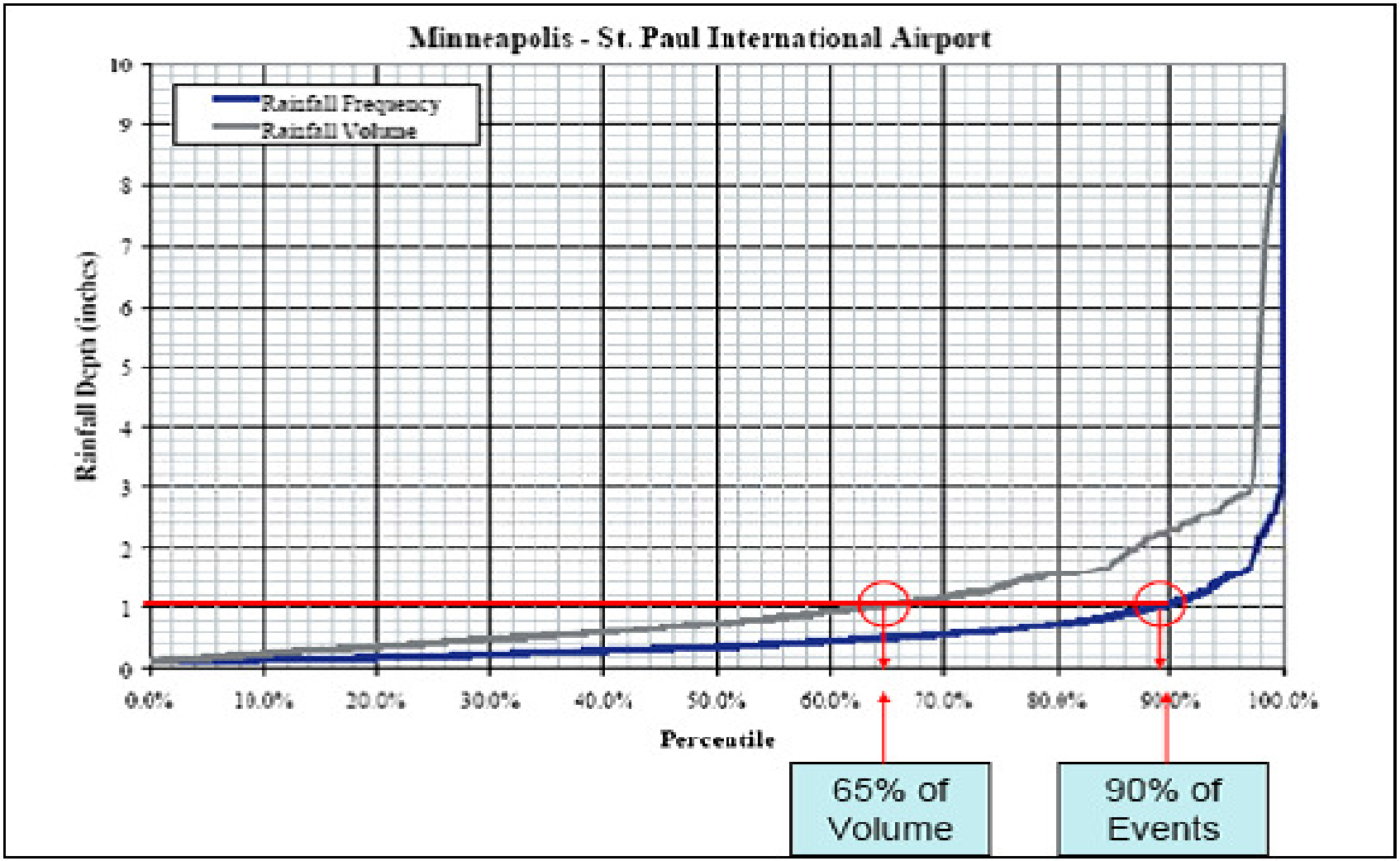
- Highly effective for stormwater runoff reduction and pollutant removal

Effectiveness and Performance:
Boston

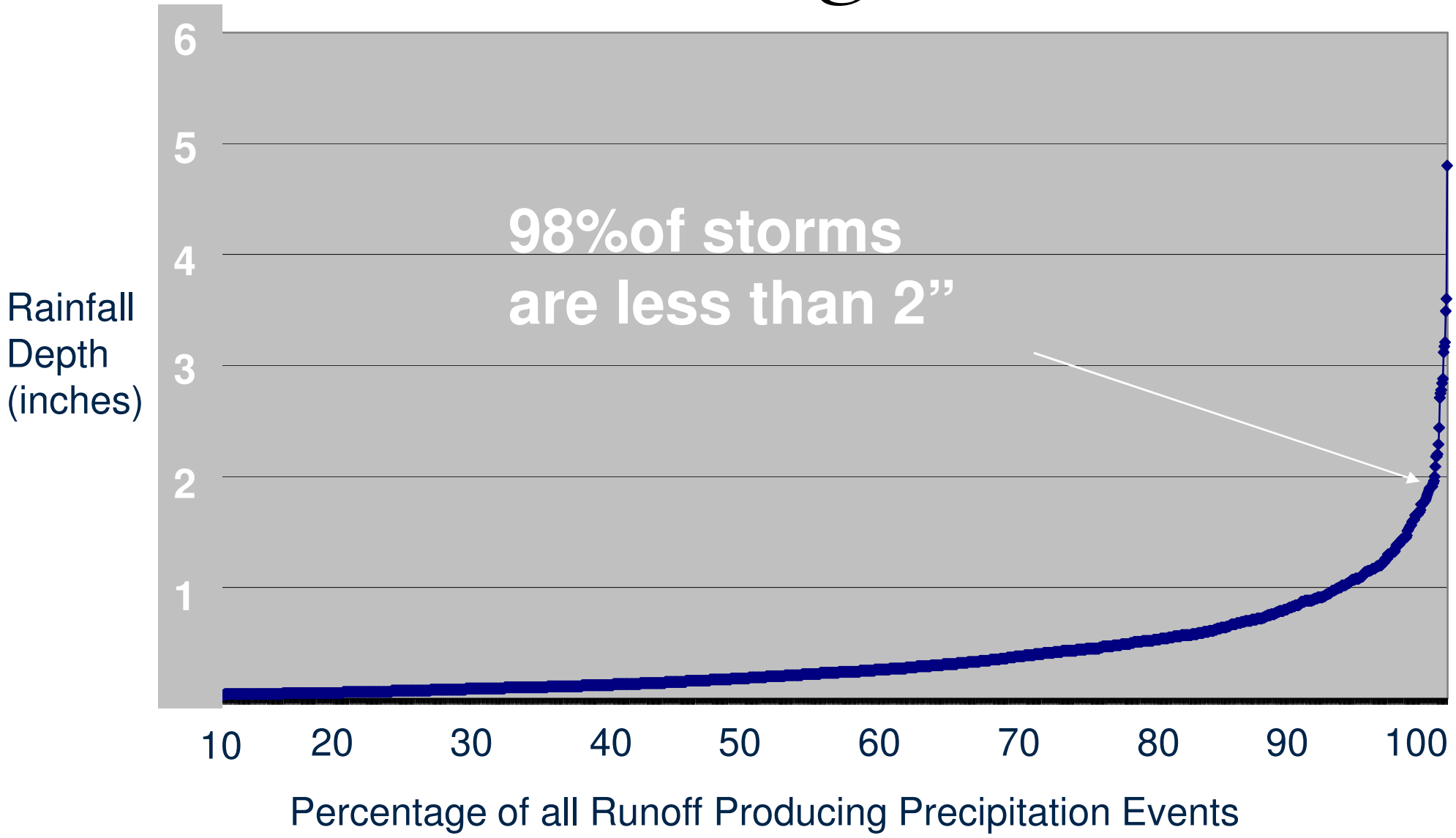


Effectiveness and Performance: Twin Cities

Figure 2. Rainfall Frequency and Volume at Minneapolis-St. Paul International Airport, 1971-2000 (for rainfall events over 0.1")



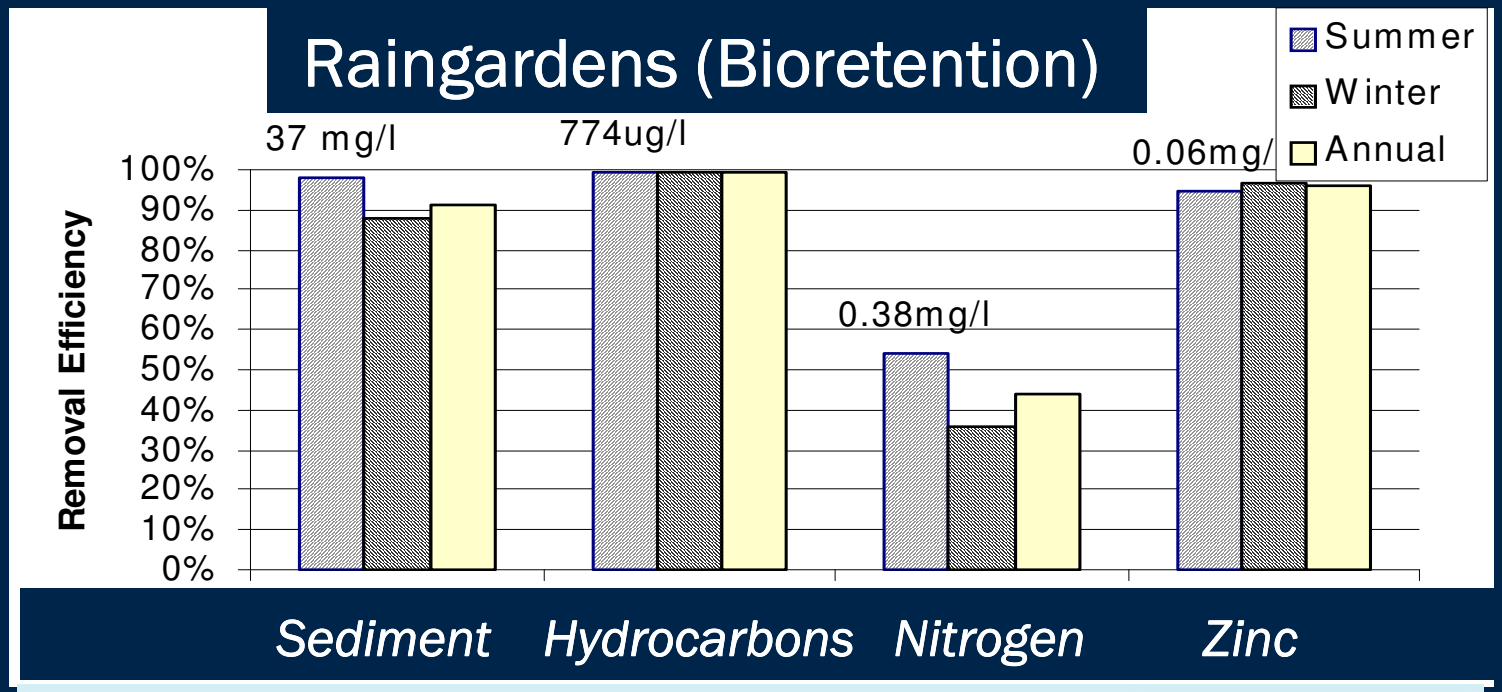
Effectiveness and Performance: Chicago

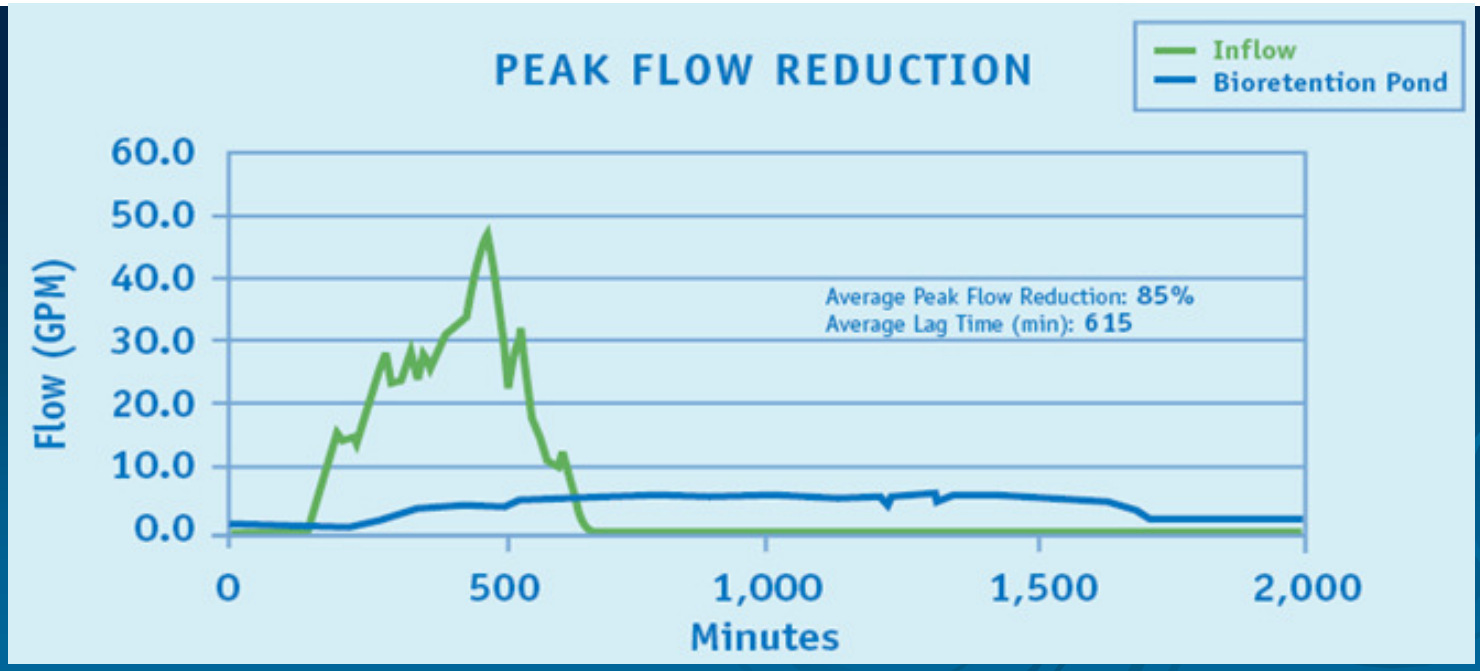


Raingarden Performance

- Infiltration reduces peak discharge rate
- Vegetative uptake of stormwater pollutants
- Pretreatment for suspended solids
- Groundwater recharge
- Aesthetic Improvement

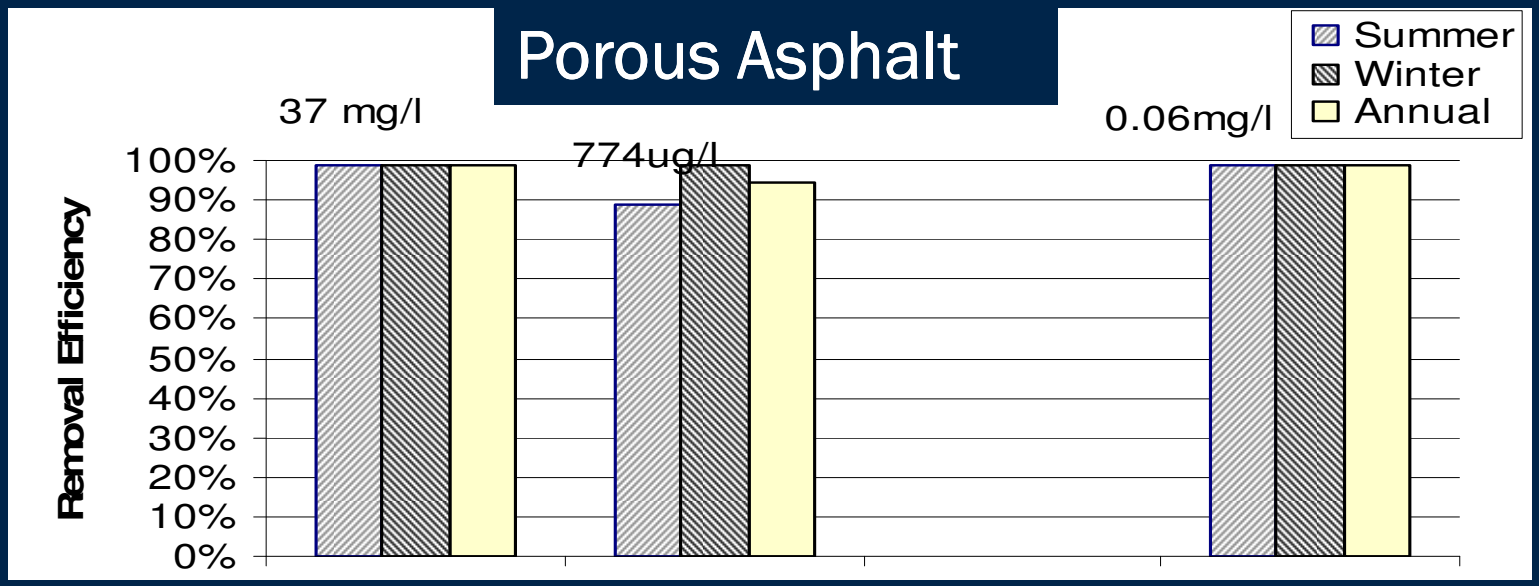
Performance Efficiencies –Filtration/Infiltration

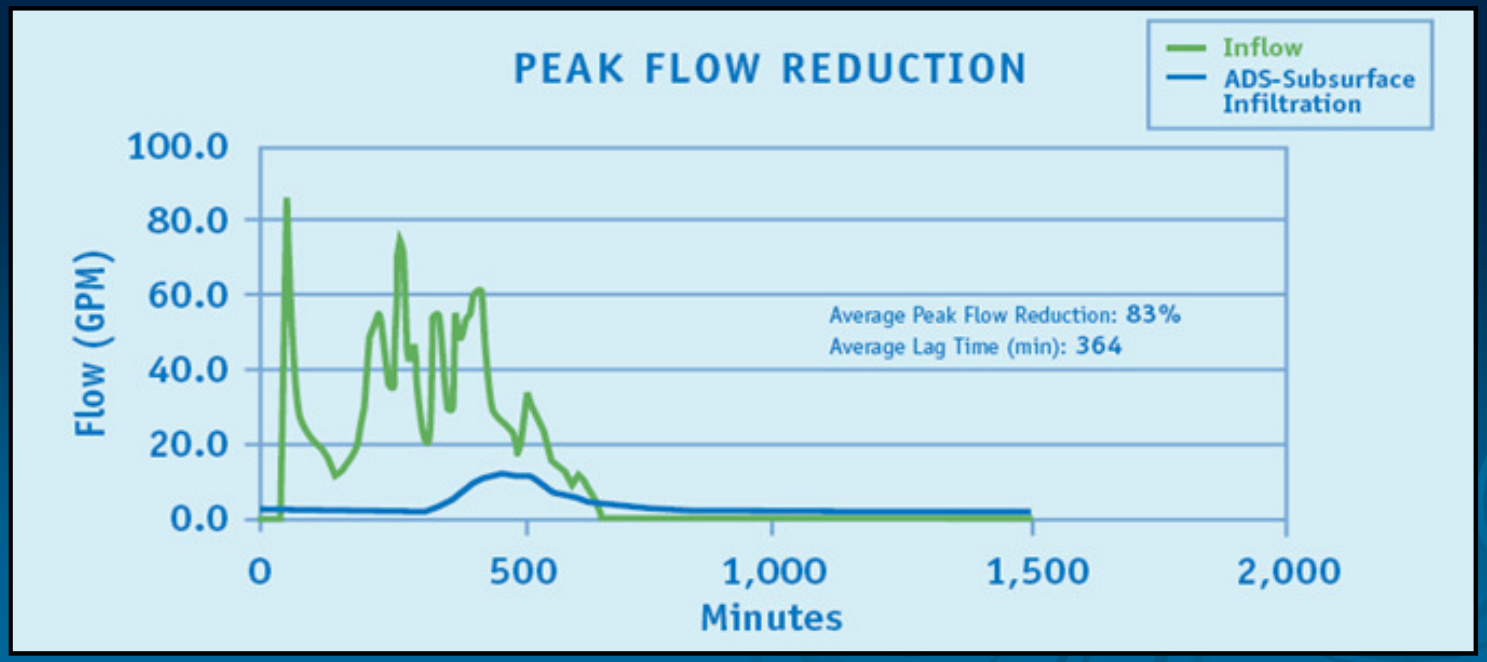




University of New Hampshire Stormwater Center

Performance Efficiencies –Filtration/Infiltration





University of New Hampshire Stormwater Center

Milwaukee School of Engineering

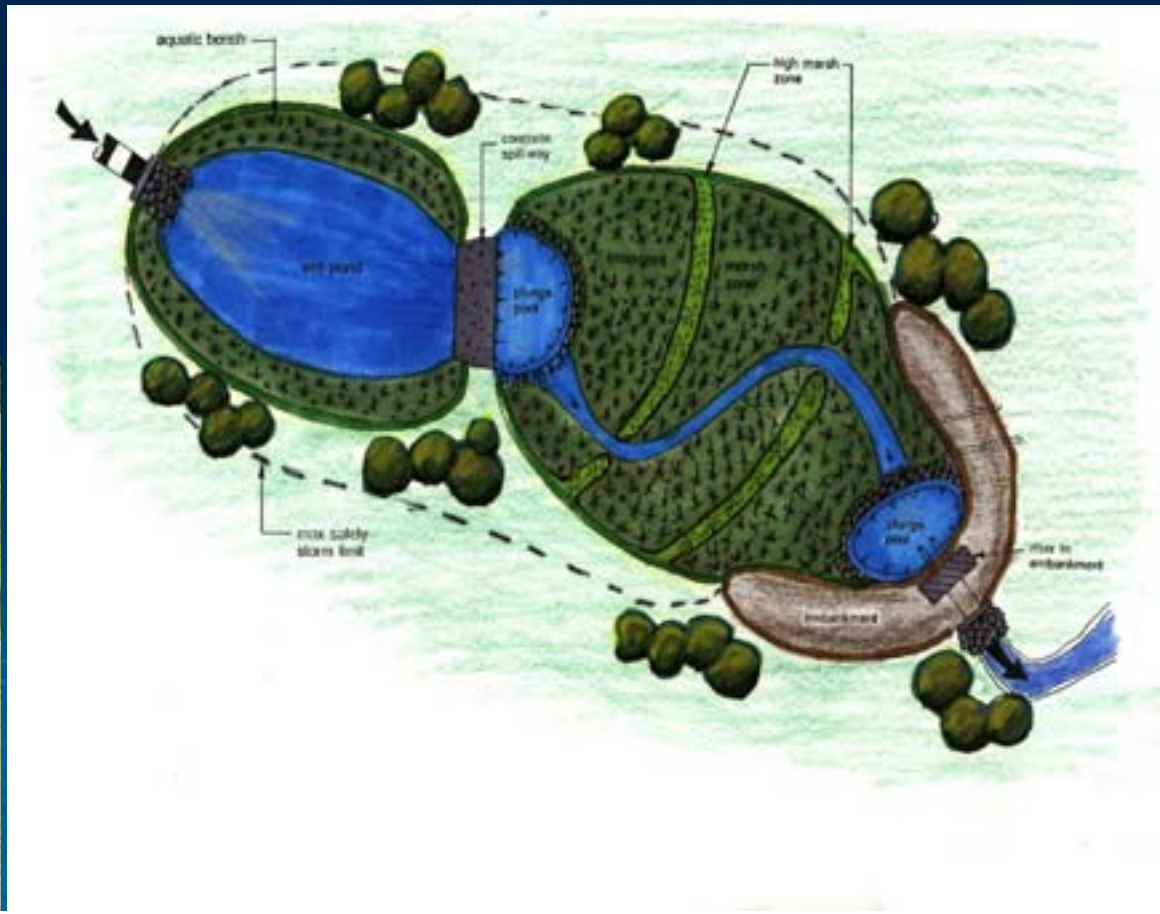
- "Water quality sampling and testing was not possible because the pervious pavements do not discharge runoff even during the simulated rainfalls. The pervious parking lot is 100% effective at eliminating discharge of contaminants through surface runoff during rainfall events." (2007 MMSD Monitoring Report)
- Comparable cost to conventional asphalt

Porous Pavement Performance

- 16 year old porous pavement in Philadelphia reported zero discharge during Hurricane Floyd in 1999 (10" rain/24 hours)
- Functions in cold weather
- 75% reduction in salt use (Toronto & NH) from reduced surface freezing

Stormwater Wetlands

- Shallow marsh
- Extended Detention wetland
- Gravel based wetland



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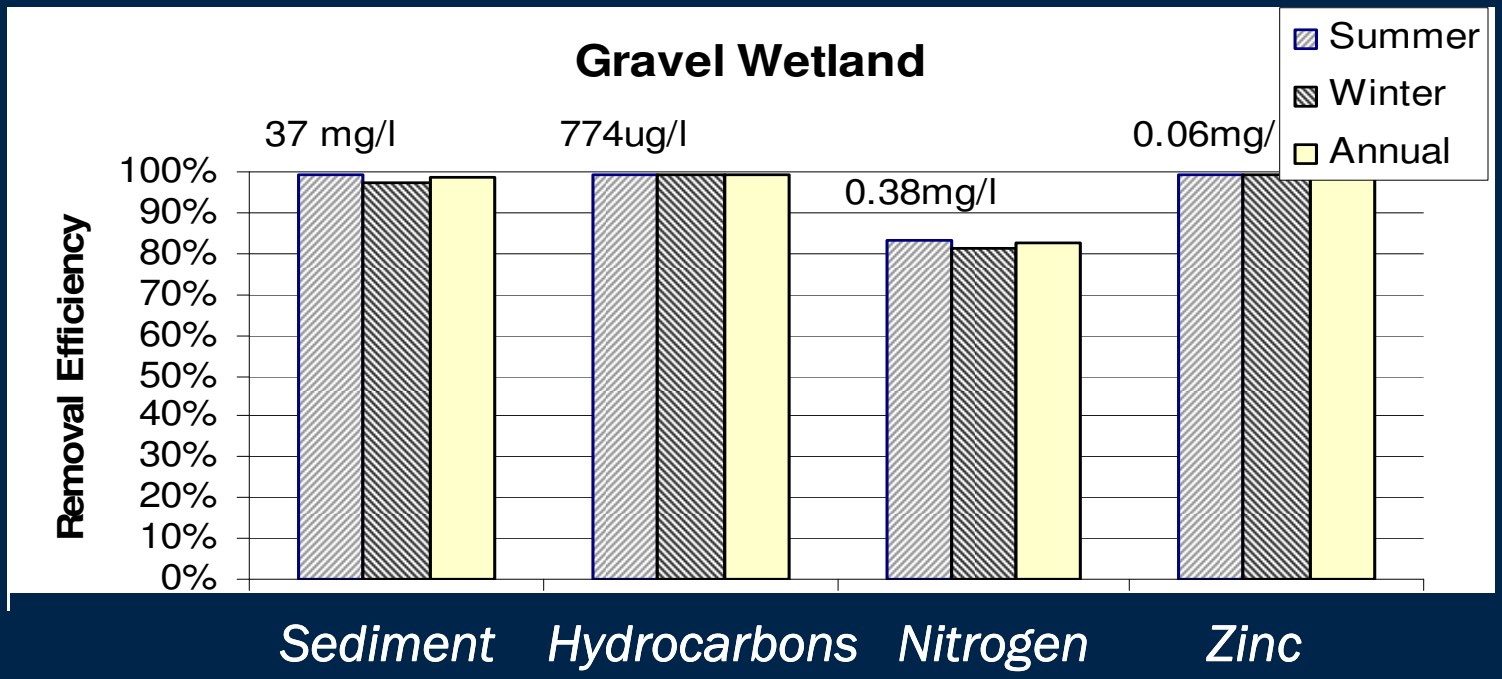
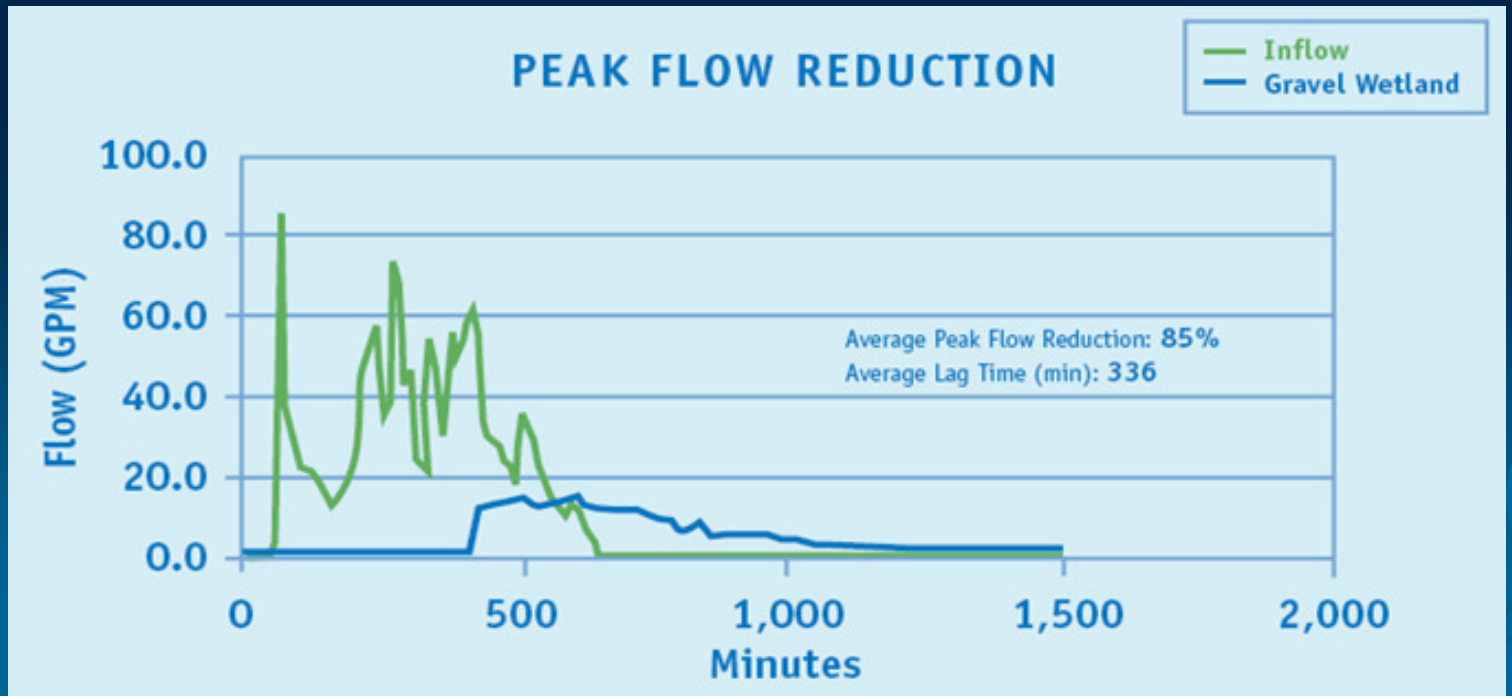




University of New Hampshire Stormwater Center

Chicago, Illinois

- Subsidized rain barrel program used to reduce basement flooding and CSO volume.
- Downspout disconnection projected to reduce CSO peak flow in target area by 20%.

Milwaukee, Wisconsin

- Green roofs, bioretention and rain barrels used to reduce combined sewer inflow.
- Green infrastructure expected to reduce CSO volume by 14-38%.

MMSD Green Roof. ***Photo courtesy of MMSD.***

Portland, Oregon

Vegetated Planter at Portland State University. ***Photo courtesy of Martina Keefe.***

- City code requires on-site stormwater management for new and re-development.
- Subsidized downspout disconnection program.
  - 45,000 participating households.
  - Infiltrates 1 billion gallons of rainwater annually.

Portland, Oregon

Vegetated Curb Extensions

- Flow testing demonstrated 88% reduction in peak flow and 85% reduction in CSS inflow for 25-year storm event.
- Sufficient to protect local basements from flooding.
- Project cost $15,000 and required two weeks to install.

Vegetated Curb Extensions. ***Photo courtesy of the Portland Bureau of Environmental Services.***

Portland, Oregon

Green Roofs

- Zoning bonus allows additional building square footage for buildings with a green roof.
- Two years of monitoring demonstrated that 58% of annual and nearly 100% of warm season rainfall was retained.
- Modeling of 300 block downtown area with ecoroofs showed 32% stormwater reduction, 6.5% energy reduction, and 1% heat island effect reduction.

Hamilton Apartments Ecoroof. ***Photo courtesy of the Portland Bureau of Environmental Services.***

Seattle, Washington

Natural Drainage Systems

- Stormwater source control.
- Monitoring has demonstrated 99% reduction in stormwater runoff.
- No measured runoff since December 2002.

2nd Avenue SEA Street. ***Photo courtesy of Seattle Public Utilities.***

Seattle, Washington

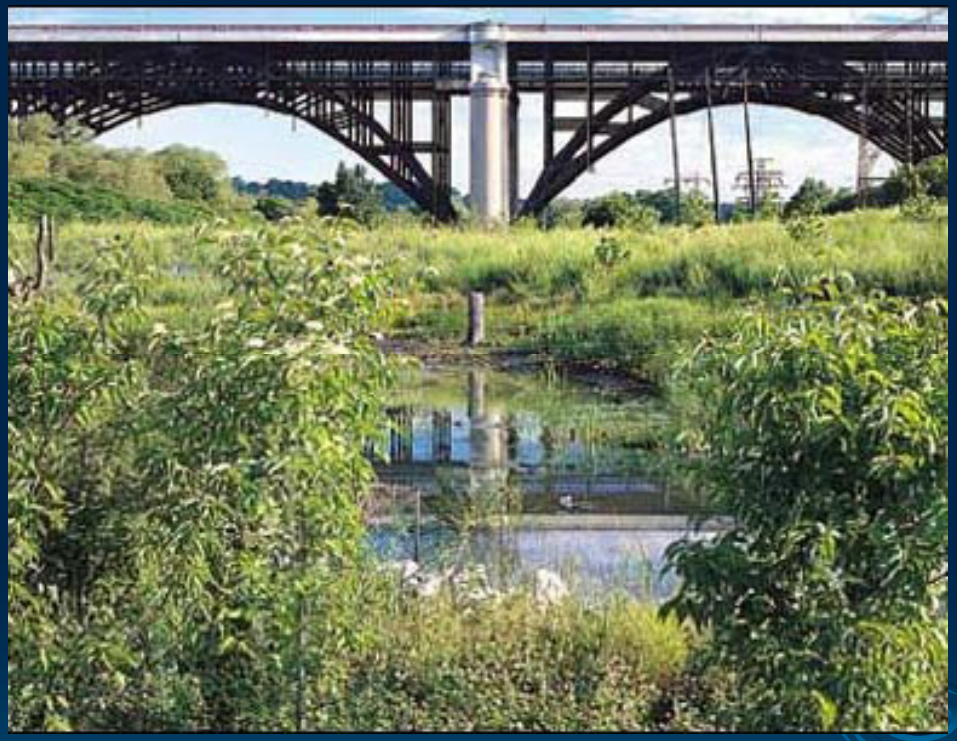
Rainwater Harvesting

- More than 16,000 gallons of storage at 327,000 ft^2 King Street Center used for toilets and irrigation.
- Provides 60% (1.4 million gallons) of toilet flushing water annually.

King Street Center.

Toronto, Ontario

- City provides free downspout disconnection
- Extensive stream restoration efforts include rehabilitating wetlands and vegetated areas.
- More than 100 green roofs have been installed in the city, which reduce roof runoff by more than 50%.



Chester Springs Marsh. ***Source: City of Toronto, www.toronto.ca.***

Vancouver, British Columbia

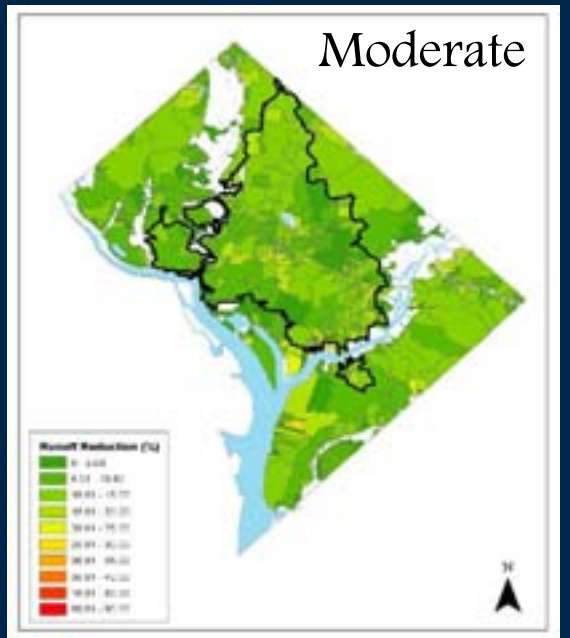
- Uses naturalized streetscapes, infiltration bulges and Country Lanes to manage stormwater from roadways.
- Street design projected to reduce annual runoff 90%.
- Installed natural biofiltration systems to manage and treat stormwater before it enters sensitive salmon waters.

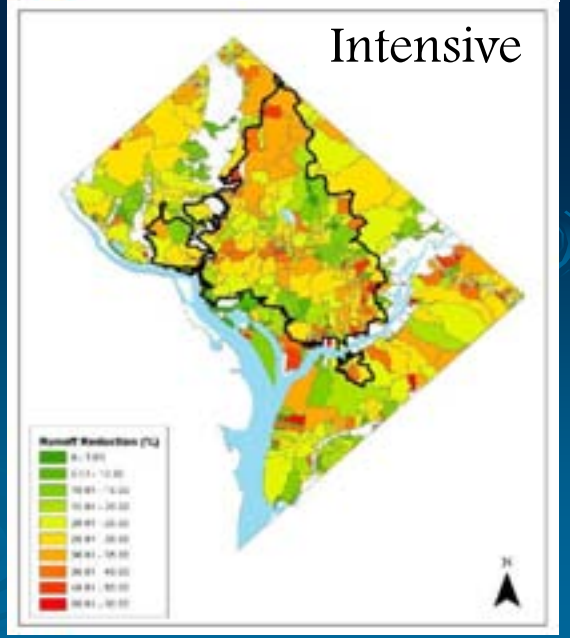
Country Lane. ***Photo courtesy of City of Vancouver Greenways Program.***

Washington, D.C.

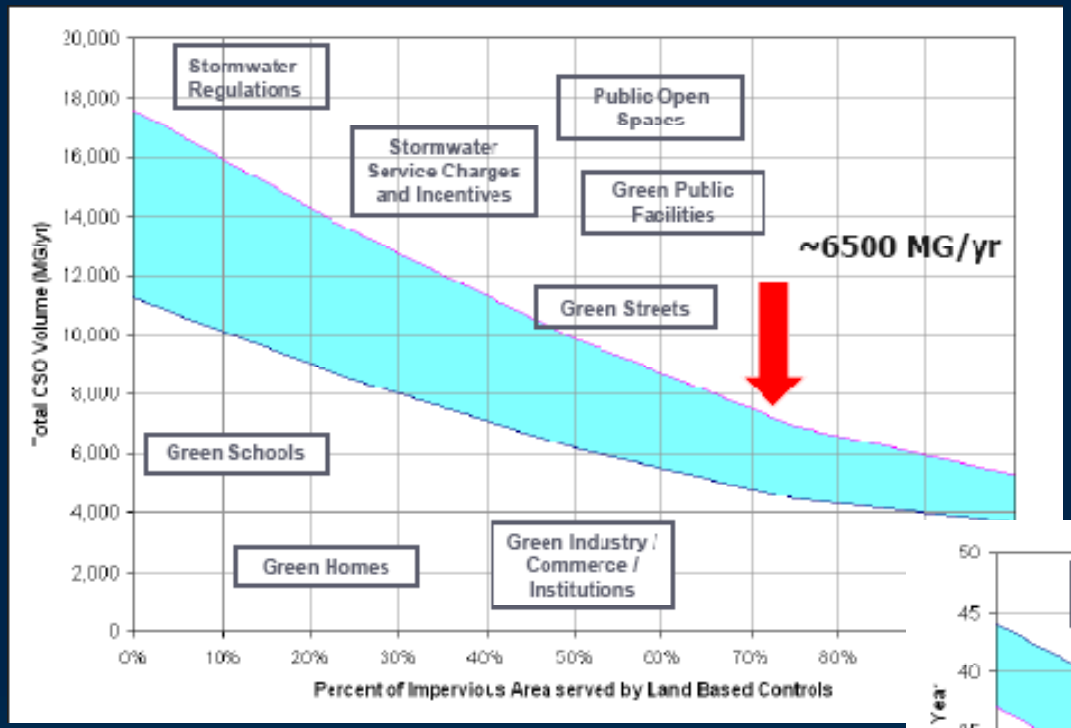
Green Build-Out Model

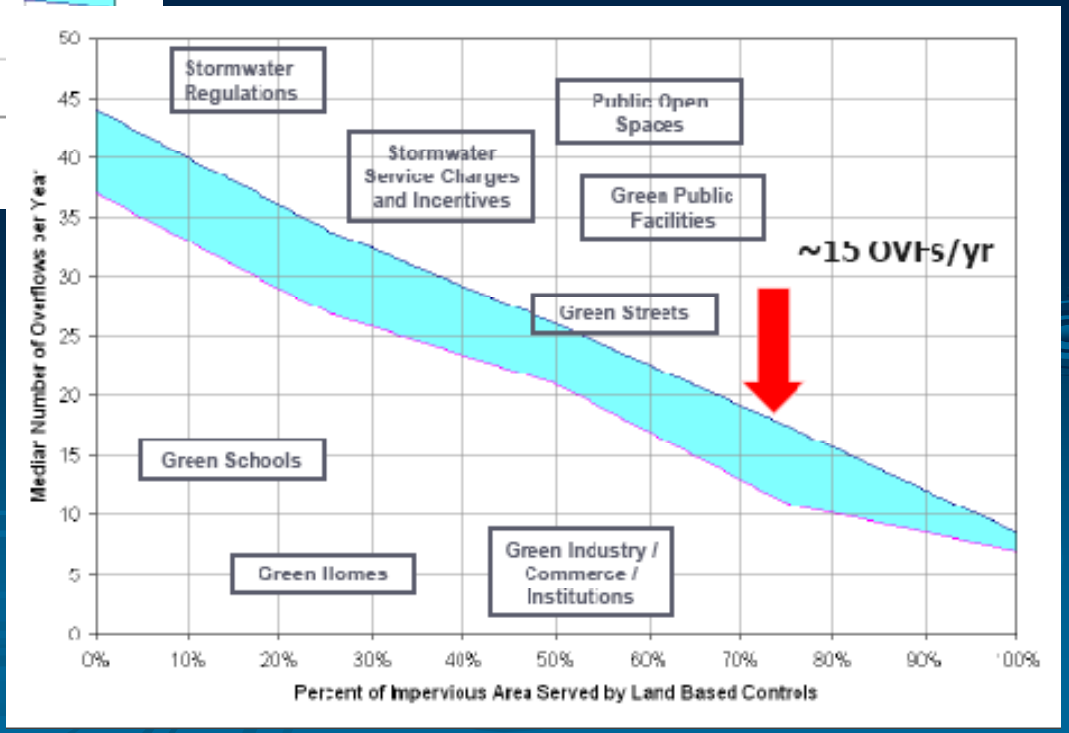
- Moderate Scenario: 1.3 billion gallon (12%) collective reduction in discharges from both sewer systems. Nearly 400 million gallons (17%) reduction in CSS discharges.
- Intensive Scenario: 3 billion gallon (30%) collective reduction in discharges from both sewer systems. Nearly 1 billion gallons (43%) reduction in CSS discharges.
- Reductions in stormwater runoff volume of up to 26% across the city, with greater than 50% reductions in individual sewersheds.





Philadelphia, Pennsylvania





Why Green Infrastructure?

- Highly effective for stormwater runoff reduction and pollutant removal
- Saves money compared to conventional infrastructure

Seattle, Washington

Street Edge Alternatives (SEA) Streets

- vegetated strips, no curbs = 11% reduction in impermeable surface
- 90+% runoff reduction
- 25% cost savings compared to conventional design

Seattle, Washington

Seattle Green Grid

- 86% annual volume

- Serves 5 blocks (49 acres)

- "double the stormwater benefit for the same cost" as SEA Street 1

Portland, Oregon

Green Streets Program

- Citywide priority – included in development, redevelopment or enhancement
- 80-85% CSO peak flow reduction
- 40% cost savings compared to conventional design

Moline, Illinois

Item	Permeable Pavers	Concrete	Asphalt
Paving/sf	$2.25	$8.00	$3.00
Excavating/sf	$1.00	$1.00	$1.00
Stone/sf	$2.00	$1.50	$1.50
Installation/sf	$4.00	(in paving cost)	$1.50
Curbs	$1.50	$1.50	$1.50
Maintenance	$0.20	0	Not known
Replacement	None	None	Every 12 years
Detention/Retention required	None	Yes	Yes
Storm Sewer System/sf paving	None	$3.00	$3.00
Total/sf	$10.95	$15.00	$11.50
Total/linear foot municipal street	$171	$218	$179

Cost Savings

Table 2. Summary of Cost Comparisons Between Conventional and LID Approaches[a]

Project	Conventional Development Cost	LID Cost	Cost Difference[b]	Percent Difference[b]
2nd Avenue SEA Street	$868,803	$651,548	$217,255	25%
Auburn Hills	$2,360,385	$1,598,989	$761,396	32%
Bellingham City Hall	$27,600	$5,600	$22,000	80%
Bellingham Bloedel Donovan Park	$52,800	$12,800	$40,000	76%
Gap Creek	$4,620,600	$3,942,100	$678,500	15%
Garden Valley	$324,400	$260,700	$63,700	20%
Kensington Estates	$765,700	$1,502,900	–$737,200	-96%
Laurel Springs	$1,654,021	$1,149,552	$504,469	30%
Mill Creek[c]	$12,510	$9,099	$3,411	27%
Prairie Glen	$1,004,848	$599,536	$405,312	40%
Somerset	$2,456,843	$1,671,461	$785,382	32%
Tellabs Corporate Campus	$3,162,160	$2,700,650	$461,510	15%

[a] The Central Park Commercial Redesigns, Crown Street, Poplar Street Apartments, Prairie Crossing, Portland Downspout Disconnection, and Toronto Green Roofs study results do not lend themselves to display in the format of this table.

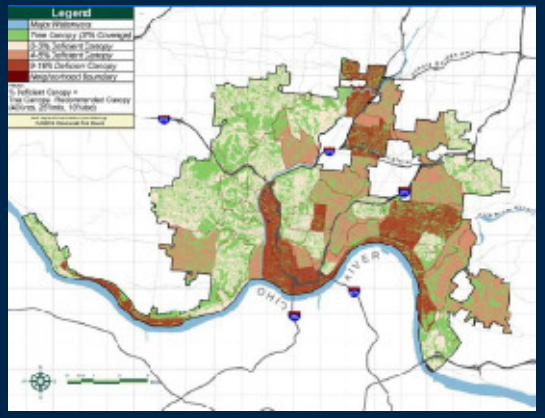
[b] Negative values denote increased cost for the LID design over conventional development costs.

[c] Mill Creek costs are reported on a per-lot basis.

Reducing Stormwater Costs through LID Strategies and Practices, EPA 2007

Cincinnati, Ohio

Pilot Project: Deer Park and Silverton

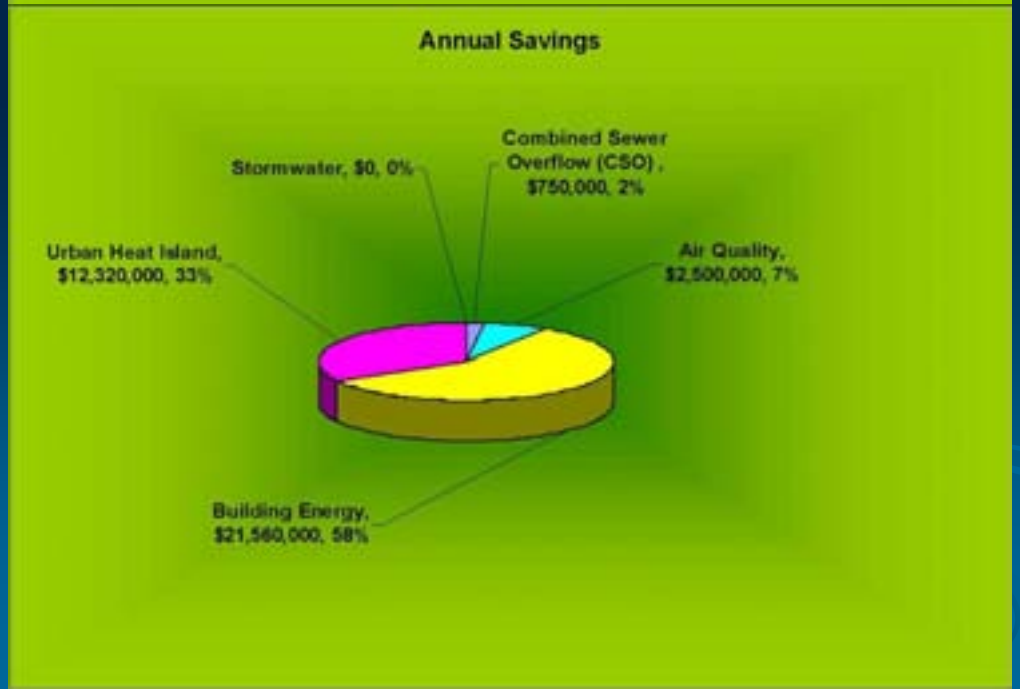


- $13.2 million of green facilities will provide an equivalent level of CSO volume reduction as $29.9 million of previously proposed storage facilities and sewer separation. Net Green Savings: $16.7 million

Opportunities Project: East Ohio

- $7.2 million in green infrastructure in this area approaches the effectiveness of $13.6 million of sewer separation. Net Green Savings: $6.4 million

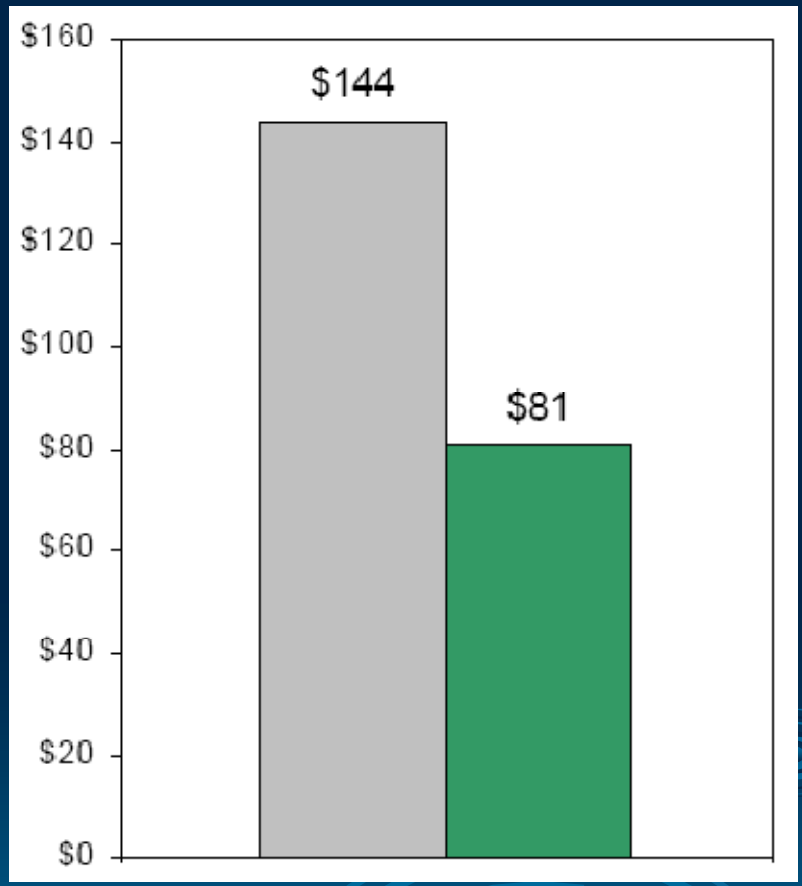
Toronto, Ontario



- Study modeled impacts of installing green roofs on all city roofs >3,750 ft^2.
  - Would result in 12,000 acres of green roofs – 8% of total city land area.
  - Estimated nearly $270 million in municipal capital cost savings and more than $30 million of annual savings.

Portland, Oregon

- Brooklyn Creek Basin
- $63 million cost savings in going from grey to green infrastructure wet weather control

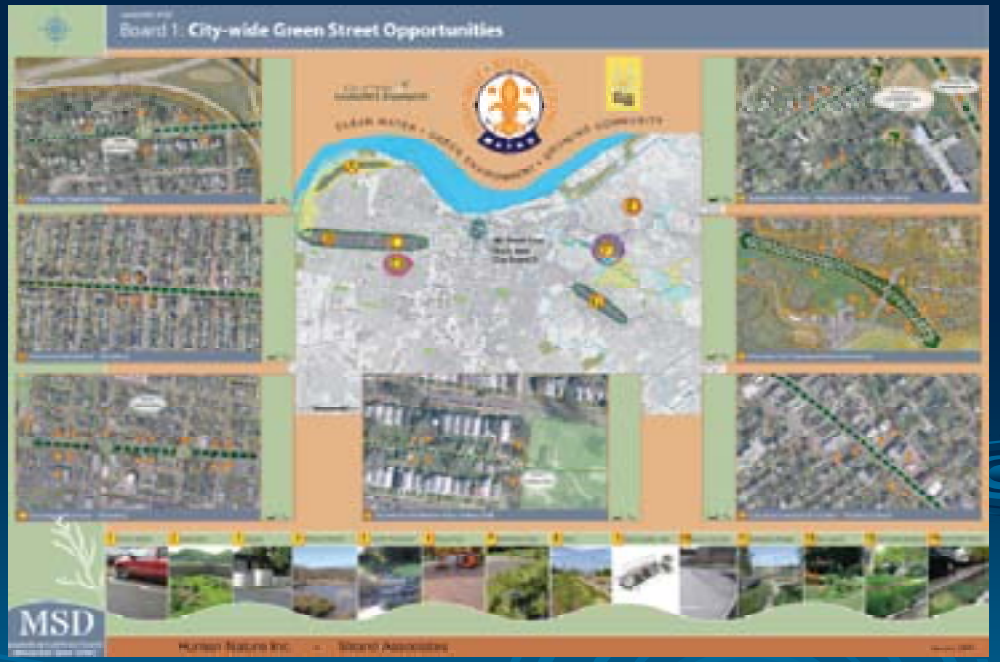


Philadelphia, Pennsylvania
Potential Impact of New SW Regs
First Inch Capture

	2006		20 years
Re-development Rate (1 mi^2/ yr)	1 mi^2		20 mi^2
Captured Runoff (per 1" event)	17 MG		340 MG
Avoided Tank Costs (@ $2/gal)	$34 M		$680 M

Louisville, Kentucky

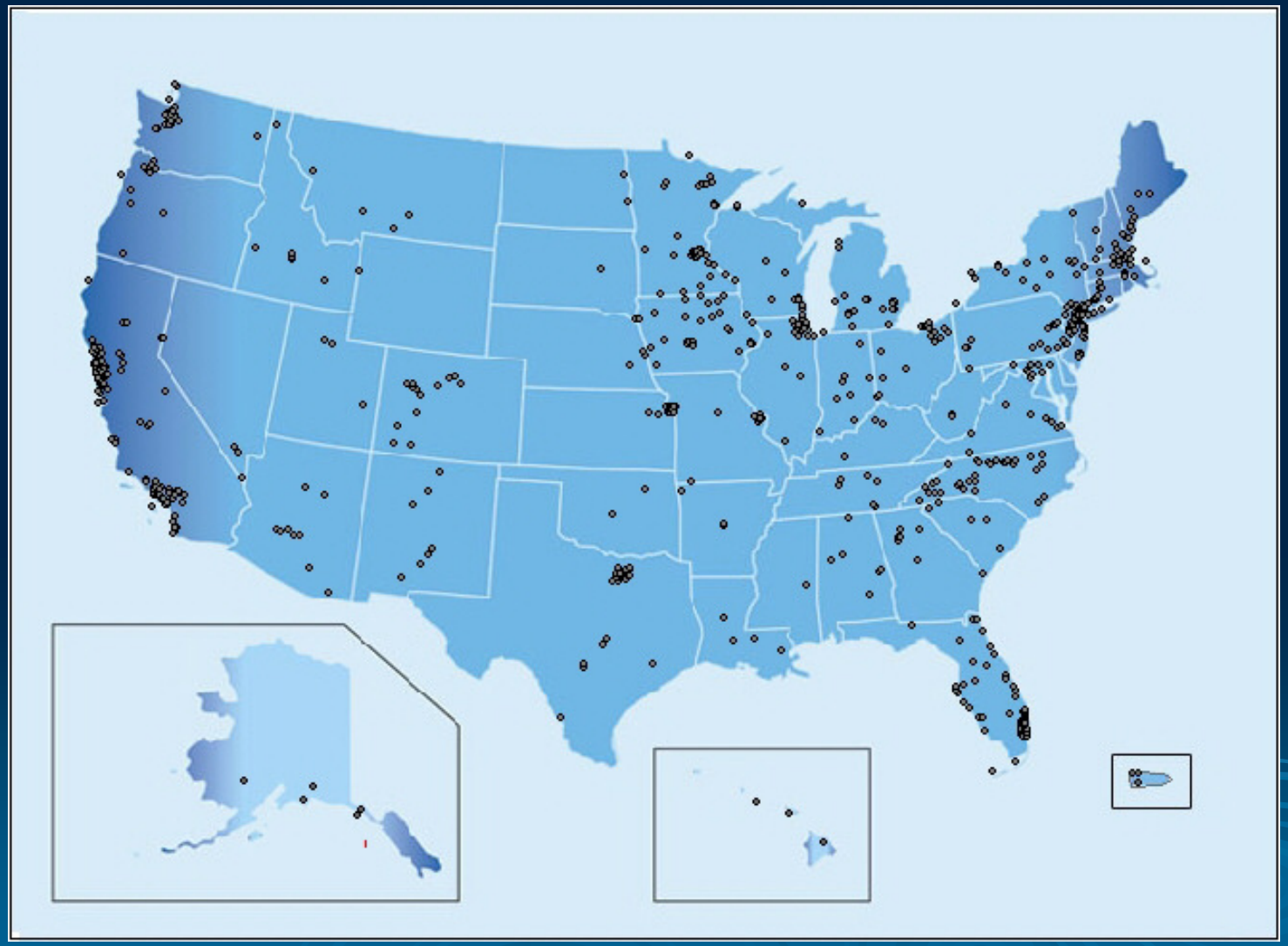
- Overflow Abatement Plan (CSOs & SSOs)
- Green infrastructure investments estimated to reduce initial costs of grey infrastructure projects by $40 million
- Potential future savings could be triple this amount



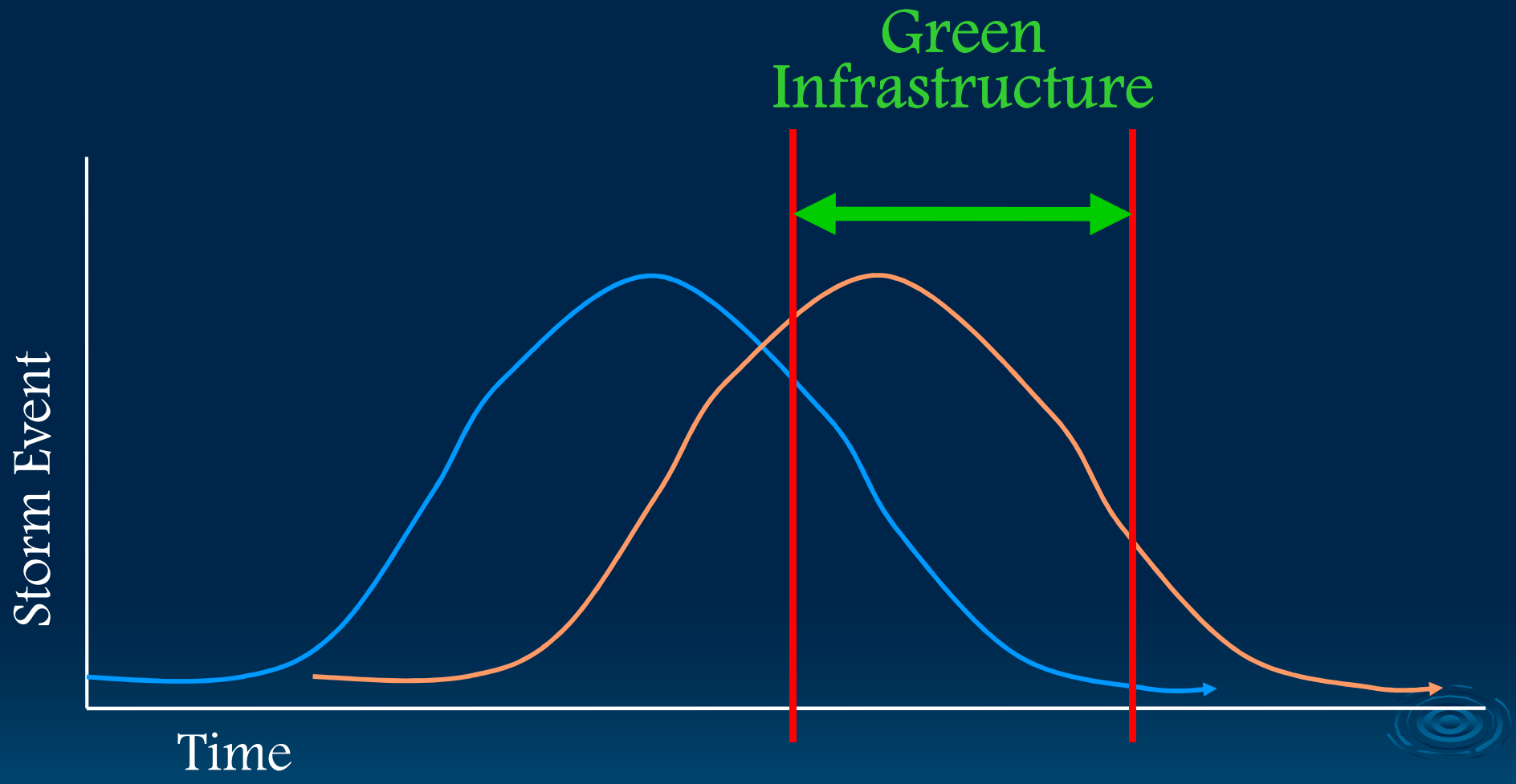
Why Green Infrastructure?

- Highly effective for stormwater runoff reduction and pollutant removal
- Saves money compared to conventional infrastructure
- Delivers multiple community benefits along with stormwater management

Mayors for Climate Protection



Climate Change Adaptation



Source: Chicago Dept of Transportation

Climate Change Mitigation

- Approximately 800 million tons of carbon are stored in U.S. urban forests with a $22 billion equivalent in control costs.
- Planting trees remains one of the cheapest, most effective means of drawing excess CO2 from the atmosphere.
- A single mature tree can absorb carbon dioxide at a rate of 48 lbs./year and release enough oxygen back into the atmosphere to support 2 human beings.
- A healthy tree stores about 13 pounds of carbon annually ~~ or 2.6 tons per acre each year. An acre of trees absorbs enough CO2 over one year to equal the amount produced by driving a car 26,000 miles.

Compiled by Colorado Tree Coalition

Energy Savings

- Chicago citywide projection: $100 million energy savings and 720 megawatts (= 3 coal fired power plants)

Data source: Weston Design Consultants

Urban Cooling

- Trees:

  10% canopy increase →5-10% energy savings from shading, windblocking

- Toronto study: permeable pavements reduce heat island

Air Quality

- One square meter green roof can remove .2 kg particulates per year
- 5 square meters = capture from 10,000 vehicle miles traveled

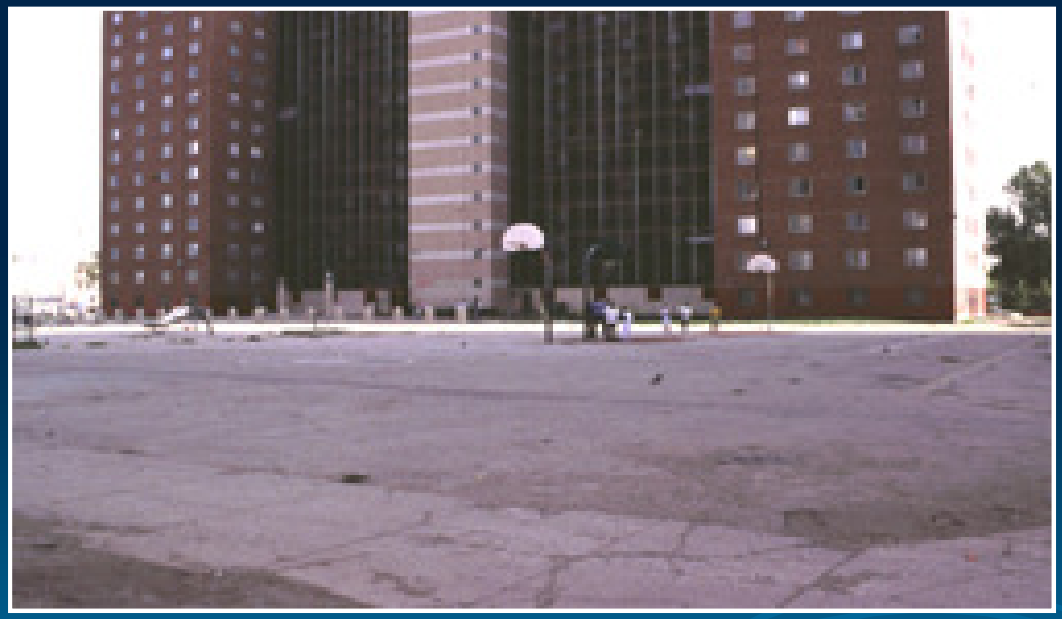
Sydney Conservatorium of Music

Water Supply

- Cook County Estimate: Apply Various Green Infrastructure →
- 40% runoff reduction
- Aquifer & lake recharge equivalent to additional supply for >1 million people

Crime Prevention

Compared with areas that had little or no vegetation, buildings with high levels of greenery had 52% fewer crimes



Landscape and Human Health Laboratory
University of Illinois at Urbana-Champaign

Community Health

"exposure to green surroundings reduces mental fatigue and the feelings of irritability that come with it. The ability to concentrate is refreshed by green views, along with the ability and willingness to deal with problems thoughtfully and less aggressively. And, in this study, ***even small amounts of greenery—a few trees and a patch of grass—helped inner city residents have safer, less violent domestic environments.***"

Landscape and Human Health Laboratory
University of Illinois at Urbana-Champaign

Habitat

Jobs Strategy

- Certified installers
- Operation & Maintenance
- High skilled engineering, landscape architecture, monitoring
- Washington, DC, via a labor demand analysis of implementation of an intensive green roof program, estimates the creation of 1769 full time jobs per year for 10 years.

Los Angeles, California

- 15% Green Roof Coverage
- 5~9 degree heat island reduction
- .5 ~ 1 Gigawatt peak power savings

Lawrence Berkely Labs Heat Island Group, 2000

Philadelphia, Pennsylvania

- Vacant land improvements increased surrounding housing values by as much as 30%
- New tree plantings increased surrounding housing values by approximately 10%

(University of PA data)

(Philadelpia Watersheds Office photos))

Philadelphia, Pennsylvania

Tree Plantings:

- $4 million property value gain
- 20 years taxed at 2.64% = $2,112,000

Lot Improvements:

- $12 million gain through
- 20 years taxed at 2.64% = $6,336,000

PA Horticultural Society photos

Vancouver, British Columbia

- The city has integrated its green infrastructure program with its greenways program, which was designed to create green city corridors and improve pedestrian access and safety throughout the city.
- Community groups donate time to maintain vegetated areas that manage stormwater

Greenway. ***Photo courtesy of City of Vancouver Greenways Program.***

New York, New York

The Solaire green roof.
Photo courtesy of Green Roofs for Healthy Cities.

- Study projects that redirecting 50% of $2.1 billion projected costs for hard infrastructure to control 5.1 billion gallons of CSO to rain gardens, street trees, green roofs, and rain barrels would:
  - capture an additional billion gallons of CSO
  - reduce annual stormwater treatment costs by 50%
  - reduce air pollution, including 3,000 tons of carbon dioxide
  - increase property values, aesthetics, and sense of community

Chicago, Illinois

- More than 80 green roofs totaling over 1 million square feet.
- A 2003 study found green roof runoff volume was less than half that of conventional roofs.

- Temperatures above the Chicago City Hall green roof average 10° to 15°F lower than a nearby black tar roof. August temperature difference can be as much as 50°F. Estimated annual energy savings of $3,600.

Seattle, Washington

Table 7. Citywide Management Unit (MU) Data*

Statistic	Citywide	
	Current	*30-year Goal*
Acres in MU	54,324	
MU as % of city land base	100%	
Canopy coverage	18%	30%
Number of trees	1,377,500	2,026,600
Plantings needed		**649,100**
One-time cost of plantings		**$114,200,000**
Maintenance Costs (yr)	$14,054,300	$21,116,300
Benefits (yr)		
Stormwater Mitigation Value (yr)	$20,643,000	**$30,215,000**
Air Cleaning Value (yr)	$4,894,000	**$7,047,000**
Carbon Sequestration (Tons CO_2)	52,400	**77,066**
Carbon Sequestration (Value $)	$1,584,000	**$2,331,000**
Other Benefits (Energy, Aesthetics, & etc)	$17,237,300	$26,342,300
Net Benefit (All Benefits - All Costs) (yr)	$30,304,000	$44,585,000

**All values are based on estimates and currently accepted models (McPhearson et al. 2002).*

12 % more Canopy:

Stormwater +

Air Quality +

Carbon +

Other Benefits =

$15 million annual net benefit

(Seattle Urban Forest Management Plan 2007)

Early Green Infrastructure efforts in Denver, Colorado

- More grey than green
- Lacks vegetation
- Relies on concrete
- Highly engineered

Could be improved by:

- Removing concrete
- Installing wetlands or xeriscape plants in low areas to encourage infiltration
- Replacing turf with native vegetation or trees could improve stormwater retention, reduce irrigation and improve aesthetics

Other (early) Denver examples

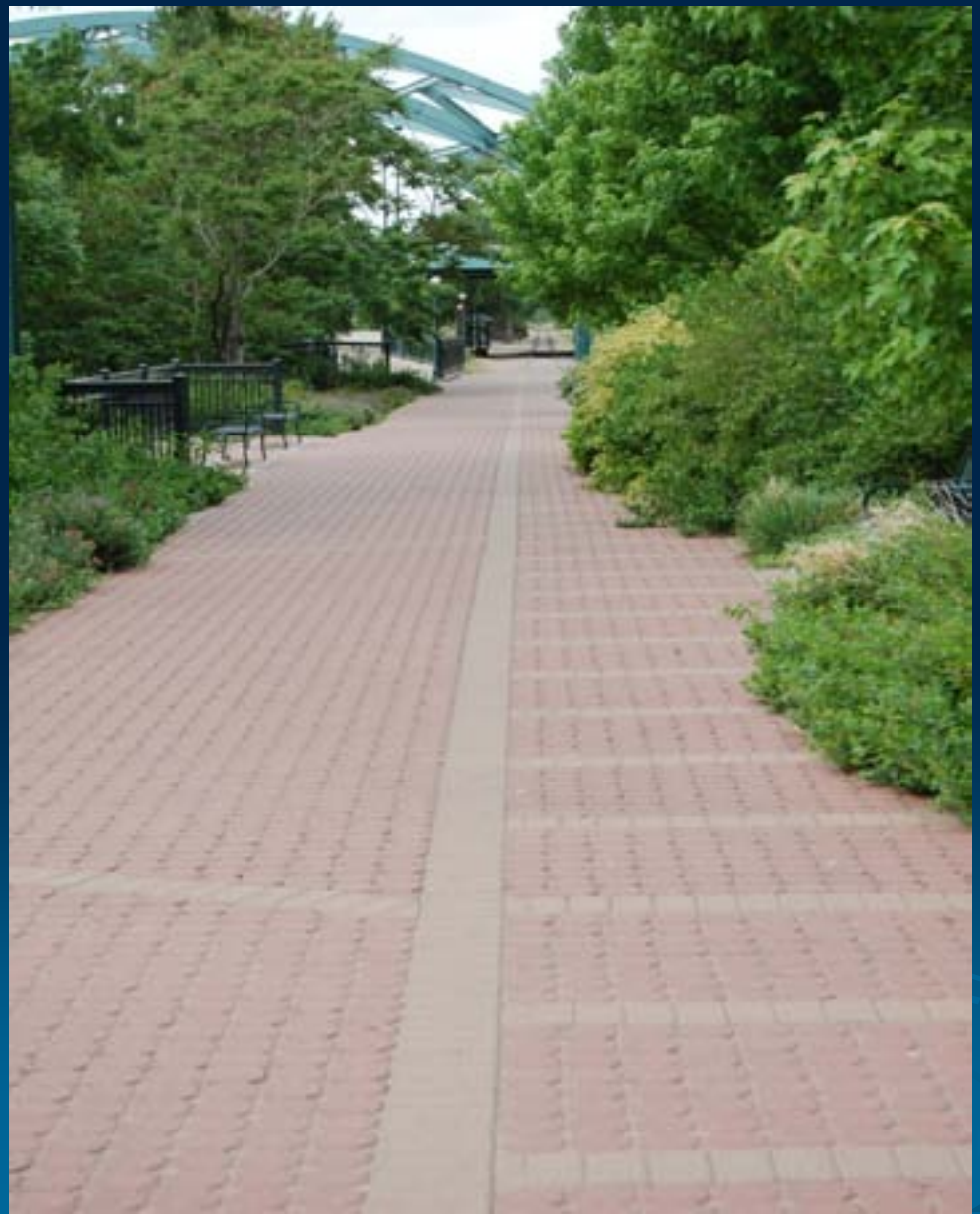
Denver, Colorado

- Vegetated low-lying catchment area reduces flooding of South Platte River
- Increases groundwater recharge
- Reduces heat island impac
- Provides community amenity for recreation
- Aesthetic benefits

Not your ordinary parking garage …

Green Roof at REI in Denver

Permeable Pavement
Denver, CO



- Reduces or eliminates pollutant discharges from stormwater runoff
- Functions in cold weather
- Allows infiltration to recharge groundwater and provide water to the urban landscape
- Aesthetic and recreational benefits

Permeable Pavement (cont.)
5% porous space = 80% infiltration

Pervious Pavers Test Site
Denver, CO

Denver, Colorado

- City Park: a series of ponds and drop structures manage stormwater and control erosion

City Park (cont.)

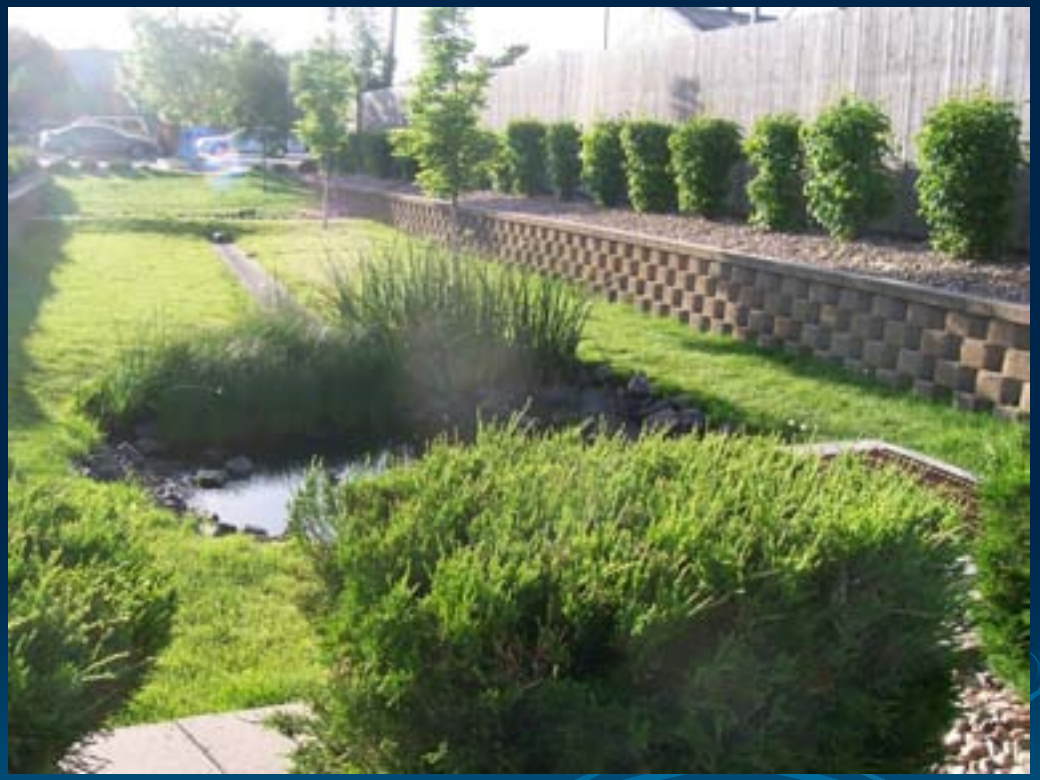
- This former lily garden could be reconfigured to allow for wetlands treatment.

Leyden Redevelopment Denver, Colorado

- Trickle channel routes the low flow through the wetlands area

Could be improved by:

- A micropool or screen would settle large debris
- Trees planted in a staggered pattern would maximize shading to reduce summer watering
- A more sinuous flow path would further reduce runoff velocity
- Replacing turf with native vegetation or trees would improve stormwater retention

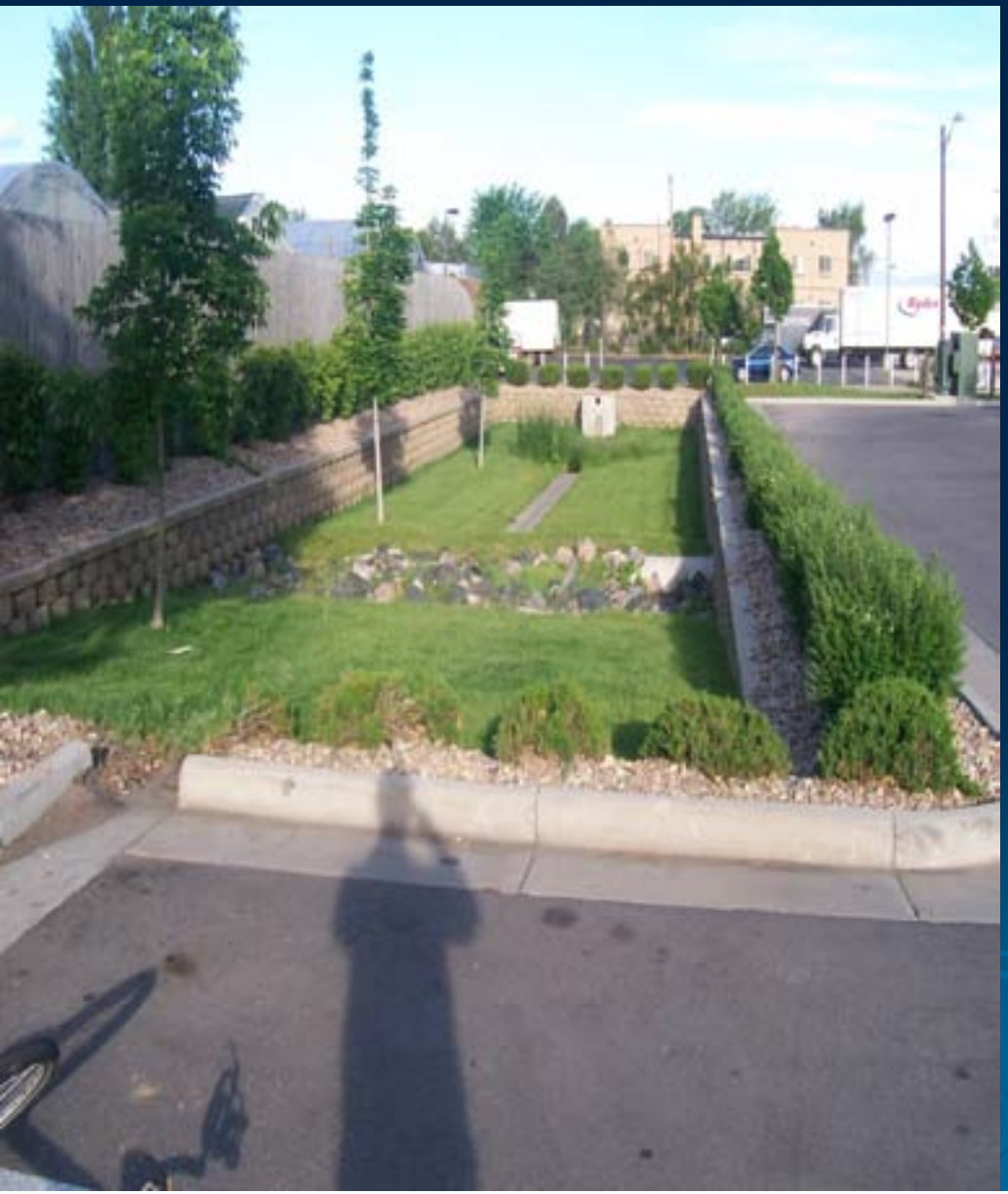


Leyden Redevelopment (cont.)

Could be further improved by:

- Installing bioretention facilities in parking medians and permeable pavement
- Planting fruit trees would provide a local source of food (permaculture).
- Buffalo grass would better withstand dry spells
- Side wall could be terraced to form a bench at the top to "chillax"

Leyden Redevelopment: Improved Parking Lots



Biofiltration (or Rain Garden) Parking Lot Boulder, Colorado

- Engineered system facilitates depression storage, infiltration and biological removal of pollutants
- Uses plants and soil to trap and treat petroleum products, metals, nutrients and sediment.
- Inexpensive, easy to maintain and adds aesthetic value

Fire Clay Lofts
Denver, CO

- Contamination issue required “no discharge”
- Runoff directed to an area with semi-arid vegetation

Green Infrastructure as Art
"Ultra-Urban BMP"

- Runoff redirected to flow across the tiles into the vegetated channels

Stapleton Redevelopment

- High-set overflow valves ensure that native species are passively watered during rain events
- Habitat corridor with connectivity to the South Platte River attracts wildlife

Stapleton Redevelopment (cont.)

- Native species adjacent to conventional landscaping; reduces residential watering and provides habitat
- Increasingly pervious walkways as development approaches the riparian area; allows filtration and recharge

Stapleton Redevelopment (cont.)

Founder's Green stormwater bioretention provides community benefits as a venue for movies and concerts, the farmer's market and the Sweet William Market

Quebec Square Shopping Center Denver, CO

- Stormwater bioretention and parking lot landscaping; constructed wetlands and a curb cut that directs flows to a bioswale
- Could be improved with bioretention in the parking lot medians, permeable pavement and vegetated swales

Taxi mixed-use development Denver, CO

- Native trees and flowers reduce stormwater runoff and improve aesthetics

Taxi mixed-use development (cont)

- Native species provide bioretention in the recessed parking medians
- Permeable pavement and vegetated swales reduce stormwater runoff

Rainwater Harvesting in the West

- Western water rights can be an impediment; prior appropriation doctrine considers diverting rainwater to a collection system "a taking" of water previously appropriated

- However, rainwater harvesting is a water conservation practice that reduces overall withdrawal and use of water, making a greater quantity available to downstream users.

Region 8 States on Water Harvesting

State	Responsible agency	Jurisdiction over atmospheric water?	Permit required?	Who may apply for a permit?	State policies and Incentives	Municipal policies and incentives
Colorado	Colorado State Engineer, Colorado Ground Water Commission, Colorado Water Conservation Board, and seven water courts	Yes	Yes	1. Residential properties that are supplied by a well (or could qualify for a well permit) and that are not served by a municipality or water district. 2. Developers wishing to apply for approval to be one of ten statewide pilot projects that harvest rainwater and put it to beneficial, but non-essential, use in the subdivision.	State law	None
Montana	Montana Dept. of Natural Resources & Conservation, Water Resources Division, Water Rights Bureau	Yes	No	Each source of water supply or each development may submit an application	None	None

Region 8 States on Water Harvesting (cont.)

State	Responsible agency	Jurisdiction over atmospheric water?	Permit required?	Who may apply for a permit?	State policies and Incentives	Municipal policies and incentives
Utah	Utah State Engineer	Maybe	Yes	N/A		
Wyoming	State Engineer and Wyoming Board of Control	No	No	N/A		

Denver's Pepsi Center: A Missed Opportunity

99.9% impermeable grey infrastructure

Two Visions of Development
Which do you prefer?

Possible Future Trainings

- Retrofits (to meet permit requirements)
- GI Codes and Ordinances
- GI Design Principles and Considerations
- Federal Regulatory Drivers of GI Approaches to Managing Wet Weather
- GI Modeling
- Funding and Incentives
- Operation and Maintenance of GI
- Green Stormwater Management