Greening Your Community

Cost-effective LID solutions

Uxbridge, MA
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NARRAGANSETT BAY ESTUARY PROGRAM

NEIWPCC
New England Interstate Water Pollution Control Commission

Mass Audubon
Protecting the Nature of Massachusetts

CMRPC
Central Massachusetts Regional Planning Commission

Horsley Witten

The Blackstone River Coalition

SHAPING the Future of YOUR COMMUNITY

Overview

- Mass Audubon's Shaping: Introduction of problem and solutions
- Blackstone River Coalition: Water quality monitoring
- Horsley Witten: BMPs, costs, case studies
- Take home messages
- Q&A

CMRPC
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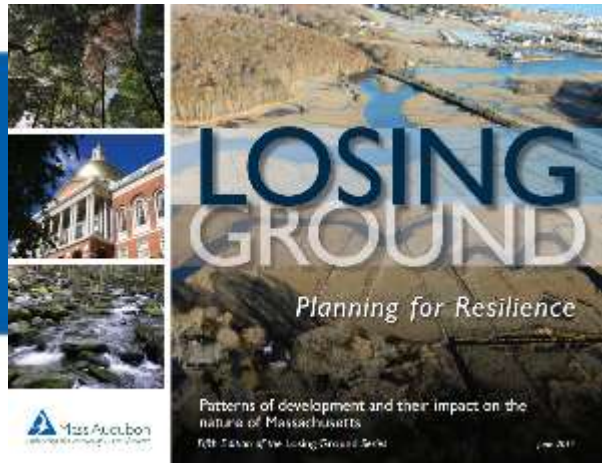
What is Low Impact Development?

“LID is an approach to land development (or re-development) that **works with nature to manage stormwater** as close to its source as possible. LID employs principles such as preserving and recreating natural landscape features, minimizing effective imperviousness to create functional and appealing site drainage that **treat stormwater as a resource** rather than a waste product.”

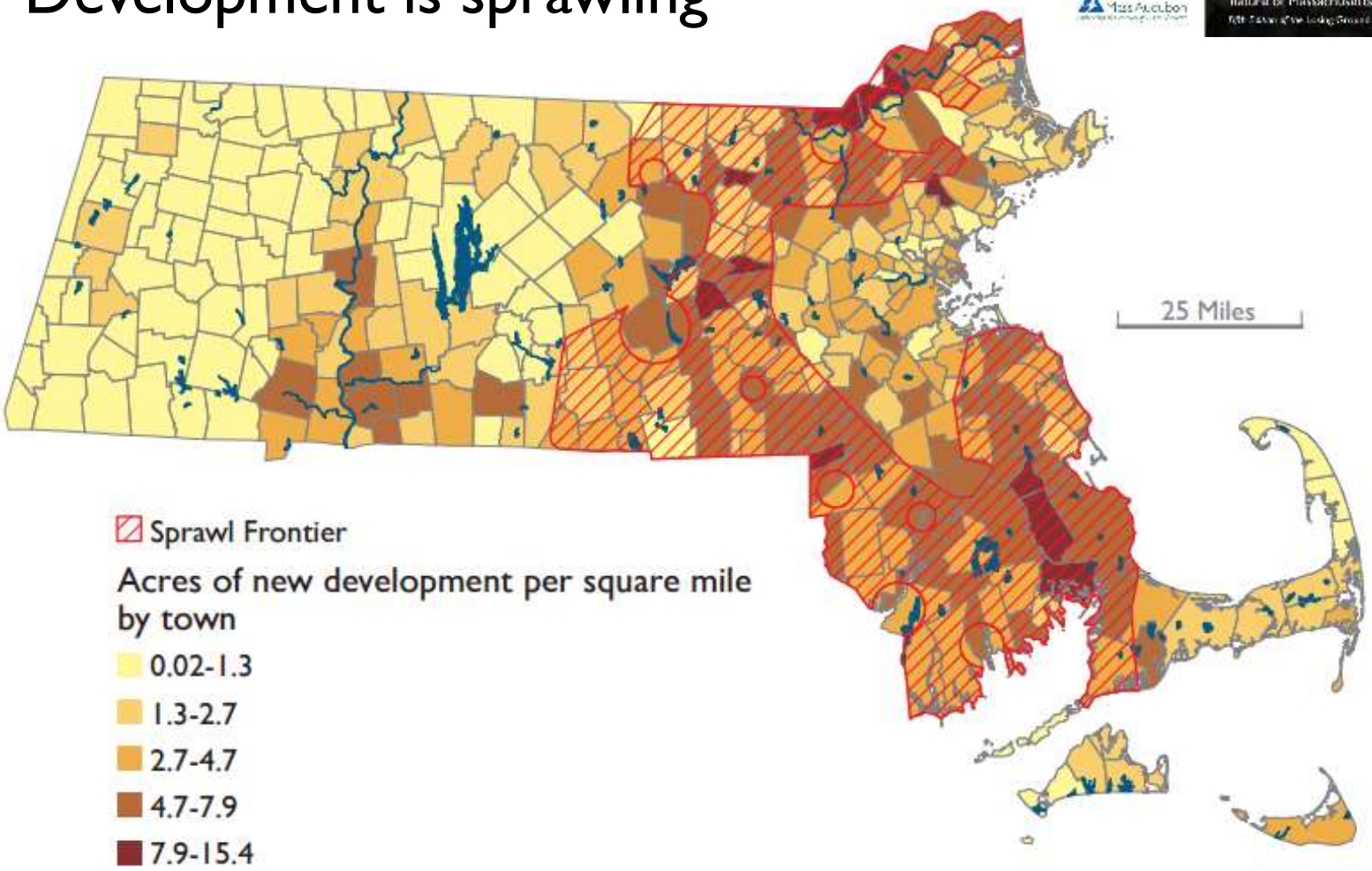
- EPA

Source: Whole Buildings Design Guide, wbdg.com

What's the Problem?

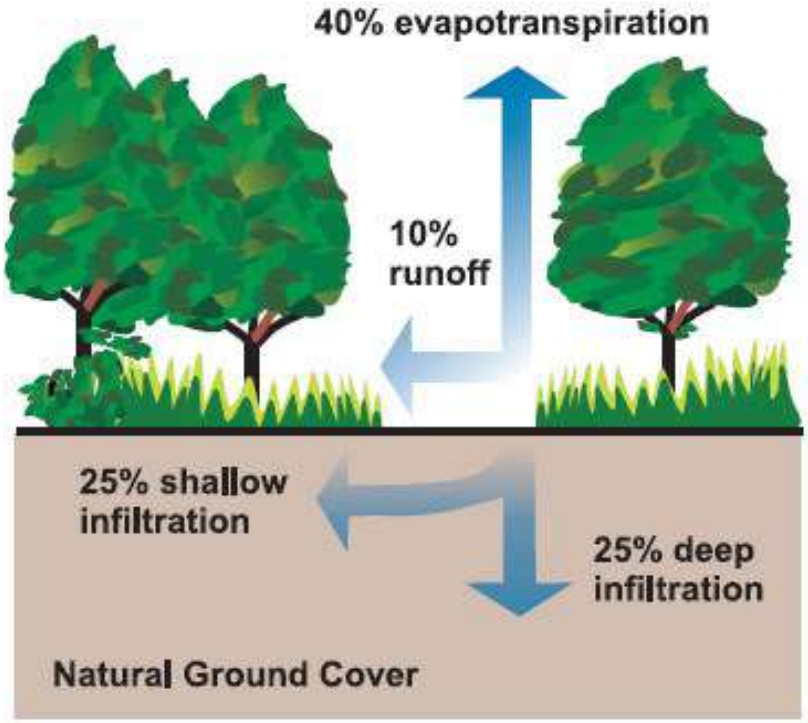


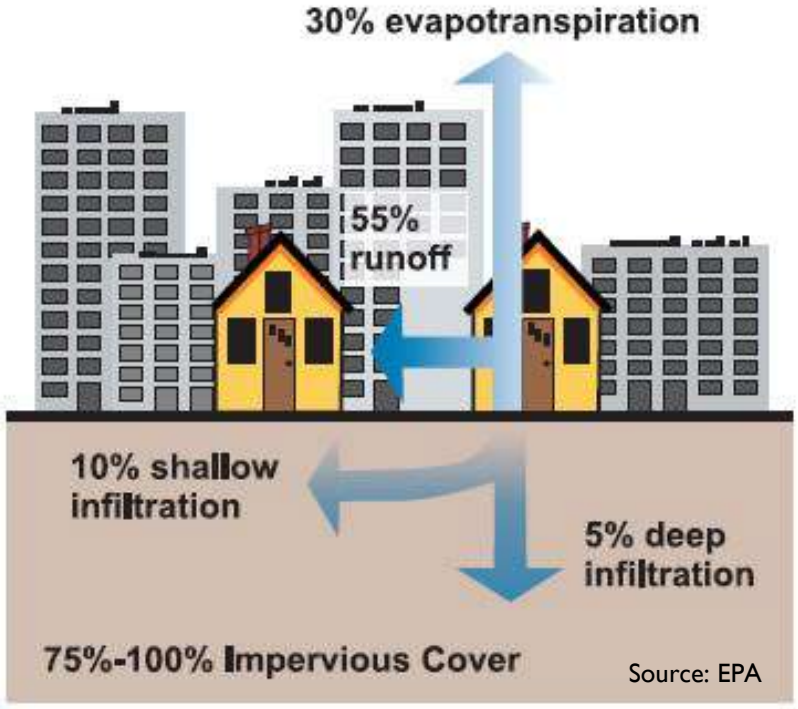
Development is sprawling



What's The Problem?

Everywhere we develop, we reduce our resilience





Source: EPA

We Need to Change Course

Traditional development

Impervious surfaces

Stormwater runoff

Water quality impairment

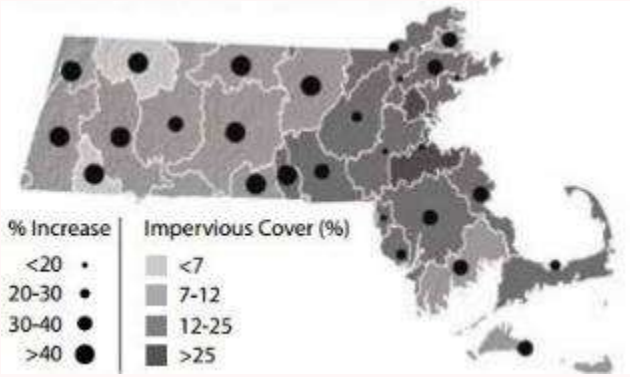
Infrastructure impacts

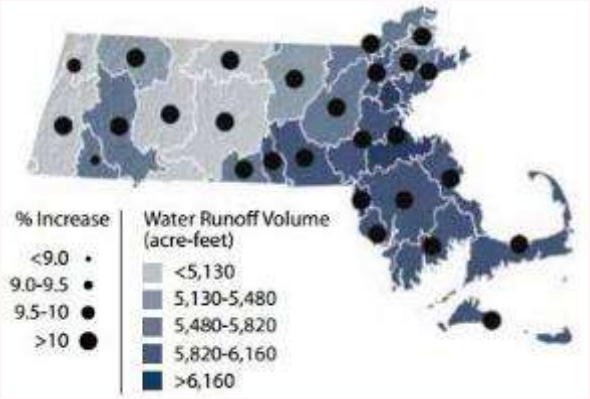
Financial and regulatory burden

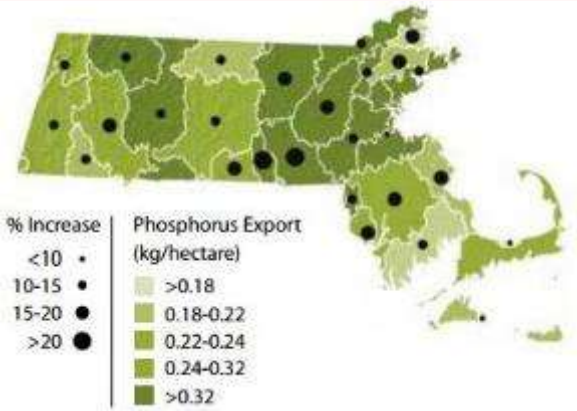
The Value of Green: Impervious, Runoff, Nutrients

Source: Harvard Forest *Changes to the Land* 2014

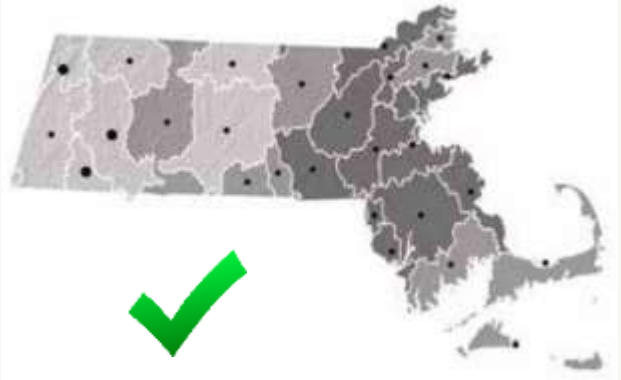
If we continue to follow opportunistic growth, in 2060:

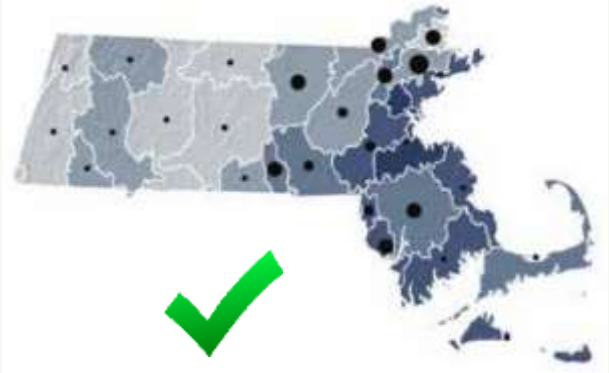


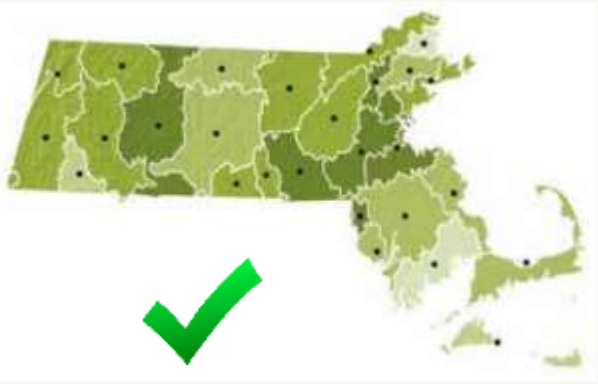




If we value forests as infrastructure, in 2060:







The Value of Green: Reducing Runoff

Source: Harvard Forest *Changes to the Land* 2014

By 2060	Number of MA watersheds experiencing >10% increase in runoff
Opportunistic Growth	25
Forests as Infrastructure	1

"Forests as Infrastructure" allows for nearly the **same amount of development** as what we're experiencing now, but 2/3 of it is **clustered** development.

A Different Direction: Greening Your Community

Sustainable development

Increased infiltration

Reduced runoff & more groundwater

Improved water quality

Intact infrastructure

Regulations met

Money saved

Start Here.

Conserve the natural green infrastructure already providing free ecosystem services

Incorporate LID and green infrastructure design into development

Restore the resiliency of urban landscapes through LID in redevelopment

Conserve

Conserve the natural green infrastructure already providing free ecosystem services

Integrate LID and green infrastructure designs into current development projects

Restore the resiliency of urban landscapes through LID in redevelopment

Integrate

Conserve the natural green infrastructure already providing free ecosystem services

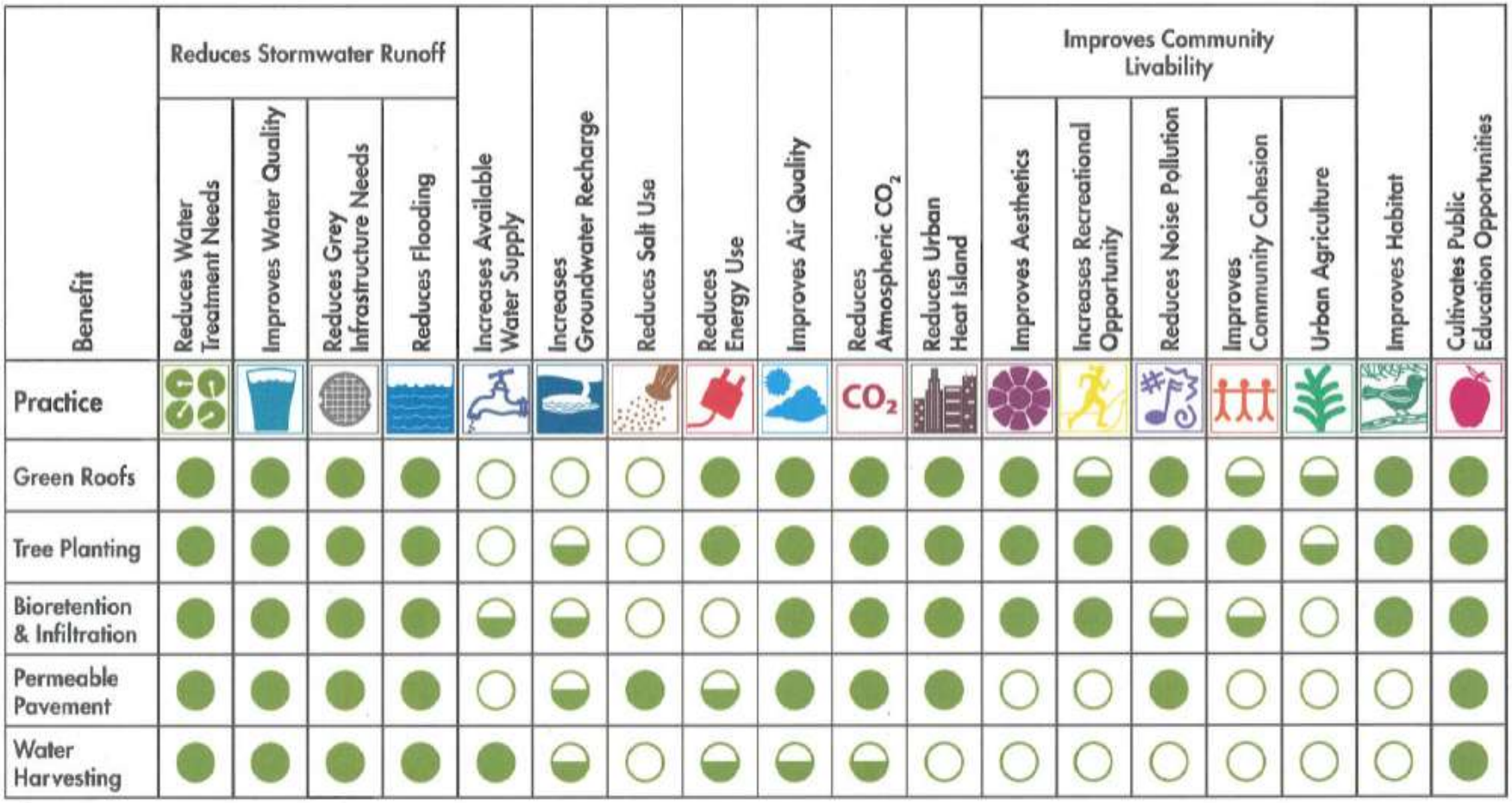
Integrate LID and green infrastructure designs into current development projects

Restore the resiliency of urban landscapes through LID in redevelopment

Restore

Conserve the natural green infrastructure already providing free ecosystem services
Integrate LID and green infrastructure designs into current development projects
Restore the resiliency of urban landscapes through LID in redevelopment

Benefits of LID Practices



Source: Center for Neighborhood Technology's The Value of Green Infrastructure

Free Ecosystem Services:

Free services provided by the natural landscape

For every $1 invested in land conservation, there is a $4 *Return on Investment* in terms of these ecosystem service values

- **Flooding**: Floodplains provide flood protection and reduce infrastructure damage
- **Public Health**: Managing stormwater and reducing retention ponds reduces creation of mosquito habitat
- **Air Quality & Public Health**: Trees reduce the urban heat island effect, reducing smog creation and resulting asthma occurrences as well as reducing nitrogen dioxide and particulate matter
- **Water Quality**: Streamside vegetation filters pollutants and reduces erosion
- **Water Quantity**: Forests and wetlands store water, improve water quality, and recharge groundwater
- **Recreation**: Clean, flowing waters support recreation, including boating, fishing, and swimming while open space provides areas for hiking and biking
- **Quality of Life**: Open space and street trees create a more enjoyable walking environment, benefiting community connection, health, and economic benefit in downtowns and commercial areas
- **Property Value**: Healthy, mature trees add an average of 10-30% to a property's value

The Value of Green: Reduced Paving Costs

Traditional paving costs $5-7/ft^2. Reducing just a short, two-mile road from 28' to 20' equates to a savings of **$422,400 - $591,360**.

That's *half a million dollars saved* by reducing a short stretch of pavement by just four feet per lane!

When the entire road is shortened for a condensed subdivision instead of sprawling development, that savings grows to the *millions*.

The Value of Green:
Reduced Clearing & Grading Costs

- A 20-unit development with two-acre lots requires 40 acres to be cleared and graded.
- Conservation subdivisions that preserve 50% of land save $200,000-300,000, while maintaining the same amount of development.

The more **land** you save, the more **money** you save.

Addressing Regulations

Possible Action	Addresses Stormwater (MS4)	Addresses Water Management Act Mitigation	Helps with Climate Resilience
Revise bylaws to allow for Low Impact Development	★	★	★
Require porous pavement in certain situations, and allow for curb cuts to improve drainage to swales	★	★	★
Culvert replacements meeting stream crossing standards		★	★
Acquire/preserve property for resource protection	★	★	★

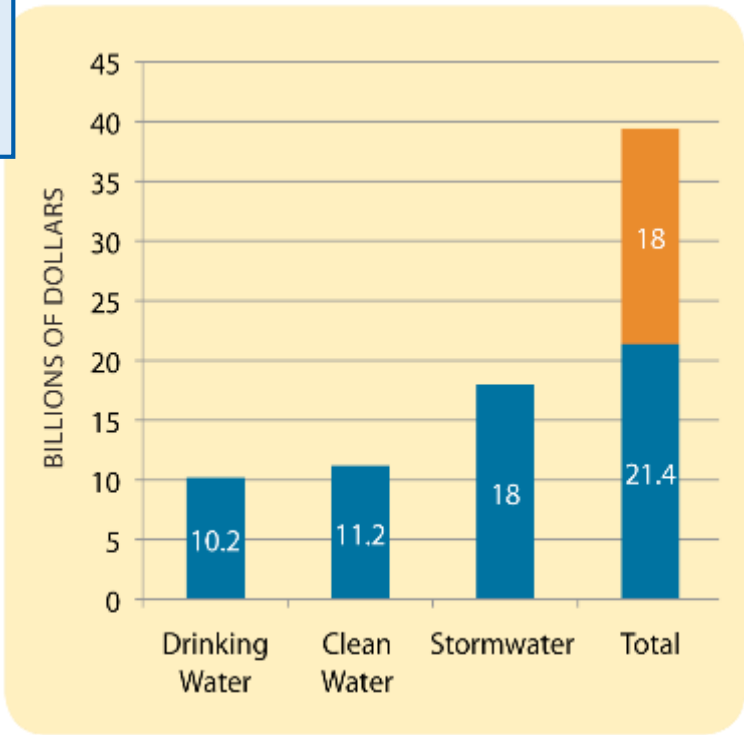
The Value of Green: Stormwater Infrastructure

Massachusetts is already facing a projected $18 billion in stormwater upgrades over the next 20 years

Climate change → increased wet weather → increased flooding

"As Massachusetts faces water management challenges related to aging civil waterworks and more intense storms, forest protection and land use offer a low-cost option for minimizing stormwater challenges and maintaining water quality."

- Harvard Forest: Changes to the Land

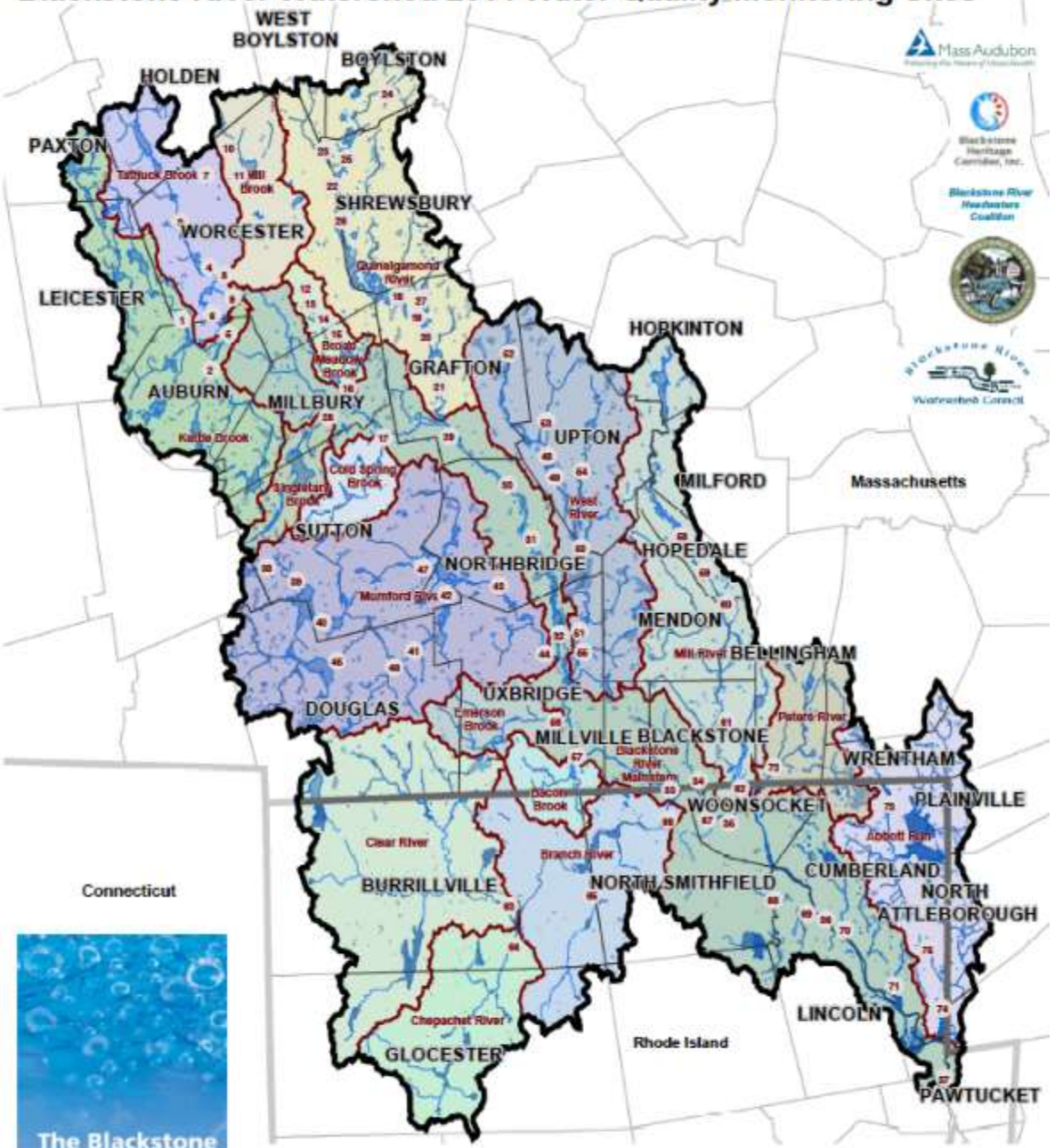


Gap in water infrastructure funding over next 20 years, Water Infrastructure Finance Commission, 2012

Blackstone River Coalition Water Quality Monitoring

- Conducted on monthly basis since 2004.
- Volunteers trained to monitor 75 sites from Worcester to Pawtucket.
- Data collected on site conditions including temperature, erosion, and water appearance.
- Tests run for turbidity, nutrients, dissolved oxygen, and conductivity.
- QAPP approved by EPA, MADEP & RIDEM.

Blackstone River Watershed 2014 Water Quality Monitoring Sites



The Blackstone River Coalition

Uxbridge Area Sites

- Bacon Brook
- Blackstone River
- Emerson Brook
- Mumford River
- West River
- Meadow Brook
- Mill River
- Centerville Brook
- Cook Allen Brook
- Center Brook

Indicators of Water Quality

- **Dissolved Oxygen:** sufficient levels required for aquatic organisms to survive; higher standards set for cold water fisheries like trout.
- **Turbidity:** from local erosion and off-site runoff; can increase temperature and decrease oxygen, impair plant growth, and harm or kill aquatic organisms.
- **Phosphate & Nitrate:** Excess levels from storm runoff and point sources can cause algal blooms that reduce dissolved oxygen, leading to fish kills.
- **Conductivity**: Sudden shifts from baseline levels can indicate presence of petroleum or animal waste.

- **Bacteria:** presence indicates input of animal or human waste; elevated levels are harmful to aquatic life, and impairs drinking water for humans.

Annual Report Card

www.zaptheblackstone.org

map #	WaterBody	Site Location	Town	Aesthetics	Temp.	DO	% Sat.	Nutrients
	BLACKSTONE RIVER							
29	Blackstone River	Fisherville Pond Outlet/122A	Grafton					
30	Blackstone River	Sutton St. USGS flow station	Northbridge					
31	Blackstone River	Plummer's Landing	Northbridge					
32	Blackstone River	Tow path / Stanley Woolen	Uxbridge					
33	Blackstone River	Upstream @Gorge/ Staples	Blackstone					
34	Blackstone River	Main St. Blackstone/TKO	Blackstone					
35	Blackstone River	River Island Park	Woonsocket					
36	Blackstone River	Below Albion Dam	Lincoln					
37	Blackstone River	Slater Mill	Pawtucket					
	TRIBUTARIES							
38	Mumford River	Hotel Pond Outlet	Sutton					
39	Mumford River	L. Manchaug Inlet	Sutton					
40	Mumford River	L. Manchaug Out./Parker Rd	Sutton					
41	Mumford River	Gilboa Street/above WWTP	Douglas					
42	Mumford River	Lackey Dam	Uxbridge					
43	Mumford River	Northbridge Middle School	Uxbridge					
44	Mumford River	Downstream @Depot Street	Uxbridge					
45	unnamed tributary	Whitin Reservoir Outlet	Douglas					
46	Centerville Brook CWT	West Street	Douglas					
47	Cook Allen Brook CWT	Upstream of bridge/Johnson	Sutton					
48	West River CWT	Hartford Avenue	Upton					
49	West River CWT	Pleasant and Glen	Upton					
50	West River CWT	Mendon Road	Northbridge					
51	West River CWT	Under Rte. 16 bridge	Uxbridge					
52	Miscoe Brook CWT	Merriam Road	Grafton					
53	Warren Brook CWT	Fowler Road Bridge	Upton					
54	Center Brook CWT	Mendon Road	Upton					
55	Meadow Brook CWT	Upstream@Blackstone St. B	Uxbridge					
56	Emerson Brook CWT	Above Quaker Highway	Uxbridge					

KEY TO COLOR CODES

- Excellent
- Good
- Fair
- Poor
- Not Enough Data

Categories

(*Each category is derived from the combination of the following factors*)

Aesthetics - turbidity, water appearance, water odor & visual assesments

Temp. - temperature

DO - dissolved oxygen

% Sat. - dissolved oxygen % saturation

Nutrients - nitrate & orthophospate

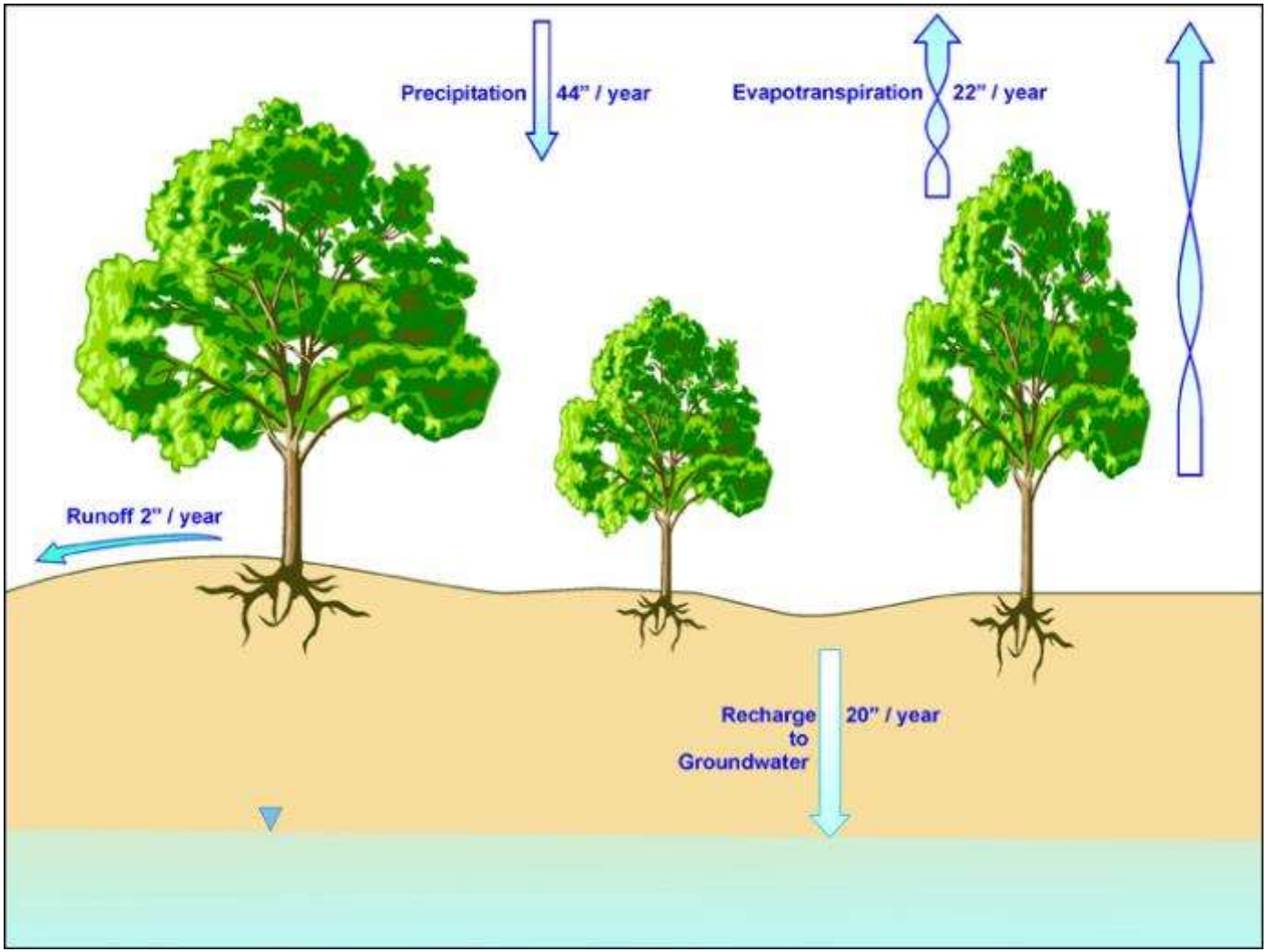
Examples of Impaired Water Quality: 2014 Field Season

Northbridge
Blackstone River@ Plummers Landing
Nutrient level "poor".

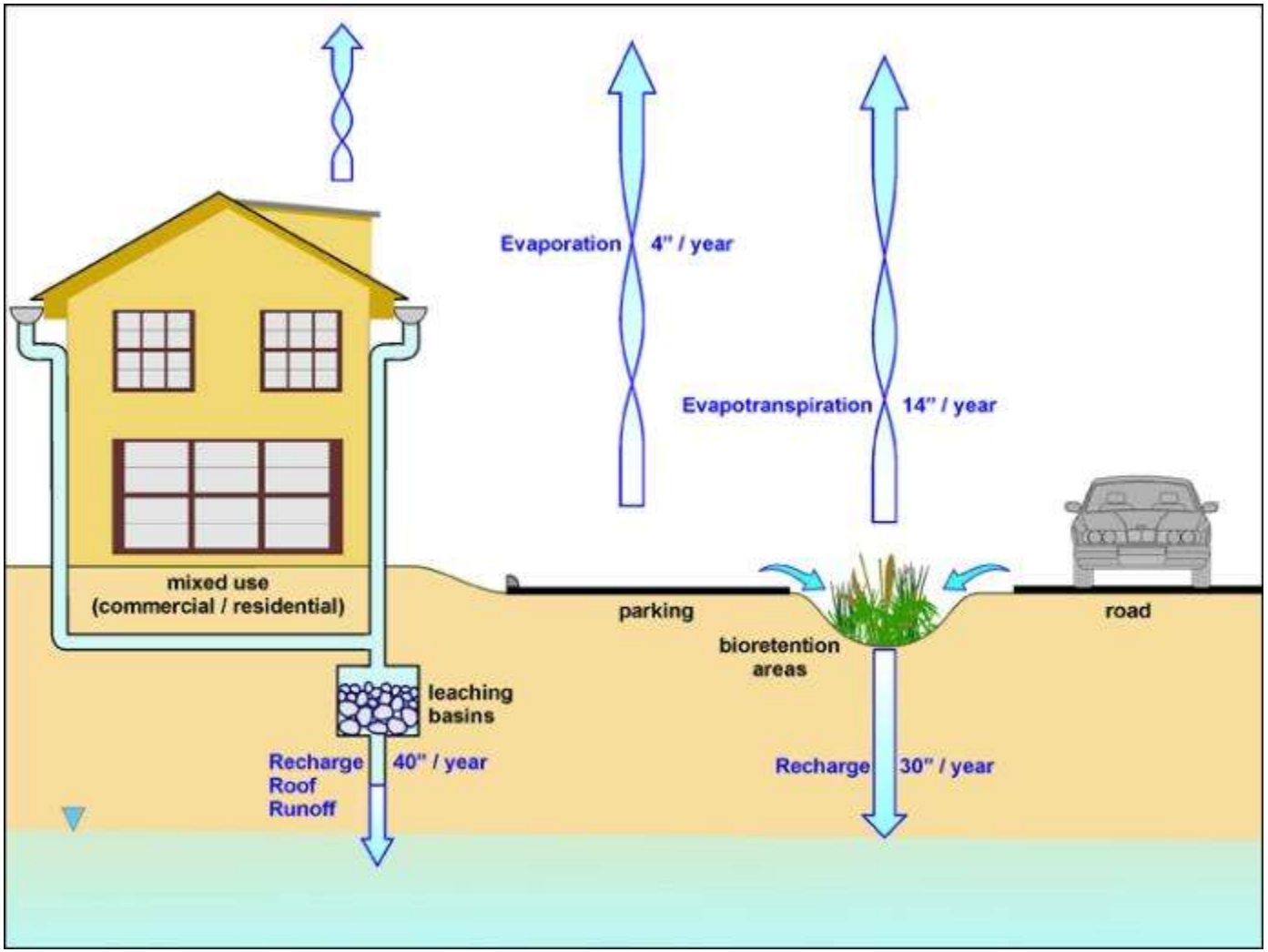
Uxbridge
B. R.@ Stanley Woolen Mill
Nutrient level "poor".

Sutton
Mumford River@ Lakey Dam
DO & % Saturation level "poor".

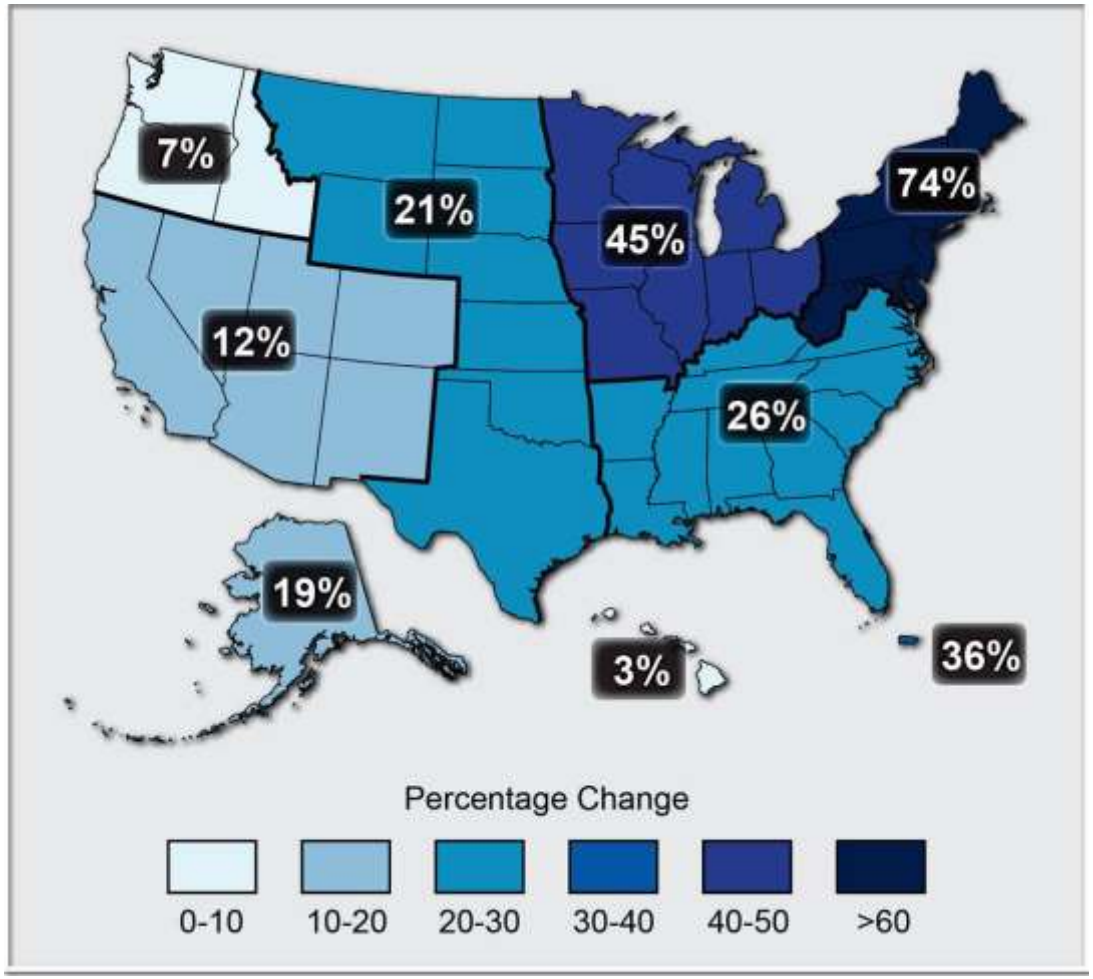
Pre-Development



Positive Impact Development



Observed Changes in Storm Intensities



National Climate Assessment 2014

Key Stormwater Regulations

Federal Clean Water Act, National Pollutant Discharge Elimination System (NPDES):

- EPA 2003 MS4 Permits
- EPA General Stormwater Permit (MA) *(expected 2016)*

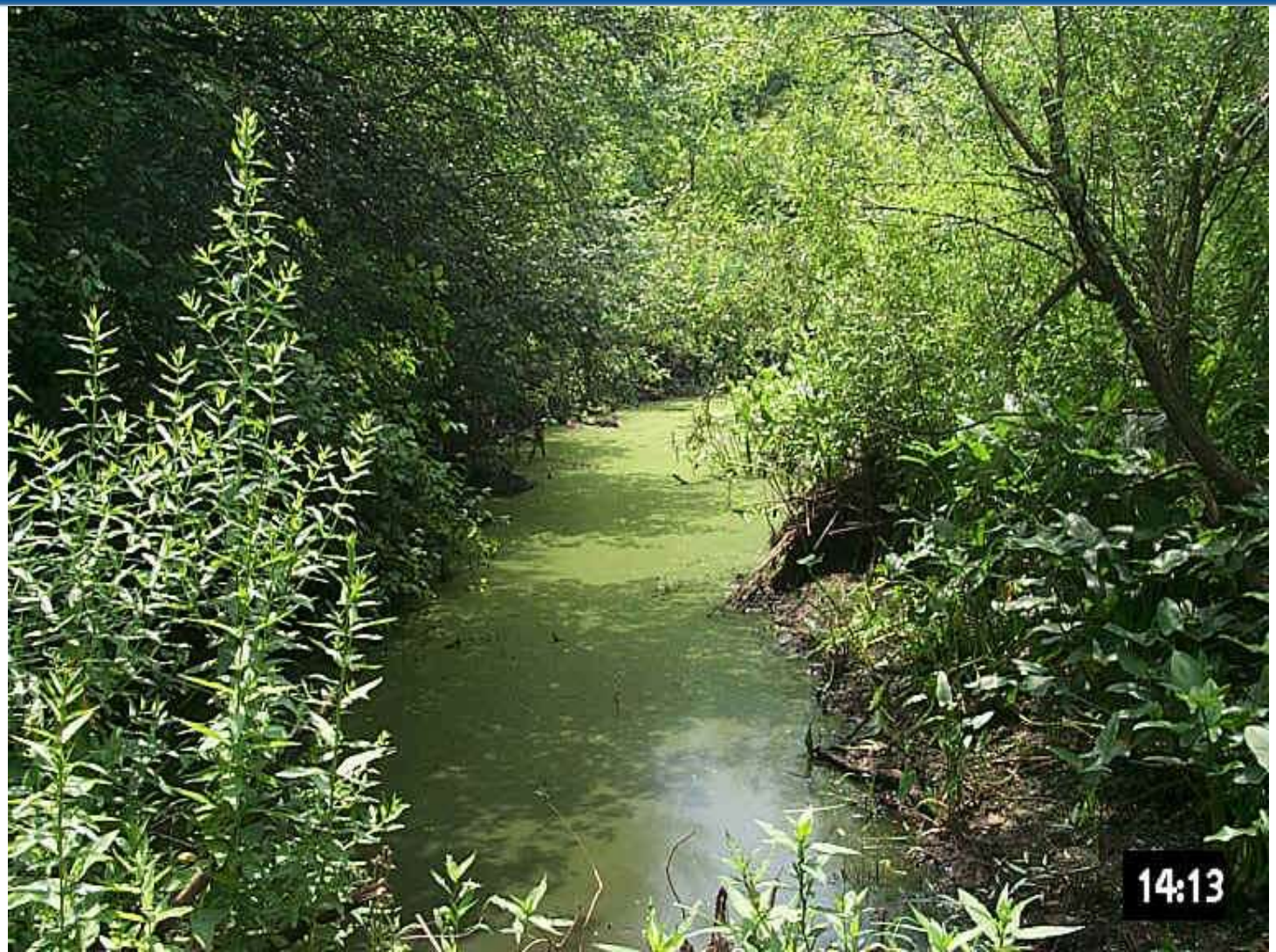
Massachusetts Initiatives:

- MA Stormwater Standards (jurisdiction under Wetlands Protection Regulations)
- MA Water Management Act (Sustainable Water Management Initiative, SWMI)
- MA Climate Change Adaptation Report/Regulatory Changes

Local Ordinance/Bylaw/Regulations (required MS4)

Impacts of Stormwater Runoff

Water Quality Degradation: Eutrophication



Beach Closures

Sources of Phosphorus in Stormwater
Upper Charles River Watershed

Source	Annual Phosphorus Input (kg yr^{-1})	Annual Phosphorus Loading (kg yr^{-1})	Percent of Total Load
Turf and Fertilizer Runoff	*174.13*	*24.33*	*18%*
Dog Waste	*232.22*	*23.22*	*18%*
Leaf Litter (Street Trees) Trees)	*27.92*	*20.94*	*16%*
Atmospheric Deposition Deposition	*126.19*	*19.00*	*14%*
Other	*unknown*	*13.08*	*10%*
Forest Runoff	*unknown*	*12.41*	*9%*
Winter Road Treatments Treatments	*6.64*	*6.64*	*5%*
Car Washing	*8.03*	*6.43*	*5%*
Motor Vehicle Traffic	*4.01*	*4.01*	*3%*
Grass Clippings	*569.06*	*1.48*	*1%*
Total	*1,148.20*	*131.54*	*100%*

Pet Waste Management Plan

LID Stormwater Management Techniques

- Rain Barrels and Cisterns / Water Re-use
- Stormwater Planters, Tree Planting
- Permeable Paving
- Open Channels
- Bioretention
- Stormwater Wetlands
- Green Rooftop Systems
- Vegetative Buffers
- Infiltration

Permeable Pavement

Source: Tata & Howard

Permeable Pavement

- Higher initial cost ($12/sf vs $5-7/sf)
- Reduces the amount of land needed for stormwater management
- Can infiltrate as much as 70-80% of annual rainfall
- Reduced flood risk may increase property value by 2-5%
- Can reduce salt use by as much as 75%

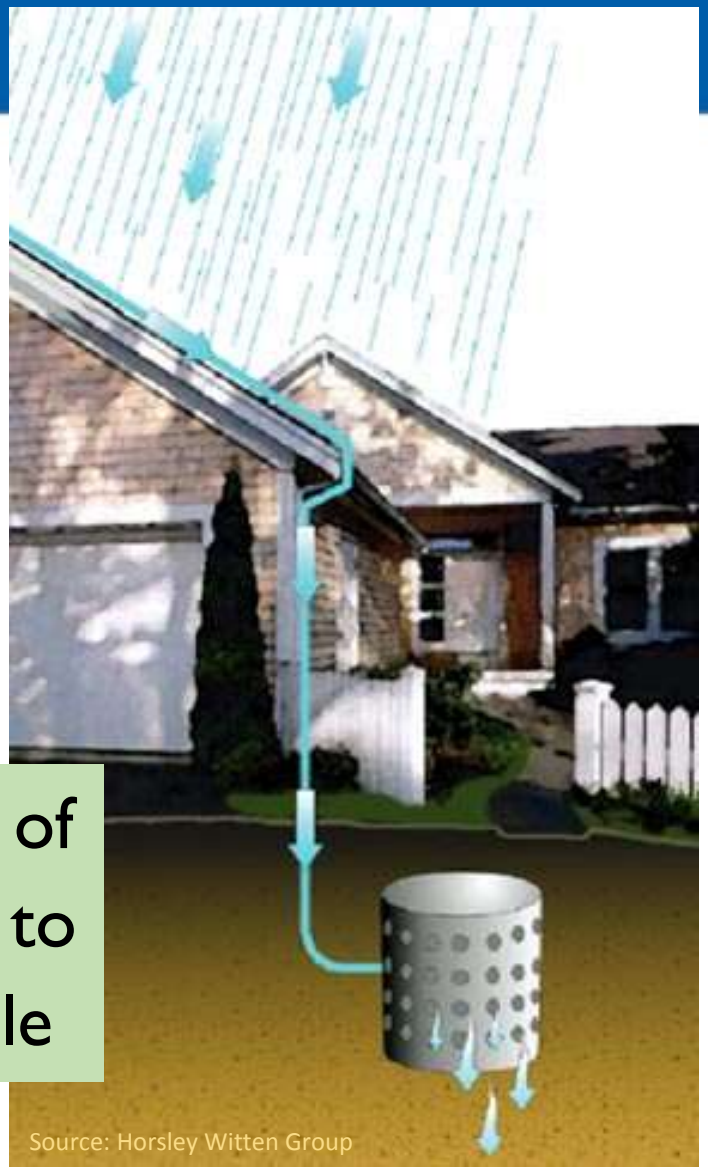
Rain Barrels and Cisterns
Runoff Reduction & Water Conservation

- Downspouts directed to tanks or barrels
- 1" rainstorm generates 623 gallons stormwater per1,000 sf of roof
- Storage: 50 –10,000 gallons
- Excess diverted to drywell or rain garden
- Landscaping, car washing, other non-potable uses

Dry Well Infiltration of Roof Runoff


Source: CWP

Disconnection of rooftop runoff to vegetated swale


Source: Horsley Witten Group

Vegetated Swales Conveyance, Treatment, Infiltration

- Roadside swales ("country drainage") for lower density and small-scale projects
- For small parking lots
- Mild side slopes and flat longitudinal slopes
- Provides area for snow storage & snowmelt treatment

Bioretention

- $300-500/year in labor for maintenance (varies by size of swale)
- 70% TSS removal credit with adequate pretreatment

Reducing Impervious Surfaces

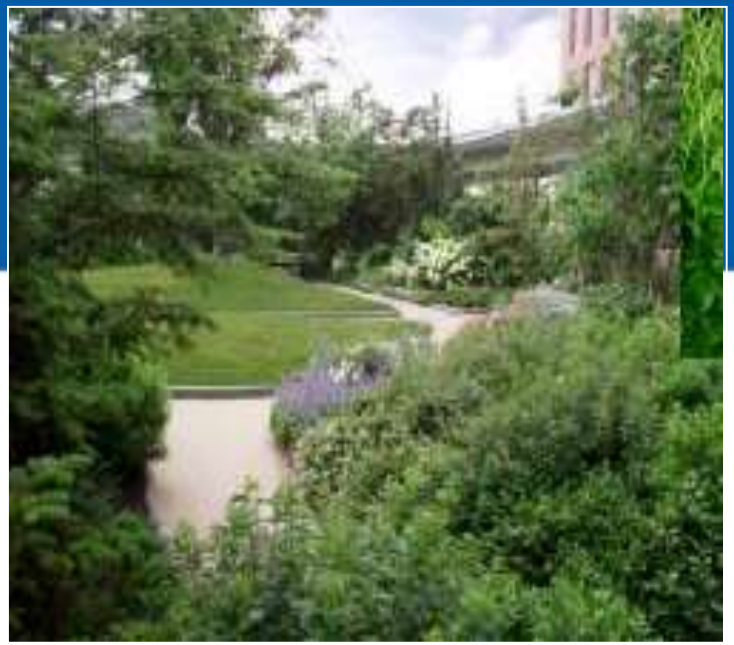
Bioretention

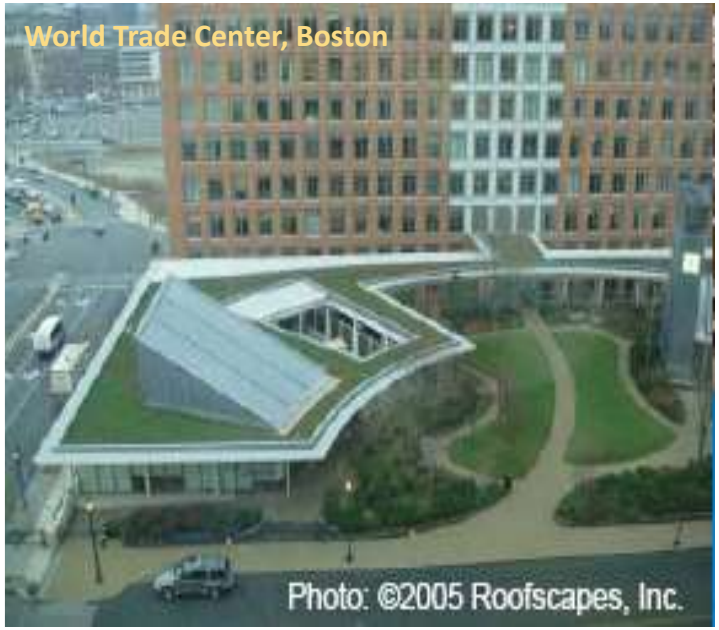
Rain Garden

- $2-12/ft^2 installed
- $200/year in labor for maintenance
- Reduces runoff by 90%
- Reduces N, P, metals, and TSS by 65-90%

Green Roofs

- Reduces runoff by 30-86%
- Reduced flooding of and damage to urban streets
- Interior heating and cooling benefits of 10 degrees or more
- Carbon sequestration & air purification
- Recreational amenity
- Improved aesthetics
- Extended roof life, estimated at 40 years





Green Roofs

- Payback of 6.2 years
- Over a 50-year period
- Installation, replacement and maintenance cost: $18/sf
- Stormwater and energy benefit: $19/sf
- Benefits to the community savings: $38/sf

U.S. General Services Administration Study: Green Roof Cost Benefit Analysis

Stormwater Planters

- Vegetative uptake of stormwater pollutants
- Pretreatment for suspended solids before they reach water-treatment facilities
- Aesthetically pleasing
- Reduction of peak discharge rate

GI Maintenance

Visible + Simple + Easily understood + *Lovable*

= *Maintained*



LID 2.0

LID 2.0 Density — Not all impervious area is equal

LID 2.0 Land — Plan with the land

LID 2.0 Nature — Approximate nature

LID 2.0 Context — Green Infrastructure designed to context

LID 2.0 Simple — Leave a simple solution behind

See "Great Places in Balance with Nature" by Jonathan Ford: http://www.planetizen.com/node/54053

Cottages on Greene: East Greenwich, RI

T-4, T-3

LID 2.0 Density

LID 2.0 Land

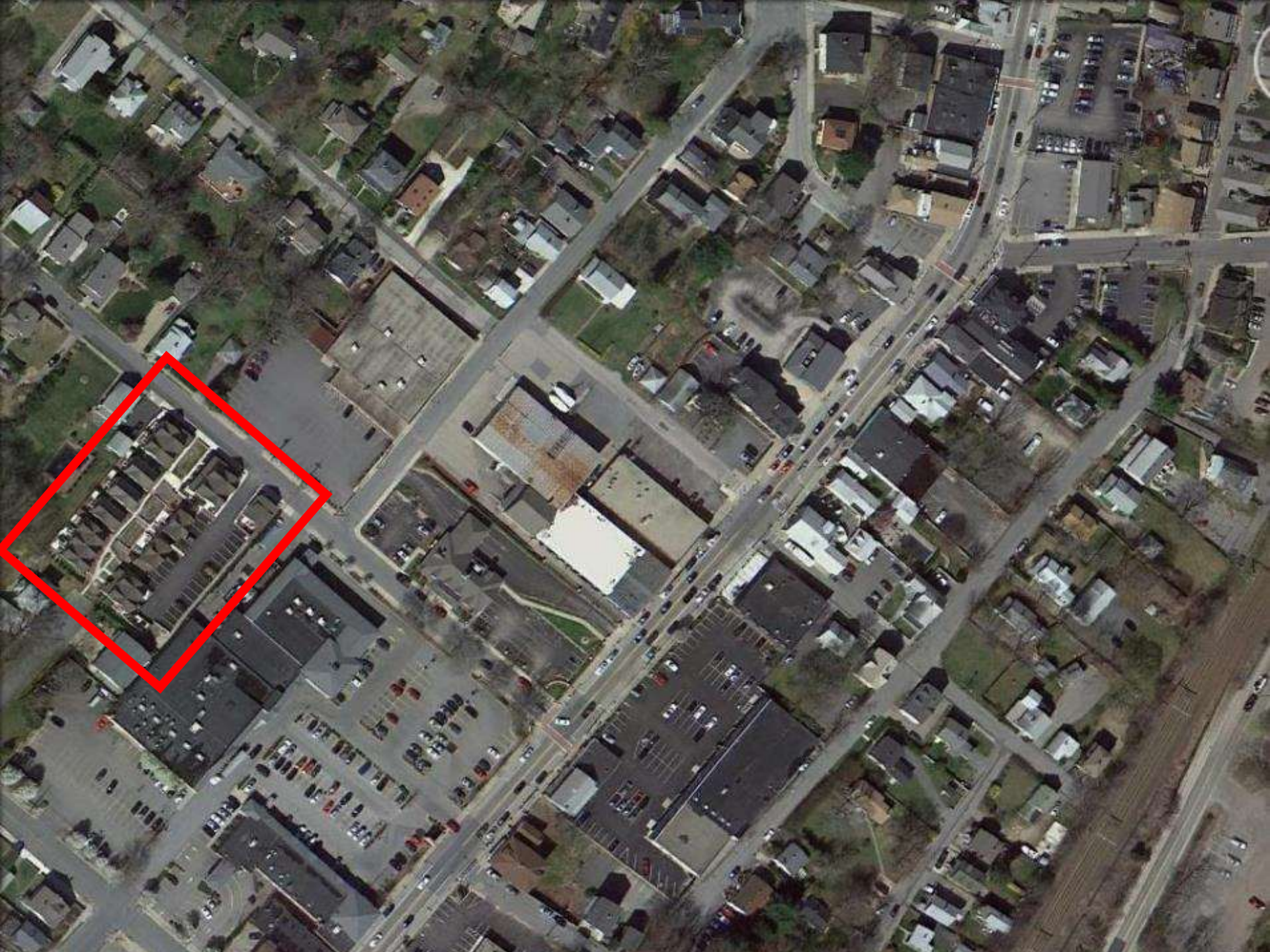
LID 2.0 Nature

LID 2.0 Context

LID 2.0 Simple

Cottages on Greene

Union Studio



Cottages on Greene

Cottages on Greene

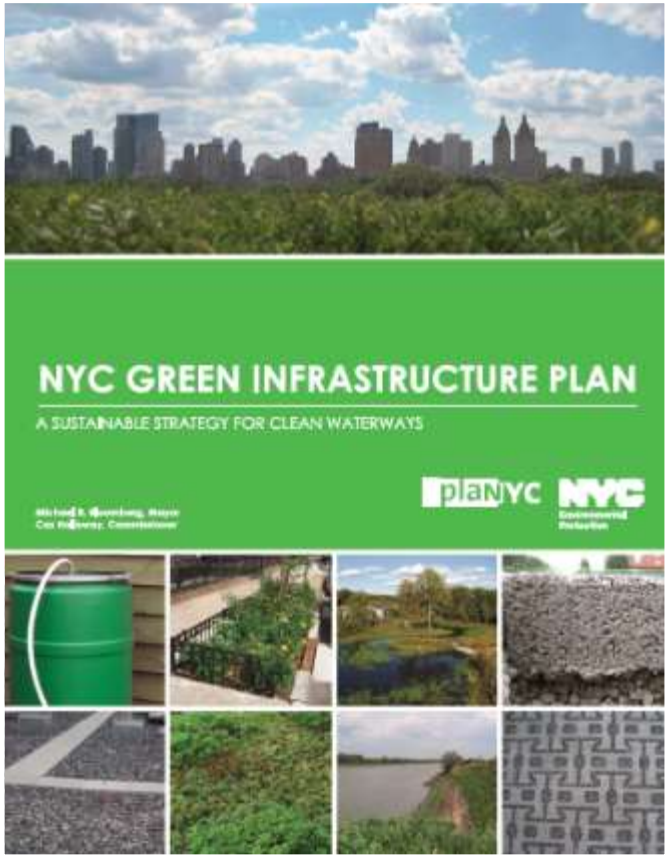
Green "LID" Alternative	**Quantity**	**Unit**	**Unit Cost**	**Total Cost**
Bioretention	2,215	sf	$20.00	$44,300
Bioswale	430	lf	$15.00	$6,450
Perforated CPP Underdrain	350	lf	$15.00	$5,250
Pavement Section (typ.)	540	sy	$35.00	$18,900
Permeable Bituminous Section	450	sy	$43.75	$19,688
Drywell	3	each	$5,000.00	$15,000
				$109,588
Conventional Alternative				
Catch Basin	5	each	$3,000.00	$15,000
12" CPP	200	lf	$30.00	$6,000
Drain Manhole	4	each	$4,000.00	$16,000
Stormceptor Unit	1	each	$20,000.00	$20,000
Underground Recharge System	1	each	$40,000.00	$40,000
Pavement Section	990	sy	$35.00	$34,650
				$131,650
		Green alternative savings =		**$22,063**
				16.8%

* Preliminary estimate – site design was revised.

** "Apples to apples" *starting with a compact site.*

NYC Green Infrastructure Plan

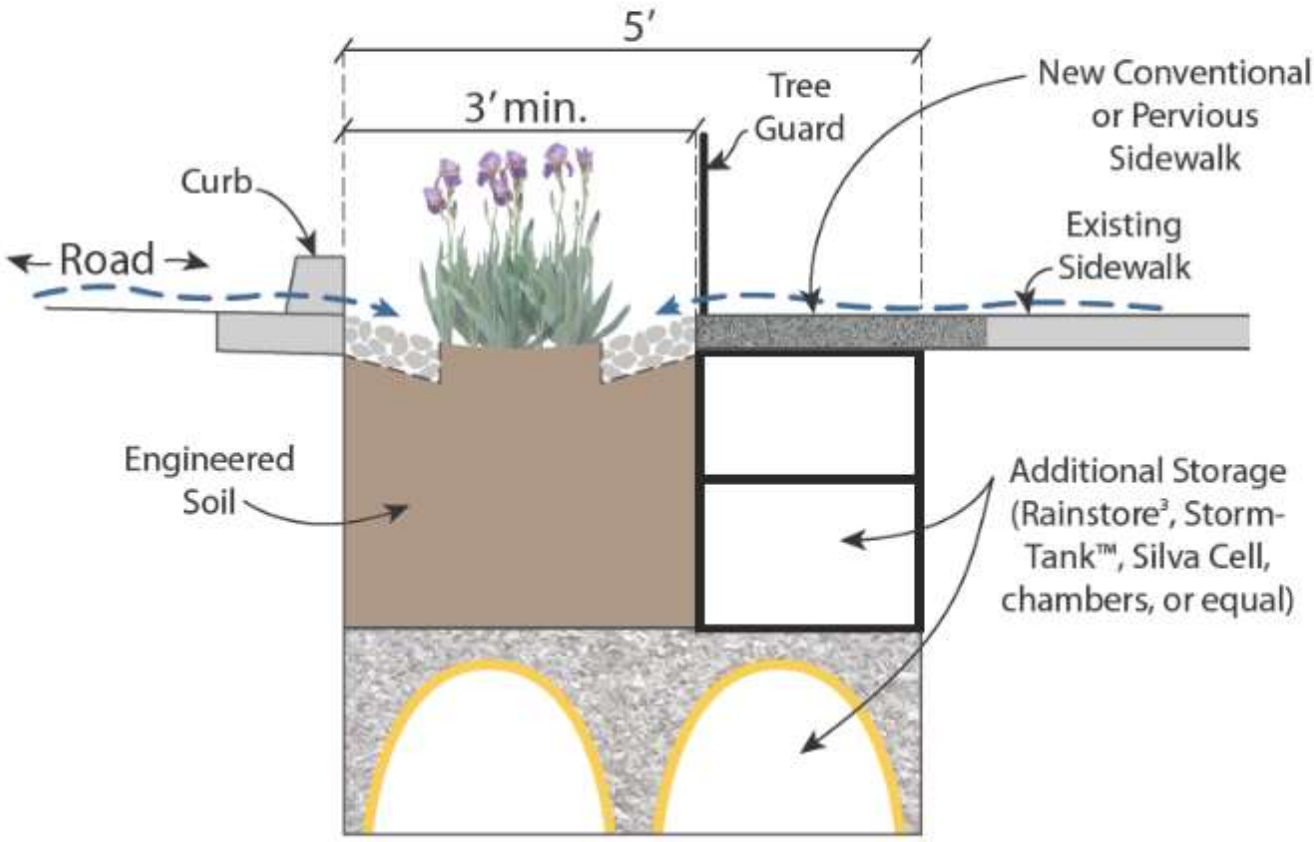
1. Build cost-effective grey infrastructure
2. Optimize the existing wastewater system
3. **Control runoff from 10% of impervious surfaces through green infrastructure and other source controls**
4. Institutionalize adaptive management, model impacts, measure CSOs, and monitor water quality
5. Sustain stakeholder engagement



NYC OGI ROW Bioswales

HAZEN AND SAWYER
Environmental Engineers & Scientists
Horsley Witten Group
Sustainable Environmental Solutions

NYC ROW Bioswales



Modified ROW Bioswale: Reduced Width

Hammond Pond, Newton

Funding Stormwater Management

There are costs to stormwater management even with LID. Options for funding include:

- Utilities: dedicated funding based on impervious surfaces, incentives to reduce effective imperviousness
  www.mapc.org/Stormwater_Financing
- Private commercial/industrial site maintenance and annual reporting requirements (Westboro)
- Regional Stormwater Collaboratives provide efficiencies and cost savings
  www.centralmastormwater.org

CMRSWC

Take Home Messages

- Green infrastructure provides numerous **free** or low cost **services** – through both natural and engineered plants and soils.
- We need to treat stormwater and precipitation as a **resource**, not a waste product.
- LID and GI provide several value-added **financial** and **quality of life benefits** for communities of all types – rural, suburban, urban.

Take Home Messages

We can't continue on our current, business as usual path.

- Conservation design, narrow streets, LID drainage need to be the **preferred**, easy-to-permit development/redevelopment option.
- Does **your** LID bylaw work well with your subdivision and other regulations?


Thank you!
We're in this together and we can't make this happen without you.

For more information, please visit www.massaudubon.org/LIDcost

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