Green Infrastructure Details, Application and Maintenance Requirements

Binghamton NY – June 10, 2014

John Dunkle, PE, CPESC, CMS4S

GI for Binghamton

GI Practices

- Green Space
- Riparian Buffers/Grass Filter Strips
- Tree Planting/Preservation
- Rooftop Disconnect
- Porous /Permeable Pavement
- Green Roofs
- Swales
- Bioretention/rain gardens/planters
- Infiltration
- Rain barrels/cisterns

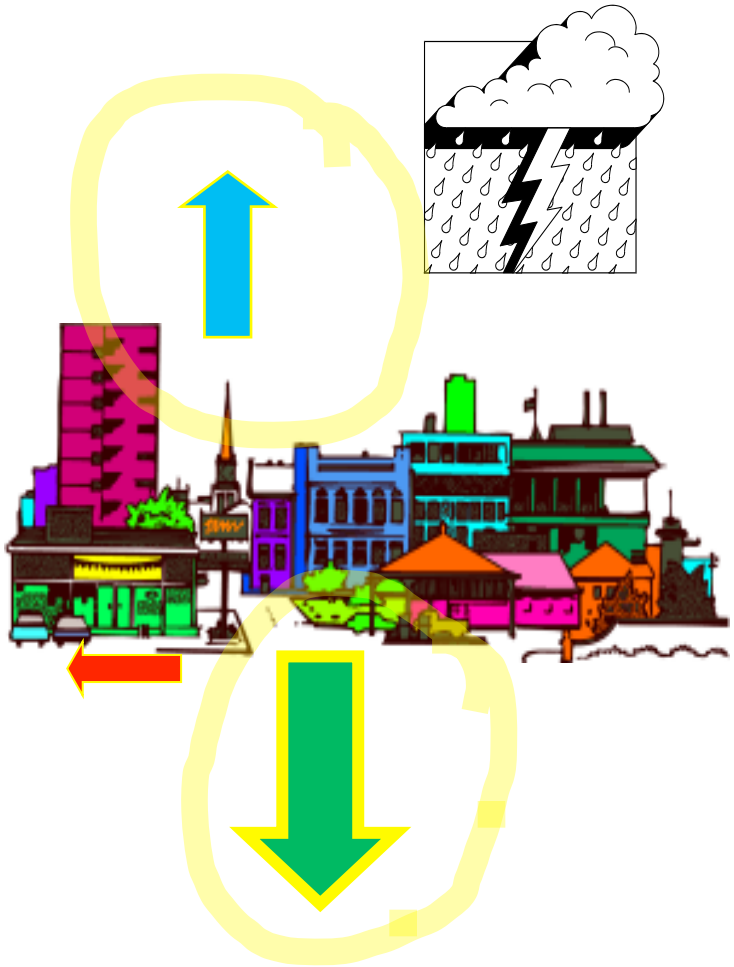
The GI Common Threads:

All GI Practices

Provide

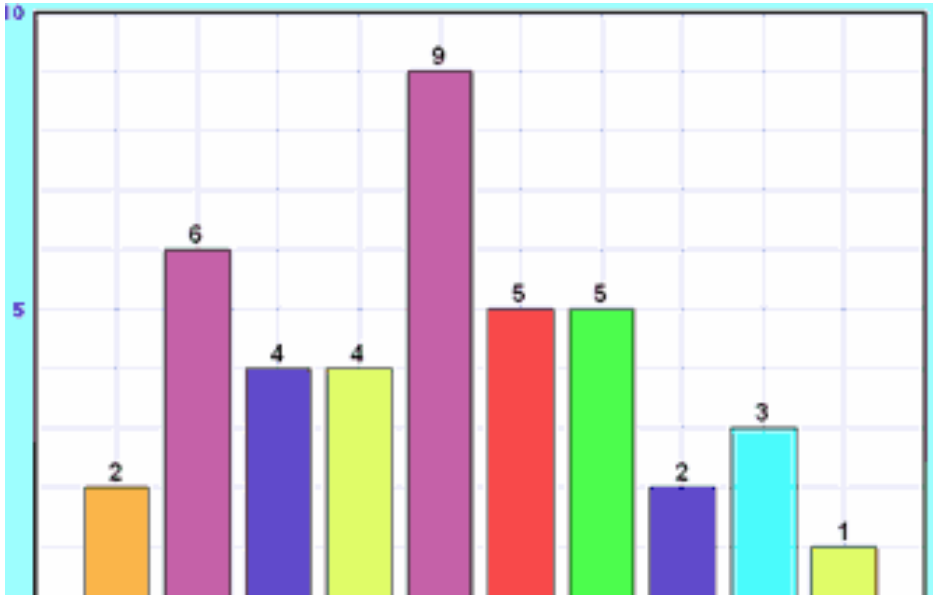
Runoff Reduction

Runoff Reduction Pathways



- Evaporation
- Evapotranspiration
- Absorption
- Infiltration
- Reuse

GI Treatment Practices have variable Runoff Reduction rates.



The GI Common Threads:

All GI Practices

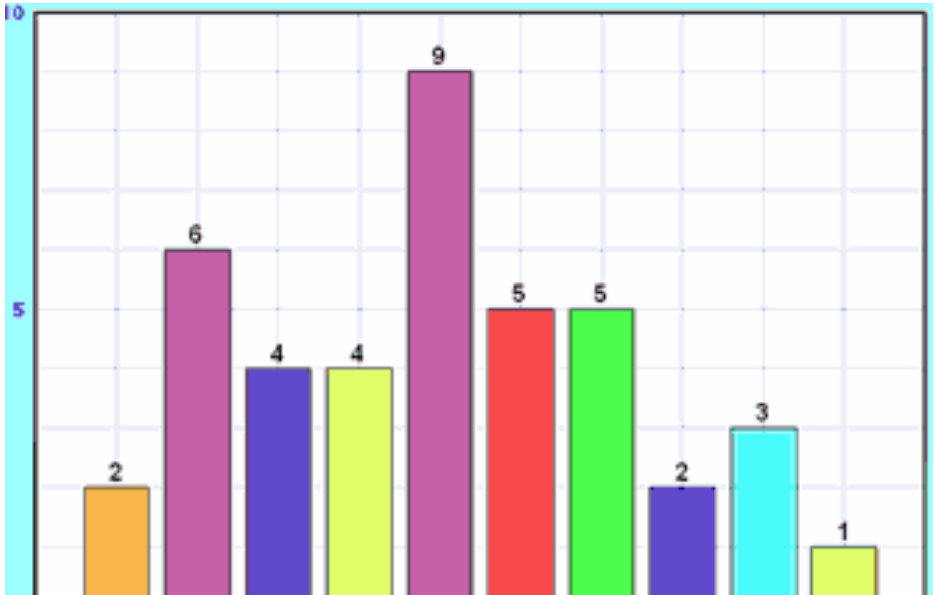
Provide

Pollutant Removal

Pollutant Removal Pathways

- Storage
- Evaporation
- Nutrient uptake
- UV treatment
- Settling
- Biology
- Infiltration
- Dilution
- Soil Stabilization

GI Treatment Practices provide variable pollutant removal.



The GI Common Threads:

All GI Practices

Need

Storage Volume

Storage – Above Ground

Storage – Underground Pipe Chambers

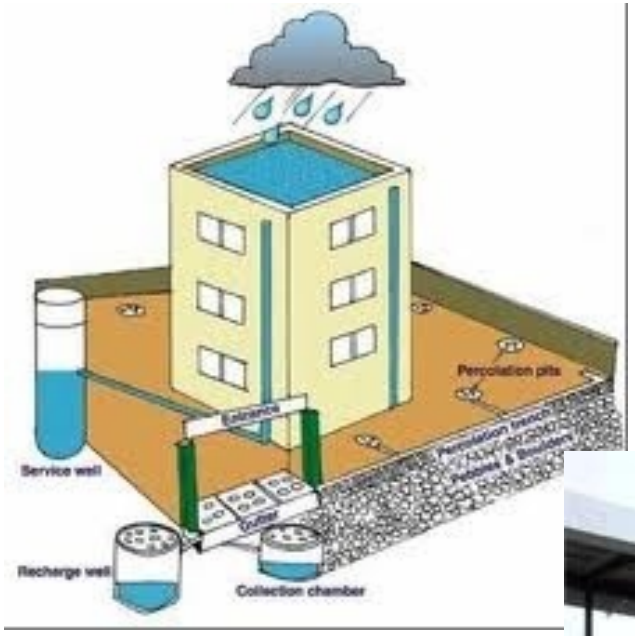
Storage – Infiltration Chambers

Storage - Tanks

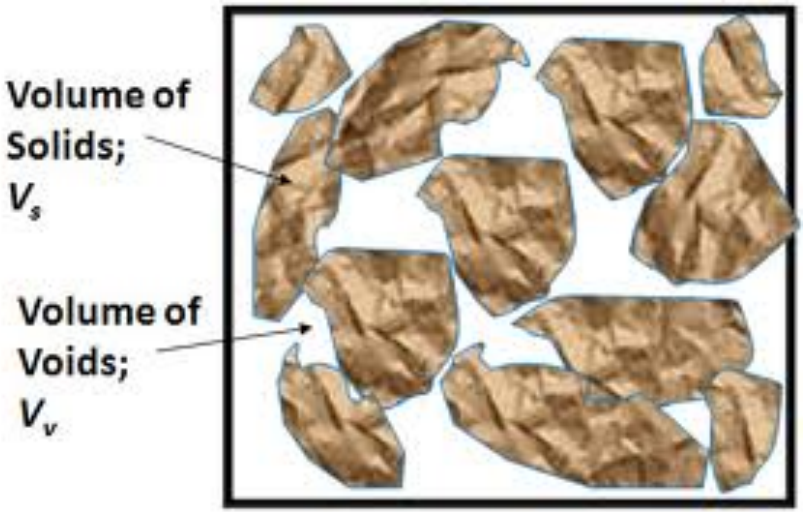
Vaults

Vaults/Tunnels

Blue Roofs/Cisterns



Storage Volume in soils



Storage - Soils

20 % Voids

Storage – Stone(uniformly graded)

40% Voids

Storage - Structural Soils

Using CU-Structural Soil™ in the Urban Environment

Cornell University

Urban Horticulture Institute
Cornell University
Department of Horticulture
134A Plant Science Building
Ithaca, NY 14853
www.hort.cornell.edu/UHI

26% Voids

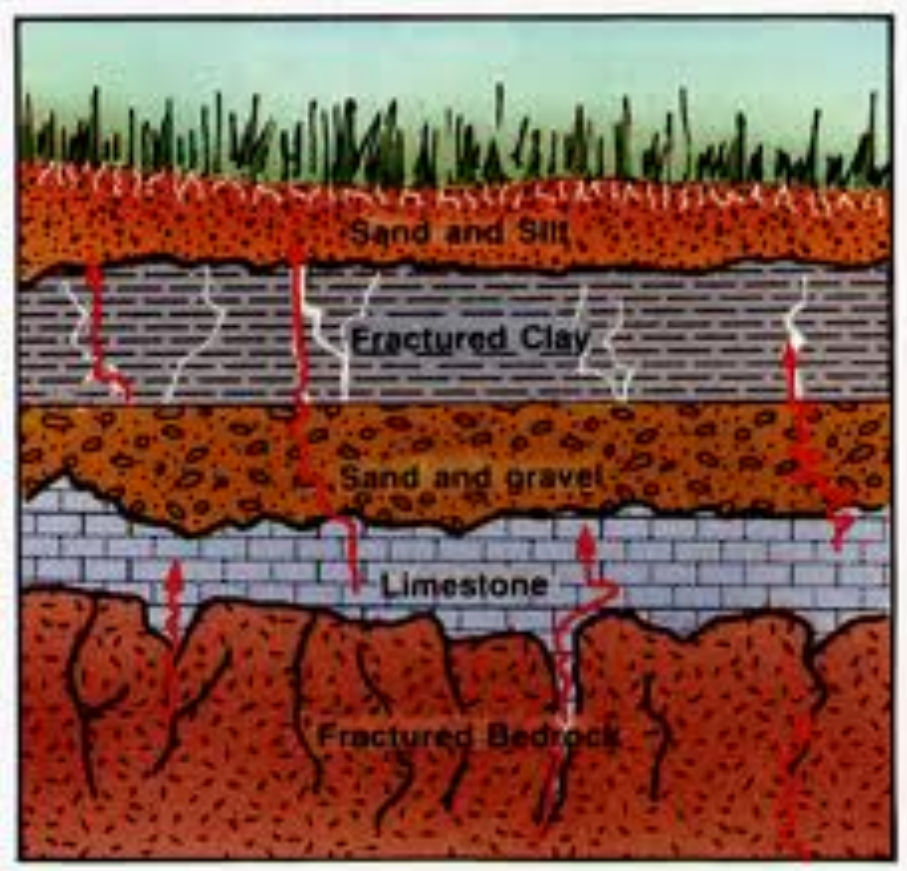
The GI Common Threads:

Most GI Practices

Need

Permeability

Got Permeability?



NOPE.

YUP

Be Careful

Infiltration

GI Practices Utilizing Infiltration

- Infiltration Basin
- Infiltration Trench
- Dry Well
- Bio-retention
- Rain garden
- Permeable/porous pavement
- Planter
- Dry Swale
- Vegetated swale
- Tree planting
- Buffers/filter strips
- Green Space

Minimum infiltration rate for infiltration based practices:

½” per hour

@ 2’ below the design bottom

Must be es  testing.

The GI Common Threads:

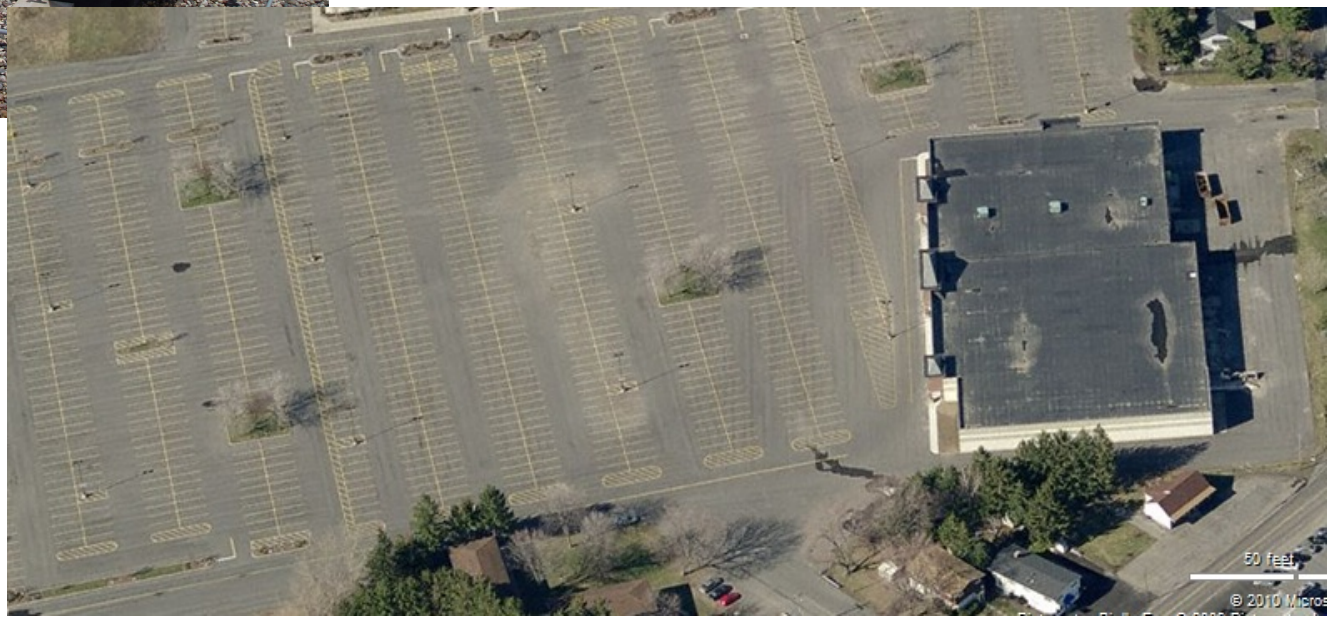
Most GI Practices

Need

Green

Roof Tops

Pavement



Ways to Add Green

Creating Urban Green Space

Creating Riparian Buffer

Add treatment to EXISTING PARKING LOTS

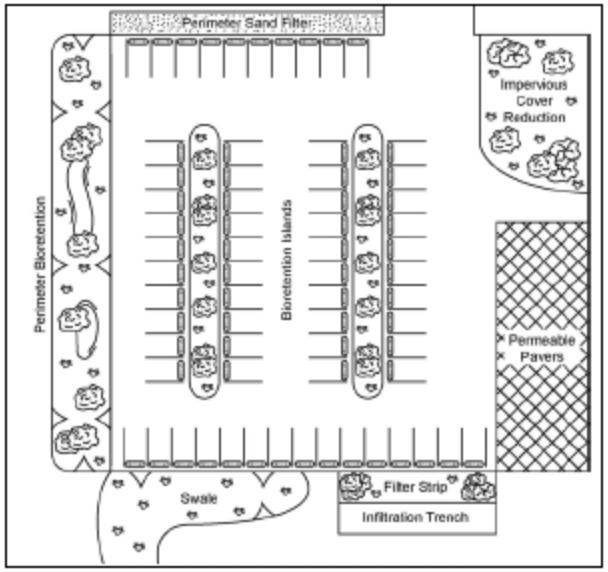
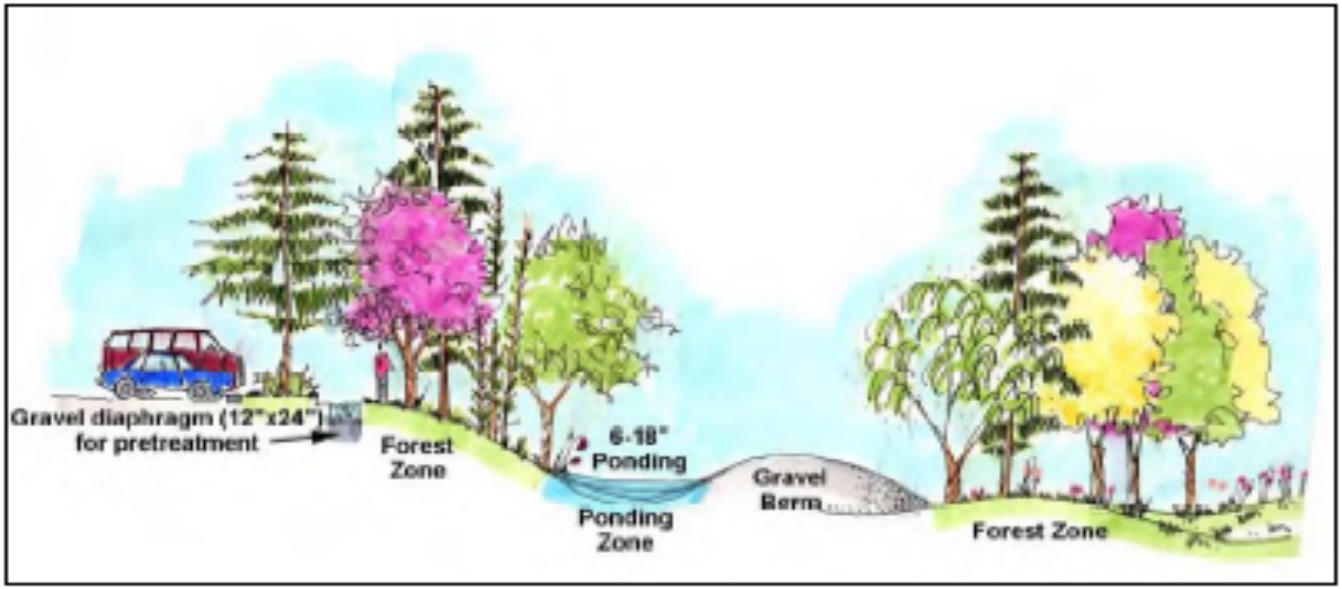
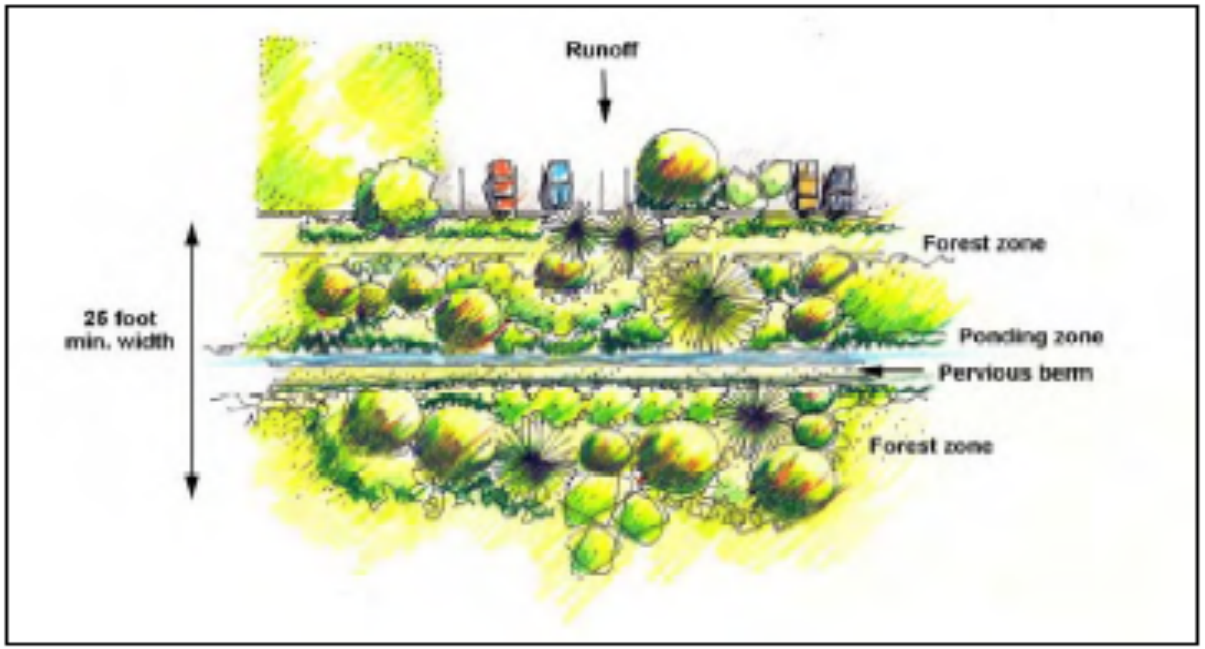


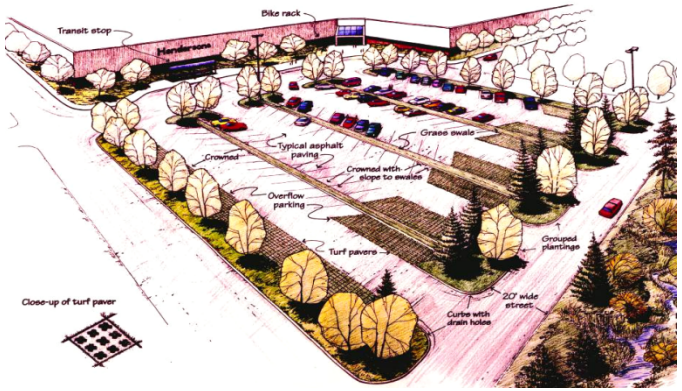
Figure 2: Examples of retrofits employed at small parking lots: permeable pavers (a); dry swale (b); perimeter sand filter (c); grass filter//infiltration trench (d;) filter strip (e); internal bioretention (f); underground infiltration (g) and island bioretention (h).

TREATMENT at EDGE
of
PARKING LOT



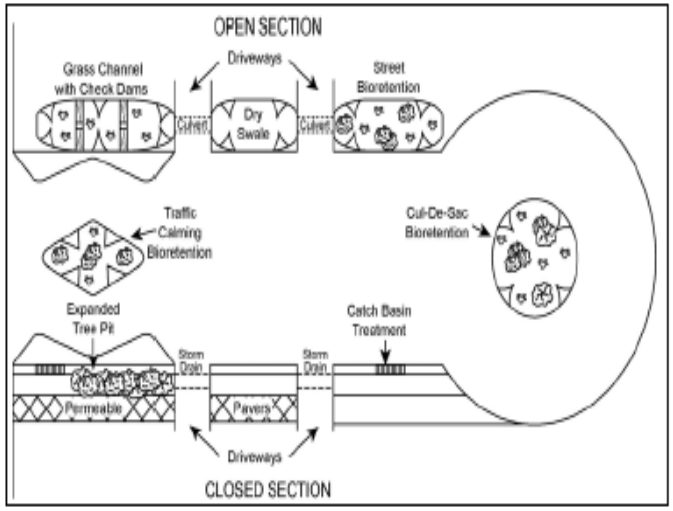


PARKING LOT RETROFIT



MODIFY PUBLIC SPACES

Figure 2: Landscape architects can creatively use stormwater as a resource in foundation planters (a); permeable pavers (b); bioretention (c); and stormwater tree pits (d).

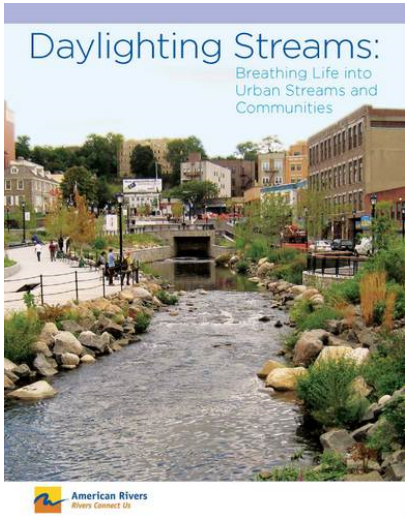


MODIFY EXISTING STREET SCAPES

Figure 4: More street retrofit ideas: SEA streets swale (a); close-up of Portland street bioretention (b) and bioretention in street medians (c/d).

Figure 3: Innovative street retrofits include: curb cuts to rain gardens (a), surface bioretention in traffic calming measures (b), larger bioretention pocket in multi-family residential (c), and curb cuts to cascading bioretention cells (d).

Stream Daylighting



Urban Stream Restoration

Tree Planting

Re-forestation/ Re-vegetation

Vegetated Filters

Rooftops

The GI Common Threads:

All GI Practices

Need

Care

Some Typical GI Stormwater Maintenance Issues:

Excess Sedimentation

Clogging at Inlets & Outlets

Erosion: Inlets, slopes, Practice surface

Vegetation

Little vegetation, no diversity

Too much vegetation, no diversity

Vegetation:

The Wrong Kind

Problems with Pretreatment

- Sedimentation &Loss of Settling Volume/Retention Time
- Contamination

Structural Integrity

Loss of Permeability

- Compaction
- Sedimentation
- Organic Degradation

Other Maintenance Problems

Typical GI Maintenance Tasks

- Mowing
- Sediment removal
  - (excavation, vacuuming, raking sweeping, washing)
- Pruning
- Weeding
- Planting
- Fertilizing
- Re-grading
- Soil restoration
- Structural Repairs

Onondaga County, New York
Save the Rain Program
Green Infrastructure
Maintenance Training

Prepared for

Onondaga County, New York

Prepared by

CH2MHILL.

March 9, 2012

Save the Rain

savetherain.us

GI Practice Design and Care Details


No nutrients
No organics
No permeability
Soil Restoration

Restore Compacted Soils

How and when to restore Soil:

p 5-22

Table 5.3 Soil Restoration Requirements

Type of Soil Disturbance	Soil Restoration Requirement		Comments/Examples
No soil disturbance	Restoration not permitted		Preservation of Natural Features
Minimal soil disturbance	Restoration not required		Clearing and grubbing
Areas where topsoil is stripped only - no change in grade	HSG A &B	HSG C&D	Protect area from any ongoing construction activities.
	apply 6 inches of topsoil	Aerate* and apply 6 inches of topsoil	
Areas of cut or fill	HSG A &B	HSG C & D	
	Aerate and apply 6 inches of topsoil	Apply full Soil Restoration **	
Heavy traffic areas on site (especially in a zone 5-25 feet around buildings but not within a 5 foot perimeter around foundation walls)	Apply full Soil Restoration (de-compaction and compost enhancement)		
Areas where Runoff Reduction and/or Infiltration practices are applied	Restoration not required, but may be applied to enhance the reduction specified for appropriate practices.		Keep construction equipment from crossing these areas. To protect newly installed practice from any ongoing construction activities construct a single phase operation fence area
Redevelopment projects	Soil Restoration is required on redevelopment projects in areas where existing impervious area will be converted to pervious area.		

Soil restoration techniques: topsoiling

- Goals:
  - Restore the upper soil horizon (A-Horizon)
  - Create a medium for plant growth.
  - Restore organic matter.

SOIL STRUCTURE

O-horizon: leaf litter, organic material

A-horizon: plough zone, rich in organic matter

B-horizon: zone of accumulation

C-horizon: weathering soil; little organic material or life

R-horizon: unweathered parent material

soil restoration techniques: Aeration

- Goals:
  - Increase macropores.
    - Decompact soil.
  - Restore infiltration.

- "Aeration includes the use of machines such as tractor-drawn implements with coulters making a narrow slit in the soil, a roller with many spikes making indentations in the soil, or prongs which function like a mini-subsoiler."

Soil restoration techniques: compost amendments

"Compost shall be aged, from plant derived materials, free of viable weed seeds, have no visible free water or dust produced when handling, pass through a half inch screen and have a pH suitable to grow desired plants."

- Goals:
  - Restore soil organic material.
  - Improve soil infiltration capacity.
  - Provide an environment

Deep Ripping

New York State
DEPARTMENT OF ENVIRONMENTAL CONSERVATION

Division of Water

Deep-Ripping and Decompaction

April 2008

New York State
Department of Environmental Conservation

< 12 depth

w multiple passes

“Complete soil restoration”

Multi-step process that includes:

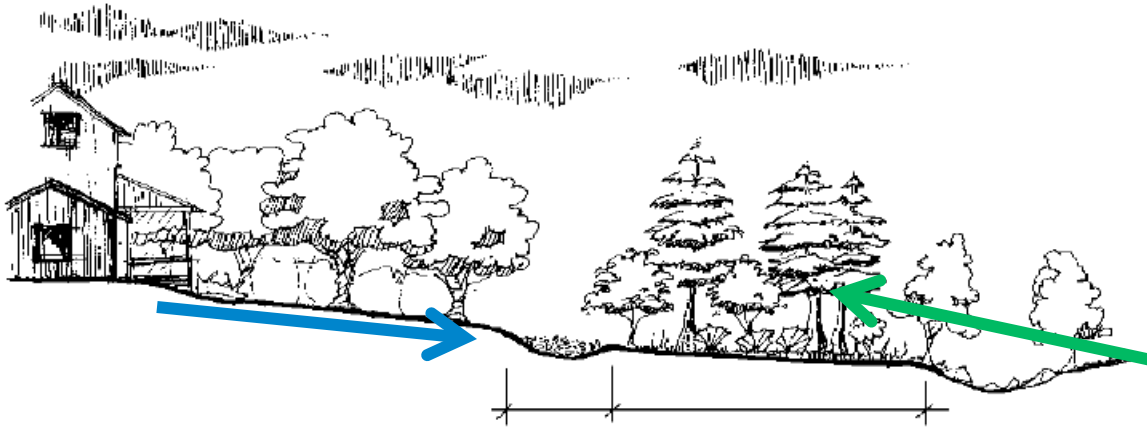
- Composting.
- Tilling compost into soil.
- Removing large rocks.
- Applying topsoil.
- Vegetating the surface.

Great Resource: “Deep Ripping and De-compaction” DEC 2008.

Access at:
http://www.dec.ny.gov/docs/water_pdf/infildecom08.pdf

Soil Restoration National Mall

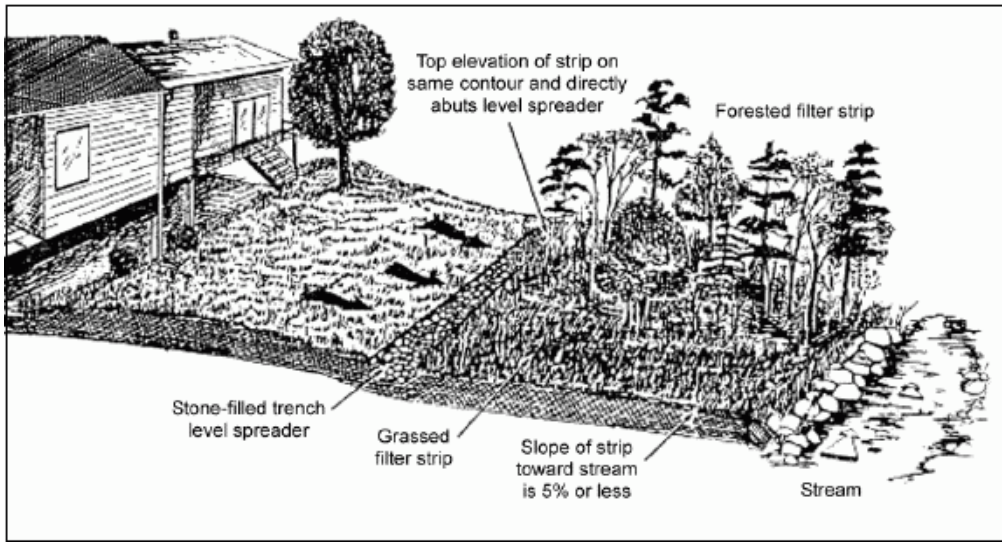
Green Space/Buffers/Filter Strips



Green Space/Buffers/Filter Strips

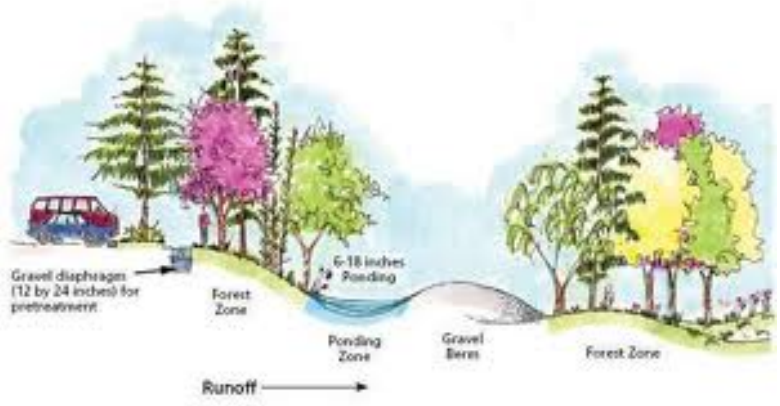
Some Critical Elements

- Pavement Removal
- Flow dissipation
- Vegetation
- Contributing length
- Width
- Soils
- Slope
- Protection



Maintenance of Green Space/Buffers/Filter Strips

- Delineation
- Protection
- Enforcement
- Maintain Health and Diversity
- Debris removal

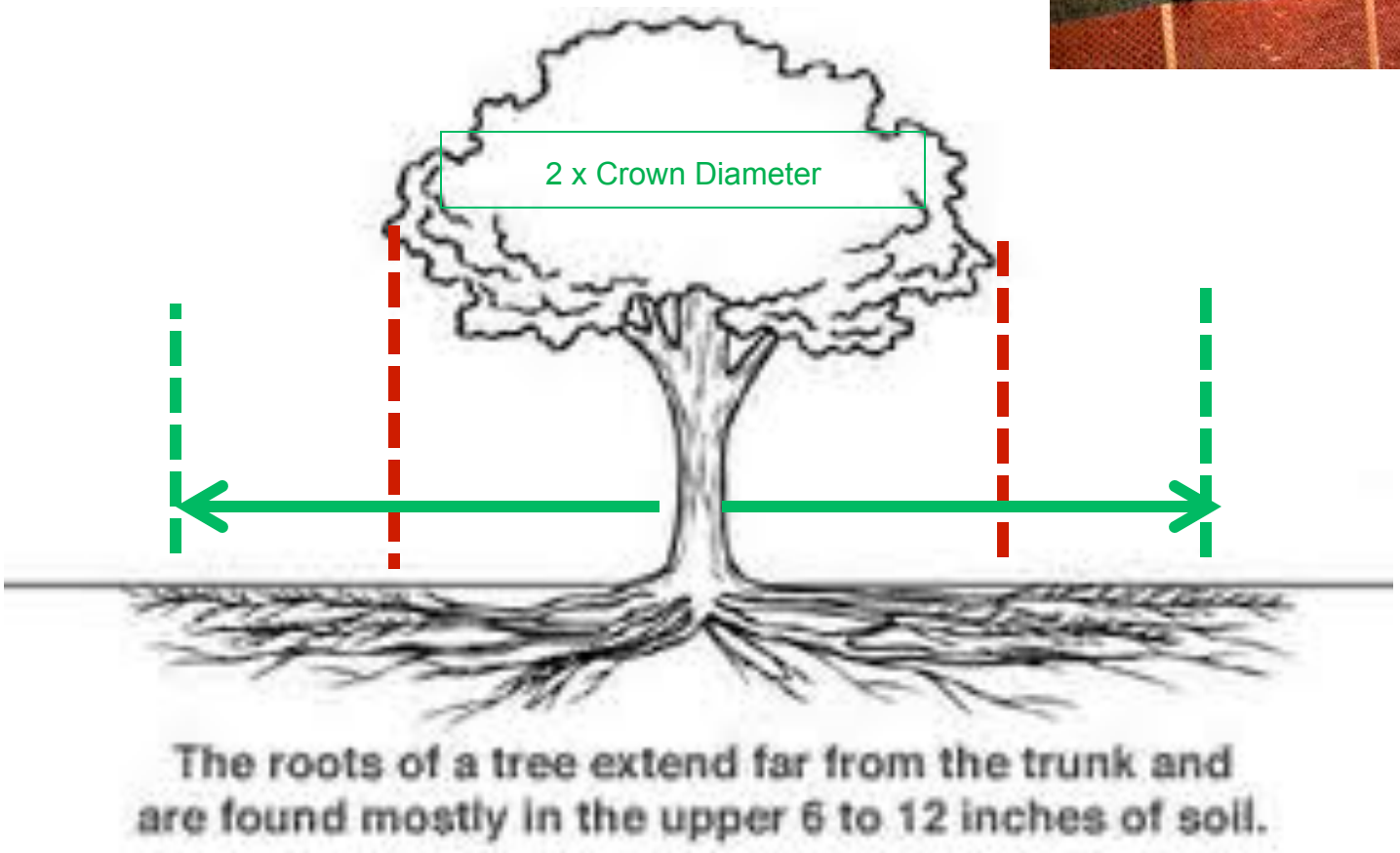


Tree Preservation/Planting

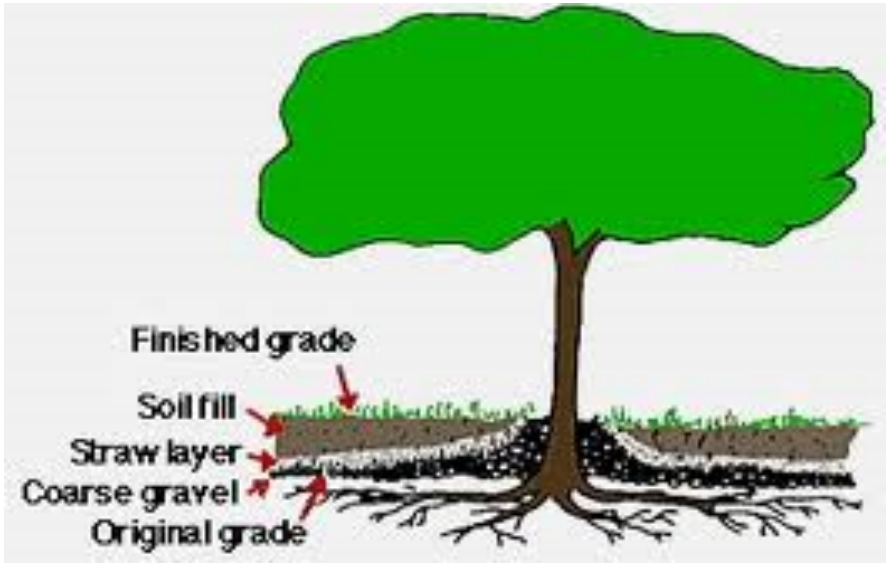
Some Critical Elements

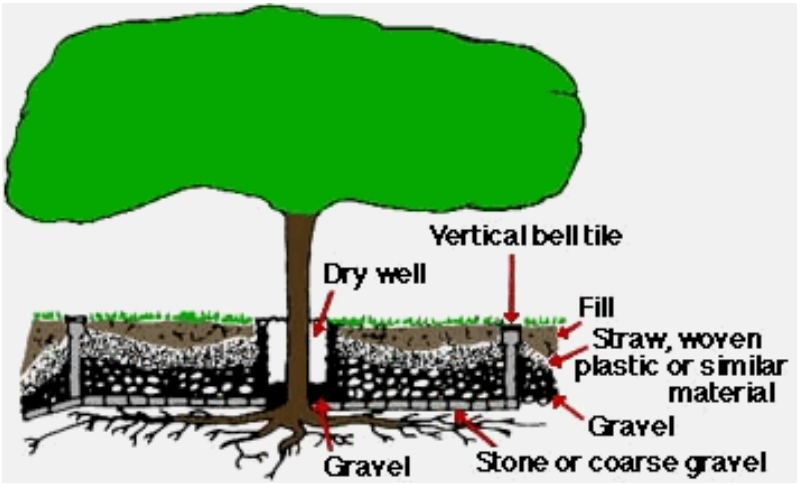
- Tree species
- Size/age
- Contributing DA
- Soil media (new plantings)

Protecting Trees



Protection of Trees



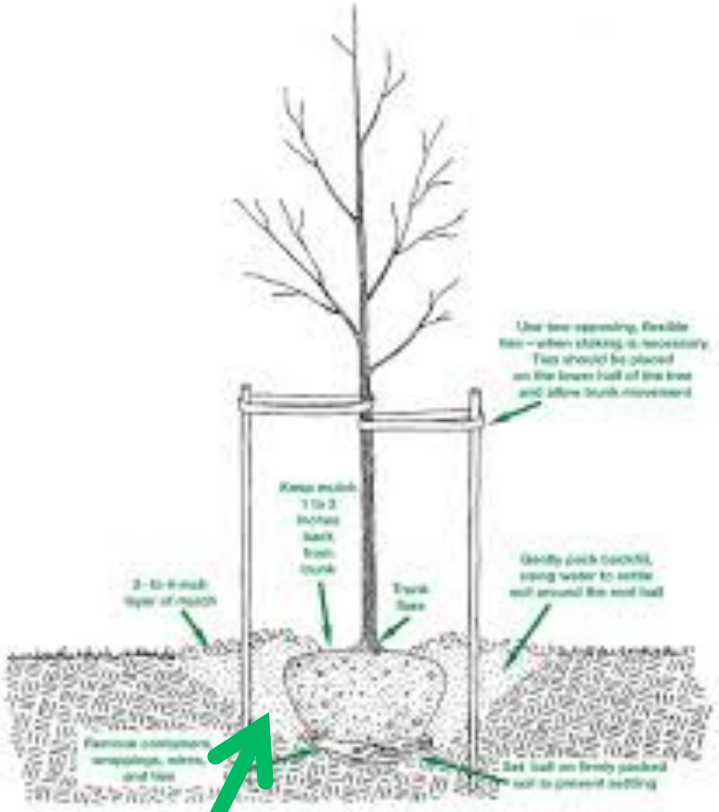


Tree Planting

Nope

YUP

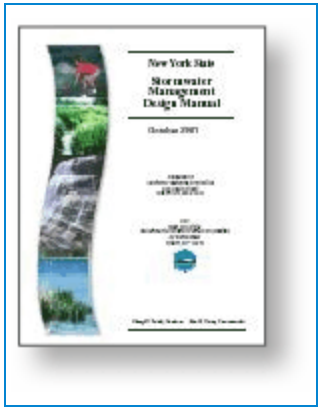
Tree Planting



2 c.f. / sf. of crown projection

Planting Soil

- PH range 5.2 to 7.00
- Organic matter 1.5 to 4.0%
- Magnesium 35 lbs. per acre, minimum
- Phosphorus (P_2O_5) 75 lbs. per acre, minimum
- Potassium (K_2O) 85 lbs. per acre, minimum
- Soluble salts 500 ppm
- Clay 10 to 25%
- Silt 30 to 55%
- Sand 35 to 60%



Planting Soil using Structural Soils

Using CU-Structural Soil™ in the Urban Environment

Cornell University

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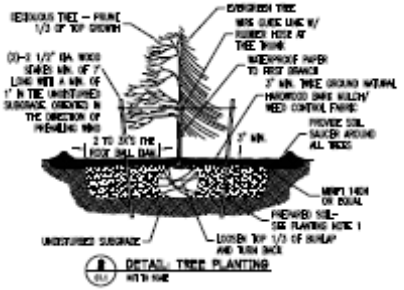
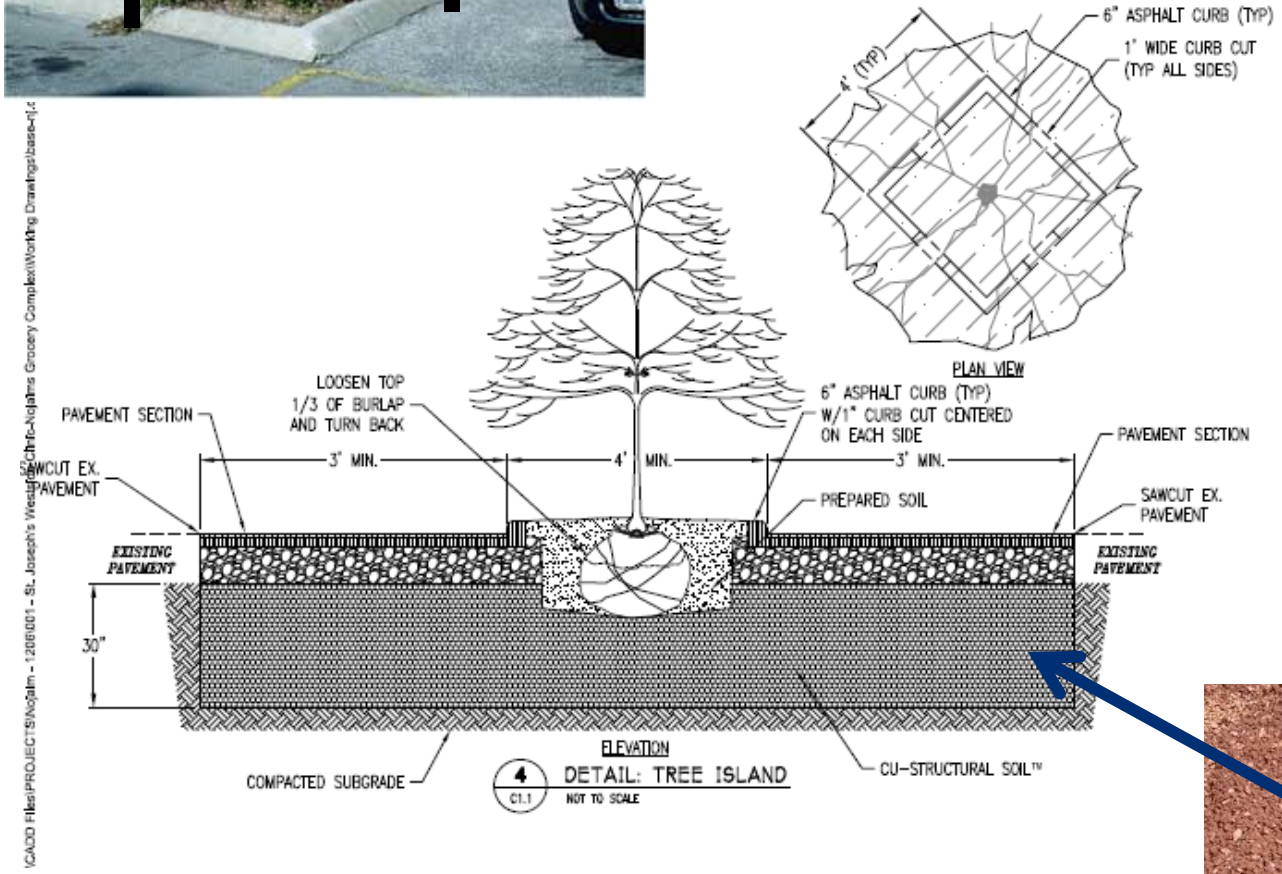
Ithaca, NY 14853
www.hort.cornell.edu/UHI

26% Voids

Tree Planting

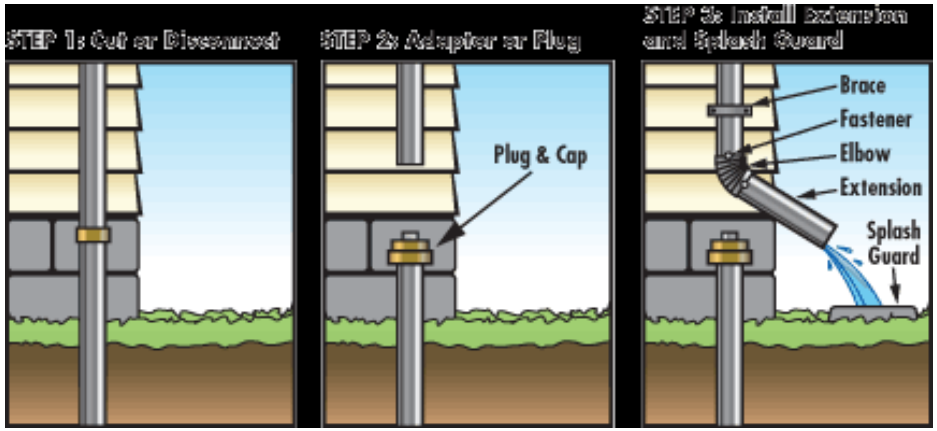




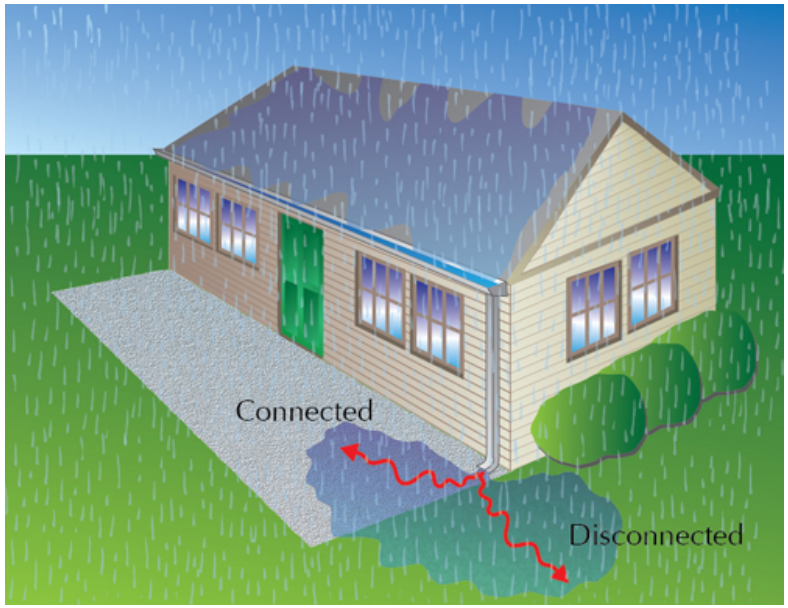
Maintenance of Tree Planting/Preservation

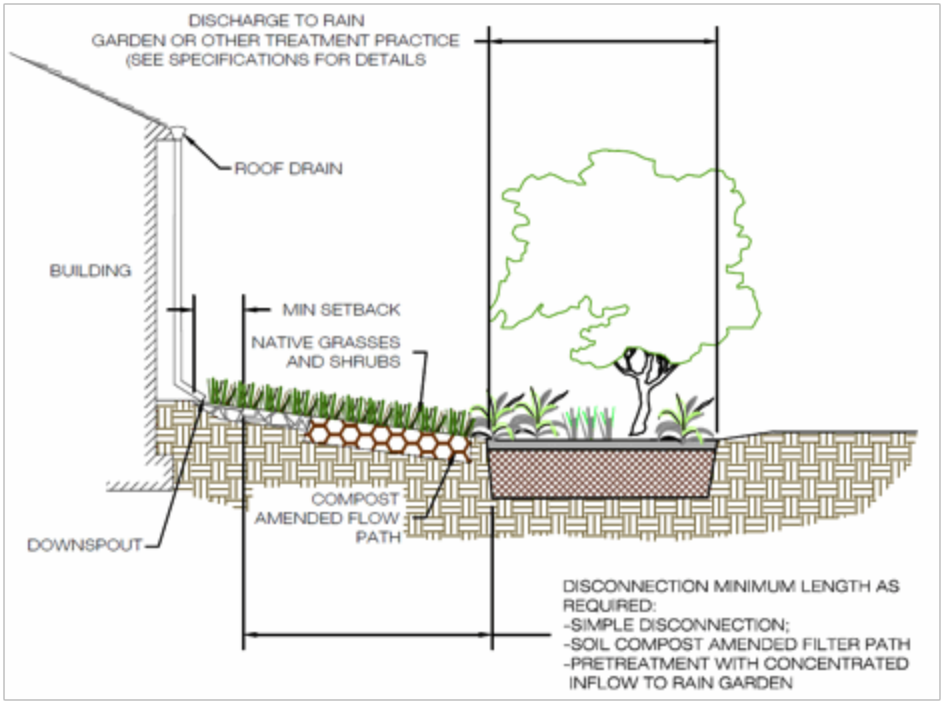
- Mulching/fertilizing
- Watering
- Pruning
- Protection
- Remediation of natural and human damage

Disconnect Rooftop Areas



Rooftop Disconnection





Rooftop Disconnection

Some Critical Elements

- Flow Dissipation
- Contributing surface area
- Flow distance
- Soils

Disconnect

Yes, or No?

Disconnect

Nope.

Disconnect

Yup.

Maintenance of Rooftop Disconnection

- Delineation
- Protection
- Enforcement
- Maintain Health
- Repair downspout erosion

Porous/Permeable Pavement

A porous pavement parking lot (Sourc
Invisible Structures, no date)

Porous /Permeable Pavement

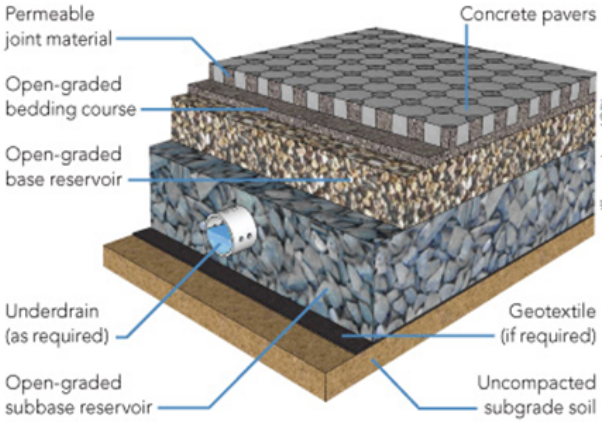
Some Critical Elements

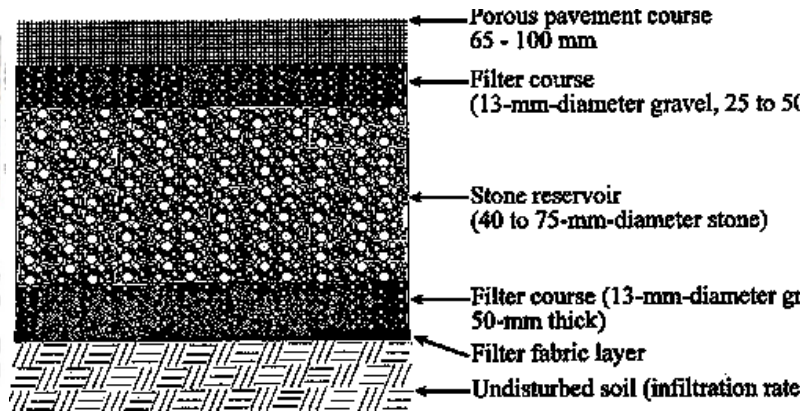
- Porosity
- Underlying soils
- Sub base
- Contributing DA
- Cross Section
- Climate
- Use

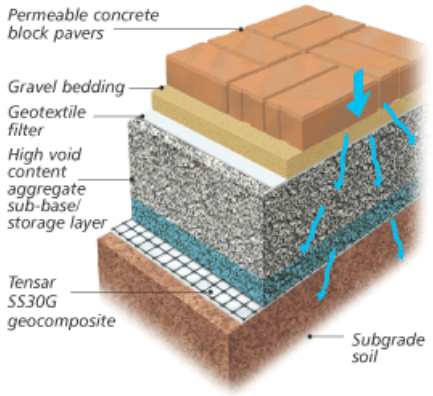
Porous/Permeable Pavement Materials

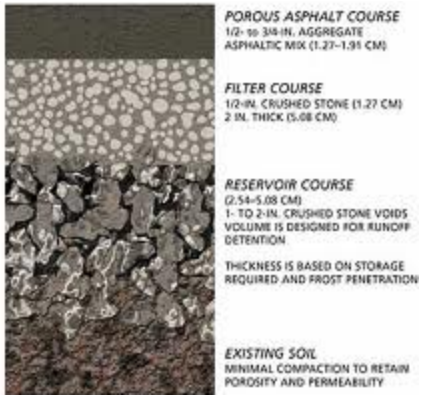
P. Pavement

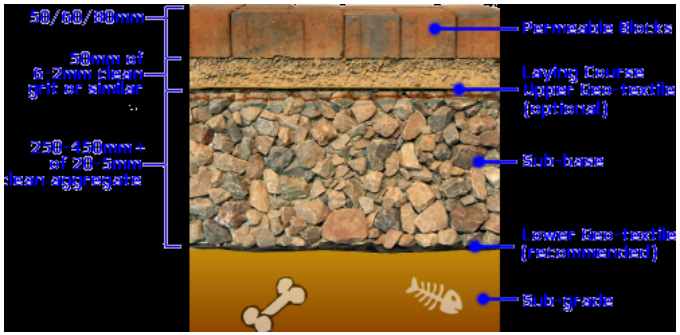
Cross Sections

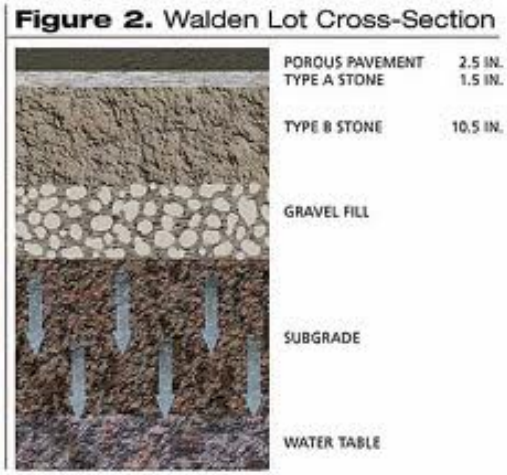






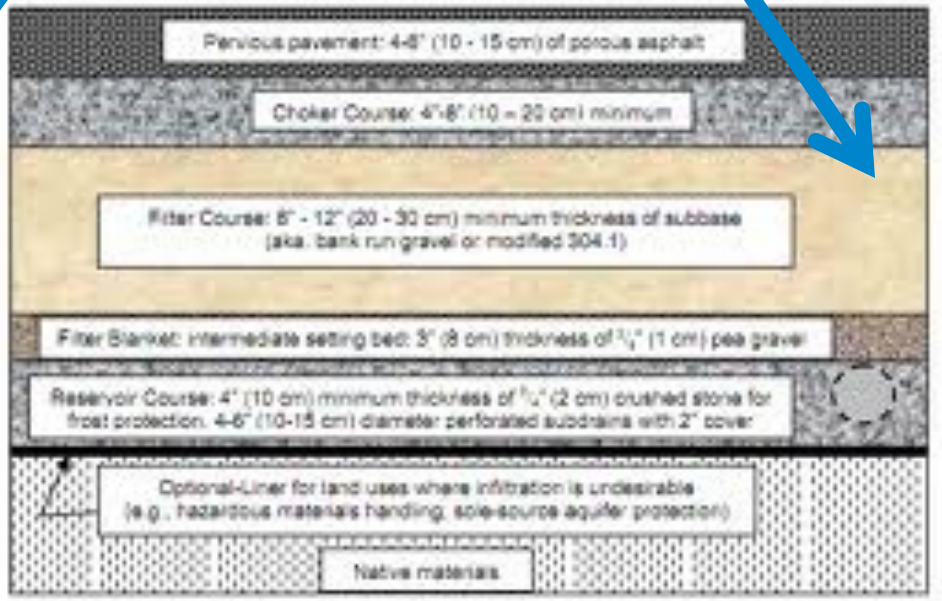




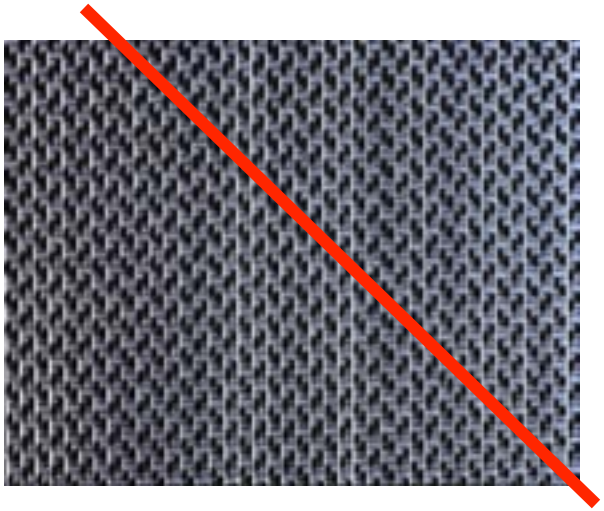


NYDOT No. 3A or ASTM No. 2 Stone

Maybe a Filter, too

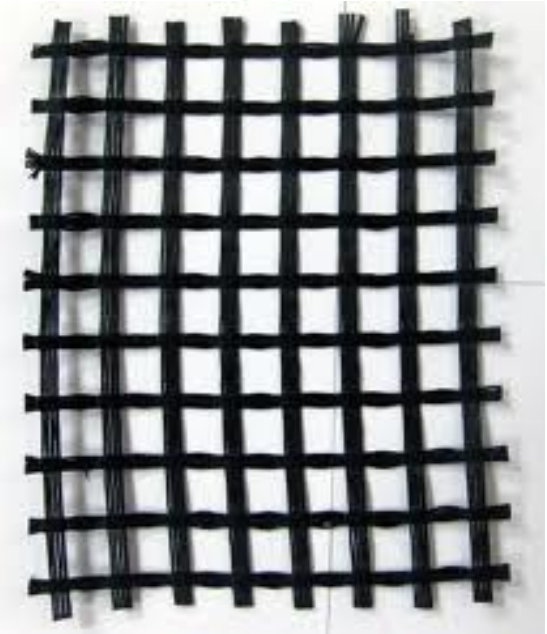


P. Pavement



?

Sure.



No, or Yes, and Where?

Not much Treatment gonna happen here:

P. Pavement

Articulated/Precast Porous Pavers

NYDOT

- Top Course Porous Asphalt
  - 475.5003
  - 475.5013
  - 475.5103
- Binder Course Porous Asphalt
  - 475.7009
  - 475.7019

Beach Road, Lake George

Cost Comparisons

Pavement	Cost per sq.ft. material (surface material only)
Standard Asphalt	$2.40 to $4.25
Porous Asphalt	$2.75 to $5.00 ($9.50 for excavation, subgrade materials and labor)
Porous Concrete (8-in)	$5.50 to $9.00
Grass / gravel pavers	$5.75 to $7.25
Permeable Pavers	$5.00 to $12.00

- Costs for conventional paving do not incorporate SW mgmt costs (i.e reinforced concrete pipes, catch basins, outfalls)
  - $9.50 and $11.50 per square foot.

Permeable Pavers in the right situation

Permeable Pavers in the wrong situation

Source: Bill Hunt, NCSU

Movement of Sediment

Maintenance of Porous and Permeable Pavement

- Check voids
- Removal of Debris and sediment
- Vacuuming
- Power washing
- Sweeping
- Ability to De-water
- Repairs of deterioration, spalling, displacement
- Maintaining adjacent areas of run-on
- Restore paver block aggregate

Winter Maintenance of Porous and Permeable Pavement

- Raise plow blade for pavers
- No road abrasives
- Reduced salt use
- No snow piles on PP

Green Roofs

Green Roofs

Some Critical Elements

- Roof design
- Climate
- Irrigation
- Access
- Soil media
- Cross section
- Drainage
- Vegetation

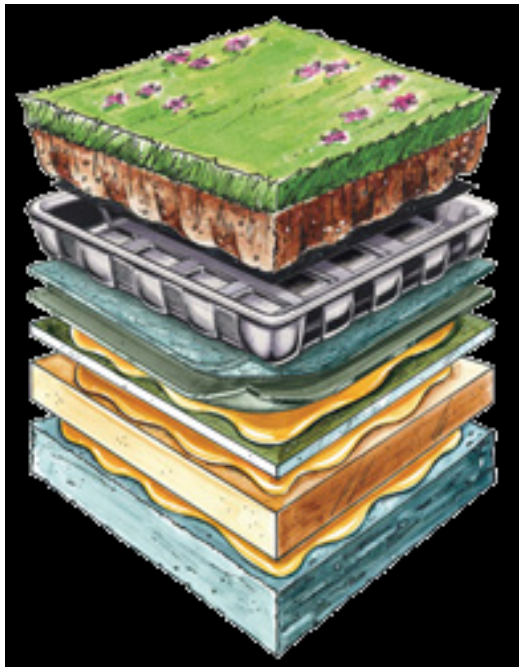
Green Roof

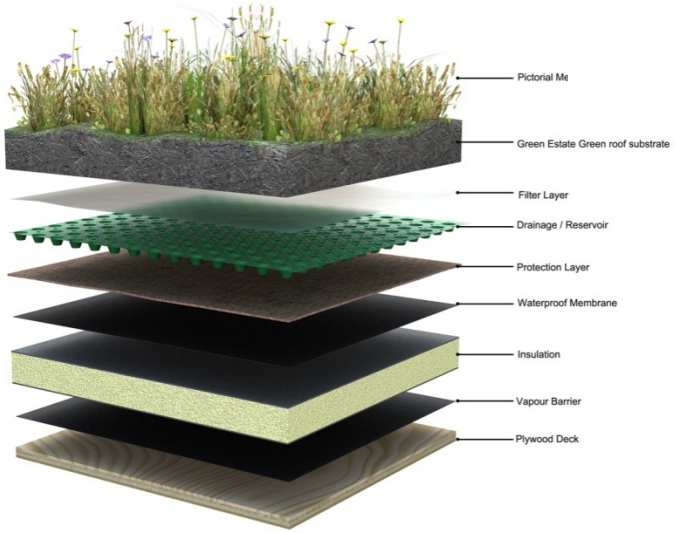
Extensive

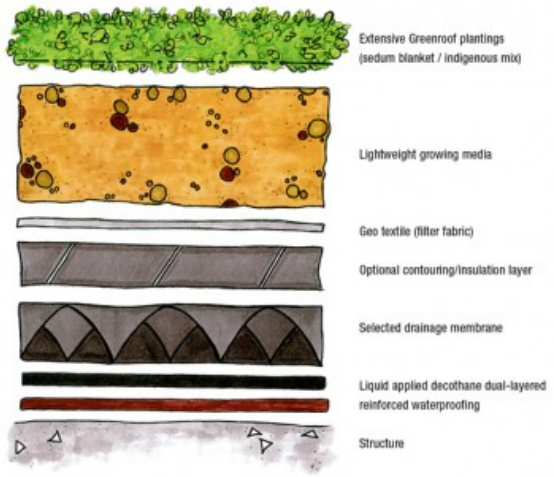
Intensive

Green Roof

Cross Section







Green Roof

Plant materials

Soil Media

Green Roof

Modular Systems

Green Roofs

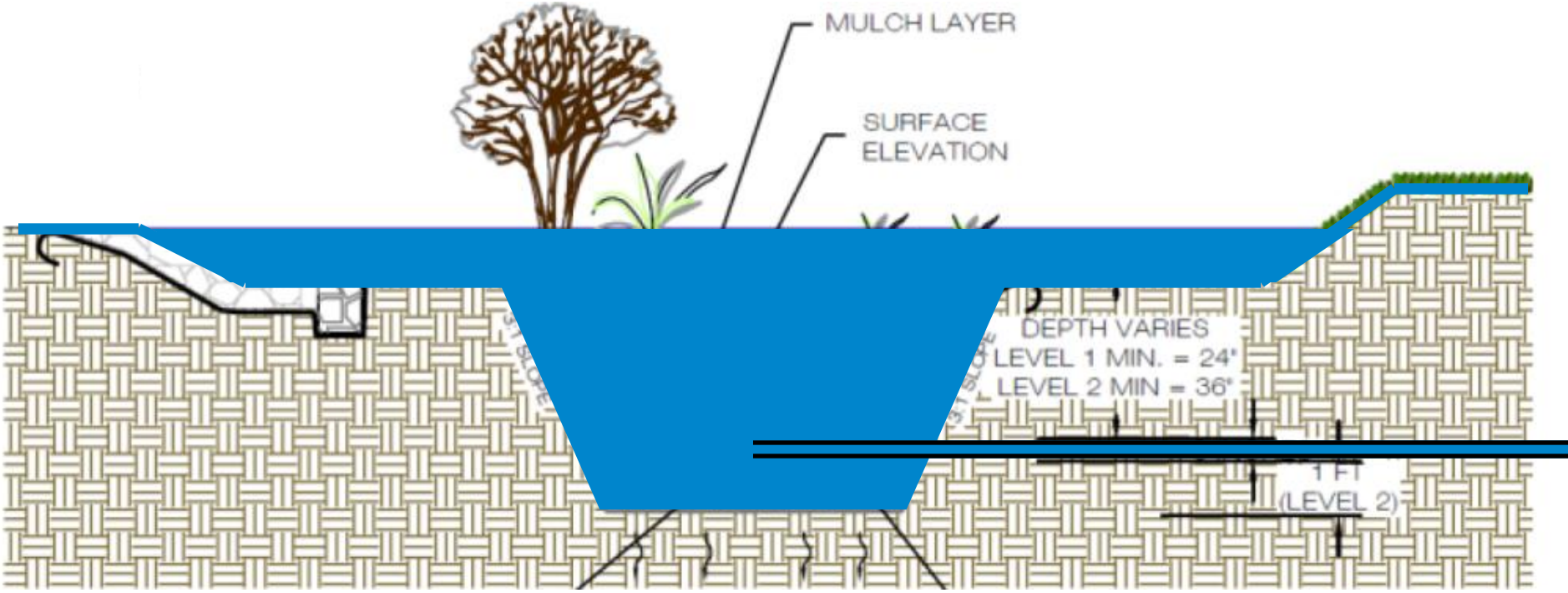

Green Roofs

Maintenance of Green Roofs

- Irrigation
- Weeding
- Fertilizing
- Drainage maintenance
- Plant replacement
- Membrane integrity

Bioretention , Rain Gardens, Tree Trenches, Planters

Bio-retention: How it Works



Runoff flows into a bioretention facility and temporarily ponds. Water then slowly filters through the filter bed and either is collected by the underdrain and sent to the storm sewer system or infiltrates into the surrounding area.

Bioretention Areas

Planters

Tree Trench

Rain Gardens/Bio-retention/ Planters/Tree Trenches

Some Critical Elements

- Inflow dissipation
- Flow bypass
- Soil media
- Surface area
- Ponding depth
- Geometry
- Vegetation
- Native soils
- Location
- Pre-treatment
- Drainage Area

No, or Yes, and Where?

Bio-Rain

Bio/Rain

Soil Mixture

New york state criteria: bioretention media

- **Parameter Value**
- PH range 5.2 to 7.00
- Organic matter 1.5 to 4.0%
- Magnesium 35 lbs. per acre, minimum
- Phosphorus (P2O5) 75 lbs. per acre, minimum
- Potassium (K2O) 85 lbs. per acre, minimum
- Soluble salts 500 ppm
- Clay 10 to 25%
- Silt 30 to 55%
- Sand 35 to 60%

New Recommendations for Media Recipe*

- Recipe for sand, soil and compost mix
  - 85% to 88% sand;
  - 8% to 12% soil fines; and
  - 3% to 5% organic matter.
  - More organic where trees are planted
  - Soil P Index less than 30

* CWP et al….Differs from the NYSDEC Stormwater Design Manual

Nope

Pretreatment

Grass Filter Strip

Grass Channel

Forebay

Mulch

Stone Flow Spreader

Stone/Rip Rap Apron

‘Bio-Typologies’

Typology: “The taxonomic classification of characteristics common to buildings or spaces …”

PERENNIAL GARDEN

TREE – TURF

PERENNIAL - SHRUB

TREE – SHRUB – MULCH

Other Types of Surface Cover


Stone/cobble


Stepping stones for pedestrian flow


Concrete cells – herbaceous

No

The LA Touch

Aesthetics of Bioretention

Aesthetics of Bioretention


Aesthetics of Bioretention

Aesthetics of Bioretention

Aesthetics of Bioretention


Stiff Stemmed Species

Succession
and
Break- in Periods


Aesthetics

Infancy to Maturity


Cornell Ornithology Lab
Summer 2002


Spring 2003
Cornell Ornithology Lab


July 2003
Cornell Ornithology Lab

Summer 2005

Cornell Ornithology Lab


Early Fall 2007
Cornell Ornithology Lab


Early Fall 2007
Cornell Ornithology Lab


Early Fall 2007
Cornell Ornithology Lab

August 2008

Cornell Ornithology Lab

August 2008

Cornell Ornithology Lab


August 2008
Cornell Ornithology Lab

Maintenance of Rain Garden/Biofilter/Tree Trench/Planters

- Occasional replacement of plants, mulching, weeding and thinning
- Watering essential the first year
- Keep plants pruned if they start to get “leggy” and floppy
- Cut off old flower heads after a plant is done blooming
- Keep free of bare areas except where stepping stones are located
- Inspect for sediment accumulations
- Replace top few inches of soil when water ponds for more than 48 hours
- Check for damage/failure of any wall, dam or berm and repair
- Correct any settlement or low spots
- Inspect and clean
- Debris and trash removal on a weekly or monthly basis
- Pruning and replacing dead or dying vegetation, plant thinning, and erosion repair

Rain barrels/Cisterns

Rain barrels/Cisterns

Some Critical Elements

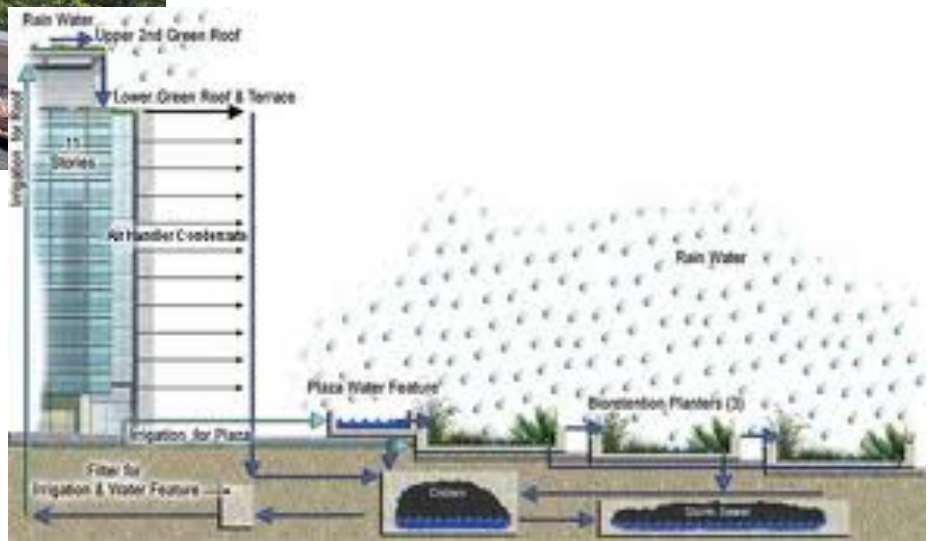
- Volume
- Climate
- Use
- Overflow

Barrels

USE IT !

Rain Barrel/Planter

Cisterns and Green Roofs



Crime Lab in Monroe County

CISTERN, RAIN GARDEN, POROUS PAVEMENT

1,500 Gallon Cistern

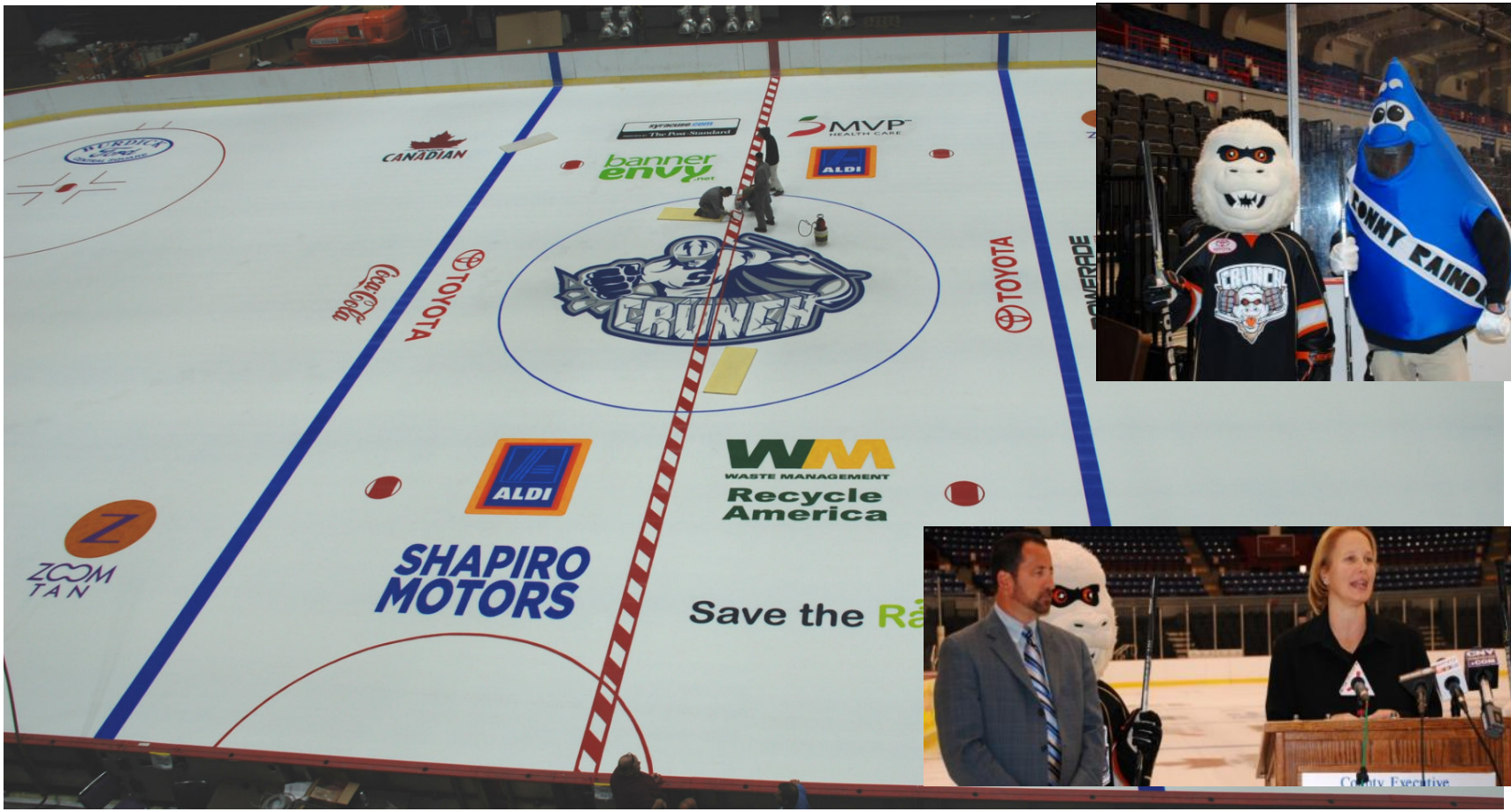
Collects Roof Water for Toilets and Mop Sinks

Finished Garden

Civic Center Parking Garage

GREEN ROOF, CISTERN

War Memorial Cistern Reuse System



Reusing rainwater appears to allow the ice making to occur one to two degrees warmer than using potable water resulting in energy savings

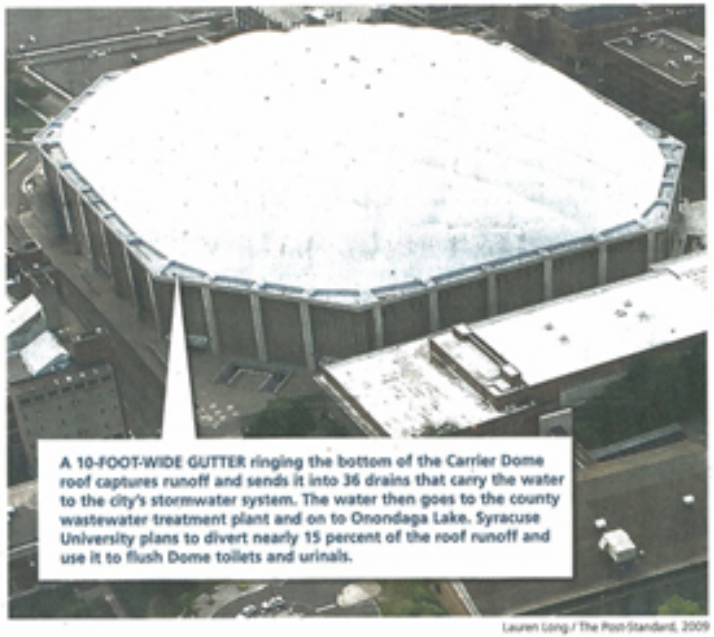
THE POST-STANDARD

SUNDAY, JANUARY 6, 2013

syracuse.com

AN ECO SLAM-DUNK: FLUSHING WITH RAINWATER

ORANGE GOES GREEN BY DIVERTING SOME DOME RUNOFF TO TOILET SYSTEM



A 10-FOOT-WIDE GUTTER ringing the bottom of the Carrier Dome roof captures runoff and sends it into 36 drains that carry the water to the city's stormwater system. The water then goes to the county wastewater treatment plant and on to Onondaga Lake. Syracuse University plans to divert nearly 15 percent of the roof runoff and use it to flush Dome toilets and urinals.

Lauren Long / The Post-Standard, 2009

By Rick Moriarty
Staff writer

The sea of orange inside Syracuse University's Carrier Dome on game days may soon flow like never before.

The university last month received a $1.35 million state grant to install a system to collect the rainwater that runs off the fabric roof of the Carrier Dome, the 49,262-seat arena where SU's basketball, football and other teams play.

Approximately 880,000 of the 6.6 million gallons of water that pours off the Dome's 7-acre roof each year will be captured by the system and stored in tanks hung from the bottom of the arena's upper bleachers. During events at the Dome, the water will be used to flush the toilets and urinals in the building's 16 public restrooms.

SEE HOW DOME'S RAINWATER DIVERSION PROJECT COMPARES WITH OTHERS IN CNY. A-8

Building codes require the water to be dyed to avoid confusion with drinking water, even though the water will only be used in toilets and urinals. So university officials are considering coloring the water orange, the school's official color since 1890.

"We've been joking, wouldn't it be neat if we could color it orange?" said Eric Beattie, the university's director of campus planning, design and construction. "There's probably some room for discussion."

Blue, which SU uses as an unofficial accent color, is also a possibility, he said.

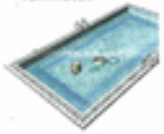
The university wants the public to notice the water harvesting system, and orange-colored water in the Dome's toilets and trough-style urinals would be hard to miss. Beattie said the project is intended as a demonstration of how such systems can conserve municipal water

SYSTEM, PAGE A-8

FAST FACTS

Each of the four 5,000-gallon tanks that will hold rainwater captured from the Carrier Dome's roof will be about 8 feet in diameter and 10 feet long and weigh 42,000 pounds when full.

■ The tanks will hold enough water to flush the Dome's toilets and urinals during two major sporting events before they'll need more rainwater.



■ Enough rainwater and snowmelt runs off the Dome's 7-acre roof each year to fill 10 Olympic-size swimming pools.

■ The gutter that rings the bottom of the Dome's roof is wide enough to hold a car.

Maintenance of Rain Barrels

- Maintenance requirements vary depending on the end use
- Winterization maintenance may be necessary
- Routine inspections to ensure the system is available for rain events
- Inspect roof catchments for particulate matter or other contaminants
- Inspect the gutters and downspouts for leaks or obstructions
- Inspect diverts, cleanout plugs, screens, covers, and overflow pipes
- Inspect inflow and outflow pipes
- Inspect connectors to adjacent storage containers or a water pump

Infiltration Practices

INFILTRATION
Some Critical Elements

- Soils
- Groundwater
- Pre-treatment
- Surface Area
- By - pass

Underground Infiltration

Infiltration Pre-treatment

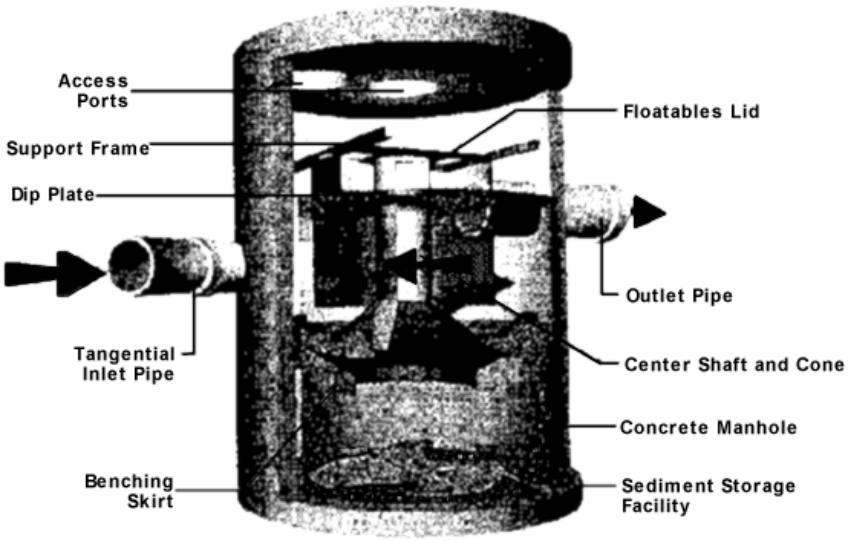
Forebay

Infiltration Pre-treatment

STONE TRENCH

Infiltration

Pre-treatment



SETTLING CHAMBERS AND MECHANICAL SEPARATORS

No Infiltration Practices Here

(At least not without “enhanced” pretreatment)

p 4-6 and 4-18 Design Manual

How Not to Build an Infiltration Practice


Not Going to Work!
08.14.2013

Maintenance of Infiltration Practices

- Inspect and clean pre-treatment
- Monitor water levels
- Remove debris from exposed infiltration surfaces
- Maintain flow pathways

Monitoring Ports for all Infiltration and Filtering Practices

Swales

Swales

Vegetated Swales

Vegetated Swale

Swales

Some Critical Elements

- Flow volume and rate
- Soils
- Vegetation
- Geometry
- Slope
- Length
- Design

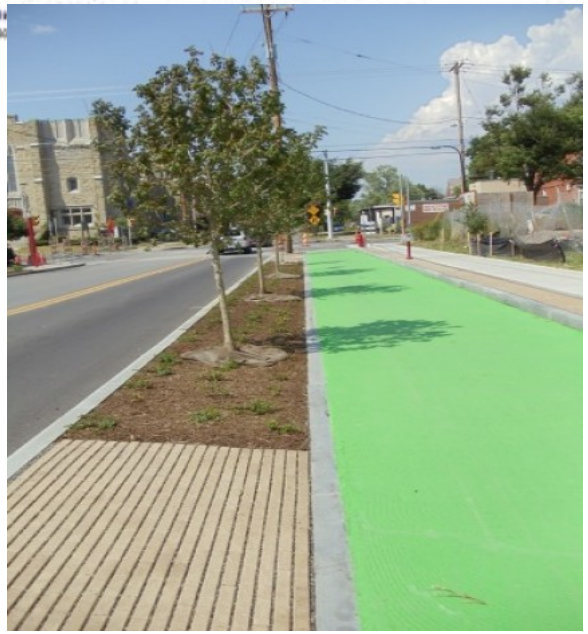
Swales - Maintenance

Maintenance Requirements

- Fertilize and lime as needed to maintain dense vegetation.
- Mow as required during the growing season to maintain grass heights at 4 inches to 6 inches.
- Remove any sediment or debris buildup by hand if possible in the bottom of the channel when the depth reaches 2 inches.
- Inspect for pools of standing water. Regrade to restore design grade and revegetate.
- Repair rills in channel bottom with compacted topsoil, anchored with mesh or filter fabric. Seed and mulch.

Putting it all together

Infiltrating/Filtering Tree Trench w Permeable Pavement

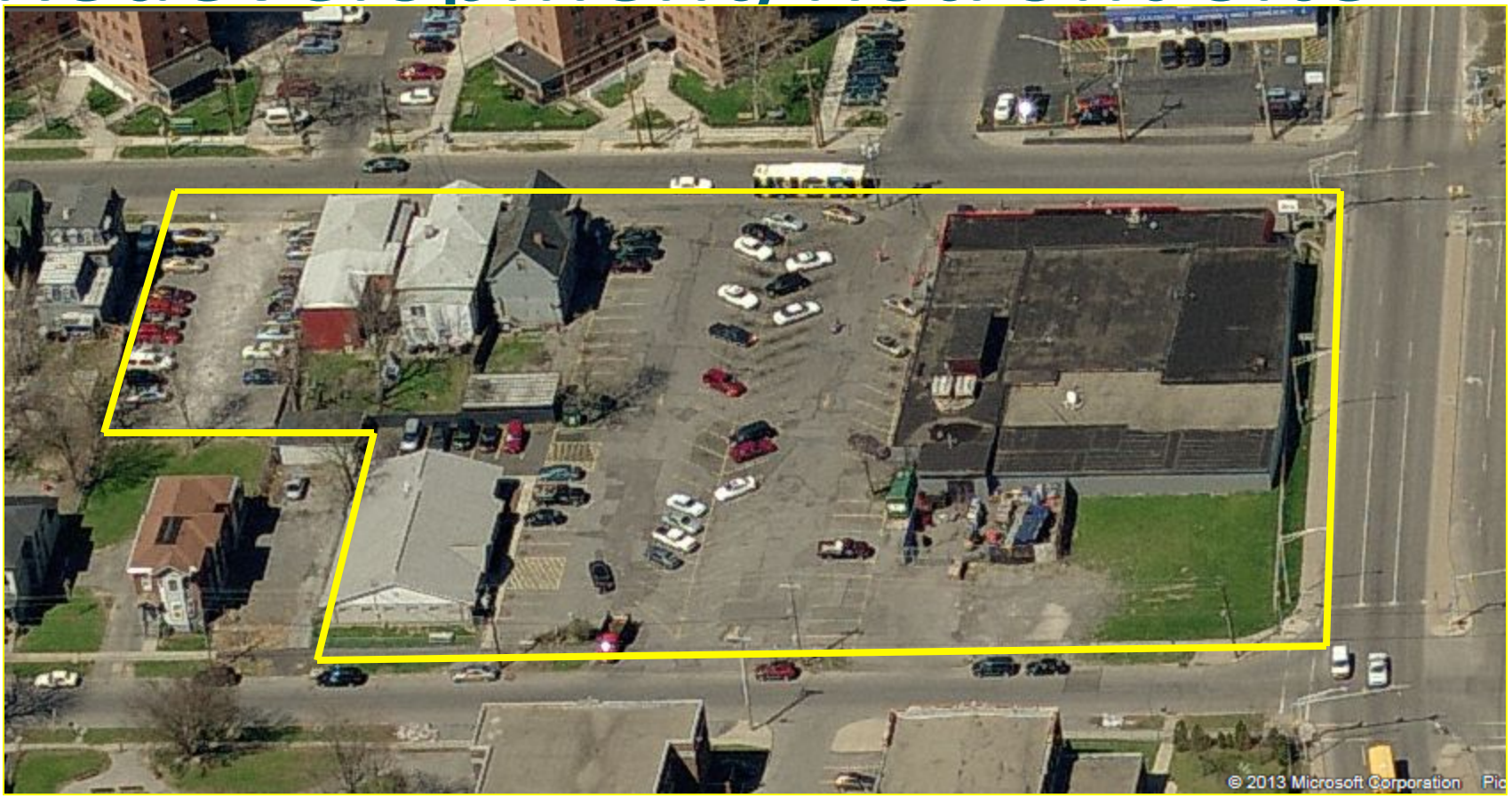


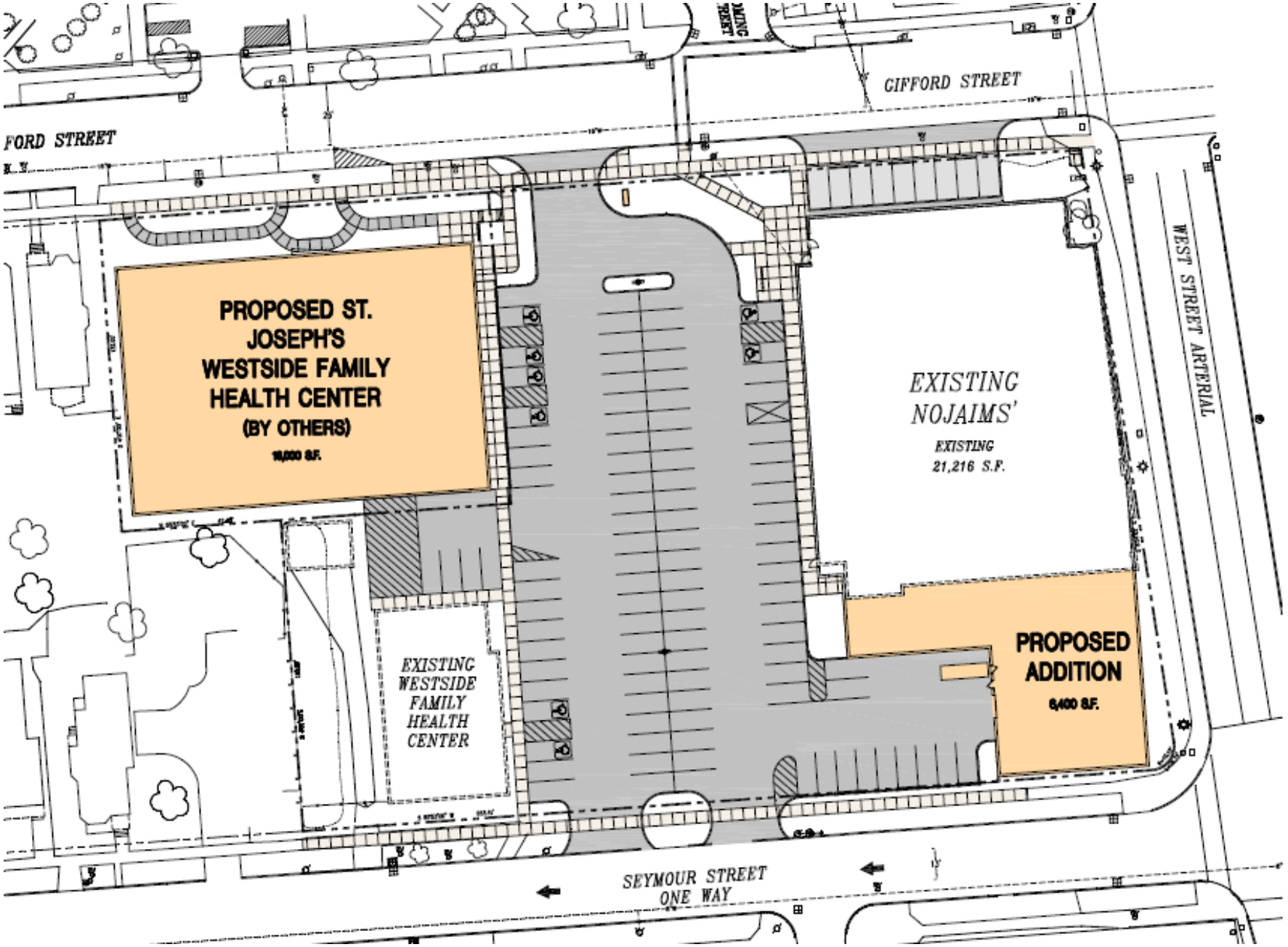

Walnut St
Clinton St
Clinton St


CHAPEL STREET (CALLETT STUDY)
WALNUT STREET (NOW)


Ledyard Creek
CHAPEL STREET
WALNUT STREET
CLINTON STREET
UNIT No. 16
UNIT No. 15
UNIT No. 14
UNIT No. 13
UNIT No. 12
UNIT No. 17
UNIT No. 18
UNIT No. 19
UNIT No. 20
UNIT No. 11
UNIT No. 10
UNIT No. 9
UNIT No. 8
UNIT No. 7
UNIT No. 6
UNIT No. 1
UNIT No. 2
UNIT No. 3
UNIT No. 4
UNIT No. 5

Redevelopment/Retrofit Site




FORD STREET
GIFFORD STREET
WEST STREET ARTERIAL
PROPOSED ST. JOSEPH'S WESTSIDE FAMILY HEALTH CENTER
(BY OTHERS)
16,000 S.F.
EXISTING NOJAIMS'
EXISTING
21,216 S.F.
PROPOSED ADDITION
6,400 S.F.
EXISTING WESTSIDE FAMILY HEALTH CENTER
SEYMOUR STREET
ONE WAY

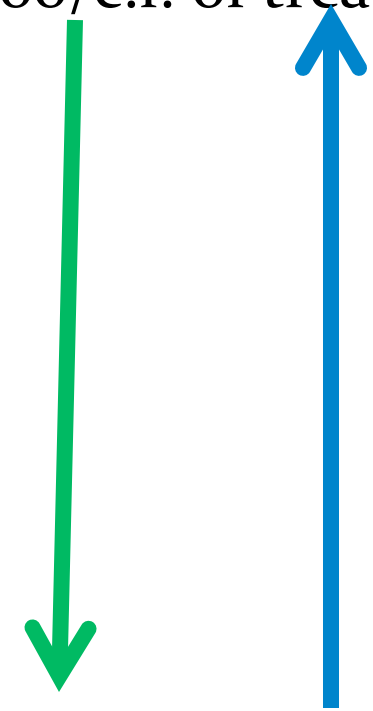
Buying In To It!

GI is essential and Important!

*

- Green Roof
- Perm./porous pave
- Rain Garden
- Planters
- Rain Barrel/Cistern
- Infiltration
- Swales
- Bioretention
- Trees
- Filter strip
- Disconnection

$200/c.f. of treatment.



$1/c.f. of treatment.

* CWP Retrofits Worksheet

Typical GI unit costs:

- Rain garden - $10/s.f.
- Bioretention - $15/s.f.
- Underground infiltration - $25/s.f.
- Green Roof - $8/s.f.
- Porous Pavement - $12/s.f.
- Tree planting - $400 ea
- Tree trench/planter - $25/s.f.
- Cistern - $10/gal
- Drywell - $10/gal
- Green space - $5/s.f.

Contact Info:

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