Green Streets, Clear Skies, Blue Waters

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Sustainable Delaware 2009
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Top Four Environmental Concerns

I'm going to read you a list of environmental problems. As I read each one, please tell me if you personally worry about this problem a great deal, a fair amount, only a little, or not at all. First, how much do you personally worry about ... ?

	Great deal	Fair amount	Only a little/Not at all
	%	%	%
Pollution of drinking water	59	25	16
Pollution of rivers, lakes, and reservoirs	52	31	17
Contamination of soil and water by toxic waste	52	28	19
Maintenance of the nation's supply of fresh water for household needs	49	31	19
Air pollution	45	31	24
The loss of tropical rain forests	42	26	32
Extinction of plant and animal species	37	28	34
The "greenhouse effect" or global warming/ Global warming	34	26	40

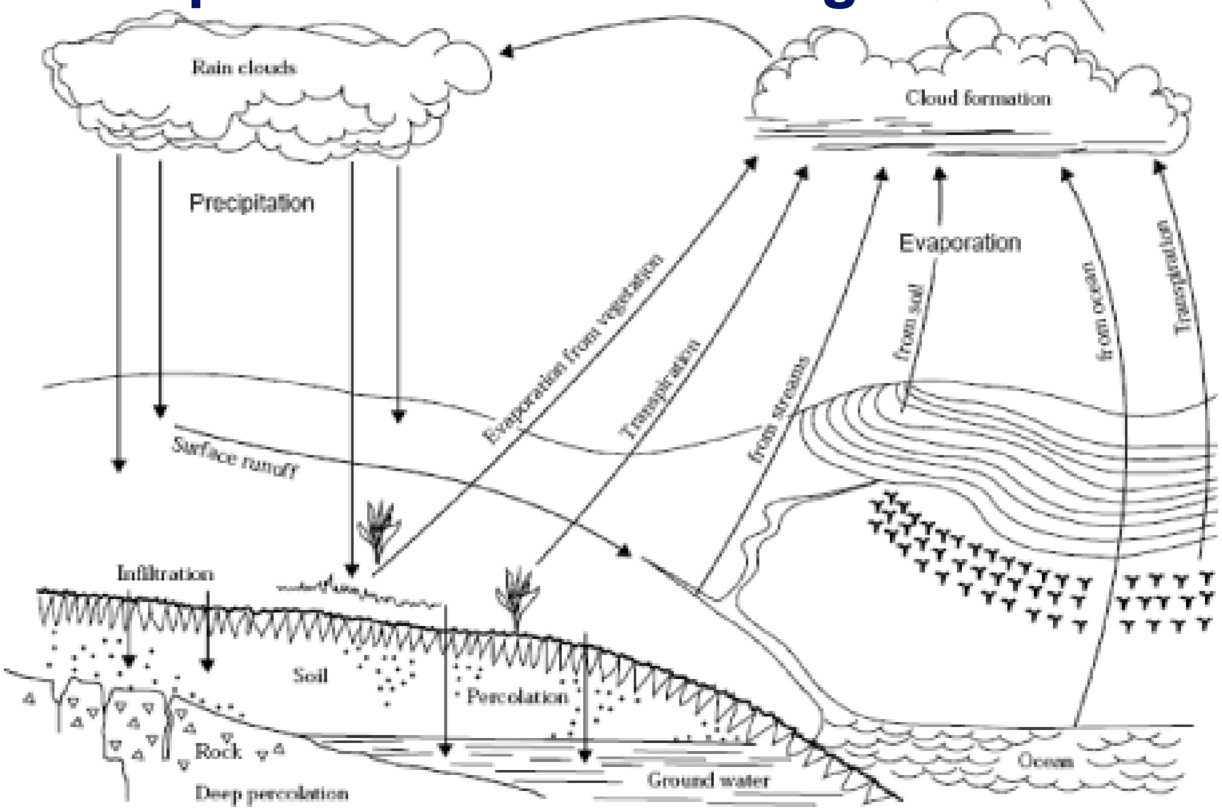
March 5-8, 2009

GALLUP POLL

The top four concerns of Americans are water-related.

The Hydrologic Cycle

Streets and roads accelerate the hydrologic cycle, causing water pollution and flooding.

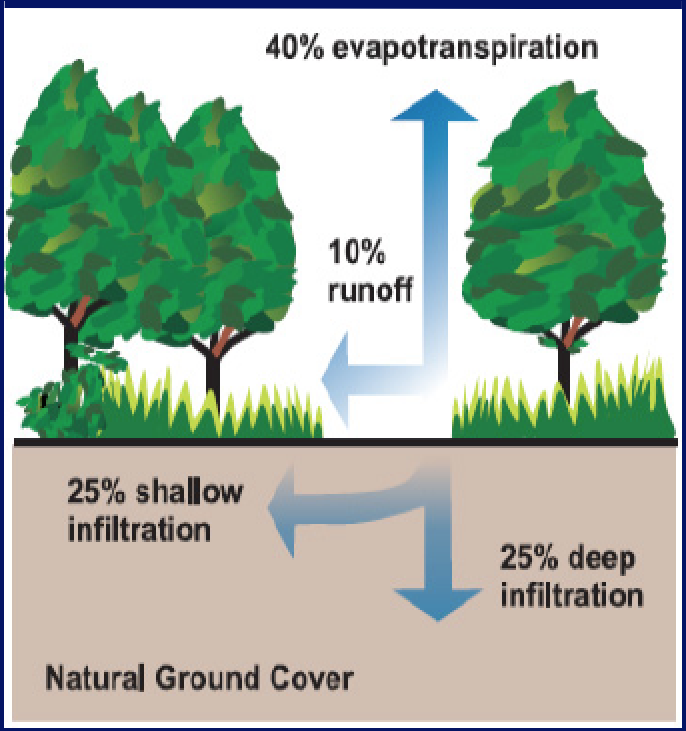


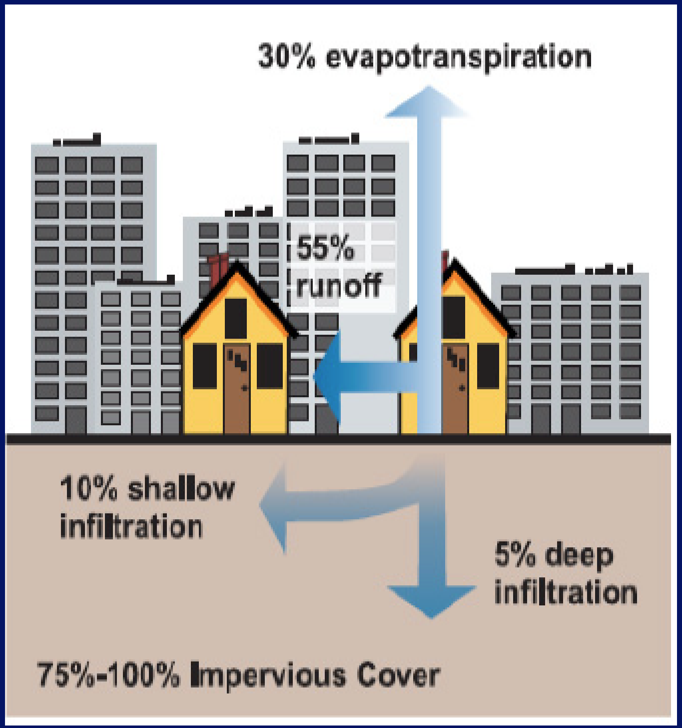
Hydrologic Basis

$$P = R + I + ET - \Delta S$$

Precipitation + Impervious Cover = Stormwater Runoff

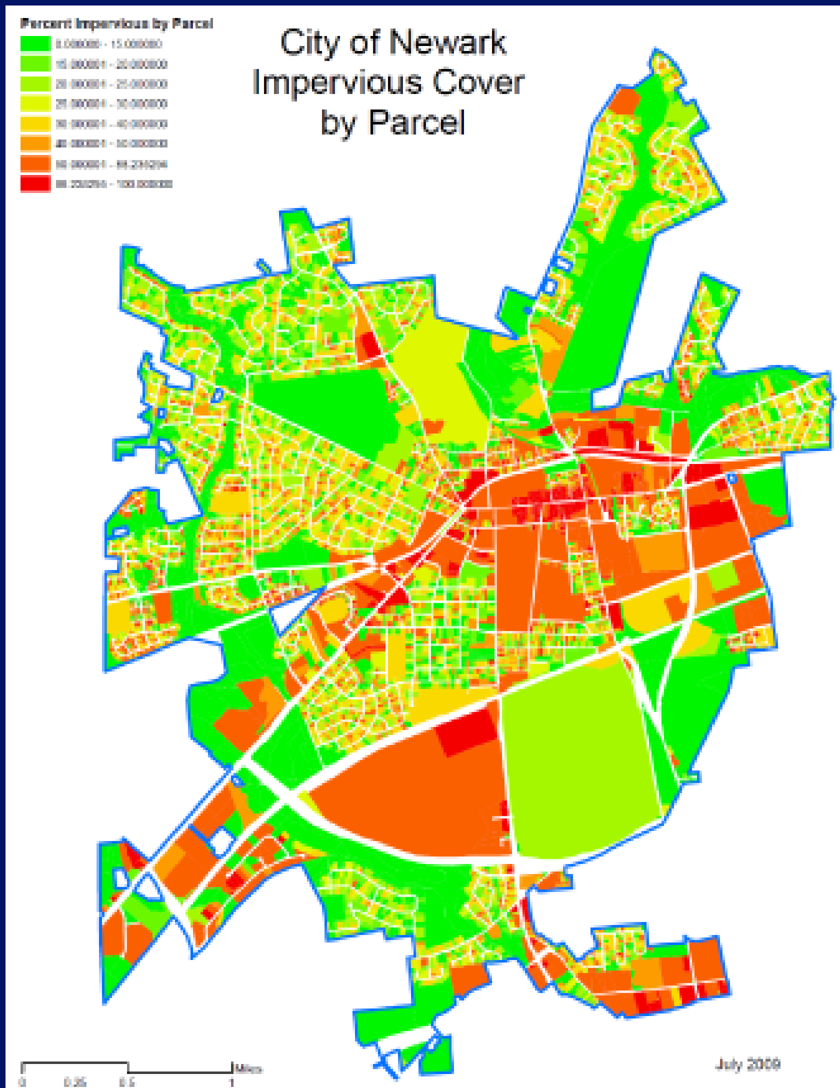
From the Science of Hydrology





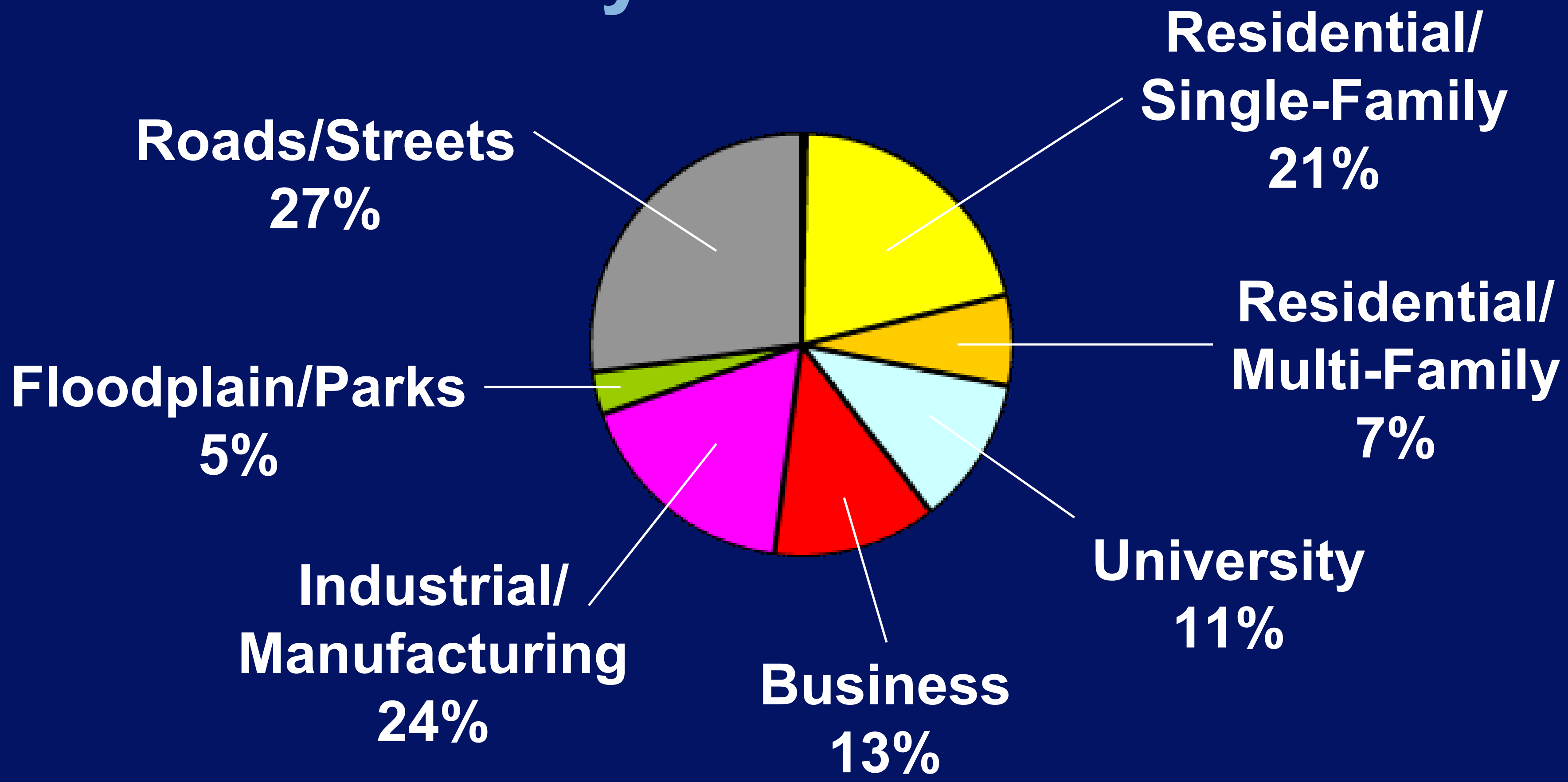
The quantity and quality of stormwater runoff is directly proportional to the amount of impervious roof and pavement area from roads and streets.

City of Newark Impervious Coverage



Over 30% of the City of Newark is covered by impervious roof/pavement.

City of Newark Impervious Cover by Land Use



What's Old Is New

"Architects have employed green street design for centuries."

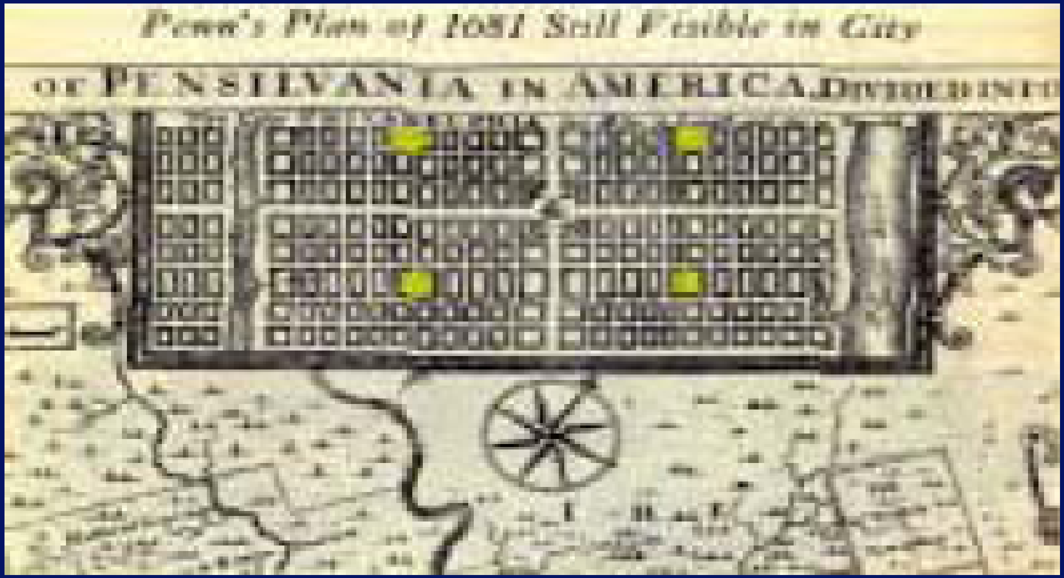
- **Greene Countrie Towne** (William Penn 1682)
- **Garden City** (late 18th century)
- **City Beautiful** (early 20th century)
- **Country Place Era** (roaring '20s)
- **Greenbelt** (1930s, Roosevelt's New Deal)
- **New Urbanism** (21st century)
- **Low-Impact Development**
- **Smart Growth**

300 BCE - Appian Way, Rome

Quote from William Penn

"Let every house be placed…in the middle of its plat, as to the breadthway of it, so that there may be ground on each side for gardens or orchards, or fields, that it may be a greene country towne, which will never be burnt and always wholesome."

William Penn, 30th of Sept., 1681, Philadelphia

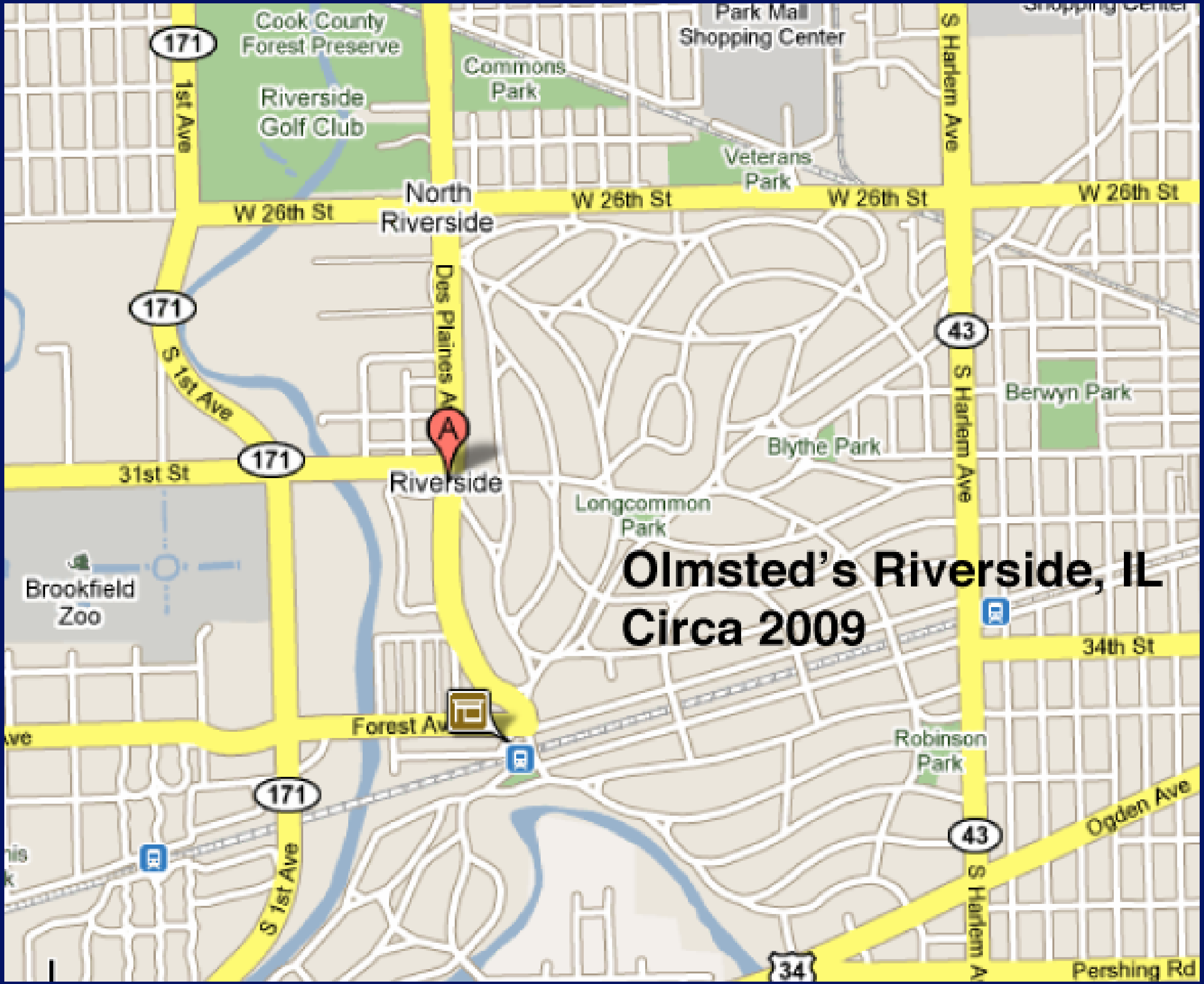


18th Century Philadelphia

Philadelphia, Near Independence Hall

Olmstead's Riverside, Illinois, c. 1870

Olmstead's Riverside, Illinois, Today



Riverside, Illinois

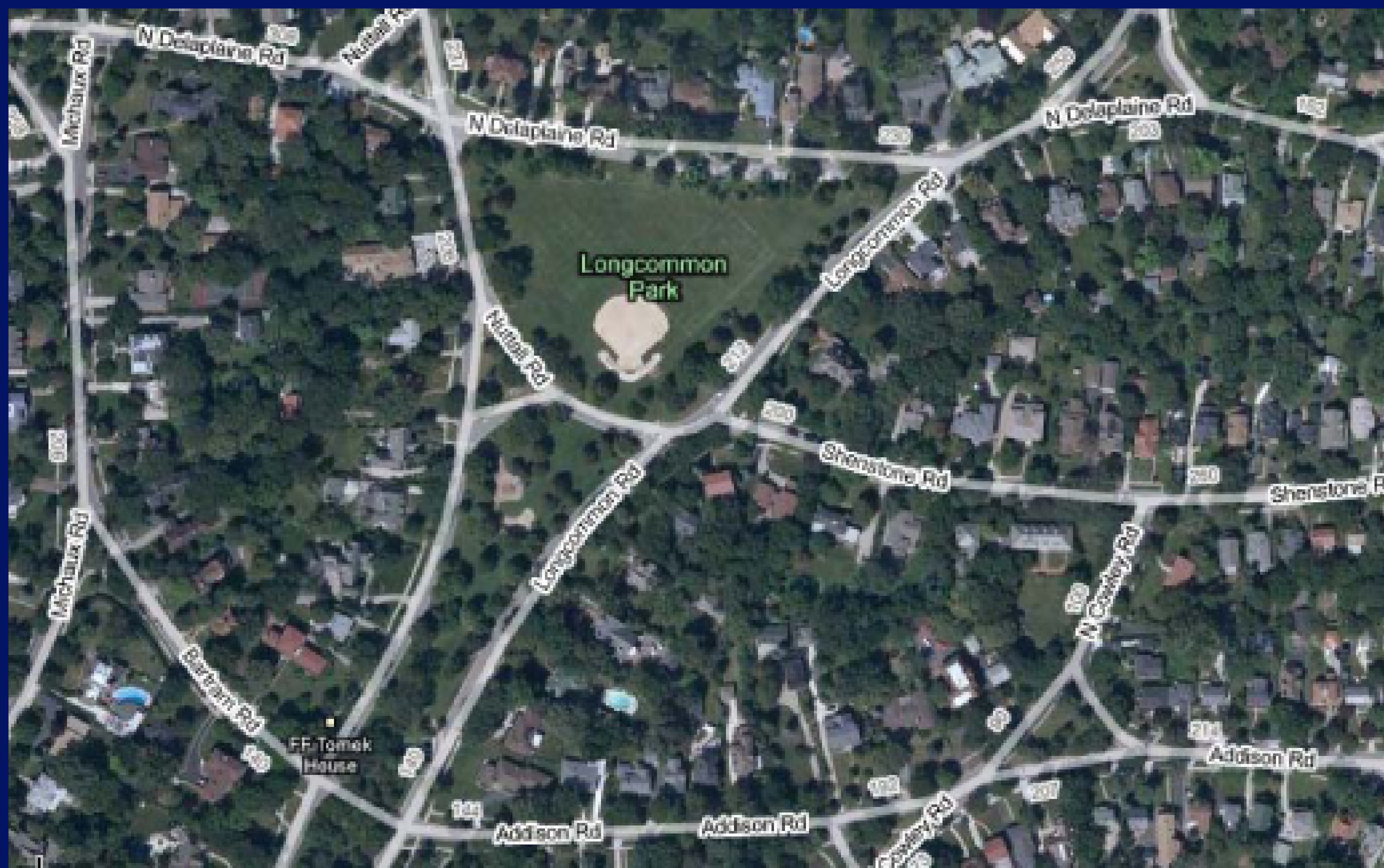
- Olmsted and Vaux designed in 1868
- 1600 acres total, 1000 acres as open space
- Shaded parkway and boulevards
- Preserved floodplain and parks
- Curved streets, following land contours
- Absence of perpendicular intersections
- Narrow streets, 18 ft.
- Minimize sidewalks
- F. L. Wright and J. Jensen built prairie-style homes here that incorporated green principles.

Olmstead's Design Principles

- Walks/roads designed for positive drainage
- 600 ft. to open space from residence
- Transportation to city via railroad and parkway
- Separate walking paths from driving
- 100-ft. lot frontage
- 30-ft. minimum setback
- Visual access to open space
- Triangle parks
- Sunken roads

Olmstead’s Riverside, Illinois, Today

Notice triangular parks and narrow 18-ft.-wide roads.



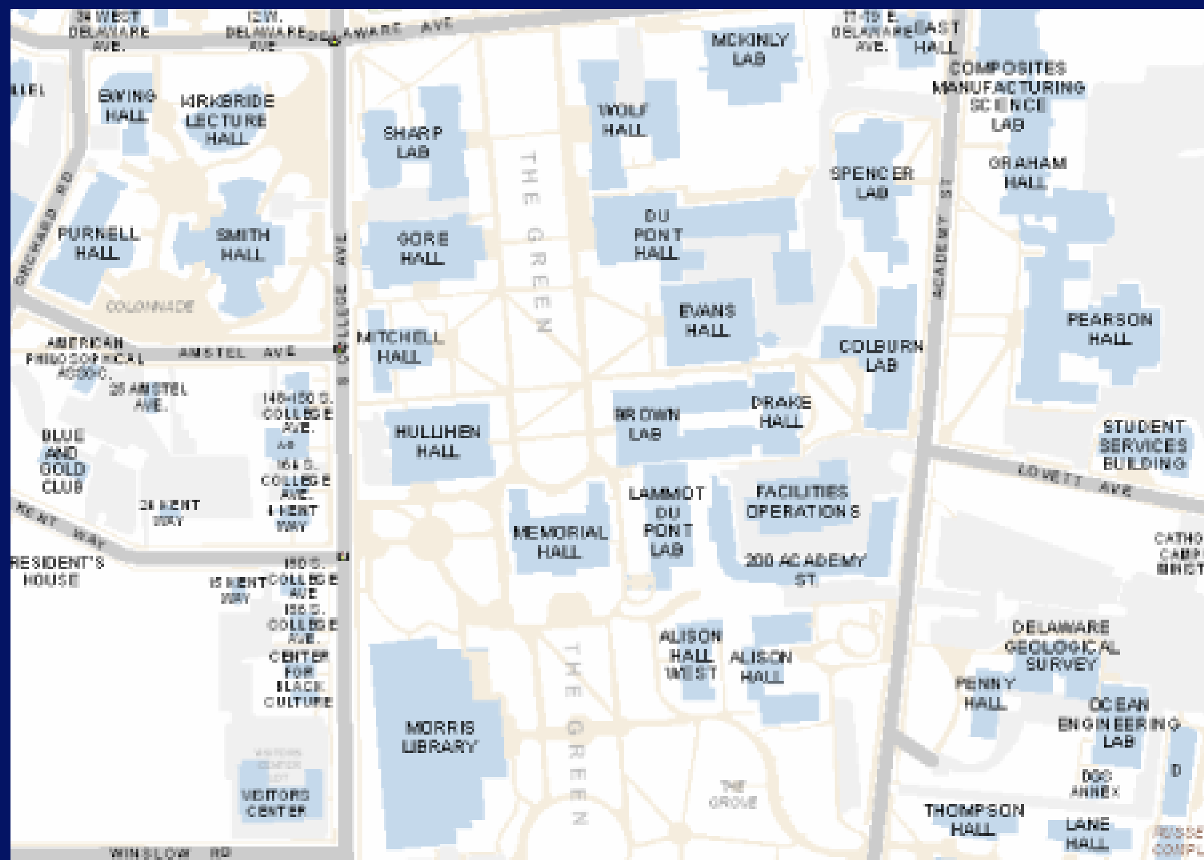
Olmstead's Riverside, Illinois, Today

Notice triangular parks and narrow 18-ft.-wide roads.

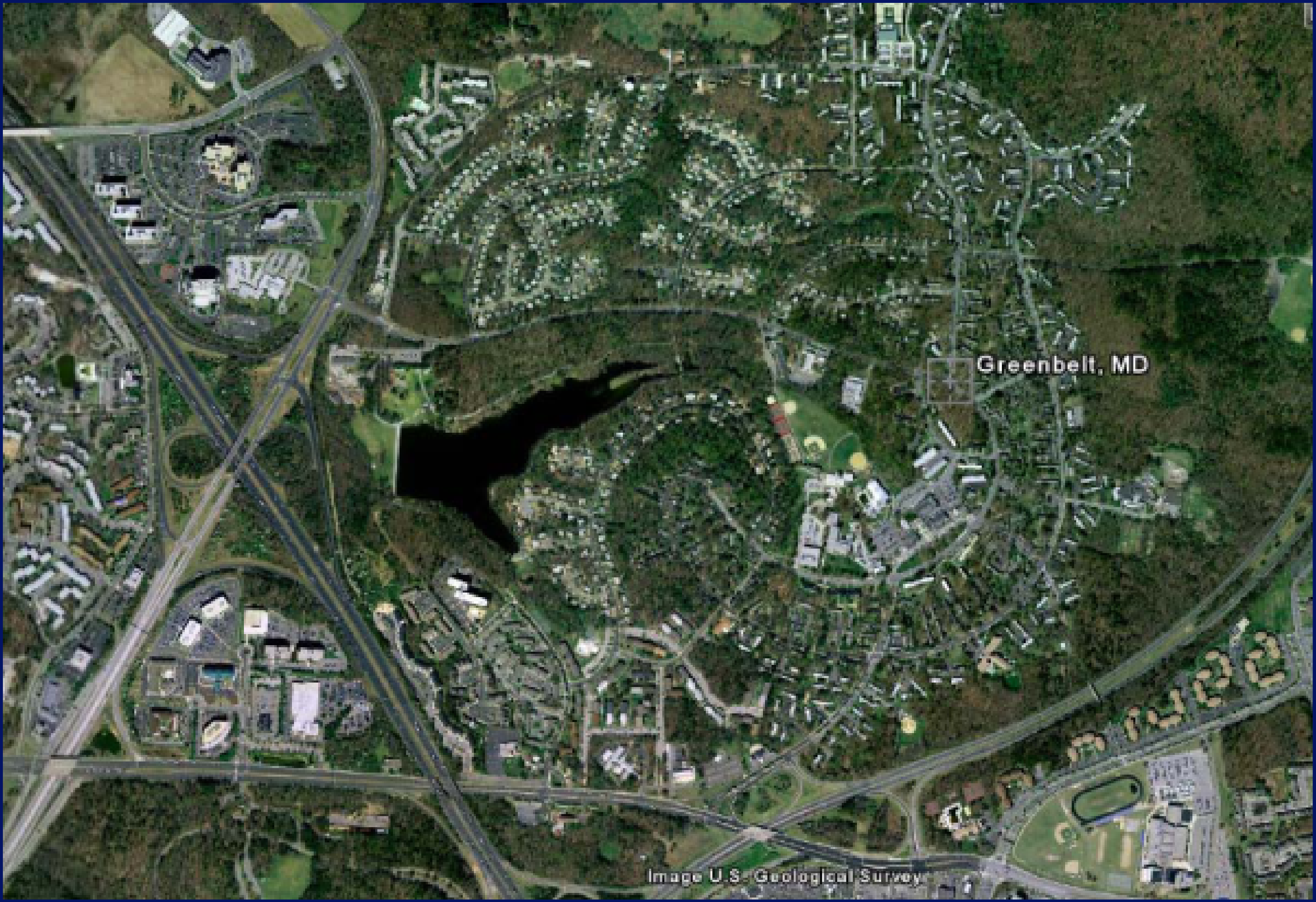
University of Delaware Campus

Marian Coffin (1920s) drew landscape plans during Country Place Era. UD campus a giant city block.

Optimum Pedestrian floor/area ratio = 0.75



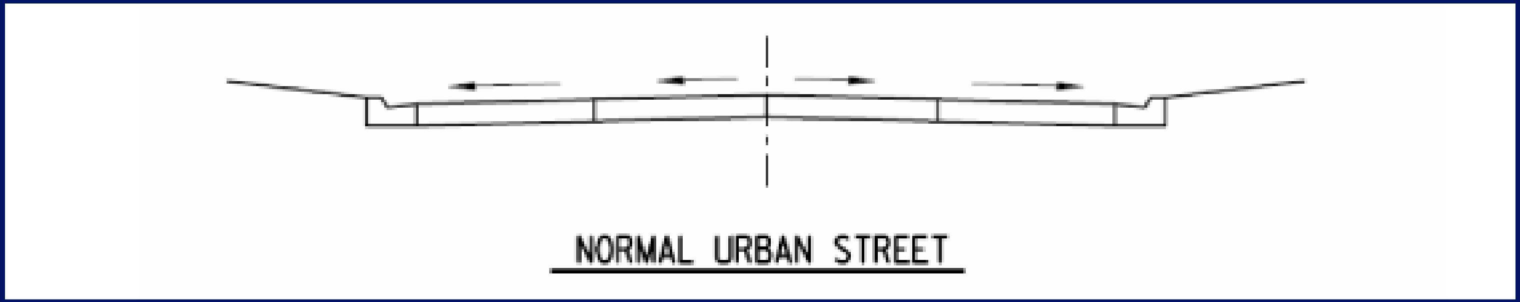
Greenbelt, Maryland, 1930s

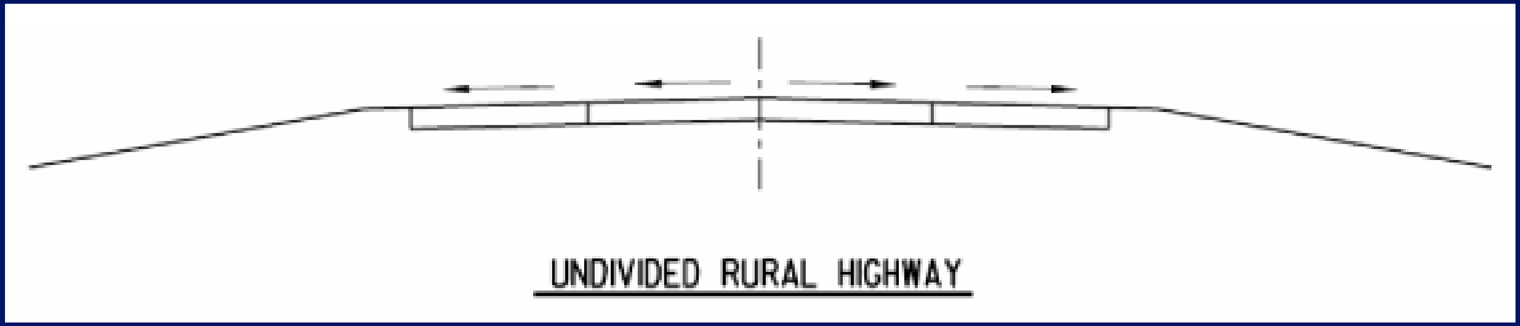


Greenbelt, Maryland, 1930s

Typical Street Design Cross-section

Highway and street design manuals (DelDOT typ.) require wide street cross-sections. These show typical 48-ft. streets, 12-ft. lanes.





Arden, Delaware, Built 1900

Comparison of Road Widths

Typical New Construction

The Math of Street Impervious

Street pavement cost per mile
(2-in. asphalt @ $\$10/yd^2$)

- **32-ft. street = 168,960 ft^2 = 18,773 yd^2 = $187,730**
- **24-ft. street = 126,720 ft^2 = 14,080 yd^2 = $140,800**
- **18-ft. street = 95,040 ft^2 = 10,560 yd^2 = $105,560**

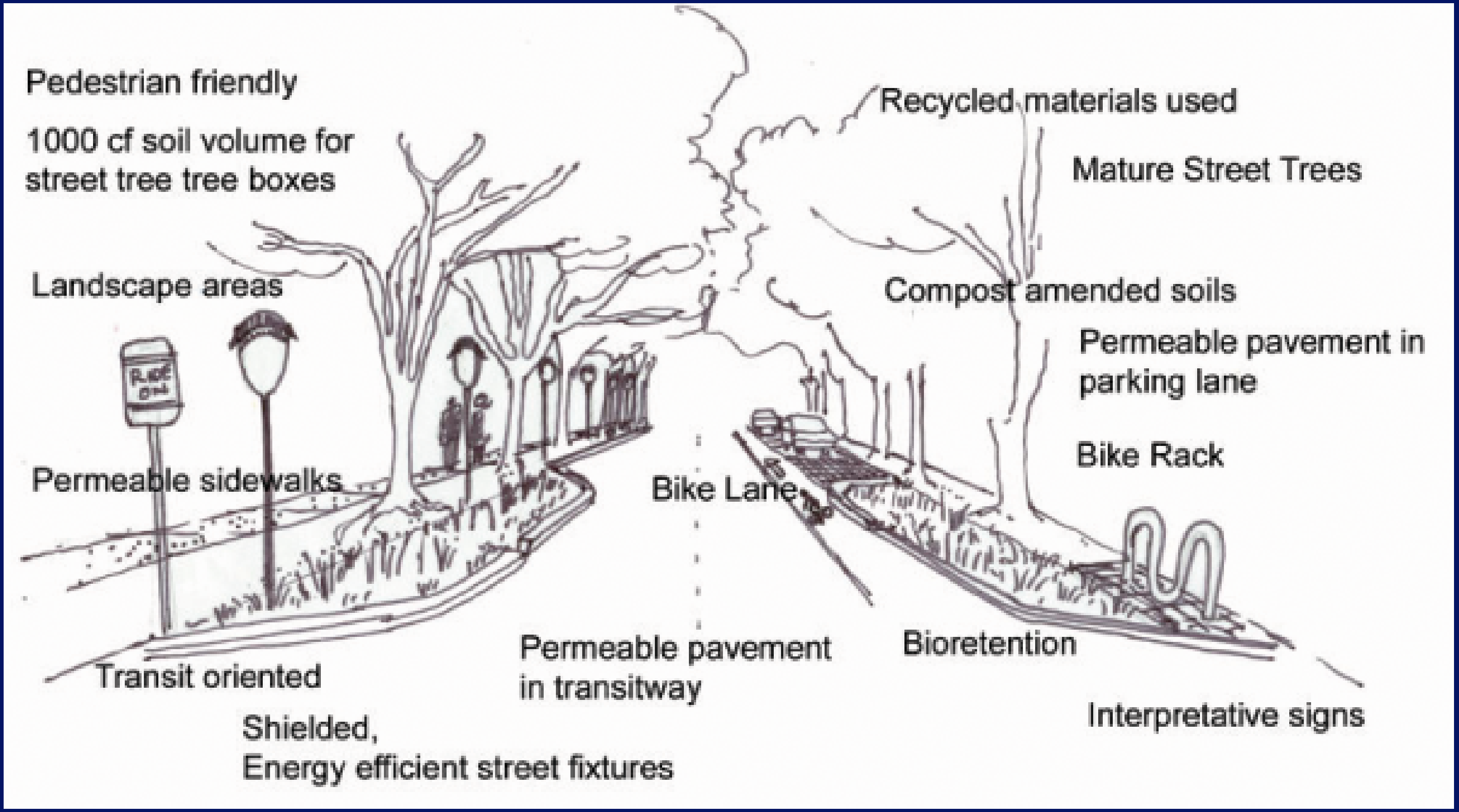
"Green Street" Techniques

"available to mitigate impervious impacts"

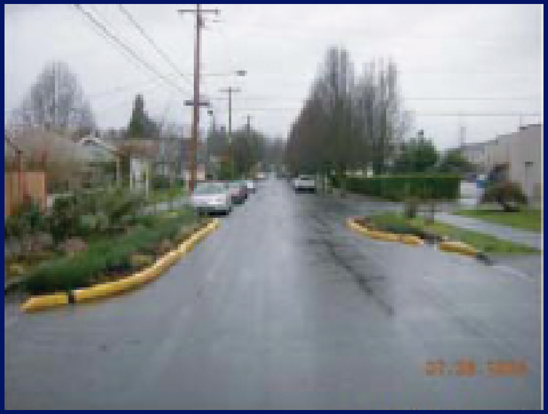
- 1. Rain Harvesting
- 2. Rain Gardens
- 3. Stormwater Planters
- 4. Permeable Paving
- 5. Green Roofs

Sources: Cities of Portland and Seattle and EPA

Anatomy of a Green Street



Examples



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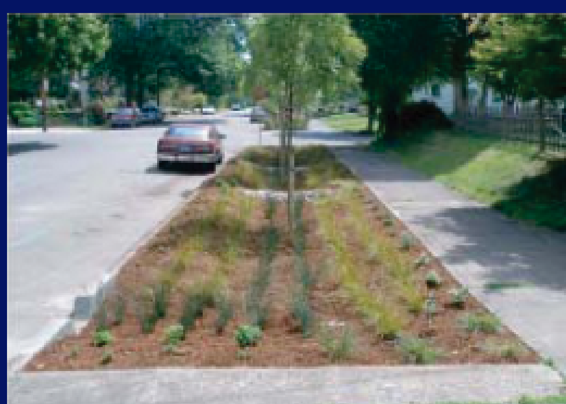
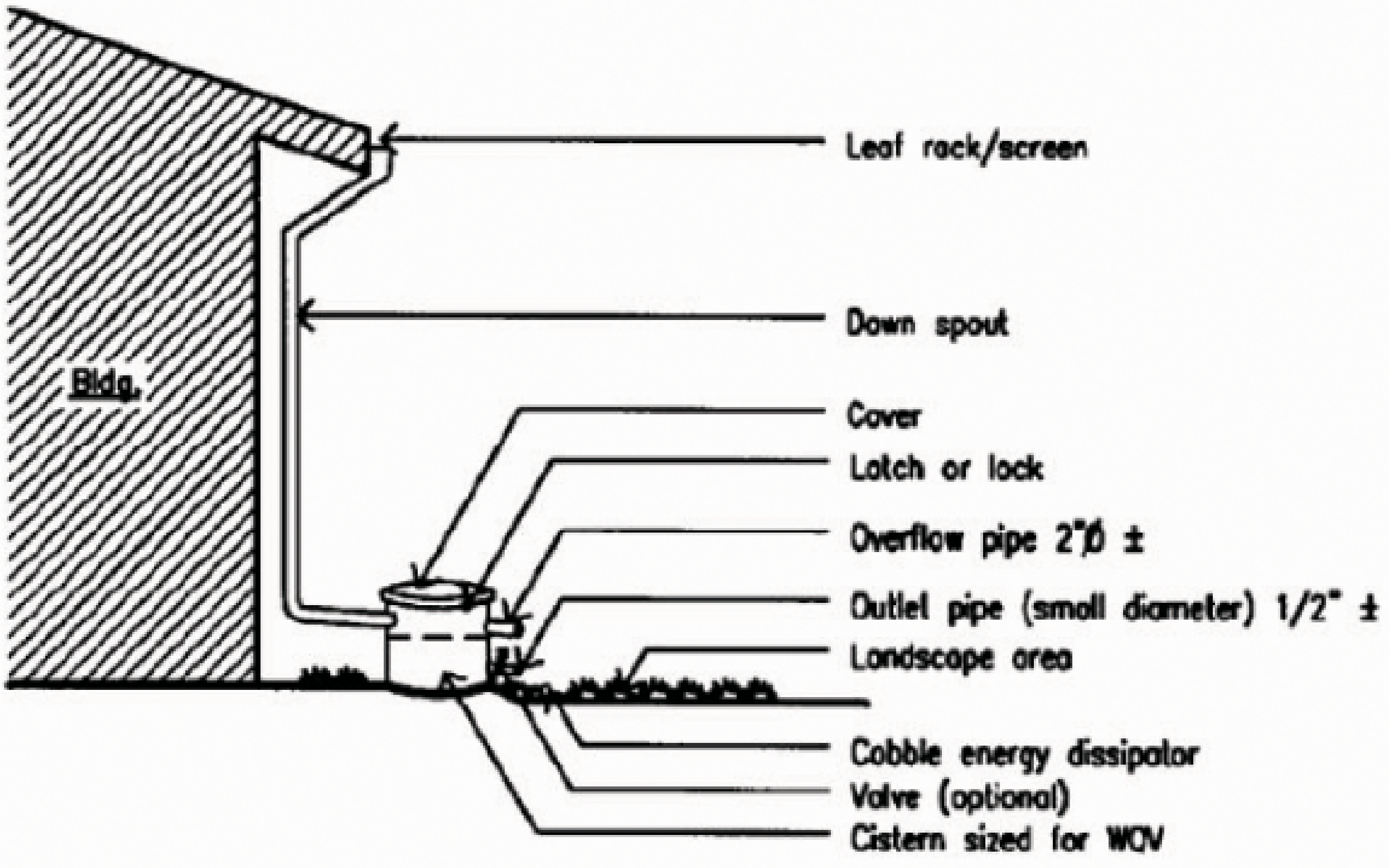


Examples

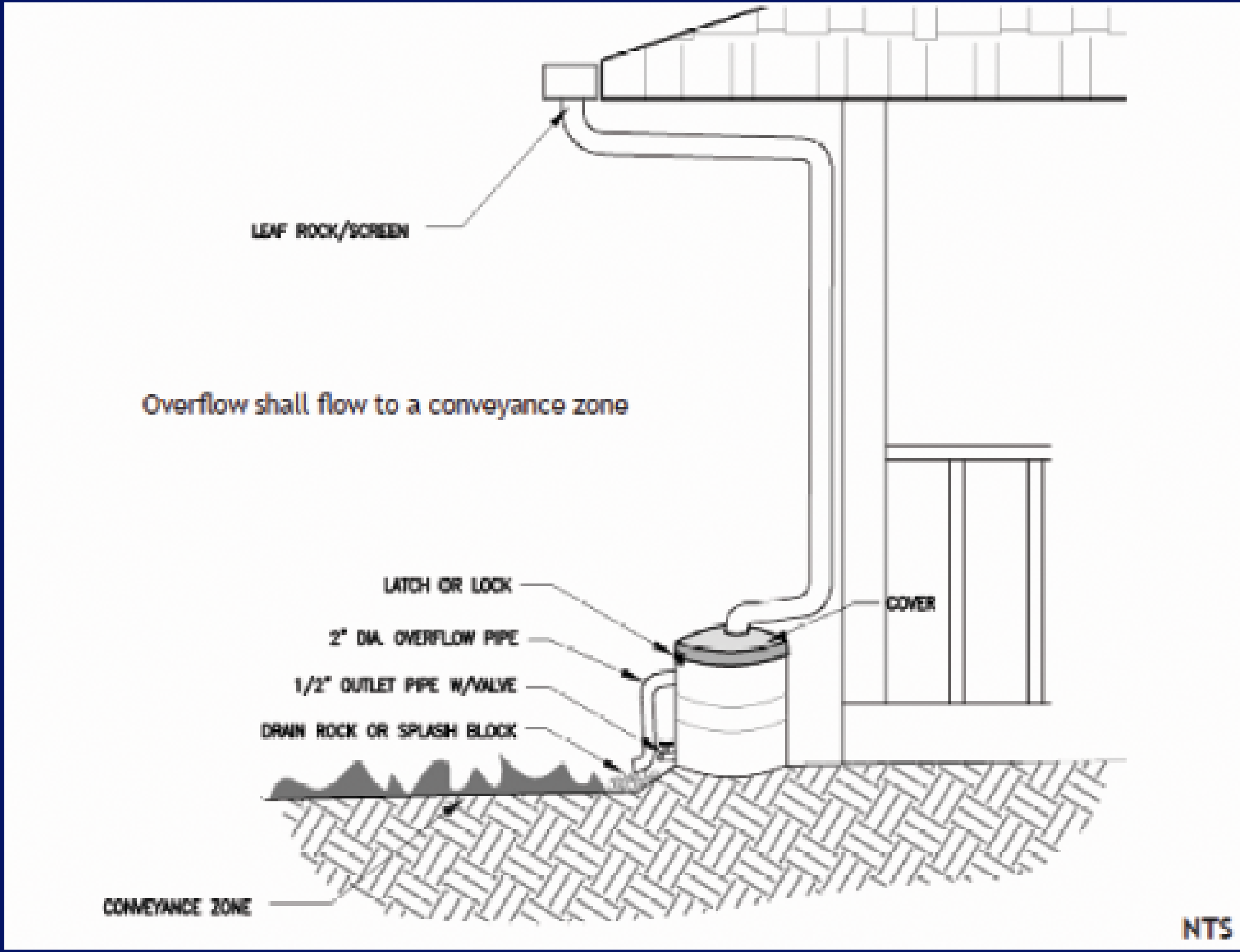

Replace Existing Bioretention
Pavement Practices
38th Street
Gutter Filters
Bioretention Cell
34th Street
Route 1
Bioretention Cell
33rd Street
Bus Depot
Eastern Ave.
Street Tree Filters

1. Rain Harvesting



Bay Area Stormwater Management Agencies Association, *Start at the Source* (1999)

Rain Barrel Connected to Downspout

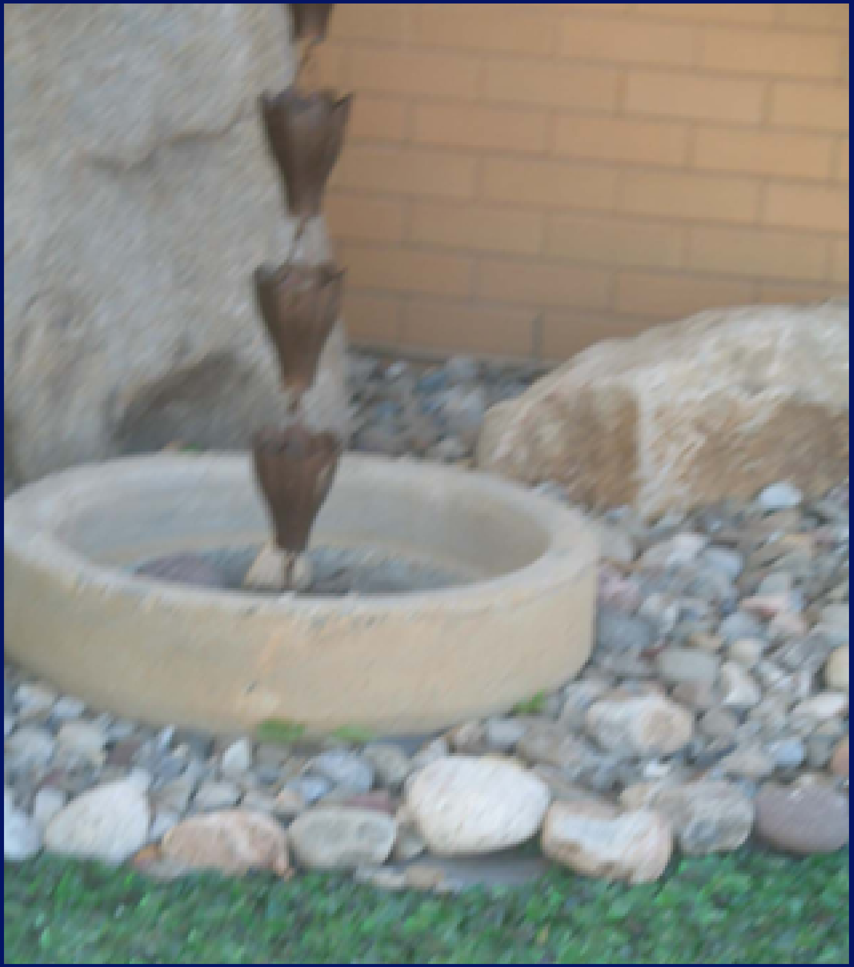


Examples

Chicago

Cisterns at CBF Headquarters

Rain Spout

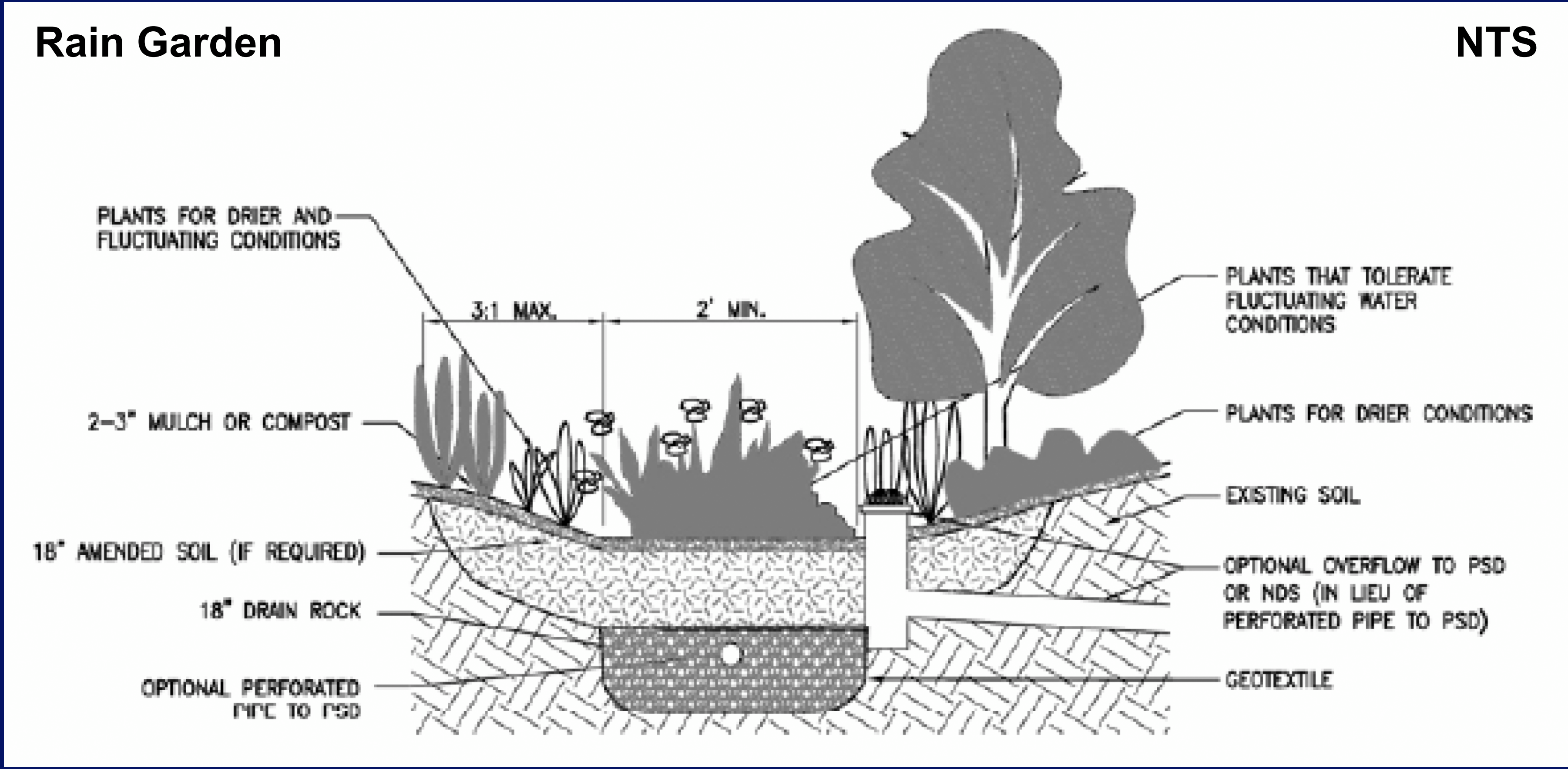


Dansko, West Grove, Pa.

Cistern


Cistern
Rain, stream, ocean
Woodlawn Library
Wilmington, Del.
TOYOTA

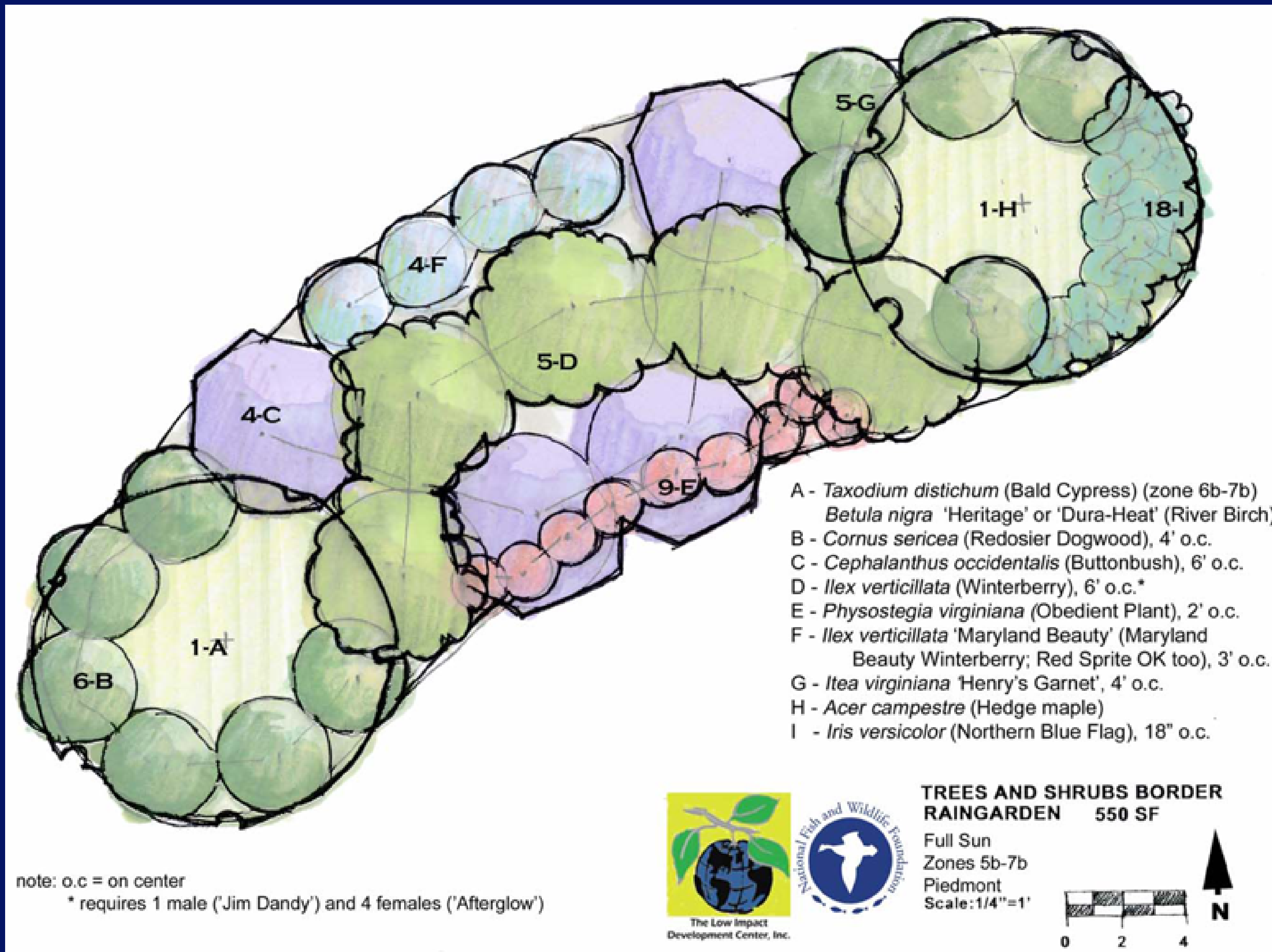
2. Rain Gardens



Residential Rain Garden

Rain gardens can be planted and shaped to fit the character of individual residences.

Design


5-G
1-H
18-I
4-F
5-D
4-C
9-E
1-A
6-B
A - Taxodium distichum (Bald Cypress) (zone 6b-7b)
Betula nigra 'Heritage' or 'Dura-Heat' (River Birch)
B - Cornus sericea (Redosier Dogwood), 4' o.c.
C - Cephalanthus occidentalis (Buttonbush), 6' o.c.
D - Ilex verticillata (Winterberry), 6' o.c.*
E - Physostegia virginiana (Obedient Plant), 2' o.c.
F - Ilex verticillata 'Maryland Beauty' (Maryland Beauty Winterberry; Red Sprite OK too), 3' o.c.
G - Itea virginiana 'Henry's Garnet', 4' o.c.
H - Acer campestre (Hedge maple)
I - Iris versicolor (Northern Blue Flag), 18" o.c.
note: o.c = on center
* requires 1 male ('Jim Dandy') and 4 females ('Afterglow')
The Low Impact Development Center, Inc.
National Fish and Wildlife Foundation
TREES AND SHRUBS BORDER RAINGARDEN 550 SF
Full Sun
Zones 5b-7b
Piedmont
Scale: 1/4"=1'
0 2 4
N

Rain Garden

Rain Garden

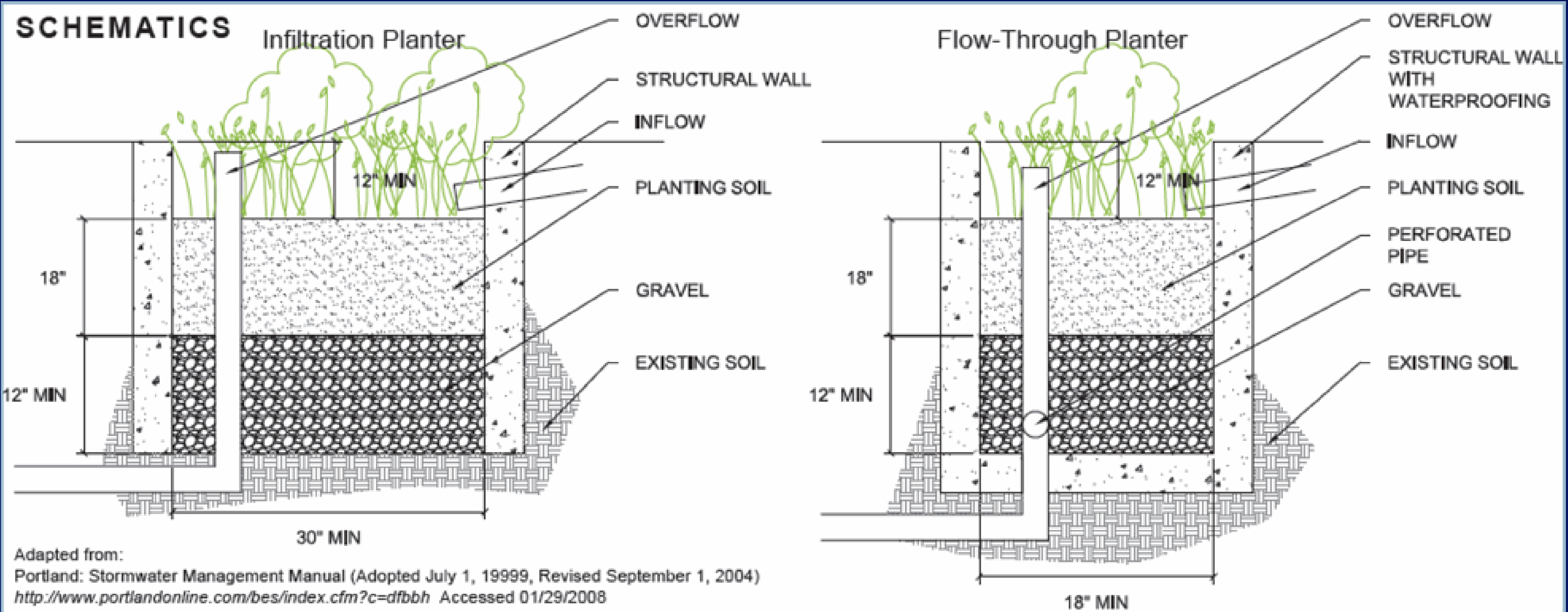
UD Rain Garden Educational Signage

UD Rain Garden

UD Rain Garden

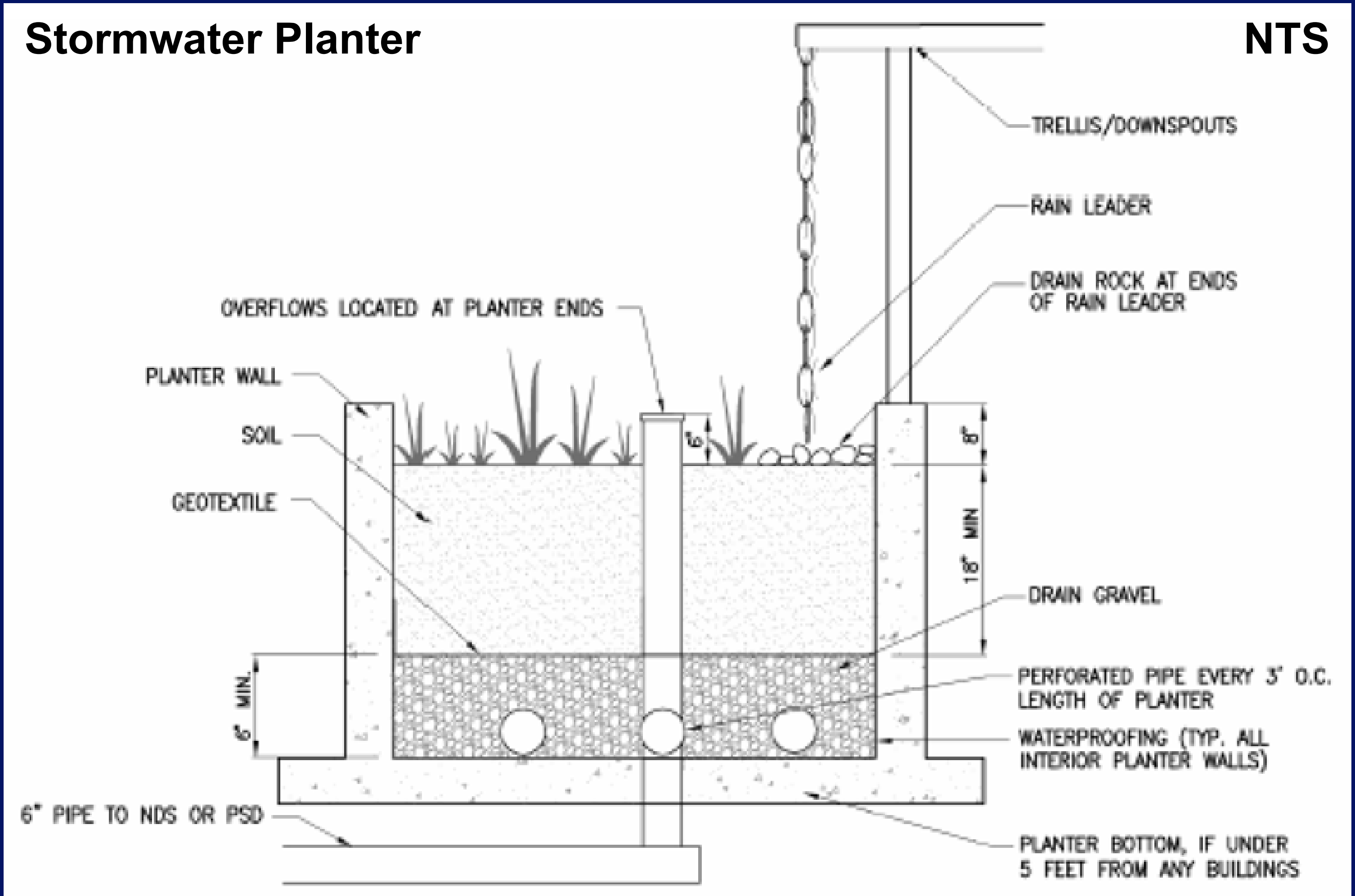
Rain Garden

3. Stormwater Planters



Adapted from:
Portland: Stormwater Management Manual (Adopted July 1, 19999, Revised September 1, 2004)
http://www.portlandonline.com/bes/index.cfm?c=dfbbh Accessed 01/29/2008

Stormwater Planters



Stormwater Planters

Stormwater Planter

Alternative Names: Infiltration Planter, Flow-Through Planter, Contained Planter

Vastra Hamnen, Malmo, Sweden
Stephanie Hurley 2007

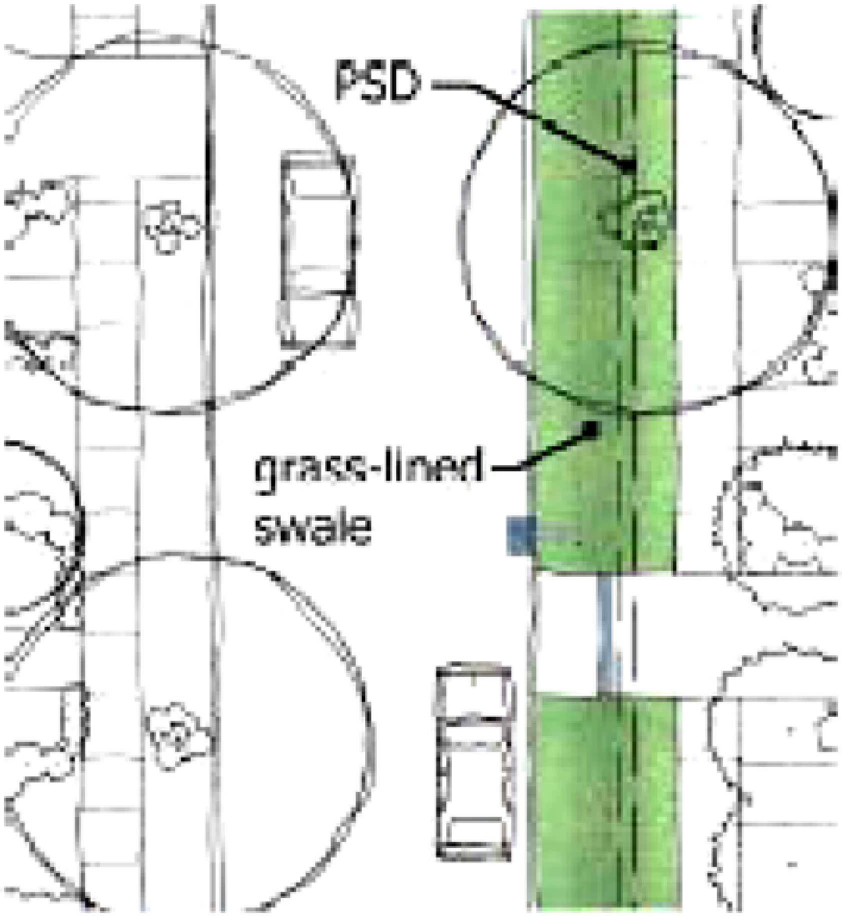
DESCRIPTION

A stormwater planter is a small, contained vegetated area that collects and treats stormwater using bioretention. Bioretention systems collect and filter stormwater through layers of mulch, soil and plant root systems, where pollutants such as bacteria, nitrogen, phosphorus, heavy metals, oil and grease are retained, degraded and absorbed. Treated stormwater is then infiltrated into the ground as groundwater (Infiltration Planter) or, if infiltration is not appropriate, discharged into a traditional stormwater drainage system (Flow-Through Planter). Stormwater planters do not require a large amount of space and can add aesthetic appeal and wildlife habitat to city streets, parking lots, and commercial and residential properties. Stormwater planters typically contain native, hydrophilic flowers, grasses, shrubs and trees.

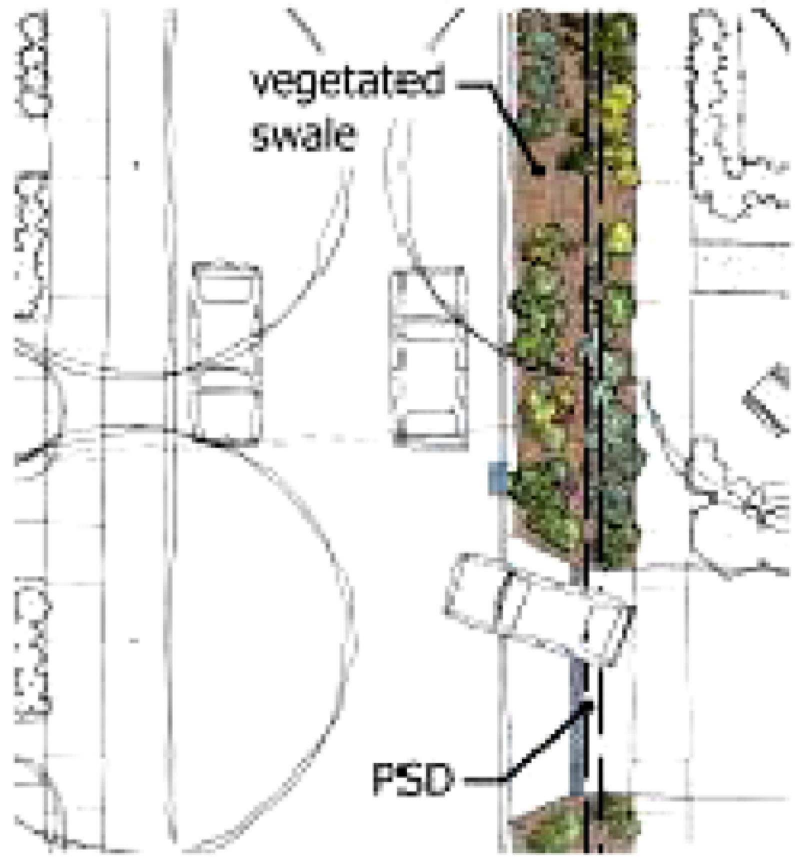
Street-side Application

Street-side Application

Street-side Application



Grass-lined swale in the NDS with the PSD buried below



Vegetated swale in the NDS with the PSD buried below

Example Swales

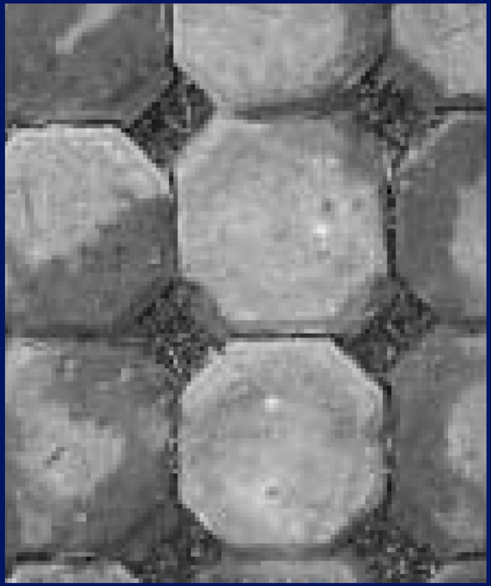
NDS
(grass-lined swale in ROW)

NDS
(vegetated swale in ROW)

Example

4. Permeable Paving

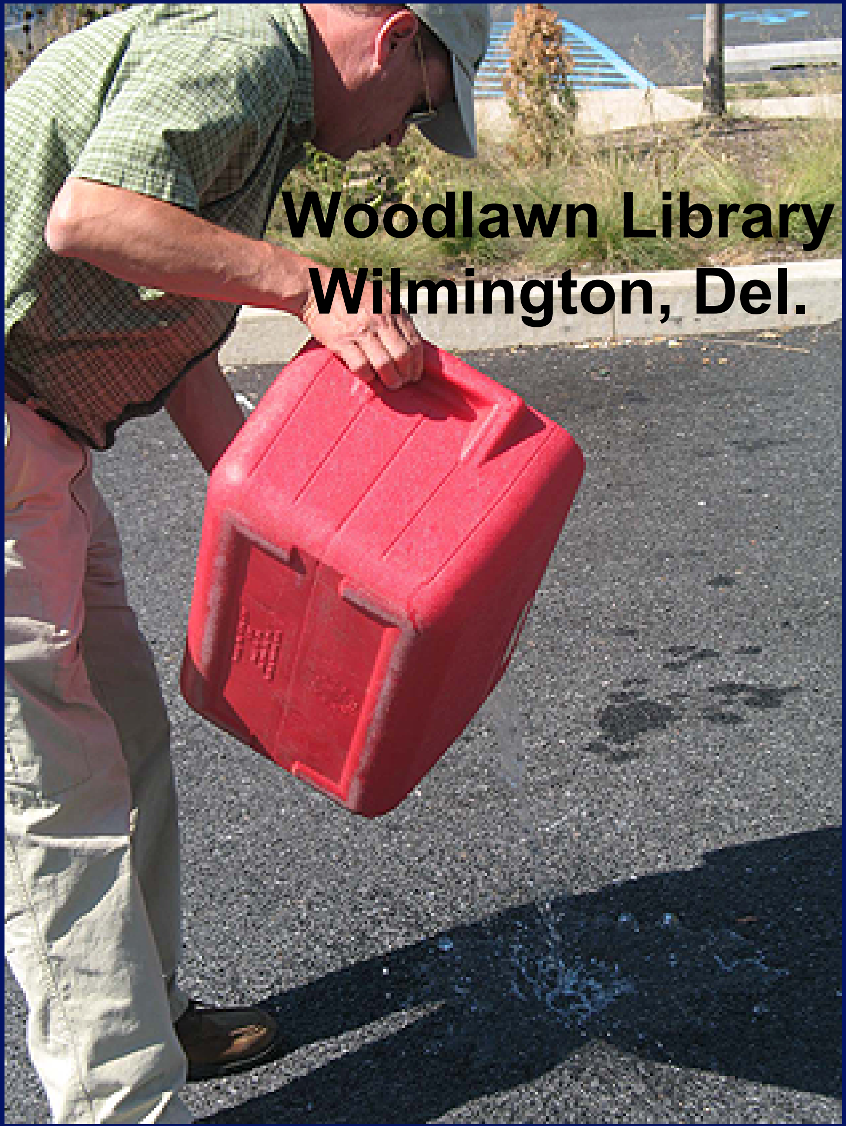
water infiltrates through porous gravel mat



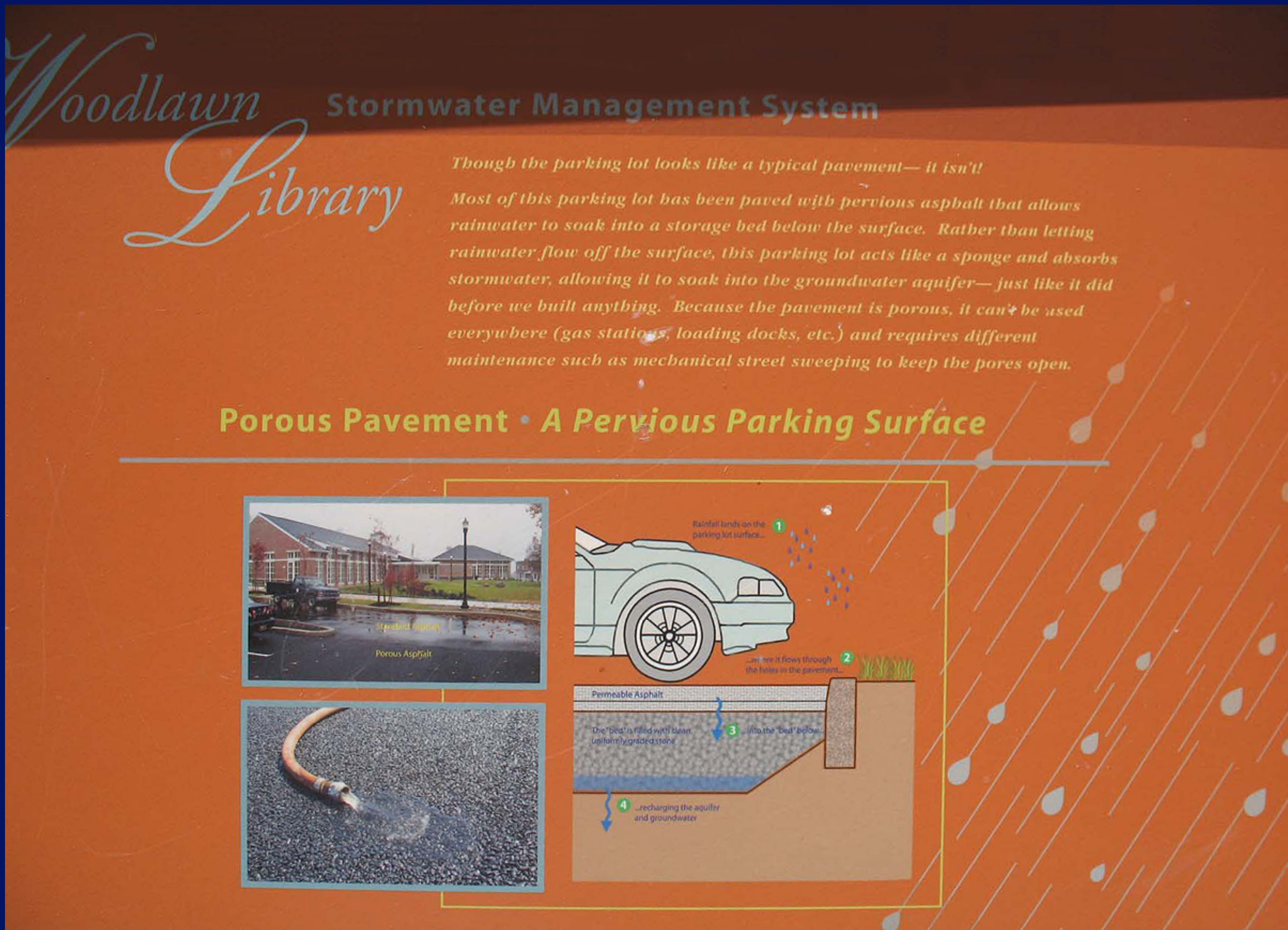
pavers on a porous base with sand-filled joints

water passes through void spaces in porous concrete

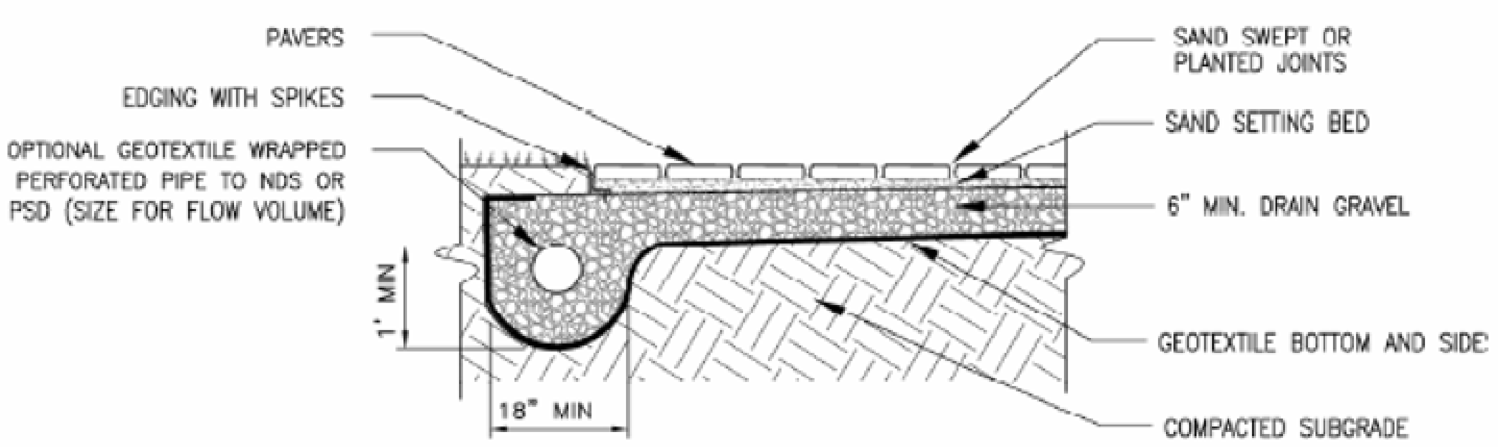
Permeable Paving



Woodlawn Library, Wilmington, Del.



Porous Asphalt



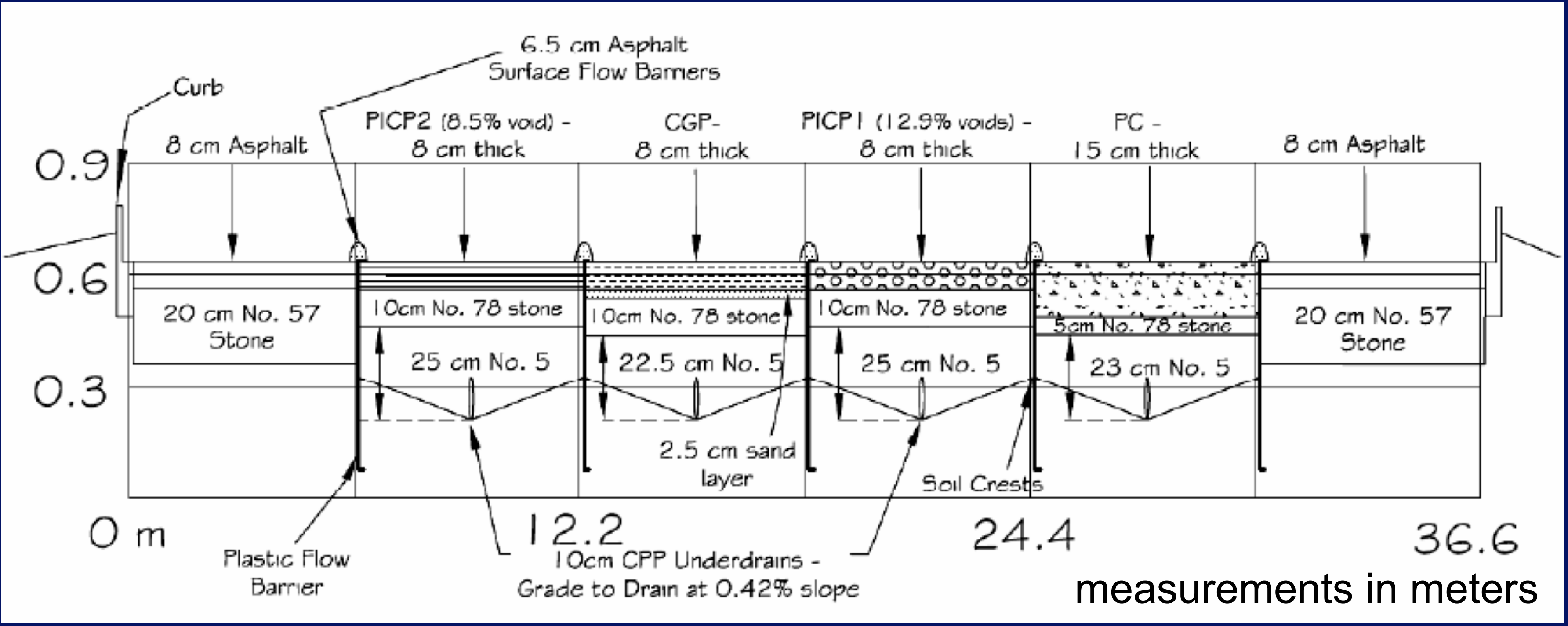
Pavers on a porous base **NTS**

Porous asphalt is a surface that is designed to allow infiltration. This material can be used for vehicular or pedestrian areas. Suppliers may require a minimum order due to asphalt-manufacturing limitations.

Examples of Permeable Pavement

Permeable pavement sections surfaced with (left to right) pervious concrete, permeable interlocking concrete pavers with 12.9% open surface area (PICP1), concrete grid pavers, and permeable interlocking concrete pavers with 8.5% open surface area (PICP2).

Parking Lot Cross-Section

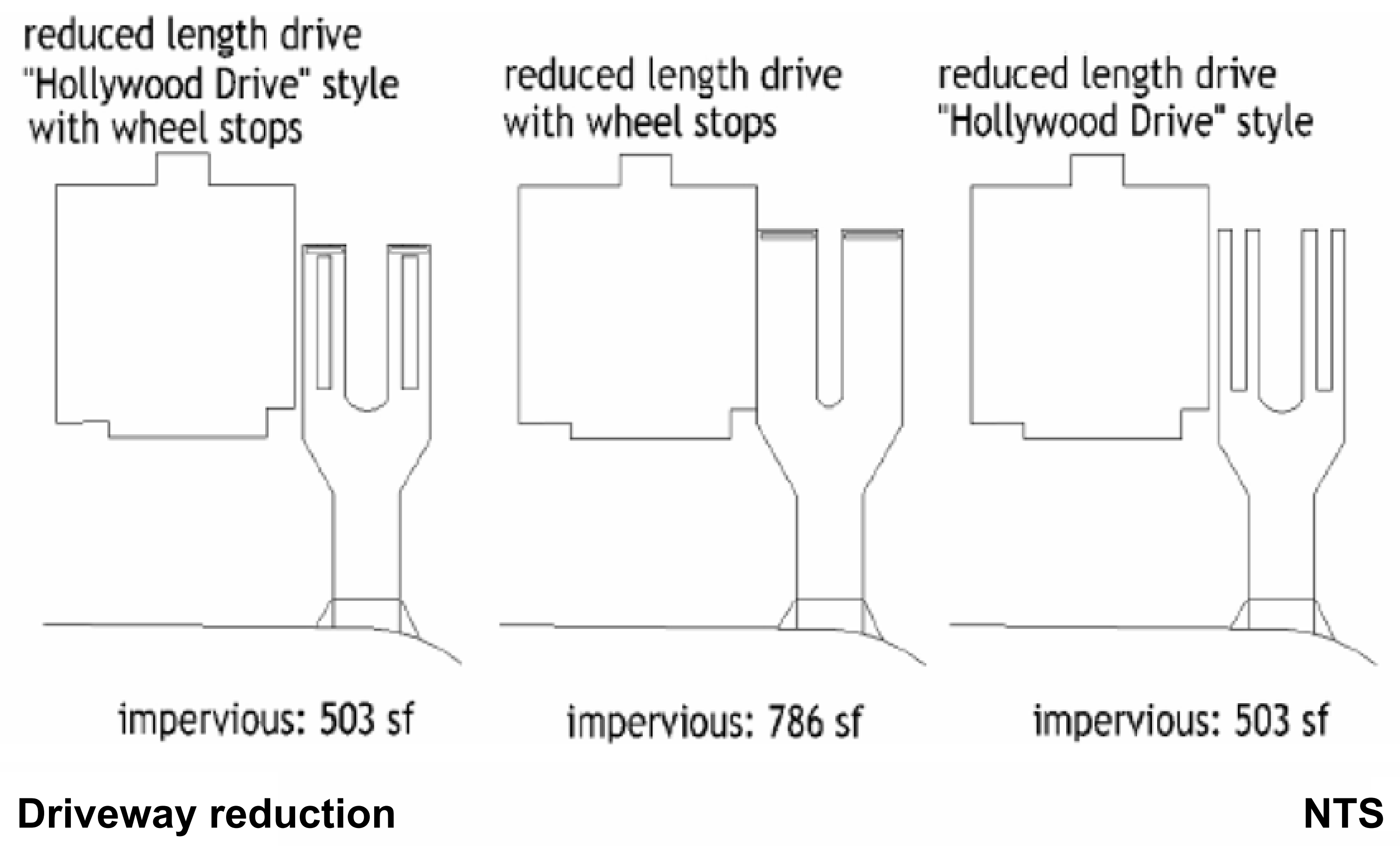


Brattebo and Booth, U. of Washington

Abstract

This study examined the long-term effectiveness of permeable pavement as an alternative to traditional impervious asphalt pavement in a parking area. Four commercially available permeable pavement systems were evaluated after six years of daily parking usage for structural durability, ability to infiltrate precipitation, and impacts on infiltrate water quality. All four permeable pavement systems showed no major signs of wear. Virtually all rainwater infiltrated through the permeable pavements, with almost no surface runoff. The infiltrated water had significantly lower levels of copper and zinc than the direct surface runoff from the asphalt area. Motor oil was detected in 89% of samples from the asphalt runoff but not in any water sample infiltrated through the permeable pavement. Neither lead nor diesel fuel were detected in any sample. Infiltrate measured five years earlier displayed significantly higher concentrations of zinc and significantly lower concentrations of copper and lead.

Driveway Reduction

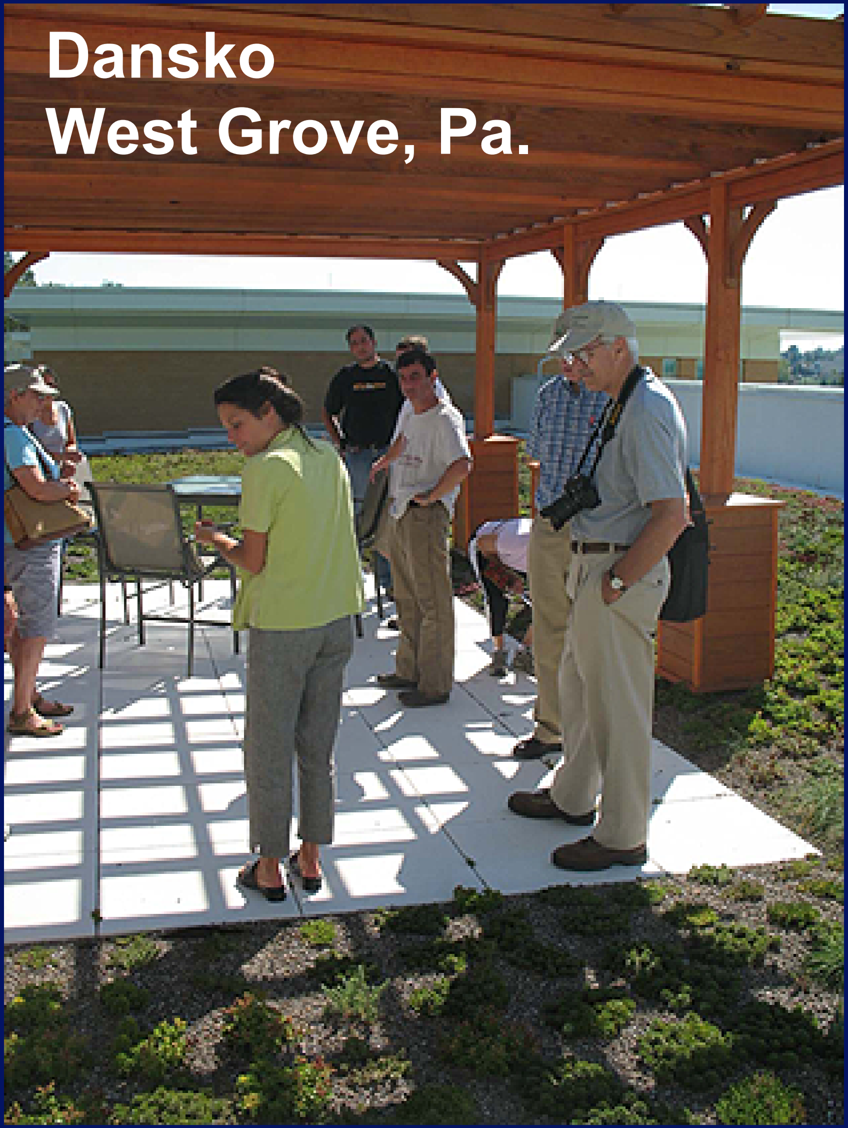


Impervious Surface Reduction

This example shows the use of a porous gravel mat for patios and porous pavement for the driveways as strategies to reduce the impervious surface area.

5. Green Roof

Green Roof



Typical Daily Water Use

Outdoor watering used 38% of water in office buildings that can be supplemented by green-streets techniques.

Daily Use	Office Buildings	Hotels
Potable indoor uses		
• Showers	—	27%
• Faucets	1%	1%
• Kitchen	3%	10%
• Other uses	10%	19%
Subtotal	**14%**	**57%**
Non-potable indoor uses		
• Toilets/urinals	25%	9%
• Laundry	—	14%
• Cooking	23%	10%
Subtotal	**48%**	**33%**
Outdoor uses	**38%**	**10%**

Estimated Energy Consumption for Water Treatment and Distribution

"The transport and treatment of water has high energy demands, 1,450 kWh per MG of water."

Activity	Energy Consumption (kWh/MG)
Supply and conveyance	150
Water treatment	100
Distribution	1,200
Total	1,450

Carbon Dioxide Emissions from Electric Power Generation

Fuel Type	CO_2 Output Rate Lbs. CO_2 / kWh	CO_2 Output / MG Water Delivered (x 1,450kWh)
Coal	2.117	3,070 lbs.
Petroleum	1.915	2,775 lbs.
Natural Gas	1.314	1,905 lbs.

The carbon reductions associated with rainwater harvesting are admittedly not on the order of magnitude required to significantly impact climate change. However, **the connection between potable-water use and energy demand is important** to recognize in the broader context of sustainable water management.

American Clean Energy Act of 2009
(approved by House, pending in Senate)

- Changes the green economy
- Puts price on carbon
- Incentives for white roofs and pavement
- Investments in reforestation by power companies to cool streets and buildings

Sustainability
= People, Planet, Prosperity
= Equity, Environment, Economy

- Maintenance concerns of green streets?
- Why not stormwater fees to pay for O&M?
- Don’t we need a UD School of Architecture?
- Revamp DNREC as the Delaware Department of Environmental Sustainability.