Principles of Stormwater Management- Minimizing Stormwater Runoff Pollution from Your Project

Presentation at Virginia Tech for
Nutrient Management Training
Virginia Cooperative Extension In Service
Virginia Department of Conservation and Recreation
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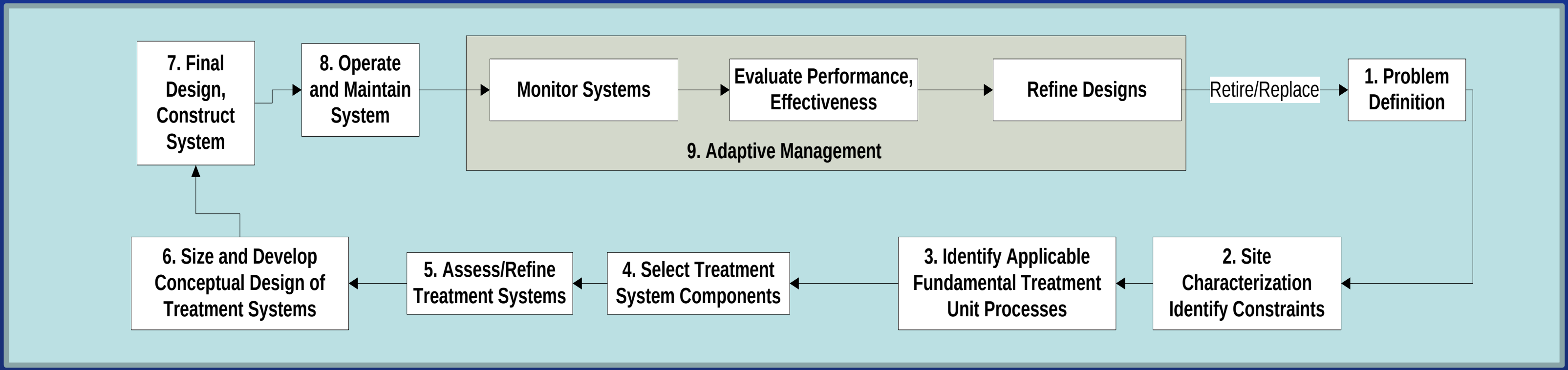
Virginia Cooperative Extension
VirginiaTech Invent the Future
VIRGINIA STATE UNIVERSITY

Biological Systems Engineering

Urban Stormwater at VT

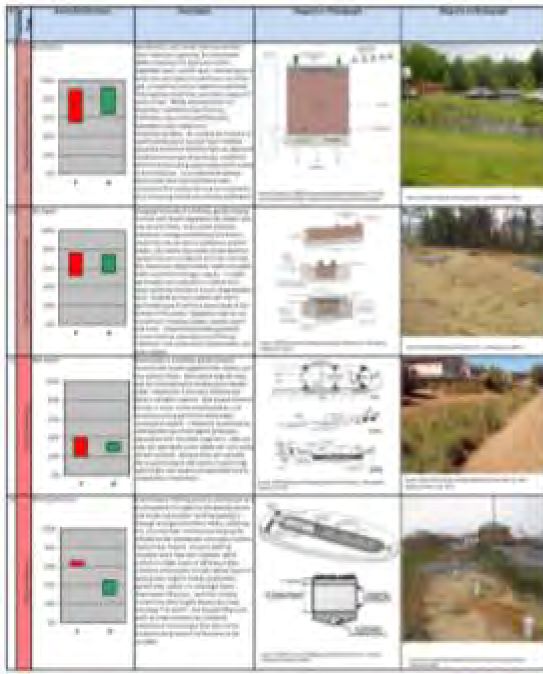
- Adaptive management in design and operation of BMPs
- Education for Virginia municipal stormwater personnel
- Evaluating life-cycle costs of LID
- Establishing water-quality testing protocols for new BMPs
- Design/construction of new or enhanced BMPs



Activities/Examples of Extension Products

- General Public audience
  - 16-part Fact sheet series
  - BMP Fact sheets series: http://pubs.ext.vt.edu/author/s/sample_david_j-res.html
- Mid-Level audience
  - Chapter 12 in Urban Nutrient Management Handbook (w/ L. Fox)
  - http://pubs.ext.vt.edu/430/430-350/430-350.html
  - Basis of training for ANR Agents, proposed in-service 1/13


Rooftop Disconnection
Best Management Practice
Fact Sheet #1



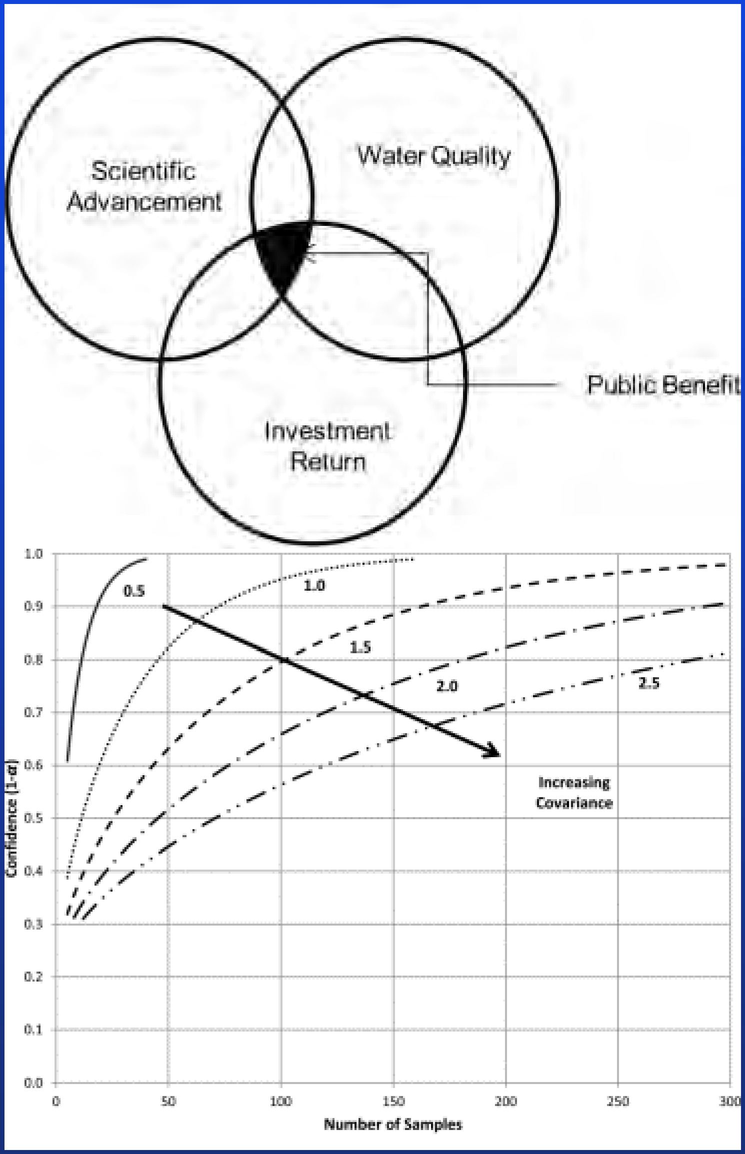
Professional Audience/Service

<u>BMP Clearinghouse</u>:

- Reviews all BMPs
- VTAP=Verify MTDs
- VTAP - to be approved 2012
- Will continue as Technical Evaluator in 2013
- VA BMP Clearinghouse: http://vwrrc.vt.edu/swc/

<u>Other Service</u>:

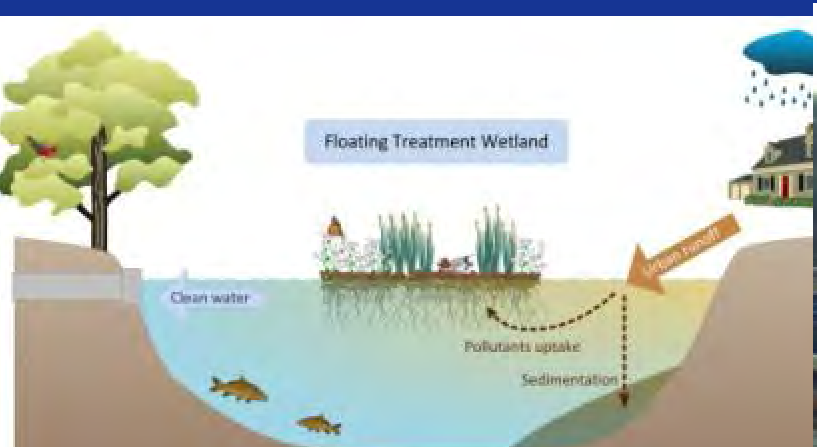
- Chesapeake Bay STAC
- ASCE Urban Water Council



Sample, D.J., Grizzard, T.J., Sansalone, J., Davis, A.P., Roseen, R.M., Walker, J., 2012. Assessing performance of manufactured treatment devices for the removal of phosphorus from urban stormwater. Journal of Environmental Management, 113, pp. 279-291, doi: 10.1016/j.jenvman.2012.08.039.

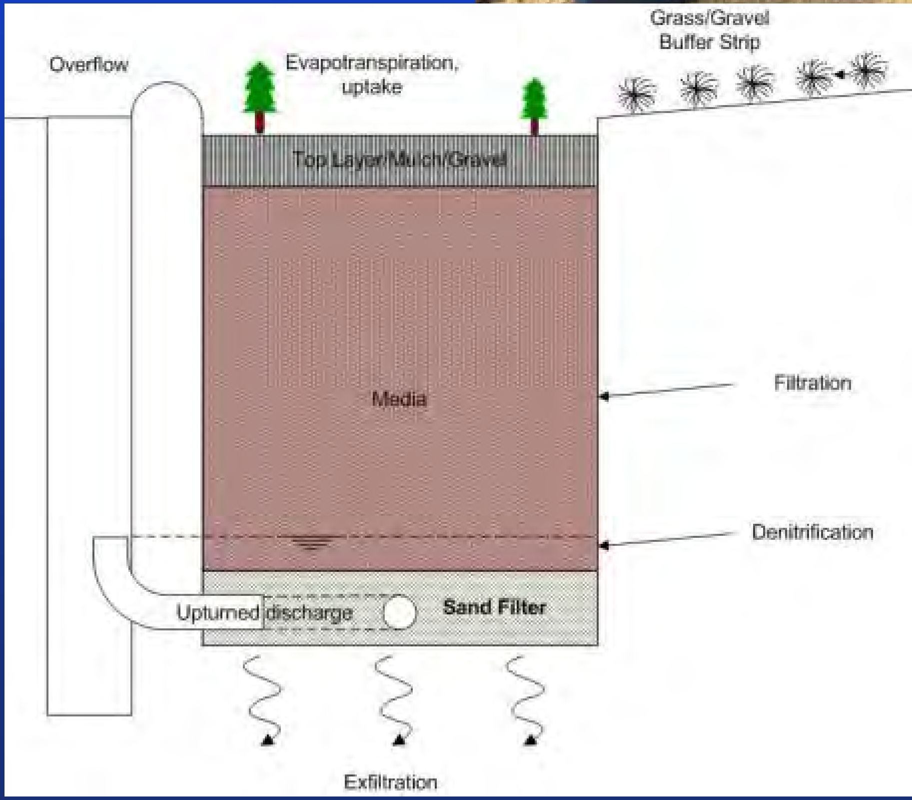
Floating Treatment Wetland Research

- Retrofit of existing wet pond
- Heavily urbanized headwater catchment
- NFWF/Ches. Bay Fund



Low Impact Development-LID

- Developing a design model
- Evaluating it in simple mesocosms
- Then will apply it to full scale



Outline

Urban Impacts and Effects on Water Quality of Stormwater – Review of concepts

- Imperviousness
- Quality, Quantity

- Impacts to Streams & receiving waters

What are we doing about it?

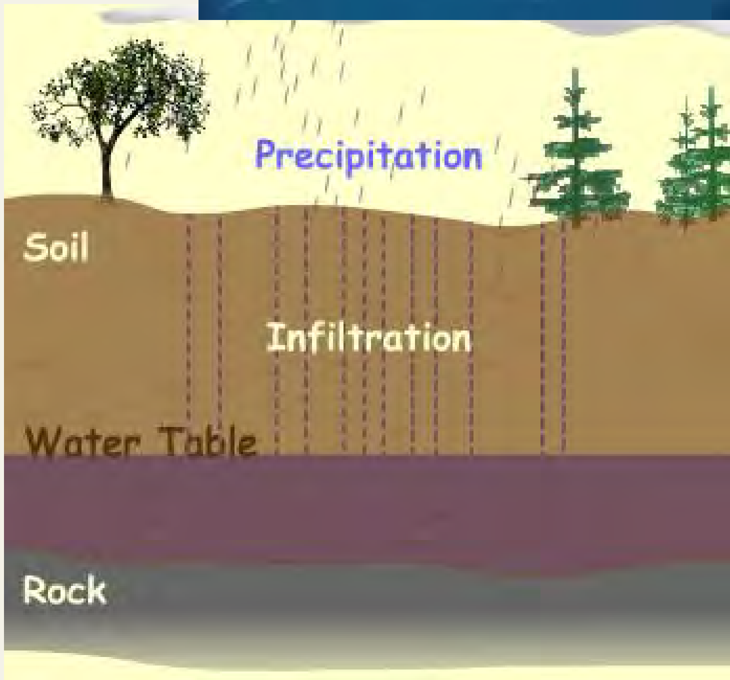
- Runoff Reduction Method, LID practices
- Rain Gardens (aka bio-retention basins Construction, maintenance, site study, soils)

Urban Impacts and Effects on Water Quality

What happens to the Rain?

- Depends on many factors:
  - Rate of rainfall
  - Soil conditions (Dry, Damp, Soggy)
  - Density of vegetation
  - Amount of urbanization
  - Topography

Michigan Tech, 2009. Michigan Environmental Education Curriculum, *http://techalive.mtu.edu/meec/module01/Infiltration.html*

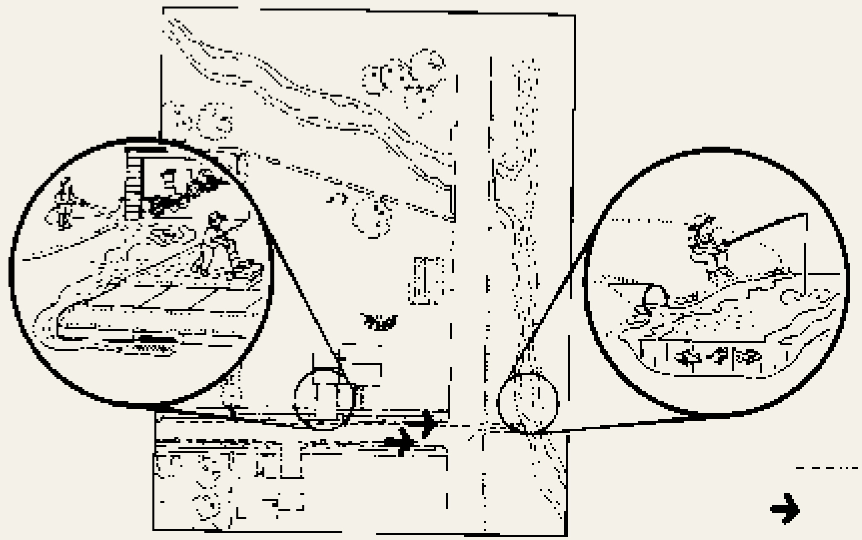


What is Stormwater?

- Water that is not reabsorbed into the ground.
  - Rain/Sleet
  - Melting Snow / Ice
  - Irrigation

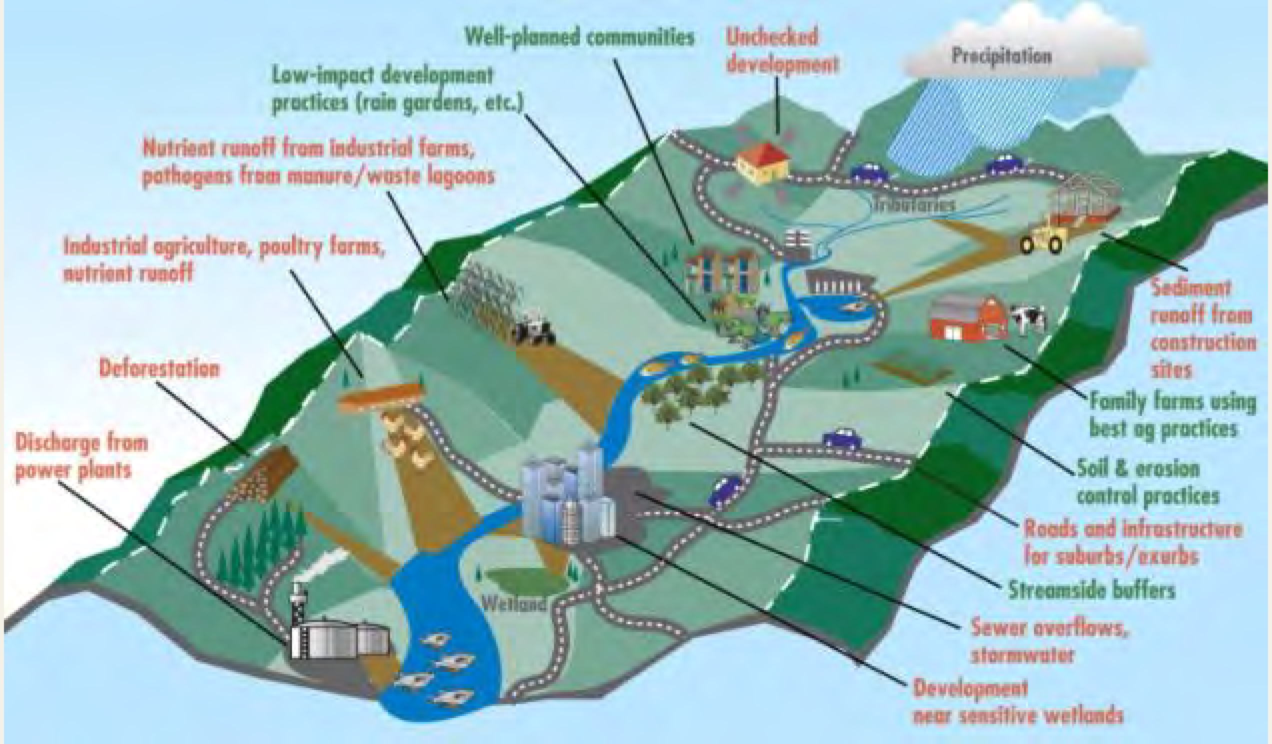
Where does Stormwater Go?

- Not to a Treatment Plant, directly into our streams, rivers, lakes, bays, and reservoirs
- Infrastructure:
    - Blue/Black/Gray/Green



What is a Watershed?

- A watershed is the land that water flows across on its way to a stream, river, or lake.
- Water either goes into the soil or flows overland



Source: Potomac Conservancy (2007) State of the Nation's River. Symbols courtesy of the Integration and Application Network (ian.umces.edu/symbols, University of Maryland Center for Environmental Science.

Stormwater is not typically an issue in undisturbed areas

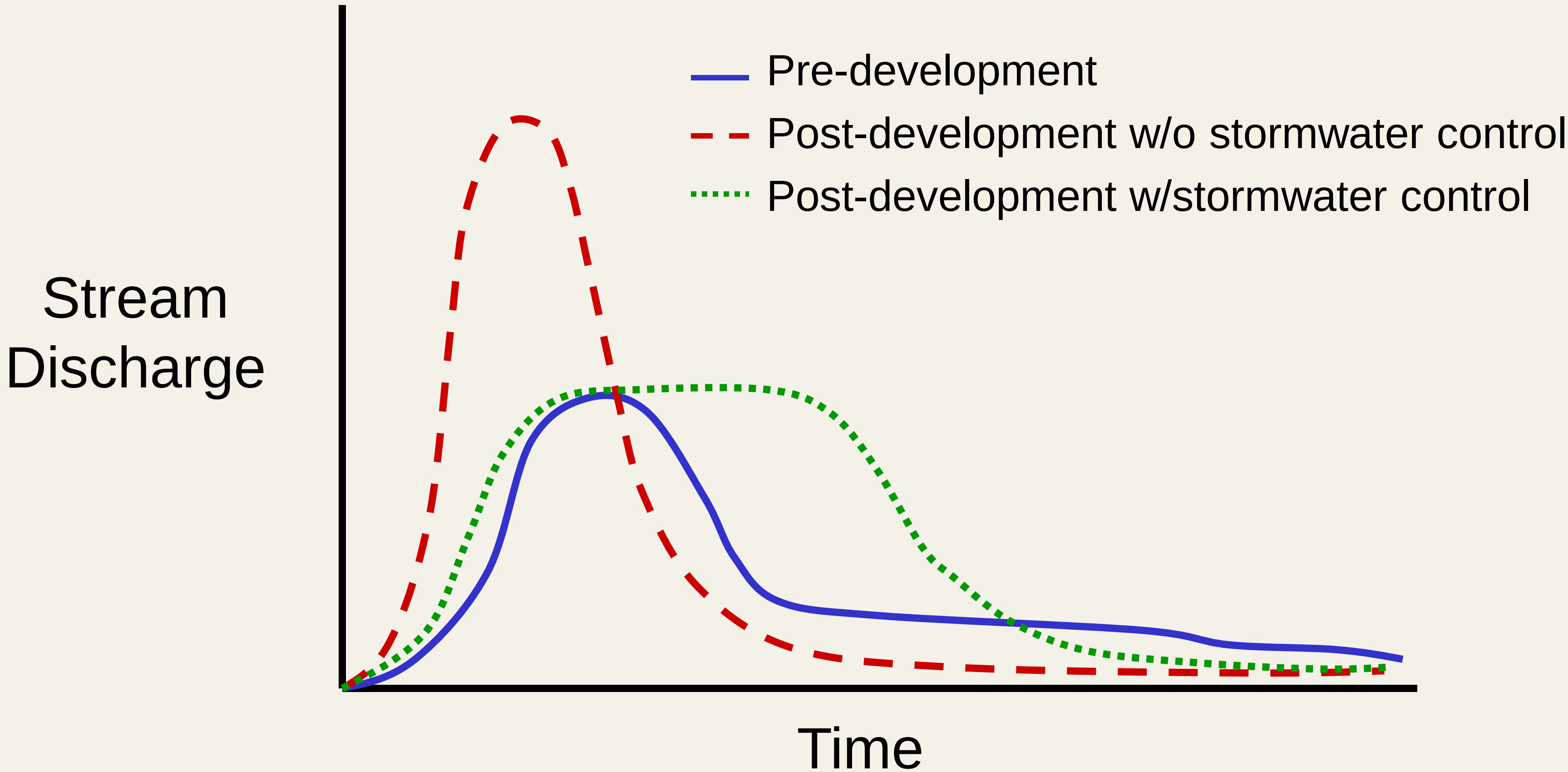
- Leaves of trees and plants break up the raindrops
- Roots of plants and healthy soil absorb water
- Because of plant cover, fewer soil particles are carried along as it travels down the watershed to a body of water.

When is Stormwater an Issue?

- Disturbed areas (lacking vegetation) causes erosion

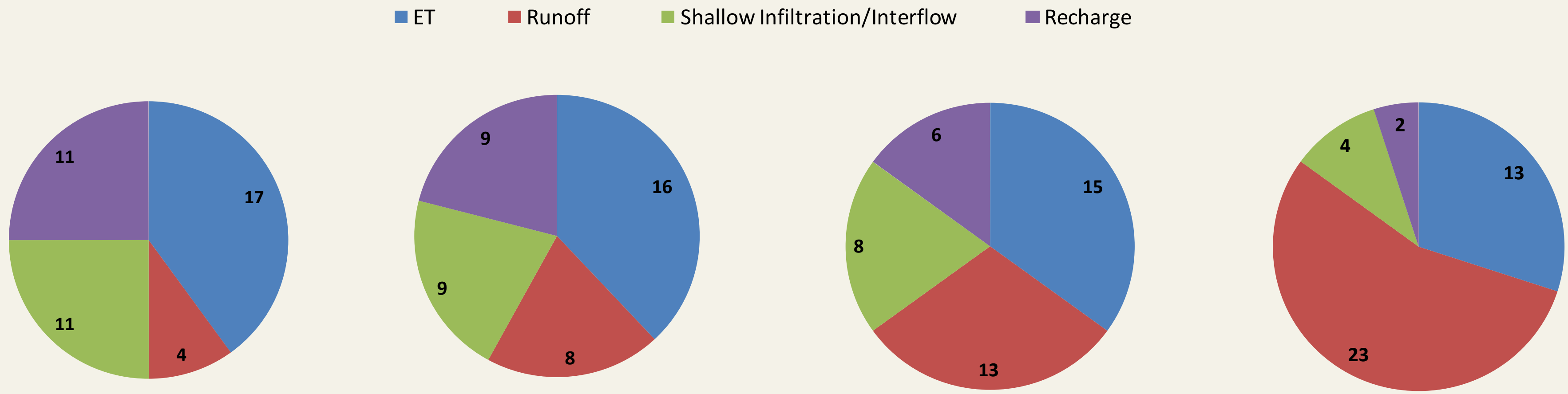
- Impervious surfaces (pavement/buildings) causes increased runoff

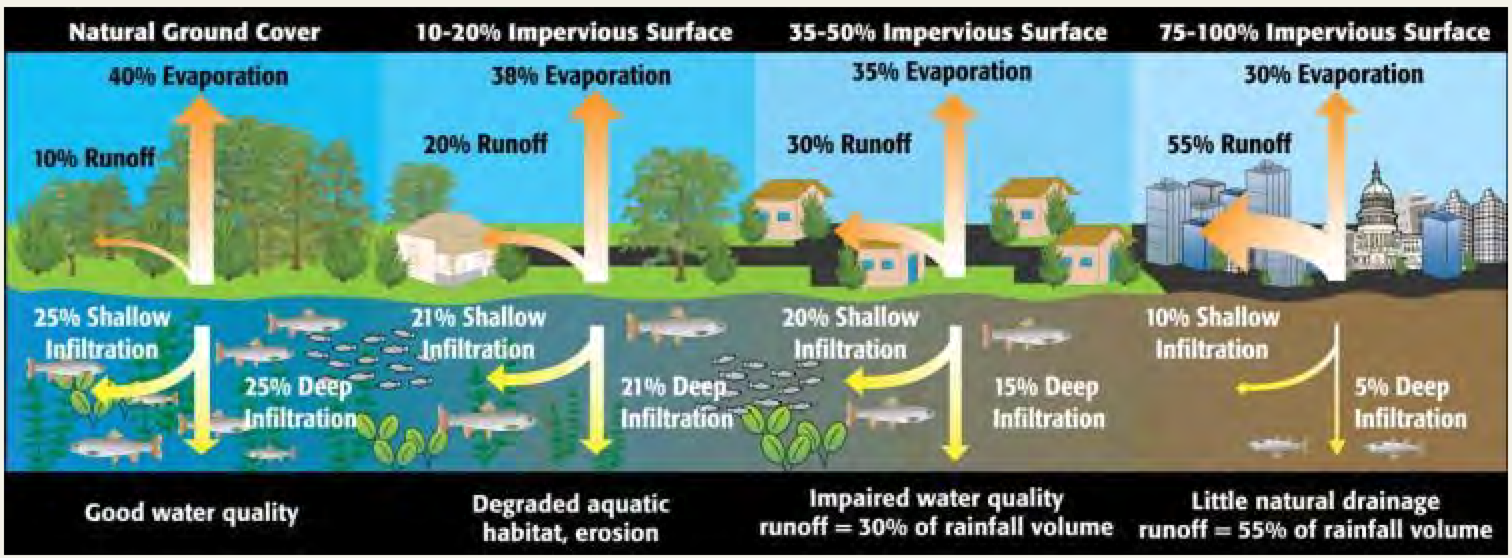
Stormwater Quantity-Peak Runoff



Sources: Tess Wynn, "Low Impact Development", 2009, Biological Systems Engineering, Virginia Tech

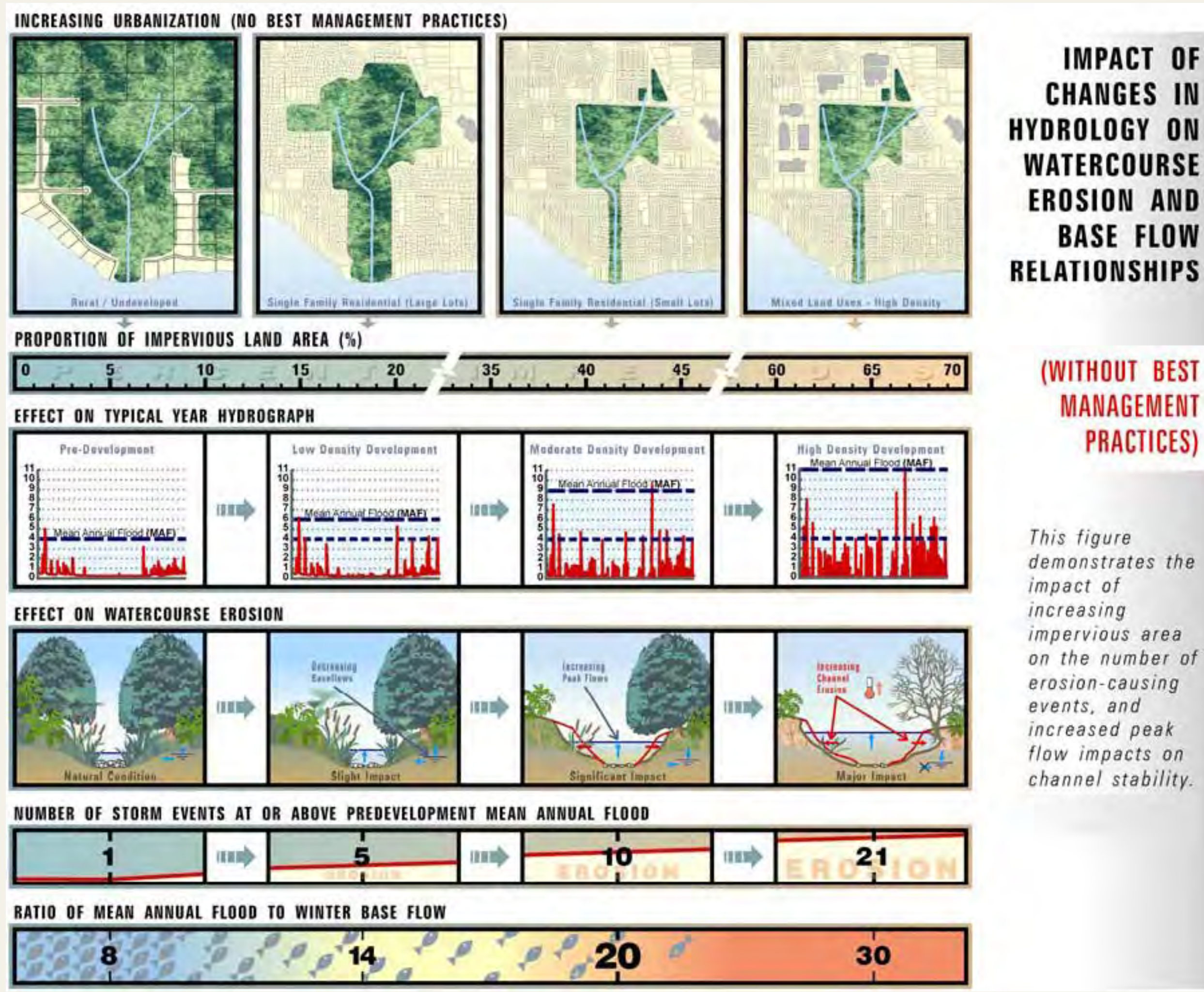
Stormwater Quantity: Impacts on Virginia Hydrologic Cycle





Source: State of the Nation's River 2008, Potomac Stormwater Runoff, Potomac Conservancy.

Stormwater Quantity:Stream Morphology



Source: Metropolitan North Georgia Water Planning District (2003) District-Wide Watershed Management Plan

Stormwater Quality: Sources of Pollutants in Watersheds

Point Sources

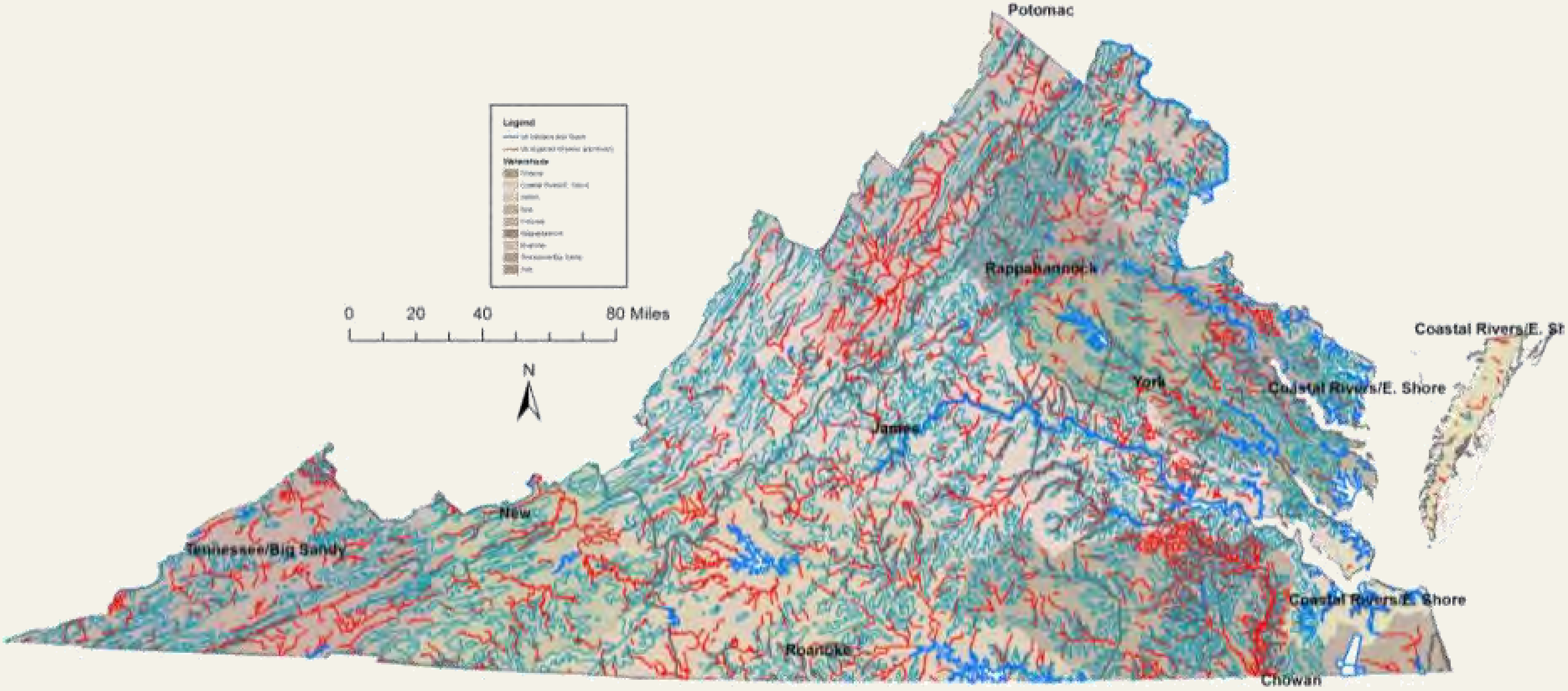
- Defined and discrete discharge point
- Examples: Industrial, Cooling water, Domestic Wastewater

Nonpoint Sources

- Diffuse sources
- Usually occur in wet weather
- Difficult to control and regulate

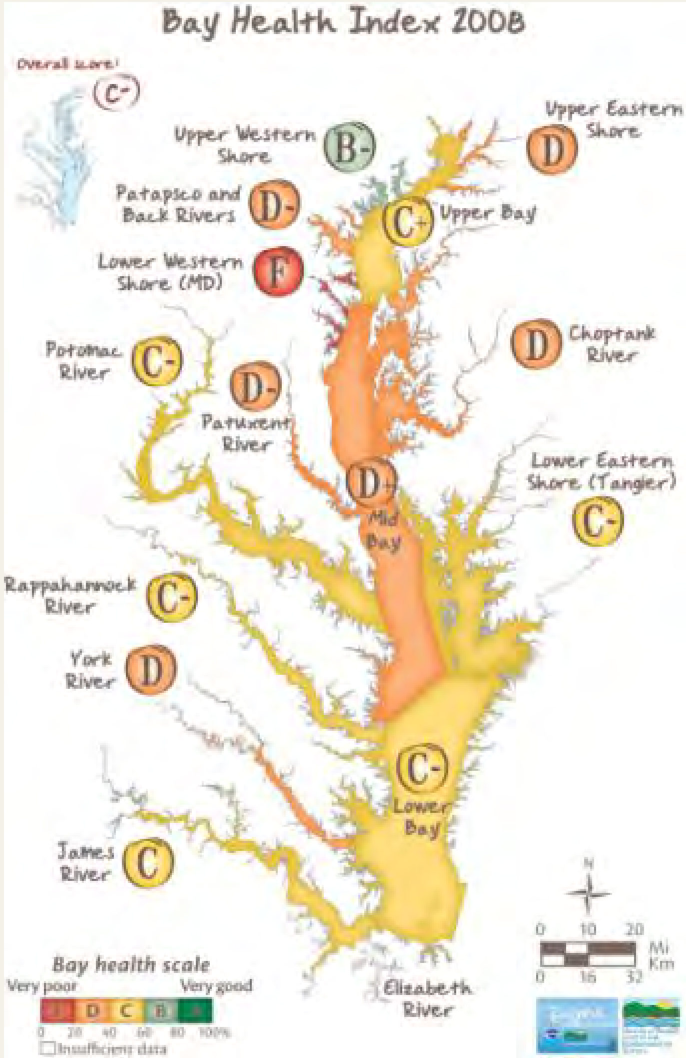
Source: Left – Rutgers University; Right – Biological Systems Engineering, Virginia Tech

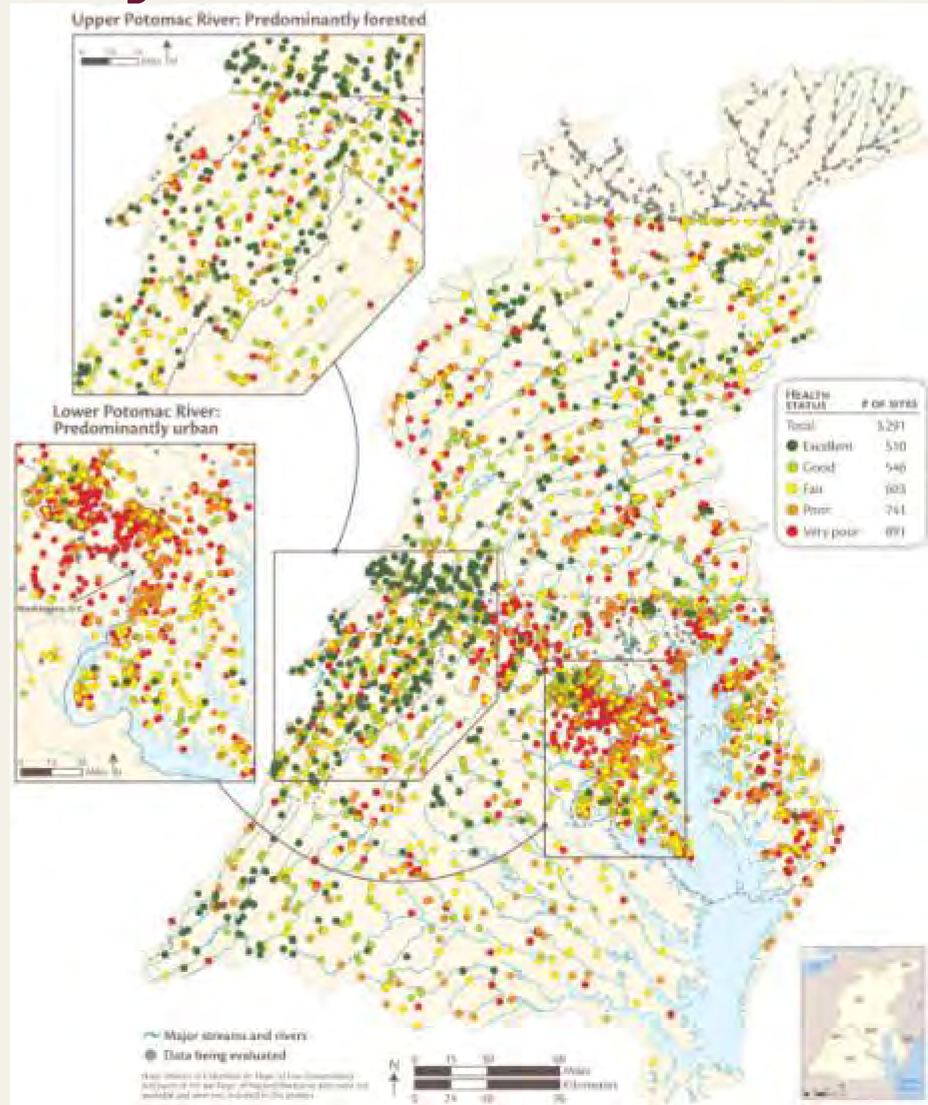
Currently Impaired Waters in Virginia



Source: VDEQ Final 2008 305(b)/303(d) Water Quality Assessment Integrated Report

Chesapeake Bay Issues

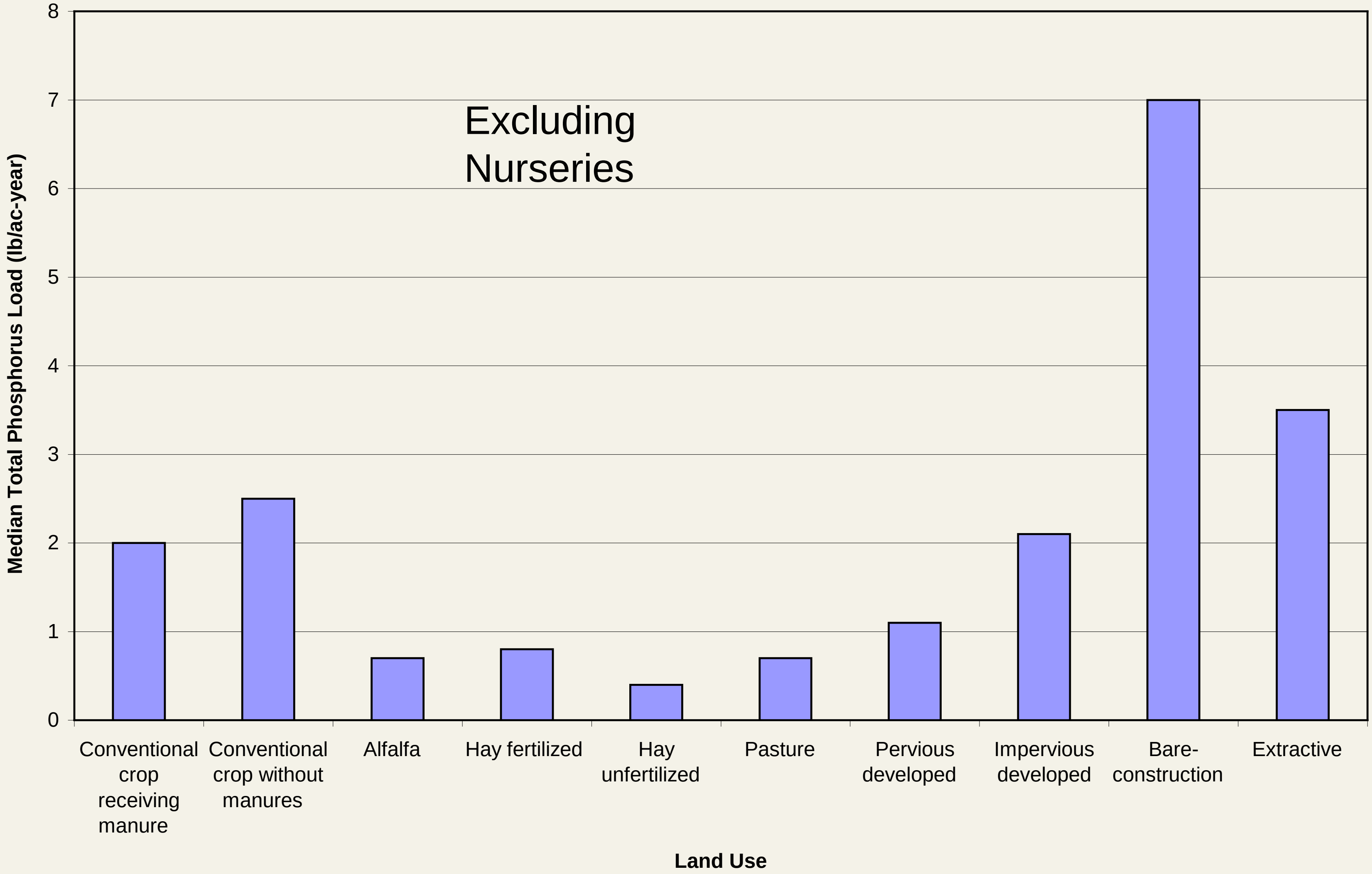




Source: *Chesapeake Bay Report Card, 2008, Integration and Application Network, University of Maryland Center for Environmental Science (UMCES) and EcoCheck, a partnership of National Oceanographic and Atmospheric Administration (NOAA) and UMCES.*

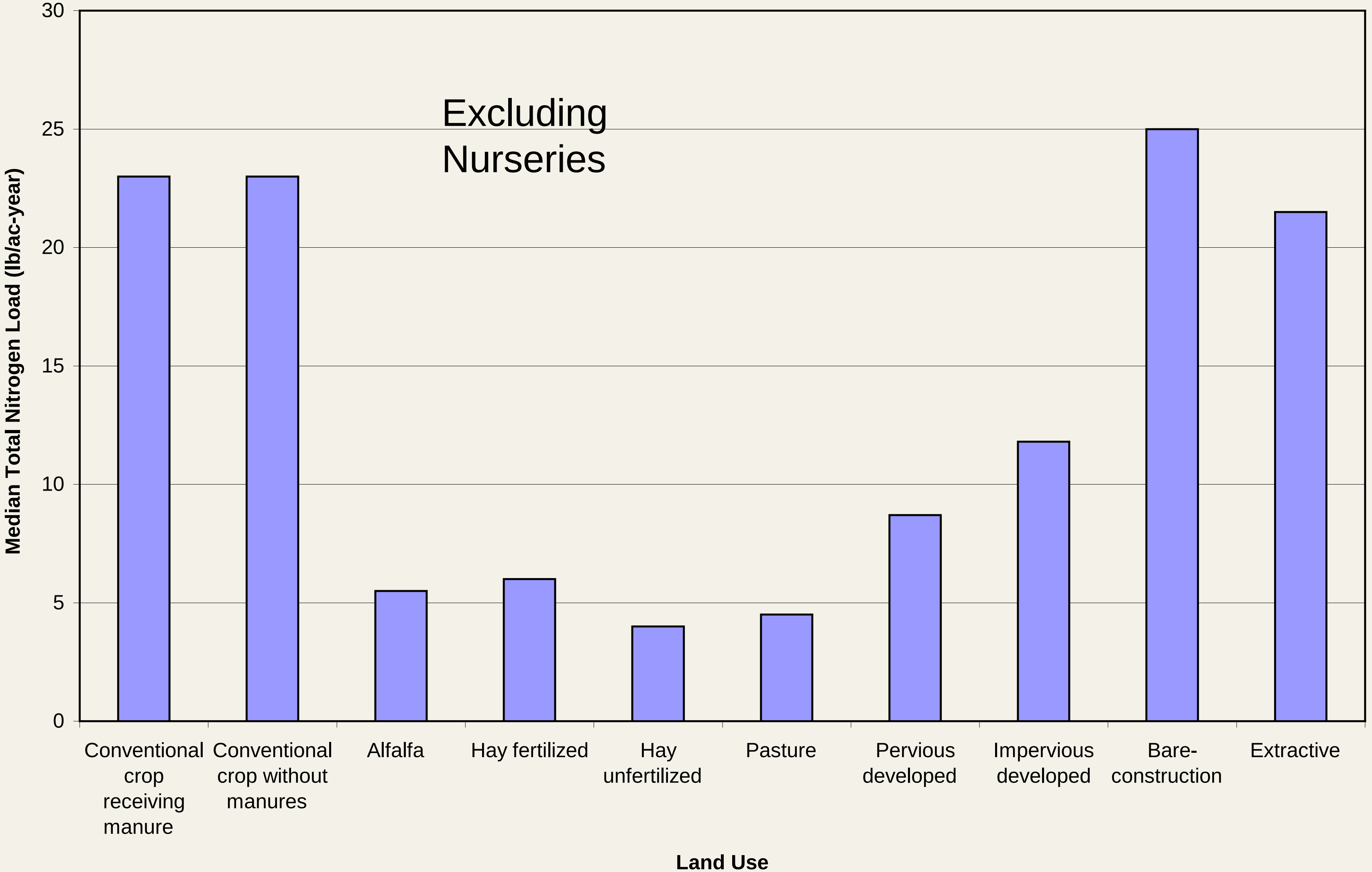
What are we doing about it?
Managing Urban Stormwater

Tributary Strategies-P Loads



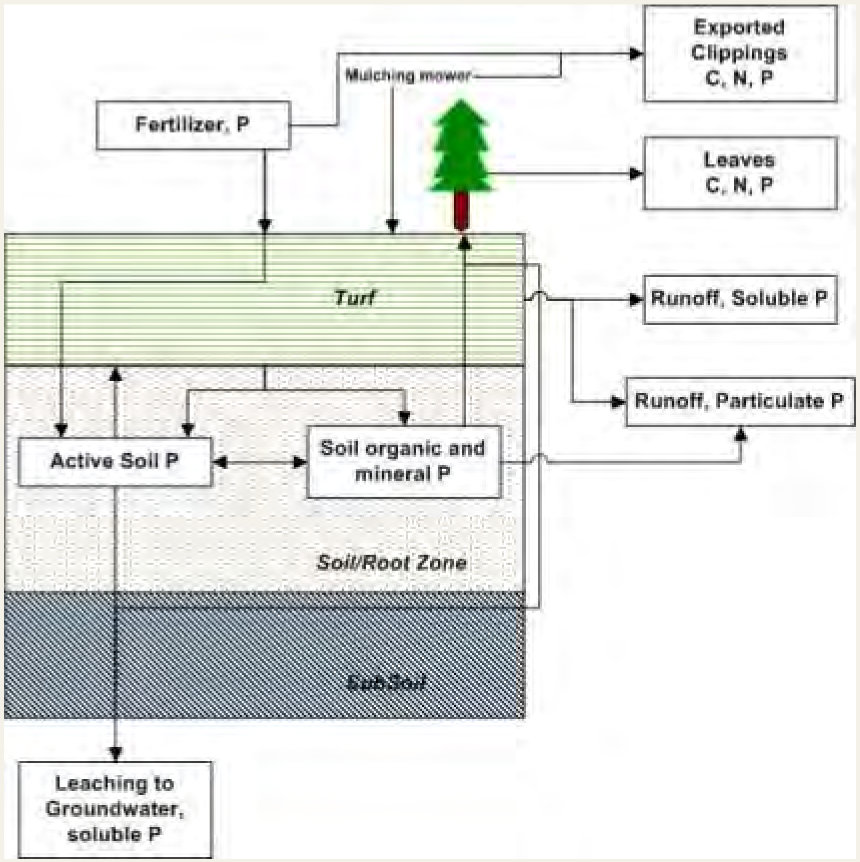
Source: EPA (2008) Chesapeake Bay Model support documents

Tributary Strategies-N Loads

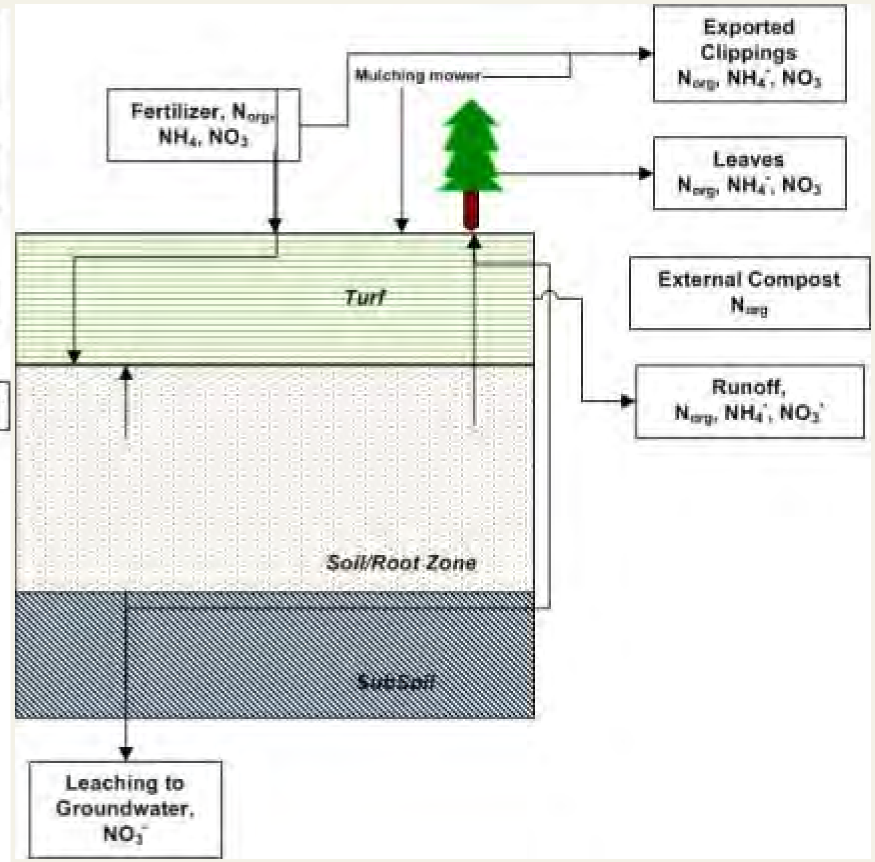


Source: EPA (2008) Chesapeake Bay Model support documents

Urban Nutrient Budget



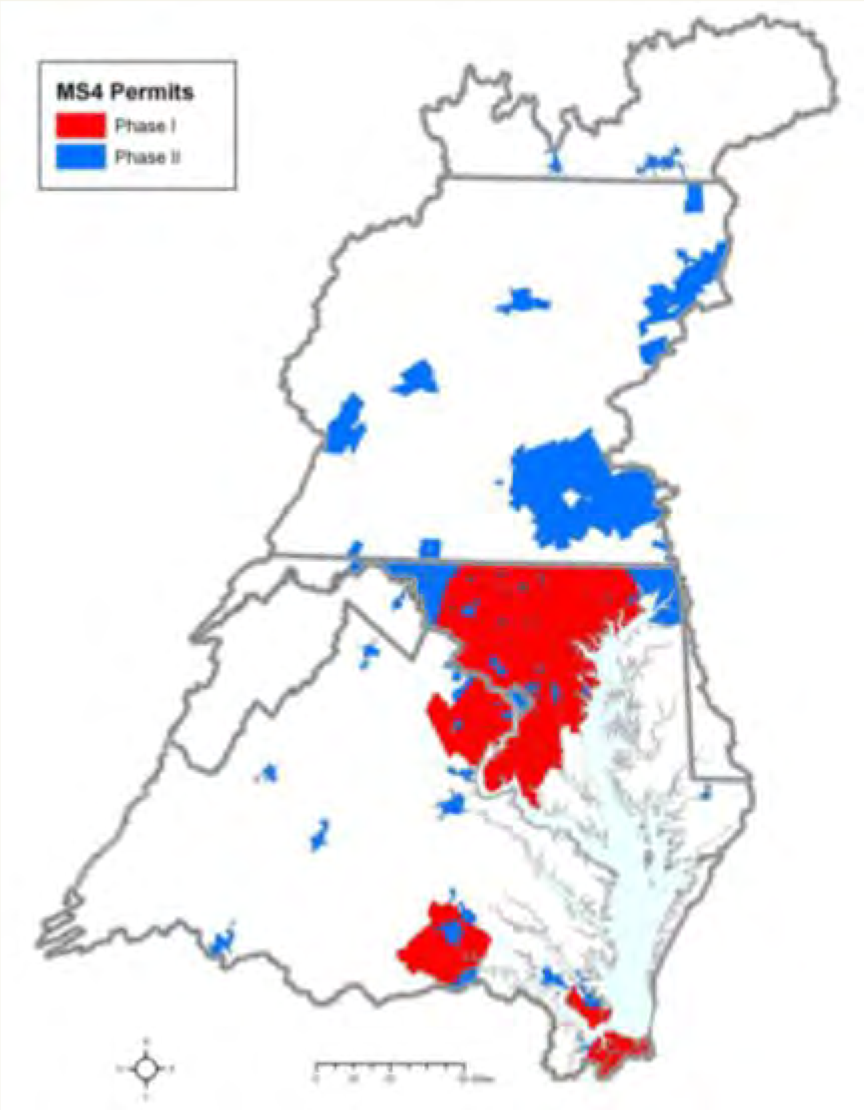
Phosphorus



Nitrogen

Municipal Stormwater Programs-Bay Wide

- Municipally Separate Storm Sewer Program (MS4) regulated under Clean Water Act/NPDES
- All jurisdictions subject to TMDL
- Phase 1 (large, previously permitted, required monitoring)
- Phase 2 (Medium sized, newly permitted, no monitoring required)



Source: EPA (2010) Draft TMDL for the Chesapeake Bay.

Municipal Stormwater Programs

- Next phase of TMDL-allocation to jurisdictions

Virginia Stormwater Criteria

Existing

Based upon Peak Runoff Control:

- Water Quality Volume-1 inch/30 hours
- Channel Protection, 1-year storage for 24 hours & evaluate velocity at 2-year, conveyance at 10.
- Flood protection, 10-year

Proposed

Based upon an Iterative Land Development Process:

- Environmental Site Design- minimize impervious surfaces
- Runoff Reduction- Increase infiltration through LID
- Pollutant Removal-Treat remaining runoff to remove Phosphorus
- Potential Channel "work" to remain constant

Virginia Stormwater Management Handbook (1999), graphic from Georgia Stormwater Manual (2001)

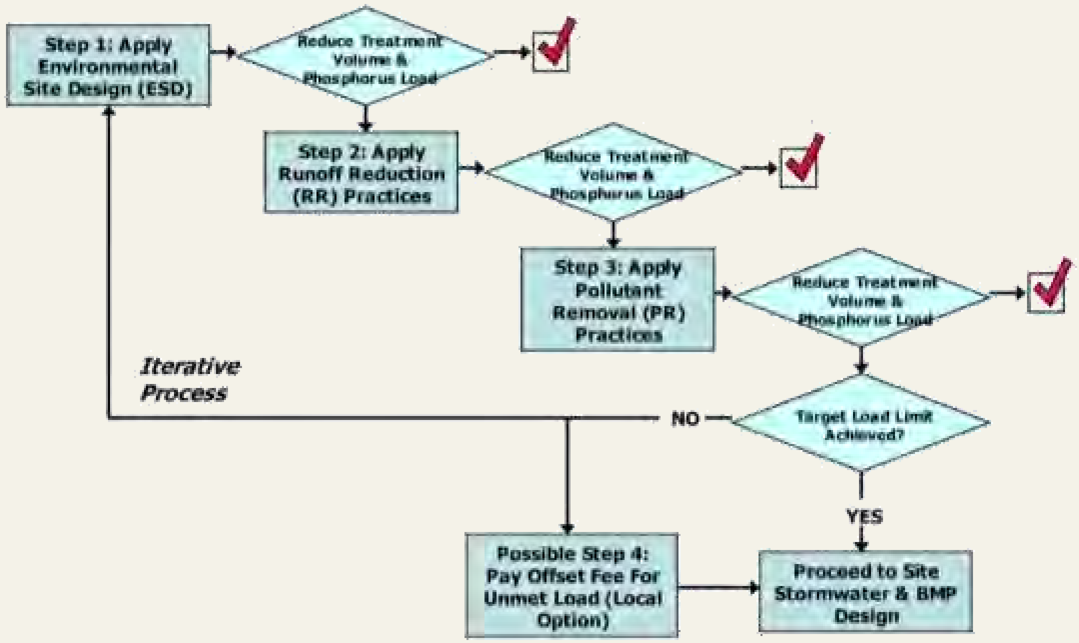
Source: Technical Memorandum: The Runoff Reduction Method, April 18, 2008, Center for Watershed Protection

Proposed 3-step Strategy

1. **Environmental Site Design**
2. **Runoff Reduction**
3. **Pollutant Removal**

Criteria:

- 0.41 lb/acre/year P loading from site through ESD, RR, PR
- Equivalent to forested conditions
- Redevelopment set at 20% improvement

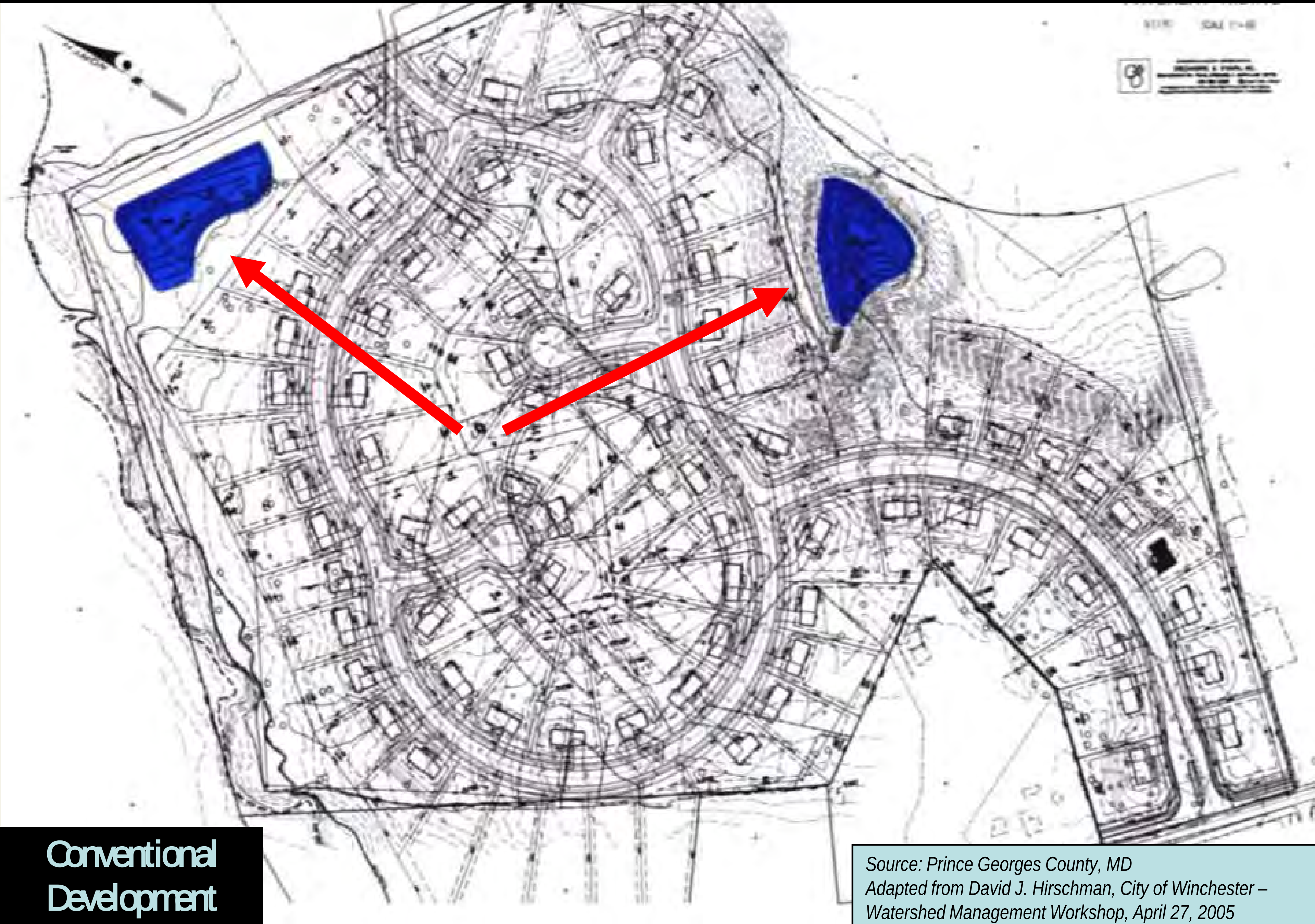


Conventional Site Design

The "Good Drainage" Paradigm

Source: Prince Georges County, MD
Adapted from David J. Hirschman, City of Winchester – Watershed Management Workshop, April 27, 2005

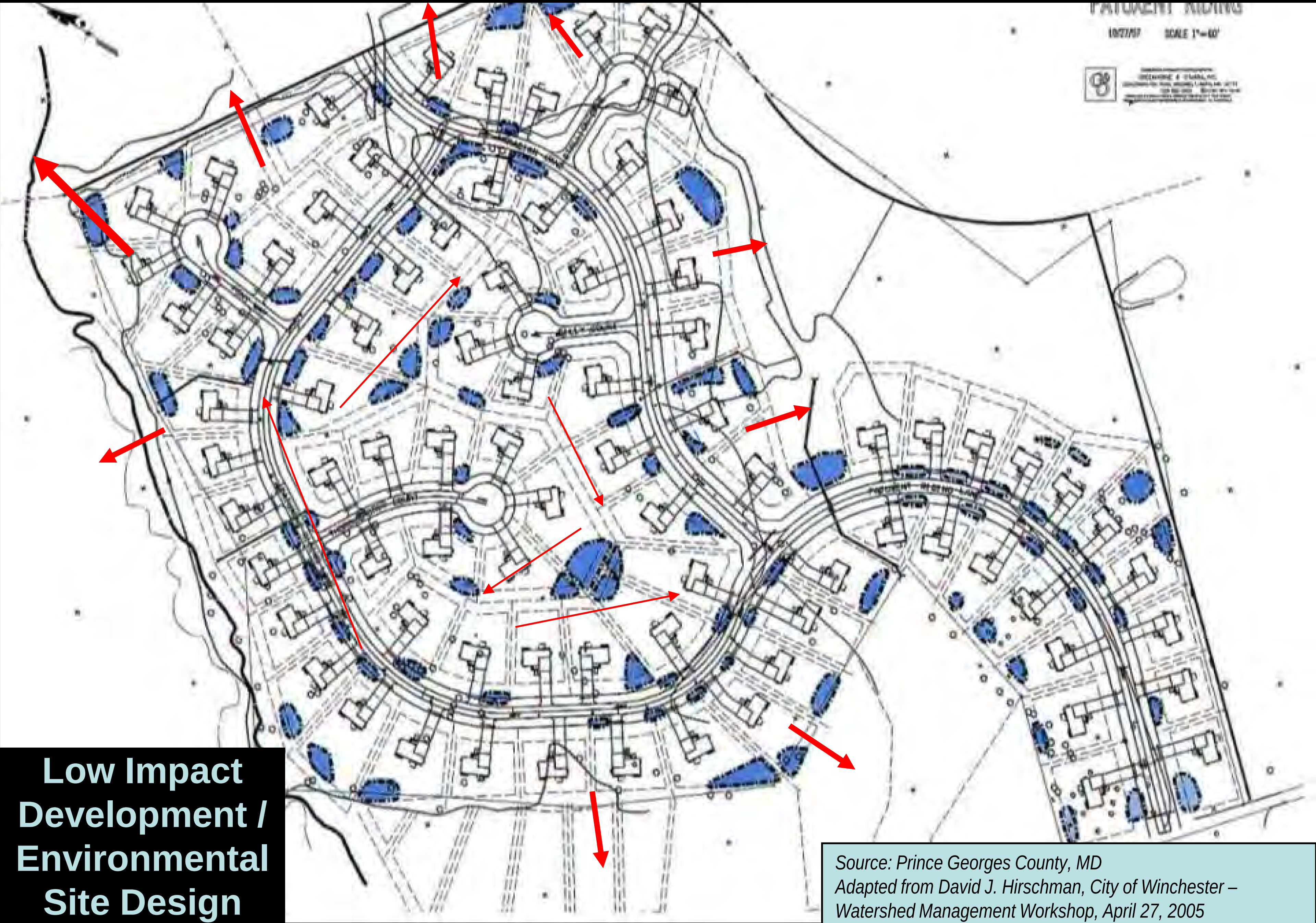
Collect, Convey, Concentrate, Centralized Treatment



Conventional Development

Source: Prince Georges County, MD
Adapted from David J. Hirschman, City of Winchester – Watershed Management Workshop, April 27, 2005

Distributed, Disconnected, Decentralized



Low Impact Development / Environmental Site Design

Source: Prince Georges County, MD
Adapted from David J. Hirschman, City of Winchester – Watershed Management Workshop, April 27, 2005

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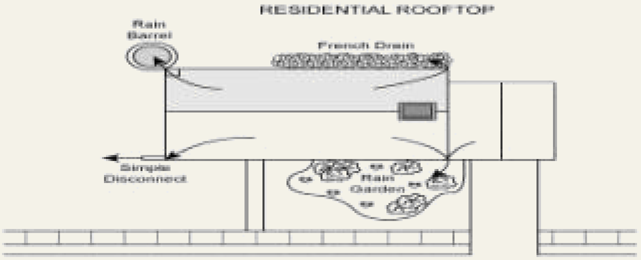
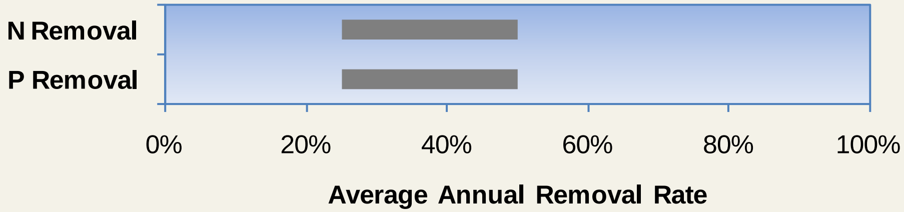
Adapted from David J. Hirschman, City of Winchester – Watershed Management Workshop, April 27, 2005

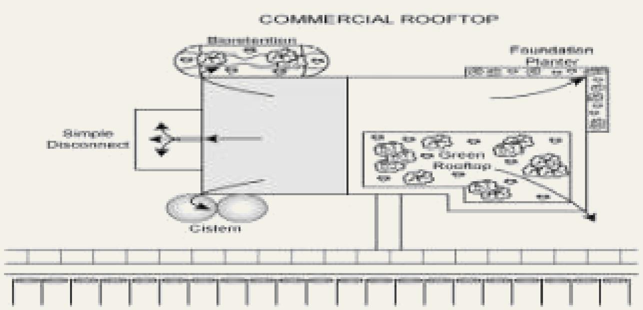
Best Management Practices

#1-Impervious Surface Disconnection (RR)

- Redirects rooftop runoff from impervious to pervious areas
- Practice can be used alone (large lot, permeable soils), or in combination
- Most economical practice available

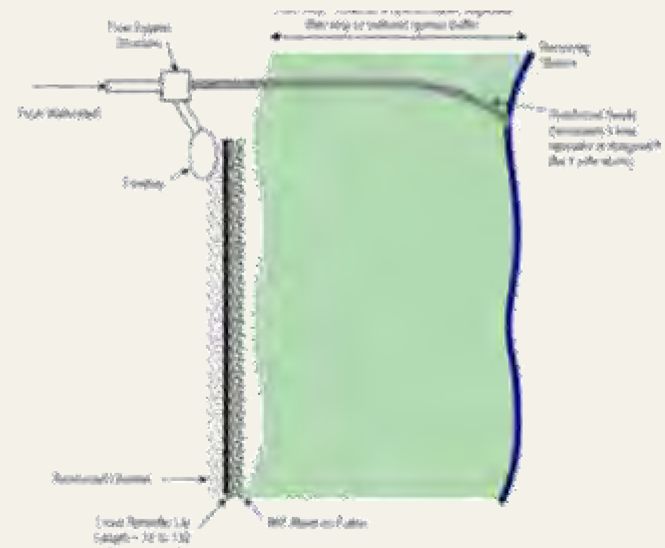


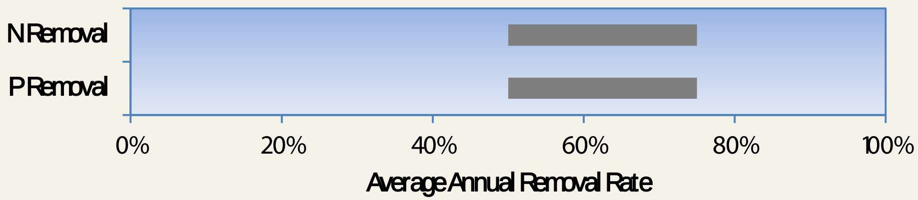




#2-Sheetflow to Open Space (RR, PR)

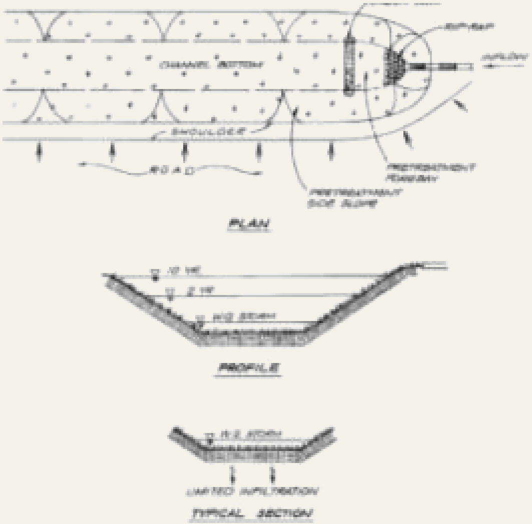
- Also known as filter strips/vegetated filter strips
- Small flows, larger flows can be accommodated with a level spreader
- Reduces velocity, minimal infiltration

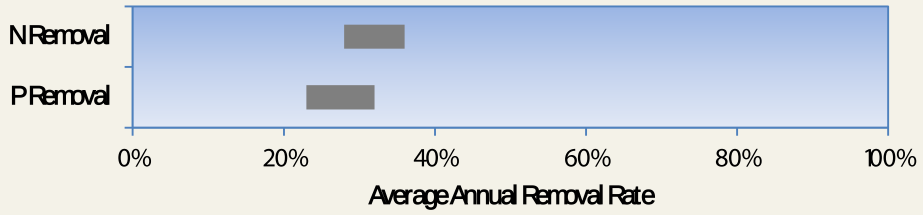




#3-Grass Channels (RR, PR)

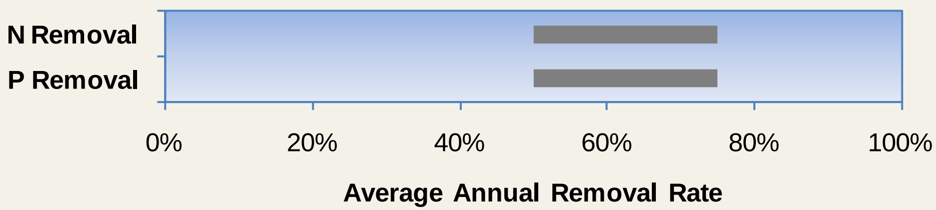
- Open channels, grassed
- Treatment via filtering, no media
- LID conveyance system
- No storage, velocity is slowed due to roughness



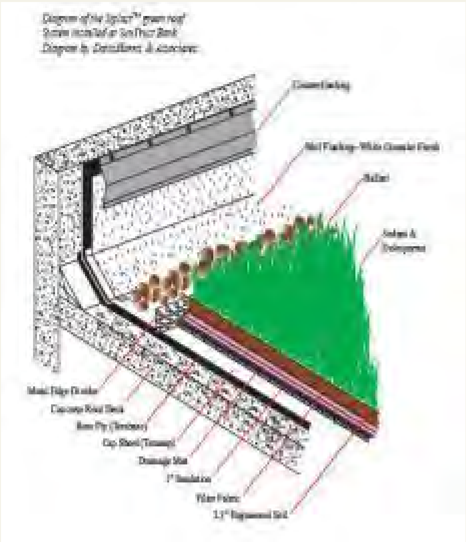


#4-Soil Restoration (ESD, RR)

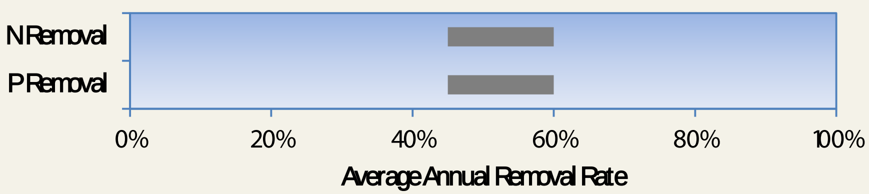
- Amending soils with compost
- Improves:
  - Soil structure
  - Infiltration
  - Rooting/Water holding capacity
  - Reduces compaction



#5-Vegetated/Green Roofs (RR)



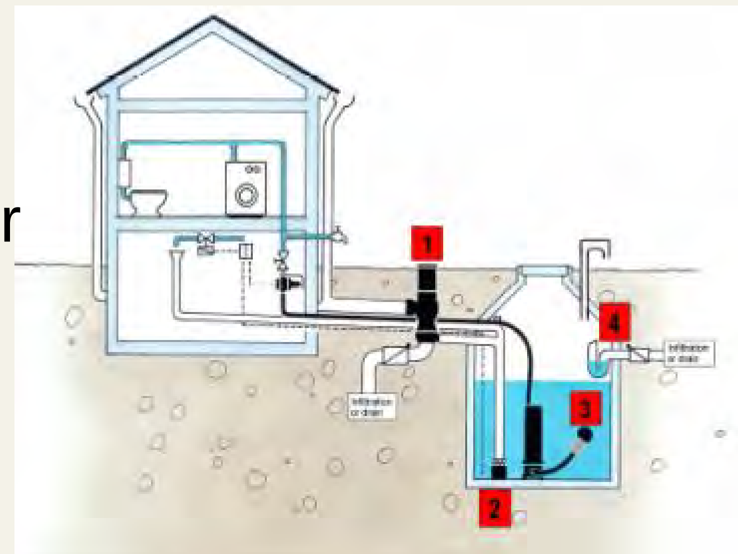
- Designed to provide modest storage
- Converts some water to ET
- Reduces Energy Loss/LEEDS
- Aesthetically pleasing
- Typically addresses small storms, <.25-0.5 inches
- Extensive-Intensive
- Ex: SunTrust Bank, Richmond



Source: Richmond Regional Planning and Development Council at http://www.richmondregional.org/Planning/Stormwater/green_roof.htm

#6-Rainwater Harvesting/Cisterns (RR)

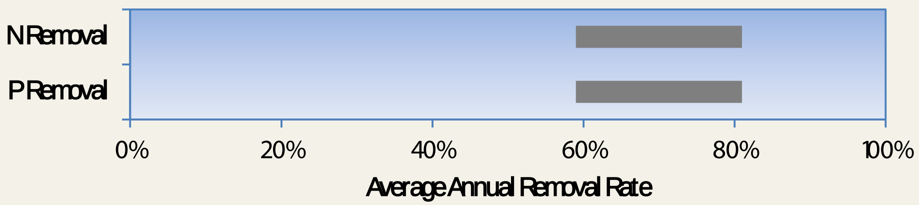
- Captures impervious runoff
- Underground/Above
- Reuse-can be Outdoor or indoor
- Supplements water supply
- Volume benefits-maximize if managed
- Removal: 40% P, N



Source: Virginia Rainwater Harvest Manual, at www.CabellBrandCenter.org and WSSI/Wetland Studies and Solutions, Inc., at http://www.wetlandstudies.com.

#7-Permeable Pavement (RR)

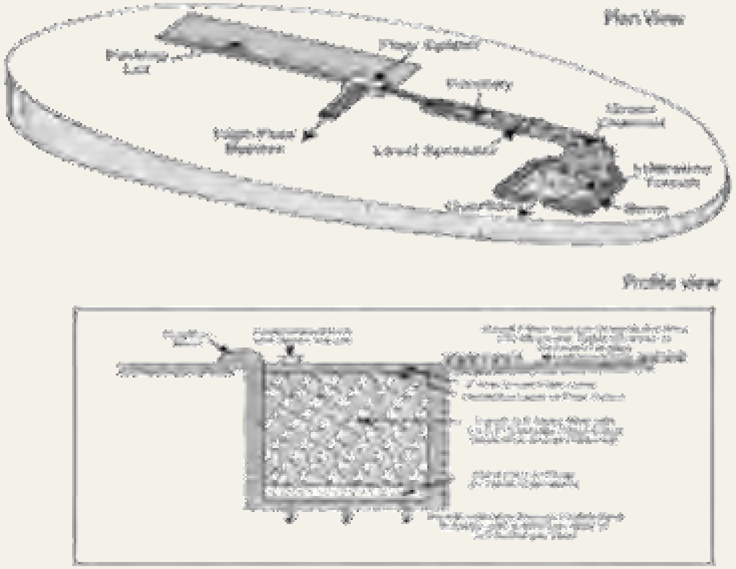
- Paver/block systems
- Porous concrete
- Provides storage by eliminating use of fine materials
- Heavy traffic areas may not be suited
- Must keep sediment off!
- Reduce/attenuates small storm runoff depending upon substrate

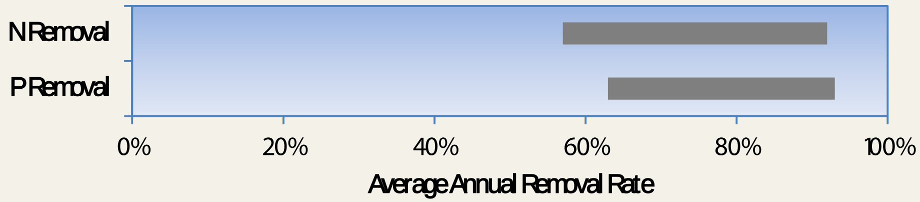


Source: William Hunt's web site at www.bae.ncsu.edu/stormwater and WSSI/Wetland Studies and Solutions, Inc., at http://www.wetlandstudies.com/

#8-Infiltration Basins (RR, PR)

- Provides storage within voids
- Surface can be used for passive storage
- Provides RR (if soil permits), attenuation, and PR
- Must be careful to avoid pervious runoff
- Maintenance costs high/clogging

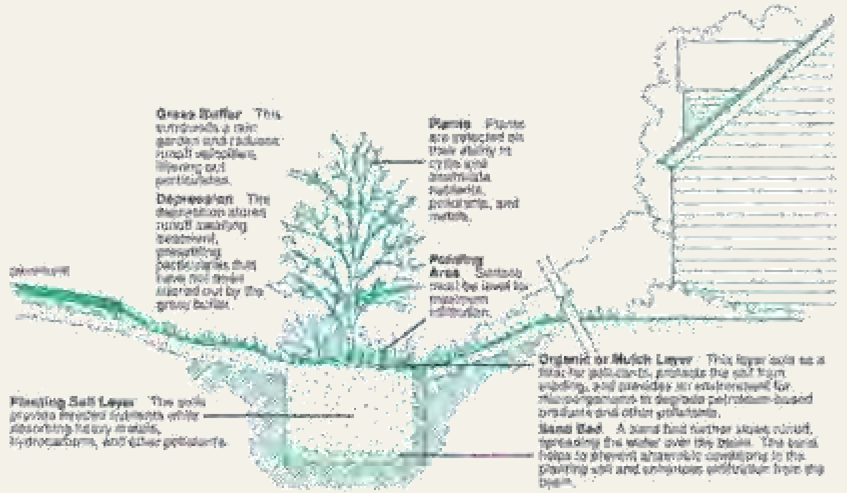


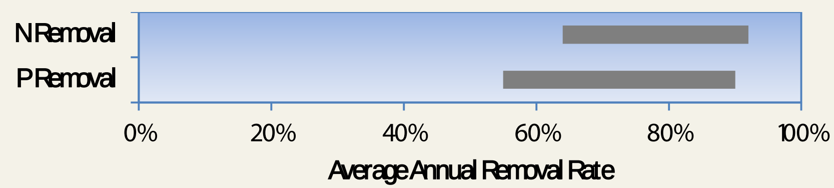


Source: www.stormwatercenter.net, and WSSI/Wetland Studies and Solutions, Inc., at http://www.wetlandstudies.com.

#9-Bioretention/Rain Gardens (RR, PR)

- Aka “Rain Gardens”
- With and without Underdrains
- Peak/Volume Benefits
- Pollutant Removal
- Issues:
  - Keep Small (5-10%) DA
  - Sediment Pretreatment
  - Soils/Media





Source: www.stormwatercenter.net, William Hunt’s web site at www.bae.ncsu.edu/stormwater, and WSSI/Wetland Studies and Solutions, Inc., at http://www.wetlandstudies.com Rain Gardens in Virginia: Technical Guide (2009) Virginia Department of Forestry and http://fairfaxcounty.gov/nvswcd/youyourland/landscape.pdf

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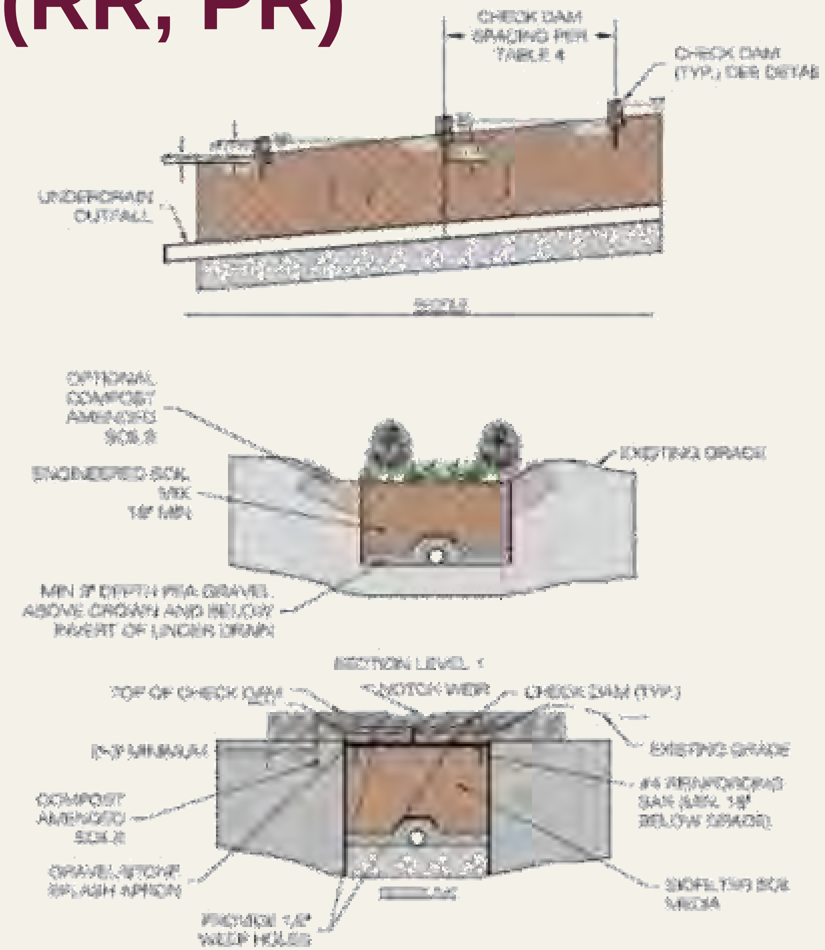
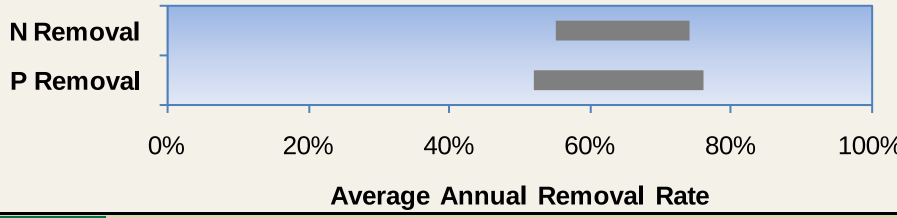
#10-Dry Swales (RR, PR)

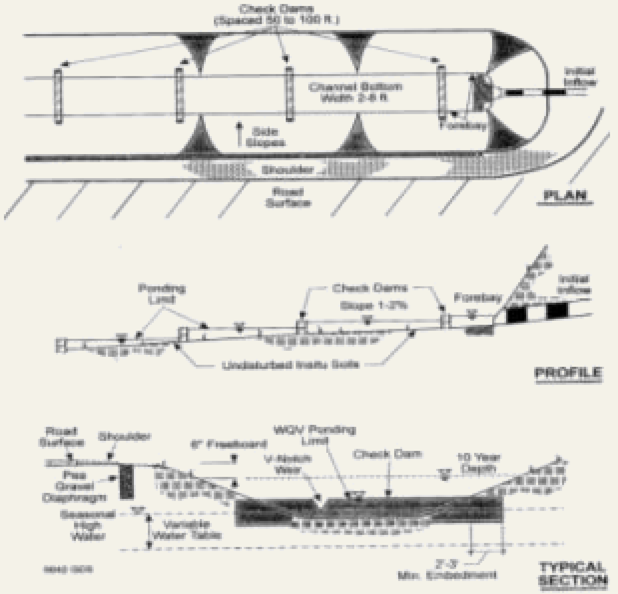
- Provides temporary storage and filtering
- “Linear bioretention”
- High nutrient removal rates, economical

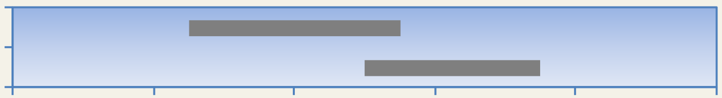




#11-Wet Swales (PR)

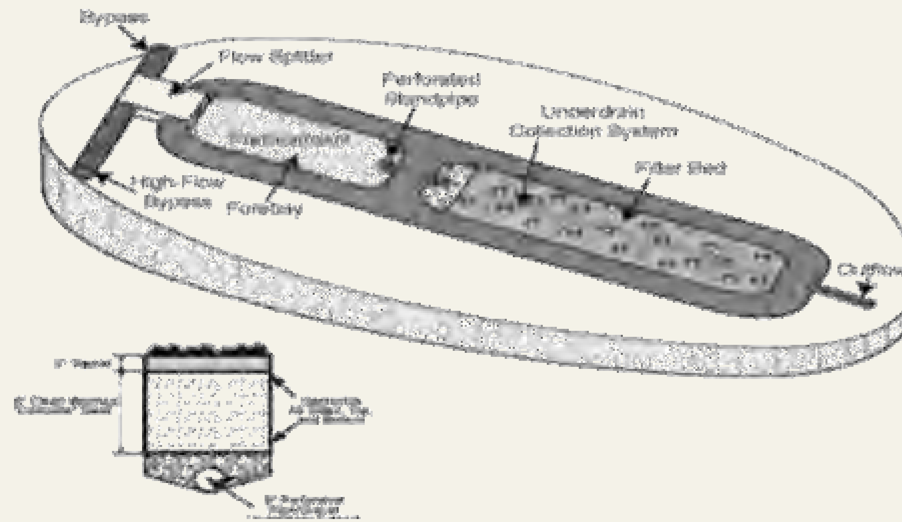
- Similar to “roadside swales, however much larger
- Vegetation/wet pool provides WQ treatment
- Not recommended and steep slopes
- Lower capital cost, higher maintenance costs

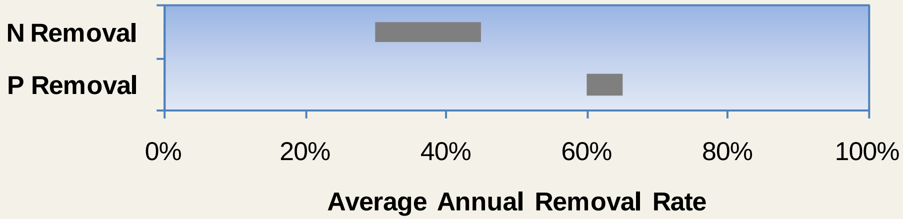




#12-Filtering Practices

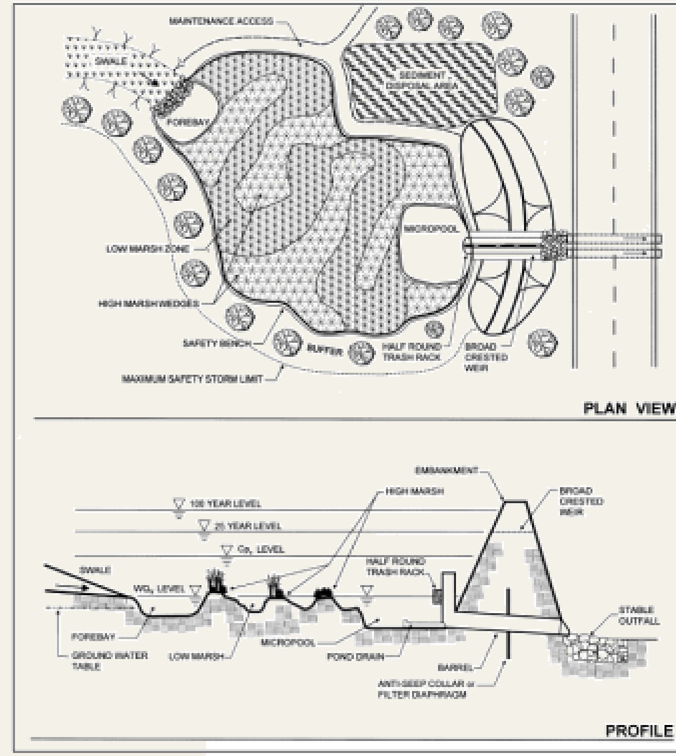
- Provides temporary storage of flow events
- Nonbypassed flow is treated through a media filter
- LOTS of different media designs

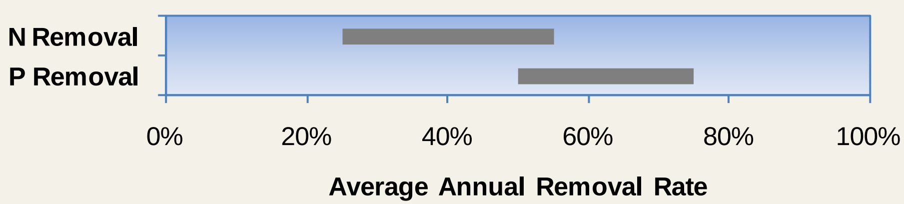




#13-Stormwater Wetlands (PR)

- Provides excellent nutrient removal
- Must have continuous base flow
- Large land area required
- Low maintenance
- New focus on emergent and forested wetlands

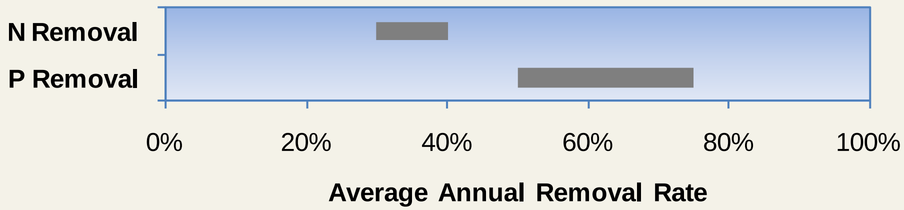




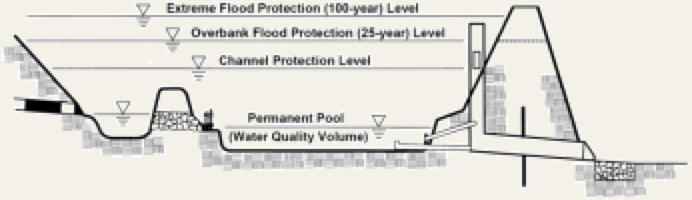
Source: www.stormwatercenter.net, and William Hunt's web site at www.bae.ncsu.edu/stormwater

#14-Wet Ponds (PR)

- Provides nutrient and sediment removal
- Can provide flood control benefits
- Must have base flow
- Maintenance can be high
- Discharge energy can be problematic

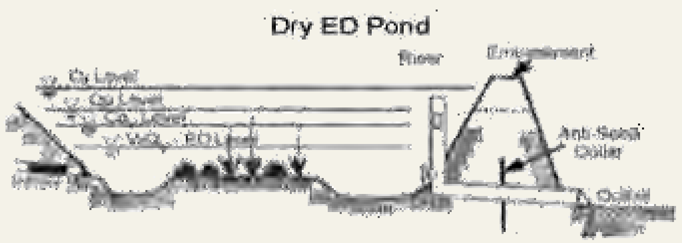


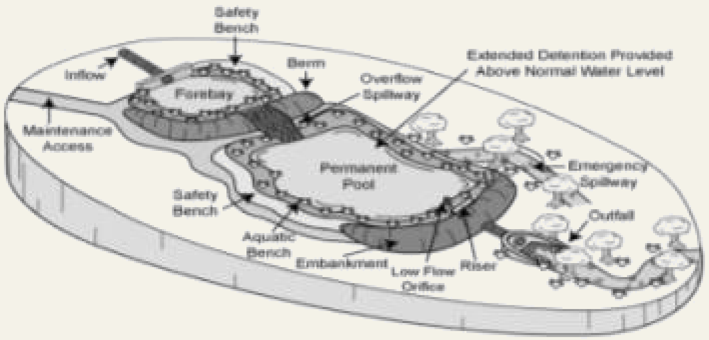
Source: Georgia Stormwater Manual (2003), [*http://www.unh.edu/erg/cstev/fact_sheets/ret_pond_fact_sheet_08.pdf*](http://www.unh.edu/erg/cstev/fact_sheets/ret_pond_fact_sheet_08.pdf)

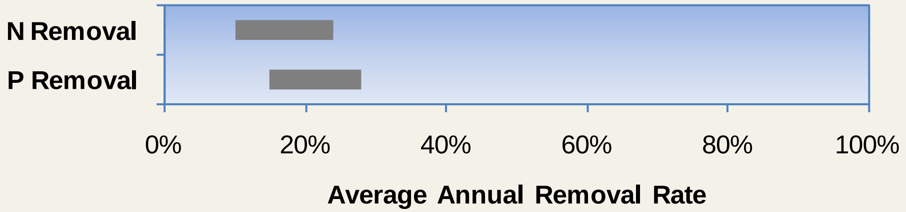


#15-Extended Detention Pond (PR)

- Dry detention that provides 12-24 hours detention during runoff events
- Good sediment removal, and nutrients that are associated with sediment
- Lowest efficiency of all practices







What About costs?

- Consider Life Cycle and Performance
- Cost tiers
  - Tier 1-Lower End
    - Rainwater Harvesting
    - Dry swales
    - Extended Detention
    - ??
  - Tier 2-Middle Range
    - Wet swales
    - Wet ponds
    - ??
    - ??
  - Tier 3-Upper End
    - Vegetated Roofs
    - ??

What About Costs?

- Tier 1-Lower End
  - Rainwater Harvesting
  - Dry swales
  - Extended Detention
  - Rooftop disconnect
  - Sheetflow/filter strip
  - Grass Channel
- Tier 2-Middle Range
  - Wet swales
  - Wet ponds
  - Infiltration Practices
  - Bioretention
  - Stormwater wetlands
- Tier 3-Upper End/Specialized
  - Vegetated Roofs
  - Soil restoration
  - Permeable pavement

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Dave Samples' Publications

Rooftop Disconnection

http://pubs.ext.vt.edu/426/426-120/426-120_pdf.pdf

Bioretention

http://pubs.ext.vt.edu/426/426-128/426-128_pdf.pdf

Rainwater Harvesting

http://pubs.ext.vt.edu/BSE/BSE-6/BSE-6_pdf.pdf

Vegetated Roofs

http://pubs.ext.vt.edu/BSE/BSE-6/BSE-6_pdf.pdf

Grass Channels

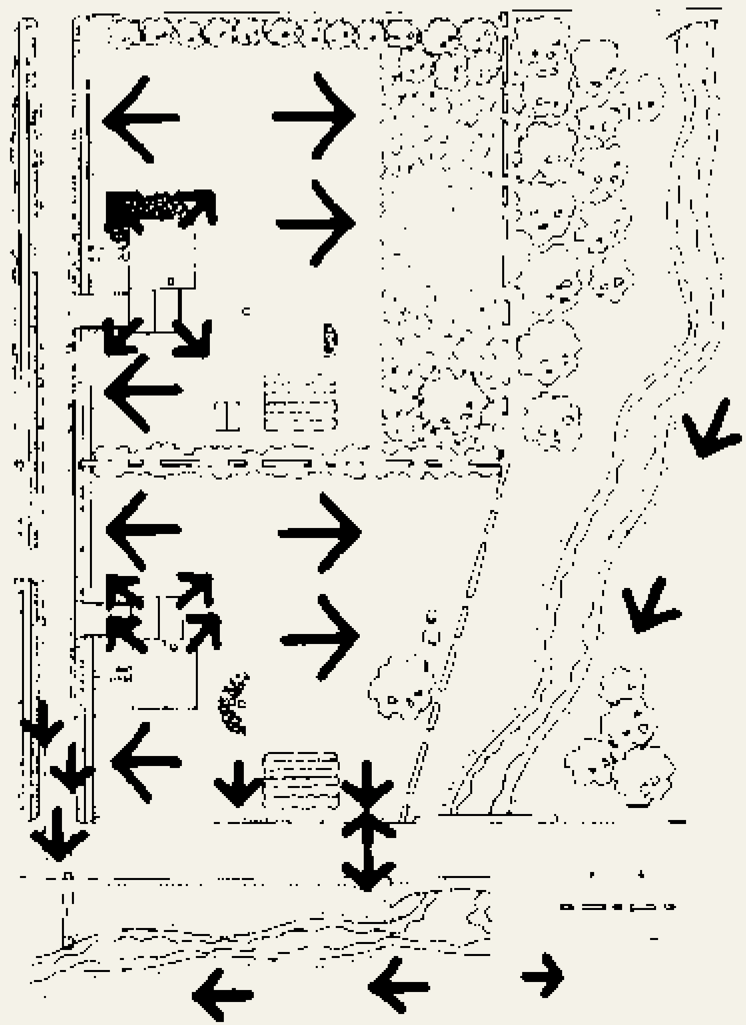
http://pubs.ext.vt.edu/BSE/BSE-6/BSE-6_pdf.pdf

Ok, but I only manage a single residential lot. What can I do?

Stormwater Management for Homeowners

Develop a Site Plan

- Identify location of impervious areas and where they drain
- Identify slopes
- Characterize soils
- Identify landscaping/vegetation
- Identify sensitive areas (creeks, ditches, lakes, wetlands, steep slopes, inlets)
- Identify paths of runoff and be nice to your neighbor.... remember where does stormwater go?



Key questions

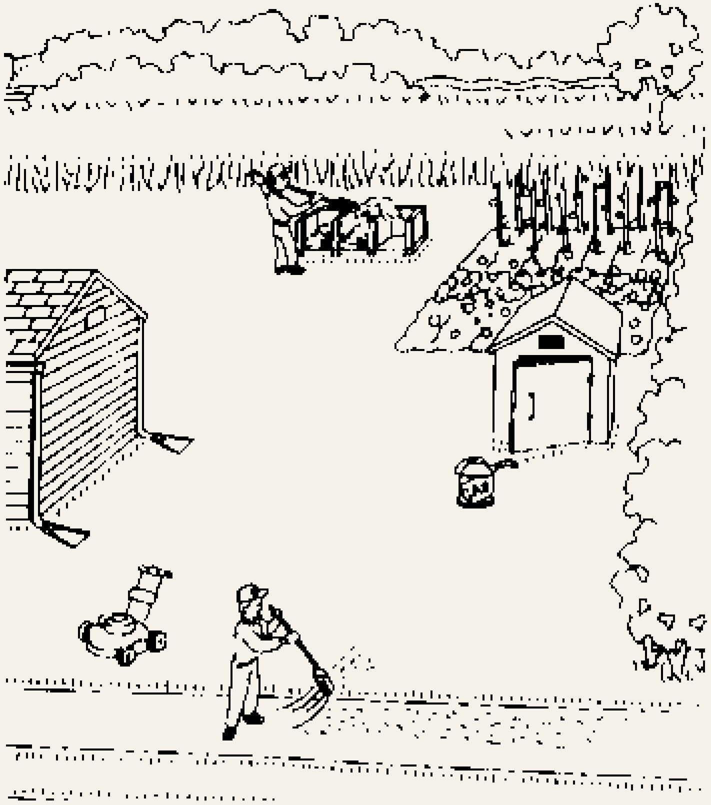
- Can you change your site layout to reduce runoff?
- Are yard and garden wastes kept away from runoff?
- Do you use and handle chemicals safely?
- Do you store fertilizers, pesticides and chemicals indoors?
- Do you fertilize in the fall or spring?
- How do you manage car/truck waste?
- How do you handle pet waste?
- Do you use salt/deicing products?
- Are there bare soil areas around your home?
- How is roof water directed (onto pervious or impervious areas)?
- Can you reduce paved surfaces or try permeable pavement?

Residential BMP#1-Modify Site Layout

- Can you find ways to:
  - Modify flow paths, make them longer
  - Restore soils where they have become compacted
  - Terrace steep slopes
- Consider "Good sense" practices:
  - Rain gardens
  - Buffer strips, especially riparian
- Consider opportunistic practices
  - Permeable pavement driveways
  - Green roofs

Residential BMP#2-Manage Your Yard/Garden Waste

- Start a compost pile
- Use a mulching mower
- Sweep up yard waste
- Planting in dry periods
- Mulch bare soils
- If Municipality provides leaf collection, time your sweep!



Residential BMP#3-Smarter Irrigation

- Avoid overwatering/don't let it die
- Get a rain gage
- Use irrigation timer/controller to set rate, rain cut off
- Install soil moisture sensors
- Advanced designs include ET sensors



Residential BMP#4-Handle Chemicals Safely

- Choose native, hardy plants
- Weed by hand
- Use pesticides as a last resort
- Avoid fertilizer/pesticide use near water or after rain
- Spot treat with pesticides
- Sweep up any residue and dispose of properly.
- Follow any pesticide label-it's the law!

Residential BMP#5-Store Chemicals Indoors

- Store materials inside, cover with a tarp, or remove materials
- Limit the exposure of potential pollutants to rainfall or runoff…..
- Minimize the amount of material stored by implementing “just in time” purchasing
- Dispose of spent materials properly-”Household Hazardous Waste Day”

Residential BMP#6-Use Fertilizers Appropriately

- Fertilizer is wasted if not needed
- To assess need, test soils-VT CSES lab every 3 years
  - Likely should fertilize in the fall, not spring
  - P content of most soils is many time what is needed
- Measure your lawn
- Use the correct amount
- Join programs like PWC Great ‘Scapes

FILAMENTOUS ALGAE

Residential BMP#7-Manage Vehicle Waste Appropriately

- Wash your car on the grass or car wash
- Use phosphate-free car soaps
- Maintain your vehicle to prevent leaks
- Use kitty litter or saw dust to clean up leaks and spills-landfill
- Collect and recycle hazardous waste oils, solvents etc. and properly dispose of auto fluids

Residential BMP#8-Handle Pet Waste Appropriately

- Always pick up after your pet and dispose of the waste properly
- Yes, the back yard too.
- Much of the P leaches in 2 days
- Seal it in a plastic bag and throw it away
- Farmettes-composting systems

Residential BMP#9-Use Deicing Products Appropriately

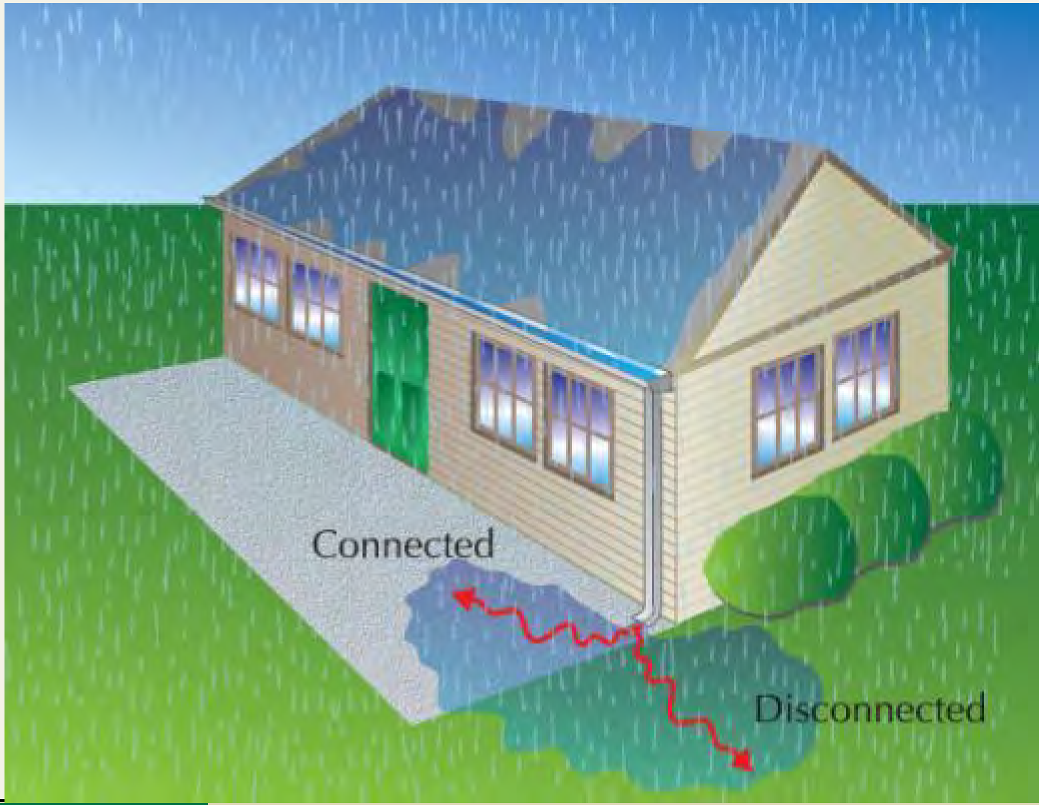
- Clear snow to the lower end of paved areas.
- Clear snow from drains to allow for better drainage
- Mix salt with sand for greater safety and effectiveness, limit impact
- Alternatives include kitty litter, cinders, ashes—Not fertilizer!

Residential BMP#10-Repair Bare Soil Areas

- Plant vegetative buffers
- Plant groundcovers using native plants
- Re-seed bare spots or mulch
- Use silt fences during projects

Residential BMP#11-Disconnect Downspouts

- Disconnect gutters, drain onto vegetated areas
- Consider connecting to rain garden or cistern
- Consider soil restoration in path
- Exercise care about foundations



Residential BMP#12-Reducing Imperviousness

- Minimize Pavement
  - Low tech-Two track driveway
  - Consider permeable pavement (with reservoir)
- Install swales, grass channels
- Install cisterns or rain gardens

Residential BMP#13-Manage Solid Waste Appropriately

- Use storage containers, recycle materials in separate container
- If no collection, bin items separately
- Home renovation waste-cover

Residential BMP#14-Limit Pressure Washing

- Limit pressure washing of pavement, buildings
- Find means of collecting wastewater generated

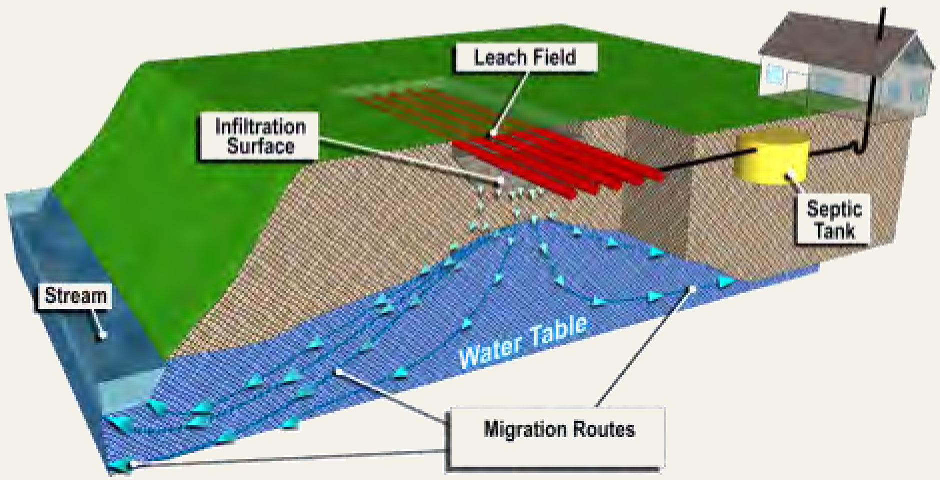
Residential BMP#15-Manage Septic Systems

Issue

- Low cost treatment of choice if sewer unavailable
- Septic Systems are a major, essentially unmanaged contribution of Nitrogen loading to receiving waters
- Fecal coliform NOT an issue unless System malfunctions

Solutions

- Inspect and maintain periodically
- Advanced Treatment Systems



Residential Lot Stormwater Management Worksheet

Designed to:

- Self evaluation for water to identify water quality concerns
- Analyzes relative safety of SW practices using risk scoring
- Determine which practices are safe and which need modification

Source: Shelton, D.P. and Feehan, K.A. (2008) Stormwater Management on a Residential Lot, University of Nebraska-Lincoln Extension Publication EC707.

Worksheet (Runoff Quality Risk)

Practice	High Risk (Risk Level 4)	High-Moderate Risk (Risk Level 3)	Moderate-Low Risk (Risk Level 2)	Low Risk (Risk Level 1)	Your Risk Score
		Potential Contaminants in Runoff			
Handling and use of pesticides, fertilizers, and outdoor chemicals	Spills are not cleaned up. Products are used in greater amounts than what is recommended on the label.	Granules, etc. are left on driveway, sidewalks or other paved areas to be carried off by stormwater.		Spills are cleaned up immediately, particularly on paved surfaces. Recommended amounts of chemicals are applied according to label instructions.	
Timing of pesticide, fertilizer, and outdoor chemical use	Application is made when heavy rain is forecast within the next 24 hours and on saturated soils or areas where runoff is likely.	Application is made when heavy rain is forecast within the next 24 hours and on unsaturated soils or areas with little slope.	Application is made when light rain is forecast within the next 24 hours and on saturated soils or areas where runoff is likely.	Application is made when no or only light rain is forecast within the next 24 hours and on unsaturated soils or areas with little slope.	
Storage of pesticides, fertilizers, and other potentially harmful chemicals	Chemicals are stored in non-waterproof containers outdoors.	Chemicals are stored in waterproof containers outdoors, but within reach of stormwater.	Chemicals are stored in waterproof containers outdoors, out of the reach of stormwater.	Chemicals are stored in waterproof containers in a garage, shed, or basement that is protected from stormwater.	
Automotive Wastes	Used oil, antifreeze, or other wastes are dumped down a storm drain or on a paved surface.	Used oil, antifreeze, or other wastes are dumped in a ditch or on the ground.	Drips and spills are not cleaned up. Car parts and other vehicle wastes are left on unpaved areas outside.	Oil drips and fluid spills are cleaned up. Dirty car parts and other vehicle wastes are kept out of reach of stormwater runoff.	
Vehicle washing	Cars, trucks, or other items are washed on a driveway, street, or other paved area.	Cars, trucks, or other items are washed on a gravel or rocked area.	Cars, trucks, or other items are washed on a lawn.	Cars and trucks are taken to a commercial car wash.	
Pet and animal wastes	Animal and pet wastes are left on paved surfaces or dumped down a storm drain.	Animal and pet wastes are left to decompose on grass or soil. Wastes are concentrated in a small area such as a pen.	Animal and pet wastes are left to decompose on grass or soil. Wastes are scattered over a wide area.	Animal and pet wastes are flushed down the toilet or wrapped and placed in the garbage for disposal.	

Worksheet-(Landscaping Practices Risk)

Practice	High Risk (Risk Level 4)	High-Moderate Risk (Risk Level 3)	Moderate-Low Risk (Risk Level 2)	Low Risk (Risk Level 1)	Your Risk Score
Landscaping and Site Management					
Landscaping	There is no landscaping to slow the flow of runoff. Soils are compacted, limiting infiltration. Yard is hilly, allowing runoff to occur.	No areas are landscaped to encourage water to soak in, and soils are compacted. Yard is relatively flat, reducing the amount of runoff that occurs.	Yard is landscaped and soils are amended to slow the flow of stormwater and provide areas where water soaks into the ground. Yard is hilly, allowing some runoff to occur.	Yard is landscaped and soils are amended to slow the flow of stormwater and provide areas where water soaks into the ground. Yard is relatively flat and little runoff occurs.	
Yard and gardens	Large areas of yard or garden are left without mulch or vegetation for long periods.	Small areas of yard or garden are left without mulch or vegetation for long periods.	Grass or other ground cover is used, but is spotty, particularly on slopes.	Bare spots in the lawn are promptly seeded and topped with a layer of straw or mulch. Bare soil in gardens is covered with mulch	
Paved surfaces	Large areas are paved for walkways, patios, and other areas.	Some small areas are paved for walkways, patios, and other areas.	Alternatives such as gravel, rock, paving blocks, brick, or flagstone are used for walkways, patios, and other areas.	Alternatives such as wood chips or mulch are used for walkways, patios, and other areas.	
Roof drainage	Most or all downspouts are connected directly to storm drains.	Most or all eave drip lines or downspouts discharge onto paved surfaces where water runs off.	Most or all eave drip lines or downspouts discharge water onto grassy or mulched areas where some water runs off.	Most or all eave drip lines or downspouts discharge water onto a grassy or mulched area or rain garden where water soaks into the ground.	
Lot during construction	Soil is left bare until construction is completed and no sediment barriers are used.	Soil is left bare until construction is completed. Sediment barriers are installed, but are poorly maintained allowing some muddy runoff to leave the site.	Soil is left bare until construction is completed. Sediment barriers are installed and maintained to detain muddy runoff until grass covers soil.	Bare soil is seeded and mulched as soon as possible (before construction is completed). Sediment barriers are used until grass covers soil.	
Buffer strips	Bare soil, sand, or gravel exists next to a stream bank or lakeshore. Stream banks or lakeshores are eroding.	Spotty mowed vegetation exists next to a stream bank or lakeshore.	Mowed grass exists next to stream bank or lakeshore.	Buffer strips of thick vegetation are left along a stream bank or lakeshore.	

Scoring

- Low risk (1): Ideal, may not always be practical
- Moderate-low risk (2): Provides reasonable water quality protection
- High-moderate risk (3): Do not provide adequate water quality protection
- High risk (4): Pose a serious danger to water quality

Source: Shelton, D.P. and Feehan, K.A. (2008) Stormwater Management on a Residential Lot, University of Nebraska-Lincoln Extension Publication EC707.

Questions/More Information

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HR AREC
(571) 363-3835

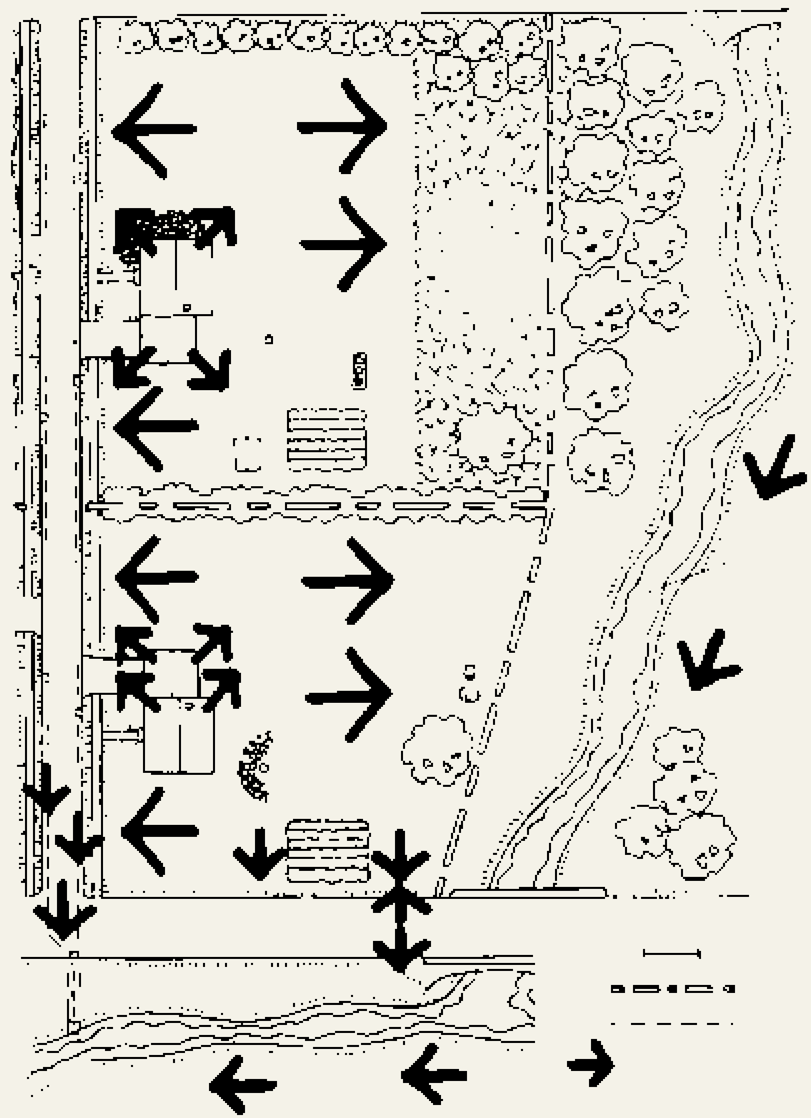
Rain Gardens

Key questions before considering any BMP

- Can you change your site layout to reduce runoff?
- Are yard and garden wastes kept away from runoff?
- Do you use and handle chemicals safely?
- Do you store fertilizers, pesticides and chemicals indoors?
- Do you fertilize in the fall or spring?
- How do you manage car/truck waste?
- How do you handle pet waste?
- Do you use salt/deicing products?
- Are there bare soil areas around your home?
- How is roof water directed (onto pervious or impervious areas)?
- Can you reduce paved surfaces or try permeable pavement?

Develop a Site Plan – look at the site as a whole

- Identify location of impervious areas and where they drain
- Consult the County Mapper
- Identify slopes, existing vegetation
- Characterize soils
- Identify sensitive areas (creeks, ditches, lakes, wetlands, steep slopes, inlets)
- Identify paths of runoff and be nice to your neighbor.... remember where does stormwater go?



Where to locate a rain garden?

Check infiltration rate of soil

1. Dig 12” hole, note soil conditions (dry/wet/clay/loamy)?
2. Fill hole with water (2 separate intervals)
3. If hole drains in 48 hours, both times, then site is suitable for a rain garden.
4. If not drained in 48 hours, then

   select a new location or amend soil or install underdrain (consider hiring contractor)

Rain Garden features

- Inflow structure (gutter downspout, sheet flow, swale)
- Ponding area
- Mulched area
- Planting area
- Other options: overflow structure, underdrain

Location of Your Rain Garden

- Locate a minimum of 10 feet from structures
- Locate outside of tree's dripline to avoid roots/competition
- Locate away from utility lines – call Miss Utility
- Do not locate in place where water pools
- Do not build where soil has high water table
- Rain gardens should not be built on land with a slope greater than 12-15%.
- Rain gardens should NOT be placed over septic systems. This can overwhelm the system.

Lawn slopes and suggested depths for rain garden

- < 4% 3-5 in
- 5-7% 6-7 in
- 8-12% 8 in
- > 12% unacceptable

Soil Amendments

- Soil amendments make the rain garden more efficient
- Amend with compost and/or sand to make it more porour or
- Replace soil with engineered mixture or sand, topsoil and organic matter (only in the poorest soil conditions)
- Check with 48 hour infiltration test

Soil Media Considerations

- Many times we see simply the following:
  - 50 – 60% sand/20 – 30% leaf compost/20 – 50% topsoil
- Virginia Bioretention Specifications call for:
  - 85 – 88% sand/8 – 12% soil fines/3 – 5% organic matter
- This is better (per the LID Center):
- 30% “Planting Soil”,
- 50 – 85% sand
- 0 – 50% silt
- 10 – 20% clay
- 1.5 – 10% organic matter
- 20% Shredded hardwood mulch

[1] [illegible] VDCR Stormwater Design Specification No 9: Bioretention, Version 1.6, [illegible] Winchester [illegible] September 30, 2009, CWP and CSN (2008) and CWP (2007).

Compute Your Drainage Area

- If you are using a downspout disconnection, compute the surface area of the roof that drains into rain garden
- For example: If your roof is 60 ft by 40 ft, or 2400 sq ft. The drain spout drains about ¼ of the roof. the drainage area for your rain garden is 2400 x ¼, or about 600 sq ft. The roof will produce nearly 100 percent runoff and a one-inch rain would discharge around 50 cubic feet or approximately 375 gallons of water to your garden.
- If you are not using a downspout disconnection, compute the area of driveway, sidewalks and other impervious surfaces.

Construction Steps

1. Stabilize upstream drainage area
2. Excavate bioretention basin
3. Rip or scarify bottom
4. Optional: Install filter fabric (sides?), stone, underdrain
5. Add soil media in 12 inch lifts
6. Plant trees and shrubs
7. Install landscape cover/mulch
8. Inspect construction

Planting Your Rain Garden

Plant Selection

- Choose plants tolerant of both occasional flooding as well as dry periods.
- Choose noninvasive plants that are adapted to the local environment.
- Choose a mixture of species. A good rule of thumb is one plant species for every 10 to 0 square feet, e.g.140-square-foot garden would have 7 to 14 different species.
- Choose plants for vertical layering – a mix of tall-, medium-, and low-growing species.

Plant Installation

- Install plants in their proper moisture zones
- Plant shrubs and perennials in groups of three to five of the same species.
- Trees can be planted in groups or individually.
- Plant taller and larger plants in the center or at one end of the garden, depending on the views.

Plant Installation (contd.)

- Plant shorter plants where they can be seen easily, around the garden edges, in front of larger plants, or underneath taller plants.
- Space and plant perennials so that their canopies will grow together and cover the ground to minimize weeds.
- Space and plant trees and shrubs according to their mature size. Use trees in rain gardens > 150 sq. feet.

Plant Installation

Plants used in a rain garden need to be able to tolerate wetness and drought

Shrubs


Callicarpa


Aronia


Hamamelis virginiana


Sambucus canadensis


Viburnum trilobum


I
lex verticillata


Clethra
alnifolia

Perennials

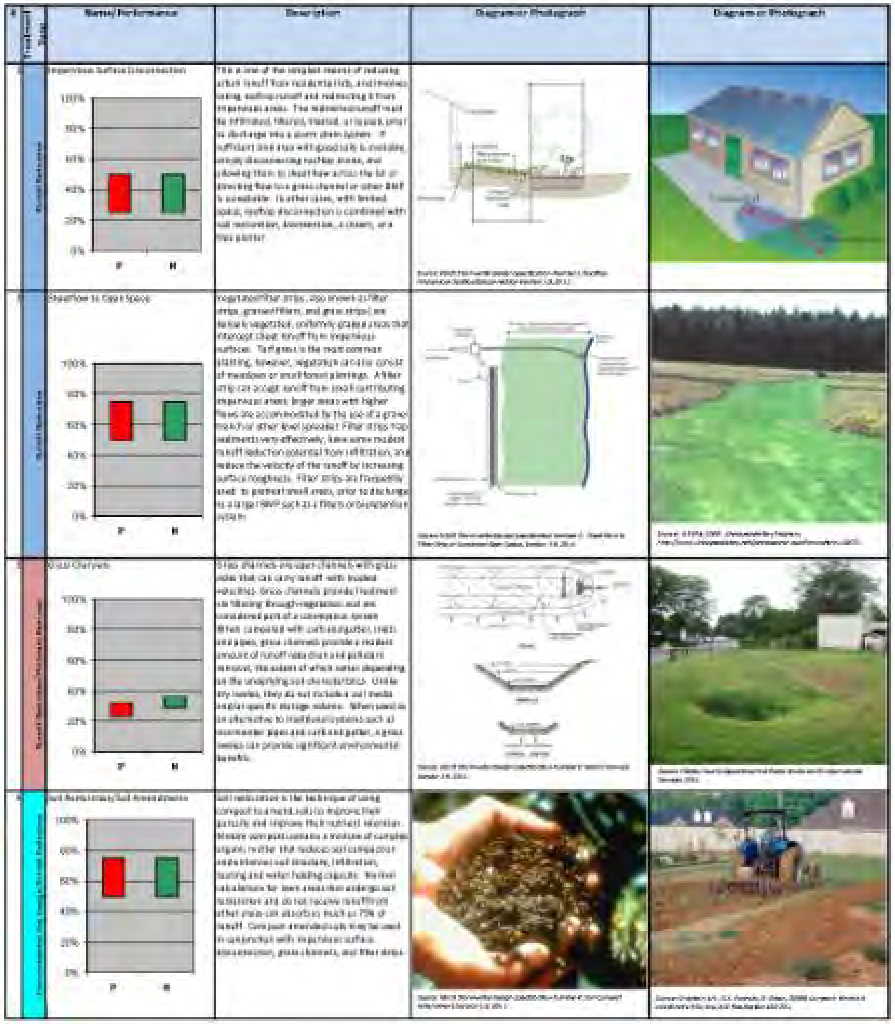
Rain Garden Design

Maintenance

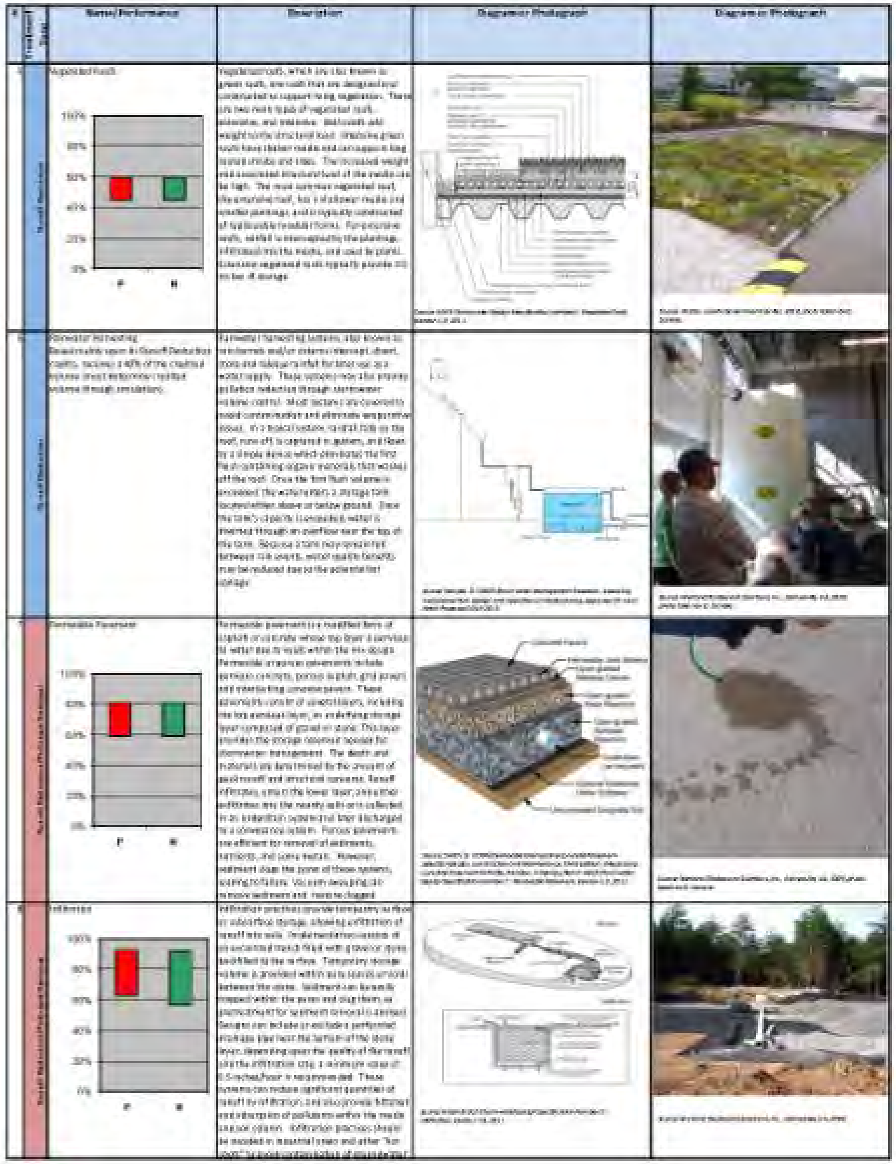
- Maintenance is similar to garden work – weed, prune the 3 D's, check for erosion
- Replace dead plants and replenishing mulch annually
- Minimize compaction of the planting media. Ideally, once the garden is planted, it will not be walked on.
- During the first season after planting, plants will need to be watered regularly so that they are given a good start on growing and getting established, as in a typical garden.
- If you have an under drain, check for clogging 24 hours after storms, Inspect forebay and mulch/media surfaces & remove sediment

Sources for Rain Garden Plant Recommendations

- PWC DCSM Manual (handout provided) – compiled by VCE Prince William MGs
- http://www.lowimpactdevelopment.org/raingarden_design/construction.htm (templates)
- http://www.fairfaxcounty.gov/nvswcd/raingardenbk.pdf
- http://www.ext.vt.edu/news/solutions/solutions2008/articles/RainGardensProvide.html
- http://www.dof.virginia.gov/mgt/resources/pub-Rain-Garden-Tech-Guide_2008-05.pdf



#	Treatment Tier	Name/ Performance	Description	Diagram or Photograph	Diagram or Photograph
[illegible]	Runoff Reduction	Impervious Surface Disconnection	[illegible]	[illegible]	
[illegible]	Runoff Reduction	Sheetflow to Open Space	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	Grass Channels	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	Soil Restoration/Soil Amendments	[illegible]	[illegible]	[illegible]



#	Treatment Type	Name/Performance	Description	Diagram or Photograph	Diagram or Photograph
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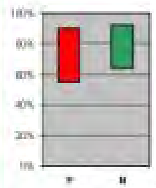
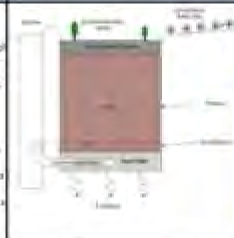
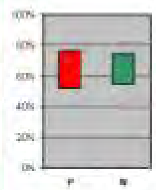
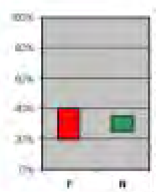
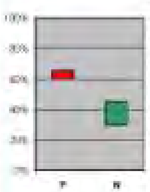
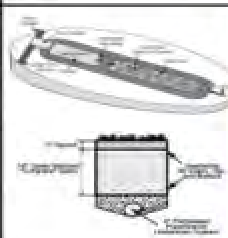
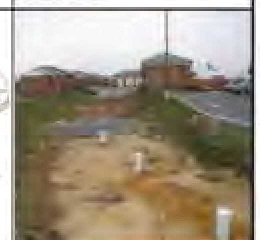
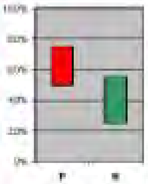
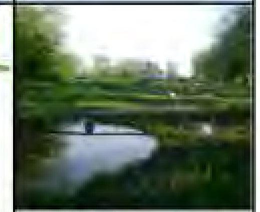
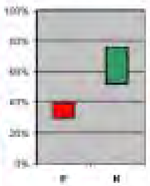
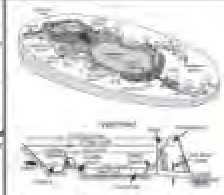
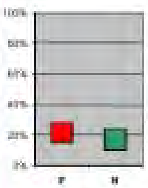
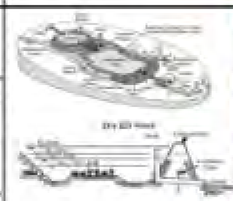
[illegible]	[illegible]	Rainwater Harvesting	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	Permeable Pavement	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	Infiltration	[illegible]	[illegible]	[illegible]

#	Treatment Type	Name/Performance	Description	Diagram or Photograph	Diagram or Photograph
9	[illegible]	Bioretention 	[illegible]	 [illegible]	 [illegible]
10	[illegible]	Dry Swale 	[illegible]	 [illegible]	 [illegible]
11	[illegible]	Wet Swale 	[illegible]	 [illegible]	 [illegible]
12	[illegible]	Filtering Practices 	[illegible]	 [illegible]	 [illegible]

#	Treatment Type	Name/Performance	Description	Diagram or Photograph	Diagram or Photograph
13	Pollutant Removal	Constructed Wetlands 	Constructed wetlands, also known as stormwater wetlands, are BMPs that use wetland vegetation to provide physical, chemical and biological treatment of urban stormwater. Constructed wetlands vary substantially in their microtopography from depressions of less than one foot to deeper micropools several feet deep. This variability diversifies wetland vegetation. There are several subtypes of constructed wetlands, including shallow marsh, extended detention, pond/wetland systems, pocket wetlands, and forested wetland systems. Treatment is provided by settling, filtration, adsorption, and biological uptake. Stormwater wetlands could be very effective at pollutant removal.		
14	Pollutant Removal	Wet Ponds/Retention Ponds 	Wet ponds (also known as stormwater ponds or retention ponds) are stormwater impoundments that have a permanent pool of water that is controlled to a specified elevation by an outfall structure. Treatment consists of settling of solids and biological uptake of nutrients. Inflow enters the pond and partially displaces water collected during previous storms. If additional freeboard is available above the outfall (freeboard), the attenuation of stormwater peak flows may also be provided through extended detention, which helps meet channel protection requirements. Because of their placement at the lowest point of a drainage area, wet ponds are the final treatment opportunity available. Therefore, other opportunities for runoff reduction and/or water quality treatment should be explored prior to resorting to this BMP.		
15	Peak Reduction/Pollutant Removal	Extended Detention 	An Extended Detention (ED) Pond provides 12-24 hours of storage during peak runoff events. Releases from the ED Pond are controlled by orifices and/or weirs within the pond's outlet structure. As the outflow is restricted, water backs up into the ED Pond. The pond slows flow velocities and enables particulate pollutants to settle. Treatment of settleable nutrients and sediment is good; however, resuspension of the settled pollutants can occur, and dissolved nutrient removal is poor. ED Ponds have the lowest overall pollutant removal rate of any stormwater treatment option, so they are often combined with other upstream LID practices to better maximize pollutant removal rates.		

VIRGINIA COOPERATIVE EXTENSION

Publication 426-120

Rooftop Disconnection Best Management Practice Fact Sheet #1

David J. Sample, Assistant Professor and Extension Specialist, Department of Biological Systems Engineering, Virginia Tech

Please refer to definitions in the glossary at the end of this fact sheet. For convenience, these terms are *italicized* in the text. For a comprehensive list, please refer to VCE Publication 426-119, Urban Stormwater: Terms and Definitions.

What is Rooftop Disconnection?

Rooftop disconnection (RD) is one of the simplest means of reducing *stormwater* from residential lots. RD takes roof runoff that has been collected in gutters and piped directly to streets, storm drains and streams; and redirects it to landscaped areas and away from *impervious surfaces* (see graphic). RD is a very *sustainable best management practice* (BMP) because it controls pollutants in runoff near their source. Redirected runoff from downspouts is be *infiltrated*, filtered, treated, or reused, prior to draining into a *stormwater conveyance system*.

Where can Rooftop Disconnection be used?

RD can be used in either commercial or residential areas with a lot size greater than 6,000 ft². It can be used in any soil, however caution should be applied to applications in poorly draining soils such as *clays* and *silts*.

What does a Rooftop disconnection do?

A variety of different means of disconnecting runoff from impervious surfaces is used in RD. If sufficient land area with good soils is available, simply disconnection the rooftop runoff, thus creating a wide, shallow flow across the ground surface in a wide shallow form can be achieved (see Figure 1). The *flow path* can be enhanced with *compost* to encourage *infiltration*. In other cases where space is limited, rooftop disconnection can be accomplished by diverting runoff into other *best management practices* (BMPs) such as a *bioretention*, a *cistern*, a *tree planter*, or a *dry-well*.

The most common of these practices is simple disconnection. This simple method can often be accomplished by cutting the downspout and redirecting it horizontally onto a splash pad and to a *pervious* area (such as a lawn) to *infiltrate*.

A *compost* amended filter path (Figure 2) involves tilling the soils in the *flow path* (about 10 ft wide) to a depth of 6-10 in. and adding 2-4 in of *compost* in the top layer, while maintaining the low point. This provides an enhanced *infiltration* of runoff through the *flow path*.

Adding a *rain garden* in series can reduce runoff and provide additional treatment and can effectively eliminate most of the rooftop runoff. Refer to Fact Sheet #9 (*Bioretention*) for further information on this practice. *Dry-wells* are described in Fact Sheet #8.

Limitations

<u>Limitations for simple RD:</u>

- Limit the contributing roof area (*roofshed*) to a maximum of 1000 ft² per downspout.
- The longest overland *flow path* after disconnection should be between 40 ft and 75 ft to allow *infiltration*.
- Should limit applications to areas with slopes less than 2 ft in 100 ft to prevent *erosion*. However if turf reinforcement is used, slopes can be as high as 5 ft in 100 ft.
- Downspout *outlets* should be located at least 5 feet from any building.
- Use screens to prevent leaves and organic material from entering gutters, can result in clogging of gutters and *flow paths*.

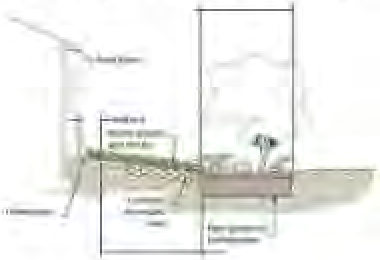
<u>*Limitations for Compost amended flow path*</u>

- Should be a minimum length of 20 ft.
- Should be a minimum width of 10 ft.
- Maintain low elevation for channel.
- Use pea gravel at the downspout to spread the flow and prevent channeling.

<u>Limitations for *Rain gardens/micro-bioretention*:</u>

Same limitations as for simple RD above, plus:

- Soil *infiltration* rate should be greater than 0.5 inches/hour, or use an *underdrain*.
- Filter *Media* should be at least 18 in.
- Need minimum of 1-3 ft of elevation drop.
- Buildings downhill, at least 25 ft away.



Maintenance

- Maintenance is similar to other landscaping and may require periodic mowing.
- Periodic inspections for clogging (failure to drain) should be made.
- If inspection reveals clogging, remove any accumulated leaves, organic materials, and *sediment* as soon as practical.

Performance

RD's are small practice whose performance is difficult to measure. Most of the treatment expected is due to runoff reduction, which reduces the mass of pollutants. Performance is thus directly affected by soils. In sandy soils, with high *infiltration*, an RD is expected to reduce Total Phosphorus (TP) and Total Nitrogen by 50%. In less *infiltrative* soils (such as *clays or silts*), this is reduced to 25% for both TP and TN (VDCR 2011).

Costs

Cost of installation for RD can vary significantly. For simple RD, the costs of materials and labor are rather inexpensive and can be done at a cost of less than $100 per downspout. The addition of *compost amended flow paths* and *rain gardens* are likely increases costs significantly. Costs must be estimated on a site basis. However, many of these practices are in use by homeowners and appear to be performing well. Maintenance for all RD practices is similar to other home landscaping tasks, and thus can be performed by the homeowner.

Where can I find additional information?

The Virginia Department of Conservation and Recreation (VDCR) is the state agency that controls nonpoint source pollution and *stormwater*. The VDCR regulates urban *stormwater* through the Virginia Stormwater Management Program (VSMP). Additional information on *BMPs* can be found at the Virginia BMP Clearinghouse at the web link in the following section. The BMP Clearinghouse is jointly administered by the VDCR and the Virginia Water Resources Research Center (VWRRC), which has an oversight committee called the Virginia Stormwater BMP Clearinghouse Committee. The committee members represent various stakeholder groups involved with *stormwater* management.

World Wide Web Resources

Chesapeakestormwater.net

http://www.chesapeakestormwater.net/all-things-stormwater/rooftop-disconnection-design-specification.html

City of Philadelphia

www.phila.gov/water/Stormwater/pdfs/WQ_Interpretation_fo.pdf

http://www.scribd.com/doc/13322624/Stormwater-Management-Guidance-Manual-Ver-20

City of Portland, Oregon

http://www.portlandonline.com/bes/index.cfm?c=43081&a=322320

City of Richmond, Virginia

http://www.richmondgov.com/DPU/documents/BMPQuantity_Rooftop_Disconnection_Inspection_Checklist.pdf

City of Toronto, Ontario

http://www.riversides.org/rainguide/riversides_hgr.php?cat=2&page=39&subpage=41

StormwaterPA.org

http://www.stormwaterpa.org/5-8-1.html

Pennsylvania Department of Conservation and Natural Resources

www.dcnr.state.pa.us/cscn08/Horner%20presentation.ppt

Virginia BMP Clearinghouse

http://vwrrc.vt.edu/swc/

Companion Virginia Cooperative Extension Publications

Goatley, J., (Ed.) W. Daniels, G. Evanylo, L. Fox, K. Haering, S. Hodges, R. Maguire, D. Sample, D. Hansen, D. Kindig, T.Sexton, R. Habel, K. Hensler (2011)Urban Nutrient Management Handbook, VCE Publ. No. 430-350.

Benham, B. and Lawrence, J. (2010), Stormwater 101: An Introduction for Master Gardeners, Winchester meeting http://water.rutgers.edu/Rain_Gardens/RGWebsite/misc/Virginia_Tech-Rutgers_Rain_Garden_Wichester_Stormwater_101_benham_040109.pdf

Gilland, T., Fox, L., Andruczyk, M., Swanson, L. (2009) Urban Water-Quality Management - What Is a Watershed? VCE Publ. No. 426-041.

Acknowledgements

The authors would like to express appreciation for the review and comments provided by the following individuals: Brian Benham, Associate Professor, Biological Systems Engineering, Virginia Tech, Jon Hathaway, Biohabitats, Inc., Thomas Bolles, Extension Agent, Virginia Tech, Adria Bordas, Extension Agent, Virginia Tech.

References

VA-DCR (2011) Virginia DCR Stormwater Design Spec. No.1 Rooftop Disconnection. Version 1.9, March 1, 2011, http://vwrrc.vt.edu/swc/NonPBMPSpecsMarch11/VASWMBMPSpec1DISCONNECTION.html

City of Portland (2009) Stormwater Manual.

Note: This Fact Sheet is one of a 15-part series on urban stormwater management practices.

Glossary of terms used in this Fact Sheet:

Best Management Practice – for urban lands refers to any treatment practice that reduces pollution from *stormwater*. BMPs can be either a physical structure or a management practice. A similar but different set of BMPs are used to mitigate agricultural runoff.

Bioretention – A BMP that is a shallow landscaped depression that receives and treats stormwater with the goal of discharging water of a quality and quantity similar to that of a forested watershed. *Bioretention* devices typically consist of vegetation, soils, an optional *underdrain*, and an *outlet*.

Cistern – A storage tank designed to store rainwater for later use. Also known as a Rainwater Harvesting System (RHS).

Clays- According to the US Department of Agriculture's soil classification system, clays are soils whose size is less than 0.002 millimeter, or mm.

Compost – Vegetative or organic matter that has been allowed to fully decompose leaving a rich organic medium that can be mixed with soils.

Compost amended flow path – is the practice of restoring soils within the *flow path* (with redirected roof runoff from RD) using *compost* (see *soil restoration*).

Dry-well – a small underground structure that disposes of stormwater through infiltration. Usually consists of a hole lined with gravel.

Erosion – the movement of soils and rock through weathering from water and wind.

Flow path – the path water takes as it flows over land, in the case of RD, after it exits the downspout.

Impervious surface – A hard surface that does not allow *infiltration* of rainfall into it, or not *pervious*.

Infiltrate, Infiltrated –The act of water entering soils (see *infiltration*).

Infiltration – the process by which water (either surface water, rainfall, or runoff) enters the soil.

Media, filter media – the topsoil that supports plant growth. *Bioretention media* typically has high sand and low clay content, and low phosphorus content.

Outlet - the point of exit of water from a downspout or other BMP.

Pervious – A ground surface that is porous and allows *infiltration* into it.

Rain garden – Often used interchangeably with *bioretention*, however is typically referred to a less formal design and installation process. Typically implemented in residential areas by homeowners.

Roofshed – The area of the roof that drains to a single downspout. The boundary is determined by the roof and the roof ridge lines.

Rooftop disconnection or RD –RD redirects runoff from streets, storm drains and streams onto landscaped areas and away from *impervious surfaces*.

Sand – According to the US Department of Agriculture's soil classification system, sands have a particle size greater than 0.05 millimeter, or mm.

Sediment – the soil, rock, or biological material particles that are formed by weathering, decomposition, and *erosion*.

Silt – According to the US Department of Agriculture's soil classification system, *silts* have a particle size between 0.002 and 0.05 millimeter, or mm.

Soil restoration –is the technique of using *compost* to amend soils to improve their porosity and nutrient retention. The restored soils are less compacted and can replicate natural, forested

Stormwater – is water that originates from *impervious surfaces* during rain events, often associated with urban areas and is also called *runoff*.

Stormwater conveyance system –Storm drain or stream that is used by more than one property upstream from it.

Sustainable – the ability of the system to endure and remain productive over long time duration.

Tree planter – An ultra urban, small BMP that is a *bioretention* system designed to exist inside a concrete box or tree planter (see *bioretention*).

Underdrain – a perforated pipe in the bottom of a *bioretention* system designed to collect water that does not *infiltrate* into native soils.

VIRGINIA COOPERATIVE EXTENSION

Publication 426-128

Bioretention
Best Management Practice
Fact Sheet #9

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Jia Liu, Ph.D. Student, Department of Biological Systems Engineering, Virginia Tech

Please refer to definitions in the glossary at the end of this fact sheet. For convenience, these terms are *italicized* in the text. For a comprehensive list, please refer to VCE Publication 426-119, Urban Stormwater: Terms and Definitions.

What is Bioretention?

Bioretention cells, or rain gardens, are a *stormwater best management practice* (BMP) designed to treat runoff from roofs, driveways, walkways or lawns. They are a shallow landscaped depression that receives and treats polluted *stormwater* with the goal of discharging water of a quality and quantity similar to that of a forested *watershed*.

Where can Bioretention be used?

Bioretention can be used in commercial areas, parking lots, and highways to treat roof and road runoff. *Bioretention* can also be used in residential landscapes or parks, however steps should be taken to minimize *sediment*. *Bioretention cells* that receive *sediment* loading tend to clog and hold water rather than *infiltrate* it.

What does it do?

The practice of *Bioretention* was developed to reduce pollution from runoff from urban *impervious surfaces* during moderate storms. A typical *bioretention cell* consists of a depression with a vegetated layer, a *mulch* layer, and several layers of sand, soil, an organic *media filter bed*, an *overflow*, and an optional *underdrain*. (see figure). A small pretreatment basin known as a *forebay* is created with river rock to trap *sediment* prior to entering the *cell*. Within a *bioretention cell*, runoff is treated by a variety of physical, chemical and biological processes.
Bioretention provides both quantity and quality control benefits. It enhances *biodiversity* by providing natural *habitat*, and can be a beautiful addition to the urban landscape.

How does Bioretention work?

Stormwater storage is provided when water ponds in the *cell*. The collected *stormwater* is filtered through different layers of *mulch*, *media*, and *compost* inside the *cell*. *Media*, plants, and microorganisms in the soil treat the pollutants carried by the runoff through physical processes like *filtration*, *infiltration* or *adsorption*; and biological processes like *biological uptake* or *microbial decomposition*.
An *underdrain* consists of perforated pipe in a gravel layer installed along the bottom of the *media filter bed*. An upturned *outlet* promotes periodic *anaerobic* conditions within a fluctuating water table and facilitates removal of nitrogen. In soils with high *infiltration* rates, the *underdrain* can be omitted, thus increasing runoff reduction. *Bioretention cells* without *underdrains* should be avoided in commercial and industrial areas to prevent *groundwater contamination*.

Limitations

- Adequate sunlight and irrigation may be required.
- Because of the potential of *bioretention cells* to clog from *sediment*, installation of *bioretention* should always wait until upstream areas are stabilized.
- Typically limited to 5% of a small drainage area (2 acres). For example, for an 18,000 ft^2 lot, a 900 ft^2 *bioretention cell* is likely needed.
- Minimum *media* depth of 1.5 ft is required, however increasing to up to 3 ft improves performance.
- At least 2-4 ft. of elevation drop from top of the *cell* to groundwater and/or the *outlet* should be available.
- Plants must tolerate dry periods and potential submerged roots for as long as 24 hours. Specific plants lists are available at VDCR 2011 and VCE (2009).

Maintenance

- Maintenance is similar to garden work.
- Inspection of the *forebay* and *mulch/media* surfaces in the treatment area to avoid clogging and repair if necessary.
- Replacing dead plants and replenishing *mulch* layer is recommended annually.

Performance

Bioretention can be a very effective at reducing runoff and removing pollutants such as excess *nutrients* from incoming water flow. A typical *bioretention cell* has a *media* depth of 1.5-2 ft. An annual reduction of 25% for Total Phosphorus (TP), 40% for Total Nitrogen (TN), and 40% for runoff can be expected. By improving the *media* and its depth to2-3 ft, and providing a gravel *underdrain* and other enhancements, improvements in estimated annual reductions of 50% for TP, 60% for TN, and 80% for runoff can be expected (VDCR 2011).

Its expected cost

The installation cost of a *bioretention cell* is approximately \$10,000 for a 900 ft^2 cell (including); the annual maintenance cost is approximately \$600 (from \$350 for *mulch* and debris removal and \$250 for vegetation replacement) (based upon Low Impact Development Center, 2005).

Where can I find additional information?

The Virginia Department of Conservation and Recreation (VDCR) is the state agency that controls nonpoint source pollution and *stormwater*. The VDCR regulates urban *stormwater* through the Virginia Stormwater Management Program (VSMP). Additional information on *BMPs* can be found at the Virginia BMP Clearinghouse at the web link in the following section. The BMP Clearinghouse is jointly administered by the VDCR and the Virginia Water Resources Research Center (VWRRC), which has an oversight committee called the Virginia Stormwater BMP Clearinghouse Committee. The committee members represent various stakeholder groups involved with *stormwater* management.

World Wide Web Resources

Chesapeake Stormwater Network

http://www.chesapeakestormwater.net/all-things-stormwater/bioretention-design-specification.html

Low Impact Development Center

http://www.lid-stormwater.net/index.html

http://www.lowimpactdevelopment.org/ffxcty/1-1_bioretentionbasin_draft.pdf

King County Road Services

http://www.kingcounty.gov/transportation/kcdot/Roads/Environment/LowImpactDevelopment_MilitaryRd/BioRetentionFacilityRainGarden.aspx

North Carolina State University Department of Biological and Agricultural Engineering Stormwater Group

http://www.bae.ncsu.edu/topic/bioretention/design.html

Pennsylvania Department of Environmental Protection

http://www.dep.state.pa.us/dep/DEPUTATE/Watermgt/wsm/WSM_TAO/reuse/V-B-2-Zeigler/Rain_Garden.htm

Prince George's County, MD

http://www.princegeorgescountymd.gov/der/esg/bioretention/bioretention.asp

US Environmental Protection Agency

http://www.epa.gov/owm/mtb/biortn.pdf

http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=factsheet_results&view=specific&bmp=72

Virginia BMP Clearinghouse

http://vwrrc.vt.edu/swc/

Companion Virginia Cooperative Extension Publications

Andruczyk, M., Swanson, L., Fox, L., French, S., Gilland, T. (2009) Urban Water-Quality Management: Rain Garden Plants, VCE Publ. No. 426-043.

Goatley, J., (Ed.) W. Daniels, G. Evanylo, L. Fox, K. Haering, S. Hodges, R. Maguire, D. Sample, D. Hansen, D. Kindig, T.Sexton, R. Habel, K. Hensler (2011) Urban Nutrient Management Handbook. VCE Publ. No. 430-350.

Gilland, T., Fox, L., Andruczyk, M., Swanson, L. (2009) Urban Water-Quality Management - What Is a Watershed? VCE Publ. No. 426-041.

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Virginia Department of Conservation and Recreation (2011) Design Specification No. 9, Bioretention, Version 1.9, March 1, 2011.

Virginia Department of Forestry (2008) Rain Gardens, Virginia Technical Guide: A landscape tool to improve water quality at http://www.dof.virginia.gov/mgt/rfb/rain-gardens.htm.

Low Impact Development Center (2005) BMP Fact Sheet, Fairfax County Bioretention Cells.

Virginia Cooperative Extension (2009) Urban Water-Quality Management: Rain Garden Plants, publication #426-043. http://pubs.ext.vt.edu/426/426-043/426-043.html.

Note: This Fact Sheet is one of a series on urban stormwater management

Glossary of terms used in this Fact Sheet:

Adsorption - is a process by which dissolved compounds separate from the liquid phase and become physically or chemically bound to solid materials and are thus removed via treatment.
Anaerobic – chemical reactions that proceed without the presence of oxygen).
Baseflow – the portion of flow in a stream that continues even during extended dry periods.
Biodiversity – refers to the number of different species, and is a measure of the health of the observed system.
Biological uptake – the process by which plants absorb *nutrients* for nourishment and growth.
Bioretention, Bioretention cells – A BMP that is a shallow landscaped depressing that receives and treats *stormwater* with the goal of discharging water of a quality and quantity similar to that of a forested *watershed*. *Bioretention cells* typically consist of vegetation, soils, an optional *underdrain*, and an *outlet*.
Best Management Practice – for urban lands refers to any treatment practice that reduces pollution from *stormwater*. BMPs can be either a physical structure or a management practice. A similar but different set of BMPs are used to mitigate agricultural runoff.
Compost – Vegetative or organic matter that has been allowed to fully decompose leaving a rich organic medium that can be mixed with soils.
Filtration - a process by which solids are separated from fluids by use of *media*.
Forebay – a small basin within a BMP that removes *sediment* by settling prior to other treatment processes, thus protecting those processes from excess *sediment* and potential clogging.
Groundwater contamination – the presence of unwanted chemical compounds in groundwater. In this case we would normally be referring to dissolved nitrogen compounds such as *nitrates*.
Habitat – the environment where organisms, like plants, normally live.
Impervious surface – A hard surface that does not allow *infiltration* of rainfall into it, or not *pervious*.
Infiltration – the process by which water (surface water, rainfall, or runoff) enters the soil.
Media, media filter bed, filter bed – the topsoil that supports plant growth. *Bioretention media* typically has high sand and low clay content, and low phosphorus content.
Mulch – An organic material applied on the surface above the *media* to protect vegetation and underlying *media*.
Microbial decomposition – the breakdown of compounds or organic matters into smaller one with the aid of microorganisms.
Nutrients – the substances that are required for growth of all biological organisms. In water quality, *nutrients* of the most concern are nitrogen and phosphorus in *stormwater*. Excessive amounts of these substances are pollution and can cause algal blooms and dead zones to occur in streams and estuaries.
Outlet - the point of exit of water from a downspout or other BMP.
Pervious – A ground surface that is porous and allows *infiltration* into it.
Sediment – the soil, rock, or biological material particles that are formed by weathering, decomposition, and *erosion*. In water environments, *sediment* is transported across a *watershed* via streams.
Stormwater – is water that originates from *impervious surfaces* during rain events, often associated with urban areas and is also called *runoff*.
Stormwater treatment practice – a type of BMP that is structural and reduces pollution of water that runs through it.
Underdrain – a perforated pipe in the bottom of a *bioretention cell* designed to collect water that does not *infiltrate* into native soils.
Watershed – a unit of land that drains to a single *pour point*. Boundaries are determined by water flowing from high elevations to the *pour point*. A *pour point* is the point of exit from the *watershed*, or where the water would flow out of the *watershed* if it was turned on end.