Vitamins & Minerals for Your Stormwater BMPs: New Prescriptions from Dr. Stormwater

Spring into Action: WSA 2021

David J. Hirschman

Hirschman Water & Environment, LLC
Stormwater & Stewardship


VITAMINS &
MINERALS

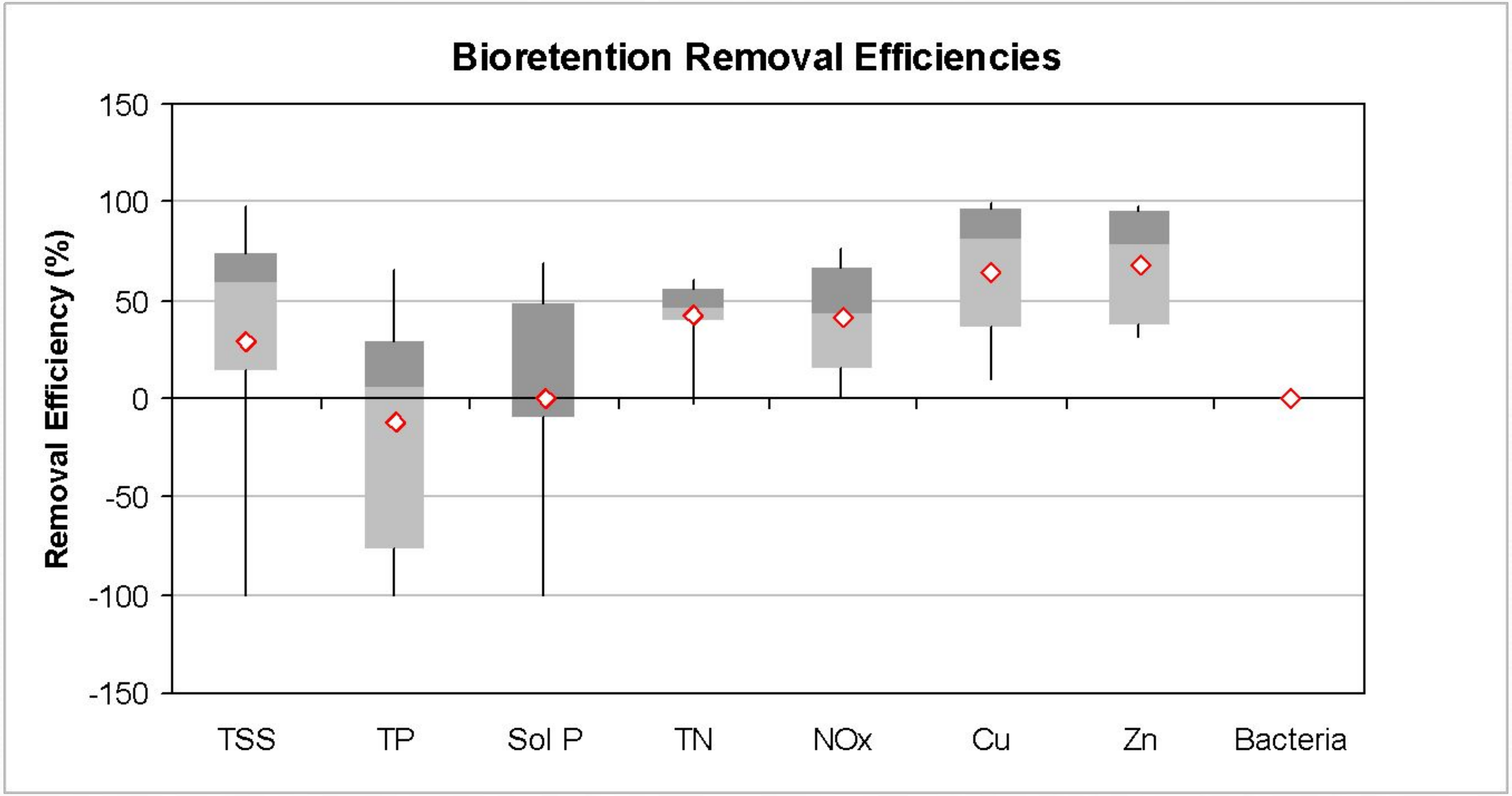

HRASH
Mag

Overview

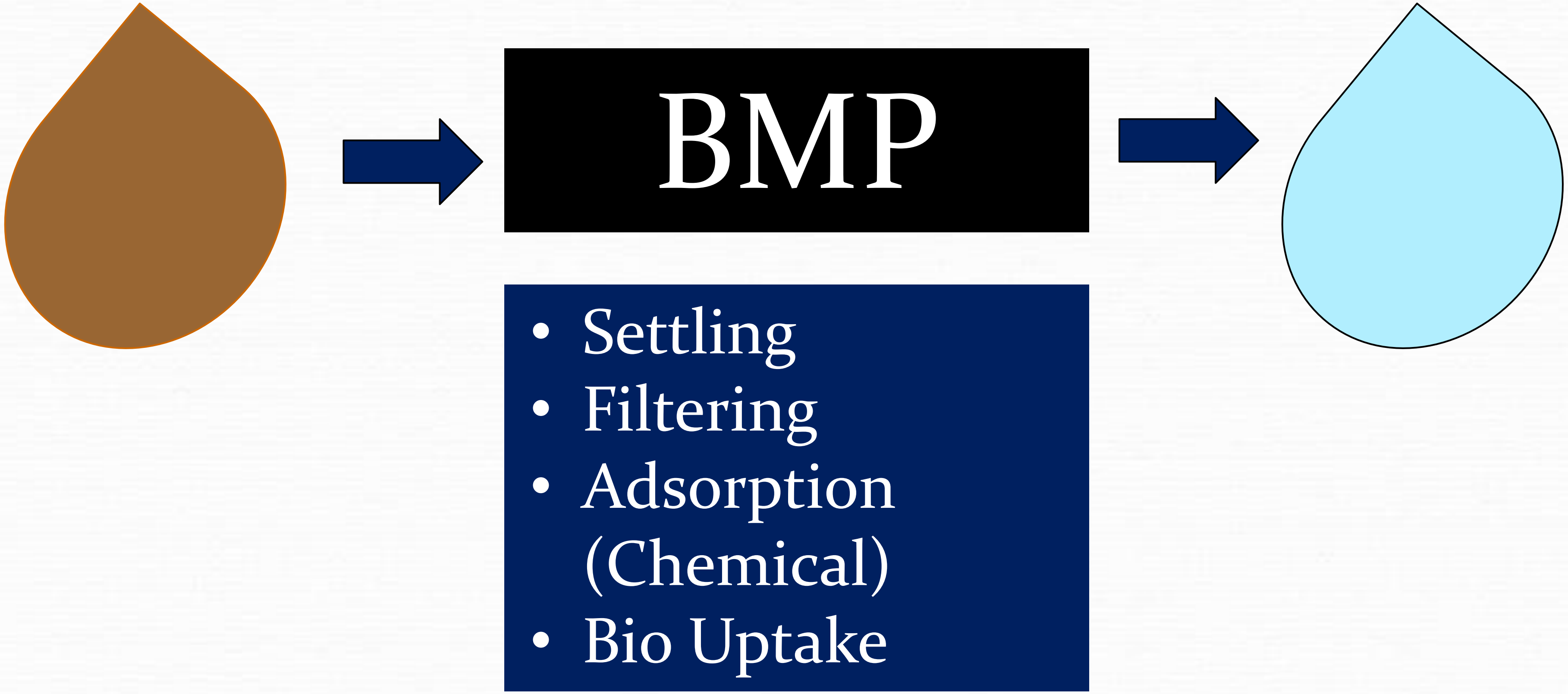
1. A Little Stormwater Science
2. What is a PED?
3. New Prescriptions for BMPs

Q1. How does the concentration of Phosphorus change when runoff is treated by a bioretention practice?

Pollutant Removal Data Difficult to Decipher



The BMP Black Box



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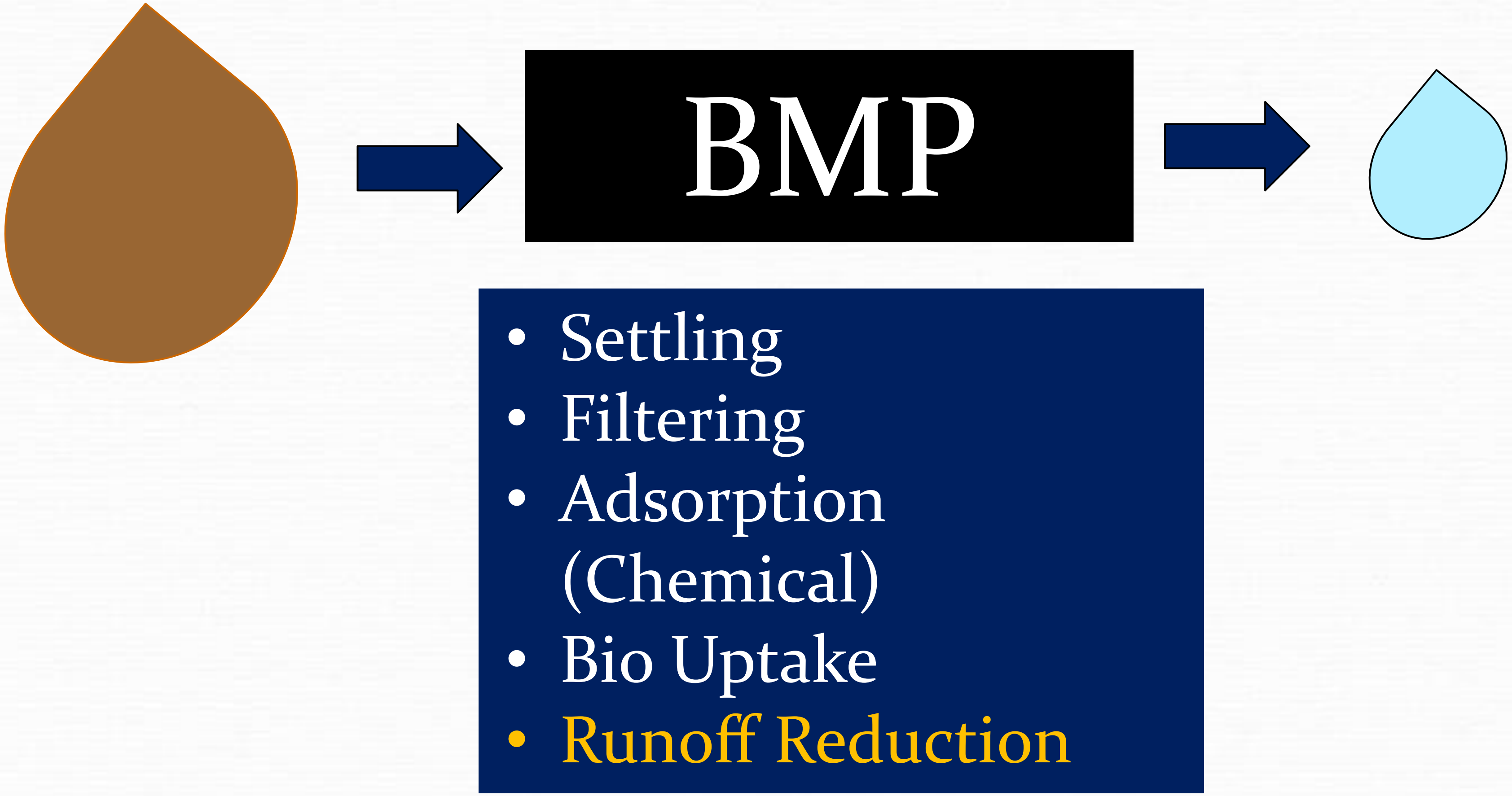

Runoff Reduction Method

April, 2008

Technical Memorandum:

The Runoff Reduction Method

Developed for the Following Projects:

Extreme BMP Makeover – Enhancing Nutrient Removal Performance for the Next Generation of Urban Stormwater BMPs in the James River Basin

Virginia Stormwater Regulations & Handbook Technical Assistance

Funding Provided By:
National Fish & Wildlife Foundation
Virginia Department of Conservation & Recreation

April 18, 2008

David Hirschman and Kelly Collins
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Runoff Reduction?

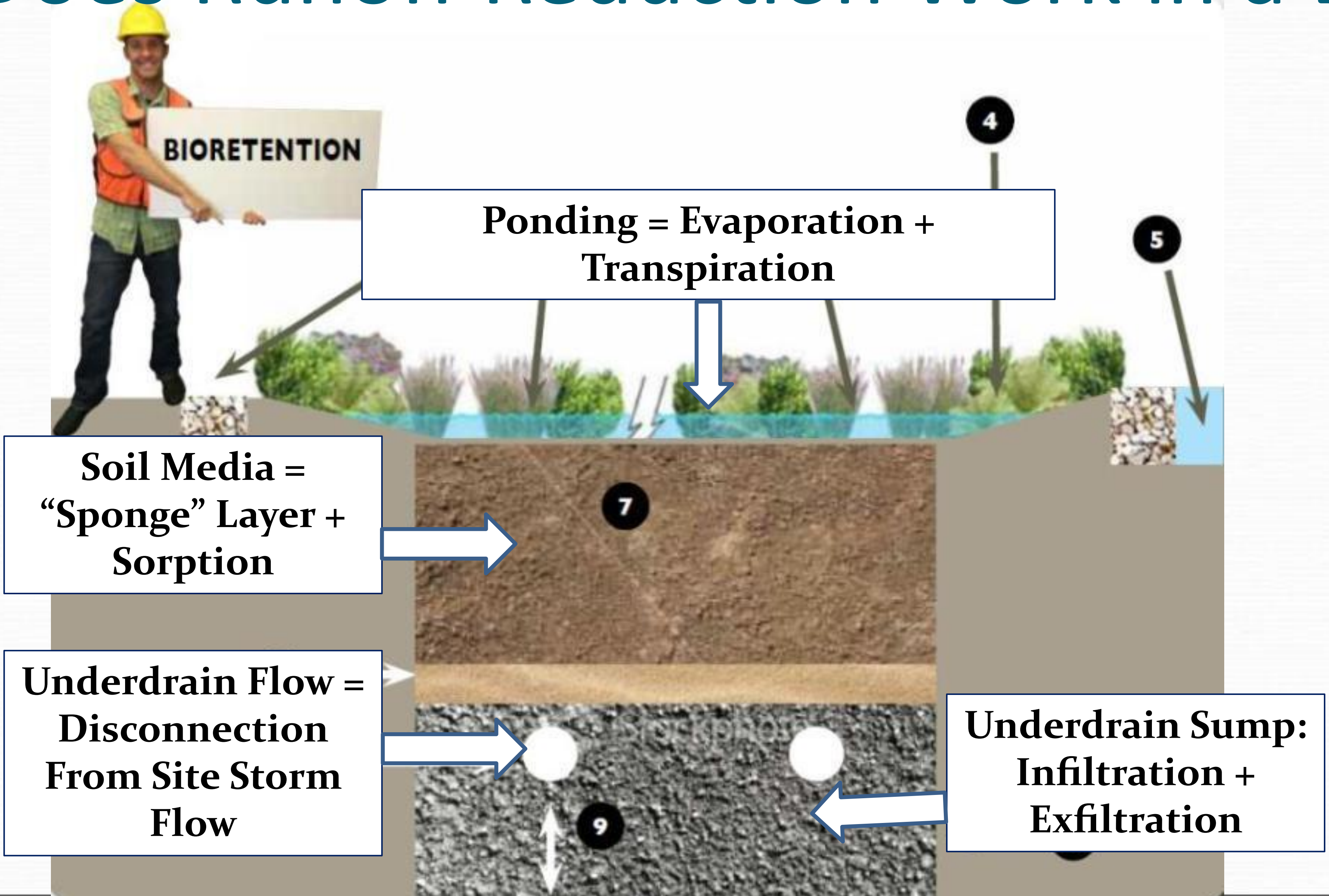
Not just infiltration!

- ✓ Infiltration
- ✓ Canopy Interception
- ✓ Evaporation
- ✓ Transpiration
- ✓ Rainwater Harvesting
- ✓ Extended Filtration

You may also know me by: Low Impact Development (LID), Environmental Site Design (ESD), Better Site Design (BSD), Green Infrastructure (GI), or Marvin

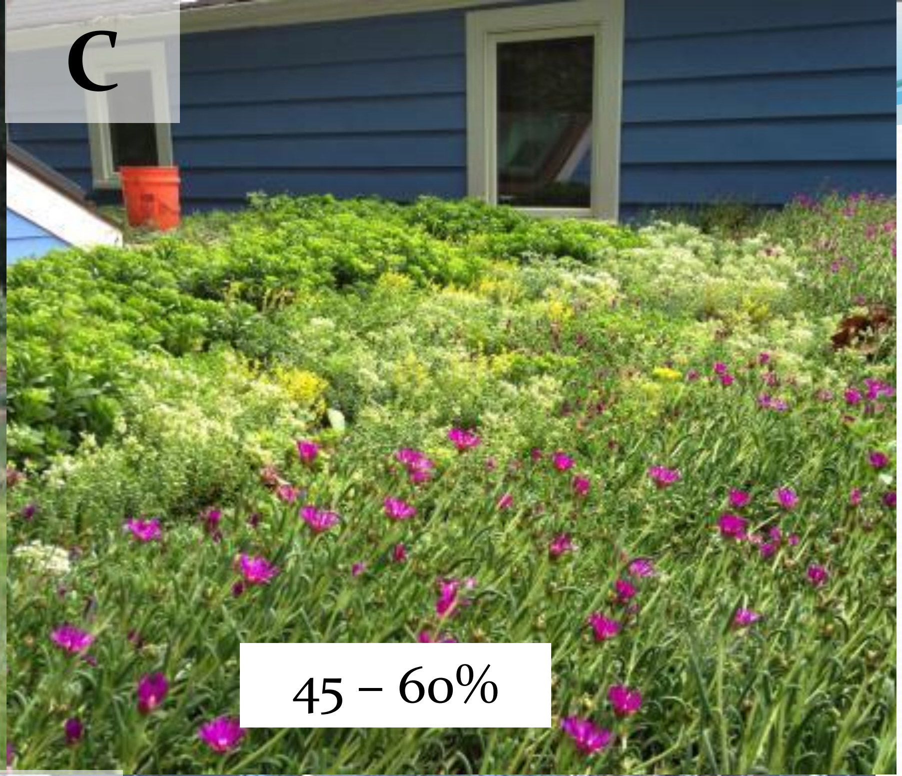
Mofidied From: Center for Watershed Protection, Chesapeake Stormwater Network

How Does Runoff Reduction Work in a BMP?



Q2. Which BMP Achieves the Best Runoff Reduction?


B
40 – 80%


C
45 – 60%


D
45 -- 75%

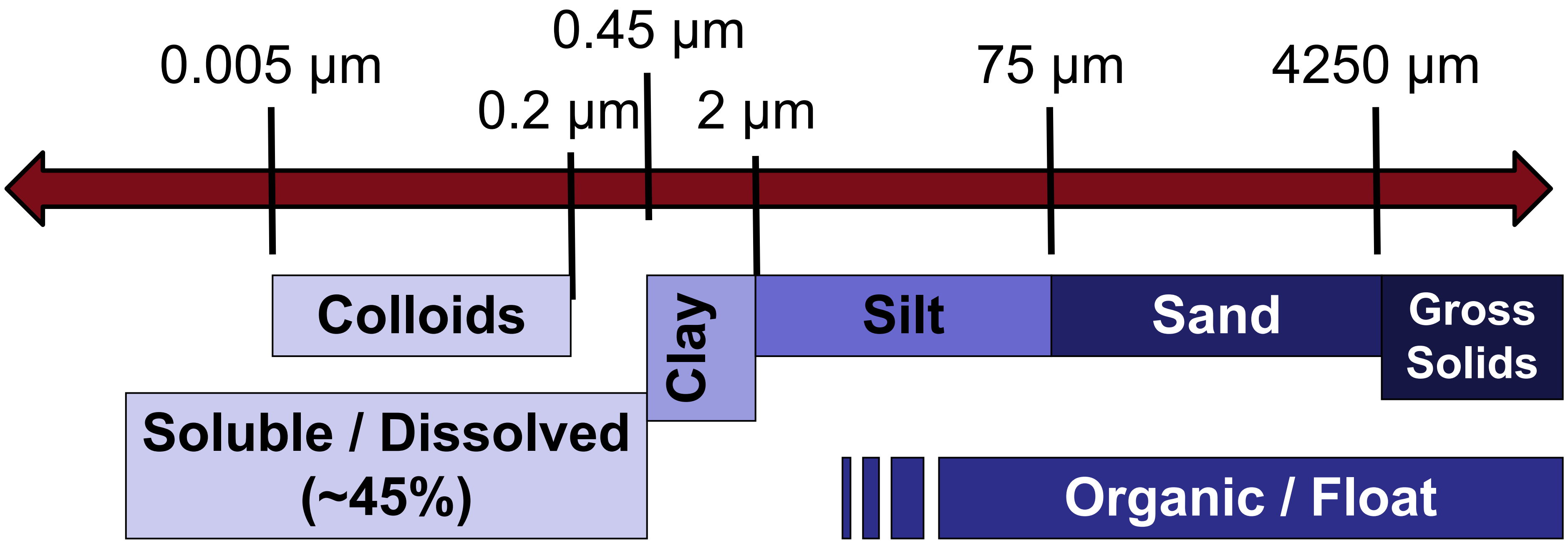

A
0 -- 15%

What's *IN* Urban Stormwater?

- Solids (inorganic, organic)
- Nutrients (nitrogen, phosphorus, etc.)
- Metals (copper, cadmium, zinc, etc.)
- Hydrocarbons
- Deicing Agents (chlorides, salts, etc.)
- Bacteria/Pathogens
- Others

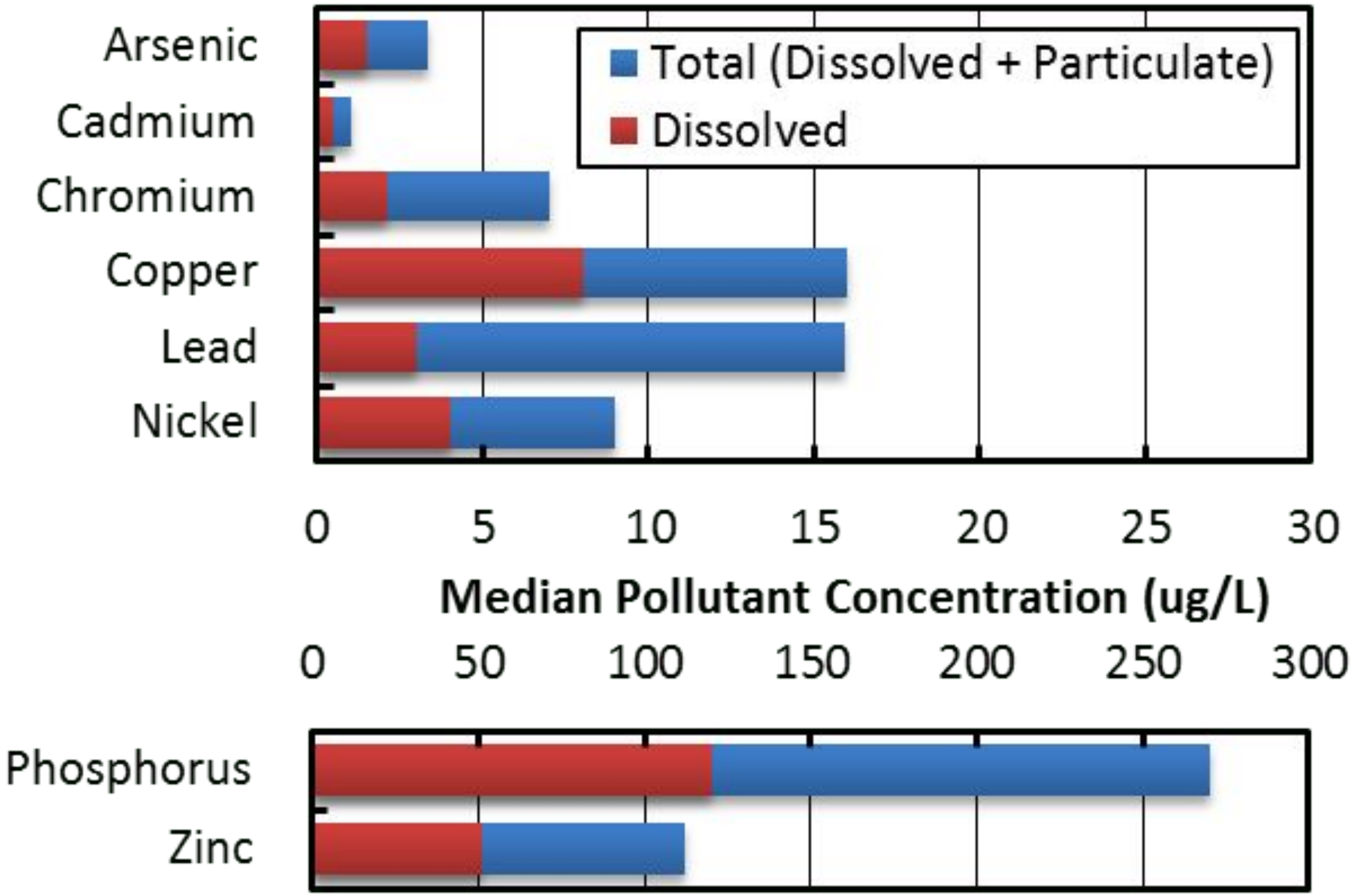
What Percent of Pollutants in Stormwater is in a Dissolved Form?

Pollutant Spectrum



- Varies by:
  - Pollutant
  - Location in Management System

What about Dissolved Pollutants?

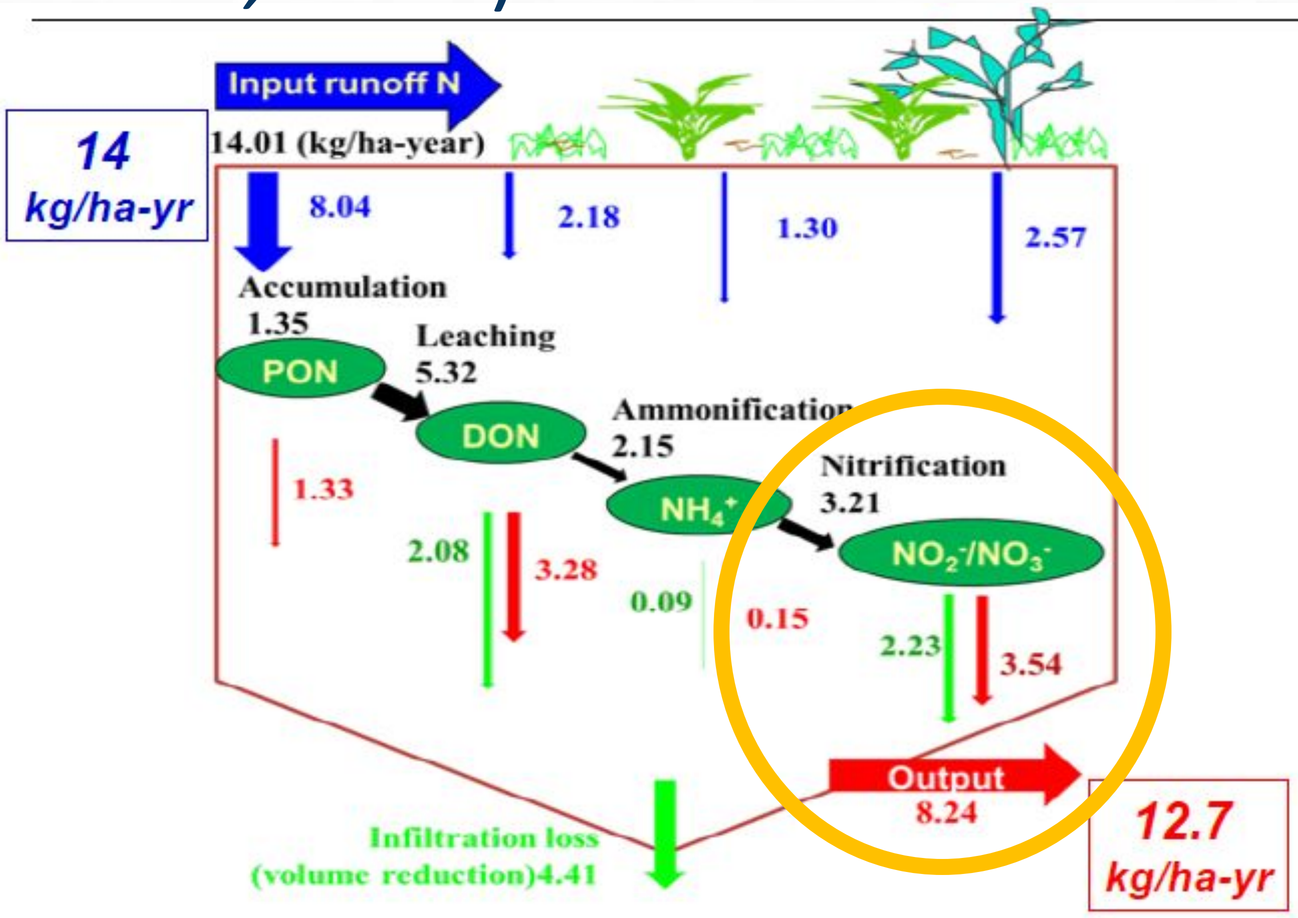


Dissolved Fraction
45.5%
50.0%
29.7%
50.0%
18.9%
44.4%
44.4%
45.5%

Source (adapted from): Pitt, R., Maestre, A., Morquecho, R., Brown, T., Schueler, T., Cappiella, K., and Sturm, P. (2005). "Evaluation of NPDES Phase 1 Municipal Stormwater Monitoring Data." University of Alabama and the Center for Watershed Protection.

What Does Phosphorus Look Like?

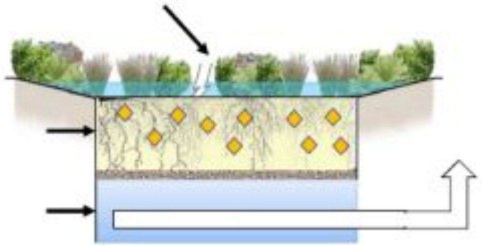
Export of Dissolved N (slide source: Alan Davis, *Fifty Shades of Green,* 2014)



Stormwater Science: Updates & PEDs

FINAL REPORT

Performance Enhancing Devices for Stormwater Best Management Practices



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Date:

April 24, 2017

Updating the Runoff Reduction Method

Prepared For:

Metro Government of Nashville & Davidson County, Tennessee
Metro Water Services, Stormwater Division

Prepared By:

David J. Hirschman, Hirschman Water & Environment, LLC
Marcus Aguilar, Ph.D.
Jon Hathaway, Ph.D., University of Tennessee[1]
Kelly Lindow, P.E., CityScape Engineering
Tom Schueler, Chesapeake Stormwater Network

[1] Special thanks to University of Tennessee graduate students: Jessica Thompson, Whitney Lisenbee, Padmini Persaud, Andrew Tirpak

Cover Photos Courtesy of: Rebecca Dohn, Metro Water Services

June 2018

Runoff Reduction Revisited

Prepared For:

Government of the District of Columbia
Department of Energy & Environment

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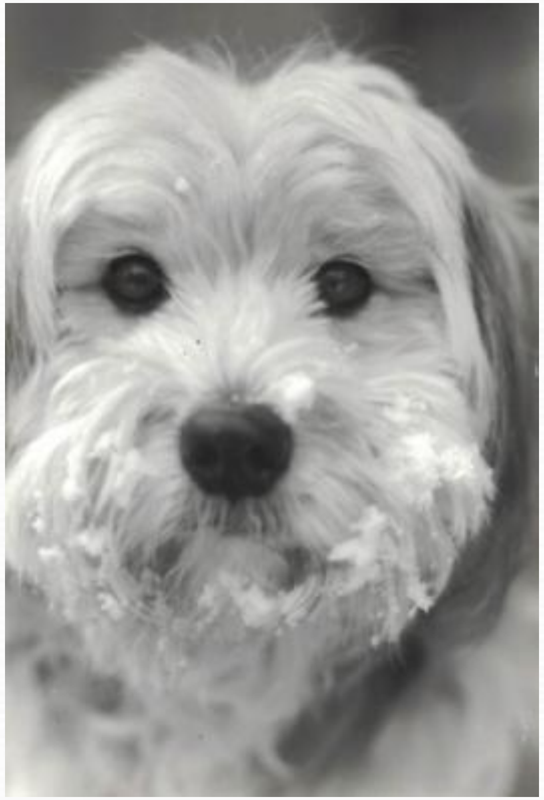
Tom Schueler & David Wood, Chesapeake Stormwater Network

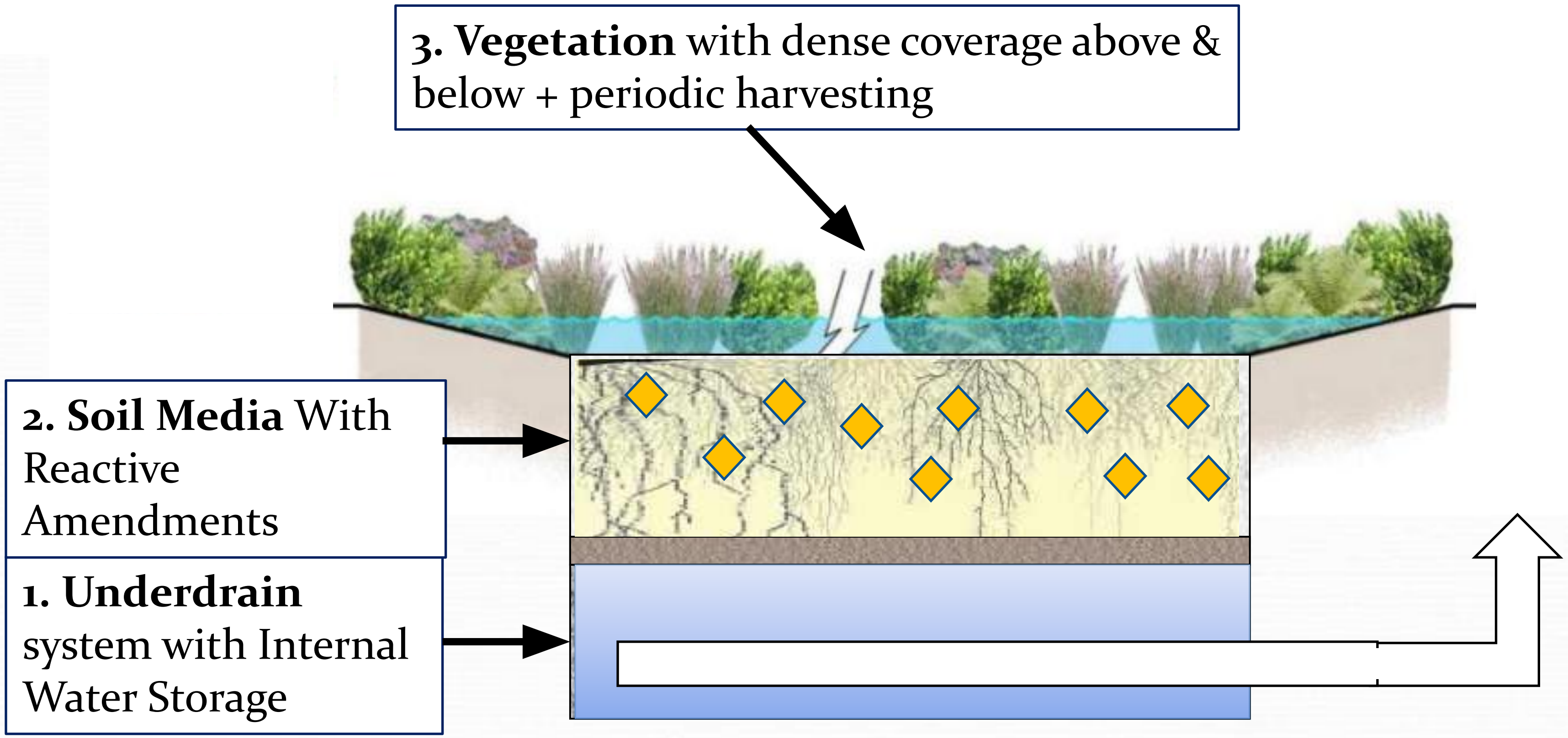
[1] Special thanks to University of Tennessee Doctoral students: Jessica Thompson, Whitney Lisenbee, Padmini Persaud, Andrew Tirpak, Aaron Akin, Victoria Rexhausen

September 2018

Q3. What is the heck is a PED?



Performance Enhancing Devices (PEDs)



Team

- Dr. Jon Hathaway, University of Tennessee
- UT Doctoral Students: Jessica Thompson, Whitney Lisenbee, Padmini Persaud, Andrew Tirpak, Aaron Akin, Victoria Rexhausen
- Kelly Lindow, CityScape Engineering
- Tom Schueler & David Wood, Chesapeake Stormwater Network
- Dr. Marcus Aguilar (City of Roanoke)
- Andy Erickson & Dr. John Gulliver, University of Minnesota, St. Anthony Falls Lab
- Greg Hoffmann, Ari Daniels, Laura Gardner, Center for Watershed Protection

Studies/Individual BMPs Analyzed

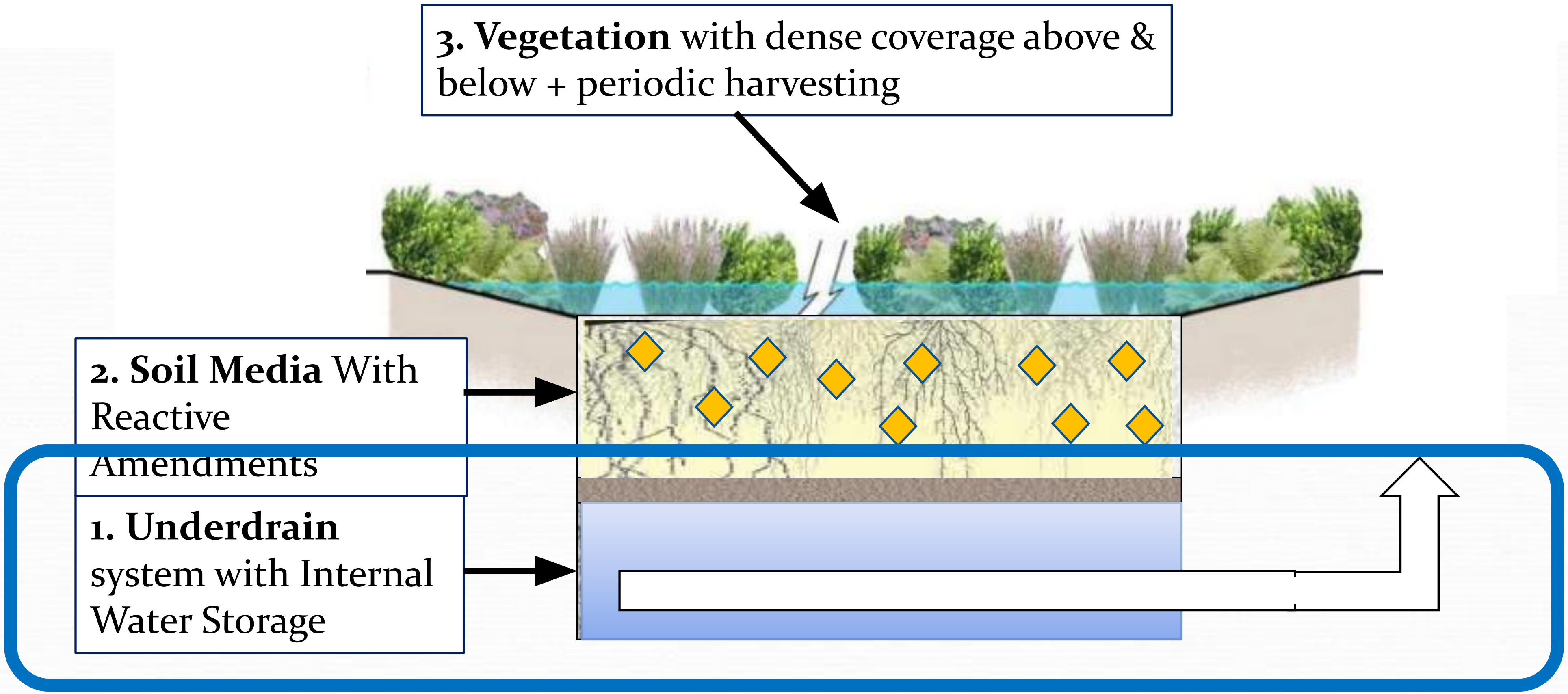
BMP Types	Original RRM (2007): volume and/or water quality[1]	# New Studies	# of Individual BMPs Studied (New Studies)
Green Roof	9	25	37
Rainwater Harvesting	3	5	37
Impervious Surface Disconnection/Filter Strip	3	9	45
Permeable Pavement	18	23	37
Bioretention	15	52	112
Infiltration	4	8	39
Grass Channels	11	11	24
Extended Detention Pond	6	6	10
Wet Pond/Wetland	22	19	43
Tree Planting/Preservation[2]	N/A	N/A	N/A

[1] Derived from Appendices B (volume reduction) and C (pollutant removal) of the Runoff Reduction Technical Memorandum (2008).
[2] Tree Planting and Preservation data were analyzed using a spreadsheet tool developed by a separate CWP project.

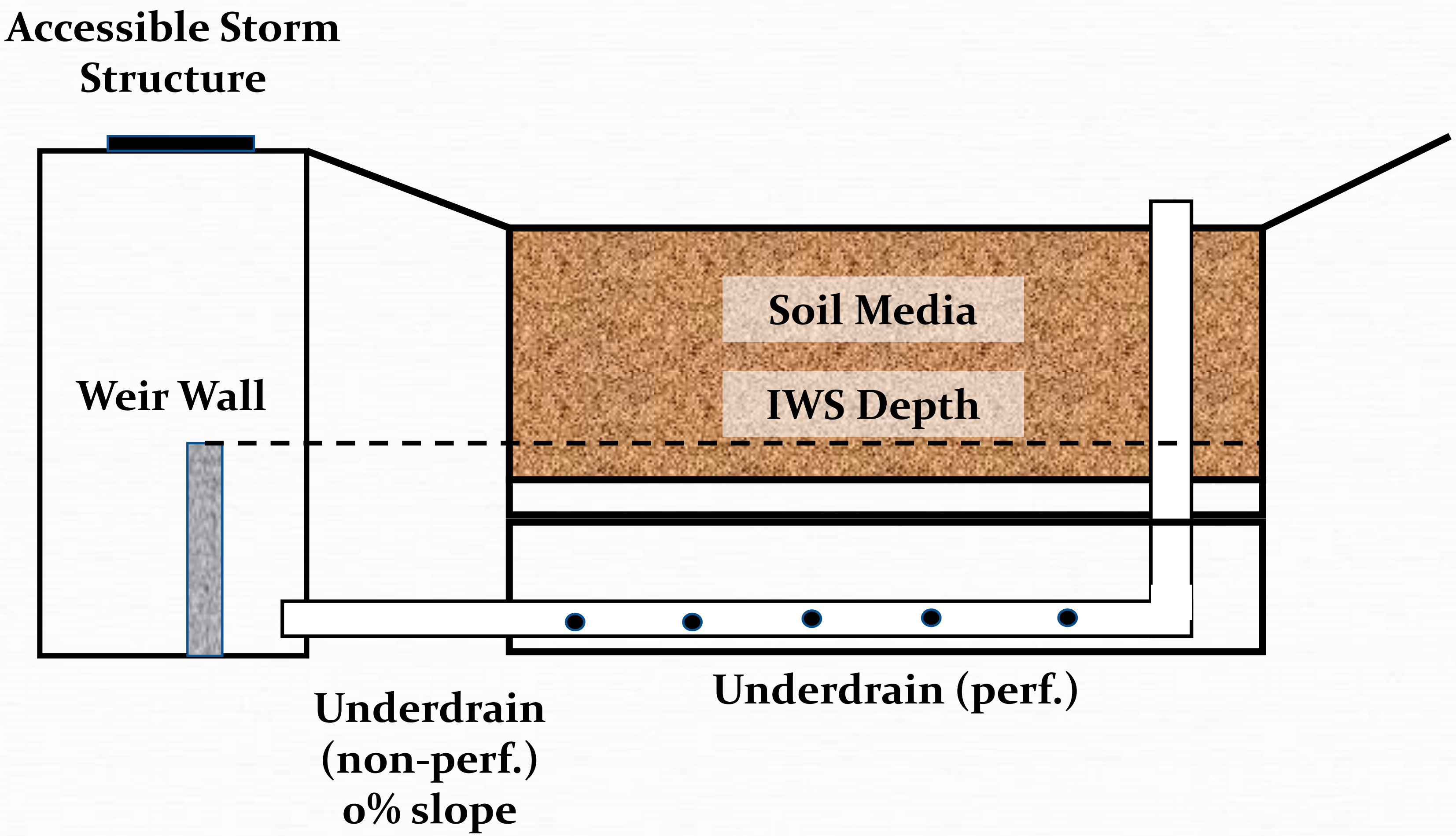
Key Finding: Runoff Reduction is not in its Final Season

PEDs: Bioretention as an Example

Performance Enhancing Devices (PEDs)

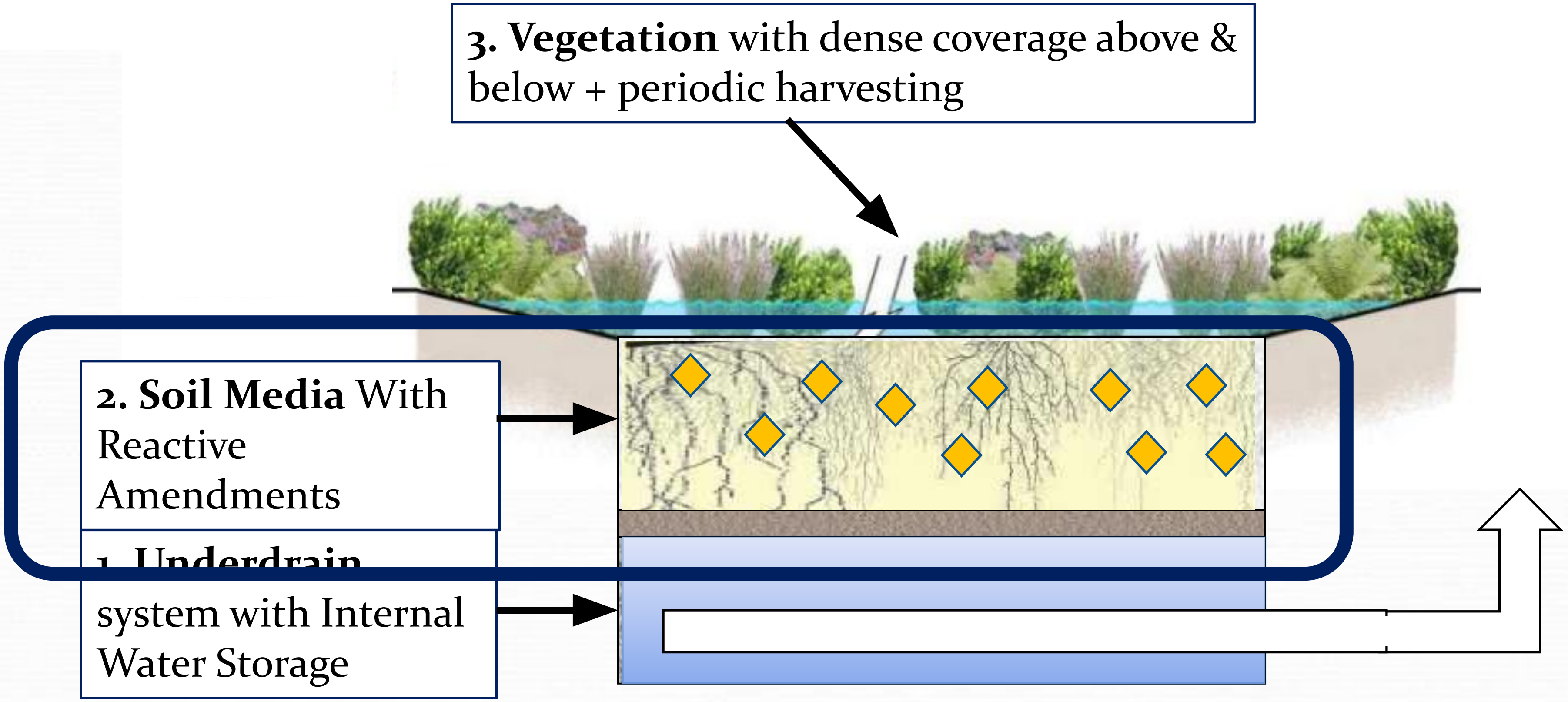


Underdrain: Internal Water Storage



Source: NC State University, *Designing Bioretention with Internal Water Storage Layer,* NC Cooperative Extension:

Performance Enhancing Devices (PEDs)



Soil Media: Reactive Amendments

Water Treatment Residuals

Q4. What is the Cation in Water Treatment Residuals that latches onto dissolved P?


LIFETIME
WTR
D.C. FRESH
06/05/18
WTR
RWSA
06/05/18

Testing WTRs

Table WTR-1. Expected Ranges for WTRs		
Parameter	Expected Range[1]	Notes[2]
Aluminum (ppm)	1800 – 3000; most will in 2500 range	This is aluminum content but not necessarily aluminum that is reactive (available for sorption of pollutants).
Sand (%)	45 -- 80	State specifications for total mix have high sand content: 75 to 90%.
Silt (%)	20 -- 55	State specifications for total mix generally 10 – 20% fines & maximum of 10% clay.
Clay (%)	1 -- 7	
Texture Classification	Sandy Loam, Loamy Sand, or Silt Loam	Largely depends on solids from raw water source and perhaps recent weather/turbidity of source water.
Organic Matter (%) **ASTM D2974**	27 -- 45	State specifications will range from 1.5 to 4% by weight (Walkley-Black method) in total mix; vendors should anticipate OM from WTRs if mixing in.
Dry Solids (%)	18 -- 27	

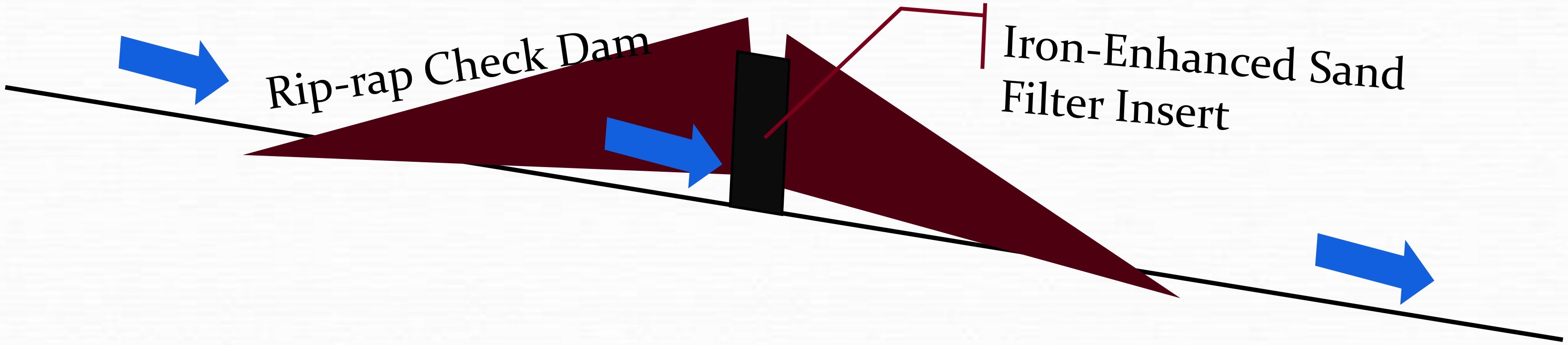
Source: John Gulliver, University of Minnesota, St. Anthony Falls Laboratory

Soil Media: Iron Amendments

Source: Dr. John Gulliver, University of Minnesota, St. Anthony Falls Laboratory

Iron-Enhanced Ditch Check

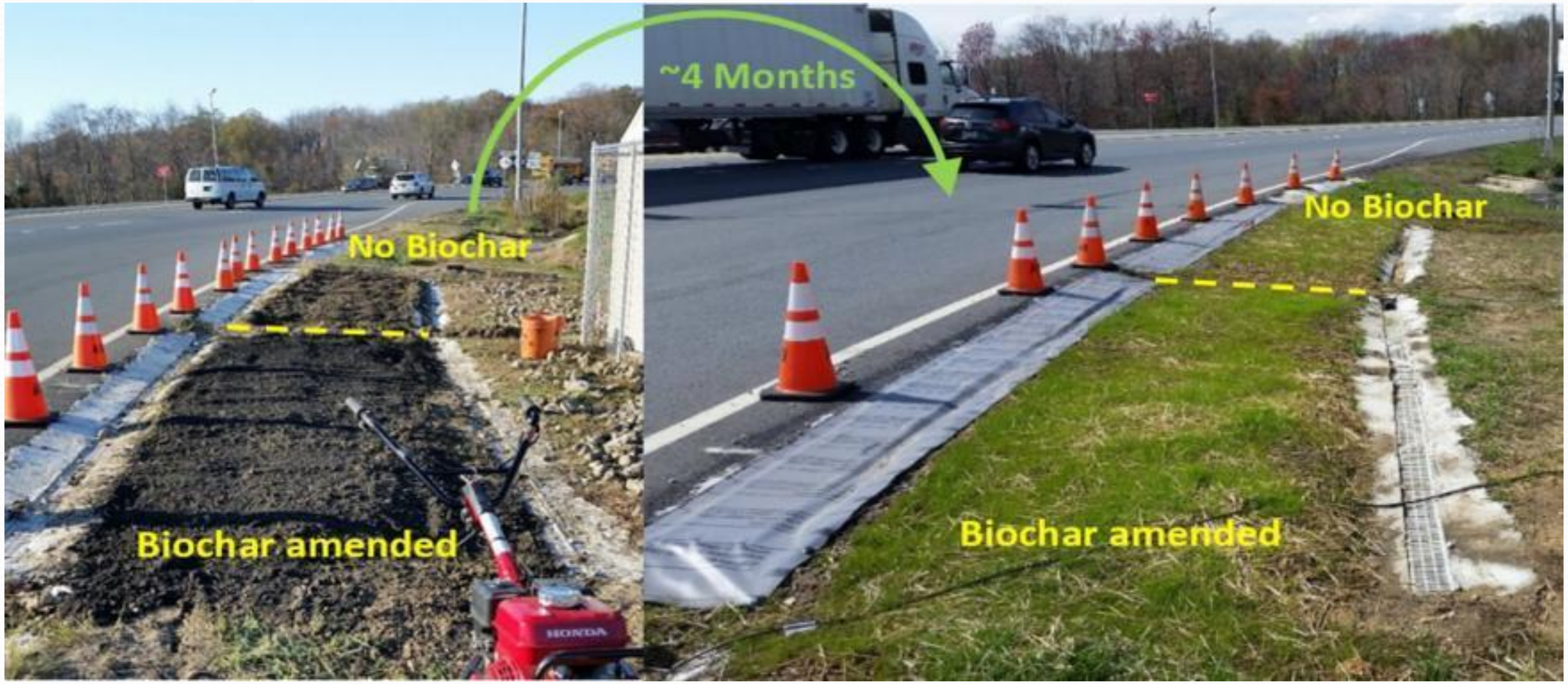
- Iron-enhanced sand filter insert within a ditch check



- Enable *<u>dissolved phosphorus</u>* retention

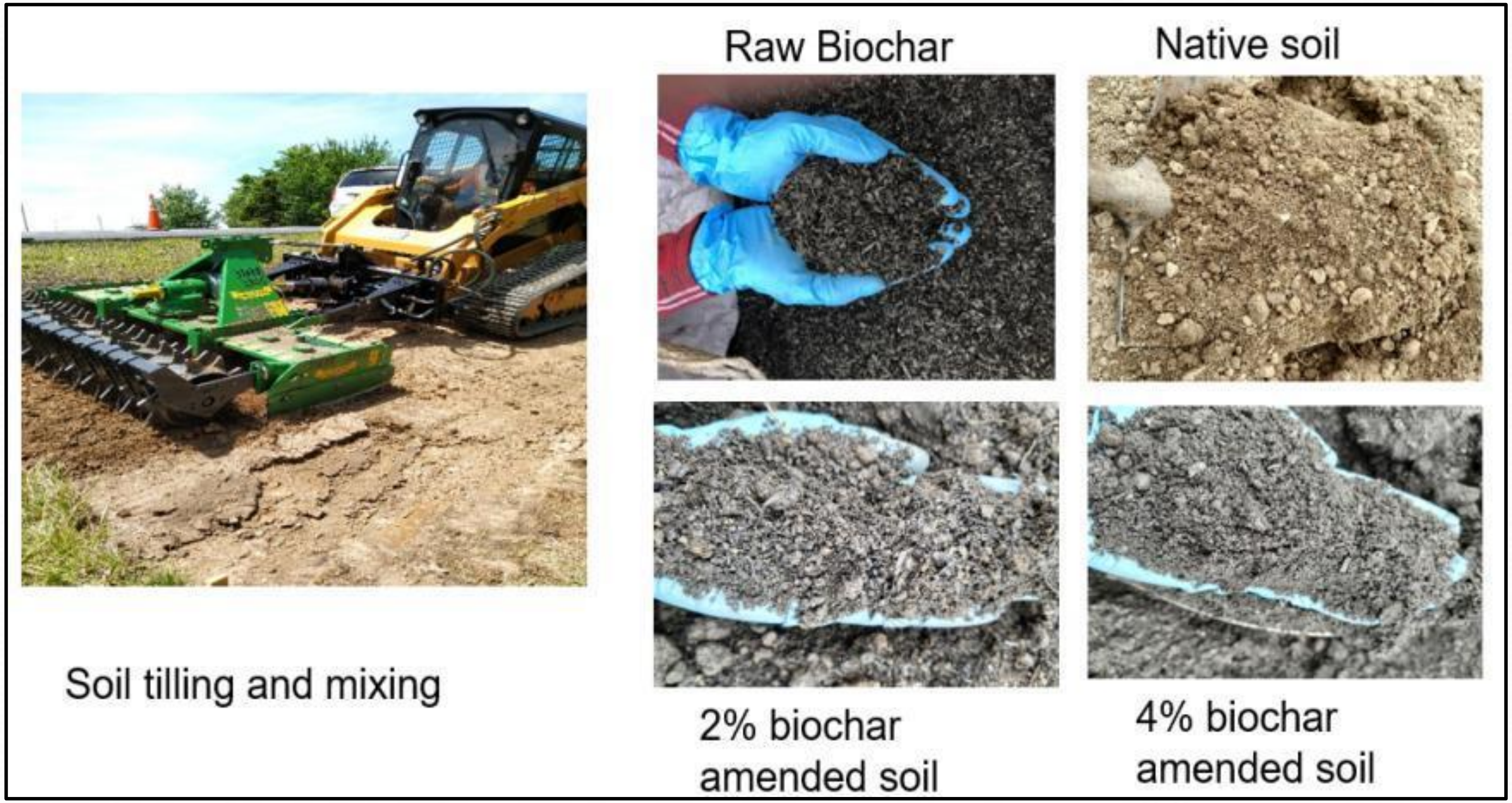
Source: John Gulliver, University of Minnesota, St. Anthony Falls Laboratory

Soil Media: Biochar



Source: Dr. Paul Imhoff, University of Delaware

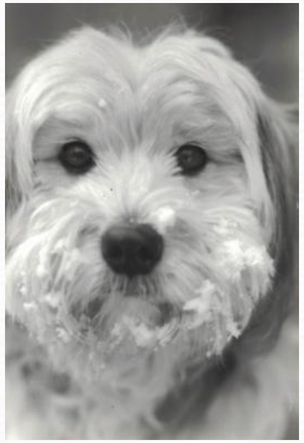
What Does Biochar Look Like?



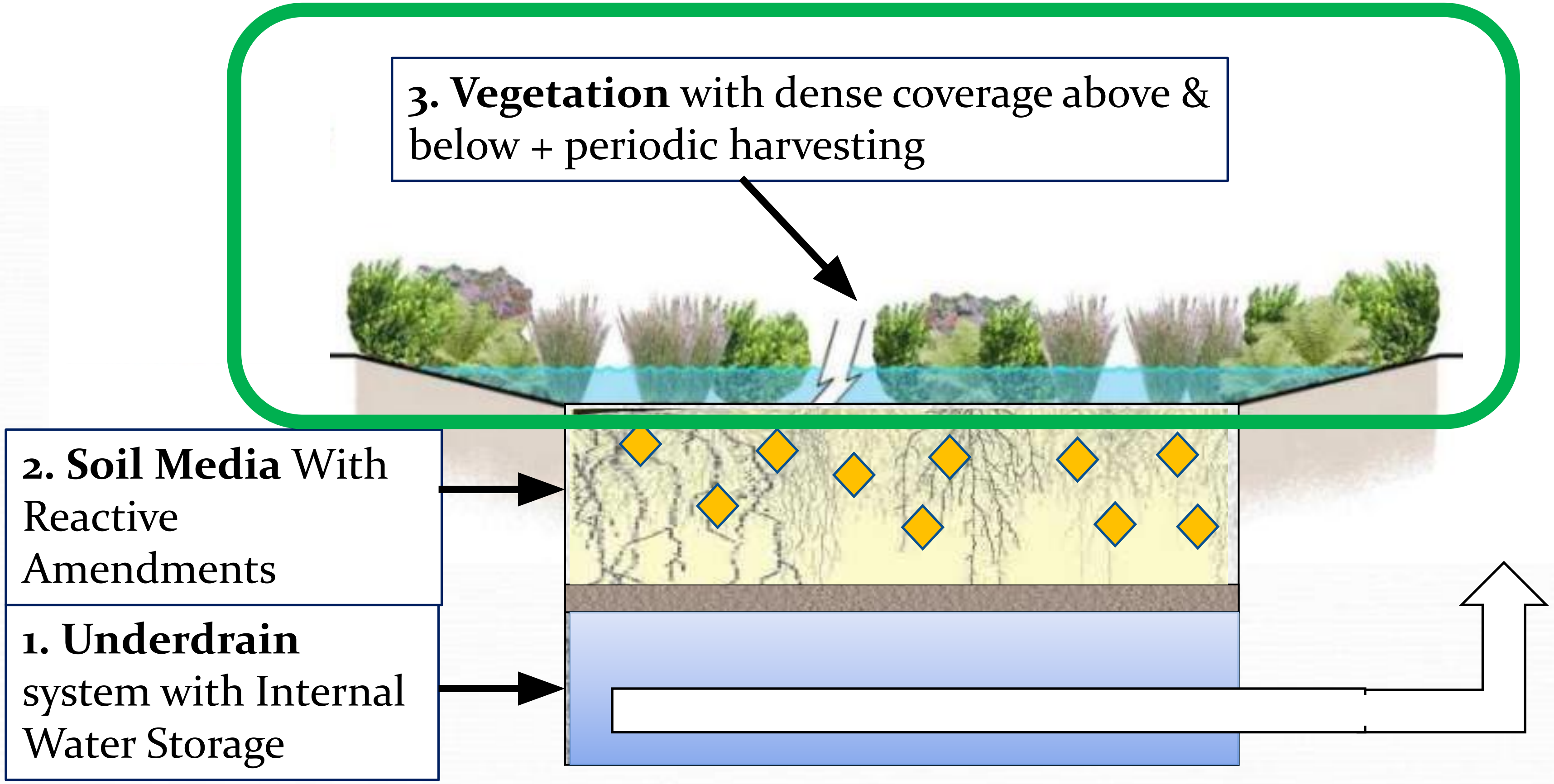
Source: Dr. Paul Imhoff, University of Delaware

south river
SCIENCE TEAM

Q5. How is biochar different than charcoal for your backyard grill?



Performance Enhancing Devices (PEDs)



Vegetation Selection & Management

Vegetation Results (selected)

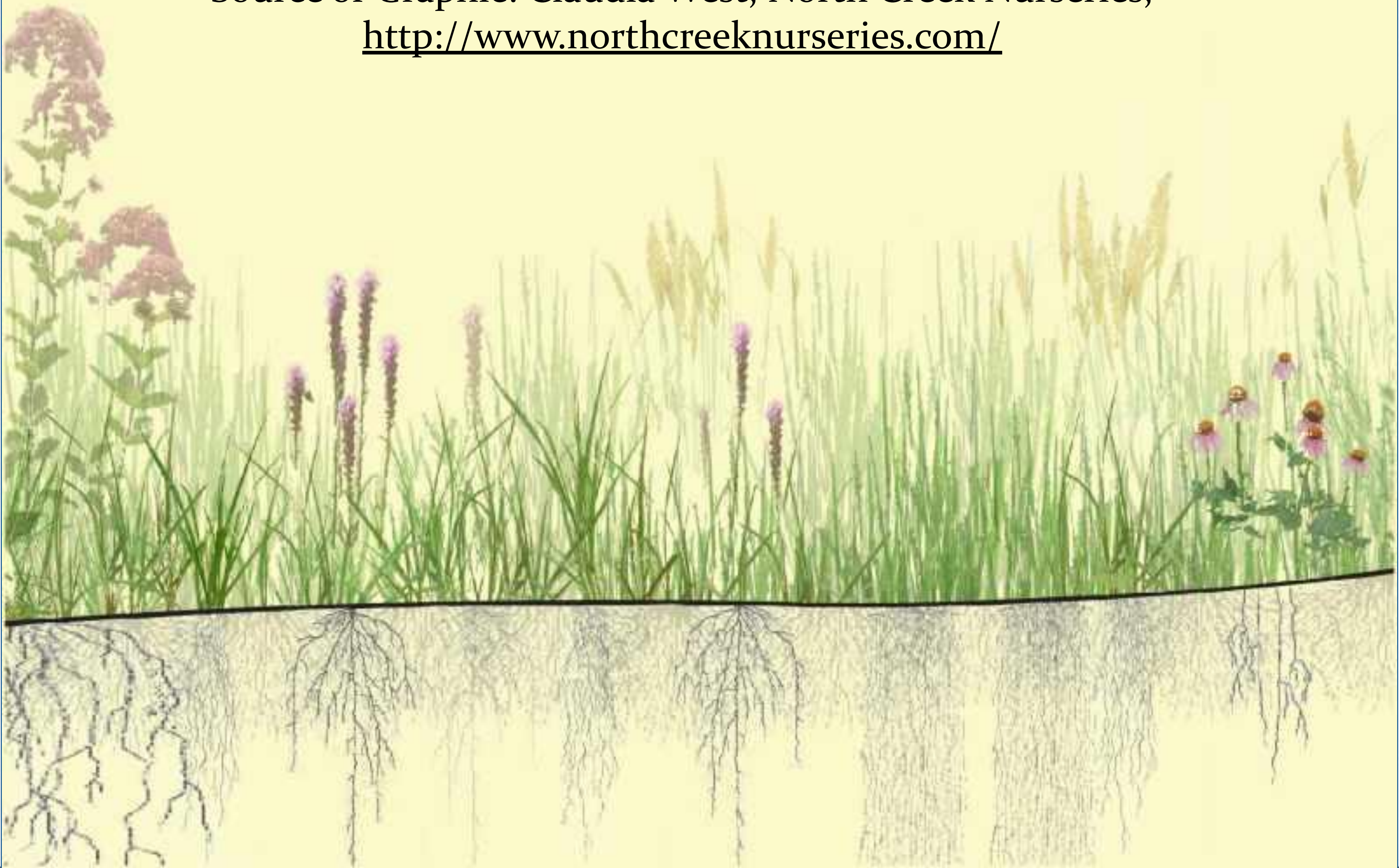
Source	Vegetation	P Removal/Retention	N Removal/Retention
Henderson 2008	Various	85-94% (31-90% for non-vegetated)	63-77% (negative to 25% for non-vegetated)
Lucas & Greenway 2008	Native grasses & shrubs from Australia	67-92% (39-56% for non-vegetated)	51-76% (maximum of 18% for non-vegetated
Barrett et al. 2013	Buffalograss, Big Muhly (native to TX)	77-94%	59-79% (negative for non-vegetated)
Read et al. 2008	20 Australian species	From 2 to > 150 fold change in removal for N and P, depending on species of vegetation.	
Scharenbroch et al. 2016	7 tree species from the Midwest	Study focused on water cycle and transpiration rather than nutrient removal; trees account for 46-72% of total water budget	

NorthCreek NURSERIES

layered structure of plant communities

Thick, Dense, Above & Below-Ground Biomass

Source of Graphic: Claudia West, North Creek Nurseries, http://www.northcreeknurseries.com/



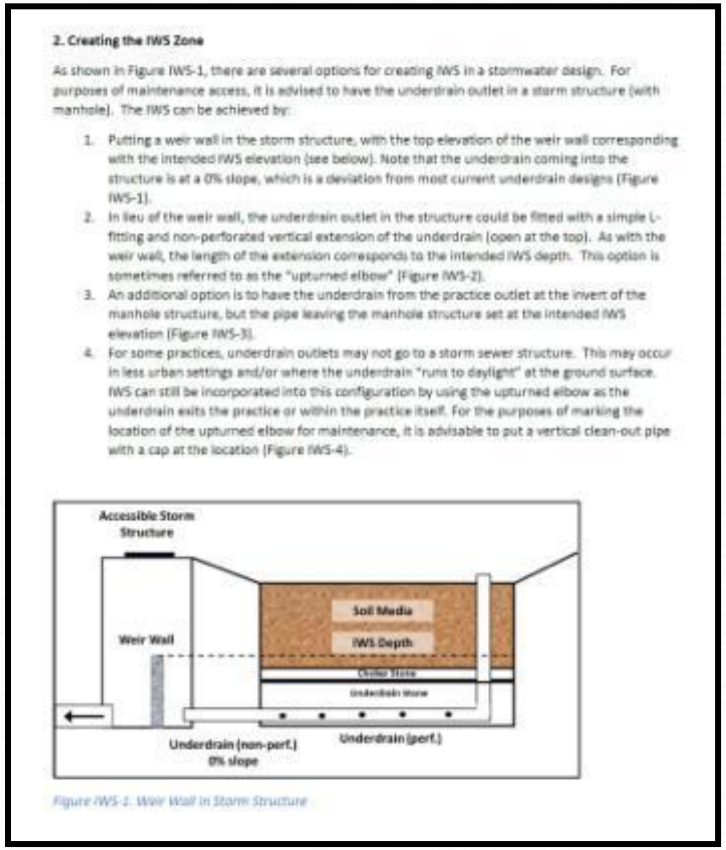
Research Shows:

- Type of vegetation is important: factors include root thickness/density, coverage, above & below-ground biomass, leaf area, etc.
- Vegetation plays a role in other performance measures: microbial activity in media (immobilization of nutrients), hydraulic performance, etc.
- Periodic harvesting may help with nutrient removal from system.
- Not much insight on C.B.-specific plants. Some to consider: *Carex, Switchgrass, Big Bluestem, Joe Pye Weed, some trees with high stomatal conductance.*

PEDs Fact Sheets

- Internal Water Storage
- Water Treatment Residuals
- Iron Amendments
- Biochar
- Vegetation

https://hirschmanwater.com/projects/
dave@hirschmanwater.com



2. Creating the IWS Zone

As shown in Figure IWS-1, there are several options for creating IWS in a stormwater design. For purposes of maintenance access, it is advised to have the underdrain outlet in a storm structure (with manhole). The IWS can be achieved by:

1. Putting a weir wall in the storm structure, with the top elevation of the weir wall corresponding with the intended IWS elevation (see below). Note that the underdrain coming into the structure is at a 0% slope, which is a deviation from most current underdrain designs (Figure IWS-1).
2. In lieu of the weir wall, the underdrain outlet in the structure could be fitted with a simple L-fitting and non-perforated vertical extension of the underdrain (open at the top). As with the weir wall, the length of the extension corresponds to the intended IWS depth. This option is sometimes referred to as the "upturned elbow" (Figure IWS-2).
3. An additional option is to have the underdrain from the practice outlet at the invert of the manhole structure, but the pipe leaving the manhole structure set at the intended IWS elevation (Figure IWS-3).
4. For some practices, underdrain outlets may not go to a storm sewer structure. This may occur in less urban settings and/or where the underdrain "runs to daylight" at the ground surface. IWS can still be incorporated into this configuration by using the upturned elbow as the underdrain exits the practice or within the practice itself. For the purposes of marking the location of the upturned elbow for maintenance, it is advisable to put a vertical clean-out pipe with a cap at the location (Figure IWS-4).

Figure IWS-1. Weir Wall in Storm Structure

Thank You!

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