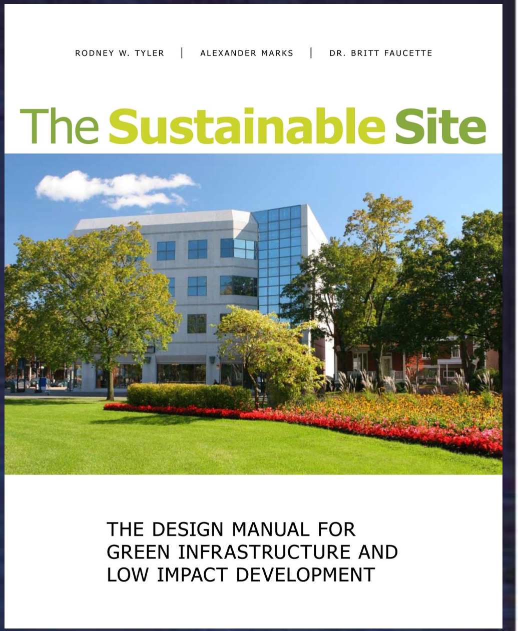
Designing *with* Nature:
Design Manual for Sustainable Stormwater Management



Dr. Britt Faucette, CPESC, LEED AP

What's wrong with this site?

Old School Stormwater Management is..$$$$$

- Centralize Collection, Conveyance, & Treatment

✓Land Intensive,

✓Infrastructure Intensive,

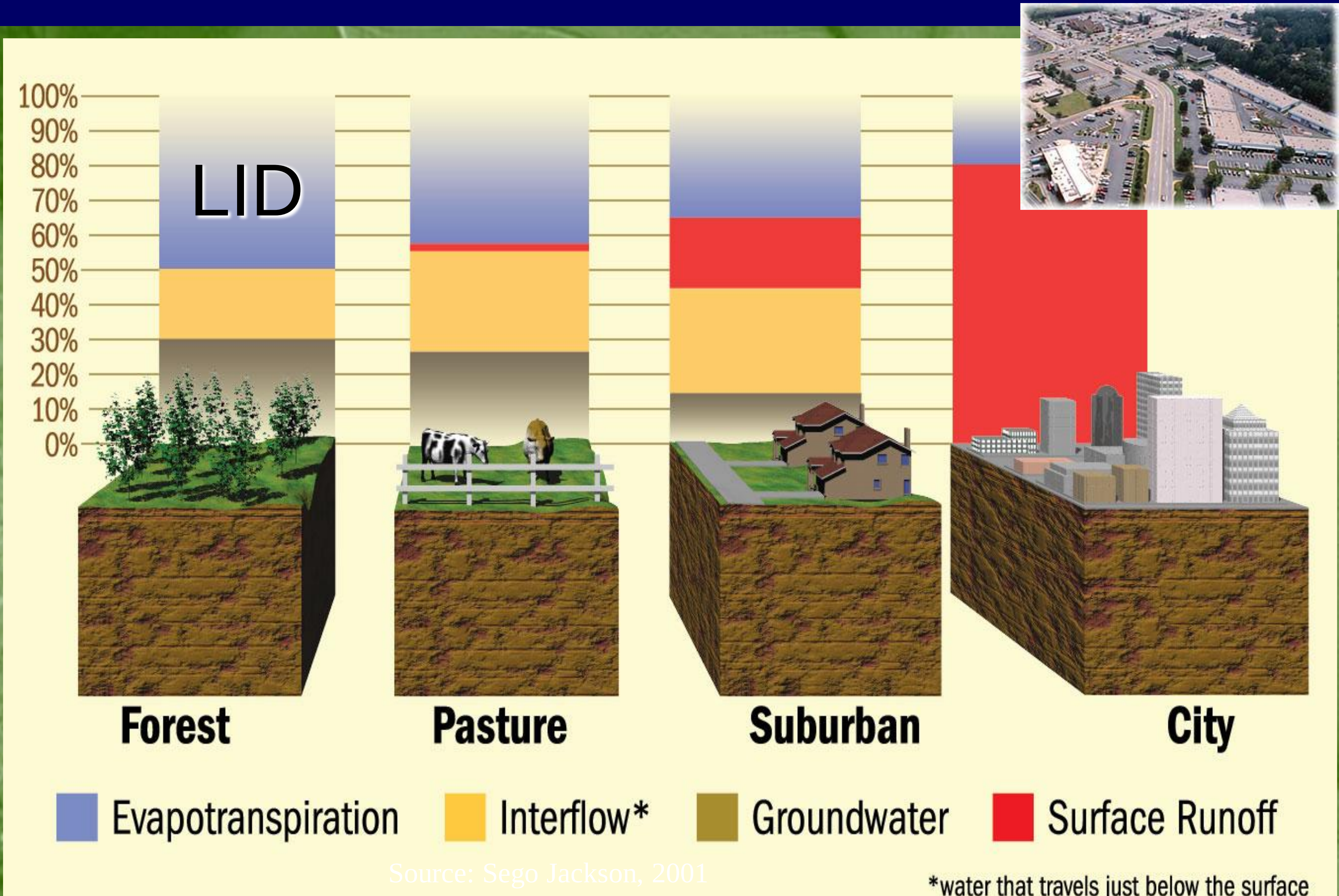
✓Pollution Intensive,

✓Energy Intensive.

By the Numbers

- 850 - US cities w/ outdated & under-designed SWM infrastructure
- 75% of Americans live near polluted waters
- $4,000,000 – amount Milwaukee spent on SWM infrastructure in last 20 years
- $8,000,000 – amount Philadelphia needs to spend in new SWM infrastructure to comply w/ CWA
- $44,000,000,000 – annual total cost to society

Land Use - Water Cycle



Low Impact Development (LID) = hydrology mimics natural site, distributed, decentralized

- Runoff Volume ⇩
- Runoff Rate ⇩
- Pollutant Loading ⇩
- Flooding ⇩

✓ *Water Quality* ⇧

✓ *Wildlife Habitat/Biodiversity* ⇧

✓ *Aesthetics/Land Value* ⇧

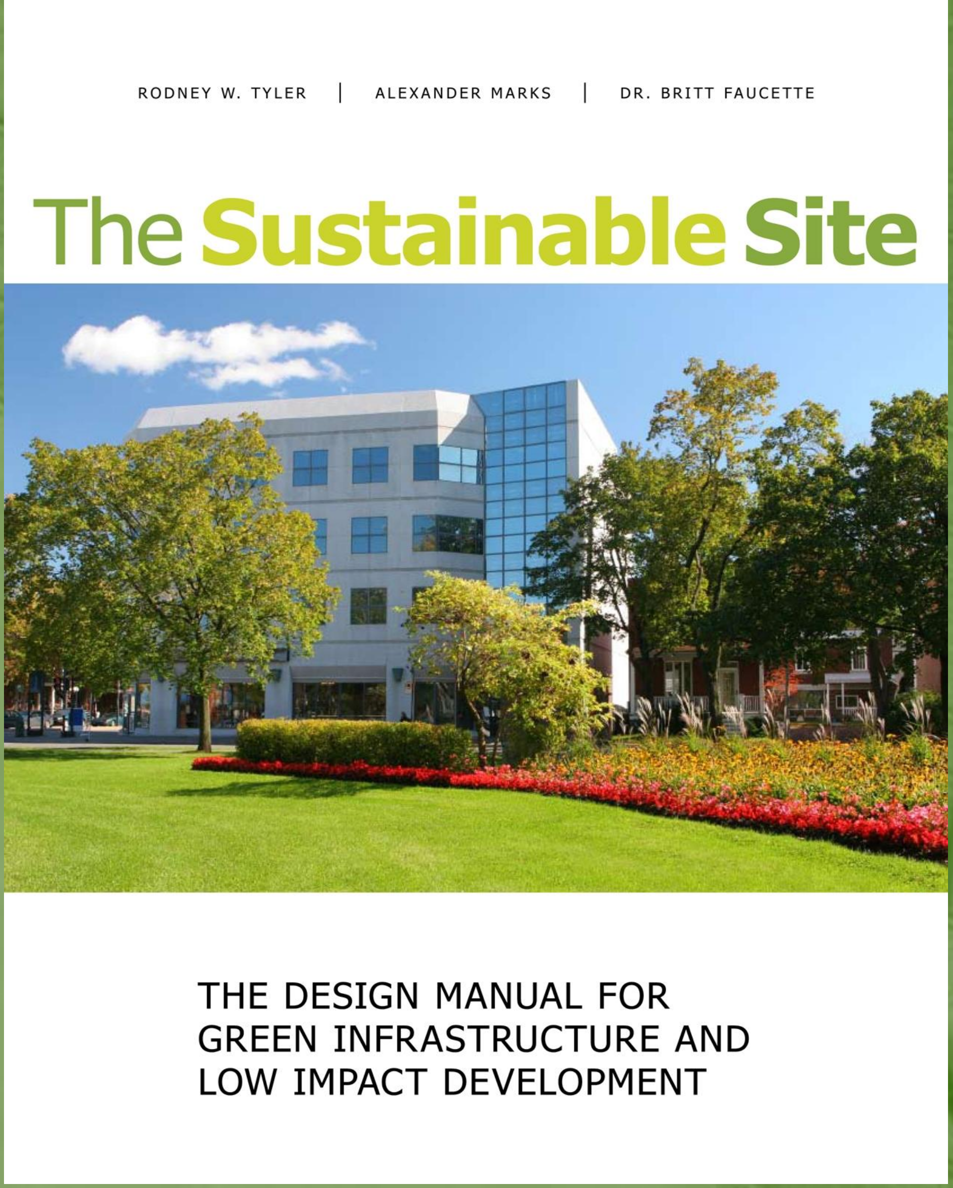
Green Infrastructure = **green stormwater management; site preservation/restoration; integrated design & practices; reuse**

Real Value of LID

- National average real estate values down 25% from 2007 (-$82,000)
- Low Impact Development Sites:

✓ $3000 - $5000 more/lot
✓ $4000 less cost/lot
✓ 25-30% less cost/lot
✓ 15% - water quality
✓ 6% - green infrastructure
✓ 5% - reduce flooding in flood plain
✓ 33-50% energy savings

(Source: NCSU)



"…. an essential tool for engineers, designers, architects, regulators, planners, managers, contractors, consultants, policymakers, builders, and water resource managers." – *Forester Press*

Table of Contents

Stormwater Management Practices

Erosion & Sediment Control

1. Perimeter Control
2. Inlet Protection
3. Ditch Check
4. Filter Ring/Concrete Washout
5. Slope Interruption
6. Runoff Diversion
7. Vegetated Cover
8. Erosion Control Blanket
9. Vegetated Sediment Trap
10. Pond Riser Pipe Filter

Low Impact Development

11. Runoff Control Blanket
12. Vegetated Filter Strip
13. Engineered Soil
14. Channel Liner
15. Streambank Stabilization
16. Biofiltration System
17. Bioretention System
18. Green Roof System
19. Living Wall
20. Green Retaining Wall
21. Vegetated Rip Rap
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23. Green Gabion
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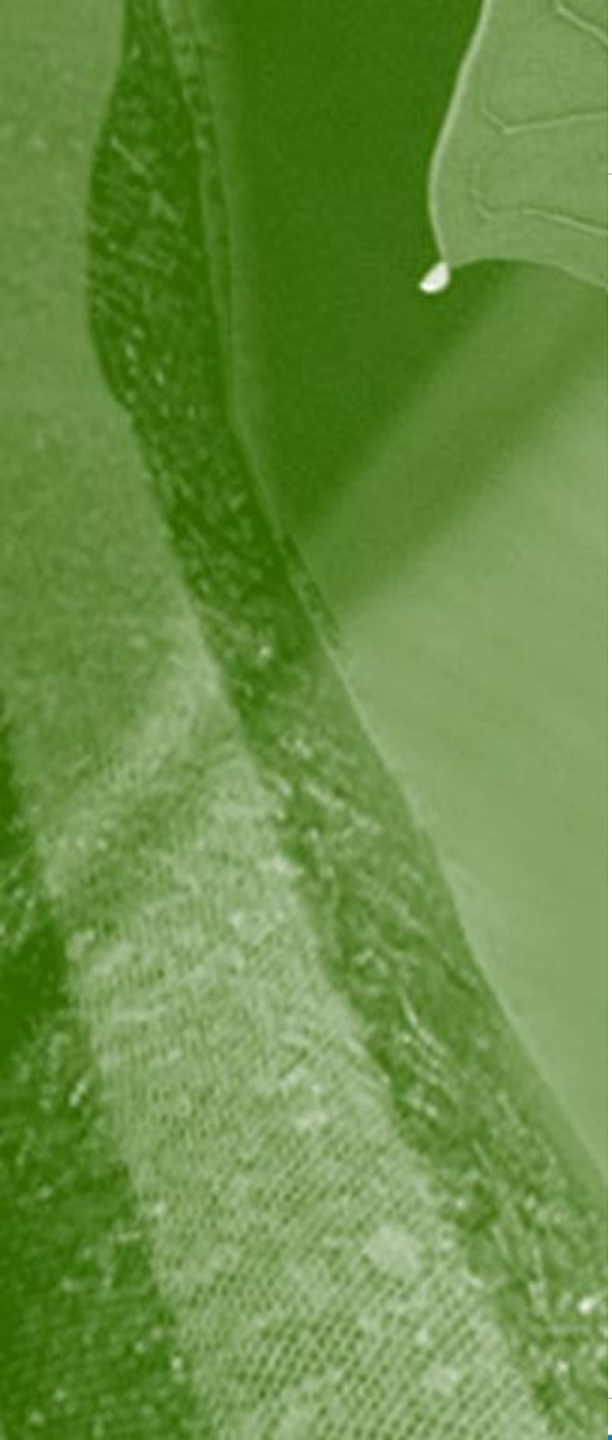


Storm Water Management in a Changing World

A perfect storm has been gathering due to changing environmental, economic, and social conditions. Land development and urbanization is increasing stormwater, pollutant loads, and their deleterious affects on receiving surface water systems. Population growth, suburban and urban expansion, decreased vegetation cover, poorly functioning soil ecosystems, and increased impervious surfaces have nearly rendered stormwater infrastructure in every metropolitan region in North America obsolete. Combined sewer overflows (CSOs), collapsed aquatic ecosystems, water bodies unfit for recreation, degraded and undersized infrastructural systems, increased flooding, decreased reservoir capacity, increased water treatment costs and depleted budgets, increased energy use and carbon emissions from industrial treatment, the loss of 25% of our topsoil, loss of productive agricultural land, wildlife habitat and biodiversity loss, interstate and international water wars, potential explosive effects from climate change on increased storm frequency and intensity, prolonged drought, and changing vegetation zones, are all components contributing to the perfect storm.

In 2040, the US population is expected to reach 400 million[1], while the global population may reach 10 billion[2], with much of the increase coming in urban areas. This increase in population, human and economic activity, and the development required to sustain this population will severely strain resources at every level. From 1940 to 2000, per capita water use has ballooned by 400%[3]. According to the US Environmental Protection Agency (EPA), over 21,000 water quality impairment cases were reported between 1995 and 2007, as 35% of US surface waters are now severely polluted or unfit for recreational purposes, and 75% of Americans live within 10 miles (16 km) of a polluted water body[4]. Although sediment continues to be the leading source of water pollution, nutrients, heavy metals, harmful bacteria, and petroleum hydrocarbons are also leading pollutants commonly found in stormwater and receiving water bodies. Soil erosion and sediment pollution alone are estimated to cost the United States between $10 billion and $44 billion per year[3,5].

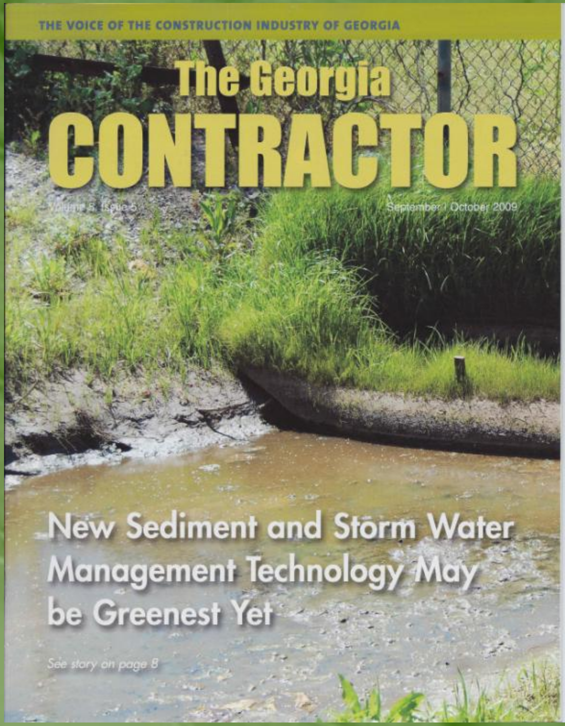
In response, federal, state (provincial), and local environmental agencies have: increased design requirements for engineering stormwater management practices; generated best management practice (BMP) lists and guidelines; implemented stormwater utilities; developed performance-based standards for receiving water quality, storm water quality, and BMPs; adopted green building ordinances or certification programs; instituted maximum daily load requirements for receiving water segments; required riparian and wetland mitigation improvement programs; created minimum green space and non-impervious area ordinances; enforced site hydrology and stream hydraulic flow standards; and developed major watershed planning programs. While any of these efforts can have a positive impact on stormwater and water quality, the best option is stormwater prevention, and secondarily, to manage stormwater entirely on site.

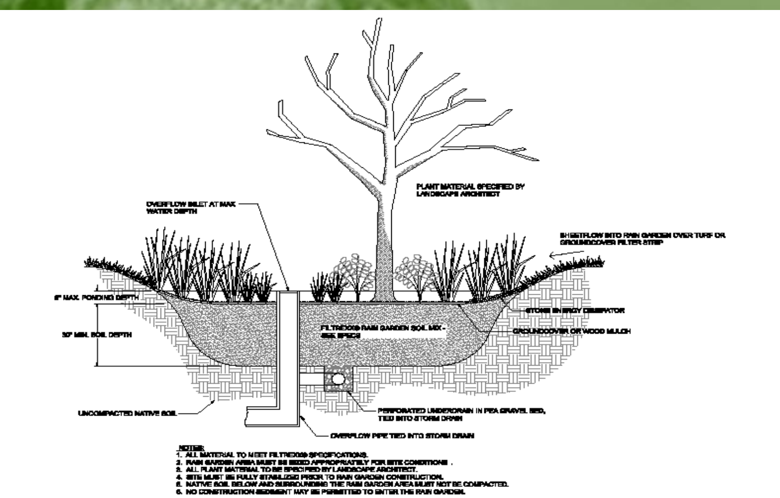
LAND MANAGEMENT IS WATER MANAGEMENT

Human systems are often less effective than Natural systems. Designers and practitioners should understand that the nature in which we manage our soil and land resources has direct consequences on our water resources. Land surfaces that increase stormwater runoff (impervious surfaces, rooftops, compacted, and eroded soils) also increase pollutant loads and transport of pollutants to surface waters. Recent studies have shown increasing watershed impervious surface area is directly correlated to declining surface water quality[6]. These same land

The *Sustainable* BMP

- 100% Recycled (compost)
- Bio-based, organic materials
- Locally manufactured
- Reduces Carbon Footprint
- Uses Natural Principles
- High Performance





Rain Gardens

Storm Water Quantity & Quality Control Practice

PURPOSE & DESCRIPTION

A rain garden is a storm water management practice that utilizes soil, compost growing media plants, and microbes to filter, retain, infiltrate, and distribute storm water runoff on developed sites. Rain gardens are an important component of Low Impact Development (LID) strategies because they are relatively simple, inexpensive, effective, and aesthetically attractive.

APPLICATION

Rain gardens can be used on virtually any site utilizing a variety of design techniques. The most straightforward designs are on sites which (Winogradoff, 2001):

- Allow the rain garden facility to be located in close proximity to the source of runoff.
- Allow rain garden facilities to be dispersed uniformly throughout the site.
- Allow each rain garden facility to collect runoff from a sub-drainage area of one acre or less (maximum of two acres).
- Are large enough to accommodate the rain garden facilities within required setbacks.
- Contain high infiltration, stabile, and well-structured soil media.

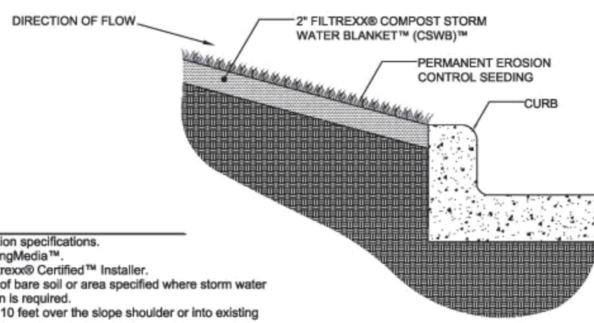
Rain gardens can be installed on sites that do not meet all of the following criteria; however, it may be more difficult and often less successful.

The key components of a rain garden include (Winogradoff, 2001):

- Pretreatment—It is important to filter excess debris and sediment from runoff before it reaches the rain garden in order to minimize maintenance and maximize performance.
- Flow Entrance—It is best to allow water to sheet flow directly into the facility, where concentrated flows enter through a curb cut or pipe. It is important to dissipate the velocity of the runoff with stone, rip rap, level spreader, or similar method.

Pnuematic Installation of Media

- Ponding Area—The surface storage of runoff is accommodated in the ponding area. Acceptable depths range from 3–12 inches (75–300 mm), with 6 inches (150 mm) recommended.
- Plant Materials—plants in a rain garden facility help to filter and uptake pollutants, remove water through evapotranspiration, encourage infiltration, and create an aesthetically pleasing landscape feature.
- Mulch—The mulch layer is an important medium for the adsorption and filtering of pollutants, as well as protecting the soil media from eroding and drying out. A 3-inch (75-mm) blanket of compost filter media is recommended for this application.
- Soil Media—The soil media in a rain garden facility is specifically designed to filter pollutants, infiltrate water, and support plant growth. The soil media must have a minimum infiltration rate of 2 inches (50 mm) per hour. Rain garden soil media



CSWB™ Section View

Notes:

1. CSWB™ to meet Filtrexx® installation specifications.
2. CSWB™ must use Filtrexx® GrowingMedia™.
3. CSWB™ must be installed by a Filtrexx® Certified™ Installer.
4. CSWB™ shall be applied to 100% of bare soil or area specified where storm water reduction and permanent vegetation is required.
5. CSWB™ shall be installed at least 10 feet over the slope shoulder or into existing vegetation.
6. CSWB™ will be placed at locations indicated on plans as directed by the Engineer.
7. Land or soil surface shall be roughened prior to application of CSWB™.
8. CSWB™ shall be applied at a minimum depth of 2 in. or at a rate of 270 cubic yards/ac.
9. Seed shall be thoroughly mixed with the Filtrexx® GrowingMedia™ prior to application or surface applied to Filtrexx® GrowingMedia™ at the time of application.
10. CSWB™ shall not be installed in areas of concentrated storm runoff flow, including channels and ditches.
11. CSWB™ installed on slopes greater than or equal to 4:1 shall be tracked; installation on slopes greater than 2:1 shall be tracked and use other support practices, such as Filtrexx® Lockdown™ Netting or Filtrexx® ProFloxx™.

Compost Storm Water Blankets

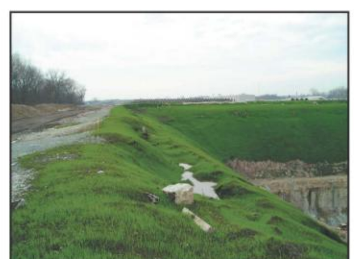
Storm Water Reduction & Vegetation Practice

PURPOSE & DESCRIPTION

Compost storm water blankets are storm water runoff reduction and permanent vegetation practices used on post-construction soil surfaces. Storm water blankets are intended for application and use where:

- Land-disturbing activities have ceased
- Permanent vegetation is required
- Reduction of pollutant loading in storm runoff is required
- Runoff volume reduction from contributing watershed is necessary
- Reduction in the size of storm water collection or bio-retention ponds, and rain gardens is necessary

Storm water blankets are designed to act like a sponge for rain water and non-concentrated storm runoff. By holding large volumes of water at and across the land surface, storm water blankets increase the infiltration and evapotransporation of water from rainfall and storm runoff. These processes aid the cycling of water by recharging ground water and atmospheric water vapor. By increasing the land surface roughness, storm water blankets slow the rate of sheet runoff, allowing it to more readily infiltrate the soil surface. Storm water blankets are also specifically designed to allow for permanent and sustained vegetation growth.



Application Compost Storm Water Blanket

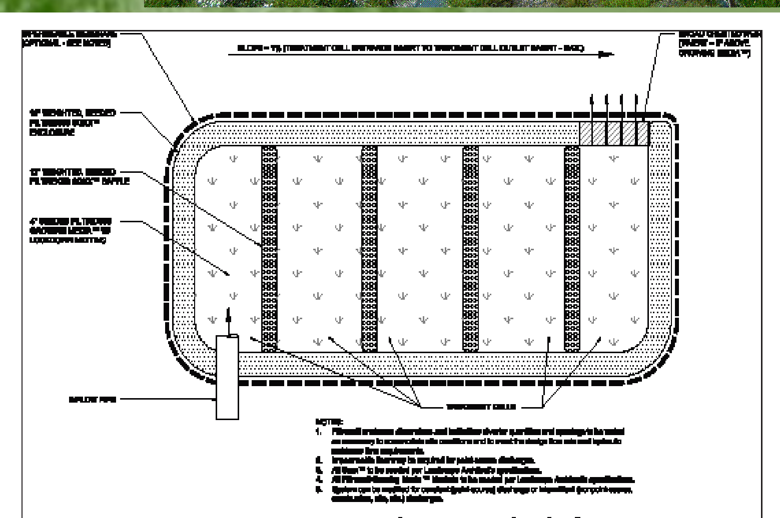
APPLICATION

Compost storm water blankets are surface applied at a depth of 2 inches (50 mm). Storm water blankets are used where reduction of storm water runoff and/or permanent vegetation is required or will improve the design and function of the landscape. Storm water blankets are generally applied after land-disturbing activities have ceased and where sheet runoff may exist under storm conditions. Storm water blankets should *not* be used in areas of concentrated storm water flow. Storm water blankets should not be used on slopes greater than 2:1 without the use of additional stabilizers or erosion control practices. Compost socks for slope interruption (See Section 1.5) may be seeded and used with storm water blankets to slow runoff velocity and reduce soil erosion potential.

ADVANTAGES AND DISADVANTAGES

Advantages

- Storm water blankets can be used for reduction of storm water runoff and permanent vegetation establishment.
- Storm water blankets can be easily designed and incorporated as part of a treatment train approach in storm water management and pollution prevention.
- Storm water blankets are easily applied and can establish vegetation in difficult areas.
- Storm water blankets have a high water holding capacity, therefore can absorb high volumes of rainfall and storm water sheet flows.
- Storm water blankets can absorb rainfall and runoff water, thereby increasing infiltration and reducing runoff, erosion, and transport of pollutants.



The Sustainable Site

Section 2: Storm Water Management – Post-Construction

Compost Sock Biofiltration System

Storm Water Pollution Control Practice

PURPOSE & DESCRIPTION

The compost sock biofiltration system is a temporary or permanent water or storm water filtration system used to remove sediment and/or soluble pollutants from water or storm water. This land-based system uses organic filter media and vegetation to remove pollutants from water and storm water before being discharged into collection ponds, constructed wetlands, infiltration basins, fields, or receiving waters. This filtration system combines the benefits of organic matter, humus, and vegetation, to clean point and non-point water sources.

APPLICATION

The compost sock biofiltration system can be used for temporary applications during land disturbing/construction activities or for permanent applications where vegetation can be established to create a permanent organic vegetative filter that is designed into the landscape. Typical applications include:

- Pretreatment for temporary sediment detention ponds
- Post-treatment for temporary sediment detention pond discharge or emergency storm overflow
- Pretreatment for permanent storm water collection ponds

Installation of a Biofiltratrion System

- Sediment and soluble pollutant control of storm runoff
- Sediment and soluble pollution filtration from contaminated effluent

Vegetated filtration systems can also be used to reduce runoff velocity flowing into surface waters. Reducing runoff velocity will decrease soil erosion and increase pollutant removal through trapping, sediment deposition, and plant uptake.

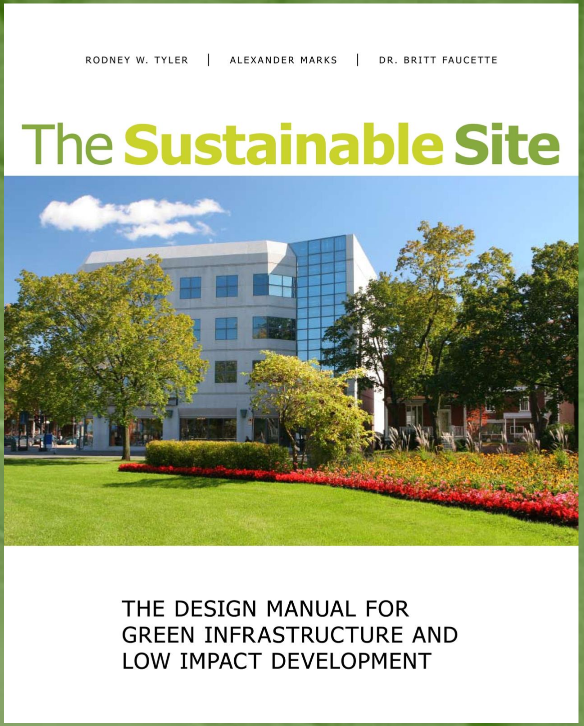
ADVANTAGES AND DISADVANTAGES

Advantages

- Biofiltration systems can be used for permanent or temporary pollutant filtration applications.
- Biofiltration systems are easily installed and can establish vegetation in difficult areas.
- Biofiltration systems can be easily designed and incorporated as one treatment in a treatment train approach to storm water management.
- Biofiltration systems can slow down runoff velocity, thereby increasing sediment deposition, reducing the erosive energy of runoff and the potential for soil erosion, and pollutant transport.
- Biofiltration systems can be used to filter pollutants and infiltrate storm water entering or leaving areas where storm water may pass, collect, drain, or be stored.
- Biofiltration systems have the ability to bind and adsorb soluble nutrients, metals, and hydrocarbons that may be in storm water runoff, thereby reducing loading to nearby receiving waters.
- Biofiltration systems can remove pathogens and pesticides from storm runoff preventing pollution of receiving water bodies.
- Biofiltration systems can be customized to remove target pollutants from contaminated water, such as phosphorus and suspended solids.
- Biofiltration systems can be customized to handle a variety of water pollutant

SMP Specification & Design

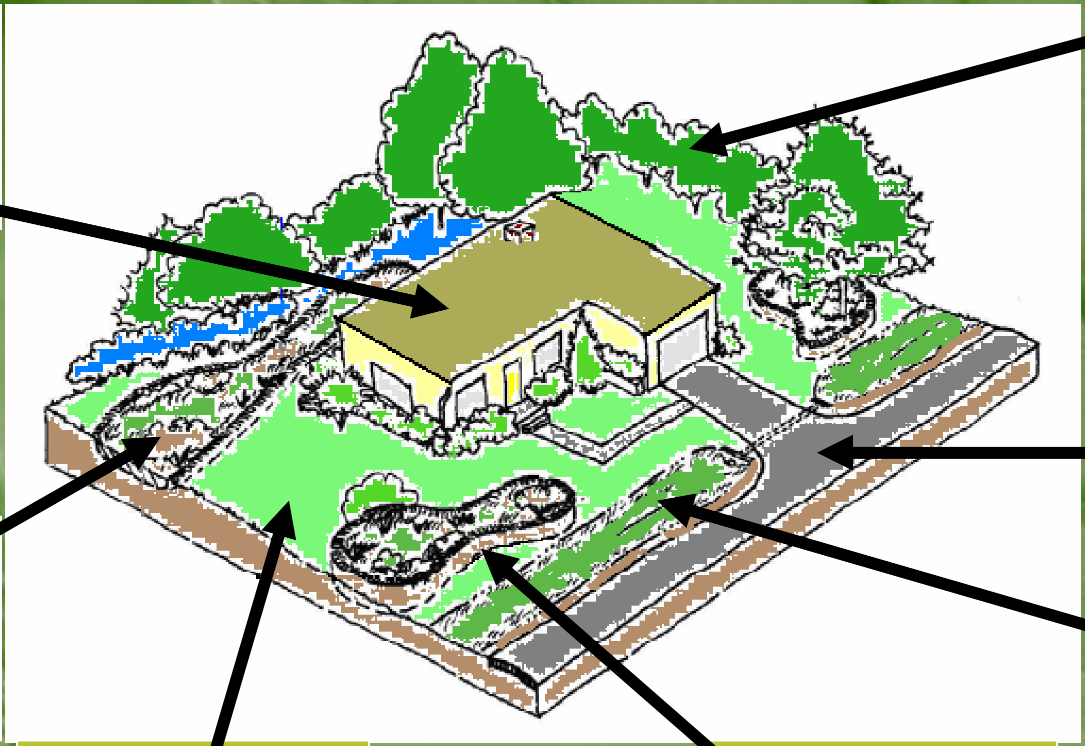
- Purpose/Description
- Applications
- Advantages/Disadvantages
- LEED Green Building Credits
- Compost Specifications
- Performance/Research
- Engineering & Design Criteria
- Installation
- Inspection
- Maintenance
- Recycling/Disposal
- Measurements
- Engineering Drawings/Construction Details
- References



LID Practices

Green Roof

Native Vegetation



Green Pavers

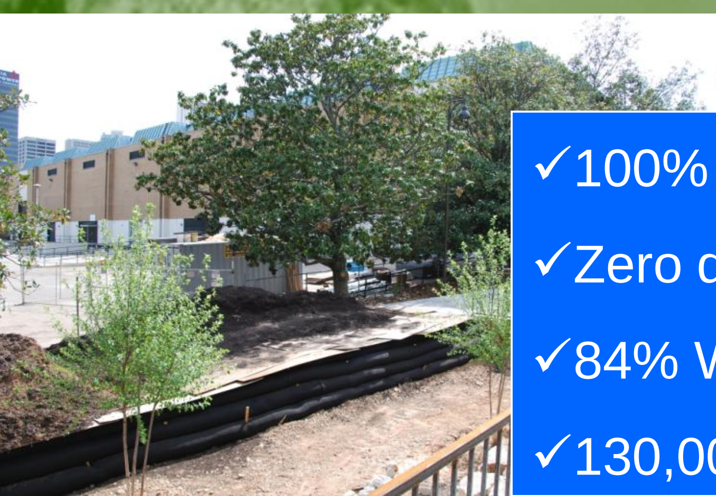
Rain Garden/ Bioretention

Bioswale

Stormwater Blanket

Engineered Soil

Southface Responsible Solutions for Environmental Living



- ✓100% rain/stormwater capture
- ✓Zero discharge
- ✓84% Water Savings
- ✓130,000 gal/yr

Book Reviews

"America's 21st Century Infrastructure will be based on a green economy. The transition from grey to green will be lead by the development of technology that is renewable, economical, and environmentally efficient. For many years a small group of researchers have been working on and promoting the integration of compost into site planning and design to help address the effects of stormwater pollution…more than a highly effective stormwater treatment system…it can be used to create green jobs, and is highly economical. This book provides a foundation on how we can begin to develop the new Green Infrastructure."

- Neil Weinstein, P.E., R.L.A., AICP, Executive Director , The Low Impact Development Center

"... This design manual should be a must-read for all landscape architects, landscape designer, horticulturalists, agronomists, hydrologists, land use planners, and public works engineers, to name a few. Anyone who either disturb the soil or wants to restore the soil should read and use the information in this book."

- Jean Schwab, Director of EPA Greenscapes Program, Office of Resource Conservation & Recovery

Questions?

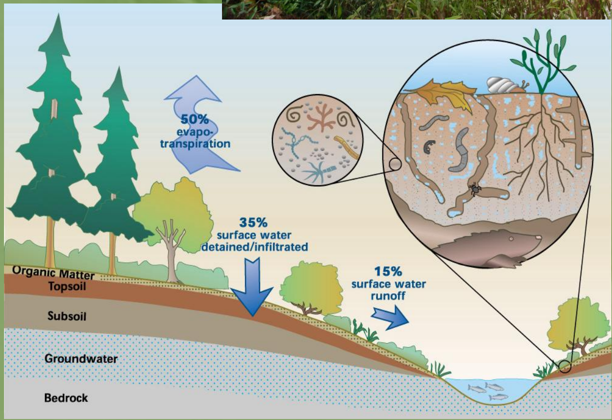
Dr. Britt Faucette, CPESC, LEED AP

Ph: 678 592 7094
brittf@filtrexx.com

LID Principles

- *<u>Restore Natural Hydrology = Water Quality</u>*

- Reduce Runoff Volume
- Reduce Runoff Rate
- Result = Reduced Pollutant Loads
- Result = Reduced Flooding
- *Water Quality*
- *Wildlife Habitat/Biodiversity*
- *Aesthetics/Land Value*



Stormwater Management Practices

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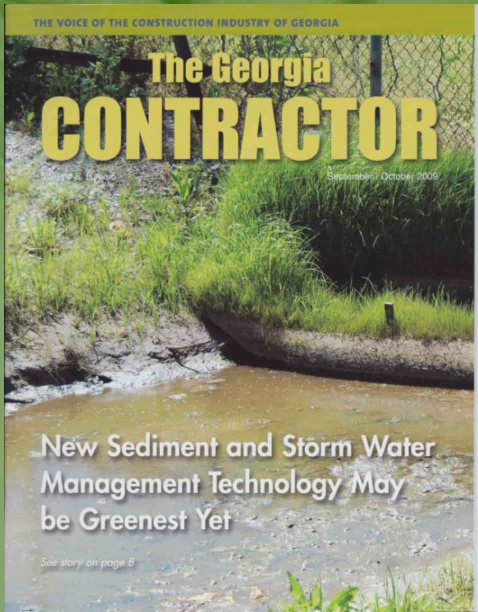
LEED Credit Categories NC 3.0

- **Sustainable Sites** (26)
- **Water Efficiency** (10)
- Energy & Atmosphere (35)
- **Materials & Resources** (14)
- Indoor Environmental Quality (15)
- **Innovation & Design Process (6)**
- **Regional Priority Credit (4)**

MIMIC NATURE™

Outline

- Stormwater & Low Impact Development
- Why Compost?
- Sustainable Management Practices
- New Design Manual
- Green Building



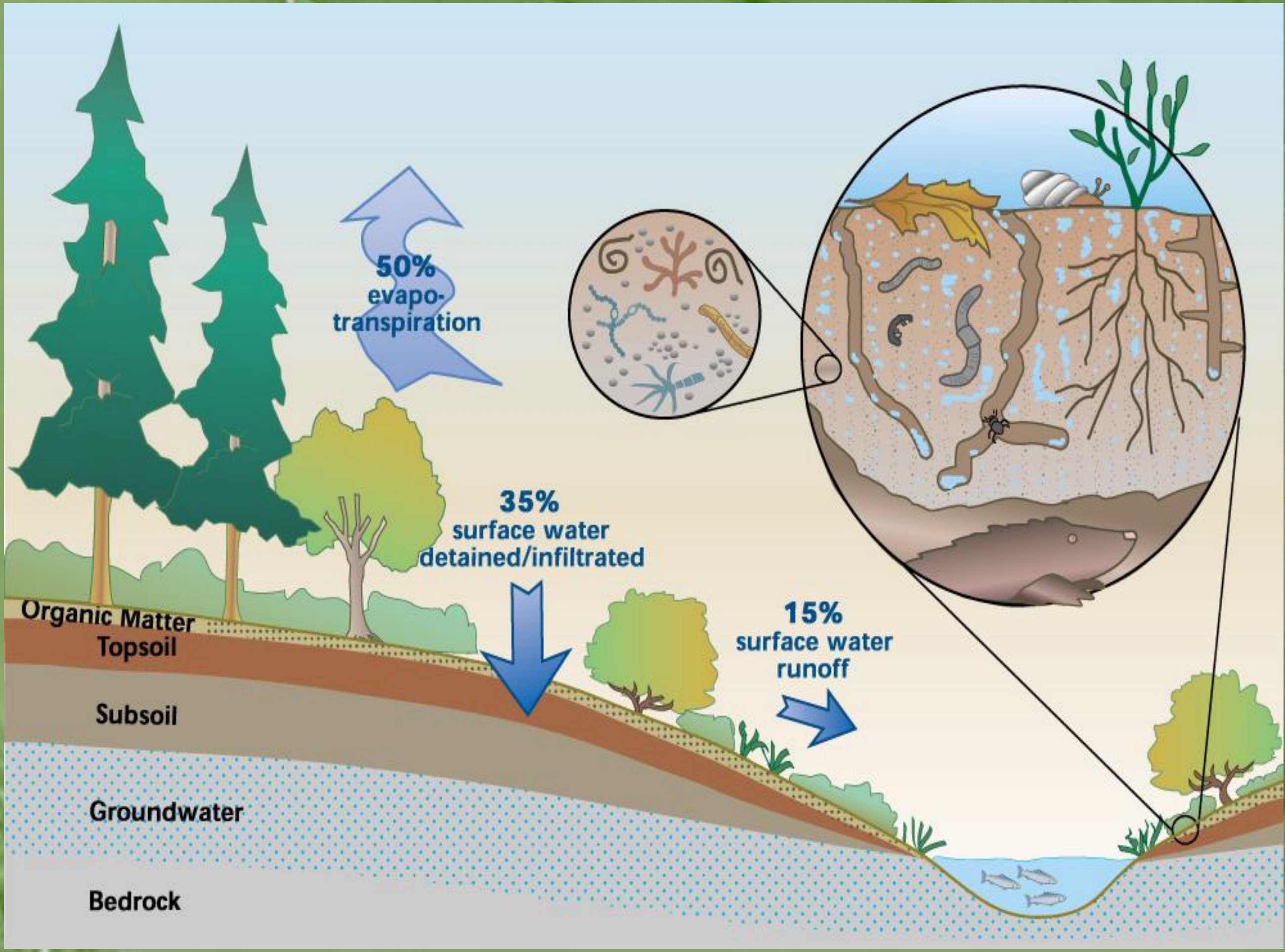
MIMIC NATURE™

Low Impact Development *Design*

……with Compost

How?

1. Interception
2. Transpiration
3. Infiltration
4. Evaporation
4. Surface Roughness
5. Flow Path Disruption
6. Filtration




10. 30. 2001









Design: CECB Thickness based on Slope & 24 Rainfall Total

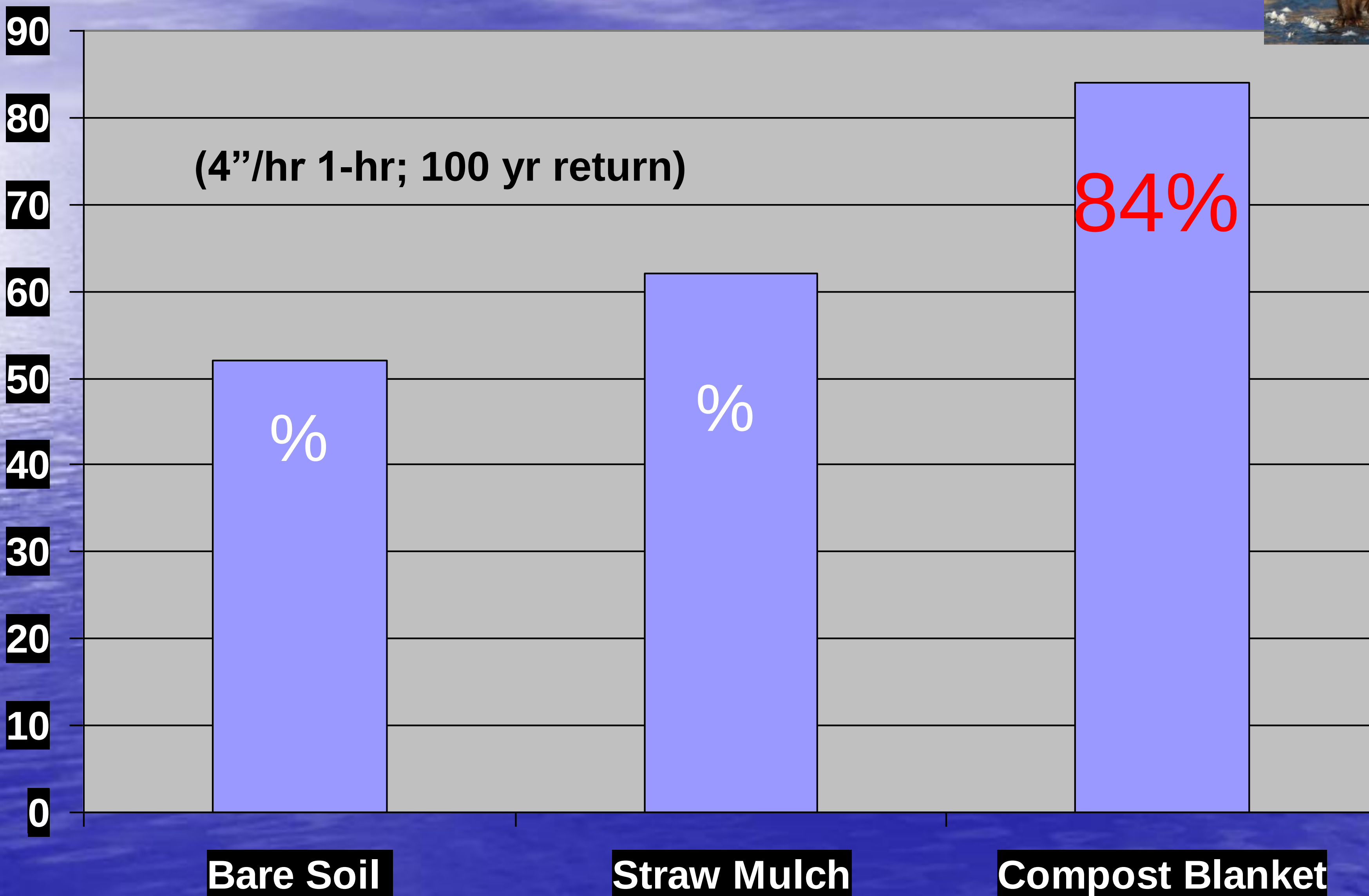
Slope Angle (≤)	Rainfall = 1.0 in	Rainfall = 2.0 in	Rainfall = 4.0 in
4:1	½ in	2 in	2 in
3:1	½ in	1 in	2 in
2:1	1 in	1 in	1 in

USLE C Factors

A= R x K x LS x **C** x P

Erosion Control	C Factor	Reference
Bare Soil	**1.0**	
Wood Mulch	**0.08-0.16**	Demars and Long, 1998; Faucette et al, 2004
Straw Mulch	**0.08-0.19**	Demars and Long, 1998; Faucette et al, 2006
Compost Blanket	**0.01-0.07**	Mukhtar et al, 2004; Demars and Long, 1998; Demars et al, 2000; Faucette et al 2005; Faucette et al, 2006
Forest floor	**0.001**	GA SWCC, 2000

LID: Rainfall Absorption



Runoff Coefficients

Watershed Surface	Coefficient
Asphalt, concrete, rooftop, downtown area	0.95
Neighborhood, apartment homes	0.7
Single family home site	0.5
Bare graded soil – clay, silt, sand	0.6, 0.5, 0.3
Lawn, pasture	0.1 – 0.35
Undisturbed forest	0.15
Compost blanket	0.1 – 0.32 (0.28)

Reference: GA Storm Water Management Manual, 2001

Runoff Curve Numbers

Watershed Surface	Curve Number*
Parking lot, driveway, roof	98
Commercial district	92
Dirt road	82
Residential lot: ¼ ac, ½ ac, 1 ac	75, 70, 68
Cropland	71-81
Pasture	61-79
Public green space	61-69
Woodland and forests	55-66
Brush >75% cover	48
Vegetated Compost Blanket	55

*Based Hydrologic Soil Group B

Reference: USDA SCS, 1986

Soil Erosion Rates

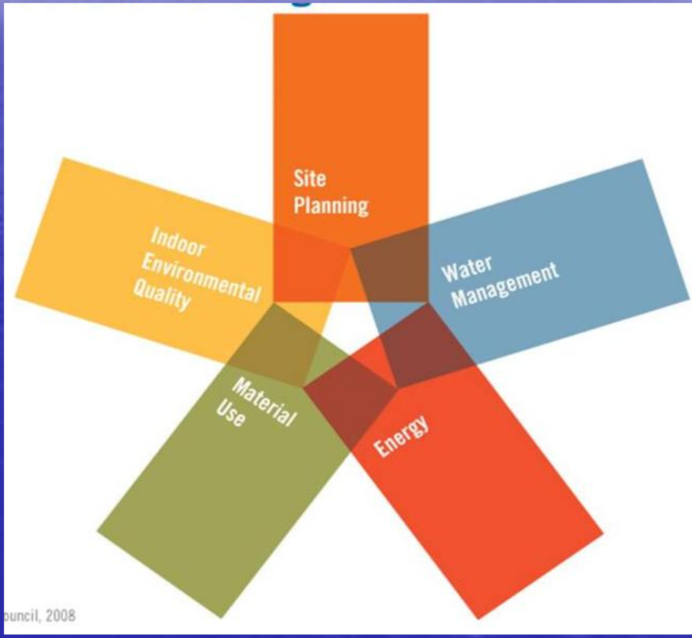
Land Use	**Loss (Tons/Acre – Year)**	**Relative to Forest**
Natural Forest **(Natural Site)**	0.04	1
Grassland	0.38	10
Abandoned Surface Mines	3.75	100
Cropland	7.50	200
Harvested Forest	18.75	500
Active Mining Operations	75.00	2000
Construction	**75.00**	**2000**

Storm Water Pollutant Removal

	TSS	Turbidity	Total N	NH4 -N	NO3 -N	Total P	Sol. P	Total coli.	E. coli.	Metals	Oil	Diesel
Filter Sock	80 %	63 %	35 %	35 %	25 %	60 %	92 %	98 %	98 %	37-78 %	99 %	99 %

Practice/Product	Max Shear Stress
Compost Sock Vegetated	**12 lbs/ft^2**
Loamy soil	0.1 lbs/ft^2
Grass	1-2 lbs/ft^2
Gravel (1-2”)	1-2 lbs/ft^2
Double-net straw RECP	2-4 lbs/ft^2
TRM	6-8, 12 lbs/ft^2
Rip Rap (1-2’)	3-5 lbs/ft^2

LEED Credit Categories NC 3.0



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Southface — Responsible Solutions for Environmental Living

✓84% Water Savings

✓130,000 gal/yr

Southface

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Director of Research/Technical Services

Ph: 678 592 7094

brittf@filtrexx.com

www.filtrexx.com

Compost Tools

Filter Media

Designed for Optimum Filtration & Hydraulic-flow

Growing Media

Designed for Optimum Water Absorption & Plant Growth

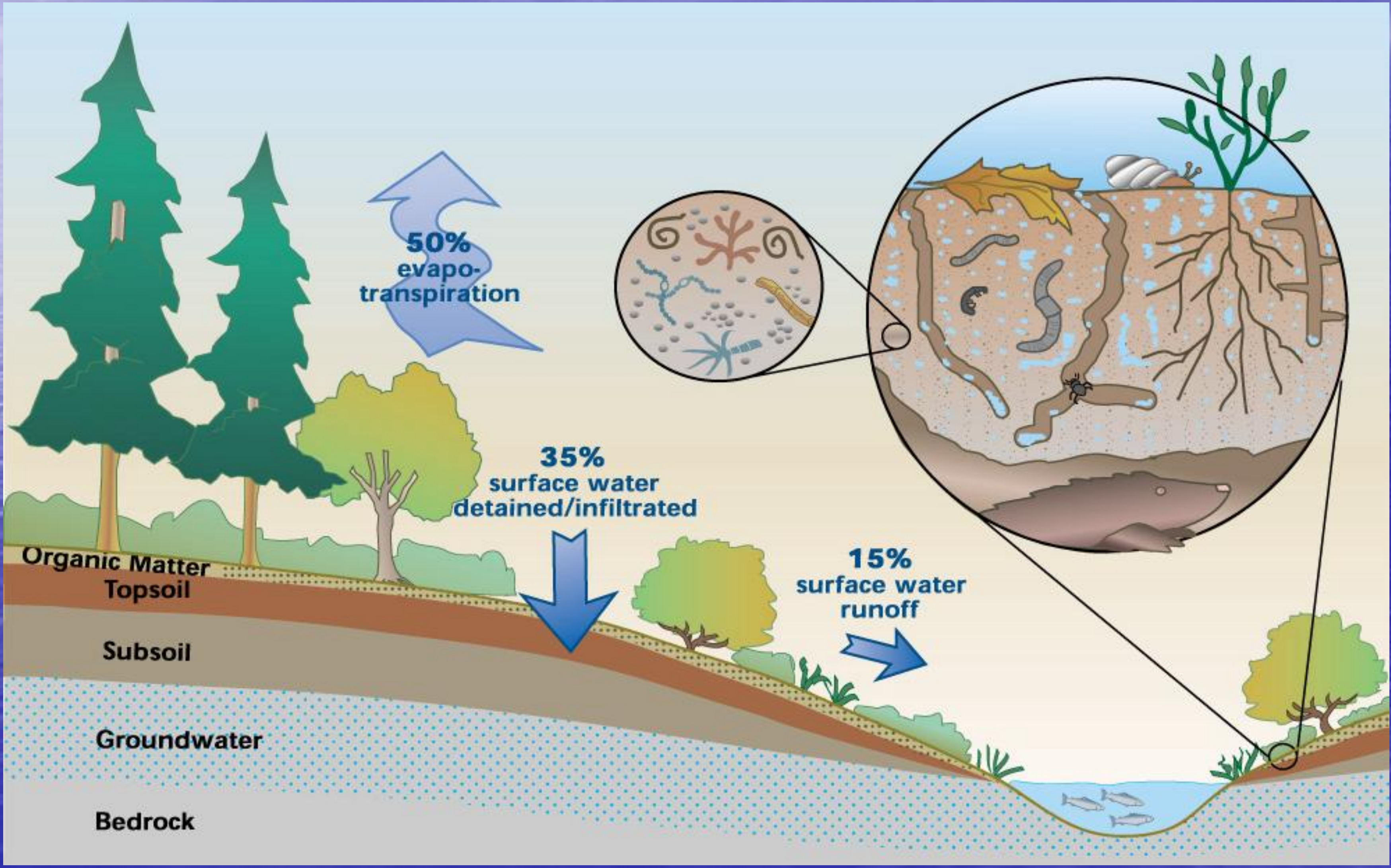
Break Time?

Performance & Design for Compost Blankets

Britt Faucette, Ph.D., CPESC, LEED AP

filtrexx®
LAND IMPROVEMENT SYSTEMS

Natural Stormwater Management



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Active Mining Operations	75.00	2000
Construction	**75.00**	**2000**

- Sedimentation is the leading source of water pollution in US
- New EPA Effluent Limit Guidelines for Stormwater from Construction Sites

Erosion Control/ Soil Stabilization BMPs

- Hydroseed
- Hydraulic Mulches
- Straw Mulch
- RECPs: straw, coconut, jute, excelsior
- RECPs: single and double net
- Tackifiers
- Polyacrylamide (PAMs)

Filtrexx Compost BMPs

Erosion & Sediment Control

1. Perimeter Control
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Compost Tools

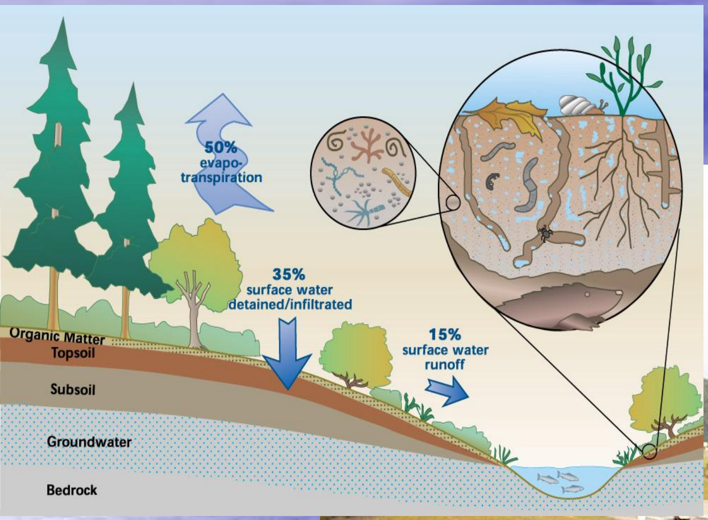
Filter Media

Designed for Optimum Filtration & Hydraulic-flow

Growing Media

Designed for Optimum Water Absorption & Plant Growth

Runoff + Erosion Control



Designed to: 1) dissipate energy of rain impact; 2) hold, infiltrate & evaporate water; 3) slow down/disperse energy of sheet flow; 4) provide for optimum vegetation growth

Particle Size Matters

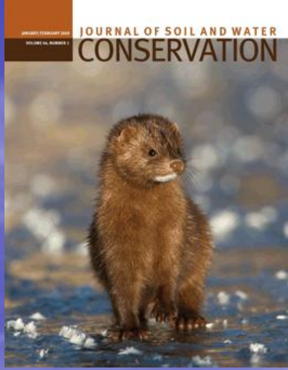
Treatment	Soil Loss (kg ha^{-1})	TSS (kg ha^{-1})	Turbidity (NTU)	Particle size % passing		
				1 in	1/2 in	1/4 in
Compost 1	95.8	52.1	36	99	64	30
Compost 2*	129.2	60.4	60	99	85	67
Compost 3*	208.3	64.6	87	99	89	76
Compost 4**	408.3	283.3	288	99	99	95

*Did not meet TX DOT specification for erosion control compost particle size distribution.
**Did not meet TX DOT, USEPA, IN DNR, or CONEG specification for erosion control blanket particle size distribution

RECP + Hydromulch

Compost Fills in the Low Spaces


Compost Blanket
Hydroseeding
Demo Project in Atlanta
after 3” storm event



Total Soil Loss

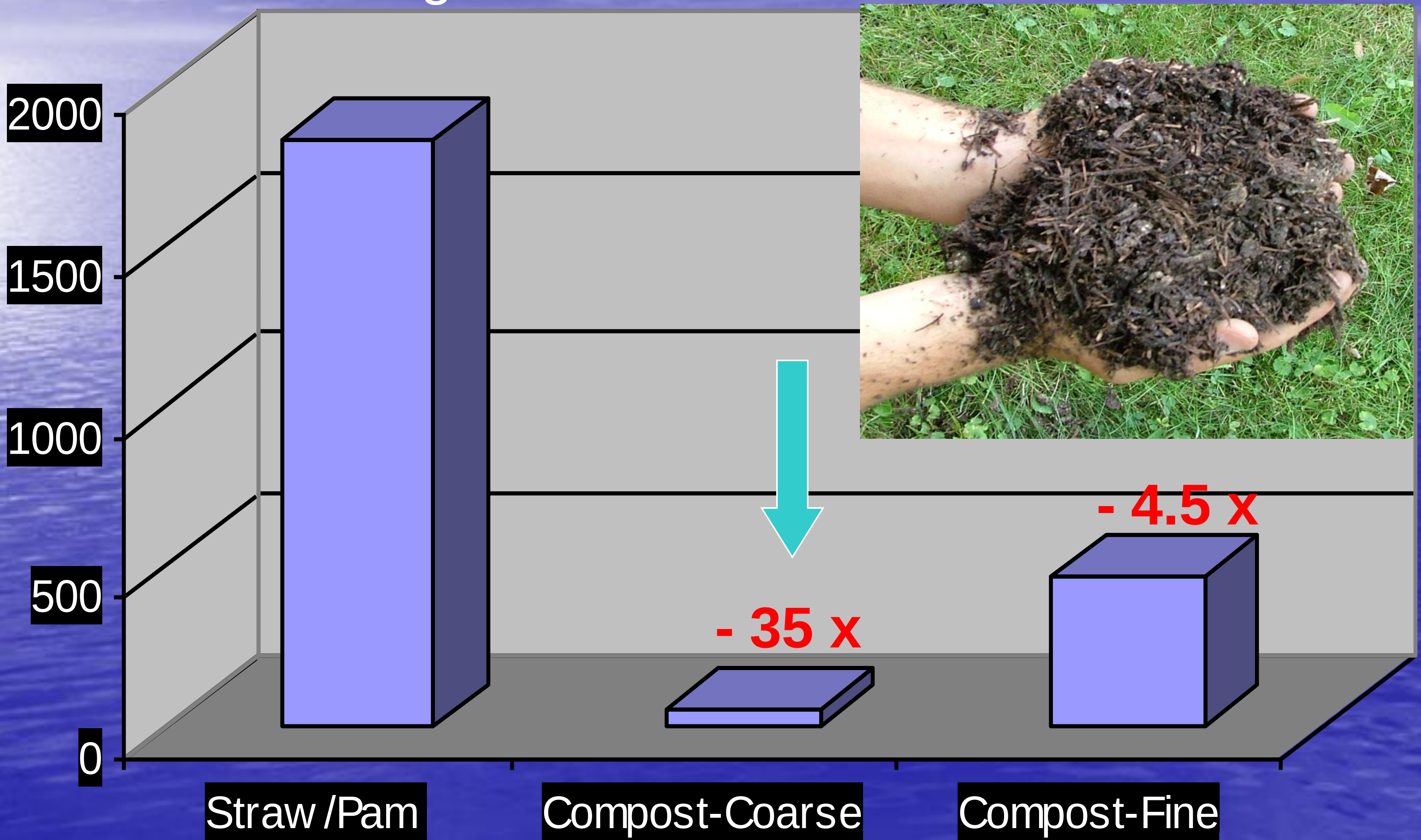
Hydromulch vs Compost Blanket:
Two 3”/hr storm events

- ✓Day 1 = **2,750 & 1,230 lb/ac**
- ✓3 mo = **1,960 & 115 lb/ac**

The University of Georgia

Turbidity (NTU)

Average from 4 inch Storm Event



Soil Erosion at 2:1

Erosion Control Practice	Soil loss @ 2 in/hr 20 min (0.67 in)		Soil loss @ 4 in/hr 40 min (2.0 in)		Soil loss @ 6 in/hr 60 min (4.0 in)	
	t/ac	% reduction	t/ac	% reduction	t/ac	% reduction
Bare soil	61	NA	137	NA	171	NA
CECB 2.0 in	0.02	99.8	46	66.8	48	71.9
CECB 1.0 in	0.09	99.1	53	61.1	53	68.9
CECB 0.5 in	29	52.1	96	30.1	72	57.7
Single-net straw	31	48.8	84	38.3	101	40.8
Single-net excelsior fiber	18	70.2	55	60.1	66	61.1
Double-net straw	23	62.7	62	54.7	76	56.0
Double-net coconut fiber	0.05	99.5	36	73.5	71	58.8
Tackifier	12	79.9	60	56.2	101	41.2
PAM	43	29.9	146	-6.8	158	7.7

Results: CECB Thickness & Slope Steepness

CECB Thickness (in)	Slope Angle (H:V)	Soil loss @ 2 in/hr 20 min (0.67 in)		Soil loss @ 4 in/hr 40 min (2.0 in)		Soil loss @ 6 in/hr 60 min (4.0 in)	
		t/ac	**% reduction**	t/ac	**% reduction**	t/ac	**% reduction**
Bare soil	**2:1**	61	**NA**	137	**NA**	171	**NA**
2.0	**2:1**	0.02	**99.8**	46	**66.8**	48	**71.9**
1.0	**2:1**	0.9	**99.1**	53	**61.1**	53	**68.9**
0.5	**2:1**	29	**52.1**	96	**30.1**	72	**57.7**
Bare soil	**3:1**	55	**NA**	132	**NA**	144	**NA**
2.0	**3:1**	0.09	**99.0**	26	**80.1**	35	**75.7**
1.0	**3:1**	0.25	**97.4**	18	**86.4**	72	**50.4**
0.5	**3:1**	0.9	**90.0**	94	**29.1**	100	**30.5**
Bare soil	**4:1**	72	**NA**	108	**NA**	110	**NA**
2.0	**4:1**	0.005	**100.0**	9	**91.4**	19	**82.6**
1.0	**4:1**	0.37	**96.8**	42	**61.4**	60	**45.9**
0.5	**4:1**	0.25	**98.2**	56	**48.4**	68	**38.0**

Design: CECB Thickness based on Slope & 24 Rainfall Total

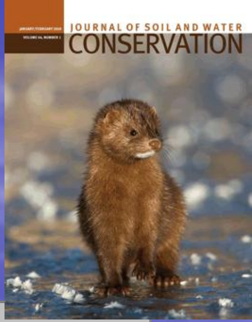
Slope Angle (≤)	Rainfall = 1.0 in	Rainfall = 2.0 in	Rainfall = 4.0 in
4:1	½ in	2 in	2 in
3:1	½ in	1 in	2 in
2:1	1 in	1 in	1 in

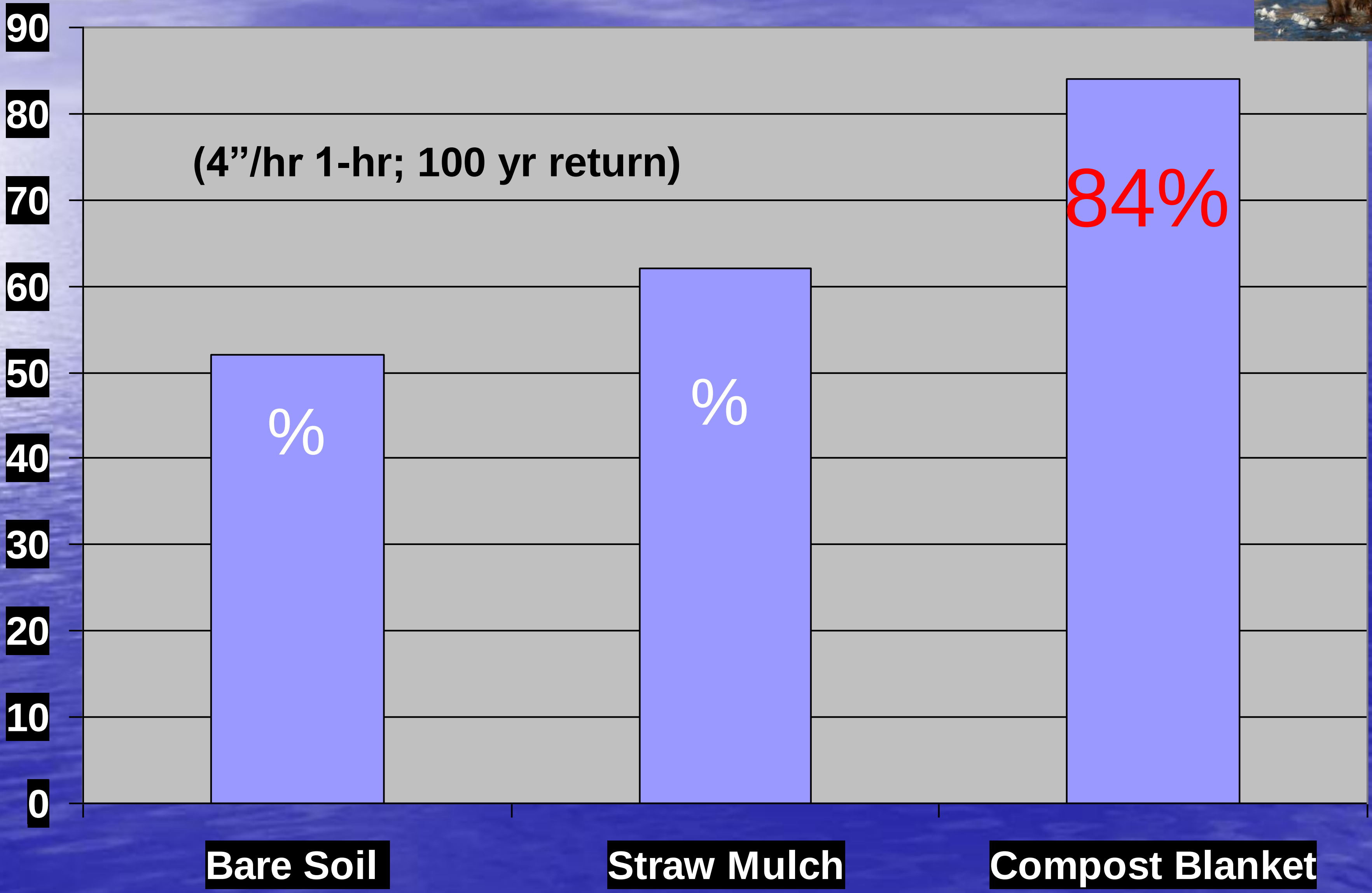
USLE C Factors

$$A = R \times K \times LS \times \underline{\mathbf{C}} \times P$$

Erosion Control	C Factor	Reference
Bare Soil	**1.0**	
Wood Mulch	**0.08-0.16**	Demars and Long, 1998; Faucette et al, 2004
Straw Mulch	**0.08-0.19**	Demars and Long, 1998; Faucette et al, 2006
Compost Blanket	**0.01-0.07**	Mukhtar et al, 2004; Demars and Long, 1998; Demars et al, 2000; Faucette et al 2005; Faucette et al, 2006
Forest floor	**0.001**	GA SWCC, 2000

LID: Rainfall Absorption





Runoff Volume Reduction

Reduction	Influencing Factors	Reference
49%	Sandy clay loam, 10% slope, 1.5” blanket, 3.2 in/hr – 1 hr rain	Faucette et al, 2005
60%	Sandy clay loam, 10% slope, 1.5” blanket, 4.0 in/hr – 1 hr rain	Faucette et al, 2007
76%	Silty sand, 2:1 slope, 3” blanket, 1.8 in/hr - 2.4 hr rain	Demars et al, 2000
90%	Loamy sand, 3:1 slope, 2” blanket, 4.0 in/hr – 2 hr rain	Persyn et al, 2004

Peak Flow Rate Reduction

Reduction	Influencing Factors	Reference
36%	Sandy clay loam, 10% slope, 1.5” blanket, 3.2 in/hr – 1 hr rain	Faucette et al, 2005
42% **(30% relative to straw)**	Sandy clay loam, 10% slope, 1.5” blanket, 4.0 in/hr – 1 hr rain	Faucette et al, 2007
79%	Loamy sand, 3:1 slope, 2” blanket, 4.0 in/hr – 2 hr rain	Persyn et al, 2004

Runoff Coefficients

Watershed Surface	Coefficient
Asphalt, concrete, rooftop, downtown area	0.95
Neighborhood, apartment homes	0.7
Single family home site	0.5
Bare graded soil – clay, silt, sand	0.6, 0.5, 0.3
Lawn, pasture	0.1 – 0.35
Undisturbed forest	0.15
Compost blanket	0.1 – 0.32 (0.28)

Reference: GA Storm Water Management Manual, 2001

Runoff Curve Numbers

Watershed Surface	Curve Number*
Parking lot, driveway, roof	98
Commercial district	92
Dirt road	82
Residential lot: ¼ ac, ½ ac, 1 ac	75, 70, 68
Cropland	71-81
Pasture	61-79
Public green space	61-69
Woodland and forests	55-66
Brush >75% cover	48
Vegetated Compost Blanket	55

*Based Hydrologic Soil Group B

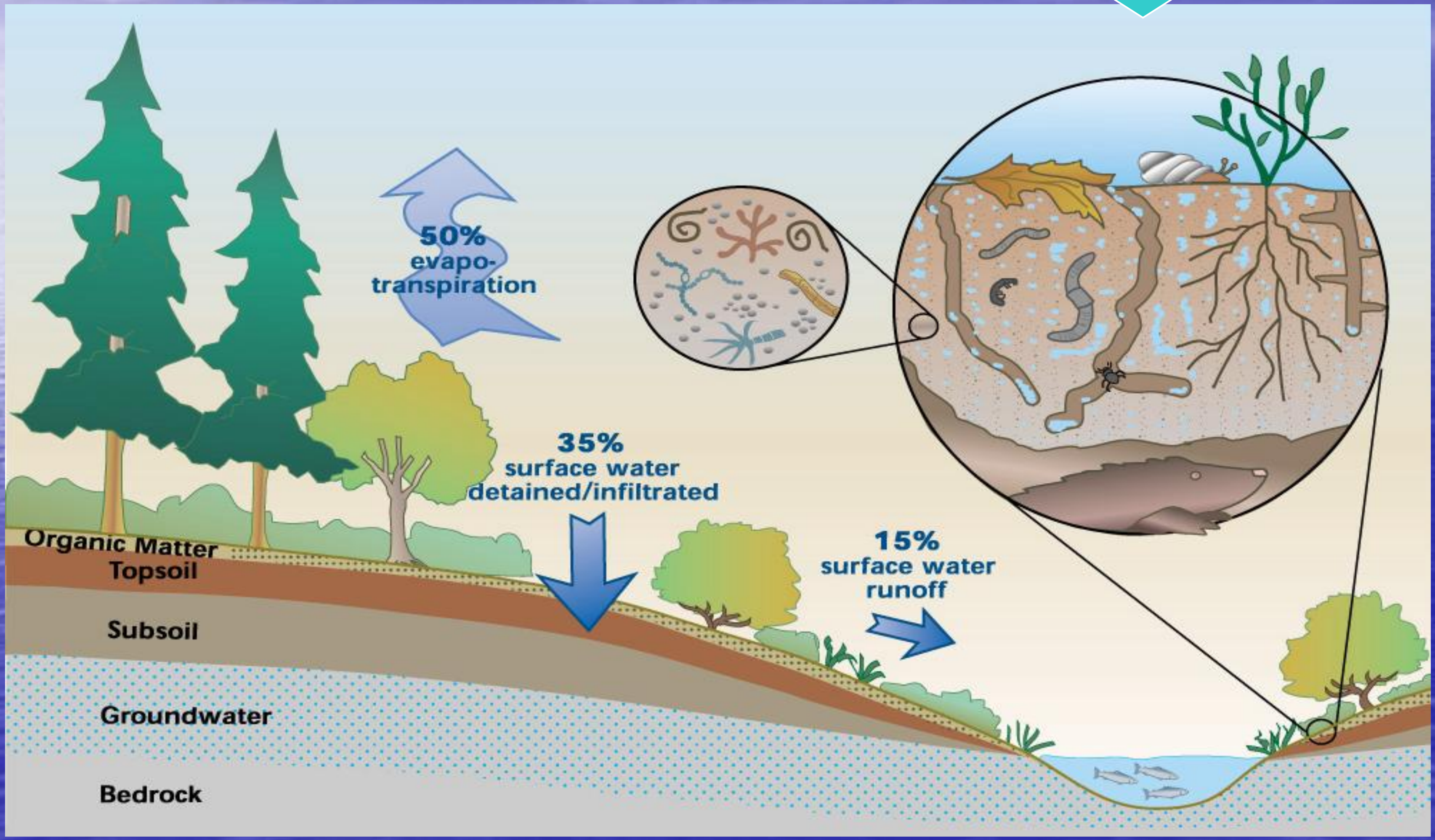
Reference: USDA SCS, 1986

Pollutant Load Reduction:

Compost Blanket vs Conventional Seeding

	Total N	Nitrate N	Total P	Soluble P	Total Sediment
Mukhtar et al, 2004 (seed+fertilizer)	88%	45%	87%	87%	99%
Faucette et al, 2007 (seed+fertilizer)	92%	ND	ND	97%	94%
Faucette et al, 2005 (hydromulch)	58%	98%	83%	83%	80%
Persyn et al 2004 (seed+topsoil)	99%	ND	99%	99%	96%

What about this?



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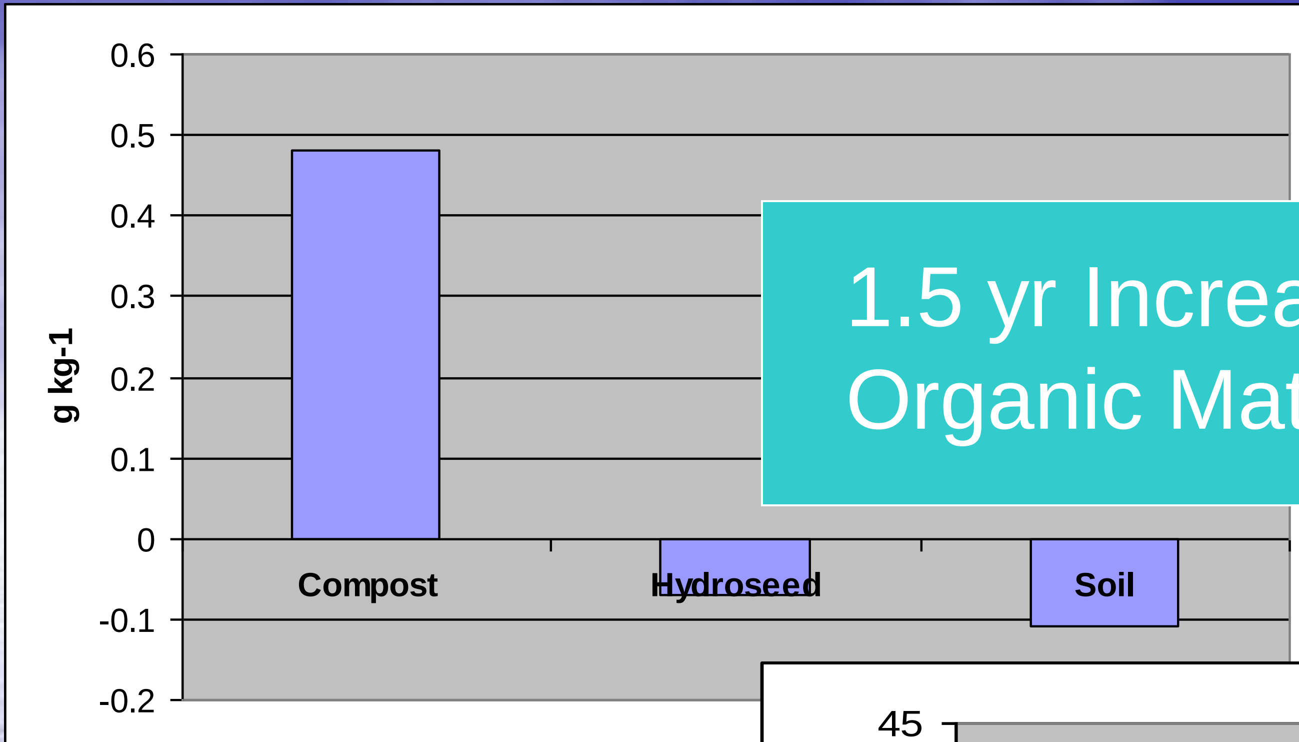
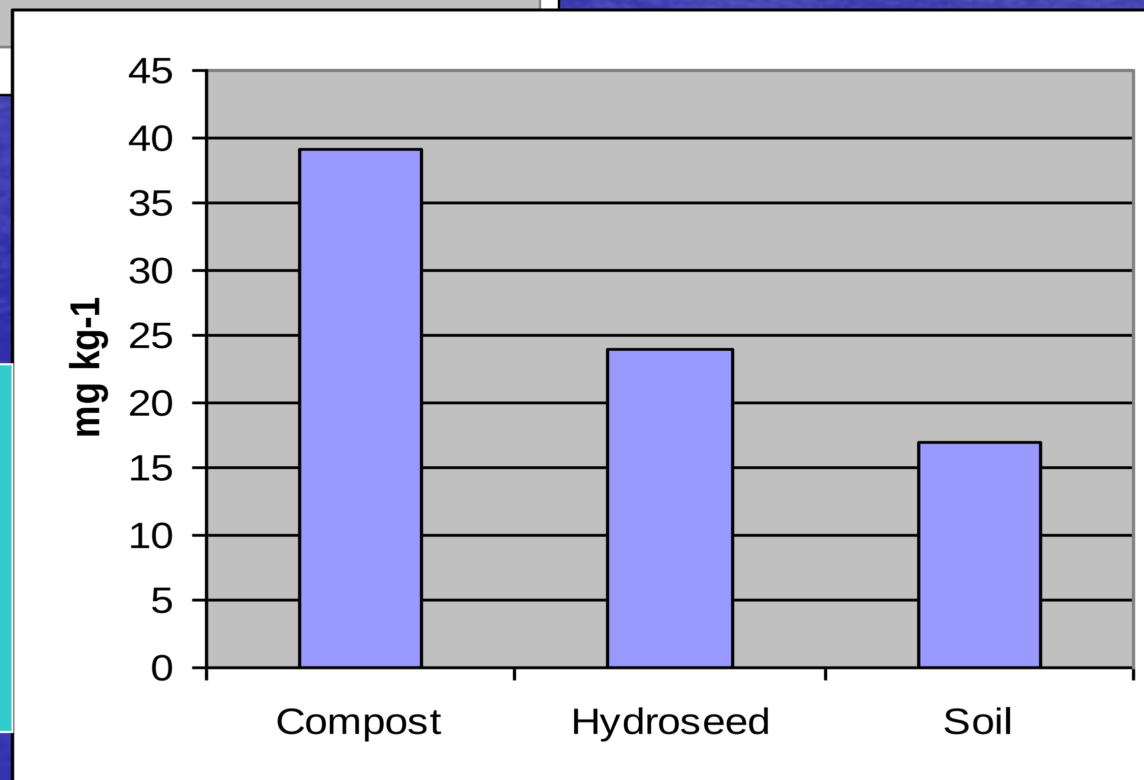
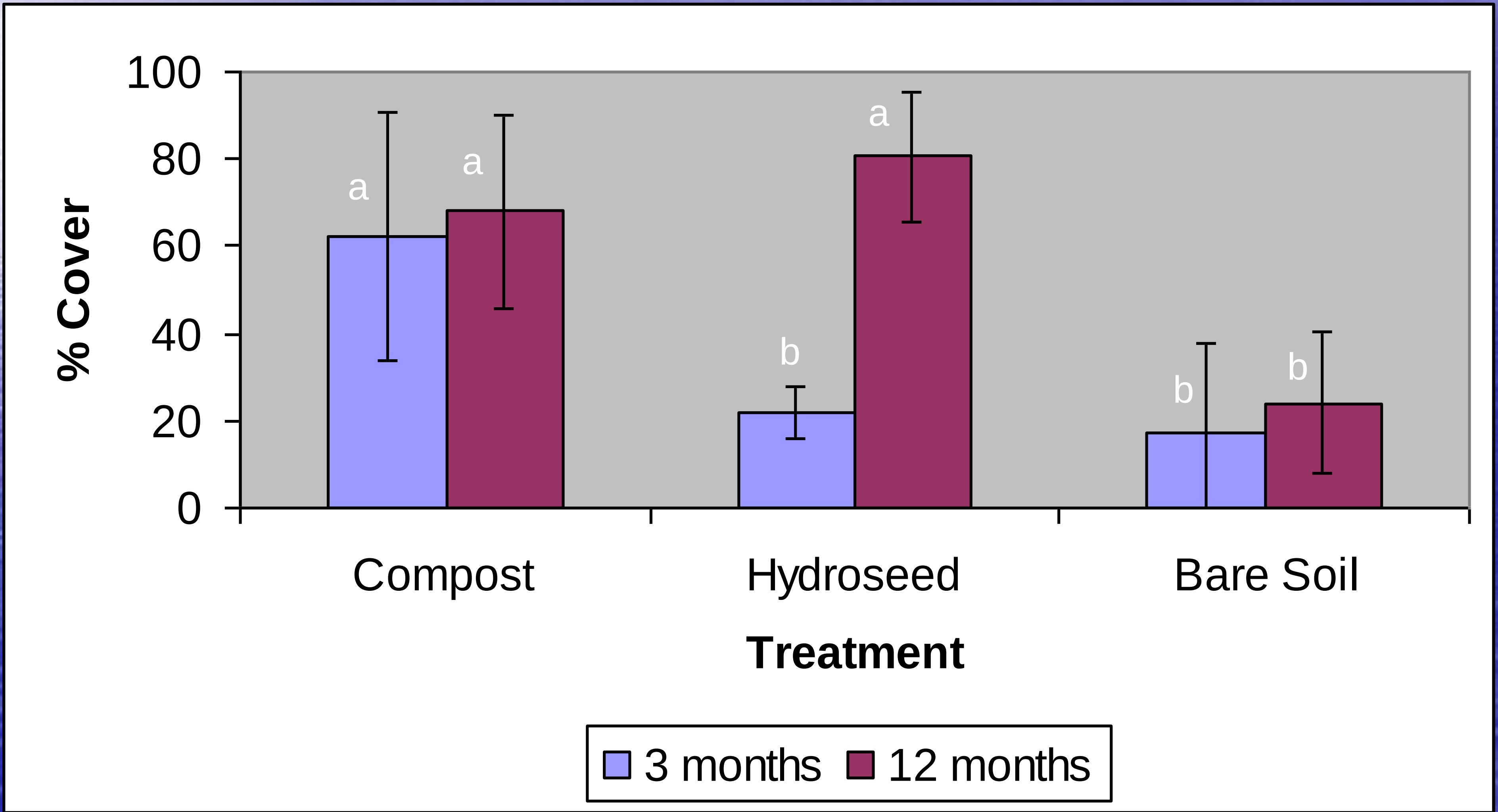
1.5 yr Increase in Organic Matter 0-6” Soil



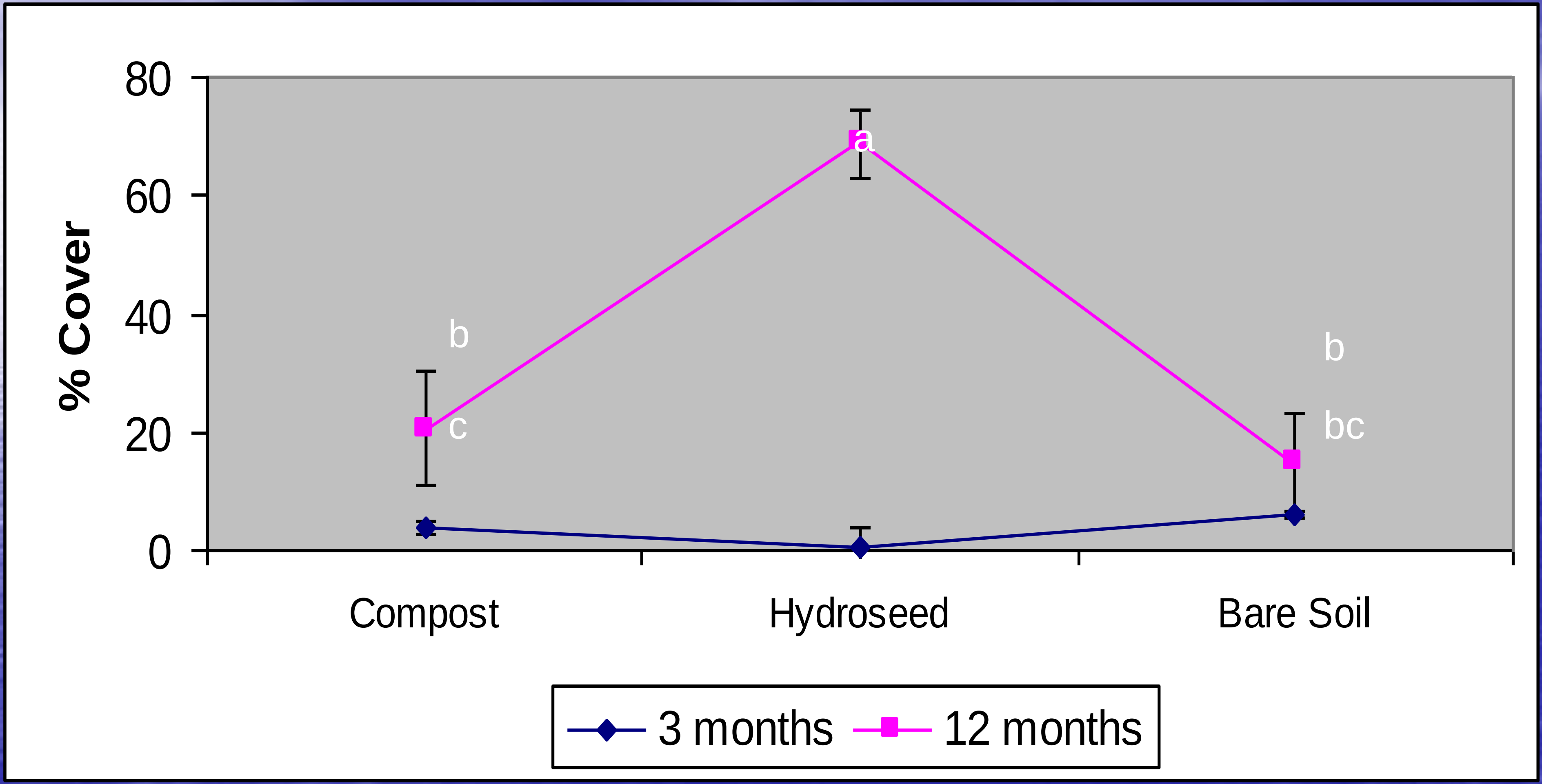
1.5 yr Increase in Soil Biology (C) 0-2” Soil



Vegetation Cover



Invasive Weed Cover



*Weed Cover & Biomass positively correlated (r>0.85) to high <u>inorganic</u> N

Compost Filter Socks: Green Infrastructure & Stormwater Quality

Britt Faucette, Ph.D., CPESC, LEED AP
Ecosystem Scientist









Sedimen Control/ Stormwater Filter BMPs

- Silt Fence
- Straw Bale
- Mulch Berm
- Fiber Rolls
- Straw Wattles
- Biofiltration Systems

Sock Specifications

Diam.	8 in	12 in	18 in	24 in	32 in
Weight	13 lbs/ft	32 lbs/ft	67 lbs/ft	133 lbs/ft	200 lbs/ft
Flow	7.5 gpm/ft	11.3 gpm/ft	15 gpm/ft	22.5 gpm.ft	30 gpm/ft
Length	unlimited	unlimited	unlimited	unlimited	unlimited

Filtrexx Compost BMPs

Erosion & Sediment Control

1. Perimeter Control
2. Inlet Protection
3. Ditch Check
4. Filter Ring/Concrete Washout
5. Slope Interruption
6. Runoff Diversion
7. Vegetated Cover
8. Erosion Control Blanket
9. Sediment Trap
10. Pond Riser Pipe Filter

Low Impact Development

10. Runoff Control Blanket
11. Vegetated Filter Strip
12. Engineered Soil
13. Channel Liner
14. Streambank Stabilization
15. Biofiltration System
16. Bioretention System
17. Green Roof System
18. Living Wall
19. Green Retaining Wall
20. Vegetated Rip Rap
21. Level Spreader
22. Green Gabion
23. Bioswale

Compost Tools

Filter Media

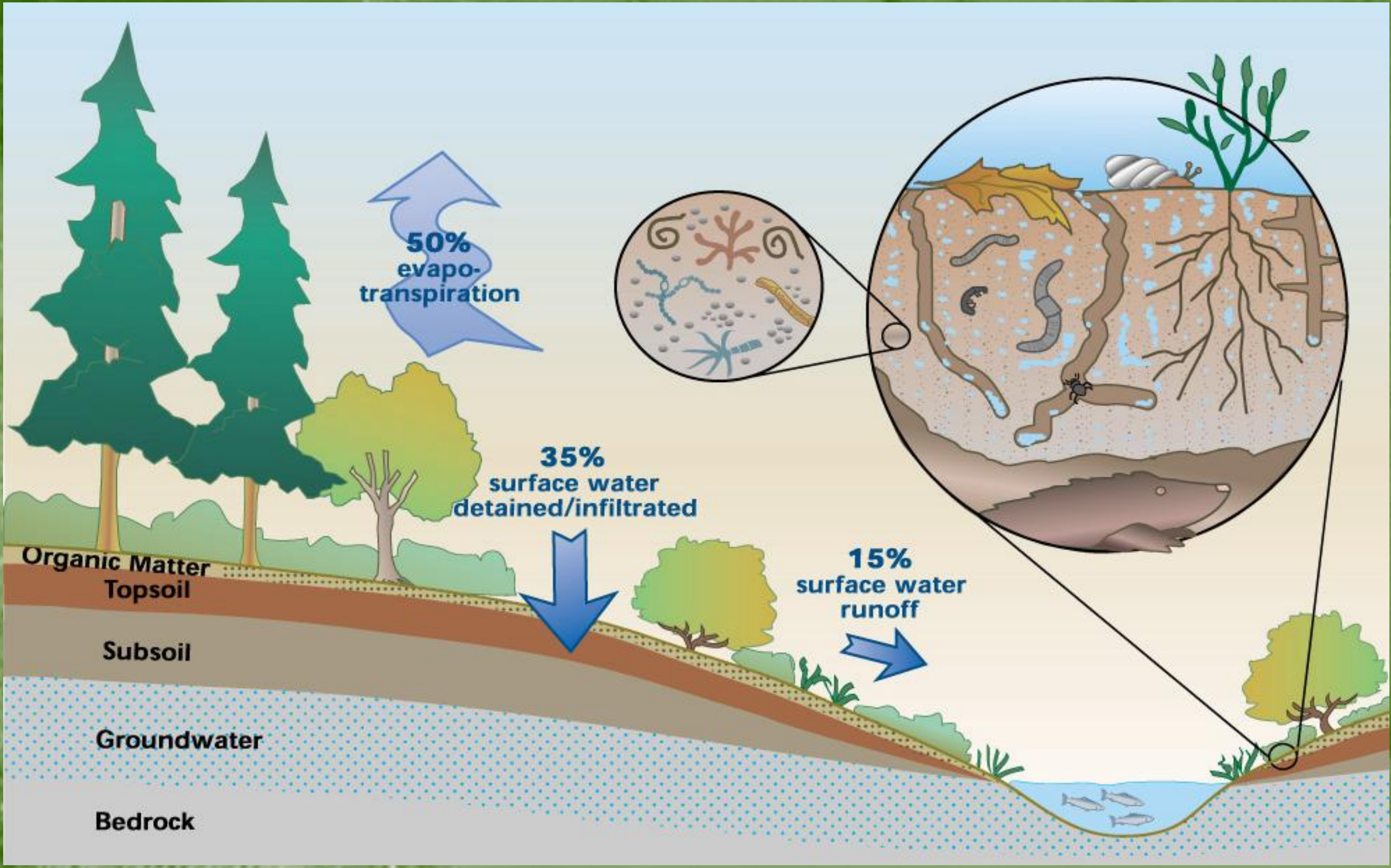
Designed for Optimum Filtration & Hydraulic-flow

Growing Media

Designed for Optimum Water Absorption & Plant Growth

MIMIC NATURE™

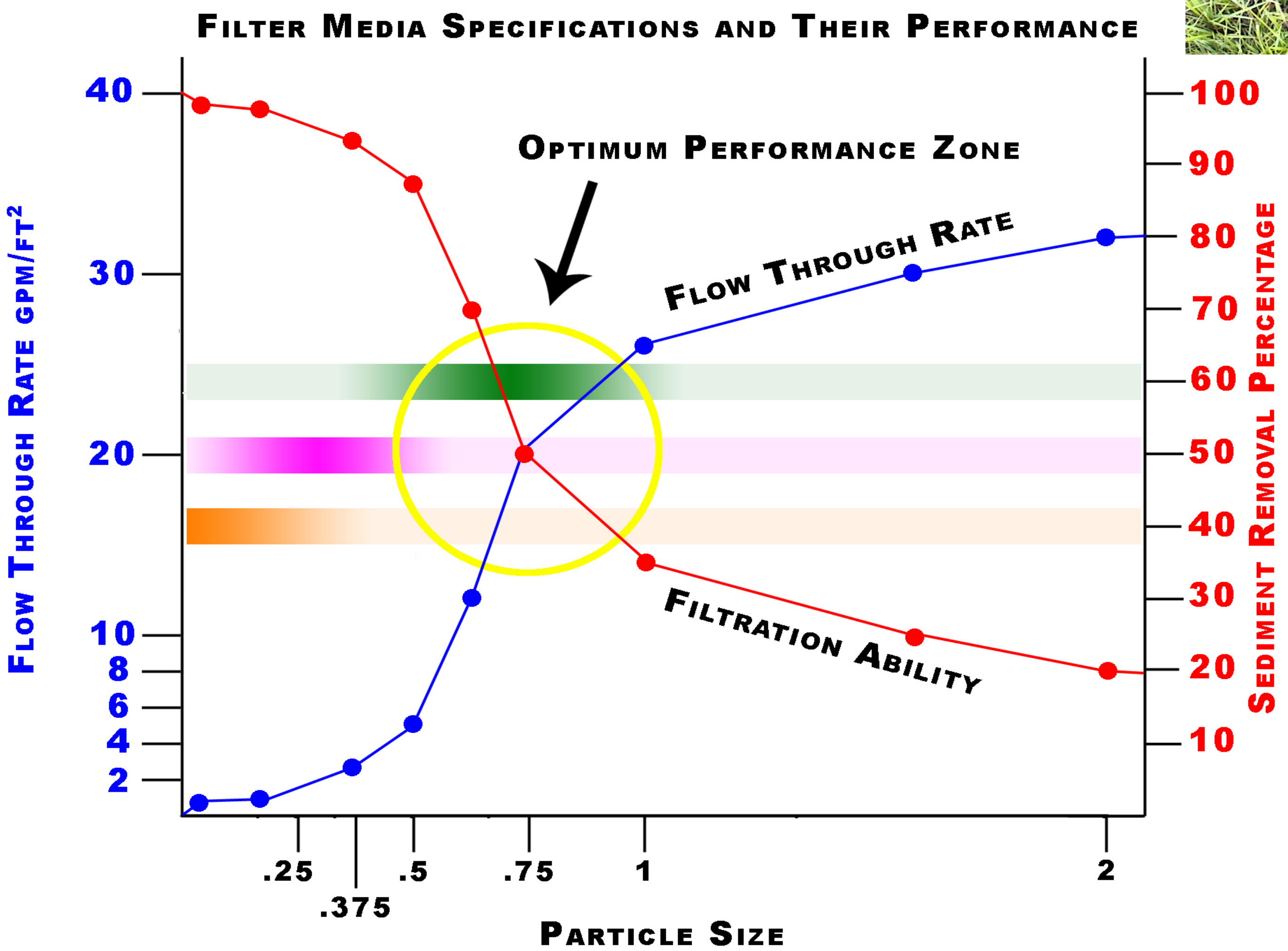
Natural Stormwater Management



Compost Sock 3-Way Filtration

- Physical
  - Traps sediment in matrix of varying pore spaces and sizes
- Chemical
  - Binds and adsorbs nutrients in storm runoff
- Biological
  - Degrades various compounds with bacteria and fungi

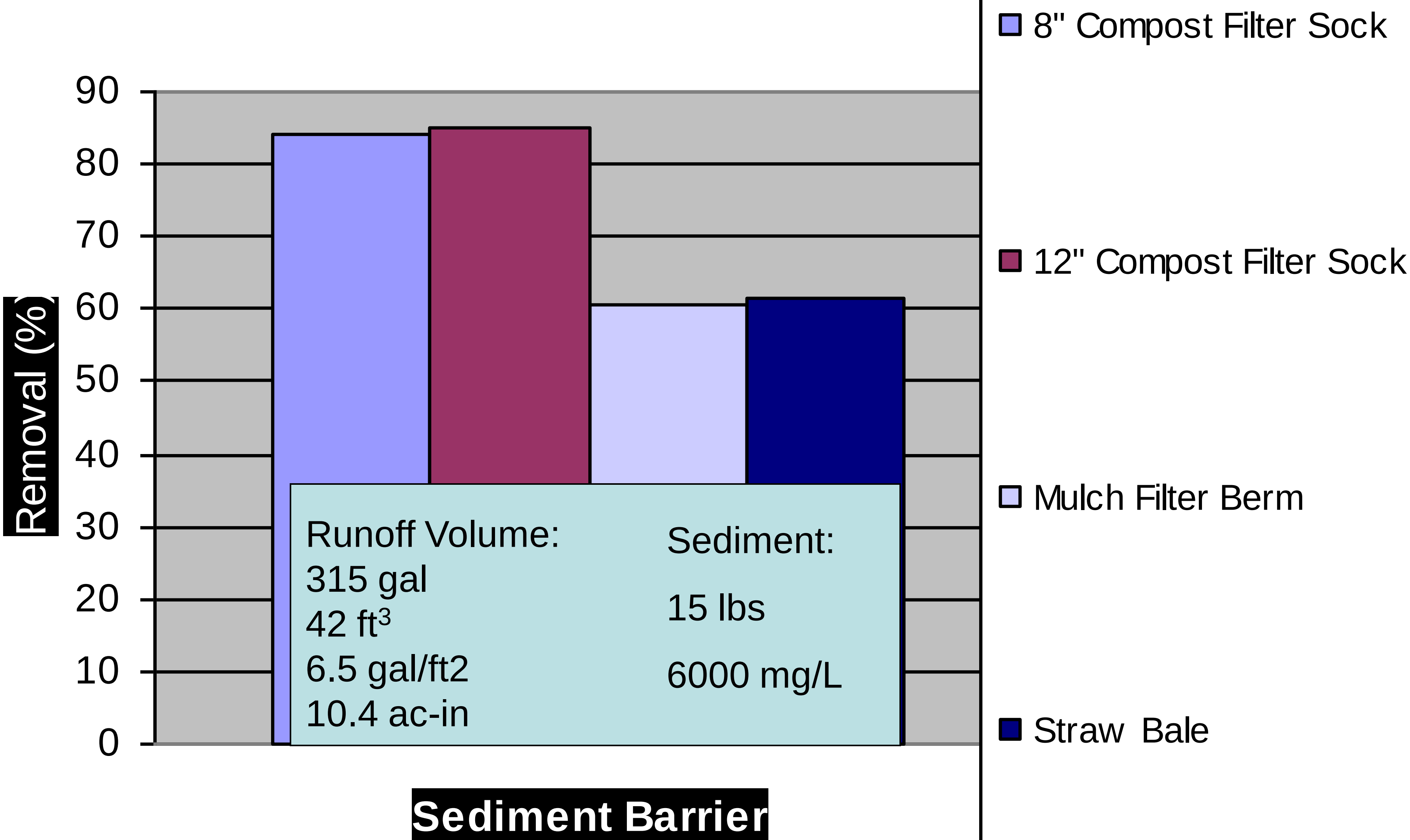
Particle Size Specifications



Filtration Devices use Filter Media

The University of Georgia

TSS Removal for Sediment Control Barriers



	Runoff Exposure	Sediment Exposure	Removal
Compost Sock	•260 gal •1.7 g/ft^2 •2.75 ac-in	•850 lbs •150 lbs/ft^2 •125 t/a	77%
Silt Fence	•260 gal •1.7 g/ft^2 •2.75 ac-in	•850 lbs •150 lbs/ft^2 •125 t/a	72%
Straw Wattle	•260 gal •1.7 g/ft^2 •2.75 ac-in	•850 lbs •150 lbs/ft^2 •125 t/a	59%

ASTM 6459 for RECPs

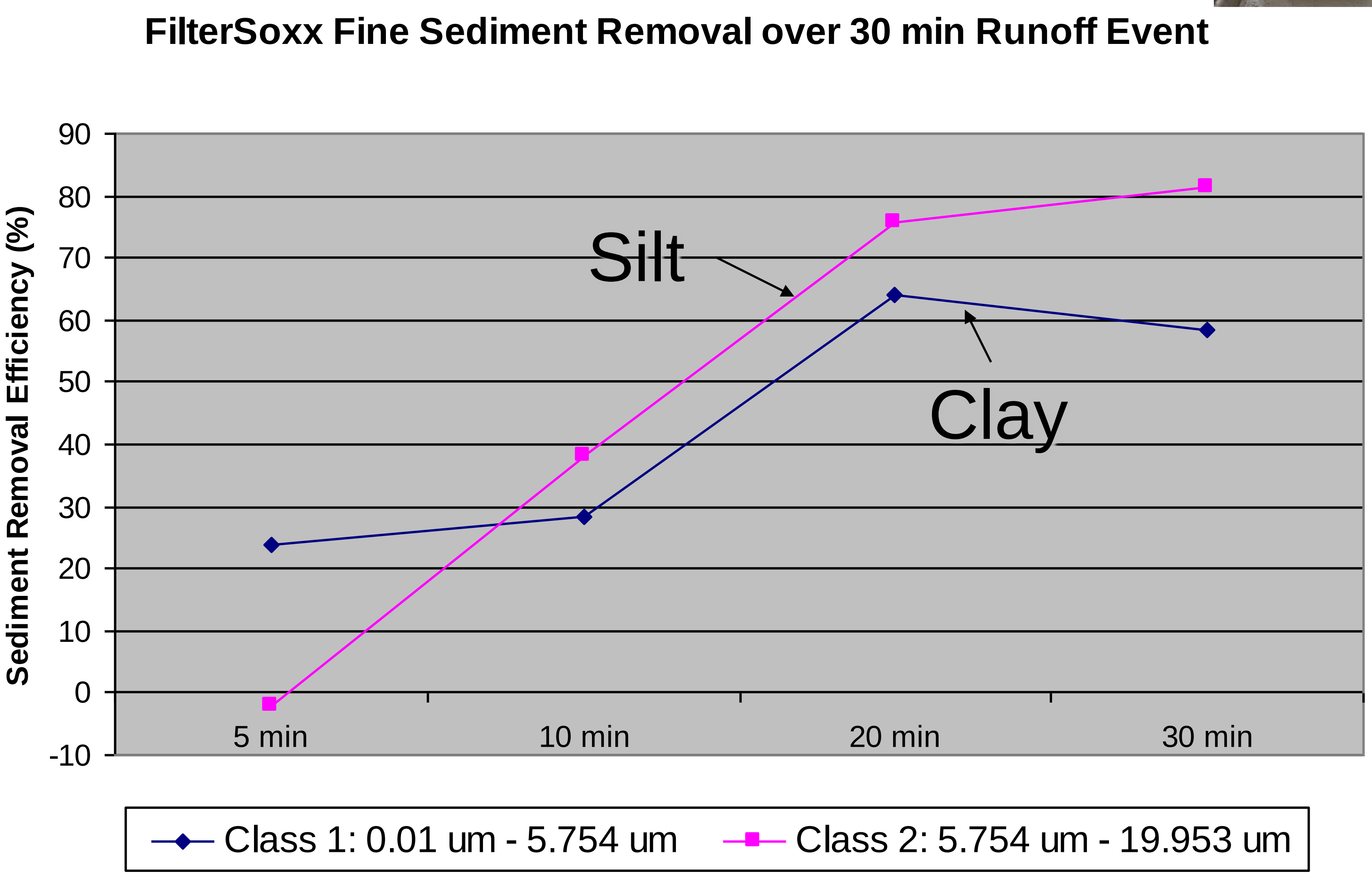
Sediment Summary

% Reduction of TSS & Turbidity

Treatment	TSS	Turbidity
Silt Fence	67	52
Filter Sock	78	63

* Based on rainfall of 3.0 in/hr for 30 min; runoff sediment concentration (sandy clay loam) of 70,000 mg/L.

Fine Sediment Removal



Hydraulic Design Capacity of Filter Socks & Silt Fence in Runoff Control Applications

H. Keener, B. Faucette, M. Klingman

- Flow through rates were **<u>50%</u>** greater for filter socks

- 12″ Compost sock = 24″ silt fence;
- 18″ Compost sock = 36″ silt fence

Filter Sock Design Tool

Step 1: Choose units, **ft** or m		ft					
Step 2. Choose input: **Tr** or **I**		Tr					
total rainfall	**inches**	1.5		**storm duration**	**hours**	24	
Step 3. Choose input: **A** or **W**		W					
width of area	**ft**	400.00		**length of slope**	**ft**	250	43560
Step 4. Input slope	**%**	10					452.588
Step 5. Input reduction runoff percent	**%**	10					
		siltsoxx (8,12,18)	silt fence(24,30)				
Step 6. Input effective length of filter	**ft**	400	400				
Step 7. Input diameter/height of filter	**inches**	12	36				

Step 8. Find time to overflow filter and
total flow/ft the filter can handle

Step 9. On figure find for given flow
expected time to overflow filter.

THE OHIO STATE UNIVERSITY

OARDC

Part A. Evaluation of q_i

I inches/hr	A acres	s percent	Q gpm	L_{ss} ft	q_i gpm/ft
0.063	2.2957	10	58.15	400	0.145

Part B. Predicted time and total flow to top filter.

	q_o gpm/ft	D inches	Effective D inches	time overflow hr	total flow gal/f	Filter Okay time > tr
SiltSoxx[TM] (Coarse Material)	0.145	12	9.6	99.1	865	OKAY
Silt Fence	0.145	36	30.6	97.5	851	OKAY

USLE

Universal Soil Loss Equation

Predict Site Soil Loss!

$$A = R \times K \times \underline{\mathbf{LS}} \times C \times \underline{\mathbf{P}}$$

- A = amount of soil loss (tons/ac/yr)
- LS = Slope Interruption Socks
- P (Compost Sock) = 0.25

Developed by USDA NRCS

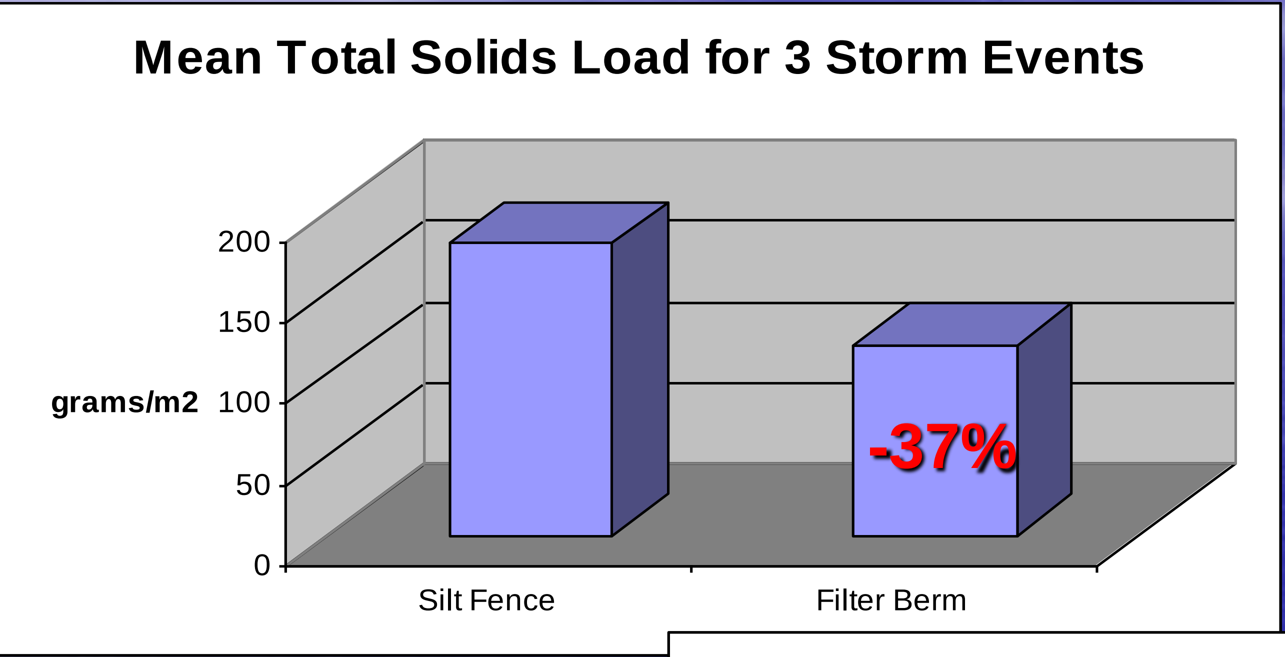
Sediment Trap Design

- Replaces conventional Sediment Traps
- Sediment barrier vs trap vs basin
- No excavation/earthmoving required
- Uses filtration AND deposition
- Pyramid stacking construction design

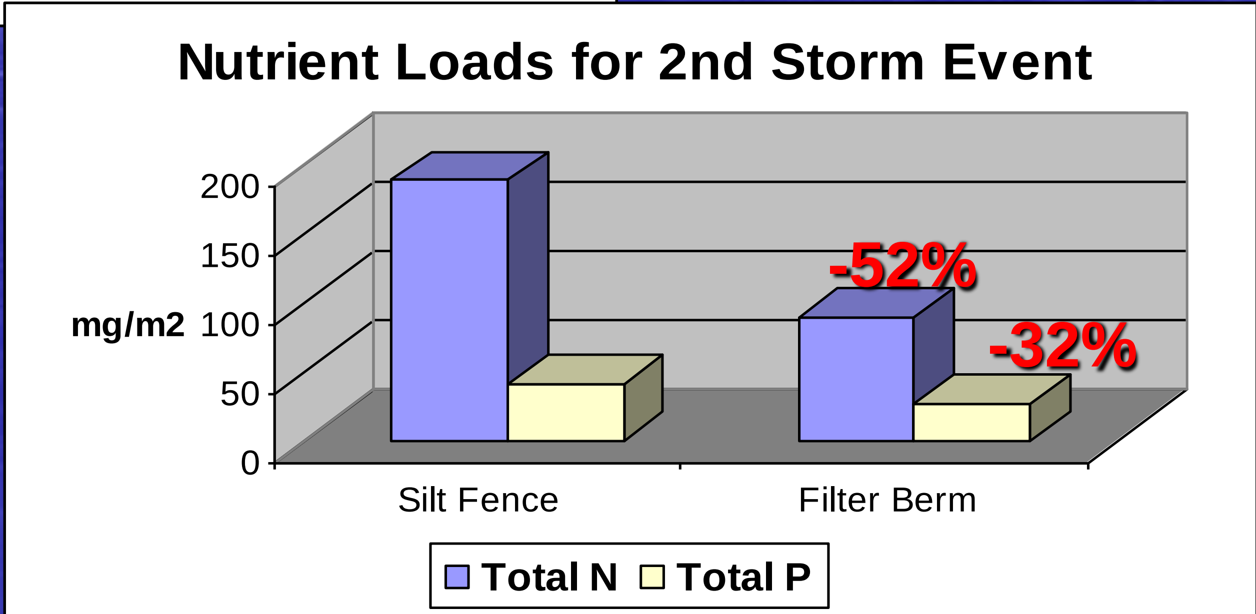
Reduce Footprint!

Save Land Area!

Silt Fence vs Compost Berm



- ✓All Plots used Hydromulching



Storm Water Pollutant Removal

	TSS	Turbidity	Total N	NH4 -N	NO3 -N	Total P	Sol. P	Total coli.	E. coli.	Metals	Oil	Diesel
Filter Sock	80 %	63 %	35 %	35 %	25 %	60 %	92 %	98 %	98 %	37-78 %	99 %	99 %

Compost + Additives

✓To target specific runoff pollutant

- Nutrients (N & P)
- Bacteria
- Metals
- Petroleum Hydrocarbons

City of Chattanooga

Analysis	2-1-2007 (Pre-retrofit)	6-8-2007	8-30-2007	12-13-2007	3-19-2008	1-28-2009	7-28-2009	% Reduction
COD	1600 mg/L	259 mg/L	255 mg/L	125 mg/L	125 mg/L	405 mg/L	214 mg/L	92
TSS	1370 mg/L	208 mg/L	38 mg/L	18 mg/L	24 mg/L	249 mg/L	177 mg/L	99
Oil/Grease	107 mg/L	27 mg/L	N/A	N/A	5 mg/L	18 mg/L	37 mg/L	74

Storm Water Pollution Areas

What

Who

- ➢Parking Lots, Highways/Streets, Rooftops
- ➢Golf Courses, Lawns, Pet Parks
- ➢NPDES Stormwater Permits: MS4s, Industrial
- ➢ CAFOs, NRCS

Sources

- ✓Trout/Salmon bearing
- ✓Endangered species
- ✓Eutrophic water bodies
- ✓Beaches/Recreational
- ✓TMDL designated streams

Priority Areas

Performance & Design for Vegetated Channel Liners & Streambank Stabilization

Texas A&M University

Applications

- Channels, Ditches, Streambanks
- Vegetated vs Mechanical Liner
- Soft Armor vs Hard Armor

Channel & Bank Stabilization

- Vegetated vs Mechanical Liner
- Soft Armor vs Hard Armor
- Rolled Erosion Control Product
- Turf Reinforcement Mat
- Vegetation
- Rip Rap
- Rock Gabion Basket
- Concrete

Filtrexx Compost BMPs

Erosion & Sediment Control

1. Perimeter Control
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Compost Tools

Filter Media

Designed for Optimum Filtration & Hydraulic-flow

Growing Media

Designed for Optimum Water Absorption & Plant Growth


OLD SCHOOL


Practice/Product	Max Shear Stress
Compost Sock Vegetated	**12 lbs/ft^2**
Loamy soil	0.1 lbs/ft^2
Grass	1-2 lbs/ft^2
Gravel (1-2")	1-2 lbs/ft^2
Double-net straw RECP	2-4 lbs/ft^2
TRM	6-8, 12 lbs/ft^2
Rip Rap (1-2')	3-5 lbs/ft^2

Manning's Equation

$$v = 1/n \times R^{2/3} \times S^{1/2}$$

- Used to calculate flow velocity in open channel
- Based on slope, hydraulic radius (cross section area/wetted perimeter), roughness coefficient (Manning's N)

Rougher is Better!

MIMIC NATURE™

Swale/Channel BMP	Manning′s n
Compost Sock w/Grass	0.035
Compost Sock /Grass + Live Stakes	0.075
Concrete Channel	0.015
Rip Rap	0.033
Dense Weeds	*0.035*
Dense Weeds & Brush	*0.10*

Natural System

Break Time?

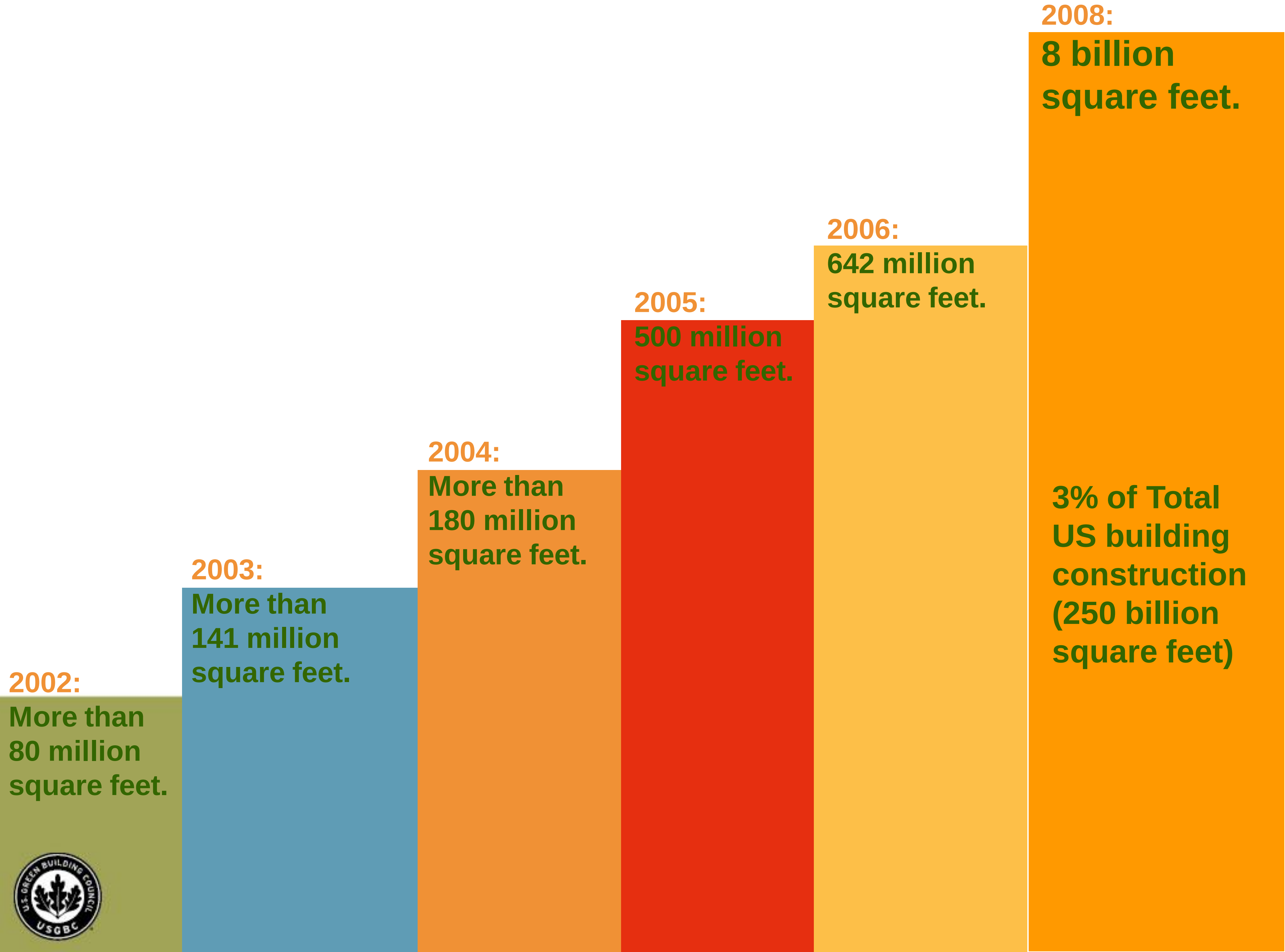
LEED Green Building

- Leadership in Energy & Environmental Design (Version 3 NC) Rating & Certification System for High Performance Green Buildings
- Developed by US Green Building Council (USGBC)
- To reduce impact of buildings on environment and *occupants*
- Design, construction, & operation/maintenance

Environmental Impact of US Buildings

- 40% of total energy
- 70% of electricity
- 50% of green house gas emissions
- 40% of municipal solid waste
- 30% of wood & raw materials use
- 25% of water use

- Transportation – 35% of energy
- Personnel – 95% of life cycle cost (construction, O&M)


2002:
More than 80 million square feet.
2003:
More than 141 million square feet.
2004:
More than 180 million square feet.
2005:
500 million square feet.
2006:
642 million square feet.
2008:
8 billion square feet.
3% of Total US building construction (250 billion square feet)

LEED Credit Categories NC 3.0

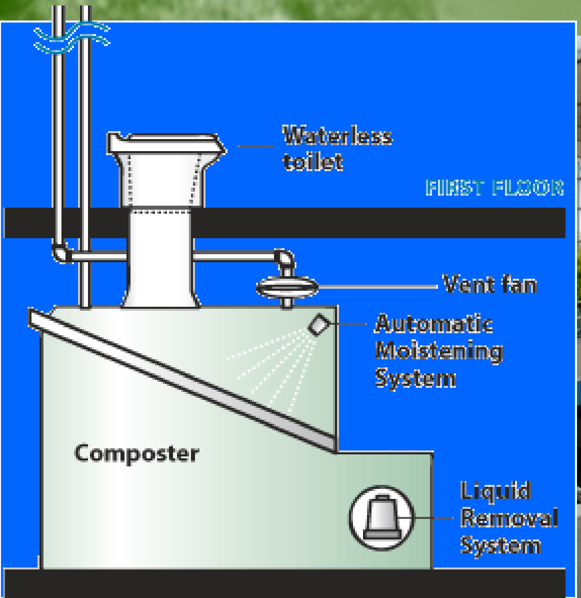
- **Sustainable Sites** (26)
- **Water Efficiency** (10)
- Energy & Atmosphere (35)
- **Materials & Resources** (14)
- Indoor Environmental Quality (15)
- **Innovation & Design Process (6)**
- **Regional Priority Credit (4)**

Sustainable Sites (6 credits):

- **3.0 Brownfield Redevelopment (1);**
  (Compost widely used for bioremediation)
- **5.1: Site Development - Protect or Restore Habitat (1);**
  (Greenfield = disturbance limits; Developed = 50% protect or restore)
- **6.1: Storm Water Design - Quantity Control (1)**
  (<50% impervious = LID <u>or</u> protect receiving stream channels;
  >50% = 25% decrease in rate & volume);
- **6.2: Storm Water Design - Quality Control (1)**
  (80% TSS reduction or capture/treat runoff from 90% annual rainfall [0.5 – 1.0 in]);
- **7.1: Heat Island Effect – Non-Roof (1)**
  (50% of hardscapes use open grid or shaded in 5 yrs)
- **7.2: Heat Island Effect – Roof (1)**
  (50% vegetated; or used with high value Solar Reflective Index roofing) ;

Water Efficiency (6 credits):

- 1.1: Water Efficient Landscape: Reduce 50% (2)
- 1.2: Water Efficient Landscape: Reduce 100% (2)
- 2.0: Innovative Wastewater Technology (2)
- (Reduce 50% or Treat 50%)



Materials & Resources (5 credits):

- 4.1: Recycled Content – 10% (1)
- 4.2: Recycled Content – 20% (1)
- 5.1: Regional Materials (500 mi) – 10% (1)
- 5.2: Regional Materials (500 mi) – 20% (1)
- 6.0: Rapidly Renewable Materials – 2.5% (1)

NOTE:

•Excludes MEP

•Recycled content = post-consumer+1/2 pre-consumer

•2.1 & 2.2 Construction waste management: 50% & 75% (cannot include soil or land clearing)

Southface

Responsible Solutions for Environmental Living

- ✓84% Water Savings
- ✓130,000 gal/yr

Southface

Responsible Solutions for Environmental Living

Carbon Footprint Management

- Carbon emissions reduction
- Carbon sequestration

Annual CO_2e Reduction

- 2 million yds^3 compost
- 4 million tons of organics diverted from landfills
- 1 ton = 140 lbs of methane (Sakai, 2007)
- 280,000 tons of methane (25 x CO_2)
- 7,000,000 tons CO_2e
- 1 car = 10 tons CO_2
- 700,000 cars off the road

Annual Carbon Sequestration

- 7,500 acres of permanent grassing
- Eastern US = 1.0 tons/ac/yr/CO_2 (CCX, 2008)
- Western US = 0.4 tons/ac/yr/CO_2 (CCX, 2008)
- 90% in East = 6,750 tons/CO_2
- 10% in West = 300 tons/CO_2
- Total = 7,050 tons/CO_2
- 705 cars off the road

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Director of Research/Technical Services

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Storm Water Pollution Areas

What

Who

- Parking Lots, Highways/Streets, Rooftops
- Golf Courses, Lawns, Pet Parks
- NPDES Stormwater Permits: MS4s, Industrial
- CAFOs, NRCS

Sources

✓Trout/Salmon bearing
✓Endangered species
✓Eutrophic water bodies
✓Beaches/Recreational
✓TMDL designated streams

Priority Areas