Filtration Fundamentals:
The basics and why filtration matters today

Fox-Wolf Watershed Alliance Watershed Conference

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Contech Engineered Site Solutions

Bridges, Drainage, Stormwater Management, Erosion Control, Structures, Retaining Walls, Roadway & Earth Stabilization

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Agenda

- Filtration Overview
- Filtration in Stormwater
- Filtration Innovation
- Discussion

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Complying with Water Quality Regs

- Low Impact Development & Green Infrastructure
- Design methodology that utilizes Integrated Management Practices (IMPs) for Stormwater Management
- Intent is to mimic predevelopment hydrology

o Examples:
  - o Natural areas
  - o Rain gardens
  - o Bioswales
  - o Porous pavements

Manufactured Treatment Devices

- Complement traditional LID practices
  - Pretreatment
  - Enhance longevity
  - Polishing BMP
- WQ solutions for sites with design constraints
  - Low permeability soils
  - Potential contamination of groundwater
  - Steep slopes
  - Maximize space
- Verified performance

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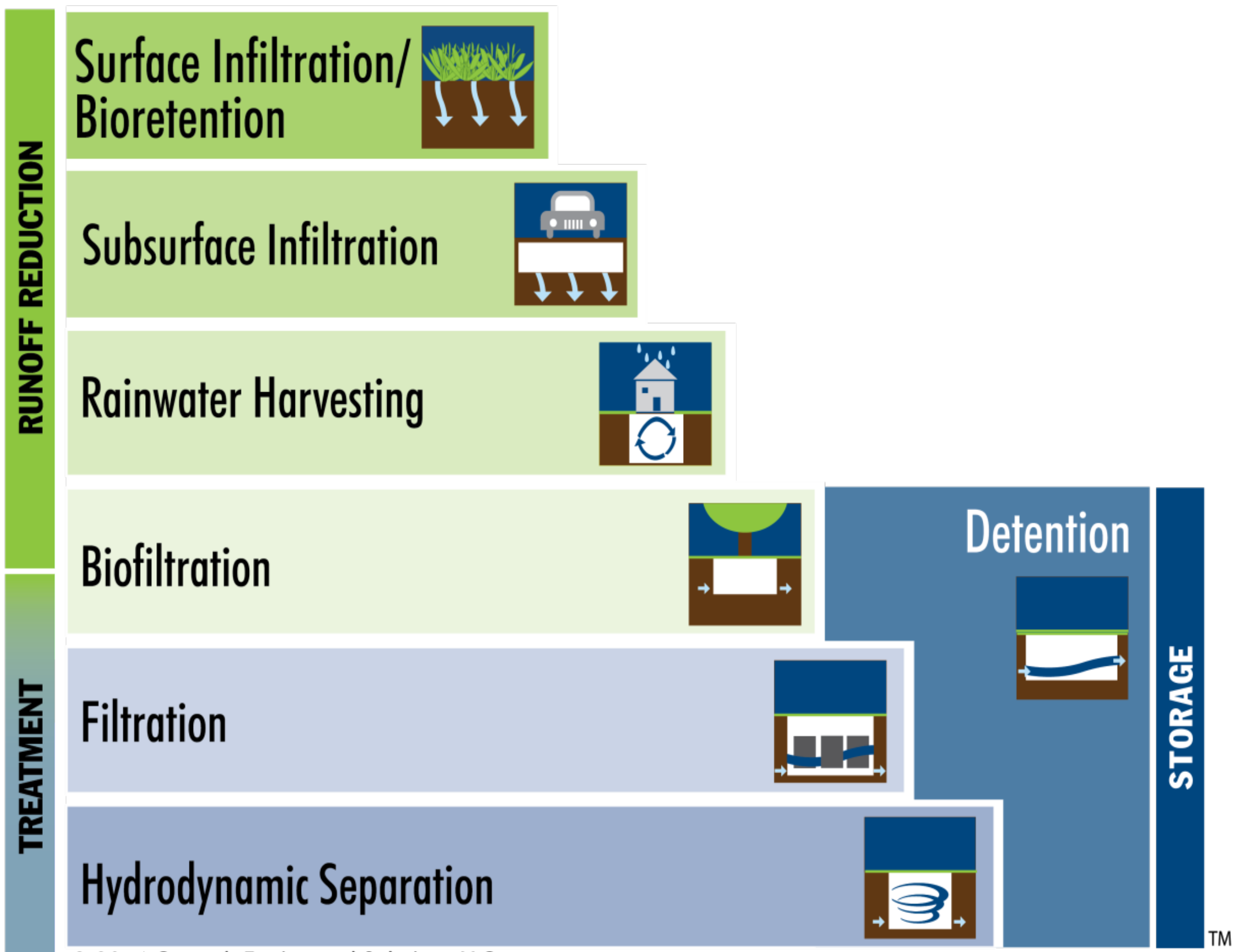
Stormwater Solutions Staircase



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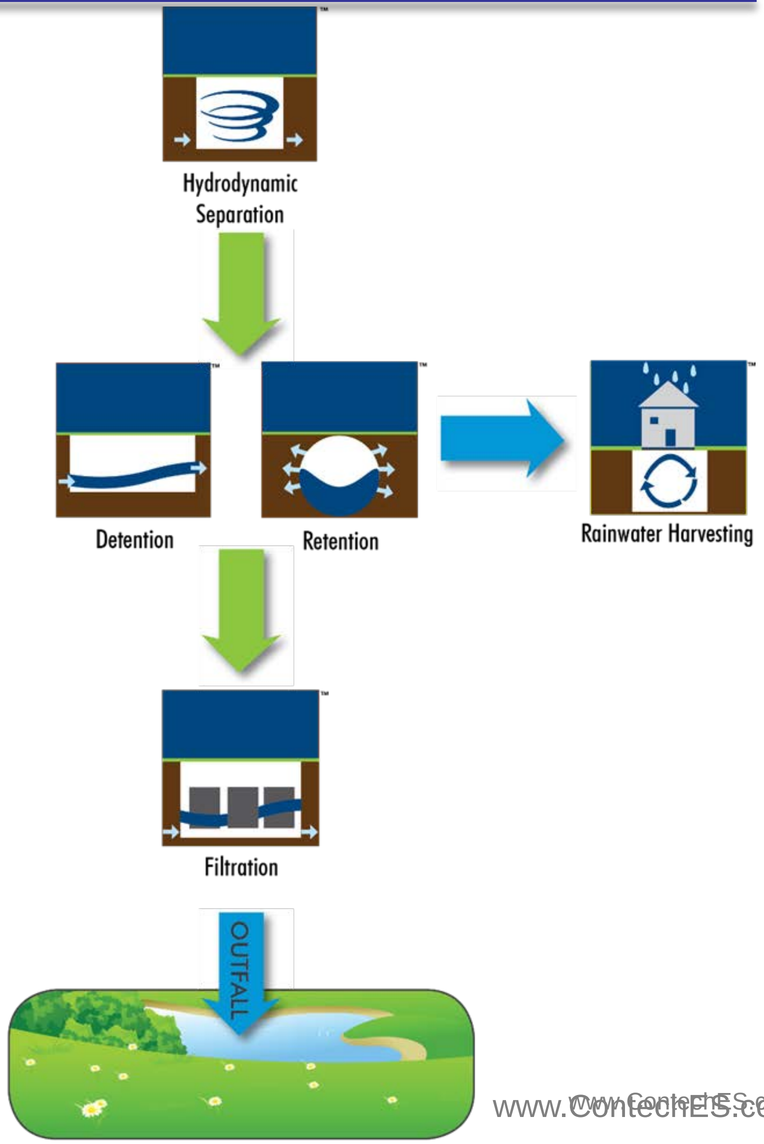
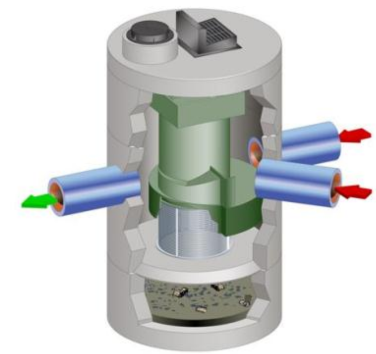
Advancing Treatment…

- Trending shift from HDS to Filtration
  - Great Lakes Region
  - Indianapolis suburbs
  - Ohio
  - Wisconsin
- Pollutants of Concern
  - TSS
  - Nutrients
  - Metals



So Many Choices…

	Hydrodynamic Separation	Filtration
Pollutants of Concern	TSS	TSS, Nutrients, Metals
Targeted Particle Size Distribution	> 50 micron	< 50 micron
Recognized Testing Protocol	• Lab Testing: NJDEP • Field Testing: TARP Tier II	• Lab Testing: NJDEP • Field Testing: TAPE or TARP Tier II
Placement Relative to Detention	• Upstream for effective performance	• Upstream or downstream



Typical Applications

- Standalone Treatment
  - New Development
  - Redevelopment
- LID Pretreatment
  - Subsurface Infiltration
  - Rainwater Harvesting
- Polishing Treatment
  - Downstream of Detention

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What is filtration?

- The act or process of removing something unwanted from liquid, gas, etc., by using a filter (Merriam Webster Learners Dictionary)

- **Inert Media Filtration**: A unit process in which suspended solids and associated particulate pollutants are removed by use of a media such as sand or perlite.
  - Source: Minton, Stormwater Treatment Second Edition

- **Sorptive Media Filtration:** A unit process in which dissolved constituents are removed by attachment to a filter media at the molecular level.
  - Source: Minton, Stormwater Treatment Second Edition

Common Filters

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Factors Affecting Filter Performance

- Media Type
  - o Active vs Inert
- Media Porosity/Gradation
  - o Coarse vs Fine
- Media Shape
  - o Irregular vs symmetrical
- Media Thickness
  - o Depth vs Surface
- Hydraulic Loading Rate
  - o Slow vs Fast

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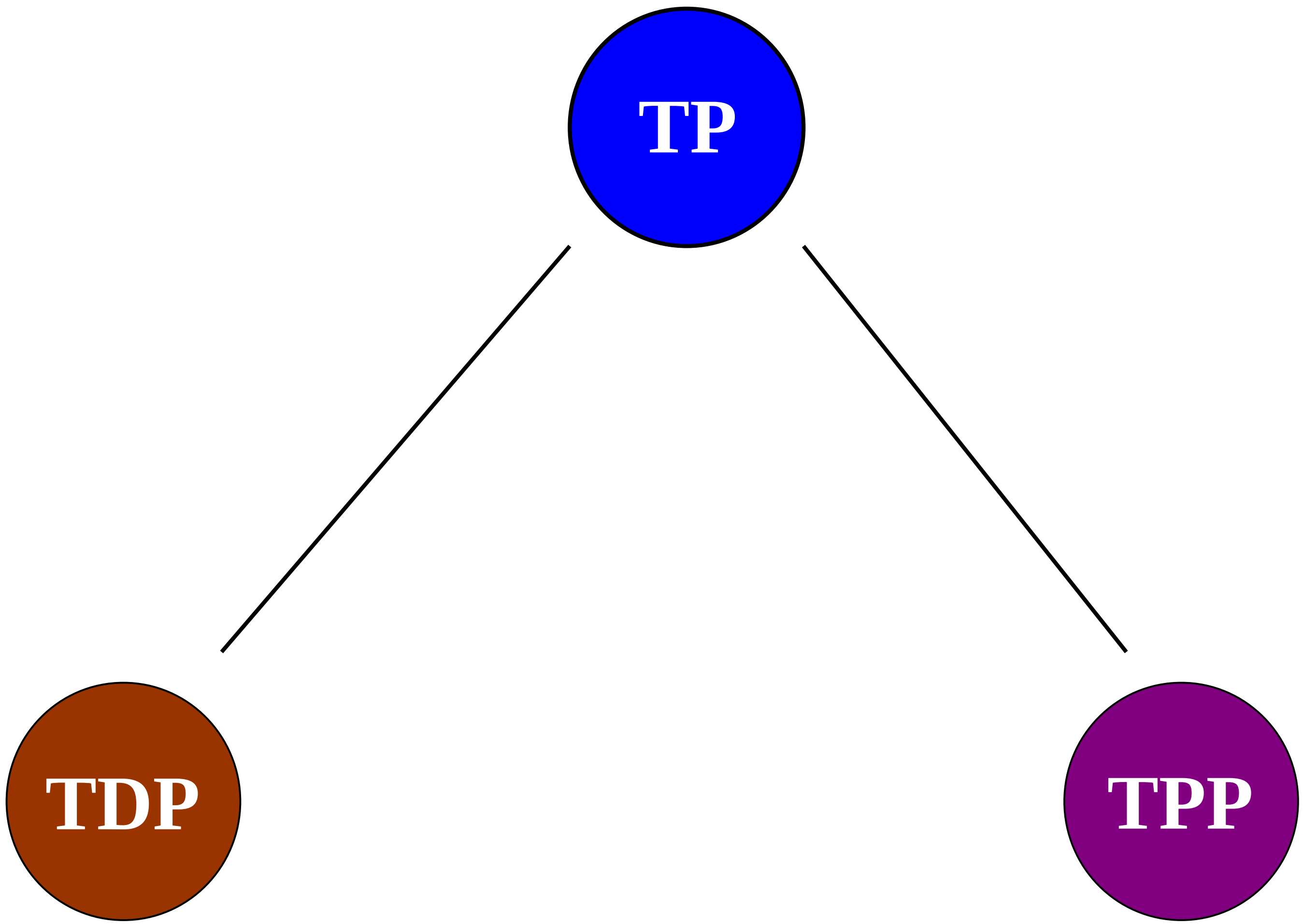
Maximizing Load Reduction

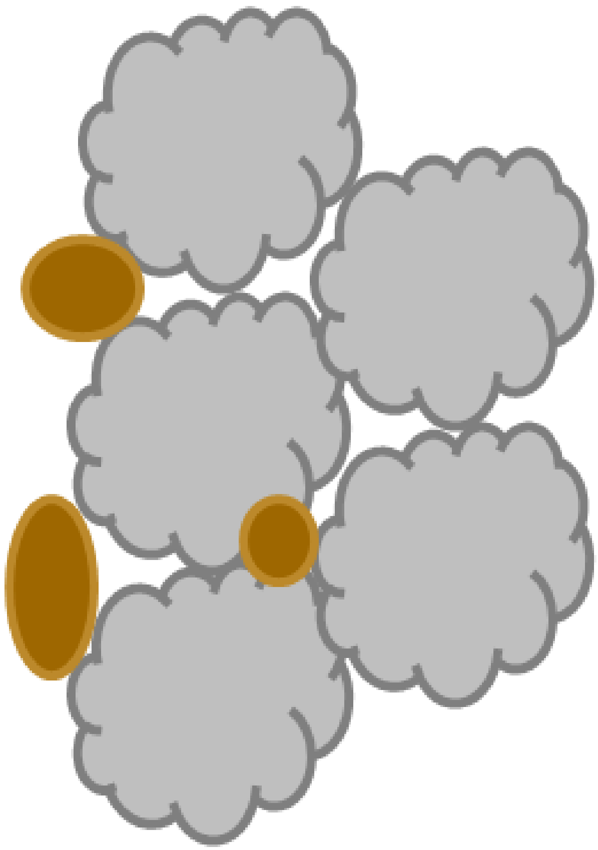
Total Phosphorus Removal



Physical/Inert Media Filtration

Examples: Screening, Media filters, Sand filters, Biofilters, Infiltration

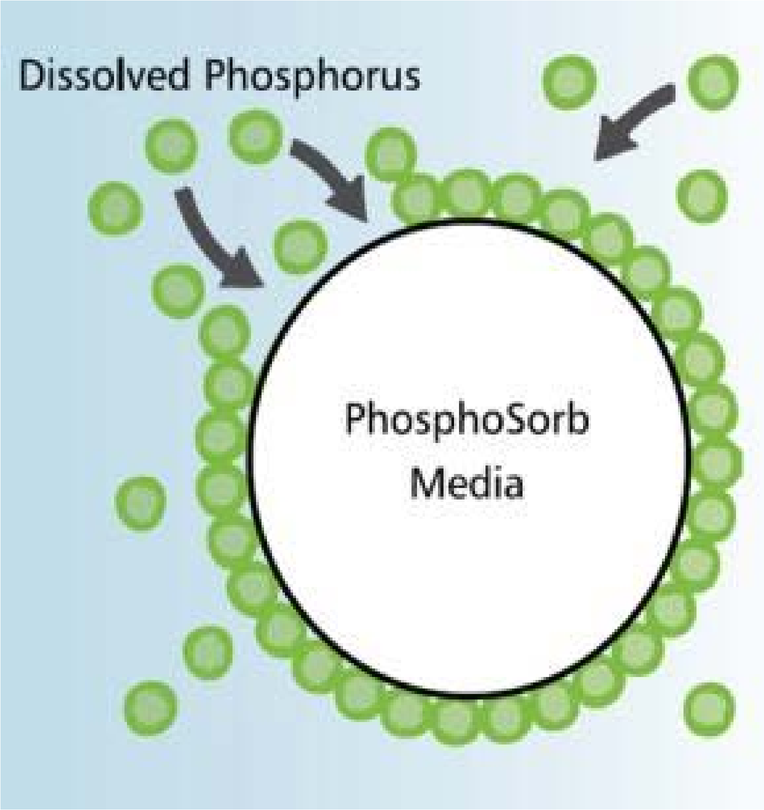
- Inert media is physical barrier to solid particles
- Sedimentation often plays major role in filter effectiveness
- Good control of solids and attached pollutants
- Removal of particulate bound pollutants (i.e. metals and phosphorus)
- No removal of dissolved/soluble pollutants
- Leaching possible
- Longevity must be considered



Reactive Filtration

Reactive filtration media with an affinity for target pollutants

- Works in parallel with physical filtration and/or sedimentation
- Target pollutant is bound to media via adsorption, ion exchange etc.
- Effective removal of soluble/dissolved pollutants
- Boosts overall pollutant load reduction
- Prevents leaching



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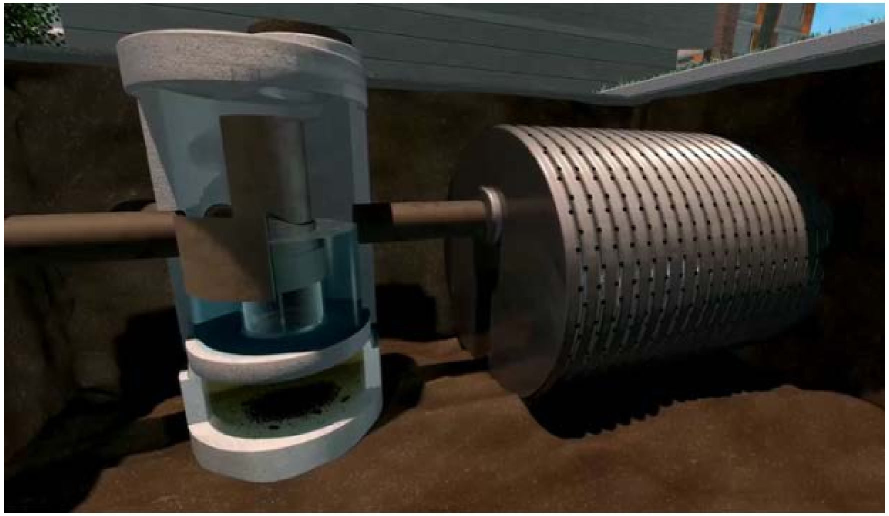
Filter Media Variables

- Range of particle sizes better than uniform size
- Finer media more effective but limits flow
- Irregular shaped particles better than symmetrical
- High surface area improves reactive capacity
- All else equal deeper is better assuming bed filtration

Critical Filter Design Considerations

- Pretreatment common to reduce load on media and extend maintenance cycle
  - o Knock out the coarse stuff
- Media type and gradation
  - o Often governed by pollutants of concern and performance goals
  - o Coarse vs Fine
  - o Irregular vs. symmetrical



Critical Filter Design Considerations

- Hydraulic Loading Rate (gpm/ft^2 of media surface area)
  - High loading rates result in smaller filters but all else equal need more maintenance
  - Loading rates in stormwater range from 0.05 - >10 gpm/ft^2
- Longevity
  - Filters must be designed with longevity in mind especially if frequent maintenance is not realistic
- Filtration red flags
  - Media toxicity
  - Media variability
  - Media availability
  - Lack of field longevity experience

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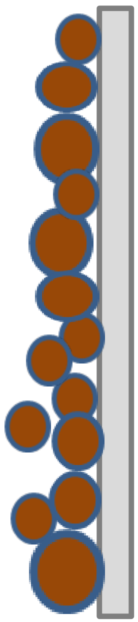
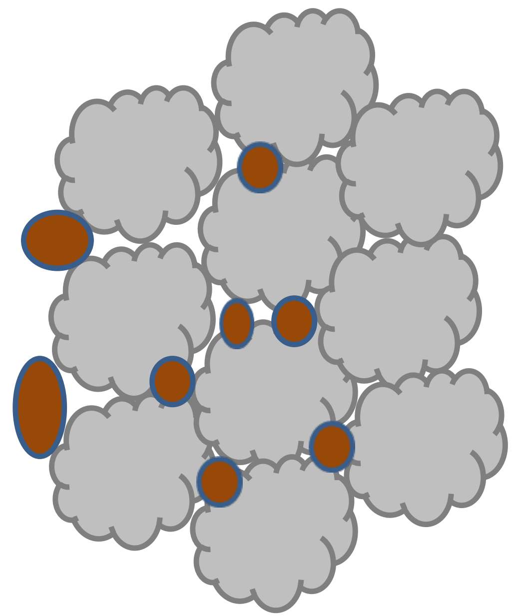
Filtration Approaches

Surface/Membrane Filtration



Bed Filtration



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Sand Filter (Sedimentation, Physical Filtration)

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Sizing a Sand Filter

$$A_f = \frac{WQ_v d_f}{k(h_f + d_f)t_f}$$

Where:

Af	=	Surface area of filter bed (ft2)
WQv	=	Water Quality Volume(cf)
df	=	Filter bed depth (ft)
k	=	Coefficient of permeability of filter media (ft/day)
hf	=	Average height of water above filter bed (ft)
tf	=	Design filter bed drain time (days) (1.67 days or 40 hours is recommended maximum t_f for sand filters, two days for bioretention)

Sand: 3.5 ft/day (City of Austin 1988)
Peat: 2.0 ft/day (Galli 1990)
Leaf compost: 8.7 ft/day (Claytor and Schueler, 1996)
Bioretention Soil: 0.5 ft/day (Claytor and Schueler, 1996)

Source: NYSDEC Stormwater Mar

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Evolution of Filter Technology

Horizontal Bed Filter

- Low infiltration rates
- Solids accumulate on surface
- Typically sand as media
- Large, land intensive

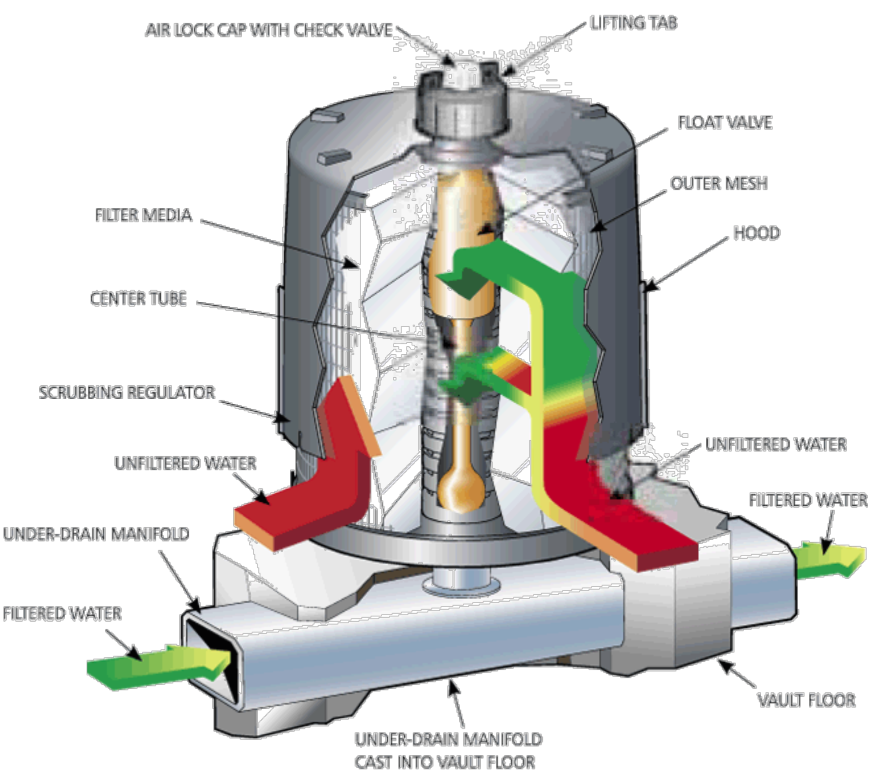
Radial Flow Filter

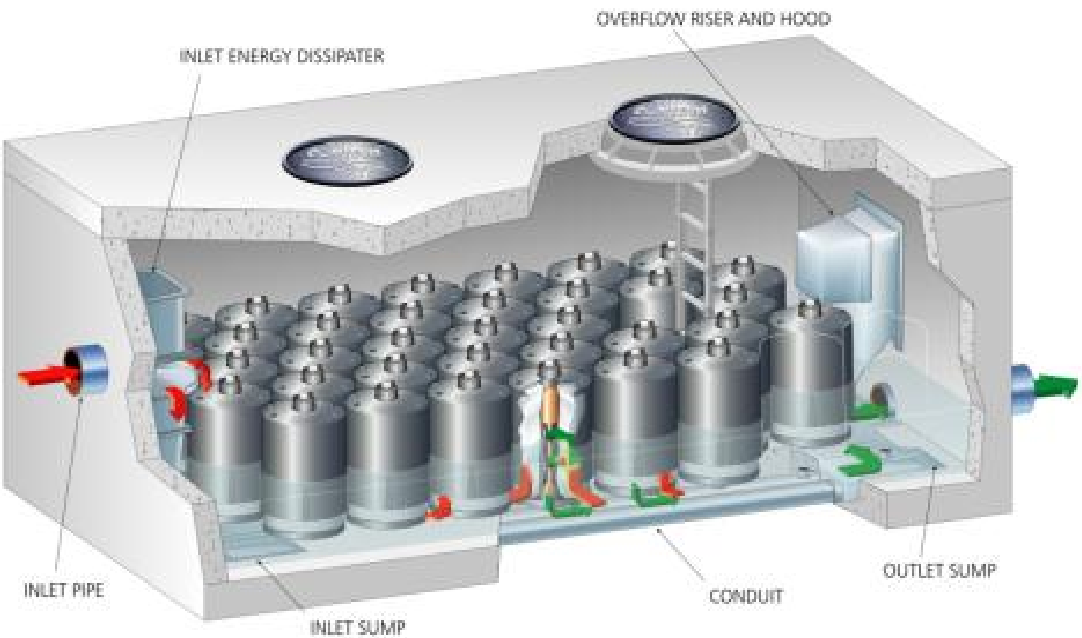
- Increased longevity
- Smaller structures
- Easier maintenance
- Custom filter media options

Horizontal Bed Filter

Manhole StormFilter

Innovative Media Filtration





Media Filtration




	PhosphoSorb™	Perlite	CSF® Leaf Media	ZPG
Sediments	■	■	■	■
Phosphorous	■			■
Oil and Grease	■	■	■	■
Soluble Metals	■		■	■
Organics			■	■
Nutrients	■	■	■	■

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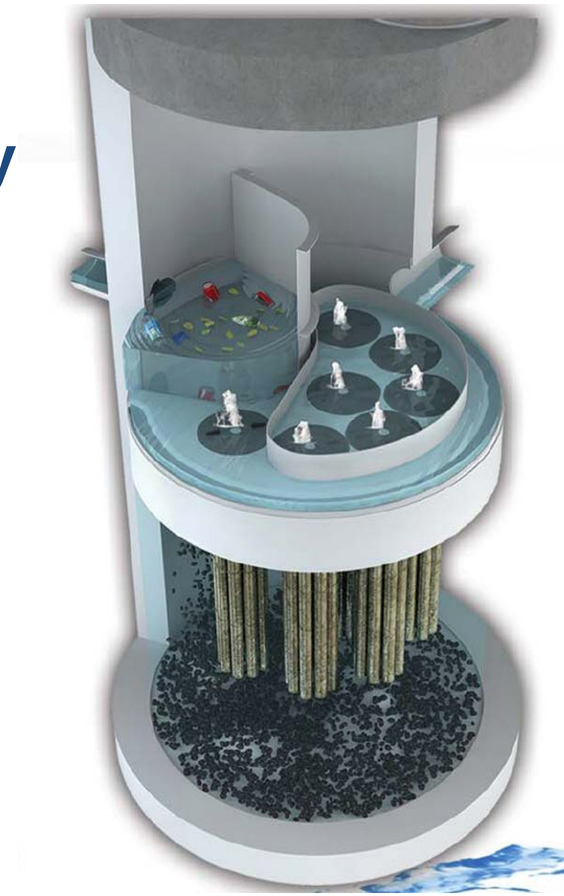
Innovative Membrane Filtration

Pleated Membrane Filter

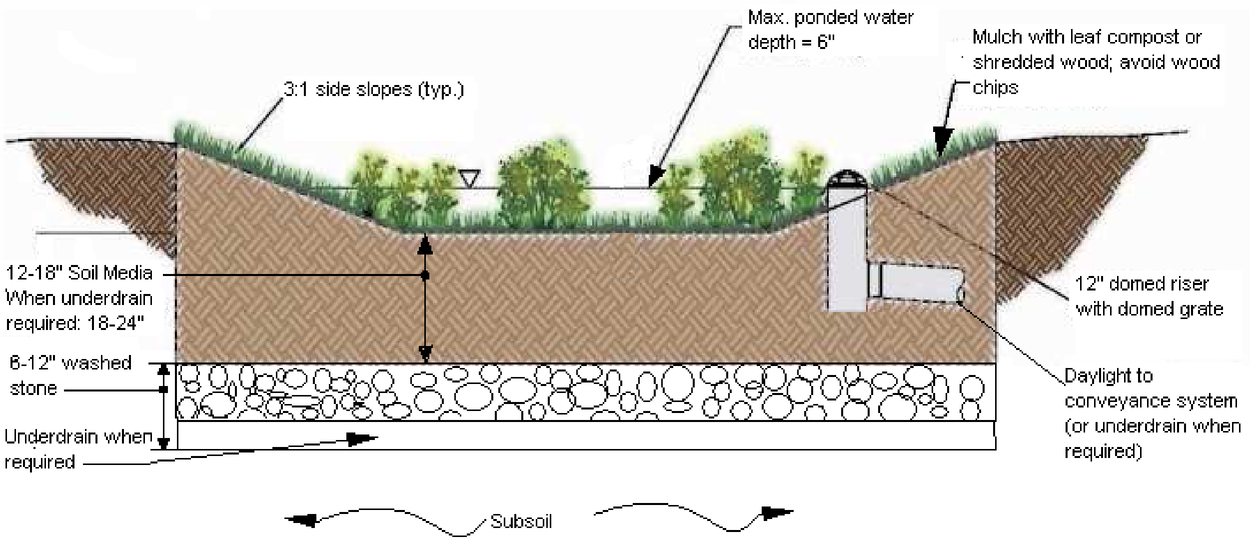
Evolution of Filter Technology

Maximum Surface Area in
Compact System



Jellyfish Filter

Bioretention/Biofiltration



Source: NYSDEC Chap. 5 NYS Stormwater Management Design Manual

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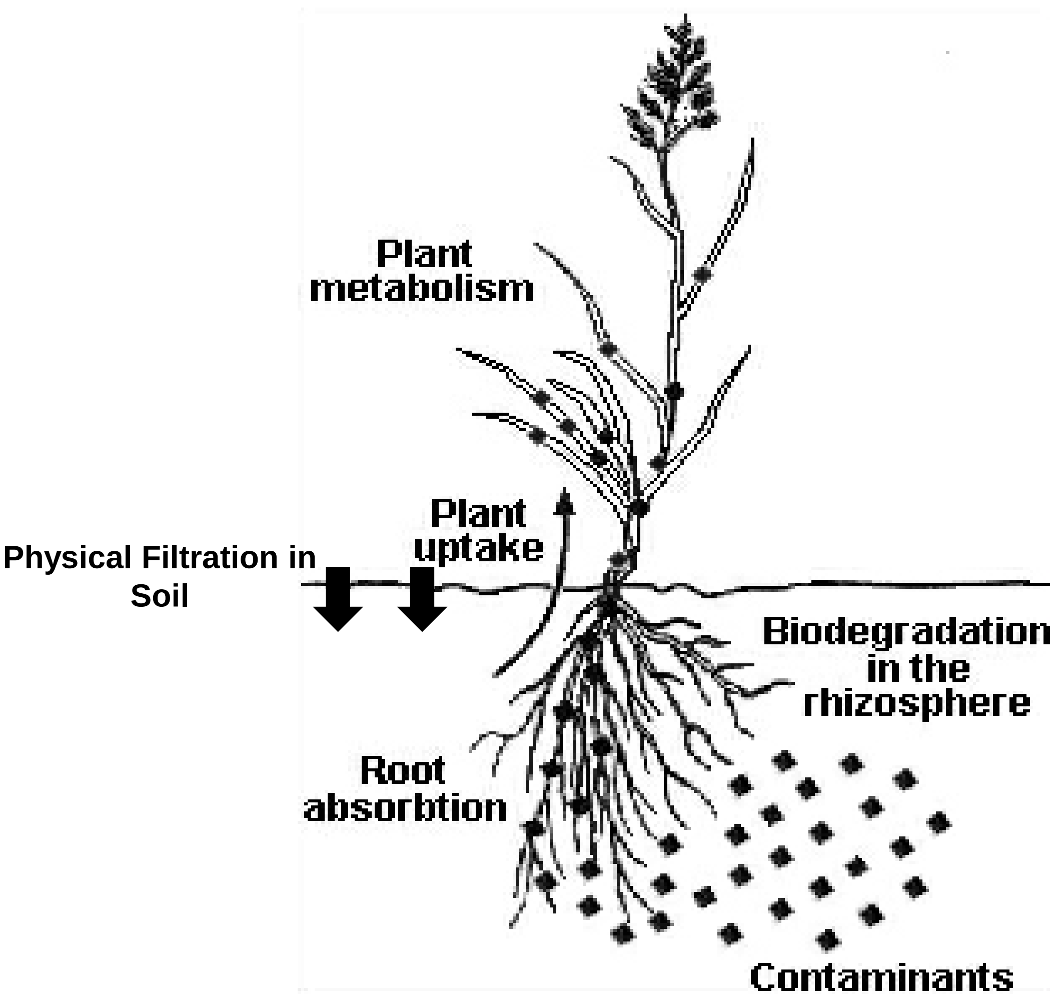
Pollutant Removal Mechanisms



- Physical/chemical processes
  - Filtration
  - Adsorption/absorption
  - Cation/anion exchange
  - Metals complexing
- Biological processes
  - Degradation/decomposition
  - Plant/bacteria uptake

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Conventional Bioretention

- Typical bioretention media infiltration rate = 1-12 in/hr
- 5-10% of contributing impervious drainage area
- Individual components designed by engineer and sourced by contractor:
  - Mulch
  - Soil
  - Stone
  - Underdrain Piping
  - Plants

- Installation by contractor
- Maintenance by landscape crew

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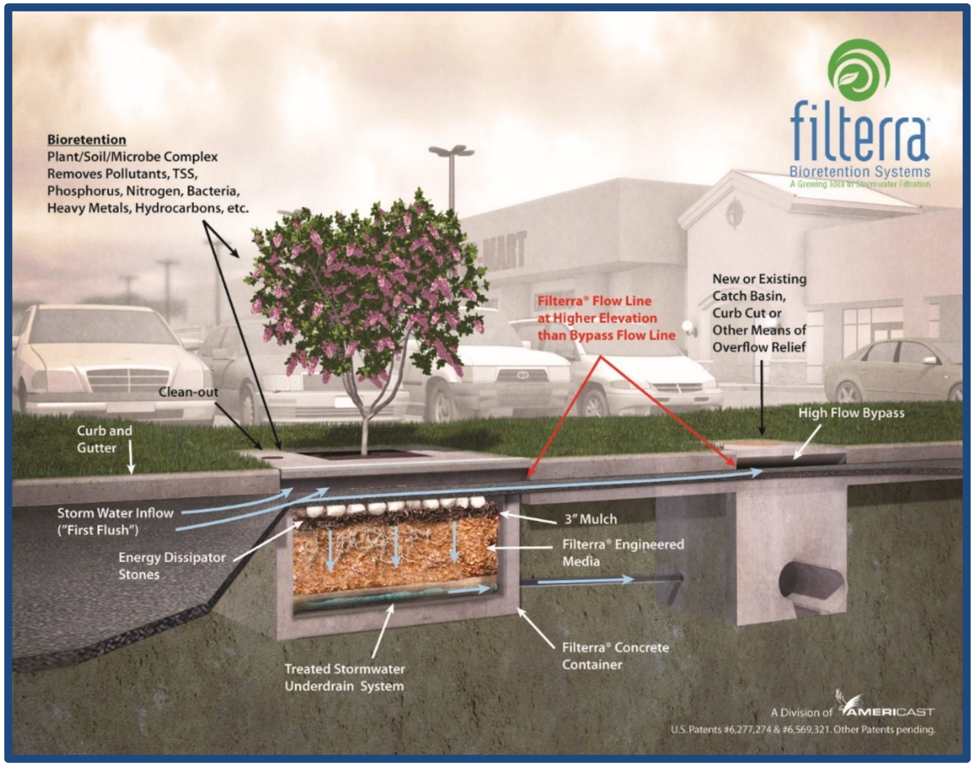
Engineered High Performance Biofiltration



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High Performance Biofiltration

- High Flow Media
  - o Same principles as traditional biofiltration
  - o 100+ inches/hr flowrate
  - o Reduced footprint – typically 1% of tributary drainage area
  - o Quality control of media composition

filterra® Bioretention Systems

Maintenance

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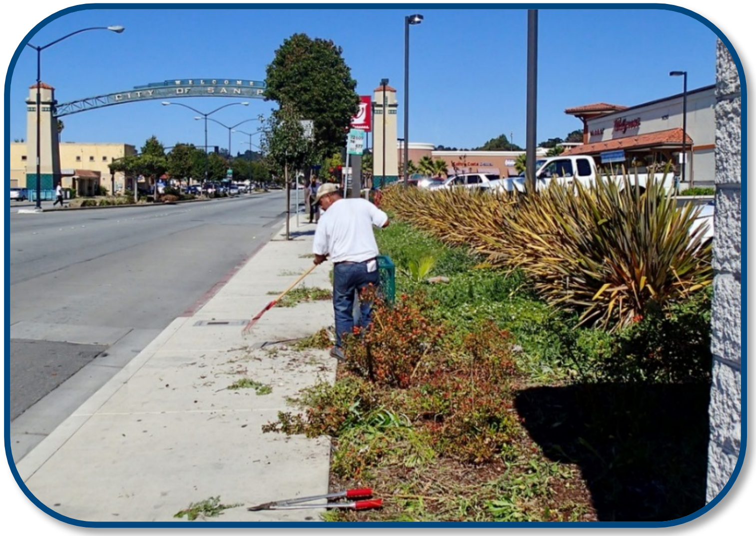
Maintenance



- **Longevity, Longevity, Longevity…..**
- All filters clog eventually
- Must strike balance between loading rate and longevity
- Ensure maintainability

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BMP Maintenance

Yearly O&M Costs per Impervious Acre

BMP	Base Cost	Sizing per Impervious Acre	Frequency	Confined Space	Annual Cost per Impervious Acre	Activities
Bioretention ASCE Mean Cost	$0.88/sf[1]	2178 sf	Annual	No	$1,900	Trash and debris removal, sediment removal from overflow, vegetation management, mulching, pest control
Bioretention Western Washington	Early $1.50/sf[2] Mature $0.75/sf[2]	1750 sf	Annual	No	Early $2,600 Mature $1,300	Trash and debris removal, sediment removal from overflow, vegetation management, mulching, pest control
Filterra®	$100-$500/system[3]	1 system	Annual	No	$500	Trash and debris removal, replace mulch, vegetation management
StormFilter®	$250/cart[3]	6 - 18" cartridges	1 - 3 years	Yes	$1,000	Vactor vault, replace cartridges
CDS®	$1,500[3]	4' dia. manhole	1 - 3 years	No	$1,000	Vactor sump and floatables

1. Clary, Jane, H. Piza. 2017, Cost of Maintaining Green Infrastructure. ASCE. ISBN:9780784414897
2. Cost Analysis for Western Washington LID requirements and Best Management Practices (Herrera 2013)
3. Third party maintenance by Contech Qualified Maintenance Providers

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Verified Performance

- NJDEP – Lab Protocol
- TAPE – Field Protocol
- WEF STEPP
- Wisconsin DNR
  - o Efficiency of Proprietary Filtration Devices Protocol

Discussion

- We rely on many different filtration systems and fundamentals are key to success/functionality
  - Choose right tool for the job
  - What are targeted pollutants?
- Inspection & Maintenance
  - Consider pretreatment and treatment trains
- Innovative is essential but don't overlook the fundamentals
  - Will it remove target pollutants?
  - Is sizing realistic?
  - Life cycle cost

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Questions?

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