


Bioretention & Rain Gardens

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Storm Water Runoff and Quality


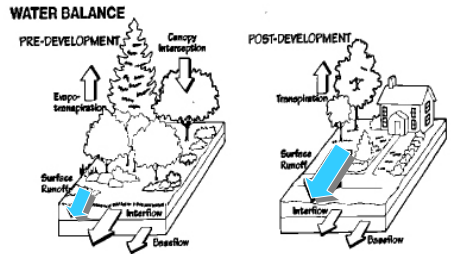


Figure 1.1 Water Balance at a Developed and Undeveloped Site
(Source: Schaefer, 1987)



Low Impact Development




- ◆ Pre-development Quantity & Quality
- ◆ Keep Stormwater On Site
- ◆ Promote Infiltration; more ET
- ◆ Filtering and other Natural Treatment Mechanisms
- ◆ Apply Green Engineering Principles to Land Development



Research

- ◆ Laboratory
- ◆ Pilot
- ◆ Field



Bioretention (Rain Gardens)



Hydrology: Pooling, Infiltration, & Evapotranspiration



Quality: Filtration, Adsorption, Biodegradation





Bioretention


Goals

- Hydrology Management
- Improvements in Water Quality
- Understand Fundamentals
- Facility Design
 - Size
 - Media
- Facility Management

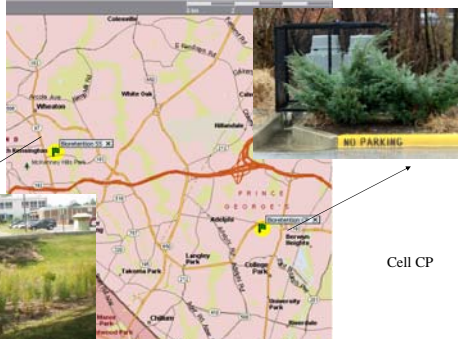


Three Timescales

- Event timescale
 - Removal or sequestration of pollutants from runoff during storm event
- Between-event timescale
 - Degradation or incorporation of captured pollutants
- Facility Life timescale
 - Ecological and Biogeochemical transformations






Field Bioretention Monitoring






Cell SS

Cell CP

Cell Characteristics

Cell	CP	SS
Cell area	181 m ²	102 m ²
Drainage area	0.28 ha	0.45 ha
Cell area/ drainage area	6%	2%
Media depth	0.5-0.8 m	0.9 m
Ponding storage depth	0.15 m	0.30 m
Date of construction	Spring 2004	March 2006
Media type	Sandy loam	Sandy clay loam

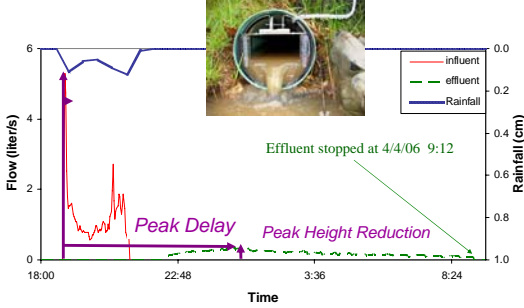
Runoff Characterization

Apr 2006 – July 2007

- ISCO 6712 Auto samplers, Rain gauges, Flumes/Weirs
- Flows & Rainfall - 22 (CP) and 60 (SS) events
- 15 WQ events per site, Flow proportional samples

TSS	TKN	Zn	Cr	Cl
TOC	Nitrite	Pb	Ni	<i>E. Coli</i>
Oil & Grease	Nitrate	Cu	As	Fecal Coliform
	TP	Cd	Hg	

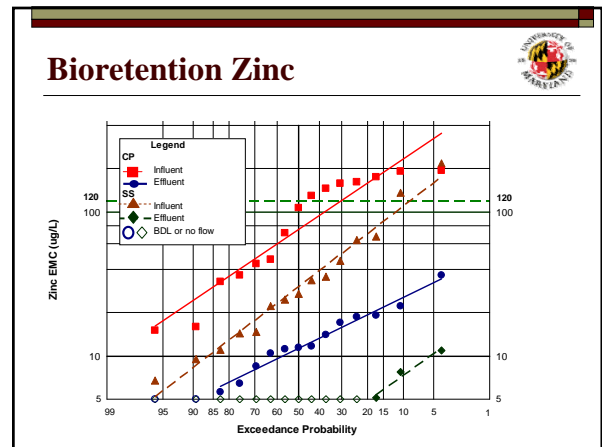
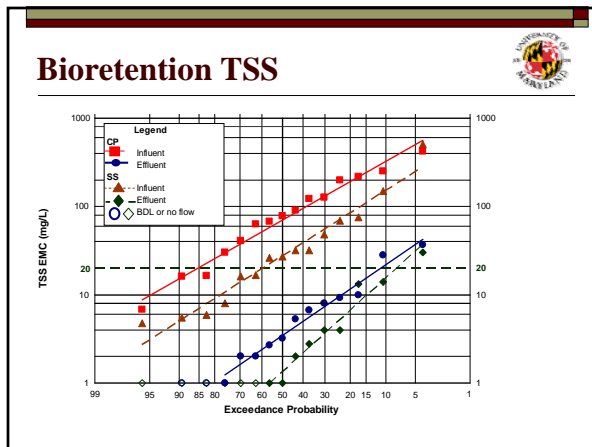
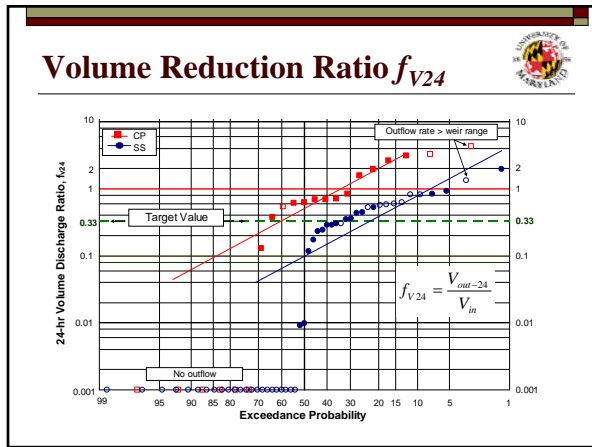
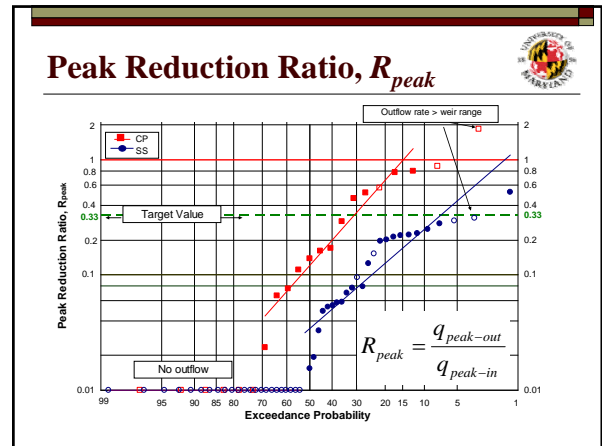
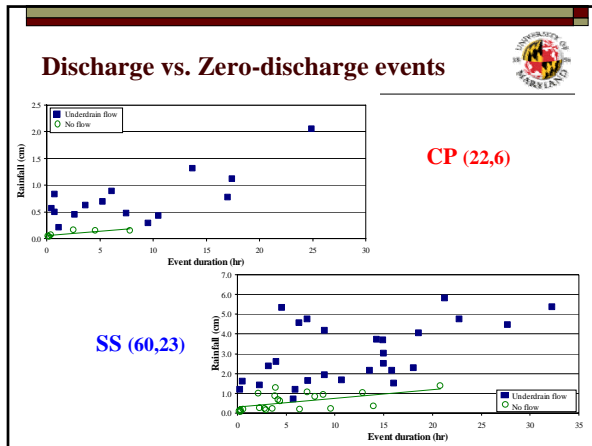
Flows, 4/3/06 Storm Event (CP)

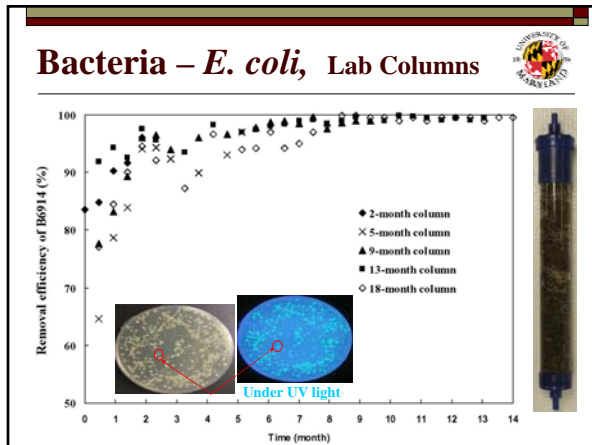
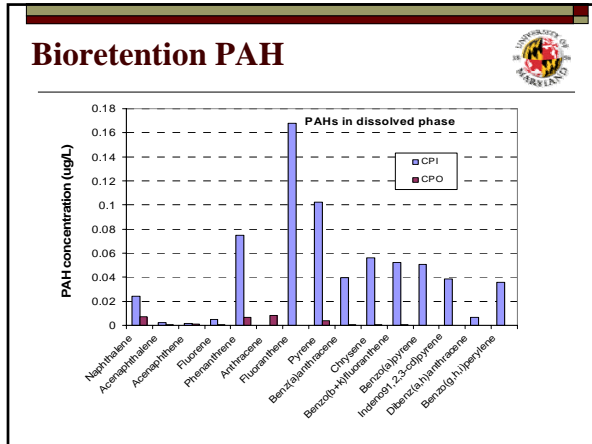


Effluent stopped at 4/4/06 9:12

Peak Delay

Peak Height Reduction





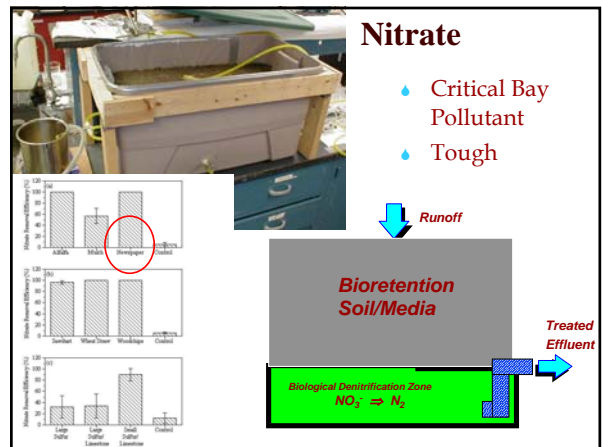
Pollutant Mass Loads

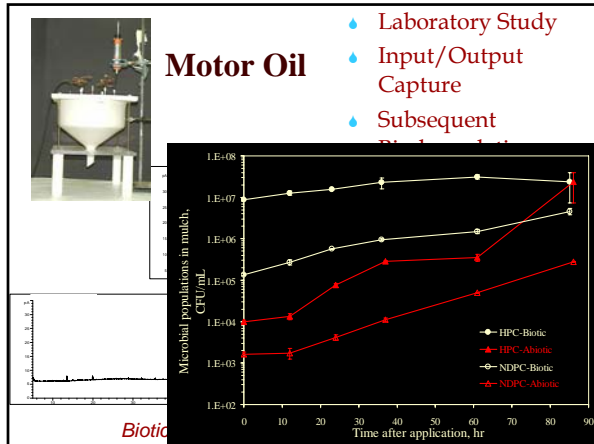
Concentration x Volume

Pollutant	CP (kg/ha-yr)		SS (kg/ha-yr)	
	Load	Discharge	Load	Discharge
TSS	674	27	233	2
Zinc	0.93	0.074	0.23	0.002
Copper	0.23	0.079	0.13	0.005
Lead	0.017	<0.017	0.017	<0.017
Chromium	0.086	0.035	0.017	<0.017
TN	15	15	10	<1
Nitrate	3	7	5	<1
TP	1	1	<1	<1
Chloride	60	154	43	1
TOC	48	55	39	<1

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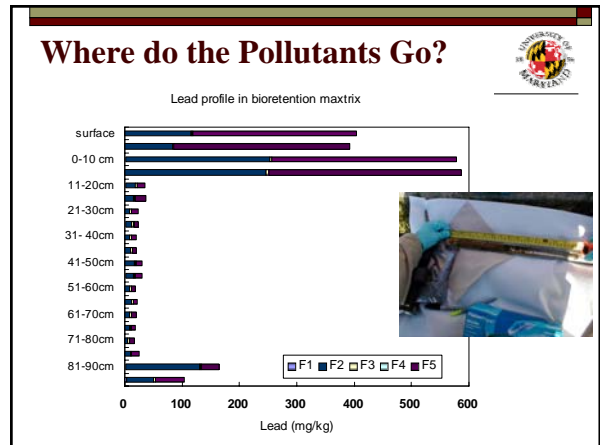
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Where do the Pollutants Go?

- Accumulation
- Biodegradation
- Removal

- Ownership
- Operation and Maintenance



Conclusions

- Excellent Management of Hydrology
 - Peak Reduction
 - Volume Reduction
 - Peak Delay
 - Evapotranspiration
 - Infiltration
- Size, Depth, Configuration of Cell Likely Control

(Hydrologic Management)

Conclusions

- Excellent Removal of Several Pollutants Independent of Media
 - Suspended Solids
 - Oil and Grease *(Physical Capture)*
 - Metals: Lead, Zinc, Copper, Cadmium
- High Infiltration Media can be Employed
 - Err on side of greater infiltration
 - Depth of Cell not Important here

Conclusions



- ◆ Phosphorus Removal Complex
 - ◆ Adsorption
 - ◆ Transport with Suspended Solids
 - ◆ Preferential Flow Pathways
- ◆ Ammonia, Organic N Removal Complex *(Chemical Processes)*
- ◆ Depth of System
- ◆ Media Characteristics

Conclusions



- ◆ Modifications for Sustainable Removal of Pollutants
- ◆ Encourage Biodegradation Processes
 - ◆ Denitrification Zone
 - ◆ Capture and Biodegradation of Oil & Grease
- ◆ Exploitation for vegetation in uptake and removal of pollutants from facility *(Biological Processes)*

Implementation Challenges



- ◆ Lack of Performance Information
- ◆ Lack of Understanding
- ◆ Space
- ◆ Utilities
- ◆ Regulatory Hurdles
- ◆ Contractor Inexperience
- ◆ Inertia



Co-Workers



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- ◆ UMBC
 - ◆ Upal Ghosh
 - ◆ Katie DiBlasi
- ◆ Low Impact Development Center
 - ◆ Neil Weinstein

Research Sponsors & Supporters



www.ence.umd.edu/~apdavis/Bioret.htm

Bioretention WQ Performance



Pollutant	CP				SS			
	In	Out	EMC Removal (%)	Mass Removal (%)	In	Out	EMC Removal (%)	Mass Removal (%)
TSS (mg/L)	78	4	89	96	27	1	95	99
Zn (µg/L)	107	11	83	92	27	3	89	99
TN (mg/L)	1.7	2.0	-28	-3	1.2	0.4	70	97
TP (mg/L)	0.1	0.3	-77	-36	<0.1	0.1	100	100
TOC (mg/L)	5.6	8.2	-180	-14	4.5	2.9	35	99
Cl ⁻ (mg/L)	7	21	-264	-154	5	2	83	97

Suspended Solids Deposition



➤ A three-layer model

