

Creating Green Stormwater

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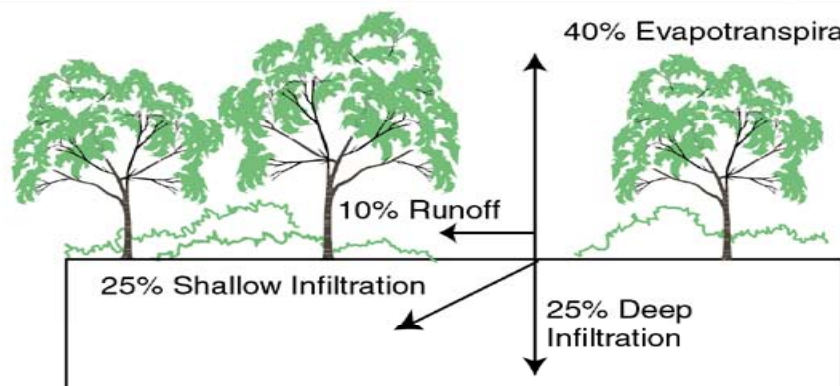
*University of Maryland
College Park, MD 20742*

October 9, 2009

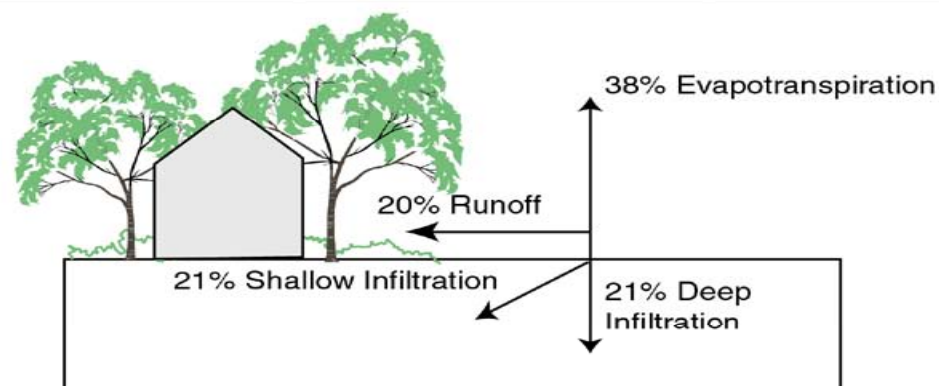




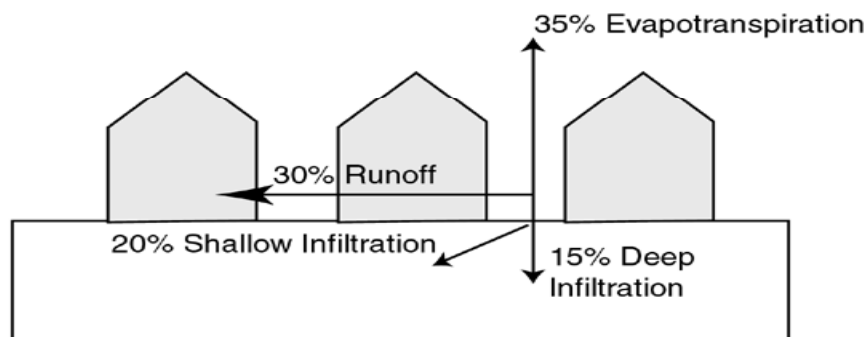
Urban Infrastructure, Imperviousness, and Runoff



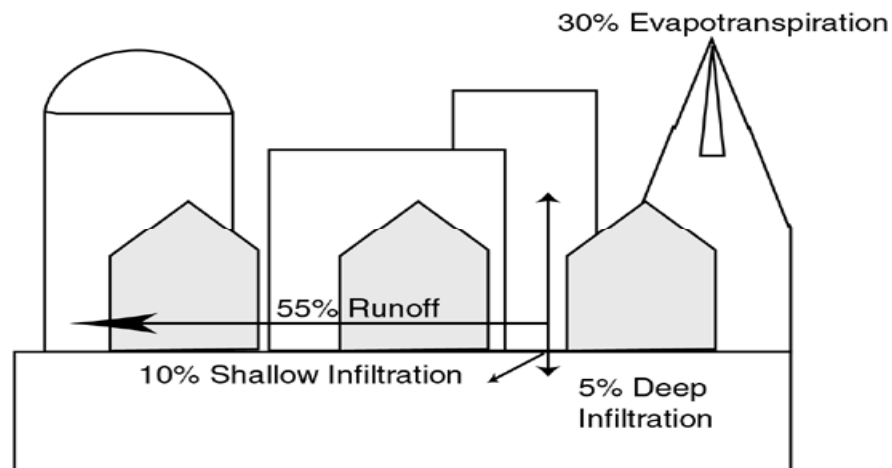
Natural Ground Cover



10% - 20% Impervious Surface



35% - 50% Impervious Surface



75% - 100% Impervious Surface

Changes in runoff flow resulting from increased impervious area (NC Dept. of Nat. Res. and Community Dev., in Livingston and McCarron, 1992.)



Conventional



Conventional





Erosive, Polluting, Ecological Impacts, Water Supply



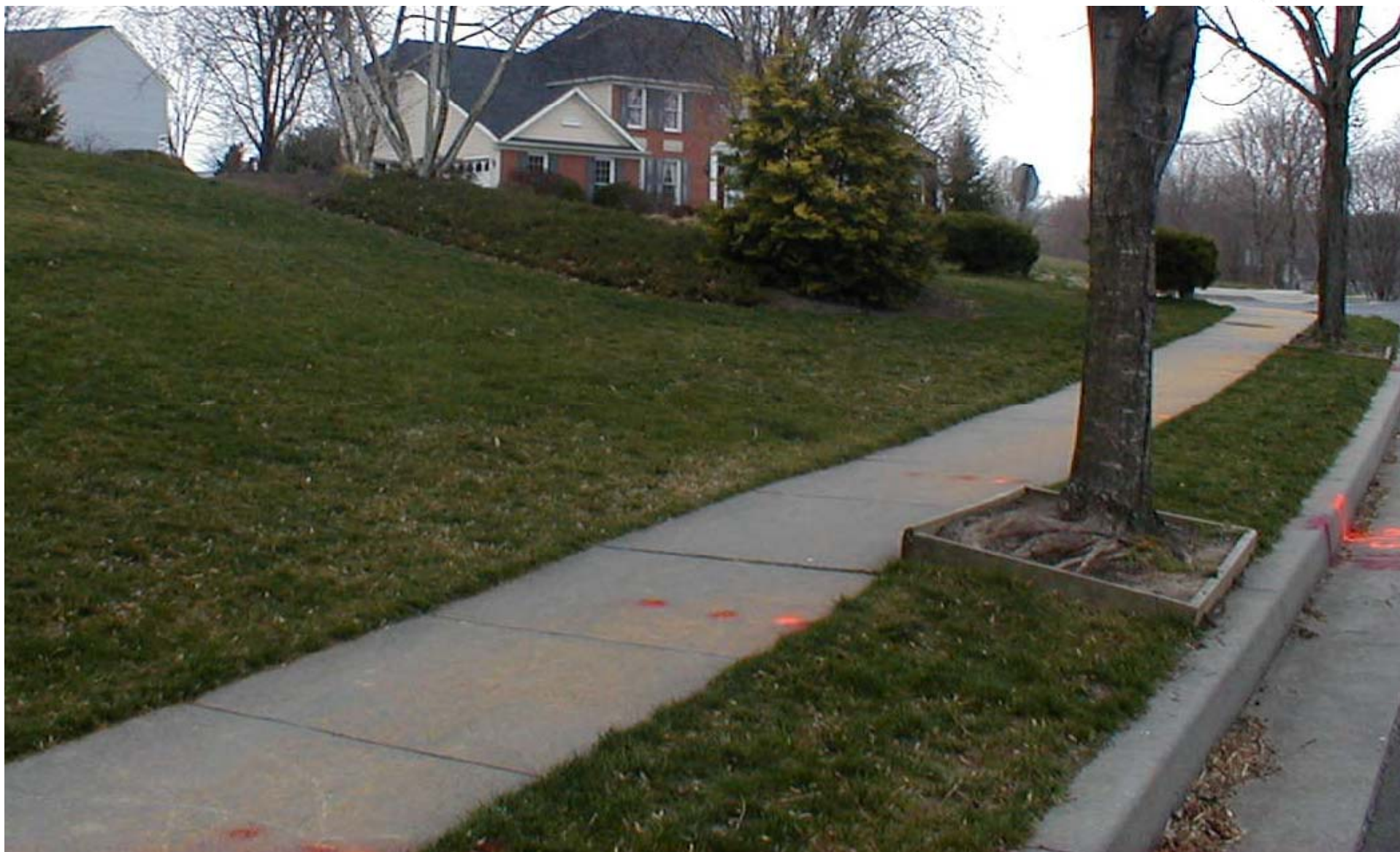


Sources of Pollutants





Sources of Pollutants



Nutrient Source





Sources of Pollutants



Novel Technologies



Bioretention



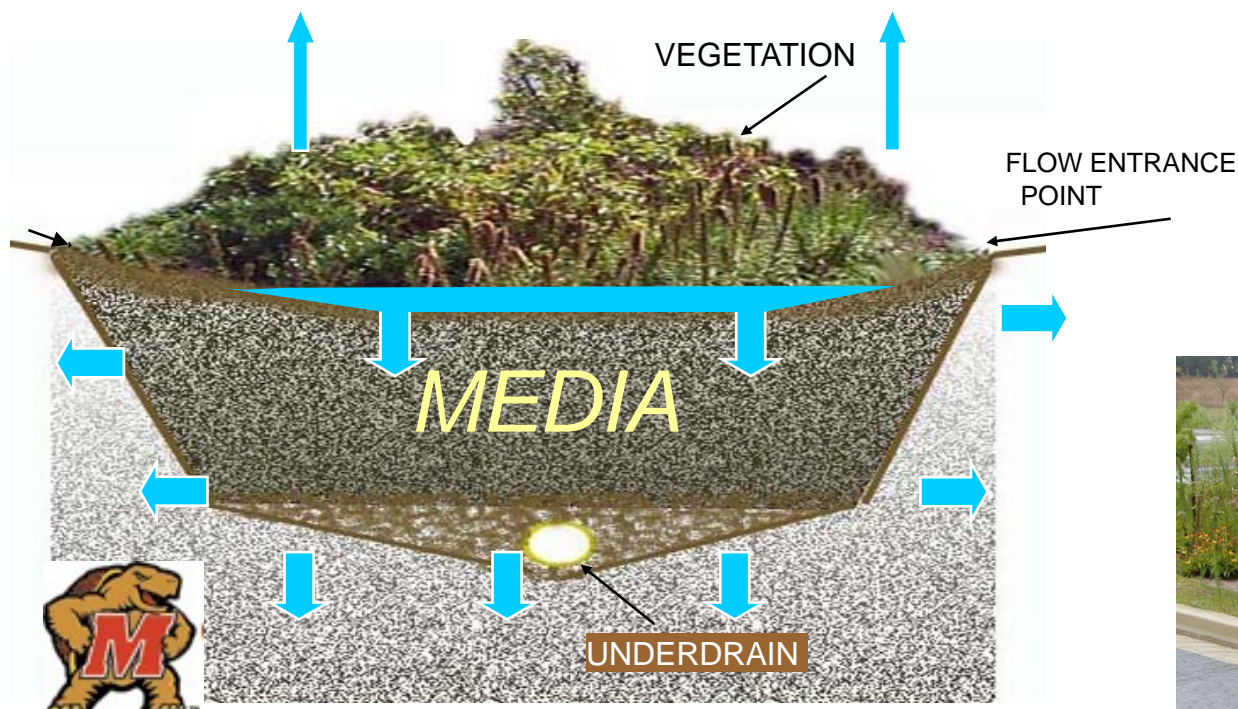


Bioretention (Rain Gardens)

Hydrology: Pooling, Infiltration,
& Evapotranspiration

Quality:

Filtration,
Adsorption,
Biodegradation



MEDIA: Sand, Soil,
Organic Matter



College Park

Bioretention

research &
monitoring



Silver Spring

Goals



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



Concurrent Challenge



- What are the proper metrics for success?



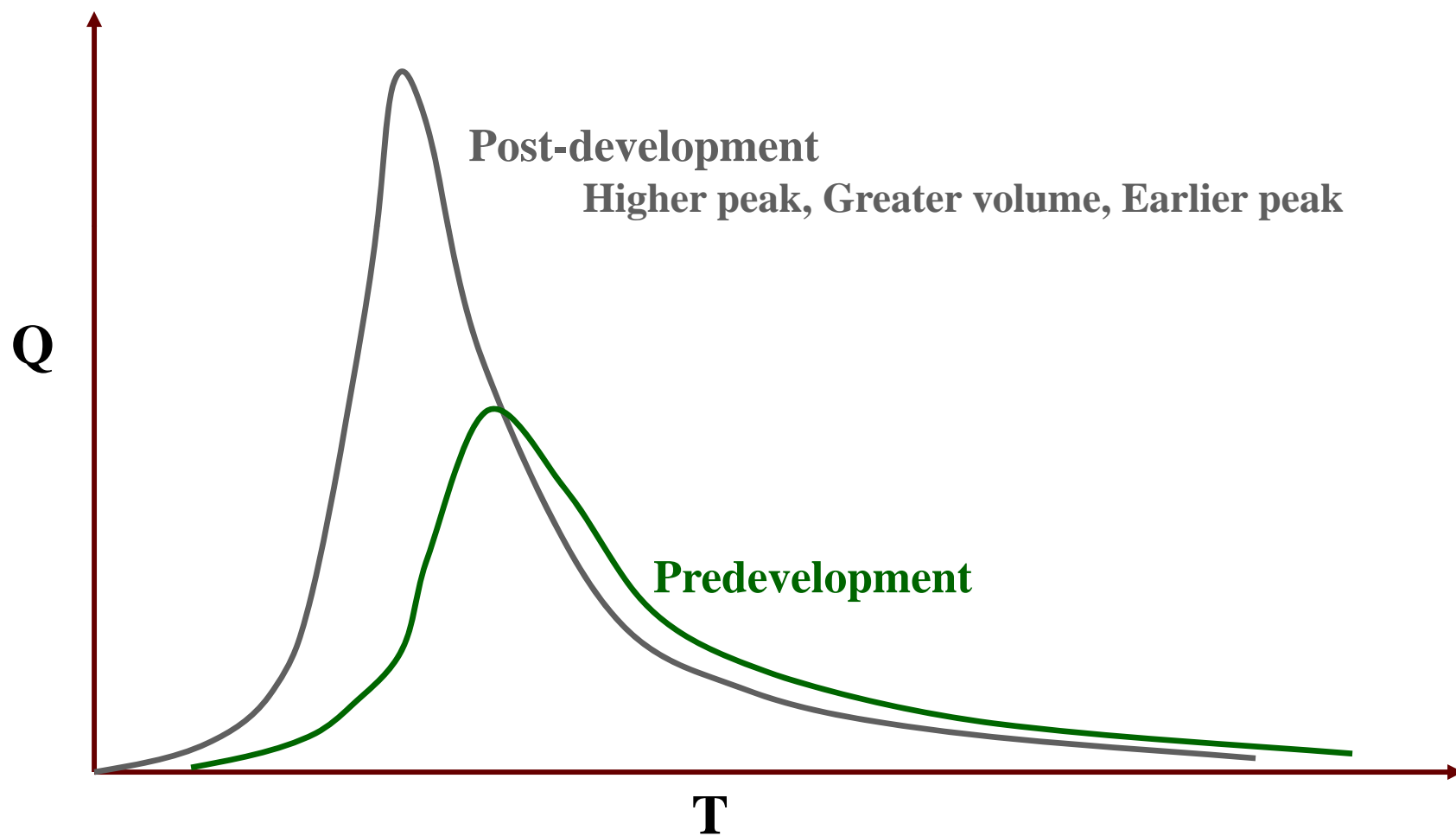


Hydrology





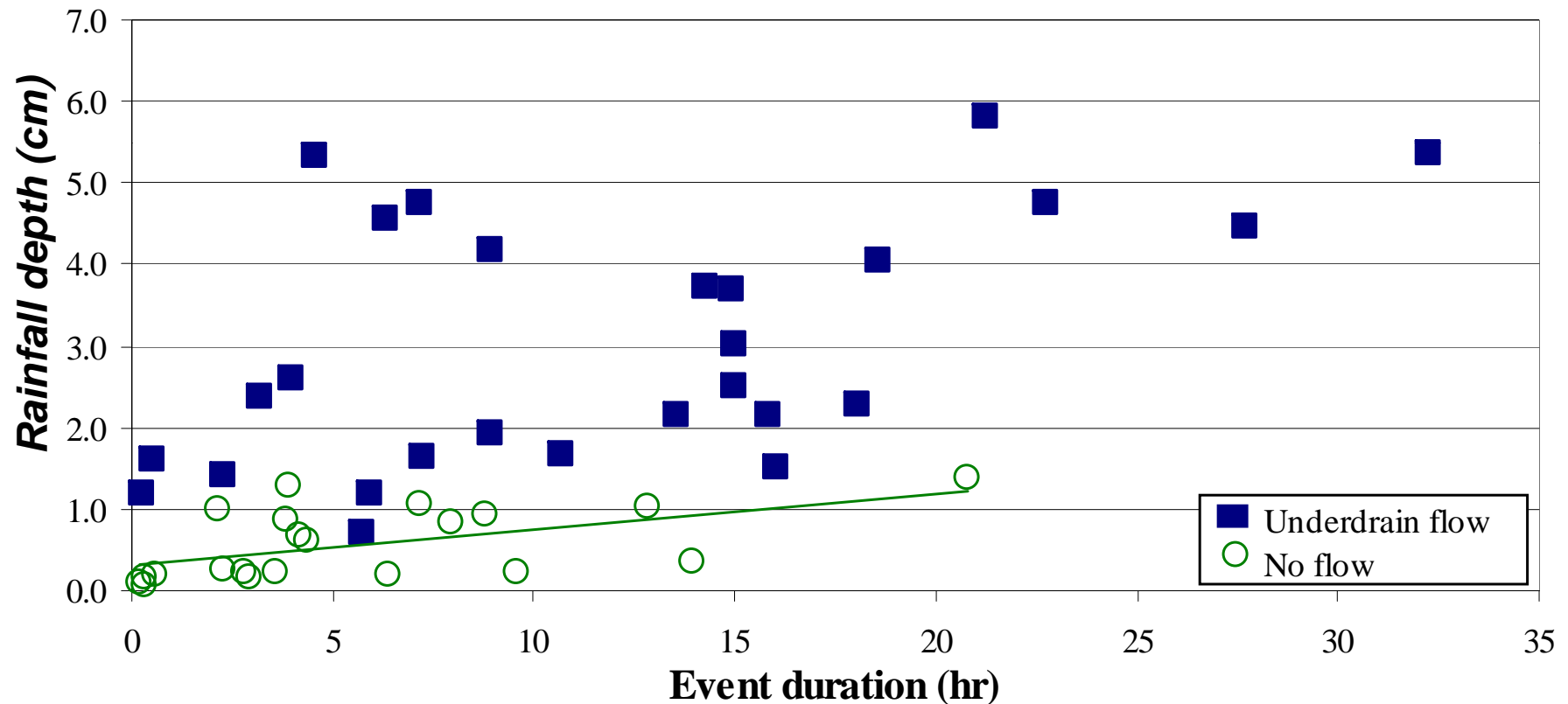
Hydrographs



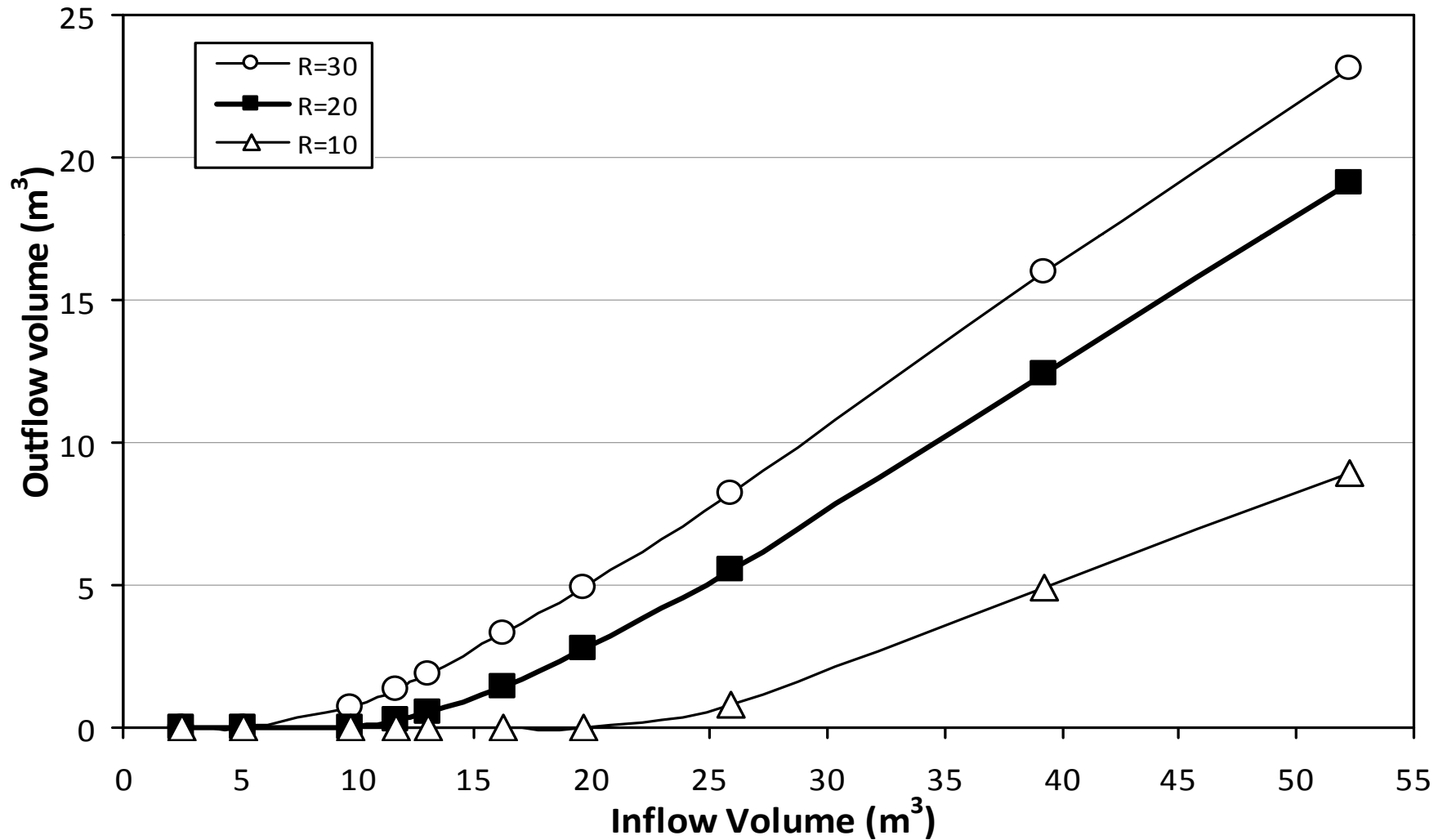


Discharge vs. Zero-discharge events

60 events, 23 with no discharge

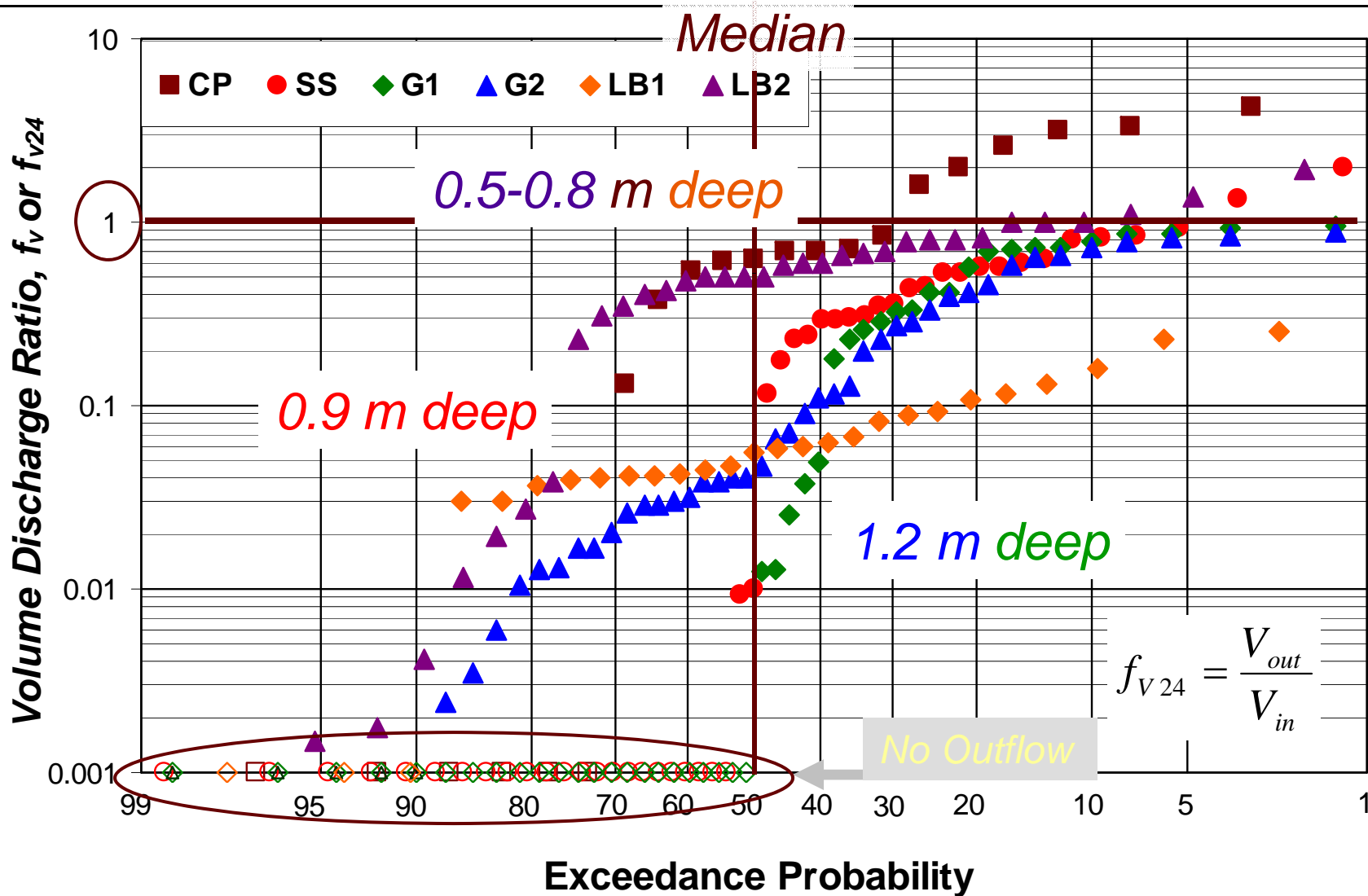


Bioretention Modeling: Size





Volume Reduction Ratio, f_v

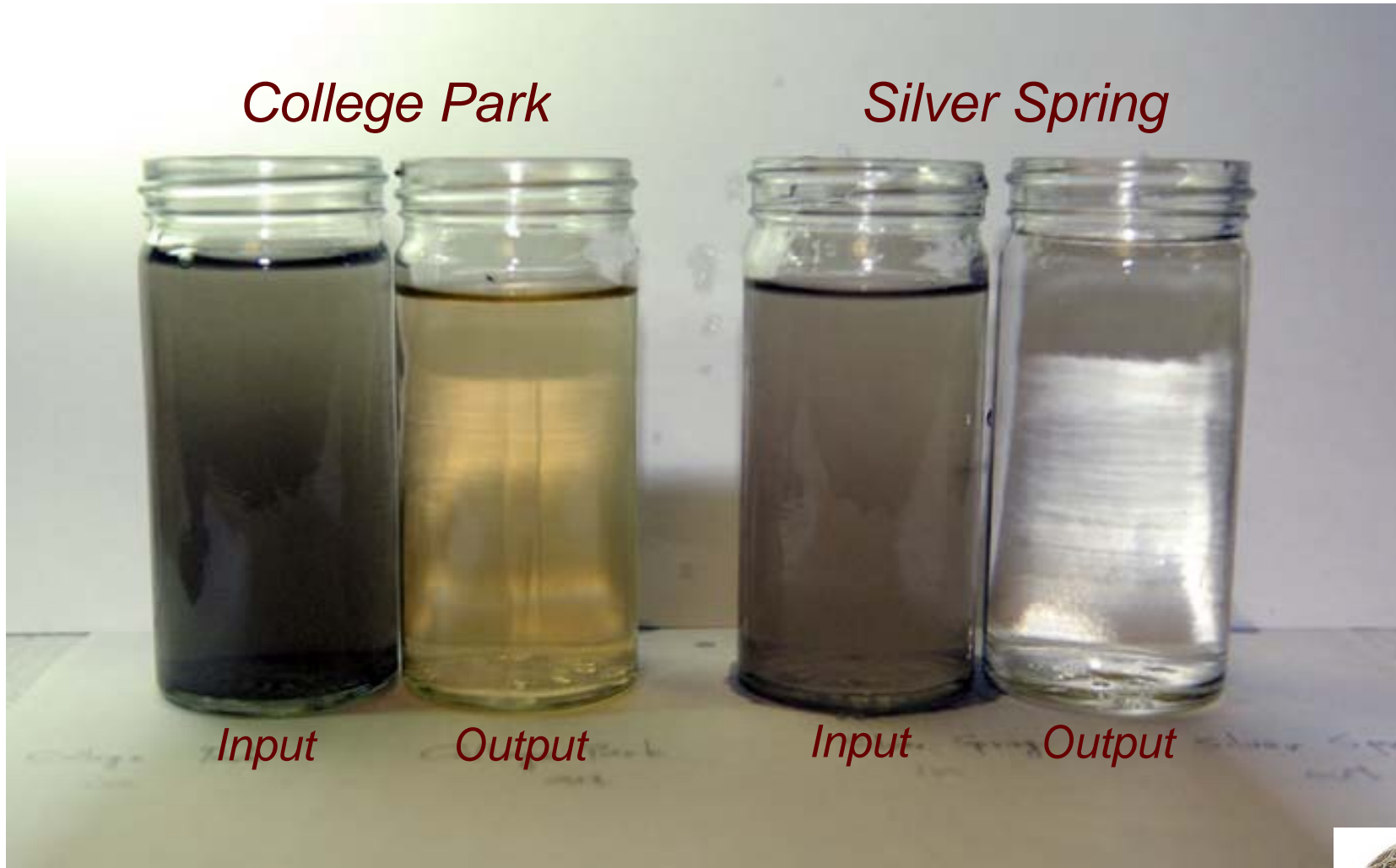


Water Quality



College Park

Silver Spring



Input

Output

Input

Output



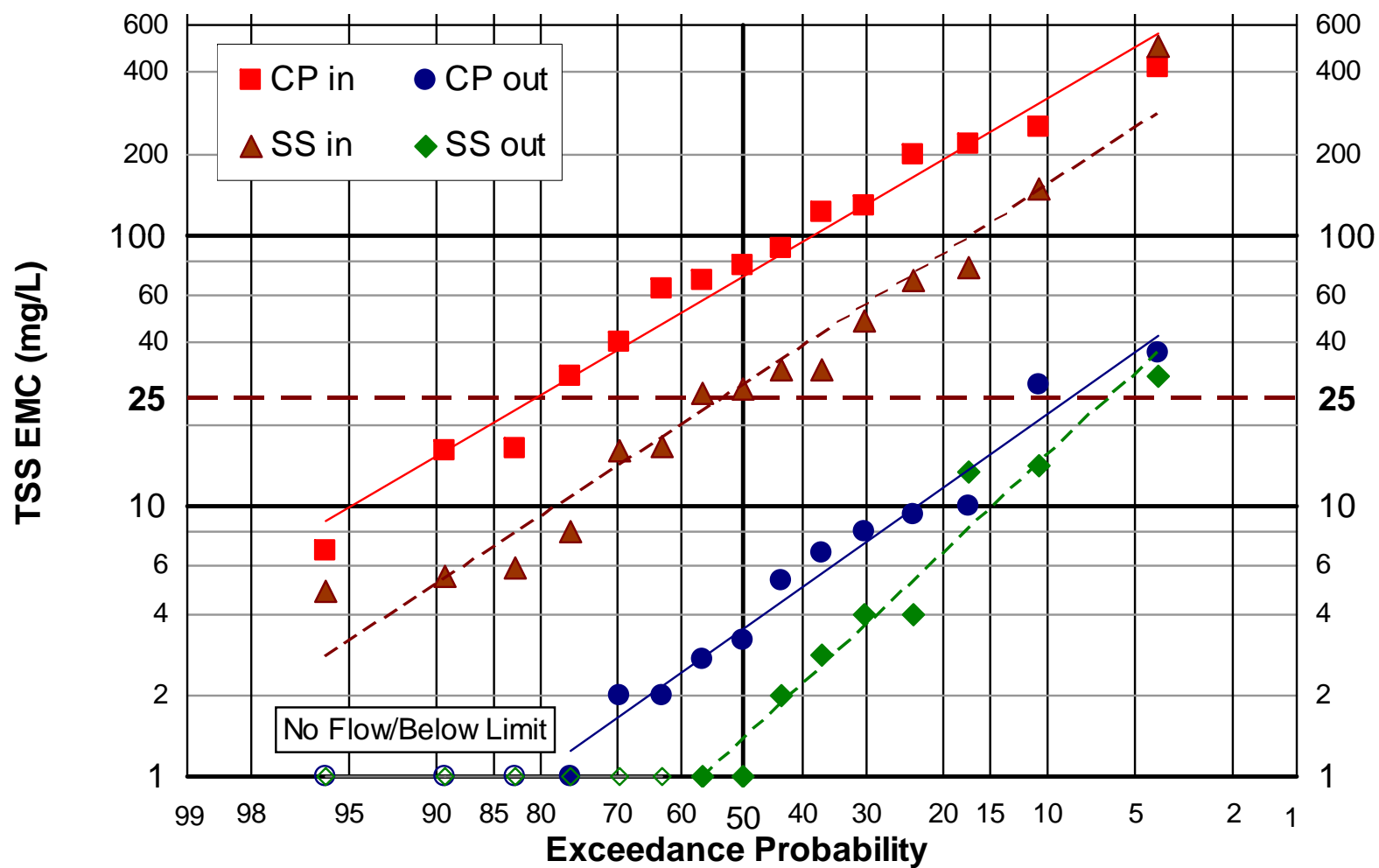


Particulate Matter & Bacteria



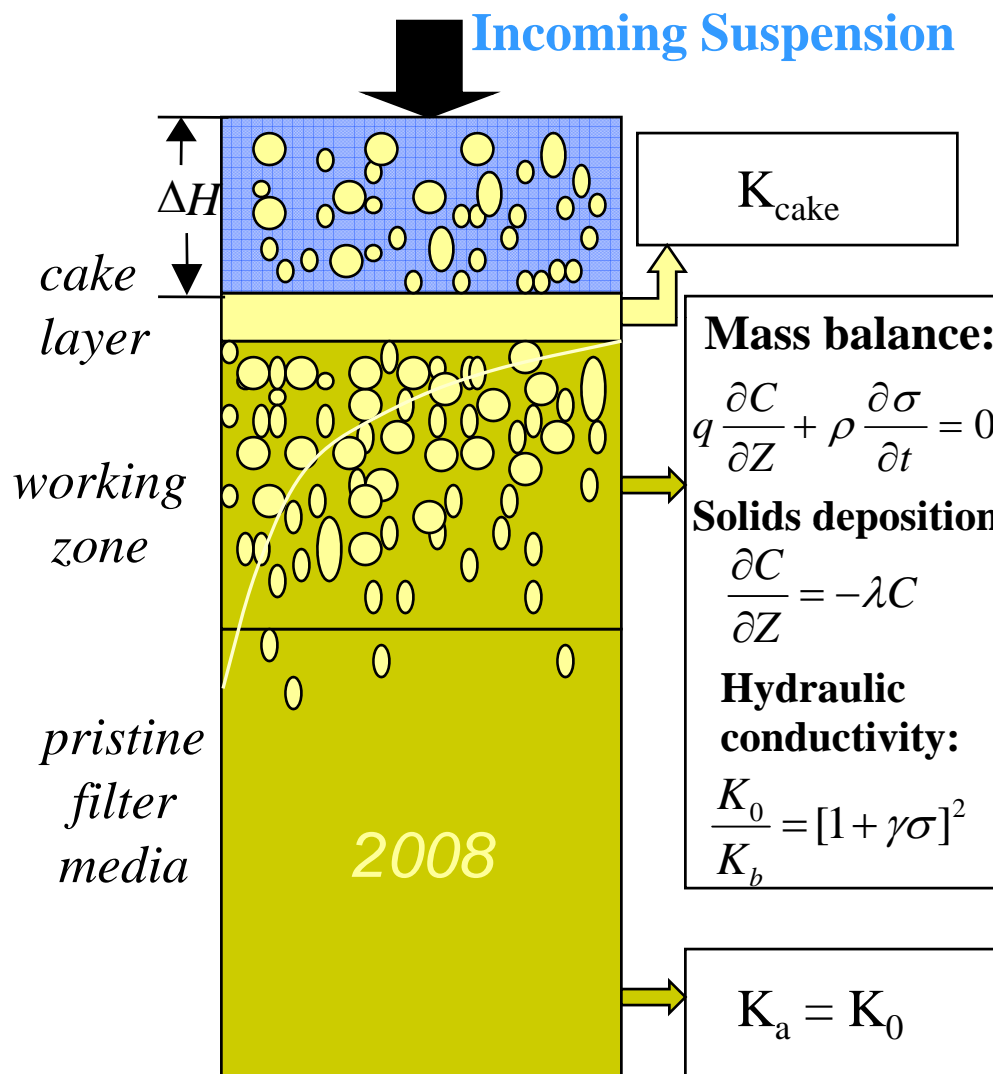


Bioretention TSS (CP & SS)



Suspended Solids Filtration

➤ A three-layer model



Bioretention





TSS Accumulation

- Intermittent flow conditions allow more particulate capture than continuous flow
- **SS do not penetrate below 5-20 cm in the media**
- Periodic surface media replacement can be used to recover hydraulic conductivity.



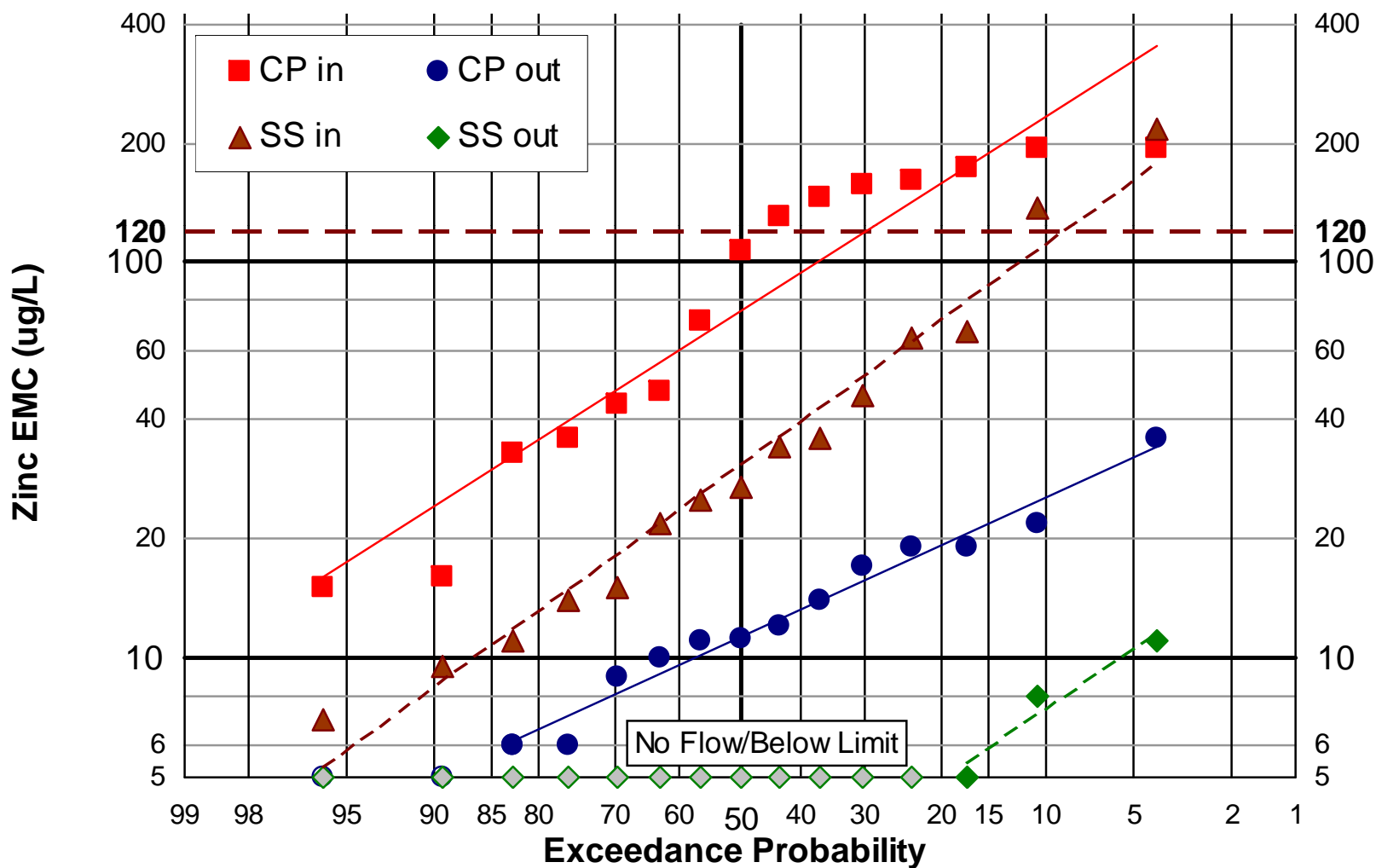


Metals & Hydrocarbons

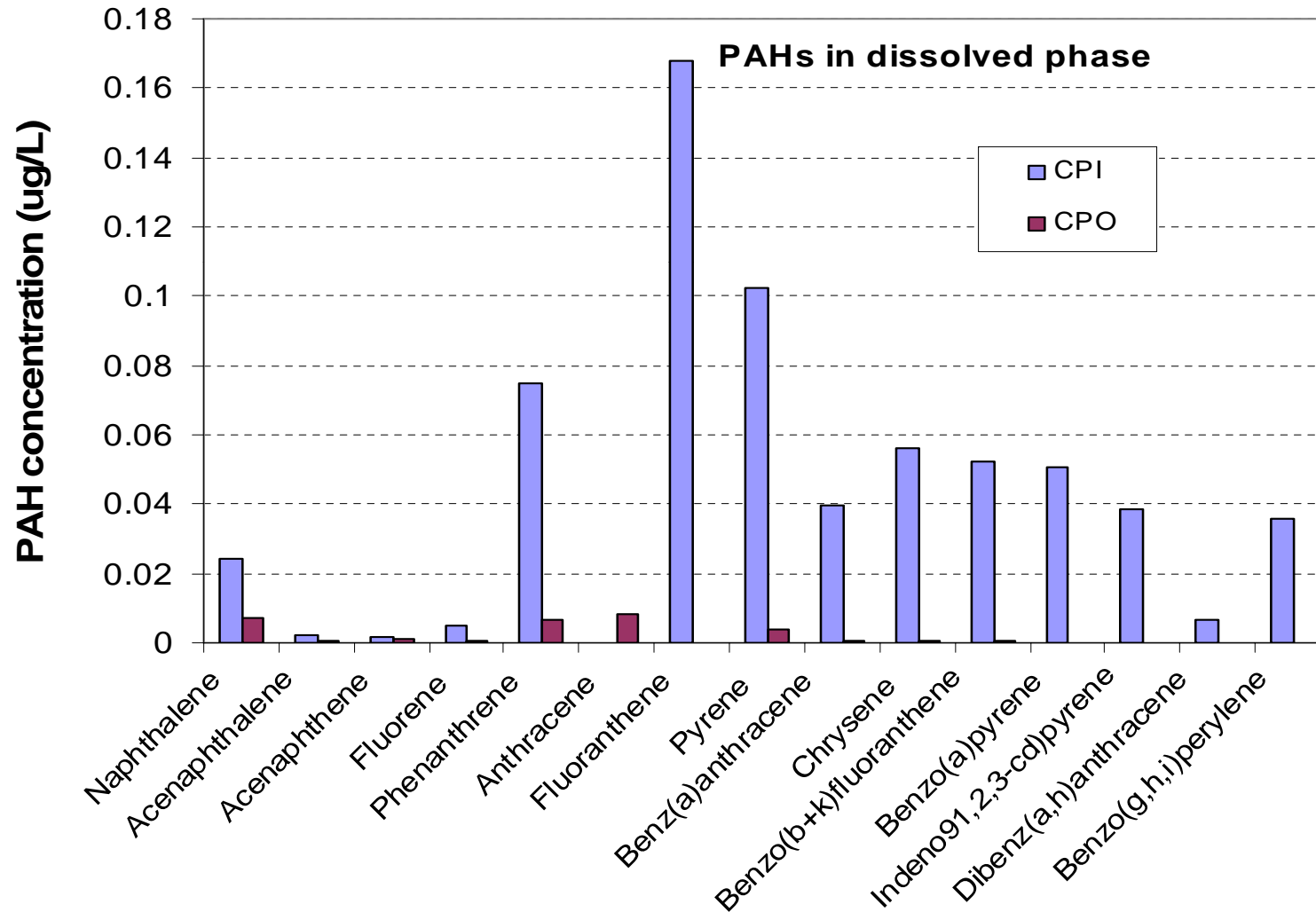




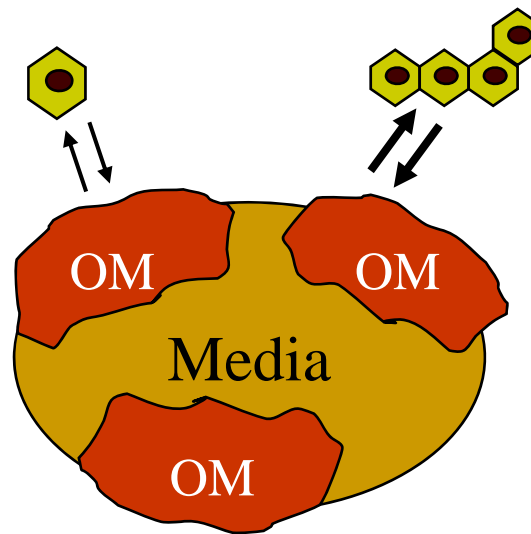
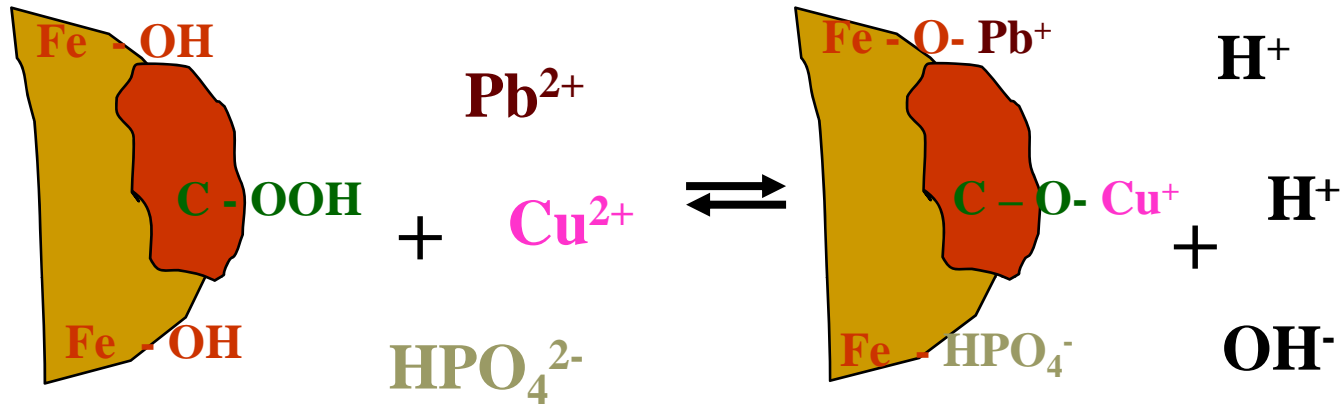
Zinc (CP & SS)



Bioretention PAH (CP)



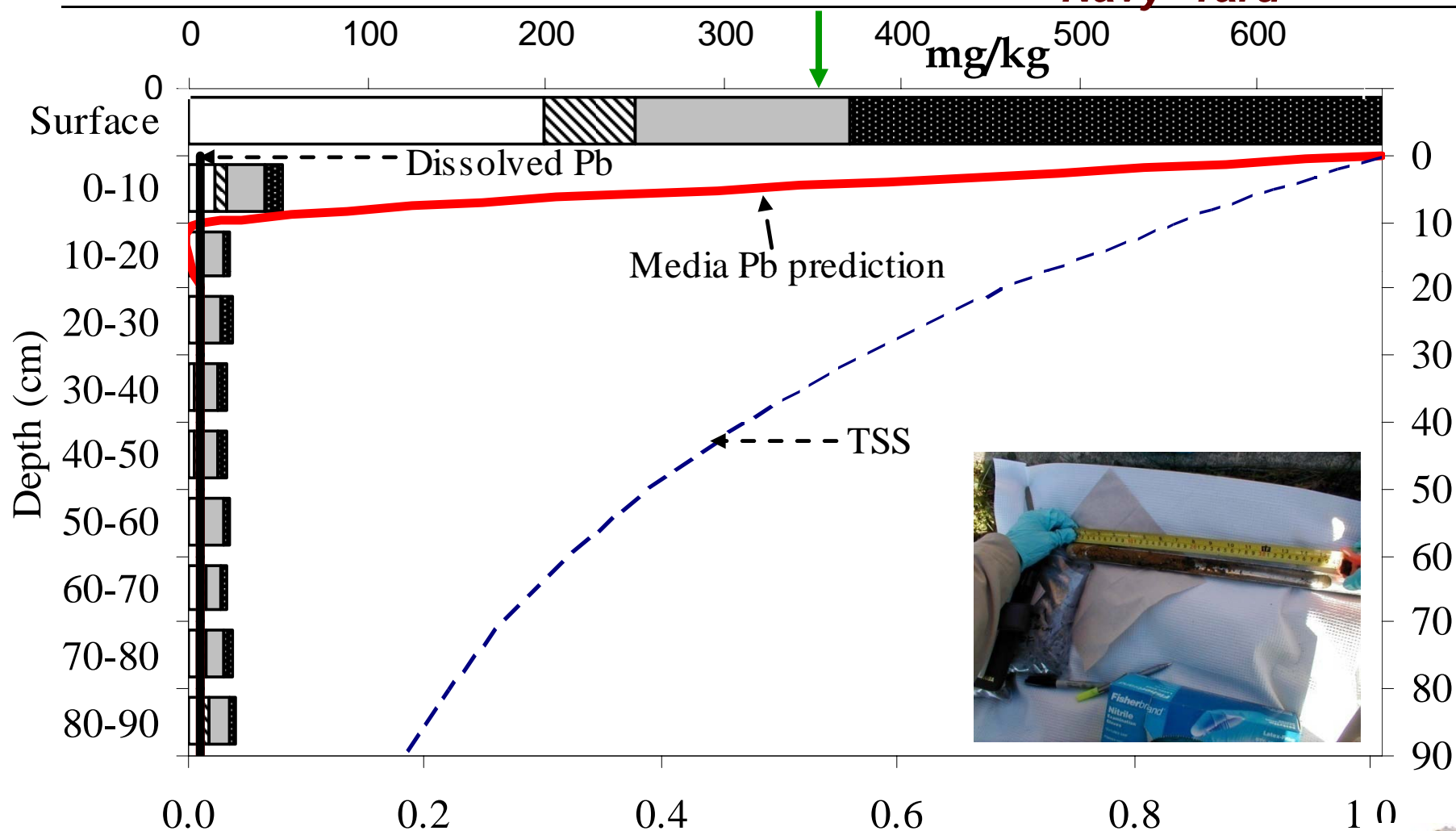
Metal & Organic Adsorption





Metals Accumulation - Pb

Navy Yard



Dimensionless TSS or Normalized Captured Pb Deposit



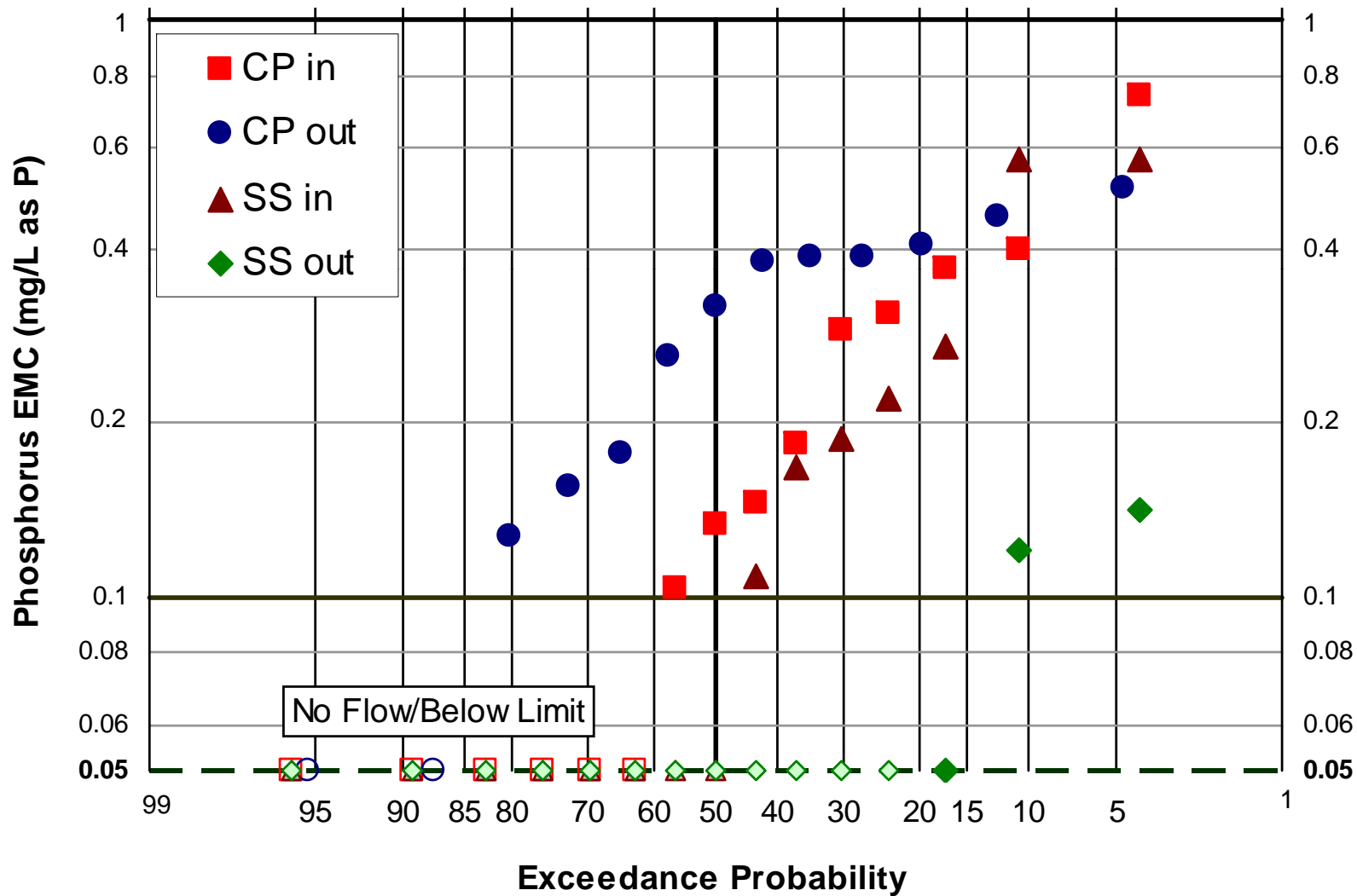


Nitrogen & Phosphorus



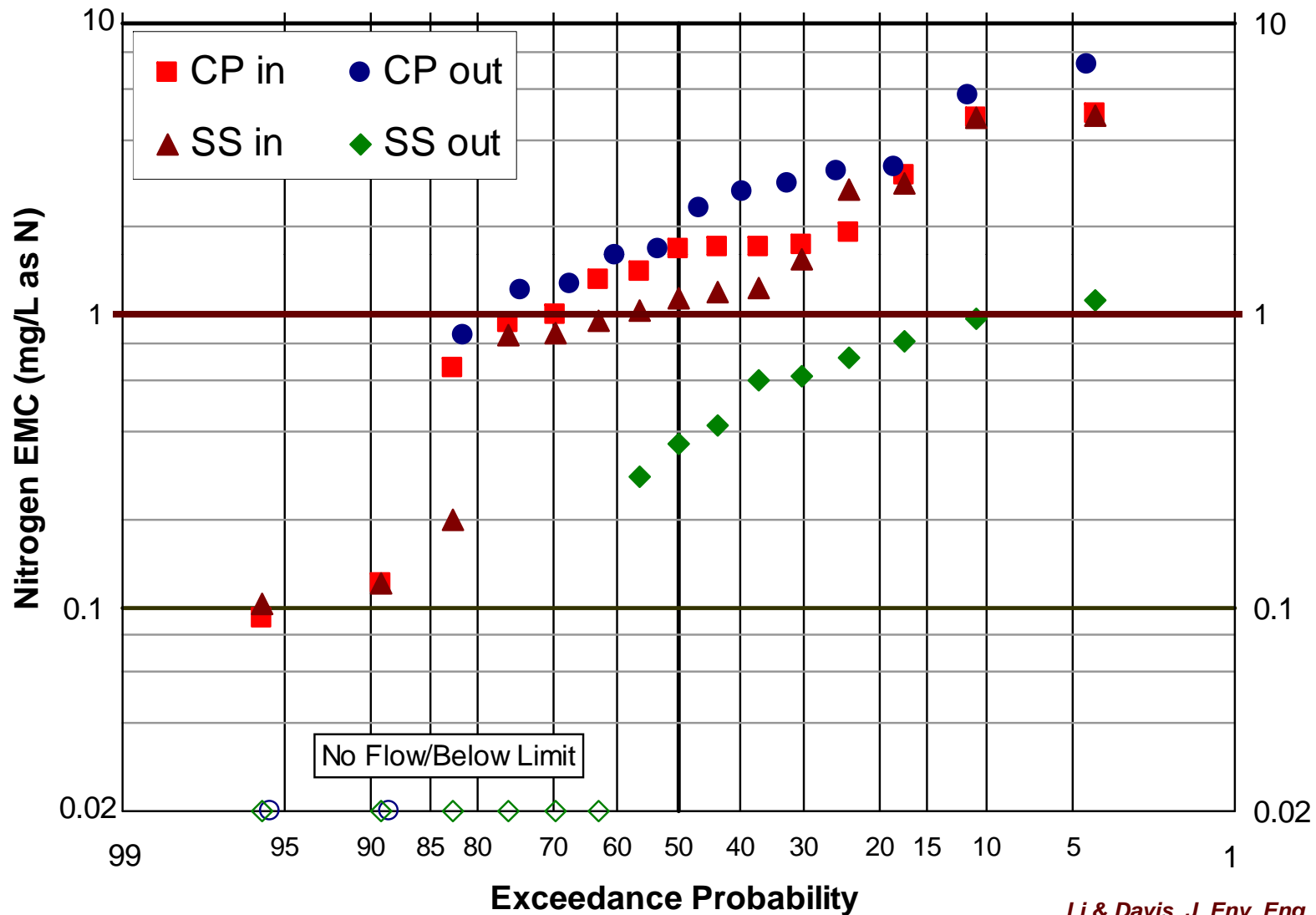


Total Phosphorus (CP & SS)





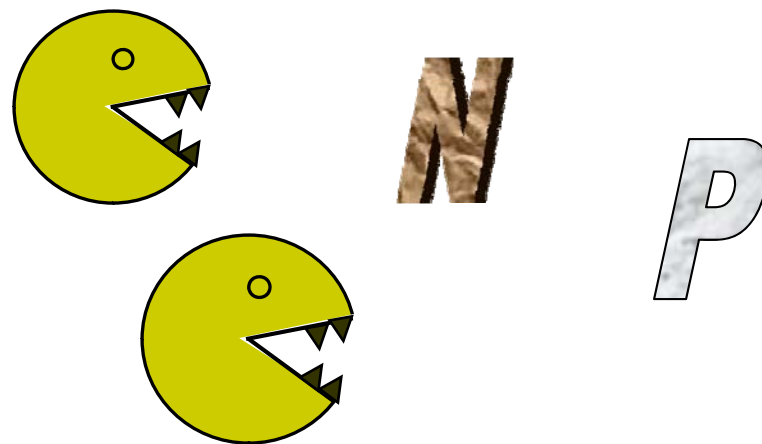
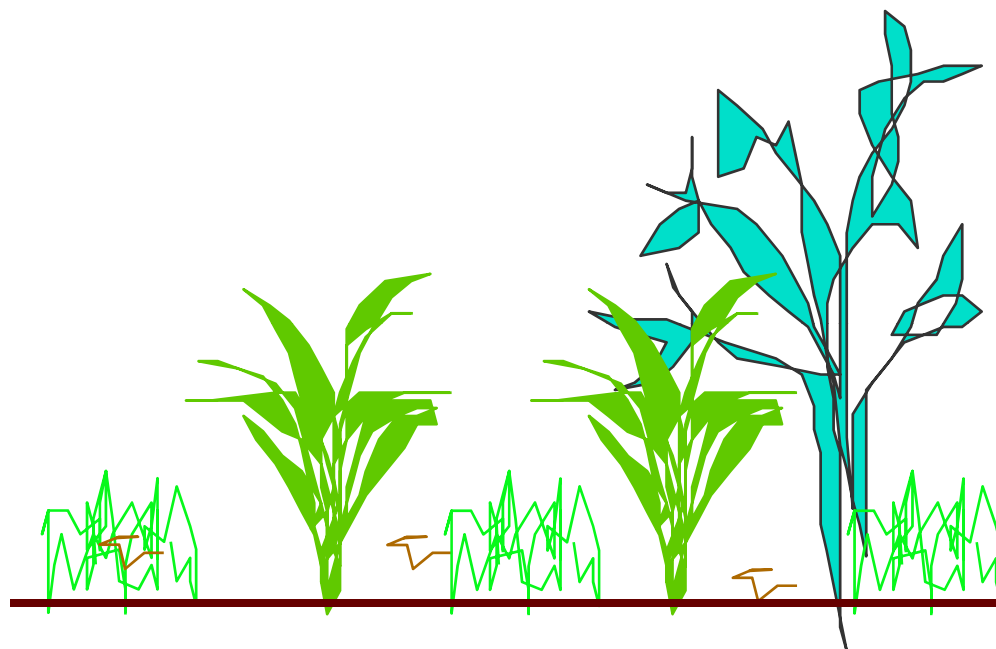
Bioretention TN (CP & SS)

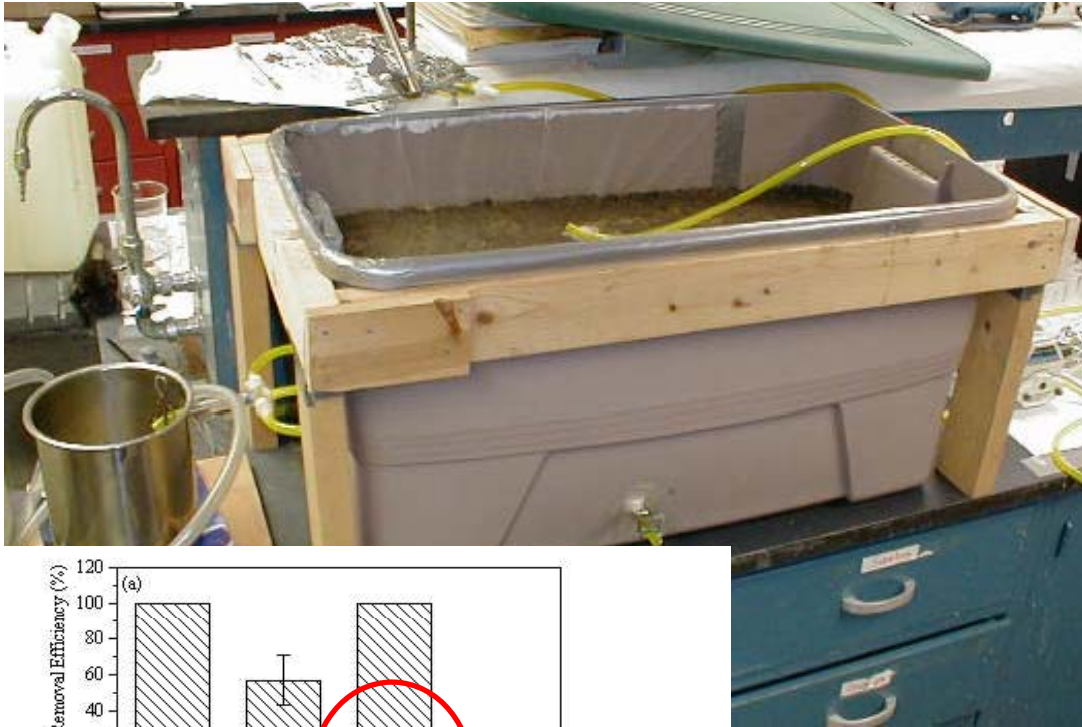


Nutrient Processes

- Phosphorus
 - Filtration
 - Adsorption
 - Bio-uptake
 - Plant Uptake
 - Decay & Discharge

- Nitrogen
 - Nitrification
 - Denitrification
 - Plant Uptake
 - Decay & Discharge

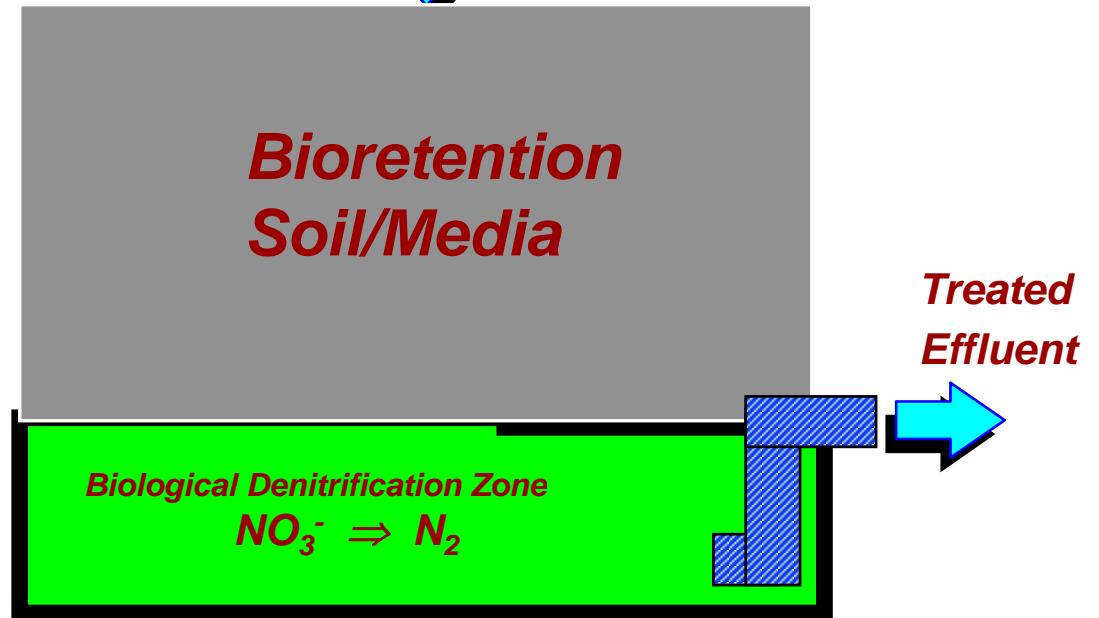
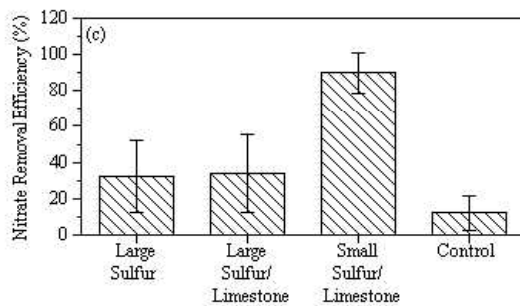
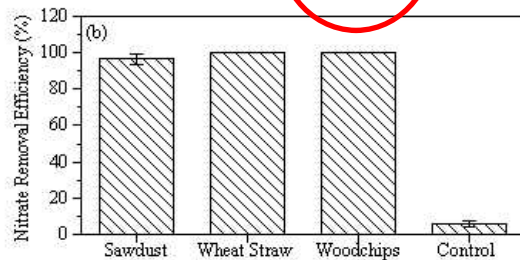
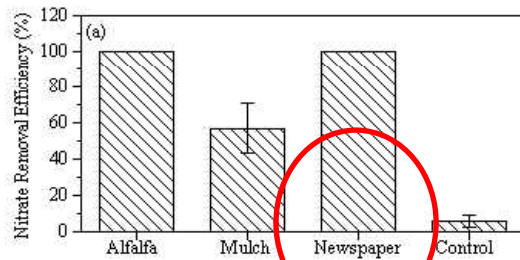




Nitrate



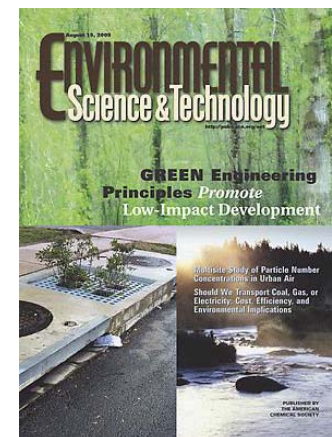
Enhanced Nitrate Removal with Internal Storage





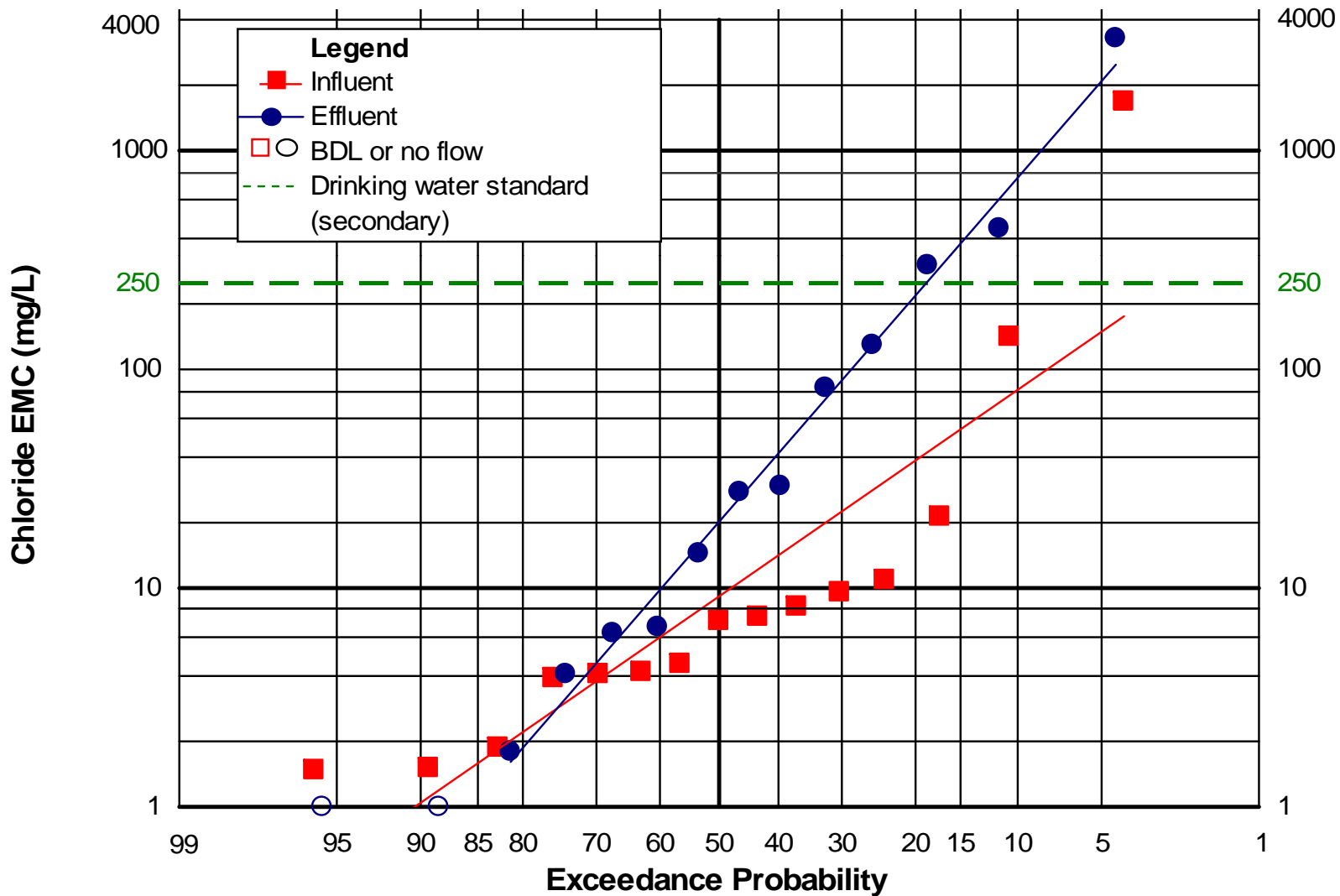
What we know so far...

- **Excellent Management of Hydrology**
 - Media Area & Depth
- **Filtration: Excellent Particulate Matter Removal**
 - Media Depth not Important; Surface Accumulation
- **Adsorption**
 - Metals, PAH Excellent: Surface Accumulation
 - Phosphorus, TKN, Complex, Depth important
- **Biodegradation Processes Important**
 - Denitrification
 - Biological Predation
 - Vegetation in uptake & degradation





Chloride (CP)





Co-Workers

💧 Students

- 💧 Mohammad Shokuhian
- 💧 Houngh Li
- 💧 Himanshu Sharma
- 💧 Eunyoung Hong
- 💧 Ameya Pradhan
- 💧 Xueli Sun
- 💧 Rebecca Stack
- 💧 Zhuangxiang He
- 💧 Roman Hsieh
- 💧 Lan Zhang
- 💧 Hunho Kim
- 💧 Kelly Flint
- 💧 Christie Minami
- 💧 Philip Jones
- 💧 Thomas Wild

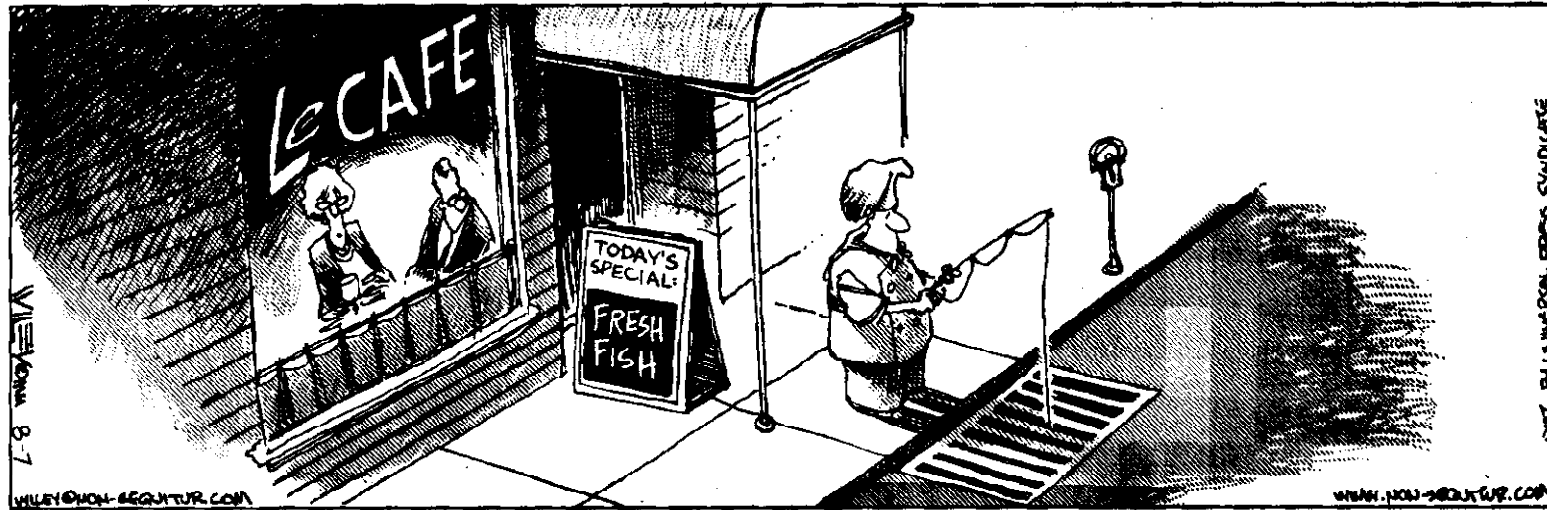
💧 Others

- 💧 Eric Seagren
- 💧 Brian Needelman
- 💧 Upal Ghosh & Katie DiBlasi
- 💧 Bill Hunt & Lucas Sharkey
- 💧 Jeff Karns
- 💧 Robert Traver
- 💧 Neil Weinstein
- 💧 Rufus Chaney

Research Sponsors



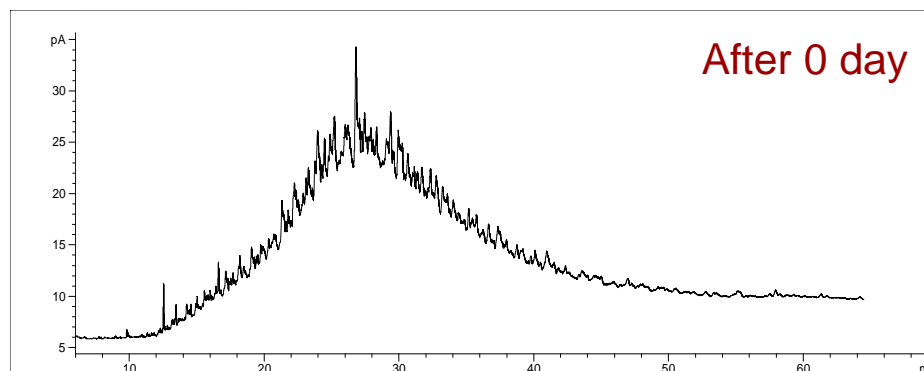
NON SEQUITUR WILEY



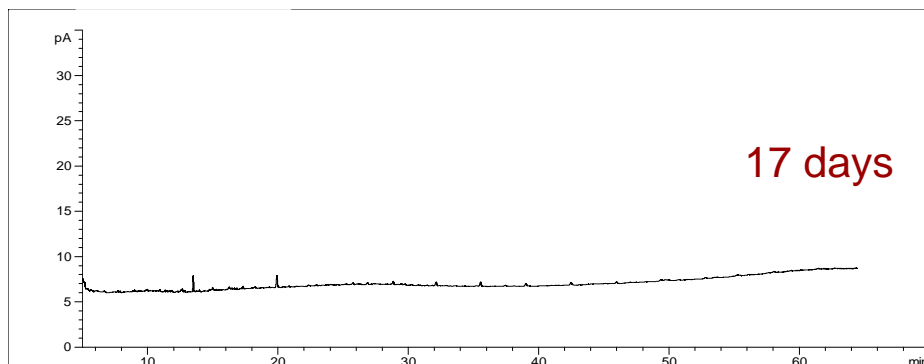
www.ence.umd.edu/~apdavis/Bioret.htm



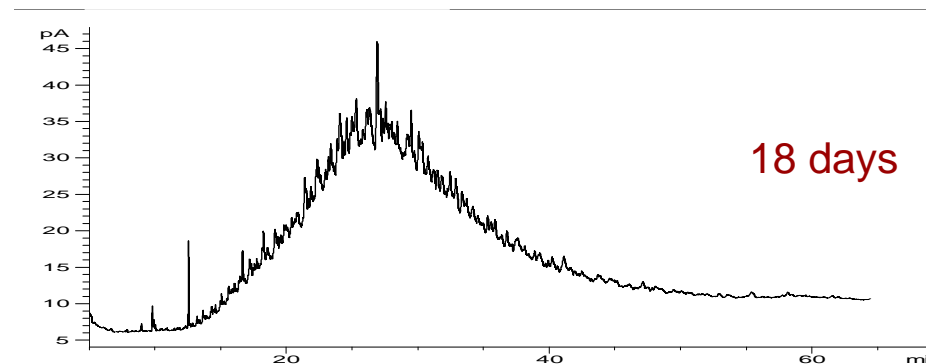
Motor Oil



Bench Reactor



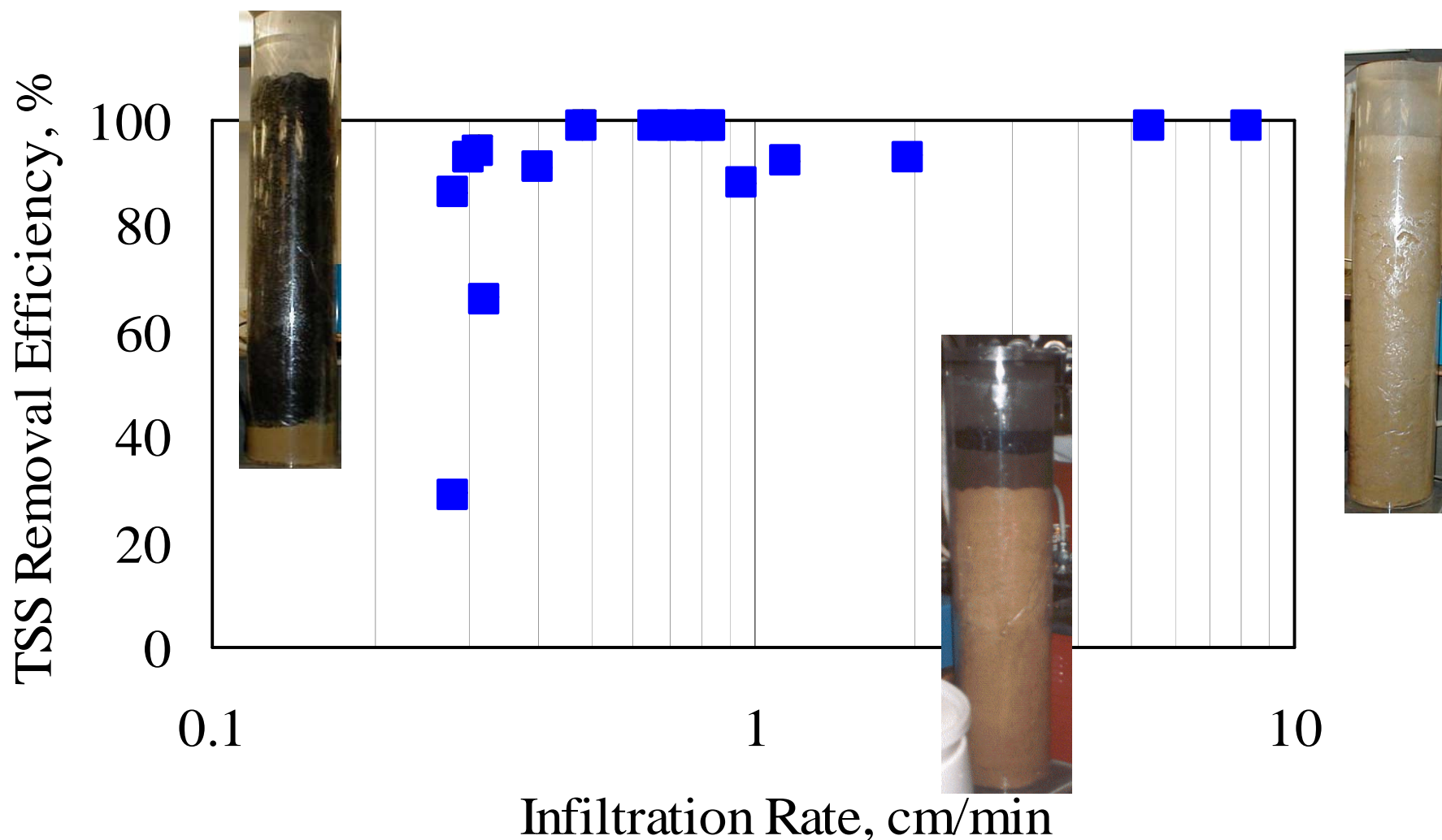
Biotic



Inhibited



Media & Suspended Solids (*O&G, Pb*)





Challenges

Practical

- Lack of Understanding
- Space/Utilities
- Regulatory Hurdles
- Inertia
- Contractor Inexperience
- Ownership of Pollutants
- Maintenance

Research

- Long term
- Chloride
- Design/
Performance
- Vegetation
- Variability
- Metrics of Success



Mass Loads (kg/ha/yr)

| | CP | | SS | |
|----------|------|-------|------|--------|
| | In | Out | In | Out |
| TSS | 1190 | 37 | 570 | 38 |
| Chromium | 0.09 | 0.015 | 0.02 | ~0.007 |
| Copper | 0.26 | 0.073 | 0.12 | 0.045 |
| Lead | 0.09 | 0.013 | 0.03 | ~0.005 |
| Zinc | 1.0 | 0.063 | 0.36 | 0.017 |
| Chloride | 6800 | 458 | 320 | 25 |
| TN | 27 | 7.2 | 9.6 | 3.6 |
| Nitrate | 12 | 2.5 | 3.7 | ~0.19 |
| TKN | 15 | 4.1 | 6.0 | 3.6 |
| TP | 3.6 | 0.72 | 0.9 | 0.38 |
| TOC | 44 | 154 | 43 | 78 |