

An Urban Stream Continuum: gutter subsidies, upland riparian zones and engineered “urban karst” and lotic ecology

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2009 Annual Meeting
of the Association of Mid-Atlantic Aquatic Biologists
Cacapon State Park, Berkely Springs, WV

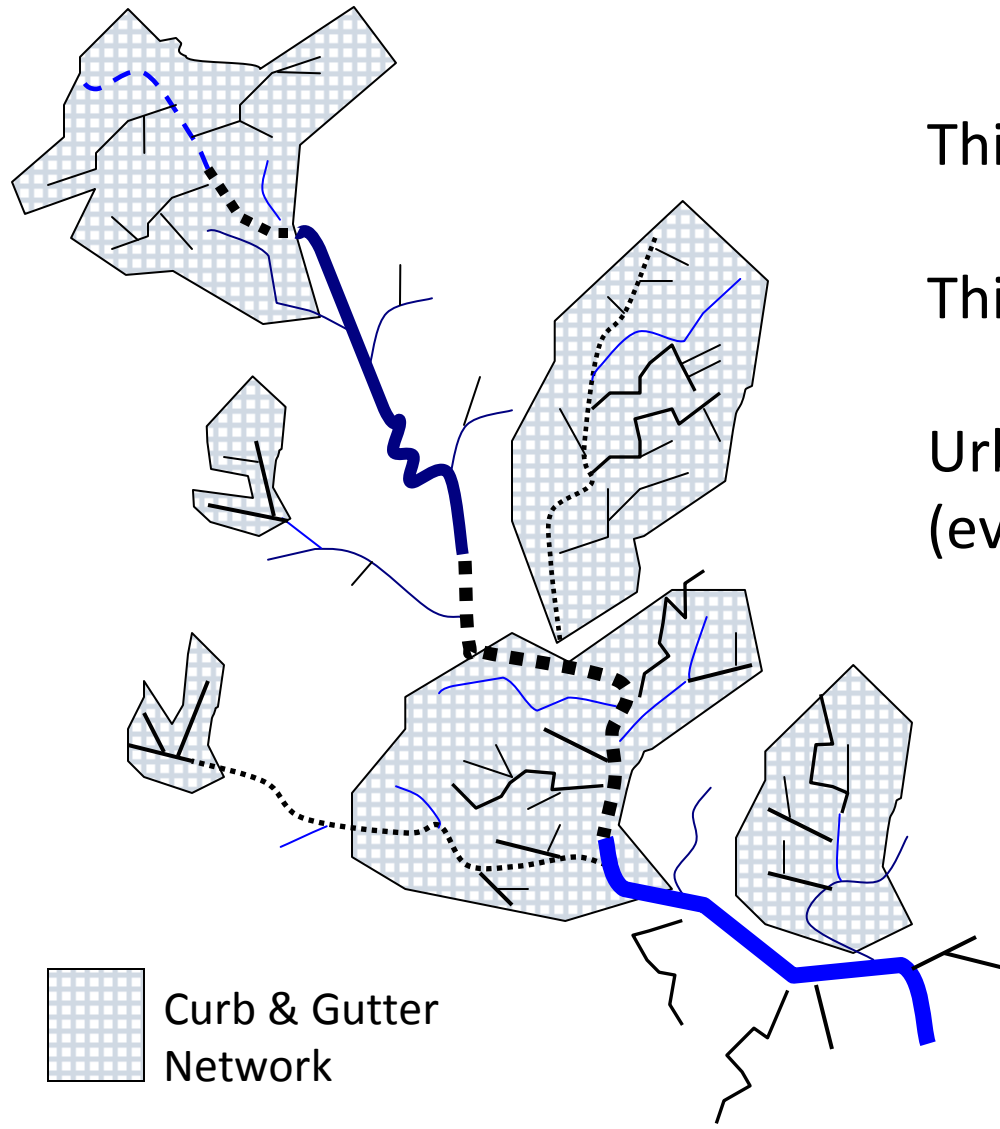
April 1, 2009



Goal:
Think “outside of the pipe”
Urban streams really are not big “gutters”



Stream Restoration Goals, Bioassessment, Watershed Mgt



Think “karst”

Think upland

Urban streams are not gutters
(even if they are)

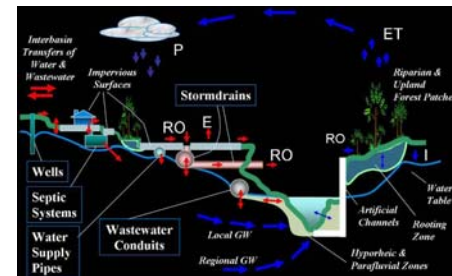


Outline

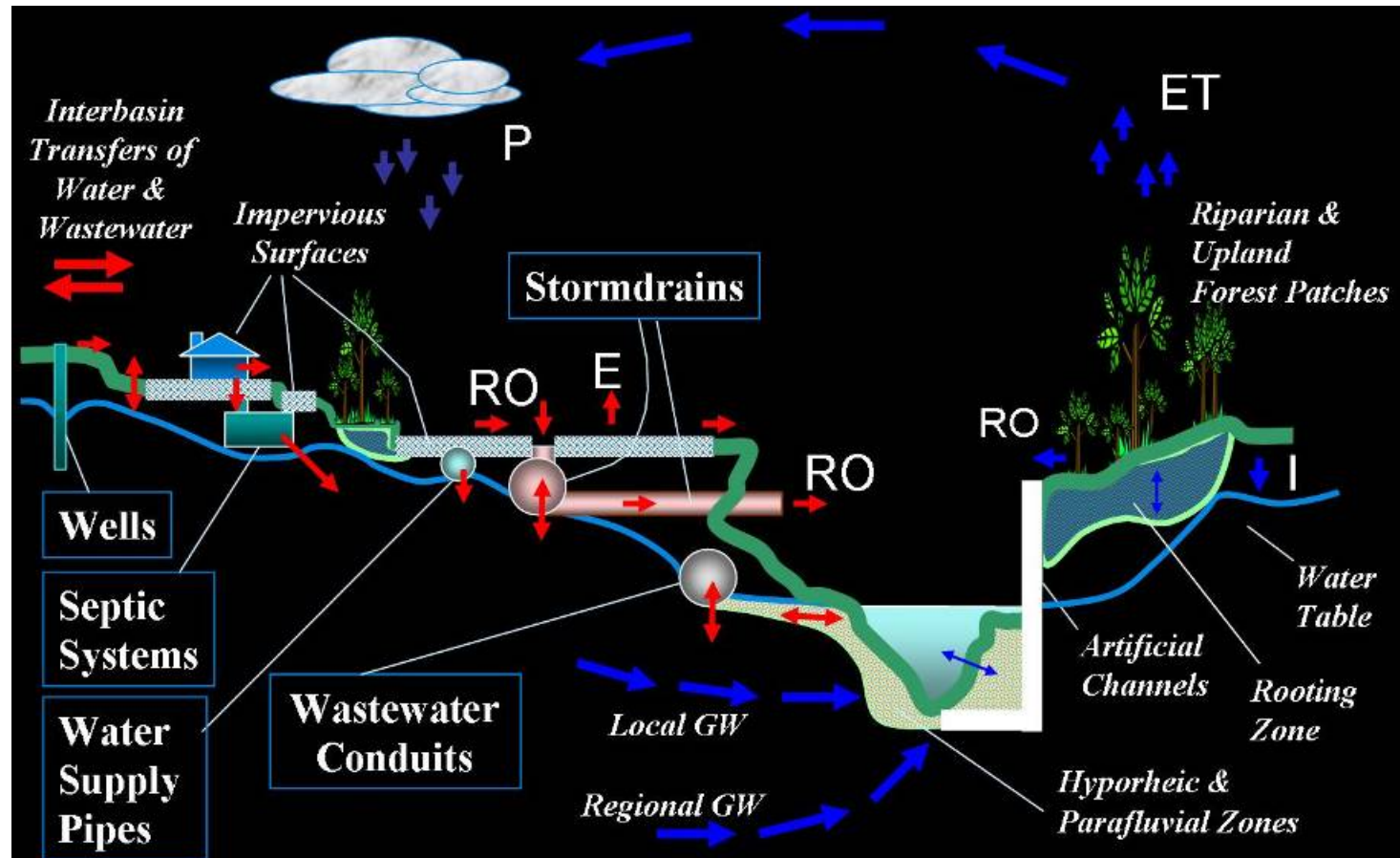
- I. Complexity of Urban Hydrologic Systems
- II. Interconnected Hydrology
- III. The Gutter Subsidy
- IV. The Urban Stream Continuum



I. Complexity of Urban Hydrologic Systems



The Urban Hydrologic System: infrastructure driven pathways

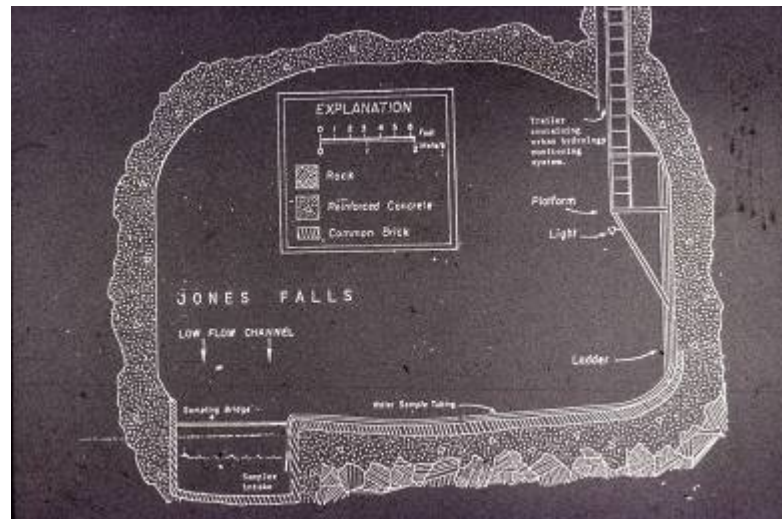
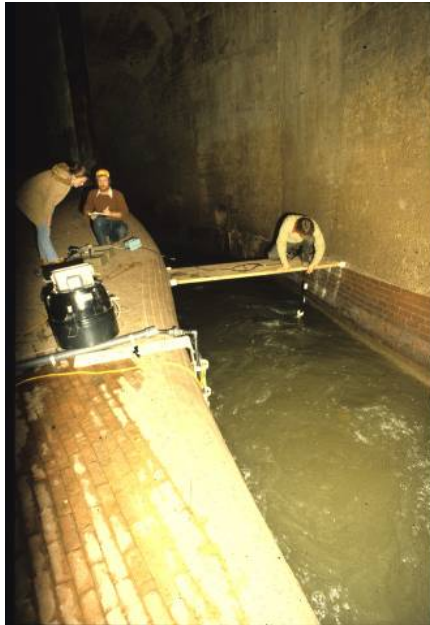


Stormwater Runoff... damage to infrastructure

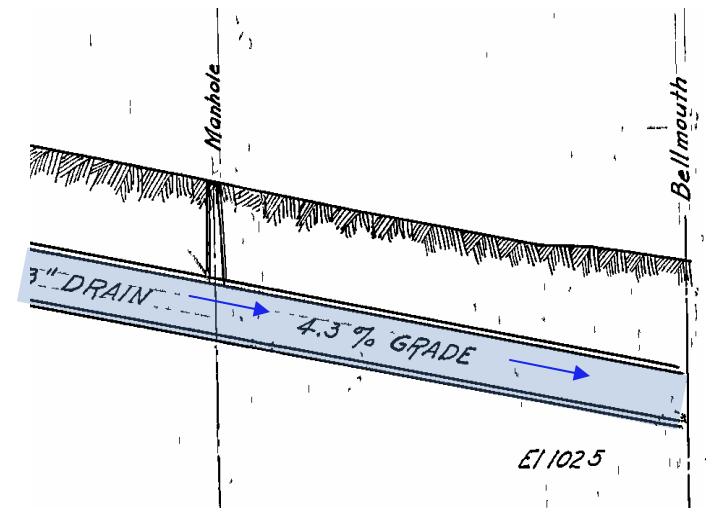
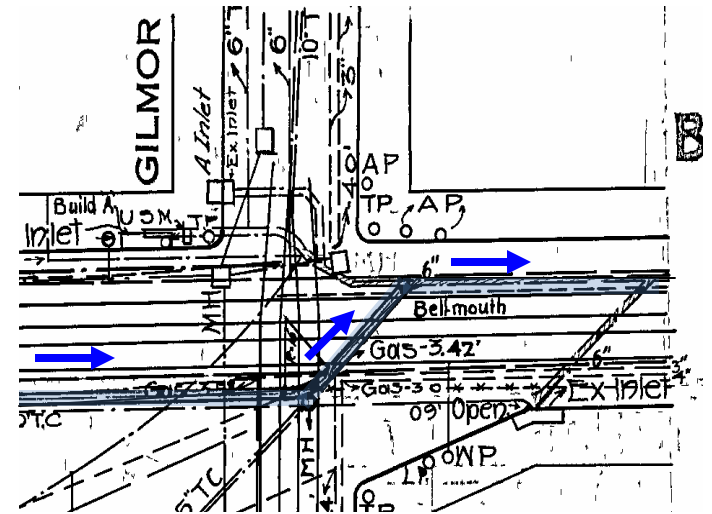
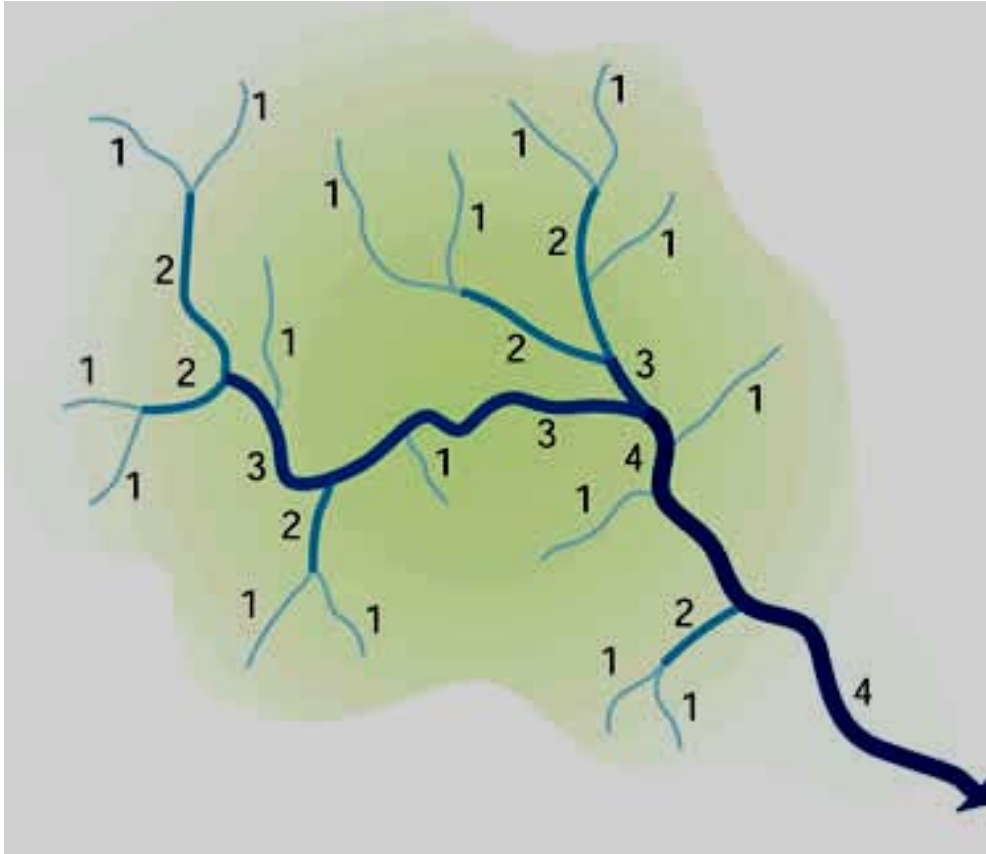
The “one dimensional” view of an urban stream



The 3rd dimension: e.g., the long buried Jones Falls (Downtown Baltimore)



The 3rd dimension: Storm Drainage Networks... the unseen “headwaters”

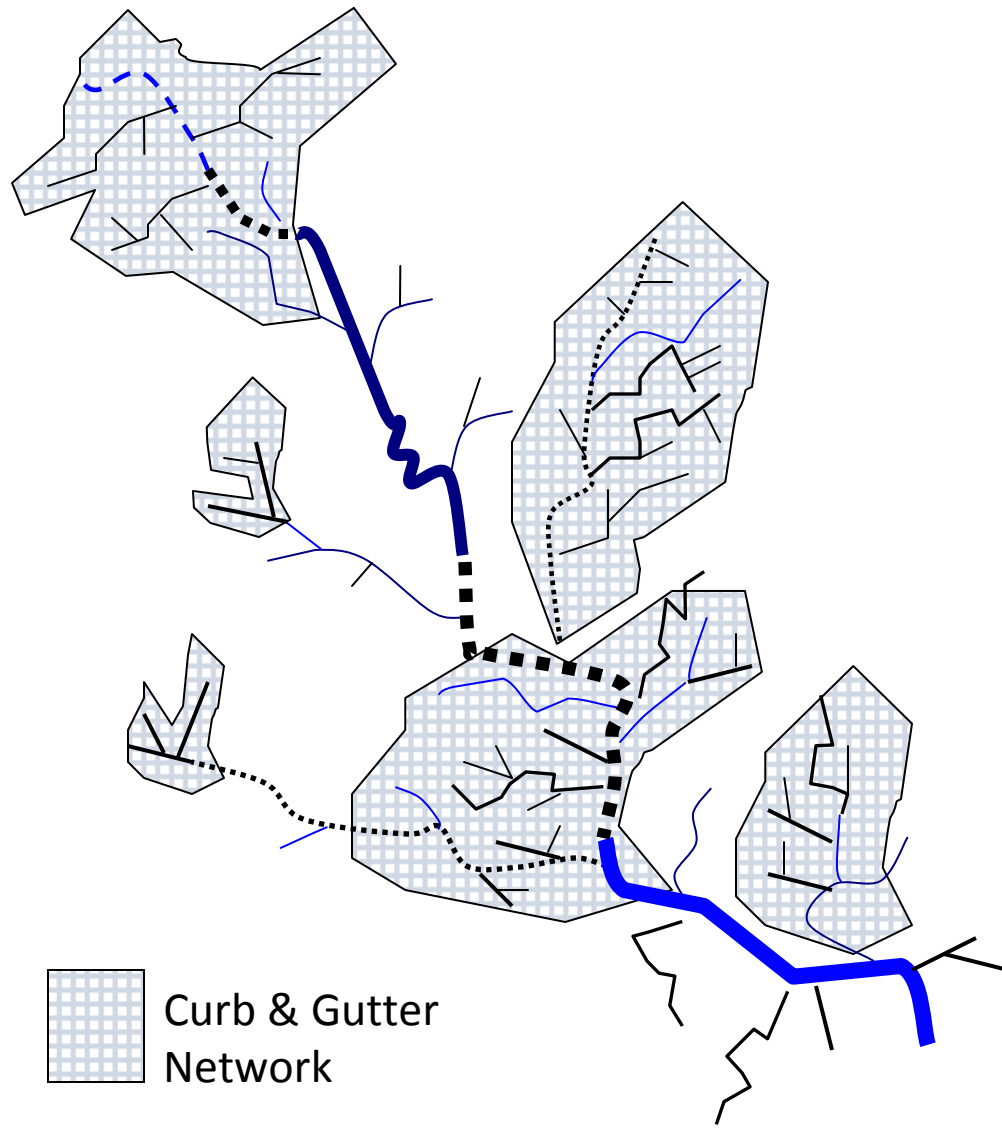


The Baltimore Street Sampling site... a buried headwater stream



Curbs & Gutters...

Increased drainage density... complex hydrology & fluxes

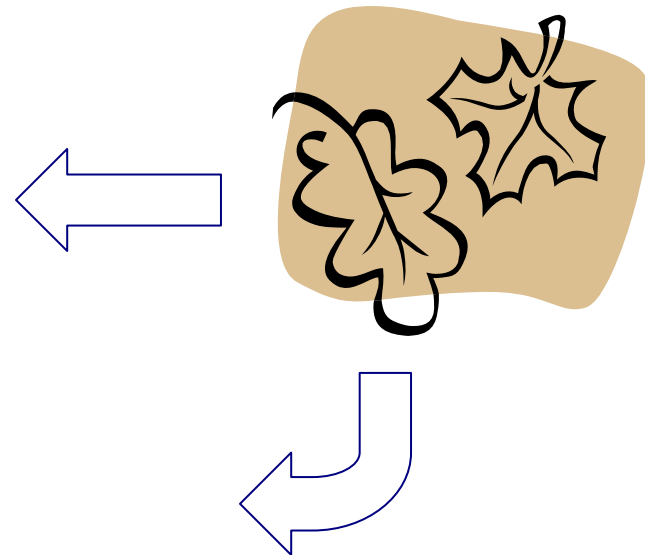


Organic Matter in Streams

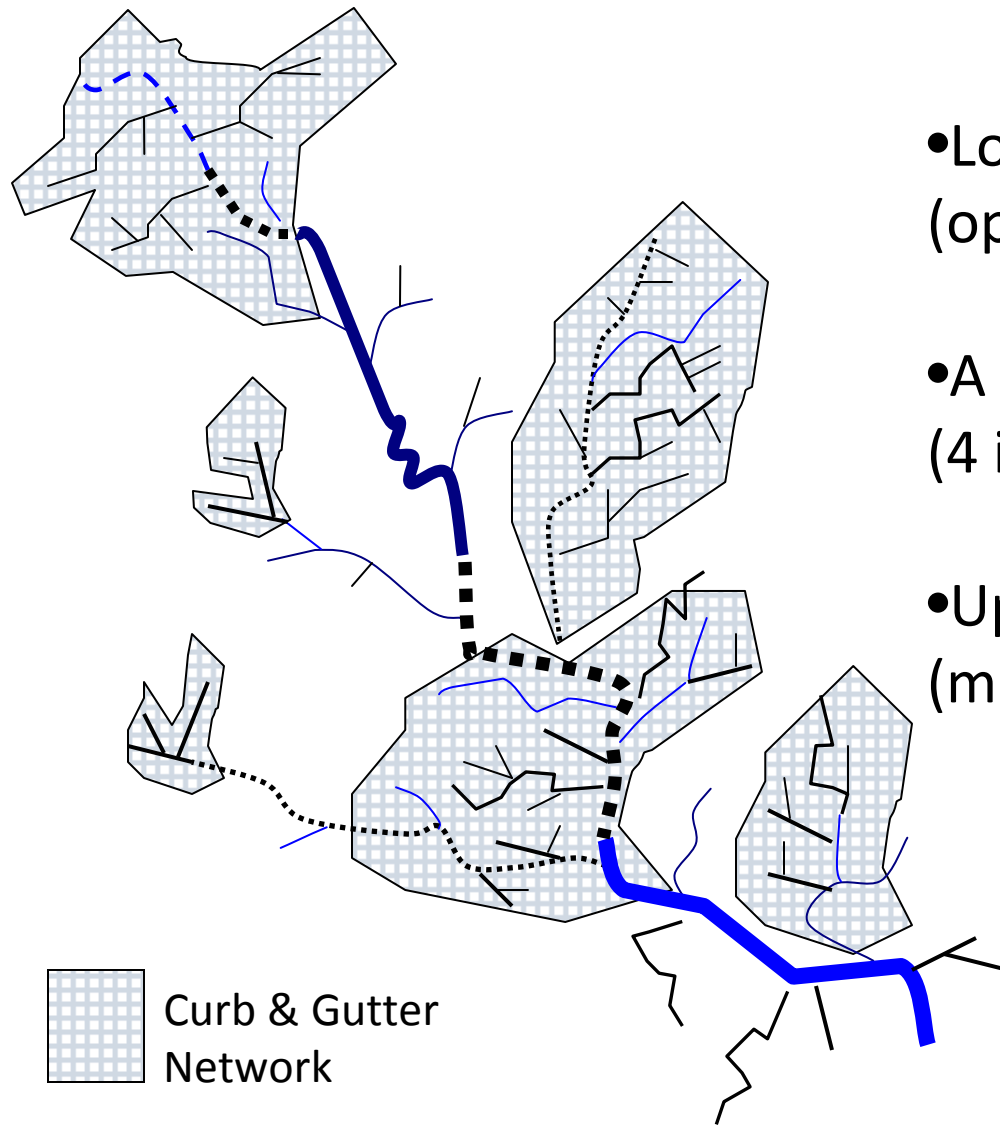
DOC- dissolved OM

FPOM- fine particulate OM

CPOM- coarse particulate OM



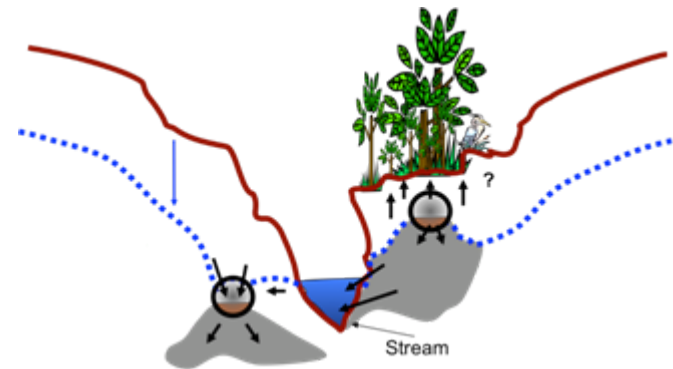
Given a 3 dimensional network.... How might restoration, mgt and bioassessment approaches change?



- Lots of drainage pathways (opportunities)
- A 3 dimensional network (4 if you count time)
- Upland hydro connections (more than riparian?)



II. Interconnected Hydrology



There is a lot of stormwater in urban streams...

The Urban Stream Syndrome...
poor water quality & biota, floods, channel
damage, etc.



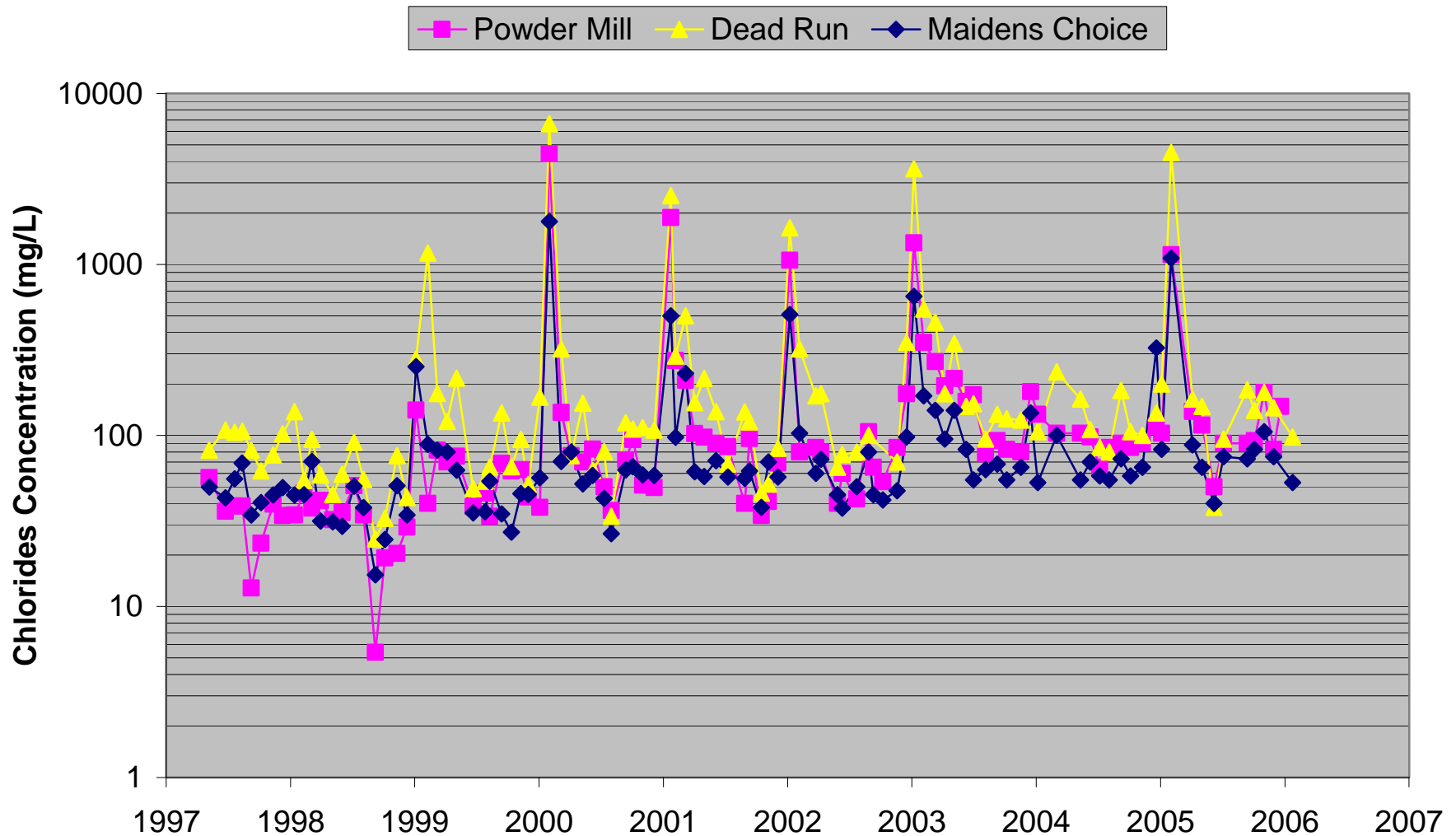
Stormwater Management...

Infiltration... a panacea ???



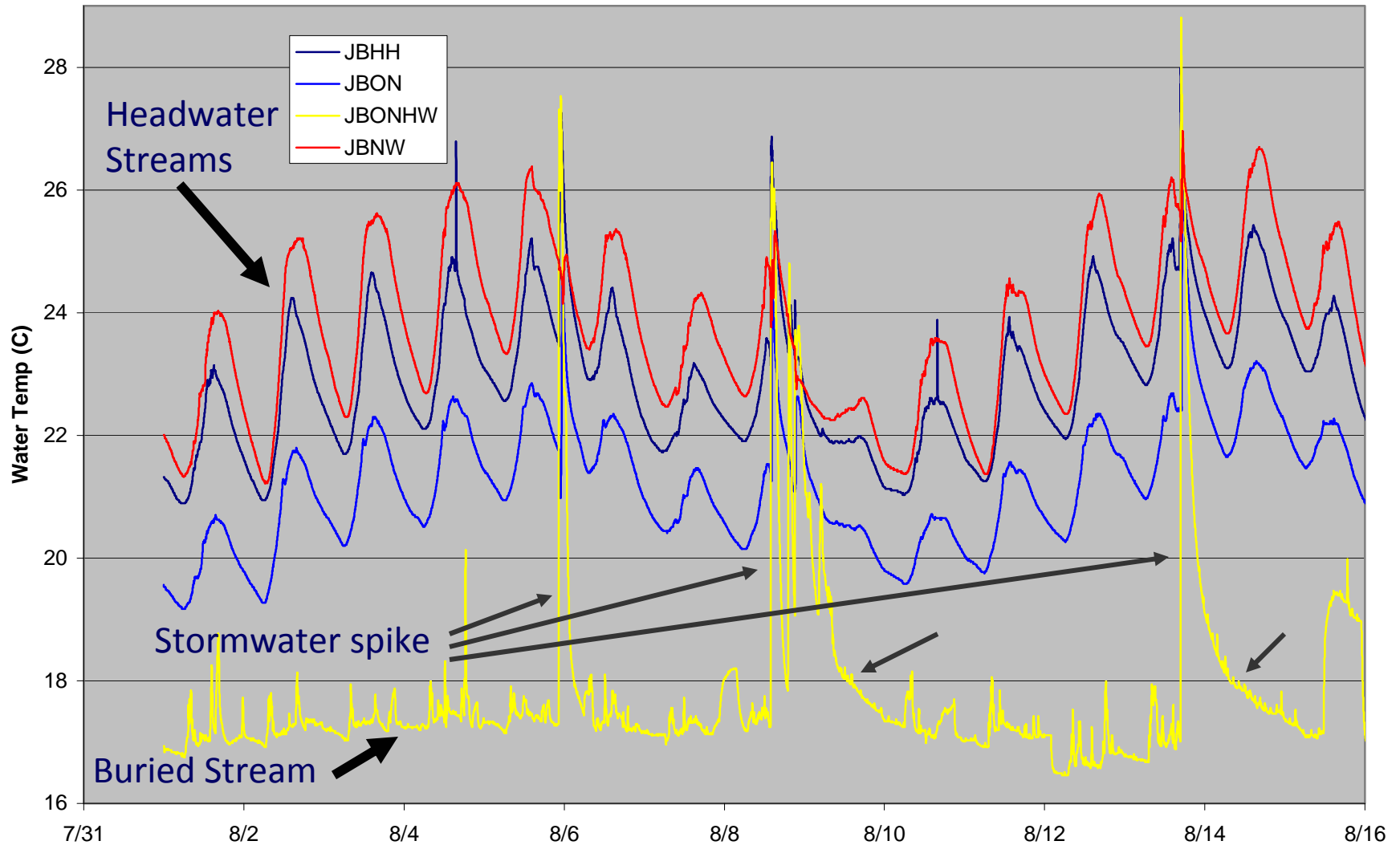
Deicers... High Chloride Year-around (and a pronounced upward trend)

**Chlorides Concentration Gwynns Falls Tributaries Dry Weather
May 1997 through January 2006**

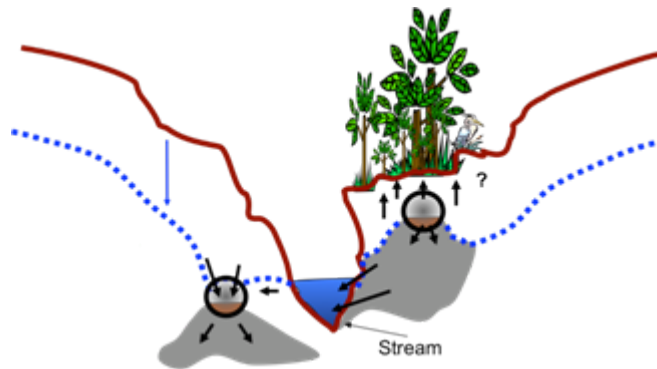


Thermal stream restoration? Stormwater effects on biota?

Cub Hill Streams: 3 scales, Aug 2005



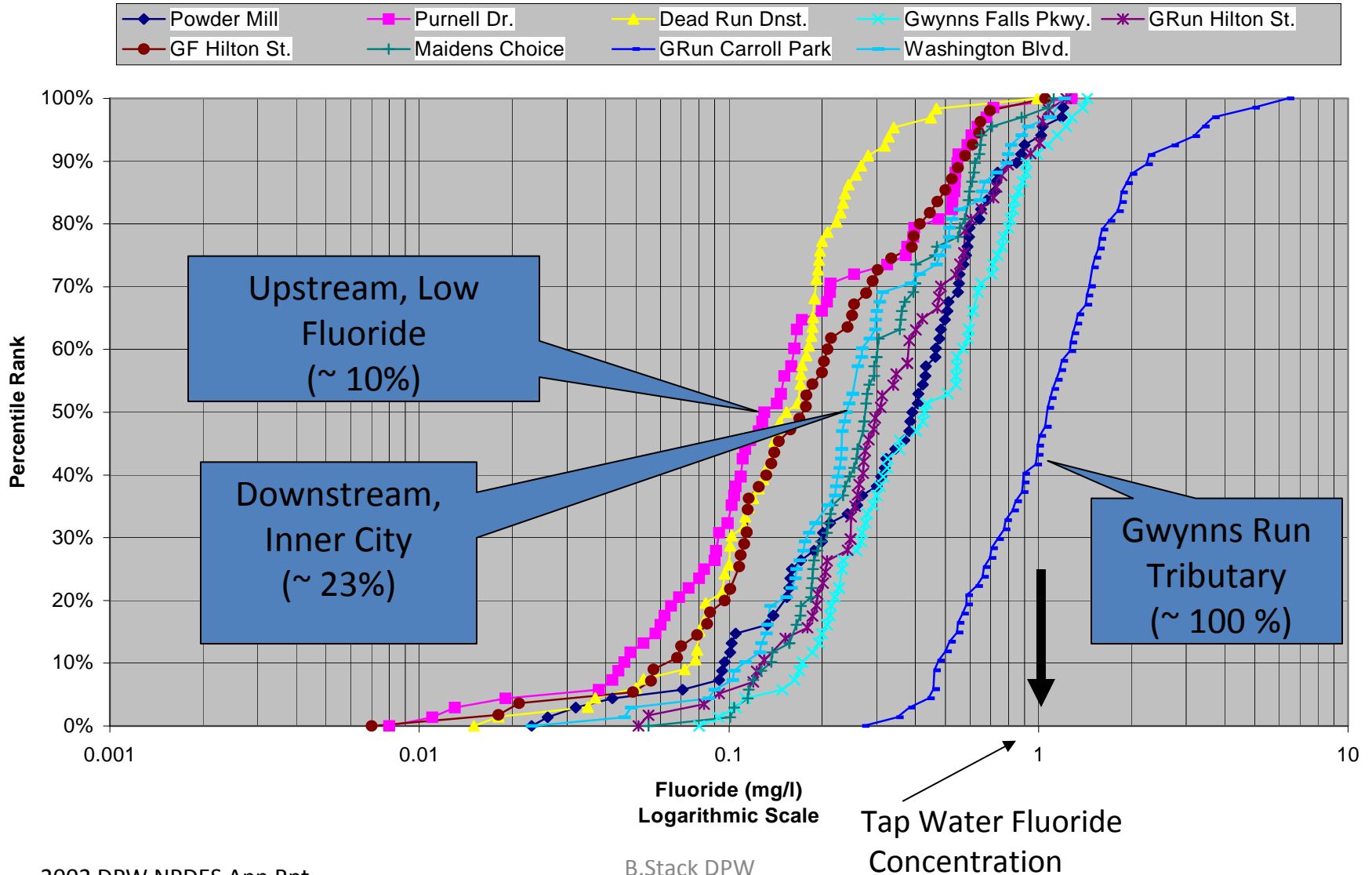
There is a lot of
potable and waste
water in urban
streams



Fluoride in Gwynns Falls Streams...

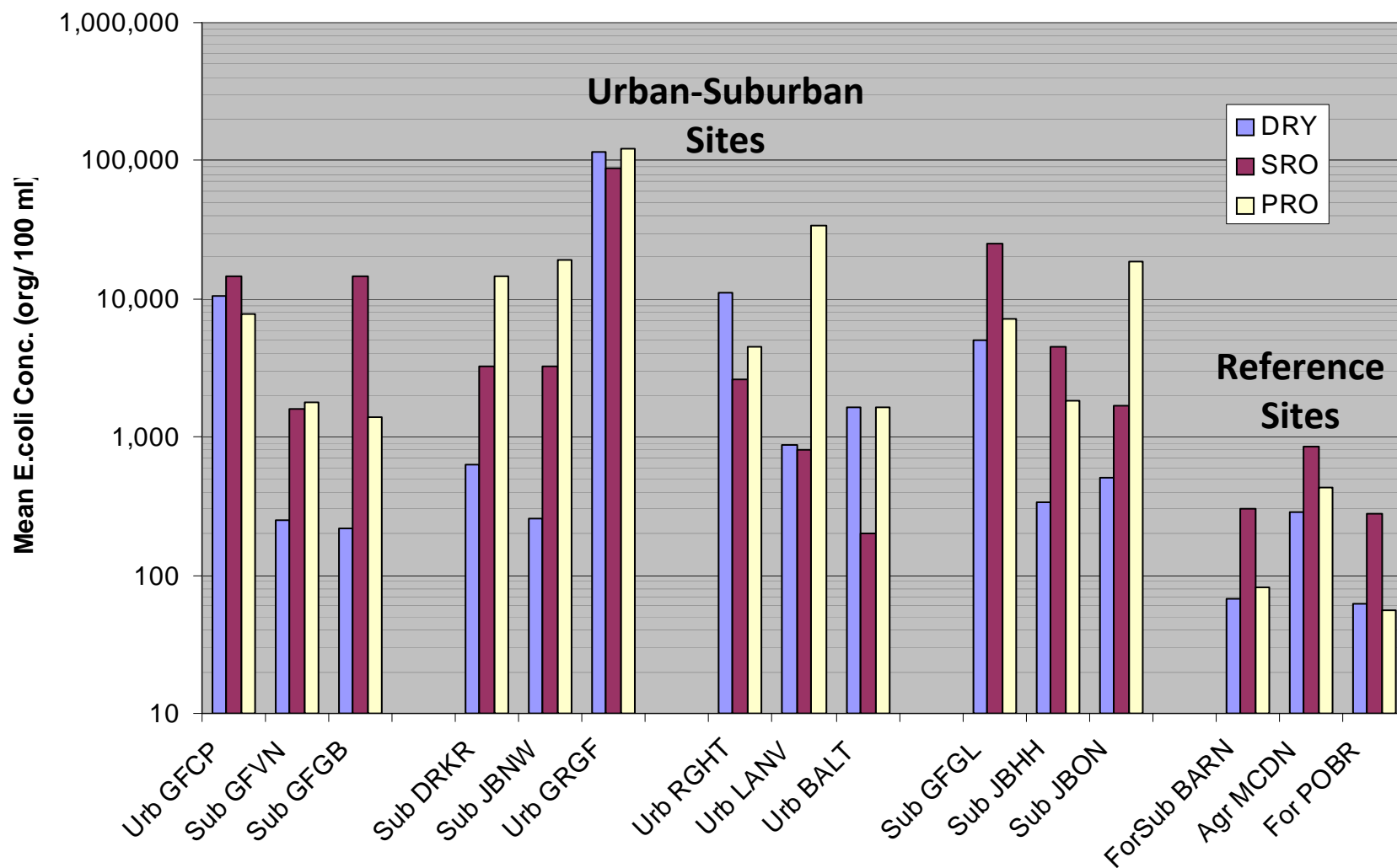
Intertwined Hydro Systems

Fluoride Dry Weather Samples Gwynns Falls Watershed (5/97-12/02)



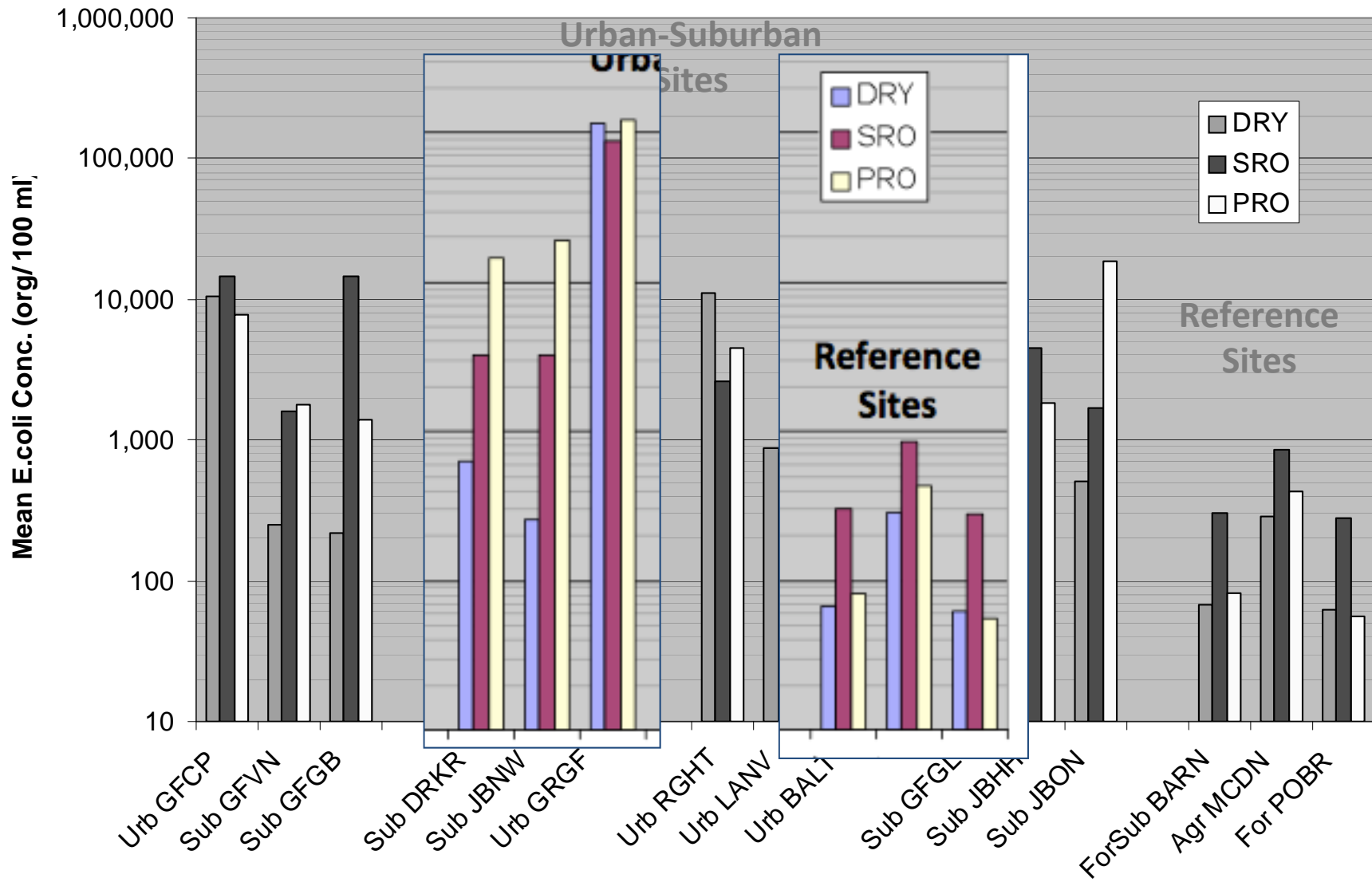
E. coli... everywhere

E.coli Mean Concentration: Dry, Storm RO, and Post Storm Runoff Flows

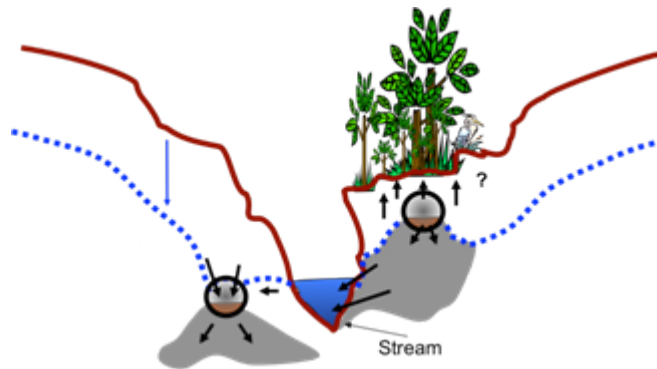


Post Storm Flows... high *E.coli*

**E.coli Mean Concentration:
Dry, Storm RO, and Post Storm Runoff Flows**



There is a lot of waste water
in urban streams...
and vice versa



Sanitary Sewers....

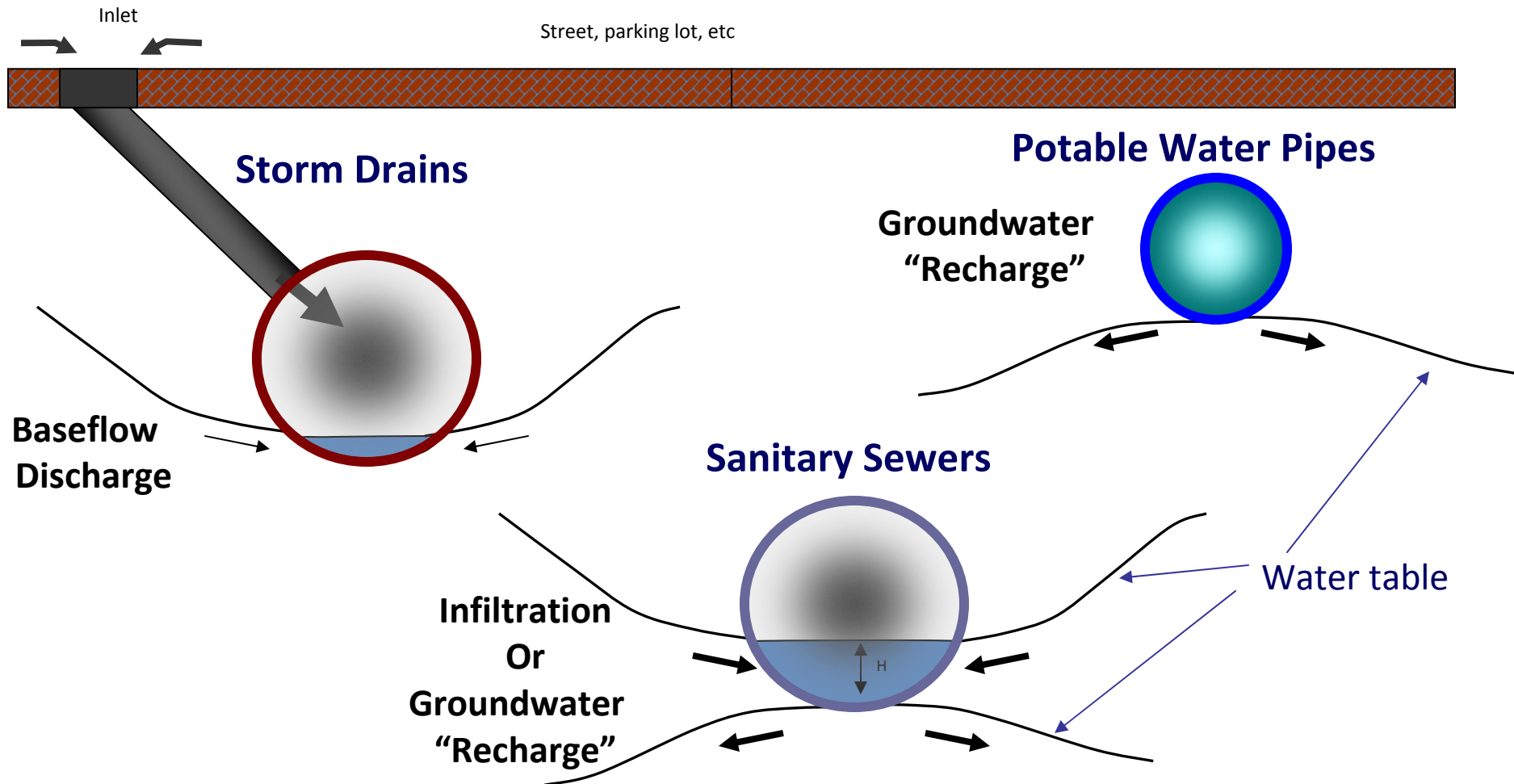
Two Way Riparian Interchanges with stream water



... how about upland ???



The Matrix: A dense, landscape-wide systems of pipes... an urban “Karst”



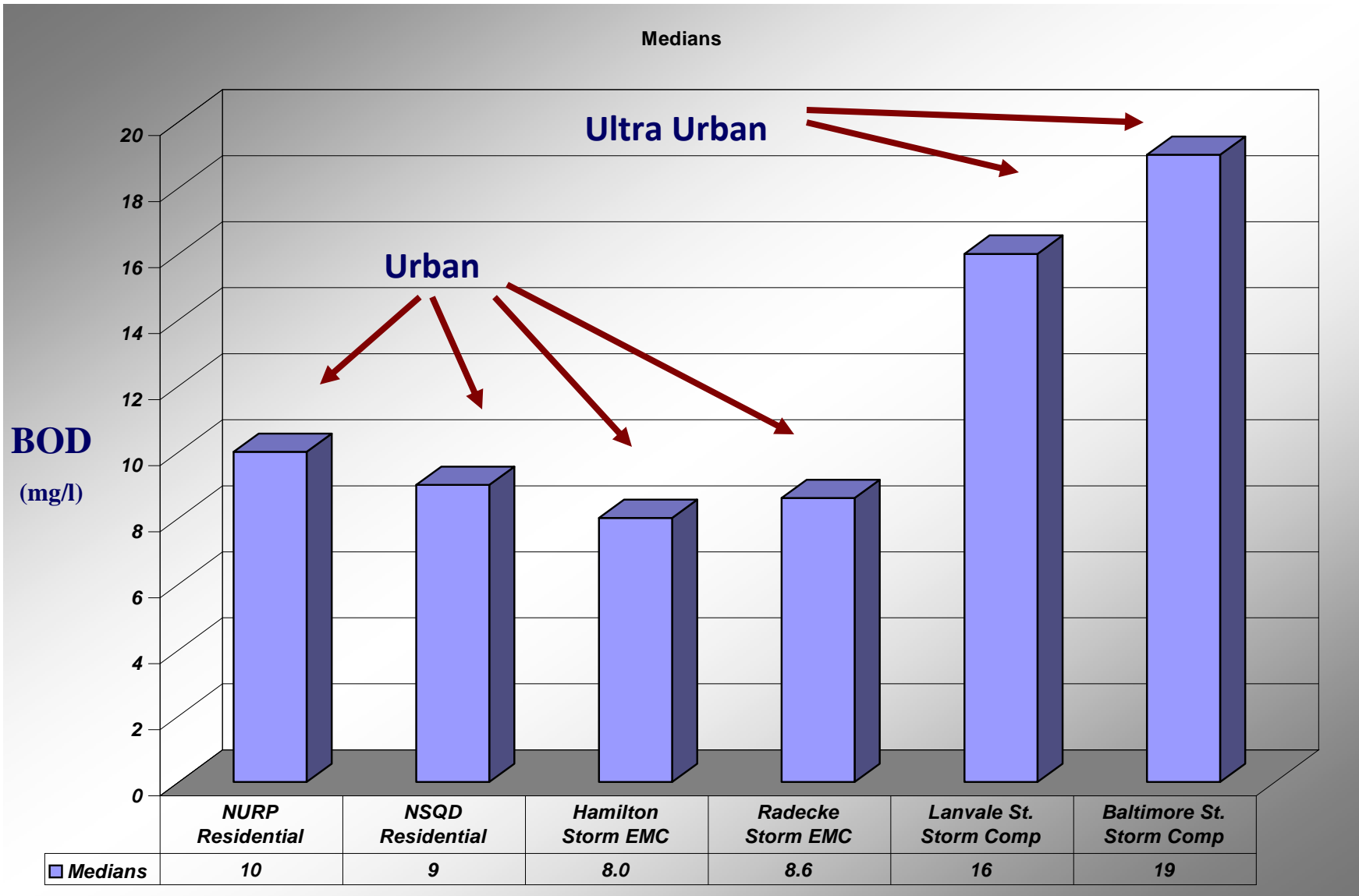
That 4th dimension...

Are old urban
catchments hotspots?



Urban Runoff...

Headwater Hotspots? Ultra- Urban?



Rognel Heights Storm Composite

Well kept, but old, neighborhood... lots of DOC

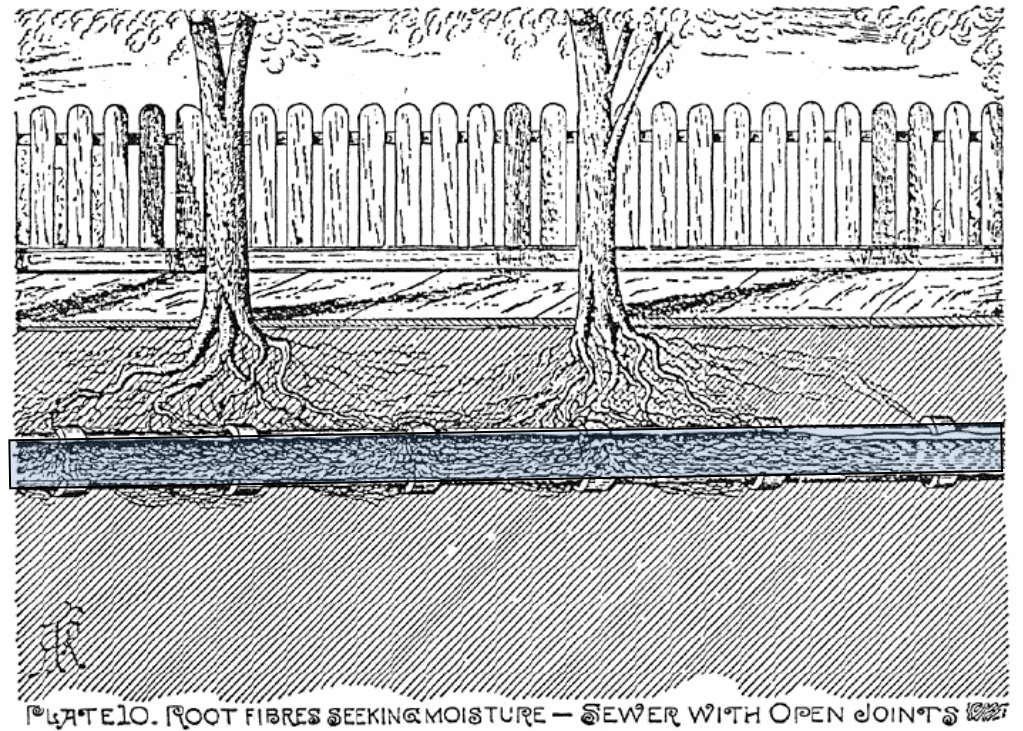




III. The Gutter Subsidy



Urban Canopy... intimately connected to drainage



Alleyways, Roof Gutters, etc... Organic Matter “Pumps”?



CPOM-FPOM-DOC... lots of processing



Cars as shredders....



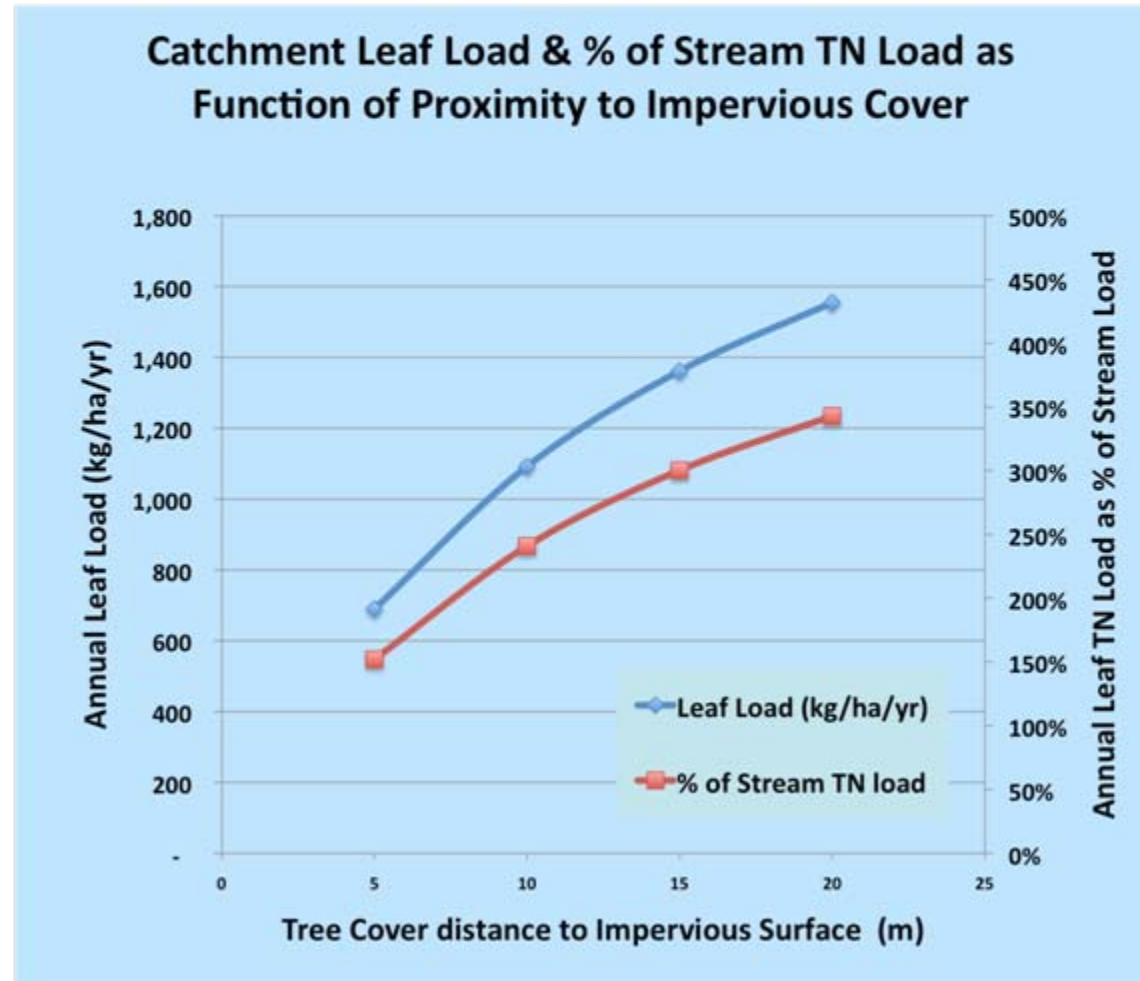
Catchbasins... urban “debris dams” ?



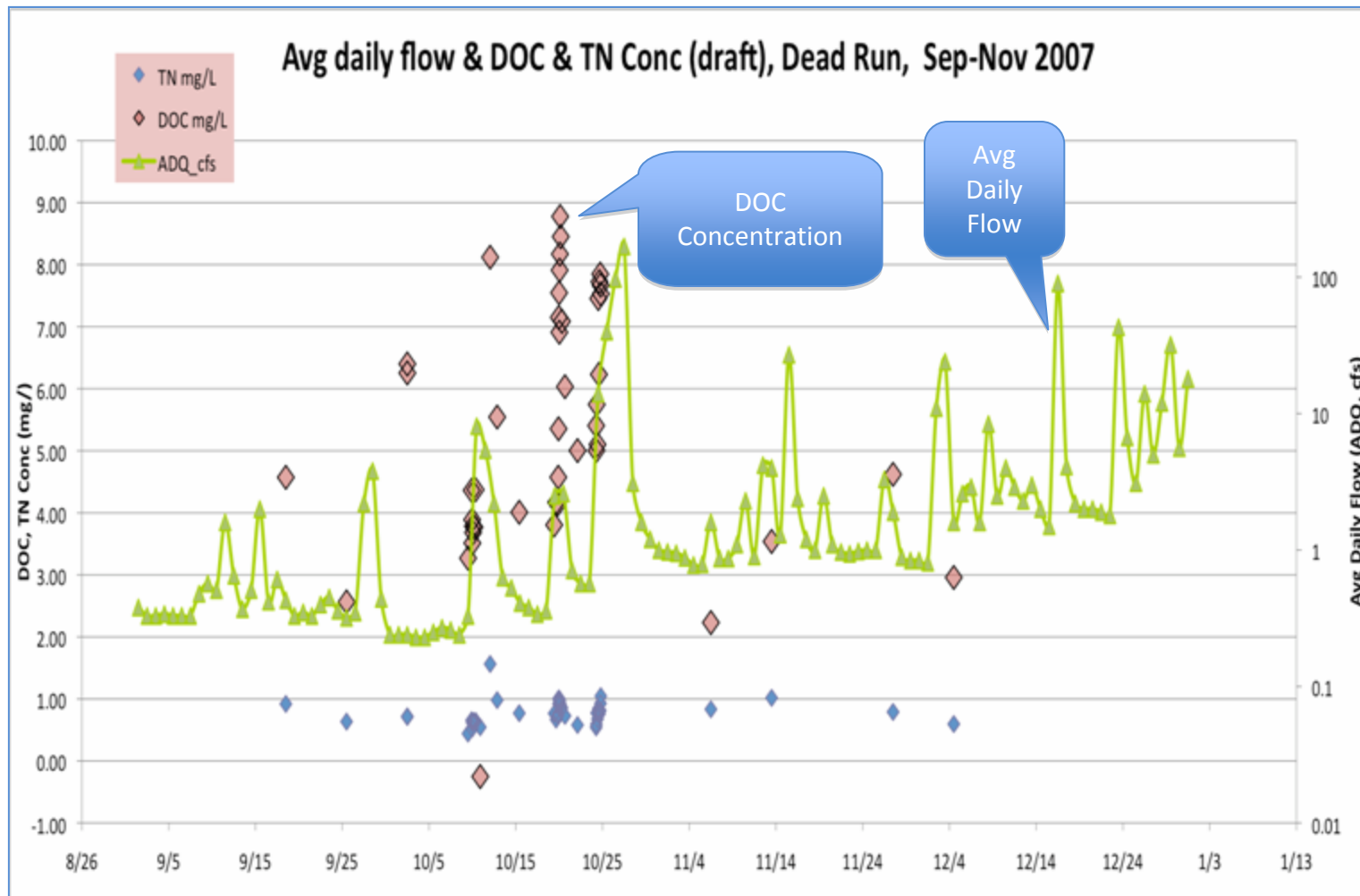
So.... Urban landscapes should be “Big Time” OM
Exporters (and Processors)



Are we missing a huge part of fluxes by not considering the particulate fraction (eg TN)?



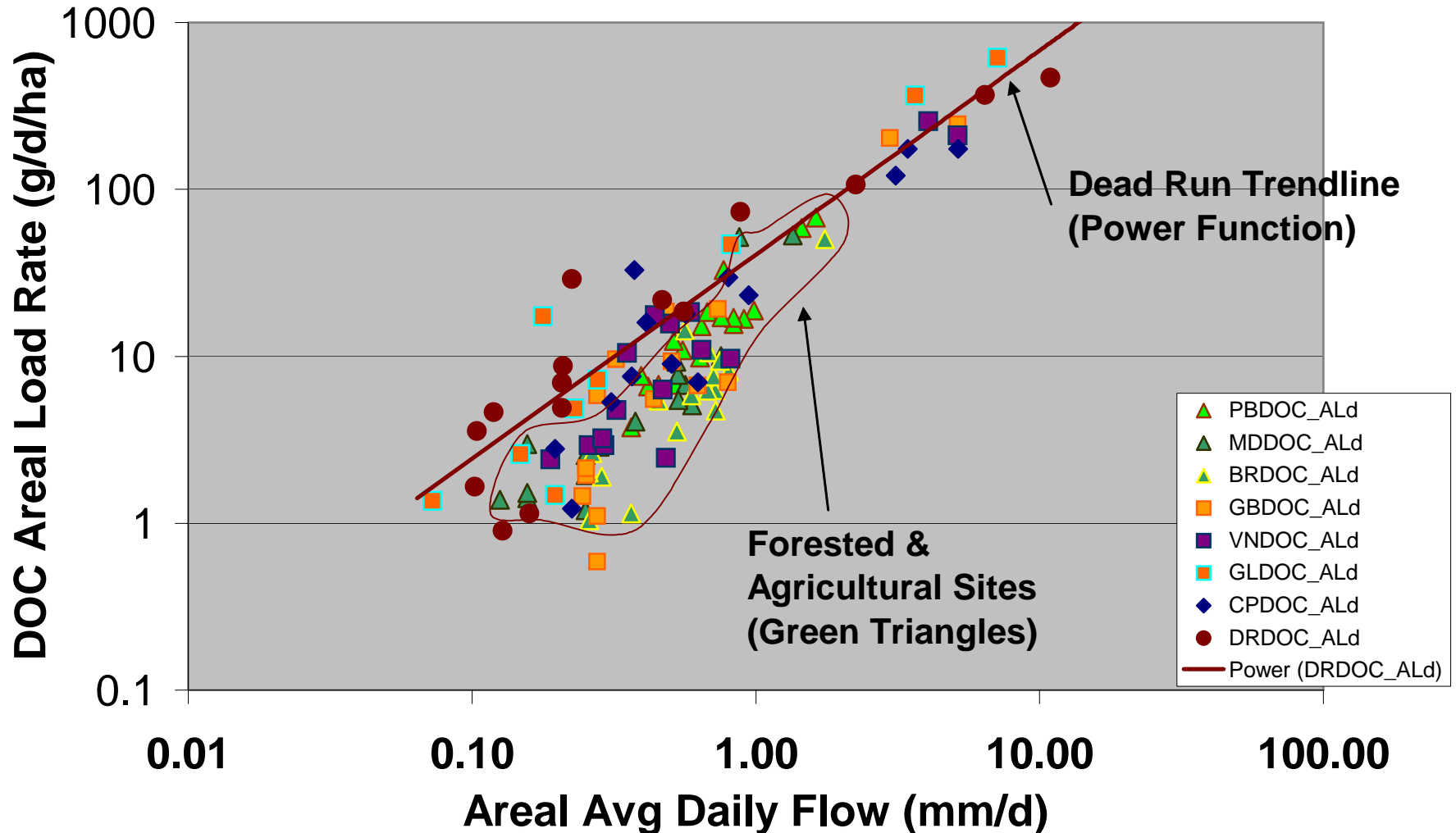
Urban Runoff... Dead Run, lots of DOC



Urban Stream DOC... Hydrology Rules!

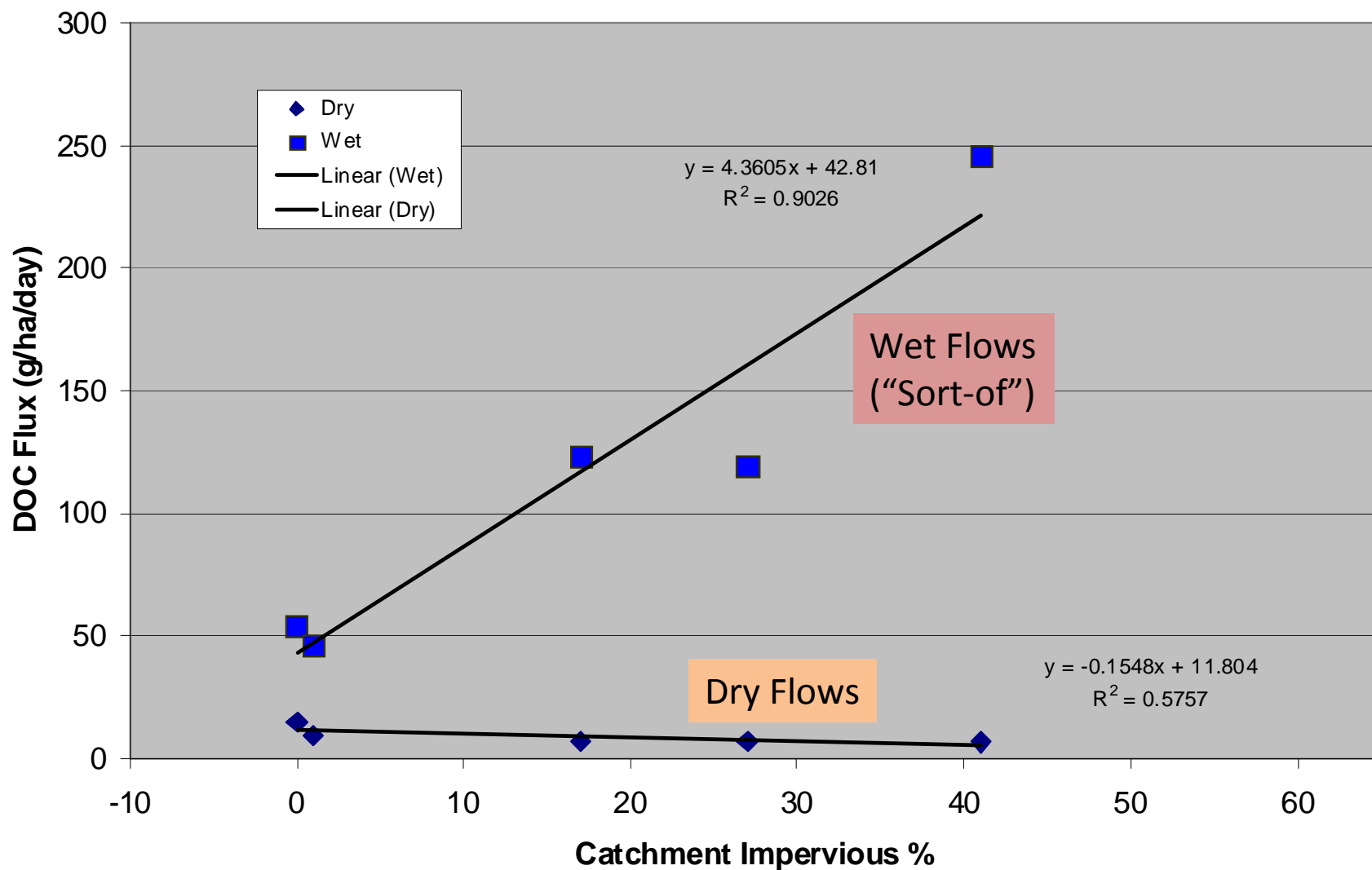
DOC Areal Load vs Areal Flow Rate

(8 catchments, 15-20 samples each, July-Nov 2005)



DOC Flux vs. Impervious Cover... the gutter subsidy?

Dry & Wet DOC Areal Flux Vs. Impervious Cover %
2005-2006

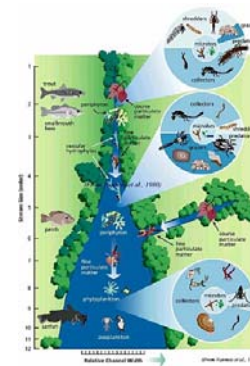


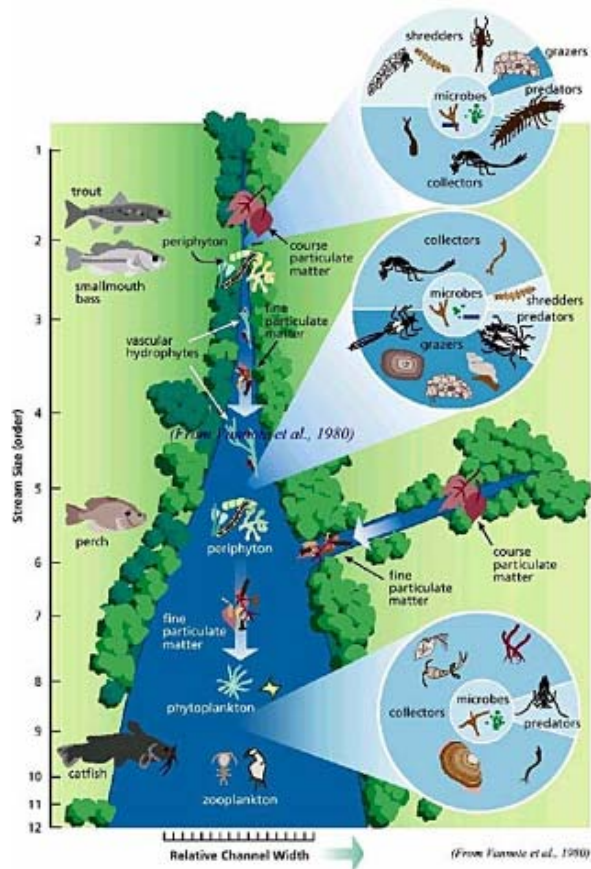
So urban streams have lots of DOC & POM...
carbon to fuel BGC processes (eg denitrification)





IV. The Urban Stream Continuum





Is there an **URBAN** Stream Continuum ?

The Natural Stream OM Continuum

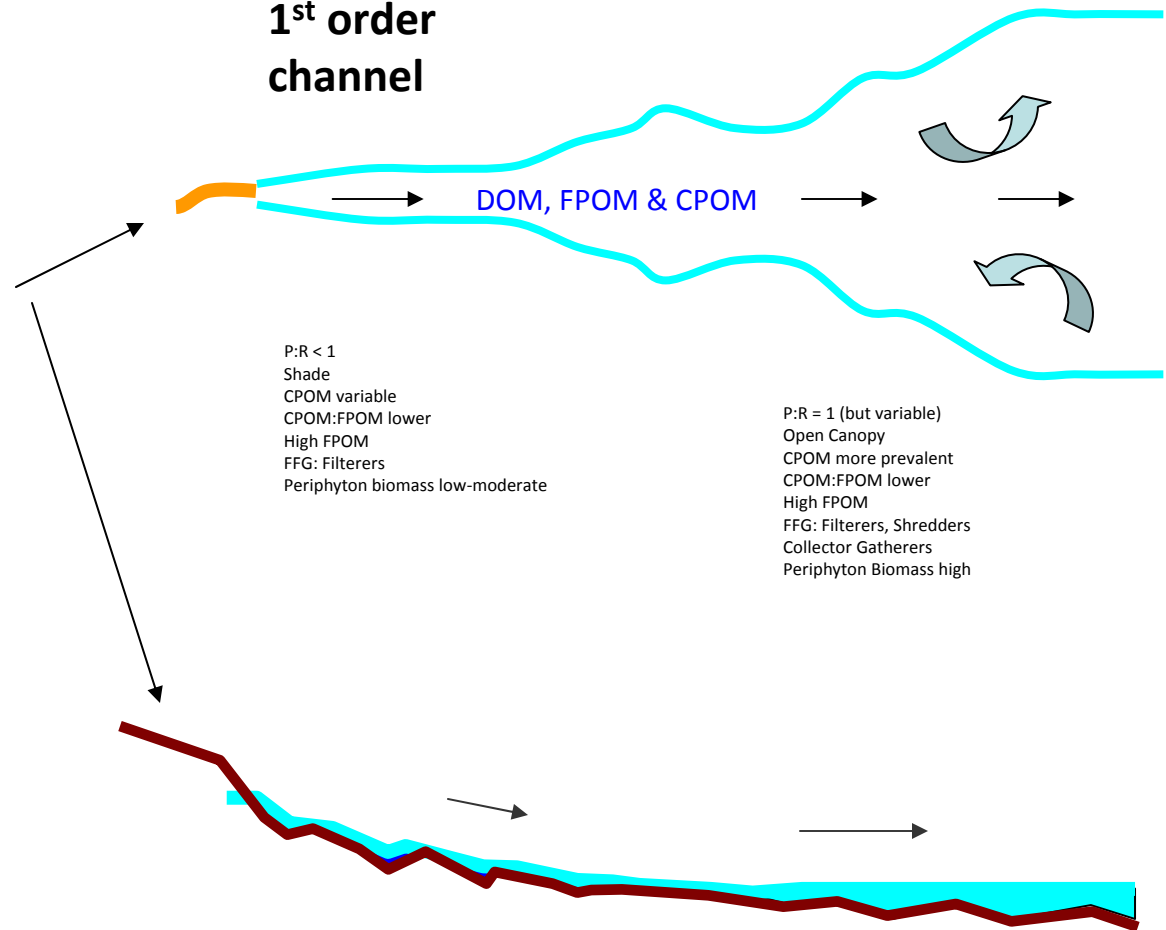


1st order channel

2nd order channel

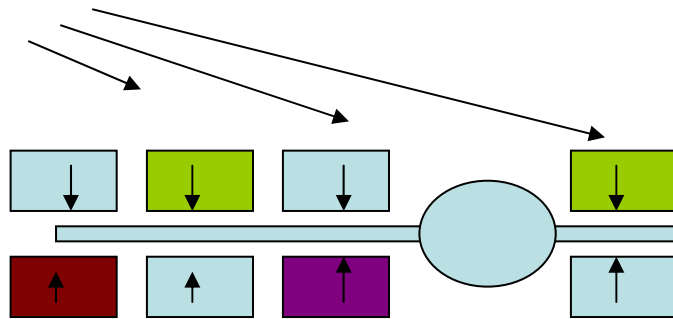
3rd order channel

Zero Order Channel
(Some RO, OM Inputs)



The Urban Stream Continuum

**Extensive New “Zero Order”
and New 1st Order (buried)
streams**



$P:R \ll 1$
Subterranean
Low CPOM
CPOM:FPOM high
No FFG

**1st order
channel**

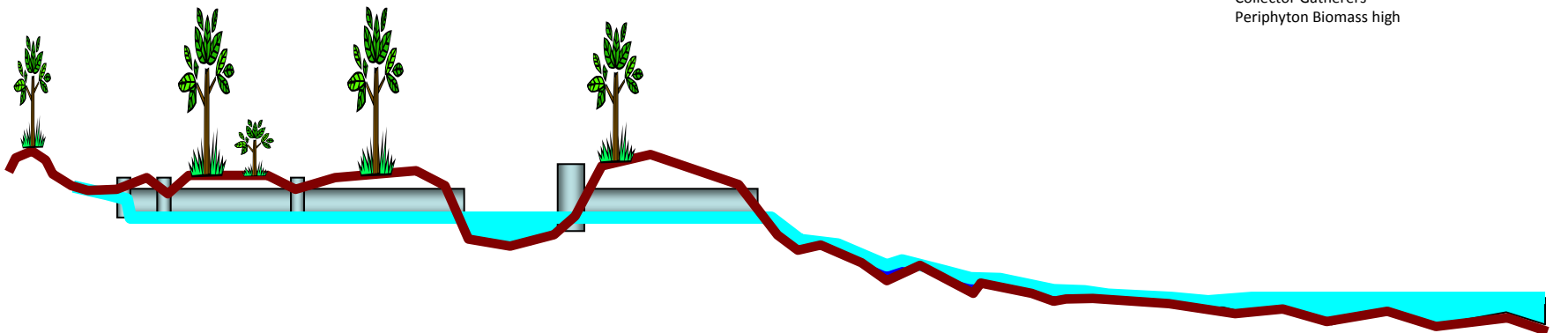
DOM, FPOM & CPOM

$P:R < 1$
Shade
CPOM variable
CPOM:FPOM lower
High FPOM
FFG: Filterers
Periphyton biomass low-moderate

**2nd order
channel**

**3rd order
channel**

$P:R = 1$ (but variable)
Open Canopy
CPOM more prevalent
CPOM:FPOM lower
High FPOM
FFG: Filterers, Shredders
Collector Gatherers
Periphyton Biomass high

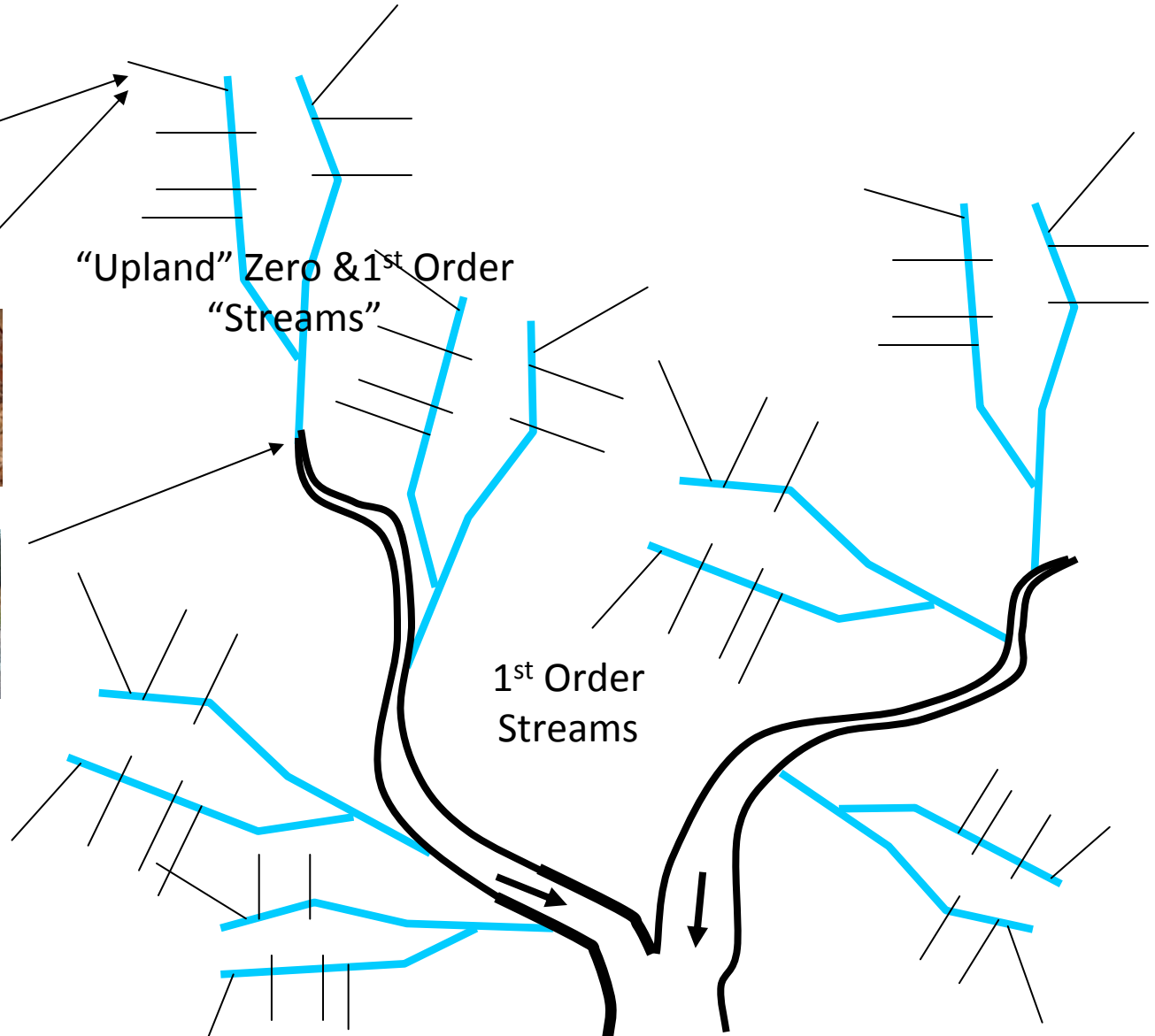


Urban Headwater Streams... additional upstream OM & contaminant sources, processing, etc.



Urban Headwater Streams...

dominate the network



Urban upland “detritivores-shredders”... processing



Catchbasins... large Volumes of OM, Debris Dam Analogues



OM Storage in the Storm Drain Pipes

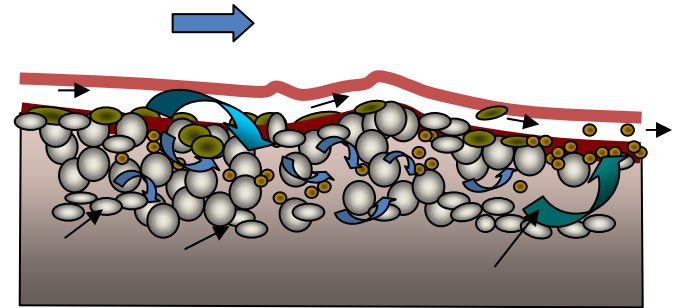


Urban Headwater Streams.... a range of types, all OM “Pumps”?



Urban headwater streams & OM... Function?

- Implications for urban BMPs ?
- Untapped lotic energy sources ?
- Contaminant fate & transport?
- Pathogen “vectors”?



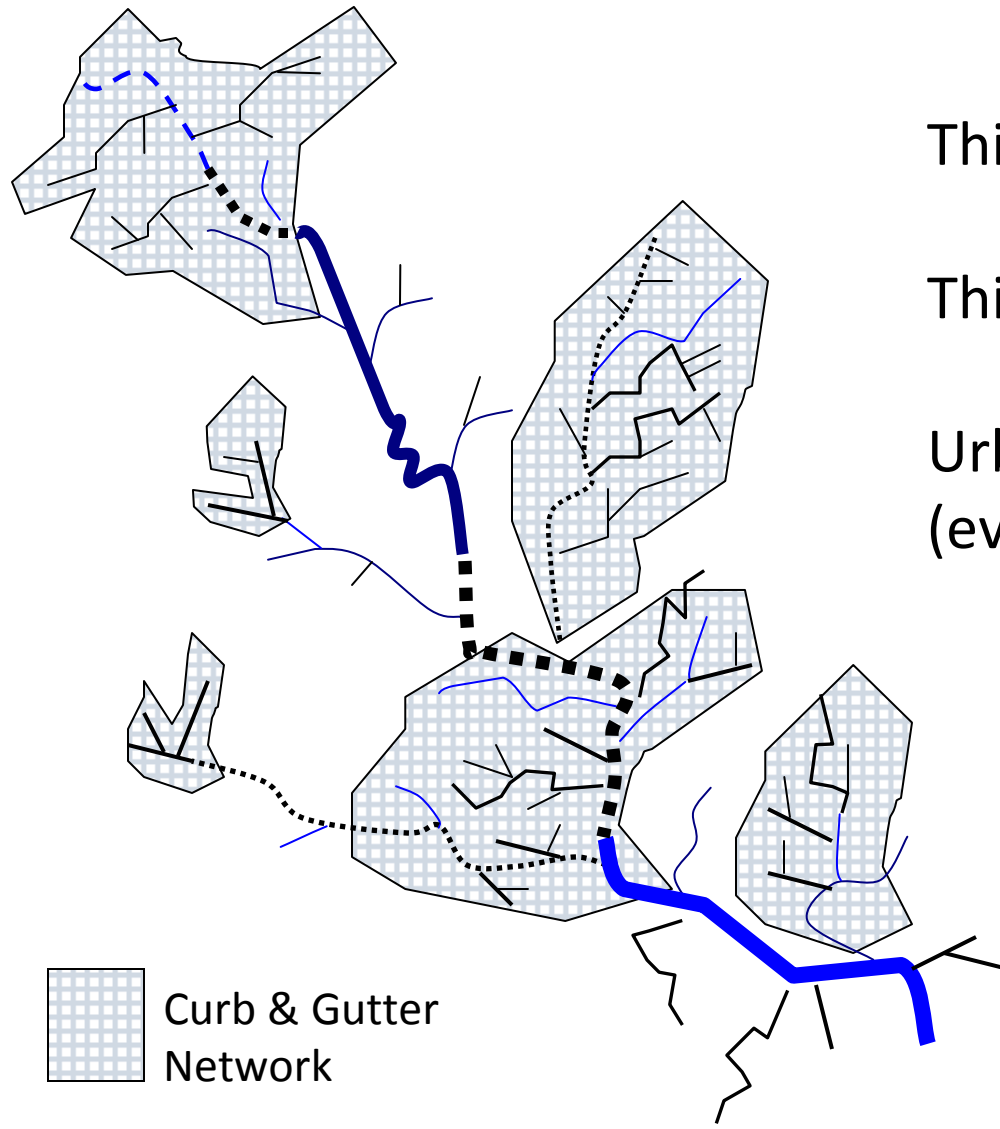
Stream Restoration Goals....

Can we use upland OM to restore urban stream food webs ?



 Curb & Gutter Network

Stream Restoration Goals, Bioassessment, Watershed Mgt



Think “karst”

Think upland

Urban streams are not gutters
(even if they are)



LTER **B**altimore
 **E**cosystem
Long Term **S**tudy
Ecological Research



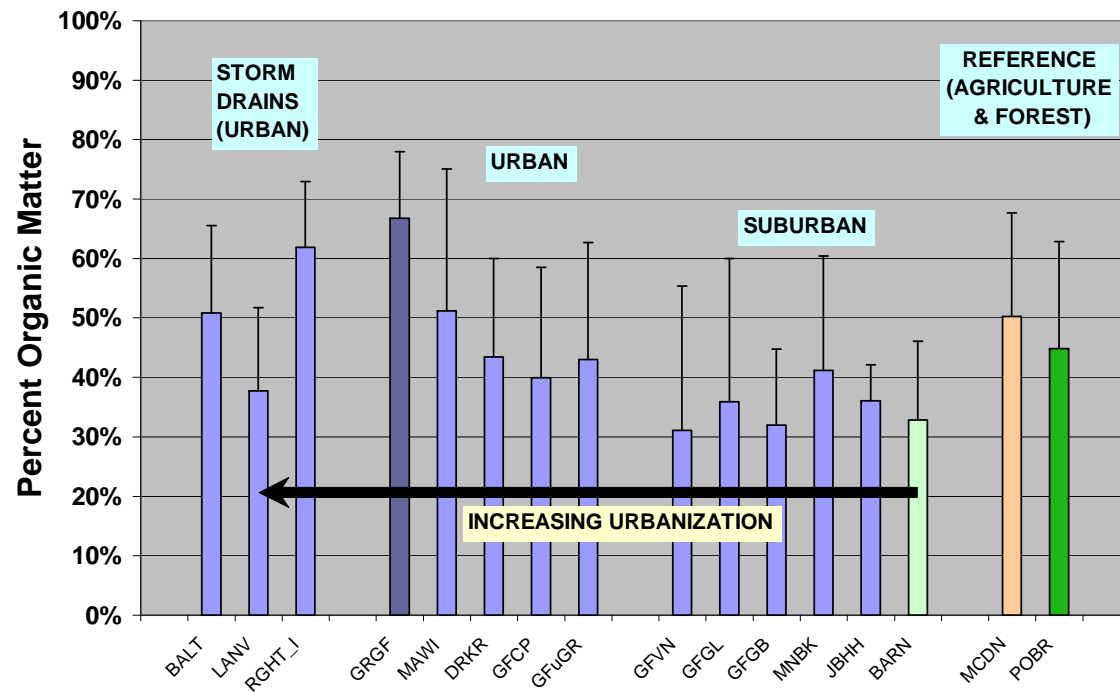
Support...

- USFS... most funding, technician support
- Rich Pouyat (USFS)...Guidance, encouragement, bag making...field work and FS technician help
- Phyl (my wife)...arthritic bag making sessions, field work...putting up with me.
- Sujay Kaushal (UMCES)...guidance, encouragement, DOC analyses
- Bill Stack (Baltimore DPW)... WS263 partner, colleague, City Stream data
- Chris Swan (UMBC GES)...guidance, encouragement, technician support
- Peter Groffman (IES)... sampling support, nutrient data, field crew support
- Claire Welty (CUERE)... facilities & lab support, autosamplers
- Brian O'Roark & Joel Baker... construction of storm shelters
- Chrissy Runyan, Tonya Watts, Istvan Turcsanyi, Bill Greenwood (FS/CUERE), Dan Jones & Michah O'Shaunessy (GES interns), Dan Dillon, Gio McClenan (BES techs)... and all those other technicians & colleagues.....

FPOM- Fine Particulate Organic Matter (VSS)



Stream Seston: % OM
Along an urban-rural gradient



Urban stream continuums and gutter subsidies: the effects of upland riparian zones and engineered “urban karst” on organic matter and lotic ecology.

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Urban streams have often been viewed as simple extensions of stormwater networks. They are, rather, very complex catchment-wide hydrologic ecosystems. Of great importance is the degree of connectivity between civil infrastructure and receiving streams, including pathways for the routing of stormflow, augmentation of baseflow by potable water networks, “upland riparian” sources, and riparian interactions with sanitary sewers. Since every hectare of the urban landscape can be underlain by this dense network of pipes and drains this creates a kind of “engineered karst.” This gives rise to an exponential three dimensional expansion of the stream network density connecting almost every groundwater and surface drainage feature in the landscape, essentially making every gutter and rooftop a zero order stream. This creates unique fluxes from ultra-urban hotspots, upland organic matter “gutter subsidies” as well as a novel “urban stream continuum.” The ecological implications for urban streams are far-reaching in terms of vastly greater CPOM, FPOM & DOC inputs and stream metabolism, which greatly alter the energetics of food webs. We present several years of base and stormflow data for streams and storm drains of the BES LTER & Baltimore City stream networks, which suggest that the altered drainage pathways and strong terrestrial-aquatic linkages of urban catchments may combine in a way such that these are important locations for the management of catchment pollutant loads to minimize impacts on aquatic ecosystems.