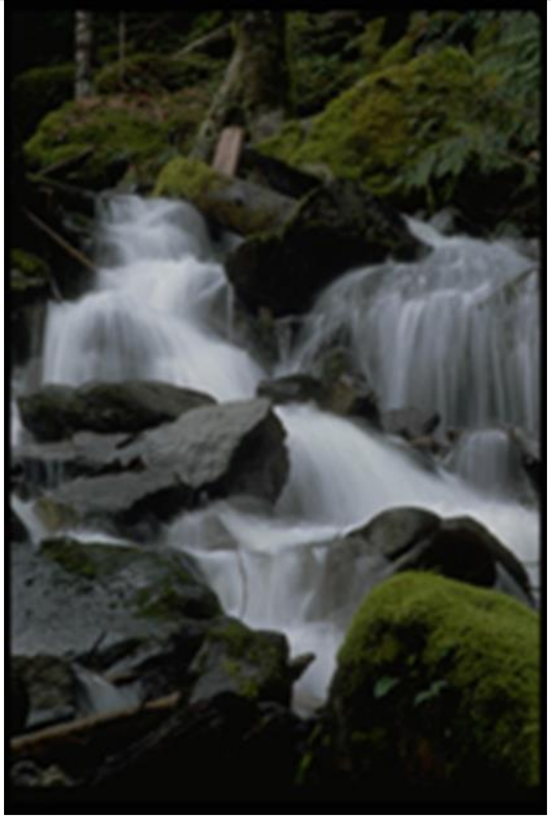
BMPs for Water Quality Management of Urban Runoff



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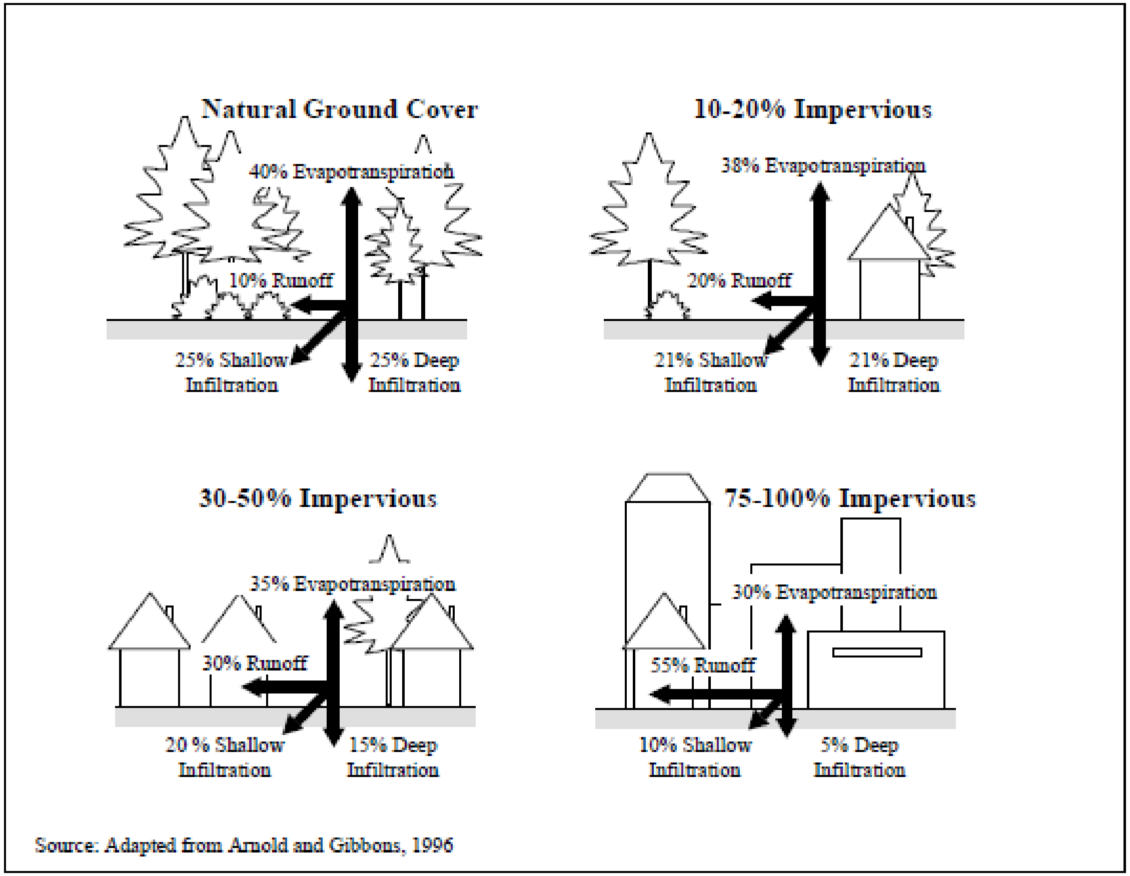
Outline

- Definition
- Nonpoint versus Point Sources Pollution
- Watershed approach for controlling NPS pollution
- Hydrological processes for NPS transport
- BMP for NPS Control

Best Management Practice (BMP)

- BMP include a device, practice, or method for removing, reducing, retarding, or preventing targeted stormwater runoff constituents, pollutants, and contaminants from reaching receiving waters.
- BMPs include both Low Impact Development (LID) and non-LID practices,
- BMP System – A BMP system includes the BMP and any related bypass or overflow.

Figure 4-1. Effects of Imperviousness on Runoff and Infiltration



Urban Water Pollution

Non Point Sources Pollution

- Hydrologically triggered (rainfall and overlandflow)
- Wide spread sources and diffuse in nature
- Major contributors: land development, construction, garden, road & highway, gas station
- In US water pollution still a problem after all point sources had been eliminated
- More difficult to quantify and control

Sullage

- **Point Source Pollution (PS)**
  - **factories**
  - **treatment plants**
- **Non-Point Sources Pollution (NPS)**
  - **Land-use activities**
  - **Urban runoff**
- **Sullage ….is still a major problem?**
  - **Direct discharge from kitchen, restaurants**
  - **E.g. Phosphate, Endocrine Disrupting Chemicals (EDCs), Personnel Heath Care Chemicals**

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Typical Stormwater Pollution

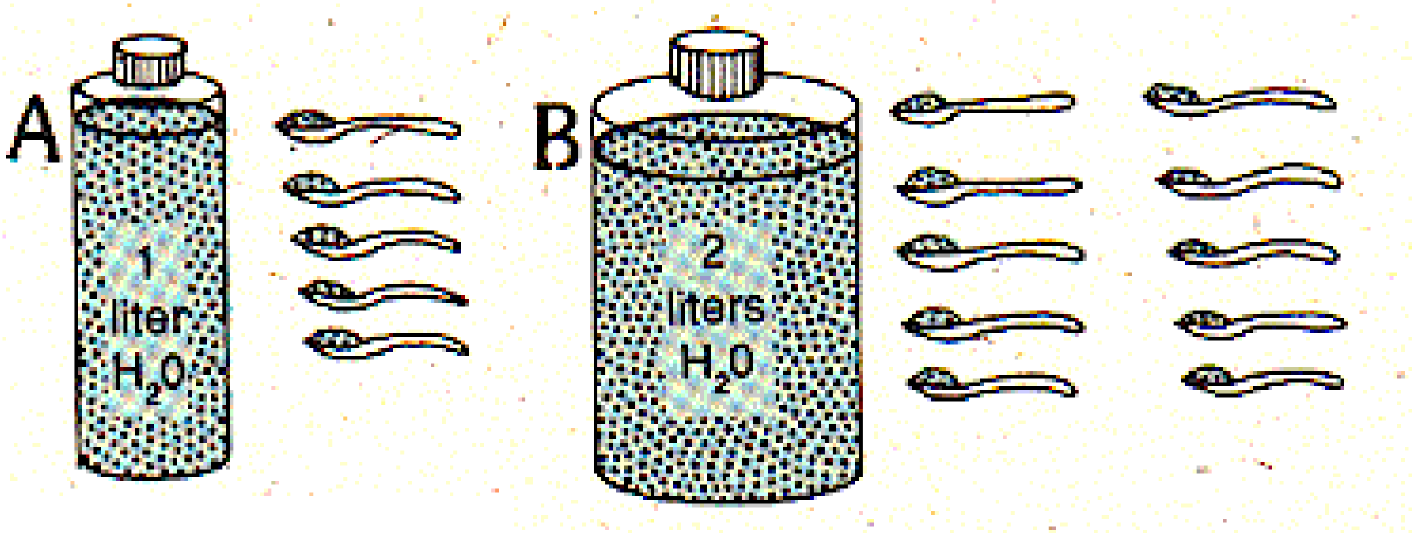
Common NPS Pollution

- TSS - Total suspended solids
- BOD - Organic pollution
- COD - Chemical oxygen demand
- Nutrients/Fertilizer (Phosphorous, Nitrogen)
- Fecal coliform,
- Pesticides
- Heavy metals (Cu, Pb, Zn)
- Polycyclic Aromatic Hydrocarbons (PAH)

Sources of Contamination in Urban Runoff

Contaminant	Contaminants Sources
Sediment and Floatables	Streets, lawns, driveways, roads, construction activities, atmospheric deposition, drainage channel erosion
Pesticides and Herbicides	Residential lawns and gardens, roadsides, utility right-of-ways, commercial and industrial landscaped areas, soil wash-off
Organic Materials	Residential lawns and gardens, commercial landscaping, animal wastes
Metals	Automobiles, bridges, atmospheric deposition, industrial areas, soil erosion, corroding metal surfaces, combustion processes
Oil and Grease/ Hydrocarbons	Roads, driveways, parking lots, vehicle maintenance areas, gas stations, illicit dumping to storm drains
Bacteria and Viruses	Lawns, roads, leaky sanitary sewer lines, sanitary sewer cross-connections, animal waste, septic systems
Nitrogen and Phosphorus	Lawn fertilizers, atmospheric deposition, automobile exhaust, soil erosion, animal waste, detergents

Quality vs. Loading



Concentration	X g/l	X g/l
Load	X load	2X

Load = f(C,Q)

Waste Assimilative Capacity (WAC)

- The amount of potential pollutants that can be discharged into the stream environment or watershed
- WAC – is very important for environmental protection

- Consider Total Maximum Daily Load (TMDL)
- Based on assumption that loading can be controlled
    - Treatment
    - Best Management Practices (BMPs)

What is TMDL

- Maximum amount of pollutant that a water body can take but still meeting the
  - Designated use
  - Water quality standard (WQS)
- Allocation of load to pollutant's sources
- TMDL must include margin of safety (MoS)
- TMDL must account for natural variation in water quality

What is TMDL

- TMDL=$\sum$Lps + $\sum$Lnps + BL + MoS

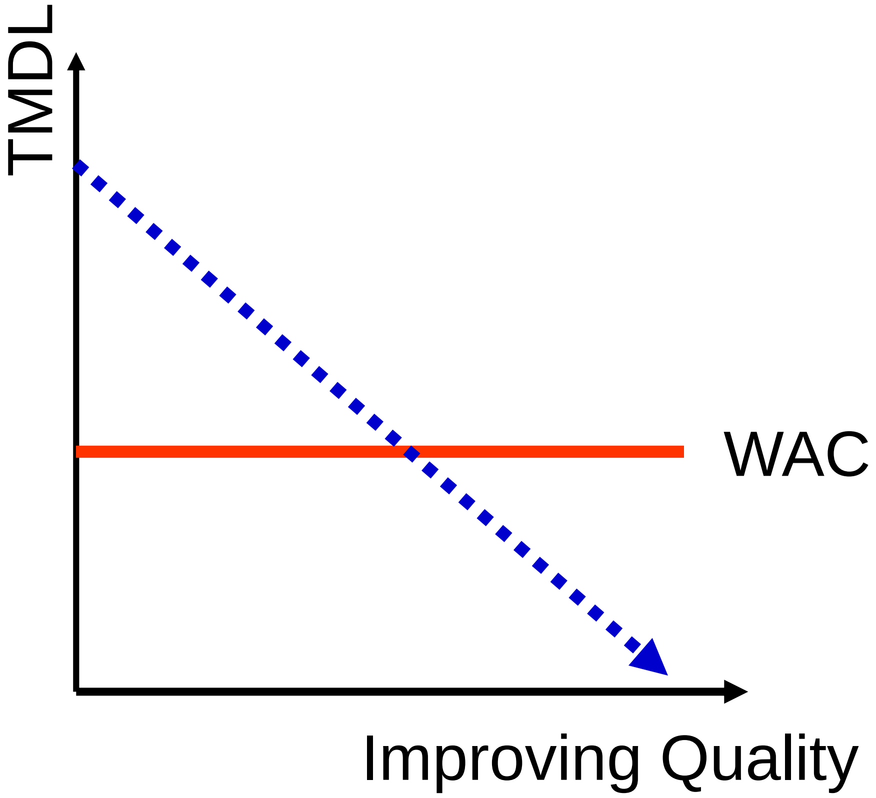
- Lps = Point source loading
- Lnps = Nonpoint sources loading
- BL = Background level
- MoS=Margin of safety

Relationship of WAC and TMDL

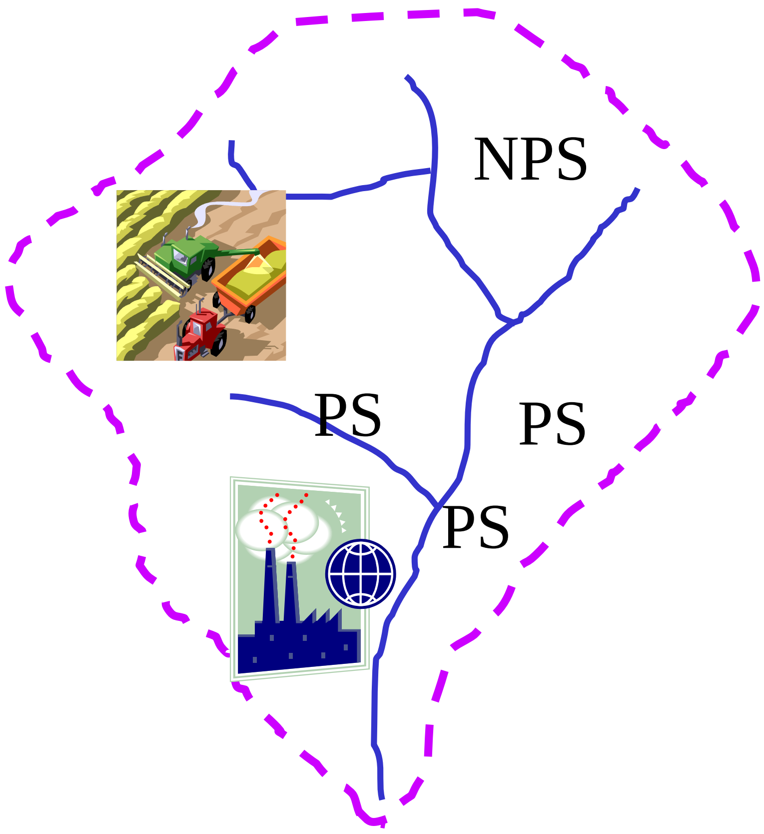
- Degrading water quality
  - TMDL > WAC

- To maintain quality
  - TMDL = WAC

- To improve water quality
  - TMDL < WAC



Catchment/river basin approach for controlling pollution

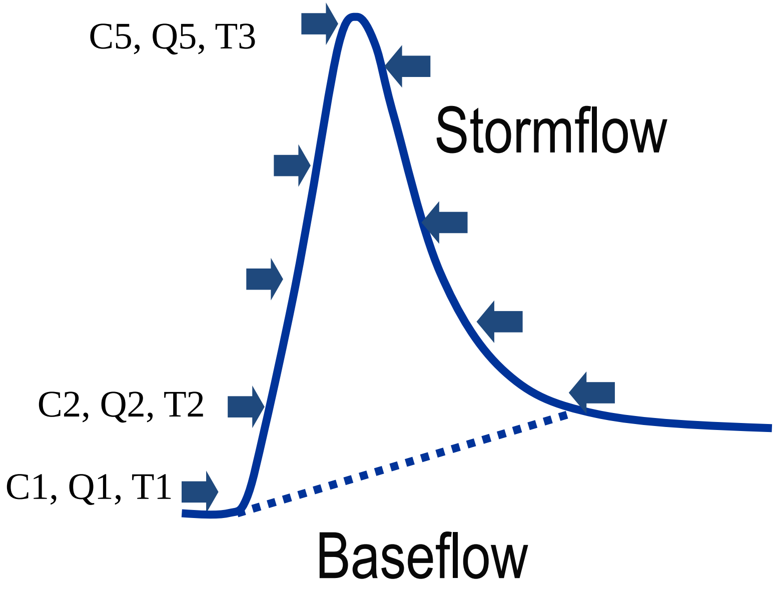


- Over a large basin
- Water quality improvement for the entire basin
- Consider
  - Spatial effects of multiple sources of pollution
  - Cumulative effect of the past, present and future
  - on-site and off-site linkages
- Total Loading = PS + NPS

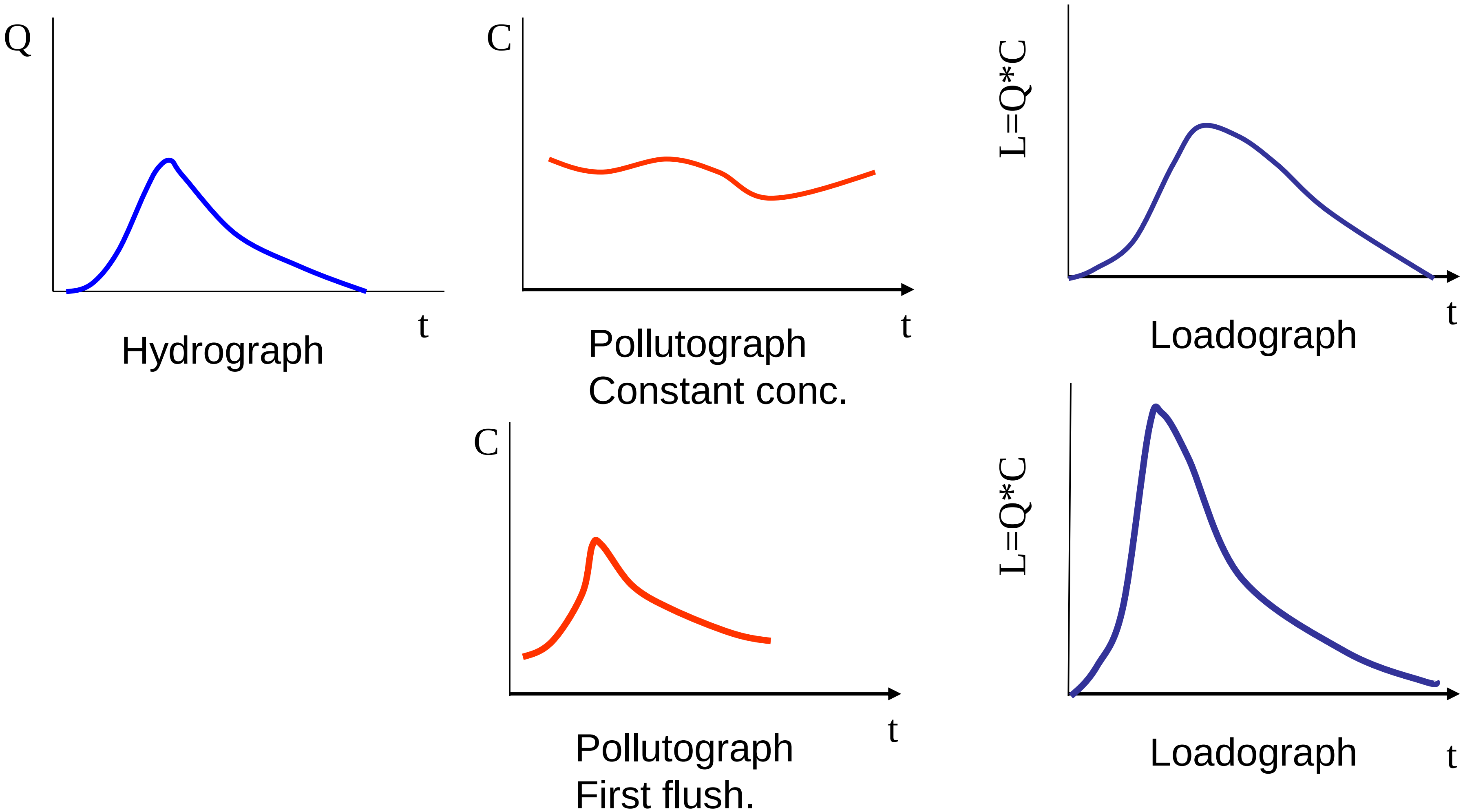
PS and NPS contribution: Sg Tebrau Case Study

Measurement of NPS pollution

- A tricky exercise
- Rainfall very localize
- Probability of success 0.2.
- Measure: Concentration, Discharge, Time for each sample
- Automatic sampler - useful

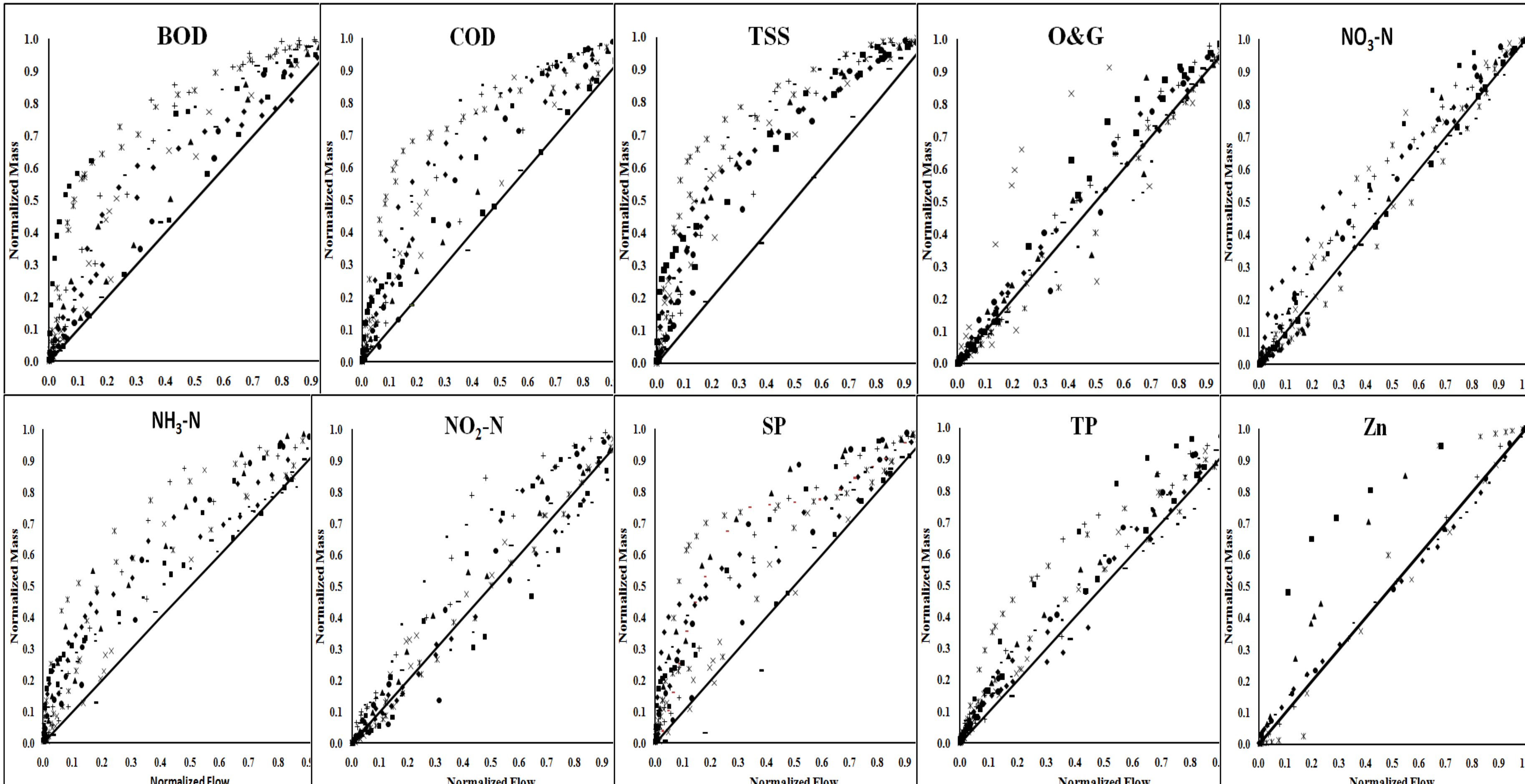


Pollutant response to discharge



First Flush Analysis

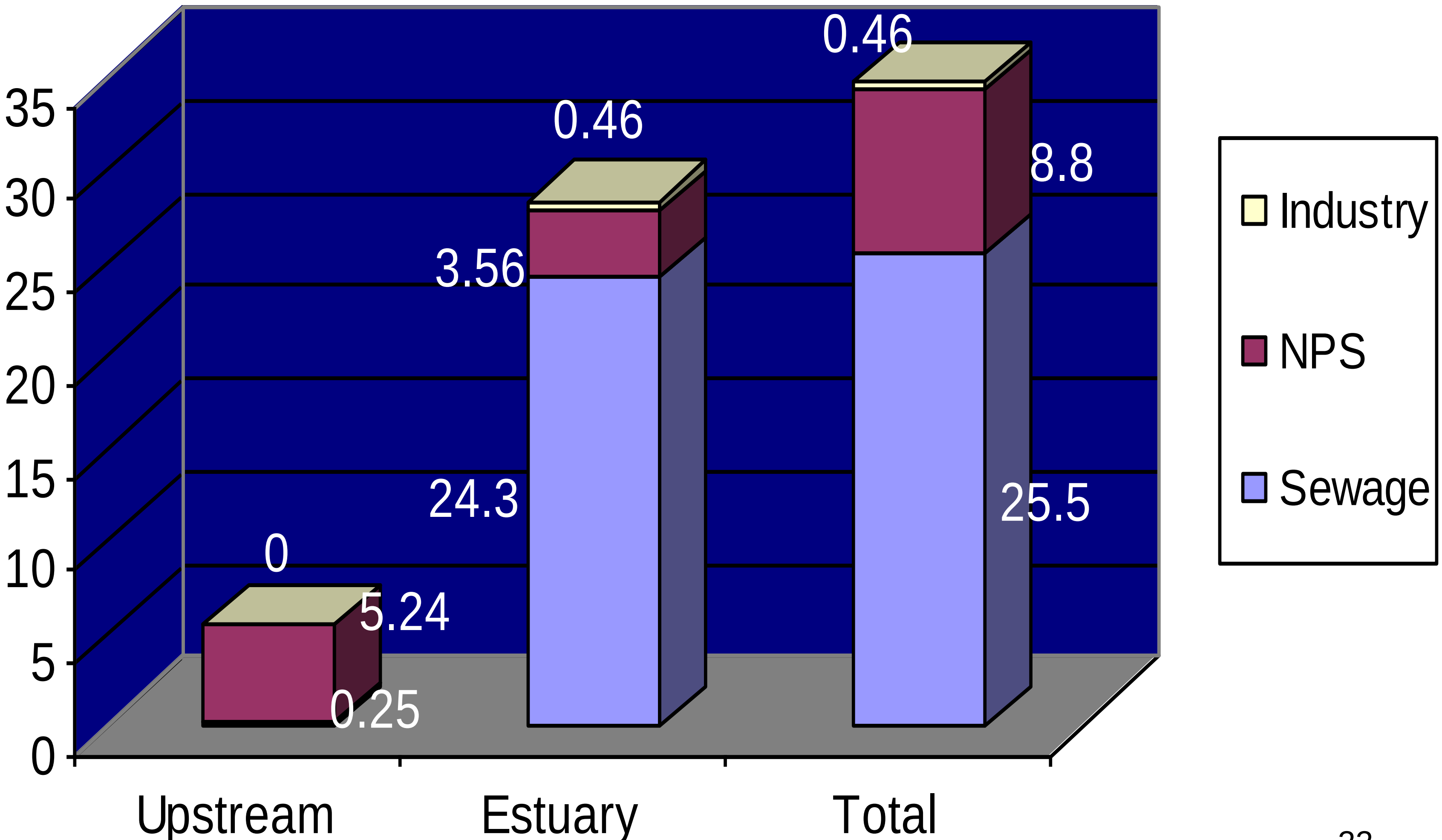
Commercial Catchment



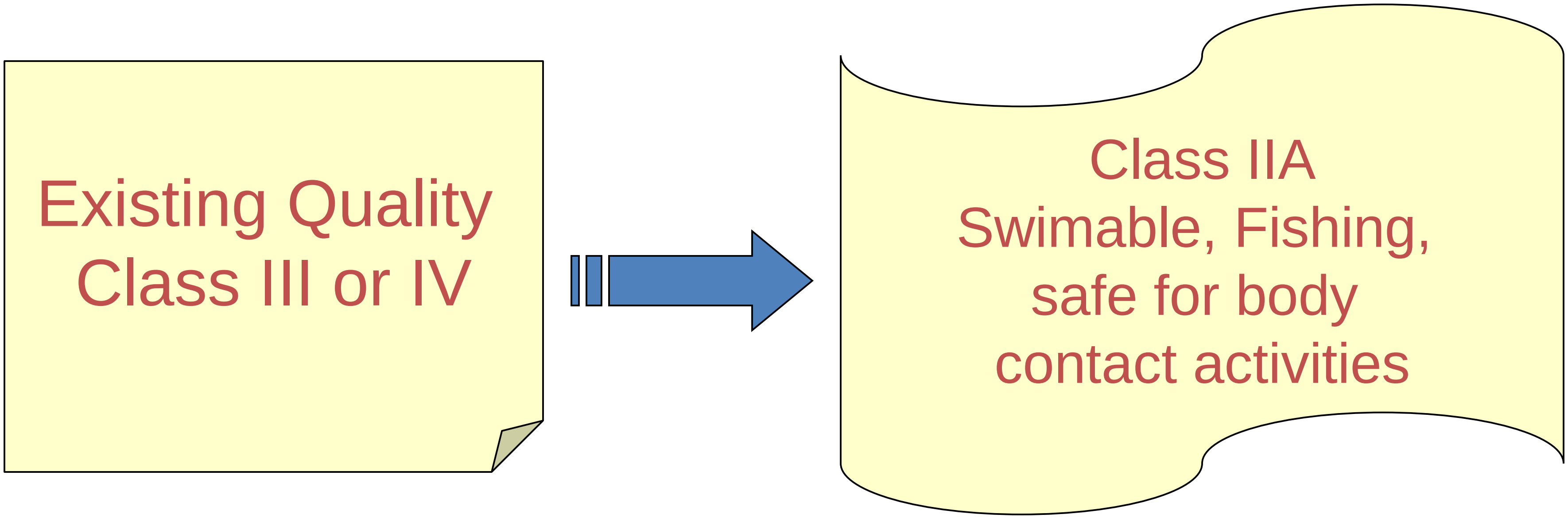
First flush analysis

- **BOD, COD** and **NH_3-N** showed consistently **strong first flush effects** at residential, commercial and industrial catchments.
- **O&G, NO_3-N, NO_2-N** and **Zn** showed weaker first flush effect during storm events.
- The maximum difference between the mass plot and 1:1 line for each event is normally occurs at around the first **30%** of the normalized runoff.

BOD load distribution (ton/day) in Tebrau Catchment



Target: Sg Tebrau and sg Segget



Interim National River Water Quality Standards

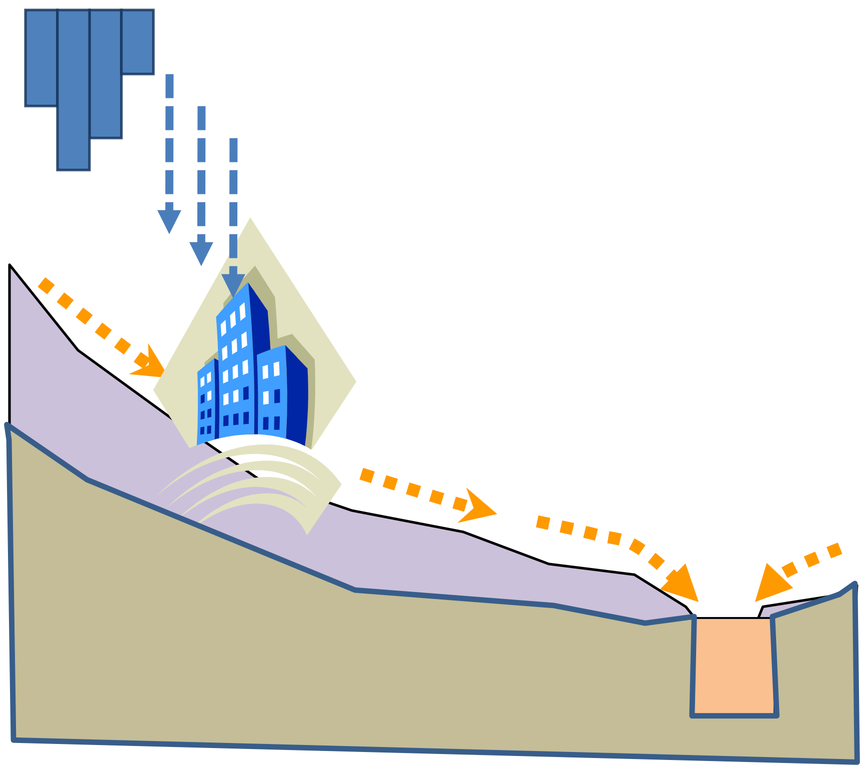
Paremeters	I	IIA	IIB	III	IV	V
Amm-N	0.1	0.3	0.3	0.9	2.7	>2.7
BOD	1	3	3	6	12	>12
COD	10	25	25	50	100	>100
DO	7	5-7	5-7	3-5	<3	<1
pH	6.5-8.5	6-9	6-9	5-9	5-9	-
Color (TCU)	15	150	150	-	-	-
TDS	500	1000	-	-	4000	-
TSS	25	50	50	150	300	>300
Turbidity (NTU)	5	50	50	-	-	-
FC(per 100ml)	10	100	400	5000	5000	-
TC(per 100ml)	100	5000	5000	20,000	50000	>

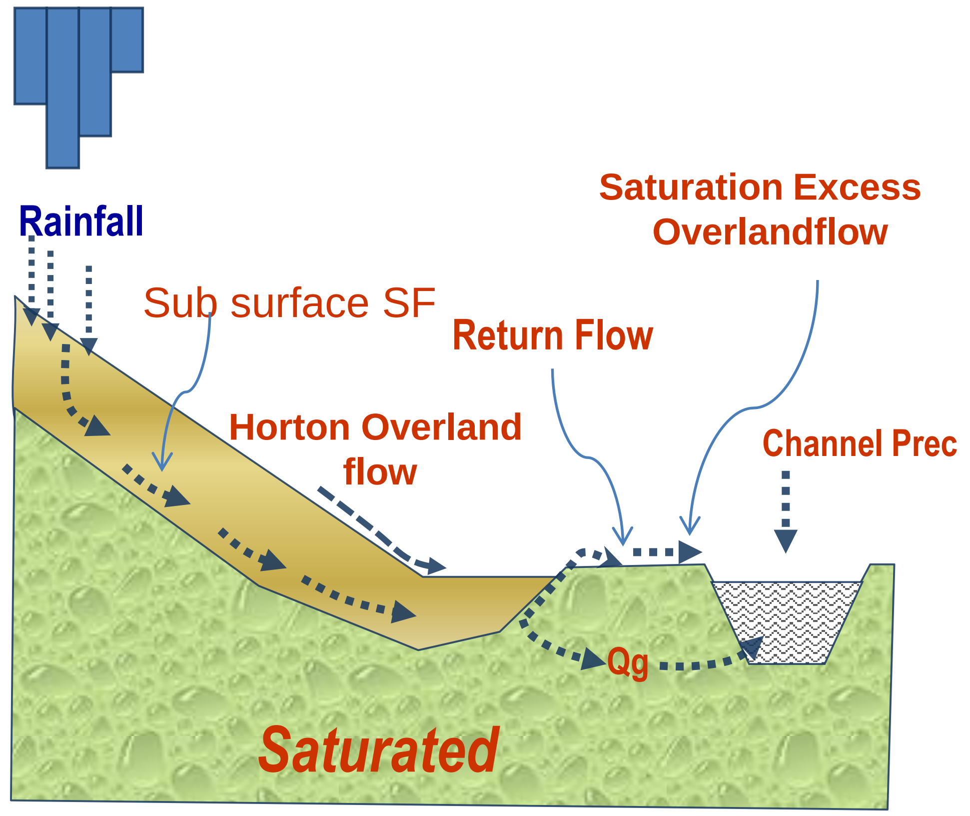
Required BOD Load reduction

BOD Loading (kg/day)	Tebrau		Segget	
	Class III	Class II	Class III	Class II
Present	33,186	33,186	1582	1582
Max permissible	7,032	5153	332	150
Load reduction needed	26,154	28,034	1250	1432
% Reduction	**78.8**	**84.5**	**79**	**90.5**

Urban catchment – Large volume of overlandflow

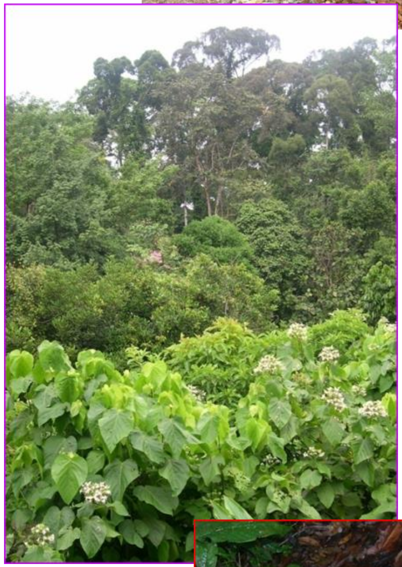
Vegetated/forested Catchment – mostly reaching the rivers through subsurface stormflow

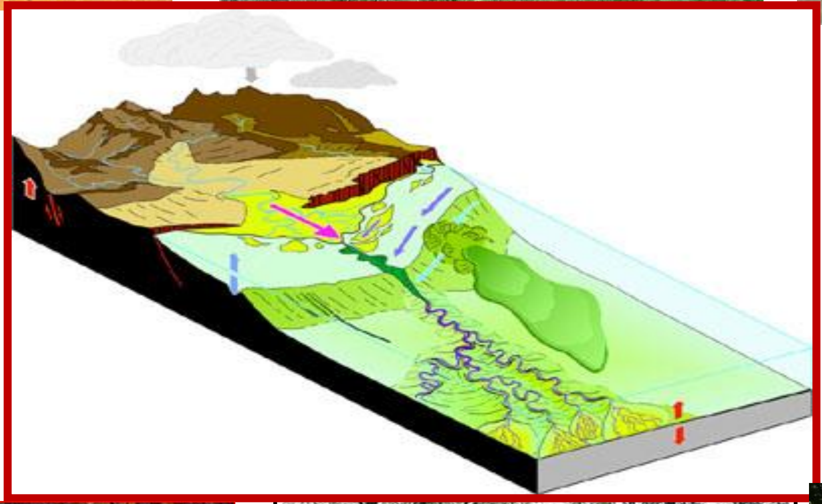




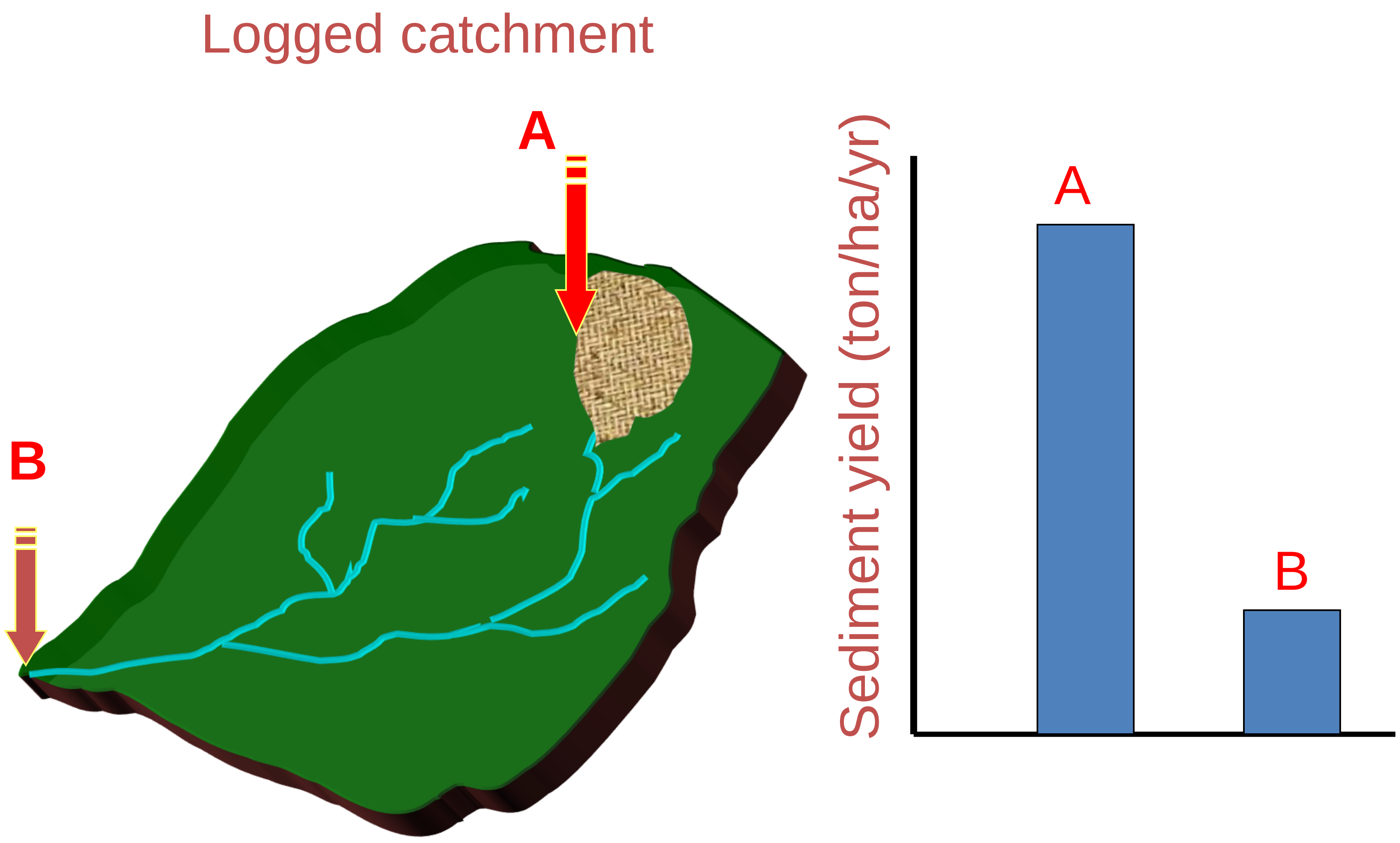
Buffer Strip/Zone

Sediment sources and sinks





Spatial Impacts on sediment Yield



Misconception

Unwelcome beautification ?
Not natural
Kill life

Green Drainage

Old Paradigm	New Paradigm
I. WATER MANAGEMENT	
▪ Provides water, drainage and sanitation	▪ Protects the environment & recycle resources
▪ Sectoral approach	▪ Holistic and integrated approach
▪ Target local scale	▪ Act locally, think globally
II. SOURCE CONTROL	
▪ To reduce flooding	▪ Improve water quality ▪ Restore habitat
III. TECHNOLOGY	
▪ Traditional – hard Technology	▪ “novel” soft technology

RESULTS

Linear flow of material Poor water quality Environmental degradation Loss of resources, habitats	Circular flow of water and resources Public participation & acceptance Changes in life style Restoration, bring back habitat

Do and Don't in Urban Runoff Management

Source: Zulkifli Yusop (UTM)

Structural Stormwater Controls and Associated Fundamental Process Categories

Fundamental Process Categ.	Unit Operation or Process Target Pollutants	Treatment System Component
Hydrologic Process	Flow & Volume Attenuation	Extended detention basins Retention/detention ponds: Wetlands: Tanks/vaults: Equalization basins
	Volume Reduction	Infiltration/exfiltration trenches & basins: Permeable or porous pavement: Bio-retention Cells: Dry Swales: Dry Well : Extended Detention Basin
Physical Treatment Operation	Particle Size Alteration (*Coarse sediment*)	Comminutors: Mixers
	Physical Sorption (*Nutrients, metals, petroleum compounds*)	Engineered media, granular activated carbon, and sand/gravel (at a lower capacity)
	Size Separation and Exclusion (screening and filtration) *Coarse sediment, trash, debris*	Screens/bars/trash racks: Biofilters: Permeable or porous pavement : Infiltration trenches and basins : bioretention systems : media/filters :
	Density, Gravity, Inertial Separation (grit separation, sedimentation, flotation and skimming, and clarification) *Sediment, trash, debris, oil and grease*	Extended detention basins : Retention/detention ponds : Wetlands : Settling basins, Tanks/vaults : Swales with check dams: Oil-water separators : Hydrodynamic separators
	Aeration and Volatilization *Oxygen demand, PAHs, VOCs*	Sprinklers : Aerators : Mixers (not common for stormwater)
	Physical Agent Disinfection Pathogens	Shallow detention ponds Ultra-violet systems

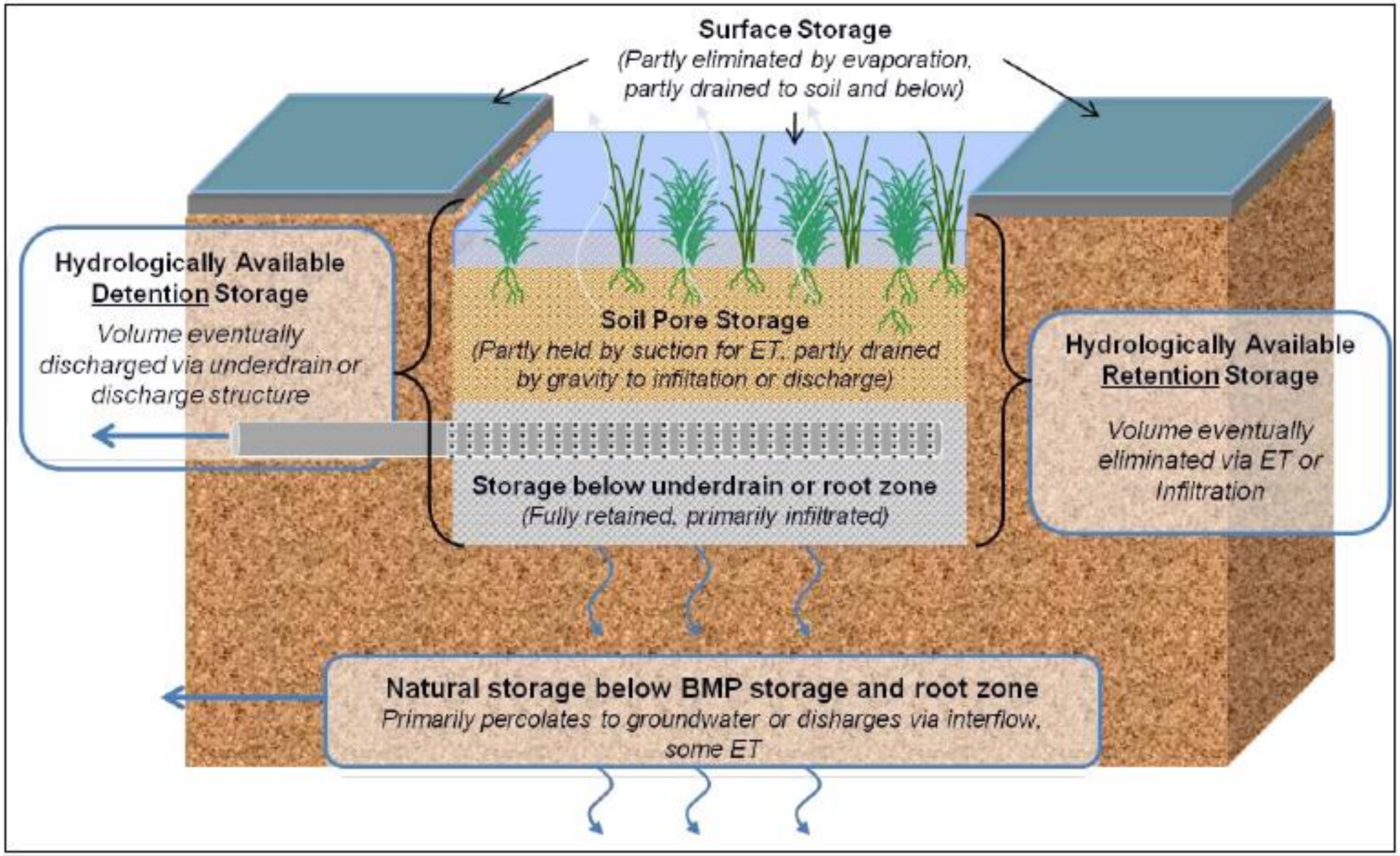
Fundamental Process Categ.	Unit Operation or Process Target Pollutants	Treatment System Component
Biological Processes	Microbially Mediated Transformation (can include oxidation, reduction, or facultative processes) *Metals, nutrients, organic pollutants*	Wetlands Bioretention systems Biofilters (and engineered bio-media filters) Retention ponds Media/sand/compost filters
	Uptake and Storage *Metals, nutrients, organic pollutants*	Wetlands/wetland channels Bioretention systems Biofilters Retention ponds
Chemical Processes	Chemical Sorption Processes *Metals, nutrients, organic pollutants*	Subsurface wetlands Engineered media/sand/compost filters Infiltration/exfiltration trenches and basins
	Coagulation/Flocculation Fine sediment, nutrients	Detention/retention ponds Coagulant/flocculant injection systems
	Ion Exchange Metals, nutrients	Engineered media, zeolites, peats, surface complexation media
	Chemical Disinfection Pathogens	Custom devices for mixing chlorine or aerating with ozone Advanced treatment systems

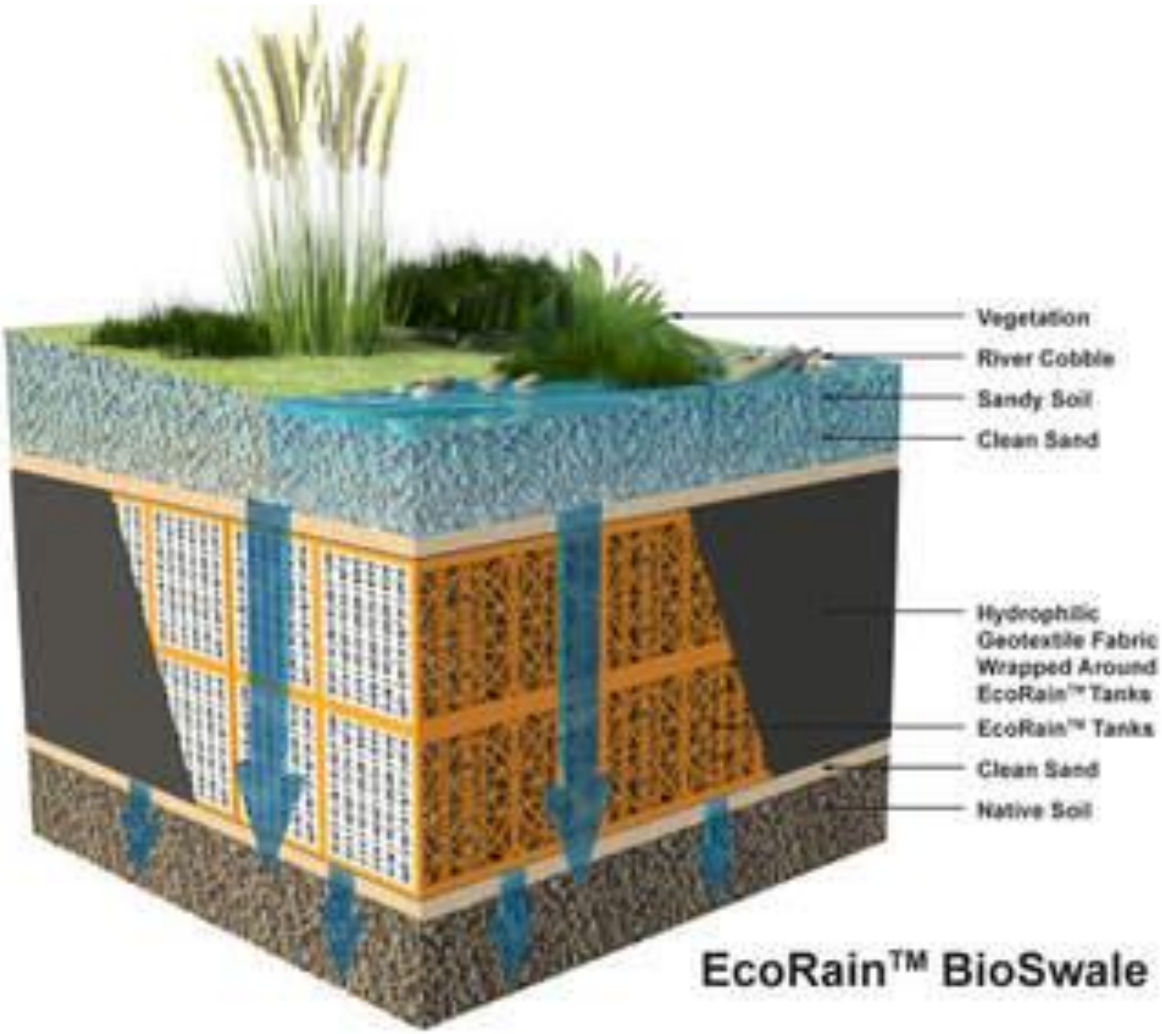
Grassed Swales to improve runoff quality

Inflow

Inflow

Components of Hydrologically Available Temporary Storage Typically Present in LID features




Vegetation
River Cobble
Sandy Soil
Clean Sand
Hydrophilic
Geotextile Fabric
Wrapped Around
EcoRain™ Tanks
EcoRain™ Tanks
Clean Sand
Native Soil
EcoRain™ BioSwale

Green Roofs and Green Facades

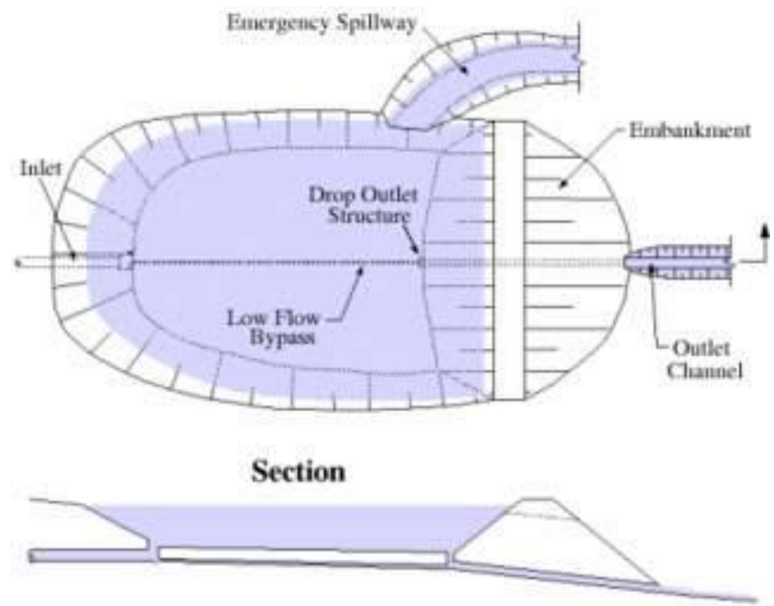
- These design features contain a specially engineered, light-weight media that supports vegetative growth—typically short, drought- and temperature-resistant grasses in a variety of forms.
- The green roof media and vegetation have the potential to store and evapotranspire precipitation, as well as reduce peak flows through temporary storage. Green roofs and facades have many additional benefits including significant reductions in urban heat island effects.

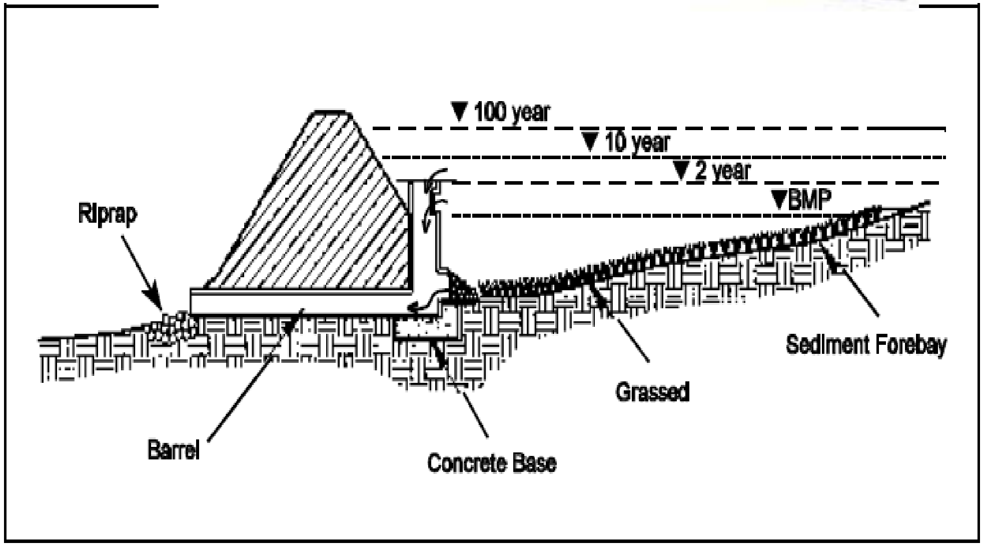
Permeable Pavements

- Parking lots and roadways contribute a significant portion of the runoff from a typical development area.
- Pervious pavements and paver systems are designed to allow stormwater to percolate or infiltrate through the surface into the soil below or to filter runoff through a subsurface media thereby reducing runoff volumes, decreasing peak flow rates, and improving water quality.

Detention Pond

- Detention basins are designed to intercept a volume of storm water,
- Temporarily impound the water and release it shortly after the storm event.
- The main purpose of a detention basin is quantity control by reducing the peak flow rate of storm water discharges.





Retention ponds

- Retention ponds or wet ponds are designed to intercept a volume of storm water runoff and to provide storage and treatment of this runoff volume.
- Water in the pond above the permanent pool level is displaced in part or completely by the runoff volume from subsequent runoff events.
- Providing both water quality improvements and quantity control, as well as providing aesthetic value and habitats

Vegetative strip

- Filter sediment
- Absorbed nutrient (NO3 & Phosphate) and other contaminants
- Enhance infiltration
- Reduce soil erosion

Conclusion

- Understanding of assimilative capacity and pollutant daily load of urban river is important
- River basin/watershed offers practical and encompassing approach for controlling NPS pollution
- BMP is relatively simple and effective
- NPS control is about putting in place BMPs, not a rocket science.

Thank You