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Cornell University Cooperative Extension

Applying knowledge to improve water quality
National Water Program
A Partnership of USDA CSREES & Land Grant Colleges and Universities

Stormwater Management in Your Backyard: Stormwater 101

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How much water do we have?

Total volume of water on the planet:
326,000,000 cubic miles

The Earth's Water Distribution

- 97% of the water on earth is in the oceans
- Only 3% of the water on earth is freshwater
- About 2.4% of the freshwater on earth is permanently frozen in glaciers and at the polar ice caps
- About 1/2 of 1 % of the water on earth is groundwater
- Only about 1/100 of 1% of the water on earth is in the rivers and lakes

Four Phases to the Hydrologic Cycle

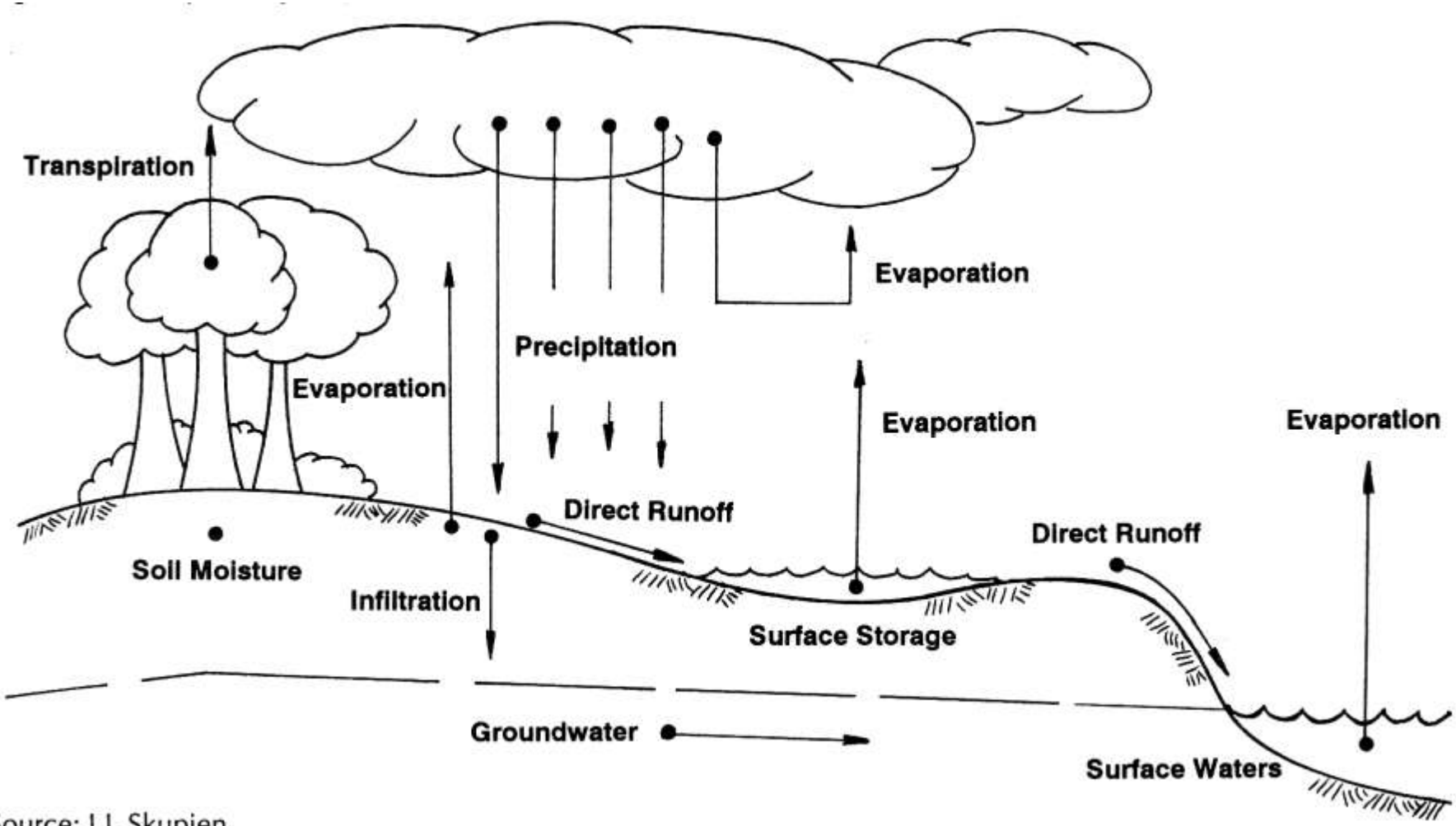
Condensation – the reduction of a gas to a liquid

Evaporation – to change a liquid or solid into vapor

Precipitation – to condense and cause to fall as rain, snow, sleet, etc.

Transpiration – the giving off of moisture through the pores of the skin or through the surface of leaves and other parts of plants

The Hydrologic Cycle



Source: J.J. Skupien.

What is stormwater or “runoff”?

Stormwater is the water from rain or melting snows that can become “runoff,” flowing over the ground surface and returning to lakes and streams.

Watersheds

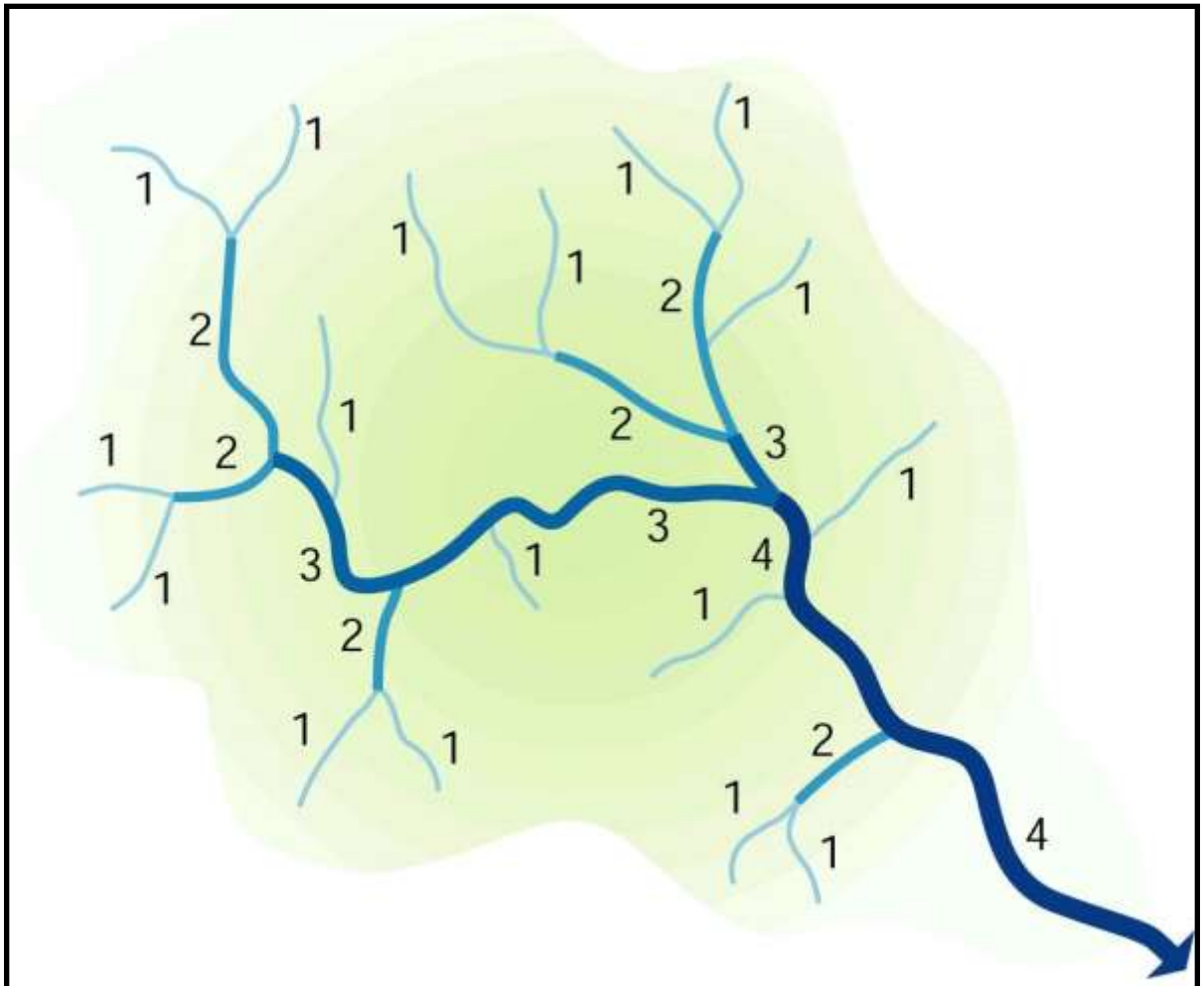
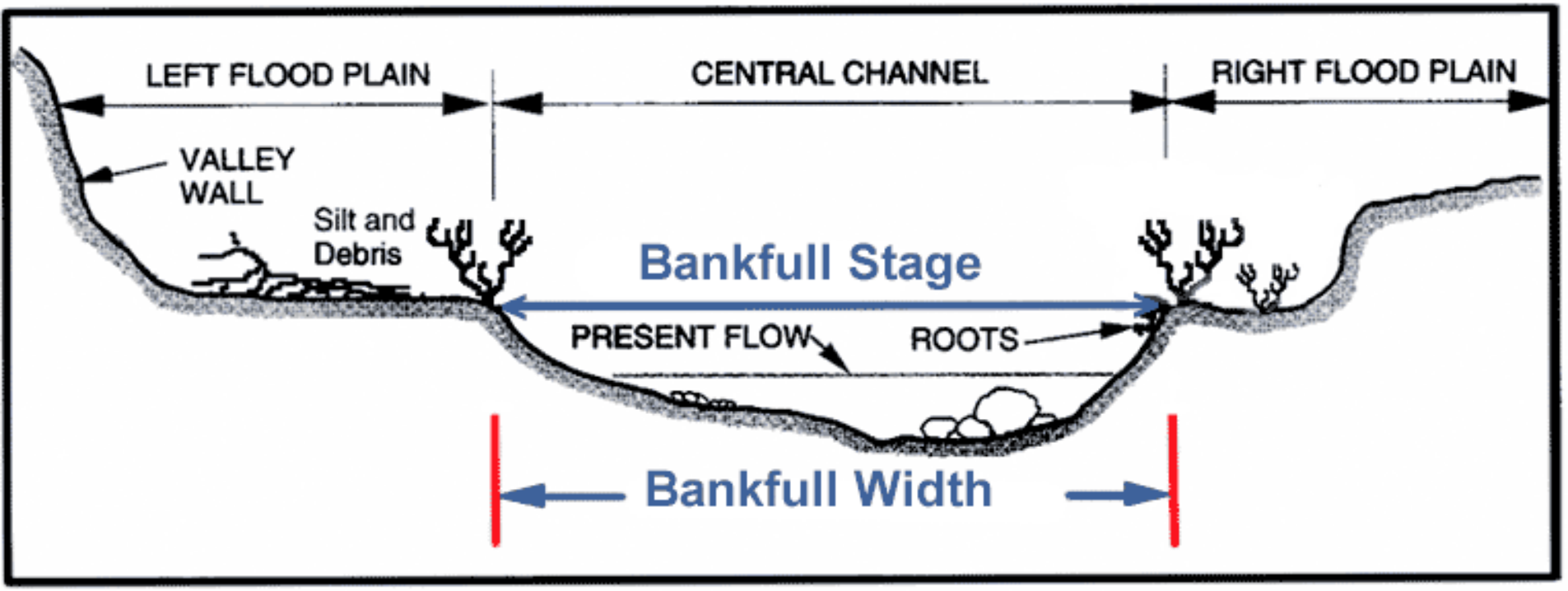


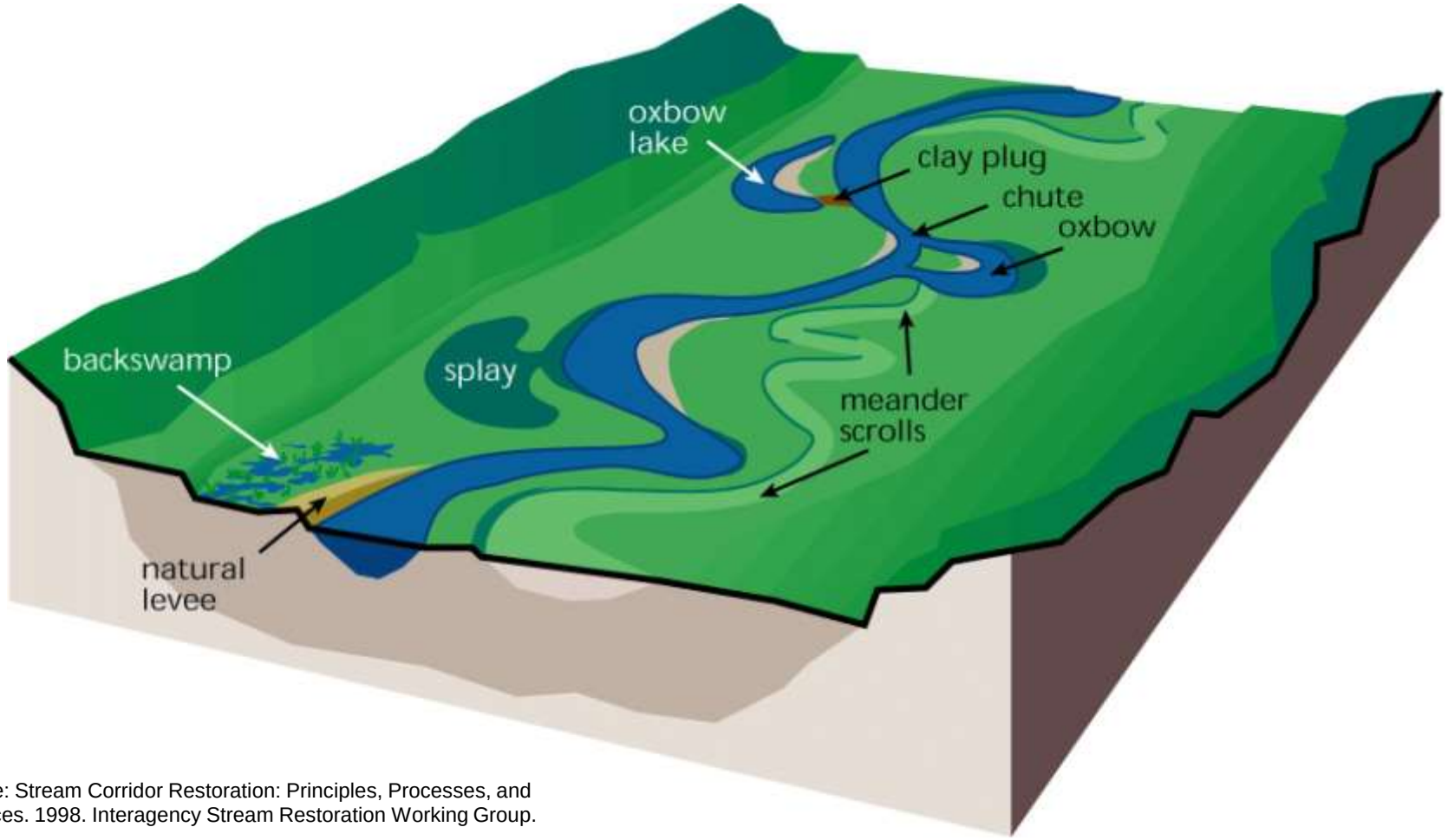
Fig. 1.30 – Stream ordering in a drainage network. "1" = first order stream; "2" = second order stream, etc.
In Stream Corridor Restoration: Principles, Processes, and Practices (10/98).
Interagency Stream Restoration Working Group (15 federal agencies)(FISRWG).

Stream Channel Cross-section



(Newbury and Gaboury 1993)

Floodplains Are Dynamic Systems



Source: Stream Corridor Restoration: Principles, Processes, and Practices. 1998. Interagency Stream Restoration Working Group.

Rivers and streams are not only conduits of water, but also of sediment.

Surface/Ground Water Interactions

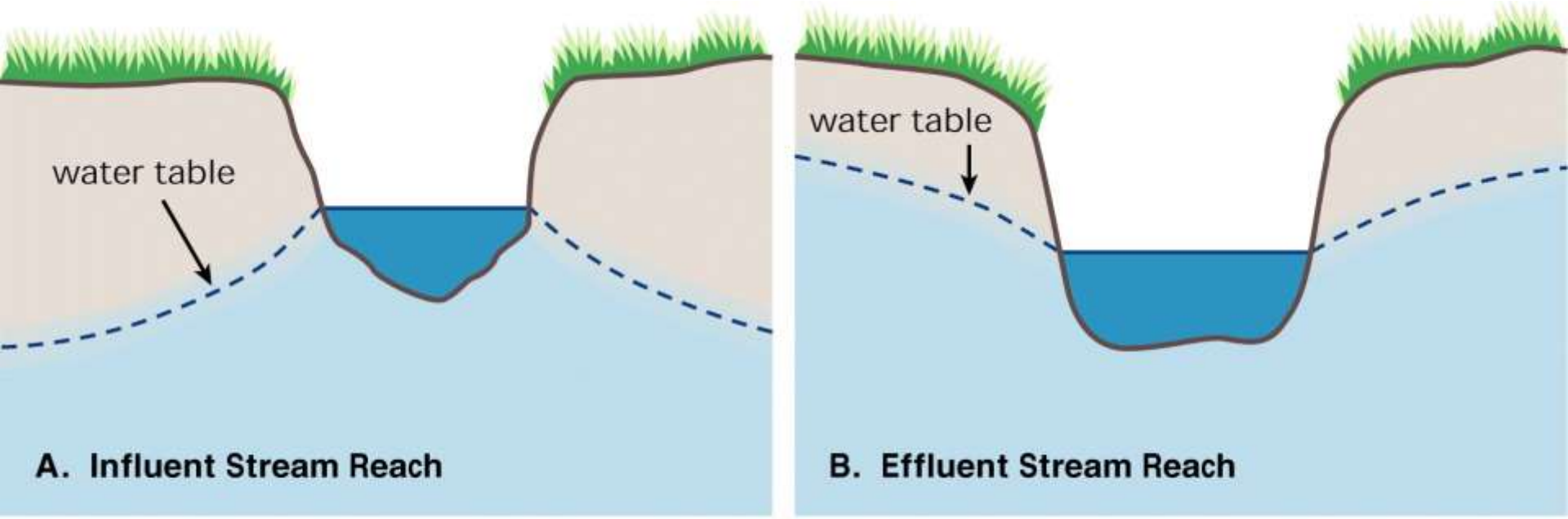


Fig. 1.16 -- Cross sections of (a) influent and (b) effluent stream reaches. Influent or "losing" reaches lose stream water to the aquifer. Effluent or "gaining" reaches receive discharges from the aquifer.
In Stream Corridor Restoration: Principles, Processes, and Practices (10/98).
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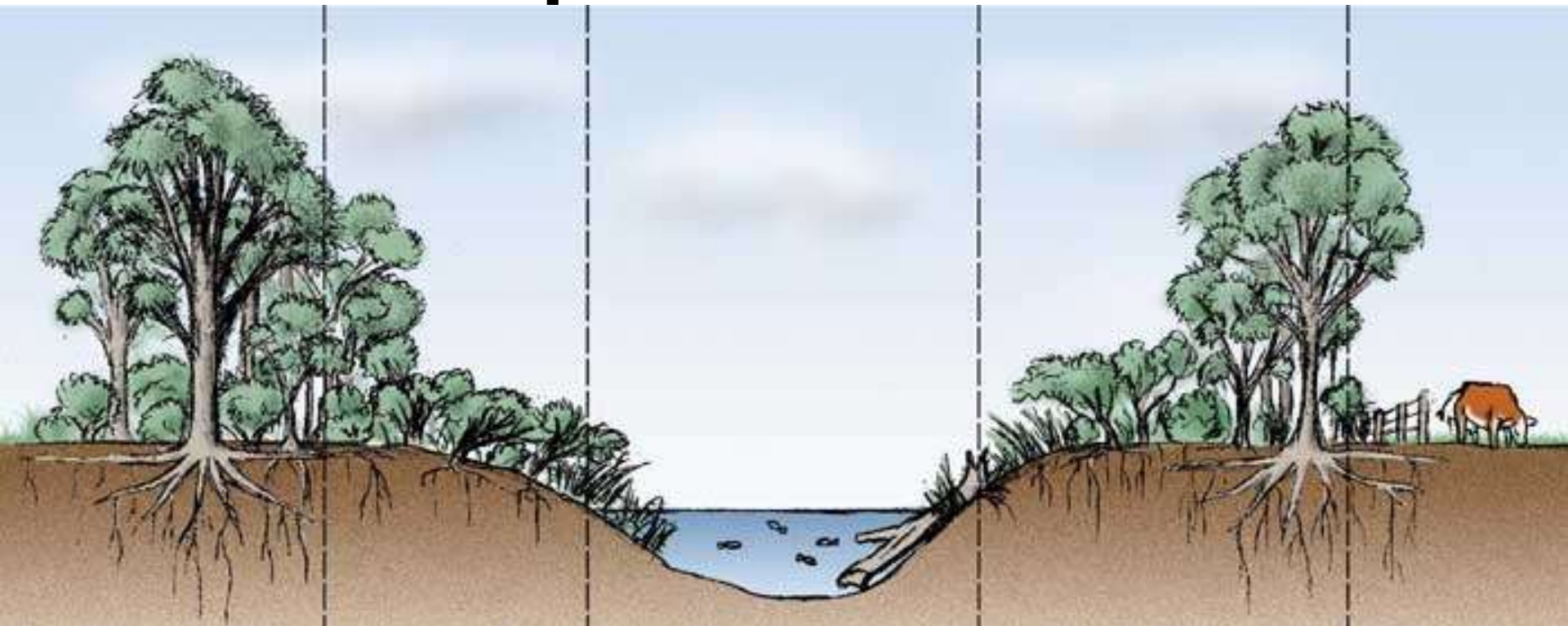
Riparian Corridor



Streamside (riparian) plants play a vital role in maintaining river health.

Plants perform a filtering function and prevent sediments and nutrients from entering the stream.

Vegetation and leaf litter slow overland water runoff, thus helping to prevent erosion.

Riparian zones also provide flora and fauna habitat.

Vegetation provides organic matter to the stream.

Trees shade the stream and reduce light and water temperature. This offers protection for instream animals and plants and helps prevent algae formations.

Large Woody Debris (LWD) or snags and living vegetation provide:

- Shelter;
- Feeding and spawning habitat for birds, fish and invertebrates.

Roots act as a binding system for the soil and, by doing so, reduce bank collapse and erosion.

Floodplains are used for agriculture but need to be carefully managed in order to protect the streambank and water quality in the river.

Source: NRCS.

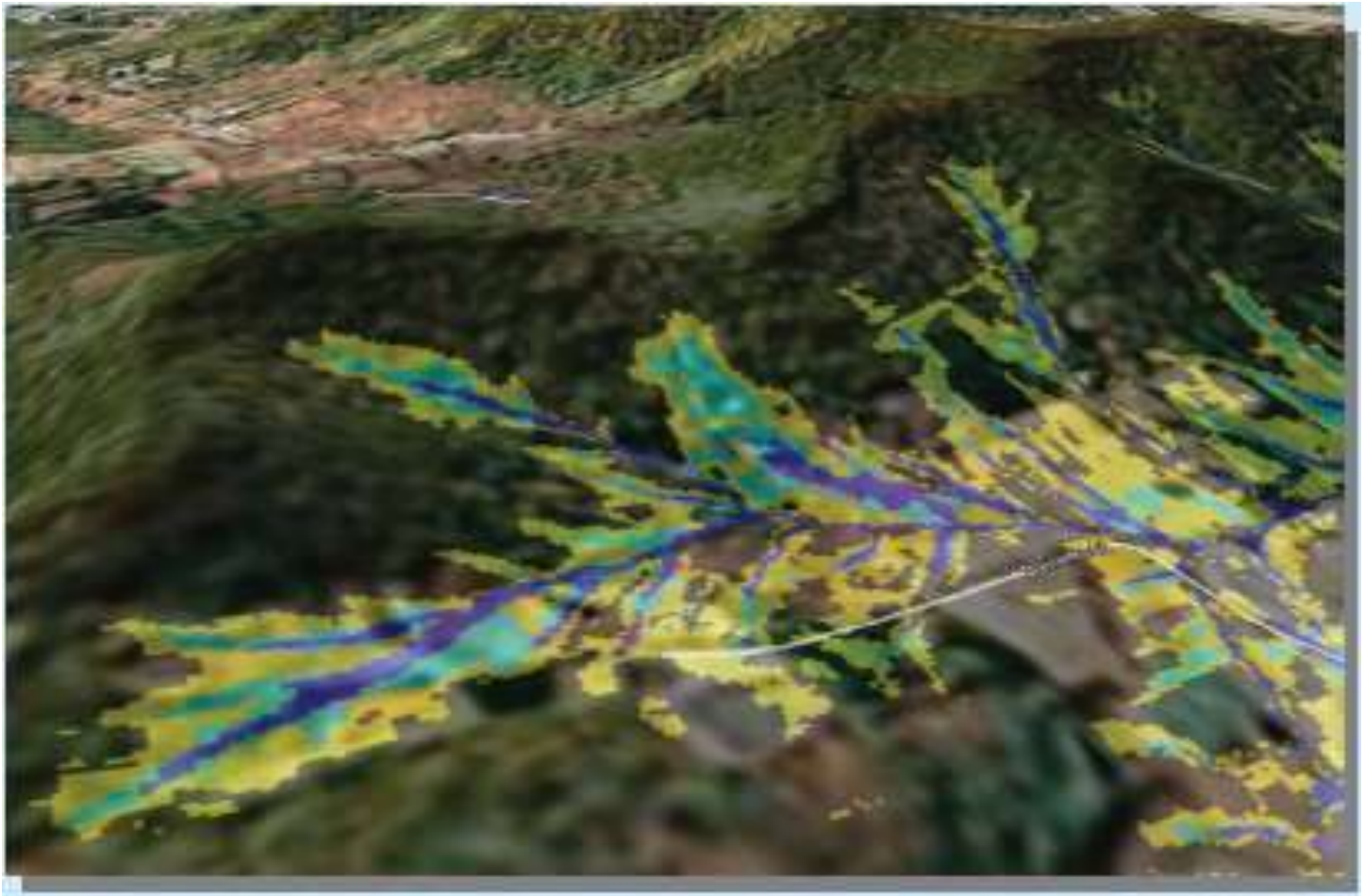
Meteorological Factors Affecting Runoff

- Type of precipitation (e.g., rain, snow, sleet, etc.)
- Rainfall intensity
- Rainfall amount
- Rainfall duration
- Distribution of rainfall over the drainage basin
- Direction of storm movement
- Proceeding precipitation and soil moisture
- Temperature, wind, relative humidity (i.e., factors that affect evapotranspiration)

Physical Characteristics Affecting Runoff

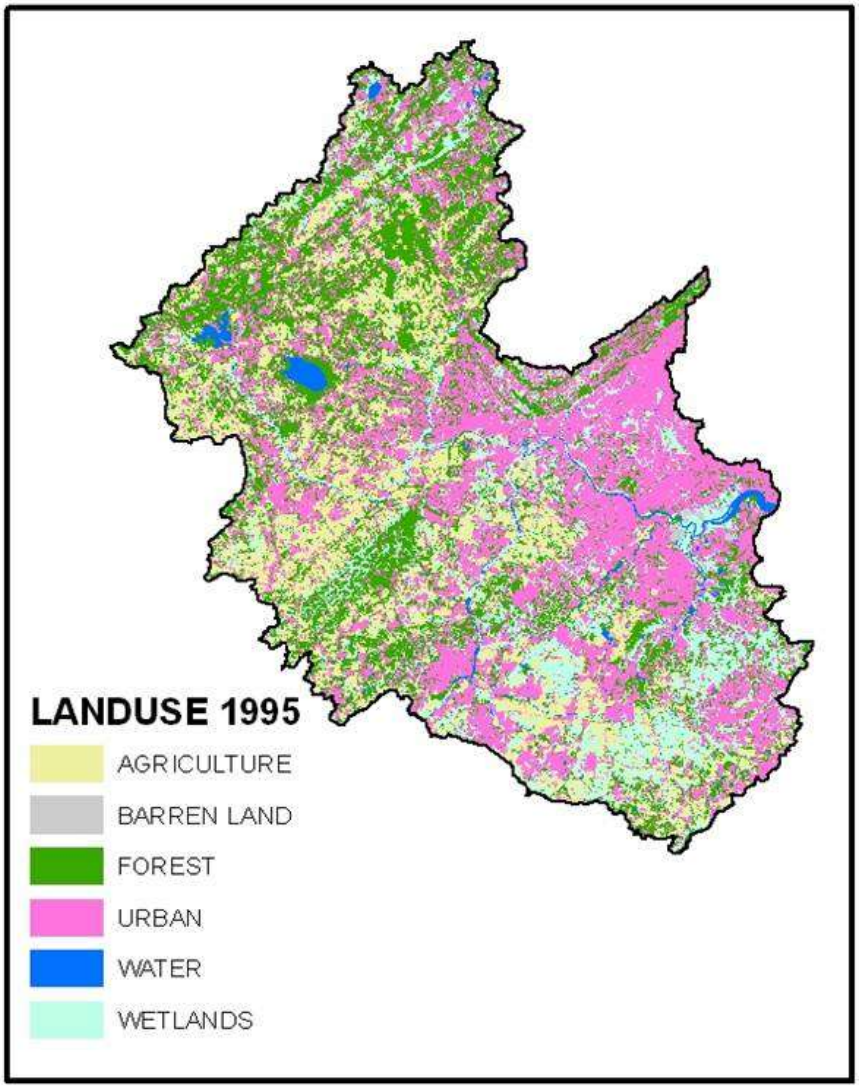
- ***Land use***
- Vegetation
- Soil type
- Drainage area
- Basin shape
- Elevation

- Slope
- Topography
- Direction of orientation
- Drainage network patterns
- Presence of ponds, lakes, reservoirs, etc.



Google Earth image of the Variable Source Area hydrology analysis for the Town Brook watershed. (Yellow is <0.2 cm, teal is 0.2 to 0.4 cm, blue is >0.4 cm; average runoff depth)

Hydrologic Implications of Land Use



Urban land uses lead to impervious surfaces

- Commercial
- Industrial
- Residential
    - Low Density
    - Medium density
    - High density
- Other
- Agriculture leads to land alteration that might lead to erosion

Linking Land Use to Waterway Condition

More Imperviousness = More Water

Impervious Cover

- provides a surface for accumulation of pollutants
- leads to increased polluted runoff and flooding
- inhibits recharge of groundwater

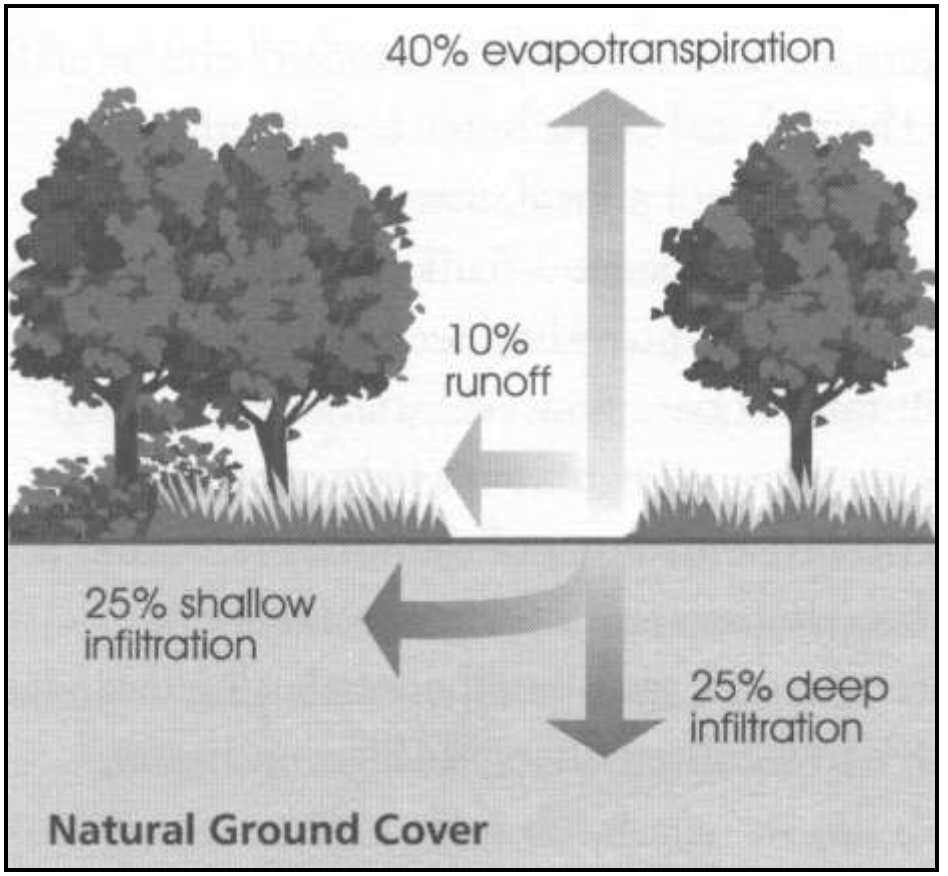
Impacts from Changing Landscape

Hydrologic Effects

- Disruption of natural water balance
- Increased flood peaks
- Increased stormwater runoff
- More frequent flooding
- Increased bankfull flows
- Lower dry weather flows

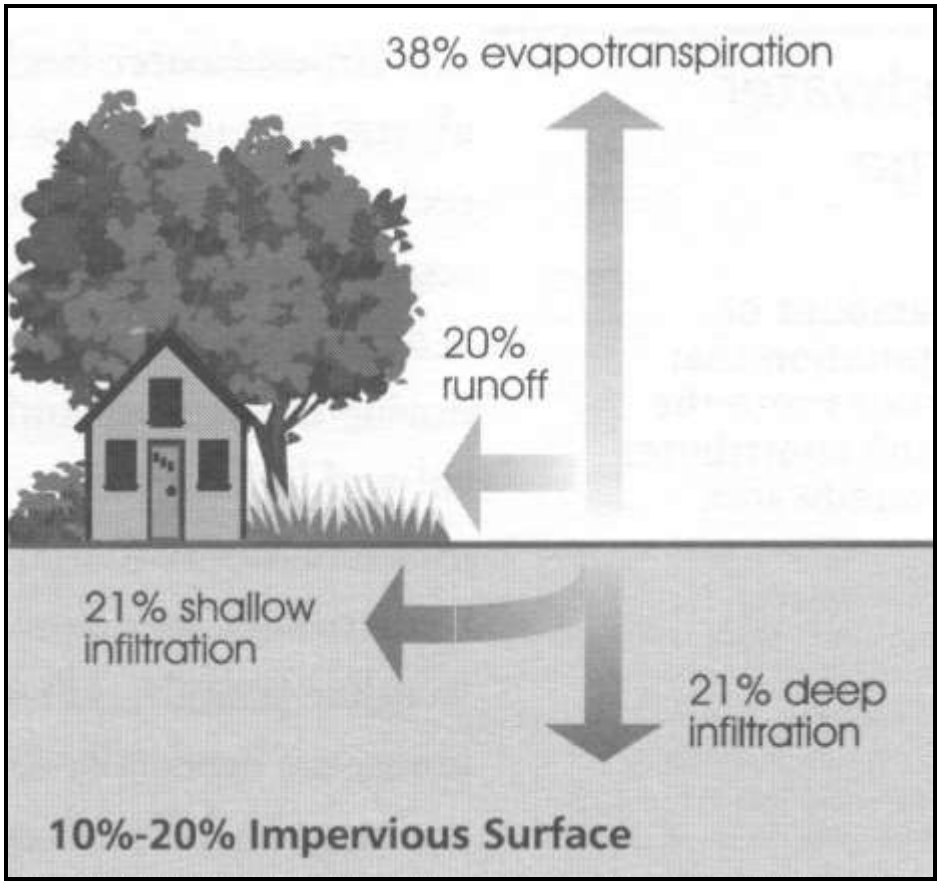
The Impact of Development on Stormwater Runoff

natural conditions



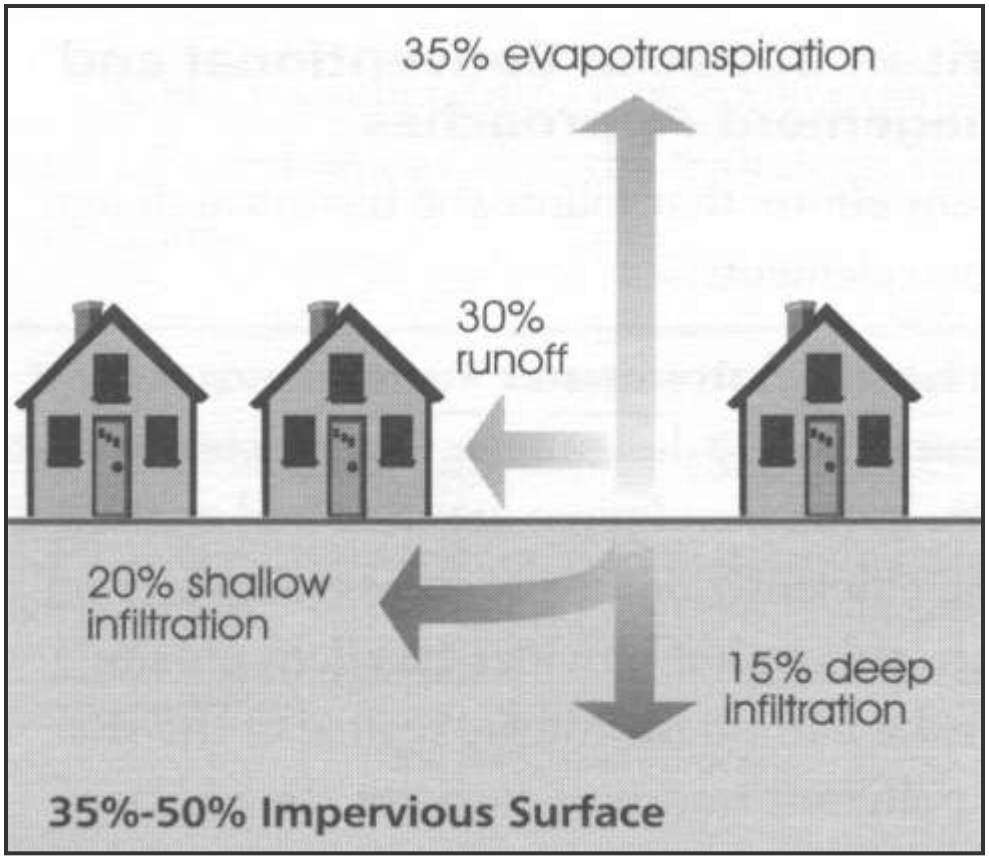
The Impact of Development on Stormwater Runoff

low density development



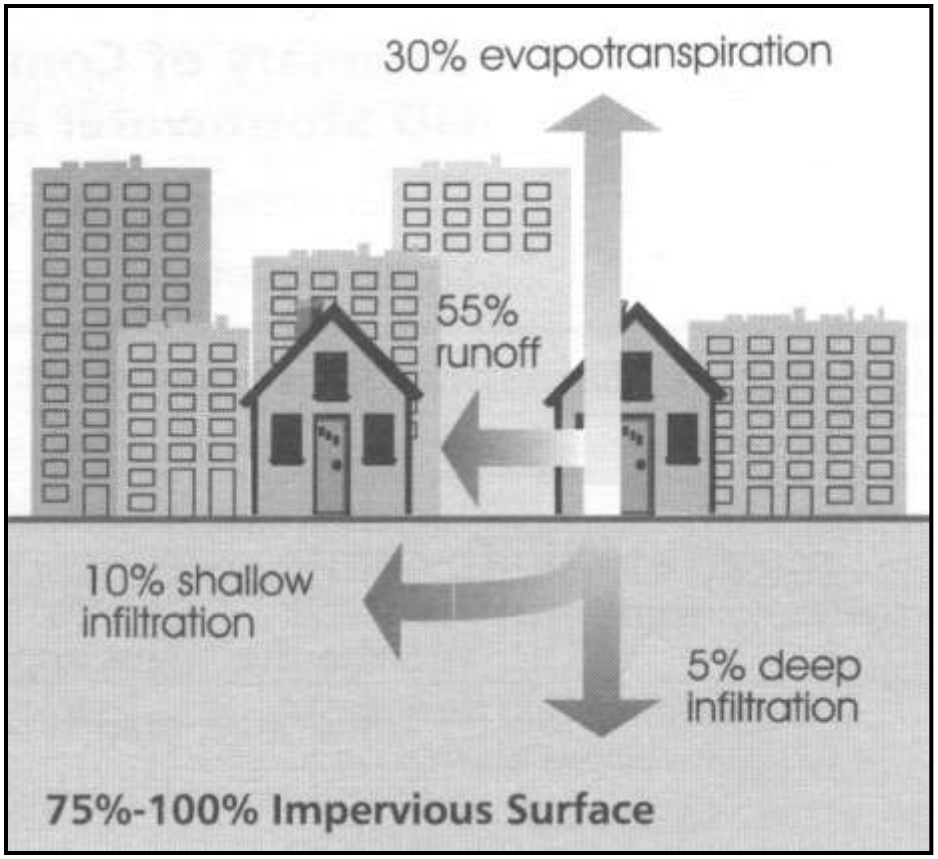
The Impact of Development on Stormwater Runoff

medium density development



The Impact of Development on Stormwater Runoff

urban development



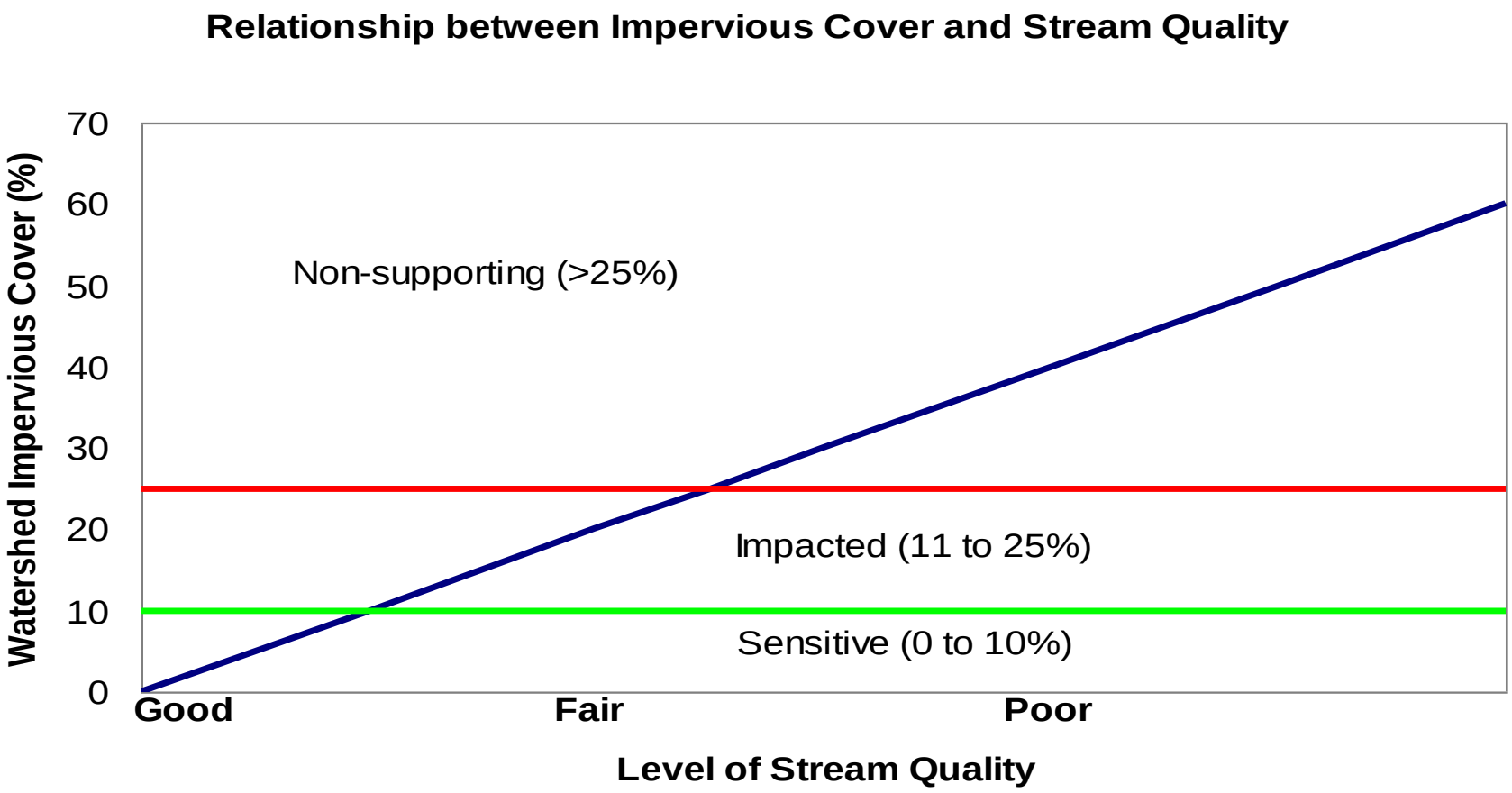
Riverine floods

- **Slow kinds:** Runoff from sustained rainfall or rapid snow melt exceeding the capacity of a river's channel.
- **Fast kinds:** flash flood as a result of e.g. an intense thunderstorm.
- DOWNSTREAM communities are always affected by the cumulative effect from UPSTREAM.
- **Examples**
  - Trenton, NJ
  - Multiple communities along the Mississippi River Last year.

Impervious Cover & Stream Quality

- At 10% impervious cover, stream degradation (e.g., changes in the aquatic biological community) is detectable.
- At 25-40% impervious cover, streams no longer support biological/human uses.

Impervious Cover & Stream Quality



Types of Stormwater Management

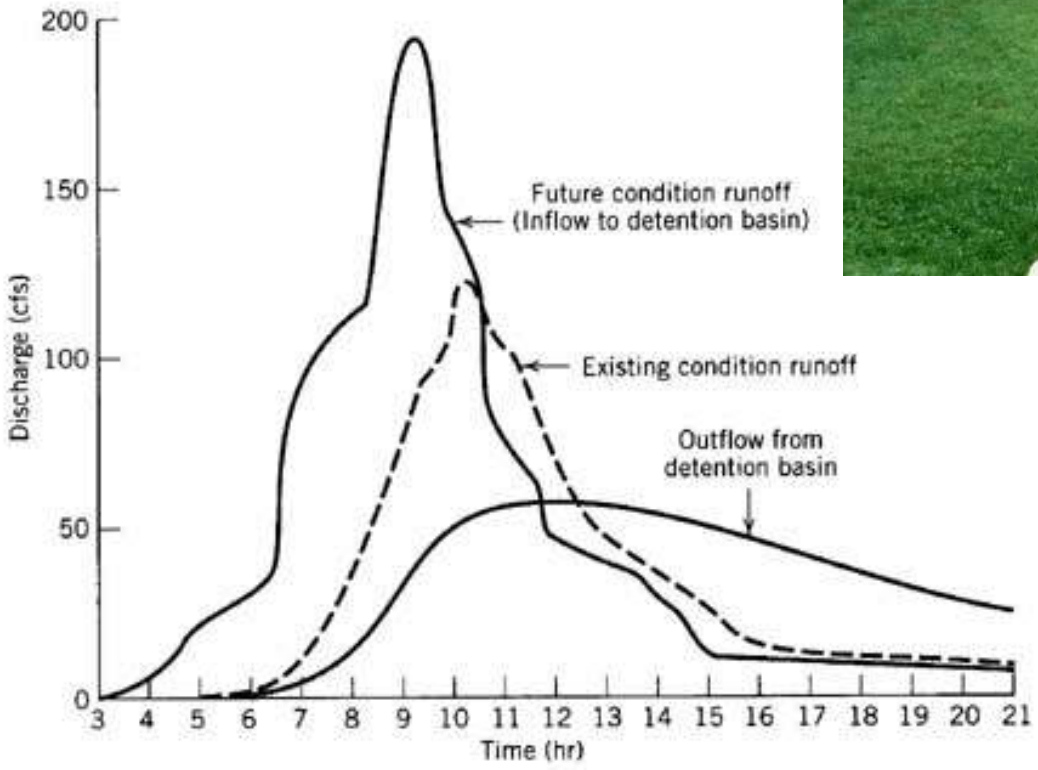
- Traditional
  - Dams, dykes and levies
  - Hydraulic alterations (straighten, channelize, piped, etc.)
  - Combined sewer systems
  - Curb/gutter or open channel gutters
- Next generation
  - Separate storm sewer systems (MS4s)
  - Detention systems (minimize peak flows and volumes)
    - Concrete flow-flow channel
    - Fill and release slowly over time
- Low Impact Development

Connected Impervious Surfaces (MS4)

- No chance for GW recharge for stream base flow
- No chance for infiltration/plant uptake for improved water quality
- Peak flow rates and volumes can be too high for stream carrying capacity

Newer MS4s are Centralized

Detention Basins and Ponds



Goals of Low Impact Development (LID)

- Mimic natural conditions and water balance
- Decentralization/ disconnection
- Uniform distribution of small-scale controls

Older NJ Municipalities are already at/near build-out

- Unique approach to watershed management
- Requires a retrofits
- Incorporate natural systems as a feature that complements the existing urban design

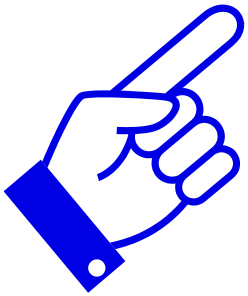
Backyard rain gardens

Education and encouragement of homeowners with help mitigate existing problem of residential impervious cover

Stormwater Management in Your Backyard

- **workshops**
- **incentive programs**
- **demonstration rain gardens**
- **website**
- **landscaper training**

Point vs. Nonpoint

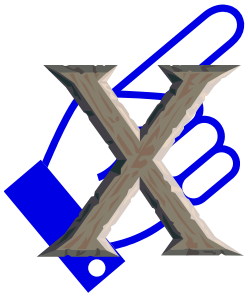


Point Source Pollution

vs.

Nonpoint Source Pollution

What's the difference?



Point Source Pollution

- comes from a specific source, like a pipe
- factories, industry, municipal treatment plants
- can be monitored and controlled by a permit system

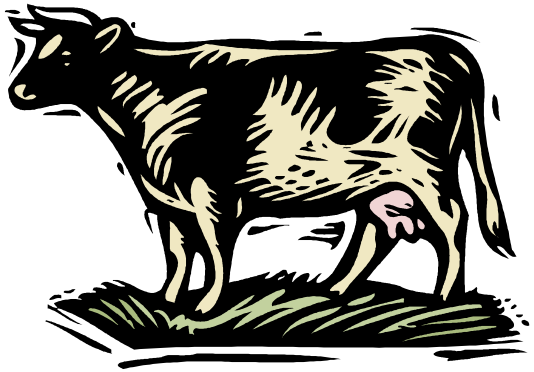
What is nonpoint source pollution?

- Nonpoint Source (NPS) Pollution is pollution associated with stormwater or runoff

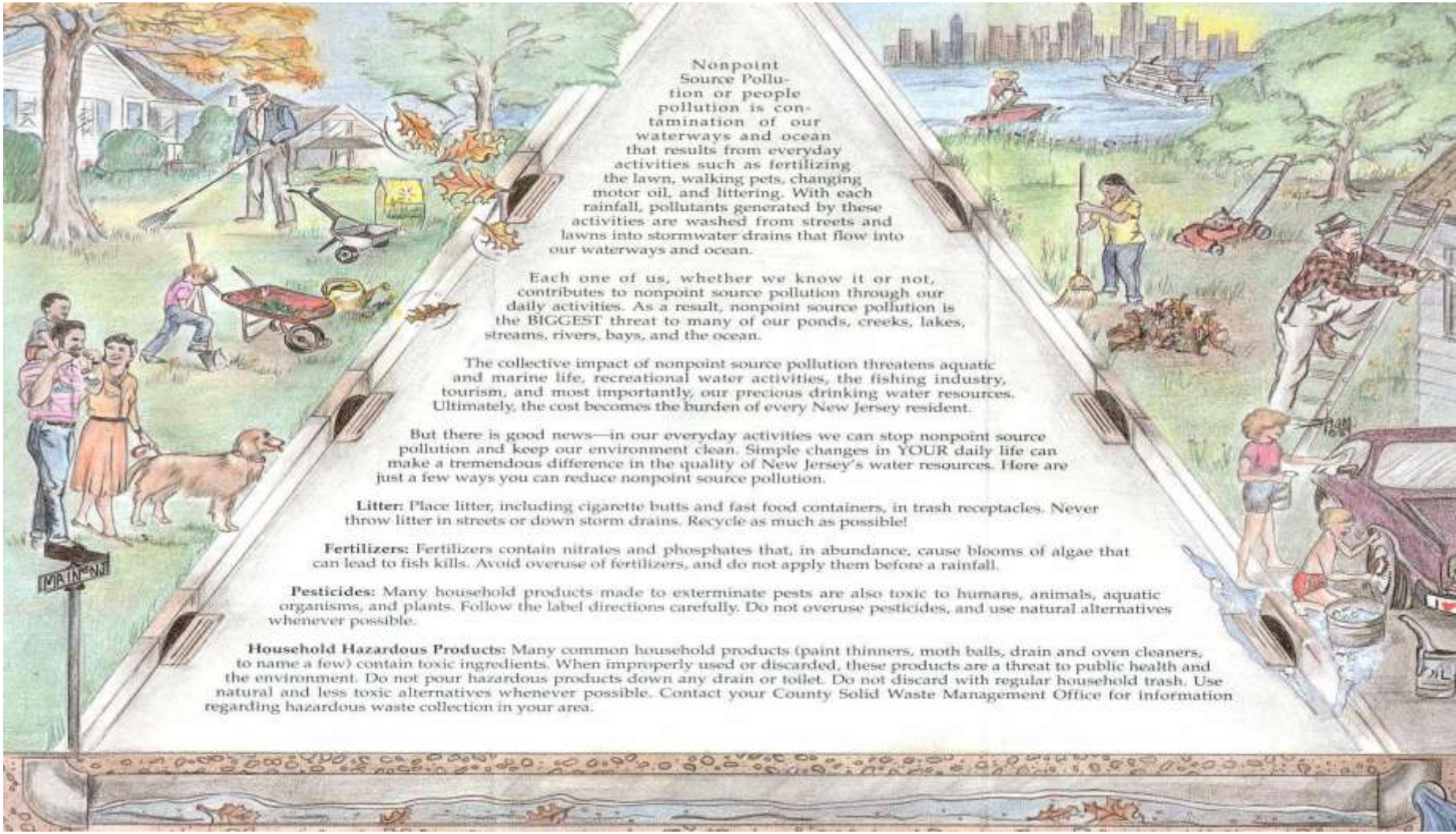
- NPS pollution cannot be traced to a direct discharge point such as a wastewater treatment facility

Examples of NPS

- oil & grease from cars
- fertilizers
- animal waste
- grass clippings
- septic systems
- sewage leaks
- household cleaning products
- Litter
- Agriculture

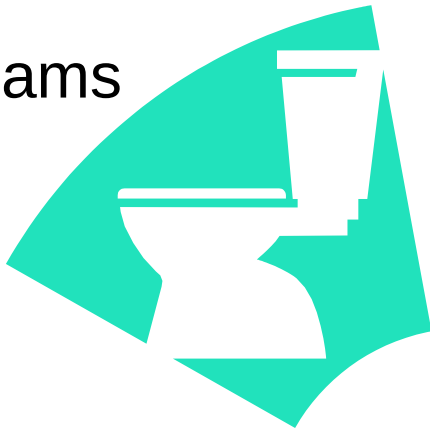


"People Pollution"



Pollutant Transport Mechanisms

- NPS pollutants build up on land surfaces during dry weather
  - Atmospheric deposition (especially mercury)
  - Fertilizer applications
  - Animal waste
  - Automotive exhaust/fluid leaks
- Pollutants are washed off land surfaces during precipitation events (stormwater runoff)
- Stormwater runoff will flow to lakes and streams
- **FIRST FLUSH EFFECT**



Impact of Nonpoint Source Pollution

- fish and wildlife
- recreational water activities
- commercial fishing
- tourism
- drinking water quality

Pollutants Found in Runoff

Sediment
Soil particles transported from their source

Biochemical Oxygen Demand (BOD)
- Oxygen depleting material
  - Leaves
  - Organic material

Toxics
- Pesticides
  - Herbicides
  - Fungicides
  - Insecticides
- Metals (naturally occurring in soil, automotive emissions/ tires)
  - Lead
  - Zinc
  - Mercury
- Petroleum Hydrocarbons (automotive exhaust and fuel/oil)

Nutrients
- Various types of materials that become dissolved and suspended in water (commonly found in fertilizer and plant material):
  - Nitrogen (N)
  - Phosphorus (P)

Bacteria/ Pathogens
Originating from:
- Pets
- Waterfowl
- Failing septic systems

Thermal Stress
Heated runoff, removal of streamside vegetation

Debris
Litter and illegal dumping

Potential Sources of Pollutants Found in Residential Areas

- Nutrients: Fertilizers and septic systems
- Pathogens: Pet waste and septic systems
- Sediment: Construction, road sand, soil erosion
- Toxic: Pesticides, household products
- Debris: Litter and illegal dumping
- Thermal: heated runoff, removal of streamside vegetation

Why are these pollutants important?

- Sediment reduces light penetration in stream, clogs gills of fish and aquatic invertebrates, increases filling of impoundments.
- Nutrients act as fertilizer for algae & aquatic plants which can cause highly varying dissolved oxygen levels. At low DO levels, the aquatic life has the potential to be harmed.
- BOD measures the amount of organic matter that is decomposed by microorganisms which deplete dissolved oxygen.
- Toxics can impact life and contaminate drinking water supplies.
- Bacteria/Pathogens are an indicator of possible viruses present in the system.