RUTGERS
THE STATE UNIVERSITY OF NEW JERSEY

Stormwater 101

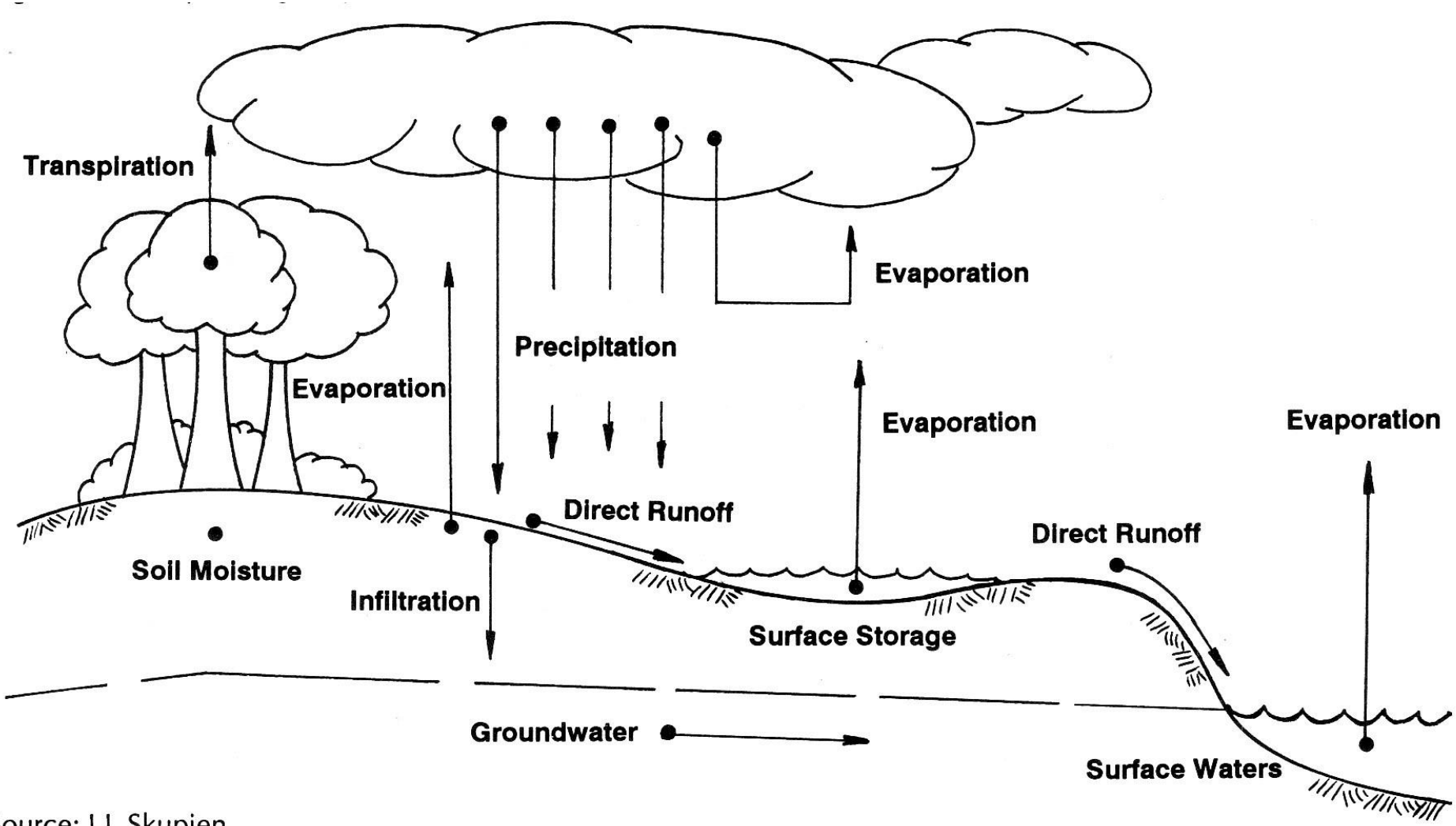
Water Resources Program

RUTGERS
New Jersey Agricultural Experiment Station

New Jersey Marine Sciences Consortium
Sea Grant New Jersey

Applying knowledge to improve water quality
Northeast States & Caribbean Islands Regional Water Program
A Partnership of USDA CSREES & Land Grant Colleges and Universities

The Hydrologic Cycle



Source: J.J. Skupien.

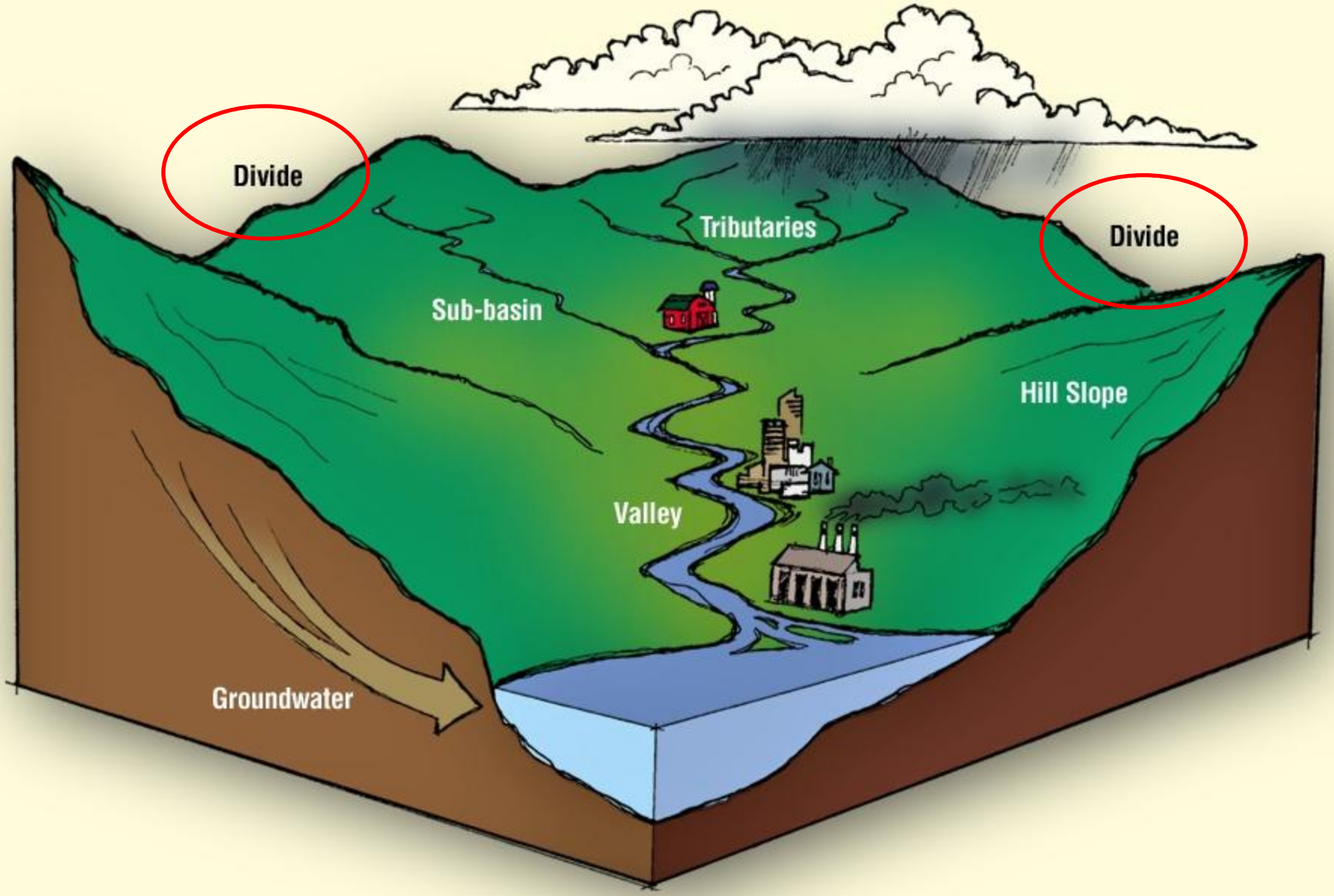
What is stormwater or “runoff”?

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

What is a Watershed?

- An area of land that water flows across, through, or under on its way to a stream, river, lake, ocean or other body of water.

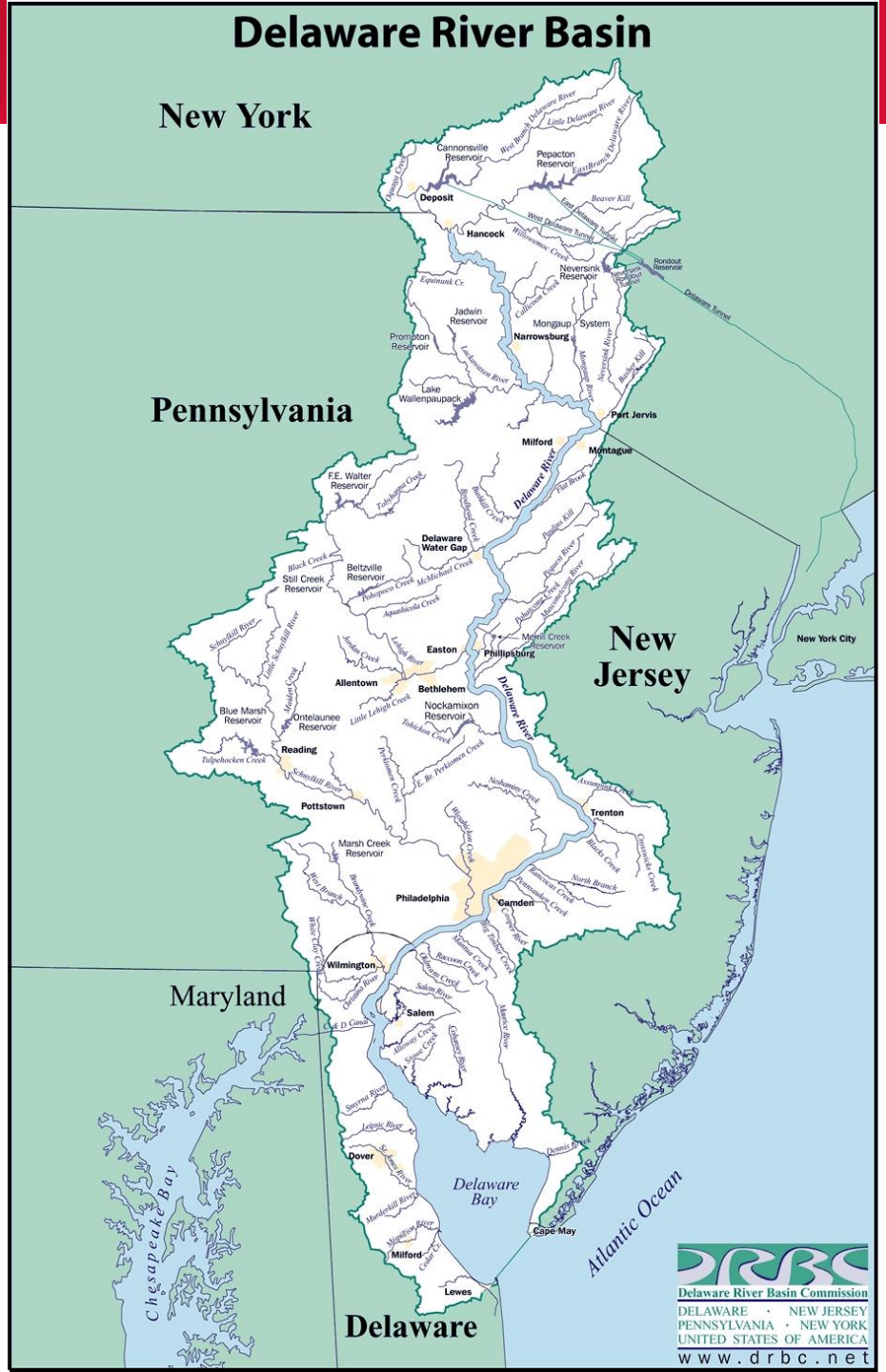
- Other terms:
  - Drainage basin
  - Drainage area
  - Catchment


Divide
Tributaries
Divide
Sub-basin
Hill Slope
Valley
Groundwater

WATERS
HED

Mississippi River Basin

RUTGERS


Delaware River Basin
New York
Pennsylvania
New Jersey
Maryland
Delaware
Cannonsville Reservoir
Pepacton Reservoir
Deposit
Hancock
Neversink Reservoir
Rondout Reservoir
Jadwin Reservoir
Mongaup System
Narrowsburg
Prompton Reservoir
Lake Wallenpaupack
Port Jervis
Milford
Montague
F.E. Walter Reservoir
Delaware River
Delaware Water Gap
Beltzville Reservoir
Still Creek Reservoir
Easton
Phillipsburg
Merrill Creek Reservoir
New York City
Allentown
Bethlehem
Nockamixon Reservoir
Blue Marsh Reservoir
Ontelaunee Reservoir
Reading
Pottstown
Trenton
Marsh Creek Reservoir
Philadelphia
Camden
Wilmington
Salem
Dover
Delaware Bay
Cape May
Milford
Lewes
Chesapeake Bay
Atlantic Ocean
Delaware River Basin Commission
DELAWARE · NEW JERSEY
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UNITED STATES OF AMERICA
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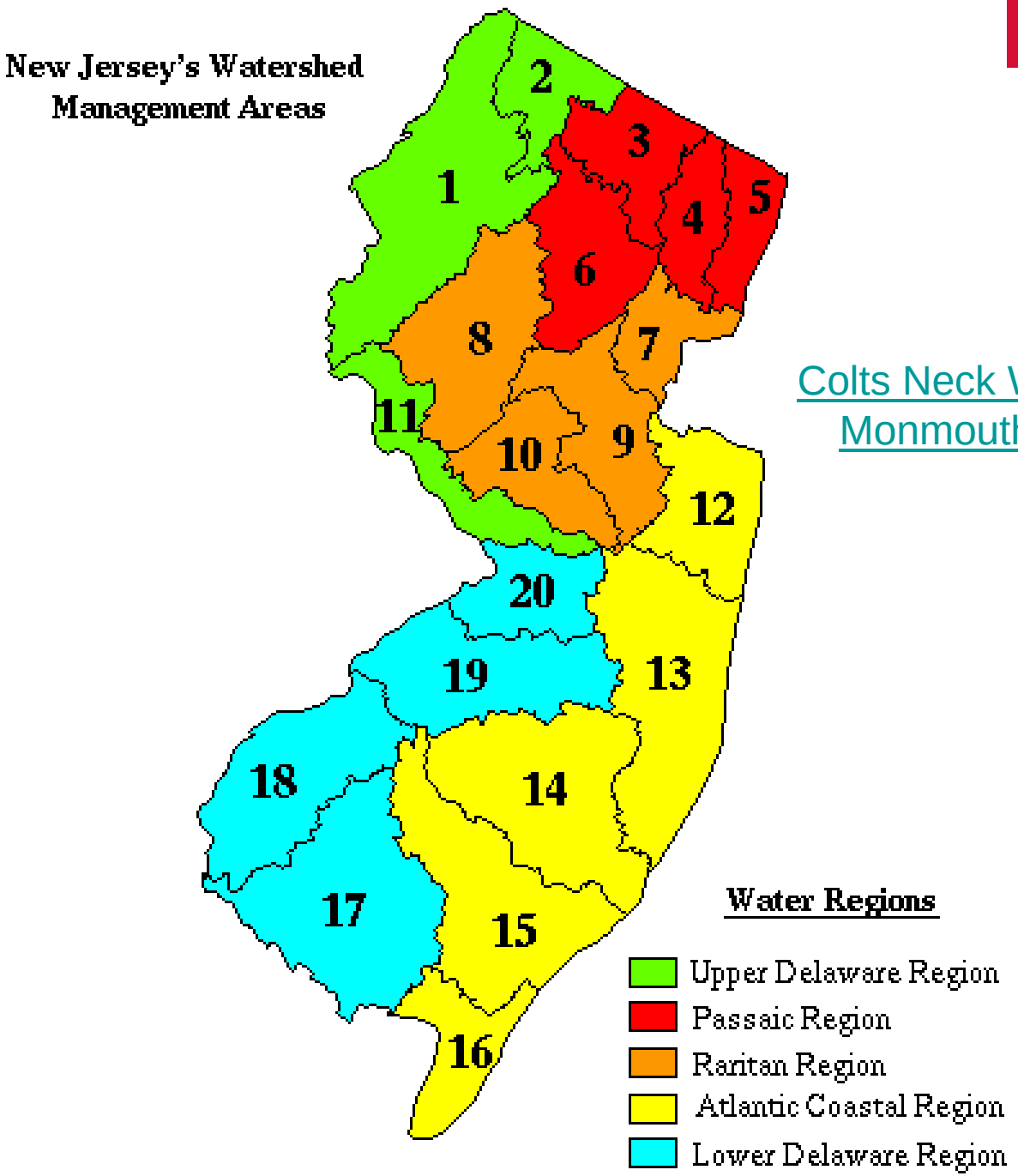


Colts Neck Watershed, Monmouth County

Source: USGS

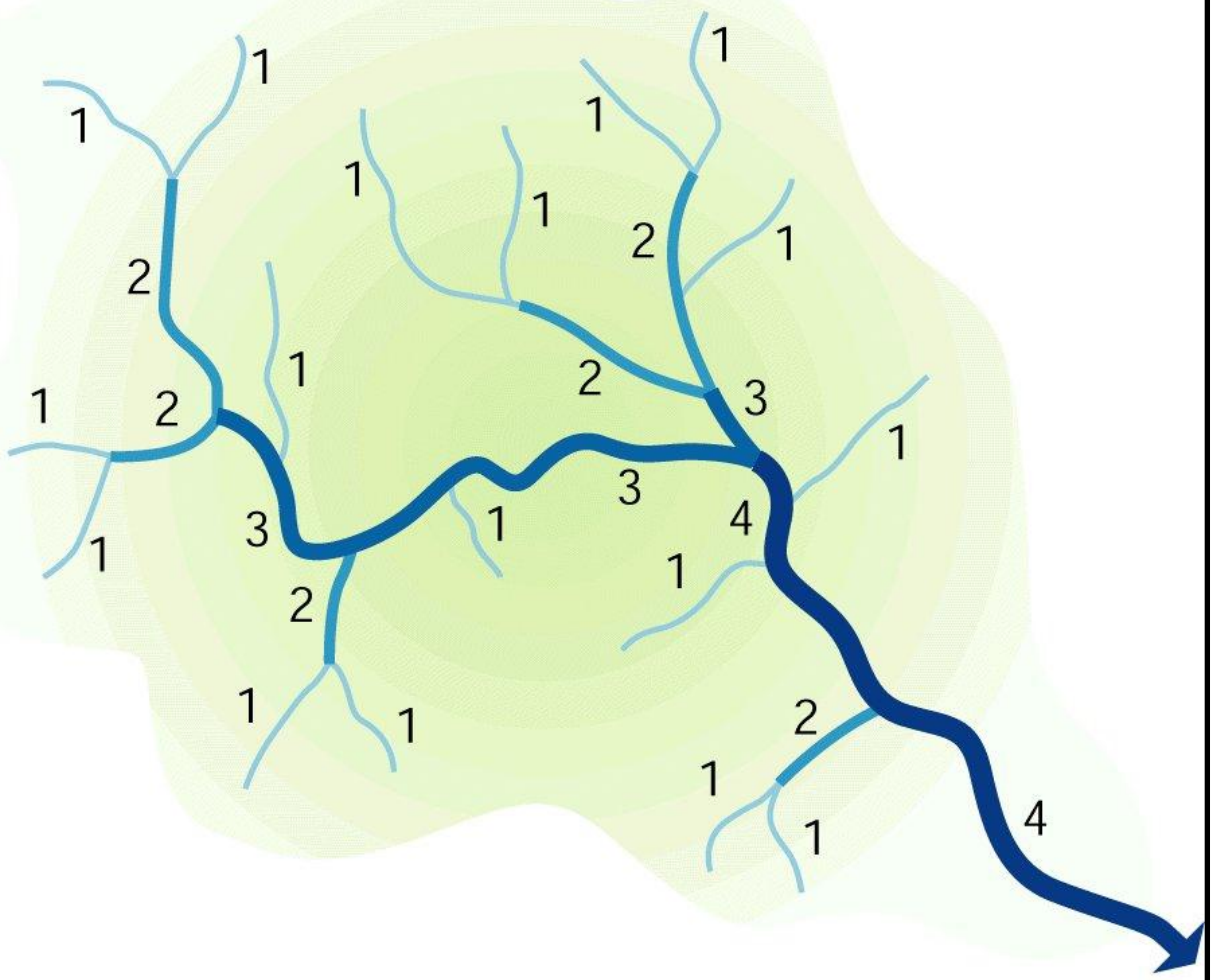
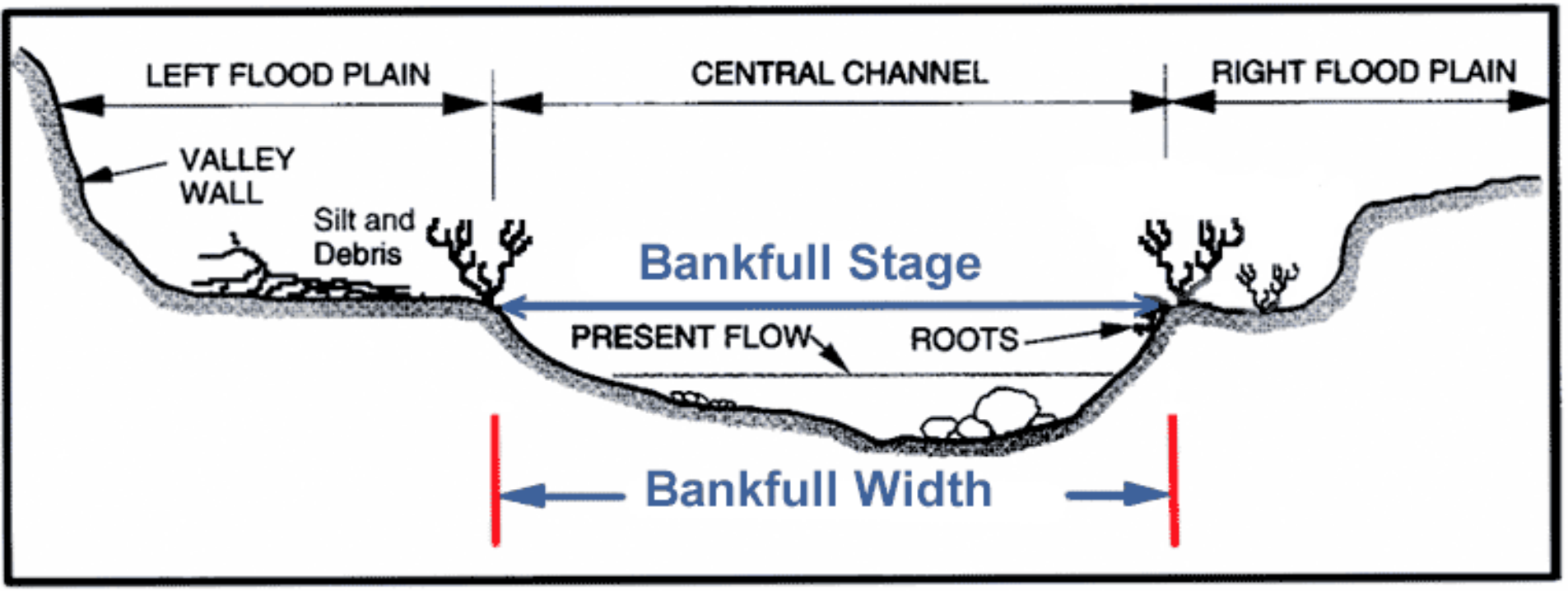


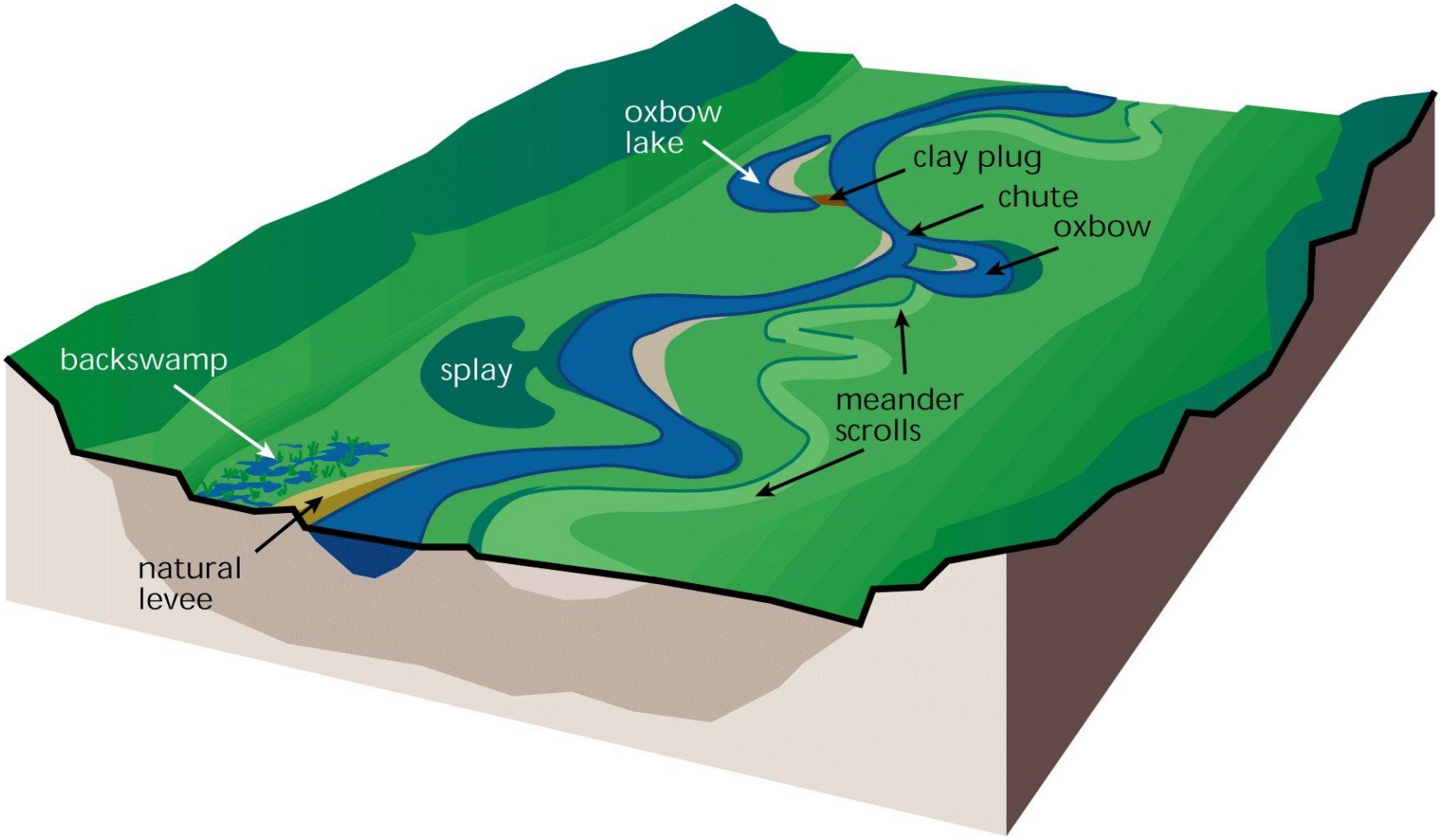
Fig. 1.30 – Stream ordering in a drainage network. "1" = first order stream; "2" = second order stream, etc.
In Stream Corridor Restoration: Principles, Processes, and Practices (10/98).
Interagency Stream Restoration Working Group (15 federal agencies)(FISRWG).

Stream Channel Cross-section



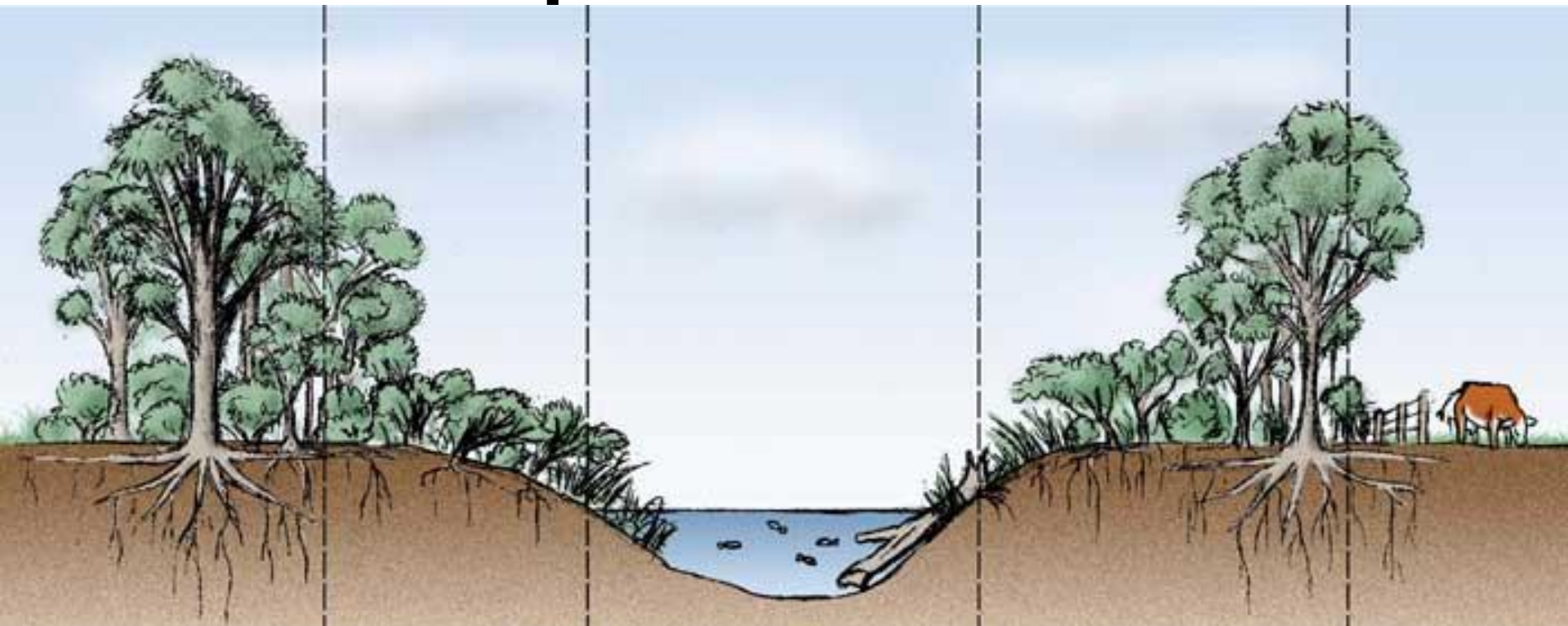
(Newbury and Gaboury 1993)

Floodplains Are Dynamic Systems



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

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.

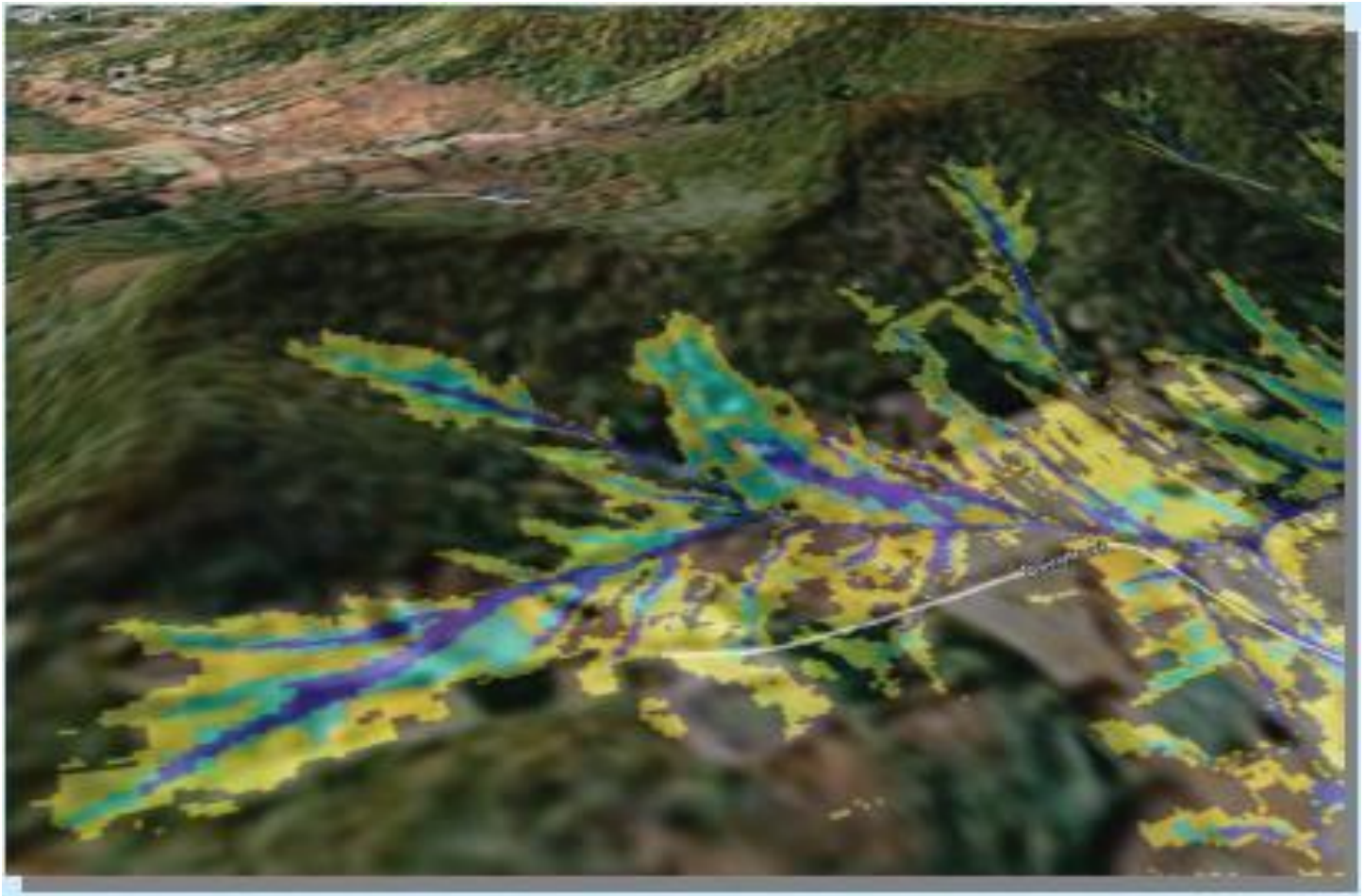
Meteorological Factors Affecting Runoff

- 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

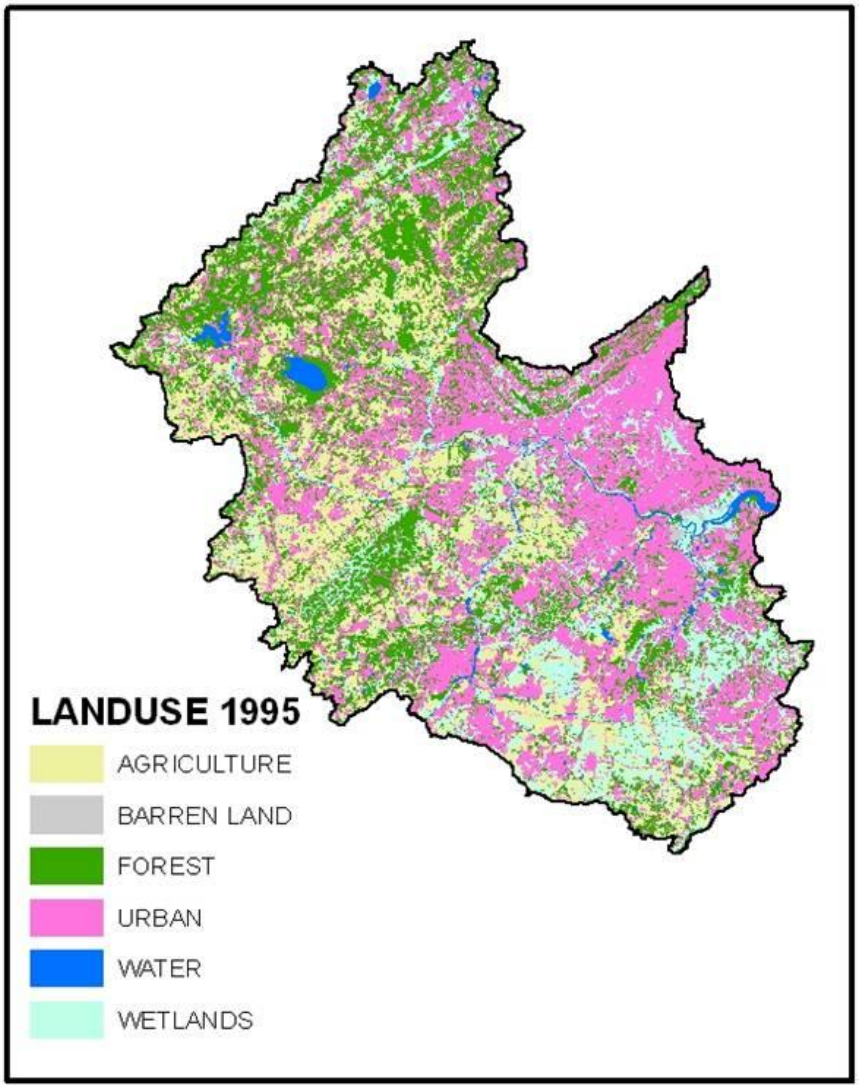
- ***Land use***
- Vegetation
- Soil type
- Drainage area
- Basin shape
- Elevation

- 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

What is impervious cover?

- roads, rooftops, parking lots, and other hard surfaces that do not allow stormwater to soak into the ground

- Even disturbed/constructed open spaces (such as parks) have become impervious due to compaction

Impervious Cover

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

Impacts from Urbanization

Hydrologic Effects

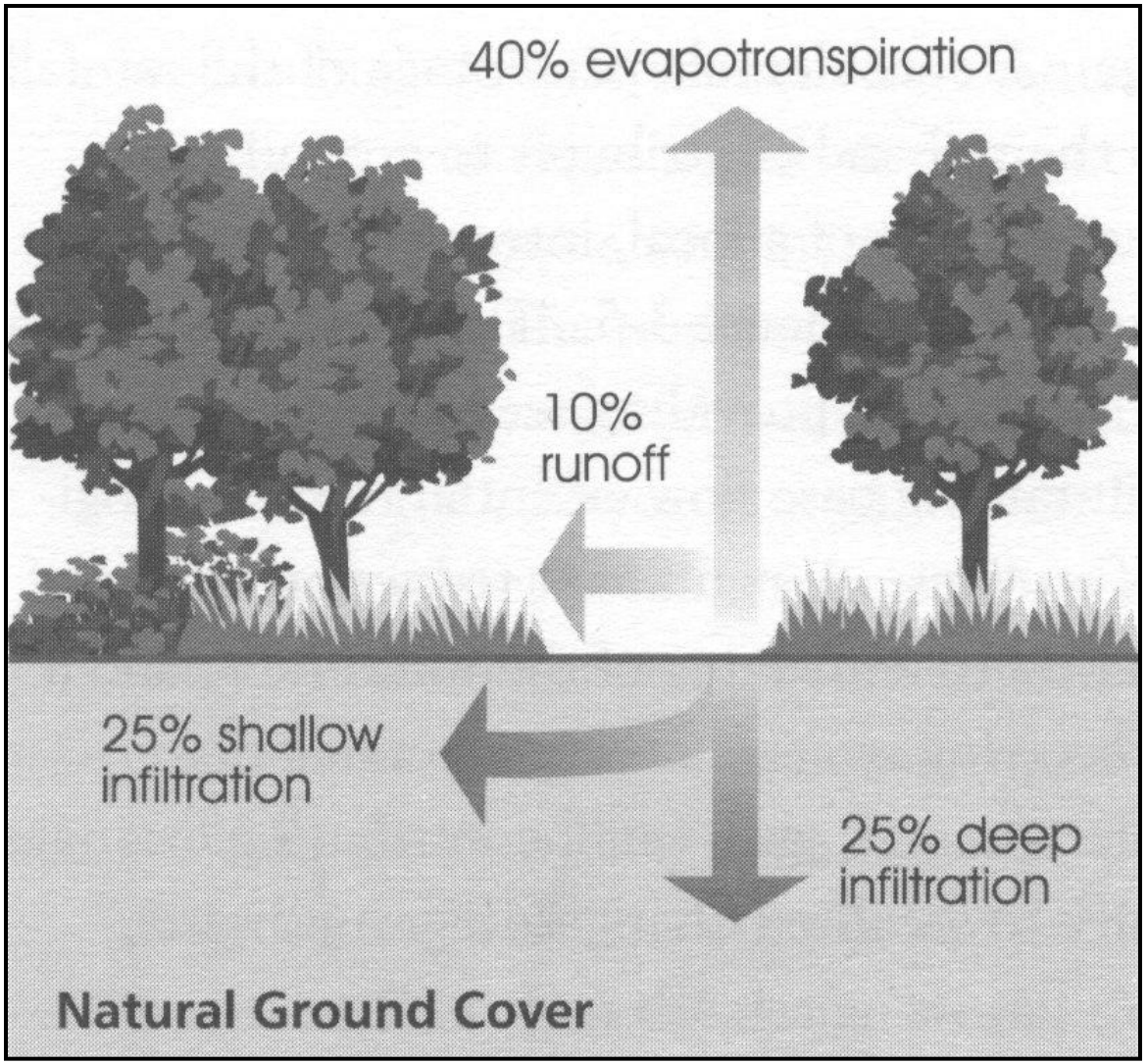
- Disruption of natural water cycle
- Increased flood peaks (peak flow rates)
- Increased stormwater runoff volume
- More frequent flooding
- Increased bankfull flows
- Decreased dry weather flows

Severe Stream Bank Erosion

Shoreline Erosion at Cooper River Lake

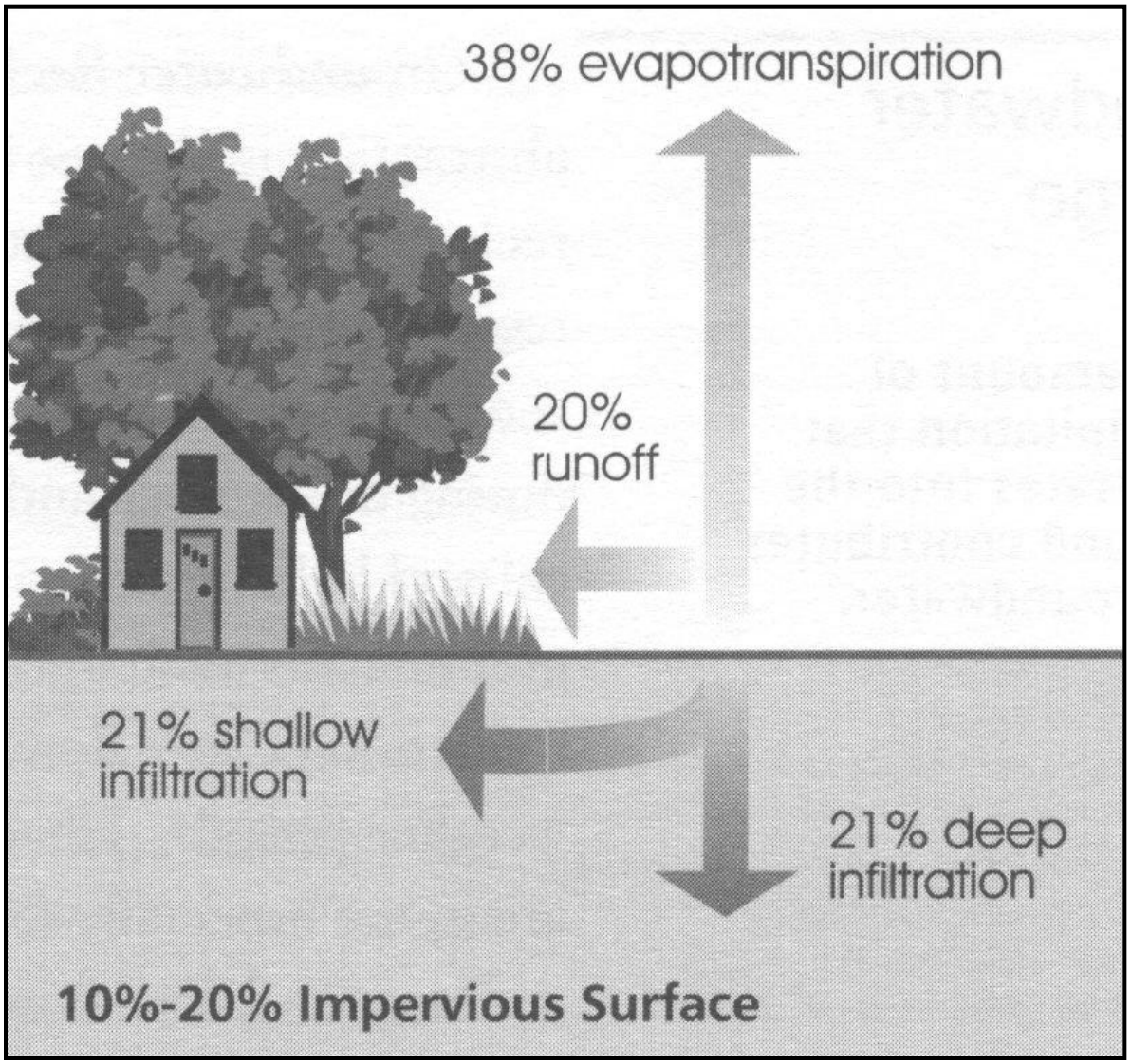
The Impact of Development on Stormwater Runoff

natural conditions



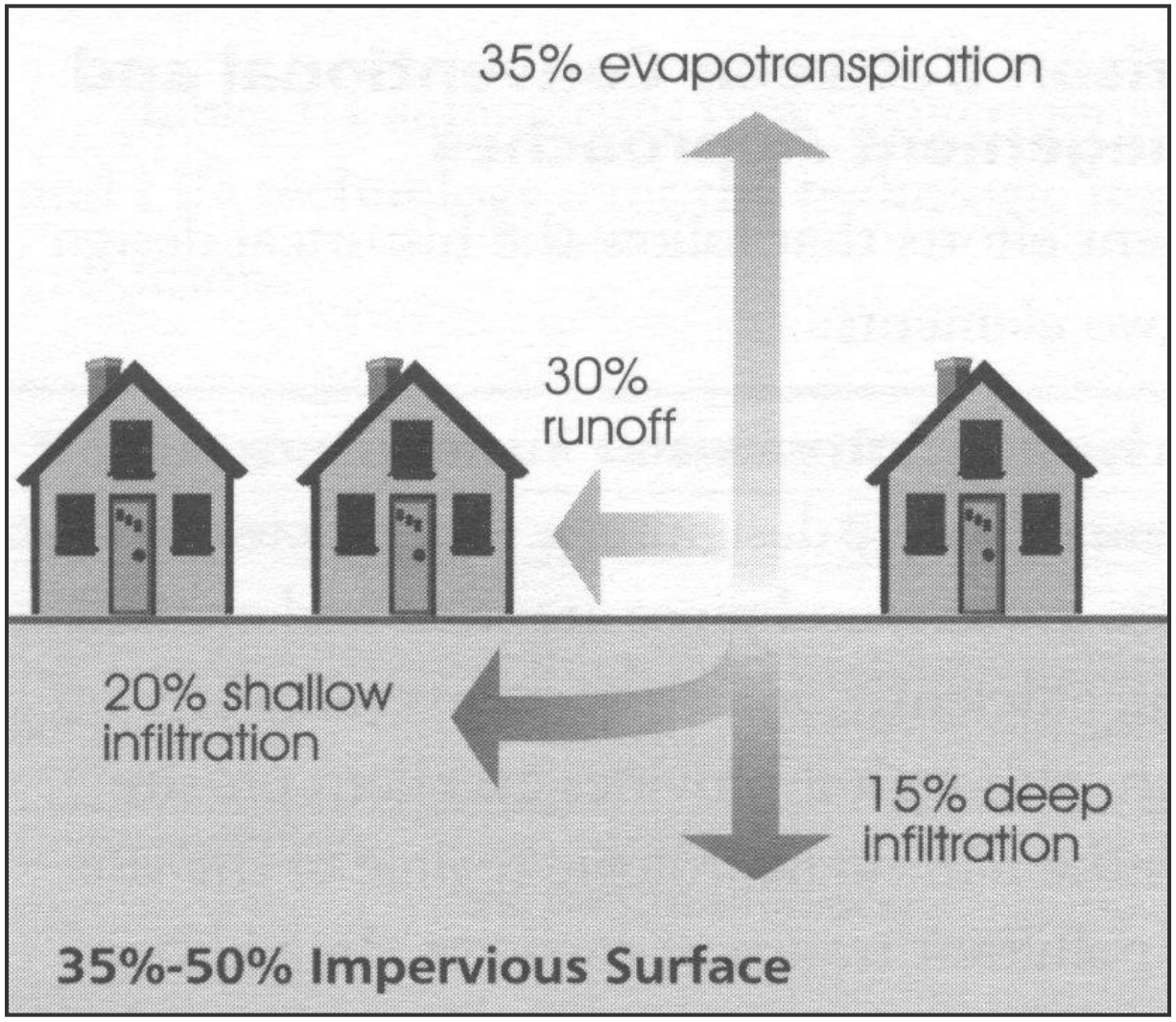
The Impact of Development on Stormwater Runoff

low density development



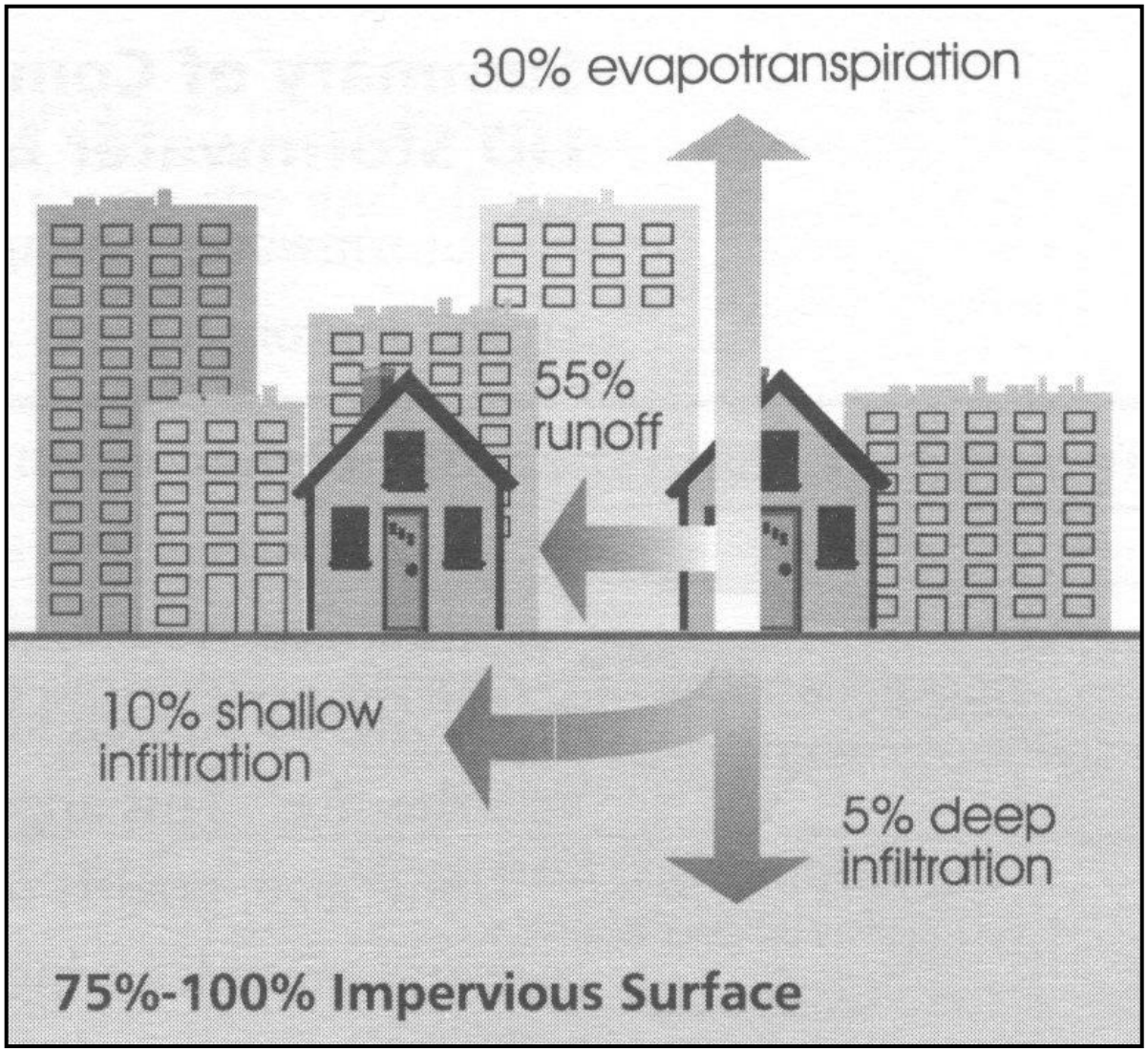
The Impact of Development on Stormwater Runoff

medium density development



The Impact of Development on Stormwater Runoff

urban development

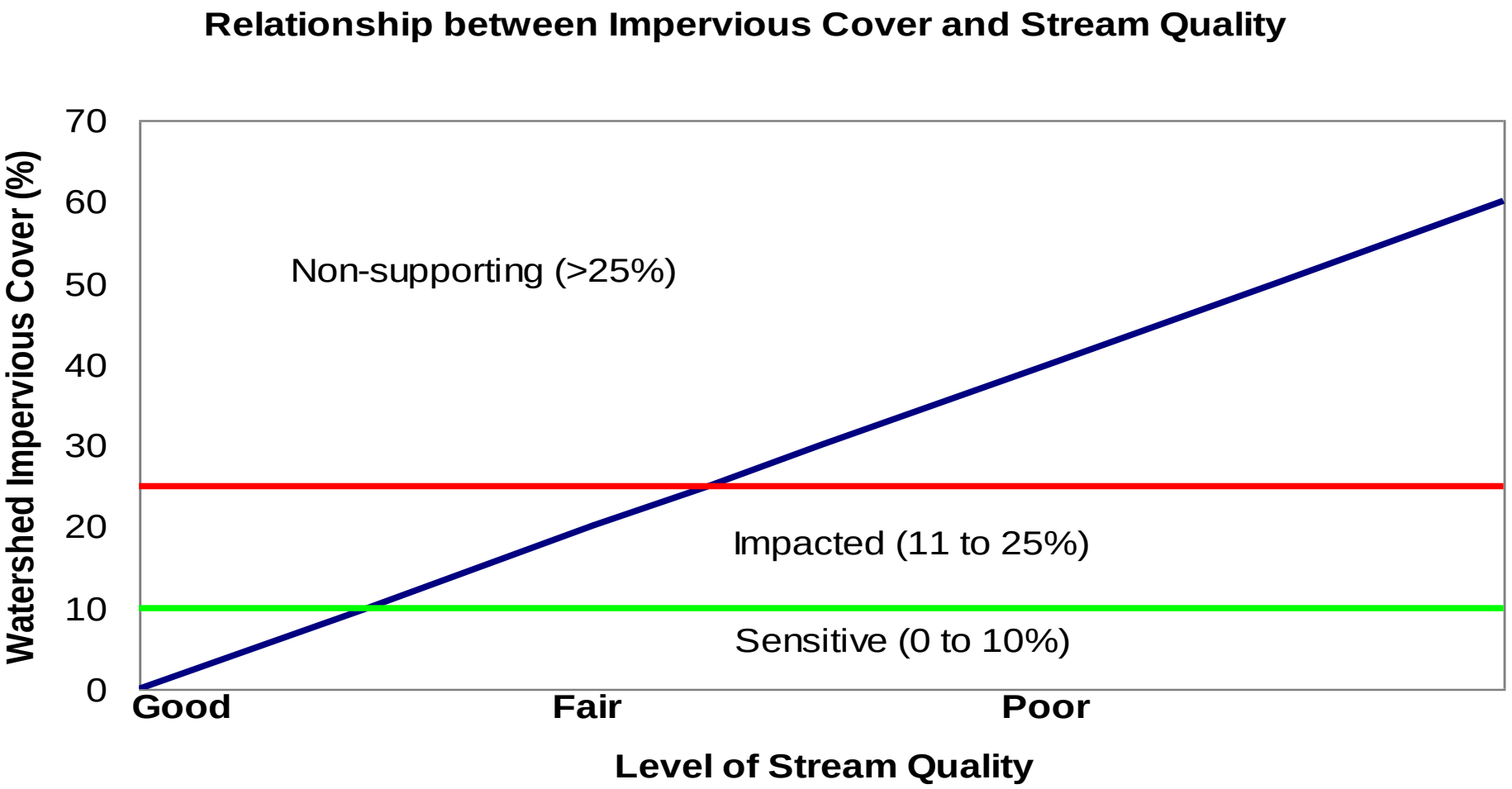


Impervious Cover & Stream Quality

- 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



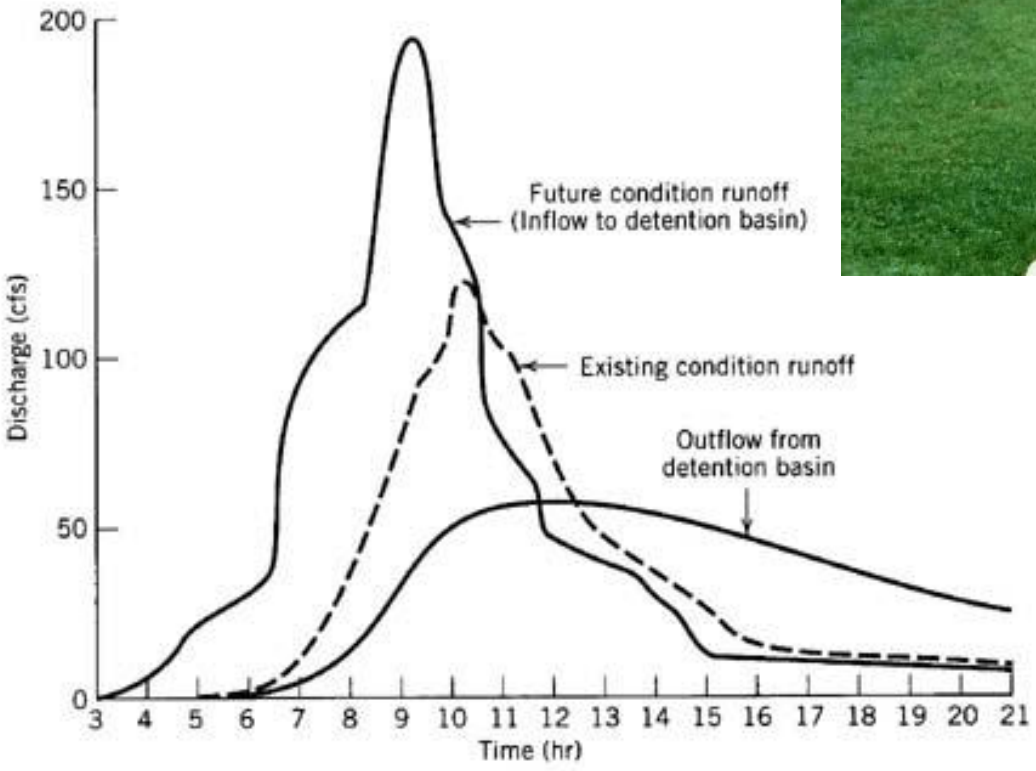
Types of Stormwater Management

1. Traditional
   - Dams, dikes and levees
   - Hydraulic alterations (straighten, channelize, piped, etc.)
   - Combined sewer systems
   - Curb/gutter or open channel gutters

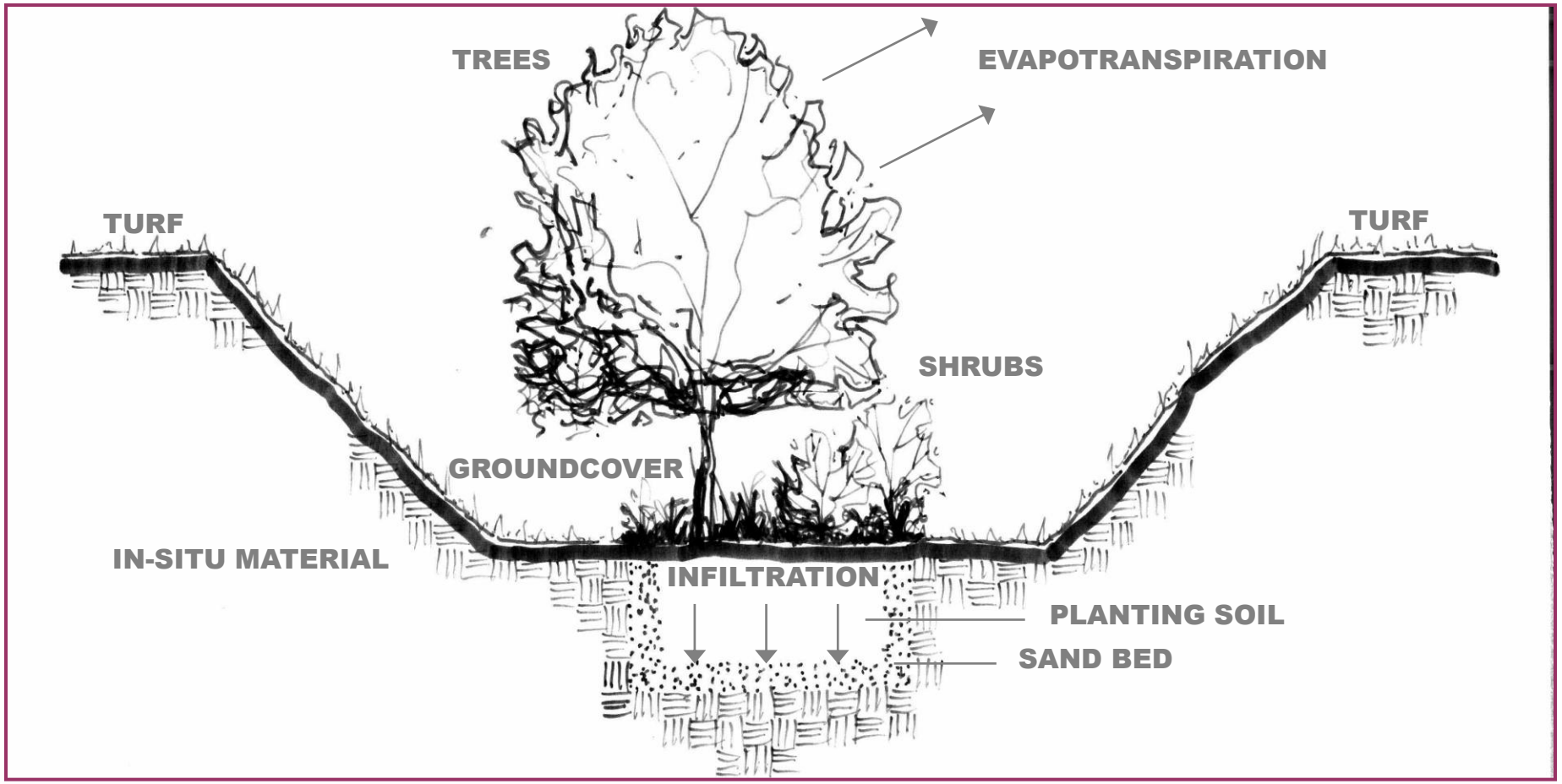
Types of Stormwater Management

2. Next generation
   - Separate storm sewer systems (MS4s)
   - Detention systems (minimize peak flows and volumes)

Detention Basins and Ponds



Bioretention Basin Concept



Goals of Low Impact Development (LID)

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

Older NJ Municipalities are already at/near build-out

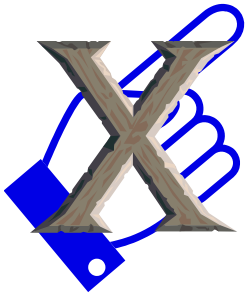
- Unique approach to watershed management
- Requires retrofits
- Incorporate natural systems as a feature that complements the existing urban design

Point vs. Nonpoint

Point Source Pollution

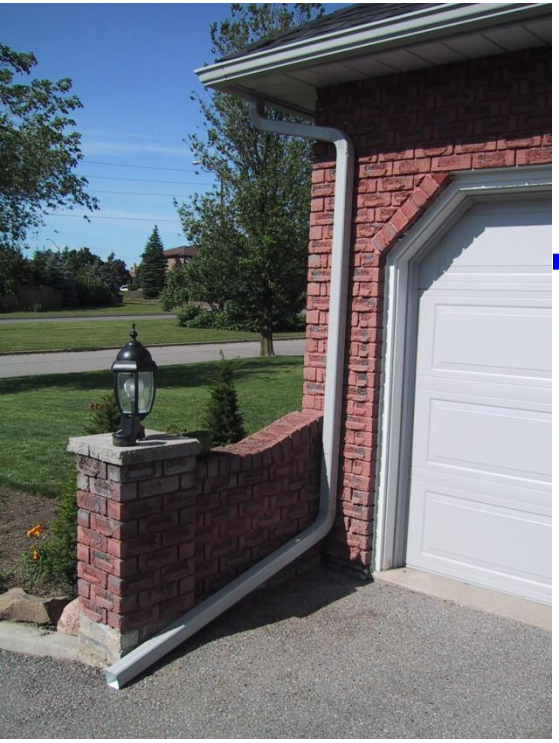
vs.

Nonpoint Source Pollution



What's the difference?

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

First Flush Effect

Backyard rain gardens

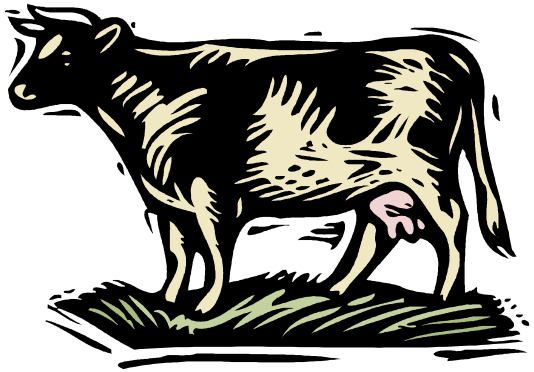
Education and encouragement of homeowners with help mitigate existing problem of residential impervious cover

Stormwater Management in Your Backyard

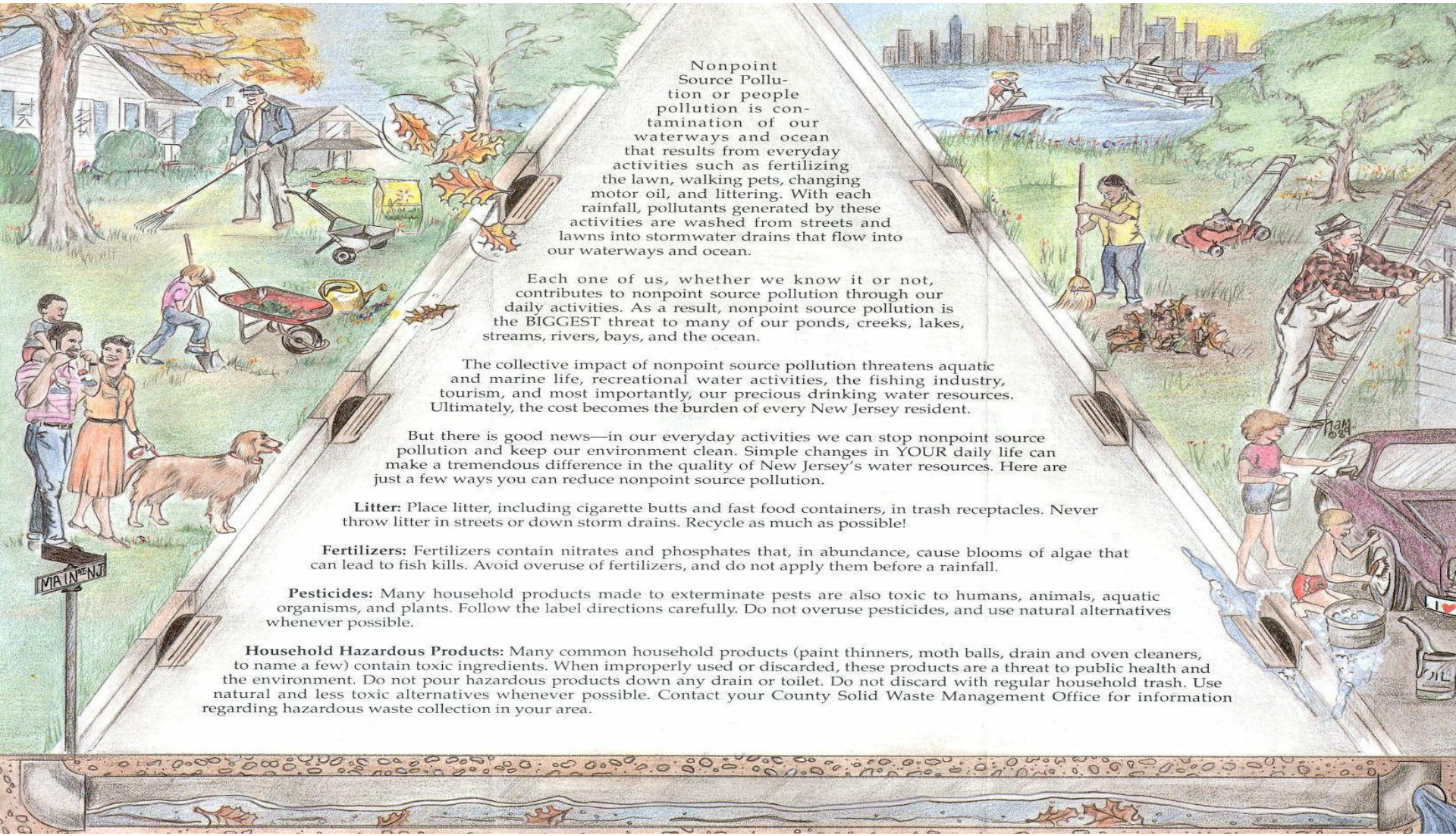
- **workshops**
- **incentive programs**
- **demonstration rain gardens**
- **website**
- **landscaper training**

Examples of NPS

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



“People Pollution”



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)

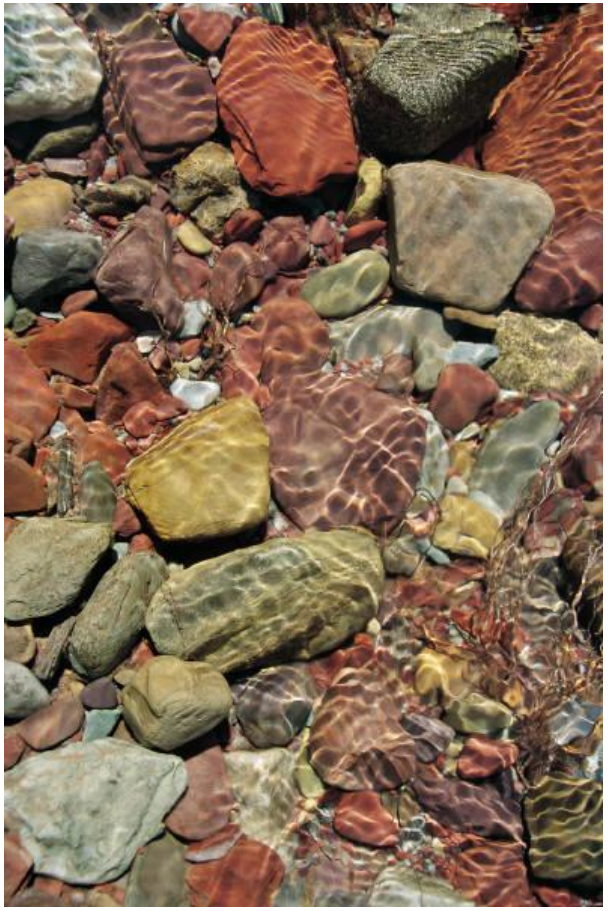
Bacteria/ Pathogens
Originating from:
Pets
Waterfowl
Failing septic systems

Thermal Stress
Heated runoff, removal of streamside vegetation

Debris
Litter and illegal dumping

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.



Stormwater Regulations

- Municipal Permit Requirements (NJAC 7:14A)
  - Every NJ municipality has permit requirements that may be passed down to residents via ordinances
  - NJ DEP administered program under jurisdiction of the Federal Clean Water Act (US EPA)
- New Jersey Stormwater Management Regulations (NJAC 7:8)
  - Infiltration requirements for new development
- Total Maximum Daily Load analysis
- Regional Planning for watershed restoration and protection