Storm Water Hydrology

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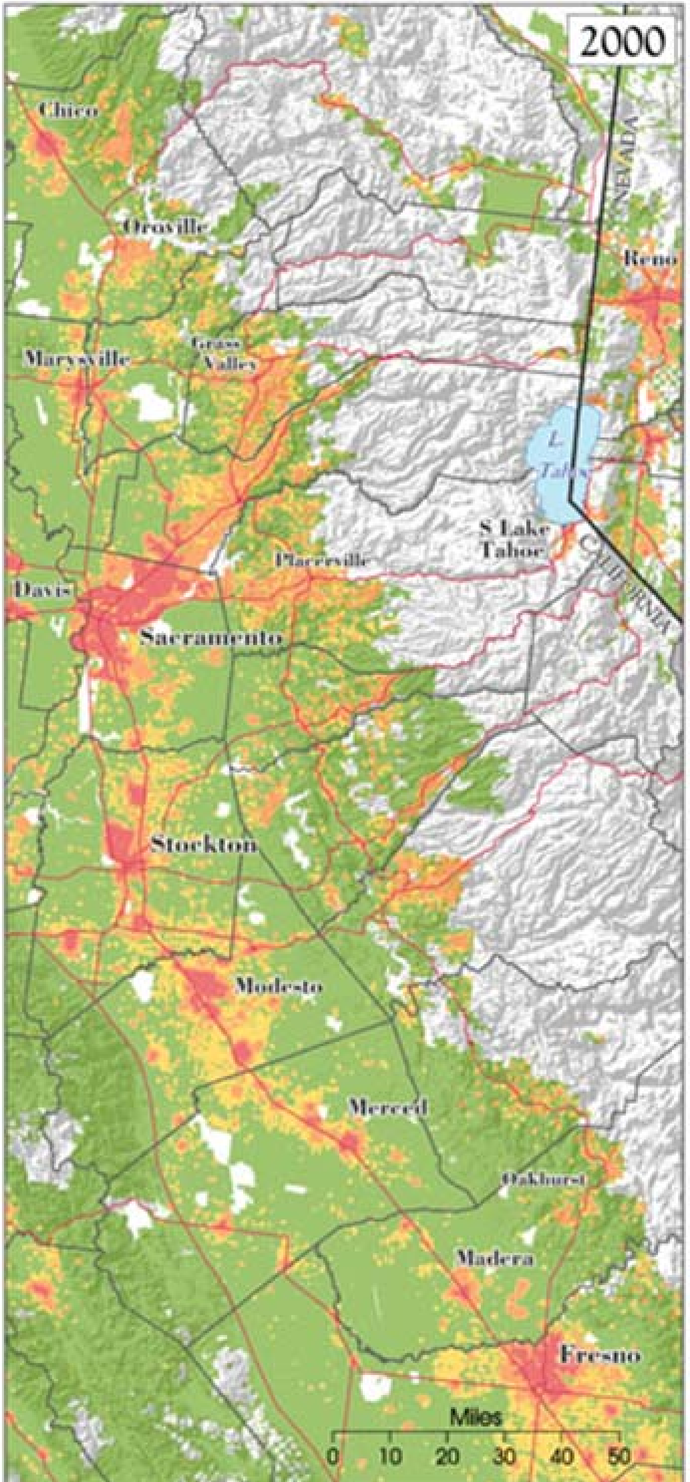
stormwater program / SWRCB

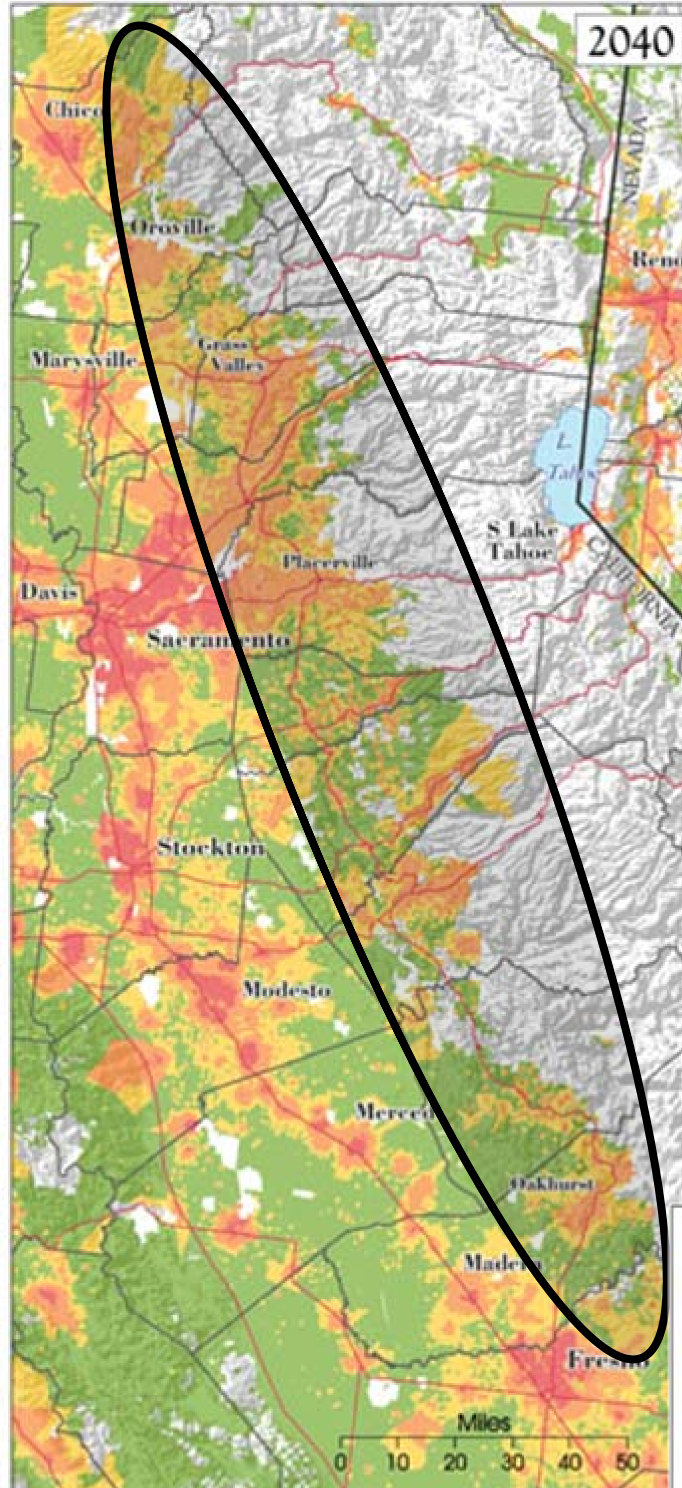
the problem is not growth

it's how we modify the landscape

Exurbanization in the Sierra Foothills

from "New Geographies of the American West" by William Travis



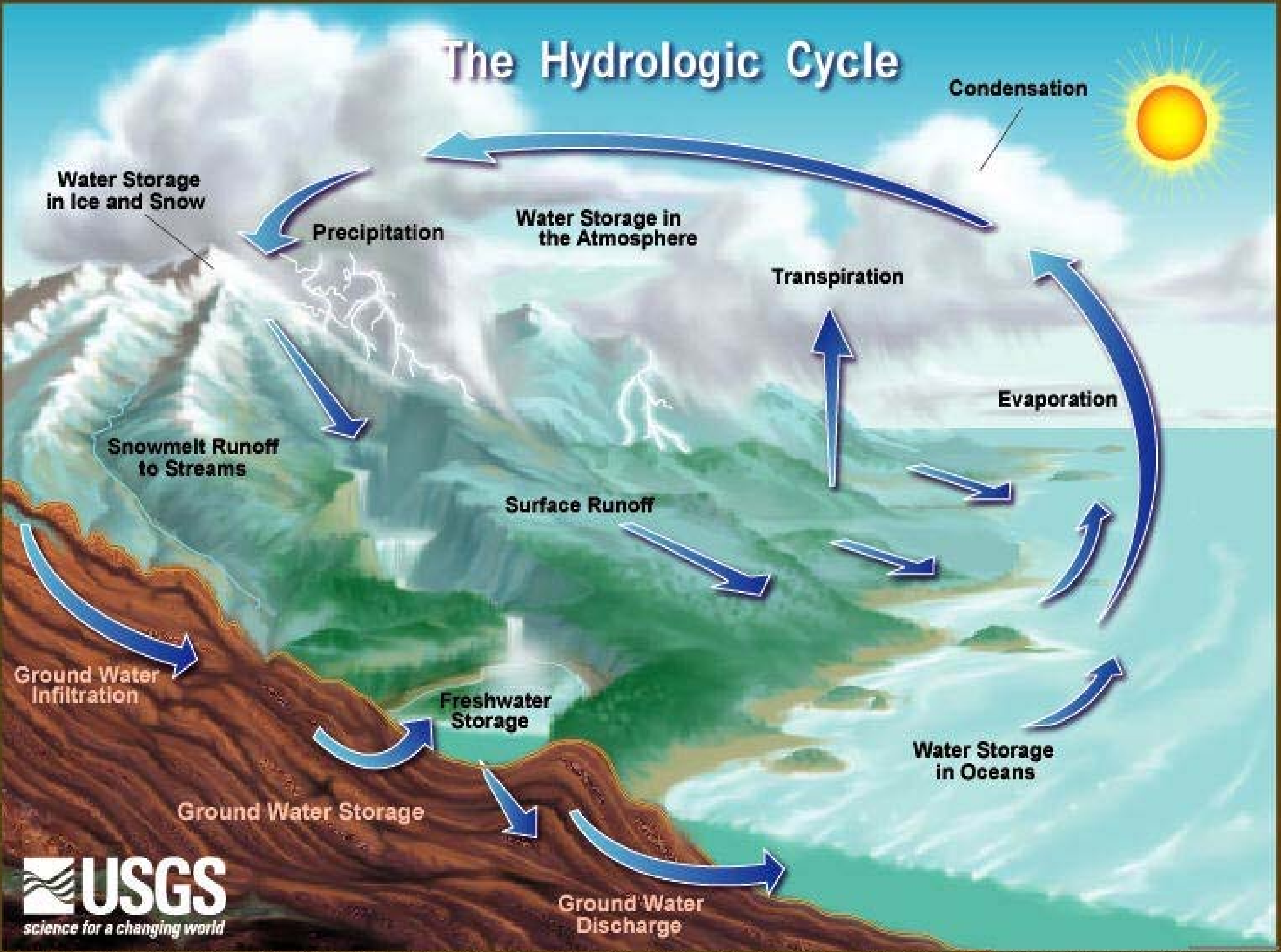


Land Use Categories

- Rural (<1 unit per 40 acres)
- Exurban (1 unit per 10 to 40 acres)
- Low Density Suburban (1 unit per 0.5 to 10 acres)
- Urban/Suburban (>2 units per acre)
- Not Buildable

"The history of every nation is eventually written in the way in which it cares for its soil"

Franklin D. Roosevelt



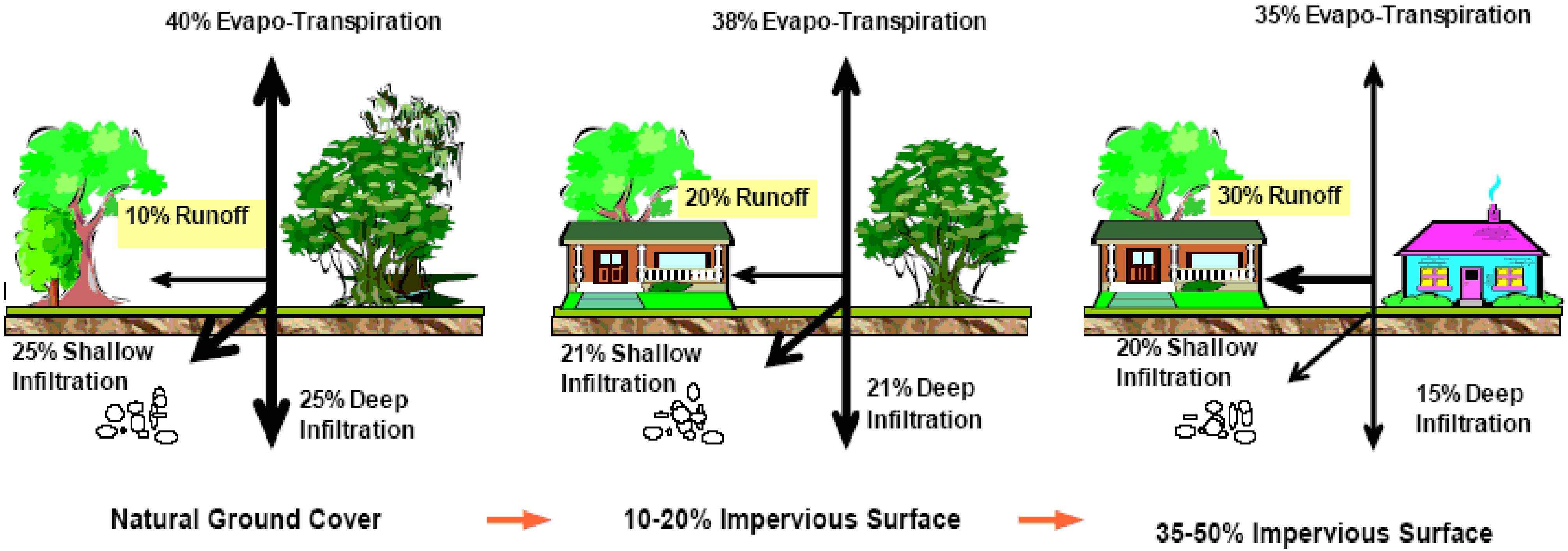
The Hydrologic Cycle
Condensation
Water Storage in Ice and Snow
Precipitation
Water Storage in the Atmosphere
Transpiration
Evaporation
Snowmelt Runoff to Streams
Surface Runoff
Ground Water Infiltration
Freshwater Storage
Water Storage in Oceans
Ground Water Storage
Ground Water Discharge
USGS
science for a changing world

Construction Storm Water Impacts


APR 28 2005


TSM

Post-Construction Storm Water Impacts



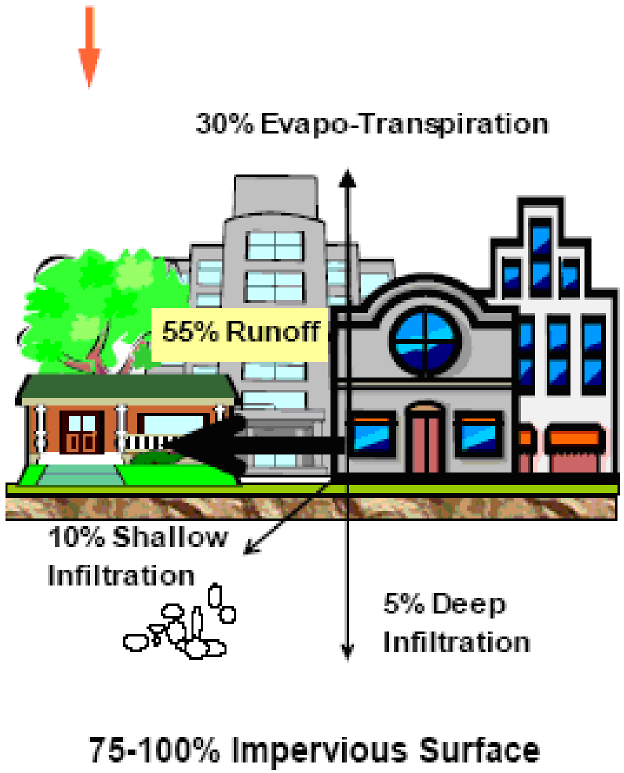


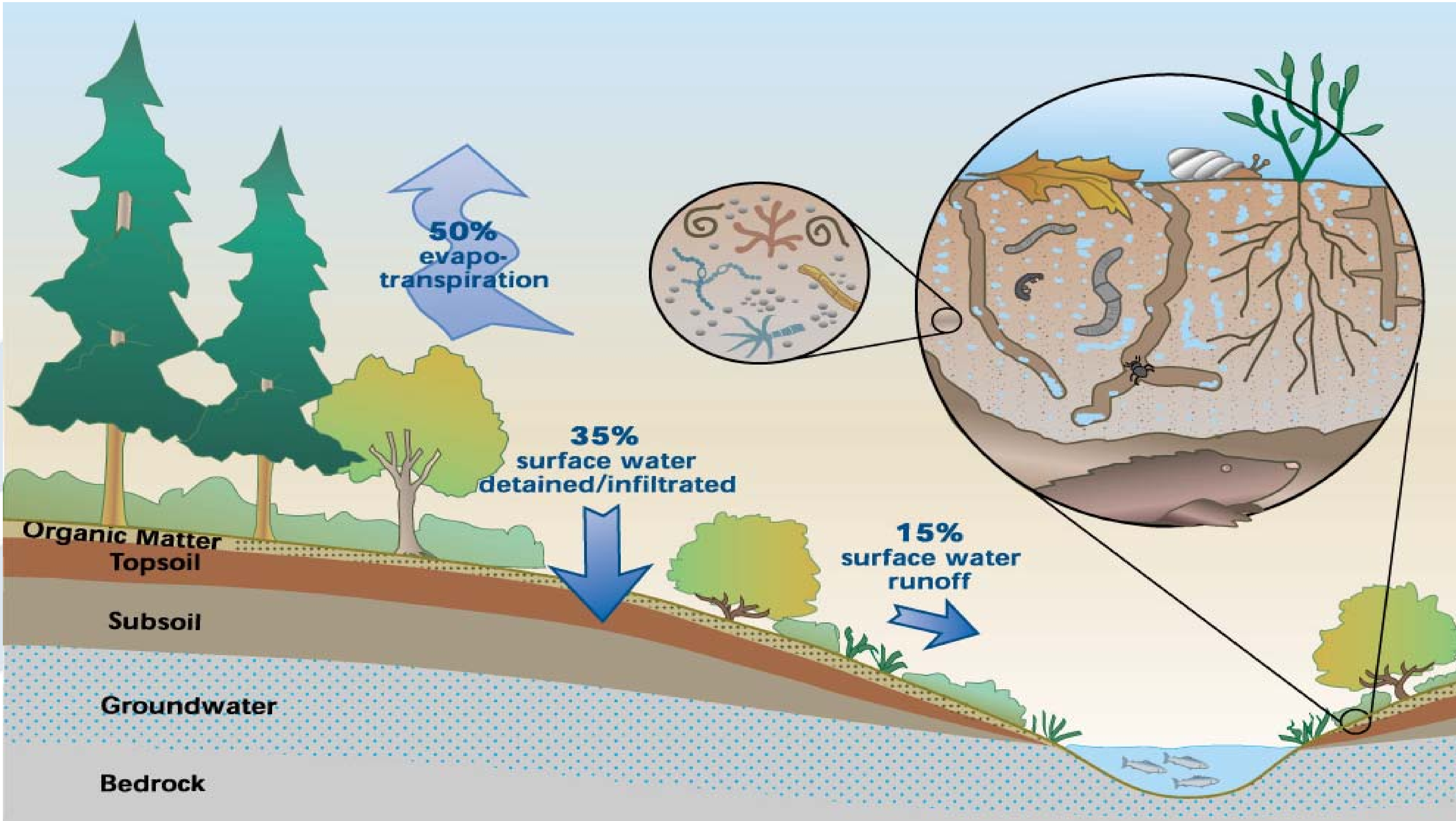
Figure 2. How impervious cover affects the water cycle.

With natural groundcover, 25% of rain infiltrates into the aquifer and only 10% ends up as runoff. As imperviousness increases, less water infiltrates and more and more runs off. In highly urbanized areas, over one-half of all rain becomes surface runoff, and deep infiltration is only a fraction of what it was naturally [6].

The increased surface runoff requires more infrastructure to minimize flooding. Natural waterways end up being used as drainage channels, and are frequently lined with rocks or concrete to move water more quickly and prevent erosion.

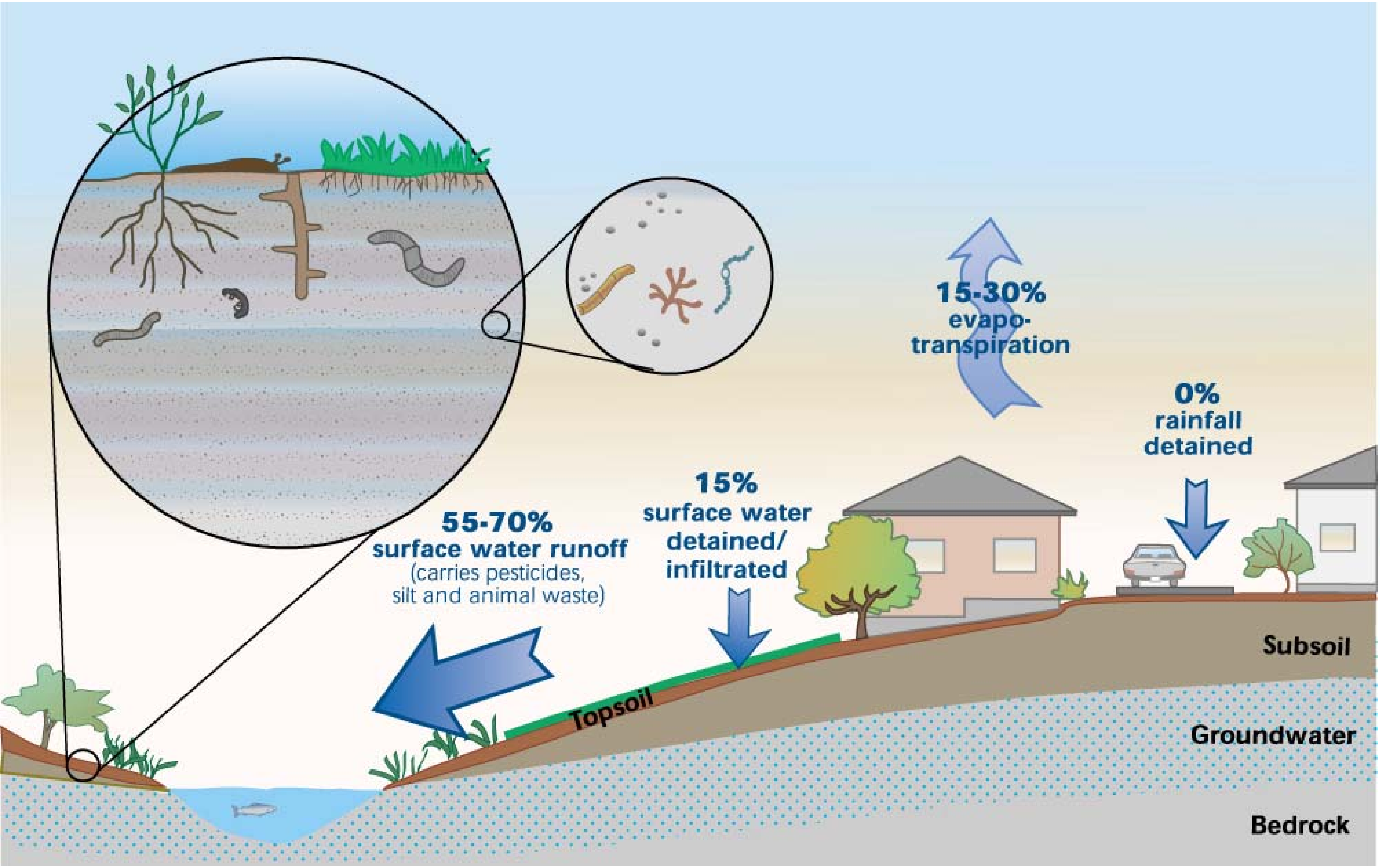
In addition, as deep infiltration decreases, the water table drops, reducing groundwater for wetlands, riparian vegetation, wells, and other uses.

Native Soil



50%
evapo-
transpiration
35%
surface water
detained/infiltrated
15%
surface water
runoff
Organic Matter
Topsoil
Subsoil
Groundwater
Bedrock

Disturbed Soil

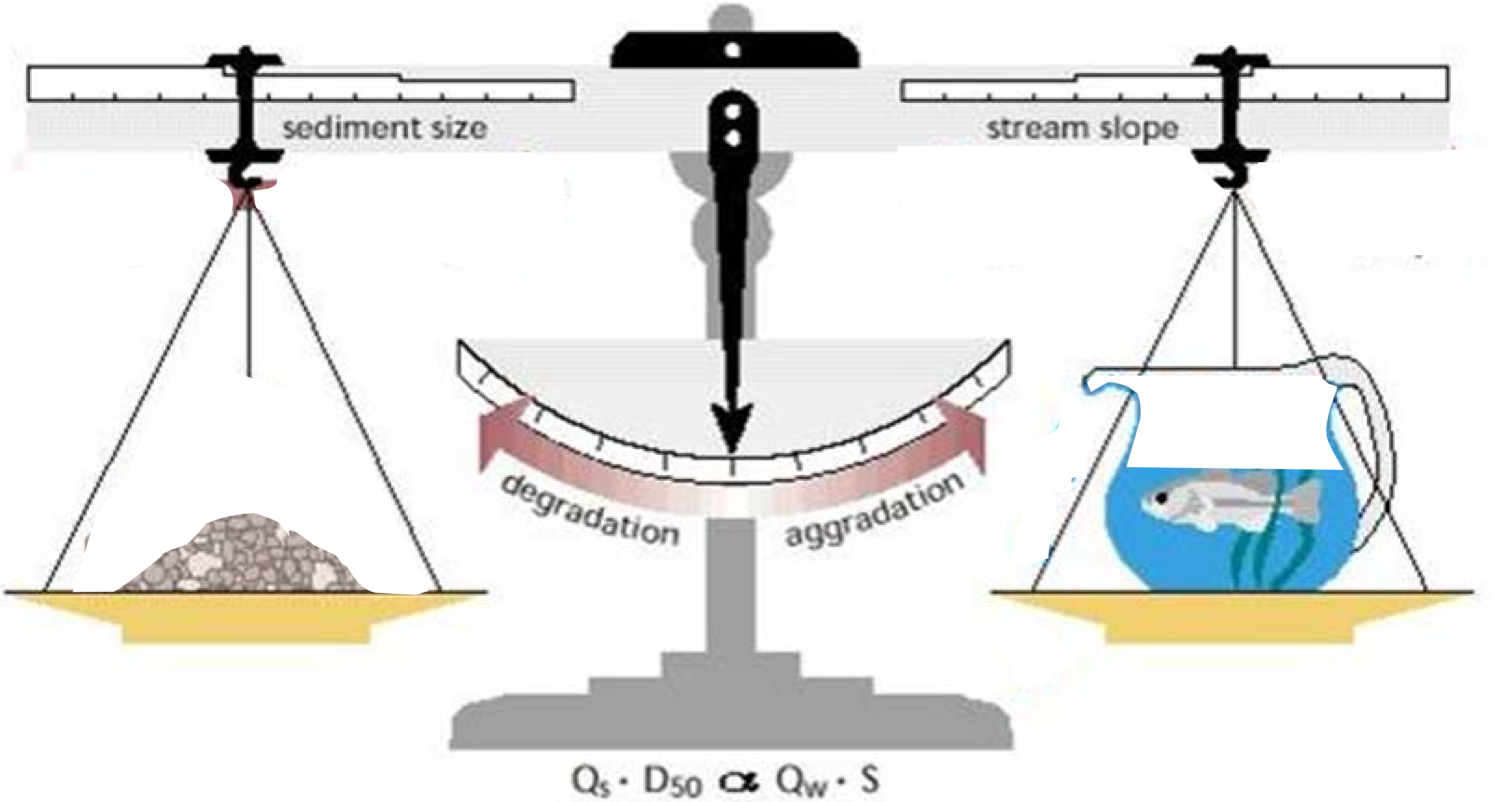


Streams

- Natural function of a stream is to move water and sediment from one area to another
- Stream erosion and sediment deposition are the principal geomorphic processes or functions at work within stream corridors

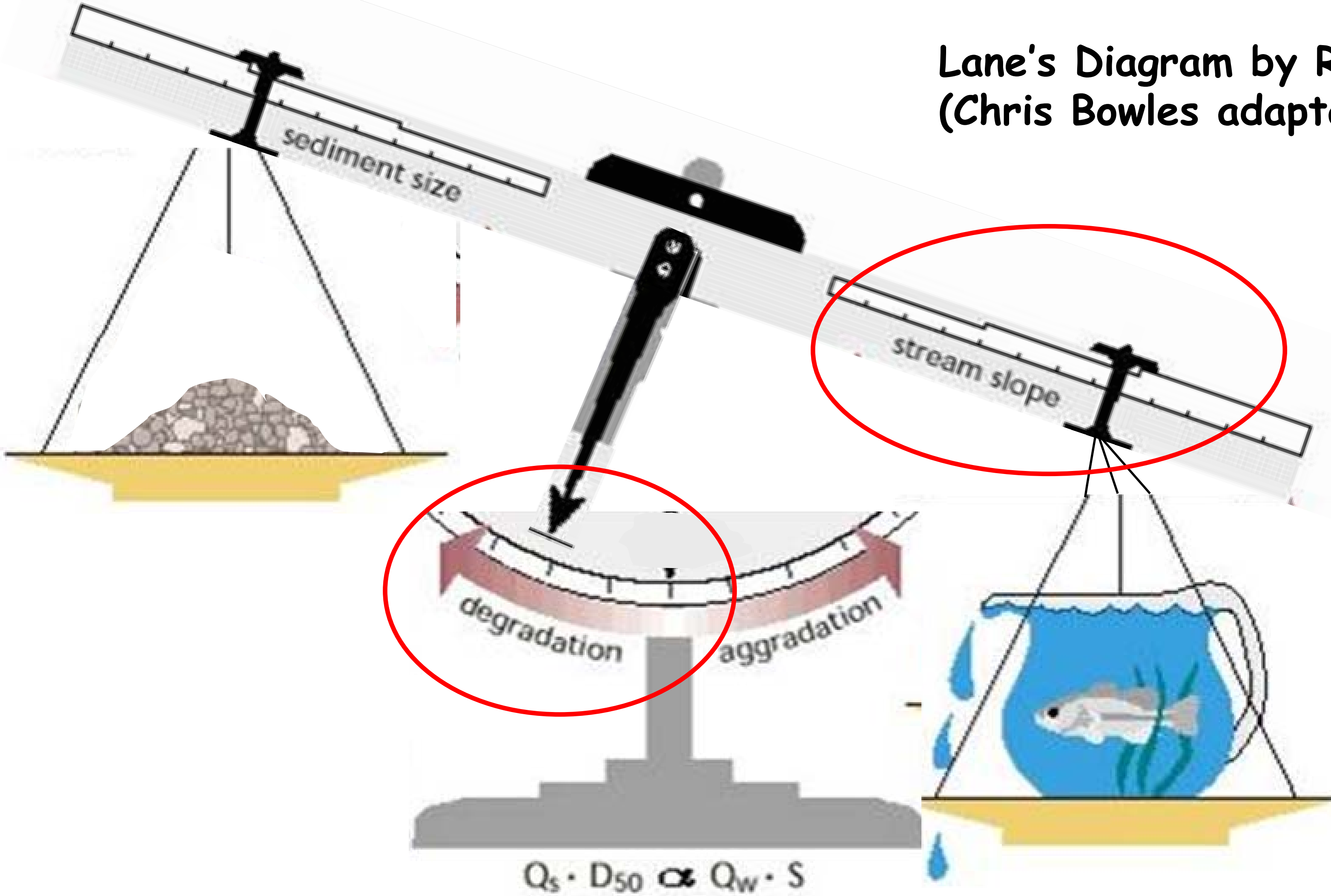
Geomorphic Processes 101

Lane's Diagram by Rosgen, 1996
(Chris Bowles adaptation)

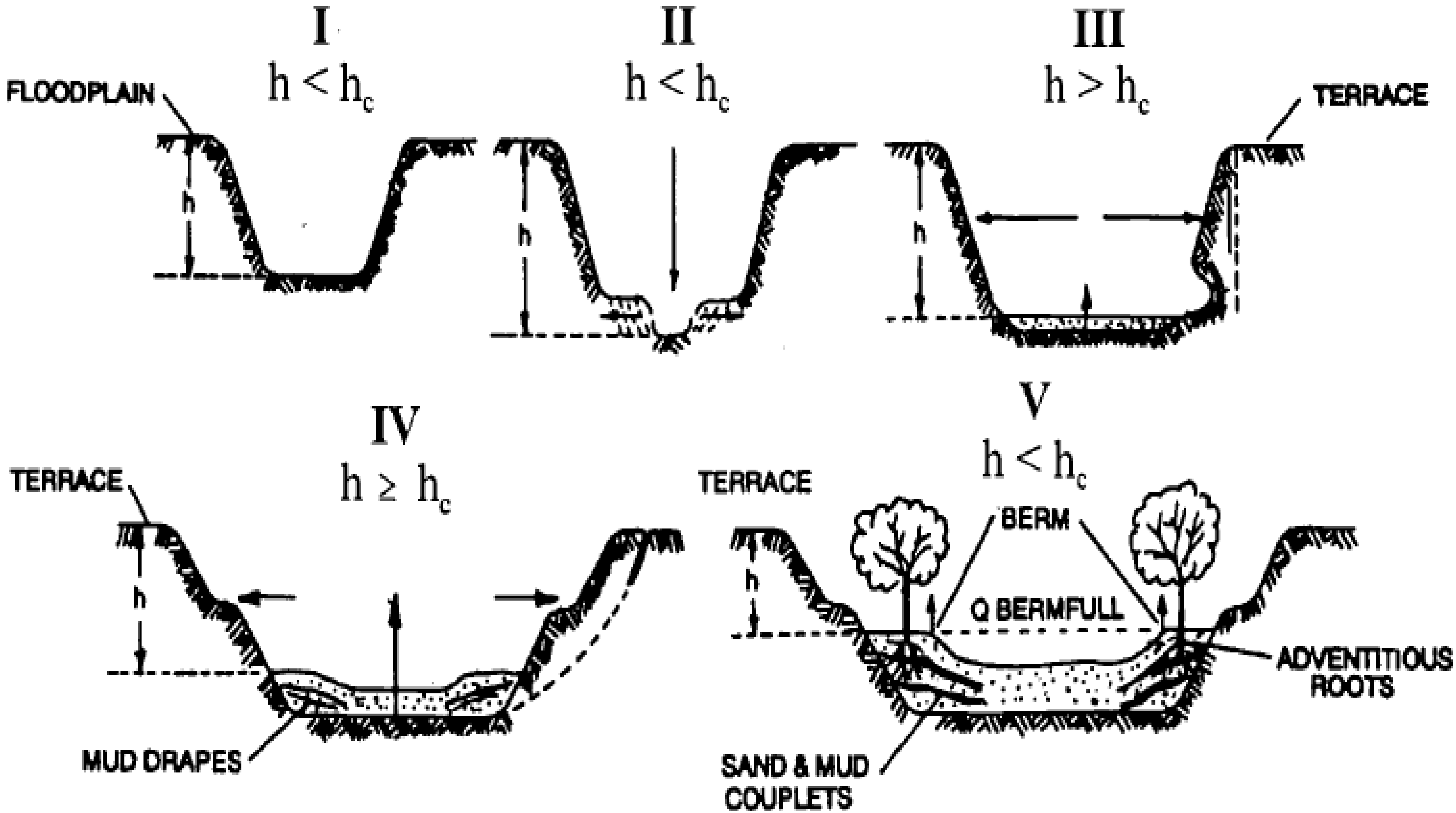


Over time channel geometry (width, depth, gradient) adjusts to be in equilibrium with water and sediment load

Lane's Diagram by Rosgen, 1996
(Chris Bowles adaptation)



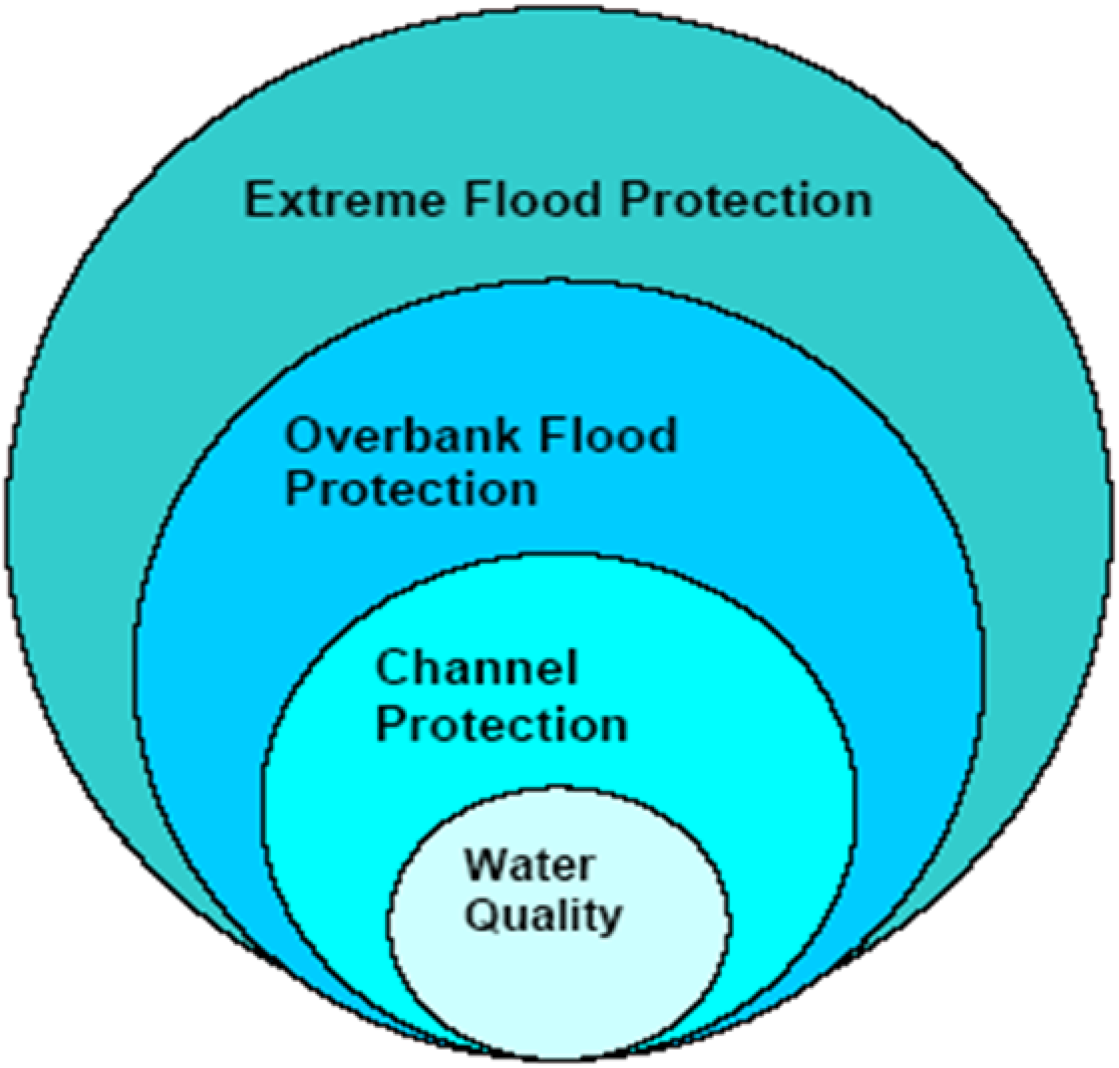
Channel Changes Associated with Urbanization



Post-Construction Impacts

Sources of Impairment (USEPA 2006)

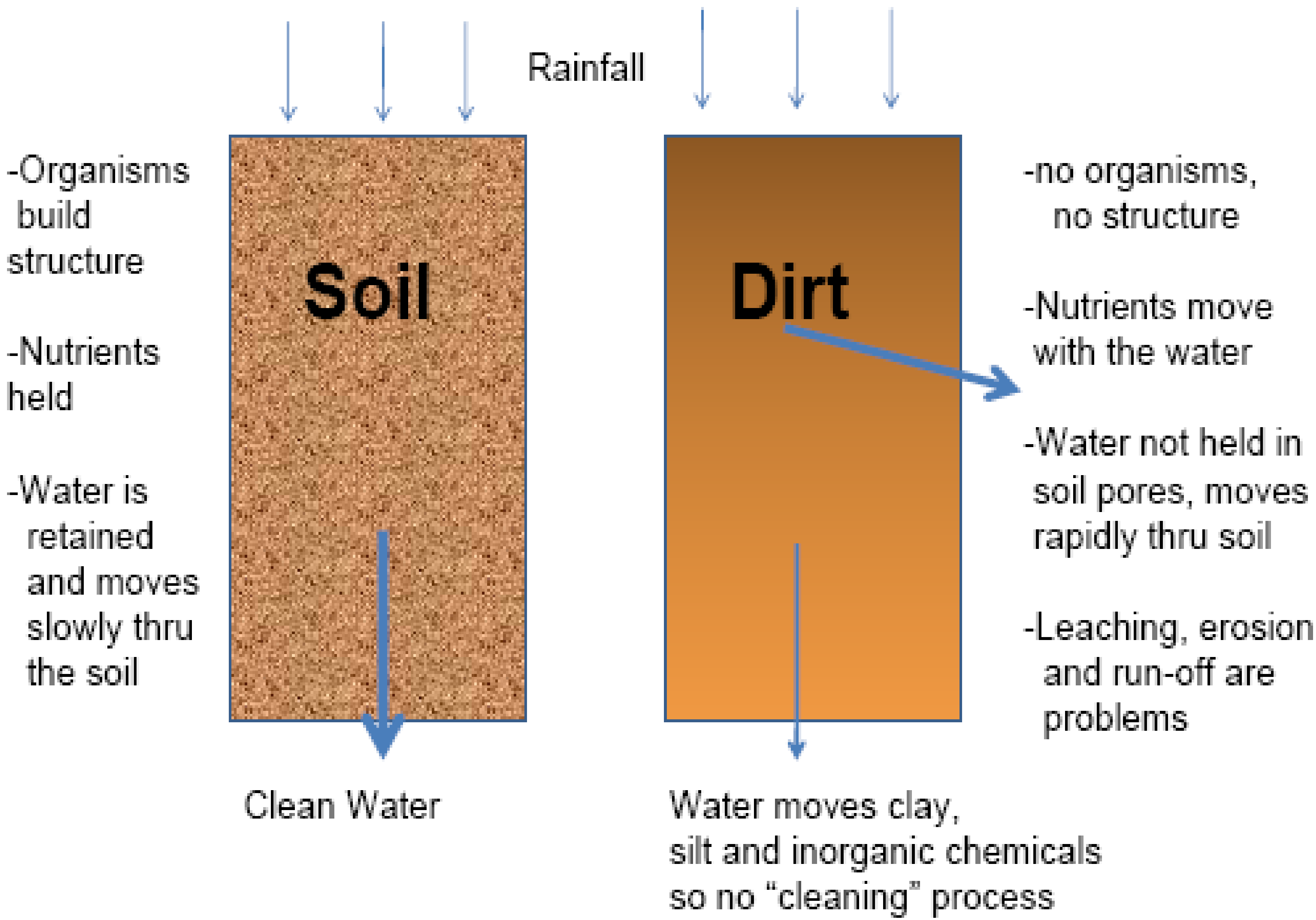
	Rivers and Streams	Lakes, Ponds, and Reservoirs	Estuaries
Sources[b]	Agriculture (48%)[a]	Agriculture (41%)	Municipal Point Sources (37%)
	Hydrologic Modification (20%)[c]	**Hydrologic Modification (18%)**	Urban Runoff/Storm Sewers (32%)
	Habitat Modification (14%)[d]	Urban Runoff/Storm Sewers (18%)	Industrial Discharges (26%)
	Urban Runoff /Storm Sewers (13%)	Nonpoint Sources (14%)	Atmospheric Deposition (23%)
	Forestry (10%)	Atmospheric Deposition (13%)	Agriculture (18%)
	Municipal Point Sources (10%)	Municipal Point Sources (12%)	**Hydrologic Modification (14%)**
	Resource Extraction (10%)	Land Disposal (10%)	Resource Extraction (12%)

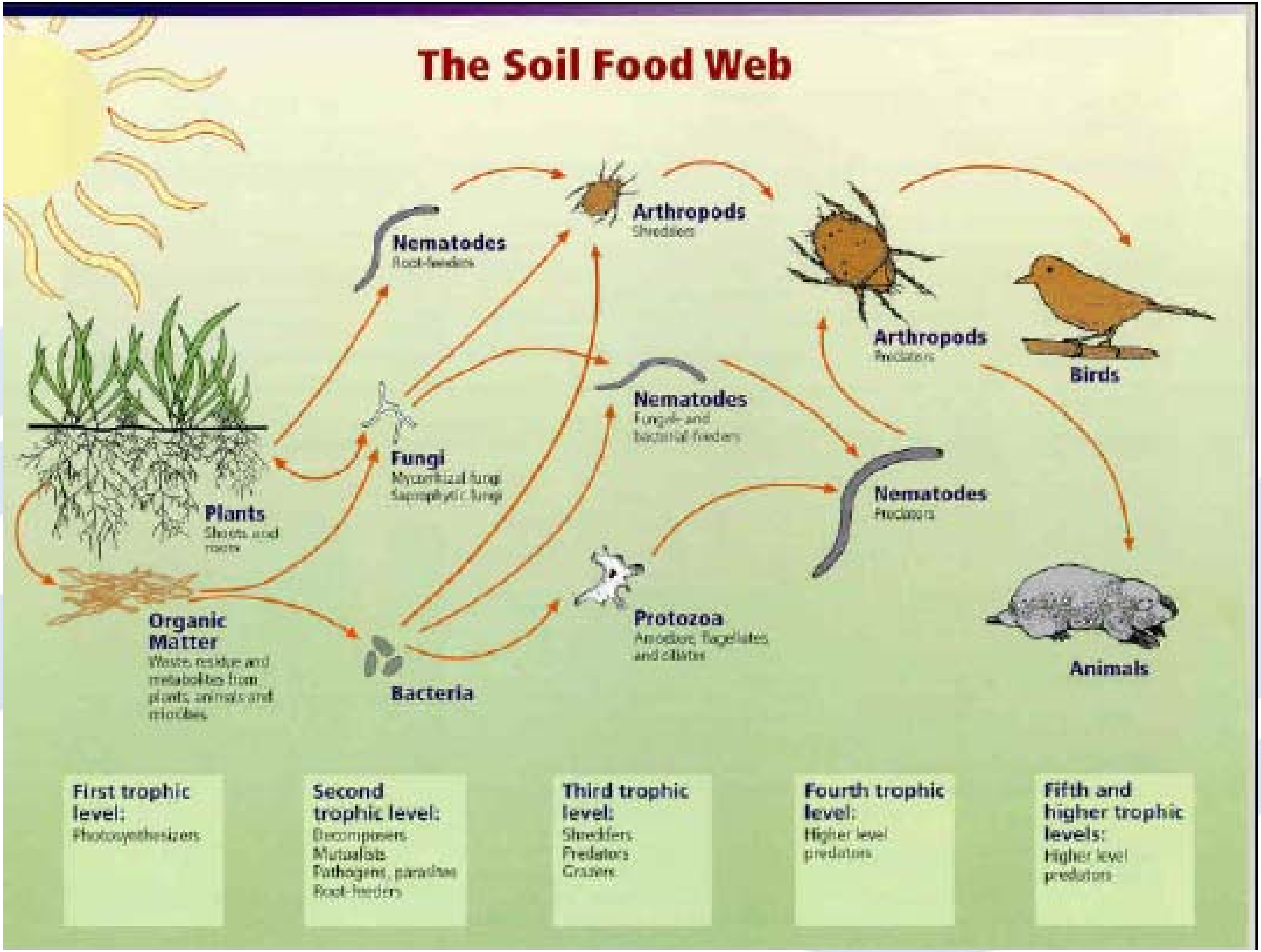


From Georgia Stormwater Manual

What happens when we maintain soil quality?

- More nutrient and water retention
- Less need for fertilizer, pesticides, etc.
- Filtering and decomposition of toxins


Rainfall
-Organisms build structure
-Nutrients held
-Water is retained and moves slowly thru the soil
Soil
Clean Water
Dirt
-no organisms, no structure
-Nutrients move with the water
-Water not held in soil pores, moves rapidly thru soil
-Leaching, erosion and run-off are problems
Water moves clay, silt and inorganic chemicals so no "cleaning" process



The Soil Food Web
Nematodes
Root-feeders
Arthropods
Shredders
Arthropods
Predators
Birds
Plants
Shoots and roots
Fungi
Mycorrhizal fungi
Saprophytic fungi
Nematodes
Fungal- and bacterial-feeders
Nematodes
Predators
Organic Matter
Waste, residue and metabolites from plants, animals and microbes
Bacteria
Protozoa
Amoebae, flagellates and ciliates
Animals
First trophic level:
Photosynthesizers
Second trophic level:
Decomposers
Mutualists
Pathogens, parasites
Root-feeders
Third trophic level:
Shredders
Predators
Grazers
Fourth trophic level:
Higher level predators
Fifth and higher trophic levels:
Higher level predators

Bacteria	Fungi	Protozoa	Beneficial Nematodes	Micro-arthropods
Disease Suppression	Disease Suppression	Make nutrients plant available	Make nutrients available to plants	Make nutrients available to plants
Nutrient Retention	Nutrient Retention	Build soil structure	Stimulate prey groups	Stimulate prey
Build Soil Structure	Build Soil Structure	Indicators of lack of oxygen, compaction	Build soil structure	Build soil structure
Decompose Toxins	Decompose Toxins		Inhibit root-feeding nematodes	Taxicabs

Sources of Information

- Soil Biology Primer (http://soils.usda.gov/sqi/concepts/soil_biology/biology.html)
- River-friendly landscaping guidelines (www.riverfriendly.org)
- California Native Plant Society (www.cnps.org)
- *Sustainable Landscape Construction—A Guide to Green Building Outdoors* By J. William Thomson and Kim Sorvig

Post-Construction Solutions

Rain chains and mulch combo

Sacramento

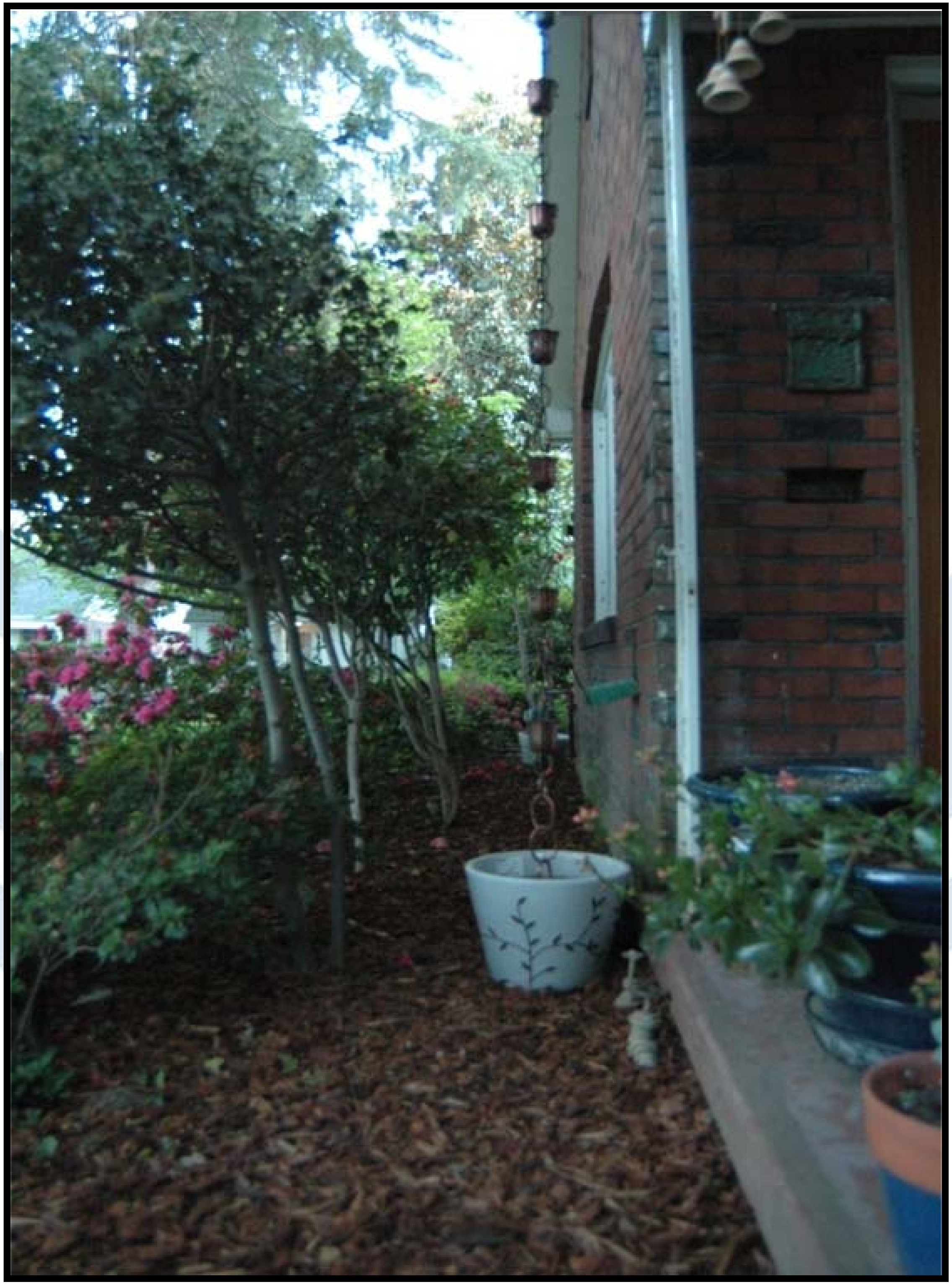



PHOTO: RIVERSIDES STEWARDSHIP ALLIANCE

School Parking Lot, Portland OR

Planning Considerations for Runoff Control

Must evaluate the site drainage patterns for:

- Pre-developed conditions
- During grading and construction
- Developed conditions
- Ultimate buildout conditions

Runoff Considerations

- Internal site conditions
  - Divert and direct sediment laden water
  - Temporary and permanent controls
- Site perimeter
  - Run on from adjacent areas
  - Runoff from site
  - Internal active inlets

Surface Runoff Predictions

- Runoff volume
- Peak rate of discharge

Factors Affecting Runoff

- Precipitation
- Soil permeability
- Watershed area
- Ground cover
- Antecedent moisture
- Storage in watershed
- Time parameters

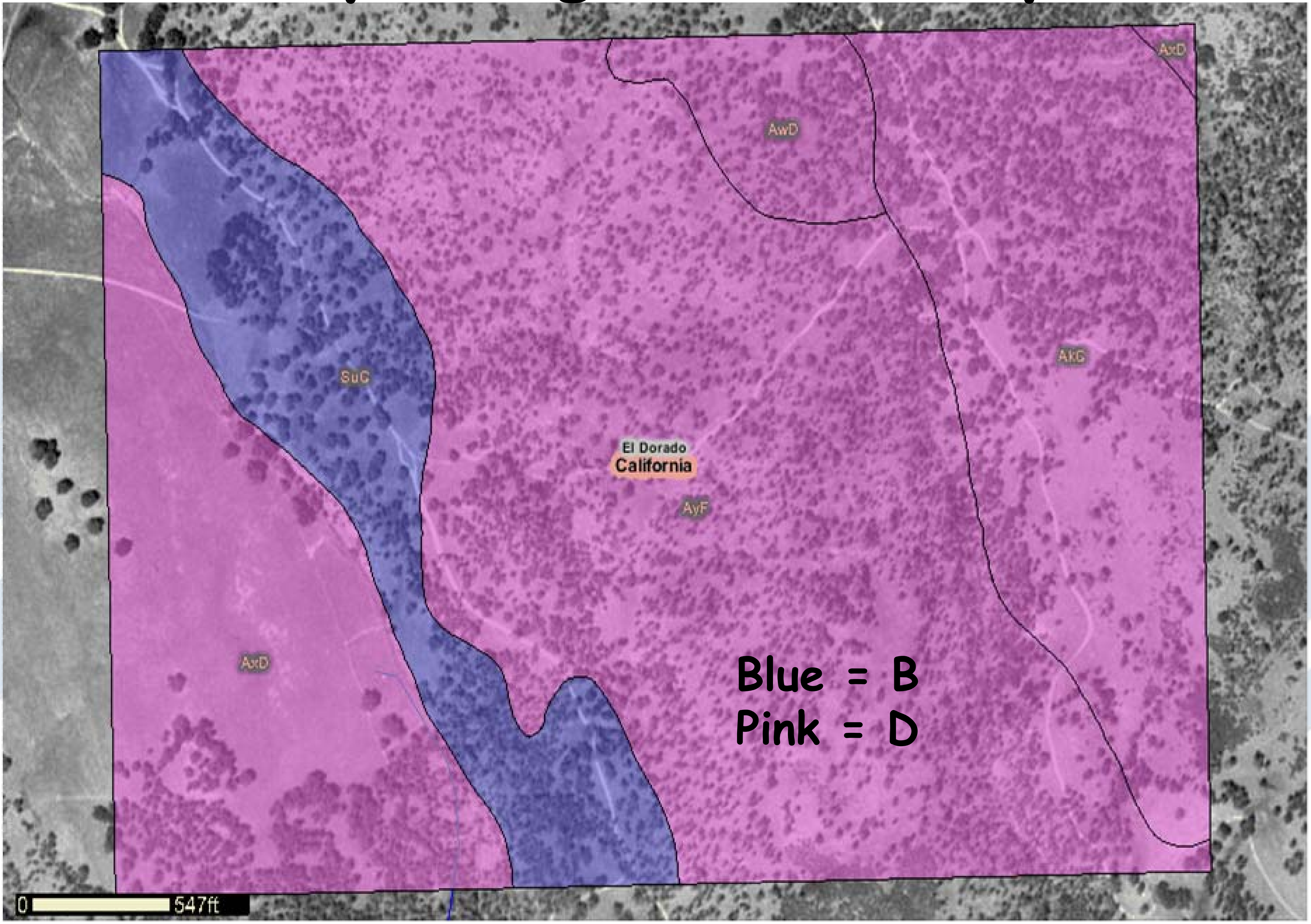
Soil Descriptions

- Soils are classified into hydrologic soil groups (HSGs).
- HSGs indicate the minimum rate of infiltration obtained for bare soil after prolonged wetting.
- The HSGs are one element used in determining runoff curve numbers:
  - A = deep sand, deep loess, aggregated silts
  - B = shallow loess, sandy loam
  - C = clay loams, shallow sandy loam, low organic soils
  - D = soils that swell significantly when wet, heavy plastic clays, certain saline soils

NRCS Hydrologic Soil Groups

HSG	Example Soil Texture	Runoff Potential	Water Transmission Rate
A	Sand	Low	High
B	Sandy loam	Moderately Low	Moderate
C	Clay loam	Moderately High	Low
D	Clay	High	Very Low

Hydrologic Soil Groups



Source: http://websoilsurvey.nrcs.usda.gov/app/

Initial Abstraction

Is all of the losses that occur before runoff begins, including interception, evaporation, and infiltration.

After initial abstraction has taken place, the runoff volume and time of concentration may be determined.

Important Time Factors

Time of Concentration (Tc) - time it takes runoff to travel from the hydraulically most distant point in the watershed to the design point or point of discharge.

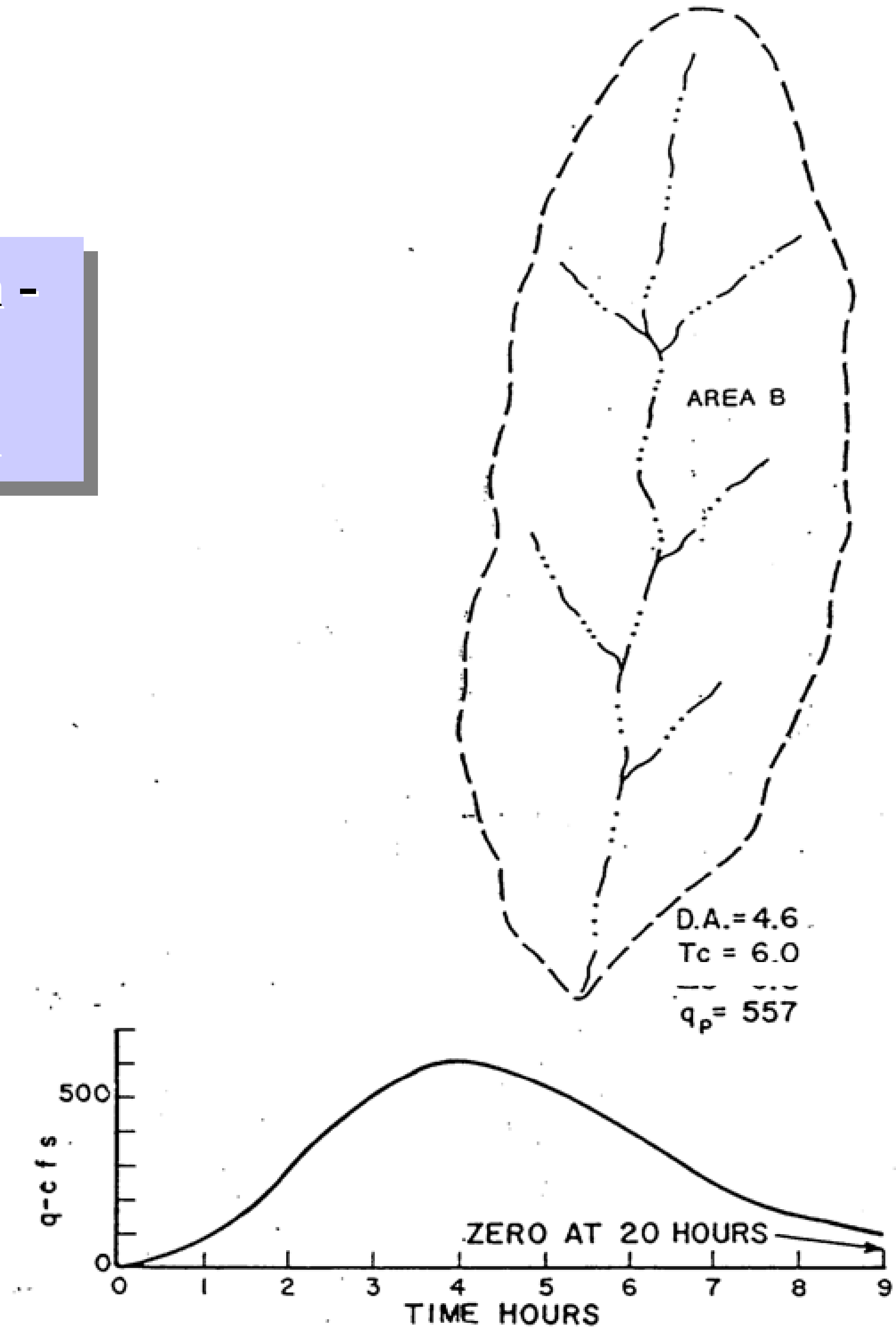
Travel Time (Tt) - time it takes runoff to travel from one point to another point down slope along a hydraulic segment in a watershed.

Time of Concentration

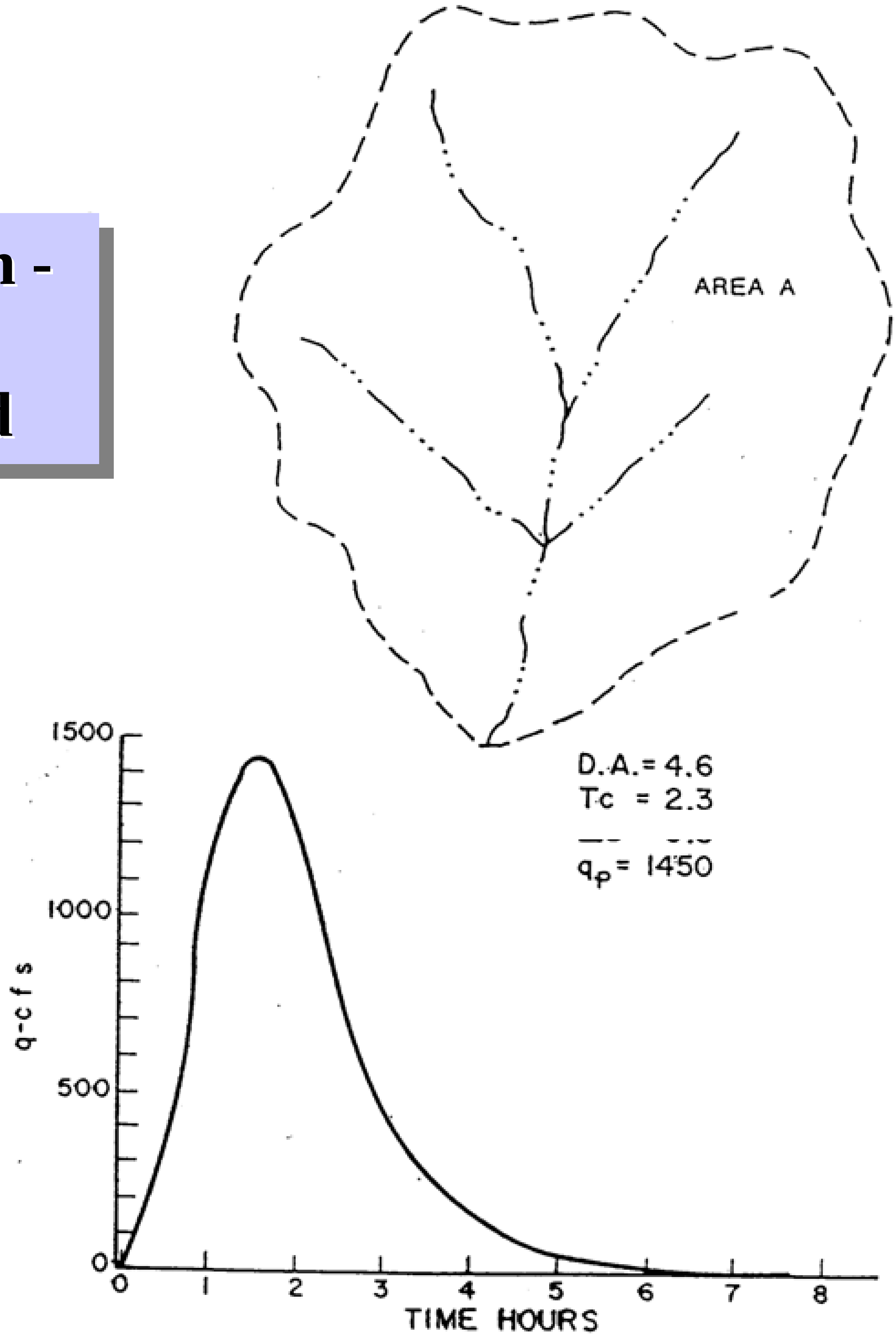
Time of Concentration (Tc) is computed by summing all the travel times (Tt) for consecutive components of the hydraulic conveyance system:

- Sheet flow
- Shallow concentrated flow
- Channel flow

Hydrograph - Narrow Watershed



Hydrograph - Wide Watershed



Sheet Flow

Sheet flow is flow over the upland portions of the watershed where there is no defined channel or watercourse.

It is usually a critical component of Tc because it can represent a significant amount of time due to the low velocities (typically in ft/sec) of overland flow in small watersheds.

Sheet Flow

$$Tt = \frac{0.007(nL)^{0.8}}{(P_2)^{0.5} s^{0.4}}$$

Shallow Concentrated Flow

Shallow concentrated flow occurs once sheet flow begins to rill together, and open channel flow occurs when rills combine and form gullies or channels.

Channel Flow

Manning's equation is used to predict velocity for channel flow

$$V = \frac{1.486}{n} r^{2/3} s^{1/2}$$

Channel Flow

Continuity Equation

$$Q = A \times V$$

Hydraulics

- Hydraulic calculations predict the flow rate (Q, cfs) and velocity (V, fps) in storm water conveyances (pipes, channels)
- Q and V are used to evaluate channel erosion and appropriate channel linings

Hydraulics

- Channel flow
  - Shear stress
  - Permissible velocity
- Flow through structures
  - Culverts
  - Bridges
  - Reservoirs

Manning's n values

Canals and ditches:				
Earth, straight and uniform	0.017	0.020	0.0225*	0.025
Rock cuts, smooth and uniform	0.025	0.030	0.033*	0.035
Rock cuts, jagged and irregular	0.035	0.040	0.045	
Winding sluggish canals	0.0225	0.025*	0.0275	0.030
Dredged earth channels	0.025	0.0275*	0.030	0.033
Canals with rough stony beds, weeds on earth banks	0.025	0.030	0.035*	0.040
Earth bottom, rubble sides	0.028	0.030*	0.033*	0.035
Natural stream channels:				
(1) Clean, straight bank, full stage, no rifts or deep pools	0.025	0.0275	0.030	0.033
(2) As (1), but some weeds and stones	0.030	0.033	0.035	0.040
(3) Winding, some pools and shoals, clean	0.033	0.035	0.040	0.045
(4) As (3), lower stages, more ineffective slope and sections	0.040	0.045	0.050	0.055
(5) As (3), some weeds and stones	0.035	0.040	0.045	0.050
(6) As (4), stony sections	0.045	0.050	0.055	0.060
(7) Sluggish river reaches, rather weedy or with very deep pools	0.050	0.060	0.070	0.080
(8) Very weedy reaches	0.075	0.100	0.125	0.150

USGS Manning's n values

- Verified Roughness Characteristics of Natural Channels
- http://wwwrcamnl.wr.usgs.gov/sws/fieldmethods/Indirects/nvalues/index.htm

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