Watersheds and Hydrology

What's Water Got to Do with It?

- More water moves through ecosystems than any other material
- The materials that it carries and deposits and the energy that it expends are **major drivers in shaping the contour** of the land and the habitat availability/suitability for organisms.
- A resource that humans cannot live without

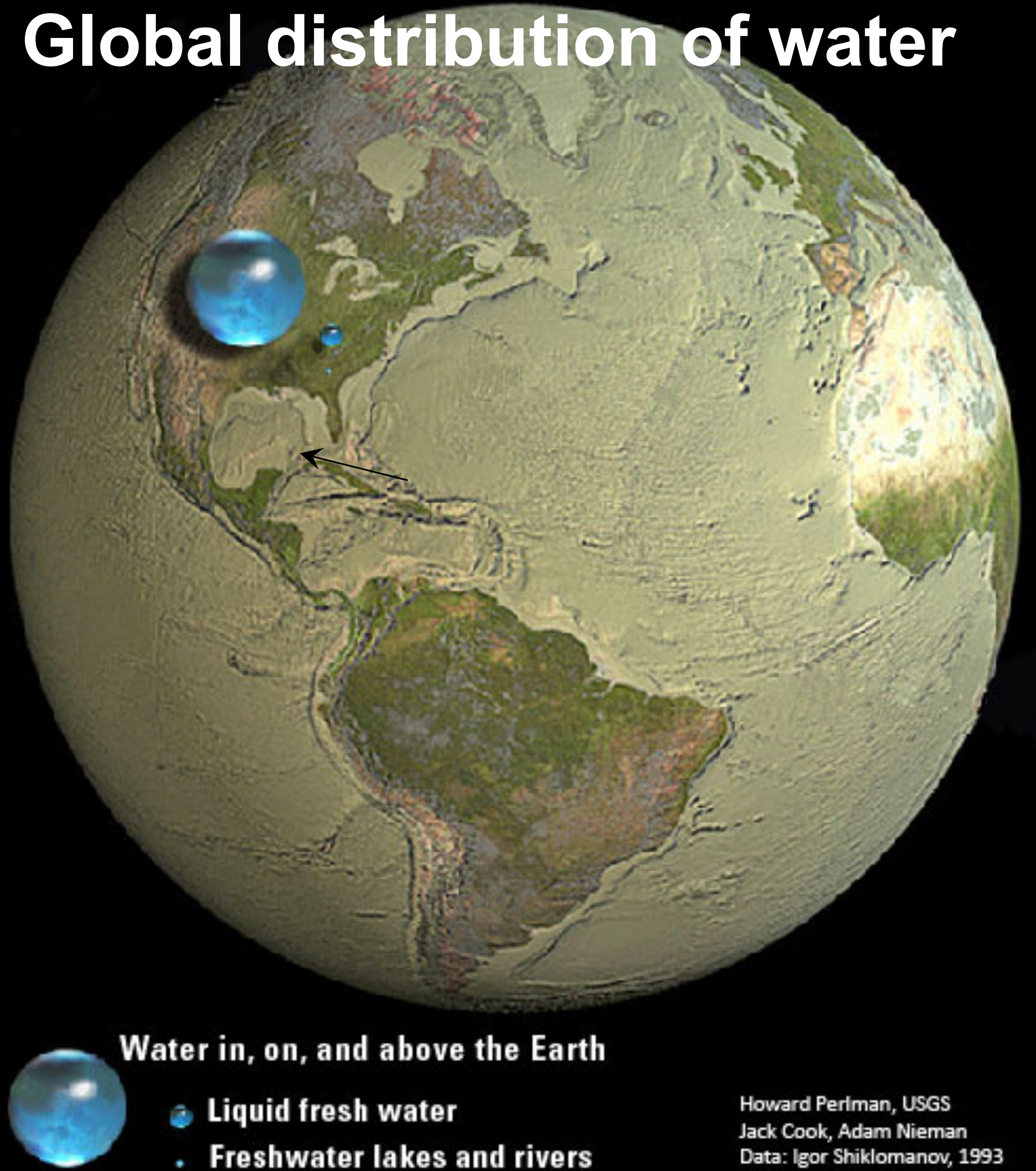
Streams and Hydrology
Learning Objectives

- **Where do we find water?**
- What is a stream
- How many dimensions does a stream have?
- How do we characterize stream water?
- What do we want to know about stream flow?

Question 1

Where do we find water?

Global distribution of water



Global distribution of sea and freshwater

Water Storage Reservoir	Percent (%) of total	Percent (%) freshwater
Oceans	96.5	0
Ice and Permanent Snow	1.74	68.7
Groundwater	1.7	30.1
Lakes	0.013	0.91
Soil Moisture including permafrost	0.023	0.26
Atmosphere	0.001	0.04
Streams, Rivers, Swamps	0.001	0.036
Biosphere	0.0001	0.003

Streams and Hydrology
Learning Objectives

- Where do we find water?
- **What is a stream**
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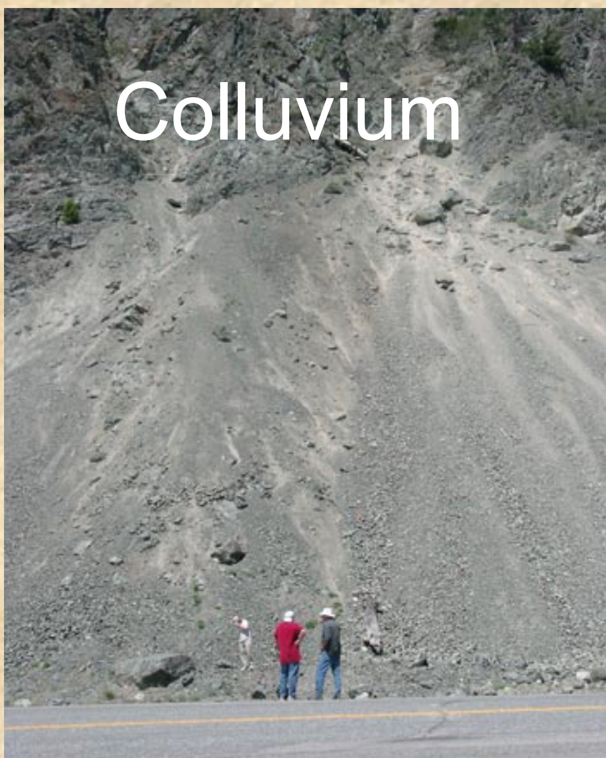
Question 2

What is a stream?

Snohomish County 30.62

A stream is defined as a reach, flowing on a perennial or seasonal basis having a continuous channel bed, whether or not the bed or banks of the reach are locally obscured by overhanging or bridging vegetation or soil mats, if the channel bed:

1. is scoured by water, or
2. contains observable deposits of mineral alluvium.



rcourse is a stream is the presen
t demonstrating fluvial processes

the channel.
eral, or intermittent.

ry or lining within which water, se
els are incised into the terrain to
o be transferred downstream. Th
nd include bedrock, morainal tills
round.

s banks. However, the banks of
e visible due to the presence of b
ments of the channel might be fill
able

1

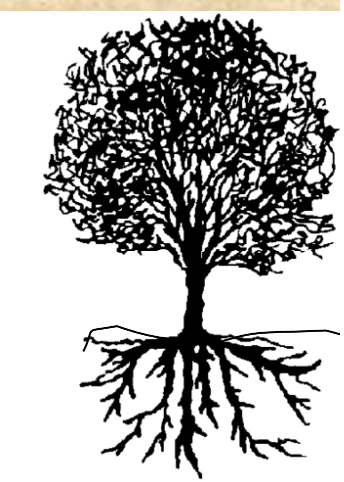
5

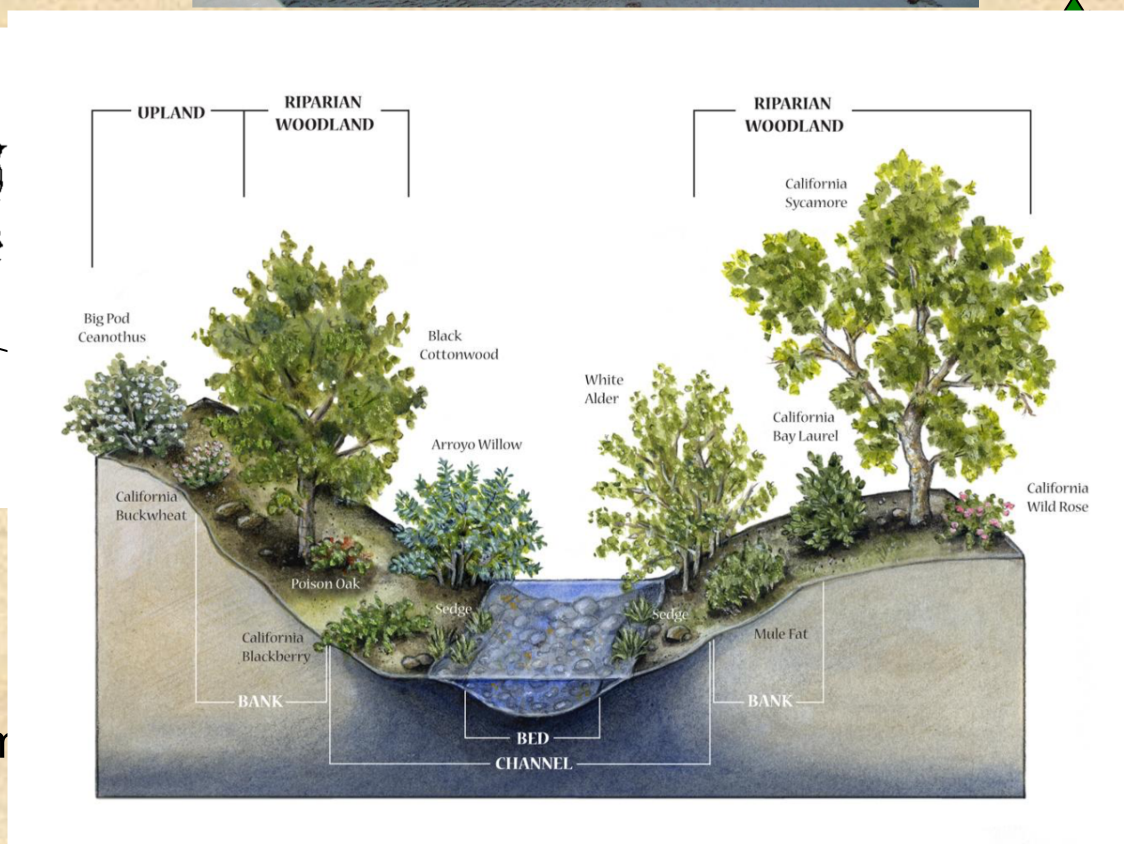
V = 2 m/s

A = 3 m^2

n = 0.04

t = 120 N/m^2





IBI = 23

H = 7.2

DS = 110 mg/l

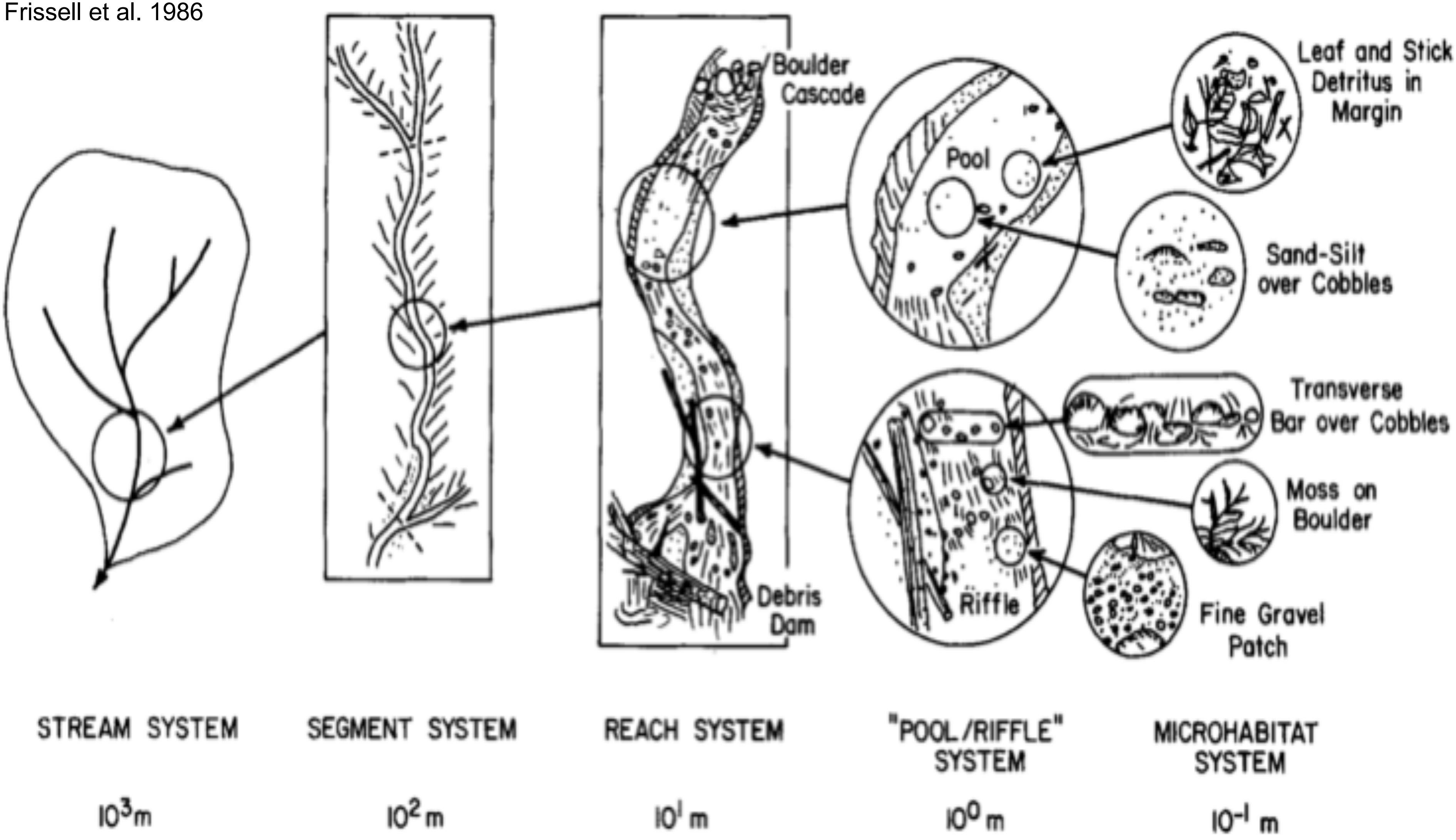
D = 8.3 mg/l

$_{50}$ = 10 cm

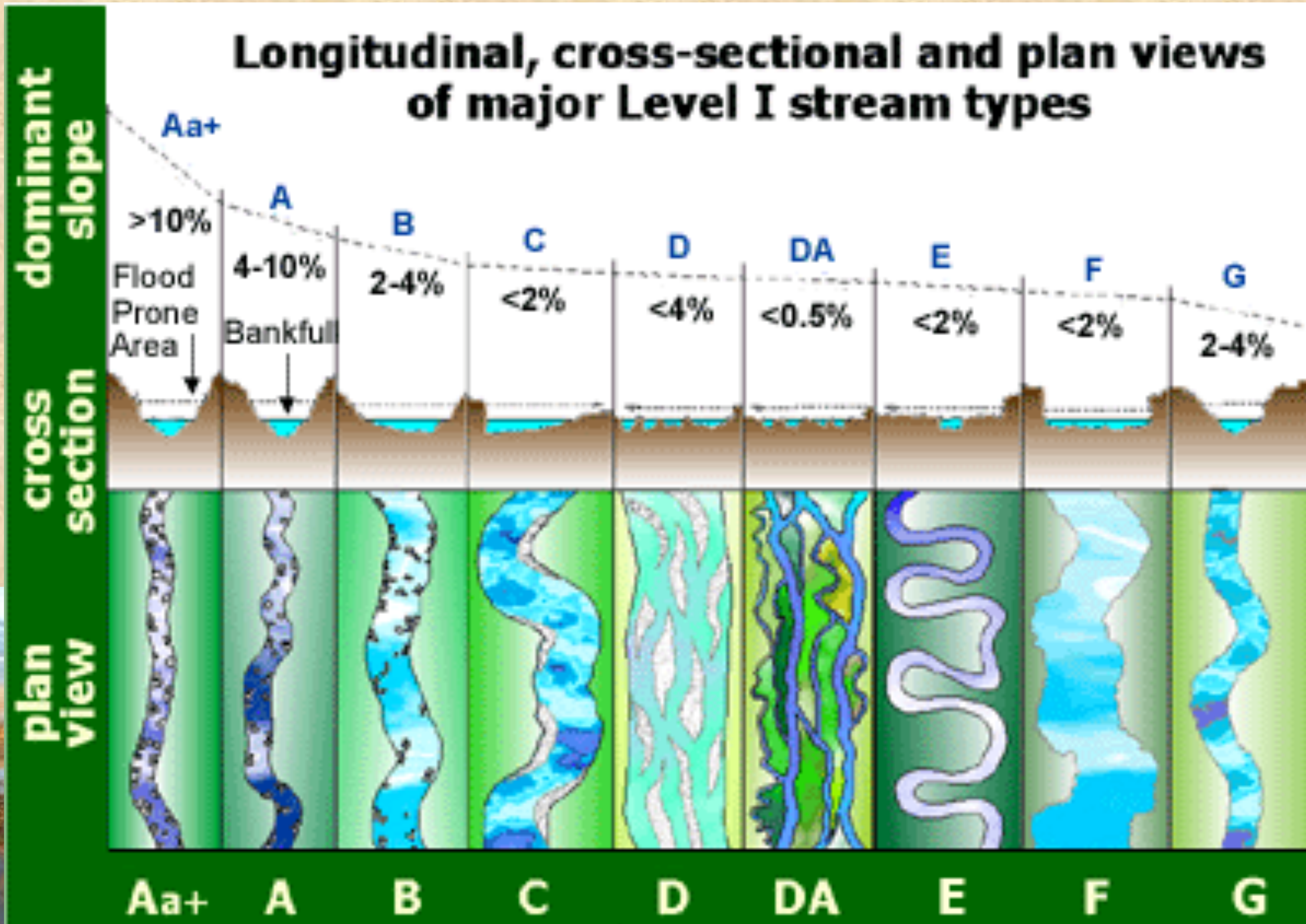
Adapted from

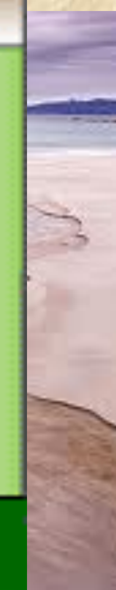
Hierarchy of stream and habitat subsystems

Frissell et al. 1986

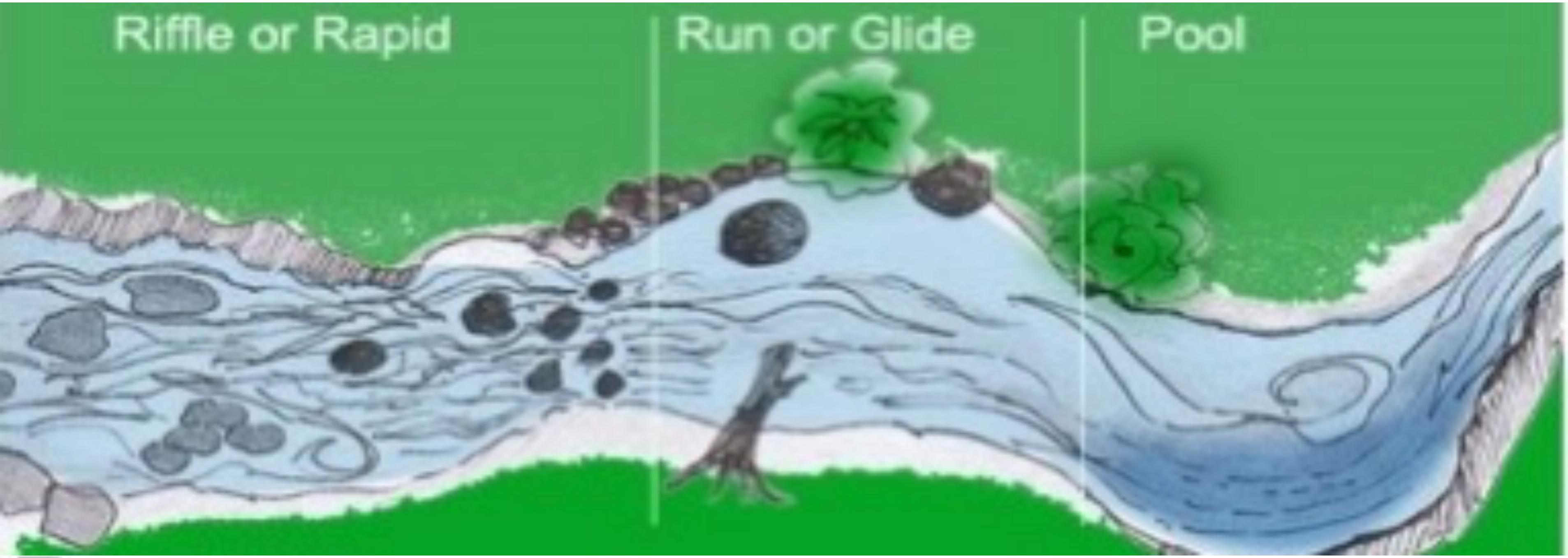


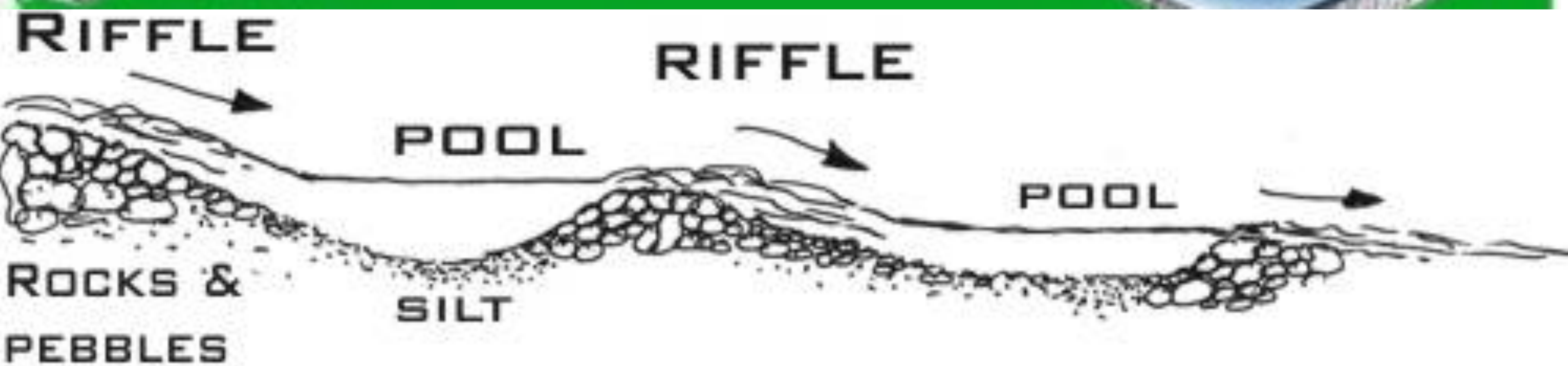
What do we want to know about stream channels?

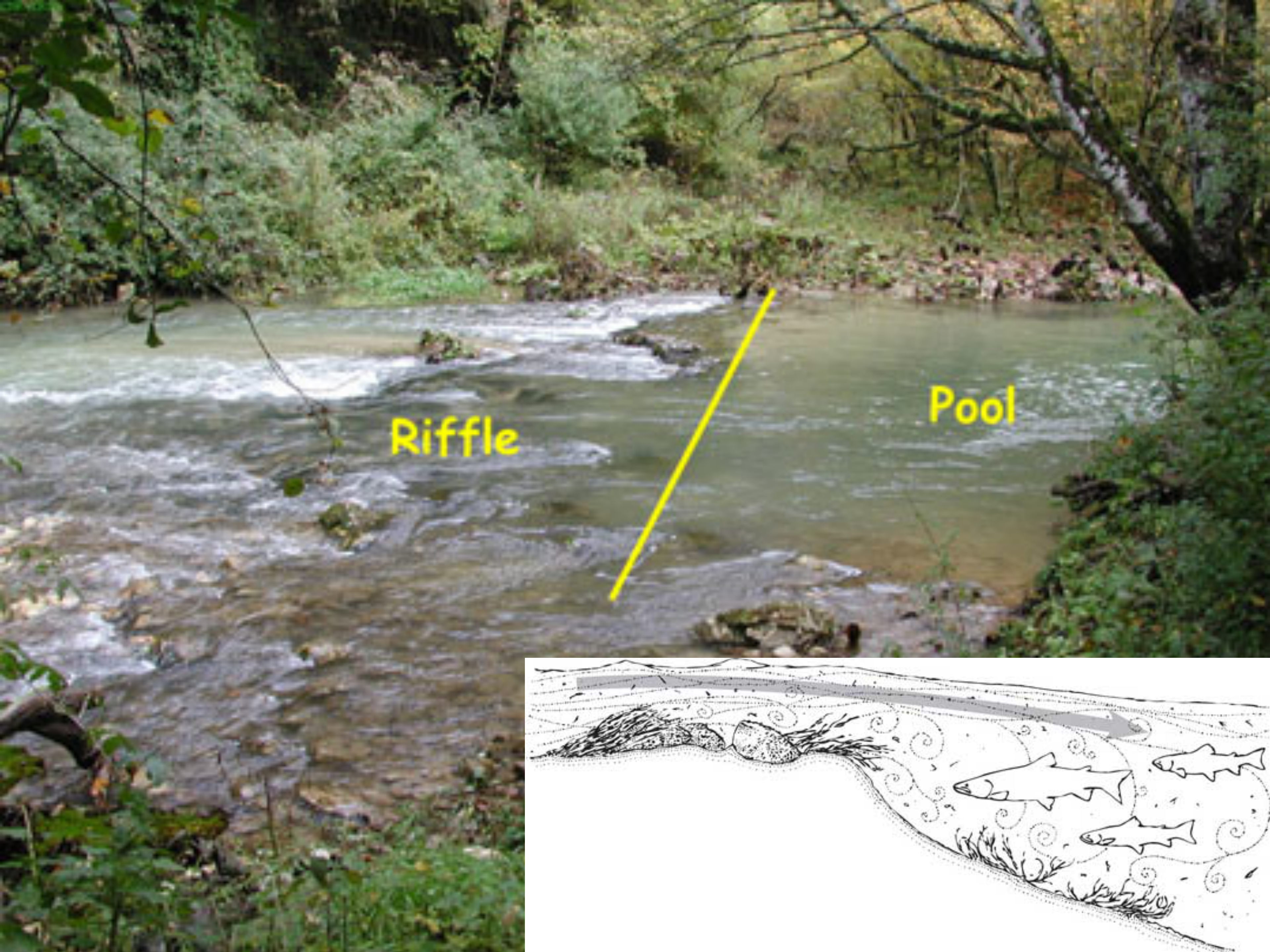


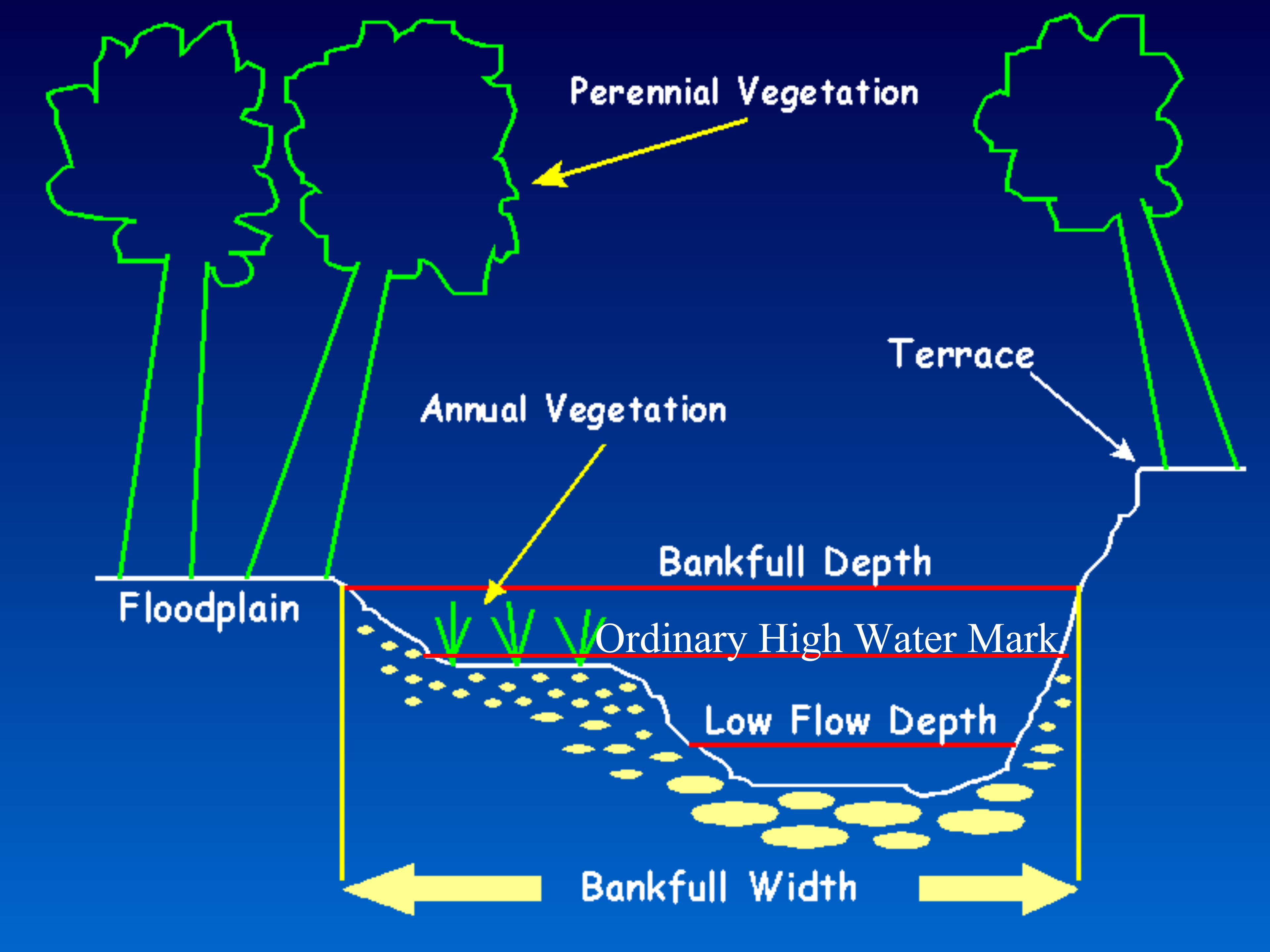


Pools, Riffle, & Glides






Riffle
Pool


Perennial Vegetation
Terrace
Annual Vegetation
Bankfull Depth
Floodplain
Ordinary High Water Mark
Low Flow Depth
Bankfull Width

Bankfull Width

- Why Is It Important?
  - Water typing system dependent on bankfull width (Type F waters)
  - Riparian Management Zones begin at bankfull channel edge
  - RMZ Inner Zone width is dependent on bankfull width
  - Bankfull width is used in determining appropriate culvert sizing
- How Is It Defined?
  - Lateral extent of water surface elevation at bankfull depth; bankfull depth is water surface elevation required to completely fill the channel to a point above which water would spill onto the floodplain

Slide by Jeff Grizzel

Ordinary High Water Mark (OHWM)

- A **high water mark** is a point that represents the maximum rise of a body of water over land.
- The **OHWM**
  - Regulatory term
  - Differentiates upland and lowland vegetation OR stream from riparian area
  - Usually based on 2 year flood event

Stream & Water types in Washington

- M – Marine
- S – shorelines
- F – Fish bearing
- Np – Non fish bearing but perennial flow
- Ns – Non fish bearing, only seasonal (intermittent) flow

www.dnr.wa.gov/BusinessPermits/Topics/ForestPracticesApplications/PermitPages/fp_watertyping.aspx

WA DNR Stream Types

Types: S, F, Np, Ns

- **Type S waters: Shorelines of the state AKA Shorelines.**
  - also include periodically inundated areas of associated wetlands, larger lakes and rivers as well as tidally influenced areas.
  - Replaces type 1
- **Type F waters: Fish Streams**
  - Not Type S waters
  - Contain fish…(and other stuff)
  - Replaces type 2
- **Type Np waters: Non-fish, perennial streams**
  - Perennial - do not go dry at any time during a year of normal rainfall (can contain dry side channels)
  - Do not contain fish – NATURAL fish barrier downstream, but are perennial
    - Perennial means waters that do not go dry at any time during a year of normal rainfall.
  - Replaces type 3,4
- **Type Ns waters: Non-fish, seasonal streams**
  - Not Type S, Type F or Type Np waters.
  - Seasonal, non-fish habitat
  - Surface flow is not present for at least some portion of a year of normal rainfall
  - Replaces type 4,5

http://www.dnr.wa.gov/Publications/fp_hcp_12ch4b.pdf

Watersheds and Hydrology

1 Where do we find water?

1 What is a stream?

1 How many dimensions does a stream have?

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Question 3

How many dimensions does a stream have?

Question

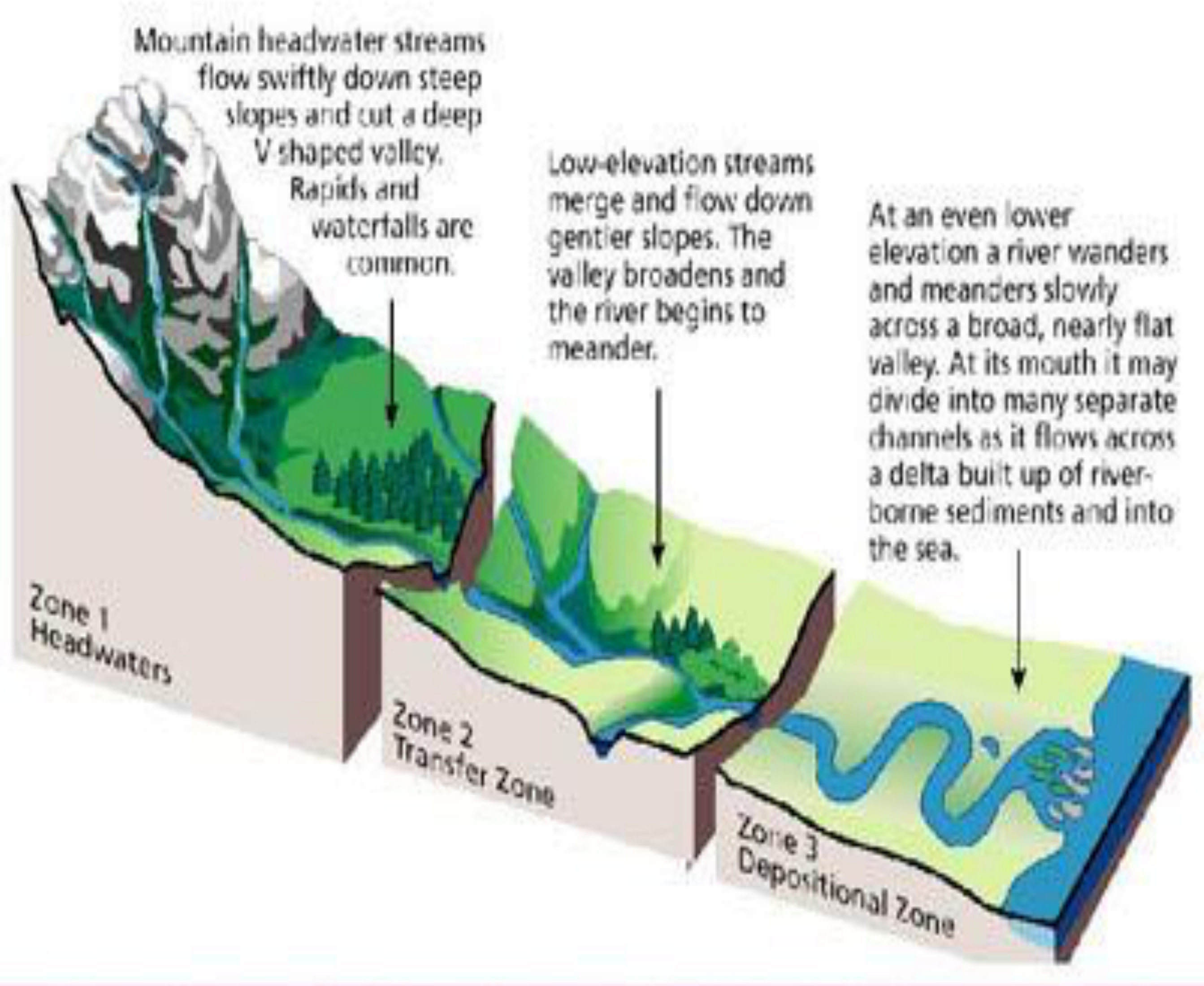
How many dimensions does a stream have?

1. Longitudinal (upstream to downstream)
2. Lateral (bank to bank and valley wall to valley wall)
3. Vertical (water surface to bed to hyporheic to groundwater)
4. Temporal (time: seconds to millennia)

Longitudinal Changes in Streams

Certain characteristics of streams change 'predictably' from upstream to downsteam

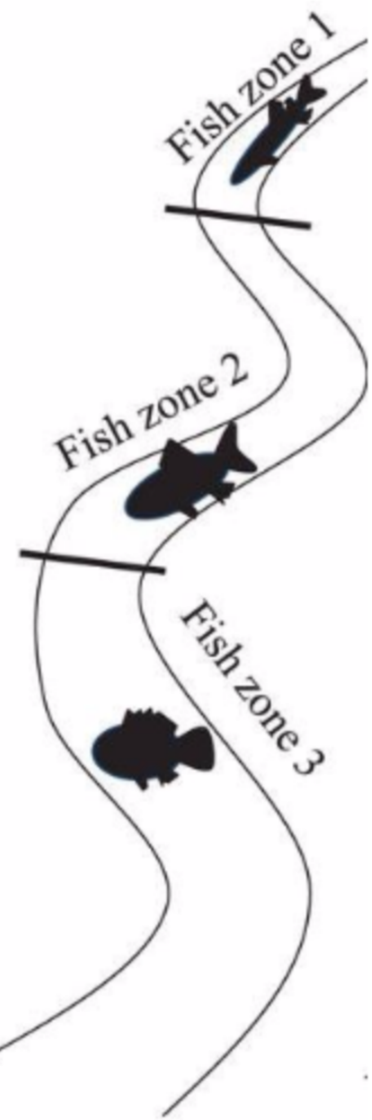
- Channels become wider
- Channels become deeper
- Flow becomes slower, but greater in volume



Three longitudinal profile zones, from headwaters to mouth

Slide modified from Gordon Holtgrieve

In western Europe, there were thought to be four zones – the trout (*Salmo*), grayling (*Thymallus*), barbell (*Barbus*) and bream (*Abramis*) zones.



Fast, cold water
Steamlined fish with low temperature tolerance and adhesive eggs.

Fast, slightly warmer water
Steamlined fish with better temperature tolerance and adhesive eggs.

Low gradient, moderate flow, warm water
Ticker fish with sub-terminal mouths
Non-adhesive eggs in laid in plants

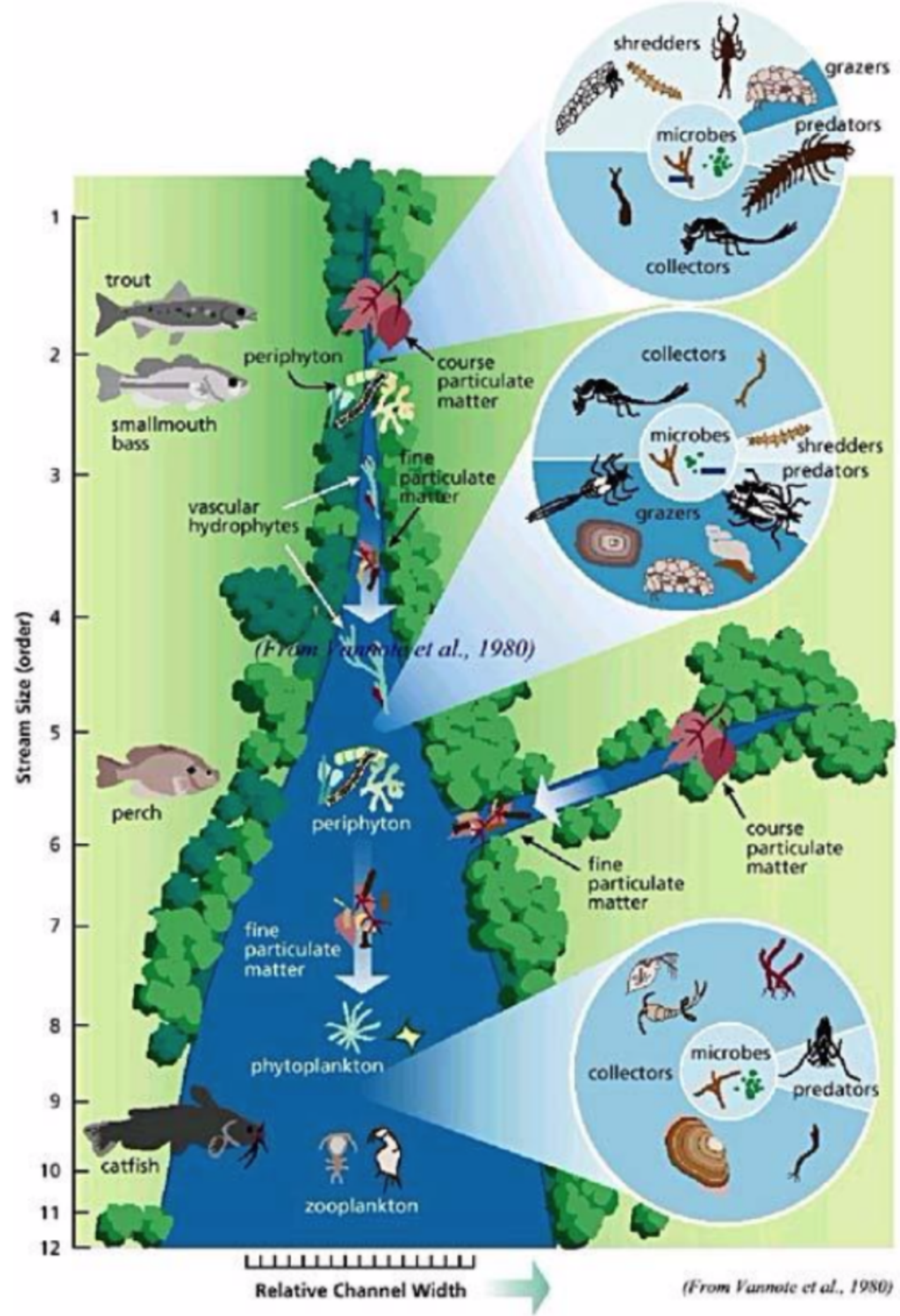
Very slow and warm water with low oxygen
Deep-bodied fish
Adhesive eggs in laid at the surface in weeds

Slide by Gordon Holtgrieve

River Continuum Concept

Vannote et al. 1980. The river continuum concept. Can. J. Fish. Aquat. Sci. 37: 130-137.

3rd most cited ecology paper from the 1980s with well over 3000 citations (which is a lot).



Longitudinal Changes – Reach Scale

- Longitudinal changes are also observed at shorter scales than the entire river length
- We call this shorter scale the **"reach"** scale
- One example of reach scale changes is the pool-riffle pattern found in many streams draining areas with **medium** gradients
- Riffle is an area of rapid flow over coarse substrate (sediment) whereas the pool is a slower flowing stretch with finer substrate

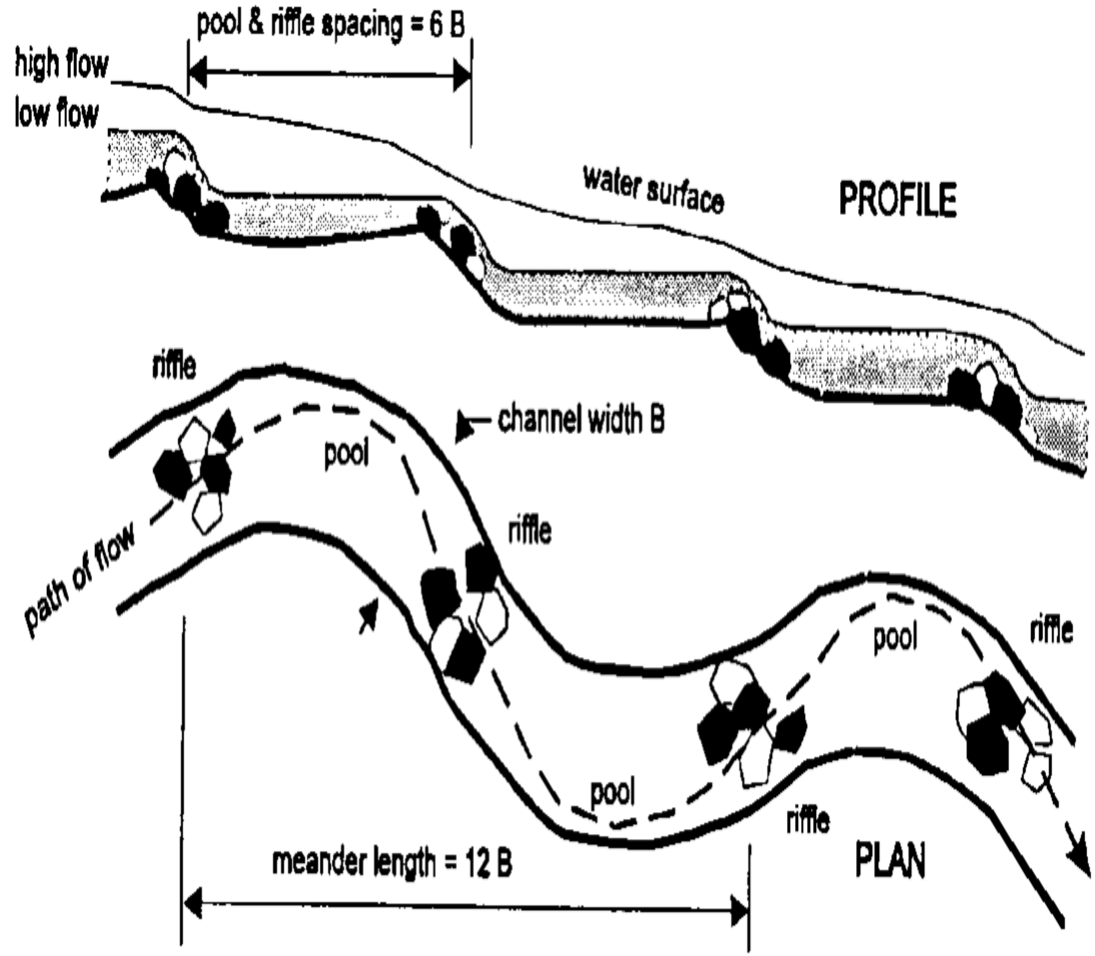
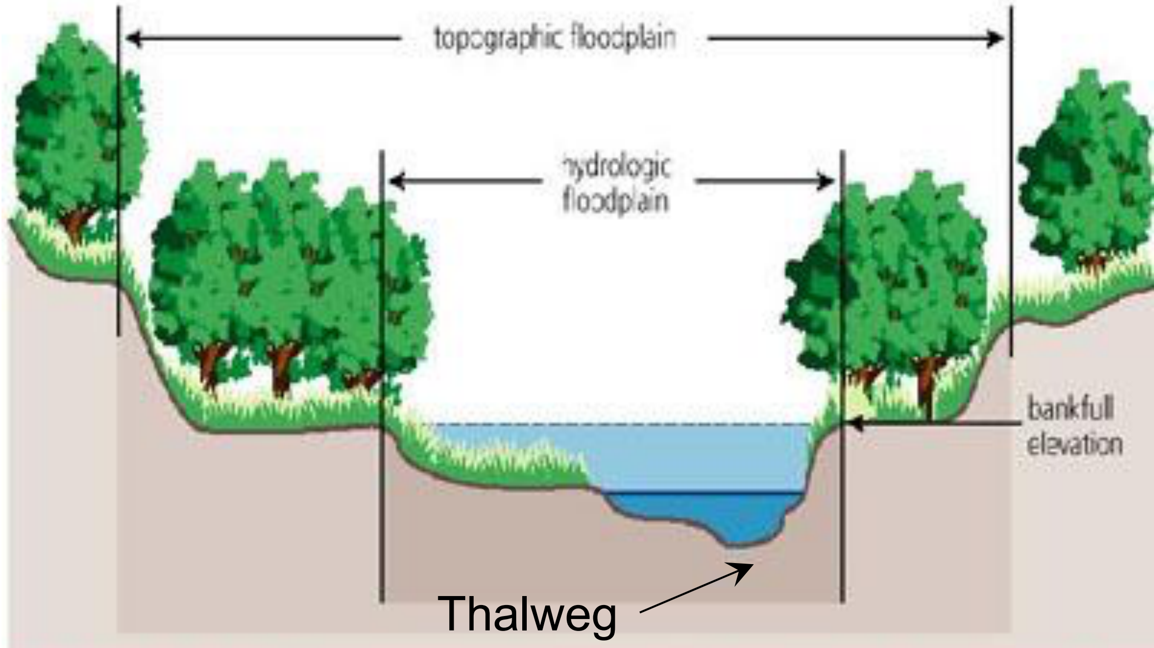


FIGURE 4.2 Average meander, pool, and riffle dimensions expressed as a ratio to the bankfull width.

Lateral Patterns

There are also some predictable changes laterally

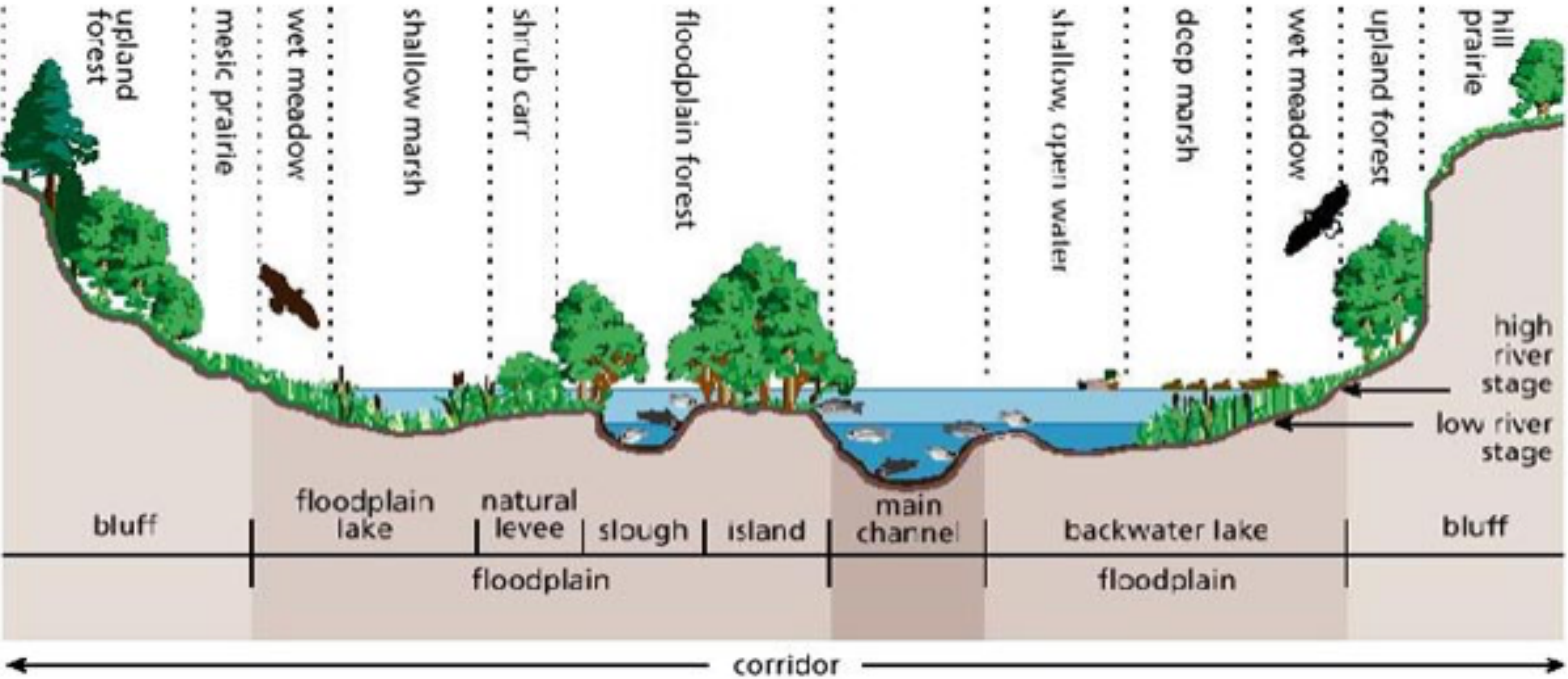
- The stream has its low flow channel, the low point of which is the thalweg
- The stream has banks which define its frequent flow limit
- The stream has a floodplain which defines its flow limit on less frequent events, annual or lesser frequency



The hydrologic floodplain is defined by bankfull elevation. The topographic floodplain includes the hydrologic floodplain and higher floodplains up to a defined elevation that corresponds to a specific flood frequency.

Lateral Features

As rivers increase in size they develop a complex floodplain system



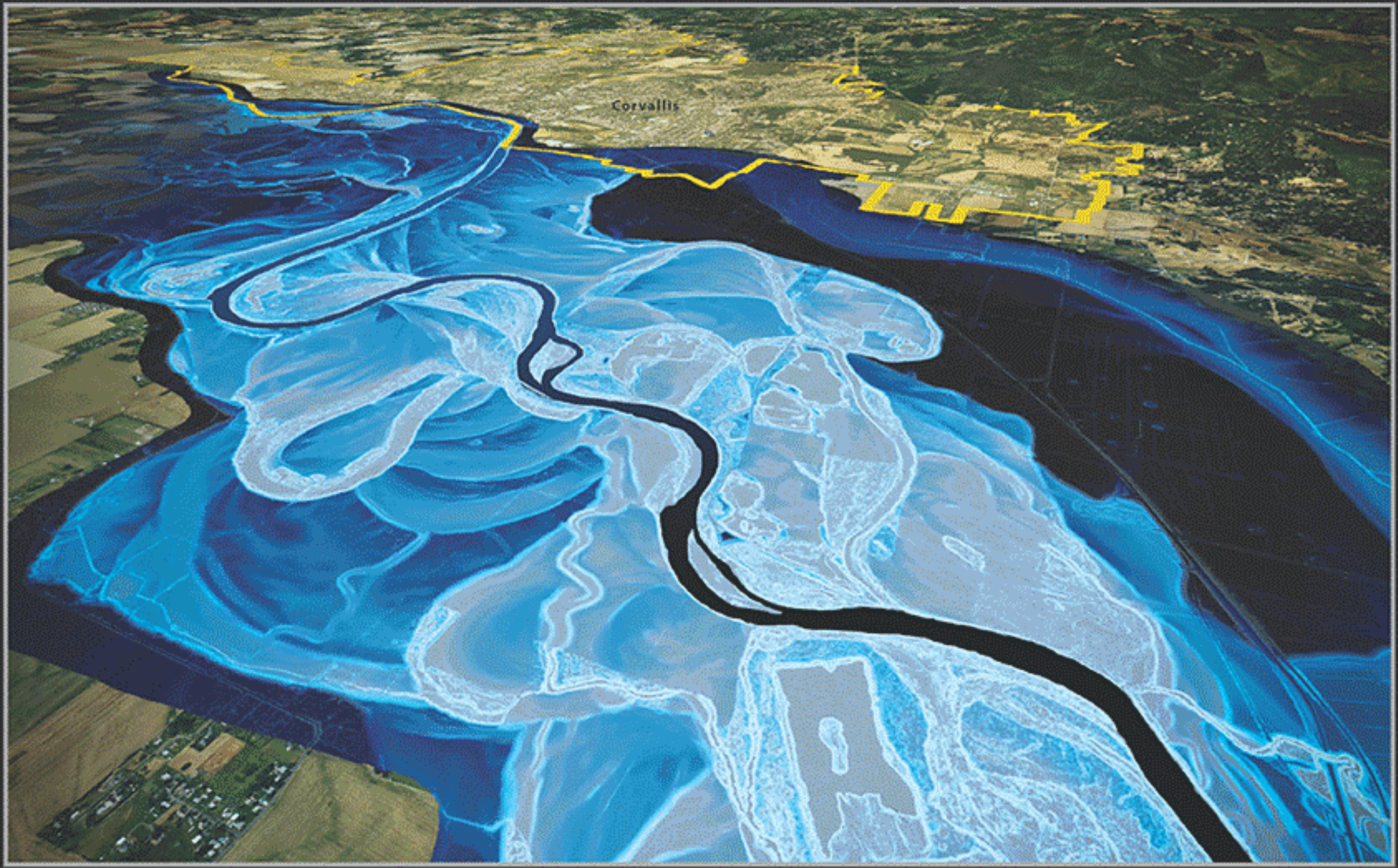
A cross sectional view of a river corridor

Lateral Patterns

Some streams and rivers will have a single dominant channel while others have a network of interwoven channels

Single-thread (left) and braided (right) channel forms. Single-thread are most common. Braided usually form in unstable conditions with high sediment supply, erosion and flow.

Willamette River Historic Channels, North of Corvallis, Oregon



L I D A R

Revealing Oregon's Dynamic Landscape

The Willamette River and its former channels near Corvallis, Oregon. For thousands of years, the Willamette River has meandered across the valley floor. This 3D enhanced image was created using a combination of lidar-derived elevation data and aerial orthophotography.

2010 Oregon Department of Geology and Mineral Industries Lidar imagery and graphic design by Daniel Coe


Google
PUCALLPA PERU
2001


Google
TIBET
2001

Vertical dimensions

- Velocity changes with depth in stream channel

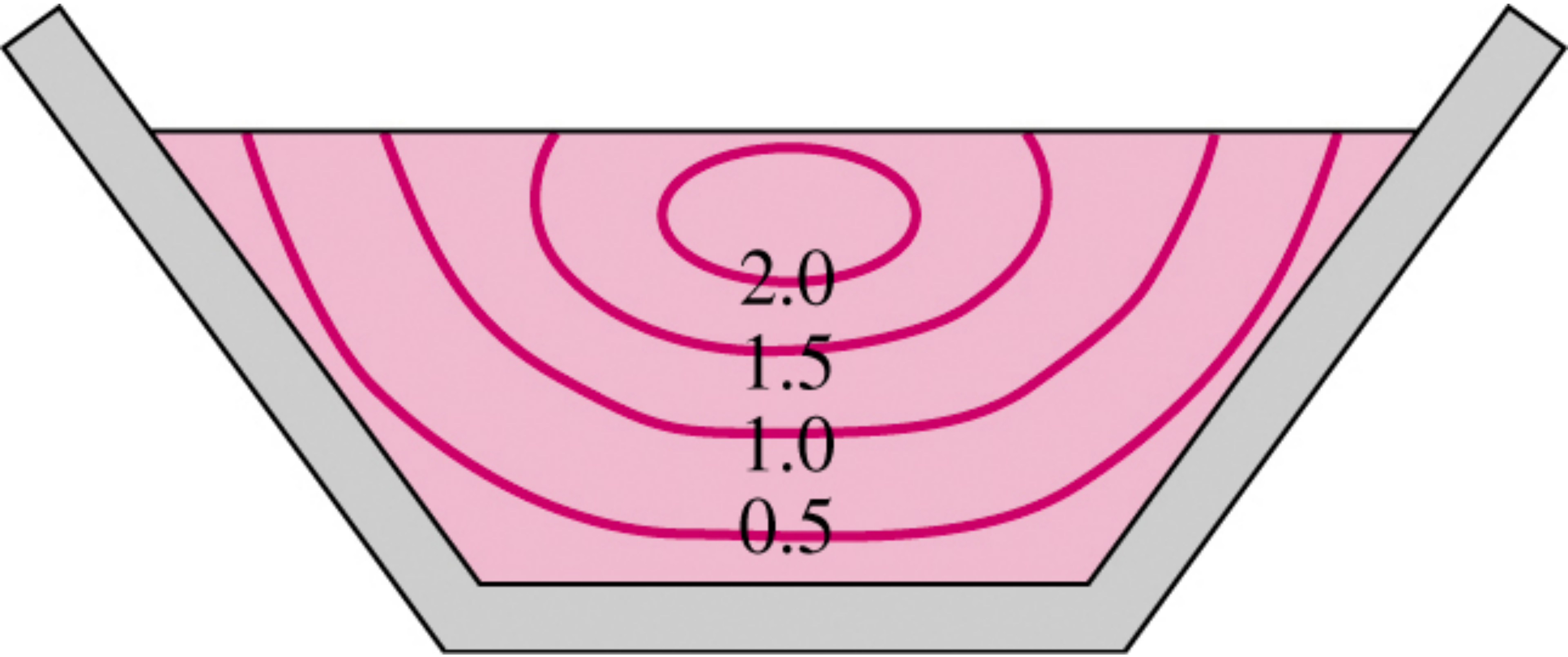
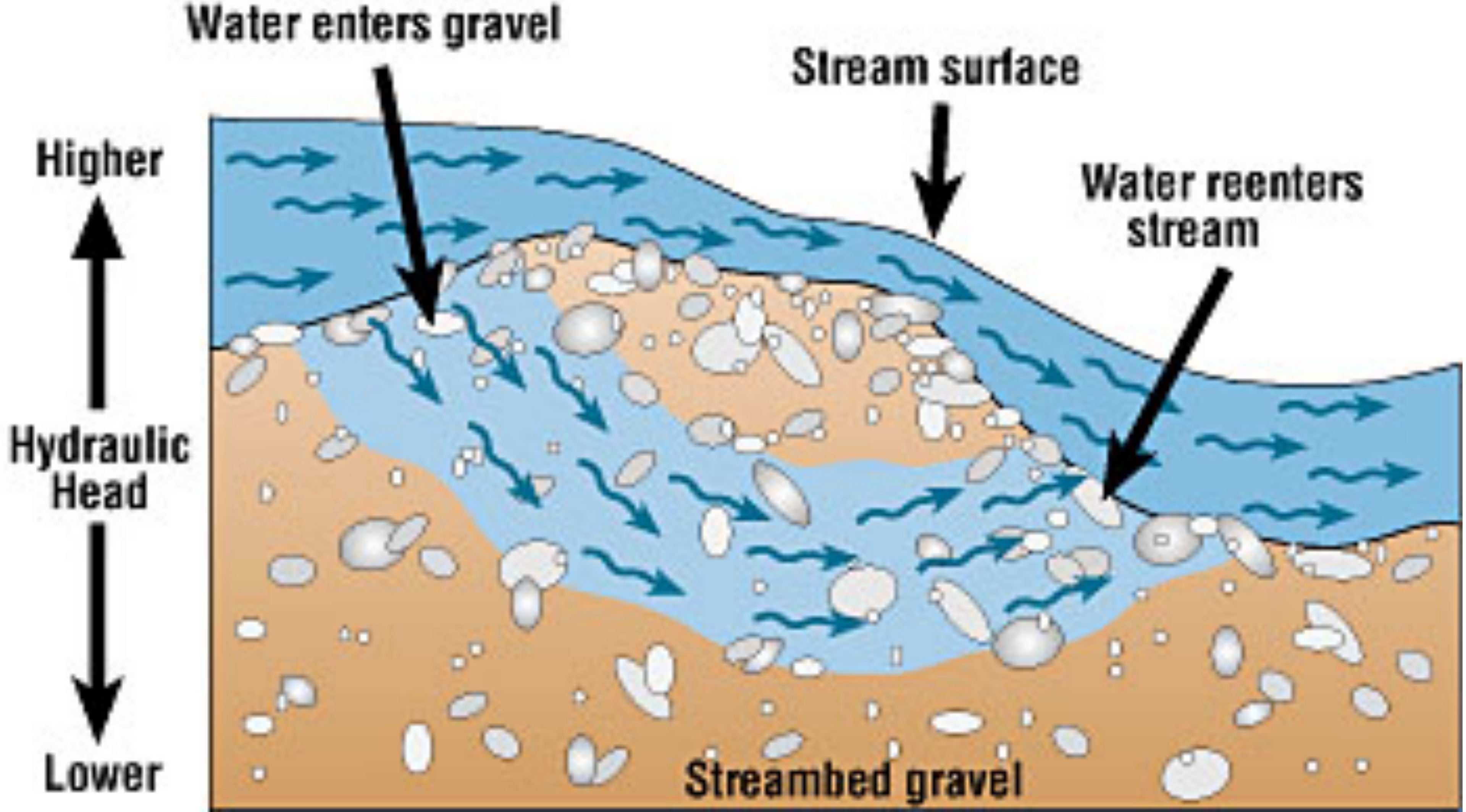


Diagram by:Eric G. Paterson, Department of Mechanical and Nuclear Engineering, The Pennsylvania State University

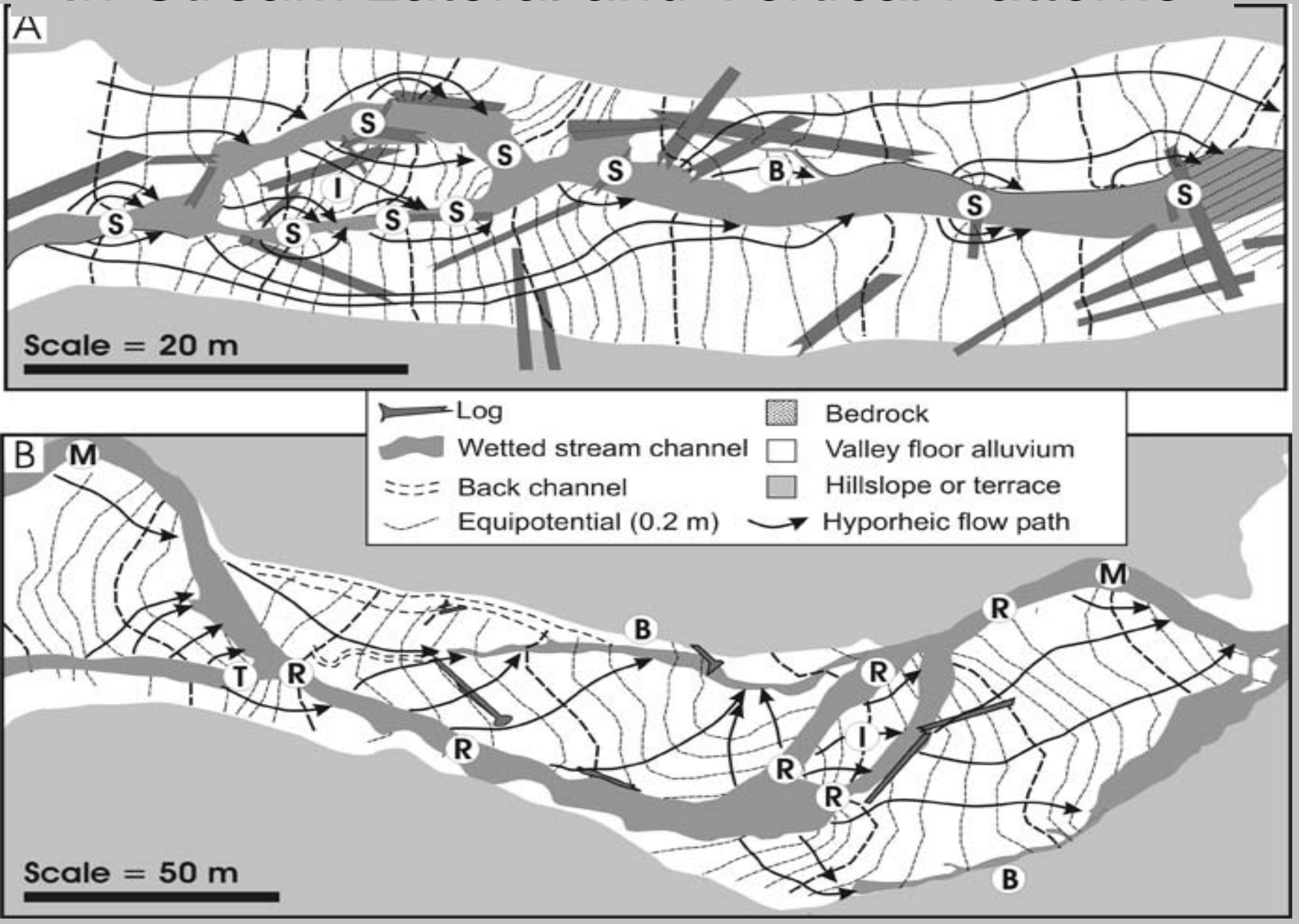
Vertical Features

Hyporheic interactions (below stream)

Exchanges occur with groundwater just below the stream

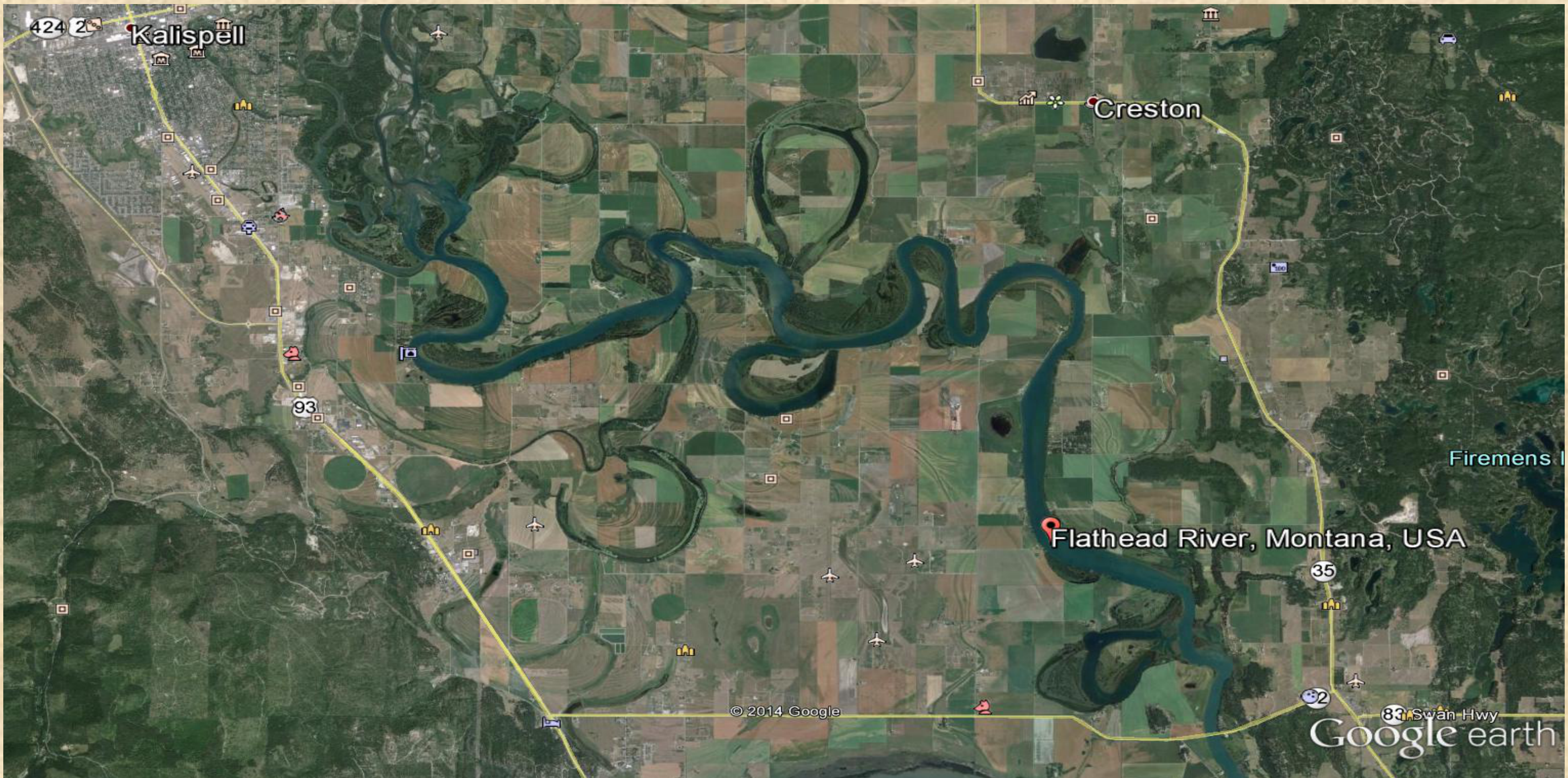


In-Stream Lateral and Vertical Patterns



Riparian Lateral and Vertical Patterns

- In many large alluvial valleys, creatures that live in ground water and hyporheic water can be found in the subsurface water kilometers from the stream.
- In other words, stream extends well beyond visible channel.



Temporal dimension

Stream flow changes

Seconds → Hourly → Daily → Monthly → Seasonally → Annually → Millennium

Watersheds and Hydrology

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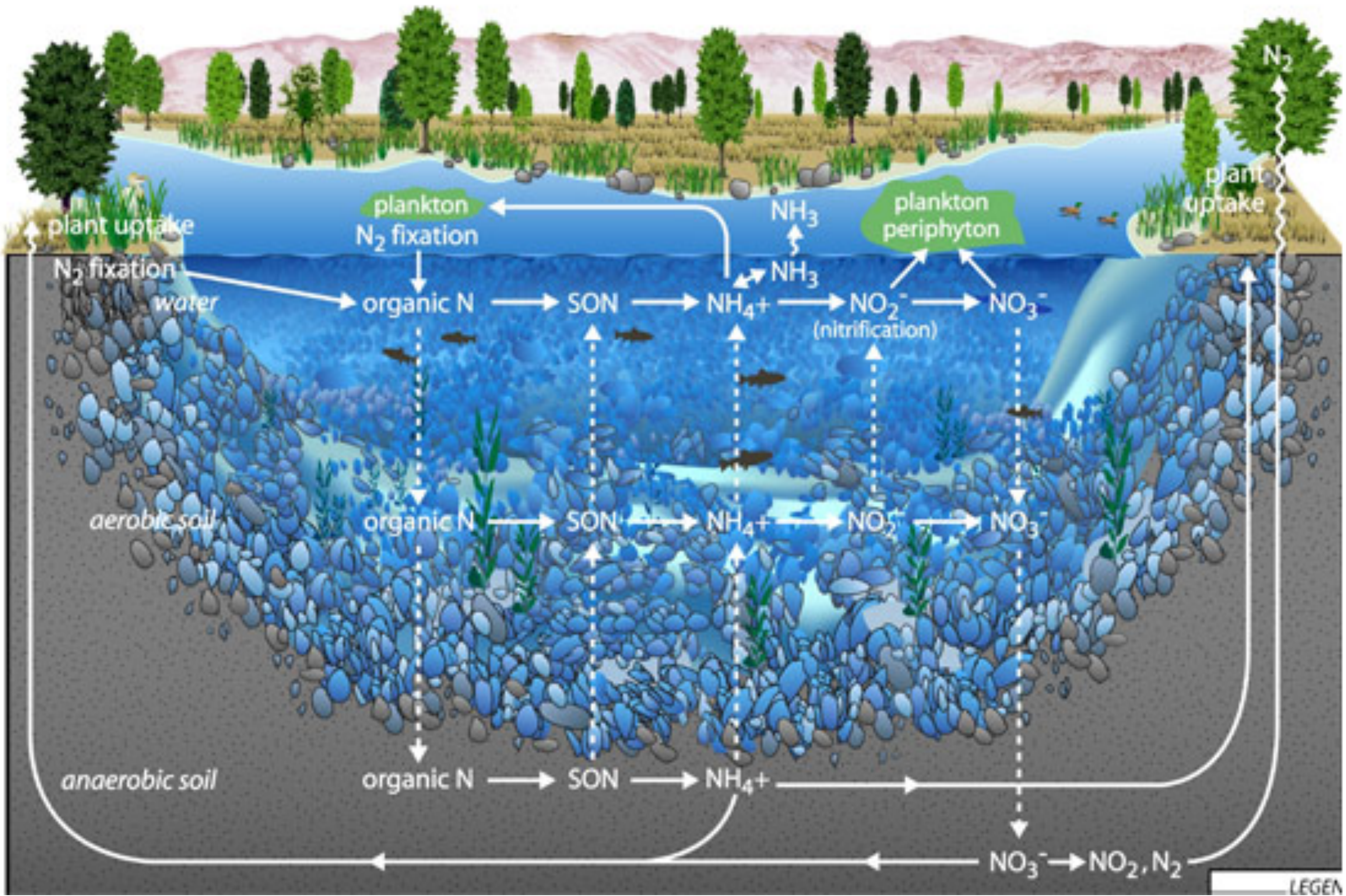
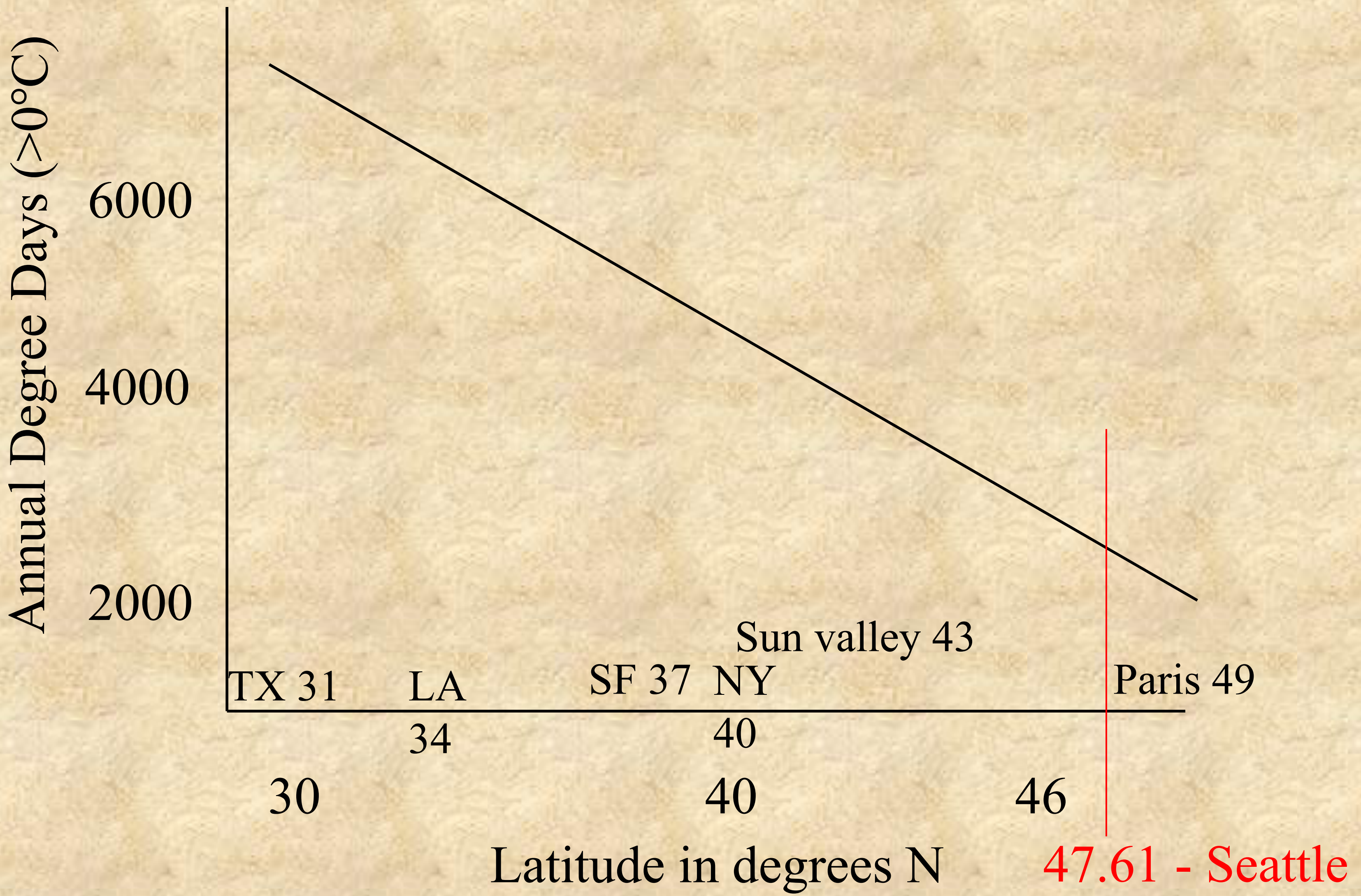
What are the major **physical, chemical, and biological components** used to characterize water quality?



Biological and Ecological Components: Selected Important Habitat Factors

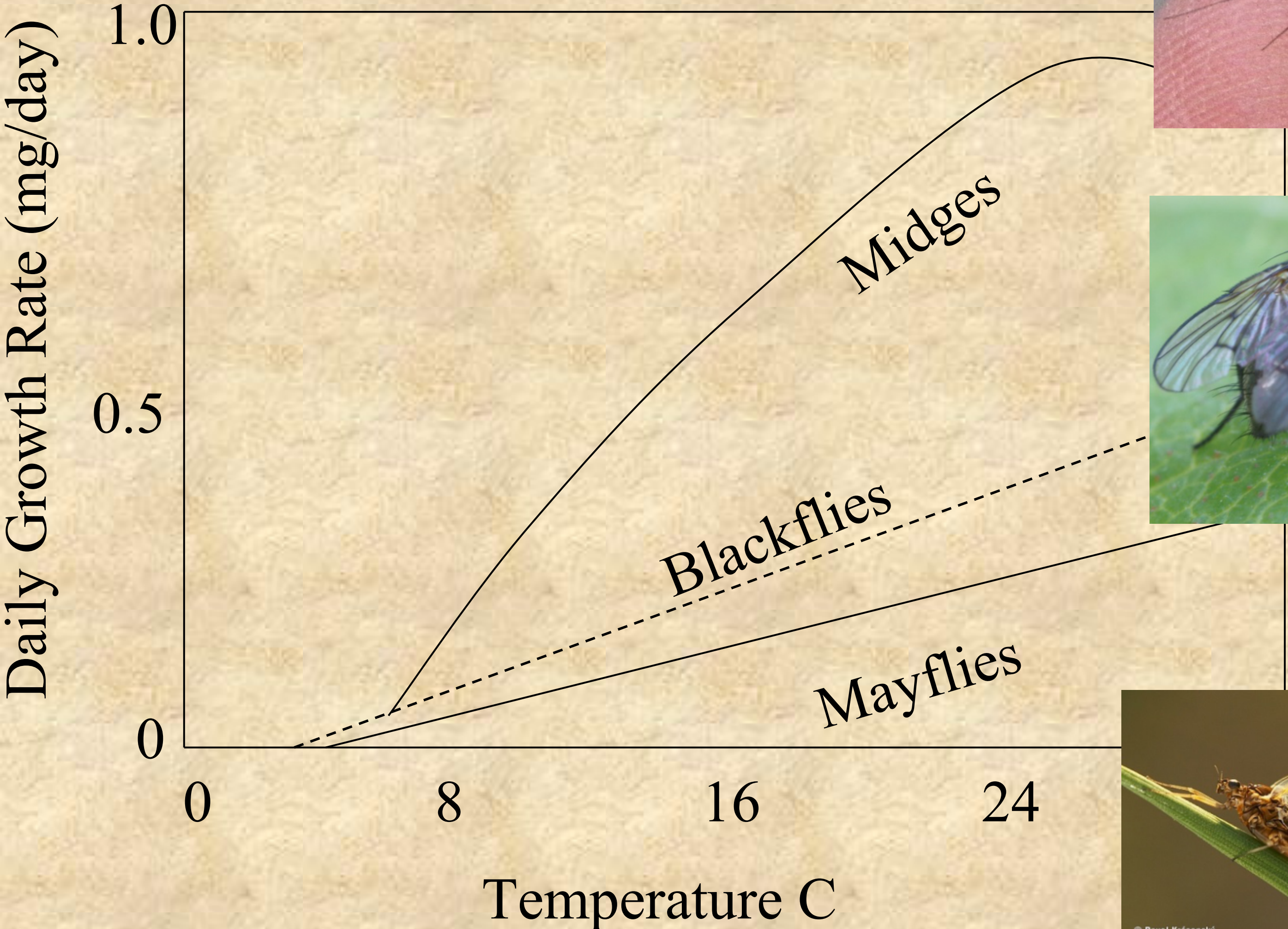
- Flow velocity
- Substrate
- Light
- Temperature
- Hydrologic, nutrient and sediment regimes
    - Organic input and transport
    - pH
    - Oxygen levels
    - Toxics and other pollutants
        - Food availability
        - Biological communities (BIBI)

10.3 Effect of latitude on stream degree days



(Modified from Vannote and Sweeney 1980)

Influence of temperature on growth rates



Modified from Benke 1993

Watersheds and Hydrology

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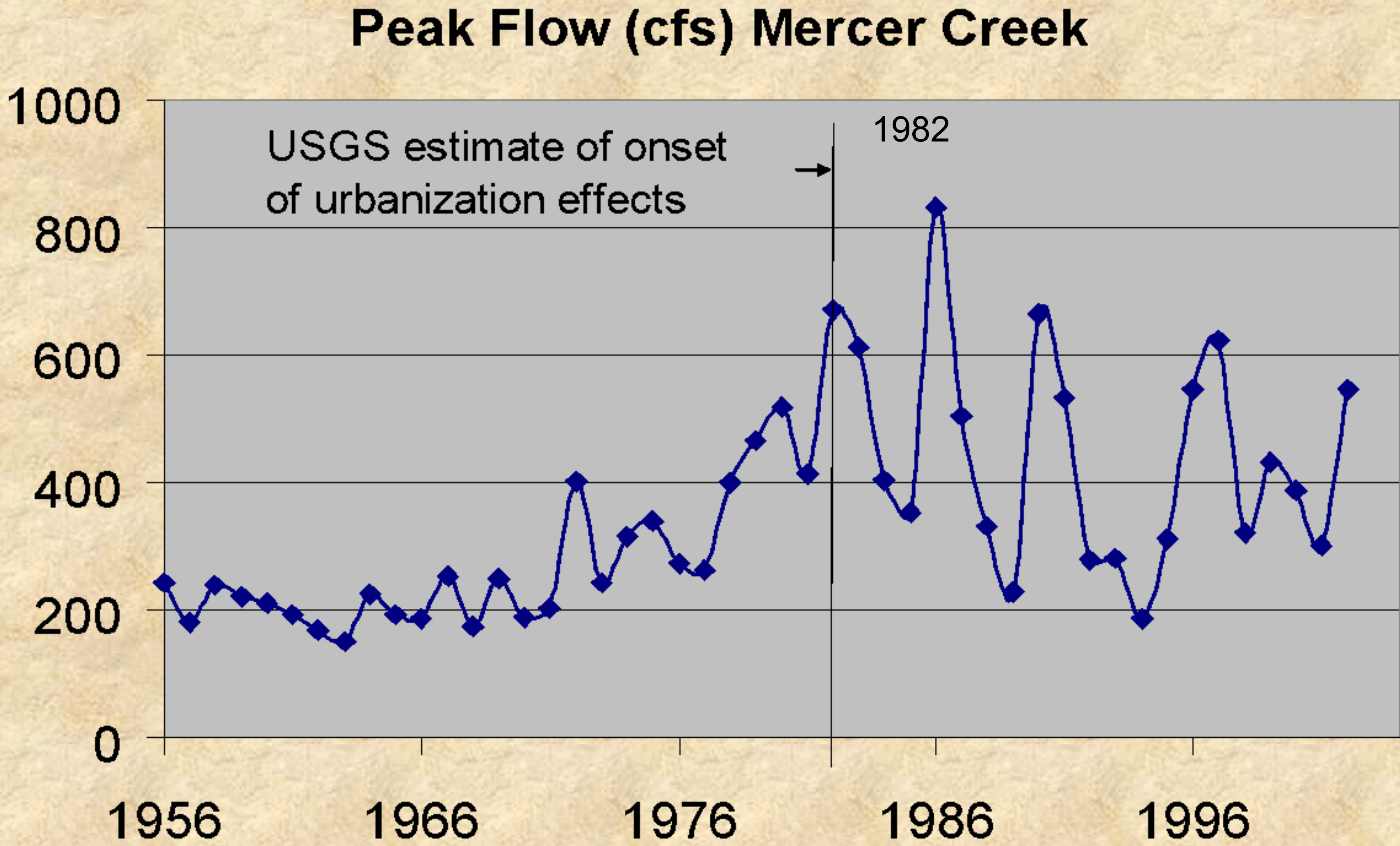
Question 5

What do we want to know about stream flow?

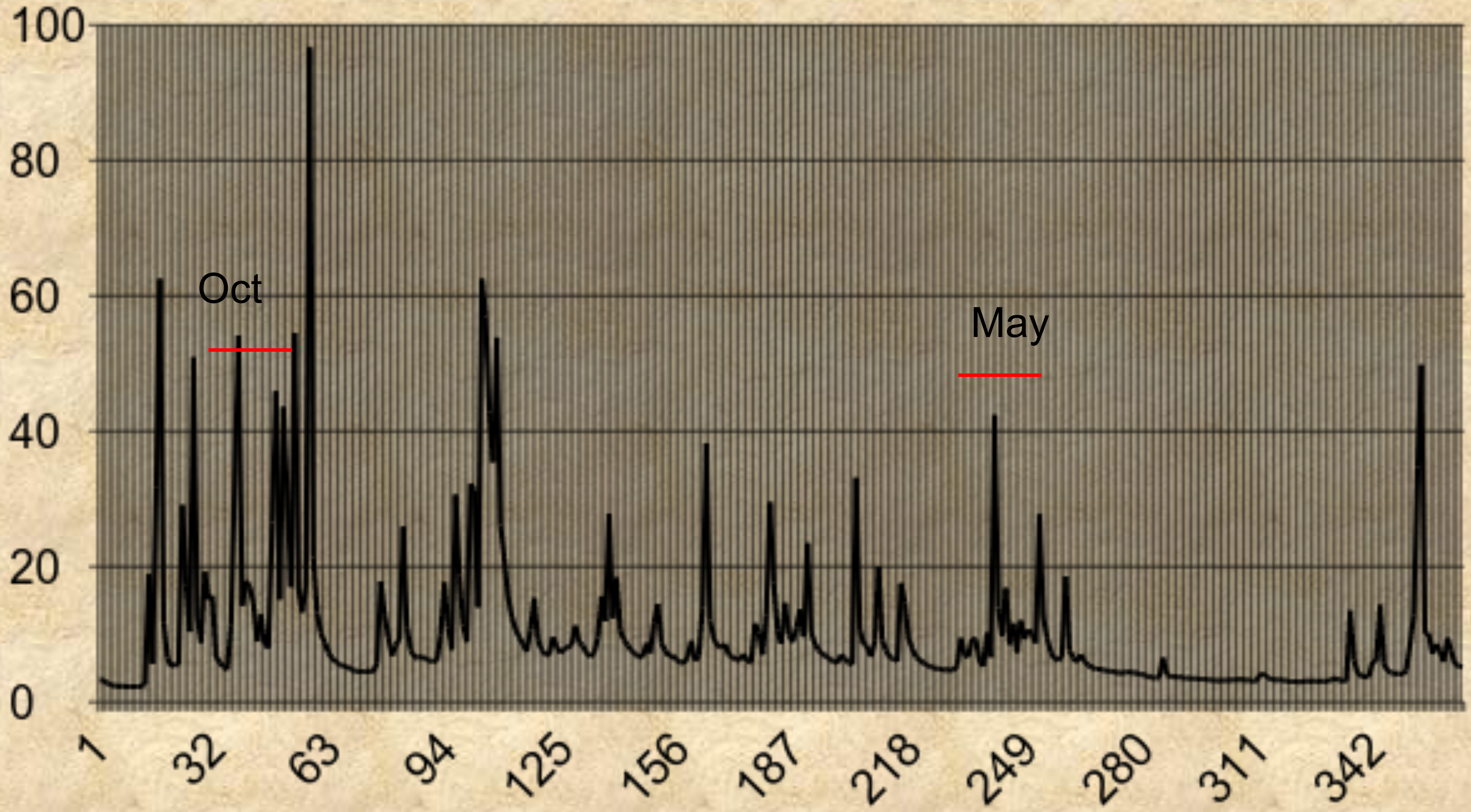
- Magnitude - how much?
- Frequency - how often?
- Timing - when?
- Duration - how long?
- Rate of change – how fast?

Magnitude, Frequency, Timing, Duration, Rate of change

Magnitude, Frequency, Timing, Duration, Rate of change

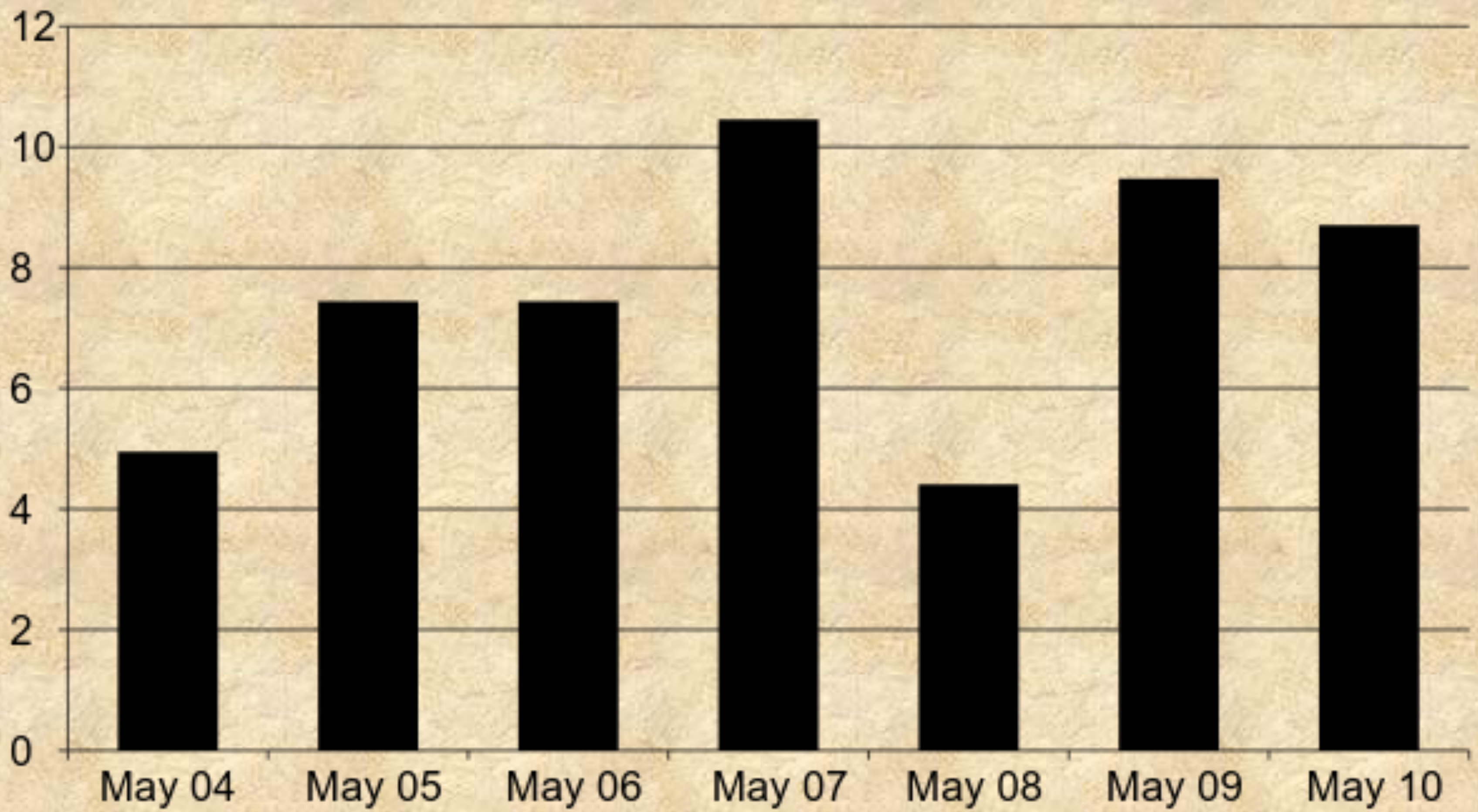


Mean daily flow (cfs) Juanita Creek Water Year 2010



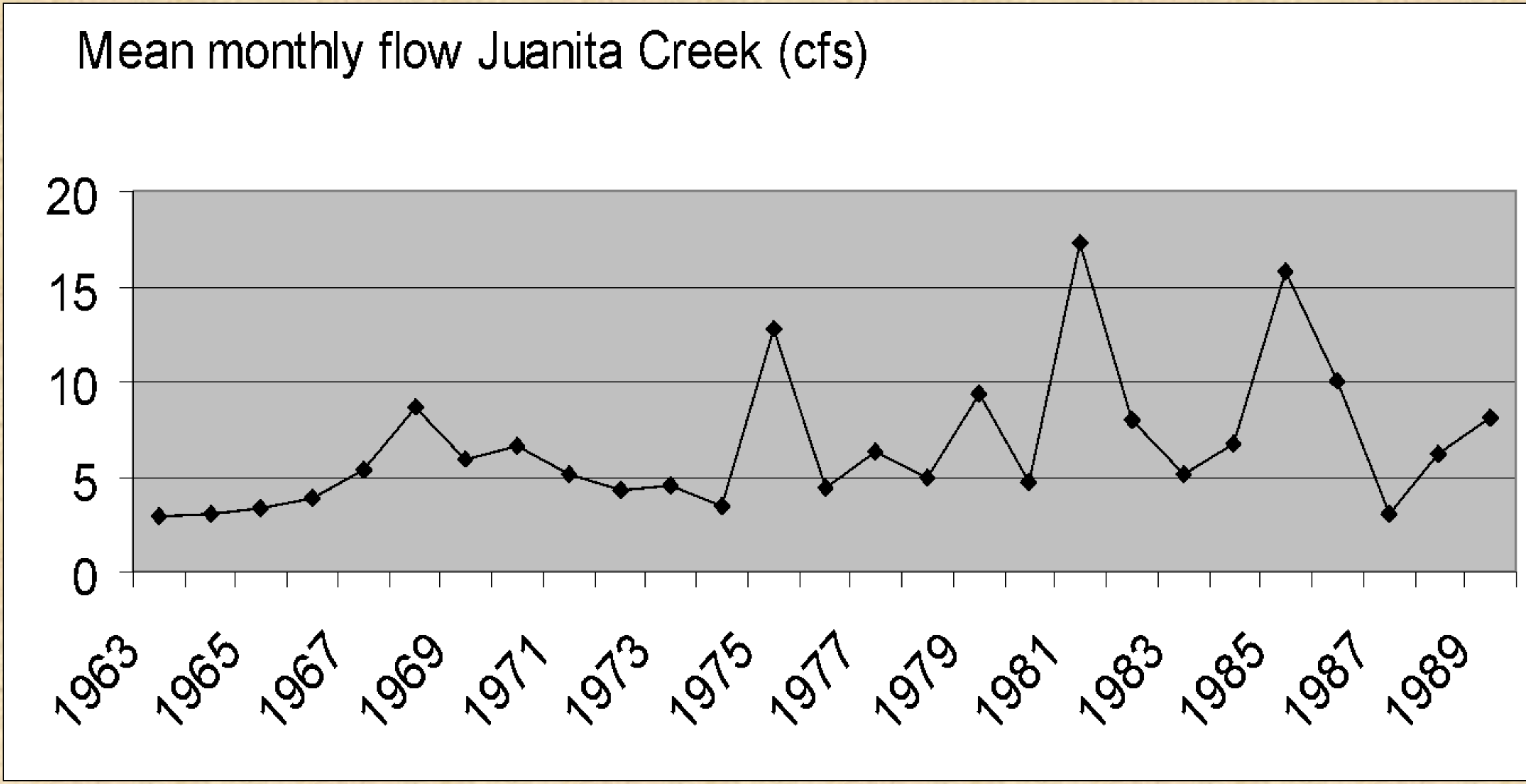
Magnitude, Frequency, Timing, Duration, Rate of change

Mean May Discharge
Juanita Creek



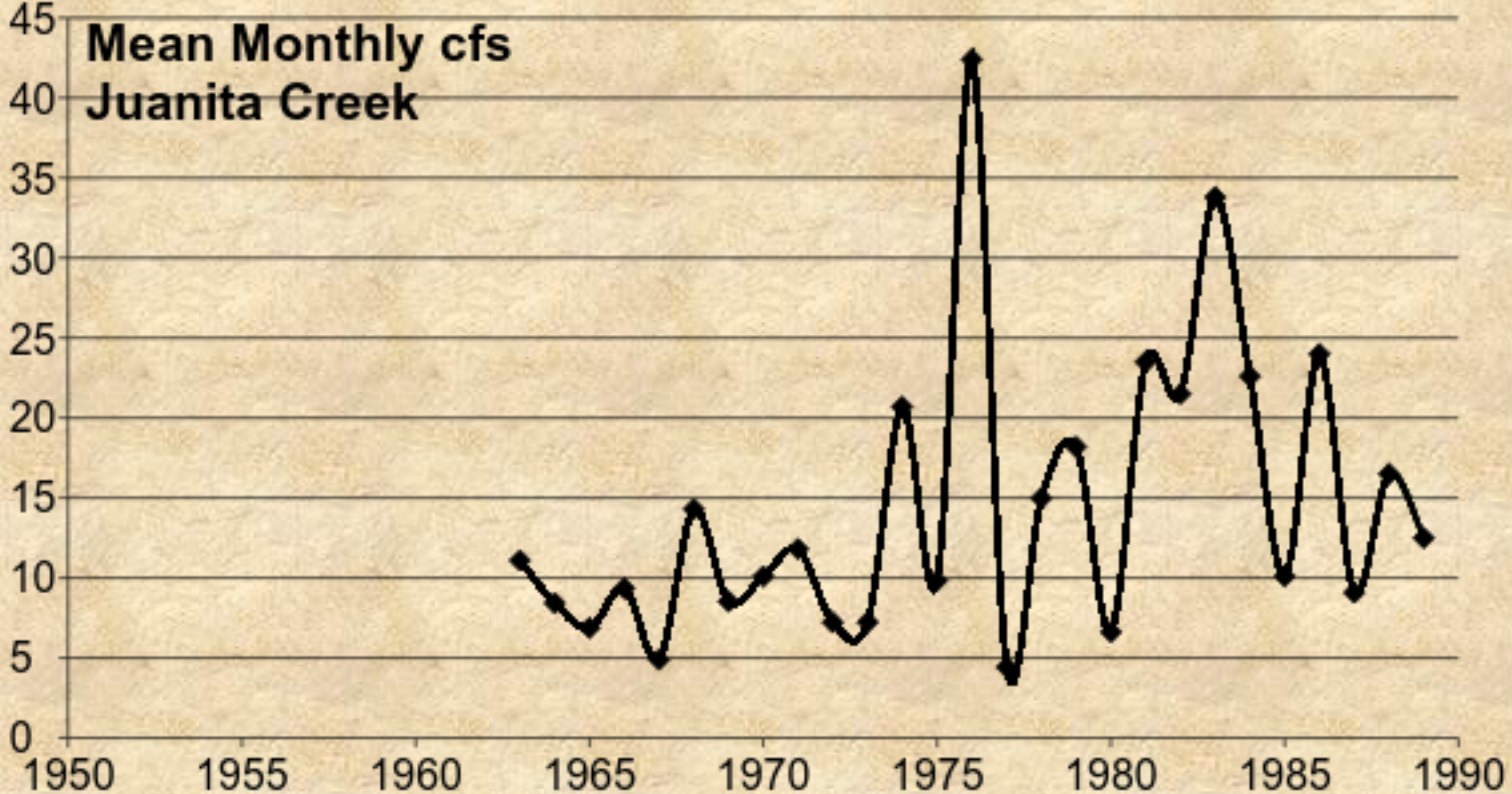
Magnitude, Frequency, Timing, Duration, Rate of change

October flows – Juanita Creek



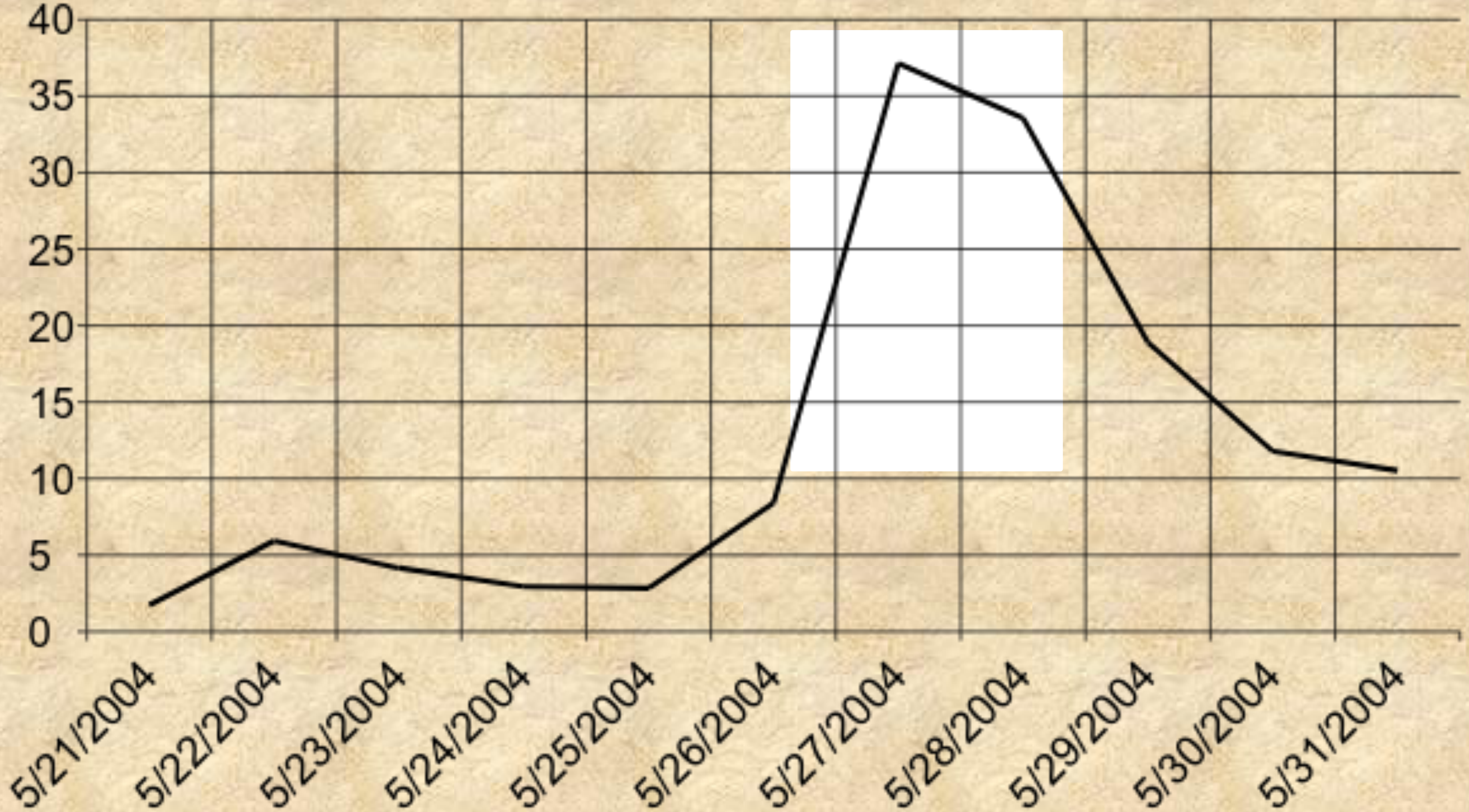
Magnitude, **Frequency**, Timing, Duration, Rate of change

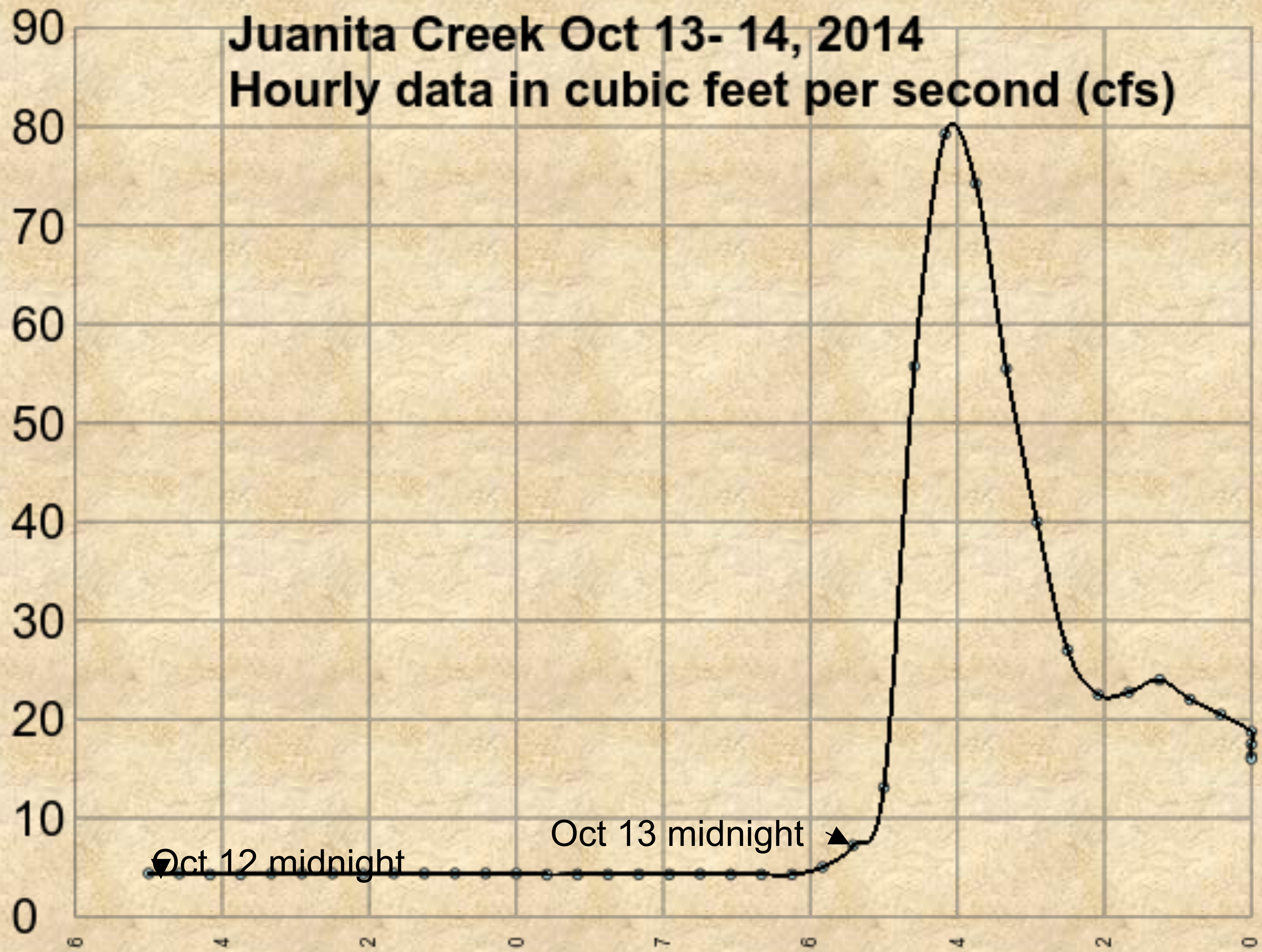
November flows – Juanita Creek



Magnitude, Frequency, Timing, Duration, Rate of change

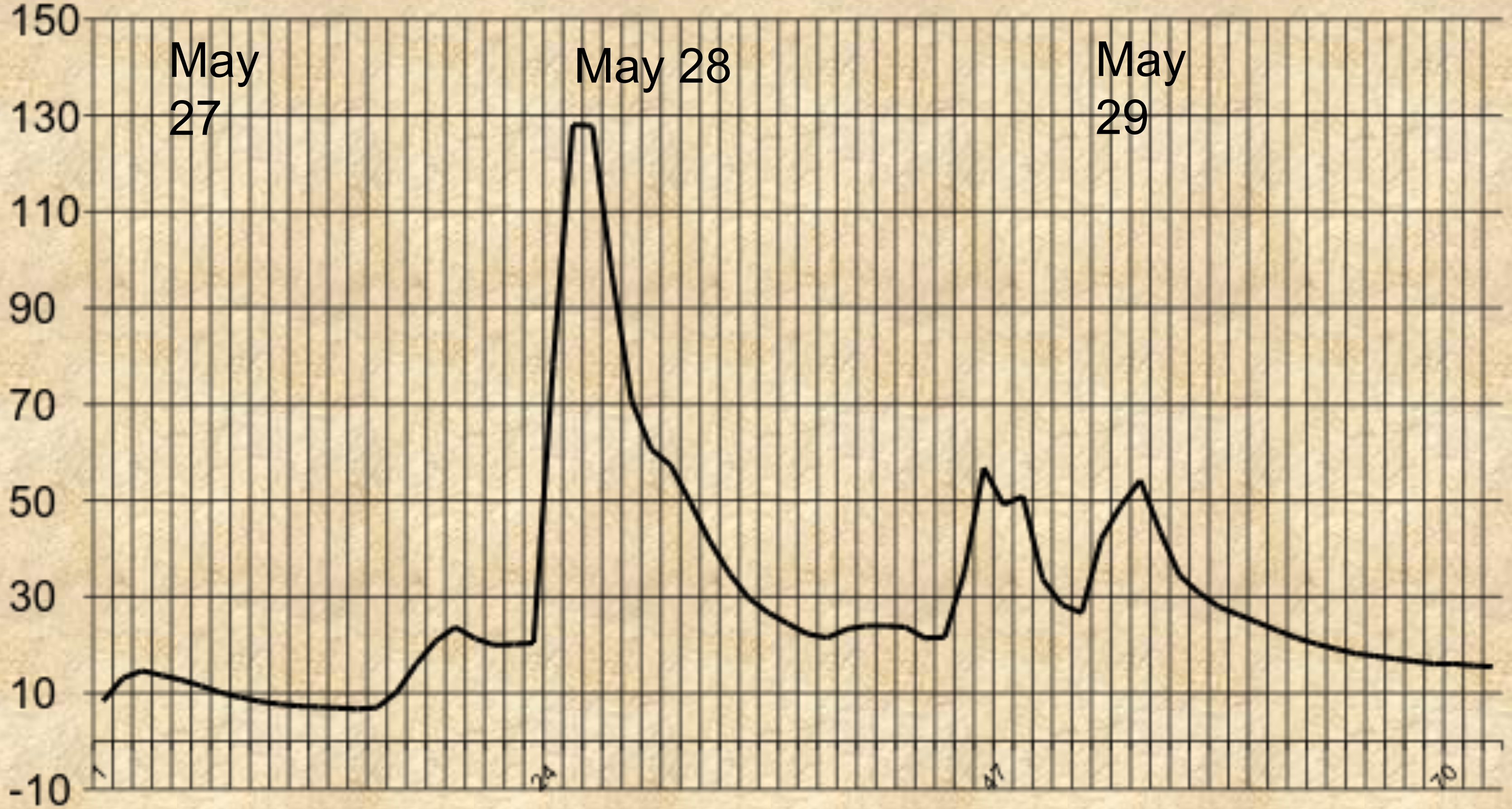
Mean Daily Flow Juanita Creek (cfs)





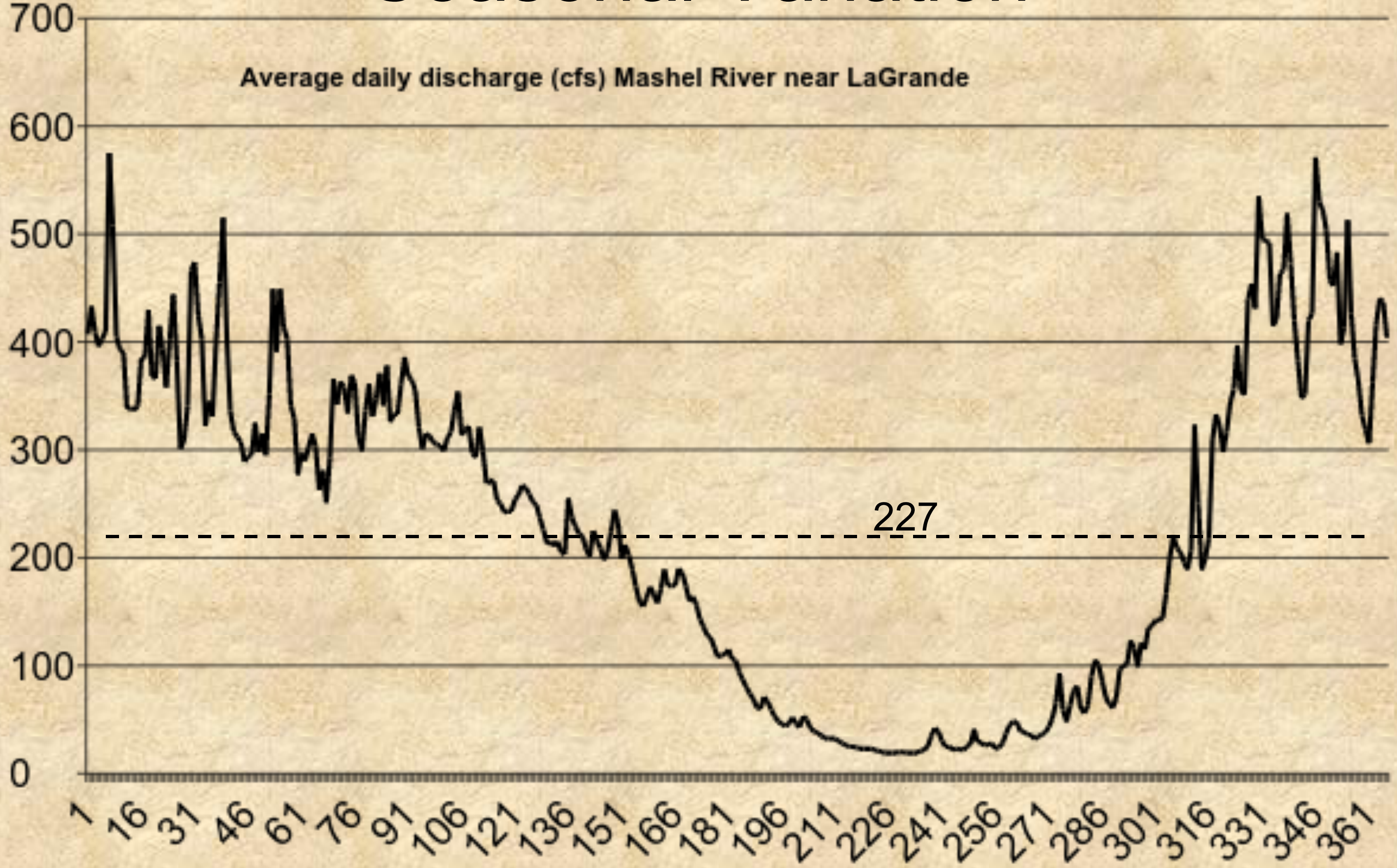
Magnitude, Frequency, Timing, Duration, Rate of change

15 minute flows
Juanita Creek May 27-29, 2004



Magnitude, Frequency, Timing, Duration, Rate of change

Seasonal Variation



Magnitude, Frequency, Timing, Duration, Rate of change

Take – home messages

- Flow regimes play a major role in habitat formation and maintenance
- Land-use alters flow paths and storage components → flow regimes
- Effects vary with spatial and temporal scales
- Don’t forget the basic processes involved