Saint Edward Stream Debrief

- Hydrologic regime
- Organic matter inputs
- Nutrient inputs
- Sediment and erosion
- Heat and light inputs

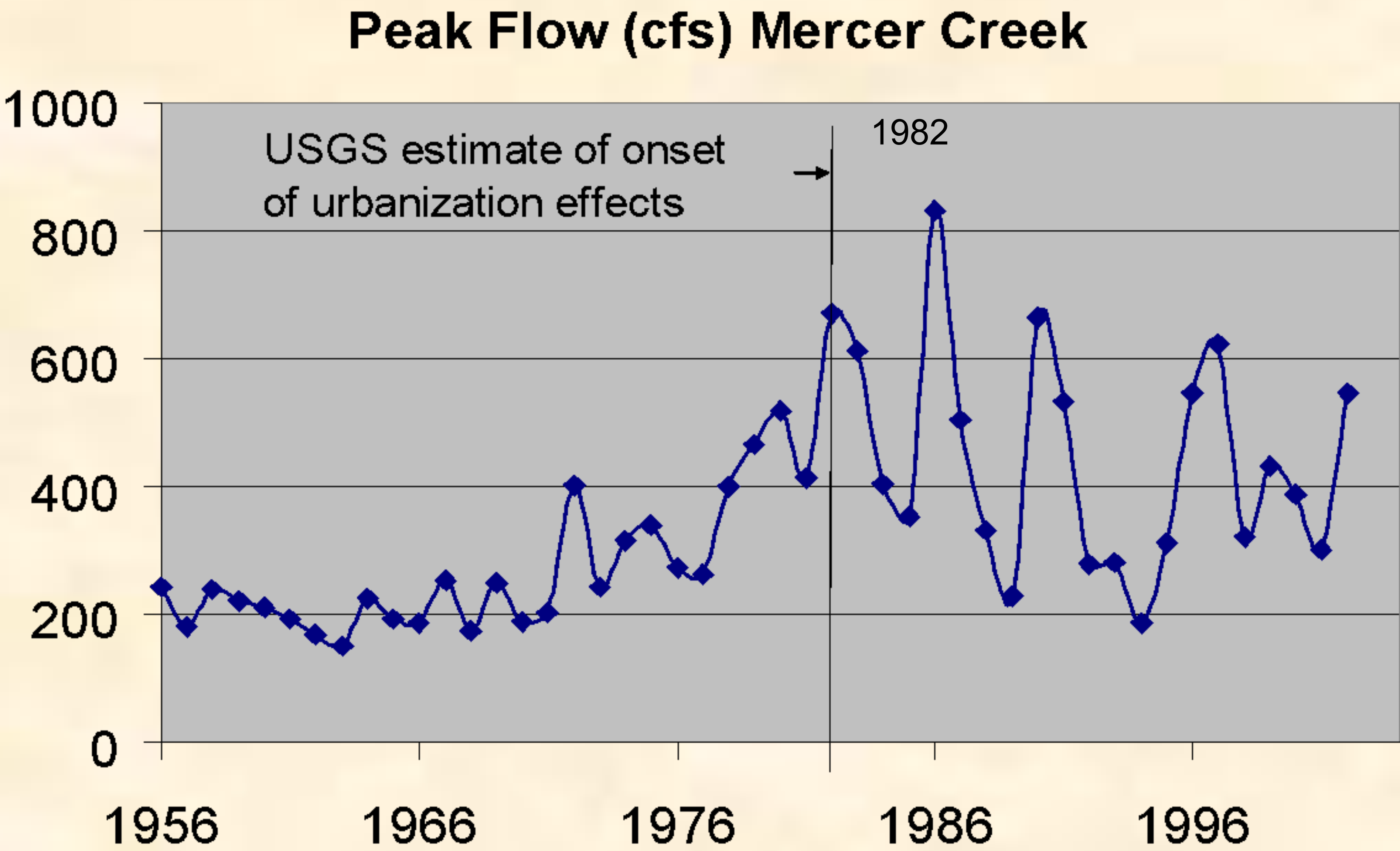
Question 5

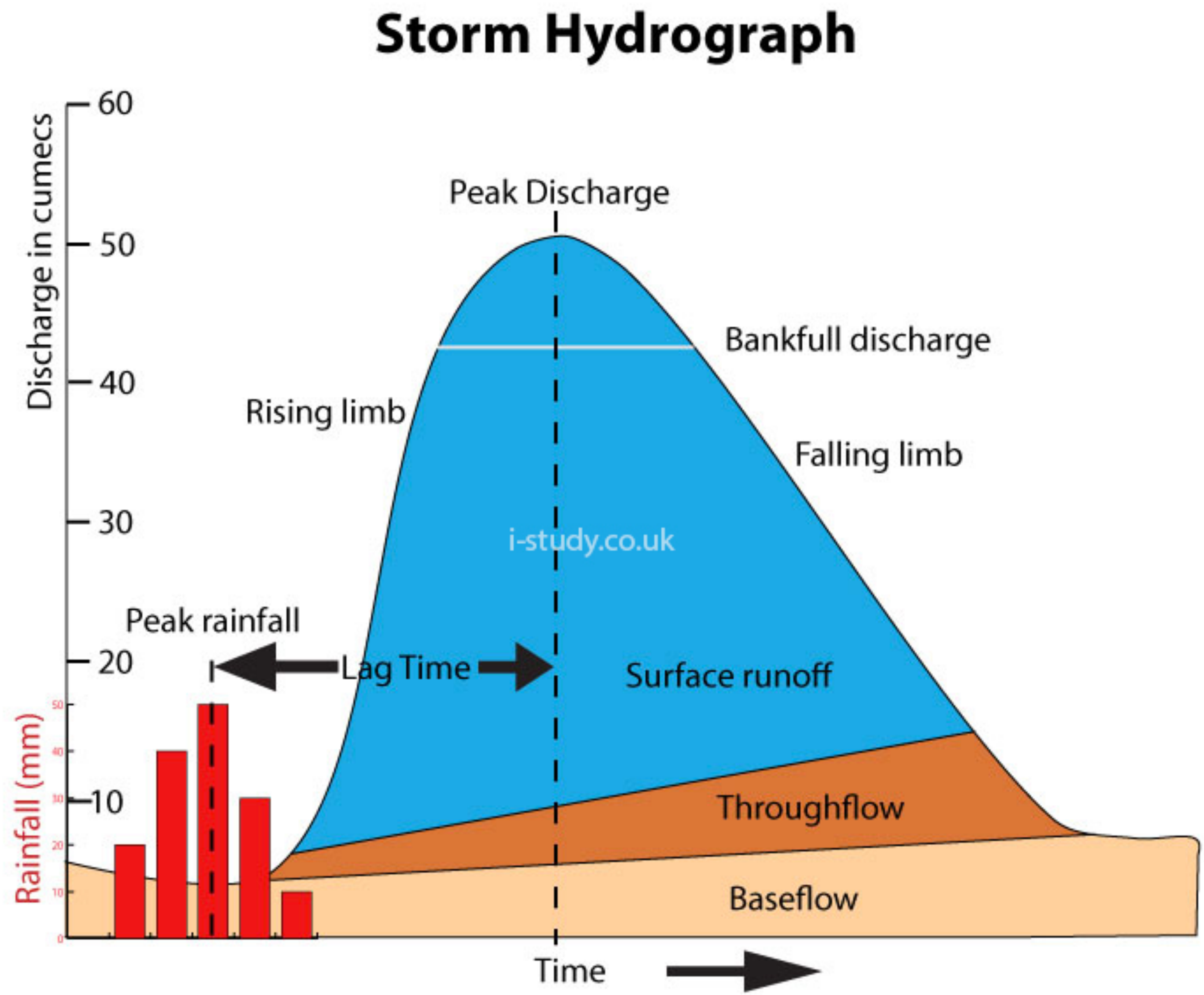
What do we want to know about stream flow?

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

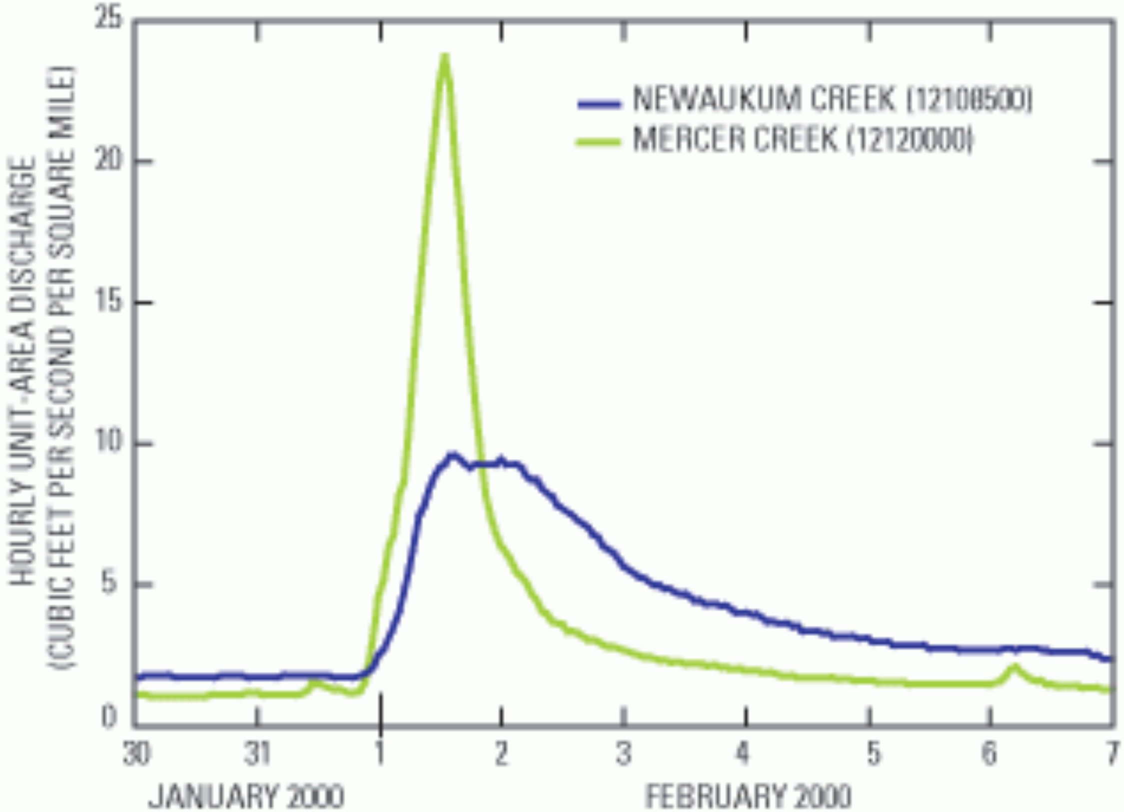
Magnitude, Frequency, Timing, Duration, Rate of change

Magnitude, Frequency, Timing, Duration, Rate of change



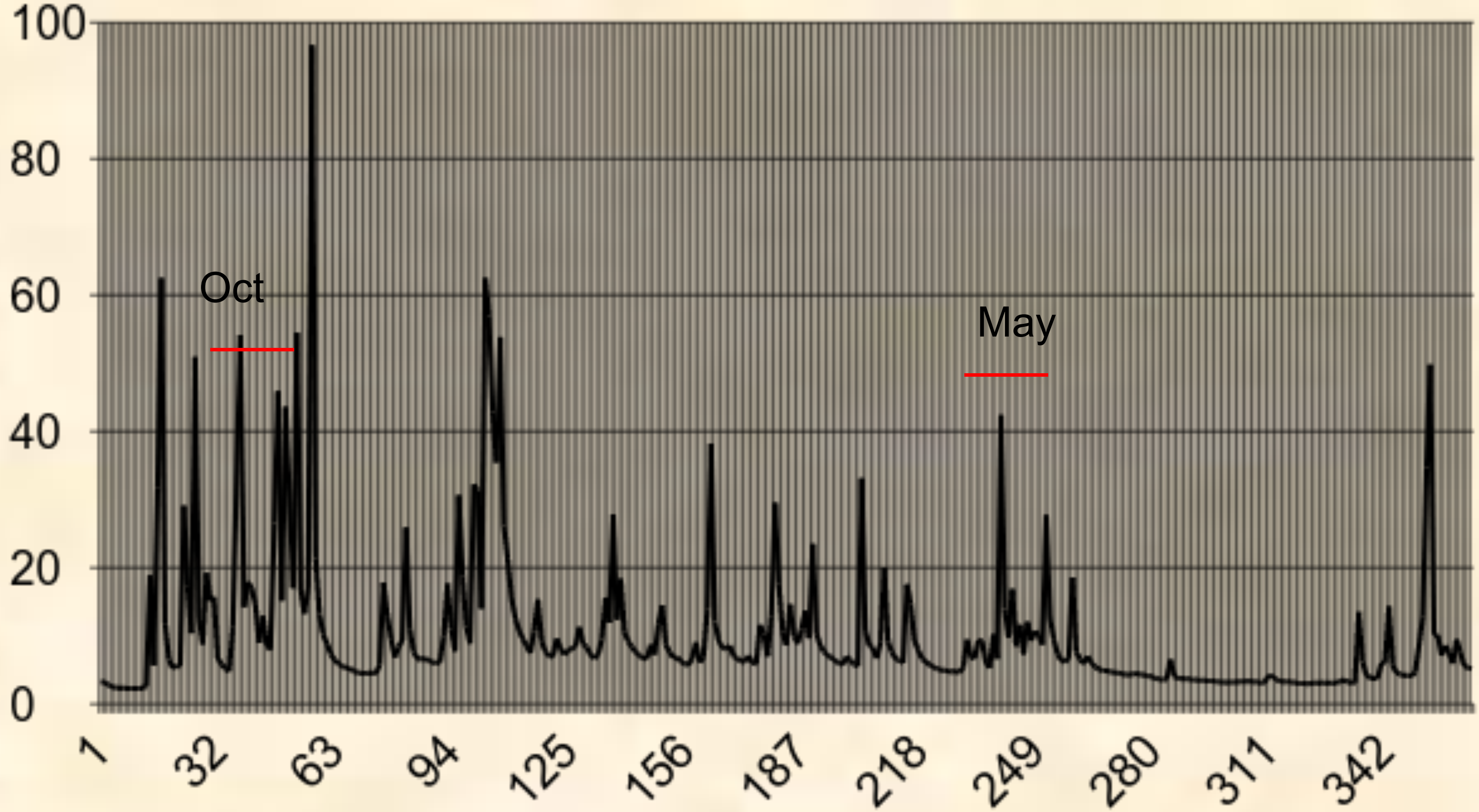


Storm Hydrograph
Discharge in cumecs
60
50
40
30
20
10
Peak Discharge
Bankfull discharge
Rising limb
Falling limb
i-study.co.uk
Peak rainfall
Lag Time
Surface runoff
Throughflow
Baseflow
Rainfall (mm)
Time



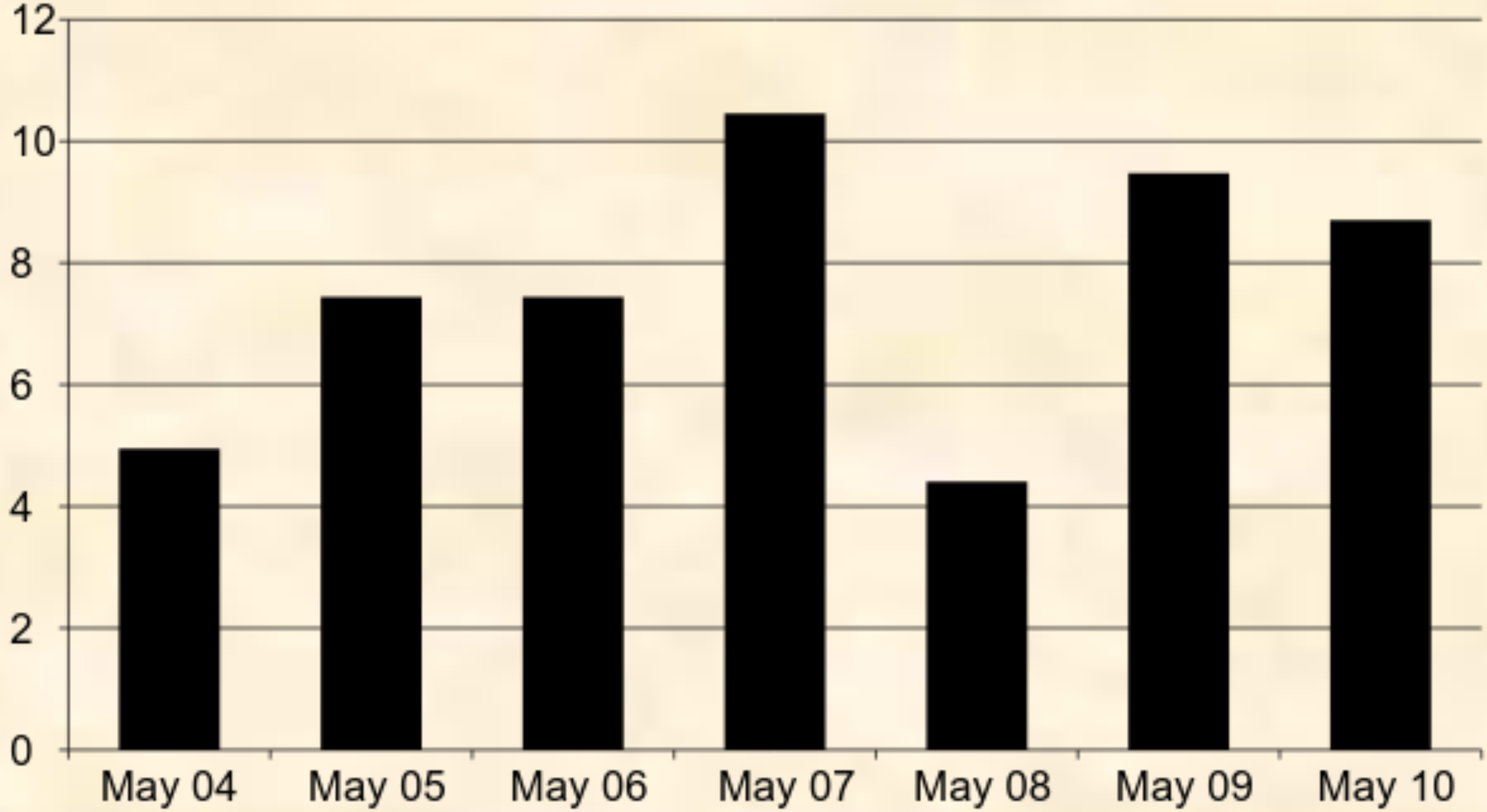
Streamflow in Mercer Creek, an urban stream in western Washington, increases more quickly, reaches a higher peak discharge, and has a larger volume during a one-day storm on February 1, 2000, than streamflow in Newaukum Creek, a nearby rural stream, a nearby rural stream that drains a basin of simlar size.

Mean daily flow (cfs)
Juanita Creek Water Year 2010



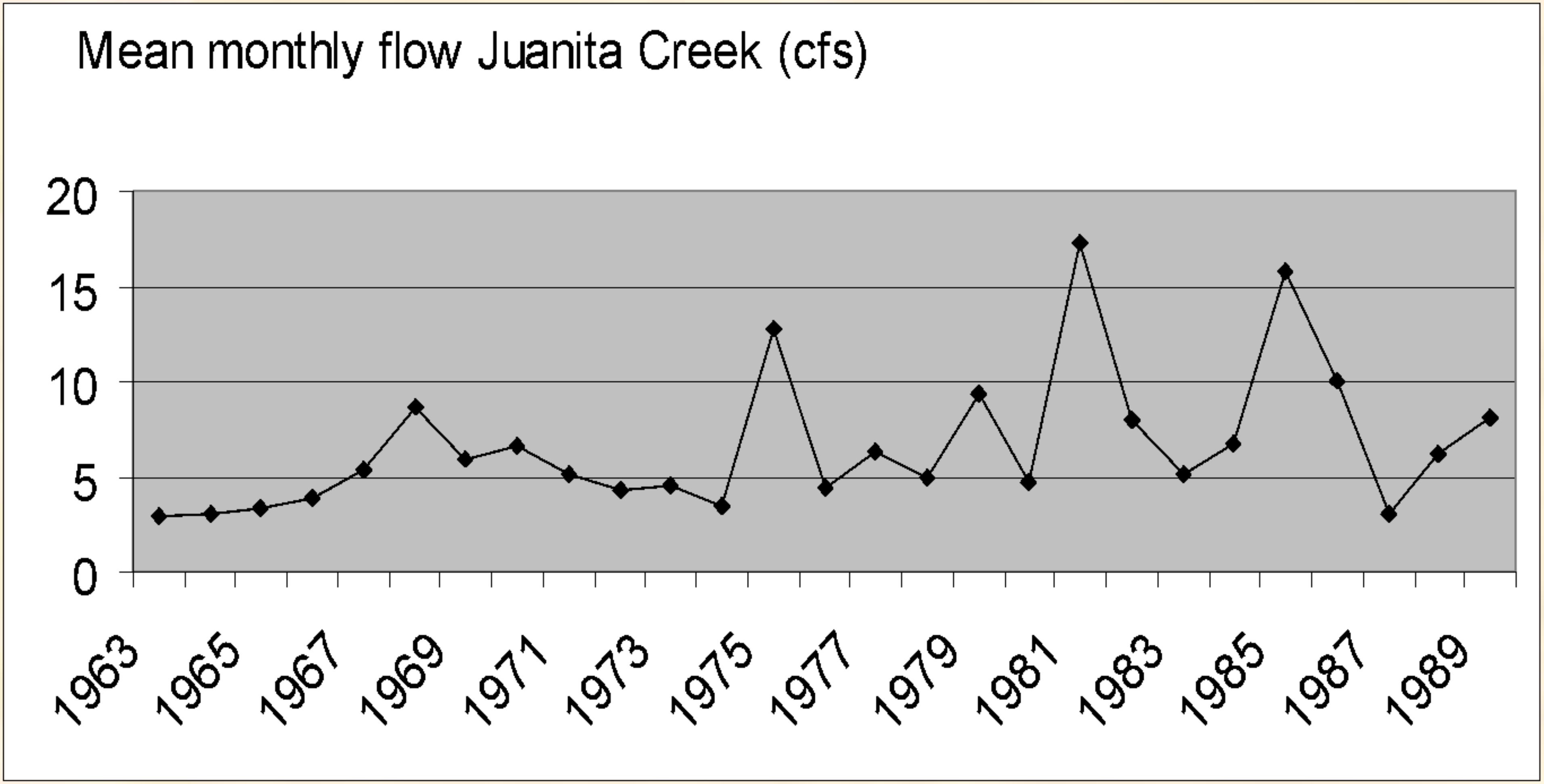
Magnitude, Frequency, Timing, Duration, Rate of change

Mean May Discharge
Juanita Creek



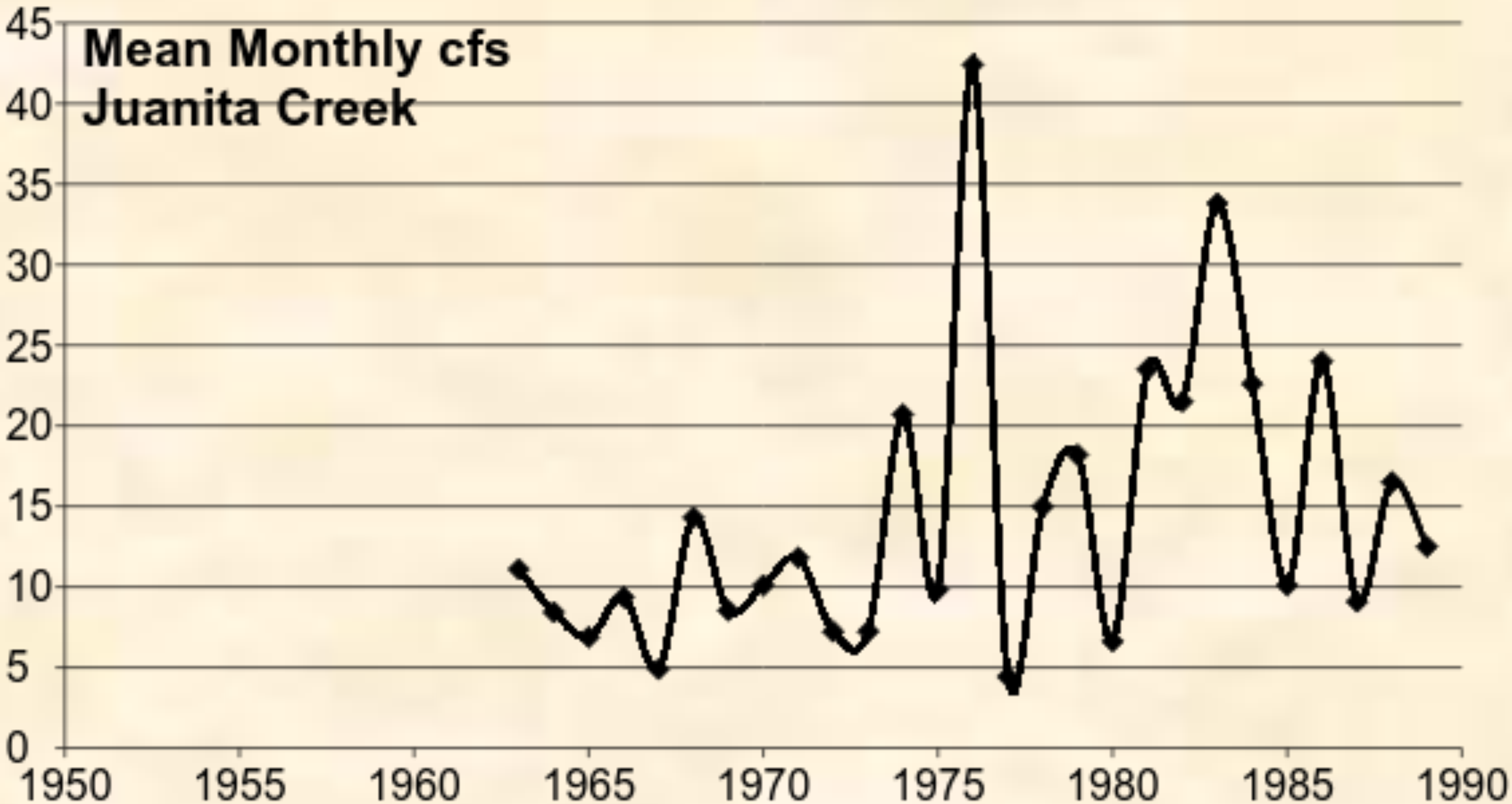
Magnitude, Frequency, Timing, Duration, Rate of change

October flows – Juanita Creek



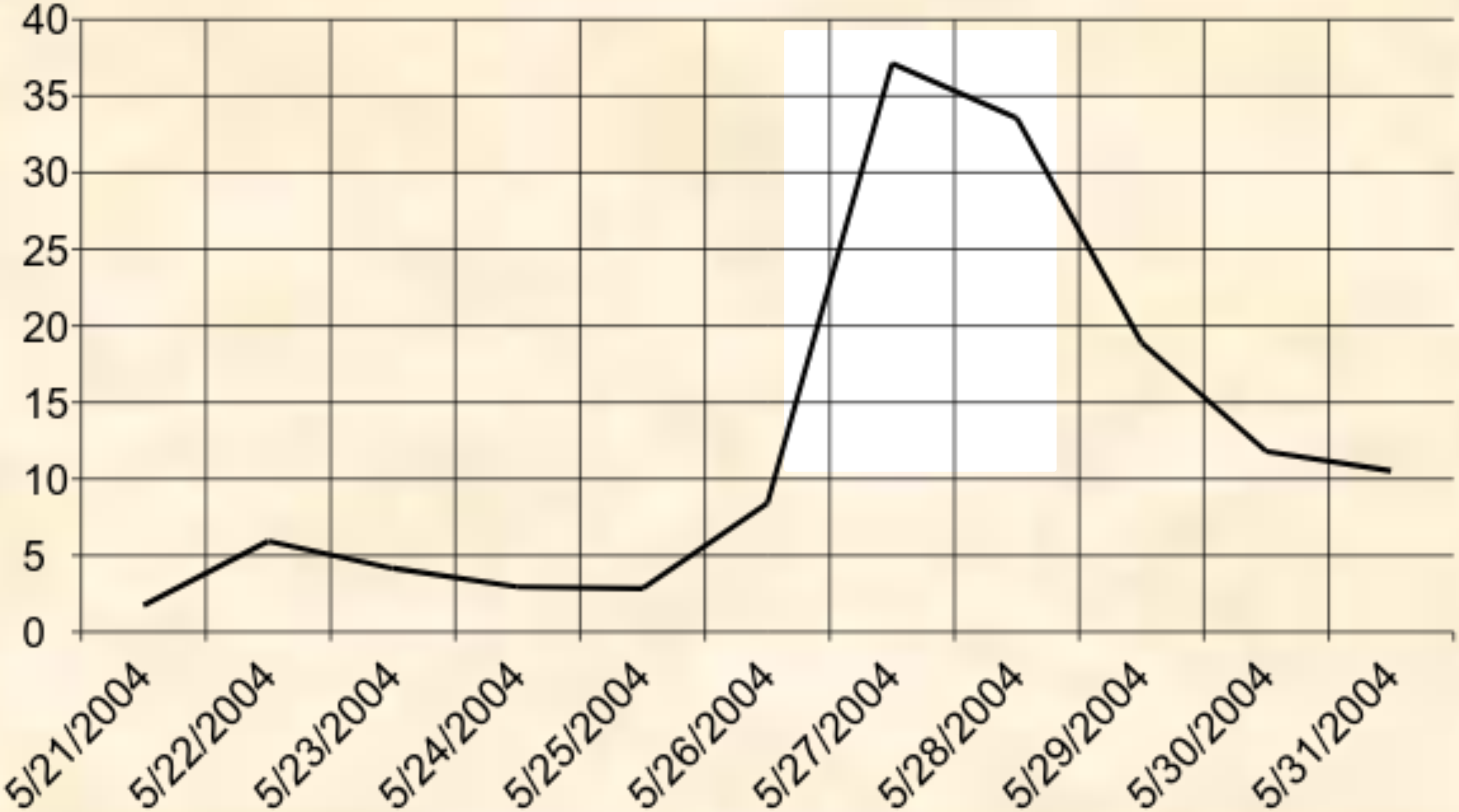
Magnitude, **Frequency**, Timing, Duration, Rate of change

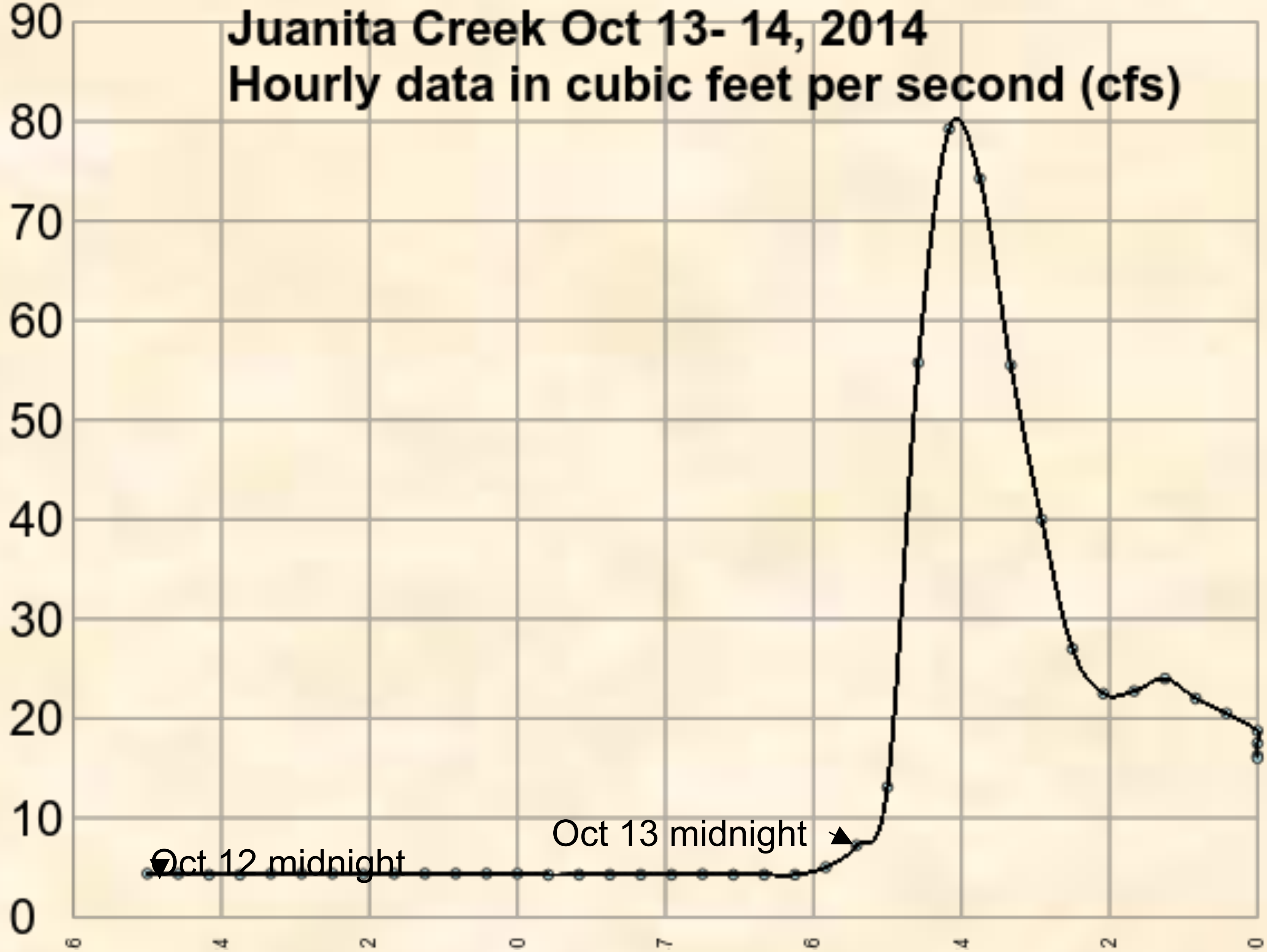
November flows – Juanita Creek



Magnitude, Frequency, Timing, Duration, Rate of change

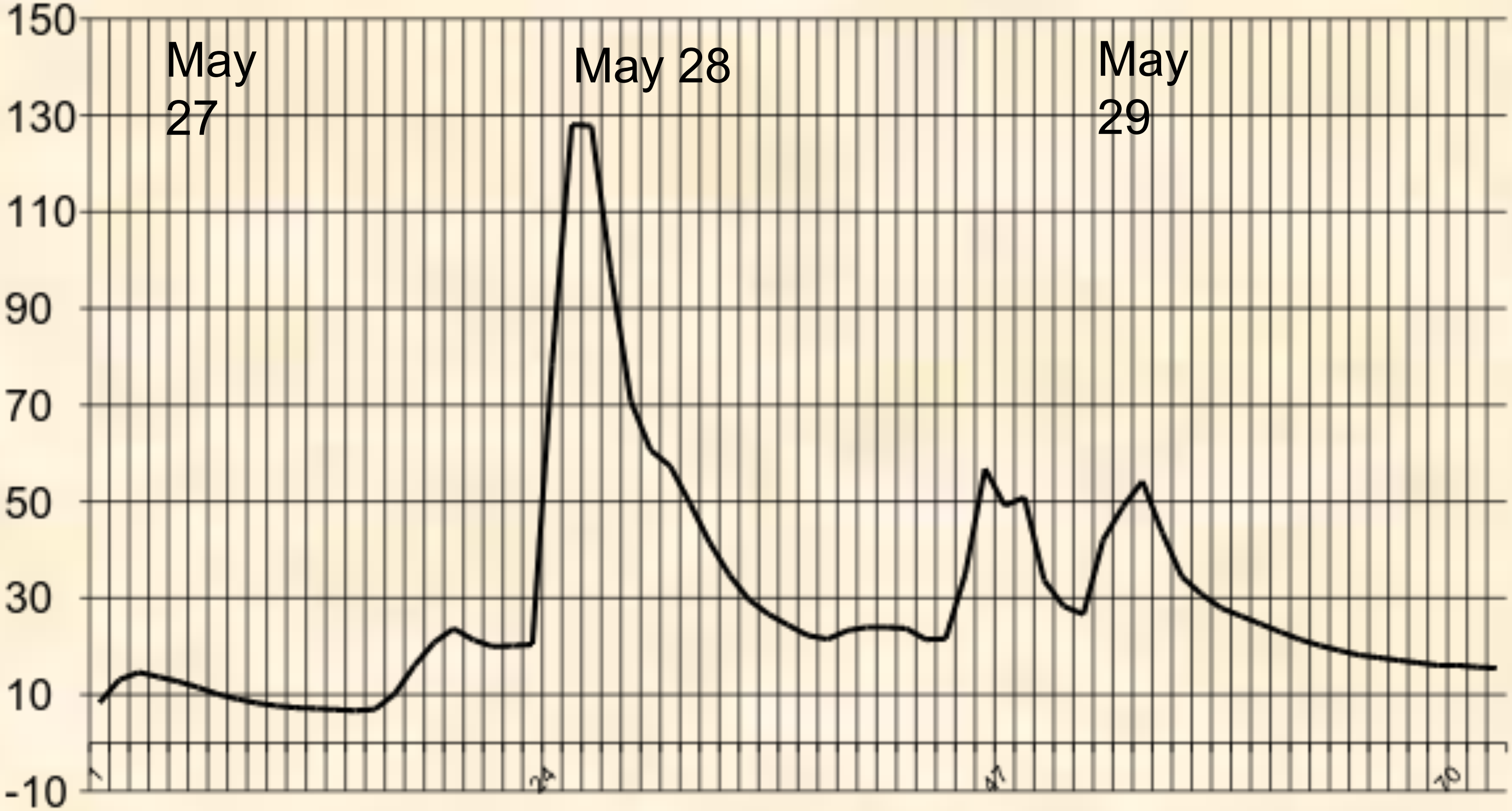
Mean Daily Flow
Juanita Creek (cfs)



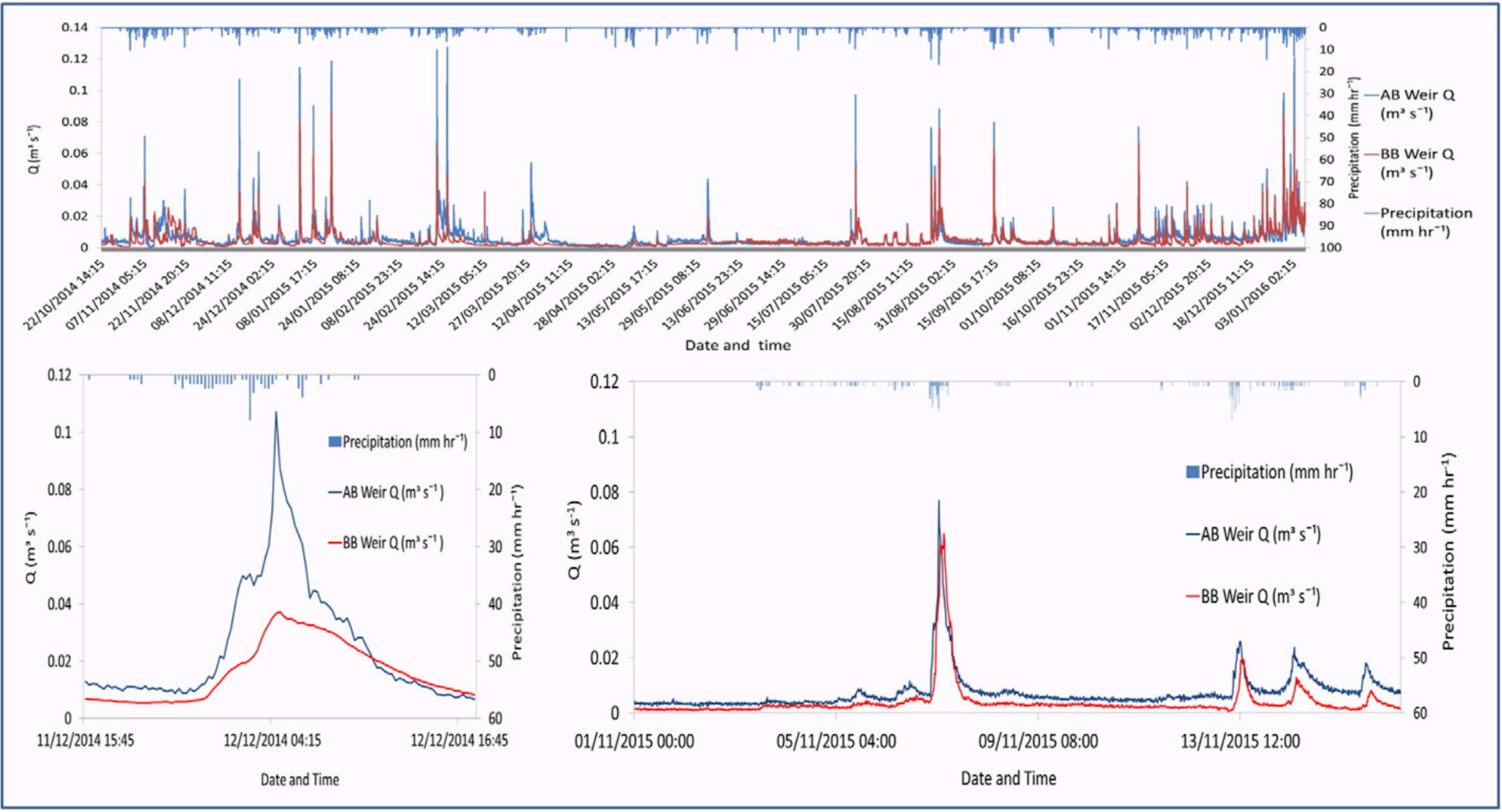


Magnitude, Frequency, Timing, Duration, Rate of change

15 minute flows
Juanita Creek May 27-29, 2004

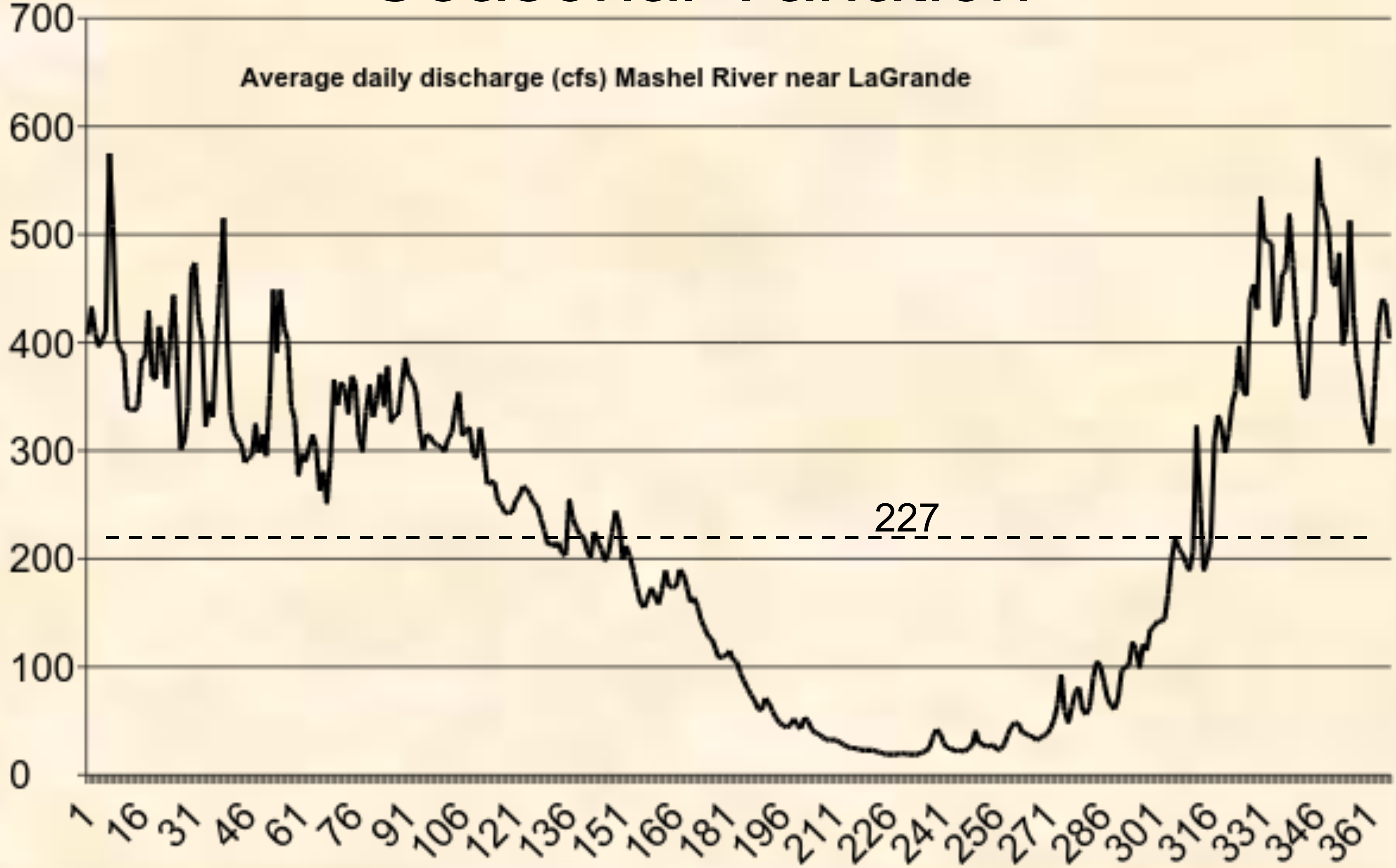


Magnitude, Frequency, Timing, Duration, Rate of change



Puttock et al. 2017

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

How do humans affect watersheds, the hydrologic cycle and stream ecology?

AKA management implications

Human caused disturbances

- ?

Human caused disturbances

- Agriculture
- Timber harvest
- Mining
- Urbanization
- Introduction of exotic species
- Harvesting of fish and wildlife
- Fire suppression
- Climate change

Land Use and Vegetation

Agriculture: forest removal and replacement with pasture or crops

andrebaertschi.photoshelter.com

www.ars.usda.gov/is/graphics/photos

dailyinfo.co.uk

Land Use and Vegetation

Forestry: tree removal and replacement over time

Land Use and Vegetation

Mining: extent of vegetation alteration depends on type of mining

Underground gold mine Wales
http://fiveprime.org/hivemind/Tags/adit,gold

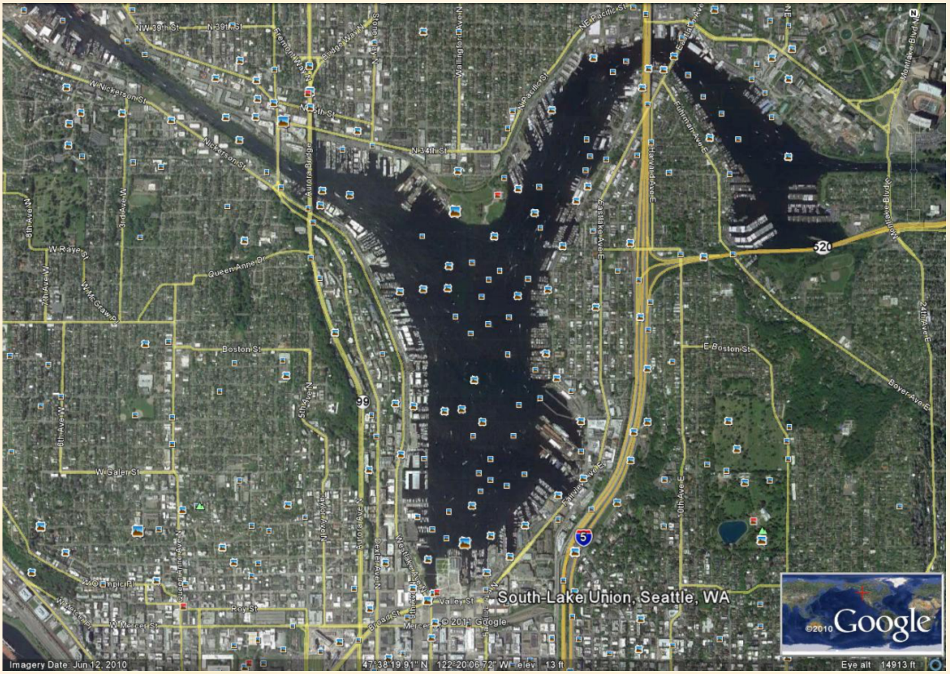
Acid mine drainage

http://water.epa.gov/polwaste/nps/images/acid_mine_drainage_2.jpg

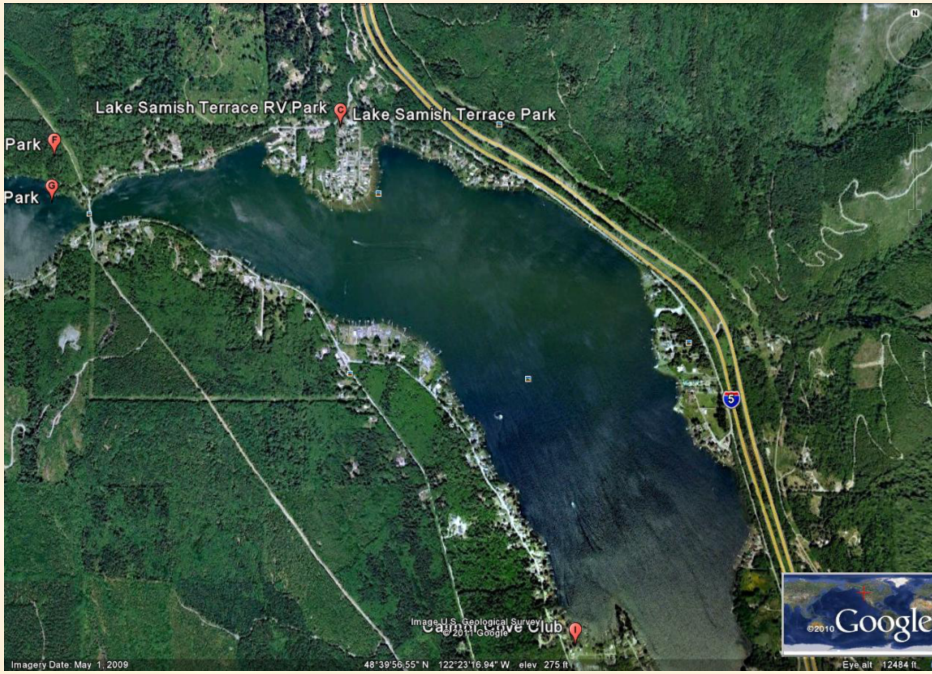
West Va Photo credit: Kent Kessinger

Land Use and Vegetation

Urbanization: tree removal and replacement with grass and impervious surfaces

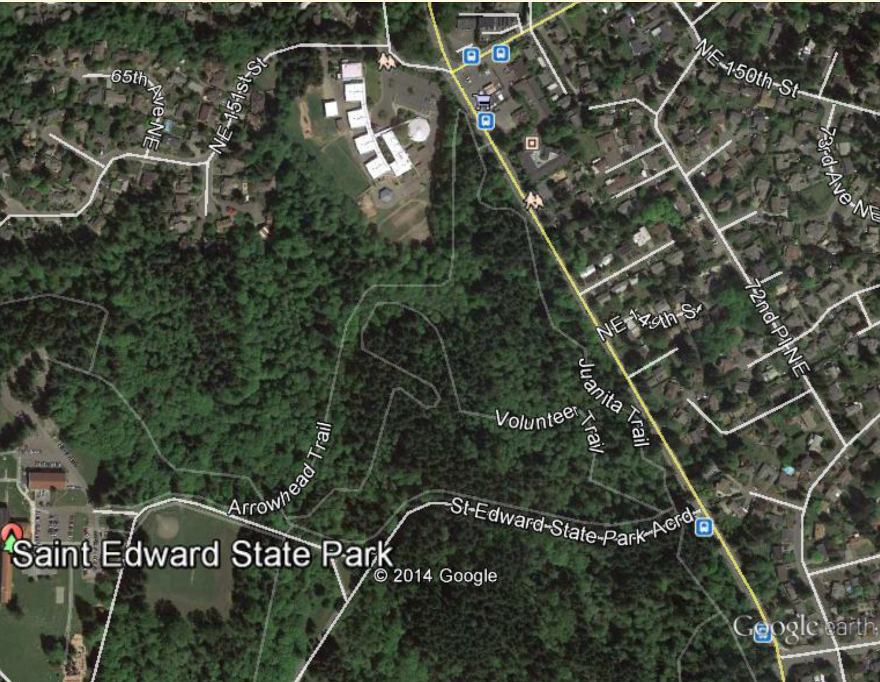


Lake Union

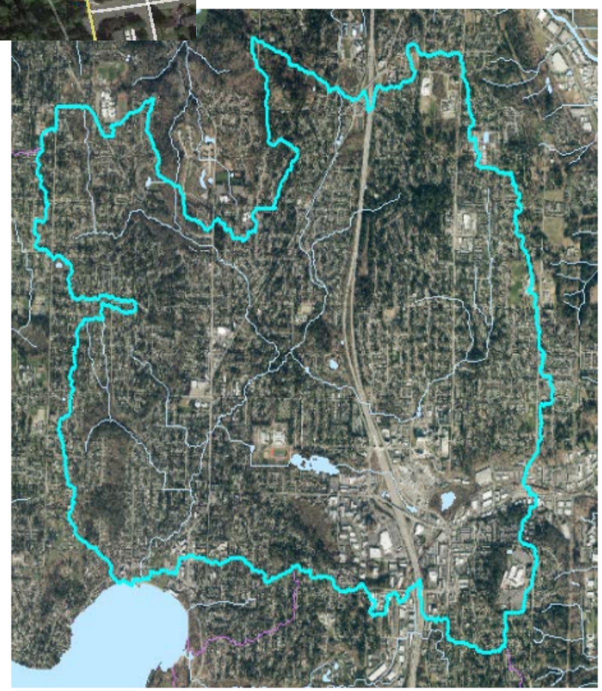


Samish Lake

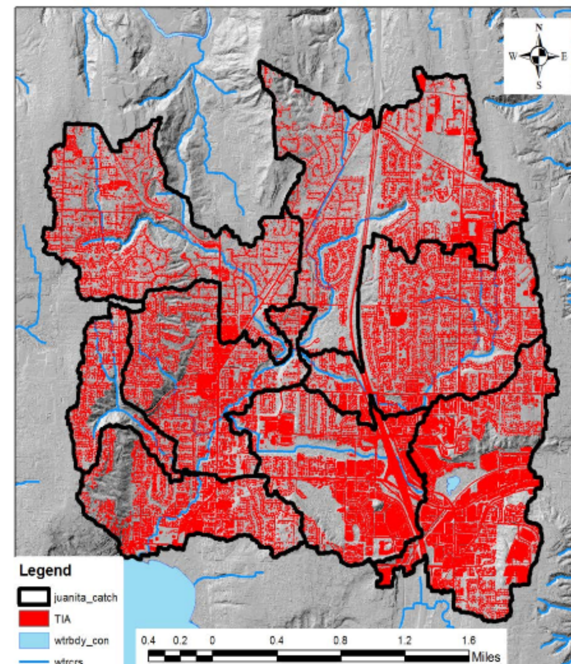
An Urban Comparison - Juanita Creek



Saint Edward State Park



Orthophoto



Impervious cover

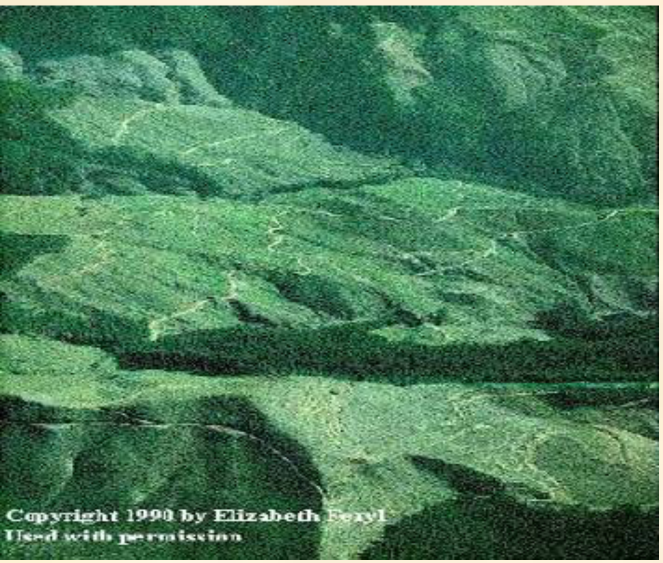
Lucchetti & Burkey 2014

Lake Union's watershed in Seattle, WA has become heavily urbanized and faces many management challenges related to the effects of urban impervious surfaces

Urbanization

What do all these human activities have in common?

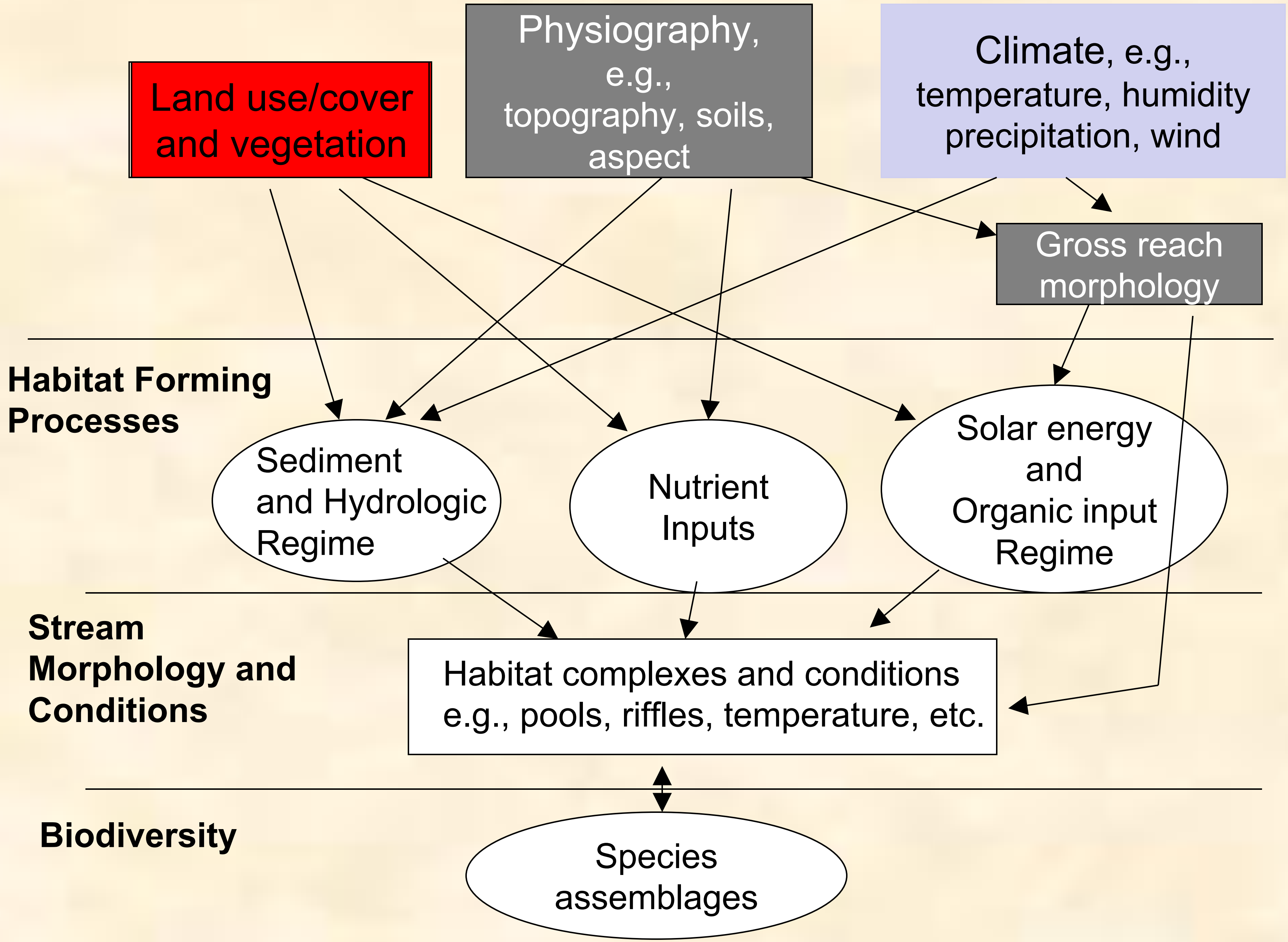
Agriculture



Forestry

Mining

Landscape controls



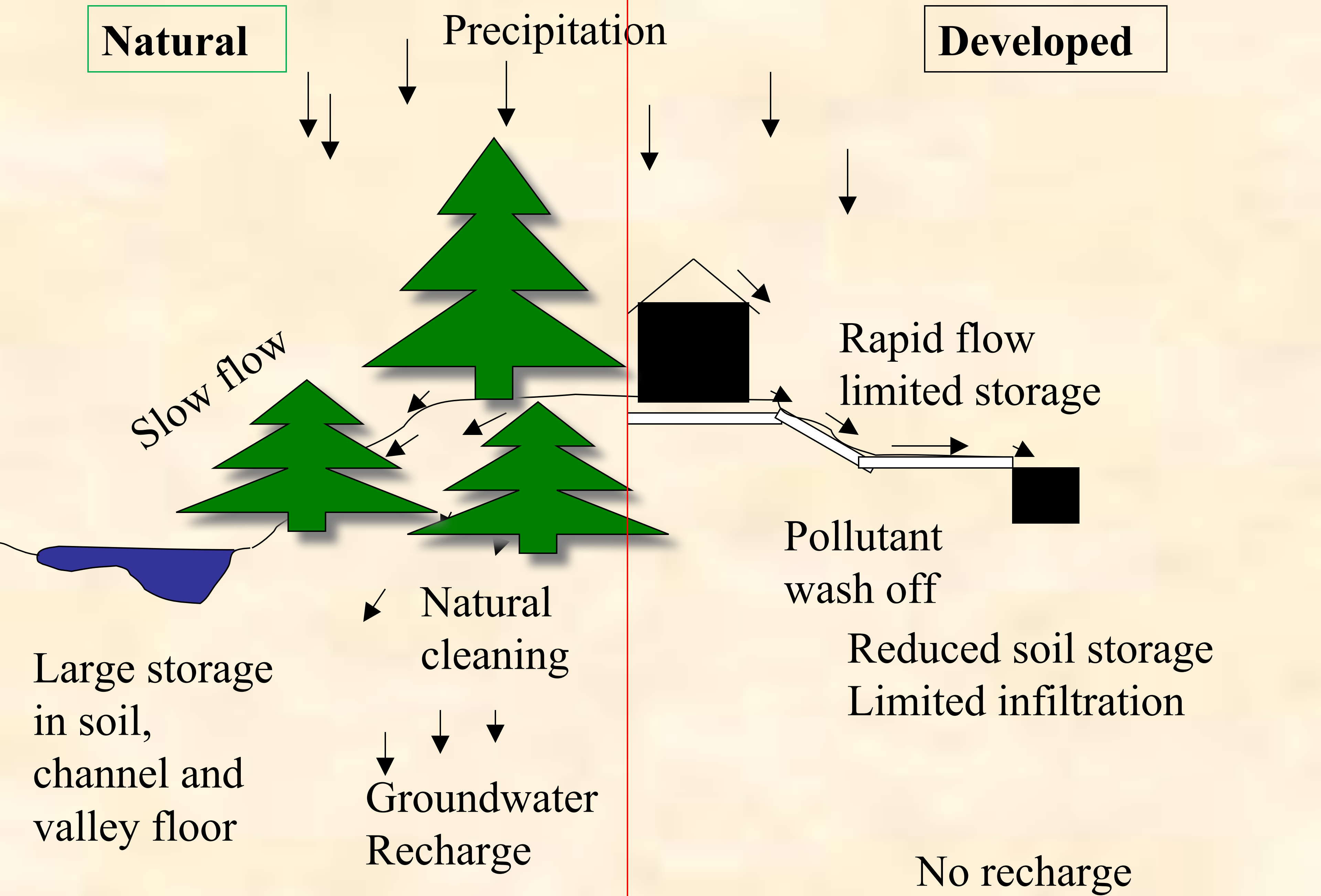
Modified from Roni et al. 2002

Forestry, agriculture and urbanization

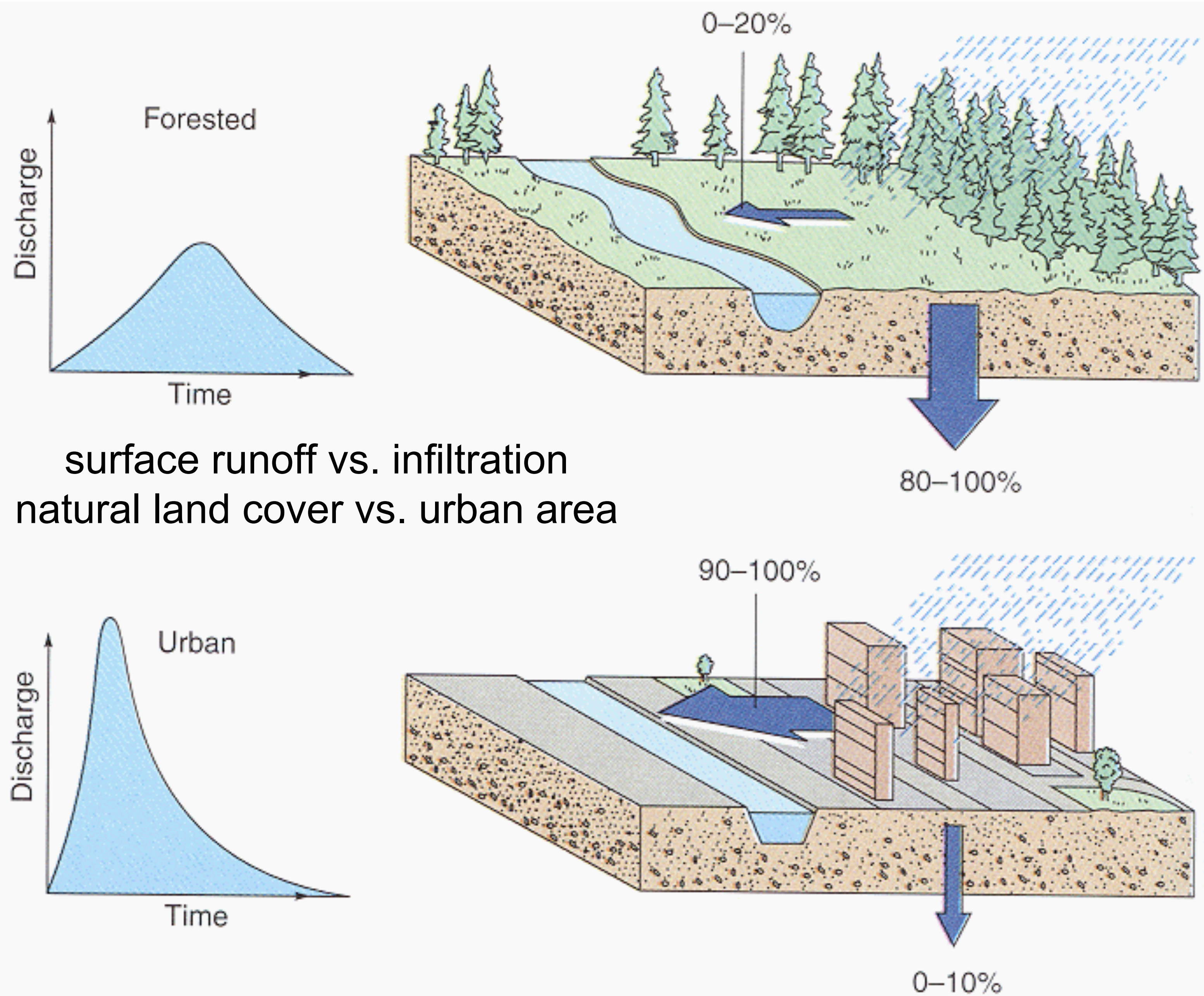
- Remove trees and other vegetation
- Alter natural organic matter, sediment, light and nutrient delivery
- Build roads, culverts, ditches (act as channels)

Effects of vegetation removal on hydrology and streams

- Precipitation ?
- Evapotranspiration ↓
- Infiltration ↓
- Surface runoff ↑ Subsurface runoff ↓
- Frequency and magnitude of peak flows ↑ ↑
- Materials transported to stream ↑


Natural
Precipitation
Developed
Slow flow
Rapid flow
limited storage
Pollutant
wash off
Natural
cleaning
Reduced soil storage
Limited infiltration
Large storage
in soil,
channel and
valley floor
Groundwater
Recharge
No recharge

Floods and Urbanization



surface runoff vs. infiltration
natural land cover vs. urban area

Not the case for all forest types-

Many tropical forests have runoff that looks like urban runoff

How do we manage watersheds?

- Dept of Natural Resources Regulations
- U.S. Forest Service Regulations

- Clean Water Act (EPA & ACoE) (1972):
  - “The objective of this Act is to restore and maintain the chemical, physical, and biological integrity of the nation's waters"
- Endangered Species Act (US FWS)
- Total Maximum Daily Loads – TMDLs (WA DOE, US EPA)

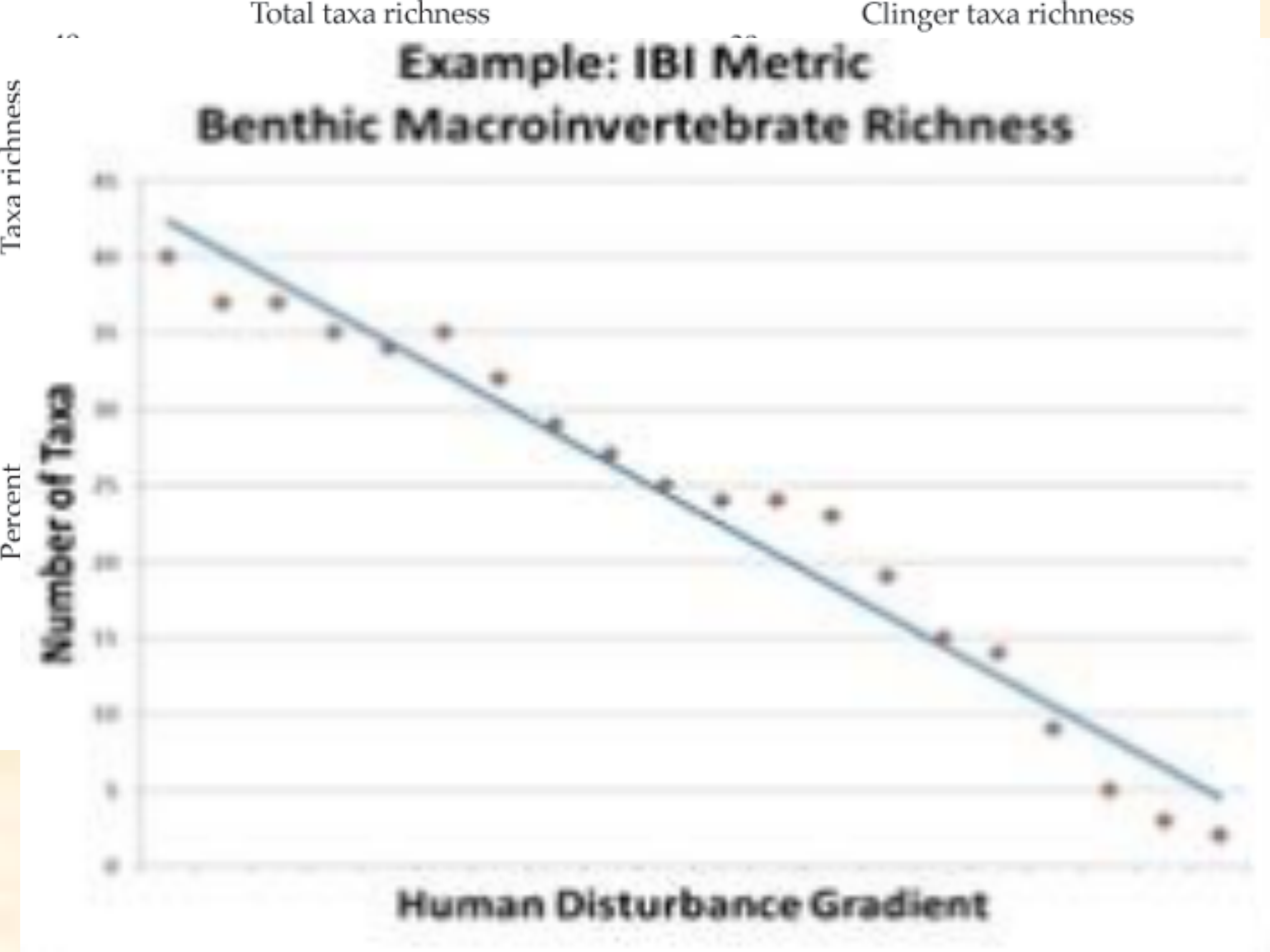
Biological Indicators - Invertebrates

- **Nutrient Cycle.** Invertebrates play a crucial role in the stream nutrient cycle.
- **Pollution Tolerance.** Some insects are tolerant of pollution, whereas others are not. For example, the order Plecoptera (Stoneflies) are very sensitive to pollution
- **Population Fluctuations.** Because many insect life cycles are short (sometimes one season in length), we can detect population fluctuations in a short period of time
- **ID sites**
  - http://www.nwnature.net/macros/index.html
  - http://www.seanet.com/~leska/Online/Guide.html
  - http://www.nwnature.net/macros/resources.html

Benthic Index of Biological Integrity, or B-IBI

- Composed of 10 metrics
  - Total richness (# of different species)
  - EPT richness (mayfly, stonefly, caddis fly)
    - Ephemeroptera, Plecoptera, Trichoptera
  - Intolerant richness
  - Clinger richness
  - Long-lived richness
  - % tolerant
  - % predator
  - % dominant

www.kingcounty.gov/environment/data-and-trends/monitoring-data/stream-bugs/quality-indicators.aspx


Total taxa richness
Clinger taxa richness
Taxa richness
Percent
Example: IBI Metric
Benthic Macroinvertebrate Richness
Number of Taxa
Human Disturbance Gradient

RIPARIAN MANAGEMENT ZONES
A Graphic Representation

Washington Water Types

- Type S
  - Shorelines and large rivers
- Type F
  - Rivers and associated wetlands, lakes, ponds, etc. that are > 0.5 acres at seasonal low level and have FISH
- Type Np
  - Perennial (water year-round) streams without fish
- Type Ns
  - All other streams not included above- seasonally dry streams without fish

Regulations a function of water type and forest site class

Washington Buffer Widths

Water Type	Site Class	Total RMZ	Core Zone	Inner Zone	Outer Zone
S or F	I (137+)	200 Feet	50 feet	83 / 100	67 / 50
	II (119-136)	170	50	63 / 78	57 / 42
	III (97-118)	140	50	43 / 55	47 /35
	IV (76-96)	110	50	23 / 33	37 / 27
	V (<75)	90	50	10 /18	30 / 22

Np	50 feet with a 30-foot equipment limitation zone
Ns	0 feet with a 30 foot equipment limitation zone

Note: Wider inner zone buffers are required on streams that are 10 feet wide or wider.

Core: No harvest or construction except for permitted road activities
Inner Zone: Harvest allowed but must meet future desired conditions standards (140 yrs); Width depends on stream size and site class
Outer Zone: Must leave 20 conifer trees per acre > 12 inched dbh

Washington Riparian Harvest Activities

Type F or S streams

Core Zone: No timber harvest or construction is allowed in the core zone except operations related to forest roads as detailed in subsection (1) of this section. Any trees damaged by yarding corridors in the core zone must be left on site. Any trees cut as a result of roads construction to cross a stream may be removed from the site…

Inner Zone: Forest practices in the inner zone must be conducted in such a way as to meet or exceed stand requirements to achieve the goal in WAC 222-30-010(2)… Timber harvest in this zone must be consistent with the stand requirements in order to reach the desired future condition targets.

Note: Desired Future Conditions are a natural unmanaged 140-year-old riparian stand. Only basal area in excess of DFC targets in the core and inner zone can be harvested from the inner zone.

Note: There are two harvest options in the inner zone. Thinning from below where the largest trees are left uniformly spaced throughout the inner zone. Leave trees closest to water where all of the leave trees are clumped in a band next to the core zone. This is often referred to as "pack and whack" which is a good description of the design.

Outer Zone: Timber harvest in the outer zone must leave 20 conifer riparian leave trees per acre after harvest 12 inches DBH or larger. In sensitive areas conifer or hardwood trees 8 inches or larger in diameter can be left as riparian leave trees. Up to 10 trees per acre can be traded for:

a. landowner participates in a large woody debris placement strategy
b. trees left in associated channel migration zones (CMZ) on a one to one basal area exchange for conifers 6 inches DBH or greater, hardwoods 10 inches DBH or larger, or on a three to one basis hardwoods greater than 10 inches can be traded for conifer basal area.

Type Np streams have a 50 foot no harvest buffer on each side of the stream.

Type Ns streams have a 30 foot equipment limitation zone and trees are to be felled away from stream.

Critical Areas Regulations
All WA Counties

Table 2a - Stream, Lake and Marine Buffer Width Standards (Feet)		
Streams and Lakes		
Type S		150
Type F with anadromous or resident salmonids		150
Type F without anadromous or resident salmonids		100
Type Np		50
Type Ns		50
Marine Waters		
Type 1	All marine waters	150

http://www.codepublishing.com/WA/SnohomishCounty/html/SnohomishCounty30/SnohomishCounty3062A.html#30.62A

Take Home Messages

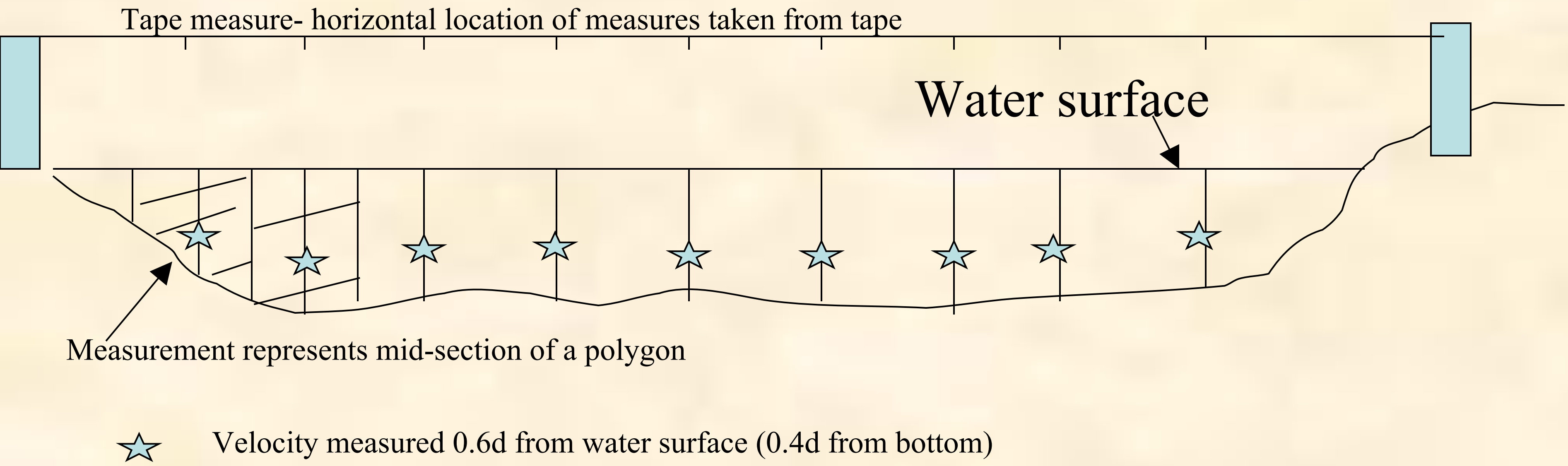
- Understand interactions between land use/land cover and hydrologic cycle processes
- Be able to describe what is typically measured in watersheds and why
- Be aware of Washington stream types and how they are used in management
- Know 2 methods for computing stream discharge

Homework hints & reminders

- Q4: Cross sectional area is used for both
  - Area-velocity method discharge
  - Float method discharge
- Q5: Must show work by including electronic version of spreadsheet
  - (google sheets or excel table)
- Q7: Don’t forget about the conversion factor to change surface V → subsurface
  - Q = A * Vsurf * 0.8

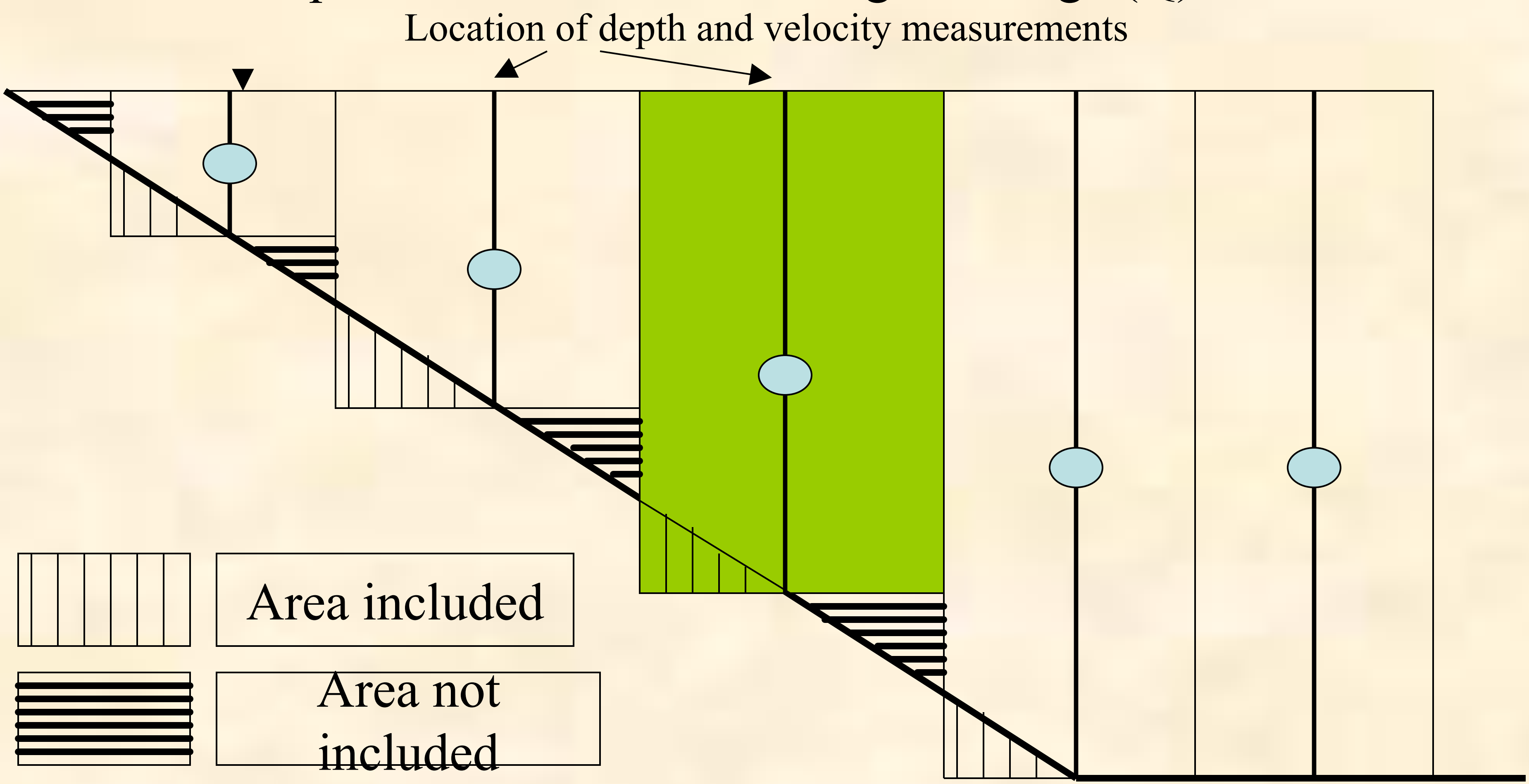
The Velocity-Area method calculates discharge within small cells

Step one is finding cross sectional area of each cell



Record x value (tape distance), y value (total depth at measurement site, and velocity at 0.6d

Mid-point method of calculating discharge (Q)



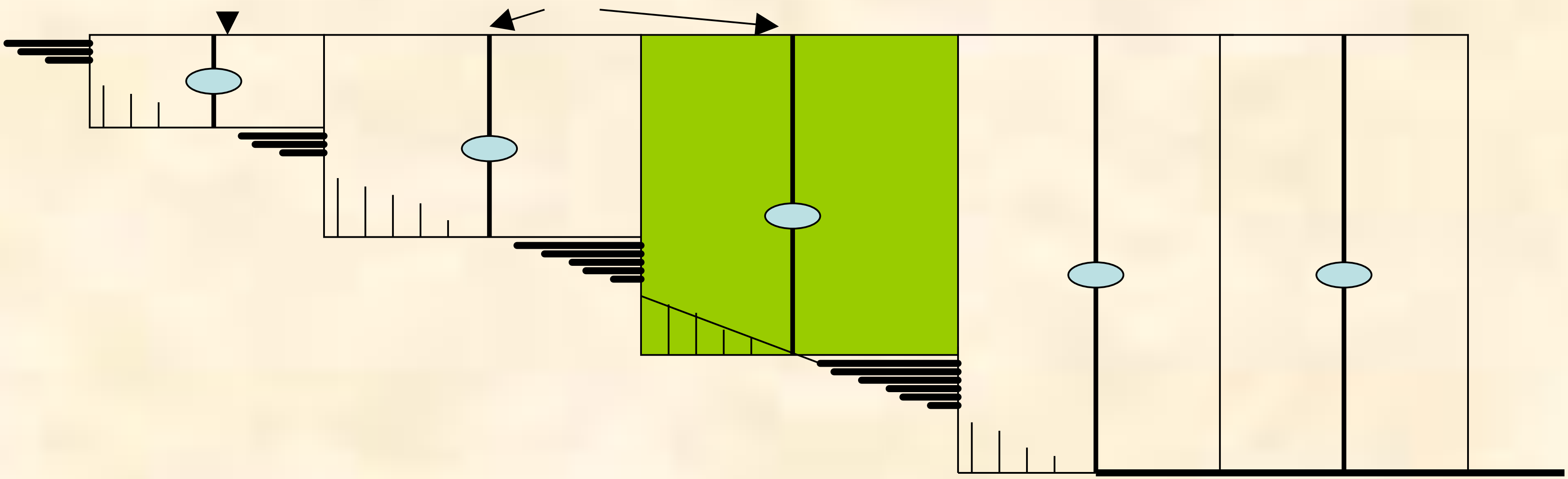
Key Assumption: Over estimation (area included) = Under estimation (area not included), therefore cross-section area is simply the sum of all the sections (rectangles), which is much easier than taking the integral!

Cross Sectional Area

Table for velocity meter

Assess your site and decide where to take your 6 in-stream measurements. Don't' forget to indicate the location of the edge of water on both sides of the stream as 2 of your 8 measurements

	X - Location (number on tape measure) units:	Y - Depth of water (from rod) units:	V - Velocity (from velocity meter) units:
edge of water		0	0
edge of water		0	0



	Site:	Goblin Creek		Gage Height/Time		11/26/00 13:00	
	Date:	11/26/00		Stage:	0.243 feet or (74 mm)		
	Method:	Six-tenths					
	X		y		V	Q	
	Tape reading	Width of Interval	Depth	Area	Velocity @ 0.6D	V*A = Q Q interval	% total flow
Left Edge of Water	9.000	1.500	0.000	0.000	0.000	0.000	0%
	12.000	2.000	0.900	1.800	0.200	0.360	2%
	13.000	1.000	1.200	1.200	0.410	0.492	3%
	14.000	1.000	1.400	1.400	0.760	1.064	7%
	15.000	1.000	1.400	1.400	0.810	1.134	7%
	16.000	1.000	0.500	0.500	0.810	0.405	3%
	17.000	1.000	0.600	0.600	0.770	0.462	3%
	18.000	1.000	1.600	1.600	0.810	1.296	8%
	19.000	1.000	1.700	1.700	0.620	1.054	7%
	20.000	1.000	1.450	1.450	1.120	1.624	10%
	21.000	1.000	1.500	1.500	1.350	2.025	13%
	22.000	1.000	1.200	1.200	1.470	1.764	11%
	23.000	1.000	0.700	0.700	1.290	0.903	6%
	24.000	1.000	0.600	0.600	1.350	0.810	5%
	25.000	0.750	1.000	0.750	0.880	0.660	4%
	25.500	0.750	1.100	0.825	1.270	1.048	7%
	26.500	1.000	0.000	0.000	0.000	0.000	0%
	27.500	1.250	0.700	0.875	0.820	0.718	5%
Right Edge of Water	29.000	0.750	0.000	0.000	0.000	0.000	0%
		excel		excel	Q total =	15.818	excel

W=(12-9)/2

W=(20-18)/2

W=(29-27.5)/2

Sum

excel

You enter x, y and v

Set your excel table up like this

- Calculate Area, then discharge for each cell
- Then, sum discharge from each cell for total Q

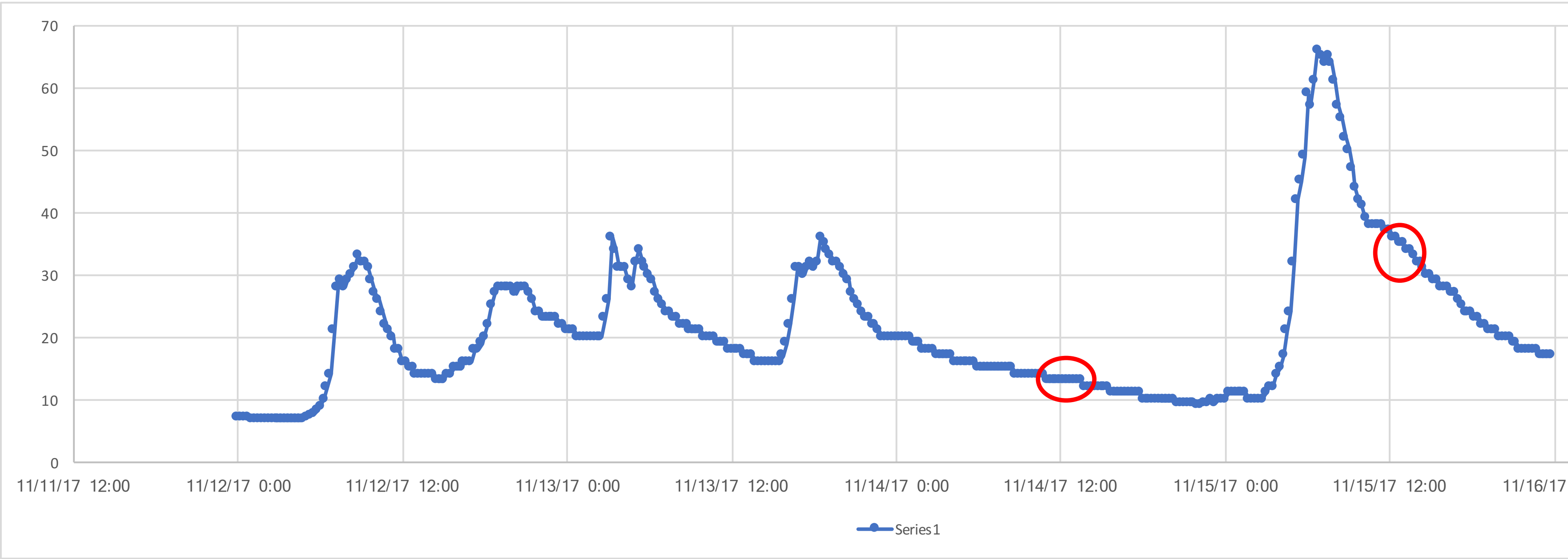
X - Location (number on tape measure) units:	Y - Depth of water (from rod) units:	V - Velocity (from velocity meter) units:
	0	0
	0	0

cell	X -Collection Point (ft)	Y - depth (tenths ft)	Area	V –velocity Ft/s (.6 or .2&.8)	Q Discharge (A*V)	notes
1	X_1	Y_1	$(X_2-X_1)/2 \cdot Y_1$	V_1	$A_1 \cdot V_1$	
2	X_2	Y_2	$(X_3-X_1)/2 \cdot Y_2$	V_2	$A_2 \cdot V_2$	
3	X_3	Y_3	$(X_4-X_2)/2 \cdot Y_3$	V_3	$A_3 \cdot V_3$	
4	X_4	Y_4	$(X_5-X_3)/2 \cdot Y_4$	V_4	$A_4 \cdot V_4$	
5	X_5	Y_5	$(X_6-X_4)/2 \cdot Y_5$	V_5	$A_5 \cdot V_5$	
6	X_6	Y_6	$(X_7-X_5)/2 \cdot Y_6$	V_6	$A_6 \cdot V_6$	
7	X_7	Y_7	$(X_8-X_6)/2 \cdot Y_7$	V_7	$A_7 \cdot V_7$	
8	X_8	Y_8	$(X_8-X_7)/2 \cdot Y_8$	V_8	$A_8 \cdot V_8$	
9						
10						
11						
12						
Total Discharge (cfs) (sum all Q cells)					ΣQ_{1-8}	
Enter discharge calculated from float method						

General Notes: Float discharge = $(\Sigma \text{Area}) \cdot (V_{surface} \cdot \text{Correction factor})$

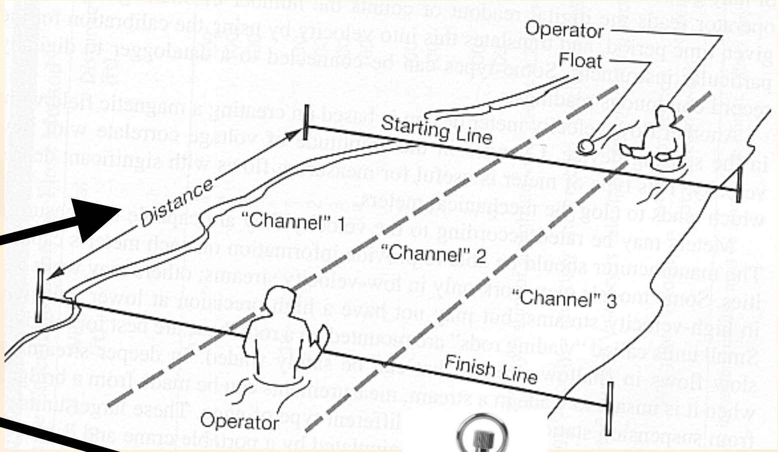
Juanita Creek

Gage = 27a

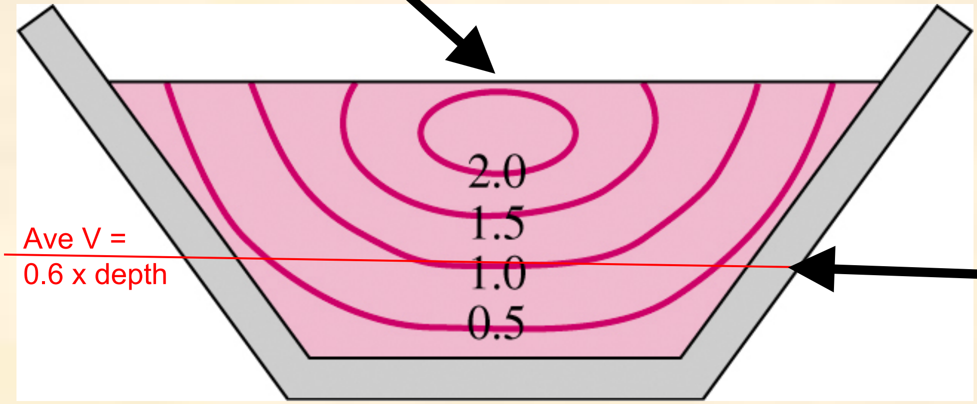


Review

Float Method



surface velocity = distance / time



average subsurface velocity = conversion factor (~ 0.8) x surface velocity

- Discharge, Q is calculated using subsurface velocity
- Float discharge equation: Q = A x V x (conversion factor)
- Conversion factor dependent upon bank and bed roughness
- Generally ~0.8 (80% as fast as surface), but highly variable

Float Method Calcs

cell	X - Collection Point (ft)	Y - depth (tenths ft)	Area	V – velocity Ft/s	Q Discharge
1	x_1	Y_1	$(X_2-X_1)/2 \cdot Y_1$		
2	x_2	Y_2	$(X_3-X_1)/2 \cdot Y_2$		
3	X_3	Y_3	$(X_4-X_2)/2 \cdot Y_3$		
4	X_4	Y_4	$(X_5-X_3)/2 \cdot Y_4$		
5	X_5	Y_5	$(X_6-X_4)/2 \cdot Y_5$		
6	x_6	Y_6	$(X_7-X_5)/2 \cdot Y_6$		
7	X_7	Y_7	$(X_8-X_6)/2 \cdot Y_7$		
8	X_8	Y_8	$(X_8-X_7)/2 \cdot Y_8$	V 8	$A_8 \cdot V_8$
9					
10					
11					
12					
				Total Discharge (cfs) (sum all Q cells)	ΣQ_{1-8}
				Enter discharge calculated from float method	

General Notes: Float discharge = $(\Sigma \text{Area}) \cdot (V_{\text{surface}} \cdot \text{Correction factor})$

For float method do at least 3 tosses	Distance float travels (units)	Travel time (seconds)

Homework reminders

- Velocity meter method:
  - Do NOT take the average velocity of your flow meter measurements and multiply by cross-sectional area to get discharge Q. The velocity meter method involves summing the delta Qi to get the total Q.
  - That is, as your diagrams indicate, each place you took a velocity measurement is the center of a small area of the stream cross-section. As the spreadsheet indicates, compute Q for each small area and then sum all the Qs to get the total Discharge for the stream.

Homework reminders

- Float method:
  - Sum the delta areas from your velocity meter method to get the cross-sectional area of flow
- Remember Q (discharge) = cross-sectional area X average stream velocity
- Q = AV
  - Q units are volume/time (cubic feet per second)
  - Area units are feet squared
  - Velocity units are ft per second
  - Float method needs a correction factor to account for the fact that surface velocity is not equal to average subsurface velocity