Week 3: Rivers as Conveyors
(Fluxes of water, sediment, and elements)

The Water:
Measuring and Monitoring Discharge (Q):

- Besides apples, how do we accurately measure Q?
- Long-term monitoring of Q.
- Channel Roughness and *Manning's* Equation.
- Bankfull discharge - identification and prediction.

The Stuff in the Water:
Sediment and element loading:

- It goes where the water goes.
- How do we measure how much is in the water?
- Sediment Loads and erosion.
- Do sediment loads today tell us about landscape erosion?

Water and Sediment

River channels develope over time in order to efficiently move water off the landscape.

They also are continually responding to the load Of sediment delivered to them from hillslopes and banks.

By slowly transporting it all away from where it came from, Rivers aid in landscapes erosion and evolution over time.

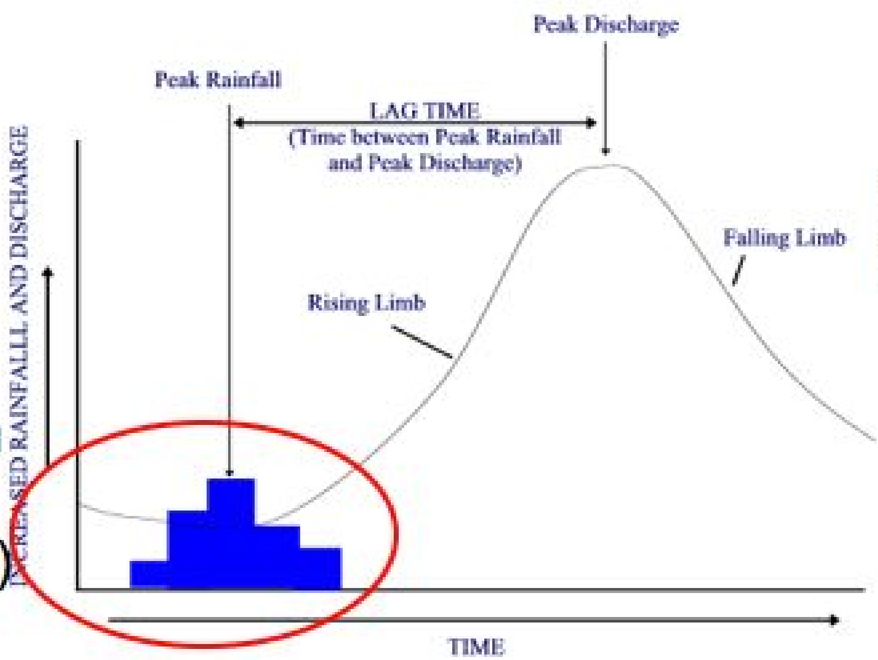
Start with the water:

Discharge (Q) m^3/sec

Stream Gauging:

Discharge has been recorded since the Egyptians:
(flooding along the Nile)

How are precipitation and river level related?



Precipitation Event (hyetograph)

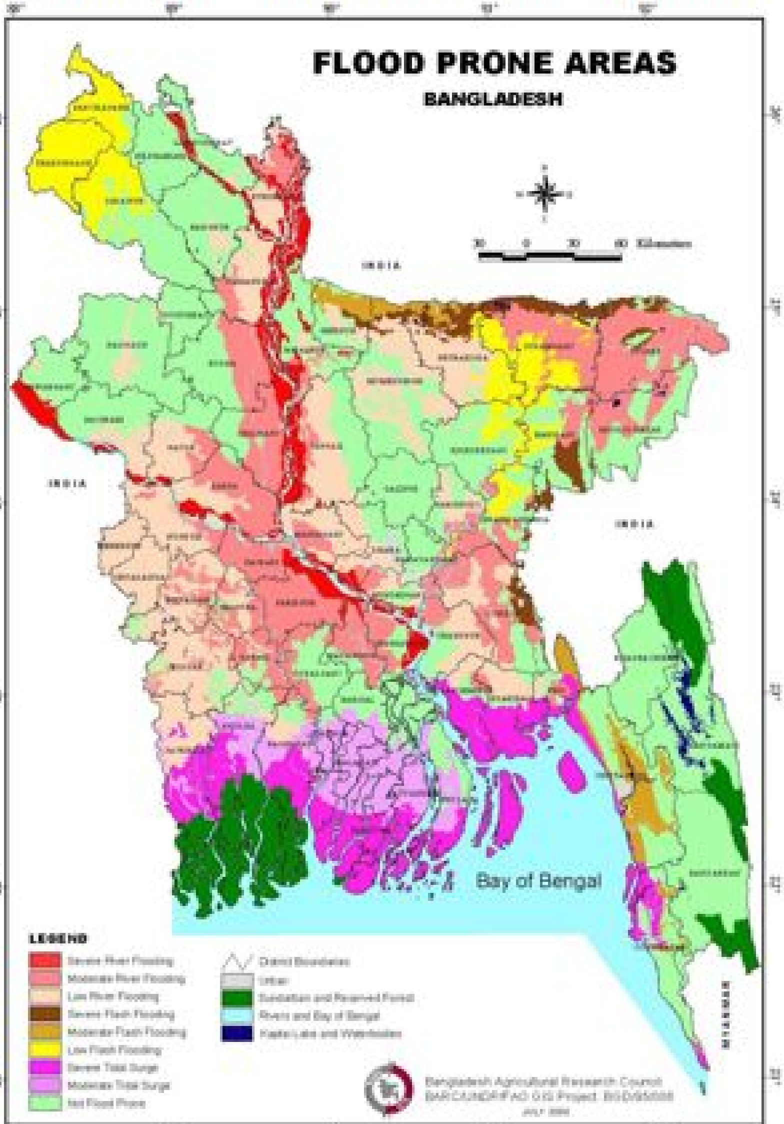
River Discharge Response

These relationships are specific to each individual channel

How much water is too much: FLOODING

How much water is too much: FLOODING

Studies around the world



Thousands of stream
Gauging stations
Around the US.

Flow Gauging:

Things we want to figure out:

1. *How much water is flowing through a river cross-section At a particular instant in time?*

2. *At a certain discharge, how deep will the water be?*

Q = A x V

What we need to answer these:

1. *Detailed cross-section of channel Geometry*
   (this gives us **Area**)

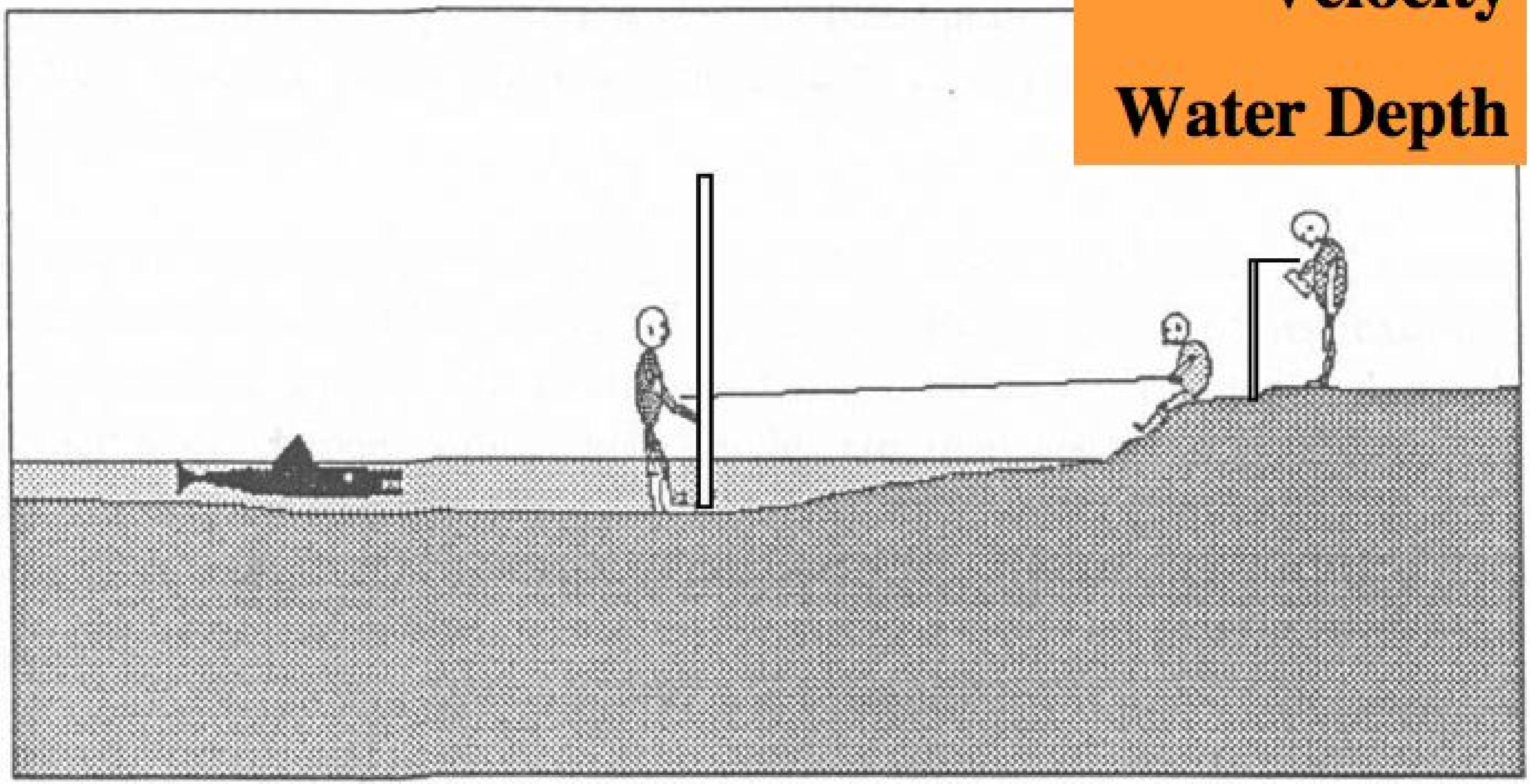
2. **Velocity** at different points across that cross-section

Surveying River Cross-Sections:

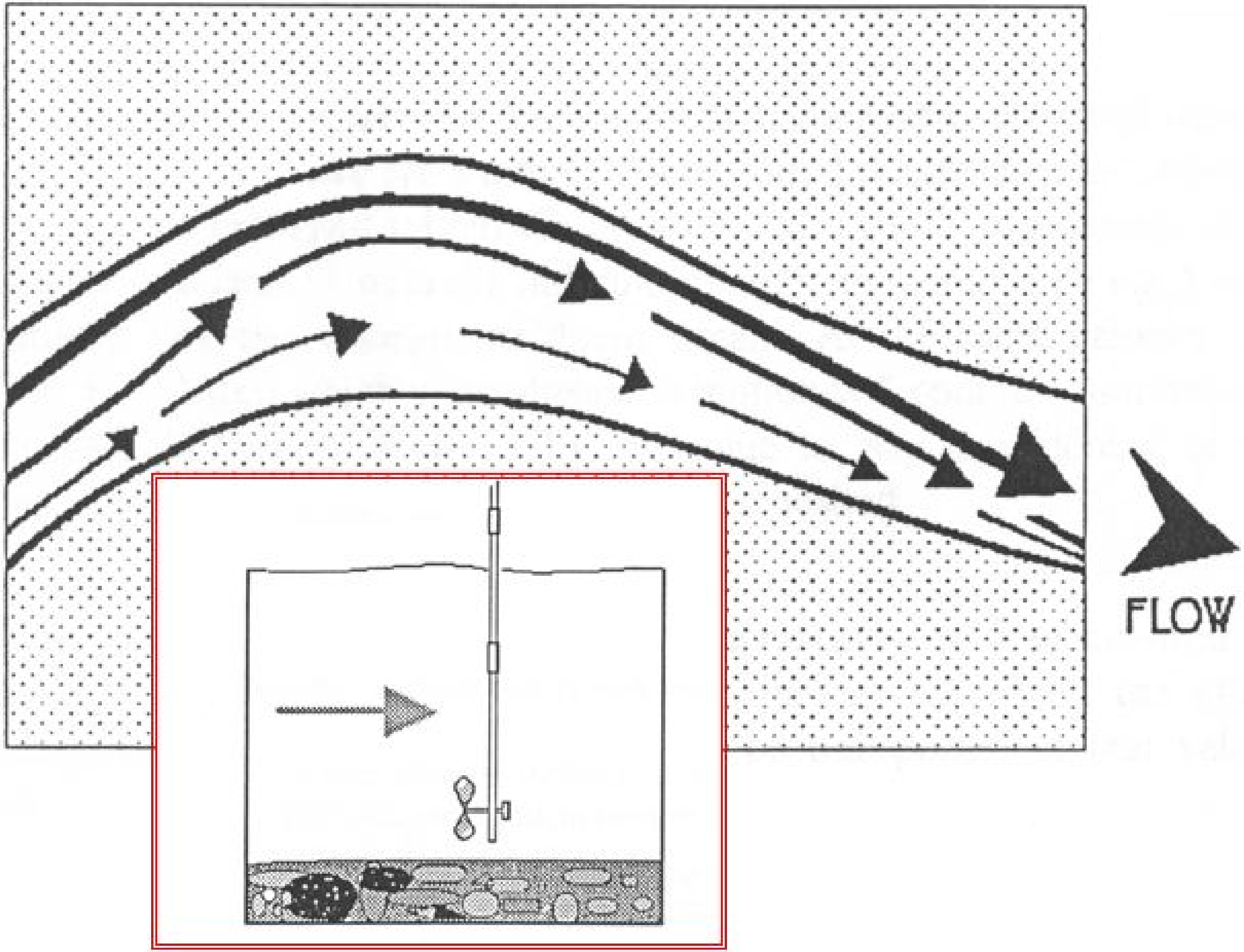
Width

Velocity

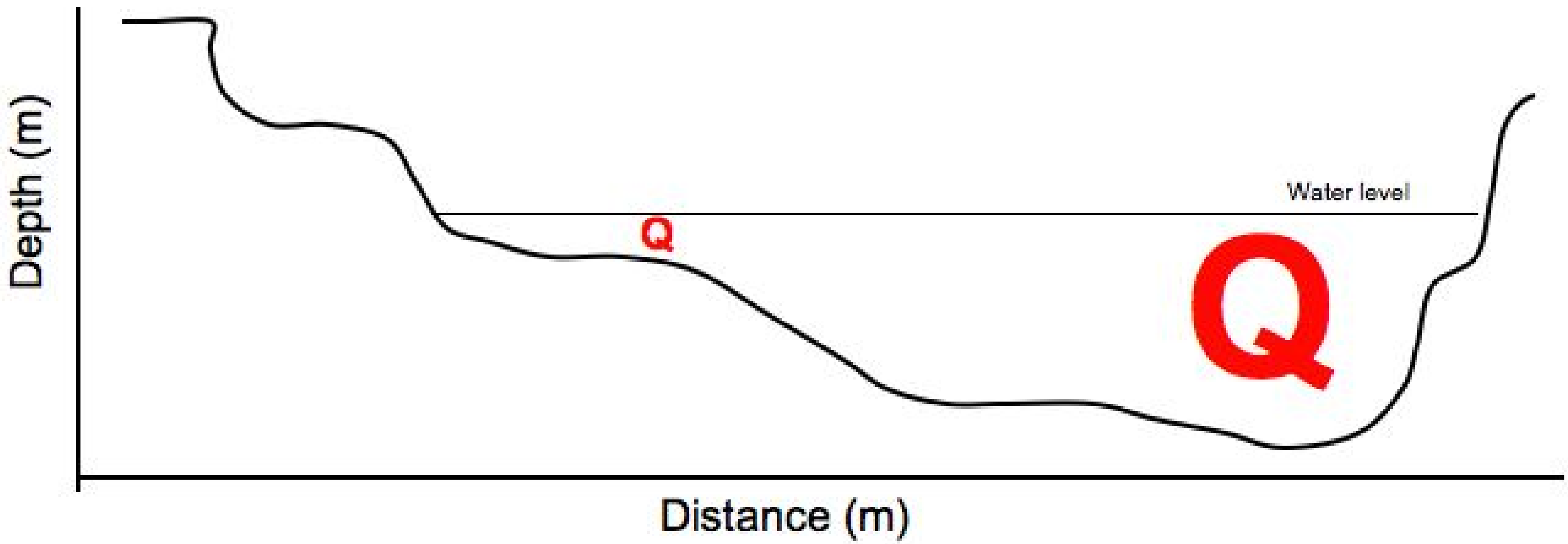
Water Depth



Flow meter for measuring water speed

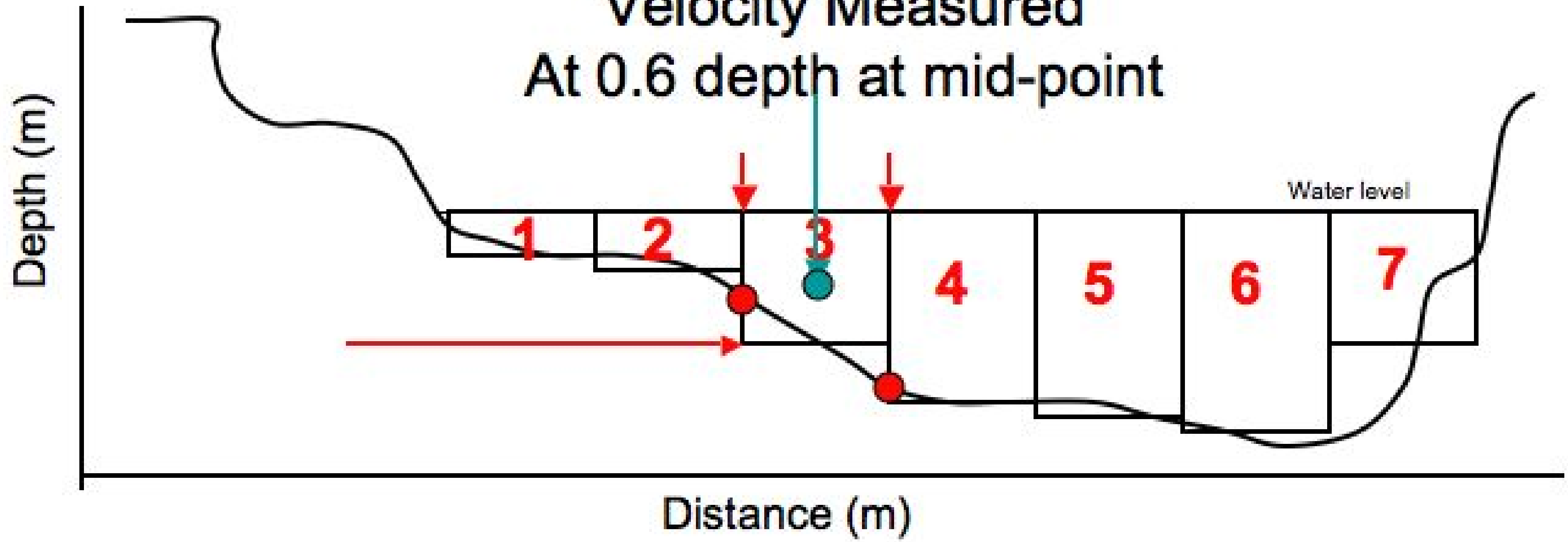


Surveying River Cross-Sections:



Width x Ave Depth x Velocity = Cruddy Q

Need Much More Detail: Divide into Sections



When you are done, you add up all the sections to get the

Total Discharge for the entire channel

Data Collection Sheet for Channel Surveying and velocity Measurements:

Channel Sub-section	Start point (m)	End Point (m)	Width (m)		Start Depth (m)	End Depth (m)	Ave Depth (m)		Velocity (m/sec)		Section Q (m3/sec)
3	12.3	13.4	1.1	x	1.5	2.3	1.9	x	1.6	=	3.3

Width

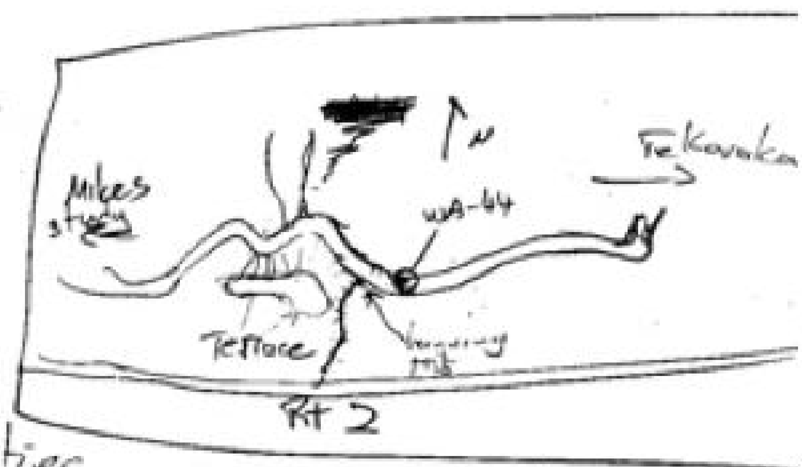
Average Depth

Critical to make a sketch of your cross-Section as you go.

This is where you catch all your mistakes

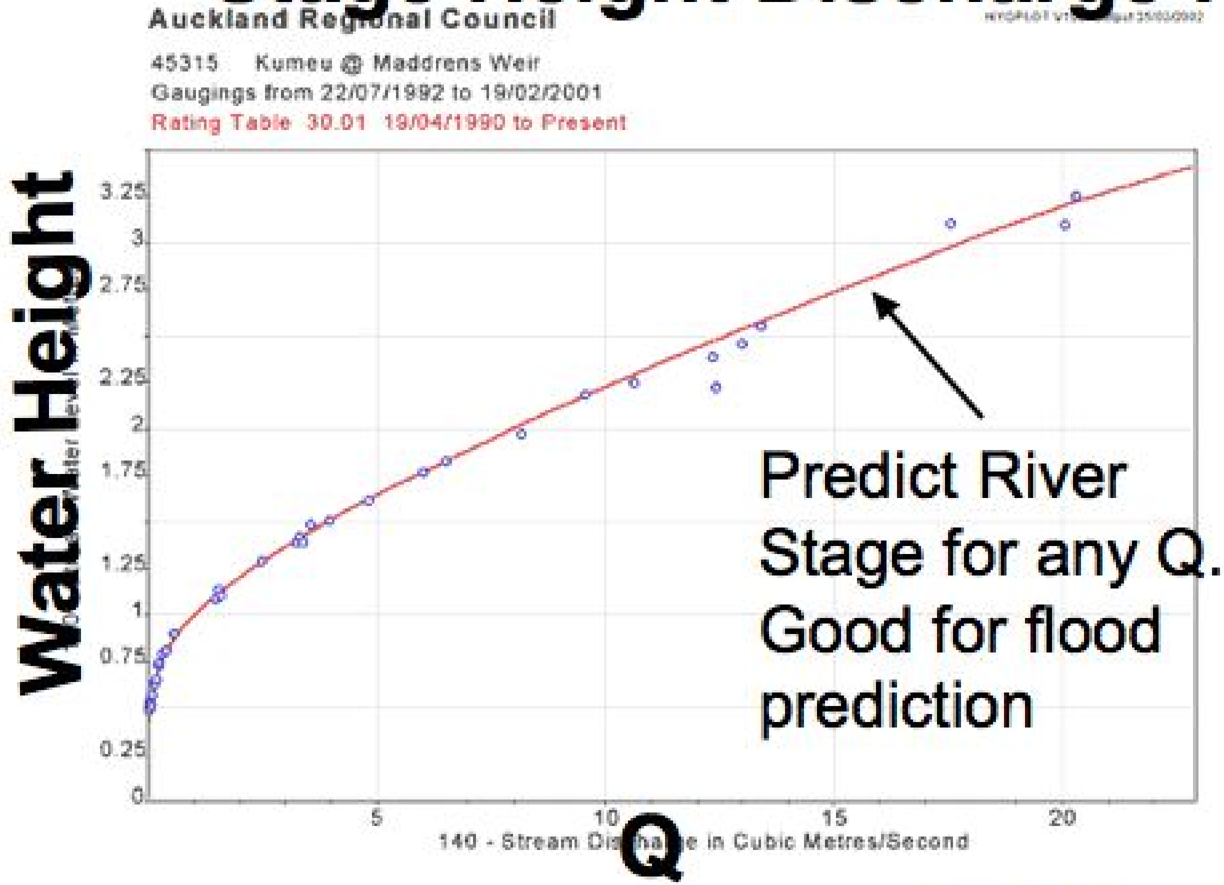
- bed Material is ss cobbles to bolders (up to ~0.5 m) mixed with finer ss & Mudstone & other lithologies

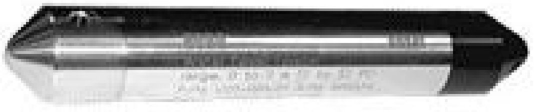
- This sample is designed to test how similar 10Be activities will be in the terrace sample vs. the Modern River.



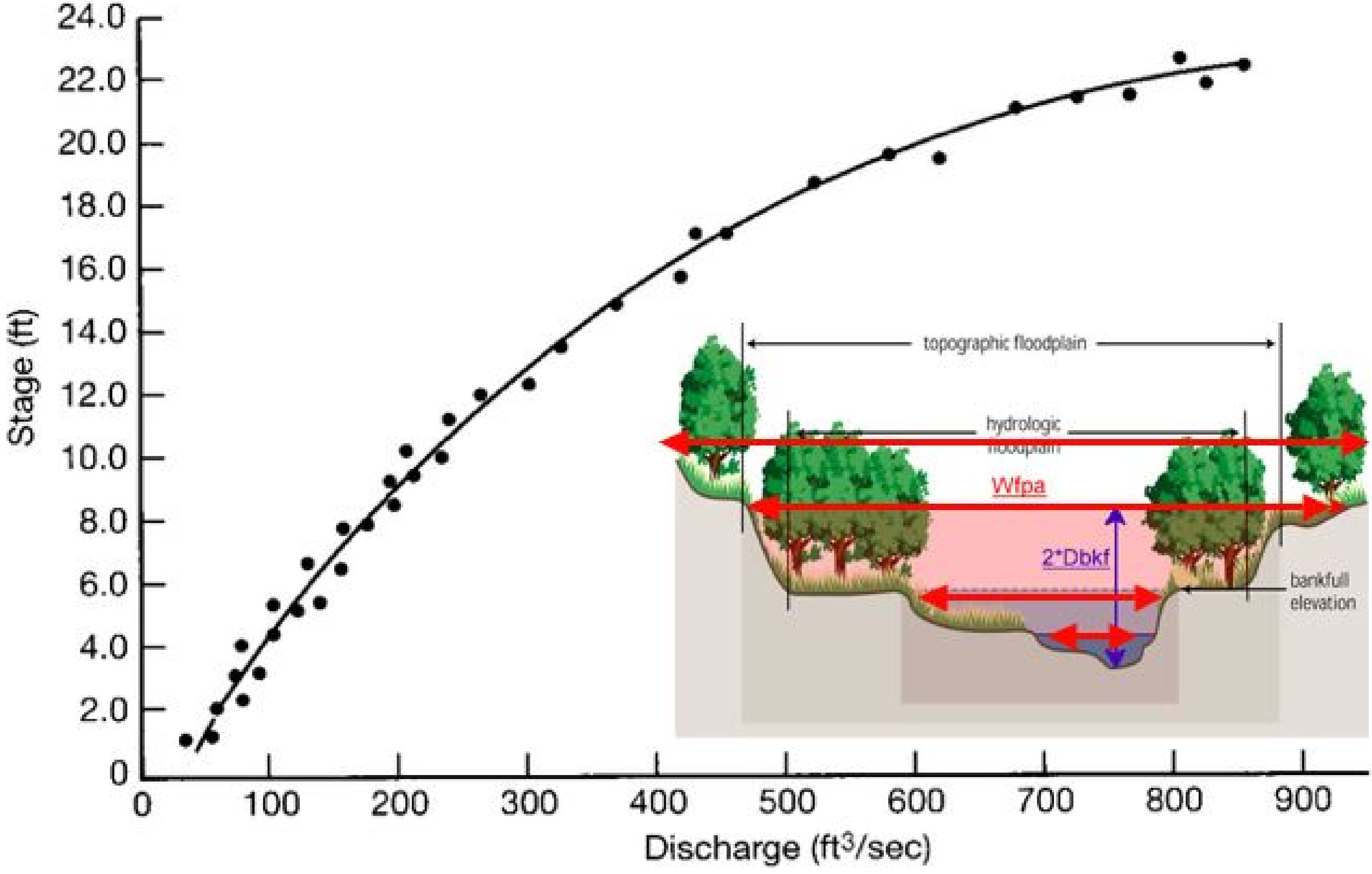
→ Many of the small tribs leading into the Waihuka are hanging ... evidence of knickpoint migration?

Do enough of these, and you can make a Stage Height Discharge Rating Curve

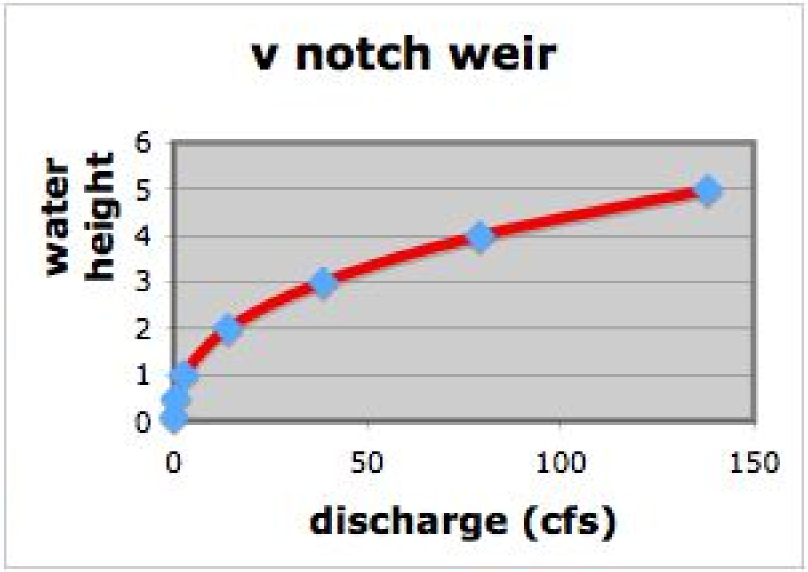


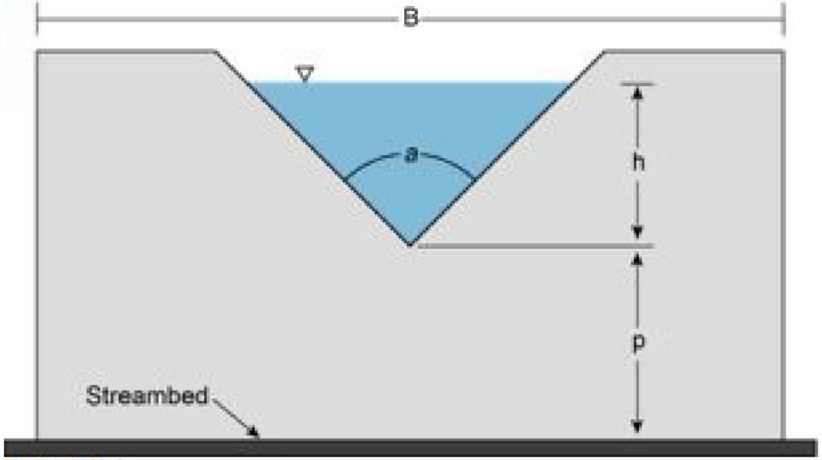


Why does the curve "Roll" over?



A Weir is another way of tracking Q On smaller streams





$$Q = 2.47h^{2.5}$$

Lots of negative impacts on ecosystems

Channel Roughness

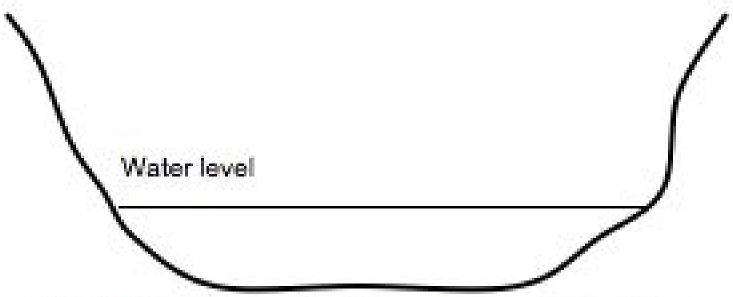
Manning Equation:

Why would anyone care how rough or smooth A river channel is?

LWD - Winooski

“smooth channel”

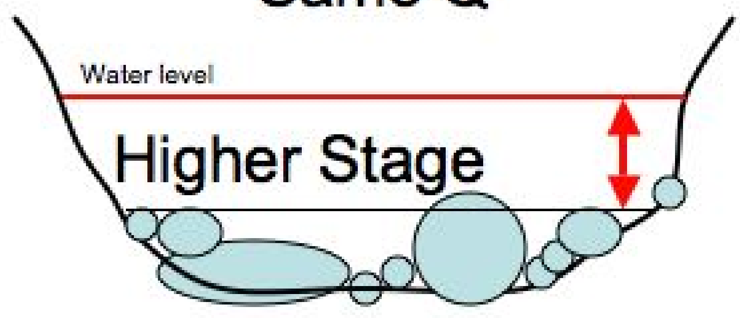
Same Q



Higher relative velocity

“rough channel”

Same Q



Lower relative velocity

Manning Equation:

Relates channel geometry, slope, and roughness with Discharge

$$Q = \frac{AR^{2/3}S^{1/2}}{n}$$

Watch Units

Q and n inversely related…if one goes up, the other must go down

A = cross-sectional area (m^2)

R = Hydraulic Radius (a/WP) (m^2/m)

S = Slope (m/m)

N = Manning n (roughness coefficient)

Bigger the n, the rougher the channel is

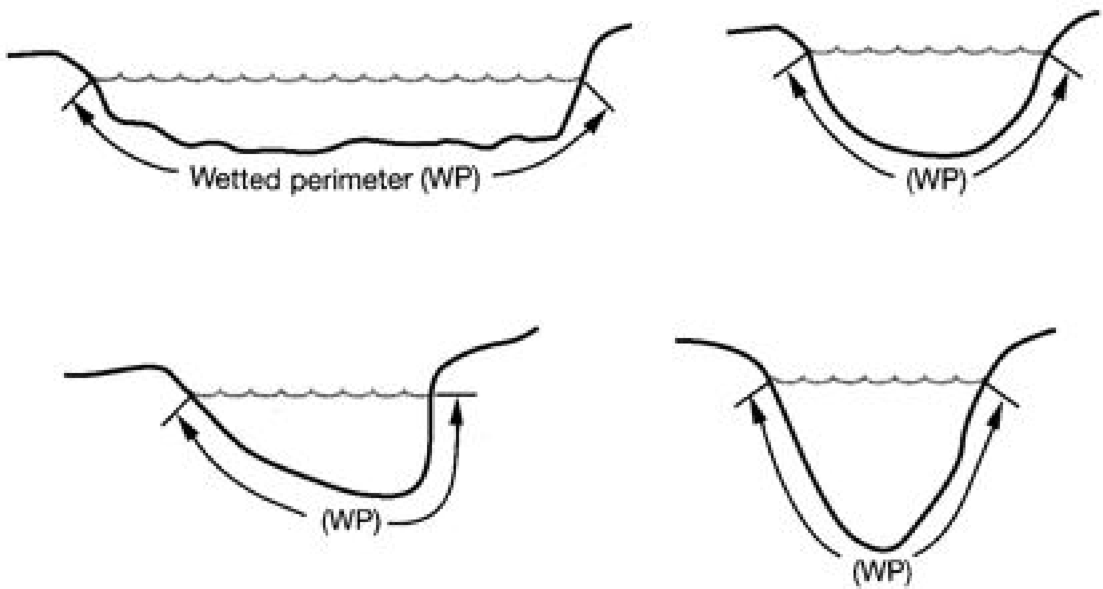
R - Hydraulic Radius

R = Hydraulic Radius (a/WP) (m^2/m)

Cross-sectional Area of river channel / **Wetted Perimeter**

(the data you will collect)
(square meters)

(WP ~ width + 2depth)
(meters)



S - Slope of WATER SURFACE

Slope = change in elevation / distance downstream

(rise) (run)

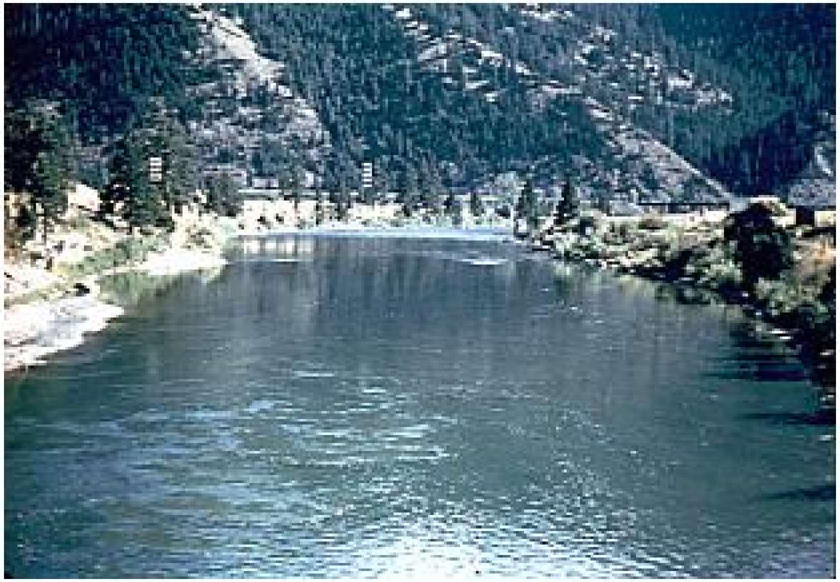
Manning *n* values:

TABLE 6.1 Manning roughness coefficients (*n*) for different boundary types.

Boundary	**Manning *n* ($ft^{1/6}$)**
Very smooth surfaces such as glass, plastic, or brass	0.010
Very smooth concrete and planed timber	0.011
Smooth concrete	0.012
Ordinary concrete lining	0.013
Good wood	0.014
Vitrified clay	0.015
Shot concrete, untroweled, and earth channels in best condition	0.017
Straight unlined earth canals in good condition	0.020
Rivers and earth canals in fair condition; some growth	0.025
Winding natural streams and canals in poor condition; considerable moss growth	0.035
Mountain streams with rocky beds and rivers with variable sections and some vegetation along banks	0.041–0.050

Source: *Handbook of Applied Hydrology*, ed. by Ven T. Chow, copyright 1964 McGraw-Hill Publishing Co., Inc.

http://wwwrcamnl.wr.usgs.gov/sws/fieldmethods/Indirects/nvalues/



Clark Fork at Missoula, Montana

n = 0.030

Boundary Ck at Porthill, Idaho

n = 0.073

Flow Levels…..

Particularly "Bankfull" Discharge

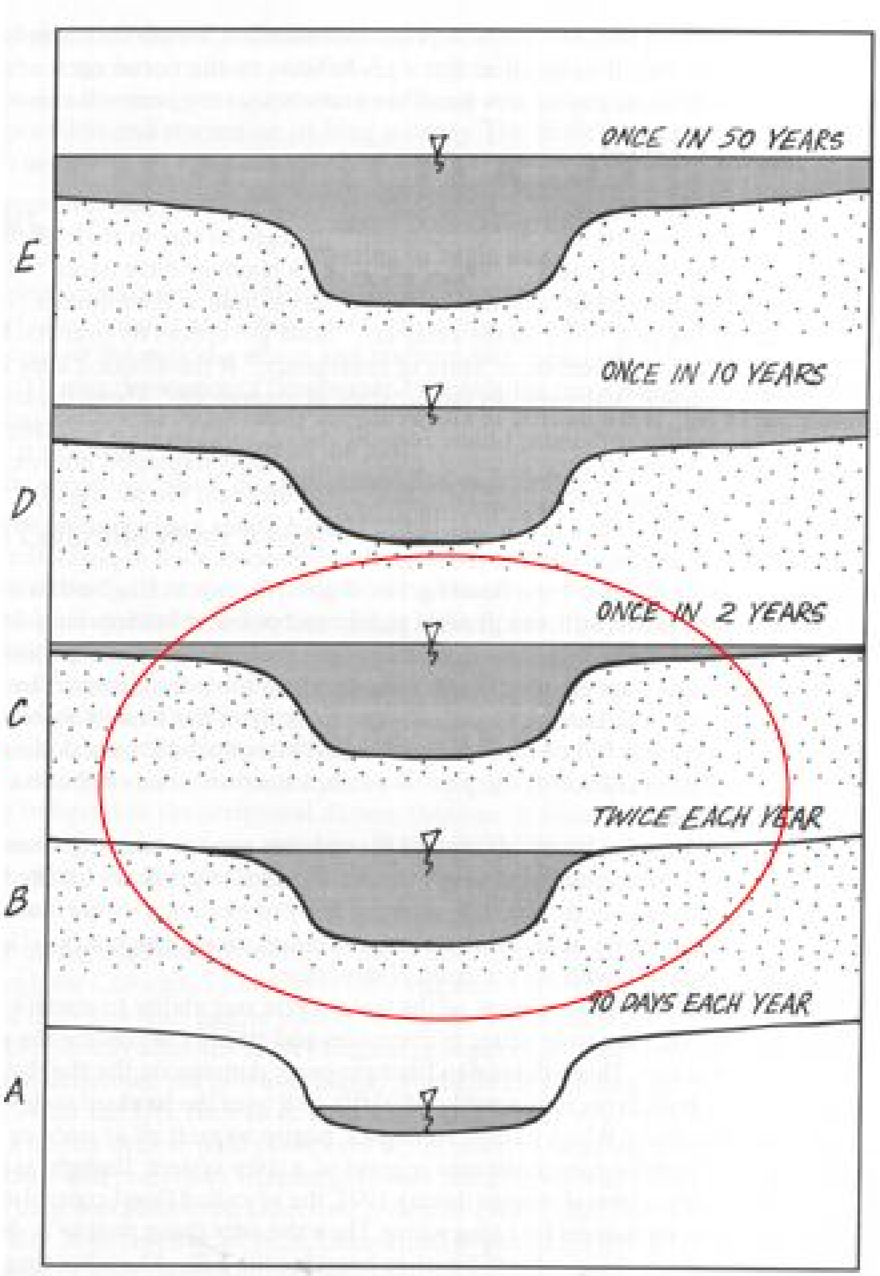
Flow Levels

Try to define in field using observations

Bank full flow

About once a year

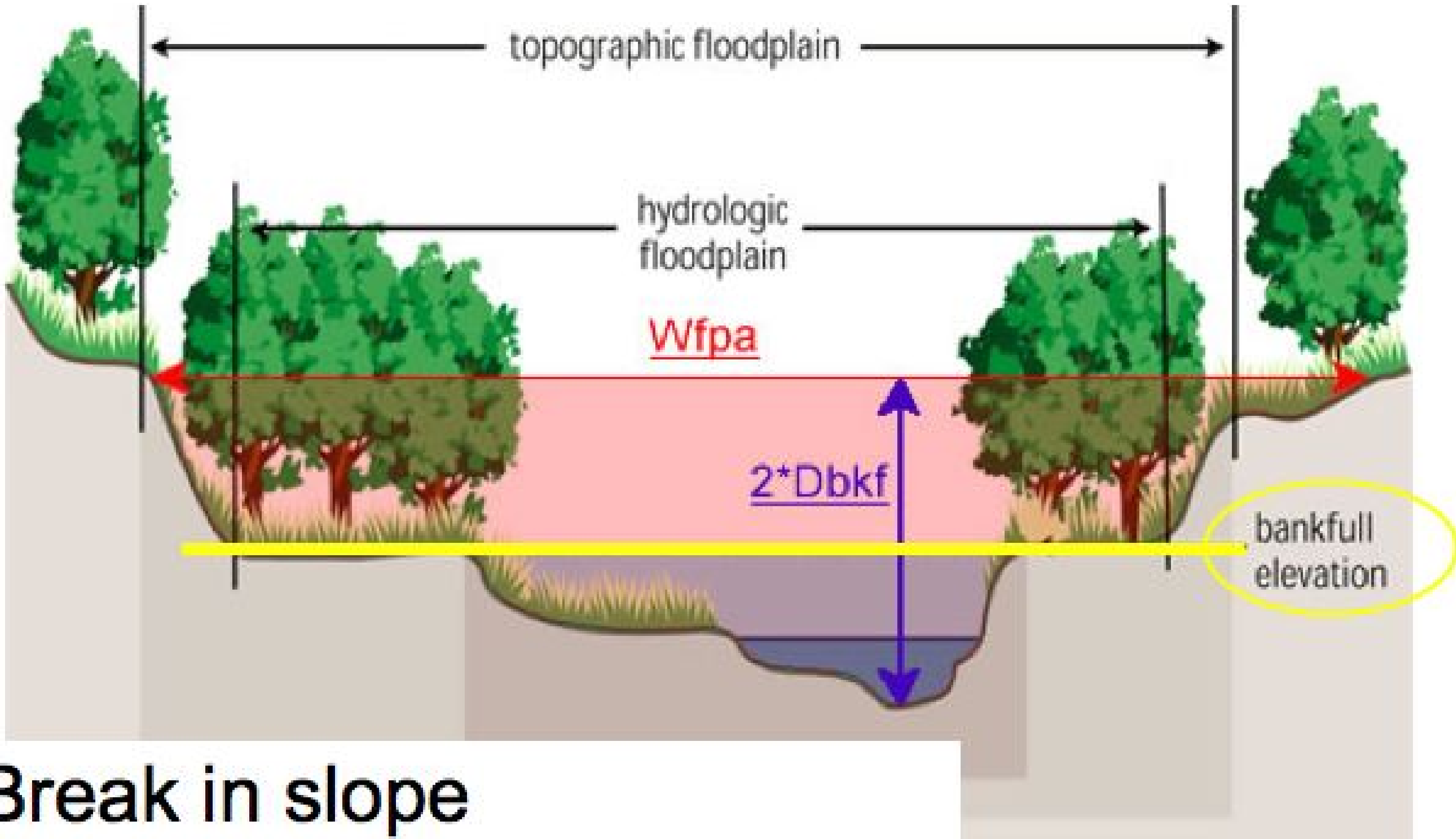
"Channel-forming flow"



This is for alluvial channels

Identifying Bankfull in the Field

(Here's where it gets interesting)



- Break in slope
- Inset bench or small terrace
- Vegetation change

Mannings and Bankfull

•Empirically derived Manning N value through Our channel surveying.

•Use this value to predict Discharge for "Bankfull Discharge that we identify in the field.

The Stuff in the water:

Sediment mass loading in rivers:

Sediment load: The mass of sediment carried in
The water column at a particular discharge and at a particular
Point along a river channel (mass / volume)

Sediment Yield: The total mass of sediment yielded per unit
Area per time (e.g. Tons / km^2 / yr).

- Changes downstream
- Changes with discharge

Sediment Transport Through Rivers

Bedload -- material moving along the bed, shear forces exerted by water sufficient to move clasts -- rarely measured (at % level)

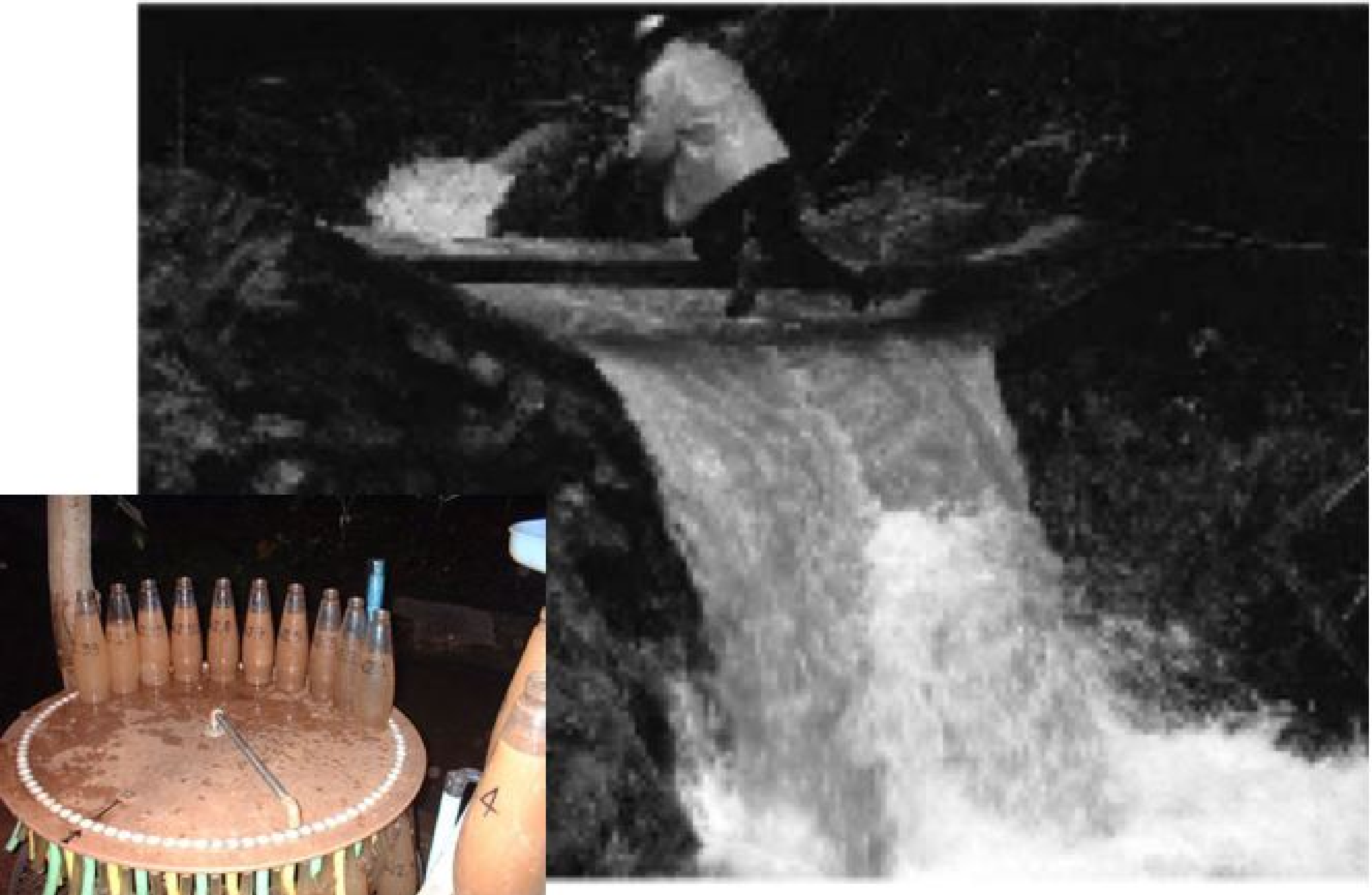
Suspended Load -- material kept in the water column by turbulence and lift forces (easy to measure in grab samples)

Dissolved Load -- material in solution (easy to measure in grab samples)

Bedload usually <<< than suspended load and ignored

Dissolved load varies, usually < than suspended load

Sampling for Suspended Load……



Getting from daily sediment yields
To total mass loading and erosion rates

Typically, measured kg of sediment each day, added together over
An entire year.

Integrate suspended load over all flows (mass/time)

+

Integrate bedload load over all flows (mass/time)

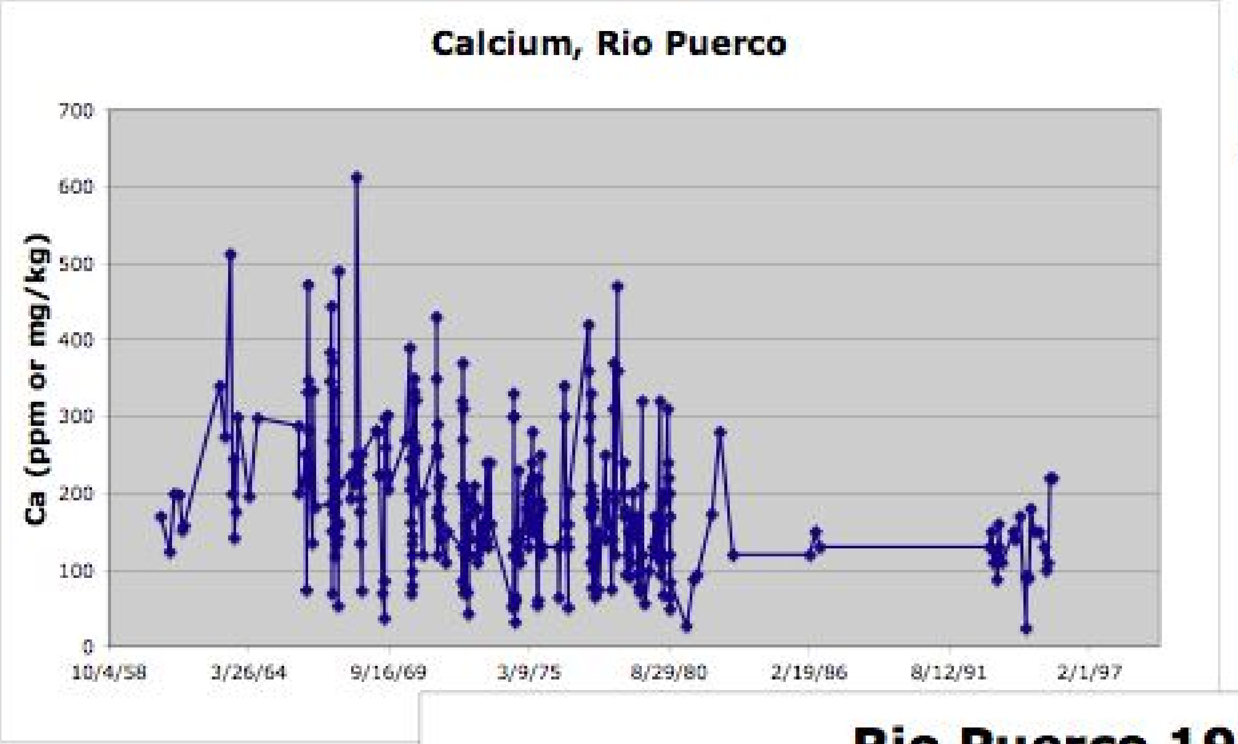
+

Integrate dissolved load over all flows (mass/time)

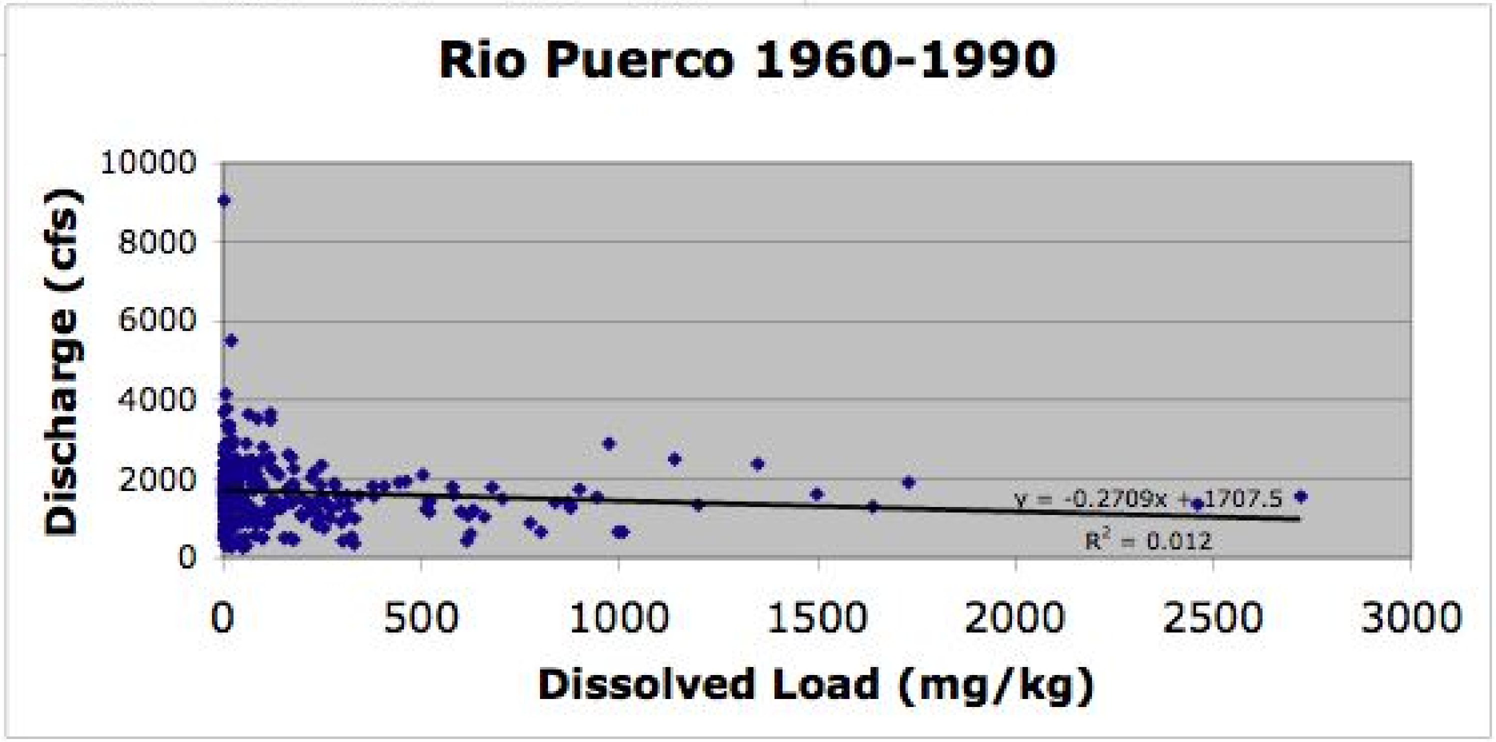
=

TOTAL MASS LOSS (mass/time)

Divide by density and can express as (Height change/time) m/My…..cm/ky

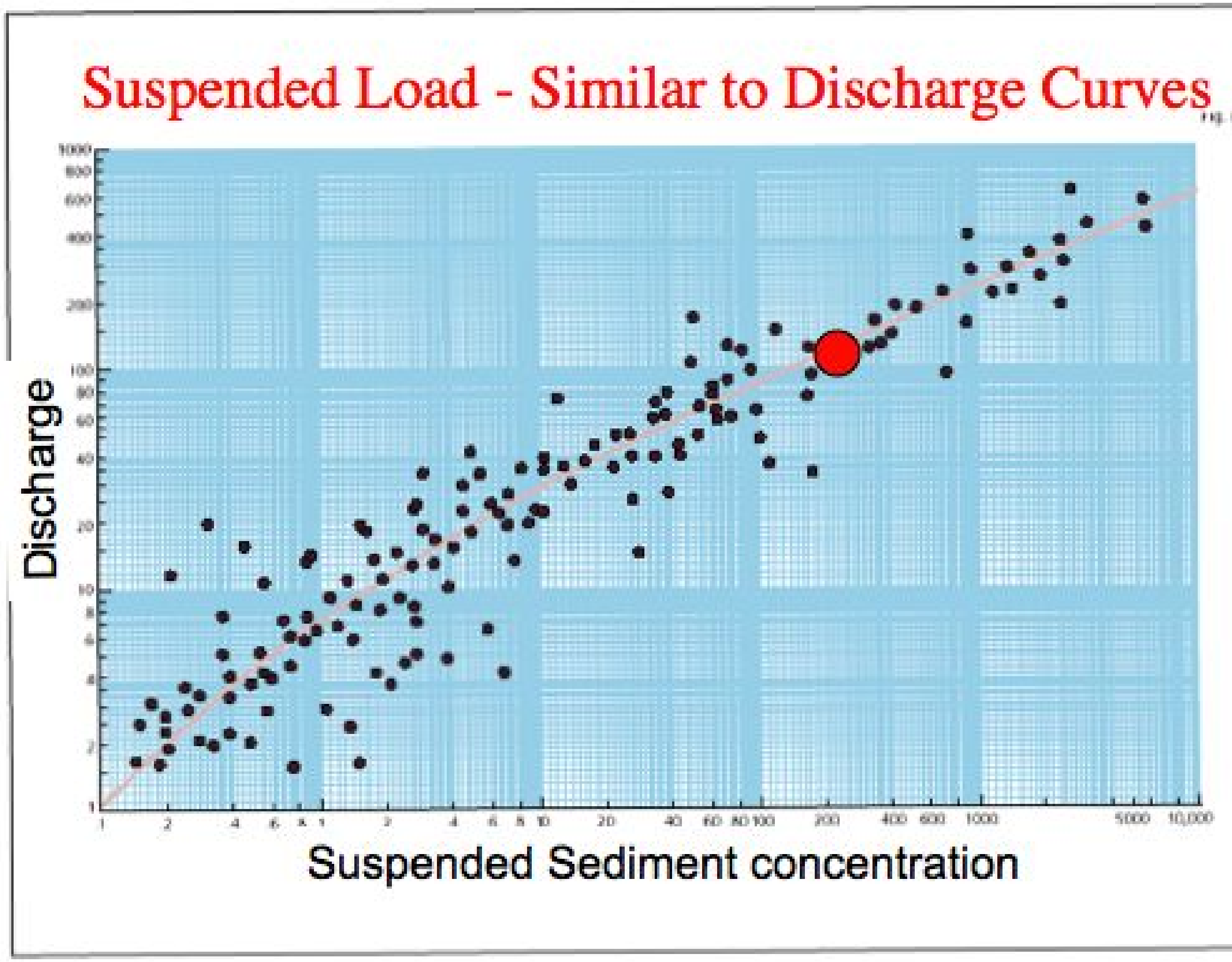


Load varies over time and discharge



Integration over all flows is a non trivial problem!

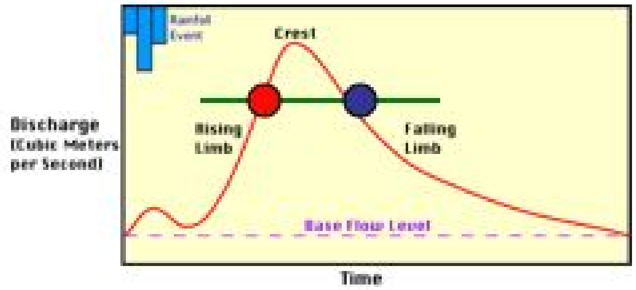
Need *Rating Curves* (suspended, dissolved, bedload)



Can predict
Concentration
At any given
Discharge

Integration over all flows is a non trivial problem!

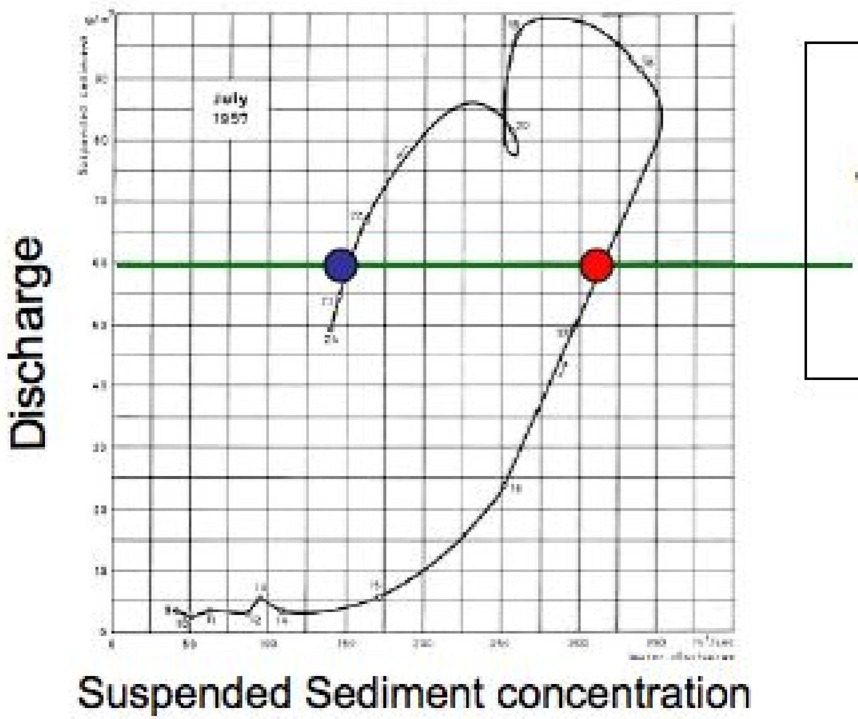
What happens when you track through the hydrograph



Hydrograph

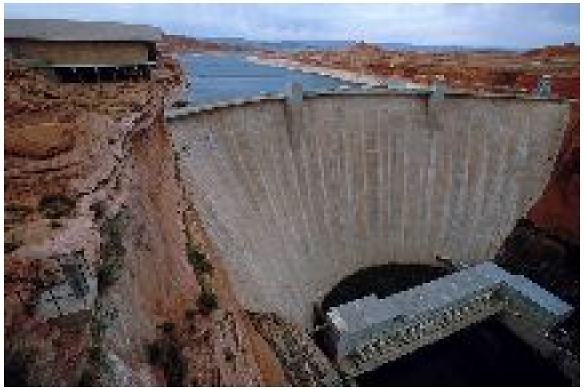
Hysteresis loop:
Sediment concentration
Different at the same
Discharge.

Make predicting
Concentration based
On discharge difficult



Any ideas
Why this might
happen

SEDIMENT YIELD
- What comes out

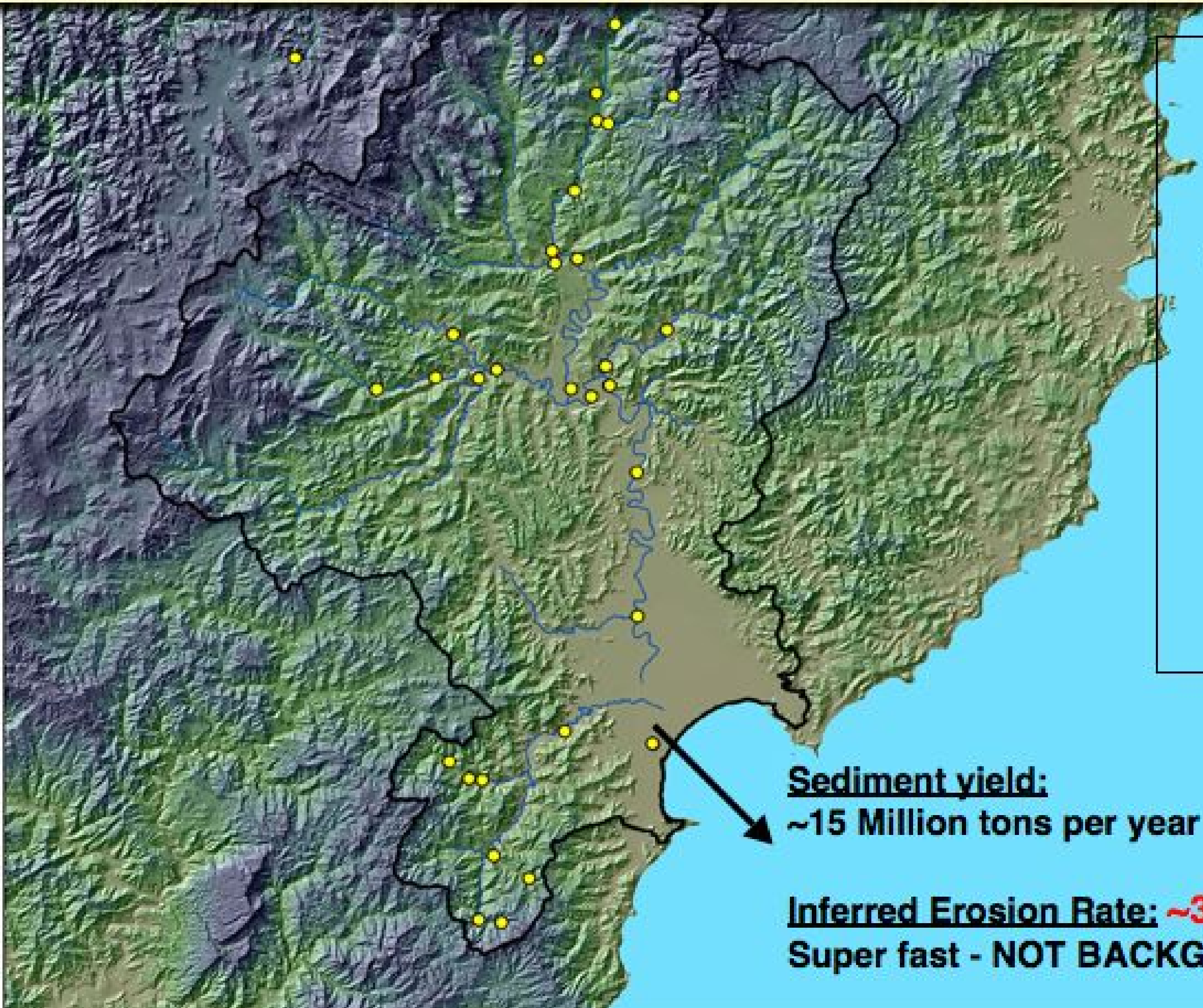


= or ≠

Timescale
Steady state
Human impact
Episodic disturbance

SEDIMENT GENERATION
- Material generated by weathering and erosion

Sediment Yield, Erosion rates, and Humans



No Trees:

Accelerated hillslope erosion, and amplified sed Yields

Similar to Winooski in Vermont after deforestation

Historic Sedimentation

Sediment yield:
~15 Million tons per year

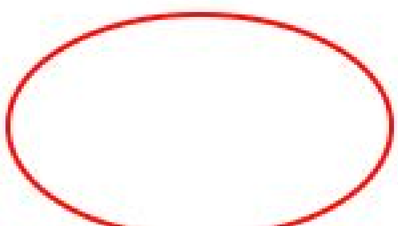
Inferred Erosion Rate: ~3 km/My
Super fast - NOT BACKGROUND

River Lab Logistics

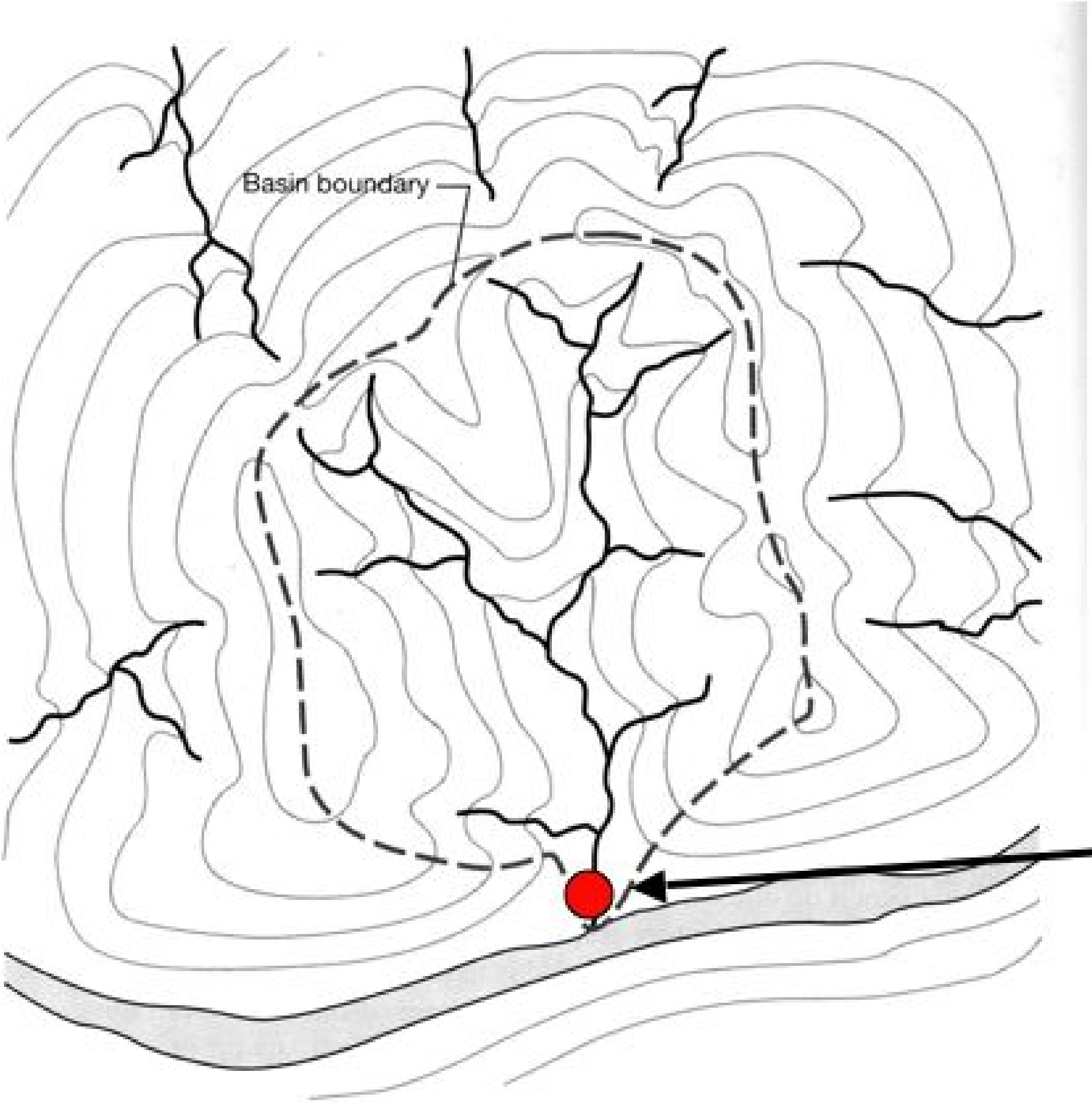
- On Huntington, in water

- Measure discharge - river surveying and velocity measurements
- Compare pools and riffles - Discharge and Roughness.
- Field estimate of bankfull stage - Need channel geometry and slope
- Suspended and dissolved load on Wednesday.

- Bring: Raingear, warm clothes, pencils and waterproof paper
- OLD TENNIS SHOES! Teva/toenail story



A - Drainage Basin Area - Have to define it



COUNT BOXES OR USE DIGITIZER

Survey Location