Water Science for Schools

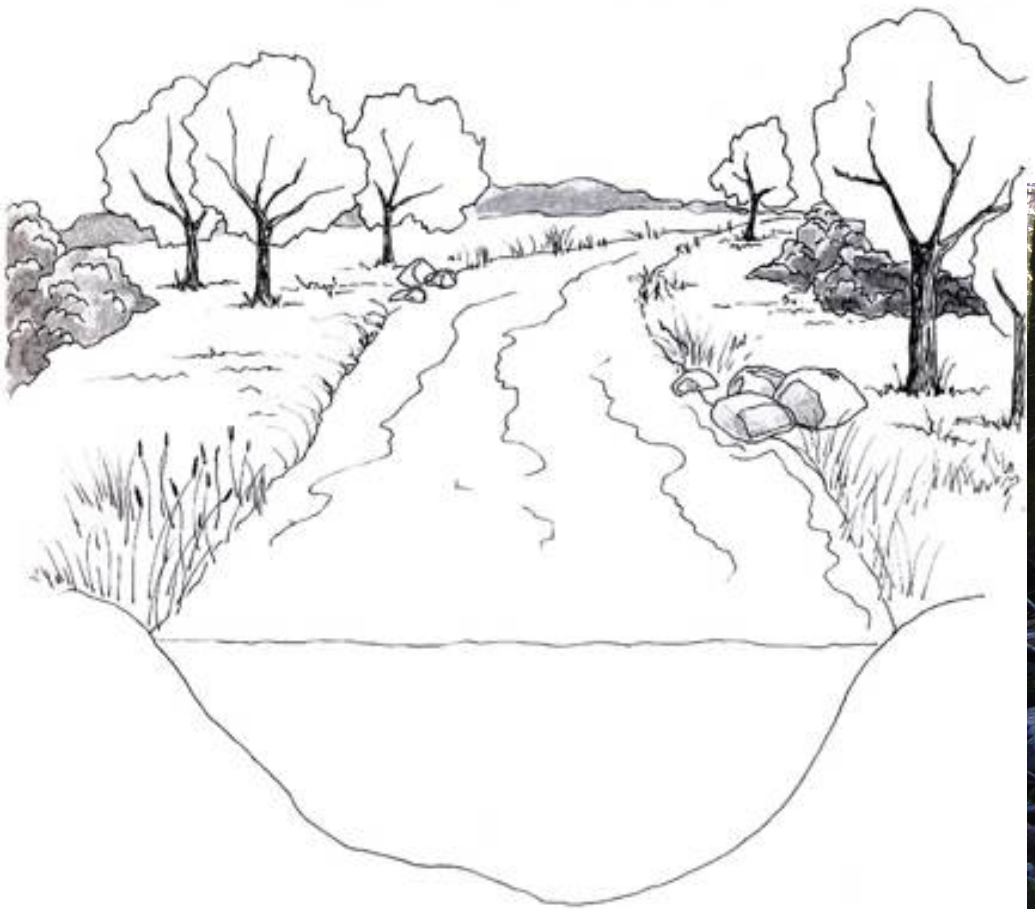
How Streamflow is Measured

If you're a teenager, I imagine your favorite activity is to sit with your parents on a quiet river bank, drink your glass of lemonade, and ponder the complexities of life. Probably the first question you ask is "How much water is flowing in this river?" You've come to the right place for an answer. The U.S. Geological Survey has been measuring streamflow on thousands of rivers and streams for many decades and by reading this set of Web pages you can find out how the whole streamflow-measurement process works.

Streamflow = Discharge = Q

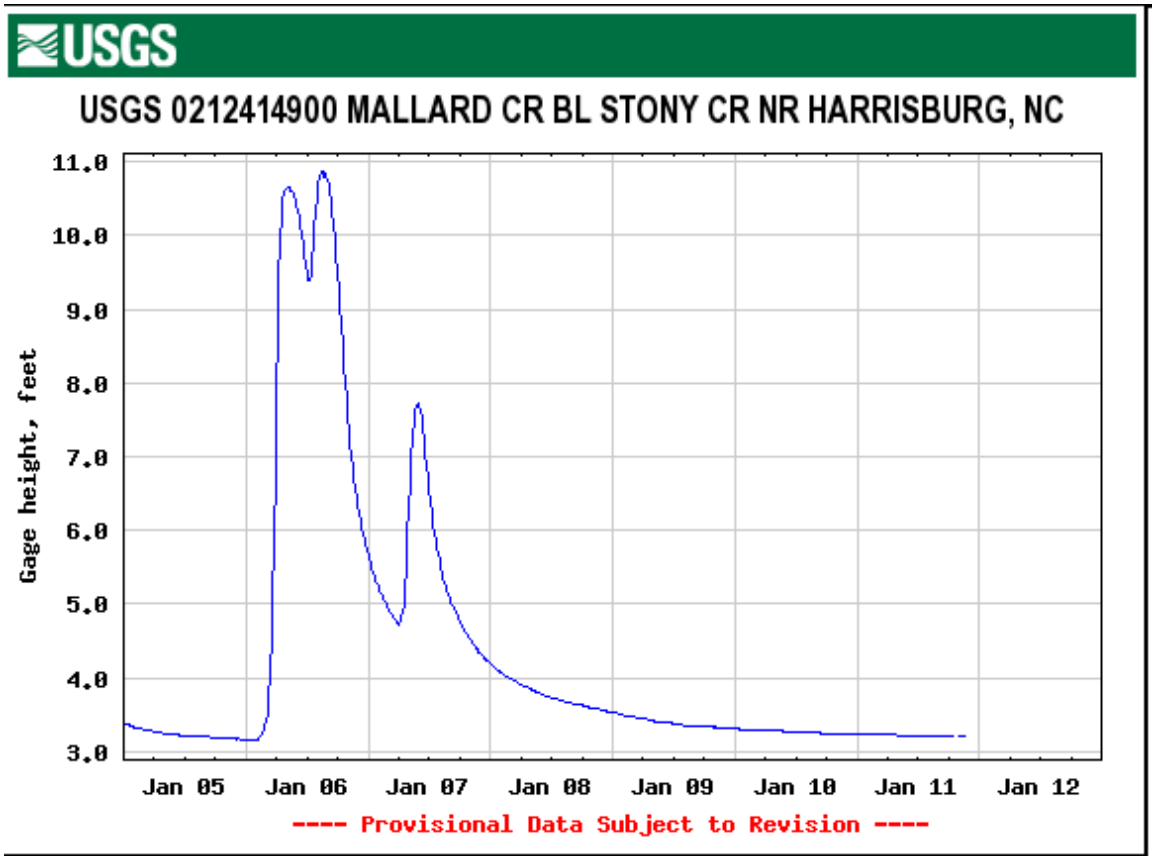
- $[L^3/T]$
- Q = w * d * v

W, D, V vary in space and time. Must measure each to calculate discharge.



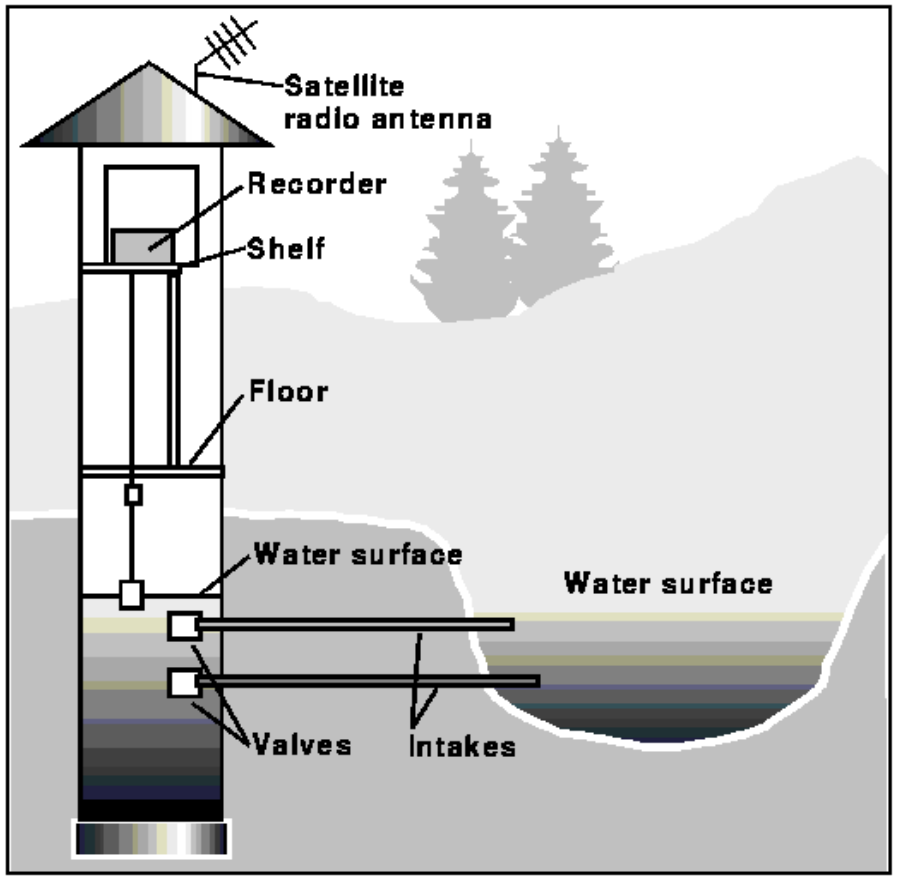
http://www.concord.org/~btinker/GL/web/water/rivers_streams.html

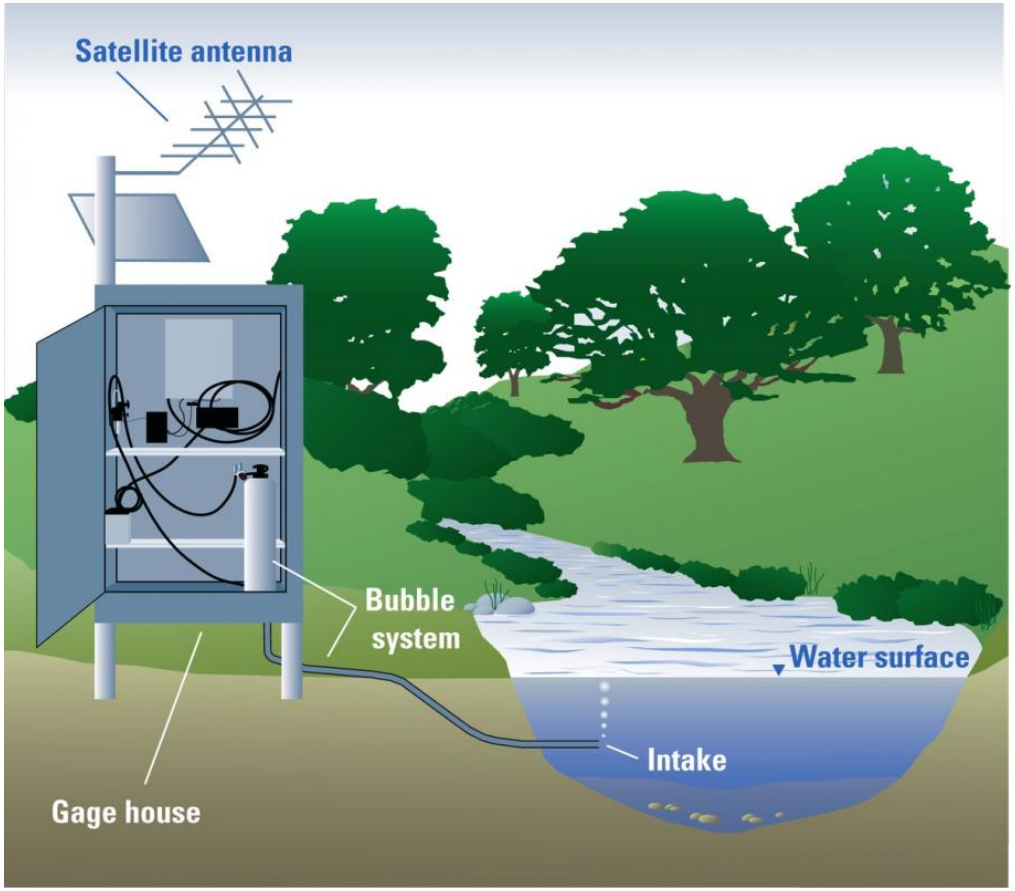
Stream gages measure stage (depth)



- USGS measures depth to a standard accuracy of 0.01 in.
- Depth is recorded every 5 or 15 minutes.
- Data are transmitted every 1 hour.
- Stage record is for one cross-section

How is depth measured?





Stilling well equilibrates with stream level. Float measures depth

Bubbler forces air out of tube. Resistance is a function of depth.

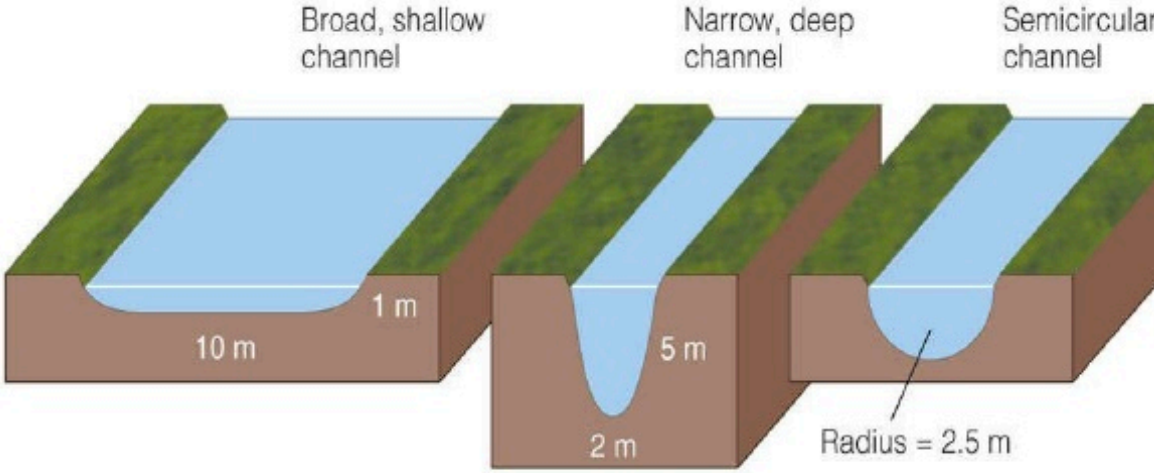
How is depth measured?

Radar sensor measures distance to water.

Pressure transducer measures weight of overlying water + atmosphere.

Relationship between stage and discharge depends on the channel cross-section & is location specific.

- Channels here have same area, but very different depths.
- Think about the difference that a water level change of 1 m would make in the area of each of these channels.

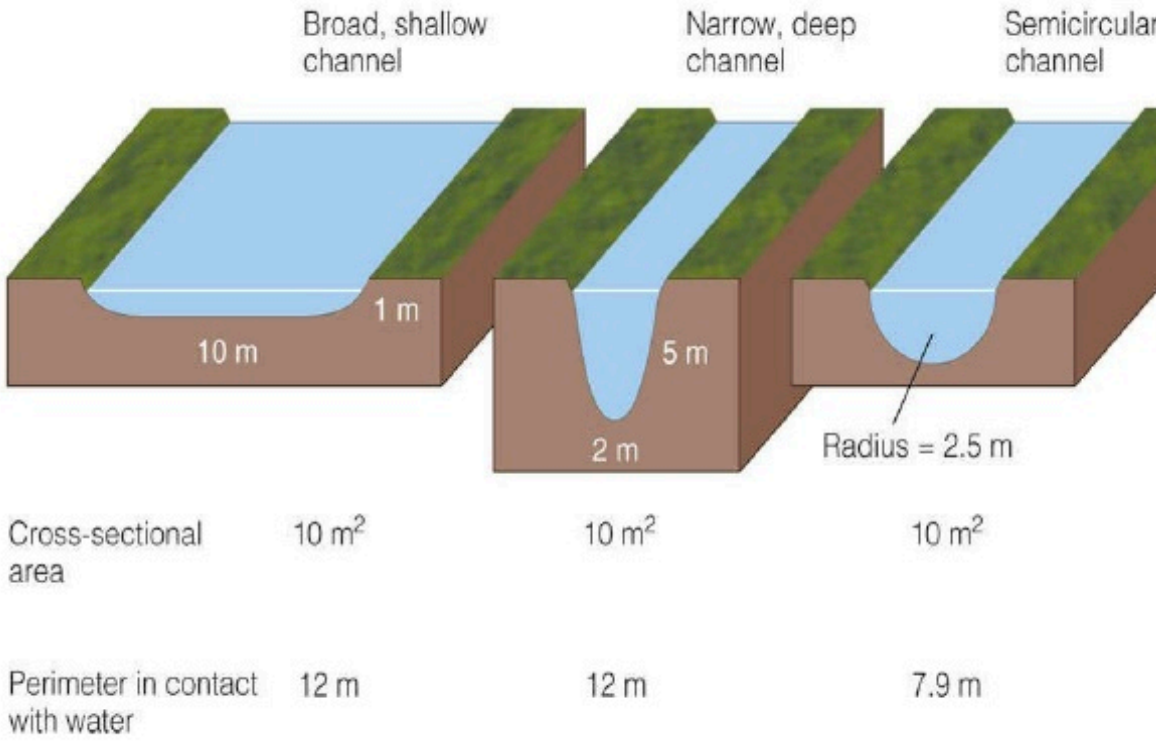


Cross-sectional area	10 m^2	10 m^2	10 m^2
Perimeter in contact with water	12 m	12 m	7.9 m

- So we can't translate stage from one location to another, if channel and valley shape vary.

Relationship channel shape and discharge.

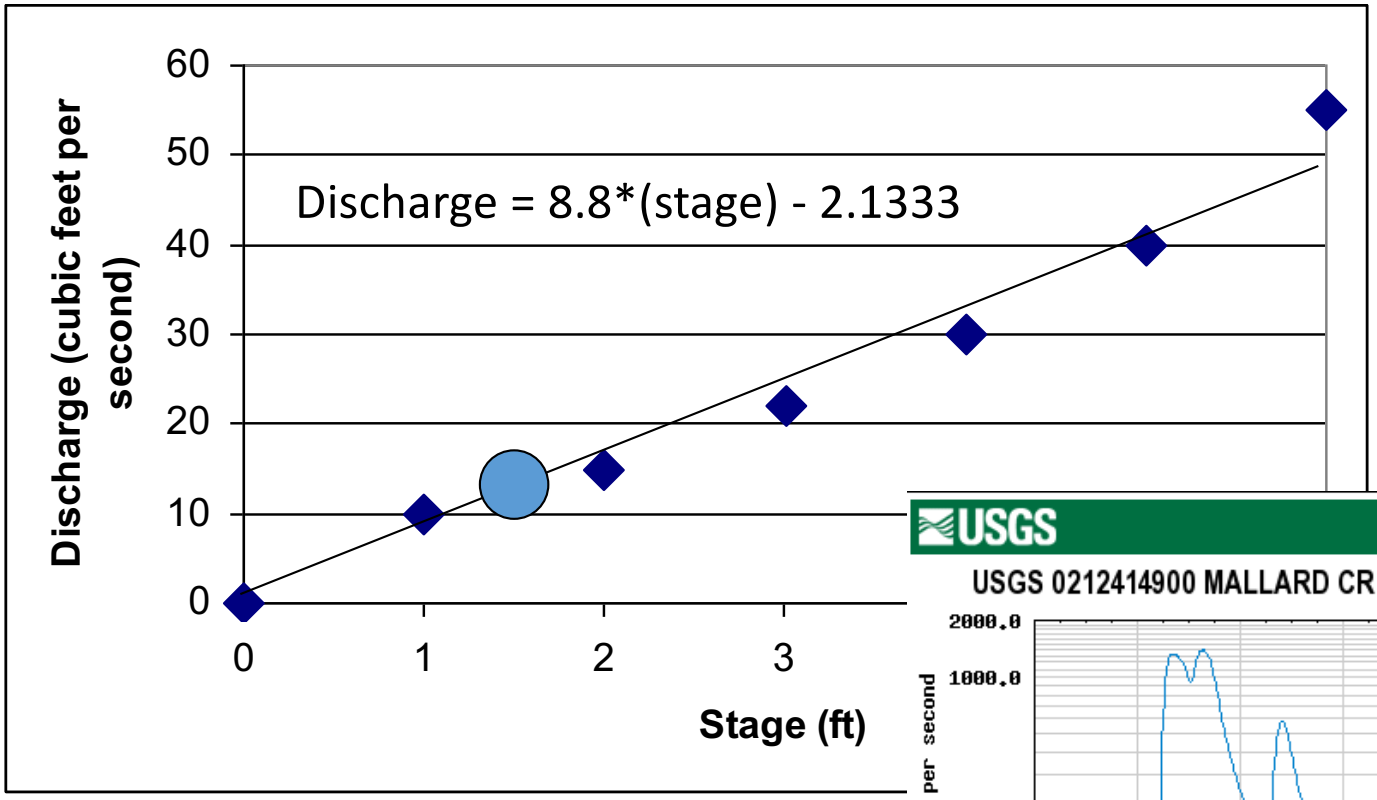
- If these three channels were in a row along the same stream with no inputs or outputs, they would have the same discharge. This is conservation of mass.



- The channels do have different mean velocity, because of drag on channel bed and banks.

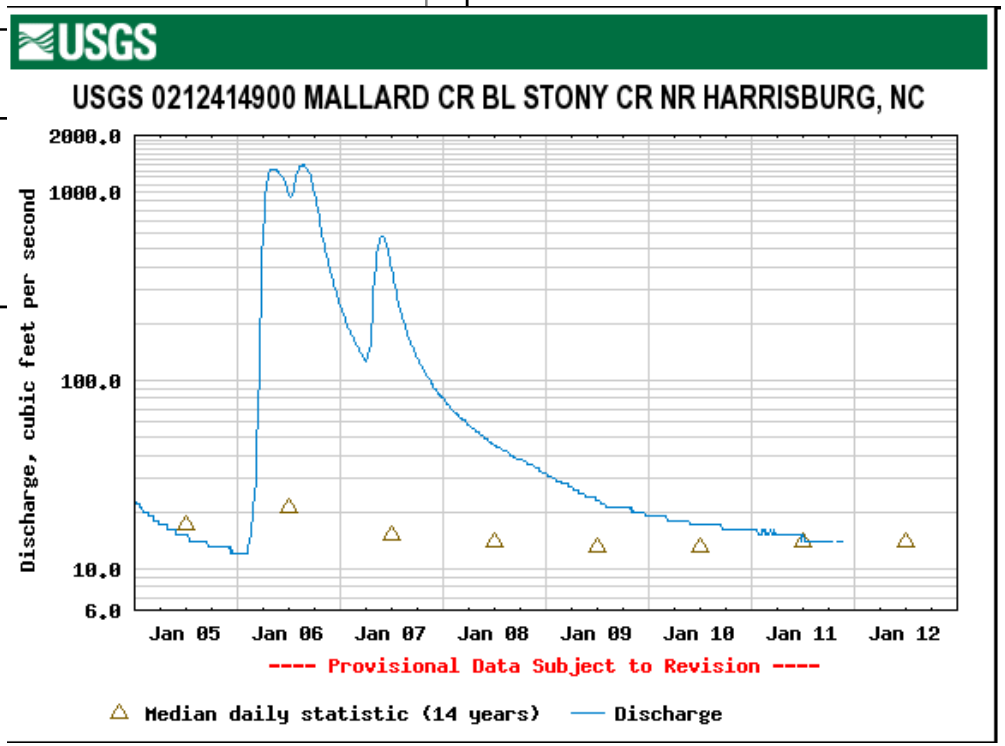
If erosion or deposition occurs, there relationship between depth and discharge changes.

Relate discharge to stage



← Rating curve

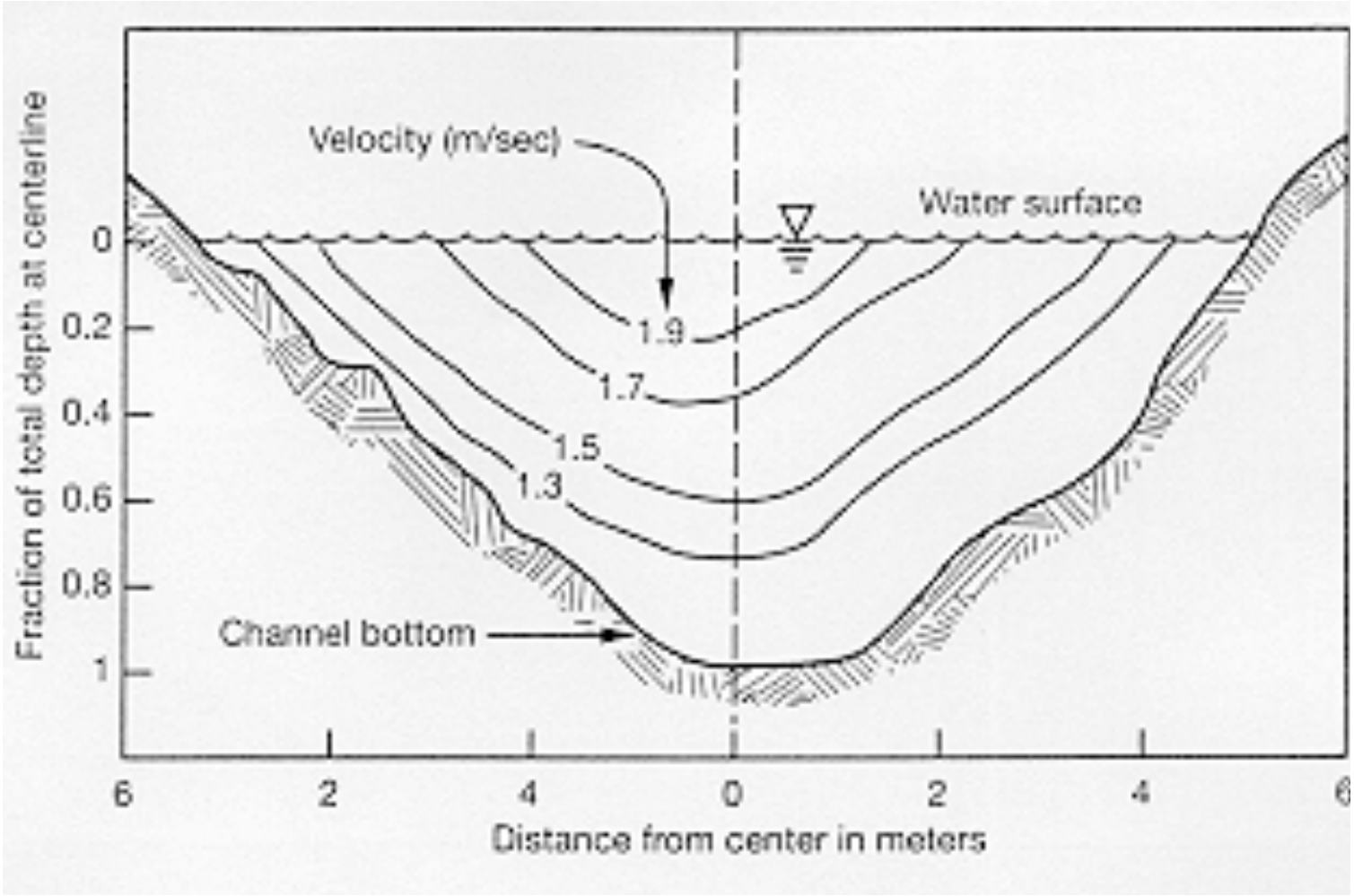
In order to go from stage to discharge, we need to measure **velocity**



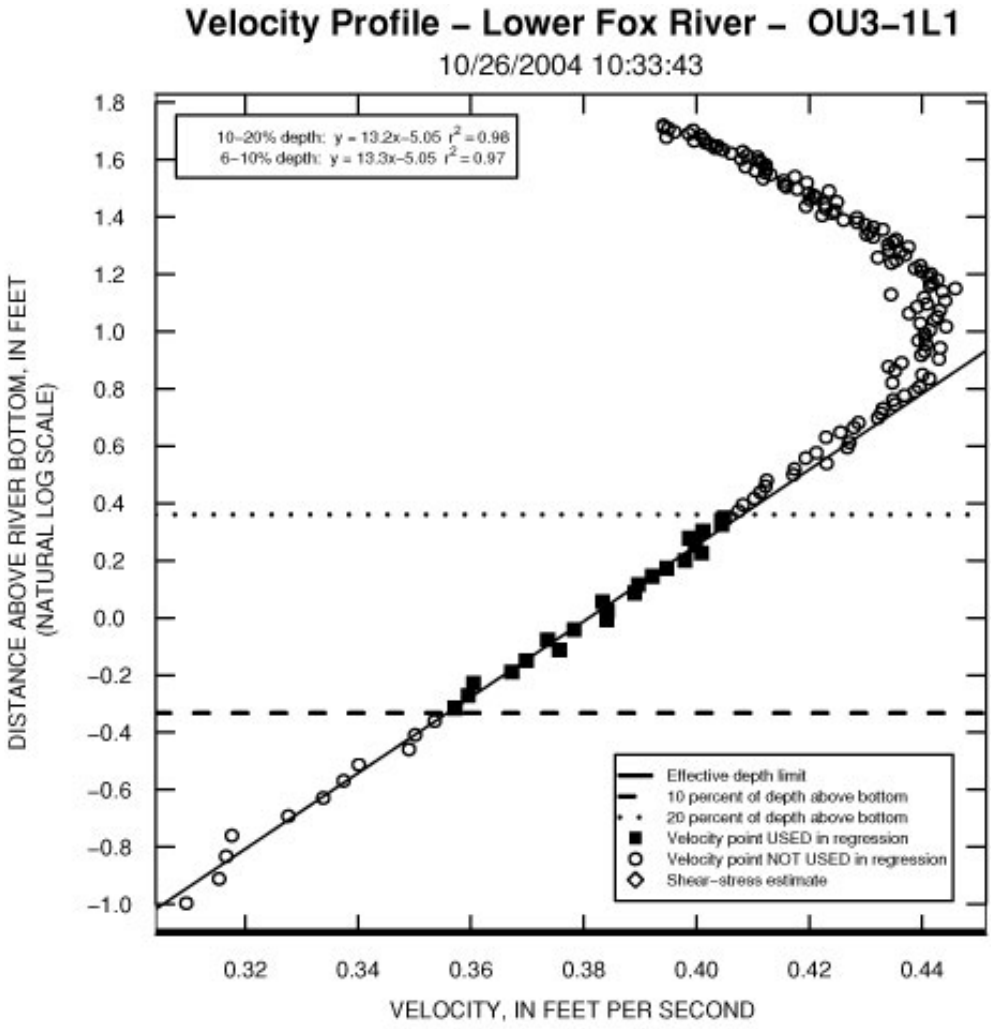
Hydrograph

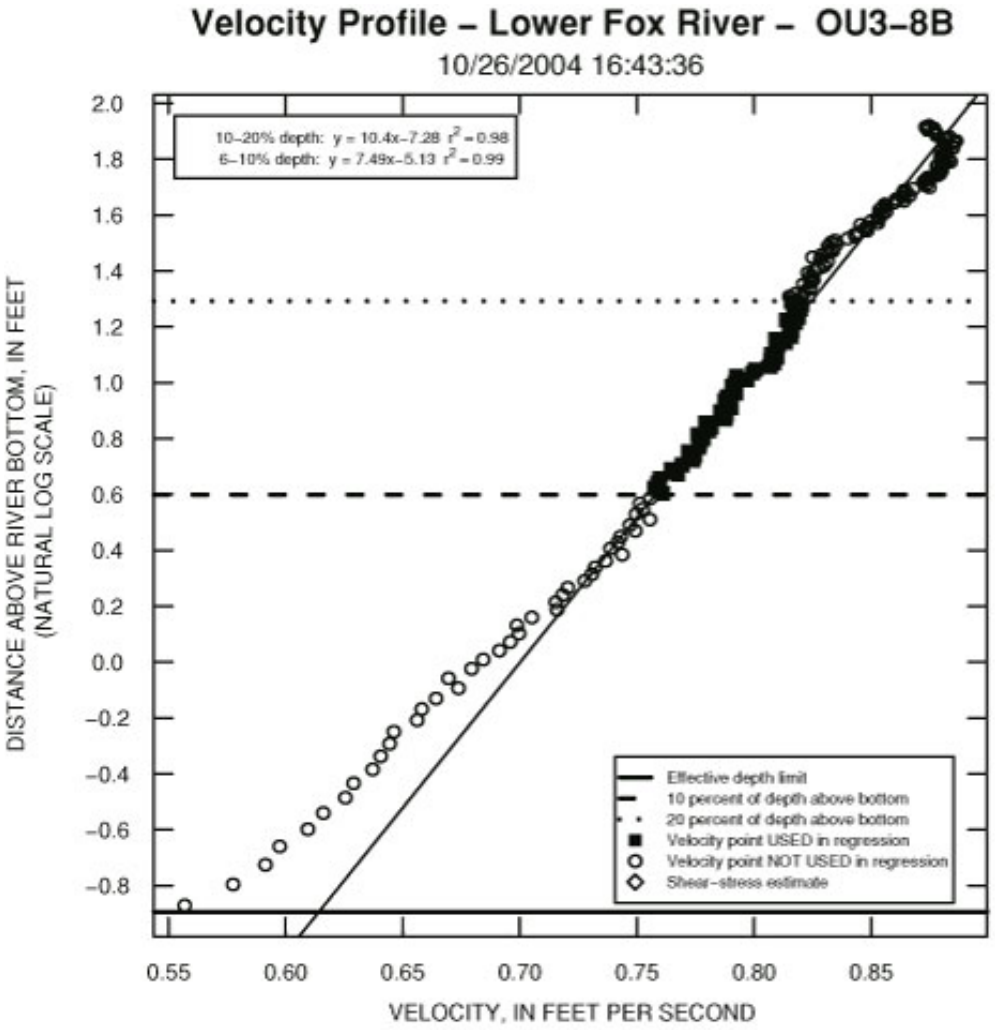
Velocity varies in 4 dimensions

- Vertically
- Across stream
- Downstream
- In time

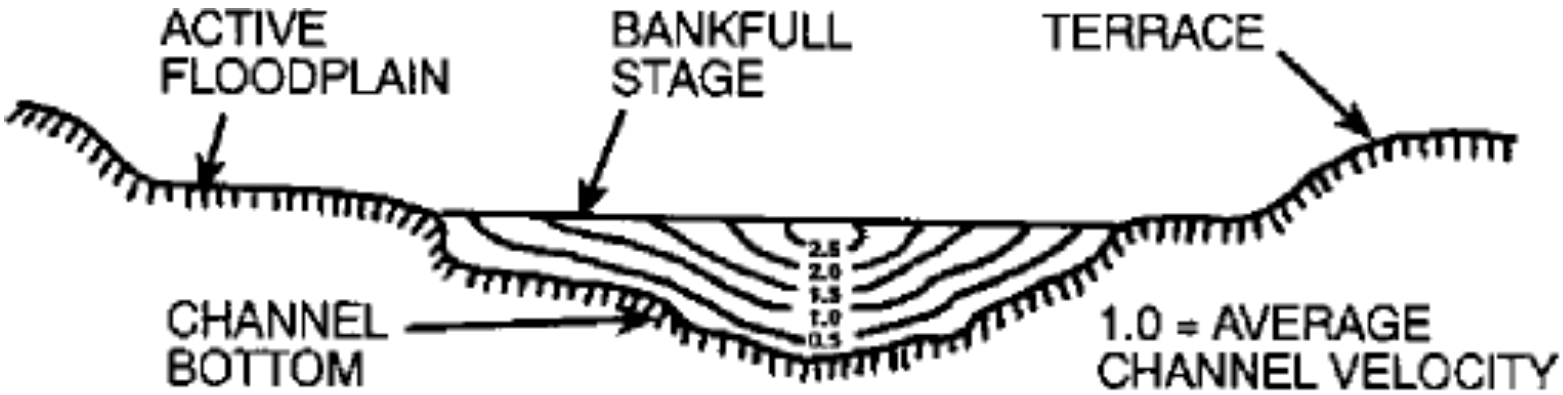


Vertical velocity profiles

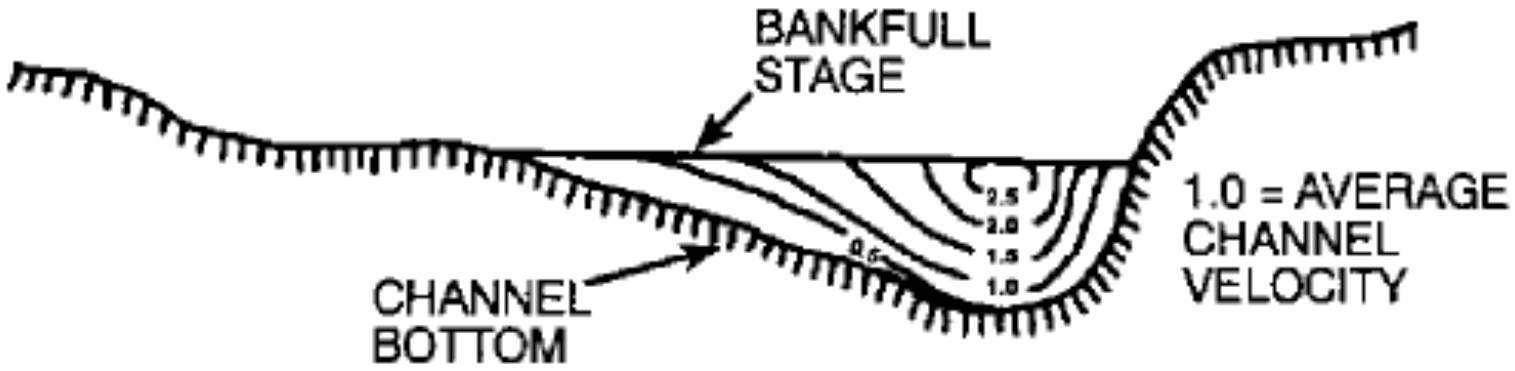




For abnormal flows, measure 0.2, 0.6, and 0.8 x depth. Average the 3 numbers.



(a) STRAIGHT CHANNEL

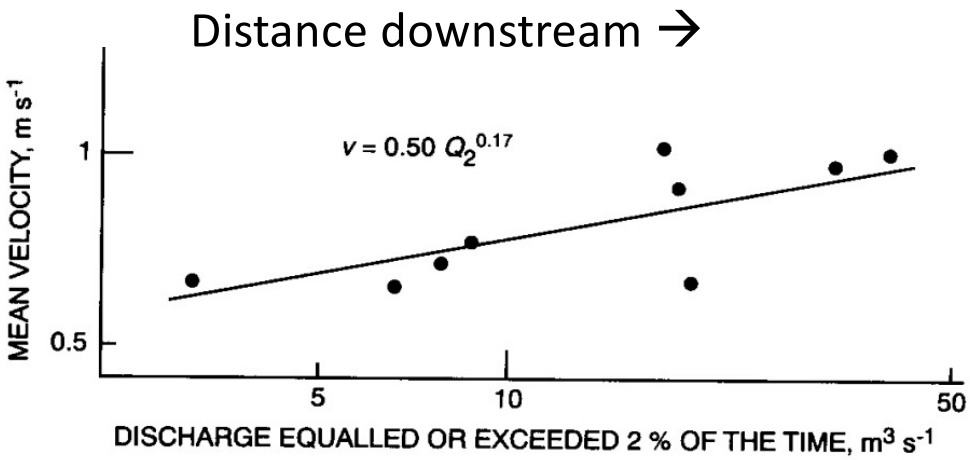


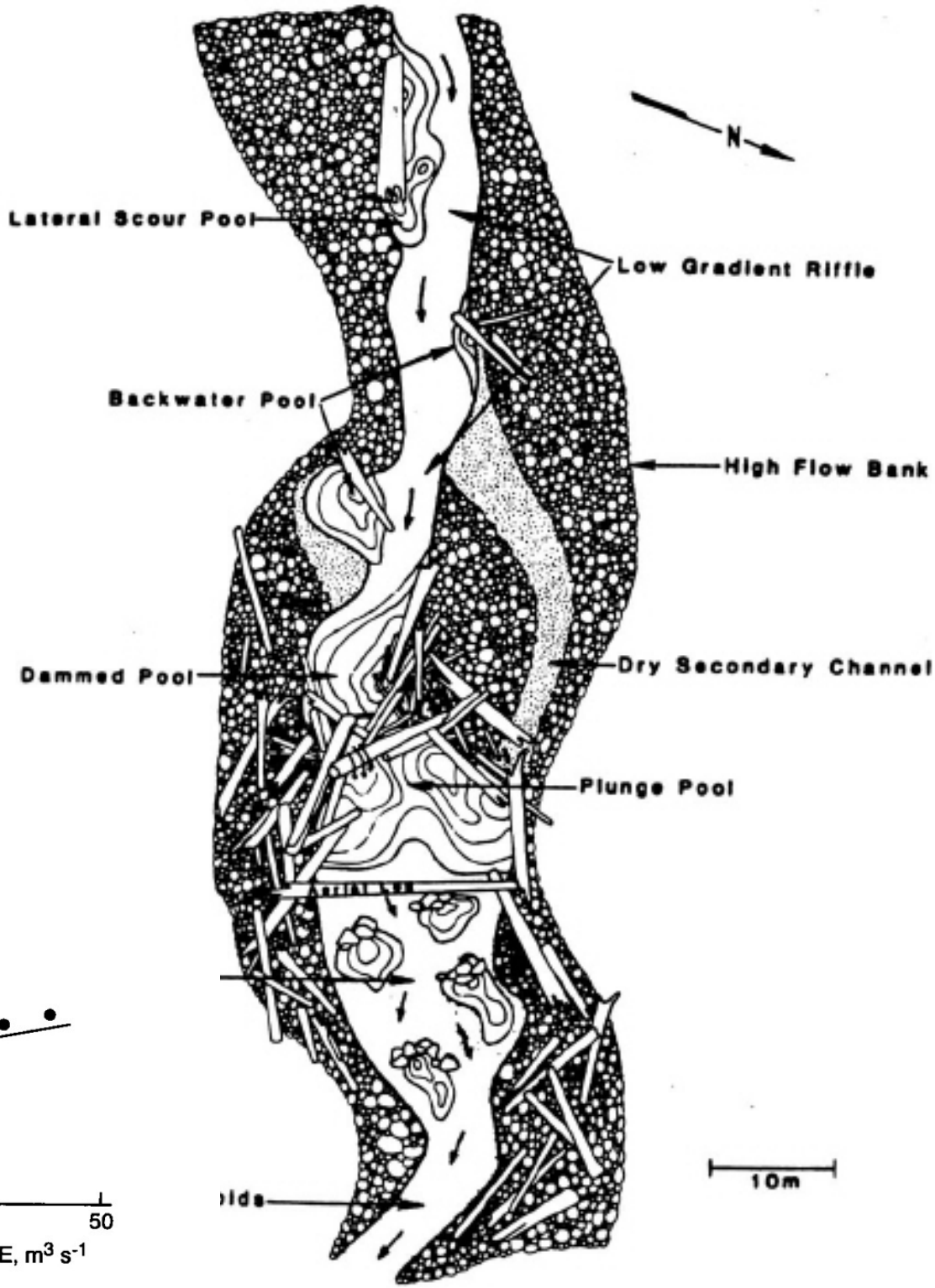
(b) CHANNEL BEND

- Stream bed and bank exert drag, create boundary layer.
- Fastest flow in middle (or outside of curve), near top of stream.

Downstream variations

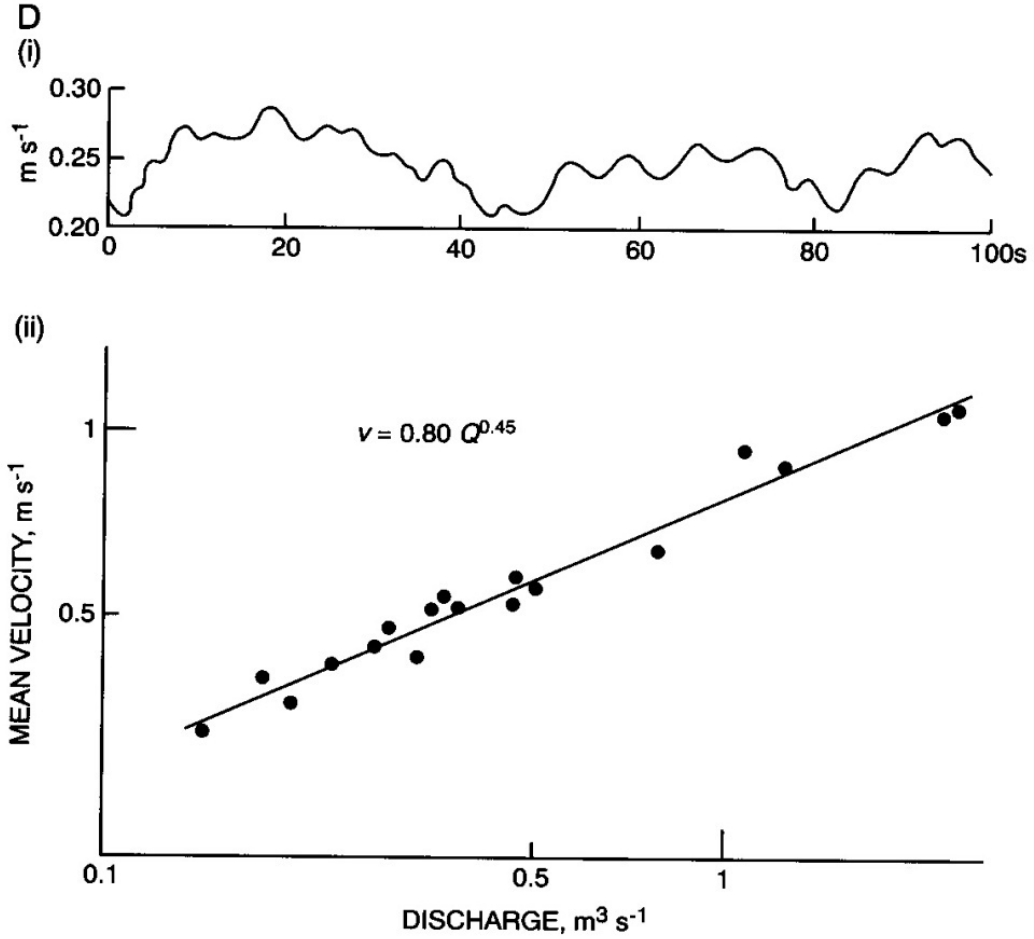
- Local changes in velocity (constrictions, pools, etc.)
- Channels become bigger, smoother → less bed and bank resistance





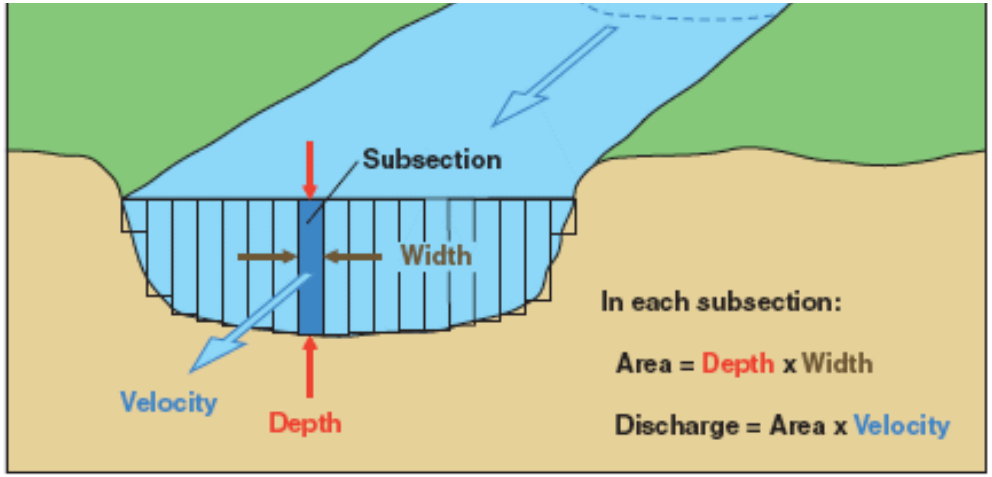
Velocity variations

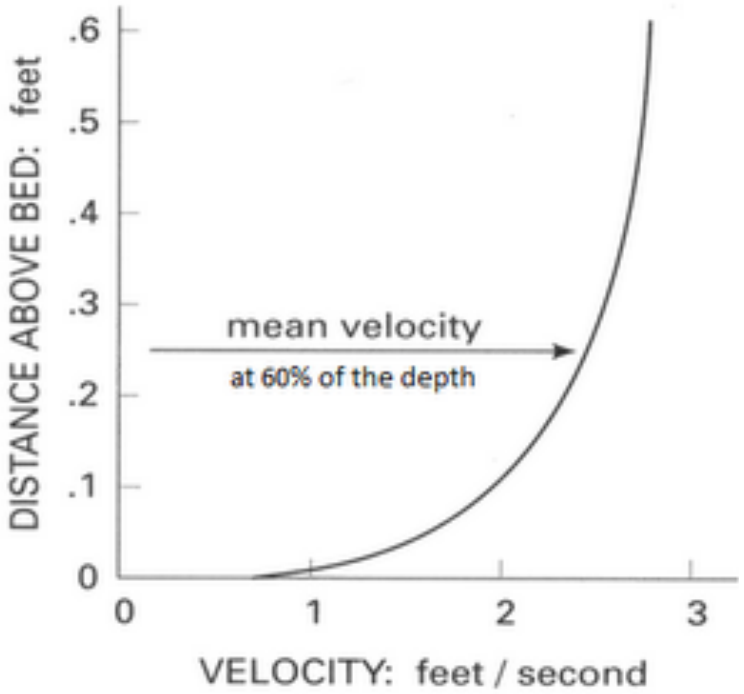
- Turbulence causes small, rapid fluctuations in velocity
  - Need to measure velocity over a period to average out
- At high flow, velocity is faster



Best practices for measuring velocity

- Divide stream into 10-20+ subsections, measure width and depth of each
- For <0.5 m deep flow, measure velocity at 40% up from bed
- For >0.5 m deep flow, measure at 20% and 80% up from bed and average
- Average each measurements over some time period (≥30 s) to account for turbulence





Velocity-area method in wadable streams

http://pubs.usgs.gov/fs/FS-036-98/graphics/bridgemeasure.jpg

http://www.usgs.gov/homepage/science_features/water_scientist.asp

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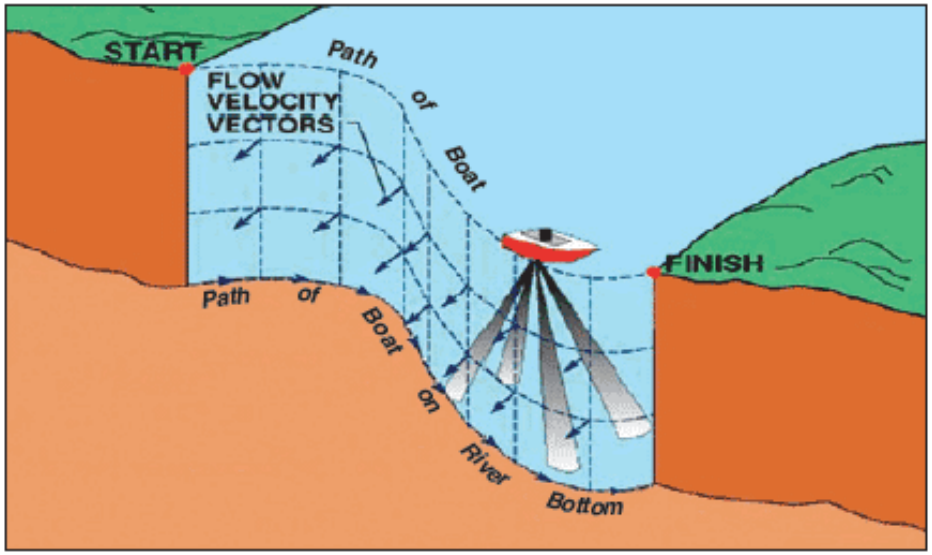
Acoustic Doppler Current Profiler

- Measures velocity at all depths as it is passes across the stream



See also: http://www.whoi.edu/instruments/viewInstrument.do?id=819

Weirs

- Simple geometry allows calculation of discharge from stage
- BUT barrier to fish & boats, so not used in larger streams

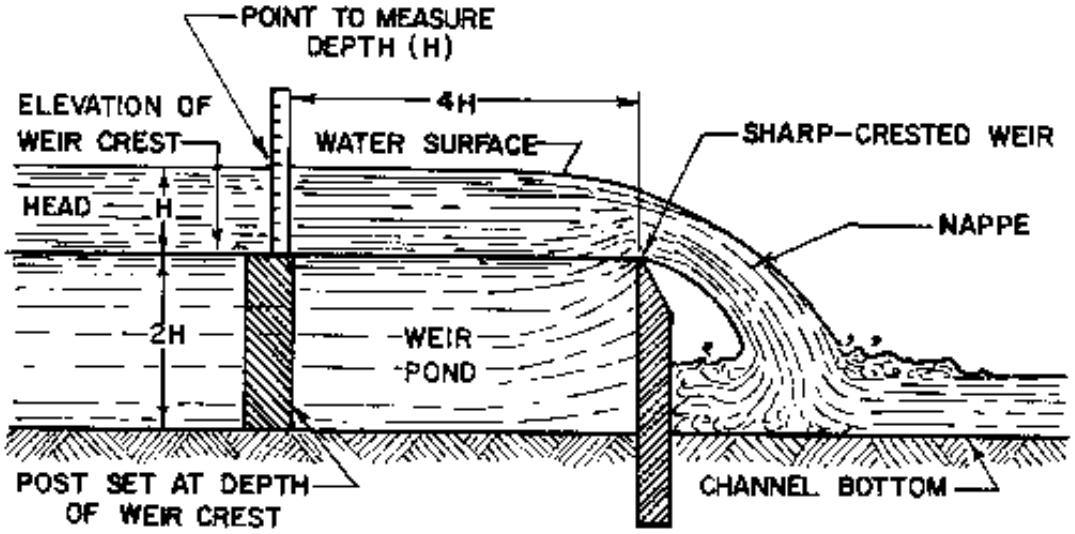
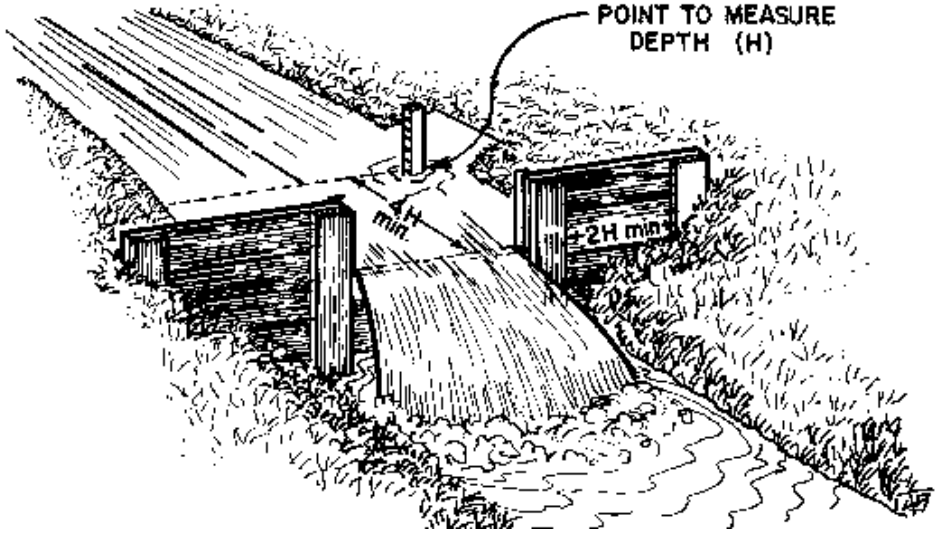
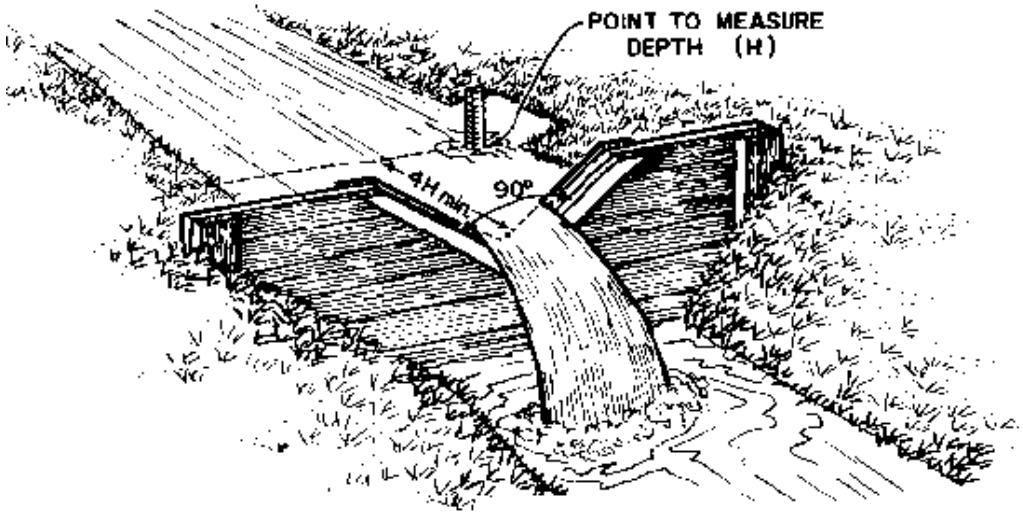


FIGURE 1.—PROFILE OF A SHARP-CRESTED WEIR





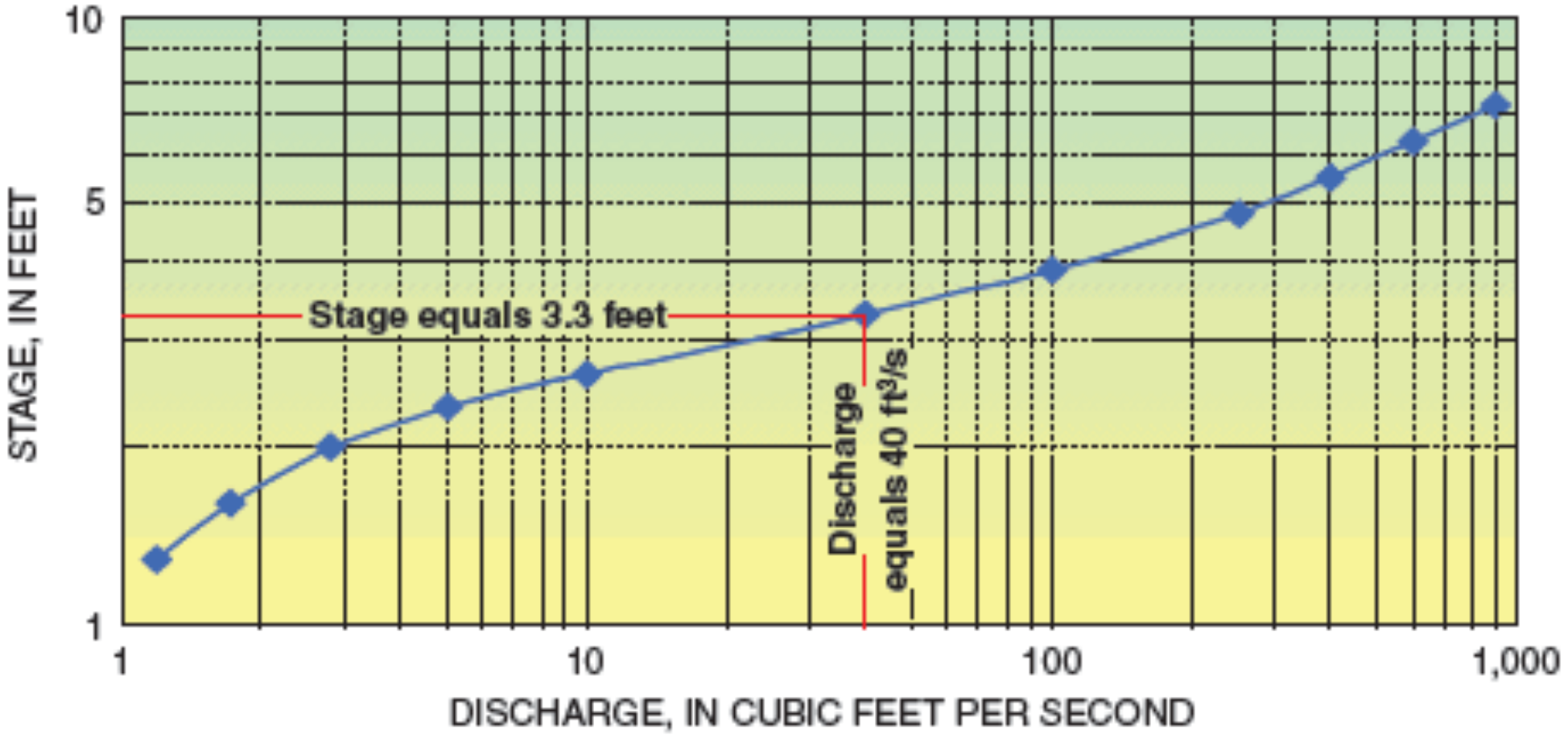
Images: University of Florida Cooperative Extension Service

See also: http://www.hubbardbrook.org/w6_tour/weir-stop/weirwork.htm

Dilution Gaging

- Involves adding a non-reactive, chemical tracer to a flowing stream, and monitoring how this tracer becomes diluted after it has completely mixed throughout the water as it travels downstream

Summary: We measure velocity x area at multiple different stages, to create a rating curve, from which we derive a hydrograph.



Note: If the cross-section where stage is measured changes (erosion/deposition), you need a new rating curve.