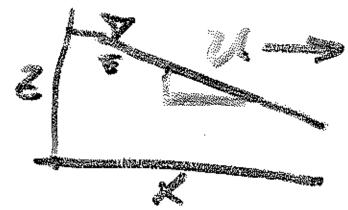
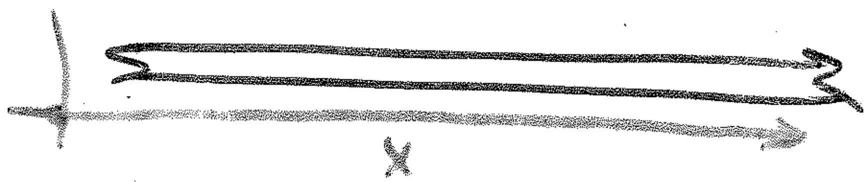
RIVERS

- Gravity-Driven Flow

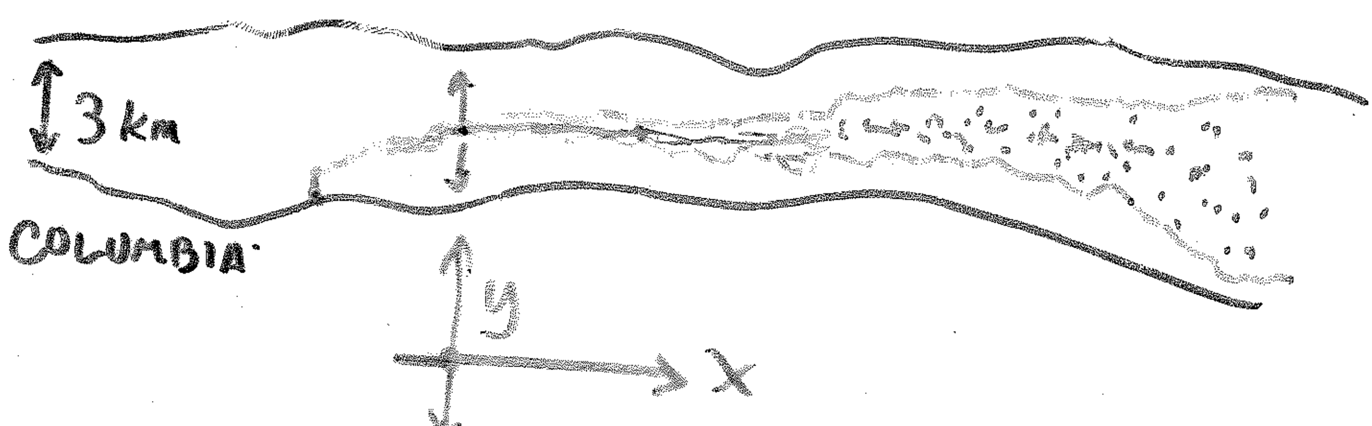


- "Long & Narrow"

- Hence often approximated as 1-D (x-dir)
  Esp. w/r/t VELOCITY & FLOW

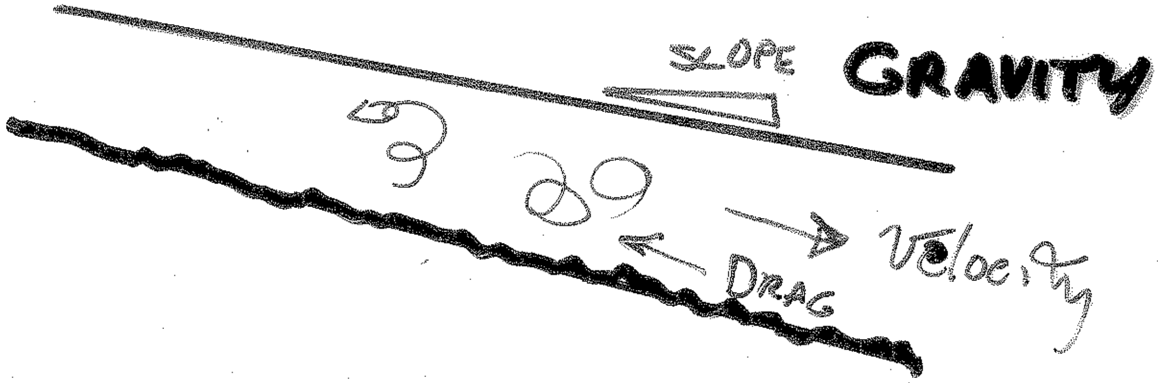


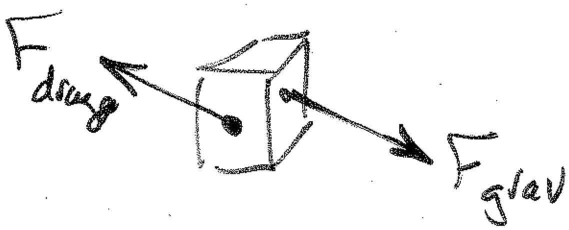
- BUT Also may need to consider
  TRANSVERSE DISPERSION (y; Horizontal

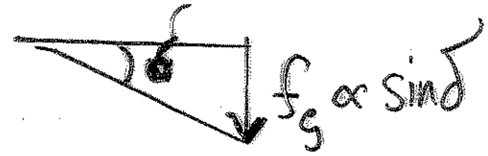


(Relatively SHALLOW: $y_{max} = 3000$ m
HENCE VERTICAL (DEPTH) AVERAGE $z_{max} = 30$ m)

PHYSICAL TRANSPORT IN RIVERS







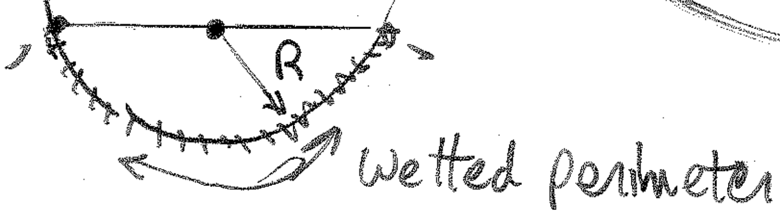
At steady velocity

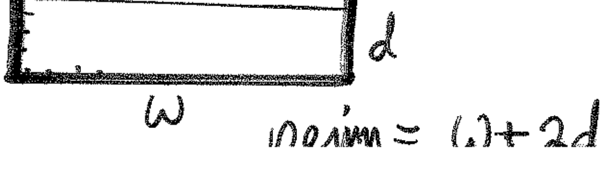
$$F_{drag} = F_{grav}$$

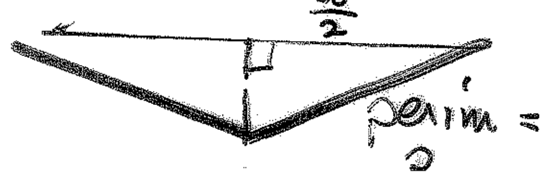
EMPIRICAL FACTORS : Manning or Chezy FRICTION FACTORS

FUNDAMENTAL PHYSICS : Slope & wetted contact area

HYDRAULIC RADIUS : $R \equiv \frac{A_{x.s.}}{\text{Wet. Perim.}}$







VELOCITY EQNS $v = f(\text{SLOPE})$

Chezy

$$V = C\sqrt{RS}$$

Manning

$$V = \frac{1.49\, R^{2/3} S^{1/2}}{n}$$

NEED DATA

1. Slope: Difference in water level relative to some datum (MSL) per axial distance.

2. Manning or Chezy Coefficients (empirical; tabulated)

3. Need A_{xs} & wetted perimeter
   - Estimate from width & depth
   - Or (better) measure in field

MANNING: More common for rivers but developed orig. for pipes & open channels

$$V = \frac{1.49\, R^{2/3}\, S^{1/2}}{n}$$

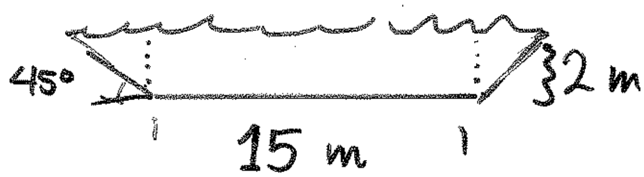
MUST USE R in <u>feet</u>
V = ft/s (fps)

$n \cong 0.035$ for winding streams

$\approx 0.04 - 0.05$ for rough, rocky beds

<u>EXAMPLE</u>

WINDING, MOD. SHALLOW RIVER ...



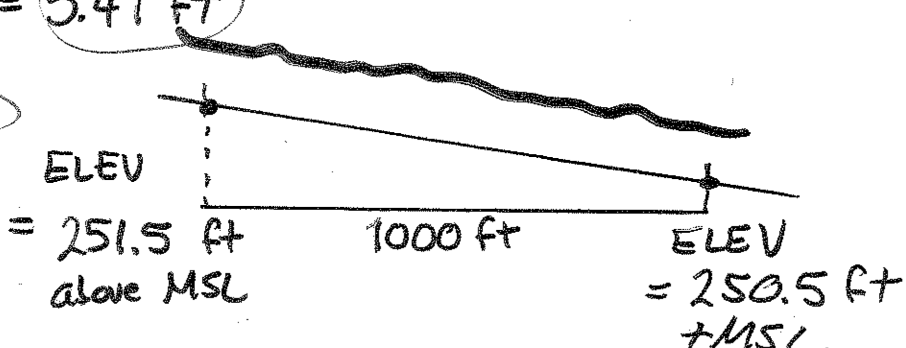
$$R = \frac{A_s}{\text{Perim}} = \frac{(15\text{ m} \times 2\text{ m}) + (2\text{ m} \times 2\text{ m})}{15\text{ m} + (2\sqrt{2} + 2\sqrt{2})\text{ m}} = \frac{34\text{ m}^2}{20.6\text{ m}}$$

$R = 1.65\text{ m} = 5.41\text{ ft}$

$n = 0.035$

$S = \frac{1\text{ ft}}{1000\text{ ft}}$

$S = 0.001$



$$V = \frac{1.49\,(5.4)^{0.667}\,(0.001)^{1/2}}{0.035} = 4.1\text{ fps}$$

RIVER HYDRAULICS

Basics we already know:

DISCHARGE: $Q = VA_{x.s.}$

- Q ← VOLUME PER UNIT TIME
- V ← MEAN VELOCITY
- $A_{x.s.}$ ← X.S. AREA

Discharge measurement:

EITHER:

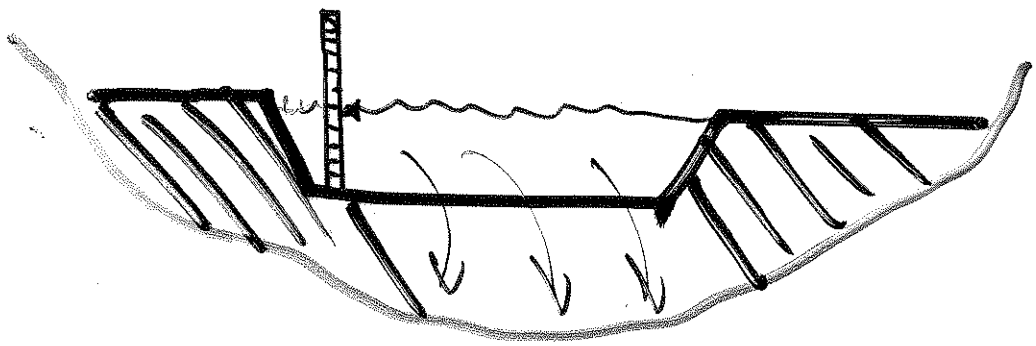
ACTUAL DISCHARGE (Q)

- Use weir or flume that's calibrated
- Depth gives Q from a "rating curve"

MEAN VELOCITY IN KNOWN AREA

- Take velocity measurments with flow anemometer (mechanical, electronic, acoustic-doppler)
- Measure cross-sectional area from bathymetry & depth

WEIR:



- Known geometry & hydraulics
- Measure head or water level
- Use table or eqn for that weir to find Q

ADVANTAGES:

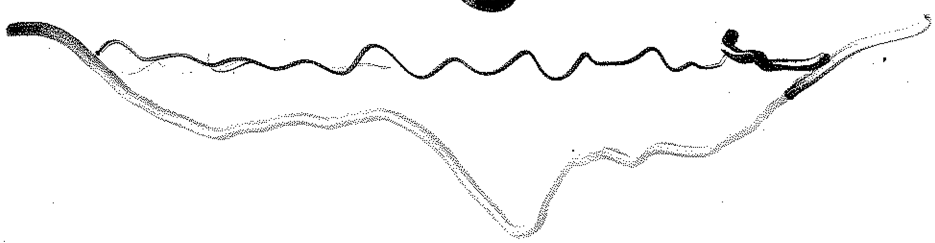
- Simple yet accurate
- Rugged
- Can be easily automated

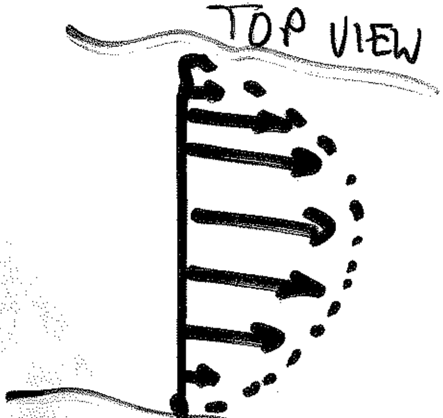
DISADVANTAGES

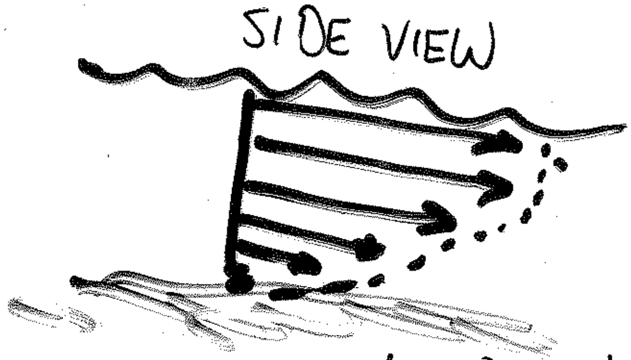
- Have to divert entire stream or river thru weir
- Disruptive, costly

VELOCIMETRY

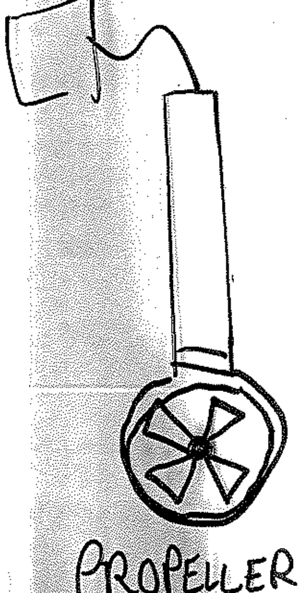
All sorts of ways to measure velocity directly



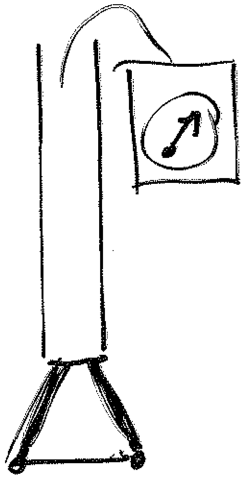




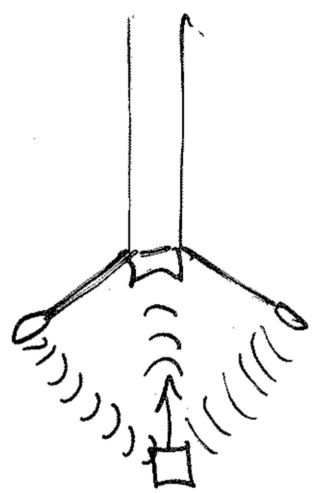
TROUBLE IS: Velocity varies with distance from boundaries



PROPELLER TYPE



"HOT WIRE" ANEMOMETER



ACOUSTIC DOPPLER VELOCIMETER

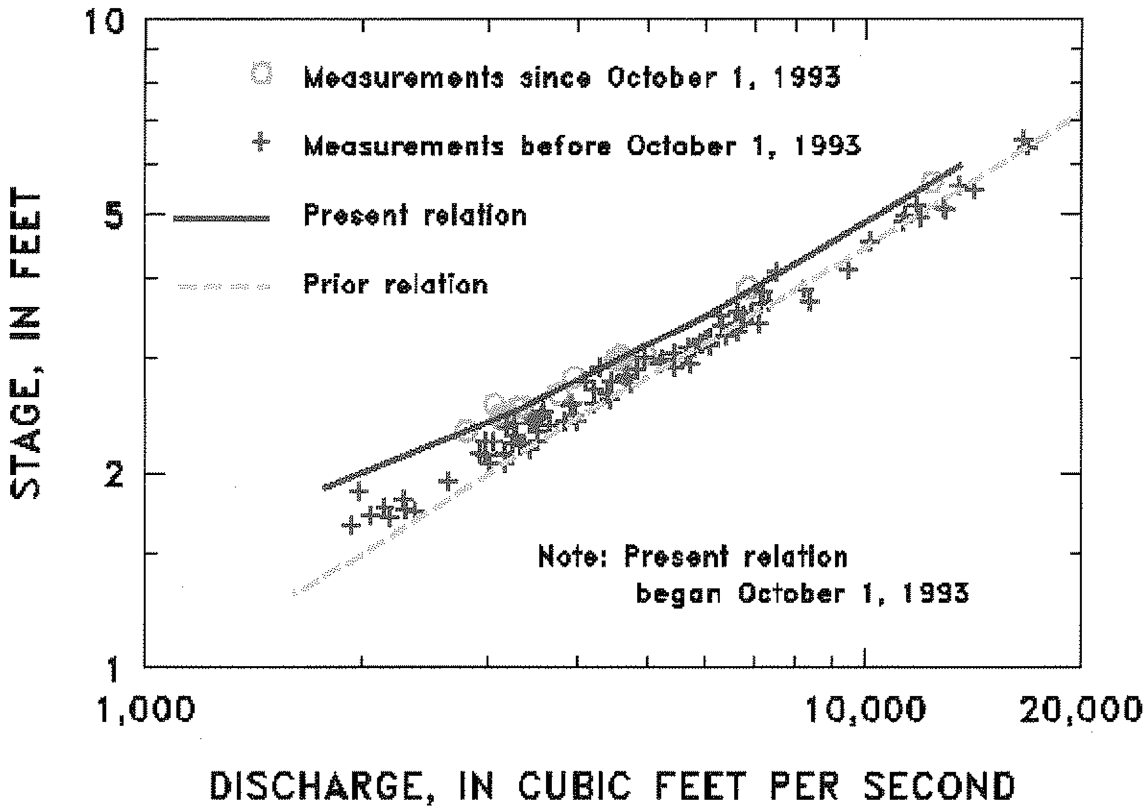
VELOCIMETRY

ADVANTAGES:

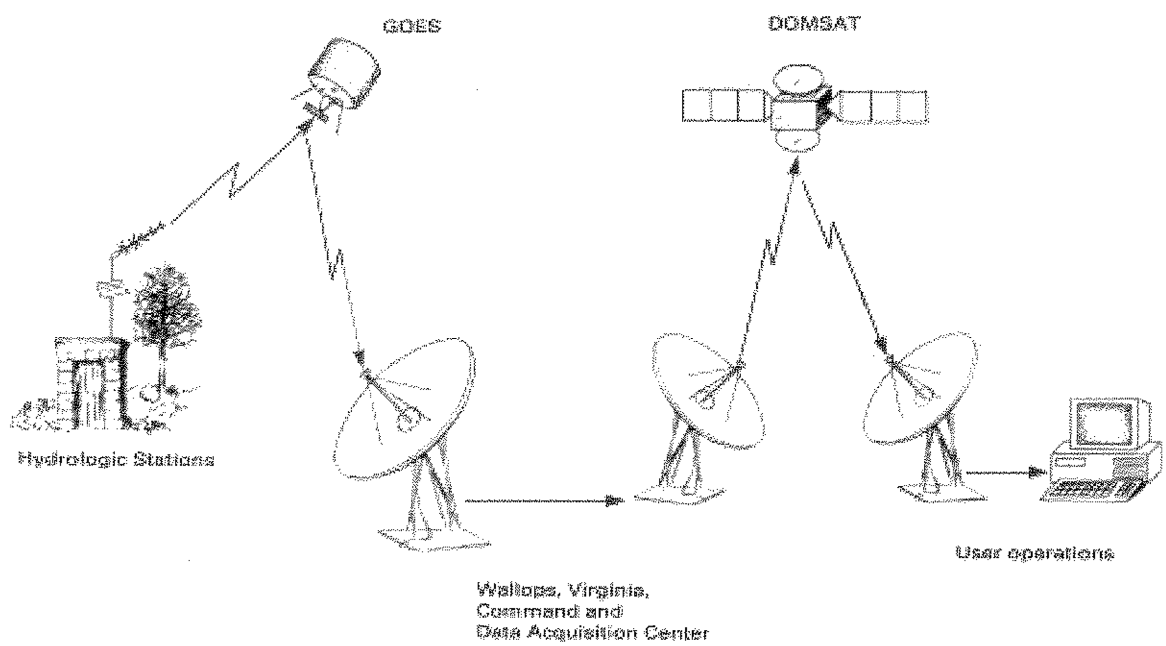
- Gives details of flow & velocity distribution, shear
- Portable, no permanent structures
- Can use in any size stream or river

DISADVANTAGES

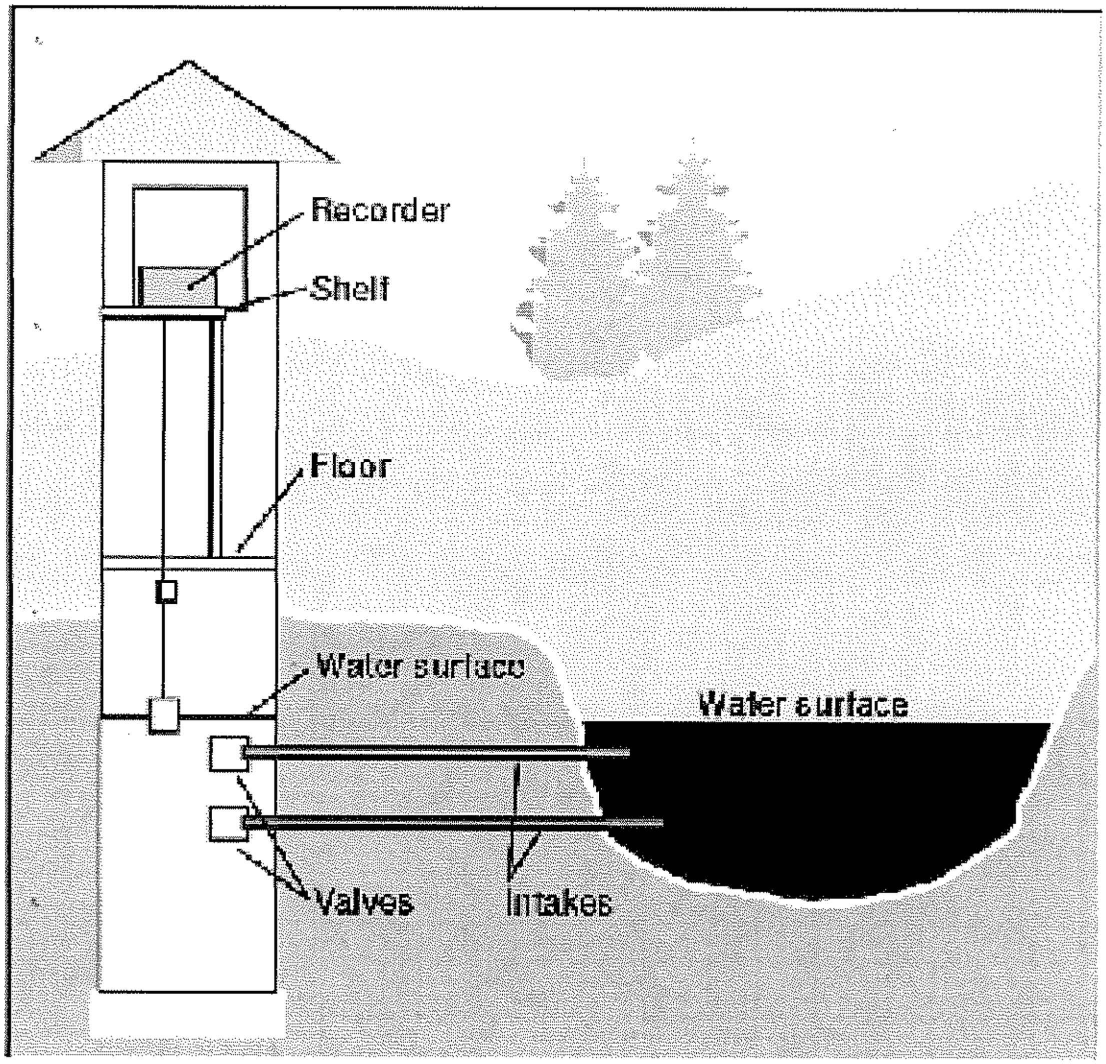
- Must know A_{xs} to get Q
- A_{xs} varies with Q & is non-linear so must measure A_{xs} for each Q
- Hard to automate, at least for Q
- Labor intensive
- Expensive, finicky equipment

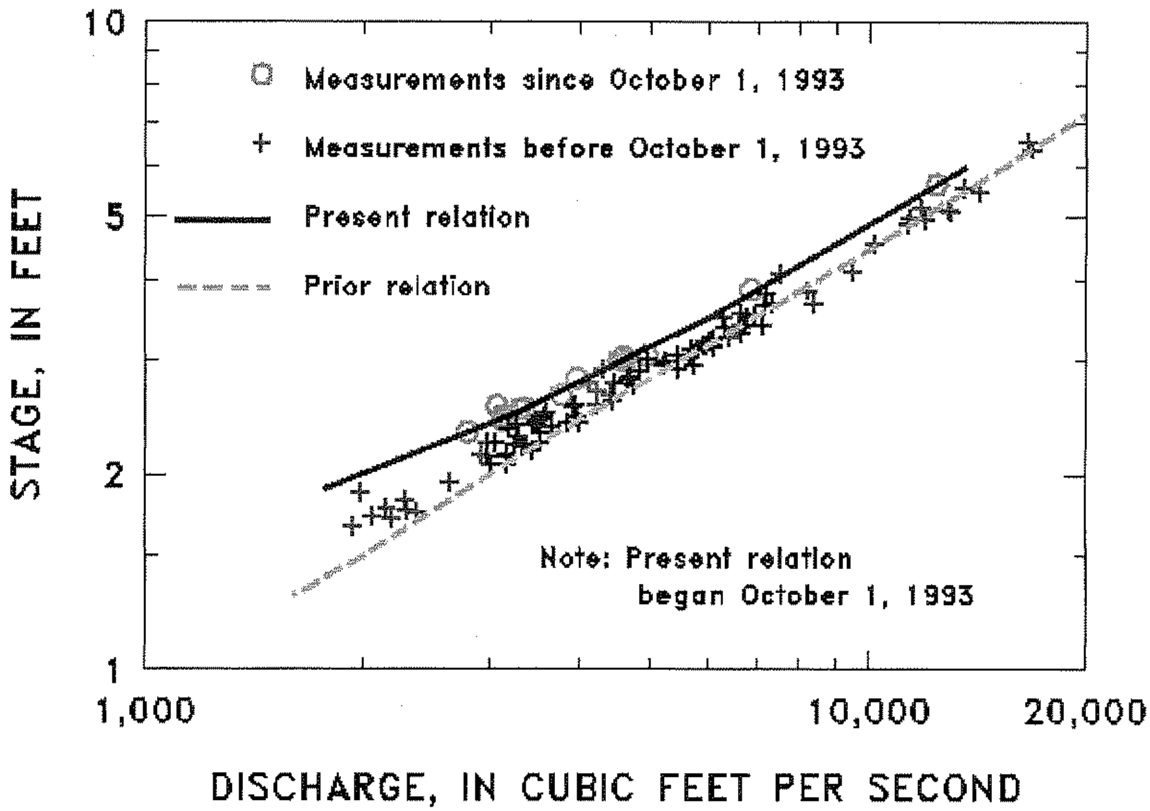


Measurements since October 1, 1993
Measurements before October 1, 1993
Present relation
Prior relation
Note: Present relation began October 1, 1993
STAGE, IN FEET
10
5
2
1
1,000
10,000
20,000
DISCHARGE, IN CUBIC FEET PER SECOND



GOES
DOMSAT
Hydrologic Stations
Wallops, Virginia, Command and Data Acquisition Center
User operations


Recorder
Shelf
Floor
Water surface
Water surface
Valves
Intakes


10
5
2
1
1,000
10,000
20,000
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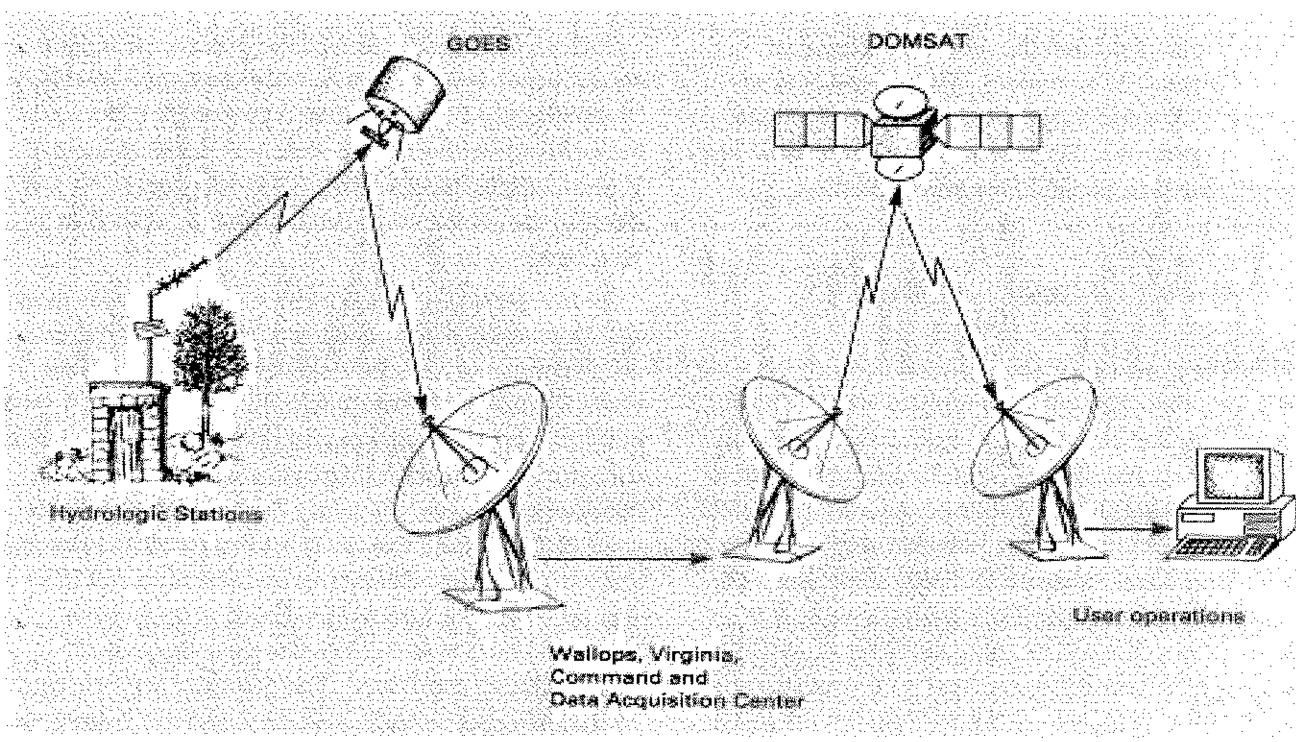
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