Updated: 11 September 2017

Print version

CEE 577: Surface Water Quality Modeling

Lecture #3
(Rivers & Streams)
Chapra, L14

Watershed & Hydrogeometric Parameters

- Geometry
  - Width and Depth
  - Slope
- Hydrology
  - Velocity and Flow
  - Mixing characteristics (dispersion)
- Drainage Area
- Dams, Reservoirs & flow diversions
- Geographical location of basin

Assessing Hydrogeometry

- Point Estimates vs. Reach Estimates
- Flow
  - often requires velocity
  - May use stage
    - USGS gaging stations

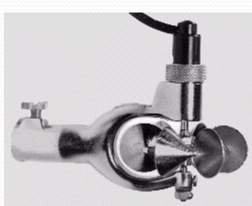
$$Q = UA_c$$

$$U = \frac{Q}{A_c}$$

- Velocity
  - Current Meter
  - Weighted Markers or Dye

Current Meters

- Price
- Pygmy



http://advmnc.com/Rickly/currmet.htm
http://www.swoffer.com/2200.htm

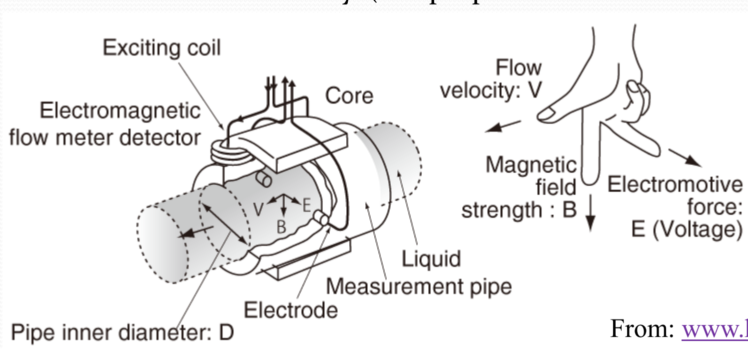
Electromagnetic sensors

- Hach FH950 flow meter

Images: www.hach.com

Principles of electromagnetic sensing

- Under Faraday's law of induction, moving conductive liquids inside of a magnetic field generates an electromotive force (voltage) in which the pipe inner diameter, magnetic field strength, and average flow velocity are all proportional. In other words, the flow velocity of liquid moving in a magnetic field is converted into electricity. (E is proportional to V × B × D)



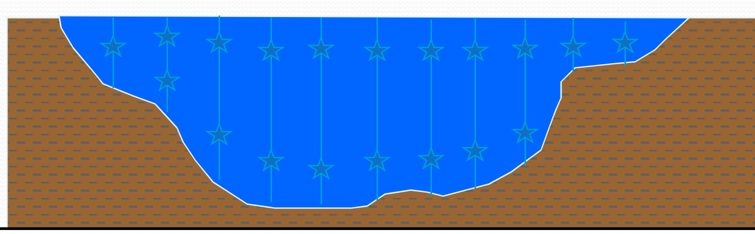
From: www.keyance.com

Current Meter Deployment

- Current meter and weight suspended from a bridge crane
- Wading rod and current meter used for measuring the discharge of a river

Current Meter Method

- Divide stream cross section into transects
- Measure velocity in each with meter
  - at 60% depth in shallow water (<2ft)
  - or 20% and 80% depth in deep water



Deployment cont.

- Crane, current meter, and weight used for measuring the discharge of a river from a bridge

From: U.S. GEOLOGICAL SURVEY CIRCULAR 1123; on the www at:
http://h2o.usgs.gov/public/pubs/circ1123/index.html

Moving Marker Methods

- Best for low velocity (<0.2 ft/s)
- Several types
  - Drogues (current at depth)
  - Dye (mixing too)
  - Surface objects (Oranges, Frisbees)
- Velocity from change in location with time

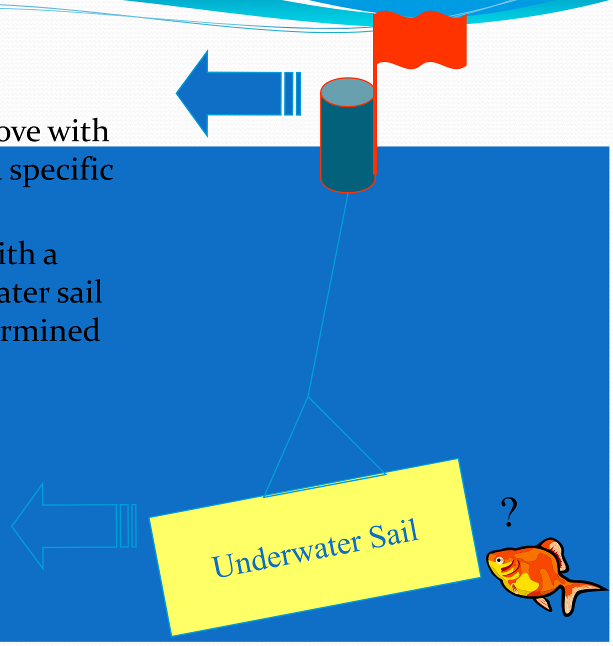
$$U_{avg} = \frac{\Delta x}{t^*}$$

Time of travel

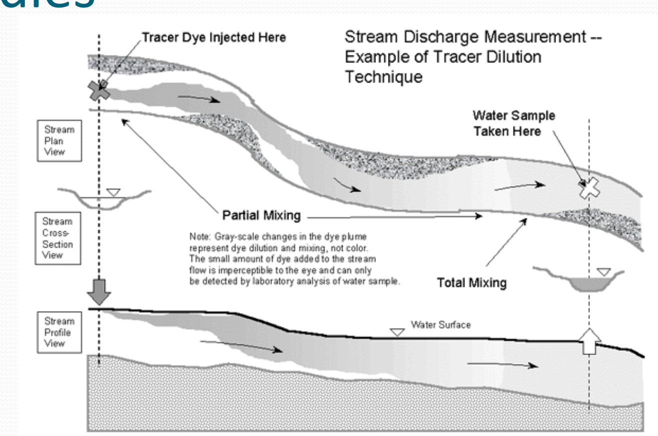
$$Q_{avg} = U_{avg}\left(\frac{A_1 + A_2}{2}\right)$$

Drogues

- Designed to move with the current at a specific depth
- Surface float with a plastic underwater sail set at a predetermined depth



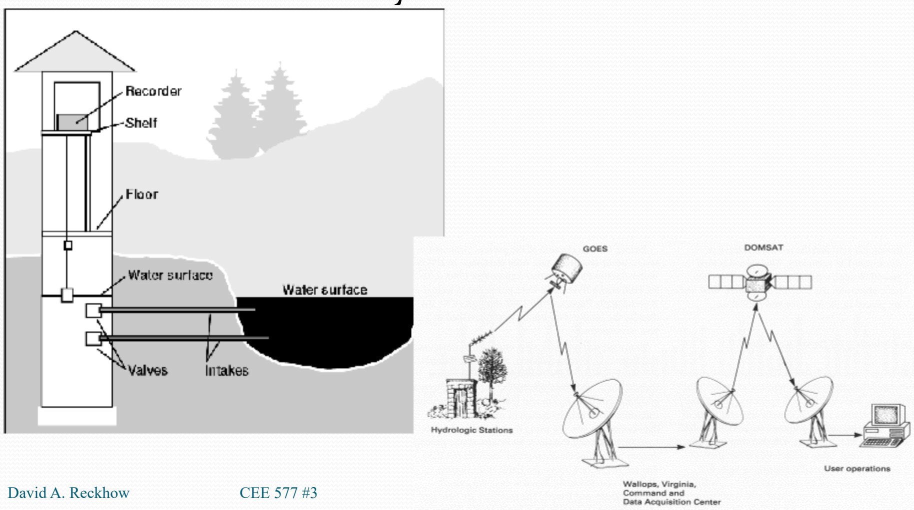
Dye studies



Drawing courtesy of R. D. Mac Nish, University of Arizona, Tucson (http://www.tucson.ars.ag.gov/salsa/research/research_1997/AMS_Posters/gw-sw_interactions/gw-sw_f1.html)

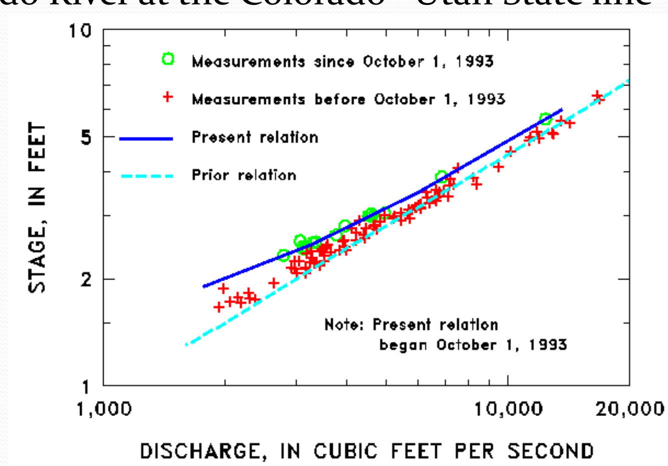
USGS Gaging Stations

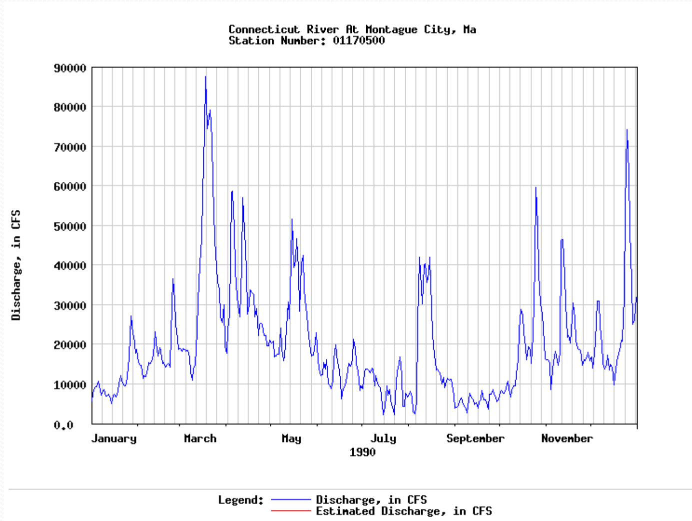
- Hardware & telemetry



Stage vs Discharge

- Sections of stage-discharge relations for the Colorado River at the Colorado--Utah State line





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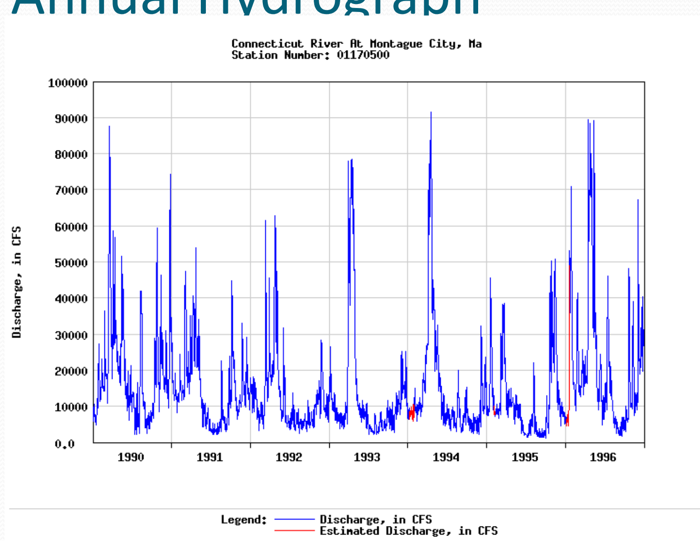
Annual Hydrograph



Perennial flow regime

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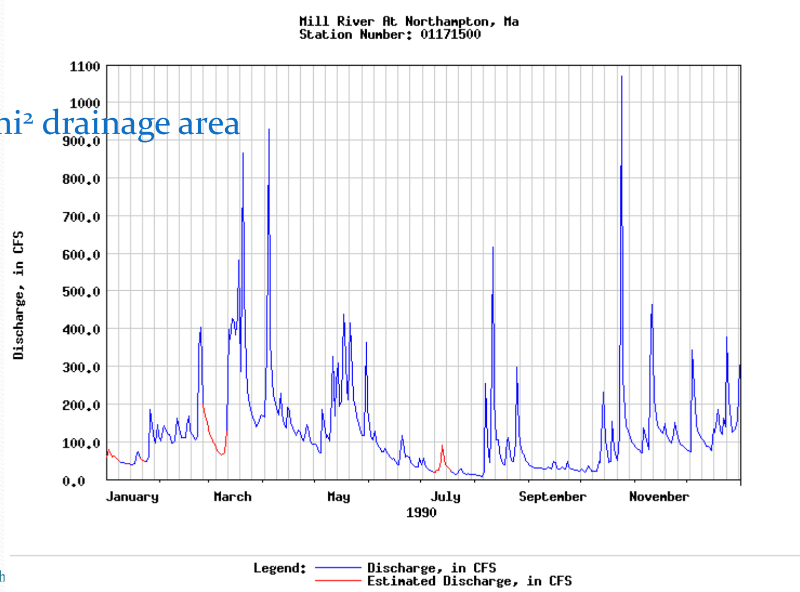
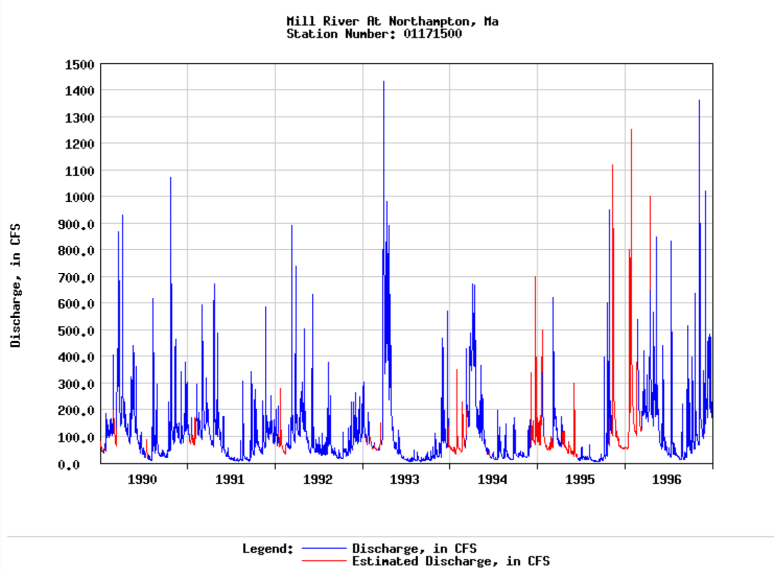
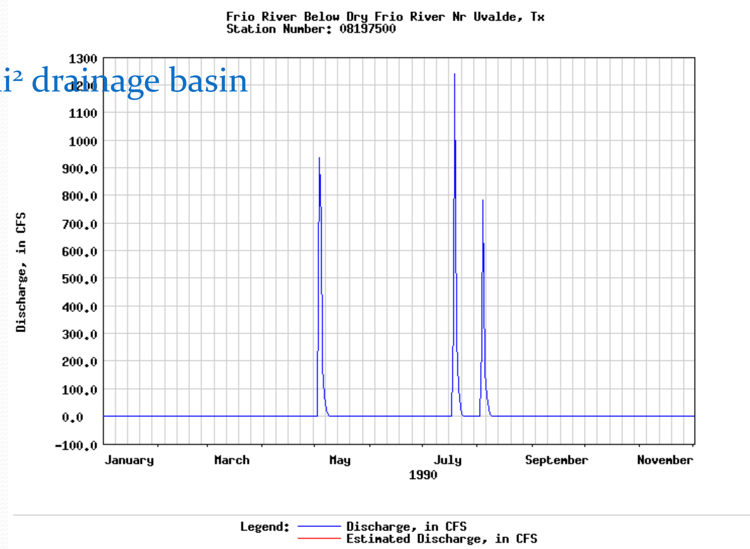
- 52 mi² drainage area





- 631 mi² drainage basin



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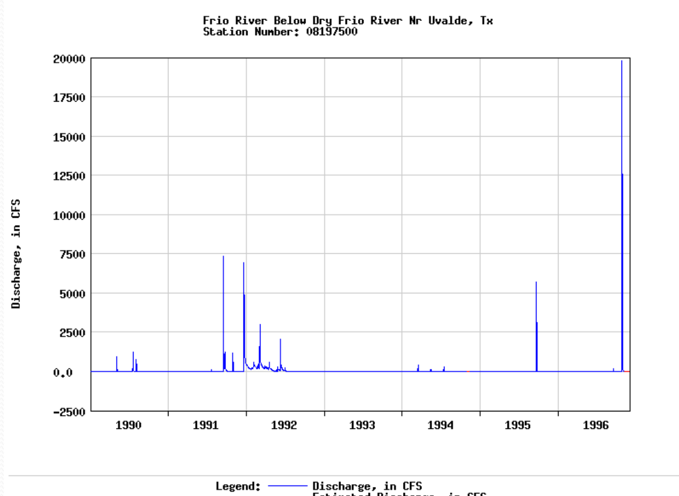
Ephemeral River



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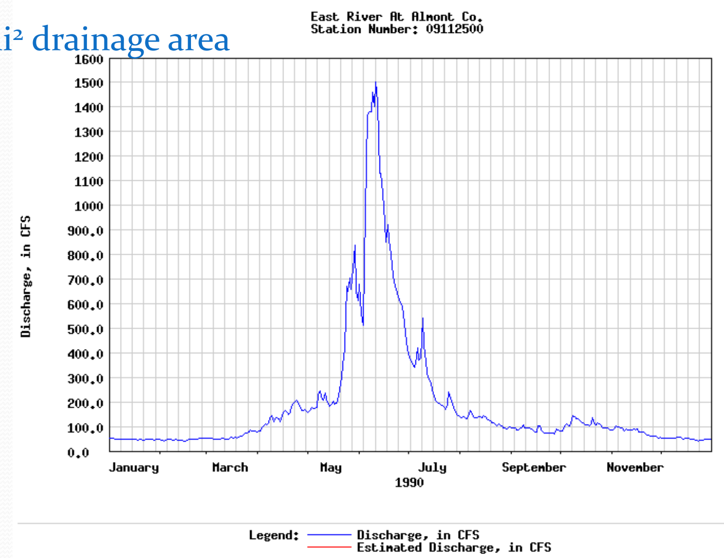
- 289 mi² drainage area



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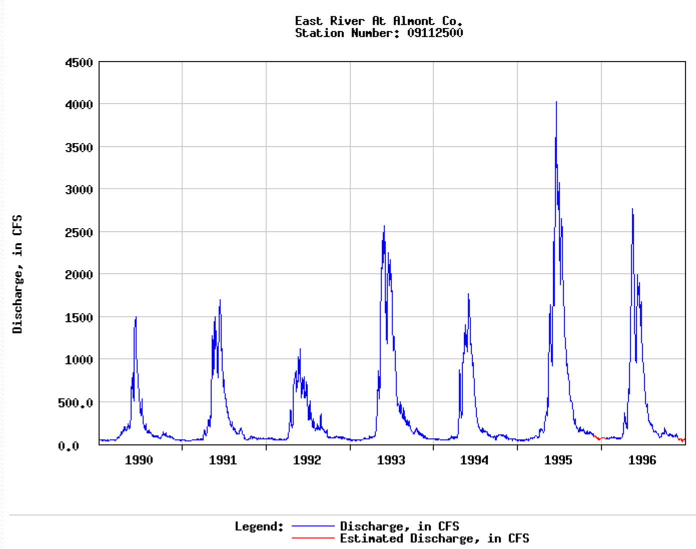
Snow melt



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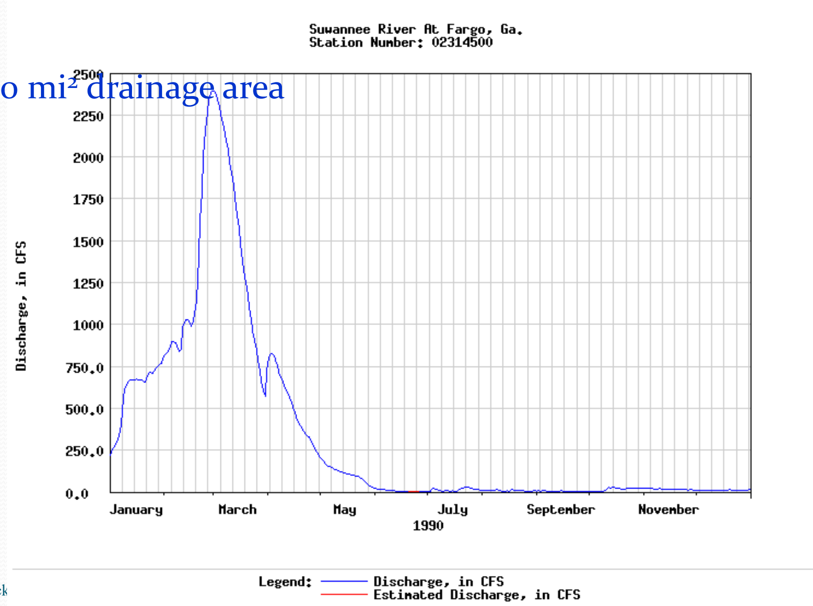
- 1260 mi² drainage area



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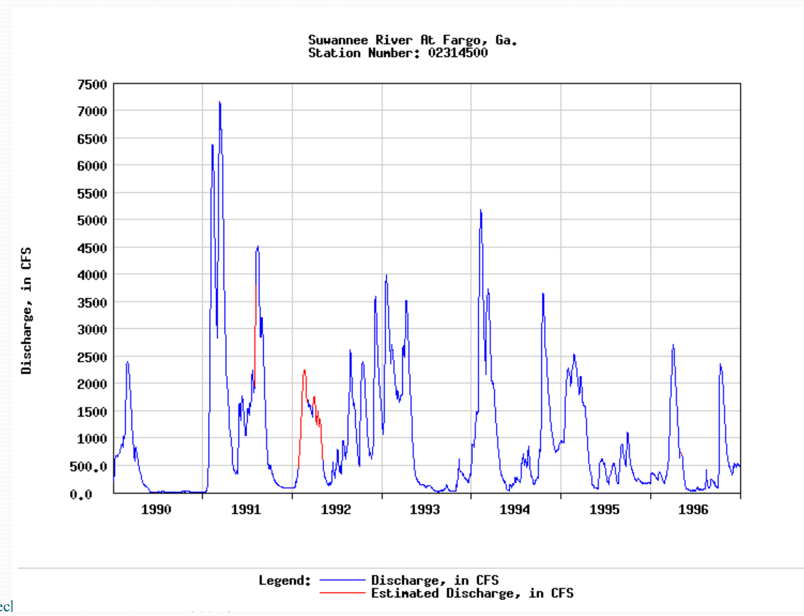

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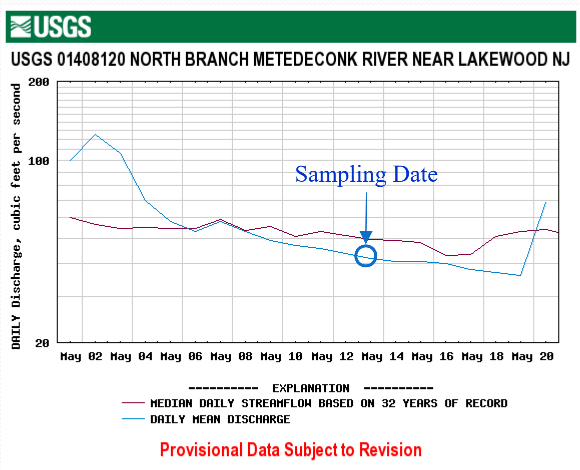
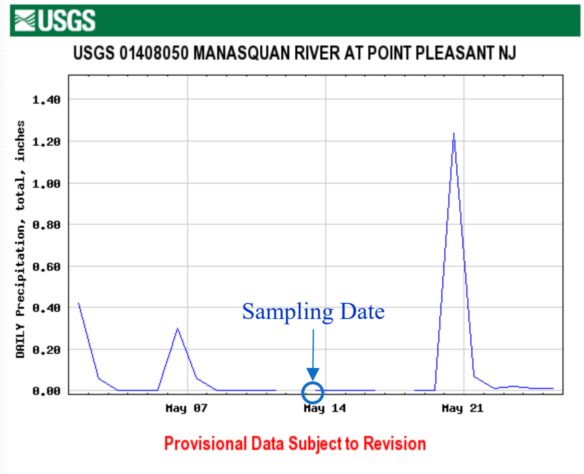
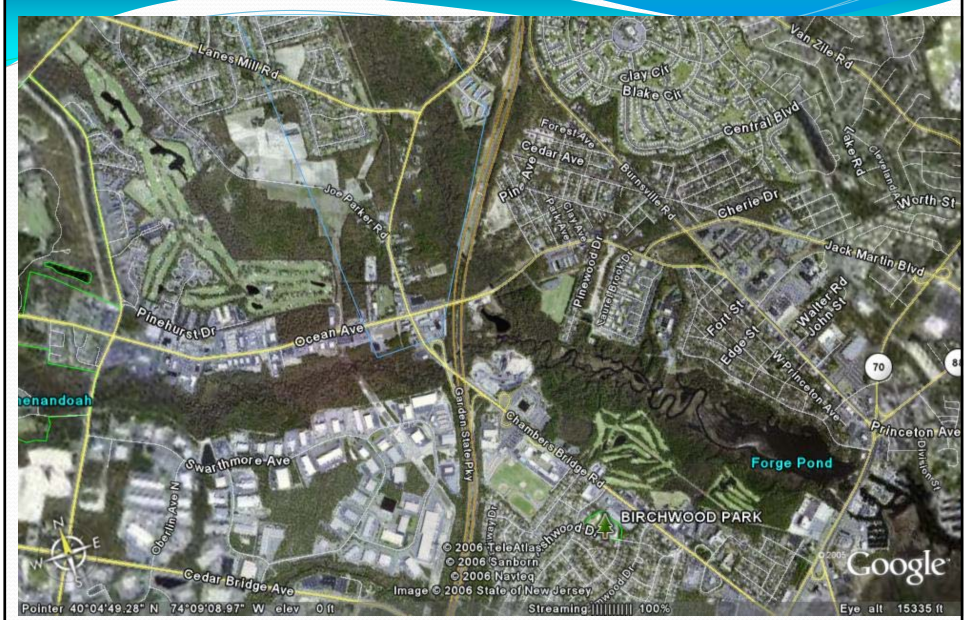
USGS Data Sources

- For "real time" data see:
  - http://water.usgs.gov/public/realtime.html
- For "historical" data see:
  - http://waterdata.usgs.gov/usa/nwis/




USGS
USGS 01408050 MANASQUAN RIVER AT POINT PLEASANT NJ
DAILY Precipitation, total, inches
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
May 07
May 14
May 21
Sampling Date
Provisional Data Subject to Revision


Lanes Mill Rd
Van Zile Rd
Clay Cir
Blake Cir
Central Blvd
Forest Ave
Cedar Ave
Burnsville Rd
Lake Rd
Worth St
Joe Parker Rd
Cherie Dr
Jack Martin Blvd
Pinehurst Dr
Ocean Ave
Fort St
Edge St
Walter Rd
John St
Princeton Ave
Garden State Pkwy
Chambers Bridge Rd
Swarthmore Ave
Forge Pond
BIRCHWOOD PARK
Oberlin Ave N
Cedar Bridge Ave
© 2006 TeleAtlas
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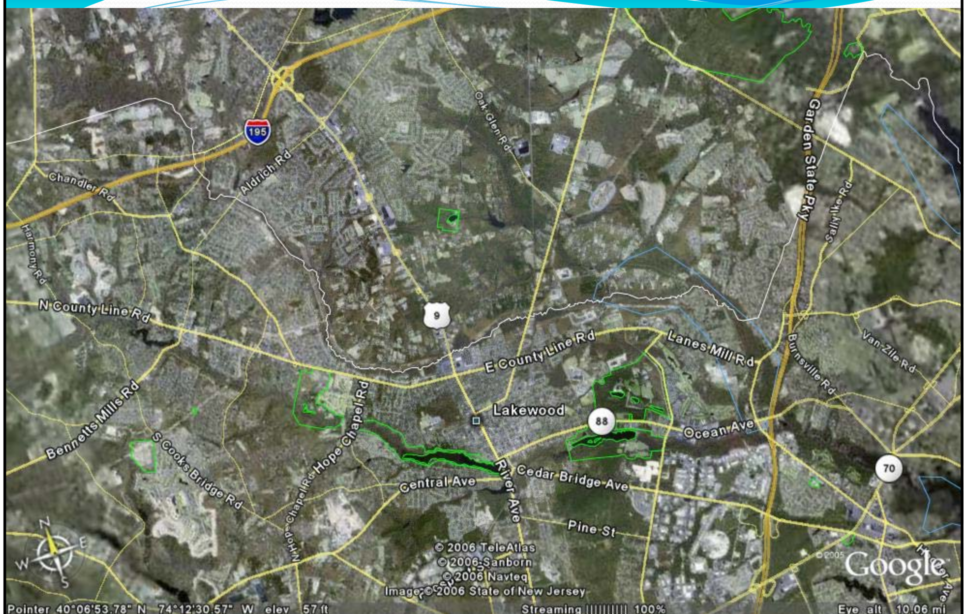
Google
Pointer 40°04'49.28" N 74°09'08.97" W elev 0 ft
Streaming 100%
Eye alt 15335 ft



Other resources

- **There are two WQN publications available from the USGS:**
  - The CD-ROMs are published in a 2-disc set as USGS Digital Data Series DDS-37, entitled "Data from Selected U.S. Geological Survey National Stream Water-Quality Monitoring Networks (WQN)" by R.B. Alexander, J.R. Slack, A.S. Ludtke, K.K. Fitzgerald, and T.L. Schertz. The cost is $42 plus shipping and handling costs.
  - Copies of Open-File Report 96-337, entitled "Data from Selected U.S. Geological Survey National Stream Water-Quality Monitoring Networks (WQN) on CD-ROM" by R.B. Alexander, A.S. Ludtke, K.K. Fitzgerald, and T.L. Schertz, are available for $12.75 in paper or $4.00 on microfiche. DDS-37 contains an electronic ASCII version of the text with GIF and PostScript illustrations and an HTML version accessible with Web browser.
- **To order, write or call:**
- U.S. Geological Survey
  Branch of Information Services
  Box 25286
  Denver, Colorado 80225-0286
  1-800-435-7627

Summary

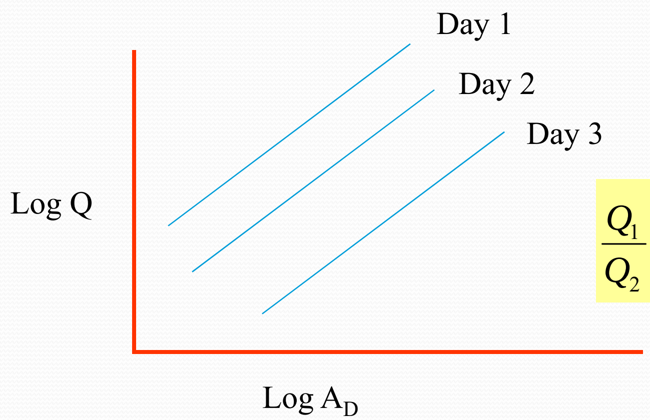
- Natural conditions that affect hydrograph
- Anthropogenic factors
  - impoundments
  - urbanization and channelization
    - quick runoff
  - human water use

Other uses and calculations

- Interpolation between measurement sites
- Dispersion, longitudinal and lateral
  - Driven by flow velocity and stream geometry
  - Determines distance to complete mixing
- Low flow analysis
  - Important for "design conditions"

Interpolating Flow Measurements

- For estimating flow between gaging stations
- Develop log-log relationship



$$\frac{Q_1}{Q_2} = \left(\frac{A_{D1}}{A_{D2}}\right)^y$$

Longitudinal Dispersion

- From Fischer et al., 1979

m/s

m^2s^{-1}

Width (m)

$$E = 0.011\frac{U^2B^2}{HU^*}$$

Mean depth (m)

Where the Shear Velocity is:

$$U^* = \sqrt{gHS}$$

Lateral Mixing

- Lateral or transverse dispersion coefficient for a stream:

Mean depth

$$E_{lat} = 0.6HU^*$$

Shear velocity

- Length required for complete mixing:

Side discharge:

$$L_m = 0.40U\frac{B^2}{E_{lat}}$$

Center discharge:

$$L_m = 0.10U\frac{B^2}{E_{lat}}$$

Width

Low Flow Analysis

- Generally the design condition
- 7Q10 = minimum 7-day flow that would be expected to occur every 10 years.
- Calculation
  - determine the minimum 7-day flow for each year of record (usually summer period)
  - list years in ascending order, assigning a rank (m)
  - Then probability or occurrence is:
  - Determine 10% probability flow from graph on probability paper

$$p = \frac{m}{N+1}$$

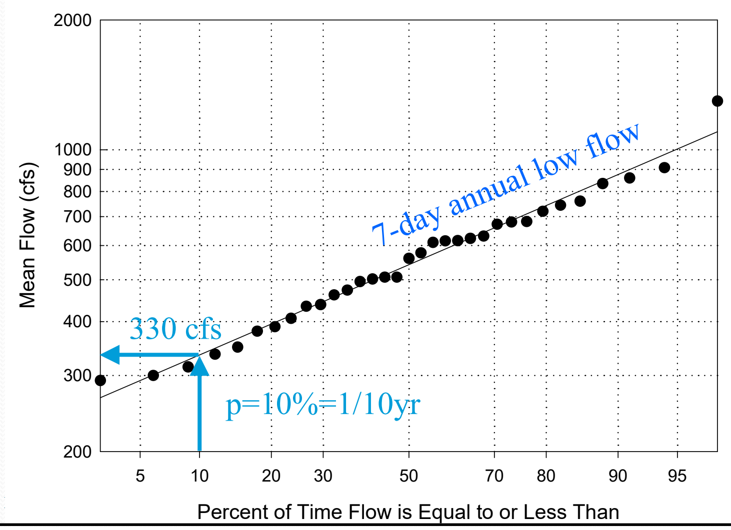
Low Flow Analysis: Data Table

- 33 years of data from: Schuylkill River @ Philadelphia

Rank	p	Q (cfs)
1	2.94	292
2	5.88	300
3	8.82	314
4	11.76	336
5	14.71	349
6	17.65	380
7	20.59	389
8	23.53	407
9	26.47	434
10	29.41	438
11	32.35	461
12	35.29	473
13	38.24	495
14	41.18	502
15	44.12	507
16	47.06	507
17	50.00	560
18	52.94	577
19	55.88	610
20	58.82	615
21	61.76	616
22	64.71	623
23	67.65	631
24	70.59	672
25	73.53	680
26	76.47	682
27	79.41	720
28	82.35	744
29	85.29	760
30	88.24	835
31	91.18	860
32	94.12	909
33	97.06	1297

Low Flow Analysis: Graph

- 7Q10 Graphical Solution: Schuylkill River @ Philadelphia



- Thomann & Mueller, pg. 39-40
- Chapra, pg. 243-244

- To next lecture