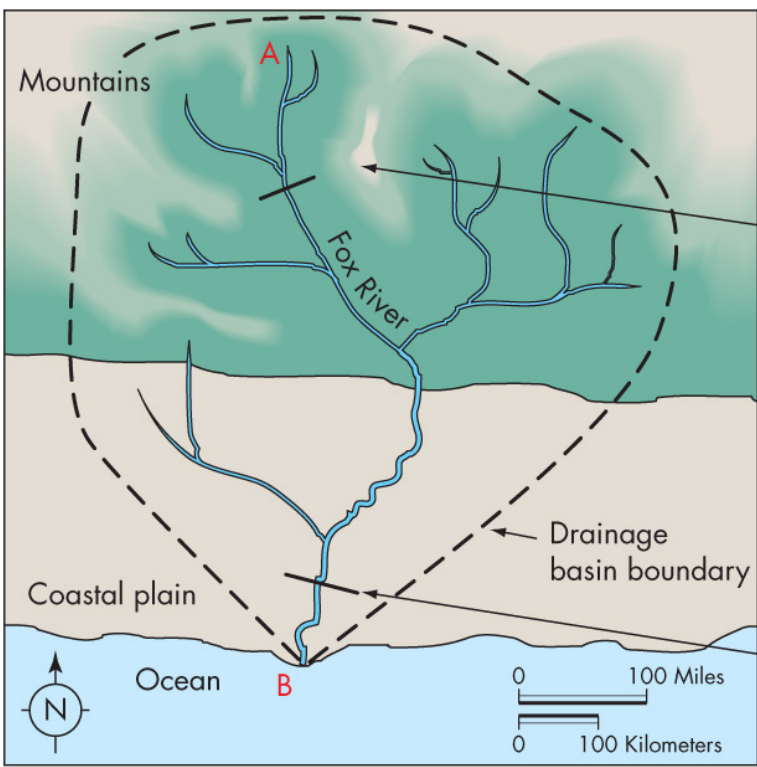
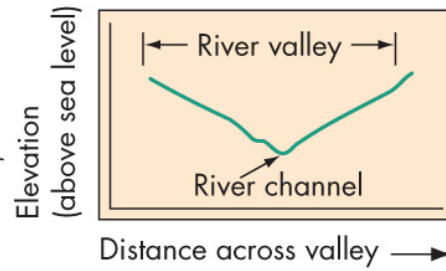


Drainage basins, river discharge, and flooding

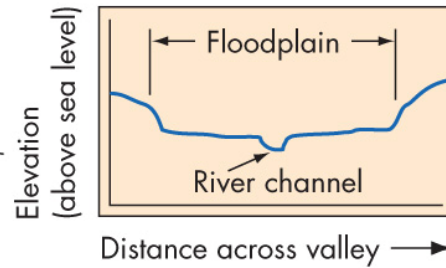




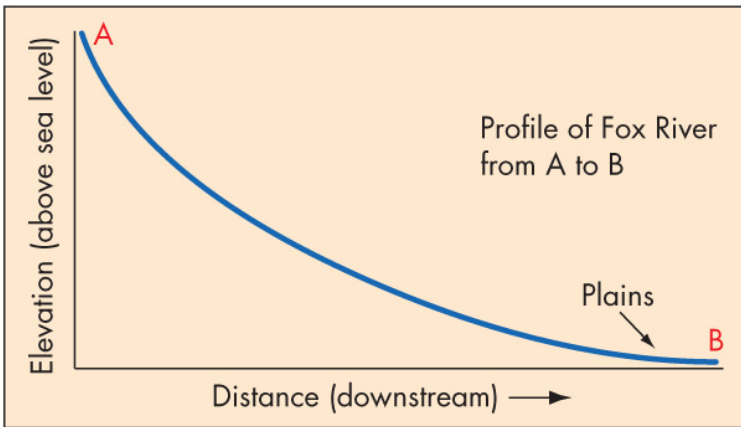
(a) Map (plan view)



(c) Cross section across river valley near headwater



(d) Cross section across river valley near base level



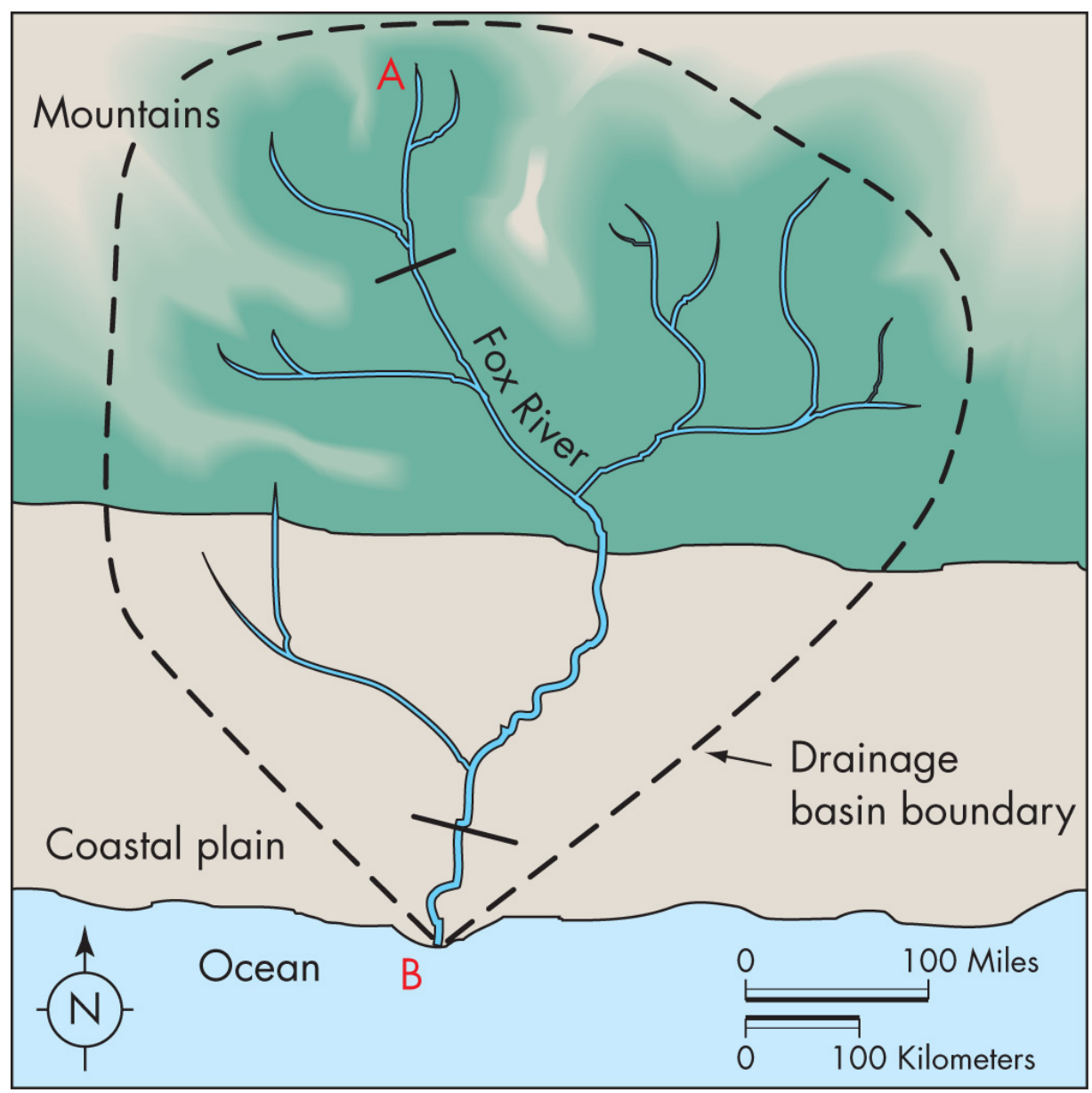
(b) Longitudinal profile

Concept of a drainage basin

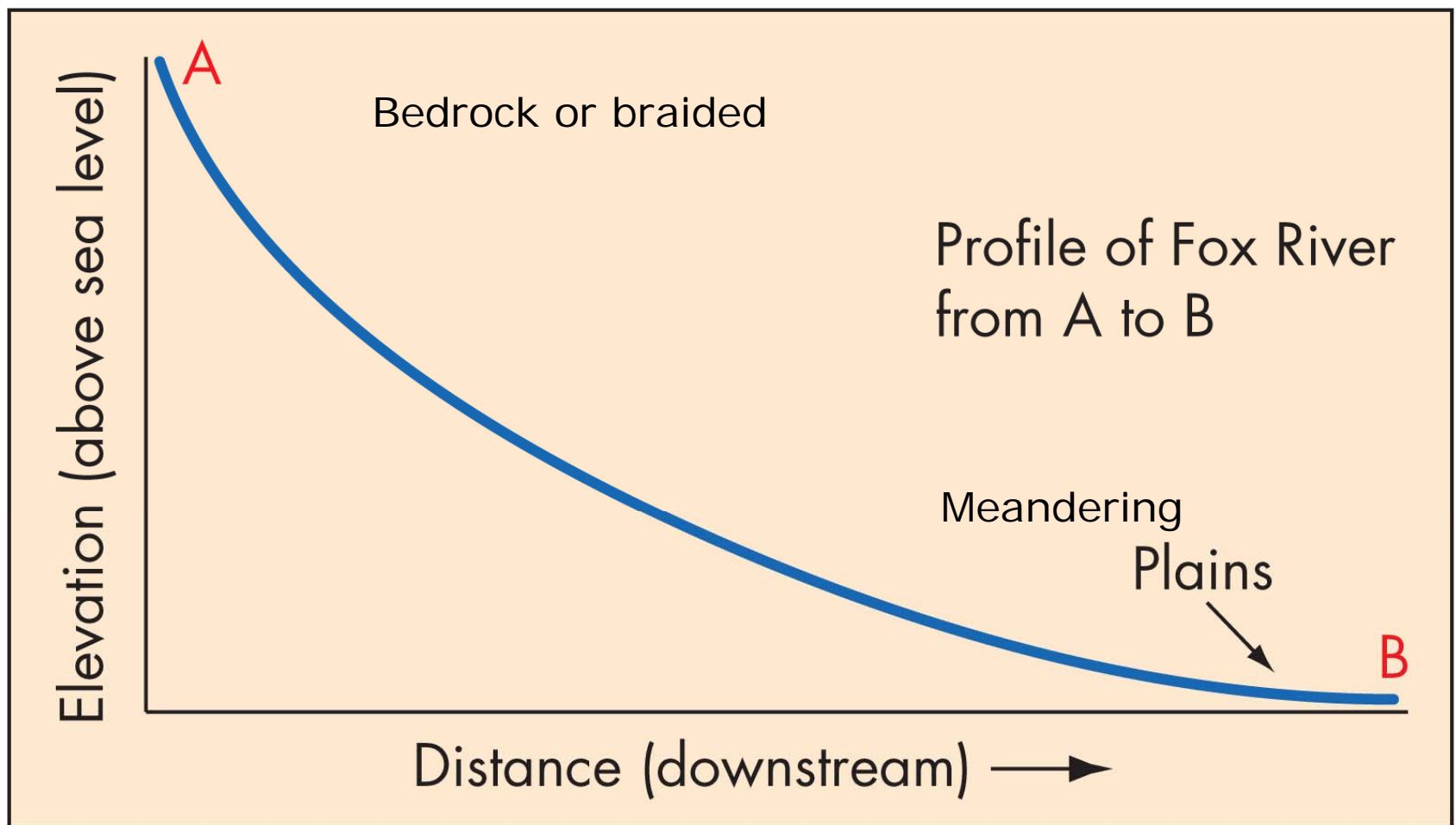
Figure 5.7

Drainage basin: All water flows out B

Also known
as a
watershed



Longitudinal profile down the river

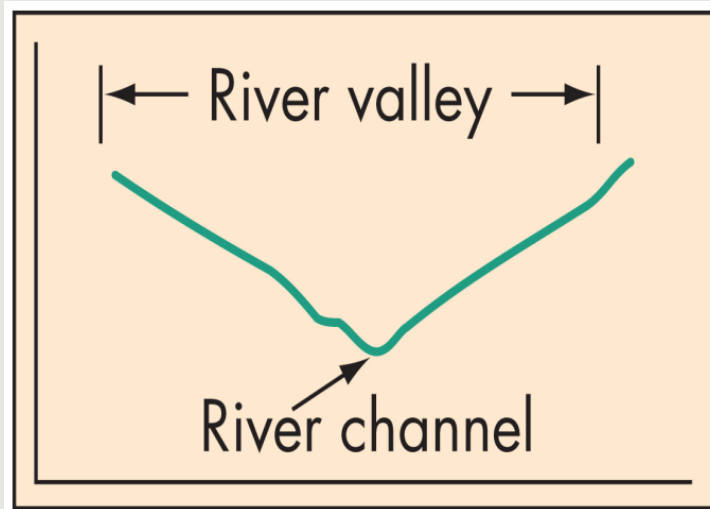


(b) Longitudinal profile

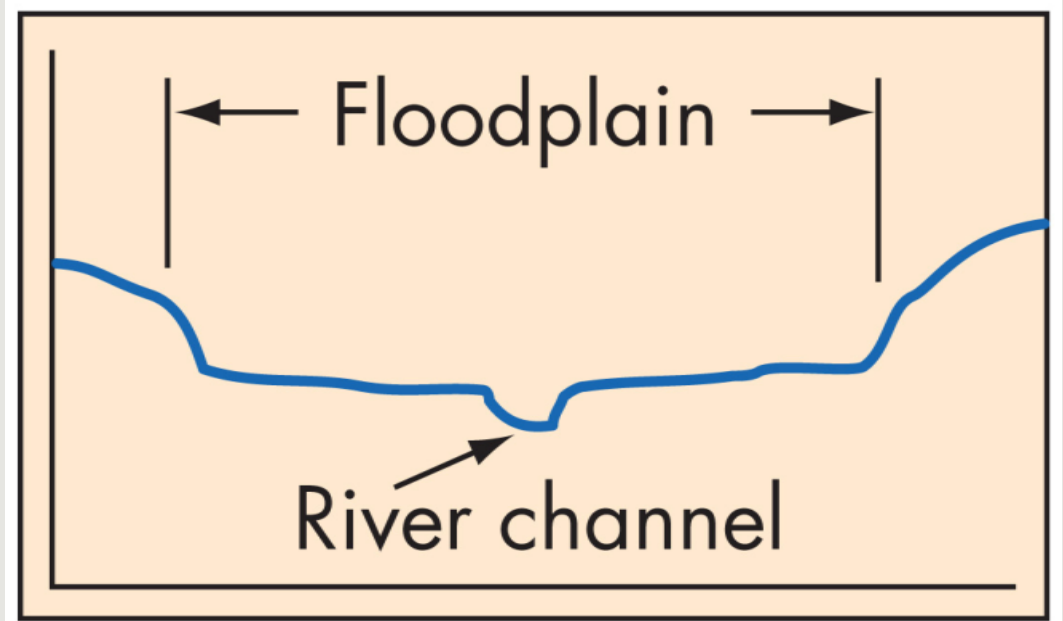
Figure 5.7b

Downstream changes in channel geometry

Upstream

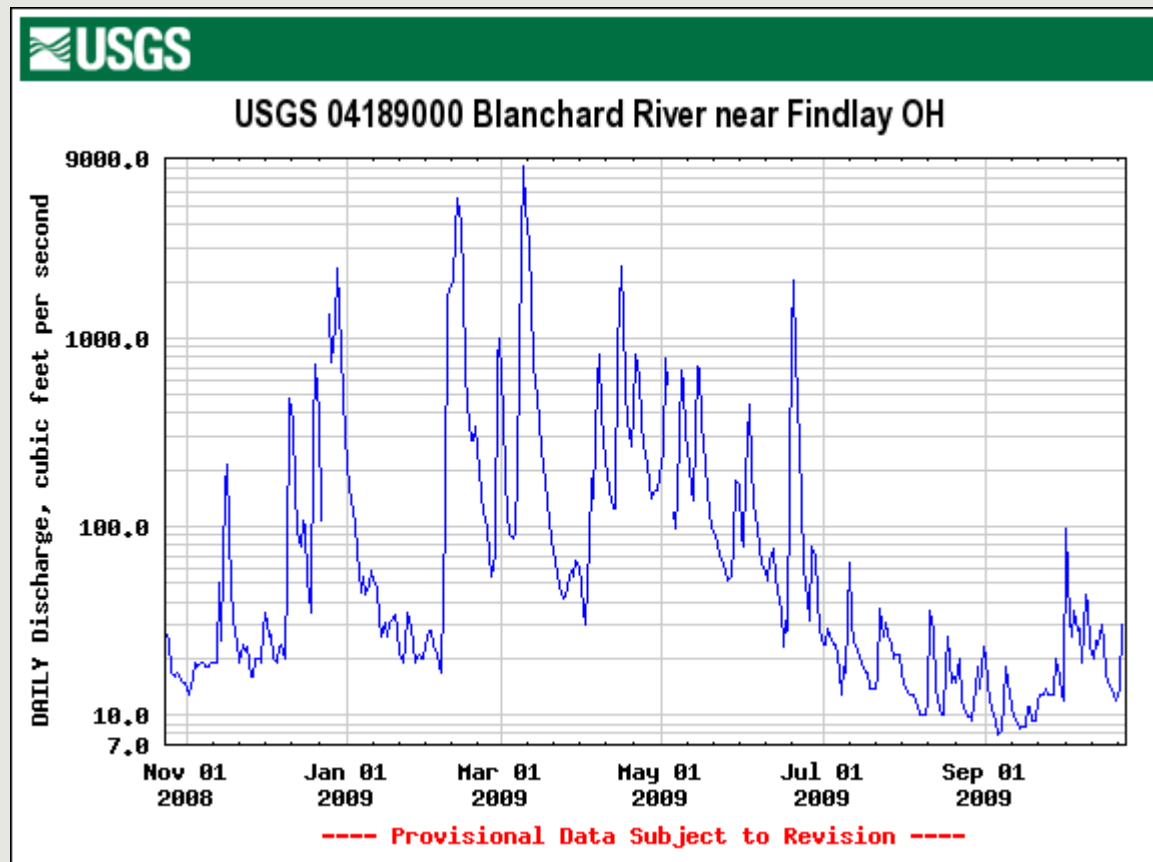


Downstream



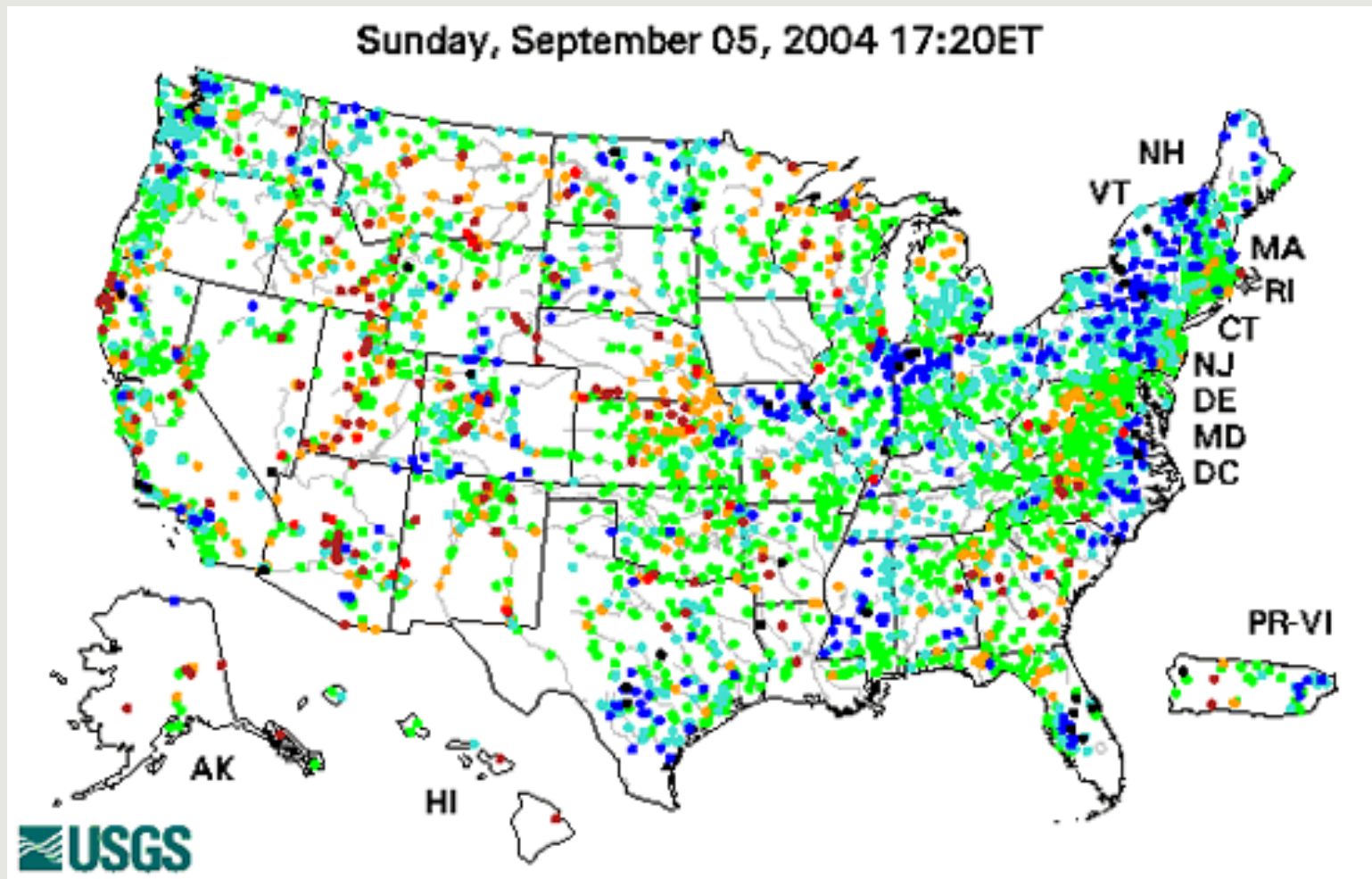
How much water? Measuring discharge

Discharge: The volume of water per unit time
USGS uses cubic feet per second

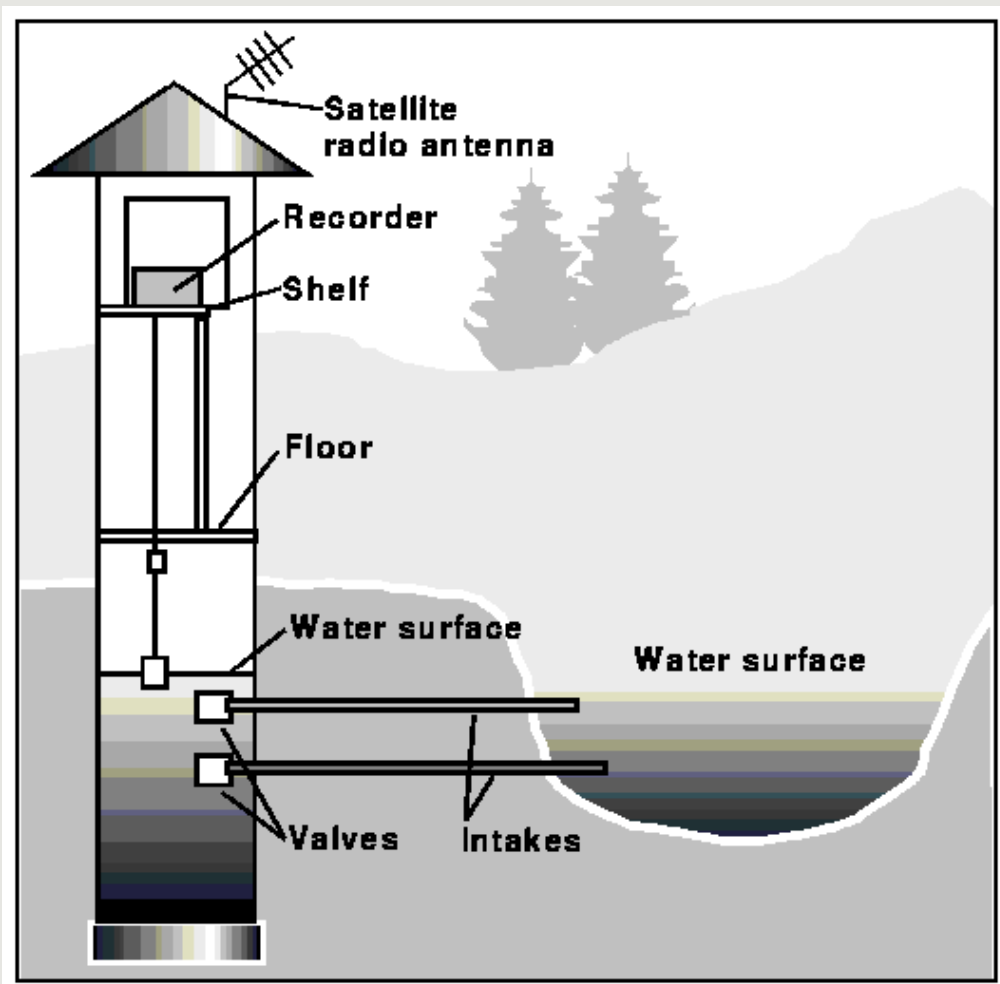


USGS stream gage network

Real-time data: www.USGS.gov



A standard USGS river gage station

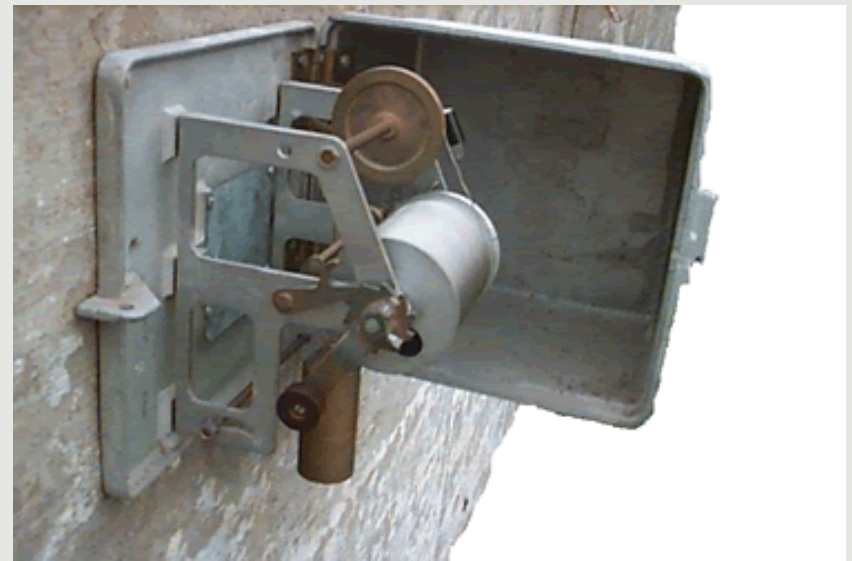


Continuous record
of water height

which is STAGE,
in feet above
a reference
elevation

Gage instruments

Staff gage

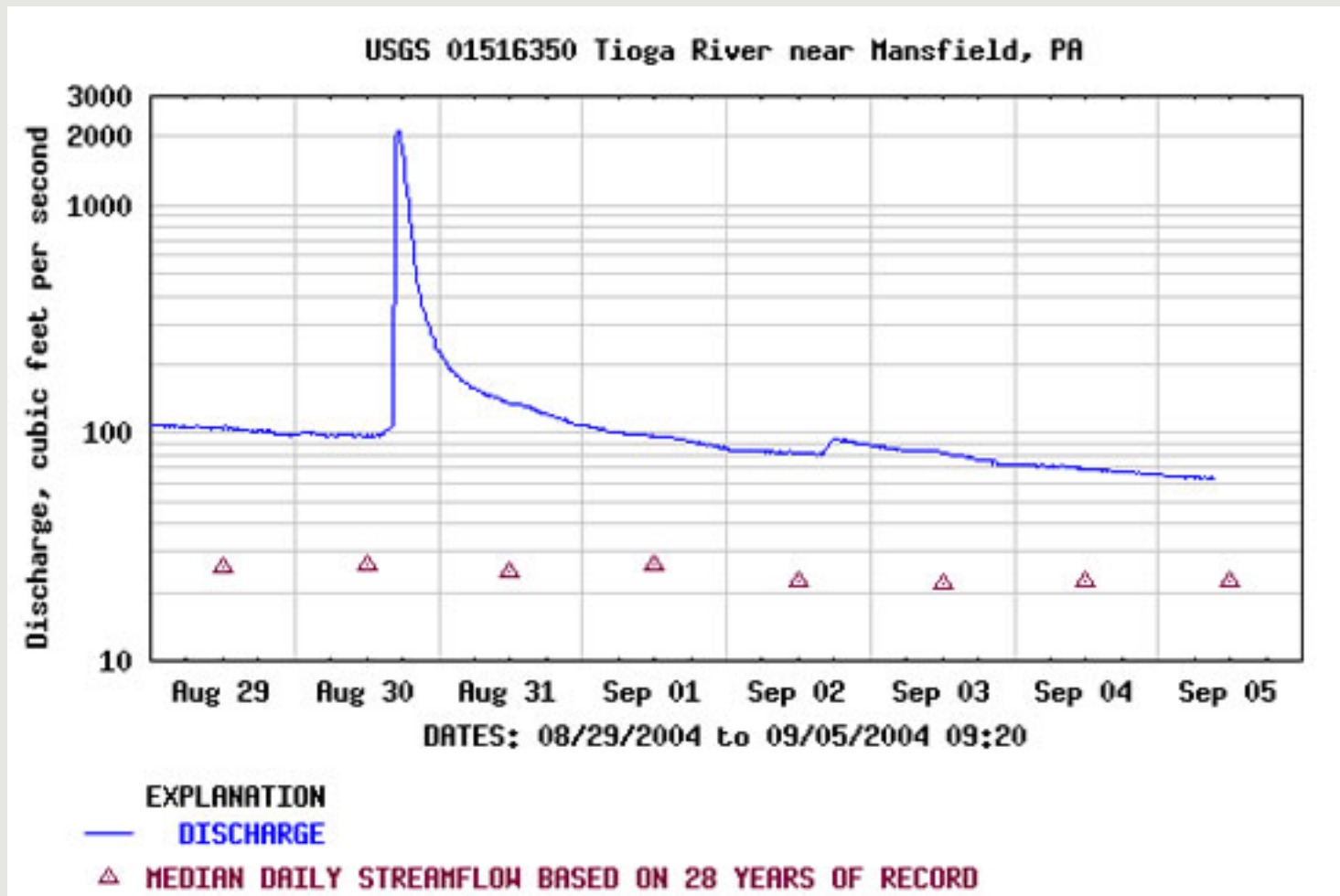


Old school

Modern electronic



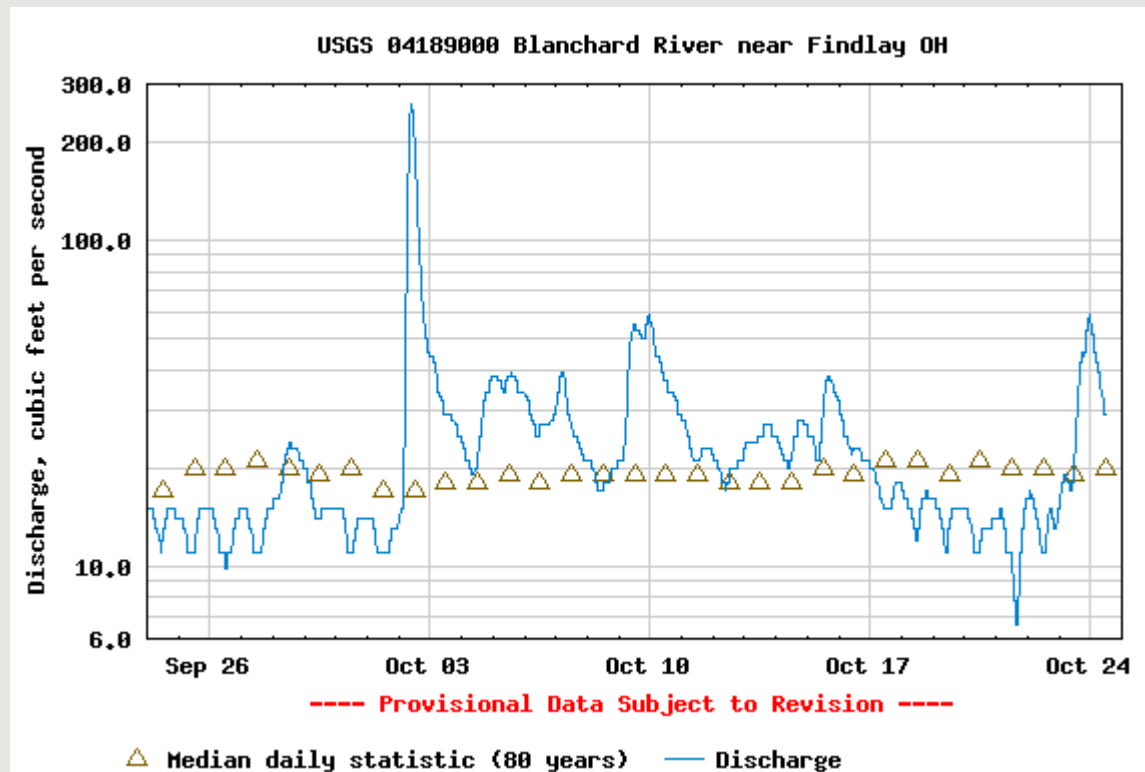
A HYDROGRAPH: Record of a flood event



But note that the X axis is discharge, not stage

Getting from stream height to discharge

A local example:



Current meter

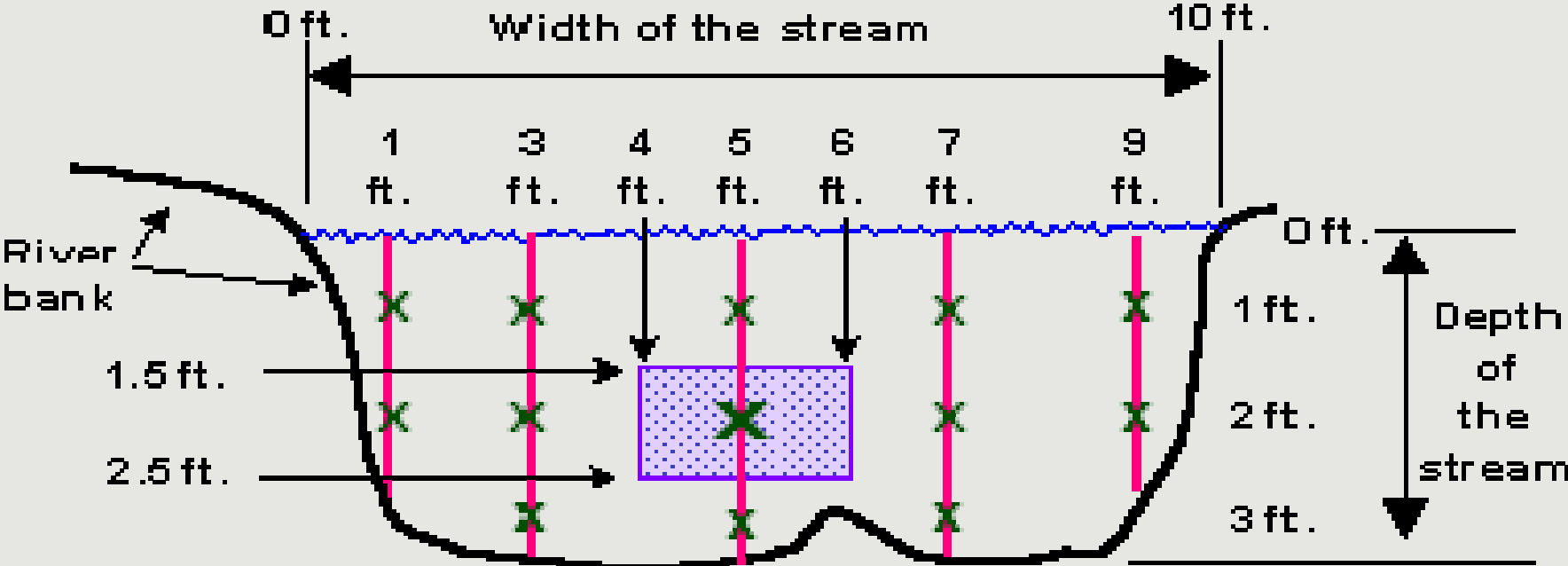
USGS technician
makes a series
of measurements
across the stream

Repeated visits at
different stages

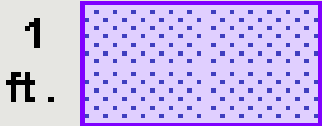


*Eric De Carlo
UH Oceanography*

Measurements of flow rate across the stream

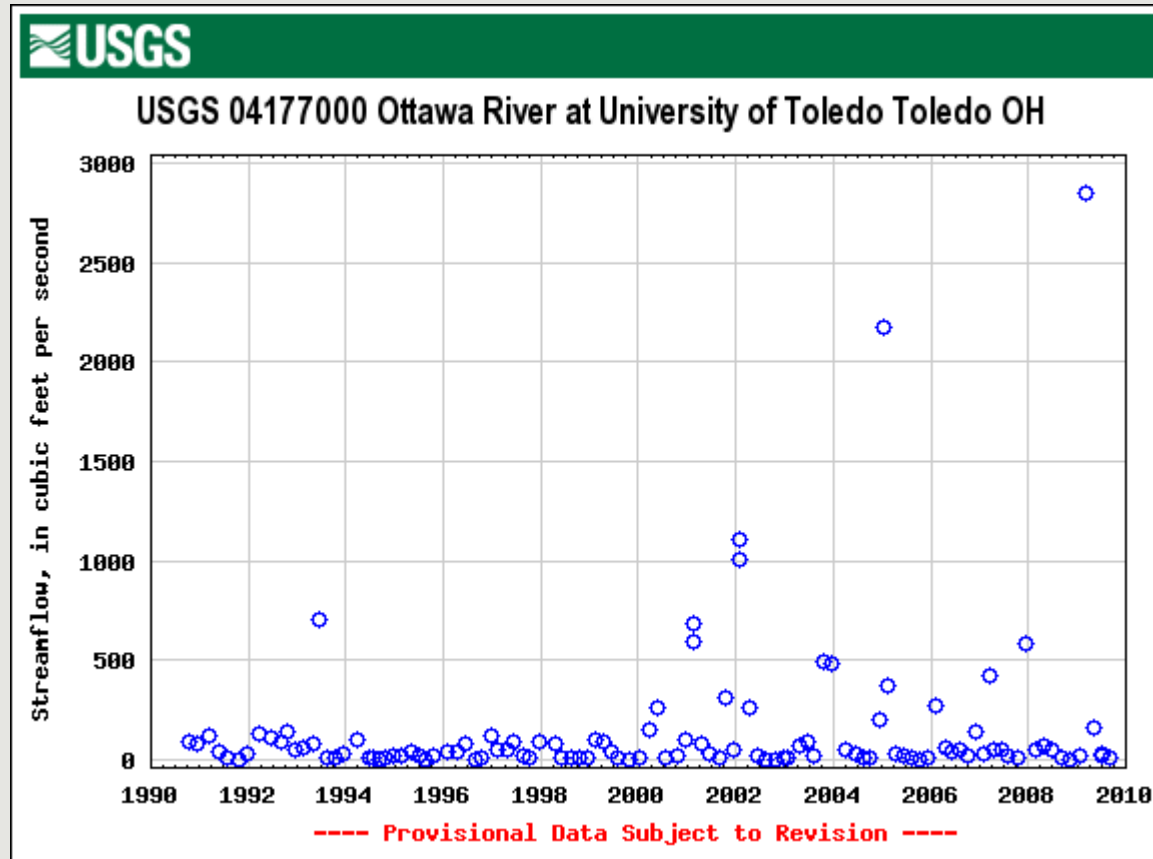


X Spot where a measurement is made.



So, this area is 1 ft by 2 ft, or 2 square feet.

Ottawa River at the University of Toledo





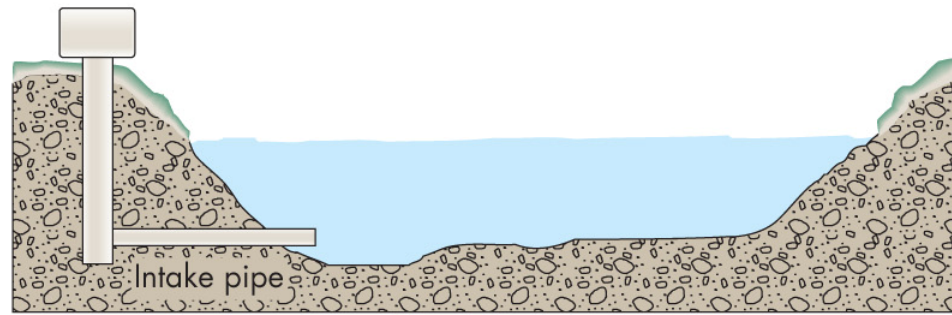
Big rivers and
high flow

This can get
dangerous



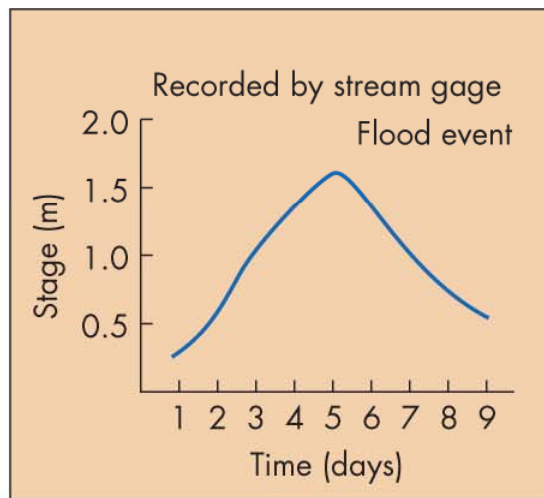
The Stage – Discharge Relationship

Continuous recording gauge measures elevation of water in meters (stage).

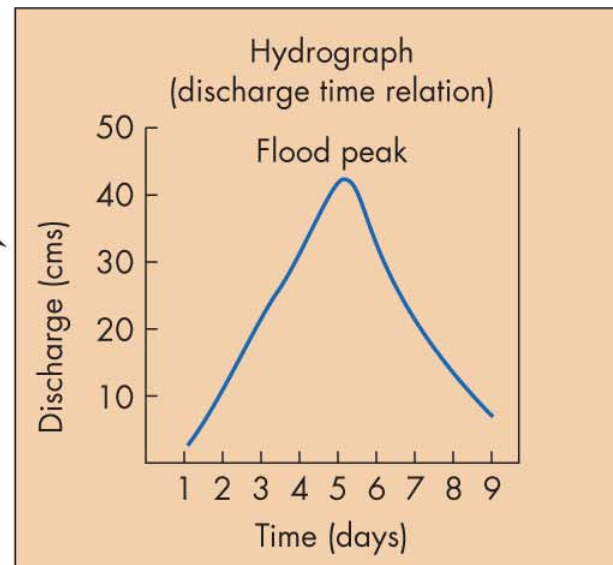


Field measurement of discharge in cubic meters/second (cms) at various stages. Discharge (Q) is calculated as the product of mean velocity of the water (V) measured with a current meter and cross sectional area of flow (A): $Q = VA$

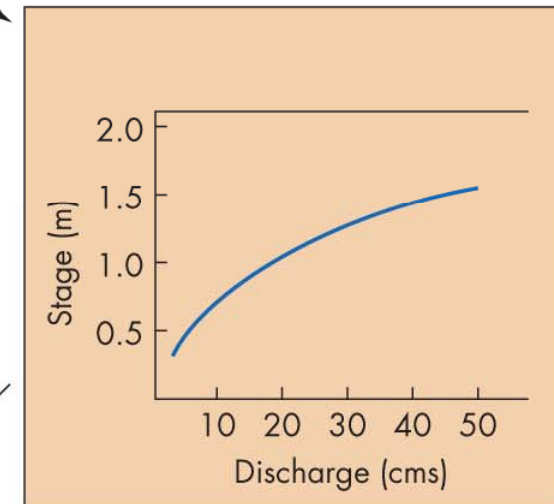
(a)



(b)



(d)

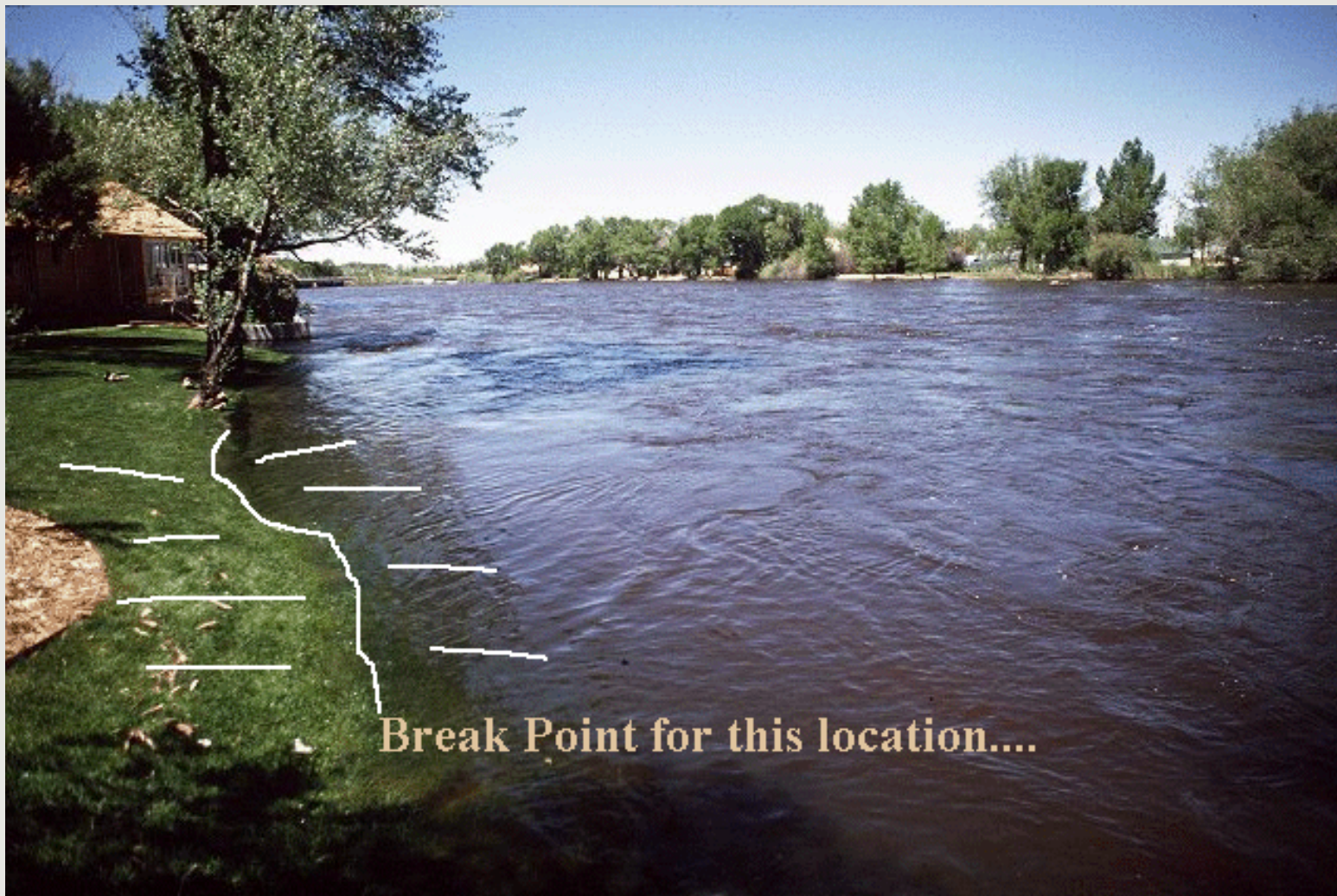


(c)

Figure 5.D

Break point for discharge measurements

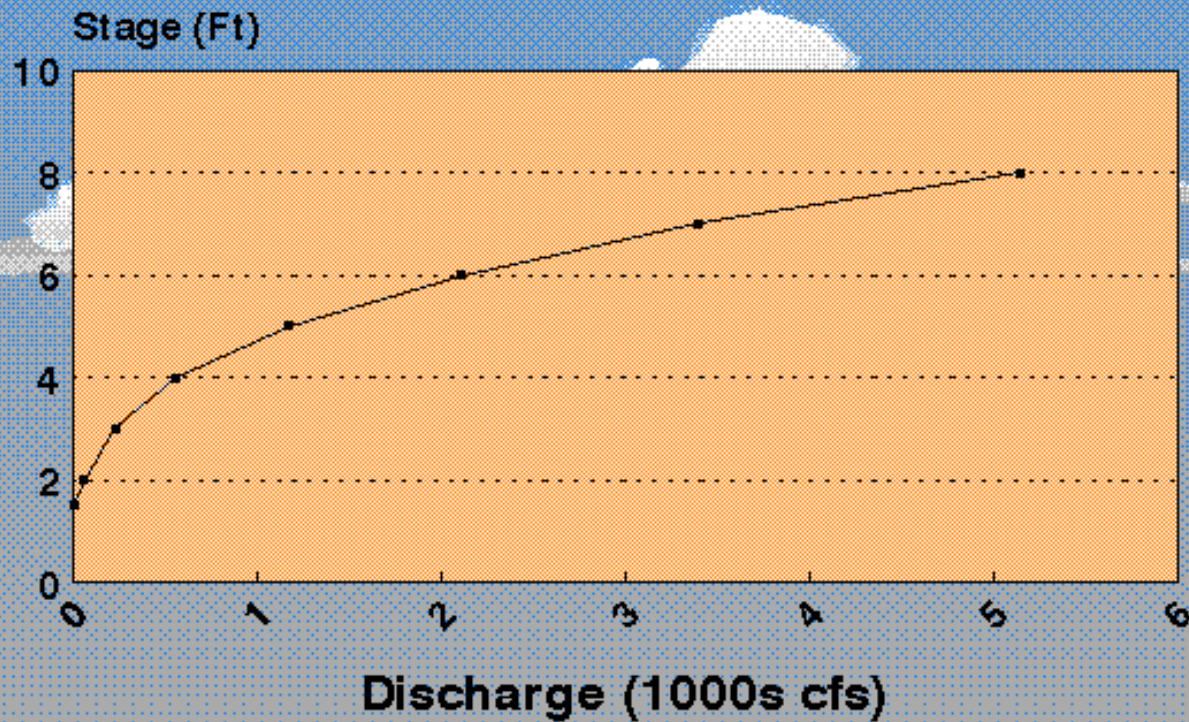
Flood spills out of the channel



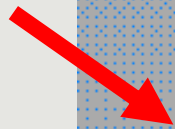
A discharge rating curve

Compiled from LOTS of individual measurements

Laramie River nr Ft Laramie, WY Rating Curve



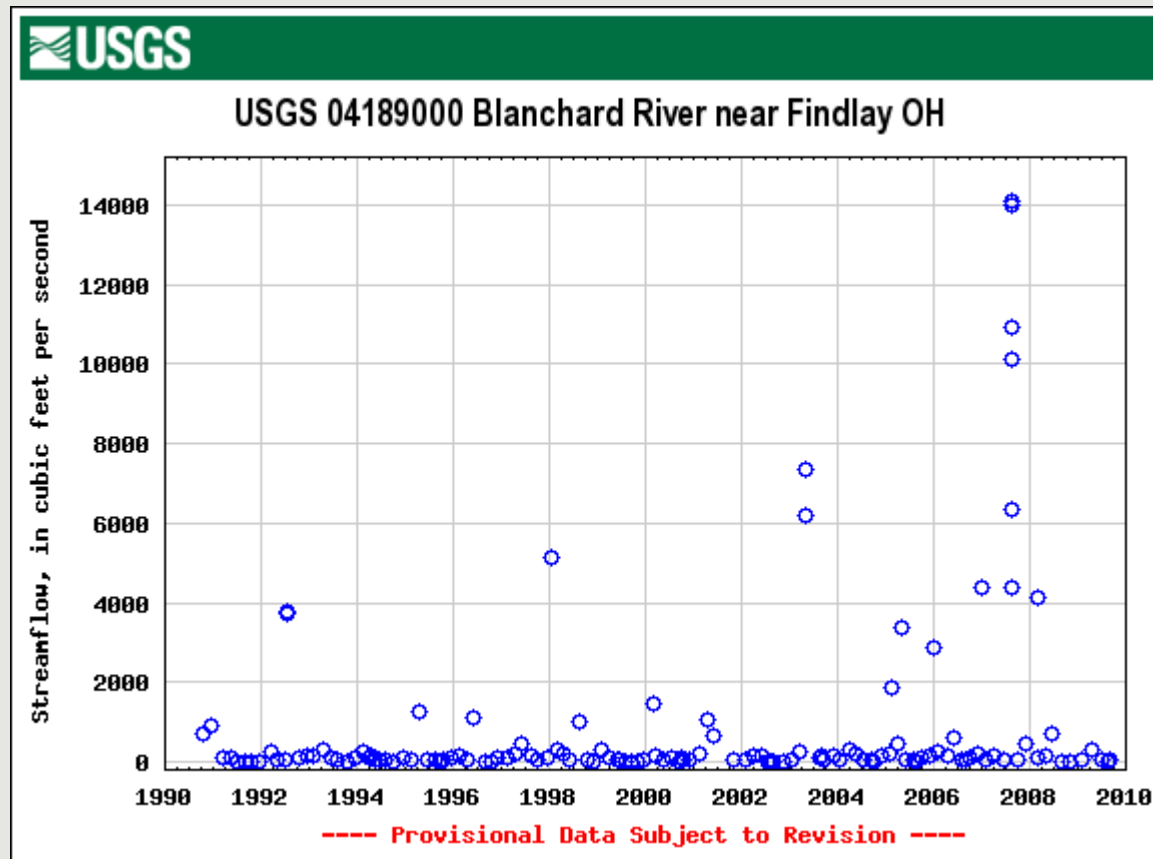
NOTE



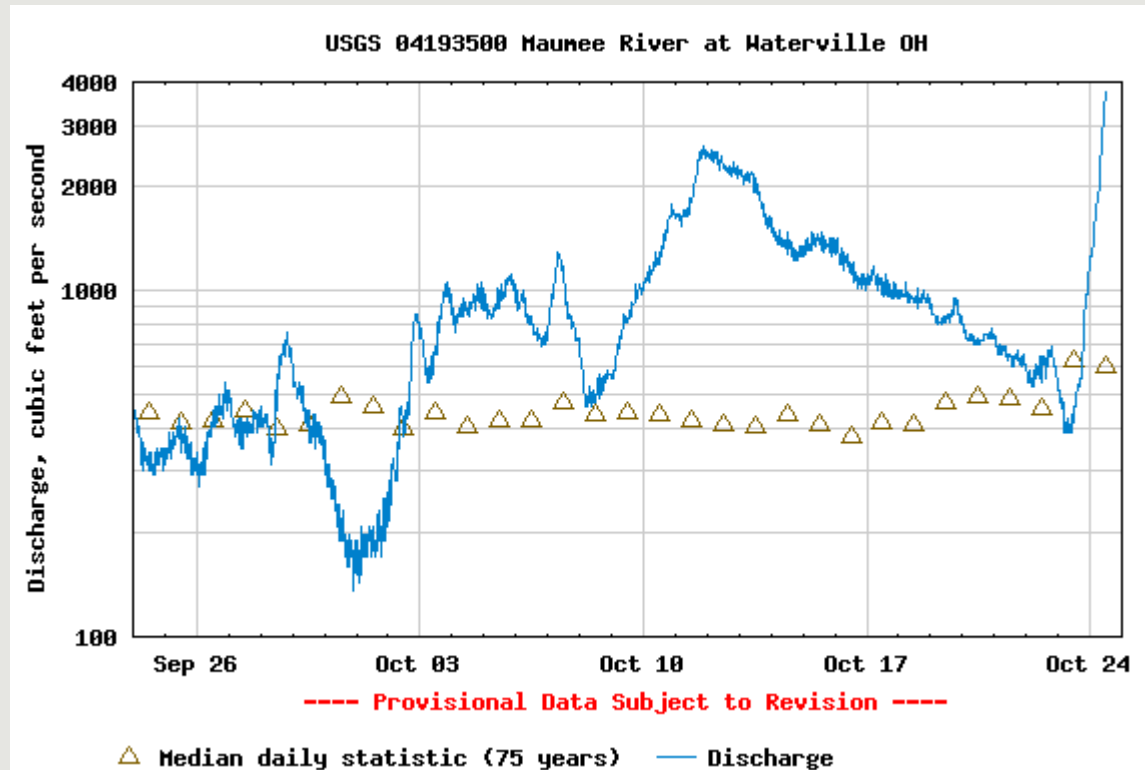
Flood stage = 5.5 Ft

Stage-discharge measurements

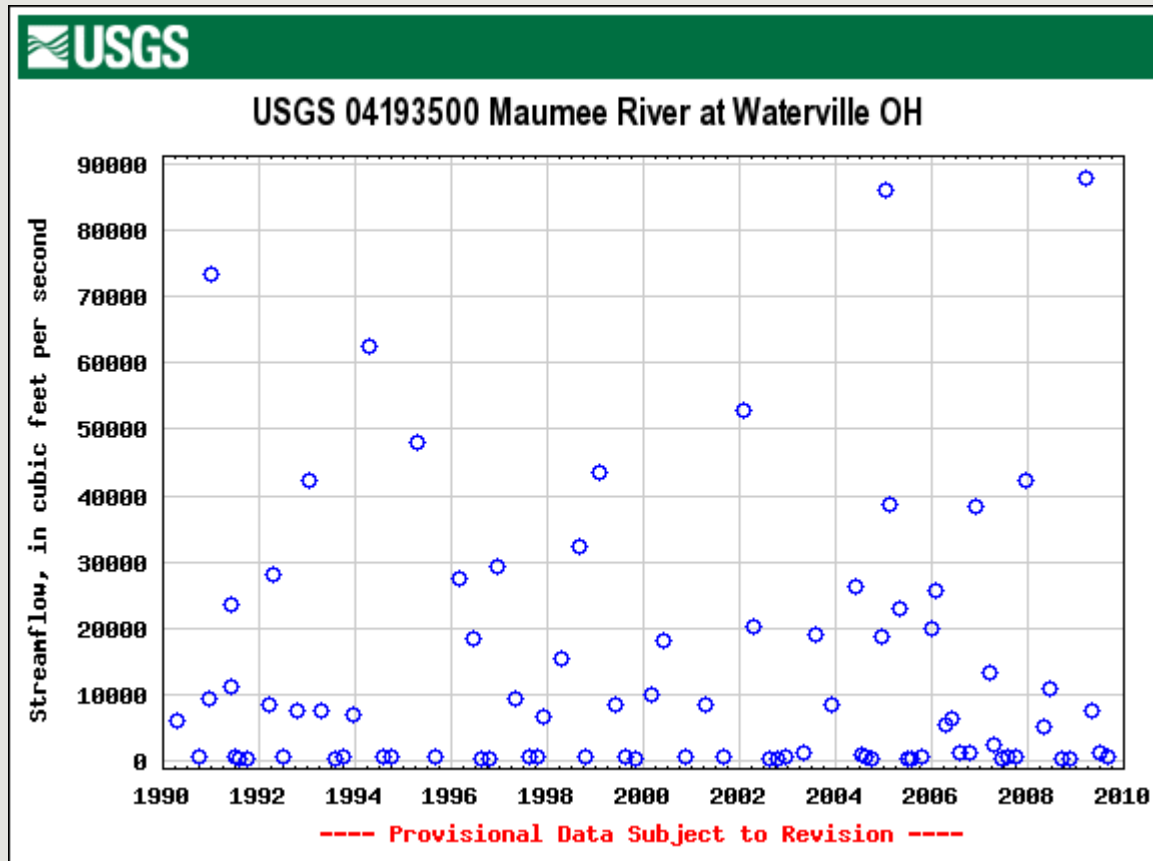
The Blanchard River near Findlay



Maumee River at Waterville



Maumee River at Waterville



Determining flood recurrence intervals

**Patrick River
Stream Gauge Data
Peak Annual Flow**

Year	Discharge (cms)	M	R (yrs)
1995	30	5	2
1996	280	1	10
1997	45	4	2.5
1998	28	6	1.7
1999	120	2	5
2000	26	7	1.4
2001	100	3	3.3
2002	23	8	1.3
2003	20	9	1.1

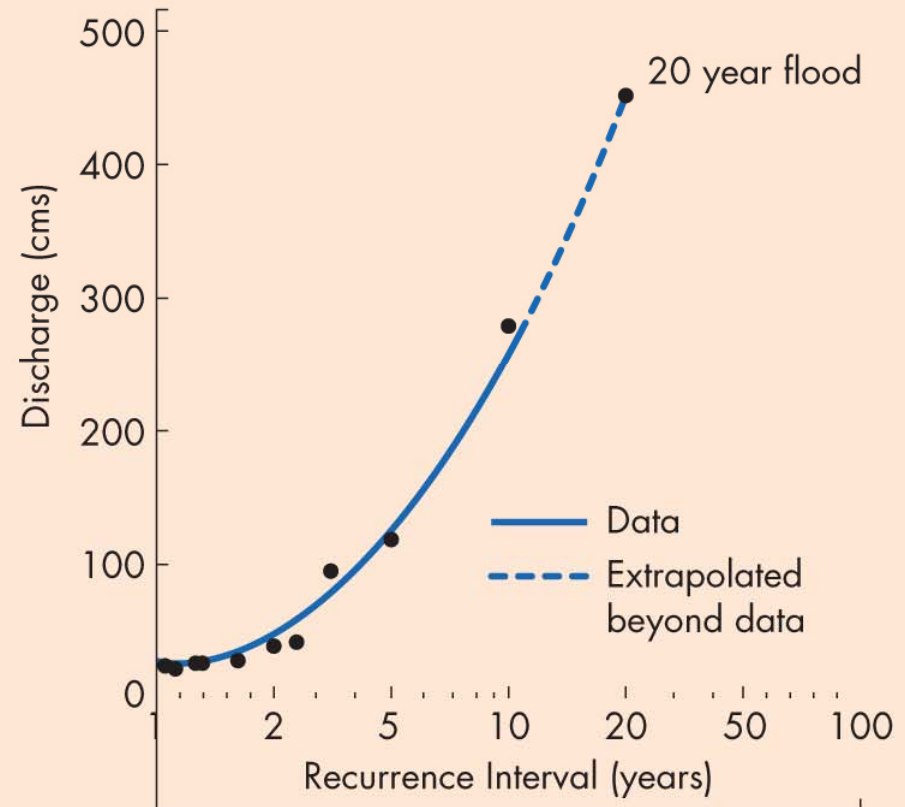
M = Magnitude
where M = 1 is
the highest flow
on record

R = Recurrence
Interval in years;
calculated by

$$R = \frac{N - 1}{M};$$

for Patrick
River N = 9

Figure 5.E

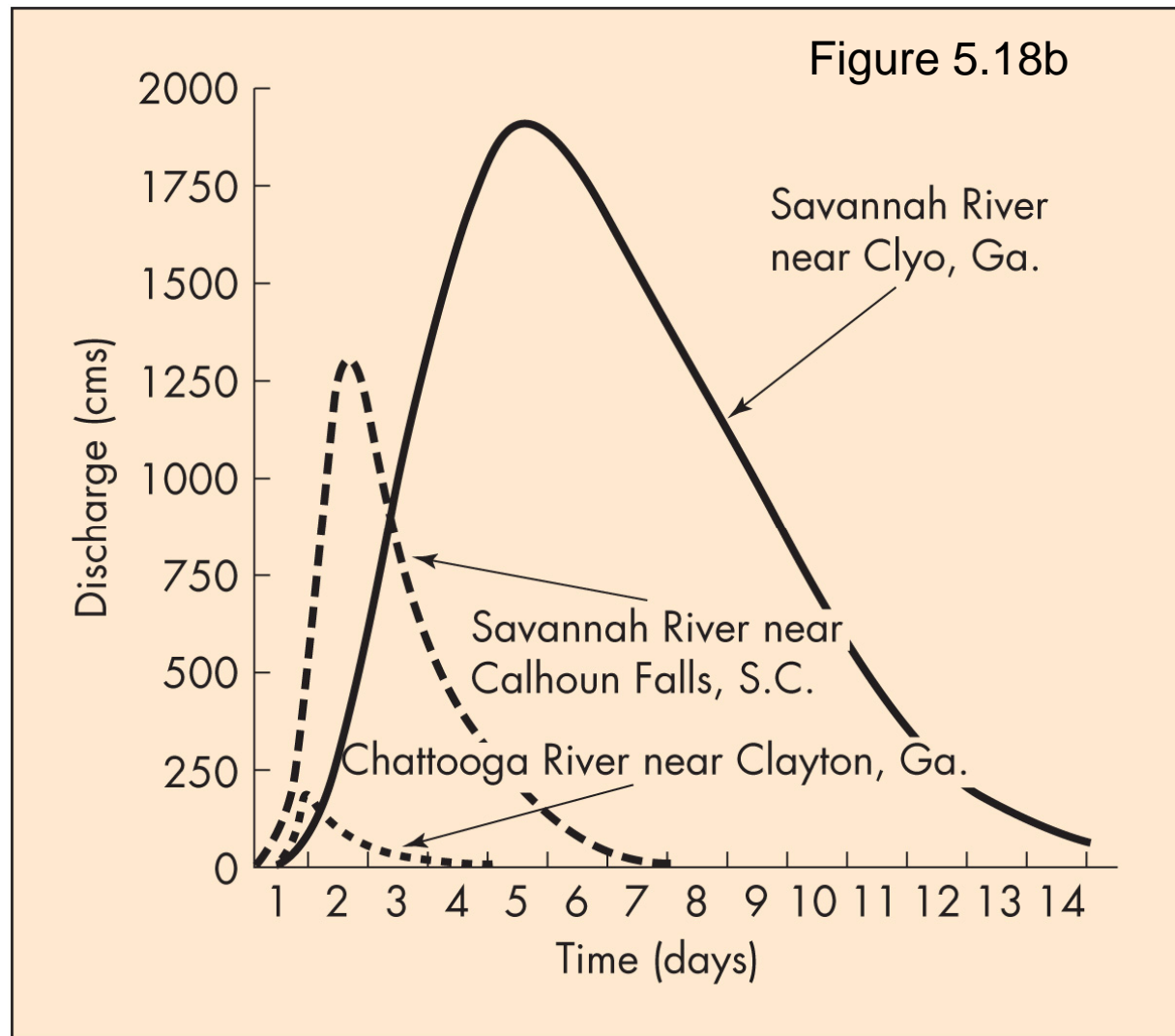


As a flood moves downstream

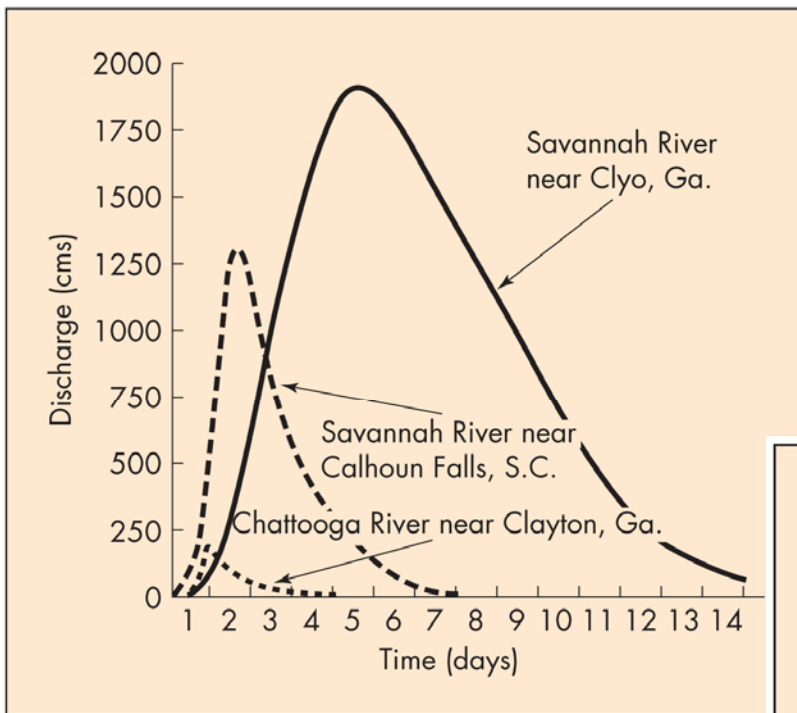


Figure 5.18a

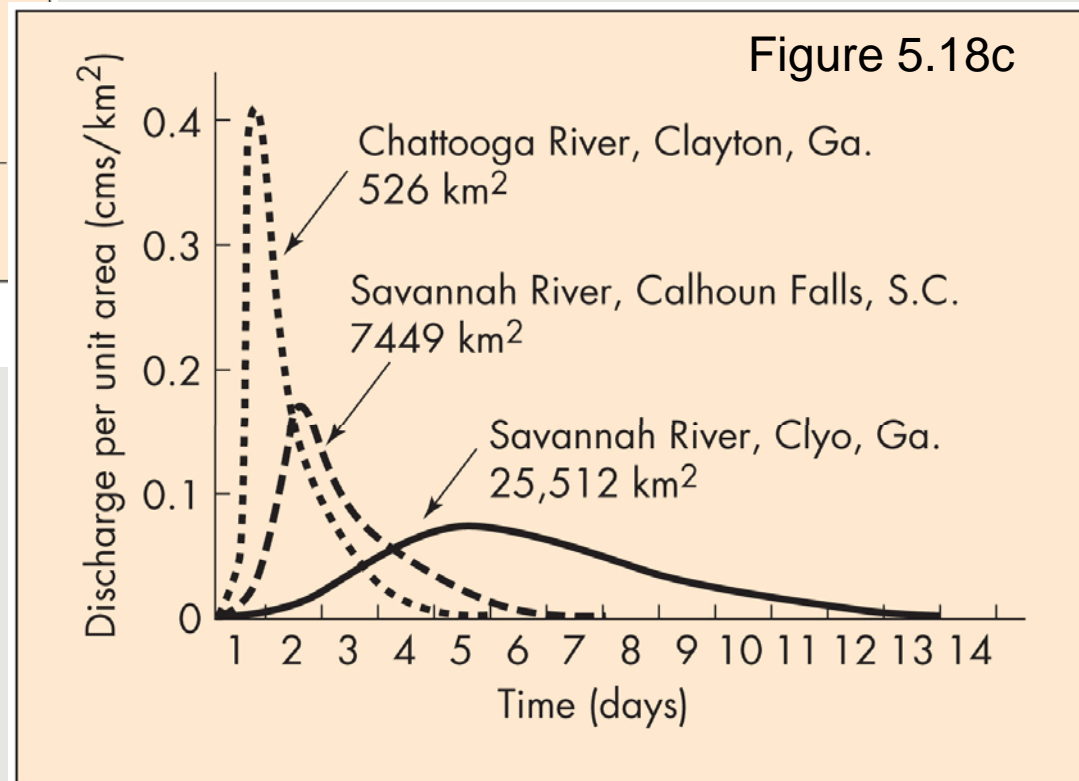
As a flood moves downstream



A different way of looking at the same data

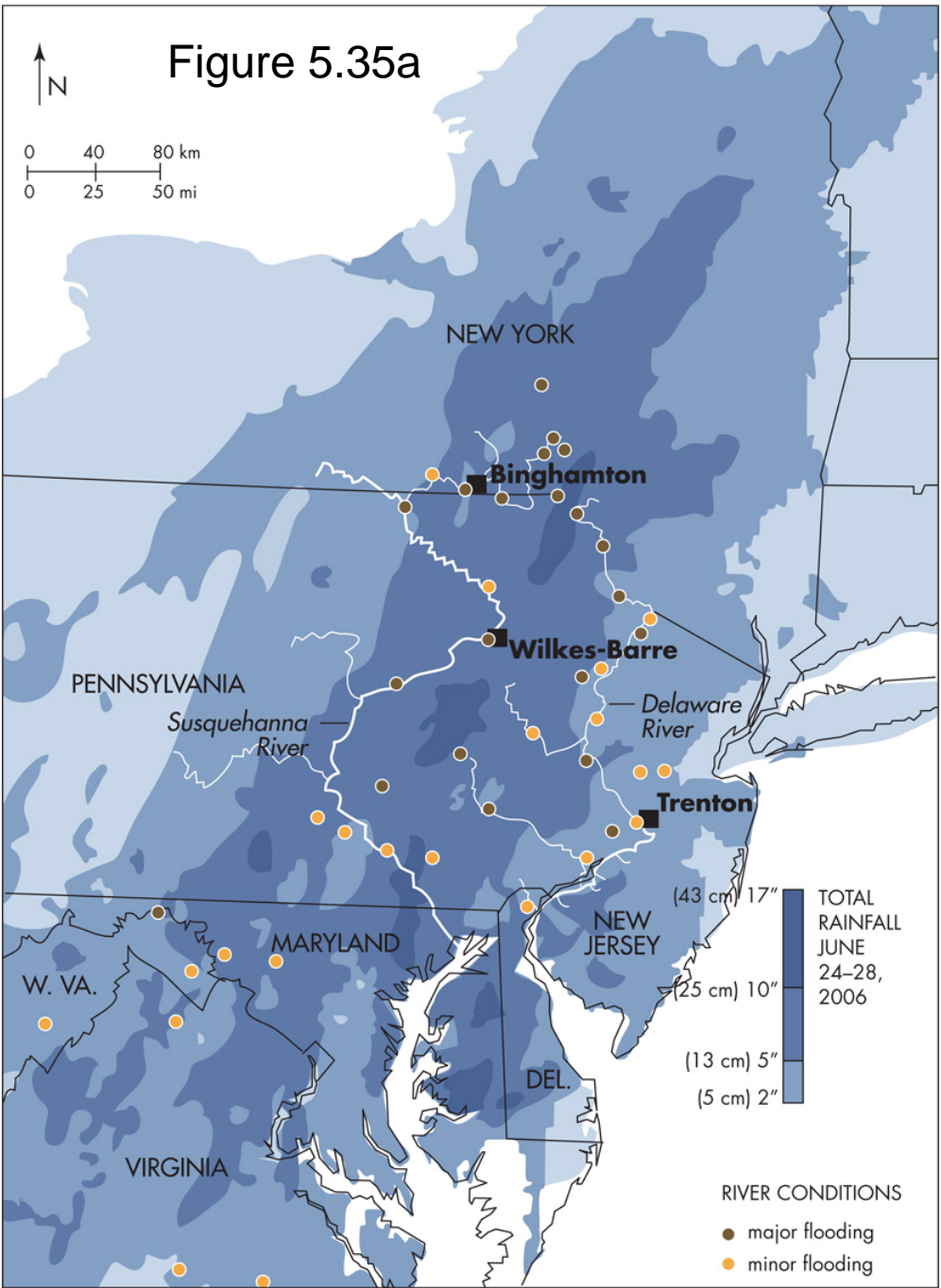


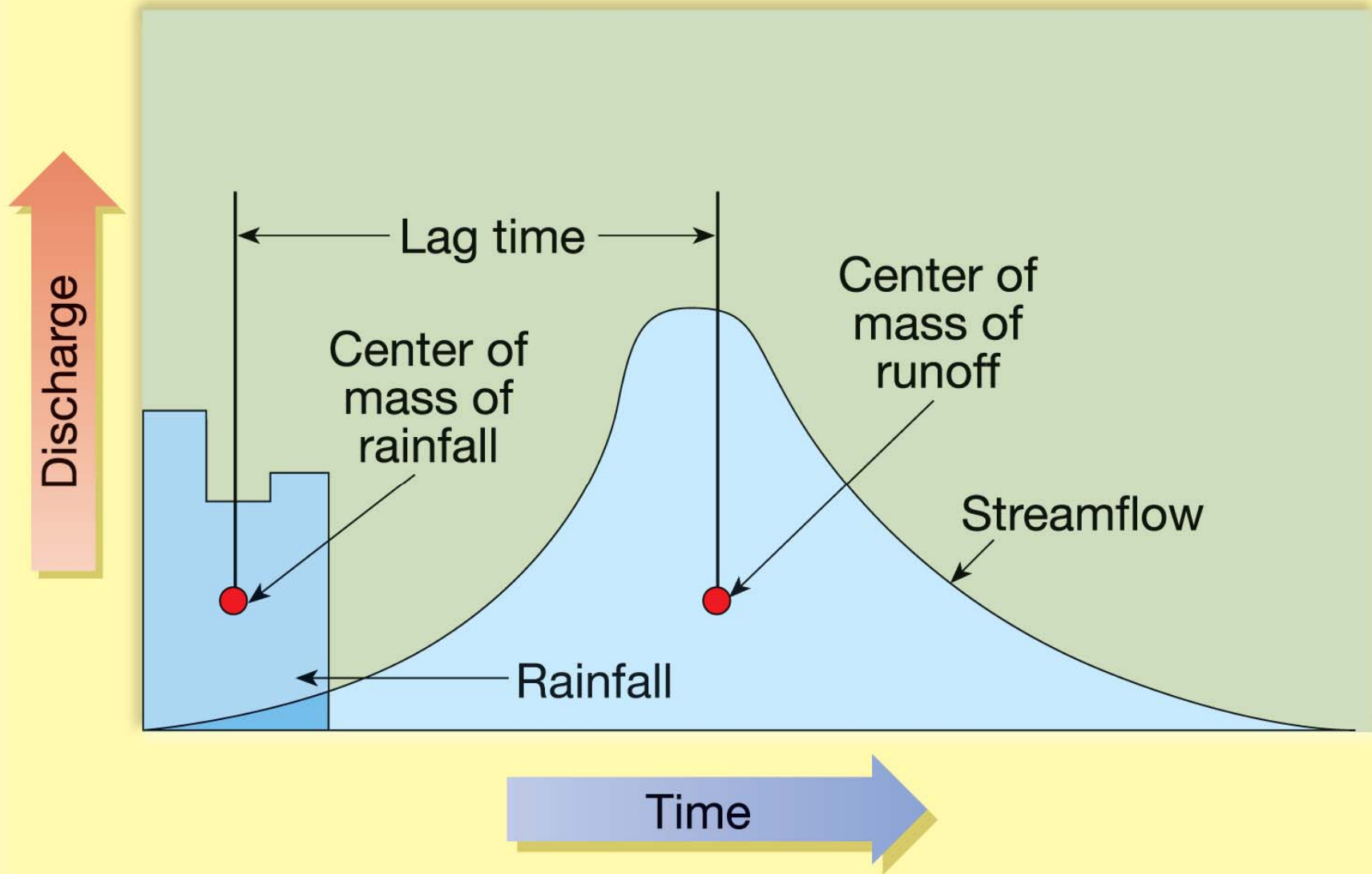
Discharge per unit area
of the drainage basin



(c)

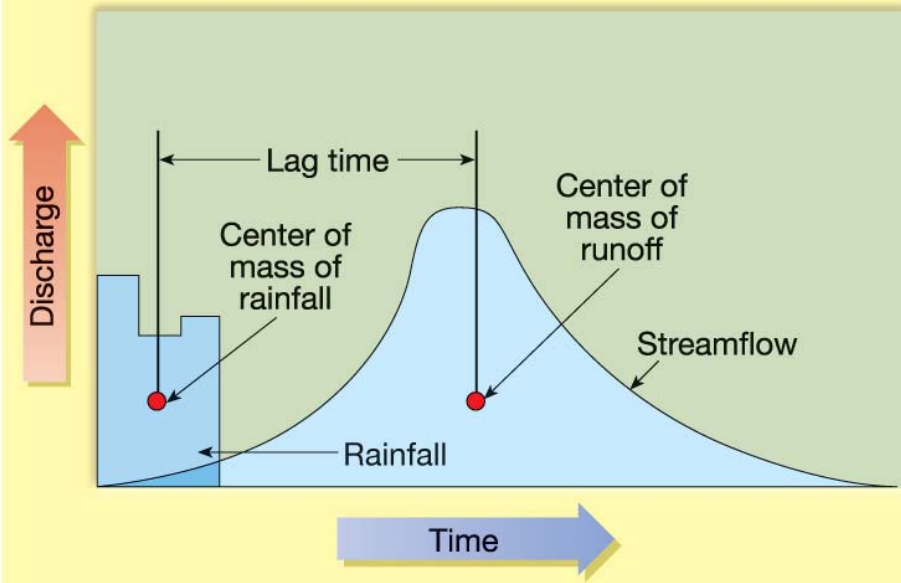
Massive rainfall in the entire drainage basin



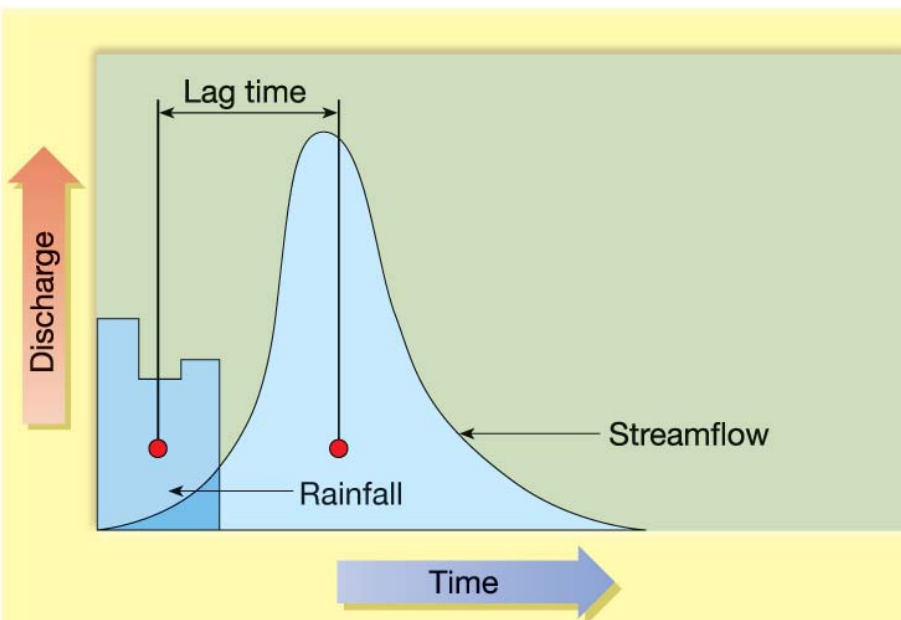


(a) Typical lag time between rainfall and runoff

Important Concept: Reservoir volume and retention time



(a) Typical lag time between rainfall and runoff



(b) Lag time between rainfall and runoff after urbanization

Figure 5.26

Watershed land use and discharge

Hardwood forest



Tallgrass prairie





Mixed prairie with wooded riparian zone

Mixed forest riparian zone



Hardwood swamp on a floodplain



Agricultural fields

Does season matter?

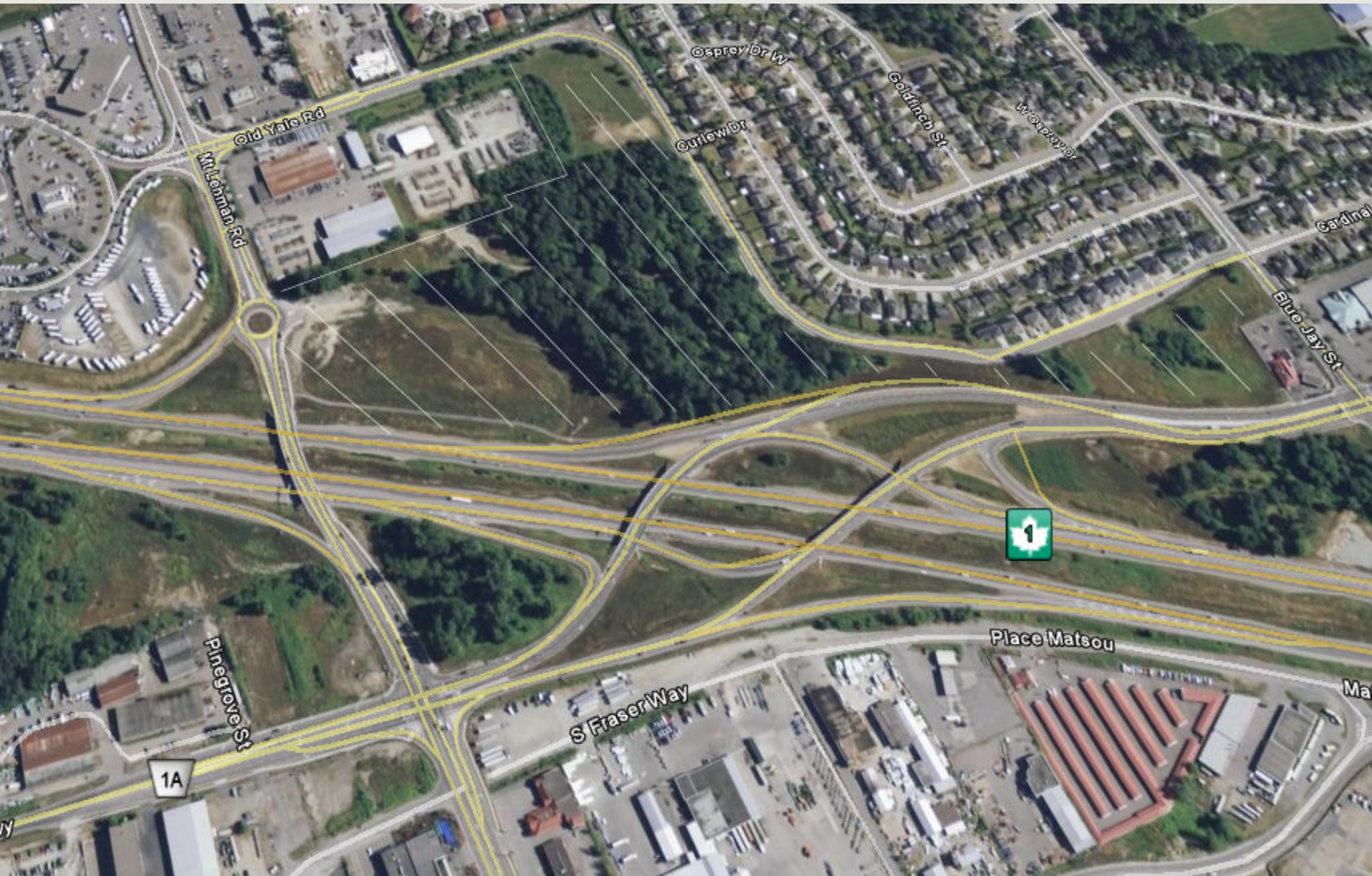
Does soil type matter?





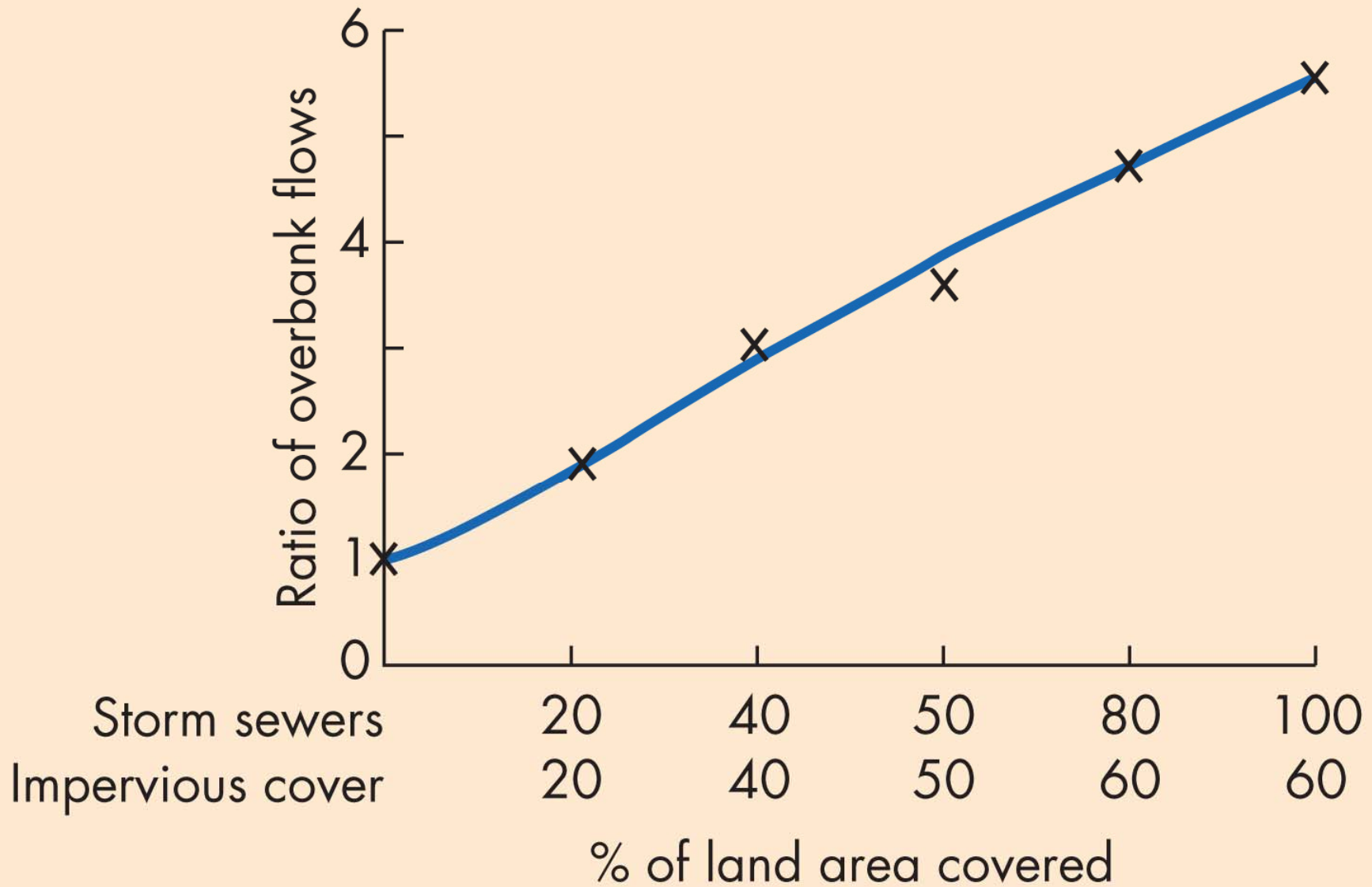
Important point: It's not just about water run-off

Impervious surfaces and engineered drainage



Where does the water go?
How fast does it get there?





Mixed land use



Mixed land use



Suburban lawns



Storm drains



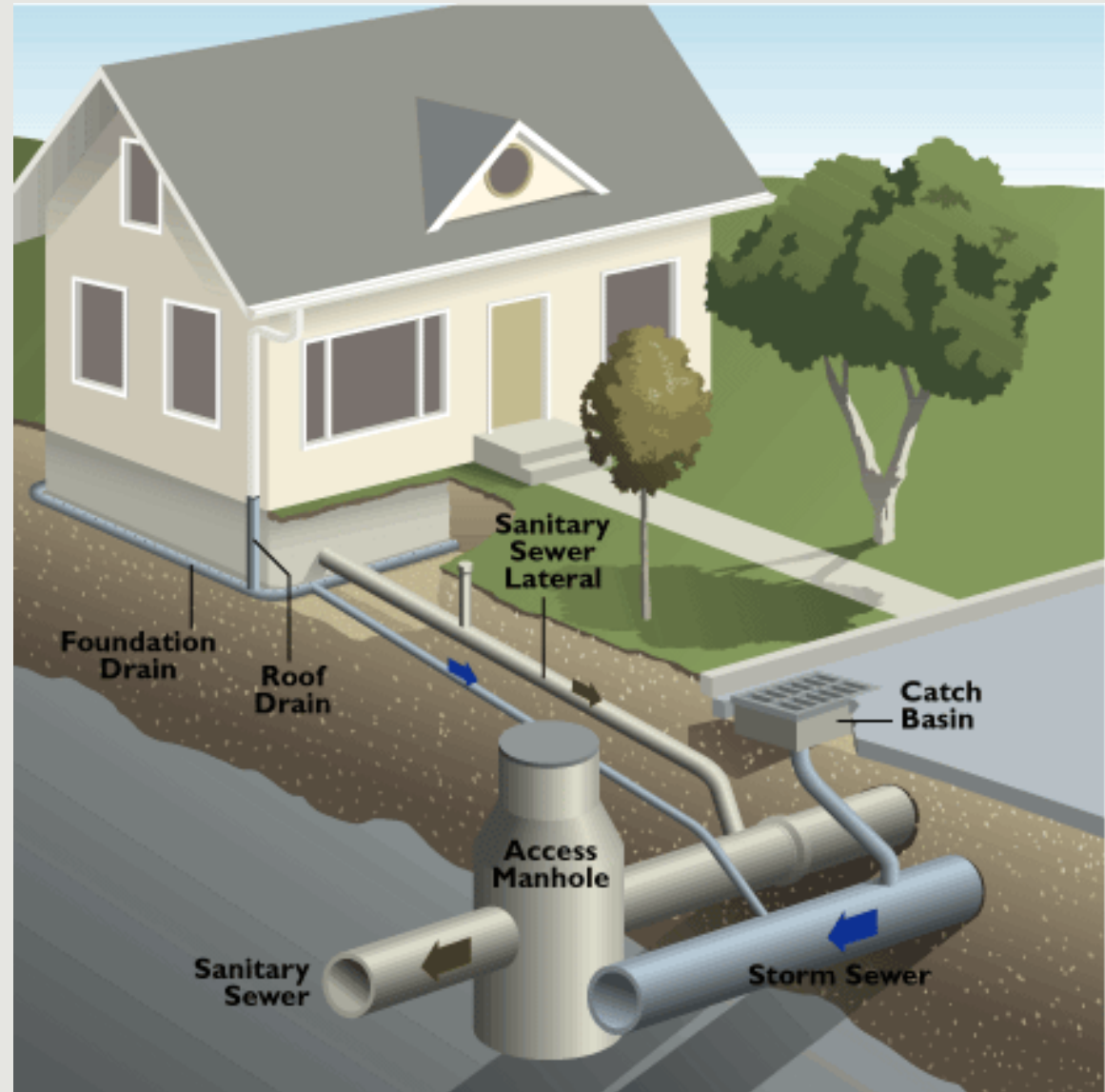
Storm drains / storm sewers

Commonly have direct
outflow into a waterway



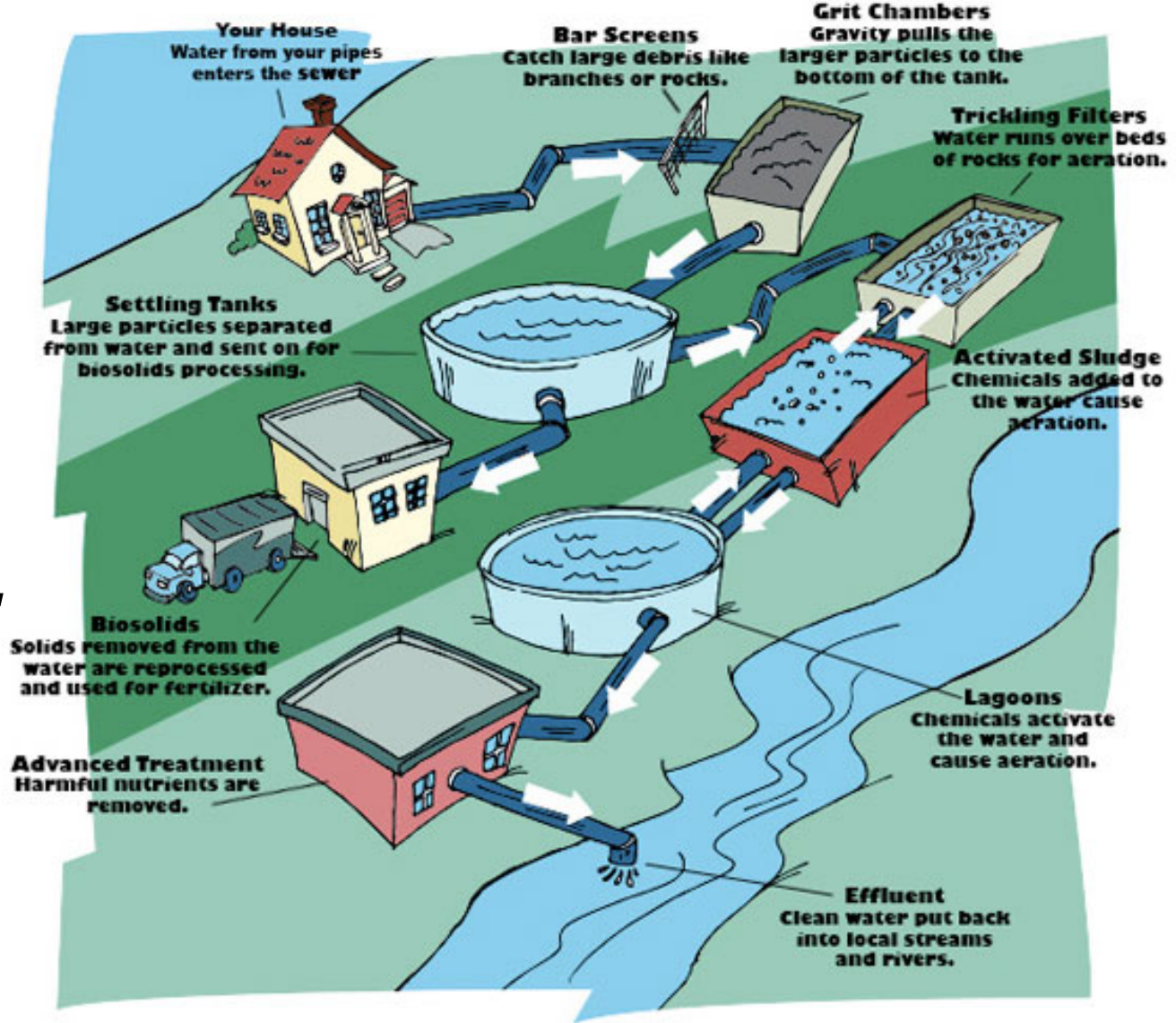
Comment: Surface runoff from Seattle metro area into Puget Sound

Separated sewer system



Municipal sewage treatment

Removes debris, sediments, organic matter, chemicals, nutrients



Primary Treatment	Secondary Treatment	Advanced Treatment
Bar Screens	Trickling Filters	Advanced Treatment
Grit Chambers	Activated Sludge	Effluent
Settling Tanks	Lagoons	
Biosolids		

Combined sewer overflow

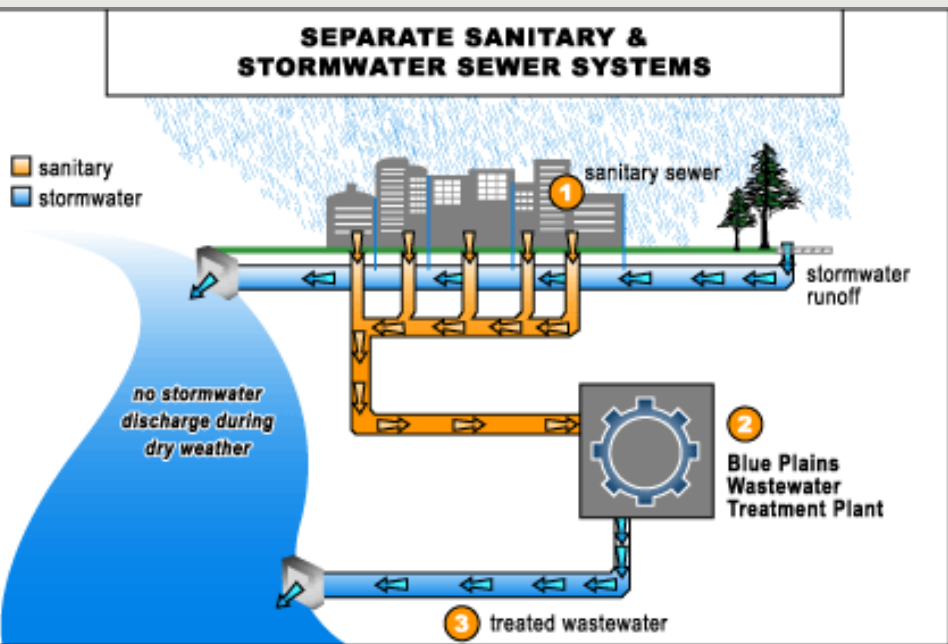
CSO

WARNING
COMBINED SEWER OVERFLOW
DISCHARGE POINT
POLLUTION MAY OCCUR
DURING RAINFALL
CSO OUTFALL NO. 019
PERMIT NO. DC 0021199
TO REPORT PROBLEMS CALL
DISTRICT OF COLUMBIA
WATER AND SEWER AUTHORITY
TELEPHONE NO. (202) 612-3400



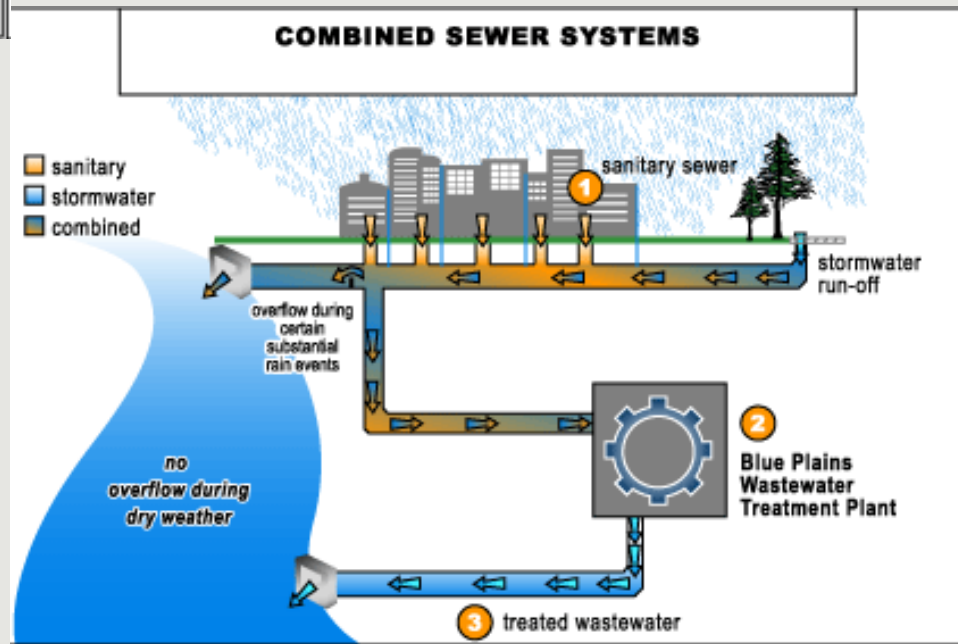


Combined vs separate sewer systems



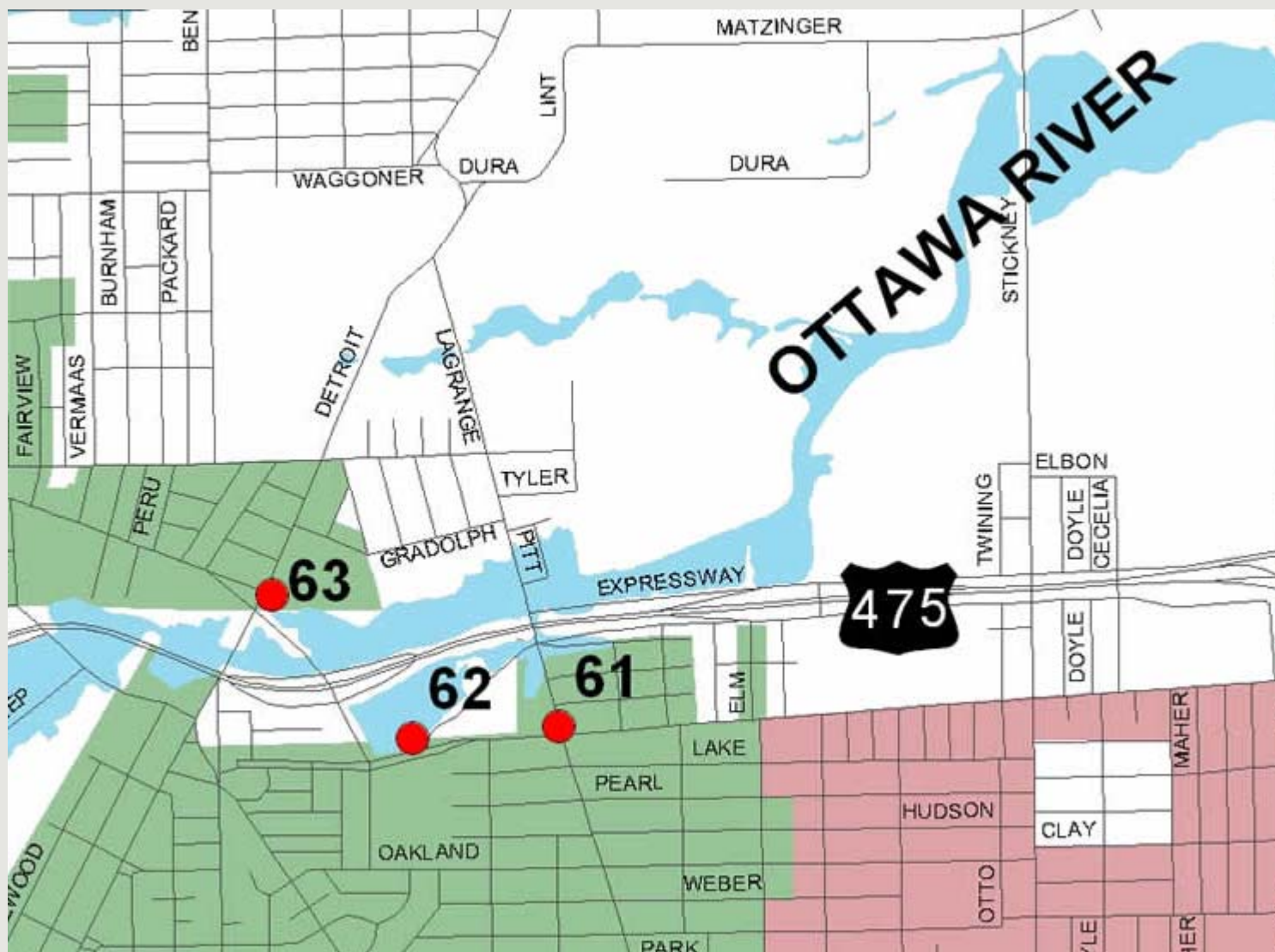
Separate

Combined



CSO's in Toledo

<http://www.toledowaterwaysinitiative.com/>



CSO's in Toledo

The 15-year series of improvements to upgrade the City's aging sewer system is expected to cost more than \$450 million. Funding for the program will come from an incremental increase of sanitary sewer rates over the next 15 years.

