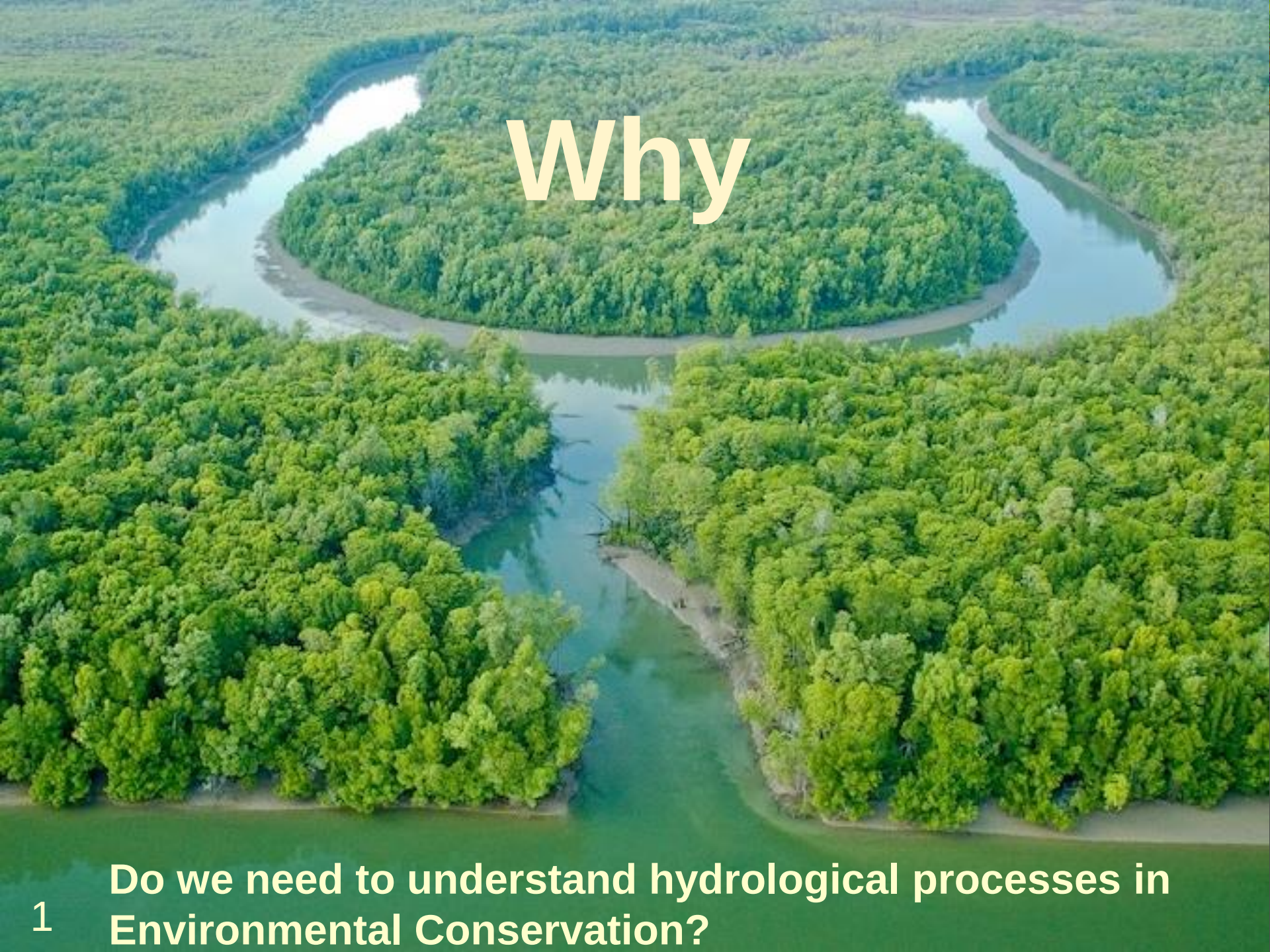


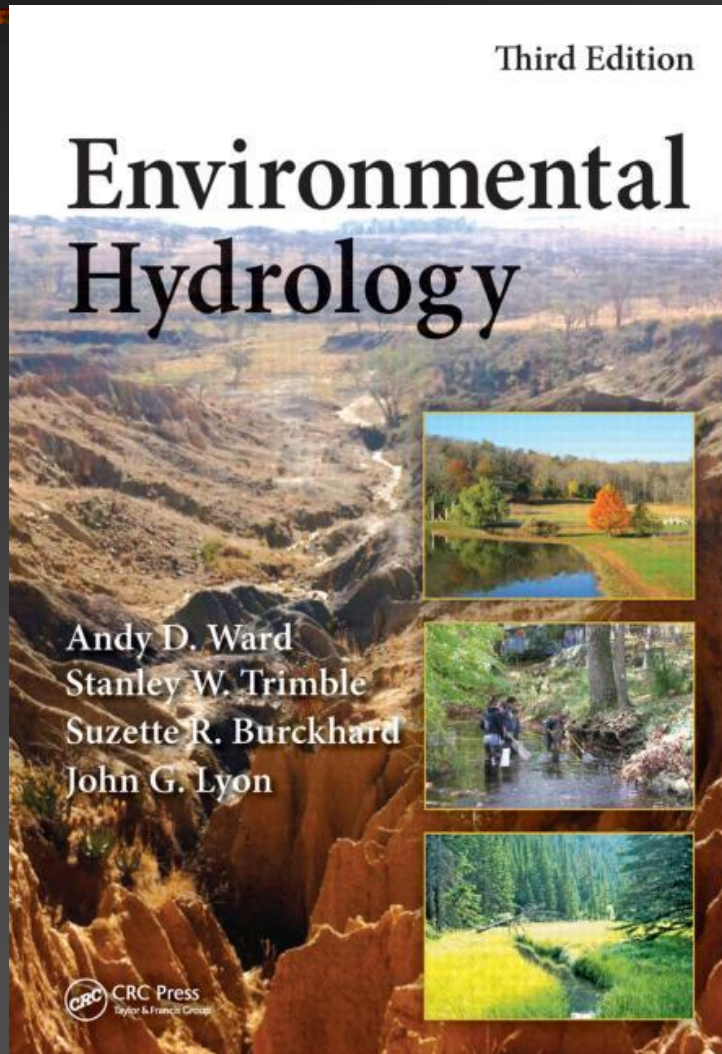
An aerial photograph of a river system flowing through a lush, green forest. The river forms a large loop around a central island, with smaller tributaries branching off. The water is a light blue-green color, and the surrounding forest is a dense, vibrant green. The word "Why" is superimposed in the upper center of the image.

Why

1

Do we need to understand hydrological processes in Environmental Conservation?

Ward et. al, (2015)



Habitat
management

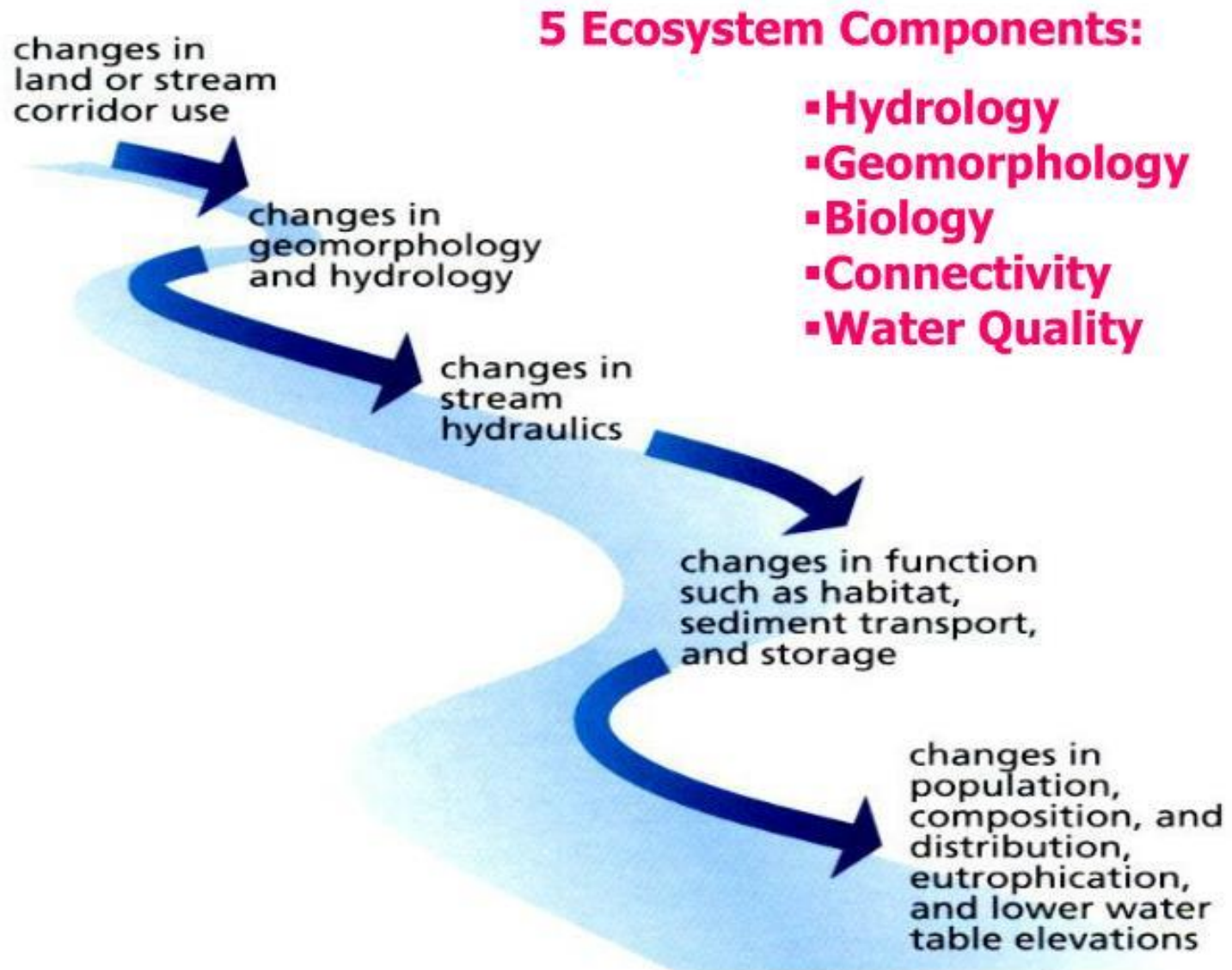
Flood
protection

Recreation

Navigation



Habitat management



RIVERS COME IN VARIOUS FORMS



Amazon

Cairngorms



Czech
Republic



Global

Freshwater 418,000 km³

Rivers 1,200 km³

Major Rivers of the World

River	River Discharge at Mouth (km ³ /s)	Drainage Area (km ²)
Amazon	0.180	6,150,000
Congo	0.041	3,720,000
Yangtze	0.035	1,810,000
Ganges	0.020	1,480,000
Mississippi	0.018	3,240,000
Nile	0.0028	3,035,000

Top 10 Rivers = 0.394 km³/s

**Ocean Water
97.3%**

**Fresh Water
2.7%**

Groundwater 0.575%

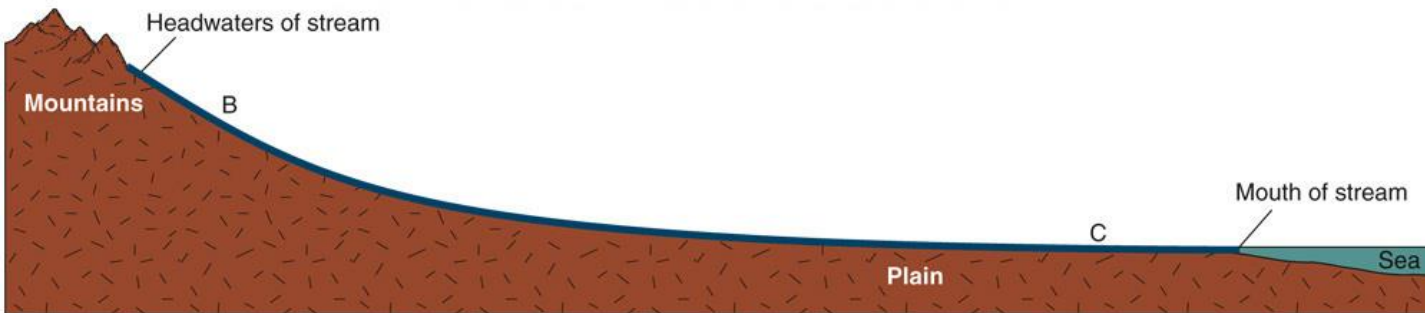
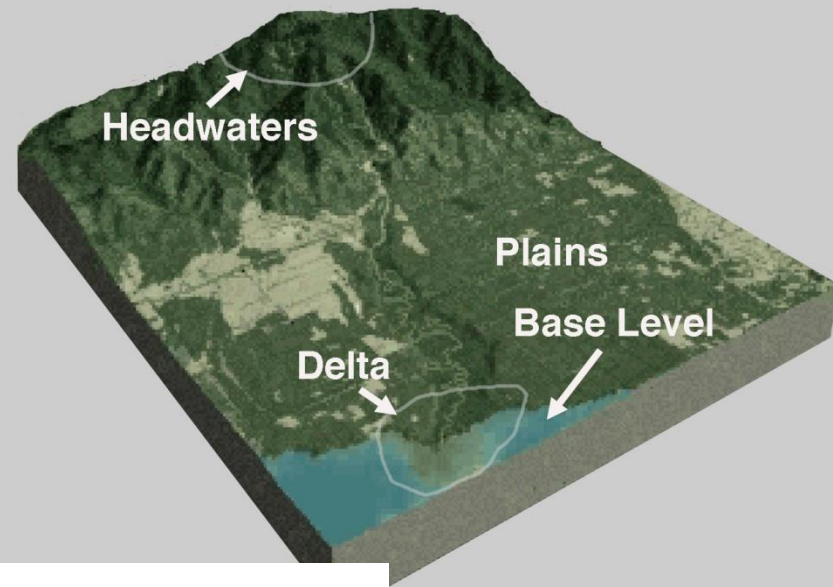
Rivers 0.001%

Atmosphere 0.0001%

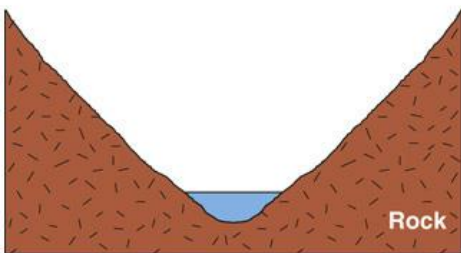
Lakes 0.017%

Ice 2.065%

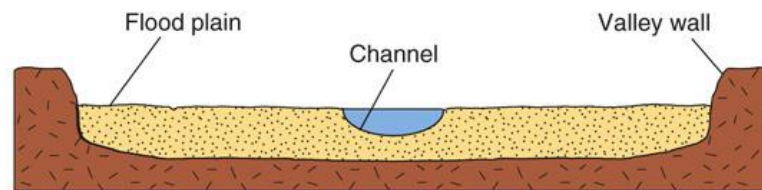
River Profile



A Longitudinal profile (dark blue line) of a stream beginning in mountains and flowing across a plain into the sea.

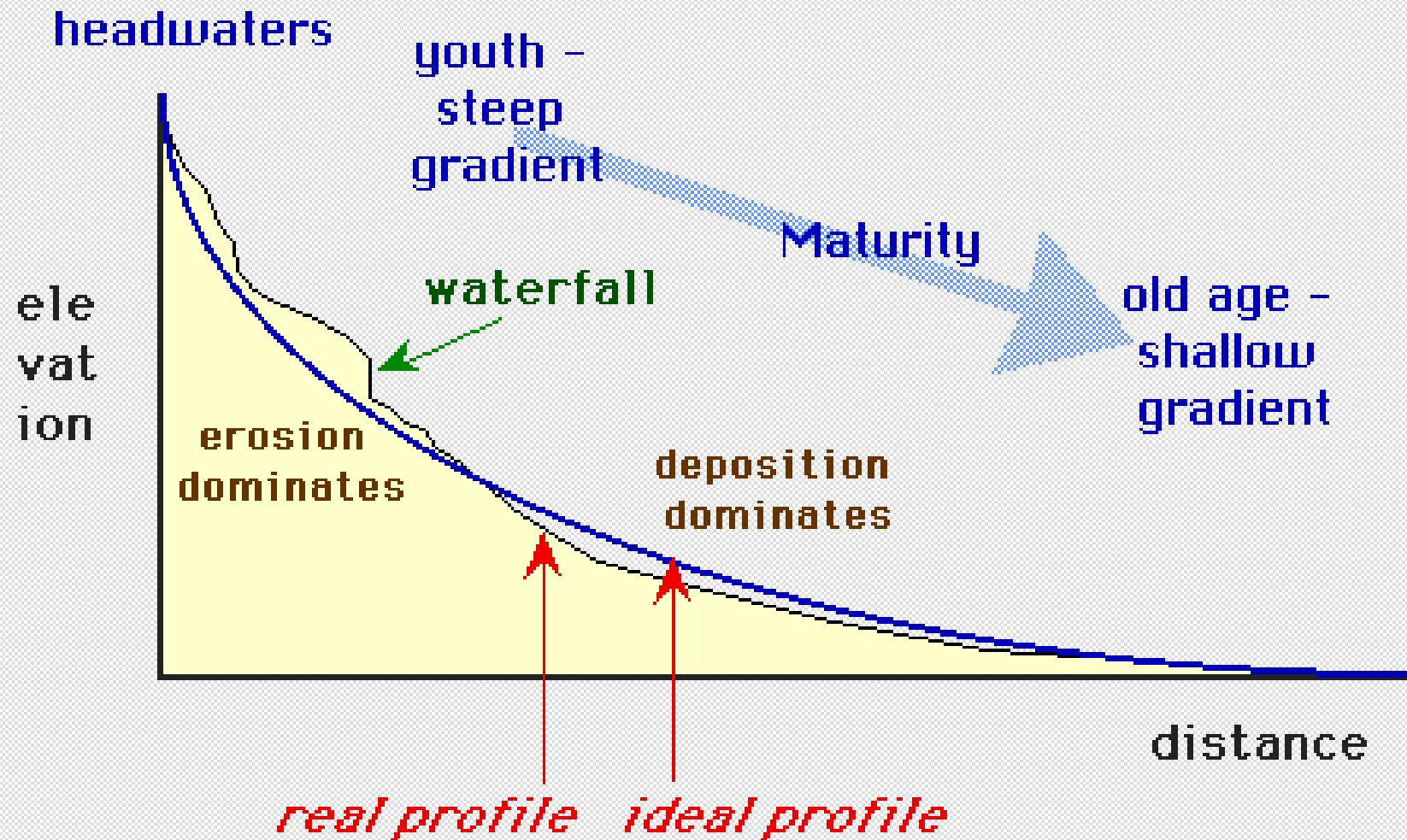


B Cross section of the stream at point B. The channel is at the bottom of a V-shaped valley cut into rock.

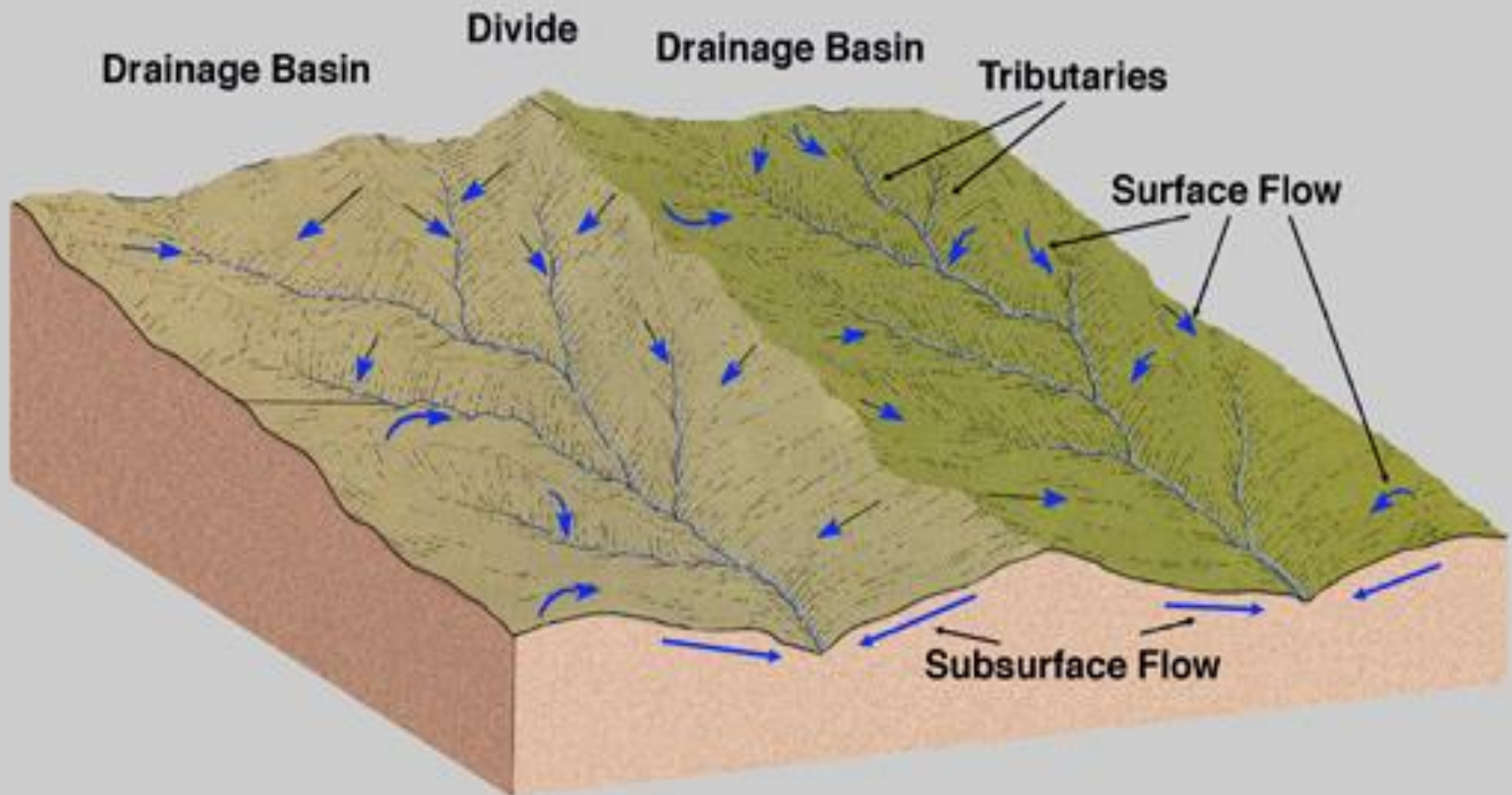


C Cross section at point C. The channel is surrounded by a broad flood plain of sediment.

River Profile Cont'd

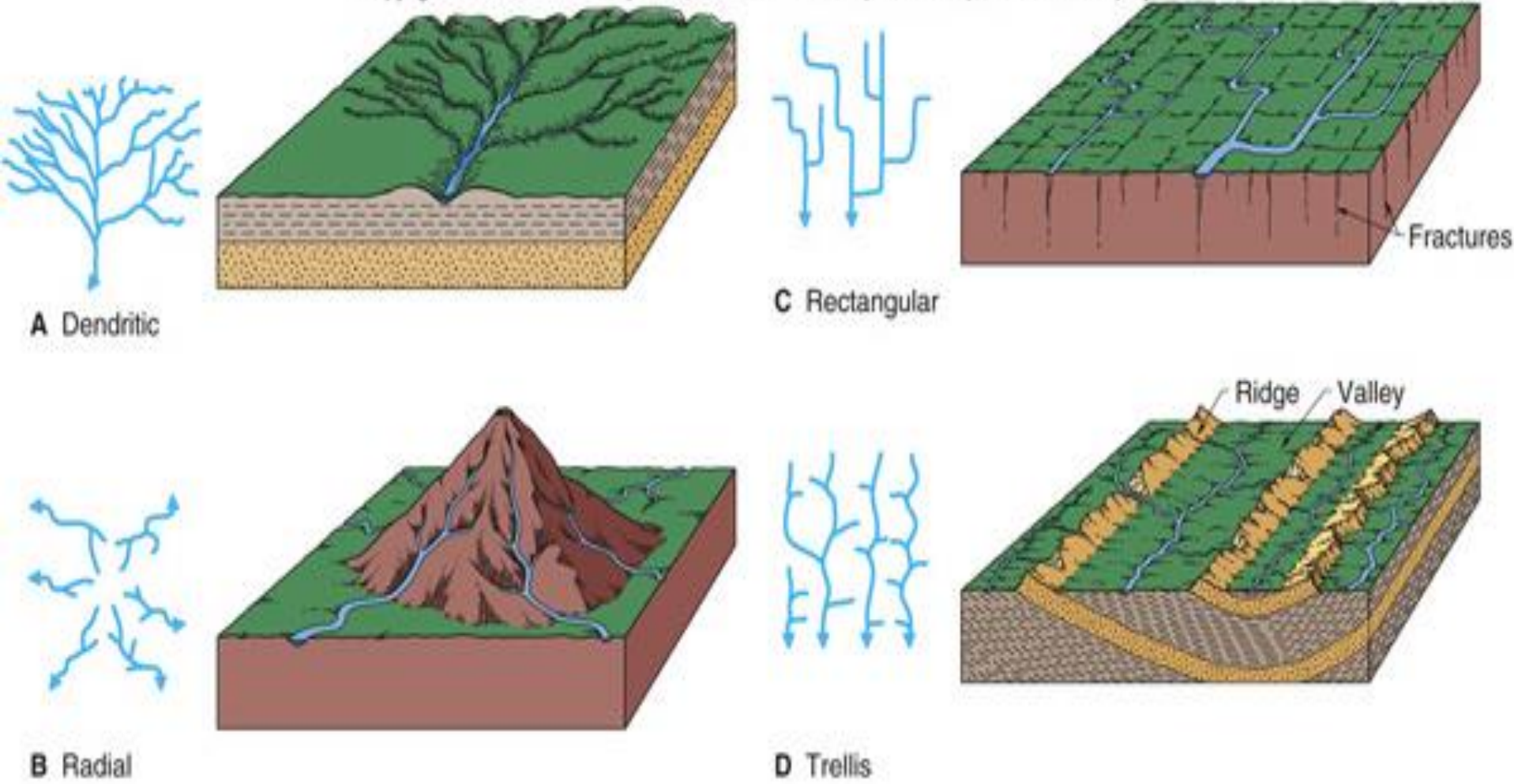


Drainage Basins



Drainage patterns

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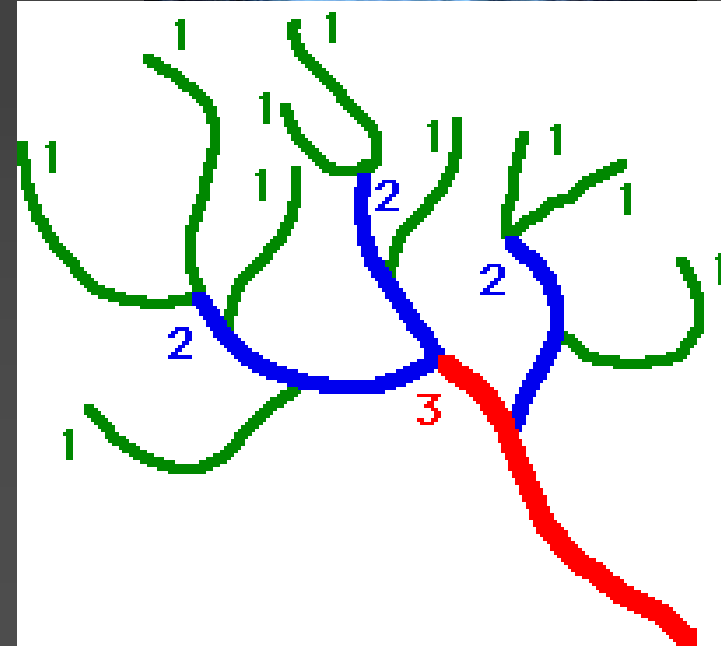
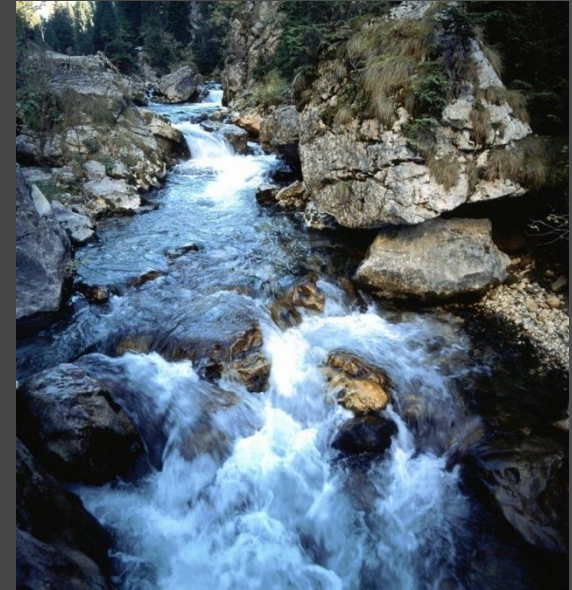
Calculations to help us describe characteristics of rivers

Bifurcation ratio

- (from Latin furca, fork) is the separation of a stream into two parts.
- In mathematics, the Strahler number or Horton–Strahler number of a mathematical tree is a numerical measure of its **branching complexity**.
- These numbers were first applied in hydrology by Robert E. Horton (1945) and Arthur Newell Strahler (1952, 1957); in this application, they are referred to as the Strahler stream order and are used to define stream size based on a hierarchy of tributaries.

Drainage density

- Complete exercises from Waugh (2002:54-55) Handout



DRAINAGE DENSITY



underlain by silty clay
-high runoff potential
-high drainage density

underlain by porous material
-lower runoff potential
-lower drainage density

Meanders and Flood Plan, Alaska

- $\text{Sinuosity} = C/V$
 - Channel length / Valley length



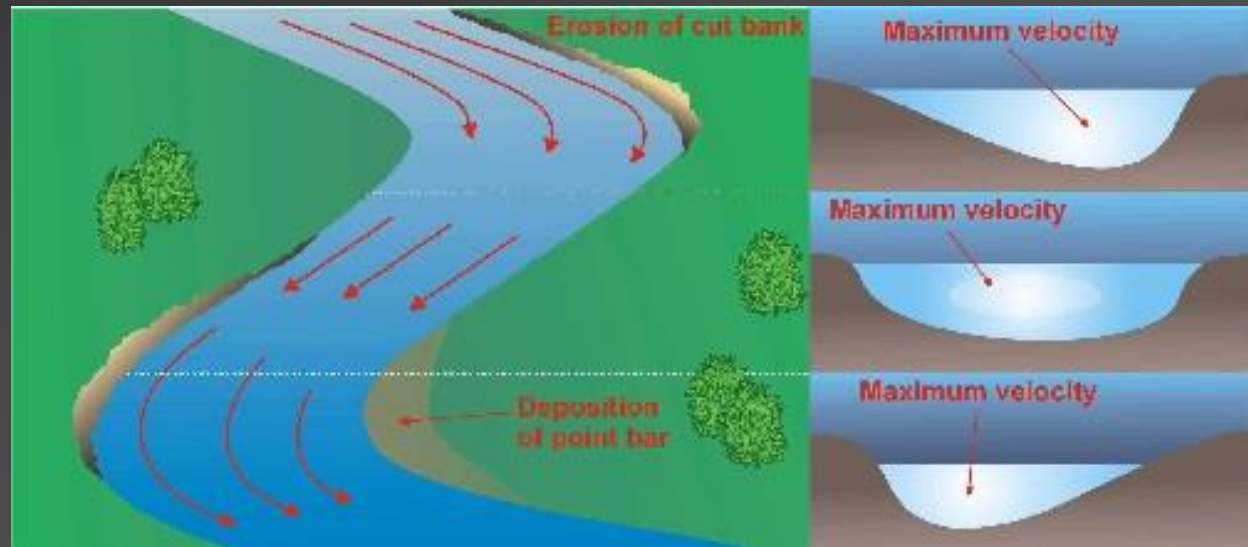
River Erosion

- Corrasion
(Sandpaper)
- Attrition
(Knocking)
- Hydraulic
- Corrosion
(Chemical)
- Frequency of occurrence

- Water exerts force

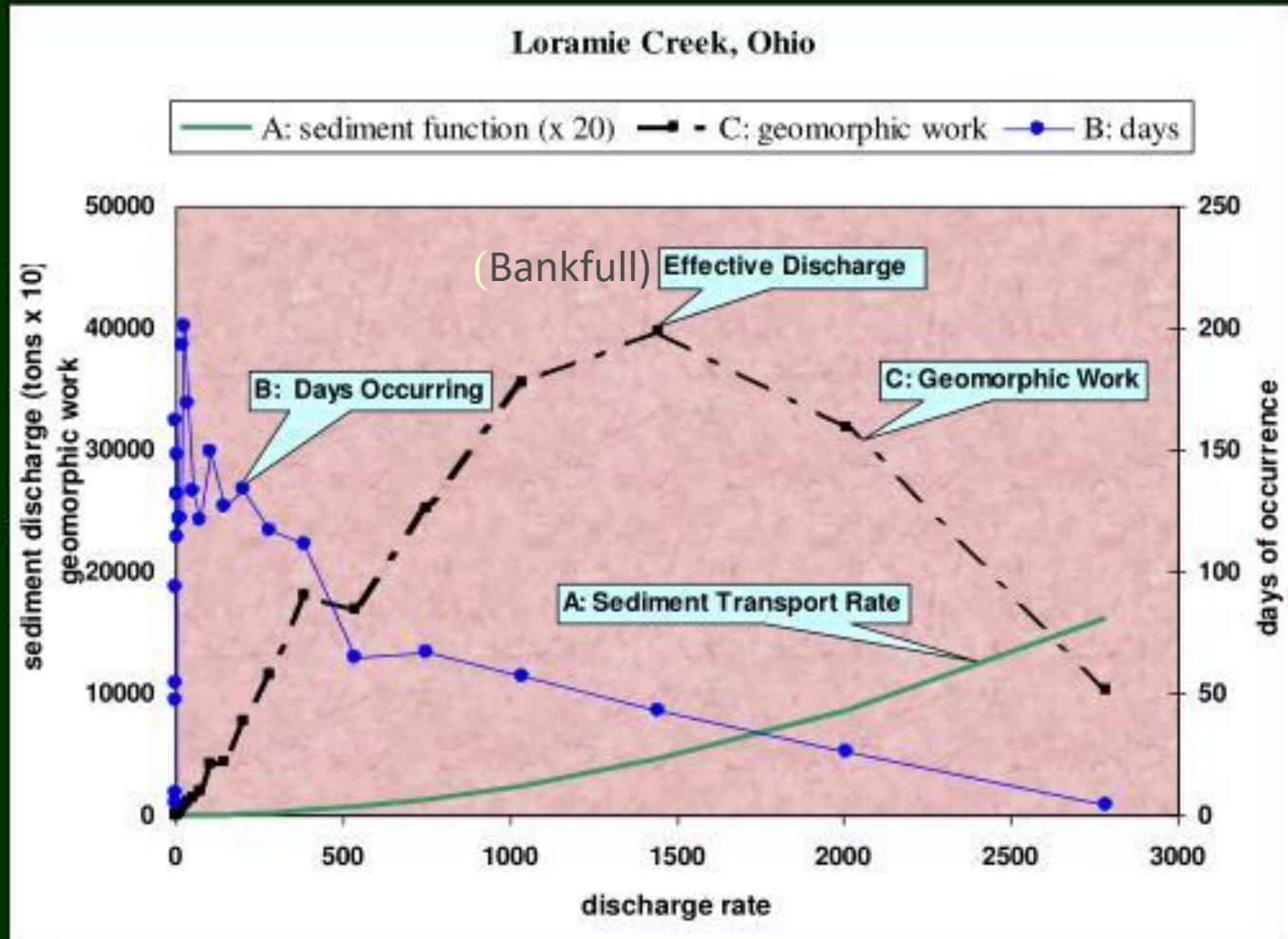


- Landscape provides resistance

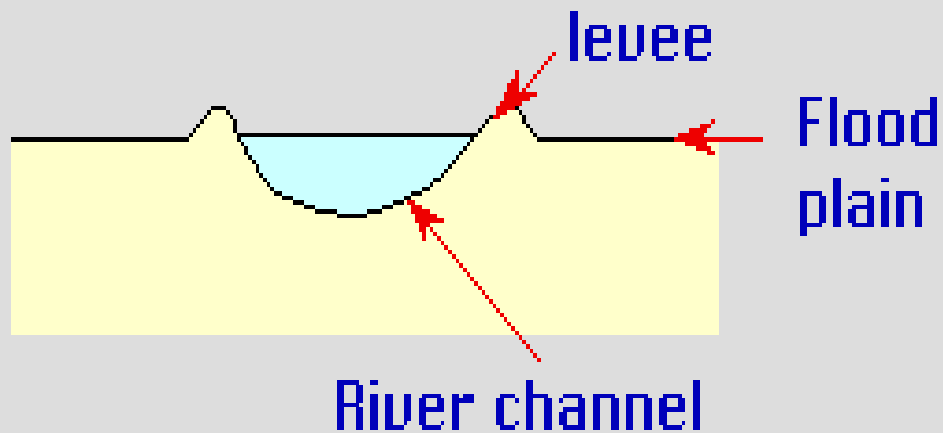


When does geomorphic work occur?

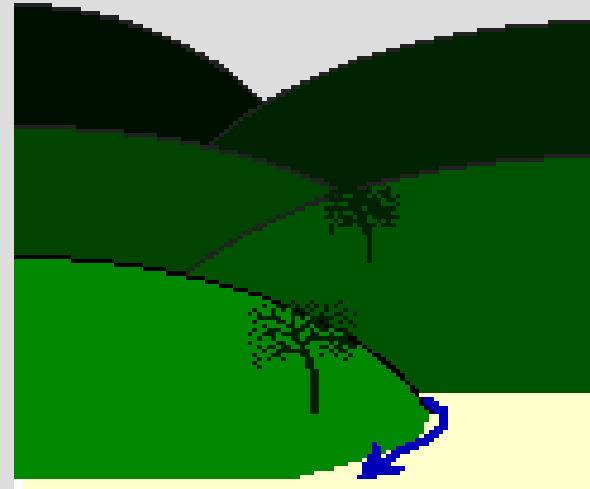
What is
Dynamic
equilibrium?



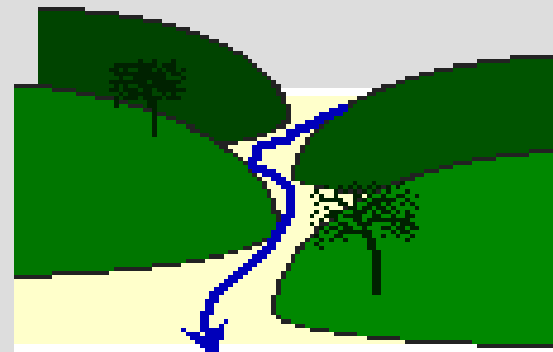
Some Physical Features of a River



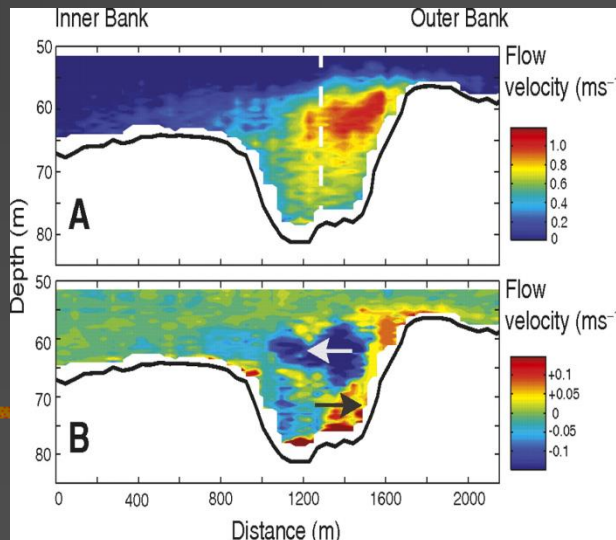
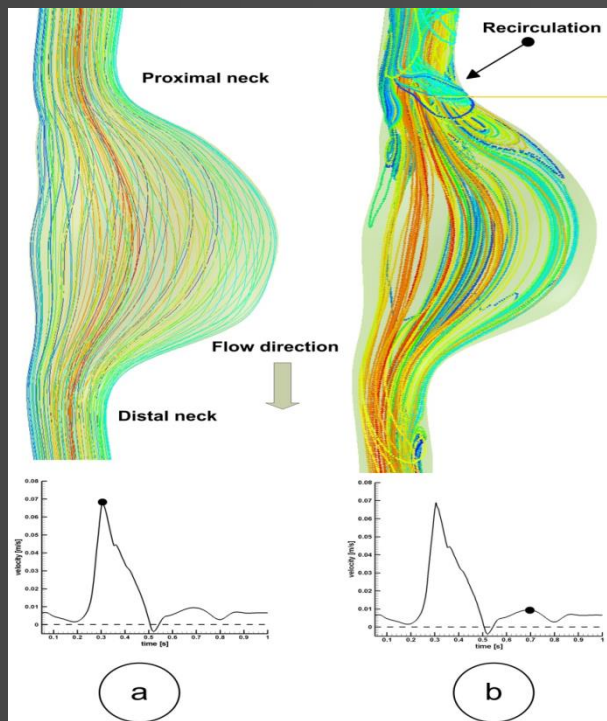
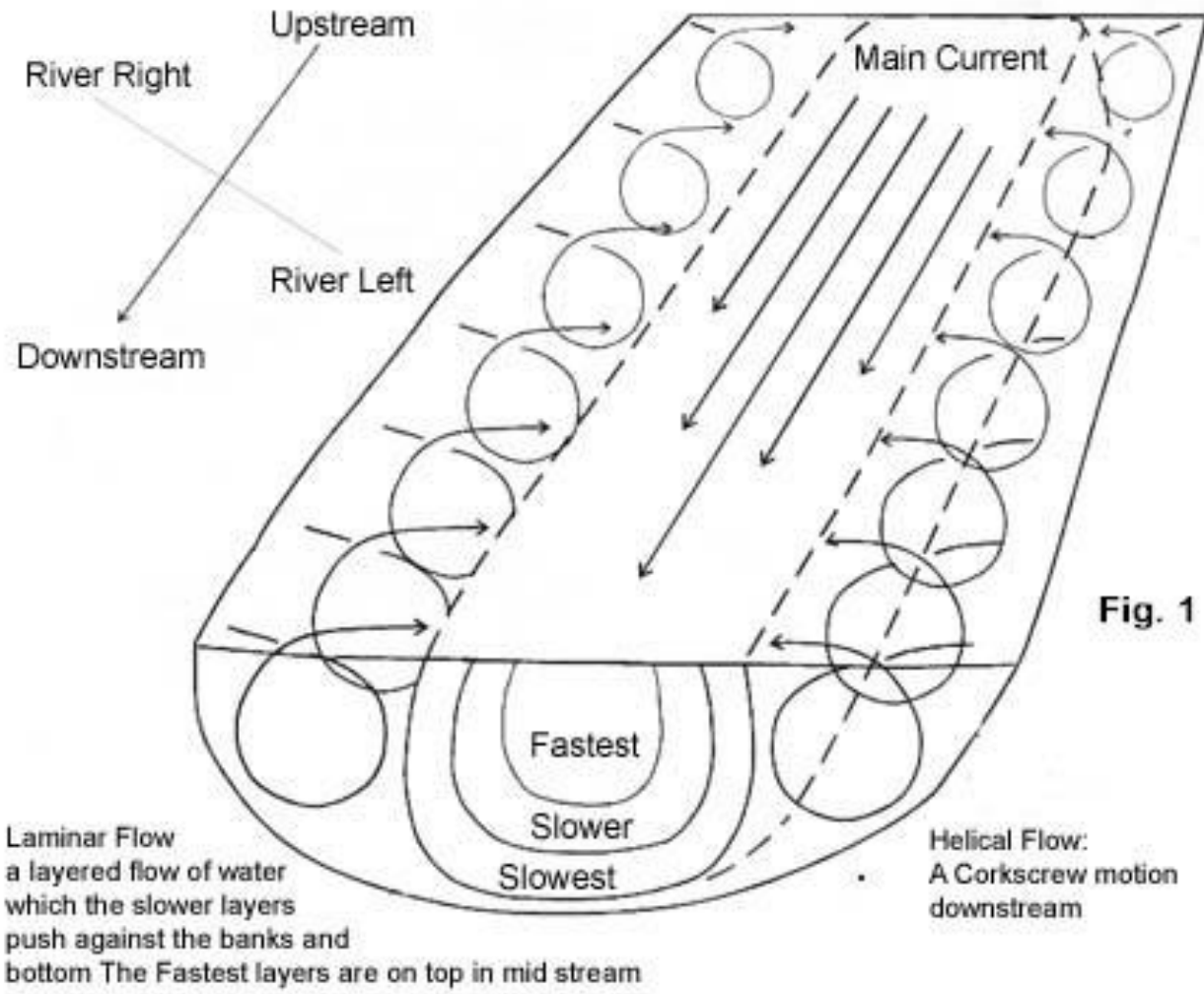
Interlocking Spurs



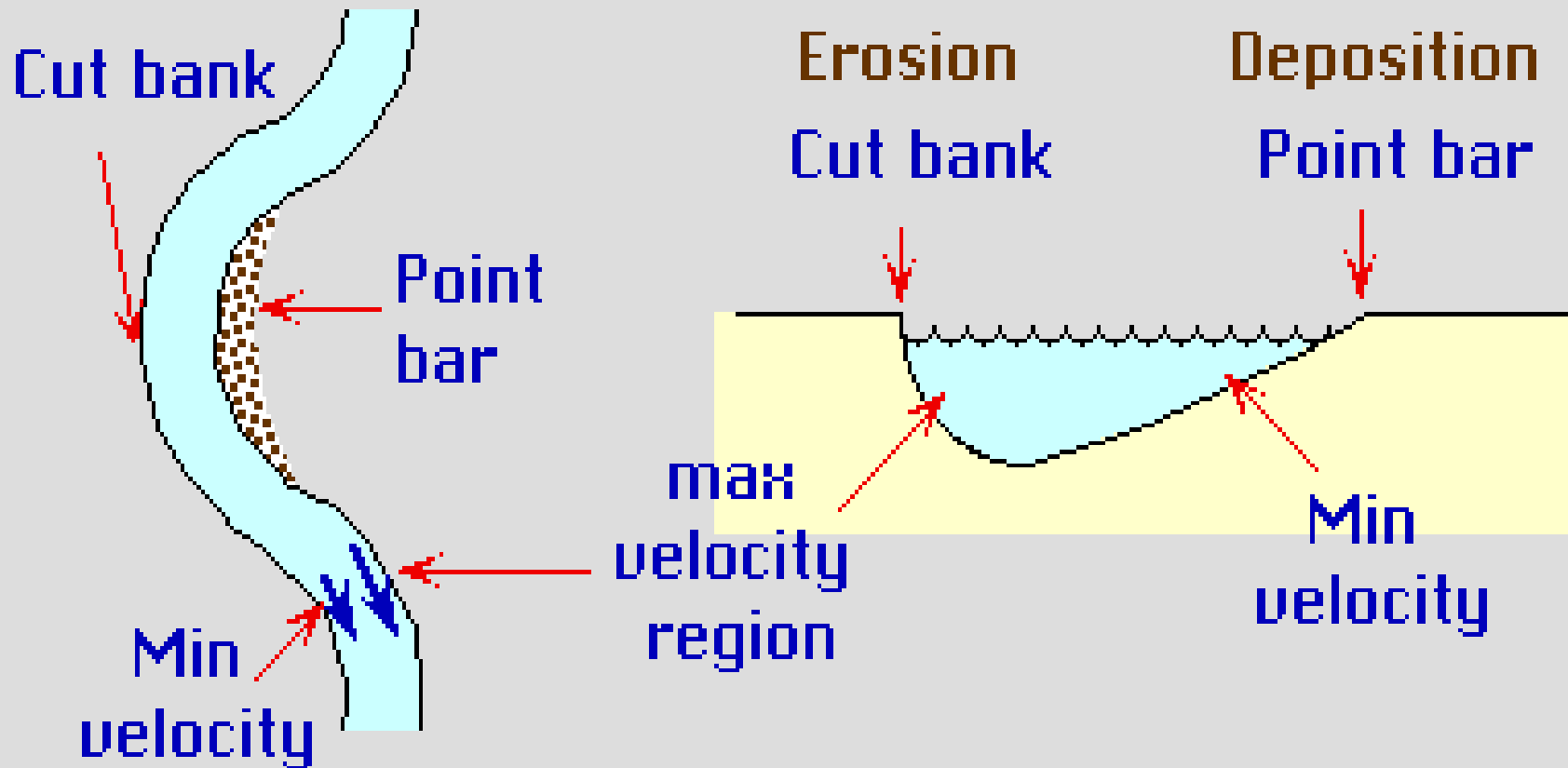
Truncated Spurs



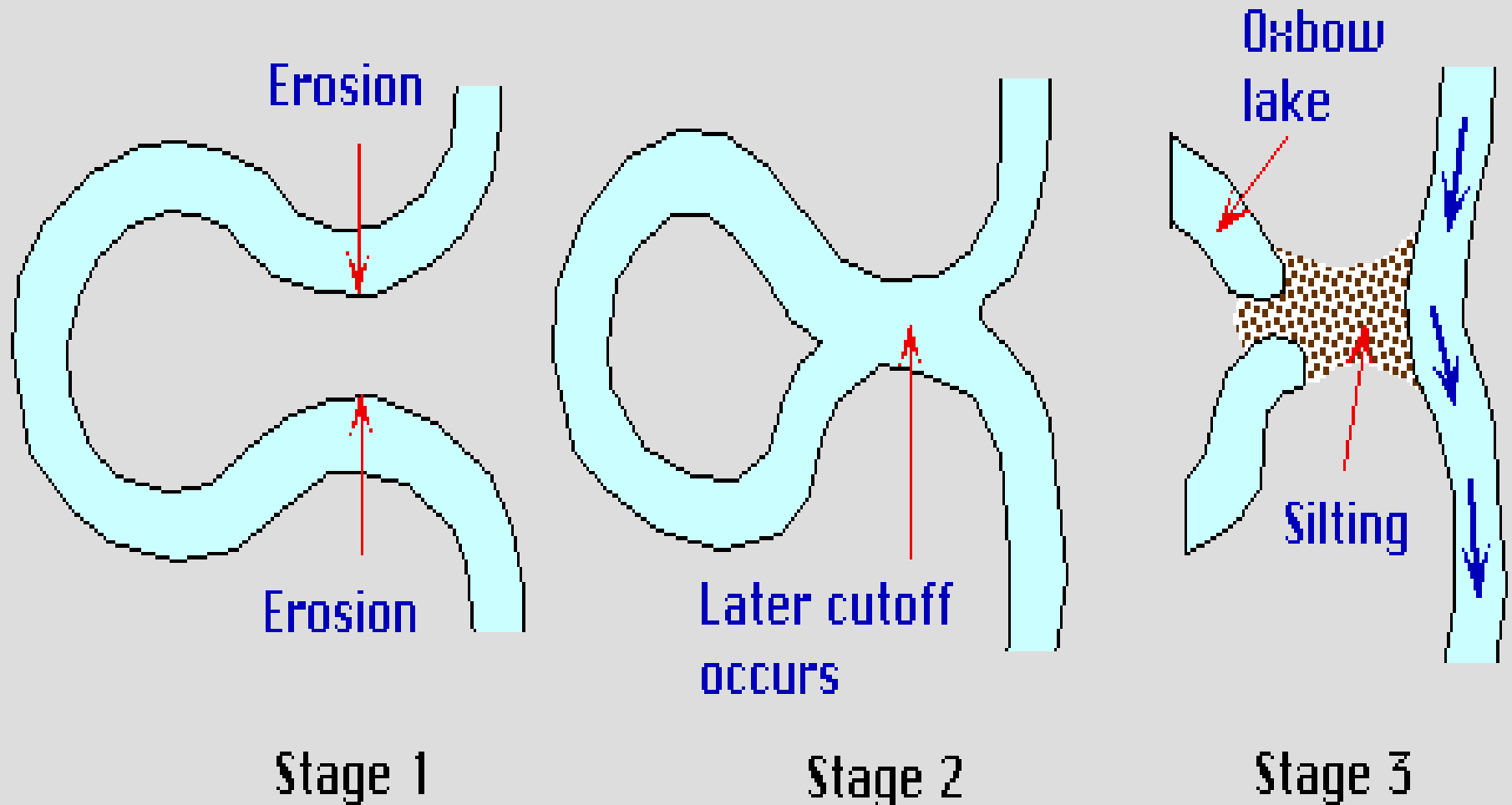
■ Helical Flow: induces meander



Some Physical Features of a River: Meander formation



Meander / Oxbow lake formation





Drainage Controls

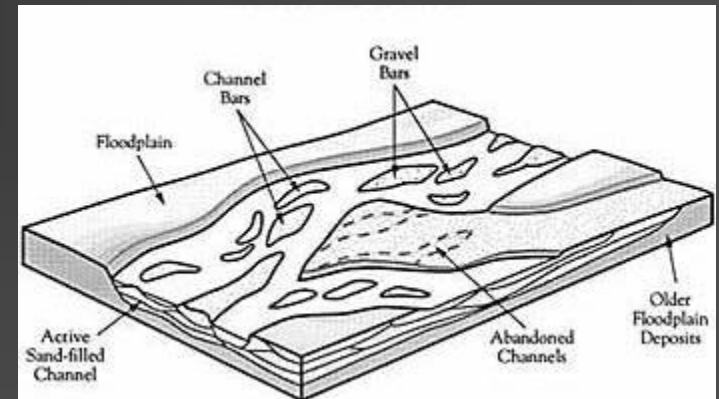
- Basin
 - Small=quicker
 - Shape: Circular < lag time > peak flow (Than elongated)
 - Relief: Steep quicker
- Type of precipitation
 - Prolonged: infiltration replaced by runoff
 - Intense storms
 - Snow melt (permafrost)

Drainage Controls cont'd

- Temperature: Extremes=<runoff
- Evapotranspiration
- Rock type: Permeability
- Soil classification
- Drainage density
- Tides and storm surges: 1953 North Sea
- Land use
 - Vegetation interception TRF 83%, Arable 9%
 - Urbanisation: Canals, runoff, culverts etc

Case Study: Cairngorms

- The channels of rivers draining the Cairngorms range from confined gorges to **dynamic braided systems**. Many elements of the valleys in which the rivers are inherited: the valley itself may have been cut or adapted by the flow of ice or meltwater and the stream itself is misfit and the valley may be choked by coarse sediments dumped by glaciers, meltwater and the river itself. The ability of the river to shape its own channel is thus closely constrained and some rock-cut channels have changed little in the last 10 thousand years.
- A river flowing on a floodplain draped with alluvium has the capacity to adjust its channel geometry in response to changes in discharge and sediment supply. Adjustment can involve
 - Channel slope
 - Flow velocity
 - Channel roughness
 - Channel shape
 - Channel pattern
 - Sediment transport



- In the Cairngorms, the most dynamic channel patterns are the braided systems of gravel bed rivers. Rivers like the Feshie and the Dorback are overwhelmed by sediment derived from thick sequences of fluvioglacial gravel and sand. The rivers shift the debris around, moving it slowly down valley, but they are incapable of clearing out the vast accumulation of accumulation and, indeed, erosion of bluffs at the channel margins bring in more debris. This creates **some of the fastest changing floodplains** in the British Isles, with switching of channels and movement of gravel bars over timescales of 10-100 years.

River Profile Characteristics

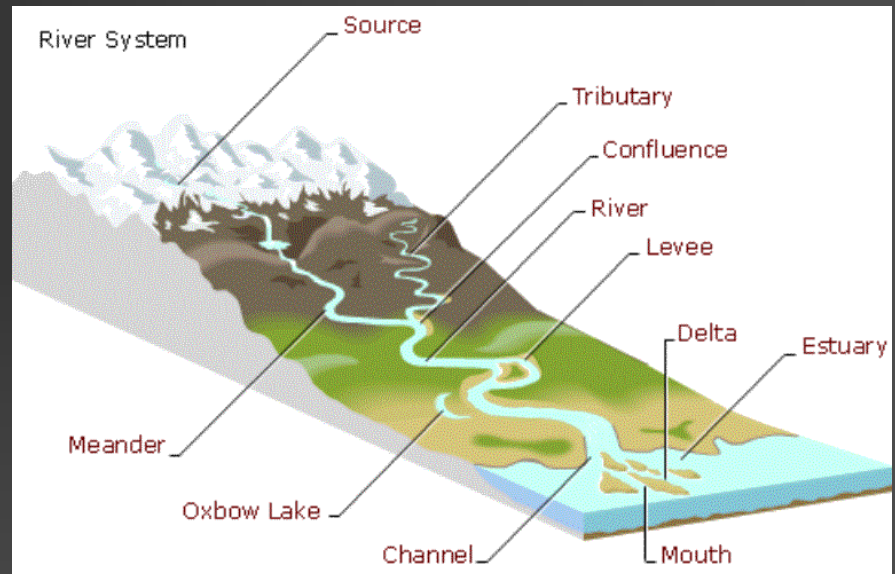
■ Source

- Turbulence
- Roughness
- Friction

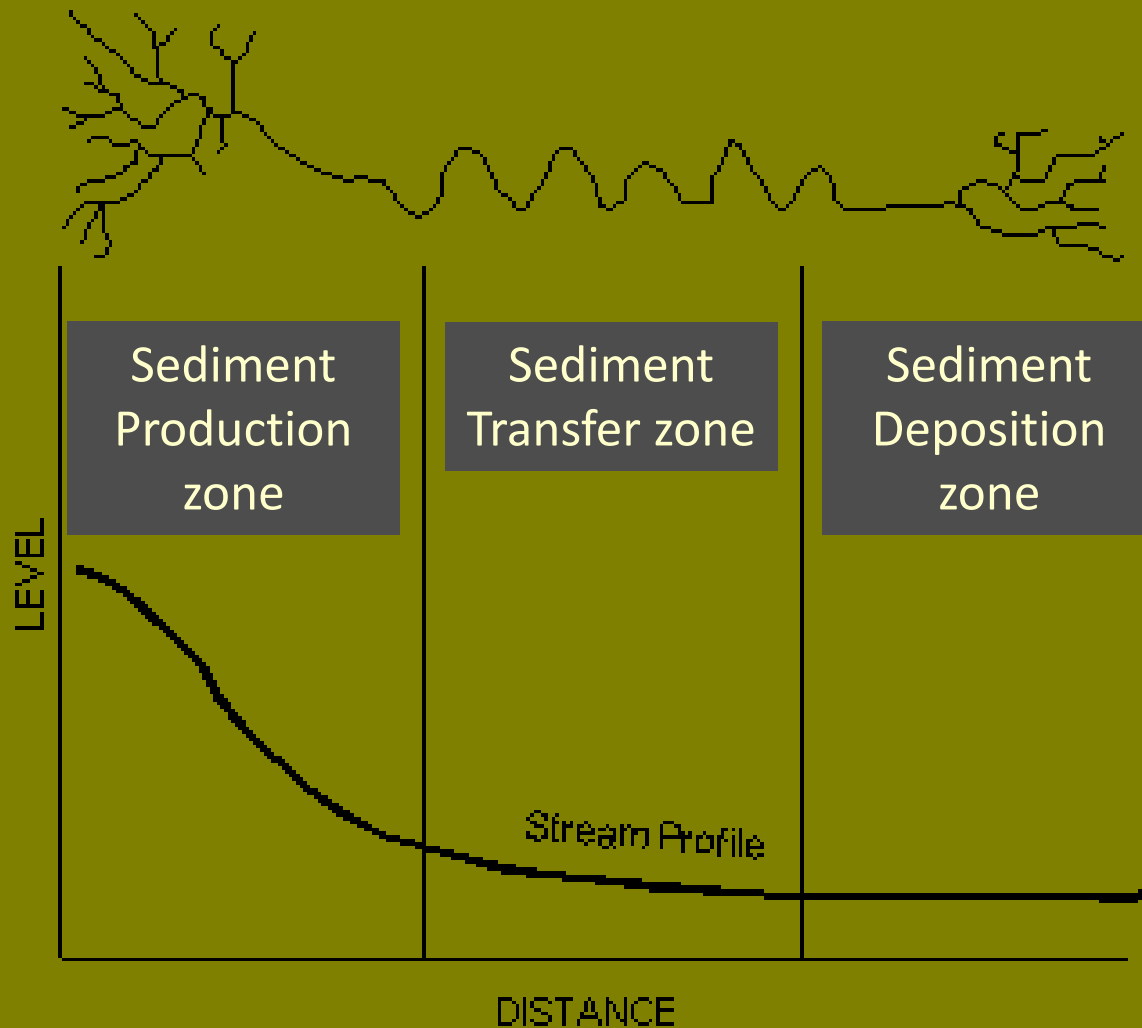
■ Concave Profile

■ Mouth

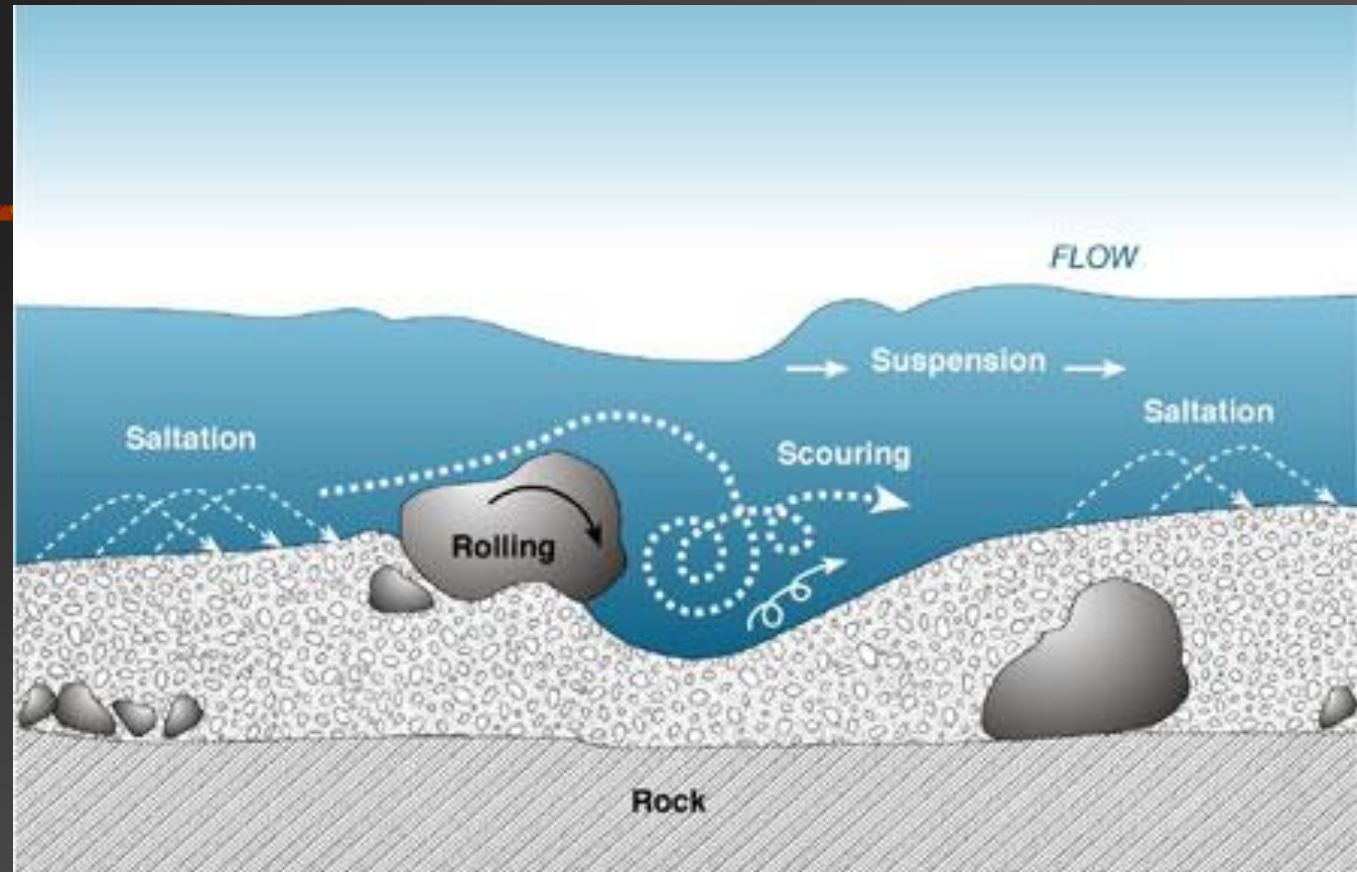
- Greatest discharge and velocity
- Highest hydraulic radius
- Highest cross-sectional area



Model of Sediment Movement

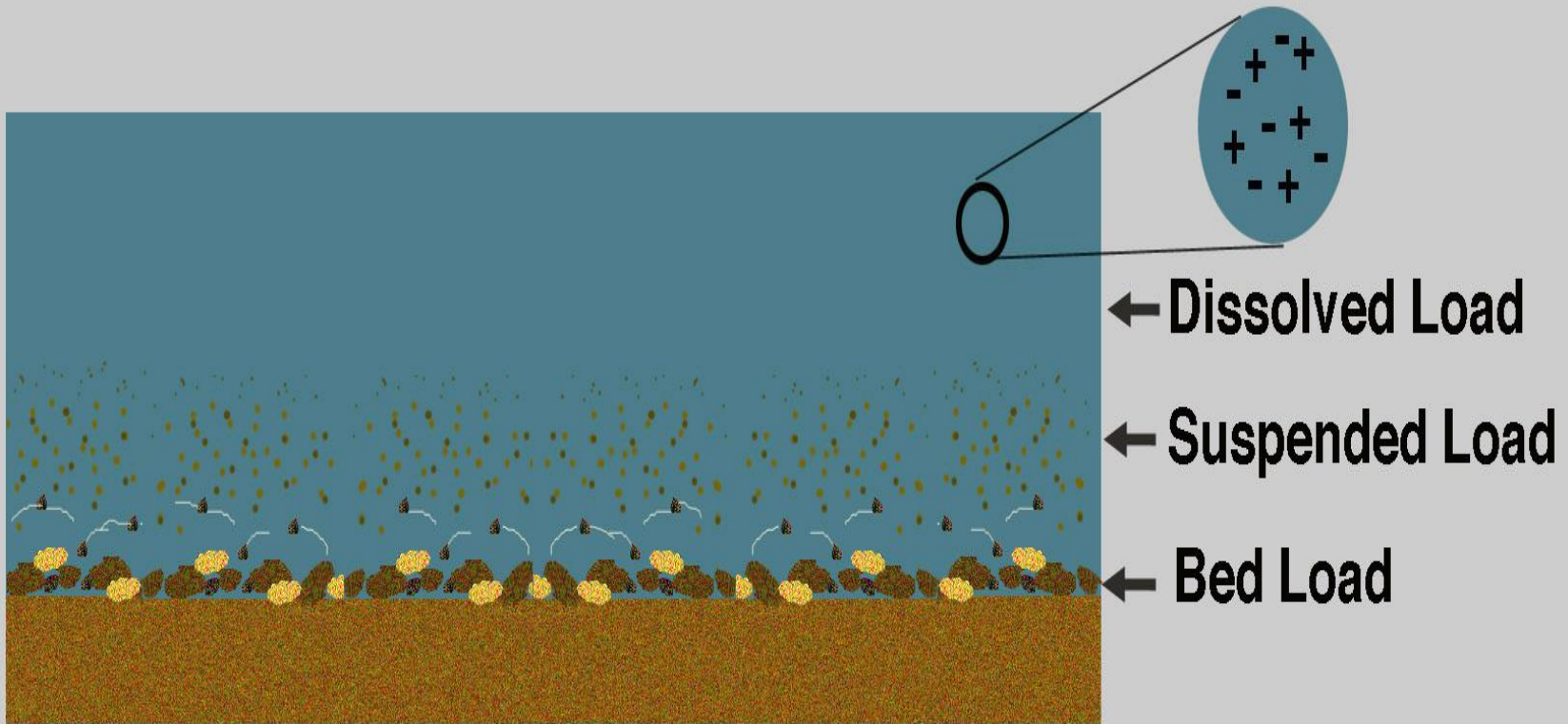


How sediment moves

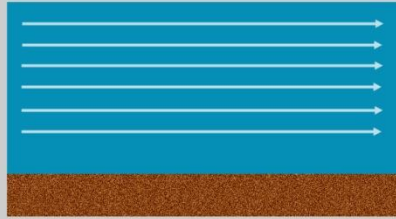


- The solid particles are then carried to the river by watercourses. Of varying sizes and weights, the particles move forward by successive small bounces along the water bottom (saltation) or directly in suspension in the water. Once introduced into a watercourse, these suspended solids drift with the current and are deposited in places where the current is weak.

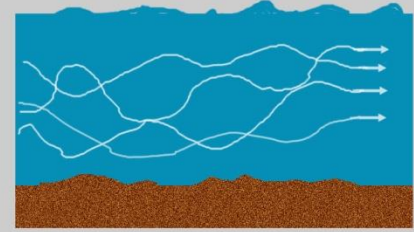
Movement cont'd



Flow and Gradient



Laminar Flow



Turbulent Flow

Base Level

No Gradient
Lowest Energy
Clay Sized

Low Gradient
Low Energy
Sand & Silt

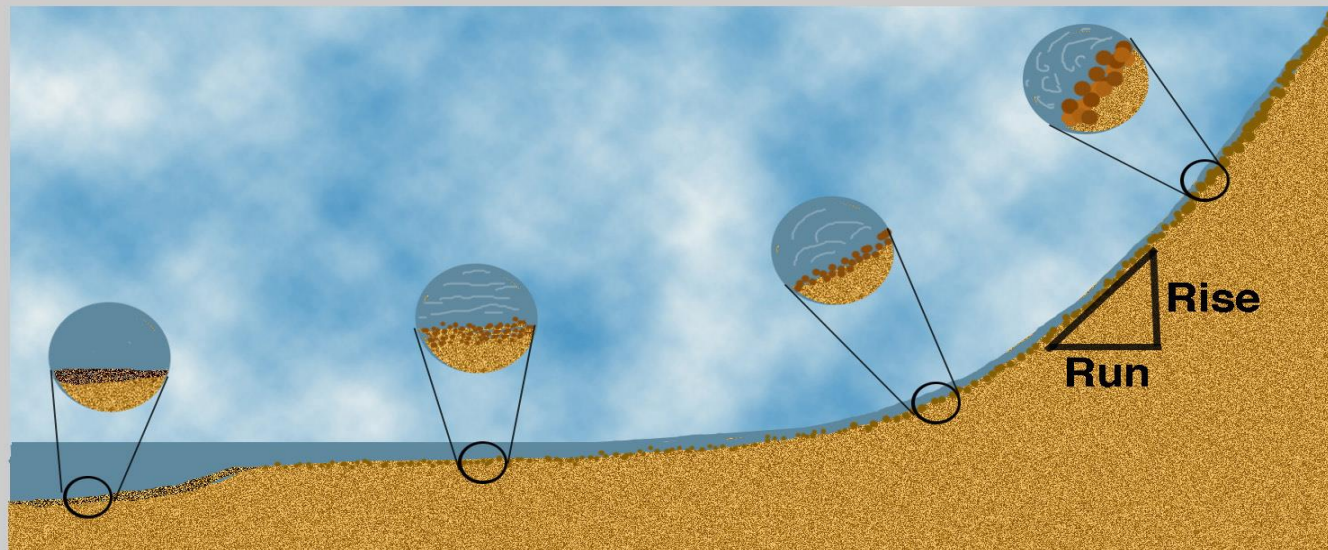
Moderate Gradient
Moderate Energy
Coarse Sand

High Gradient
High Energy
Coarse Gravel

Laminar Flow

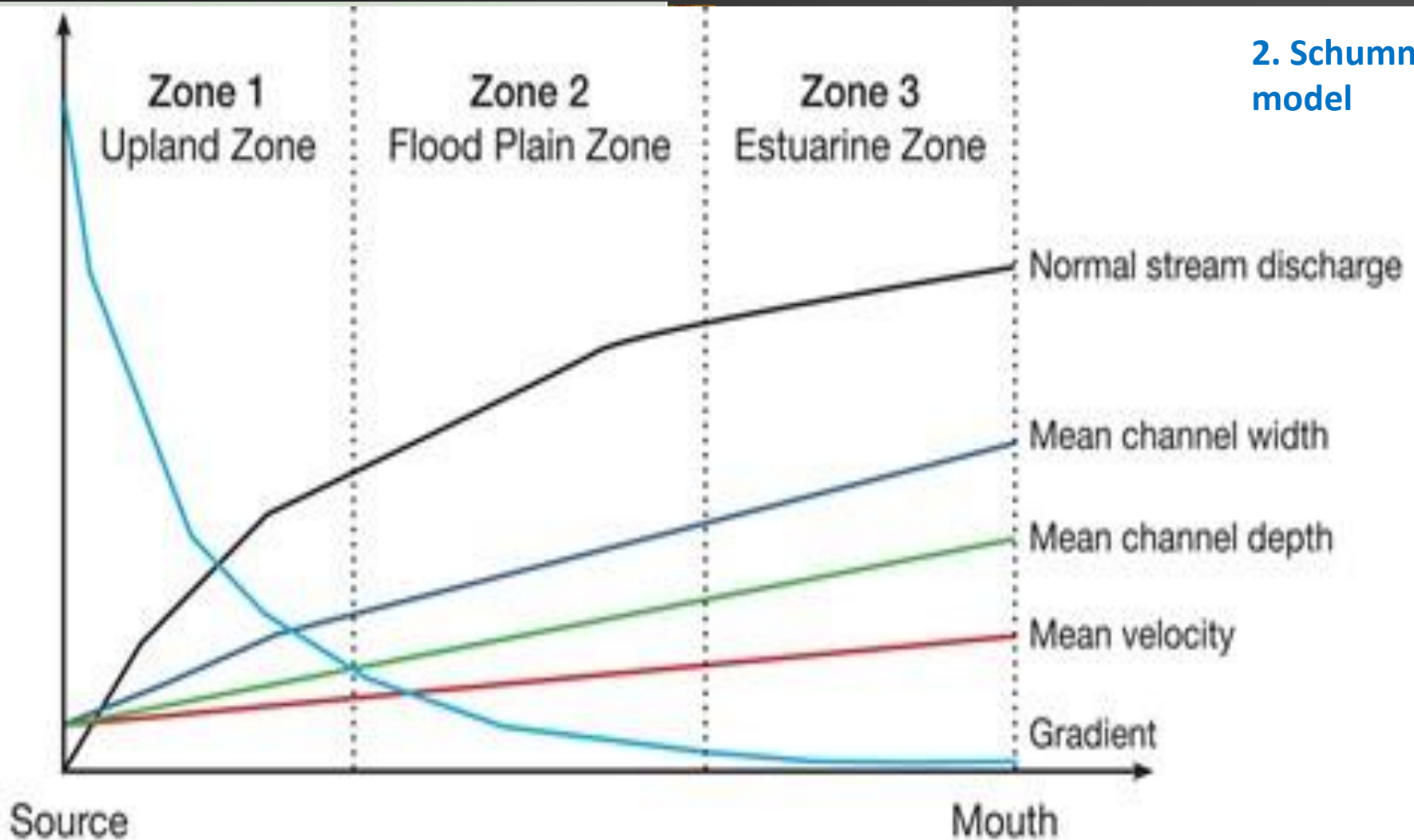
Turbulent Flow

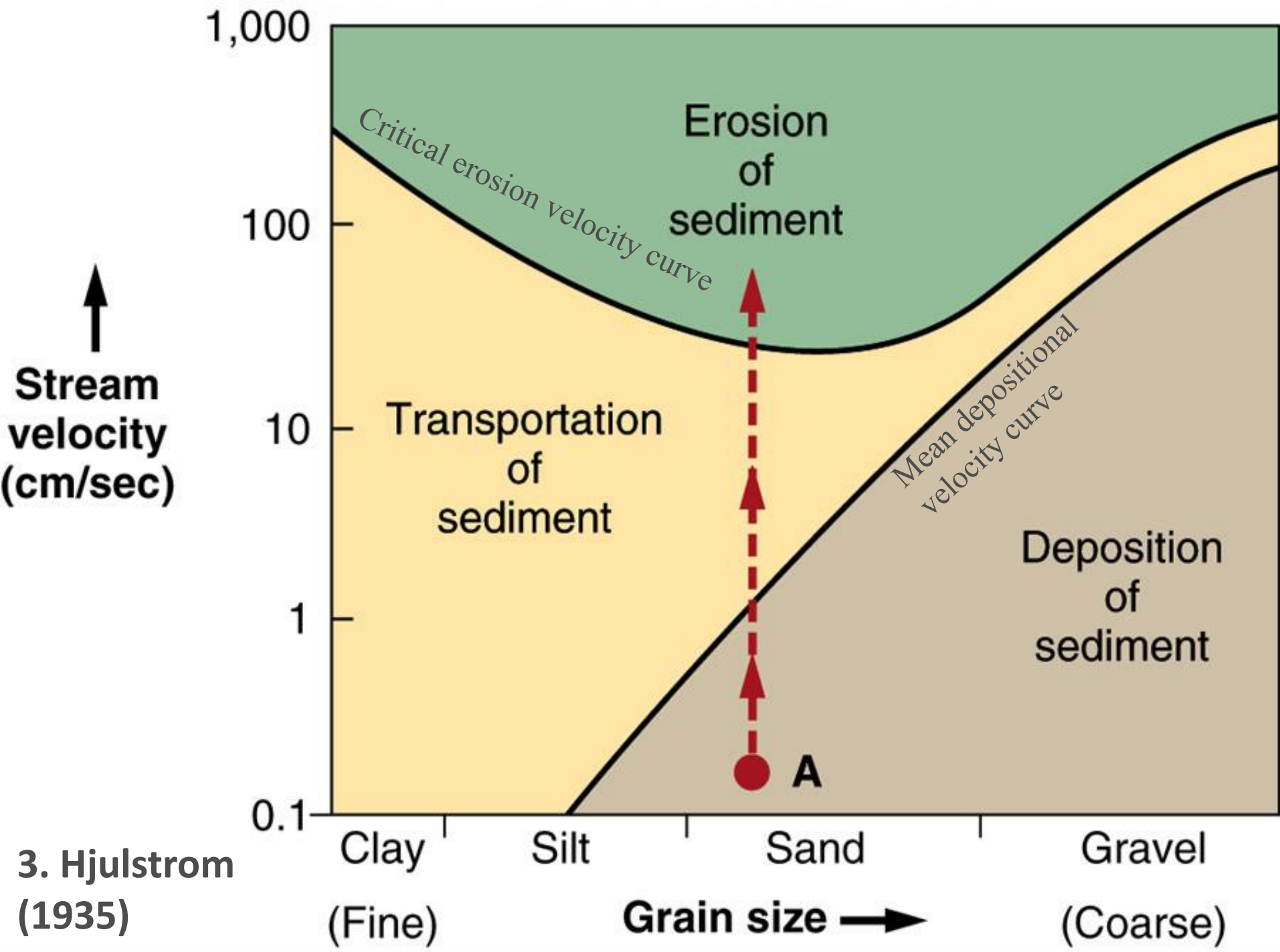
Headwaters



3. Models of river hydrology

2. Schumm model





3. Hjulstrom (1935)

All models have anomalies

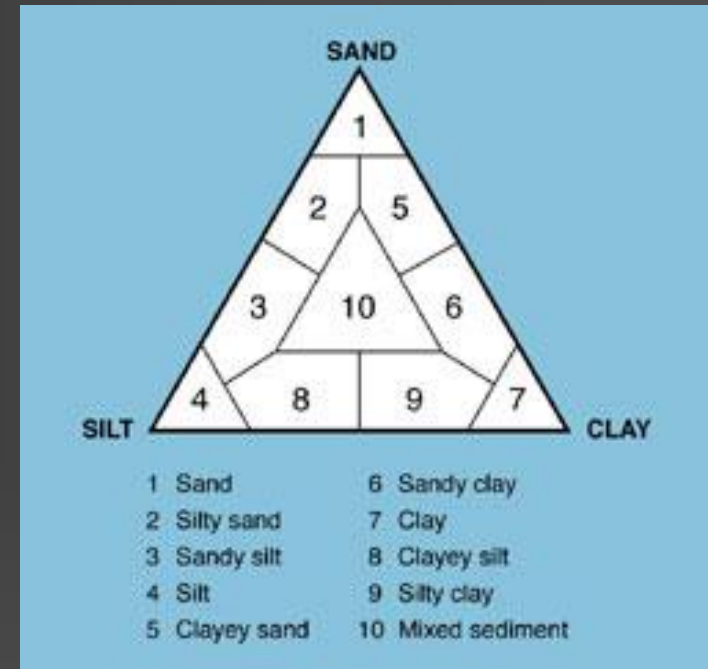
- Discuss and construct a table of potential anomalies

Bradshaw	Schumn	Hjulstrom

Sediment Classification

Sedimentation Classification

- Wentworth's classification (1922) is one of the most widely used in the field of sedimentology. It comprises four main classes of particles:
- **Gravel:** particles greater than 2 mm in diameter
- **Sand:** particles between 0.064 mm and 2 mm in diameter
- **Silt:** particles between 0.002 mm and 0.063 mm in diameter
- **Clay:** particles less than 0.002 mm in diameter.
- In order to obtain a qualitative description of texture, the results of Wentworth's classification are used in ternary diagrams based on Shepard's nomenclature (1954).



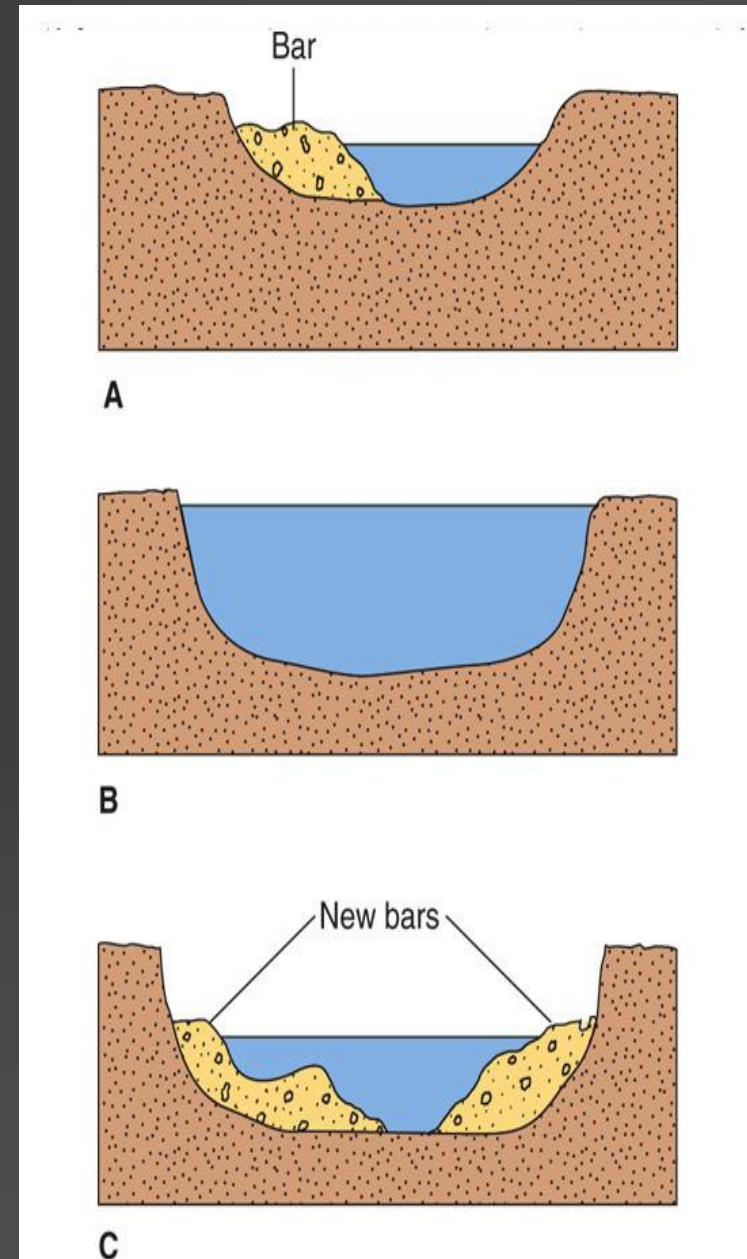
Deposition Features: Bars

- **Landforms** may also be created by deposition of sediment within the stream.
- **Bars** are ridge-like deposits of poorly sorted sediment found near the banks of a stream or in the middle of the stream channel. The presence of bars indicates that at some time in the past the discharge of the stream was higher and coarser sediment was transported by the stream water. When the discharge decreased, the coarse sediment was deposited, forming a ridge-like structure usually parallel to the direction of flow. During a flood, all grain sizes of sediment might be transported down a stream that, under normal circumstances, might only transport silt or clay. When the flood recedes and the discharge is diminished, the coarse cobbles and boulders are deposited on the bed. This further slows the flow of water, resulting in the deposition of finer sand and silt among the boulders and cobbles.



Bar formation

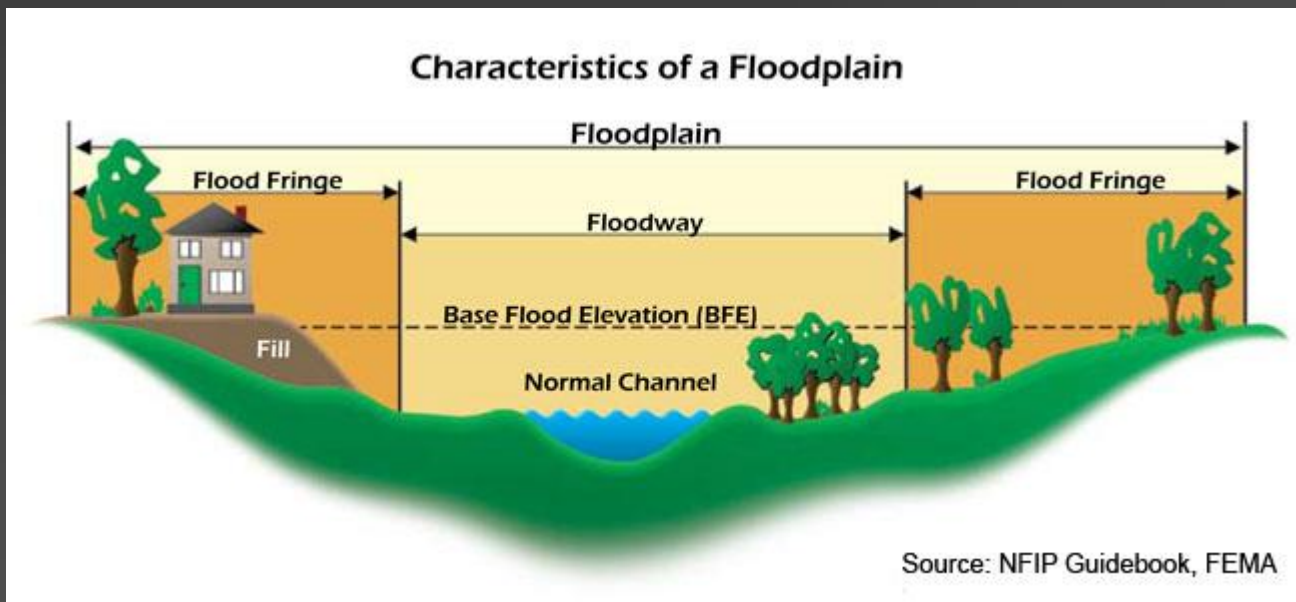
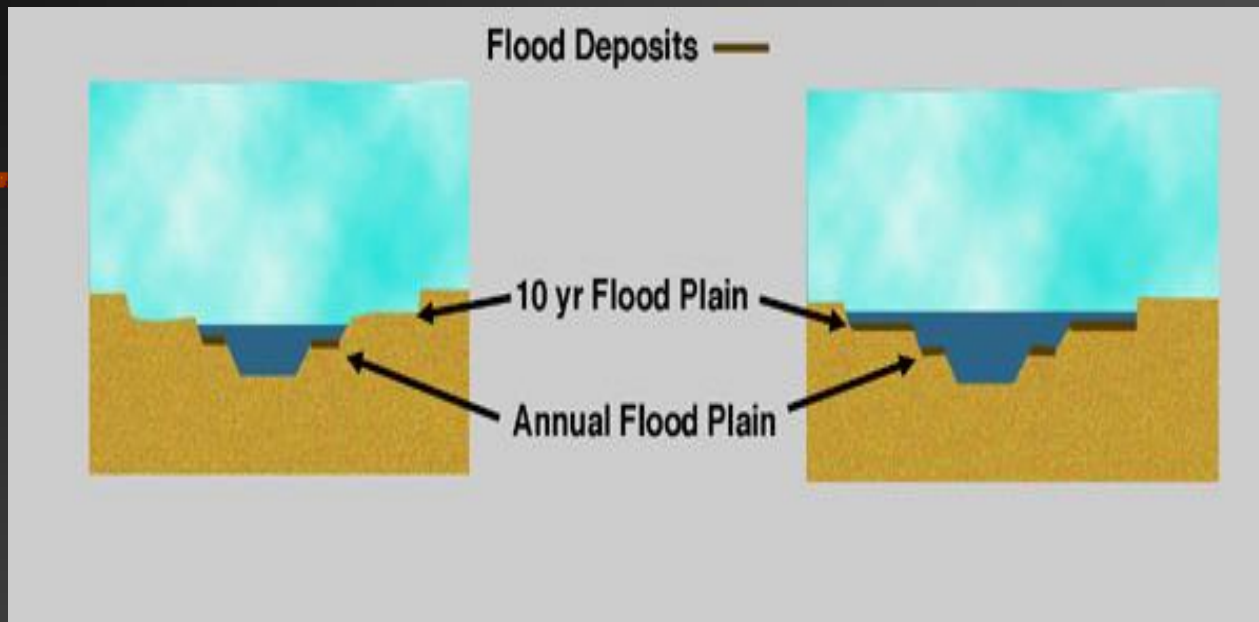
- In the diagram the evolution of a bar is shown. At the beginning of the cycle
 - A. (A) a stream is shown with a bar deposit along its bank, resulting from an earlier flood.
 - B. Later (B), another flood occurs eroding and transporting the sediment in the bar downstream.
 - C. After the later flood recedes (C), a new unsorted bar deposit is formed.



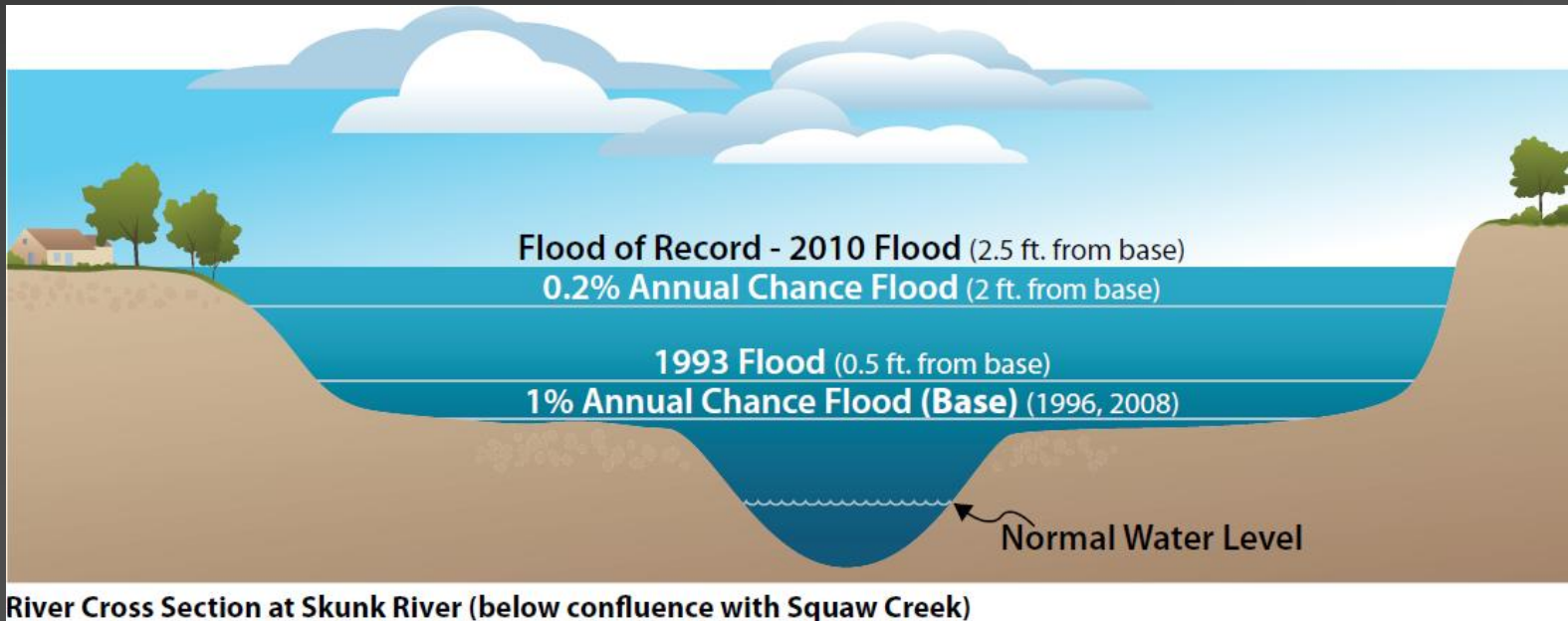
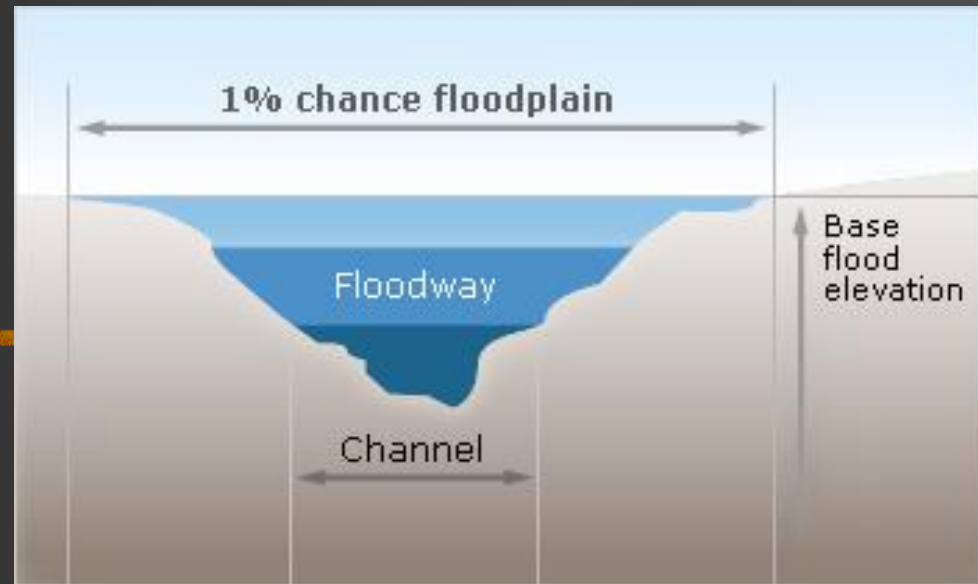
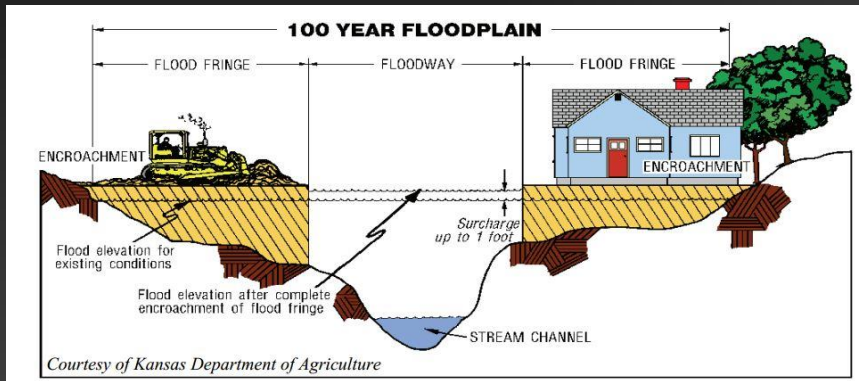
Arncliffe Yorkshire Dales



Channel Profile and deposition



Flooding



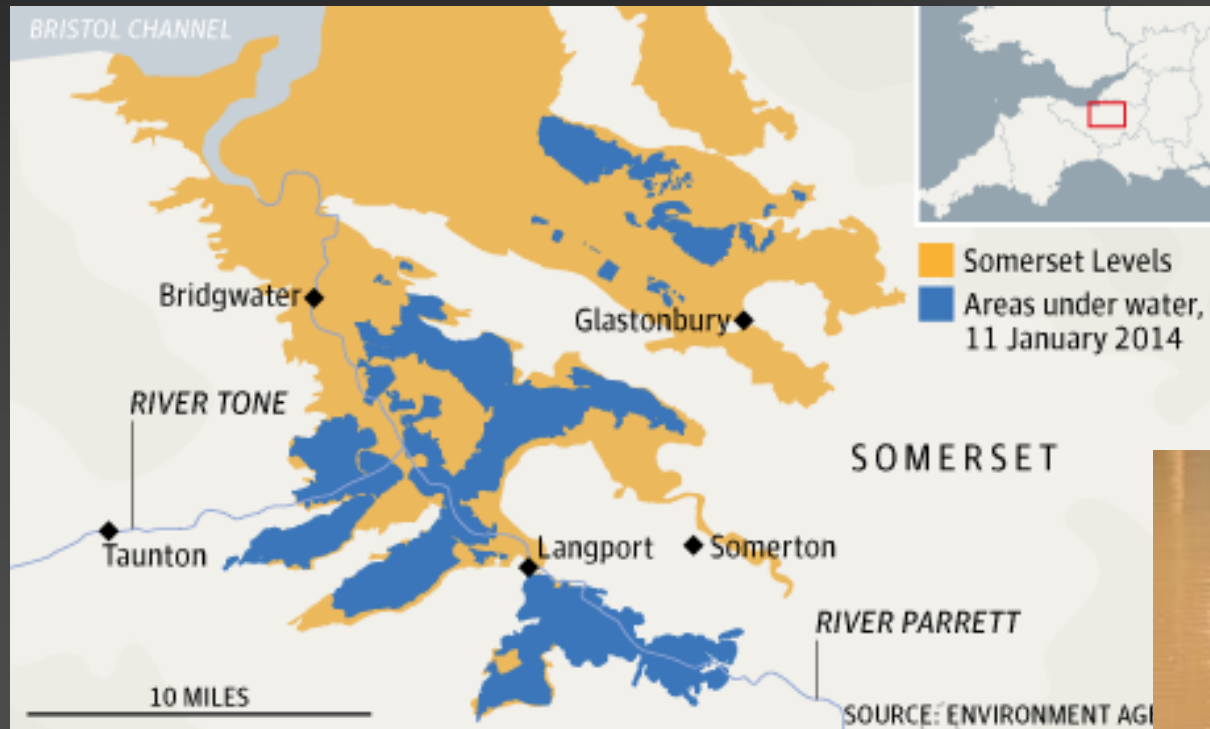
River Management

Hard and soft engineering

- <http://www.youtube.com/watch?v=t632Bz8AQoU>
- Discuss



Flooding



Student dissertations and jobs

Dimensions of Sustainability Philosophy: An Innovative Concept Design for Rapid Assessment

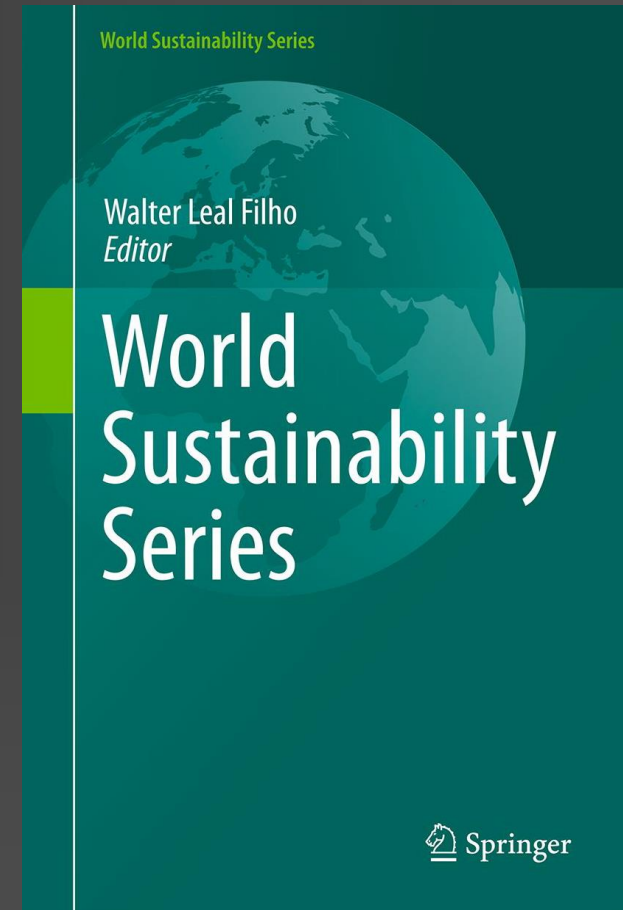
J. Wakeford, C. House, T.E. Butt, P. Paul and C.D. Beal

Abstract

This paper proposes the concept design of a novel Localised Rapid Flood Vulnerability Index. This proposed index has been initially tested and applied to a specific locale in Somerset, UK. The early analysis demonstrates that flood vulnerability may be unique to an individual location, despite the flood risk being considered the same for identical adjacent properties. Interpretation of these findings should provide increases in understanding of the interaction between the socio-economic and natural environmental requirements and overall flood vulnerability at a localised level. This initial research demonstrates the need for a rapid and cost effective flood vulnerability assessment tool at the localised scale.

Keywords

Climate change • Socio-economic • Sustainability • Flood risk • Flood mapping
Flood vulnerability • GIS



Now works
for NRW

Cont'd

- Now works for DWR Cymru



Perception Versus Skepticism—An Environmental Communication Issue and Climate Change

C. House, N.L. Jordan, T.E. Butt, J. Kwan and A. Alam

Abstract

'Perception' plays an influential role in policy formulation, implementation, and monitoring. It varies between individuals, communities, and administrative levels, and in degrees of importance. Furthermore, perception can be good or bad, positive or negative, yes or no, right or wrong, belief or disbelief, or even true or false. In parallel to perception, 'skepticism' is referred to in literature and practice, and is a corollary to understanding human interaction in environmental communication. A review of the perception-associated literature and anecdotes collected from researchers and practitioners reveals that there is no clear definition of the remit of these two terms. At least not when it comes down to research and its application in controversial topics and scenarios cropping from sustainable development and climate change, which are two of the most multi- and interdisciplinary fields in their own individual right. The purpose of the paper is to identify and propose the definitional boundaries between perception and skepticism in a systematic manner, and propose a conceptual model in the form of a schematic. Based on illustrative case studies, the paper also paves a path for further research areas in which the conceptual model can be applied to real-world scenarios for testing and sensitivity analysis, whereas such scenarios



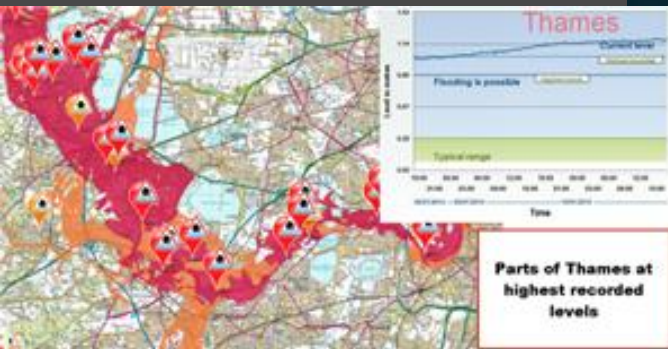
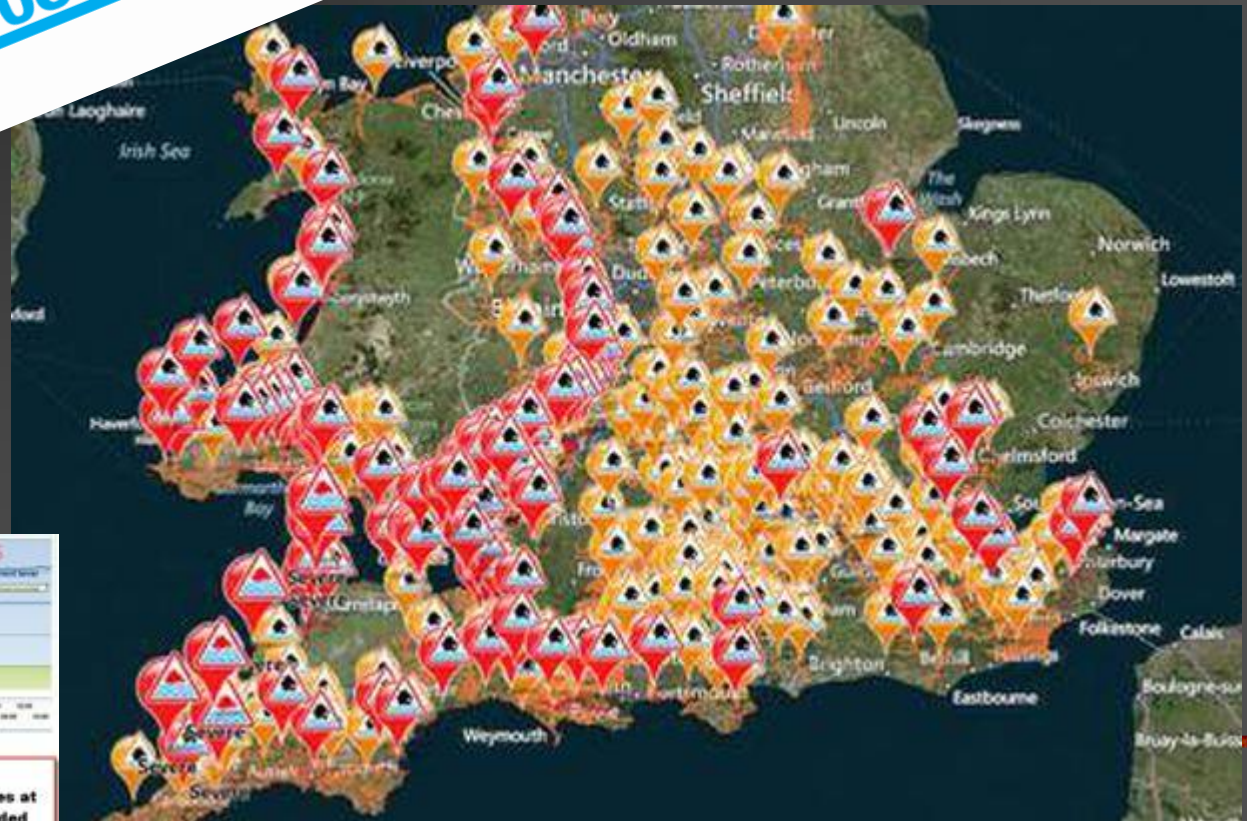
Environment Agency NRW



Floodline
0345 988 1188

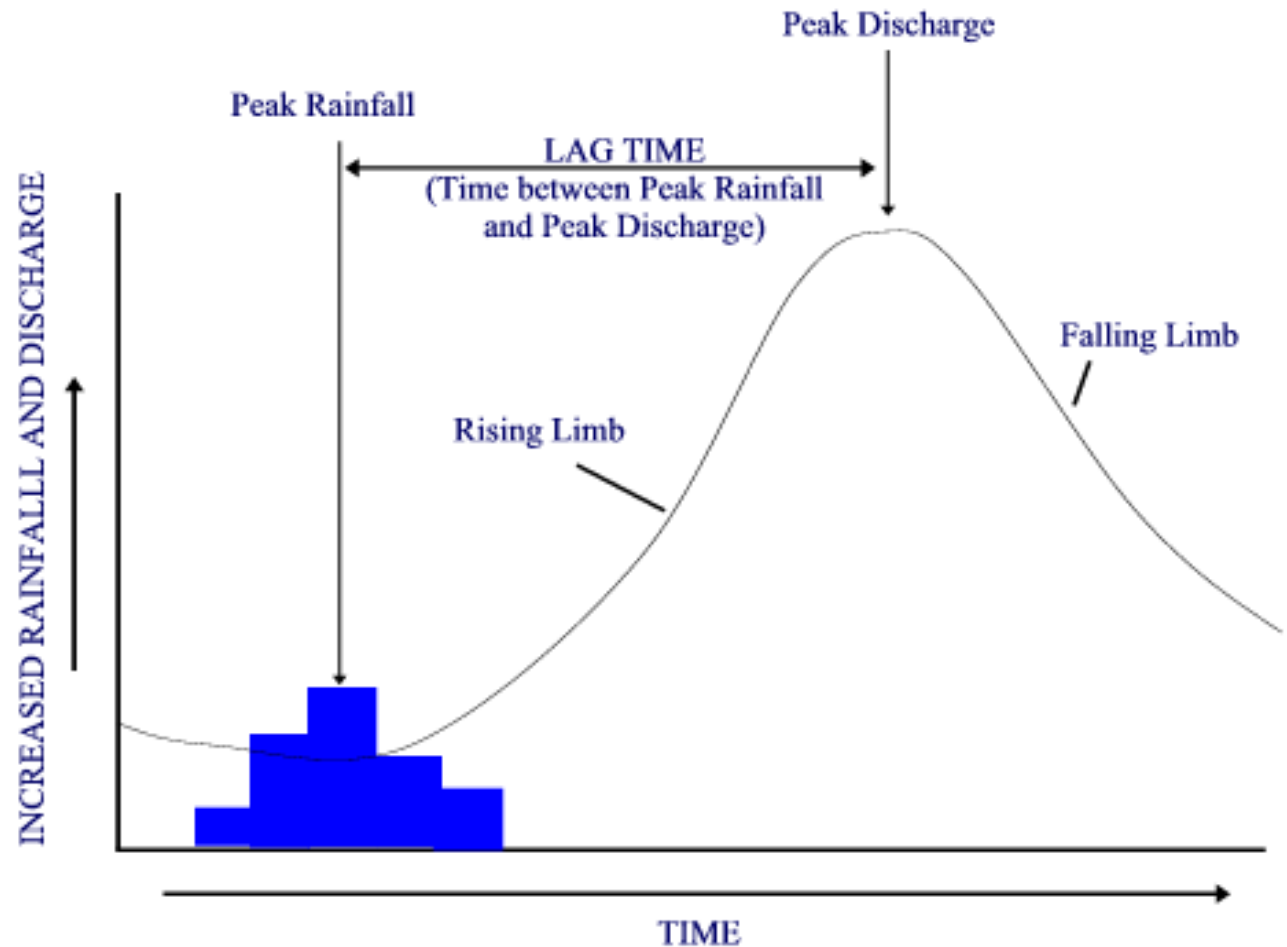
0845 988 1188

**FLOODS
DESTROY
BE PREPARED**



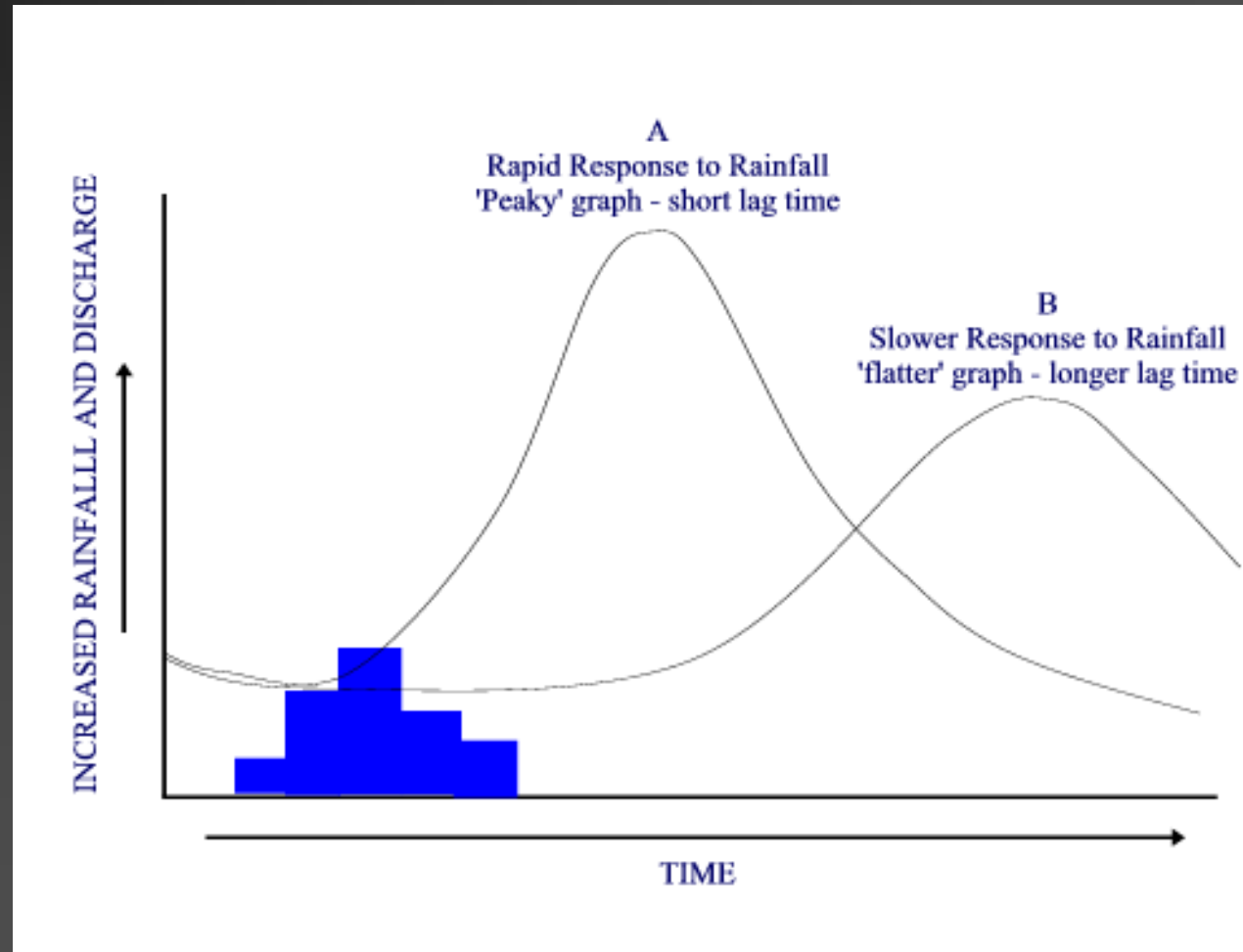
Hydrograph

- Discharge:
Measured
in Cubic
metres per
sec.

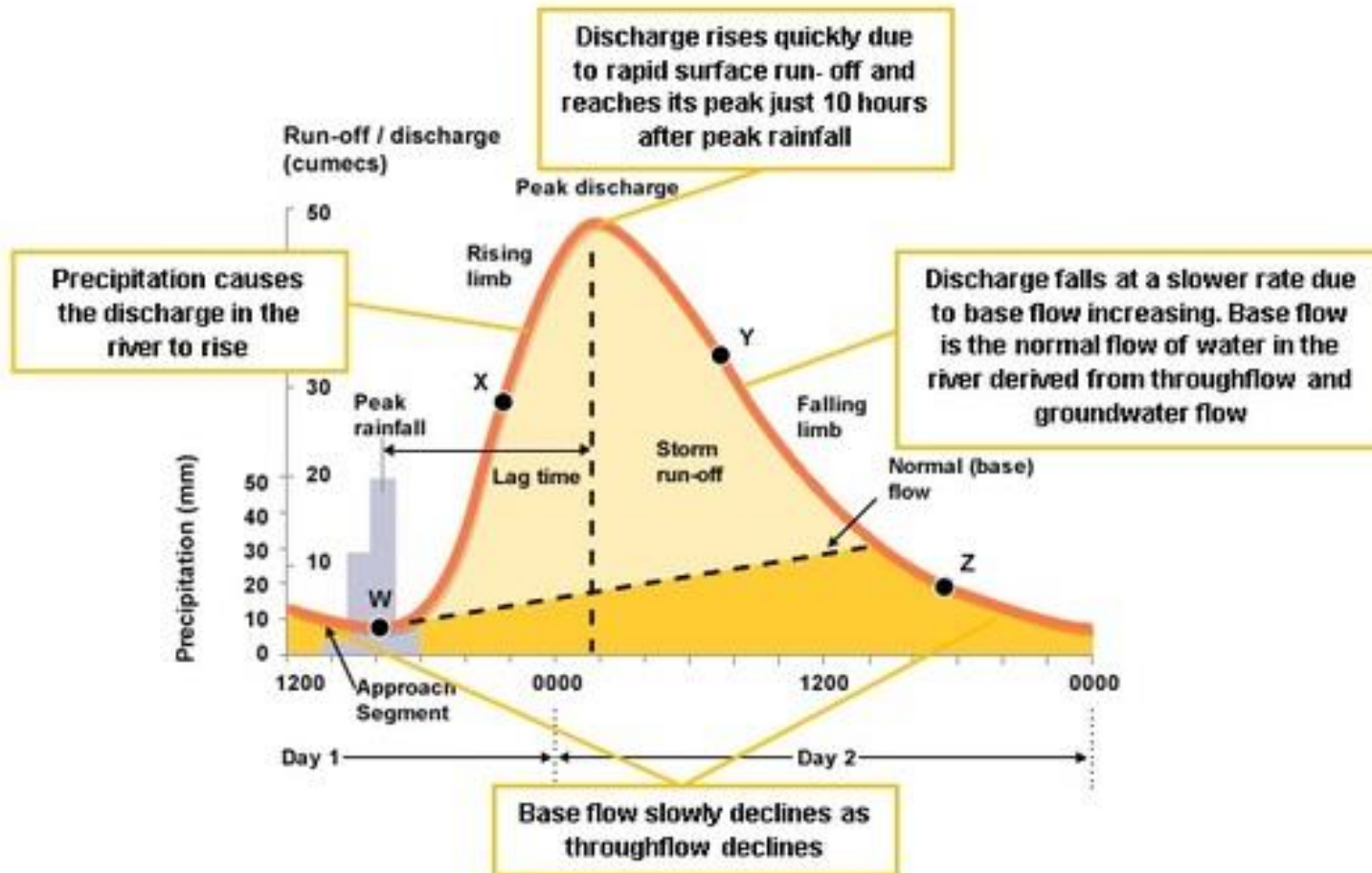


Use of Hydrograph

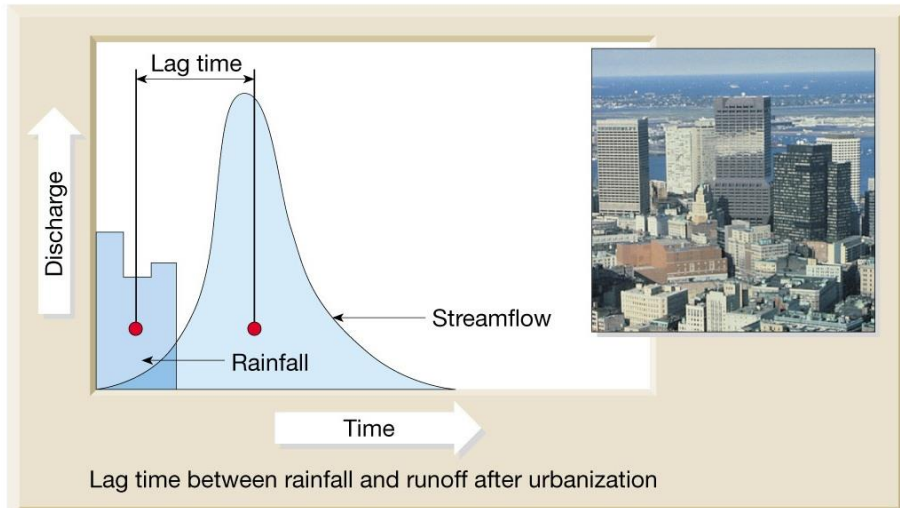
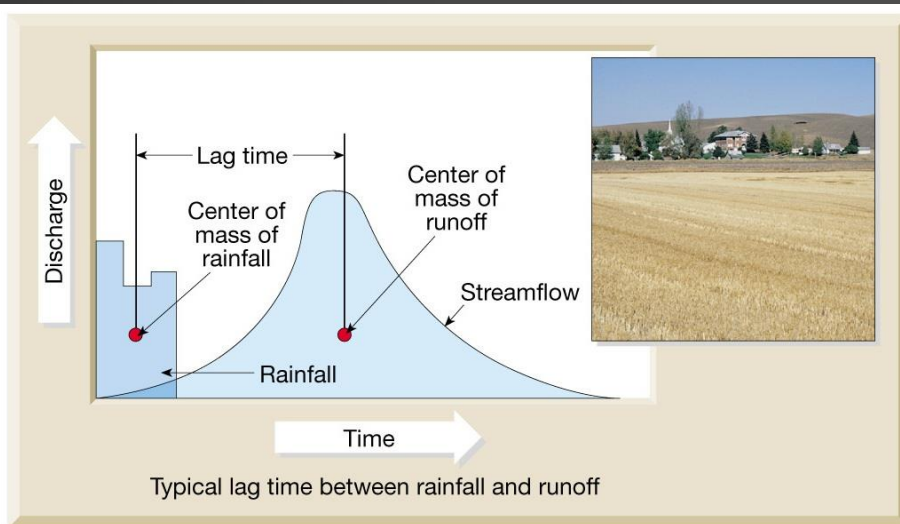
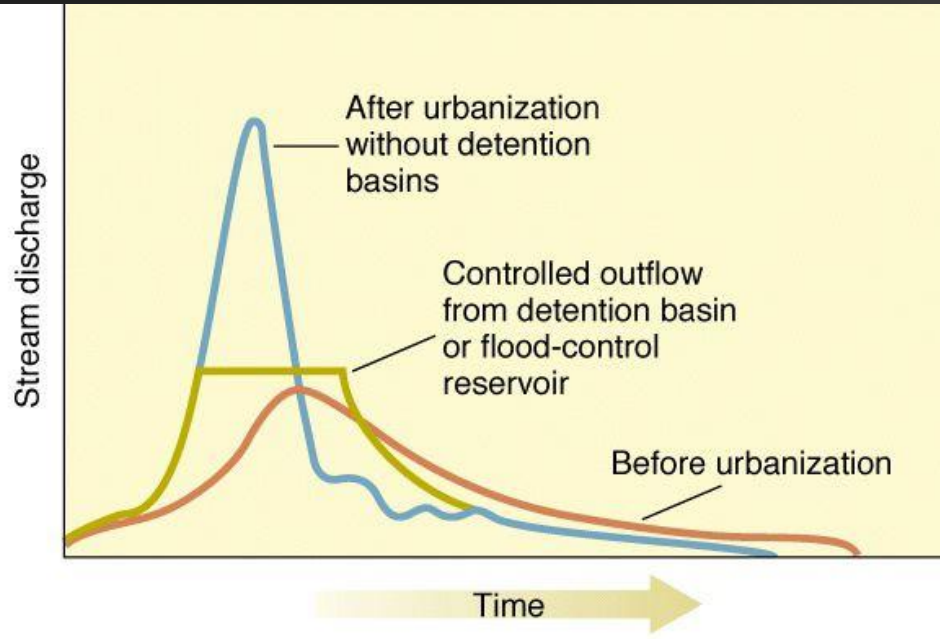
- Shape and flood management
- A > overland
- B > groundwater flow

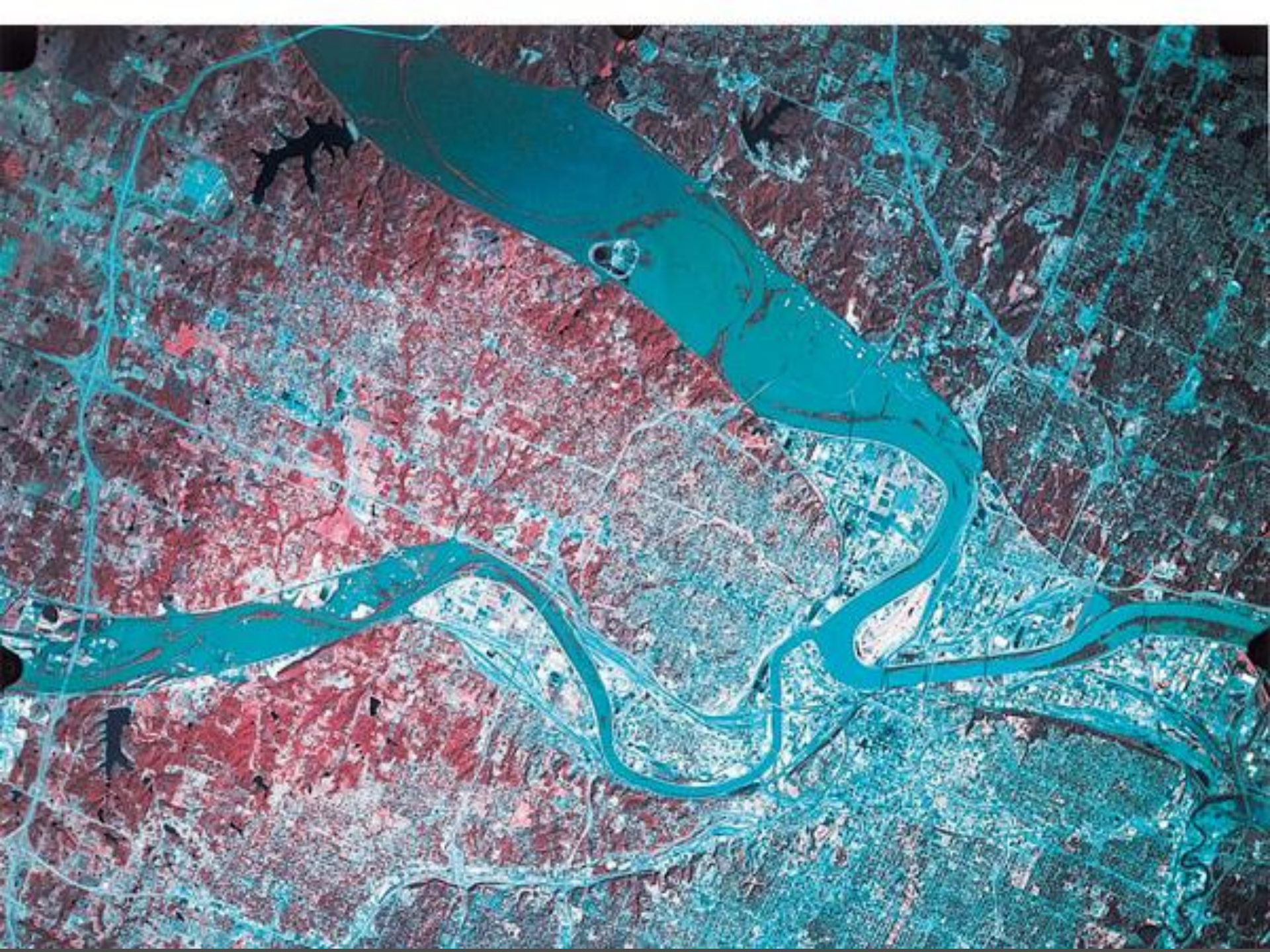


Explanations



Control





Floods are expensive

- Floods are among the most difficult natural hazards to mitigate although they have occurred since the beginning of recorded history.
- Property damage in the U.S. from floods topped \$12 billion in 1993 and is now more than \$30 billion, and the number of deaths due to flooding is the only natural hazard-related death figure to rise on an annual basis since 1940.
- UK about £1 billion annually but can be over £5 billion (Insurance, UK, 2021)
 - The flooding in 2015/16 was estimated to cost the economy £1.6 billion. The flooding in 2019/20 was estimated to be £78 million, although it would have cost an extra £2.1 billion without food defences (Gov.uk, 2021)
- Flooding is one of the most common, widespread and destructive natural perils, affecting approximately 250 million people and causing USD 40 billion in losses on an annual basis. (OECD, 2021)

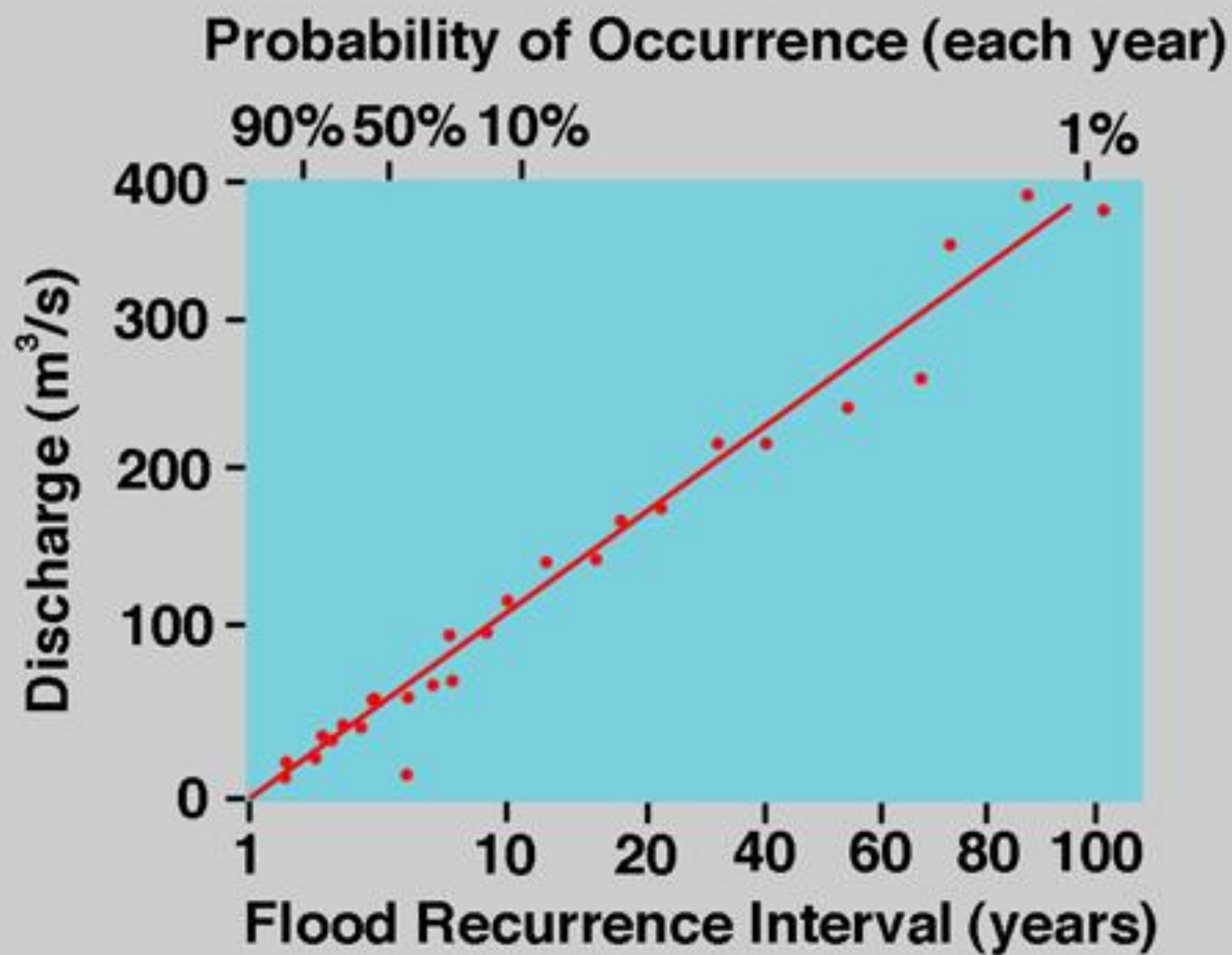
Floods are dangerous

- Floods can destroy entire towns and cities. In 1931 the flood of the Hwang Ho River, in China resulted in more than 4 million people drowning when it suddenly overflowed its banks in a violent flood.
- The lethal nature of this flood was due to the unconfined nature of the Hwang Ho River valley. The Hwang Ho flowed over a flat plain as it moved toward its terminus.
- The level of the channel bed had also risen with time, resulting in a greater sensitivity of the area to flooding. When increased discharge caused water levels to rise, there was little to hold back the flood waters.



Flood perception

- **Floods and Flooding Cycles.** We do not think of floods as major threats to life and limb, in part because we experience small floods each year.
- **The Johnstown, Pennsylvania flood in 1889** resulted in over 2,500 deaths. Today the risk of death due to flooding is somewhat lower than in 1889 because the occurrence of flooding of river systems can be predicted using an occurrence table, as shown next slide.
- **Flood frequency, or recurrence interval** can be predicted on the basis of the discharge of the river.
- **Prediction saves lives**



Local examples

- Erosion along the Salmonberry River (Oregon) after flooding in February 1996 and in 2016 caused the washout of part of the Port of Tillamook Bay Railroad. Mud from landslides threatened prime steelhead trout spawning grounds. (Governor John A. Kitzhaber Records, 2020)
- The Oregon conservation Strategy e.g. Pesticide Stewardship Partnership Program [Website](#)



River Finn Donegal

- How do we use our hydrological knowledge to manage aquatic habitats?
 - 9 mins
 - Watch and discuss.
 1. In what ways do Welsh rivers have similar issues?
 2. In what ways are rivers in Wales different?
 3. Can we learn from this experience for rivers in Wales?



River Finn 'Action'



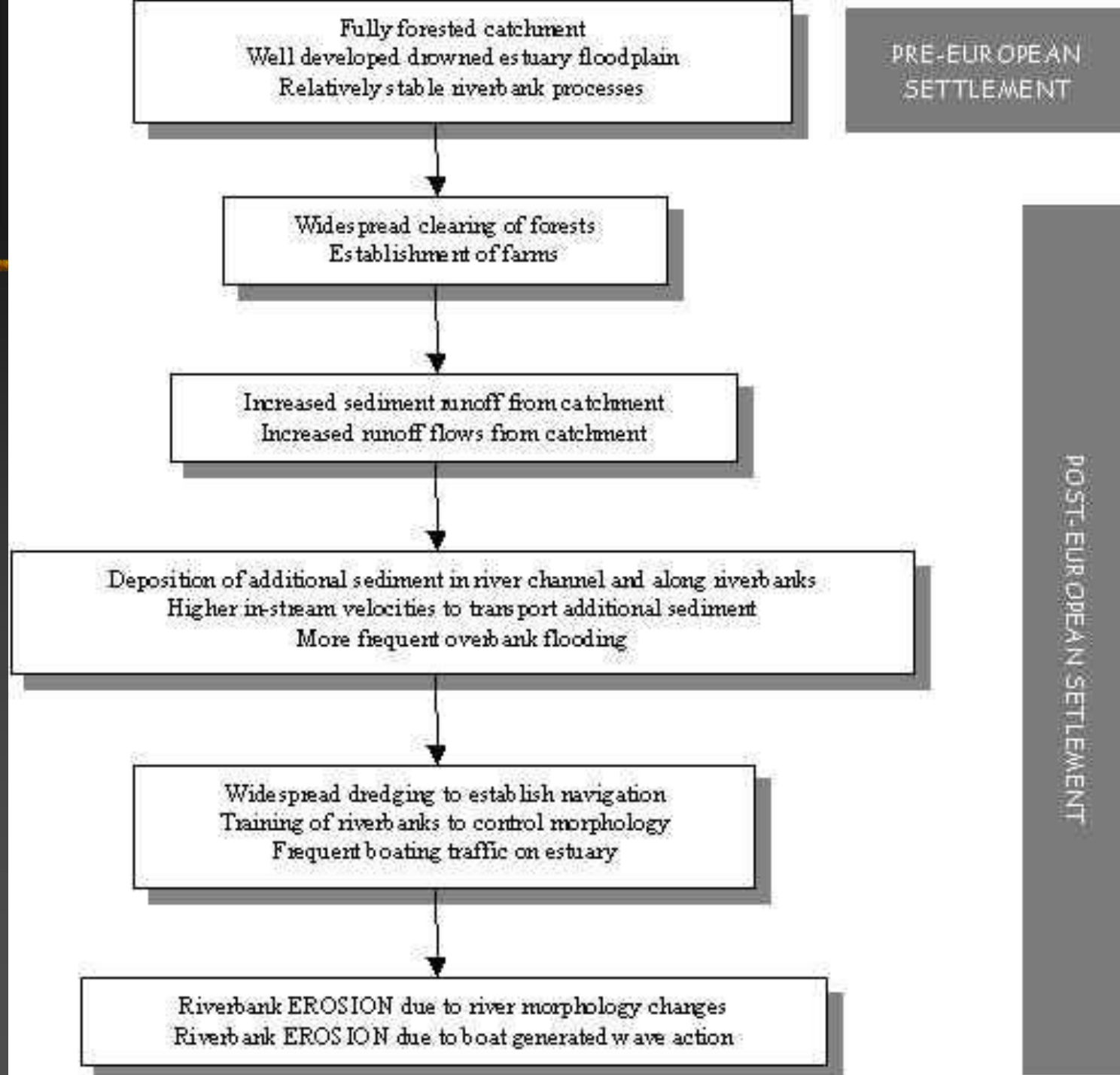
- River Finn Characterisation pdf
 - List the themes that are covered
 - Consider the catchment pressures slides
 - What do they tell you about aquatic conservation?
 - Consider the RHAT survey for the River Finn
 - RHAT explanation
 - Are they are useful tool? What are their challenges/weaknesses?
 - What does this document tell you about river conservation and management?

Flood monitoring in the UK

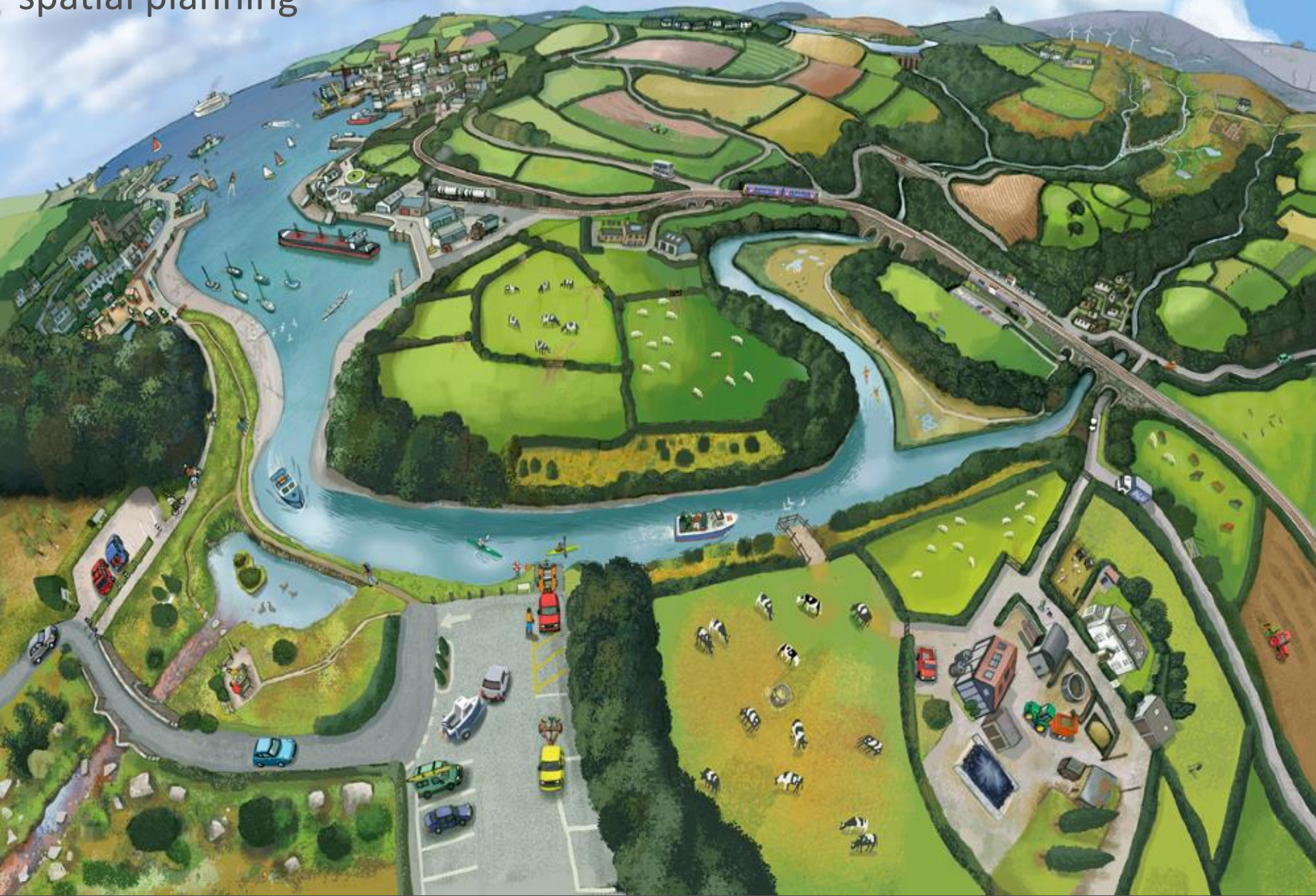
- 1952 Lynmouth, 2.3 metres rain in 12 hours
- Flooding Environment Agency
- Environment Agency (England) NRW Wales
- Insurance
- GIS
- Lapse time
- Flood and Coastal Erosion Risk Management
2021 Read and discuss



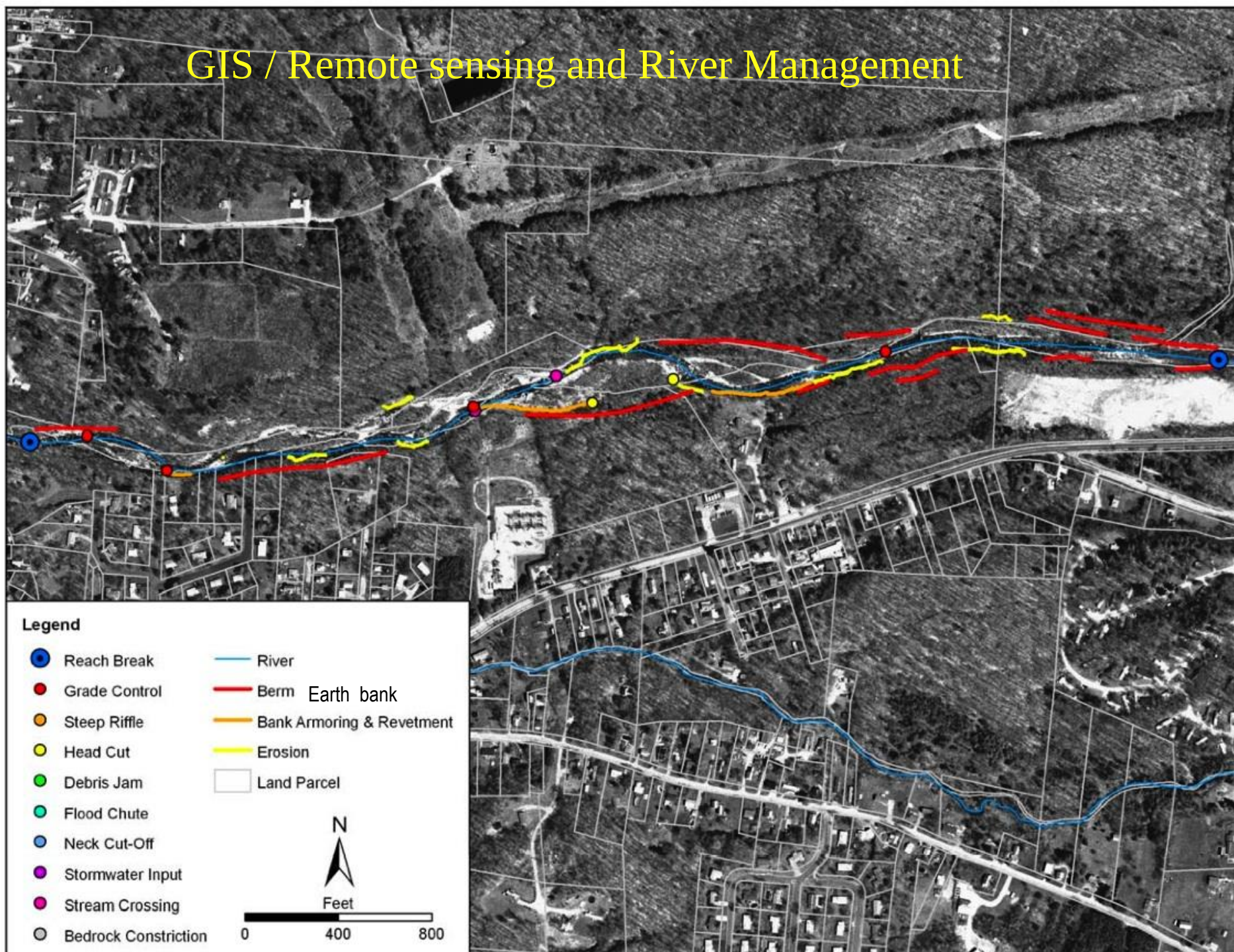
Over time



Difficulties of spatial planning



GIS / Remote sensing and River Management



Danube



International Commission
for the Protection
of the Danube River

Internationale Kommission
zum Schutz der Donau

Rivers in Romania and Hungary were hit by a spill of 100,000 m³ of toxic mining water containing cyanide. In Hungary, 200 tonnes of dead fish had to be taken from the river Tisza that empties into the Danube 2009.



Toxic sludge Hungary 2010 and 2017
By product of refining bauxite



Danube river management

- <http://icpdr.org/main/activities-projects/flood-risk-management>
- Read through link and report on your allocated section
 1. Raab flood 4cast
 2. PLATFORM
 3. SEDDON
 4. Sturgeon 2020 program



Course of River Danube

What does this mean for environmental management?



New updated
Management
Plan for 2021
ICPDR



River Management China

- Yellow river management 5 mins
 - Part 1 and 2
 - Review this video
 - How does it compare and contrast with the UK experience? Why?
 - Problems
 - Solutions
 - Integrated management
 - Flip chart present
-

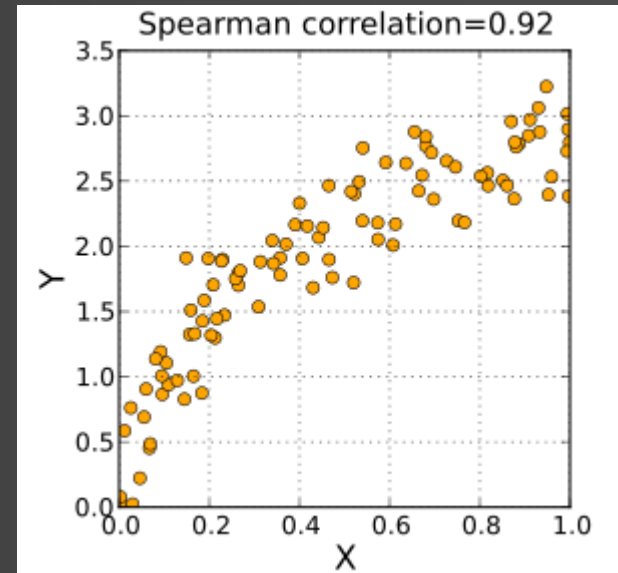
How can our urban areas deal with future flooding?

- New York flood defences of the future



Ilston river study

■ Statistical test (Handout)



Spearman's Rank Correlation Coefficient

Location River Ebbw Pollution event	Distance from point source pollution metres	Ammoniacal nitrogen (NH ₃ -N) mg/L (milligram per litre). Ammonium from fertilisers
1	50	1.8
2	175	1.2
3	270	2.0
4	375	1.0
5	425	1.0
6	580	1.2
7	710	0.8
8	790	0.6
9	890	1.0
10	980	0.85

Location River Ebbw Pollution event	Distance from point source pollution metres	Rank	Ammoniacal nitrogen (NH3-N) mg/L (milligram per litre). Ammonium from fertilisers	Rank	Difference	d ²
1	50	10	1.8	2	8	64
2	175	9	1.2	3.5	5.5	34.25
3	270	8	2.0	1	7	49
4	375	7	1.0	6	1	1
5	425	6	1.0	6	0	0
6	580	5	1.2	3.5	1.5	2.25
7	710	4	0.8	9	-5	25
8	790	3	0.6	10	-7	49
9	890	2	1.0	6	-4	16
10	980	1	0.85	8	-7	49

Answer

- $\sum d^2 = 285.5$
- $T = -0.73$
- The closer T is to $+1$ or -1 , the stronger the likely correlation. A perfect positive correlation is $+1$ and a perfect negative correlation is -1 . The T value of -0.73 suggests a fairly strong negative relationship.

Significance

A further technique is now required to test the significance of the relationship.

1. The R value of -0.73 must be looked up on the Spearman Rank significance table below as follows:
 2. Work out the 'degrees of freedom' you need to use. This is the number of pairs in your sample minus 2 ($n-2$). In the example it is 8 ($10 - 2$).
 3. Now plot your result on the table in the next slide (YOU CAN ALSO DO THIS VIA CRITICAL VALUE TABLE).
 1. If it is below the line marked 5%, then it is possible your result was the product of chance and you must reject the hypothesis.
 2. If it is above the 0.1% significance level, then we can be 99.9% confident the correlation has not occurred by chance.
 3. If it is above 1%, but below 0.1%, you can say you are 99% confident.
 4. If it is above 5%, but below 1%, you can say you are 95% confident (i.e. statistically there is a 5% likelihood the result occurred by chance).
- *In the example, the value 0.73 gives a significance level of slightly less than 5%. That means that the probability of the relationship you have found being a chance event is about 5 in a 100. You are 95% certain that your hypothesis is correct. The reliability of your sample can be stated in terms of how many researchers completing the same study as yours would obtain the same results: 95 out of 100.*

The significance of the Spearman's rank correlation coefficients and degrees of freedom

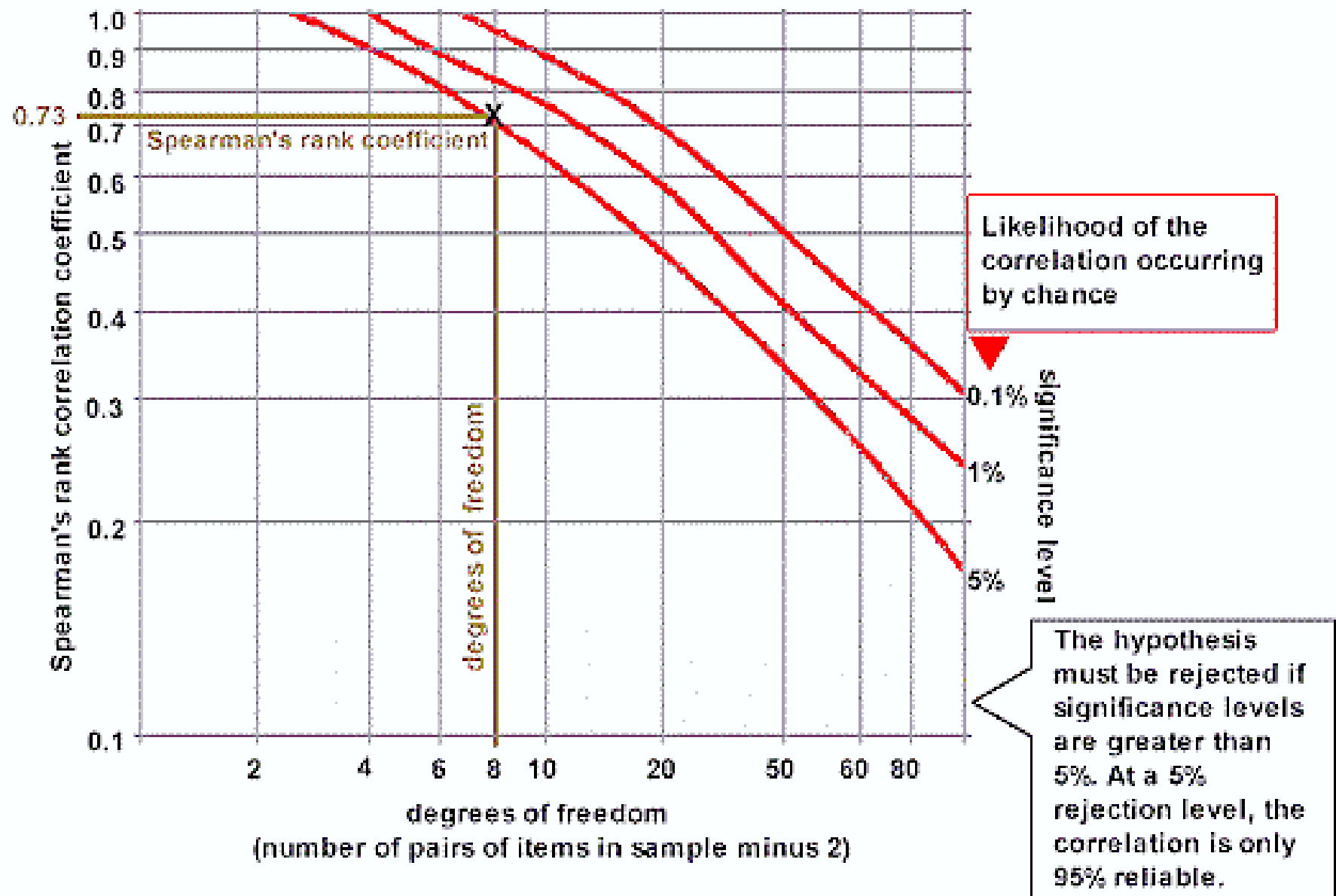


Table D.6 *Selected values of Spearman's rank correlation coefficient (r_s). The results are significant if the calculated value of r_s is higher than the table value*

n	r_s		n	r_s	
	$P = 0.05$	$P = 0.01$		$P = 0.05$	$P = 0.01$
5	1.000	—	18	0.472	0.600
6	0.886	1.000	19	0.460	0.584
7	0.786	0.929	20	0.447	0.570
8	0.738	0.881	21	0.436	0.556
9	0.700	0.833	22	0.425	0.544
10	0.648	0.794	23	0.416	0.532
11	0.618	0.755	24	0.407	0.521
12	0.587	0.727	25	0.398	0.511
13	0.560	0.703	26	0.390	0.501
14	0.538	0.679	27	0.383	0.492
15	0.521	0.654	28	0.375	0.483
16	0.503	0.635	29	0.368	0.475
17	0.488	0.618	30	0.362	0.467

Answers cont'd

- In the example, the value 0.73 gives a significance level of slightly less than 5%. That means that the probability of the relationship you have found being a chance event is about 5 in a 100. You are 95% certain that your hypothesis is correct. The reliability of your sample can be stated in terms of how many researchers completing the same study as yours would obtain the same results: 95 out of 100.
- The fact two variables correlate cannot prove anything - only further research can actually prove that one thing affects the other.
- Data reliability is related to the size of the sample. The more data you collect, the more reliable your result.