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Catchment Scale Processes and River Restoration

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3 Main Catchment Elements

Hydrology

Energy associated with the flow of water affects the system

Sedimentology

Relationship between silt, sand and gravel size/position to hydrological regime

River Processes

Adjustment in shape and size of the river and topographical changes in the floodplain in relation to climatic conditions and geology

DRIVERS = Natural and Anthropogenic

Affect the relationship between river and floodplain features, habitats and their quality

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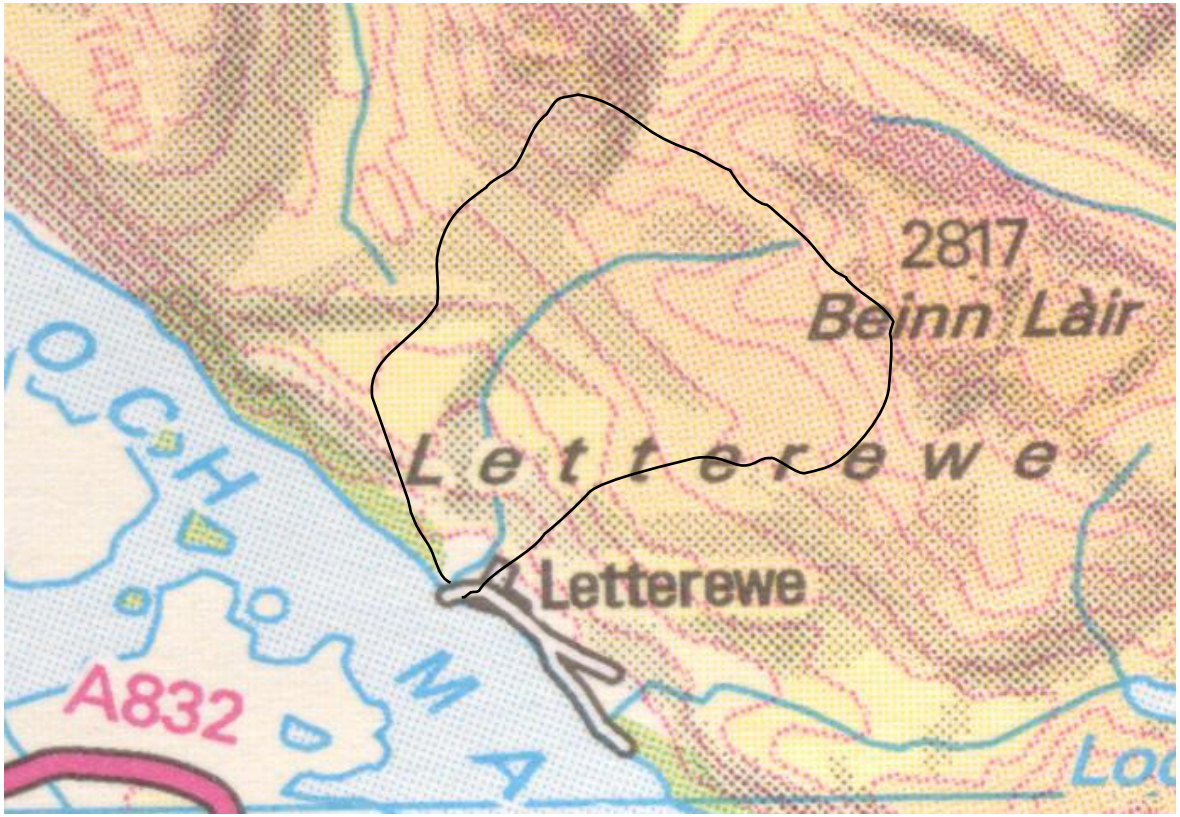
Definition:
River and Floodplain Processes...

The study of sediment sources, fluxes and storages within the river channel over short, medium and longer timescales and; of the resultant floodplain morphology (Sear and Newson, 1993). The pattern is determined by the hydrological regime in a natural system.

Helps to identify appropriate mitigation measure.



Catchments



- Streams receive water from their drainage basin
- Discharge: related to catchment area plus other influences



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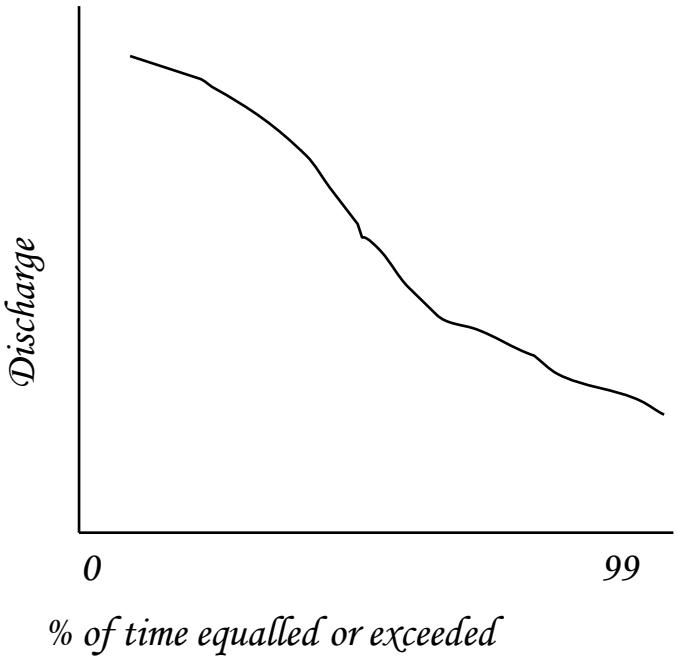
Discharge

- Discharge (cubic m/s). It has a magnitude-frequency relationship – both the very high and very low flows are rarer, the middle size flow more common
- Small flow is exceeded a lot of the time, a given high flow is rarely exceeded.





- Important because impact on how much sediment and associated pollutants will move in the system and where they will be transported to within the context of the catchment characteristic.

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Types of Flow to the River

- *Base or steady flow:* Slower route: rate depends on geology and landuse and flows through rather than over land.

- *Flashy or overland:* Catchments respond very quickly: depends on geology and human intervention.

Affects how quickly sediment, water and pollutants enter the river. Impact on aquatic habitat distribution and quality. Impacted by human intervention in the catchment

Effects of Hydrology

- Catchments receive inputs (precipitation)
- Transformed to outputs (streamflow and evaporation)
- Input = output (allow for storage)
- Output is continuous.
- Inputs (precipitation) are discrete (i.e. separated by time/space).

Note:

- Visible and invisible inputs (e.g. seepage)
- Some river flow in summer maybe sustained by the flow of groundwater

River

… what characteristics can you see?

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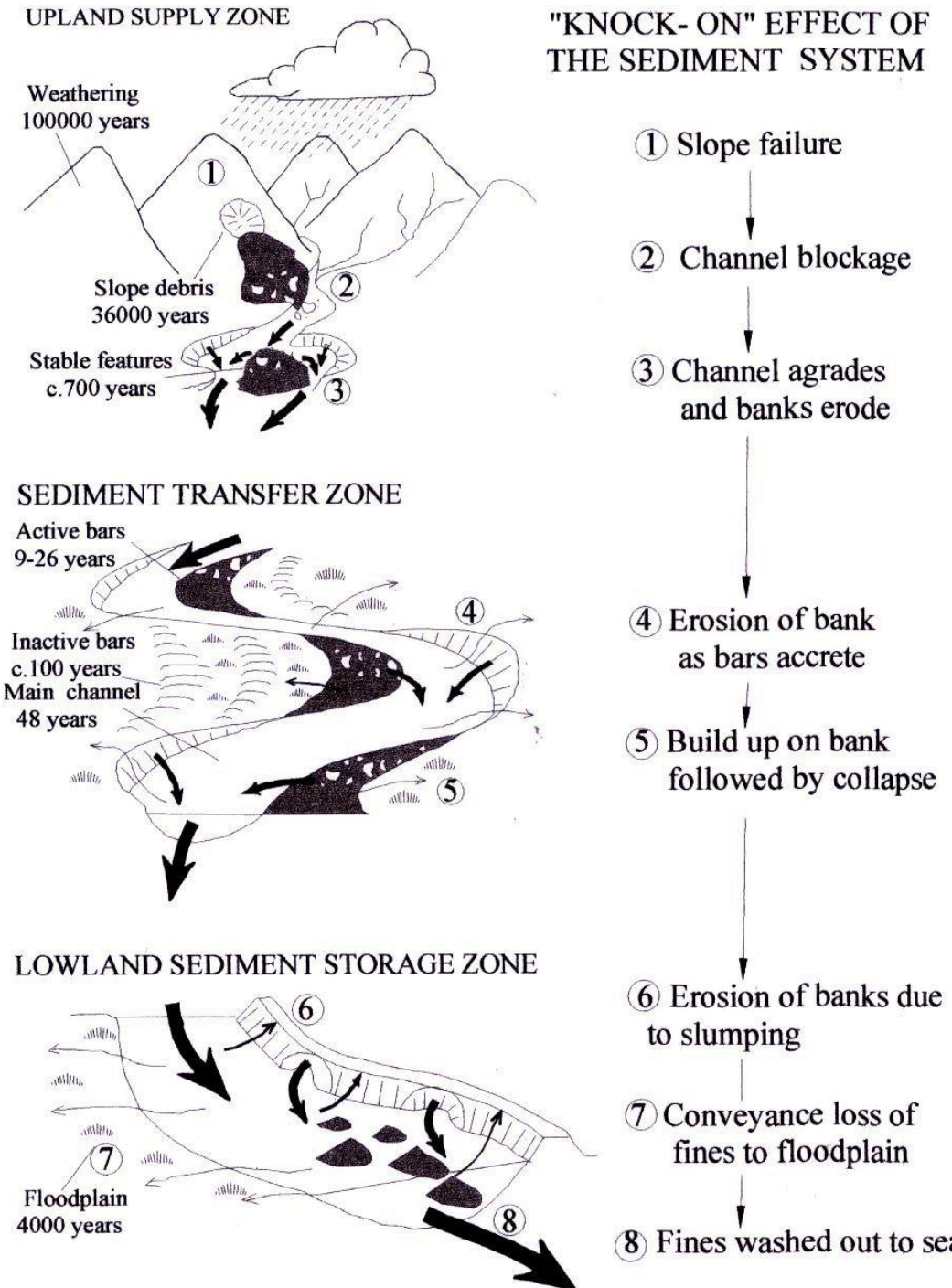
Mechanisms of Sediment Movement

Understanding connectivity in the sediment transfer system

Where are the sediment 'sources', 'transfers' and 'sinks'?.. Helps to identify risk



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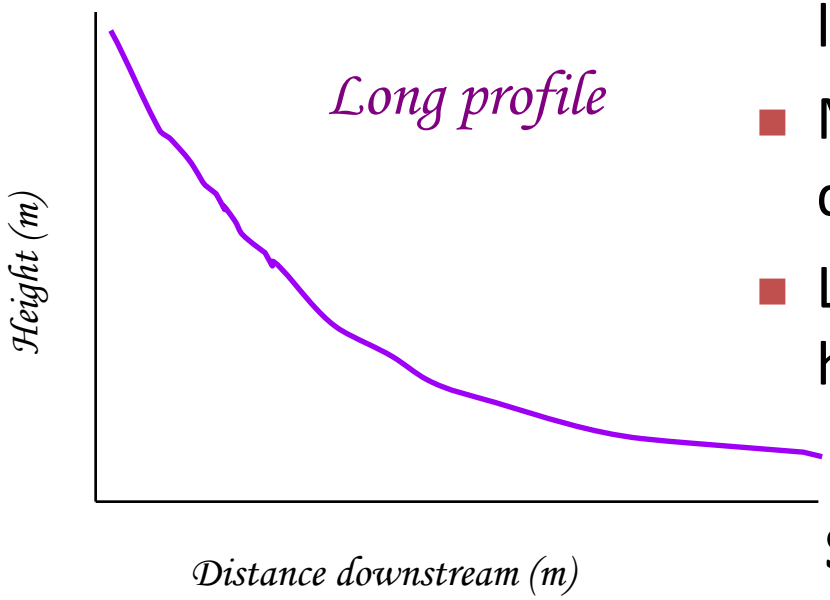
Gradient or long profile (the energy curve)



Catchments naturally saucer shaped

- Steeper at the top - lots of energy but less catchment area so less discharge.
- Middle reaches - less gradient, more discharge from larger catchment.
- Lower reaches- lower gradient but highest discharge.

So where you are in the catchment effects erosion/deposition characteristics

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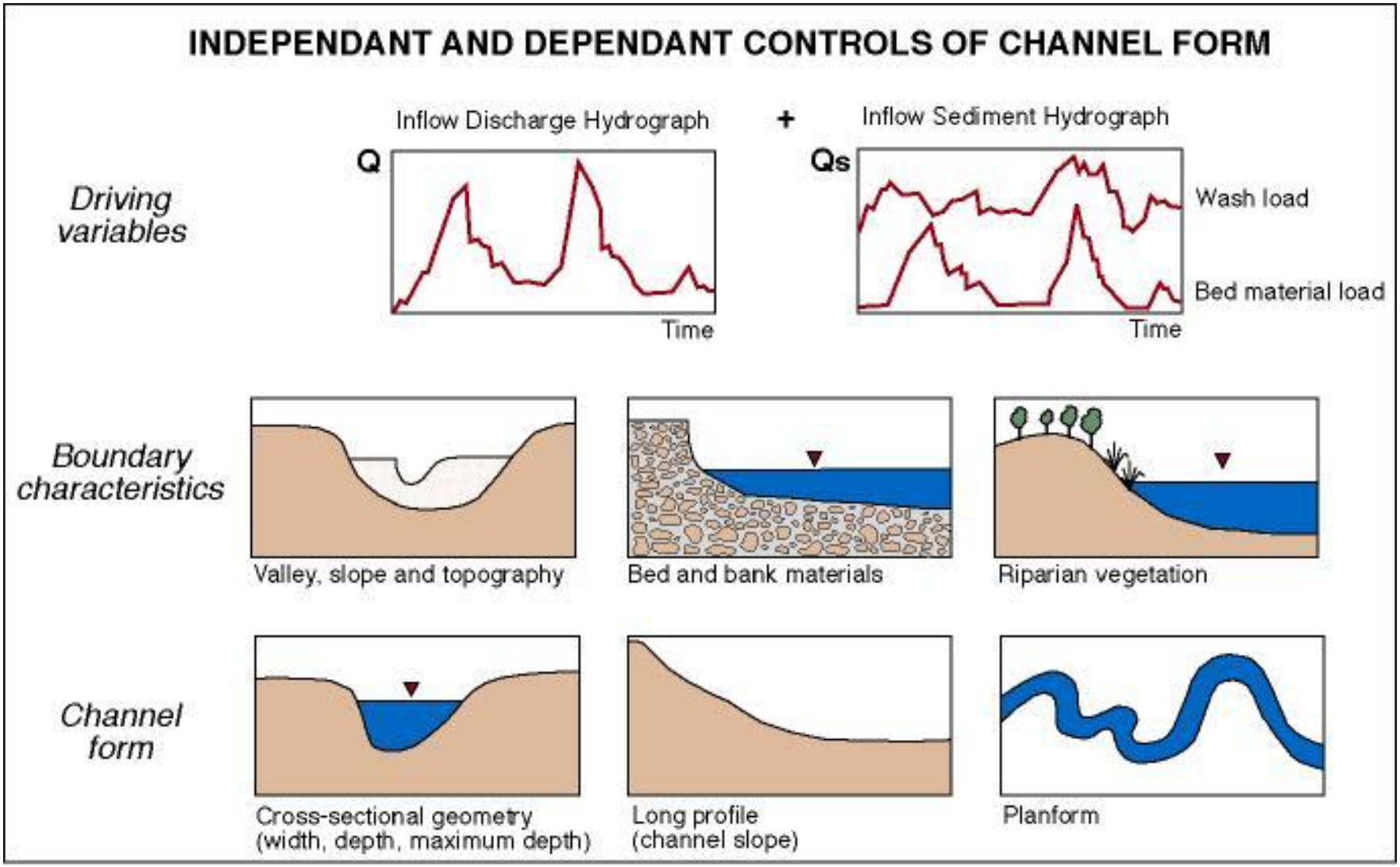
Summary of Controls





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Human Intervention and Disruption to Natural Sediment Sources

The Case of Realignment

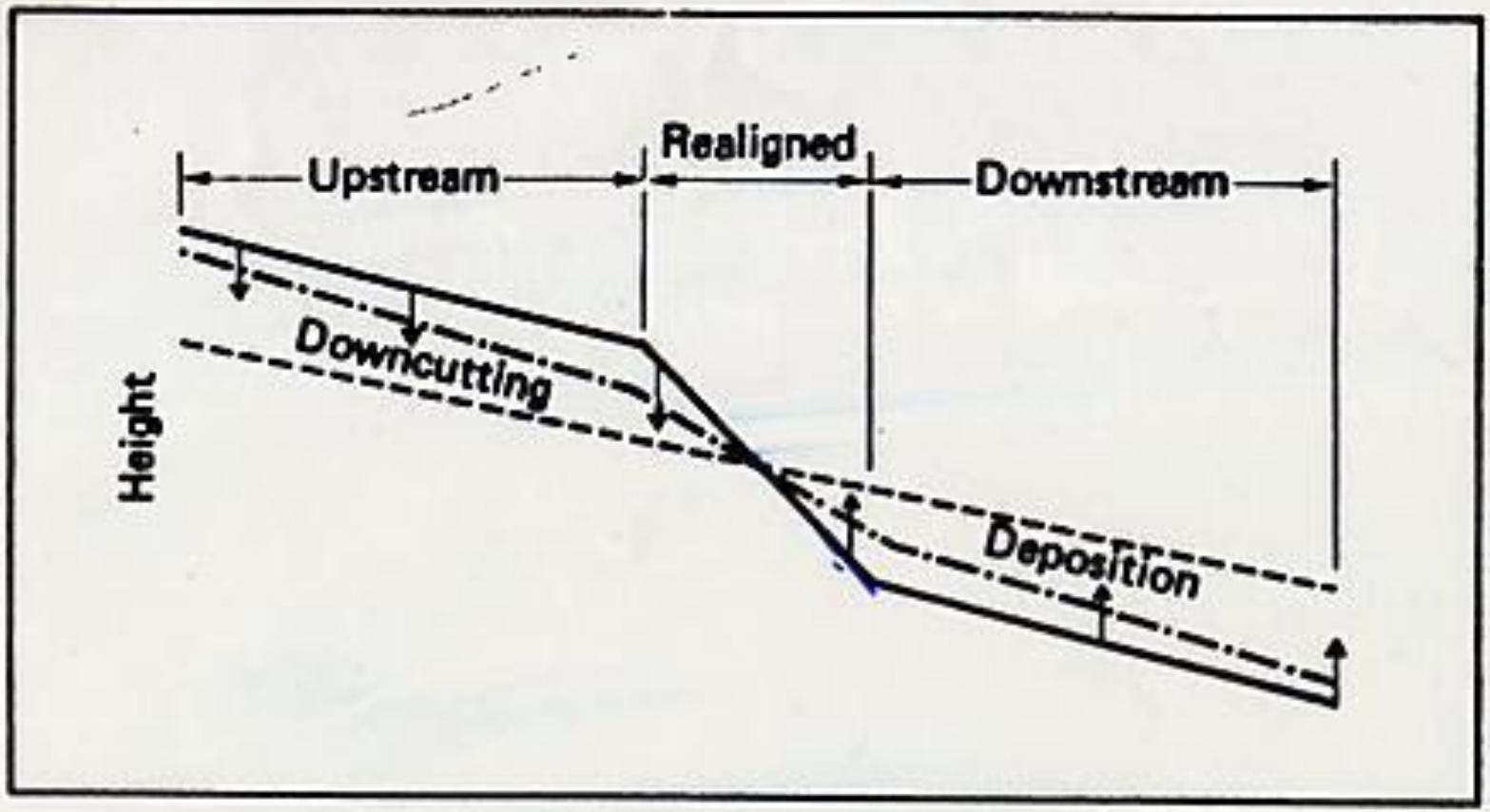

Figure 5a. Degradation in straightened river channels (after Parker and Andres, 1976)

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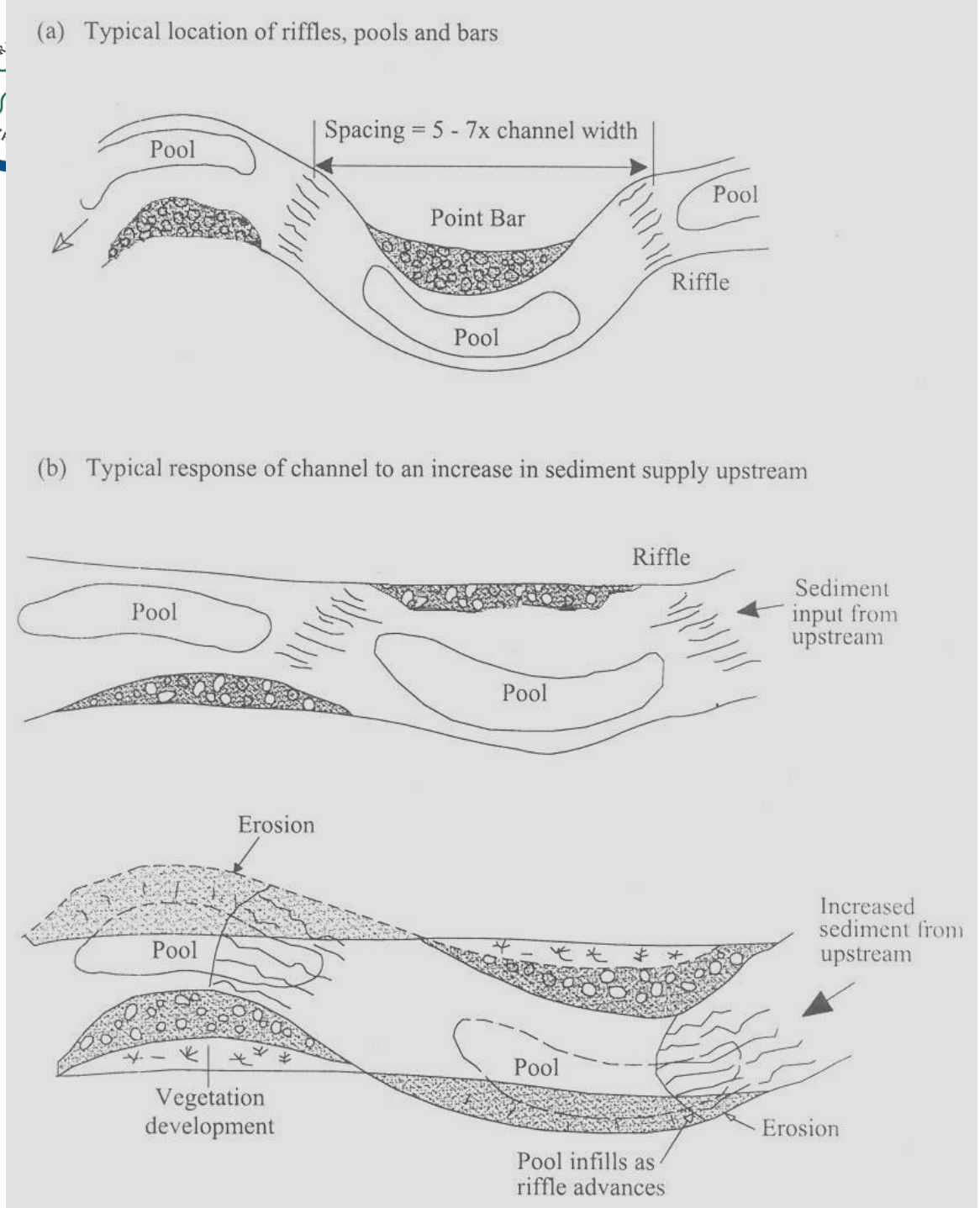


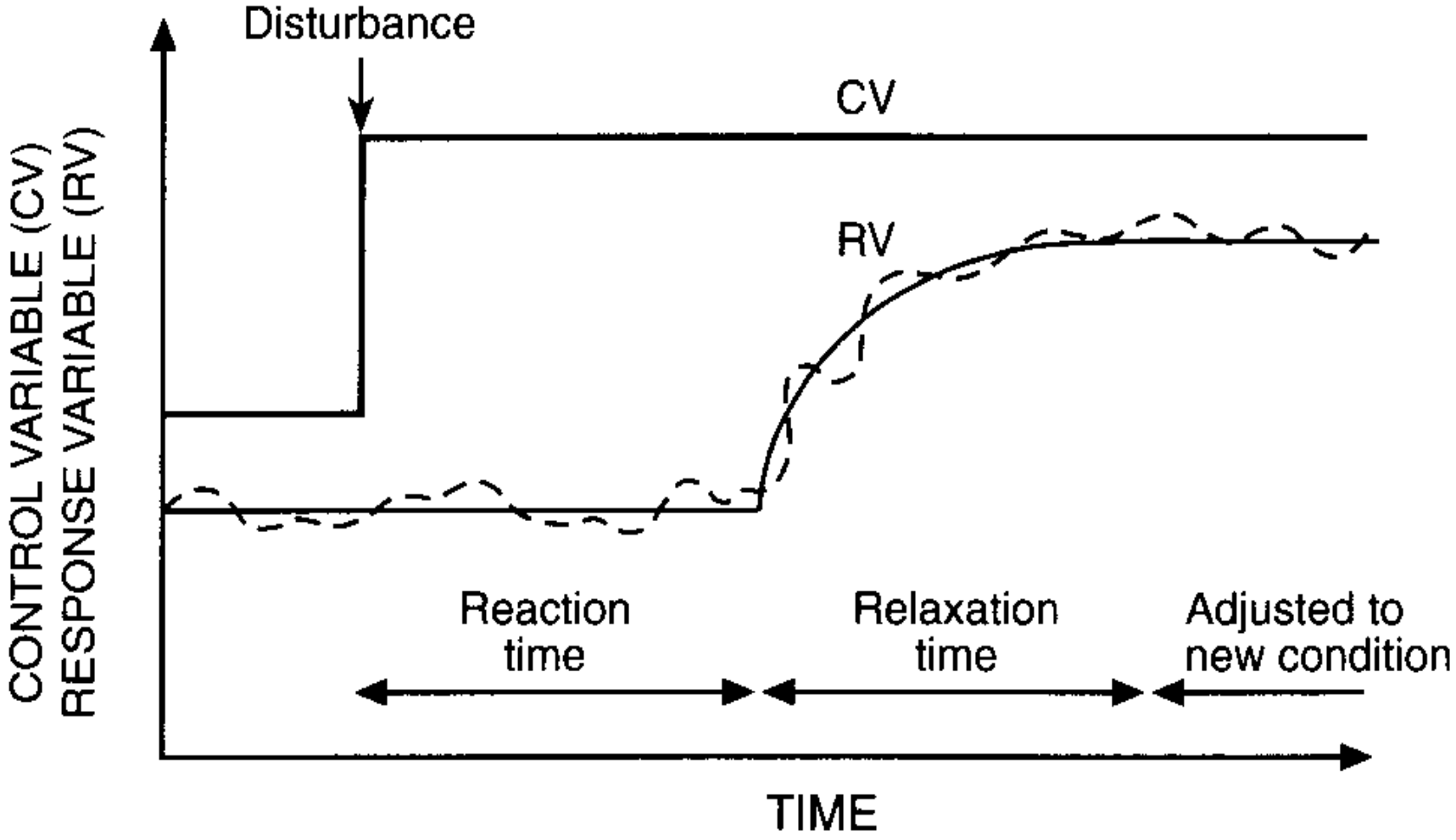
The effect of a sediment pulse from upstream

Erosion and Sedimentation in the middle course

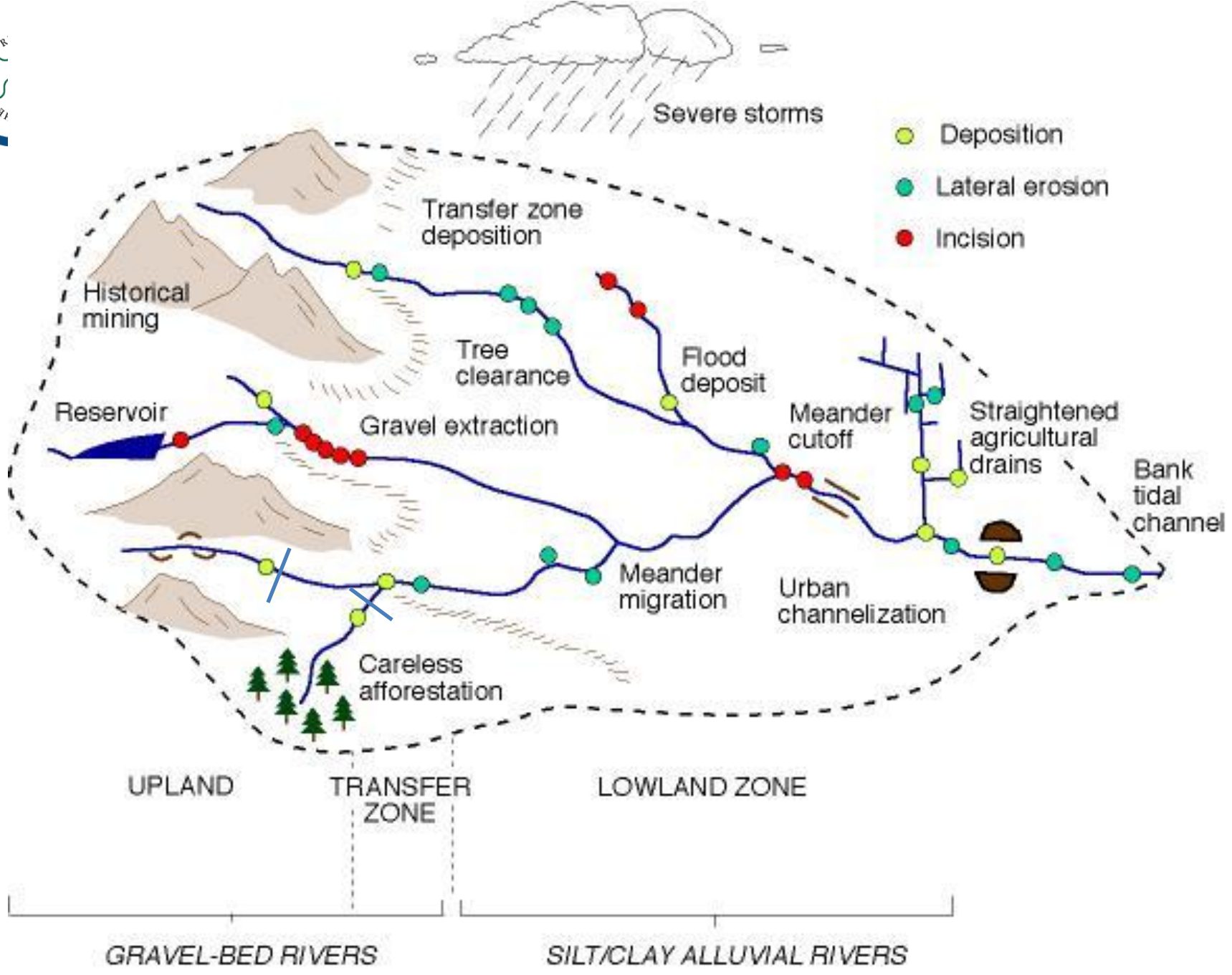
a) Lateral channel shift

b) Increase in sediment supply

Adjustment to Disturbances



Minimising Risk and Uncertainty: Understanding the Catchment Context


Severe storms
Deposition
Lateral erosion
Incision
Transfer zone deposition
Historical mining
Tree clearance
Flood deposit
Reservoir
Gravel extraction
Meander cutoff
Straightened agricultural drains
Bank tidal channel
Meander migration
Urban channelization
Careless afforestation
UPLAND
TRANSFER ZONE
LOWLAND ZONE
GRAVEL-BED RIVERS
SILT/CLAY ALLUVIAL RIVERS

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Hydrology/Hydraulics

Relevance to River Restoration?

- River restoration can change the shape, size and slope of river reaches
- Has impact on the amount of water a channel carries
- Flood levels might change
- The flow characteristics might change – velocities, flow spilt down channel and on floodplain

Need to understand hydrology (how much water coming through the catchment) and impact on sediment movement to inform flood risk management and habitats

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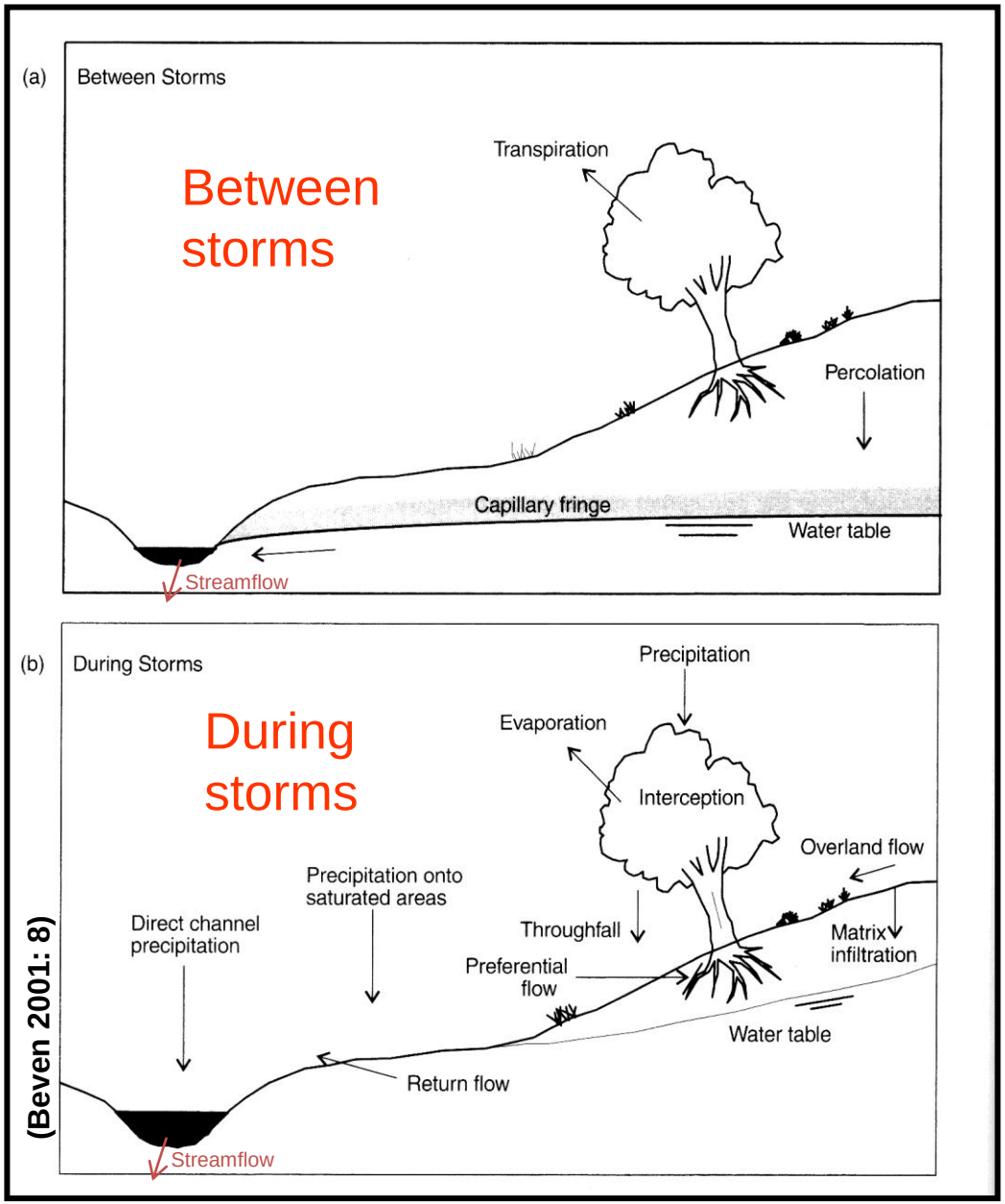
Hydrological components affecting streamflow

- Catchment characteristics
- Rainfall



The Purpose of Hydraulics Studies?

- Determine the level/depth and extent of the water, and the velocities in the channel and floodplain under normal and flood conditions:
  - Experience/anecdotal evidence of what has happened previously
  - Or.. Models… complexity used depends on what you need to know! (Risk of increase water levels)

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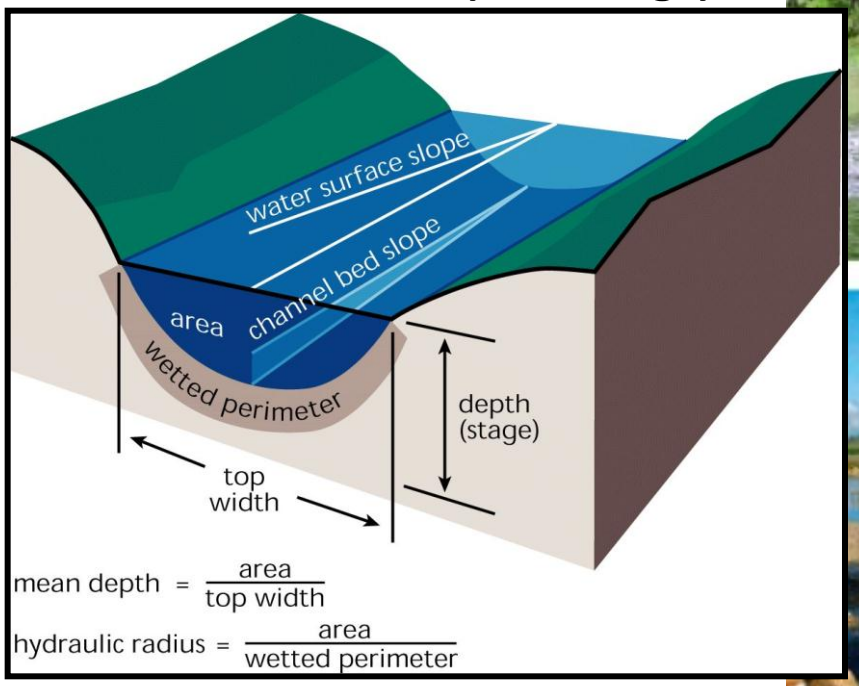
Hydraulics – Base Calculation (Mannings)

$$\bar{v} = \frac{R^{2/3} s^{1/2}}{n}$$



Where

v = Mean flow velocity (m/s)

R = Hydraulic radius

s = Channel gradient (energy slope)

n = Manning's roughness coefficient

How Does this Help us in Restoration Design?

- Water levels within, upstream and downstream reach (flood, channel forming, normal)
- Some models = flood routes, flood flow rates and direction, flood storage
- Helps geomorphology design (v profile and Q)
- Enables assessment of the impact on 3rd parties from works and provides required assurances

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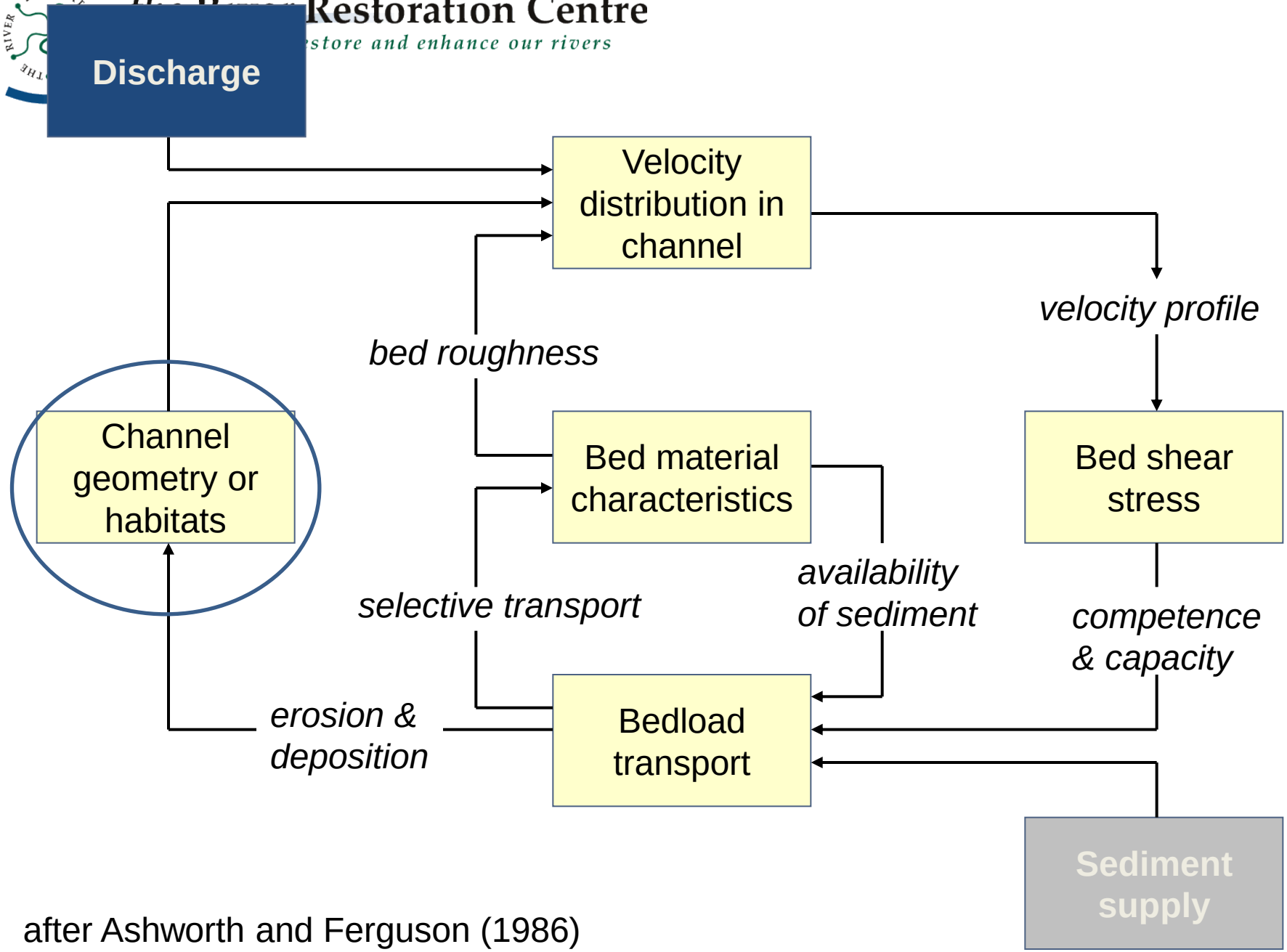
Comparison of Drainage and Restoration – impact on Hydraulics

	Drainage	Restoration
Aim	**To drain away stormwater quicker, reduce water and flood levels**	**Restore more natural channel geomorphology, flows and features. Reconnect channel and floodplains**
Impact on velocity and flow	increased flow velocity, increased discharge	More variable velocity, more natural flows, less flow in channel
Impact on Roughness Coefficient	Reduced roughness (less vegetation, bed features and regular channel shape)	Restore more natural roughness or increase roughness
Impact on Slope	Increased (steeper) slope	Restore 'natural' bed profile considering sediment continuity
Impact on Hydraulic Radius	Increased (larger) channel width & depth area	Change channel dimensions to provide self sustaining in channel features



after Ashworth and Ferguson (1986)

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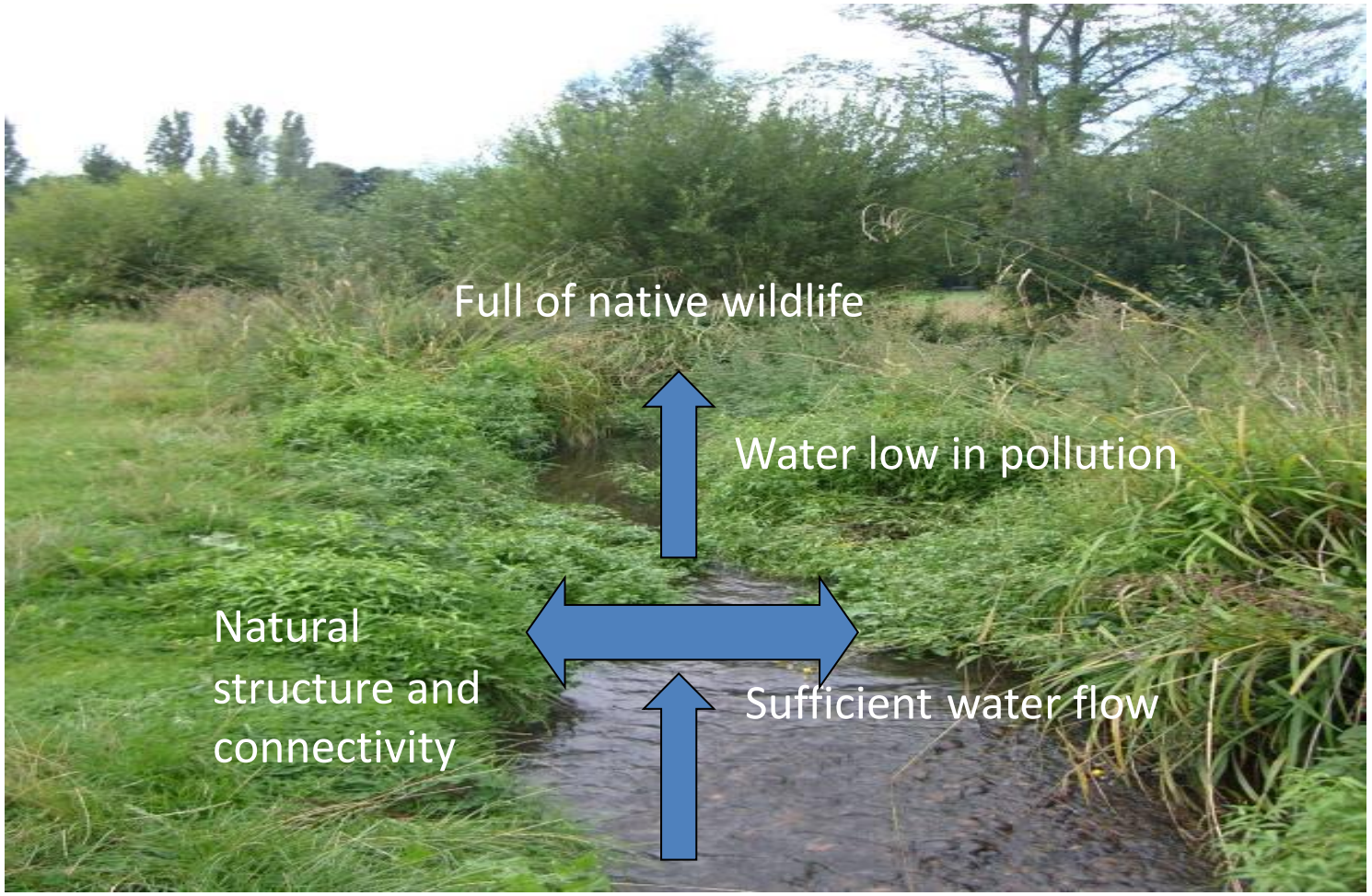
What do we Want to Achieve?



From RRC's PRAGMO document (Judy England)

River Habitats