Limnology and Oceanography

Limnology: Abiotic Nature of Lotic Habitats

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Learning Outcomes

To introduce the key characteristics of lotic habitats

To examine in detail the key physical and chemical abiotic factors influencing lotic systems

What are the Key Characteristics of Lotic Habitats?

Lotic Habitats

Lotic = running water e.g. streams and rivers

A river is a channel of flowing water whose movement is determined by gravity (flows downhill)

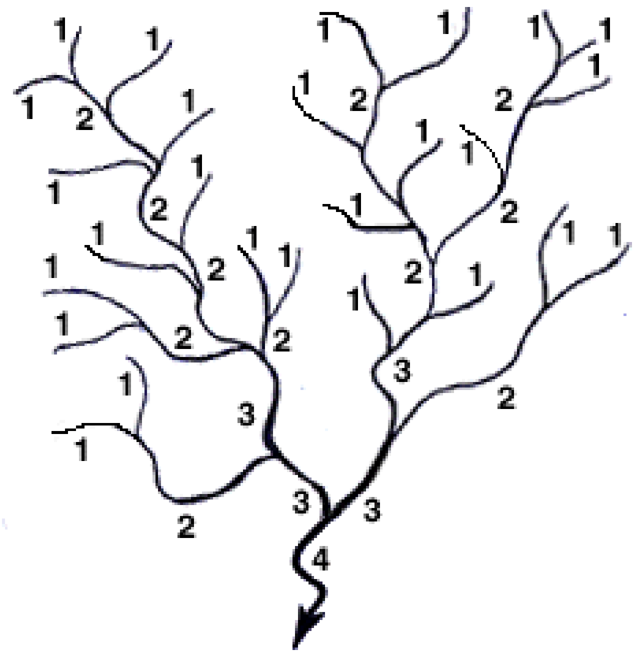
- Swift/torrential and cascading in headwaters
- Slow-flowing in lowland areas

Worldwide, estimated to drain c.150 M km^2 of land with average water volume c. 2000km^3 = c. 41000km^3 discharged to the world's ocean every year

- Mean residence times c. 7-14 days

Lotic Habitats

Tributary streams erode the landscape along weaker strata of bedrock and eventually coalesce to form the main river channel which flows downhill – the drainage pattern



Strahler Classification Method

1st order: single, unbranched head-water channels

2nd order: when two 1st order streams meet

3rd order: when two 2nd order streams meet

Steam order only increases when two streams of equivalent rank merge

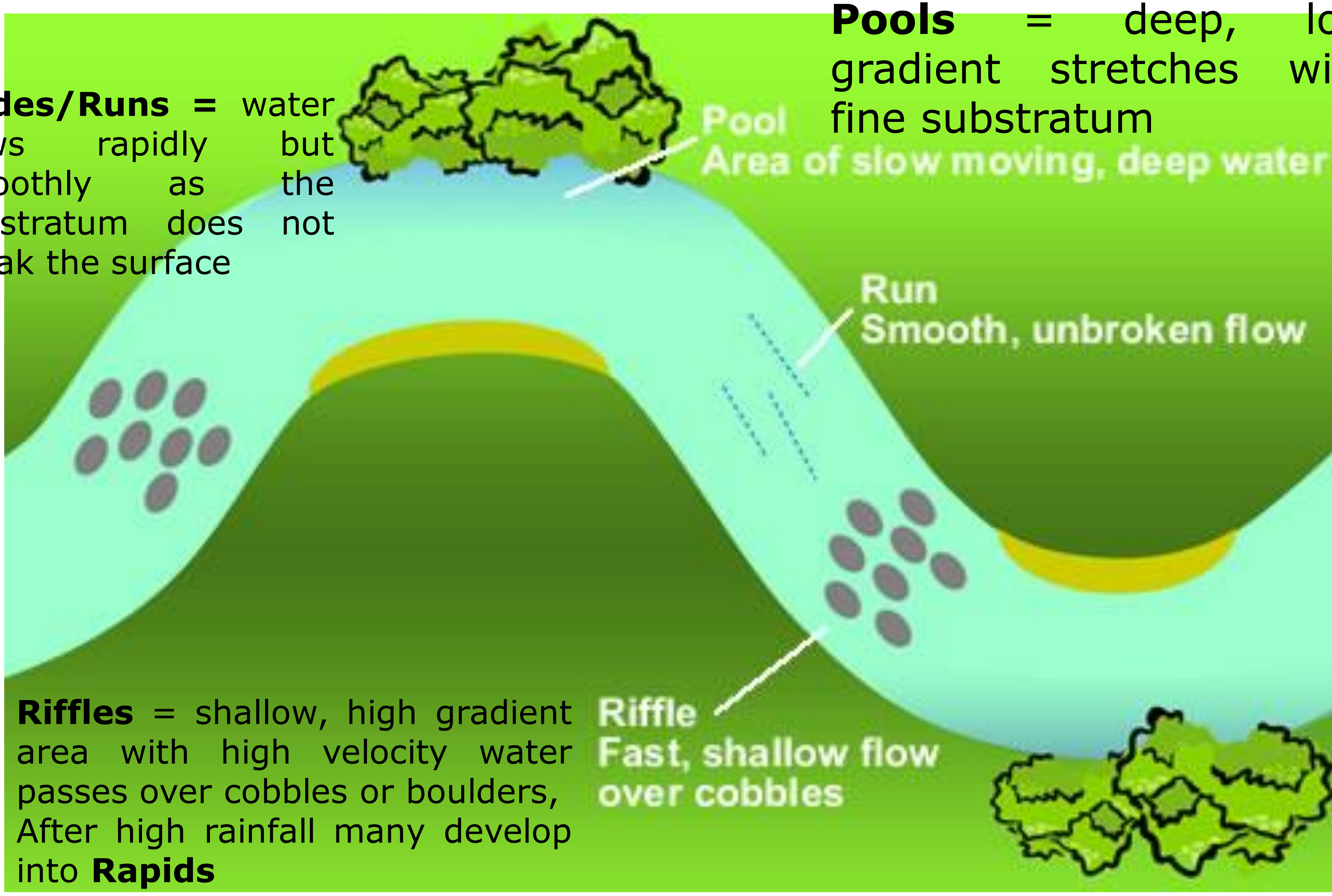
Headwater streams: orders 1-3; Medium sized streams: orders 4-6; Rivers: orders >6

Lotic Habitats

Sub-habitats within lotic systems

Pools = deep, low gradient stretches with fine substratum

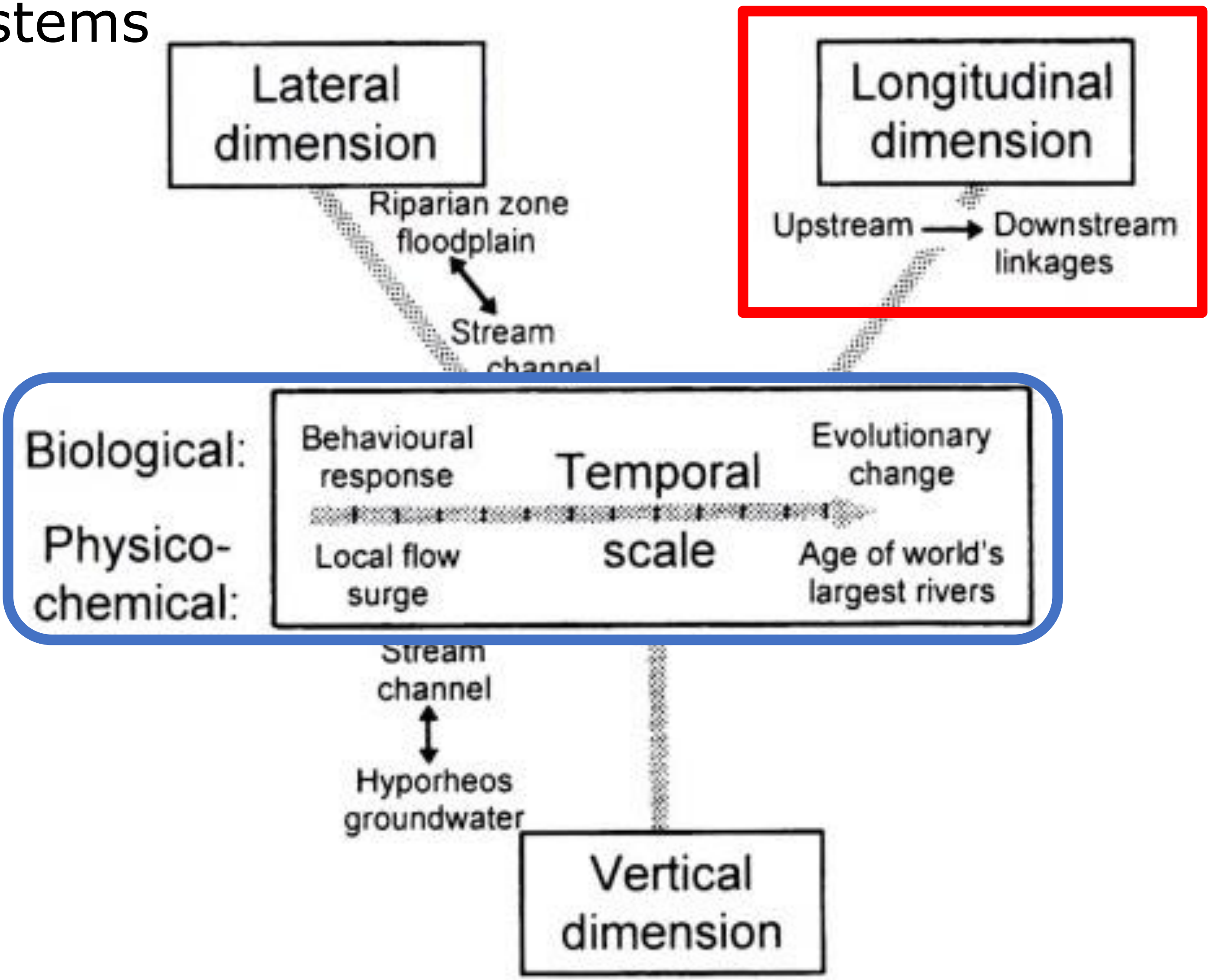
Glides/Runs = water flows rapidly but smoothly as the substratum does not break the surface



Riffles = shallow, high gradient area with high velocity water passes over cobbles or boulders, After high rainfall many develop into **Rapids**

Lotic Habitats

Four dimensional nature of river and stream ecosystems



Lotic Habitats

Characteristics of lotic systems:

- **Unidirectional flow** with variable velocity
- **Linear form with changing gradients** e.g. long, thin systems, poorly integrated
- **Erosion and deposition:** transports & deposits material, continually changing the physical environment
- **Complex variable channel:** changes in substrate size, vegetation, current velocity, water chemistry
- **High stream variability:** no two lotic systems are the same e.g. geology, soil type, geomorphology of the catchment, riparian vegetation
- **Unique biota**

Lotic Habitats

Everything about rivers changes **longitudinally**

Generally:

Defined by **supply of water & sediment**

Headwaters
(erosion zone)

Rivers originate in mountainous regions from springs

Middle-order
(sediment transfer zone)

Coalesce to fast-flowing turbulent & shallow streams

Lowlands
(sediment deposition zone)

Large, smooth flowing, deep rivers that meanders

Lotic Habitats

Characteristics of **Headwaters** (Erosion Zone):

- V-shaped valleys
- May be shaded by trees
- Major **source** of water and sediment
- Channel slope **steep** (gradient >12m/km)
- Channel **erosion active** and frequent
- Substratum particles are large e.g. **cobble/boulders**
- Discharge is highly variable – dependant on rainfall
- **Rapid, turbulent flows** with riffles, rapids

Lotic Habitats

- **Cold** water temperatures
- **Oxygen-saturated** water
- Can cause waterfall formation e.g. **Iguacu, Argentina/Brazil** (largest volume - 13.5 M L/sec); Angel Falls, Venezuela (highest)

Lotic Habitats

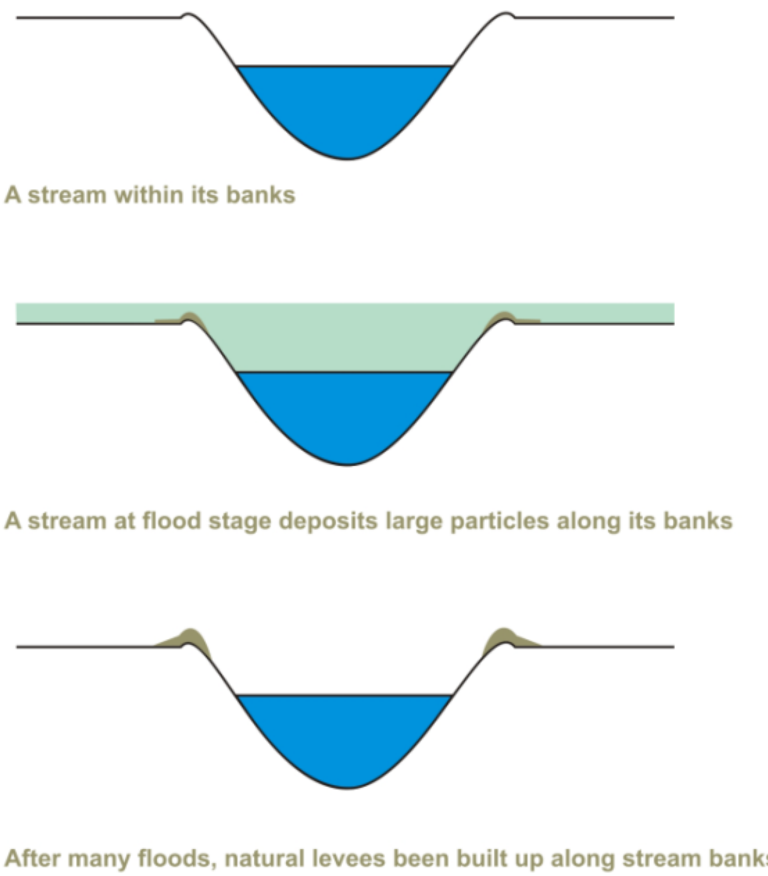
Characteristics of Middle order (Sediment Transfer Zone):

- River gradient is reduced (~4.5m/km)
- **Volume/Discharge** greatly **increases**
- Water & sediment transported with ease
- Carries **greater sediment load**
- Deposition is balanced by erosion
- Lateral cutting/erosion
- Ox-bow lake formation in meanders (see lake formation lecture 4)

Lotic Habitats

Characteristics of Lowlands (Sediment Deposition Zone):

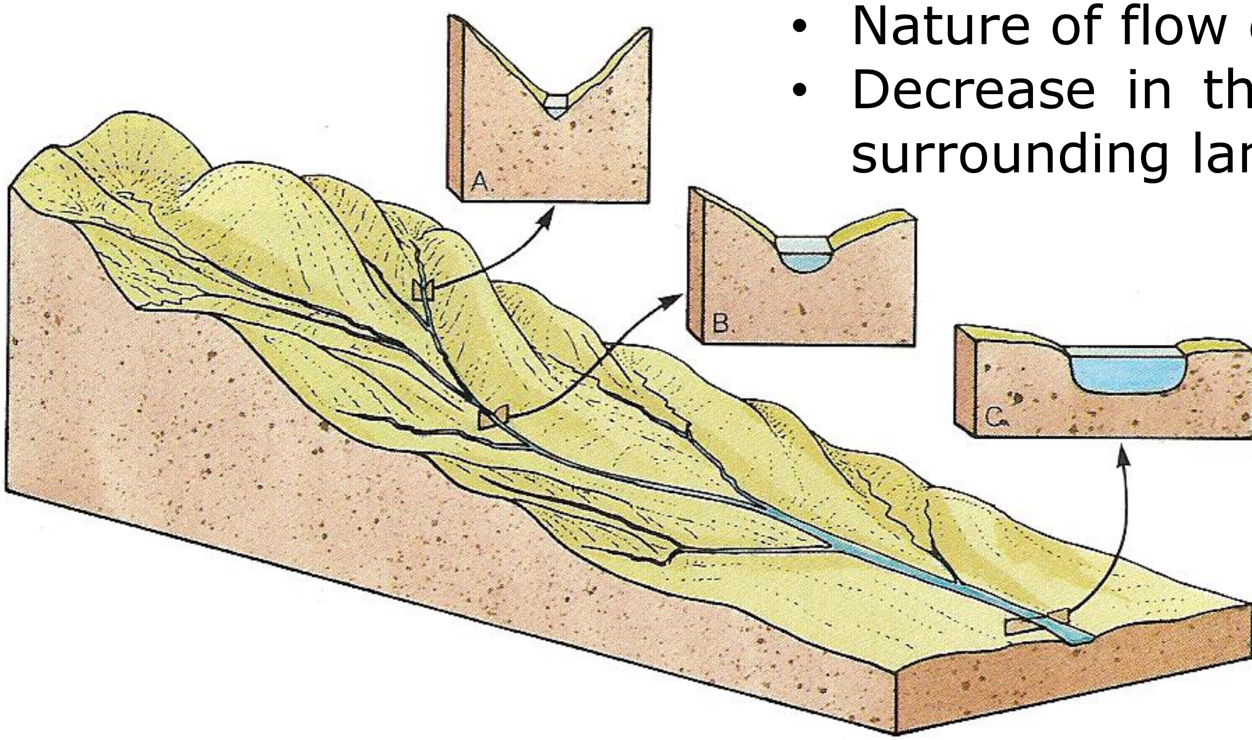
- **Low gradient** (<0.1m/km) & **deep**
- Stable and predictable discharge
- Maximum volume/discharge
- Deposits **fine silt sediment** loads e.g. delta or estuary formation if there is little or no tidal range - Ganges, Nile, Mississippi
- **Deposition** of suspended solids causes levees

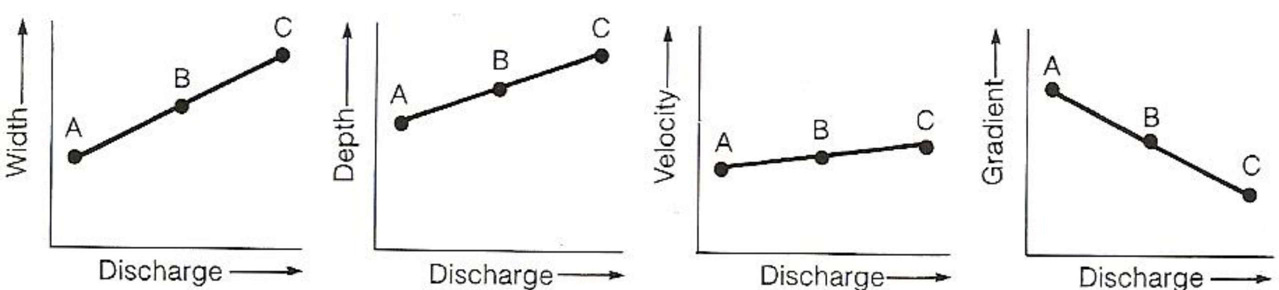


Summary of River Zones

Key points:

- Slope decreases
- Discharge increases variability
- Nature of flow changes
- Decrease in the direct affect of the surrounding landscape





What are the key physical and chemical abiotic factors influencing lotic systems ?

1. Flow

The physical habitat of the lotic system – predominantly channel size is determined by:

- The **volume of water** (discharge)
- Its **velocity** (speed of water)
- **Channel morphology**

This in turn influences particle size, nature of the substrate, channel morphology and supply of dissolved oxygen

Flow varies in response to short- and long- term weather and climatic patterns

- **Base flows** (normal water levels)
- Flood flows (**spates**) – rapid rise in discharge followed by a slow decline (check out www.waterlevels.ie)

1. Flow

River discharge (Q) – measures the volume of water flowing down the channel at a given point per unit time ($m^3\ s^{-1}$)

- Cross-sectional area = average depth x width
- Discharge = Cross sectional area x velocity
- Determined by stream width, depth, current velocity, roughness of substrate
- Remember ! Discharge increases downstream and with depth

1. Flow

Velocity (current) - speed at which the water moves

- Measured by calculating the distance travelled per unit time e.g. m^3/sec (rarely exceed 3 m^3 s^{-1})

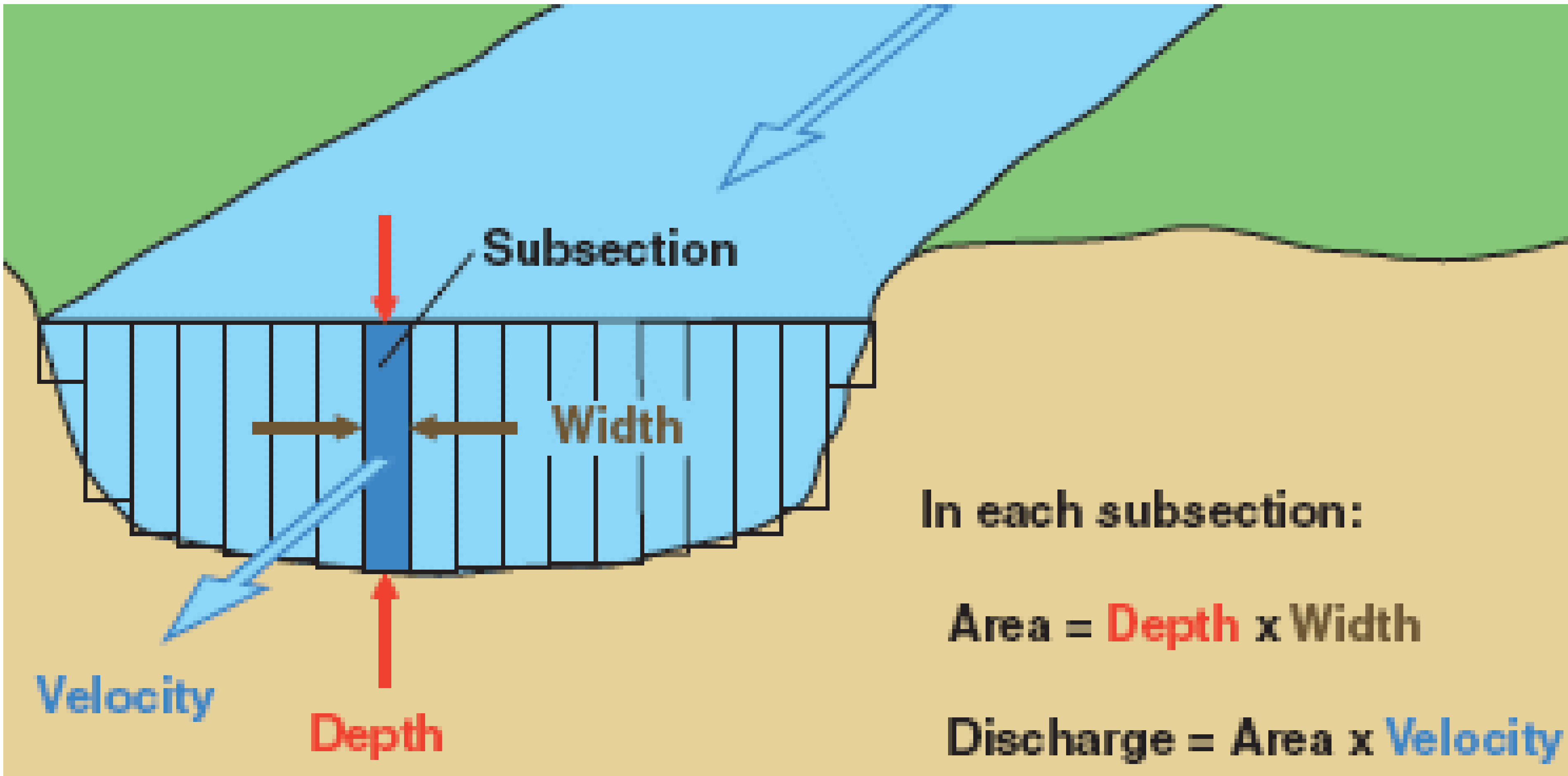
- Measured using a flow meter

- Determines where and what kind of debris is deposited in the stream

- Influenced by the shape and gradient of the stream bed, nature of the substrate (laminar vs. turbulent flows), water depth, precipitation

1. Flow

Calculating discharge



2. Substrate - Inorganic

- Inorganic (anything physical) e.g. sand, silt, gravel to pebbles, cobbles, boulders, bedrock

- Mean substrate particle size declines downstream

- Increased heterogeneity with fine sands and gravel collecting between larger boulders

- Classified using the Wentworth Scale

Classification	Particle size (diameter)
Boulder	Above 256 mm
Cobble	64–256 mm
Pebble	4–64 mm
Gravel (or Granule)	2–4 mm
Very coarse sand	1–2 mm
Coarse sand	0.5–1 mm
Medium sand	0.25–0.5 mm
Fine sand	0.125–0.25 mm
Very fine sand	0.062–0.125 mm
Silt	0.004–0.062 mm
Clay	Less than 0.004 mm

2. Substrate - Organic

- Organic (anything biological) e.g. leaves, fallen trees, aquatic plants

Detritus Categories and Subcategories	Approximate Size Ranges
Coarse particulate organic matter (CPOM)	>1 mm
Large woody debris	>64 mm
Terrestrial leaves forming leaf packs	>16 to <64 mm
Leaf, twig & bark fragments, needles, fruits, buds and flowers	>4 to <16 mm
Plant and animal detritus, faeces	>1 to < 4 mm
Fine particulate organic matter (FPOM)	>0.5 µm to <1 mm
Ultrafine particulate organic matter (includ. microbes)	>0.45 µm to <75 µm
Dissolved organic matter (DOM)	<0.45 µm

Key Points

Rivers are lotic habitats with longitudinal water movement with cold, well oxygenated, fast flowing, erosive, waters found in their headwaters and warmer, less oxygenated, slower moving, depositing, waters found in their lowlands

Streams and rivers are classification according to the Strahler Classification Method

There are three important micro-habitats found in rivers: riffles, glides, pools

Flow and substrate are key physical factors determining the physical nature of rivers

Reading List

Smith, T.M. & Smith, R.L. (2012). Elements of Ecology. Benjamin Cummings, London.

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Moss (2010). Ecology of Freshwaters. Wiley-Blackwell, Oxford, UK.

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Giller, P. and Malmqvist, B. (1998). The Biology of Streams and Rivers. Oxford University Press, New York, USA

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Freshwater Ecology and Limnology books in the library ;)

Thank you