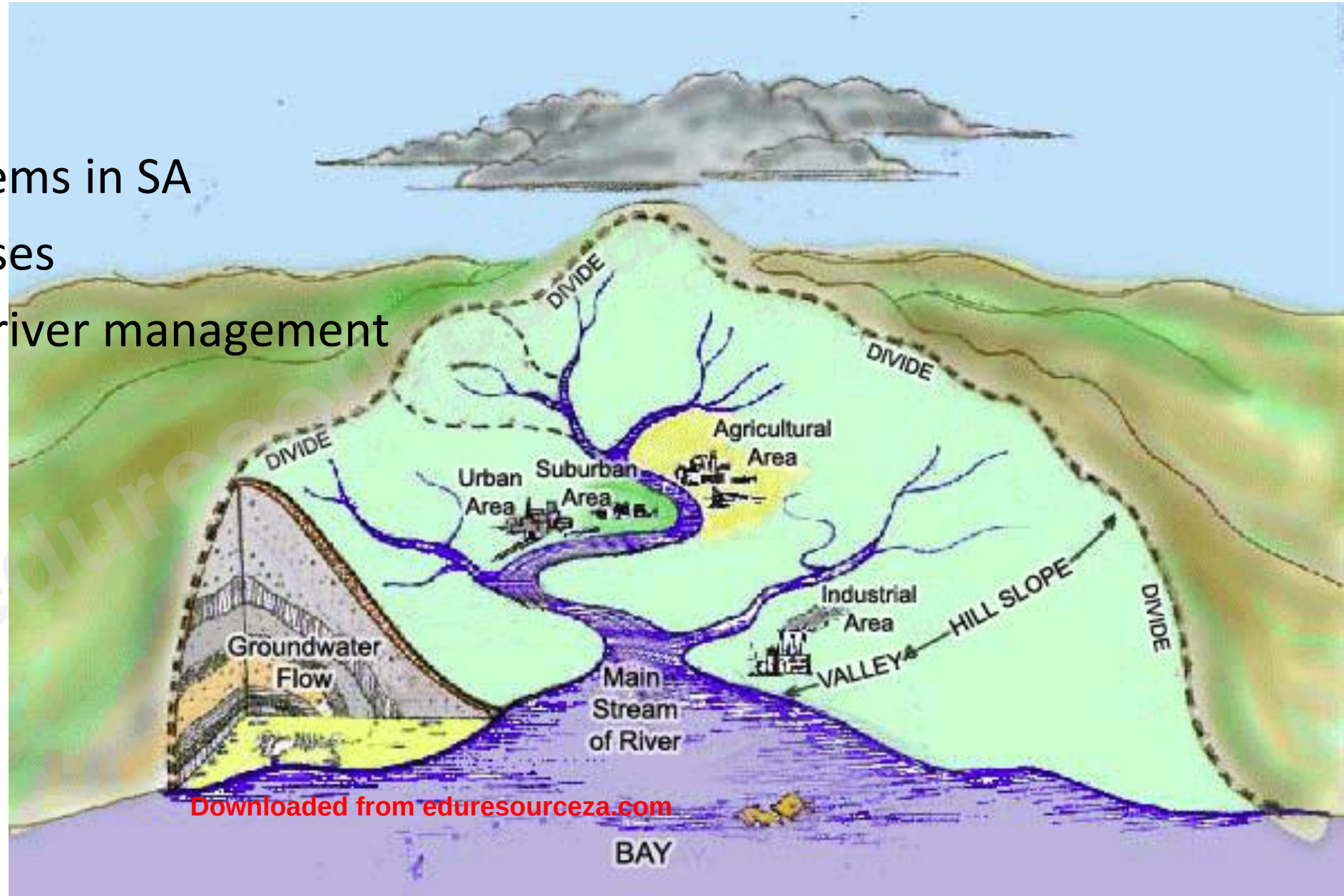




FLUVIAL GEOMORPHOLOGY

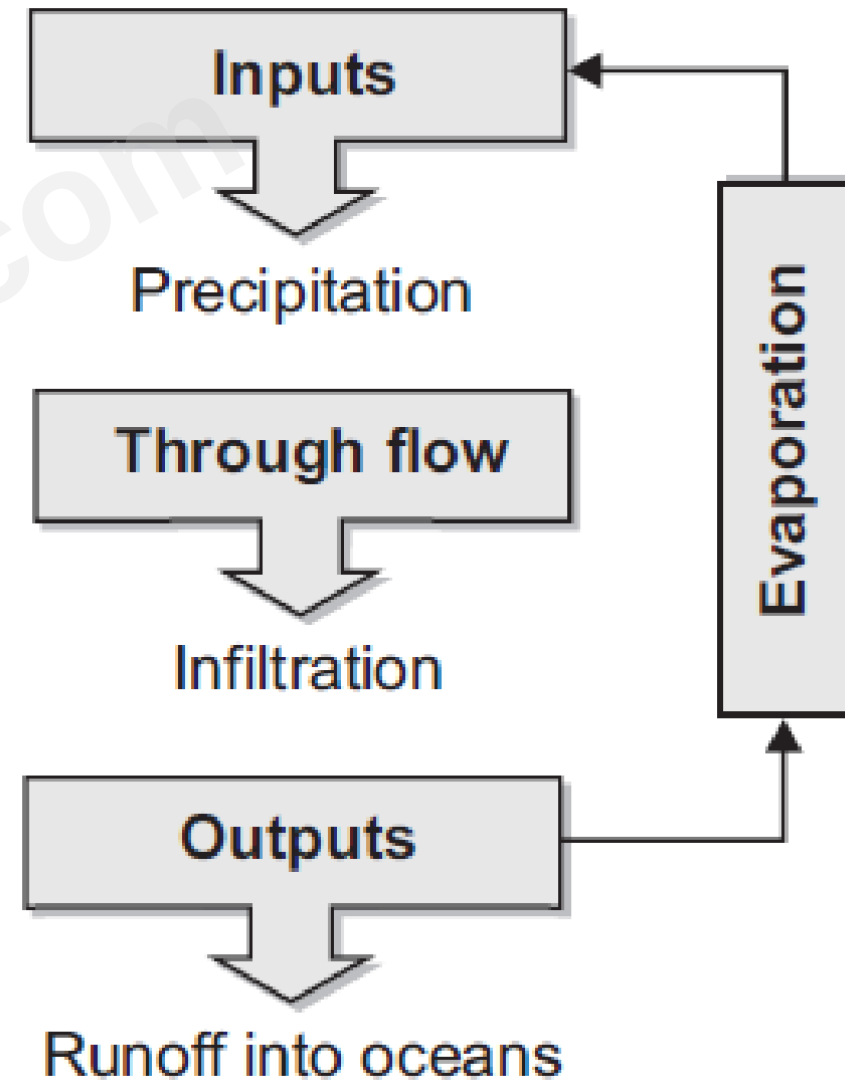
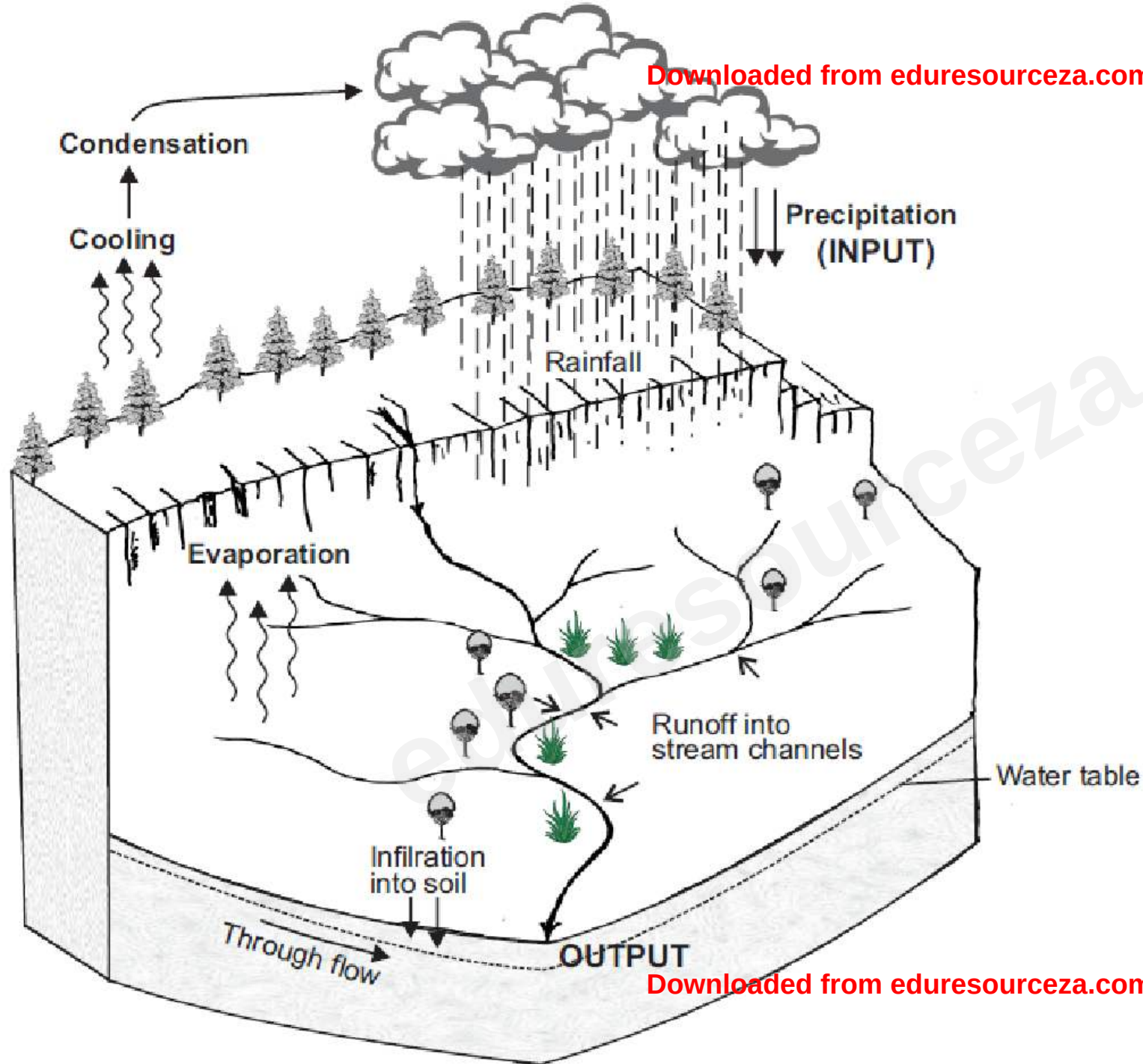
Contents

- Drainage systems in SA
- Fluvial processes
- Catchment & river management



Drainage systems in SA

- **Drainage basin** = area drained by a river system
- **Catchment area** = drainage area that supplies water to a river
- **River system** = small streams & rivers join
- **River** = a body of water flowing in defined channels from source to mouth
- **Watershed** = high ground separating one drainage basin from the adjacent drainage basin
- **Tributary** = individual river channel forming the stream network (upper course)
- **River mouth** = where a river flows into a sea or lake
- **Source** = place where a river begins
- **Confluence** = point where one river in the network joins another
- **Water table** = upper surface of the groundwater
- **Surface run-off** = rainwater flowing over the surface
- **Groundwater** = underground water
- **Stream or river network** = individual streams & rivers that are connected
- **Interfluves** = ridges of high ground or spurs between individual channels



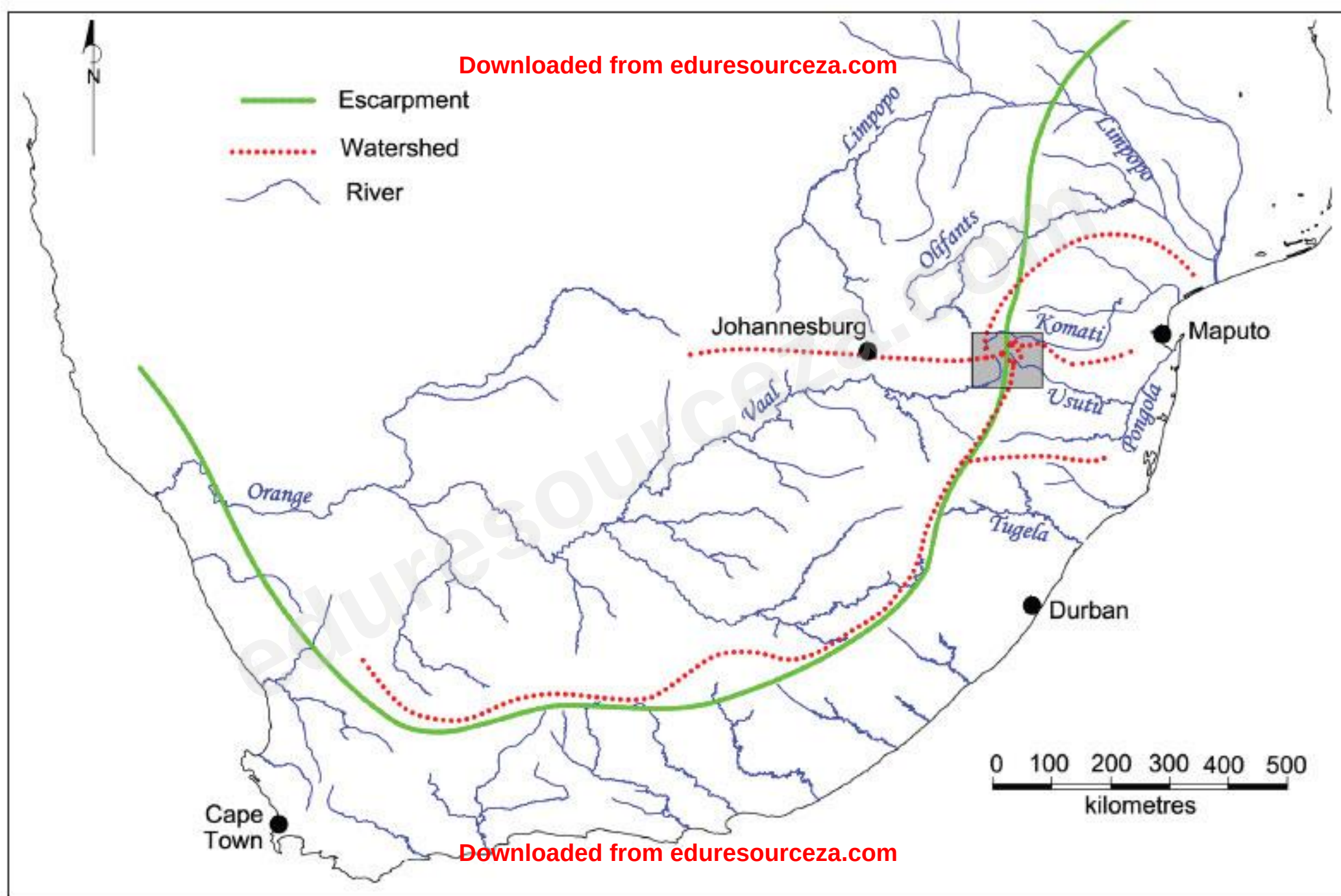
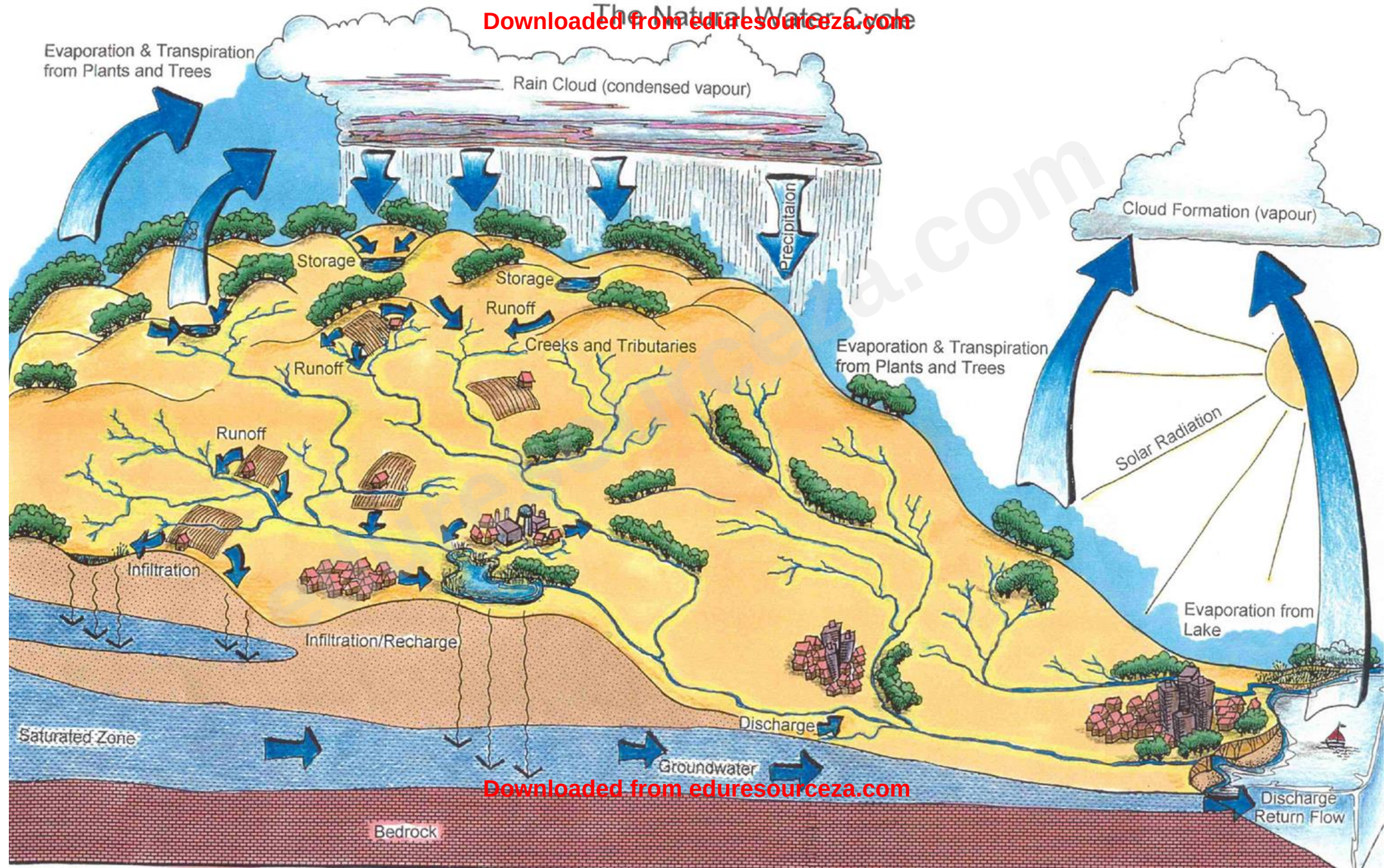
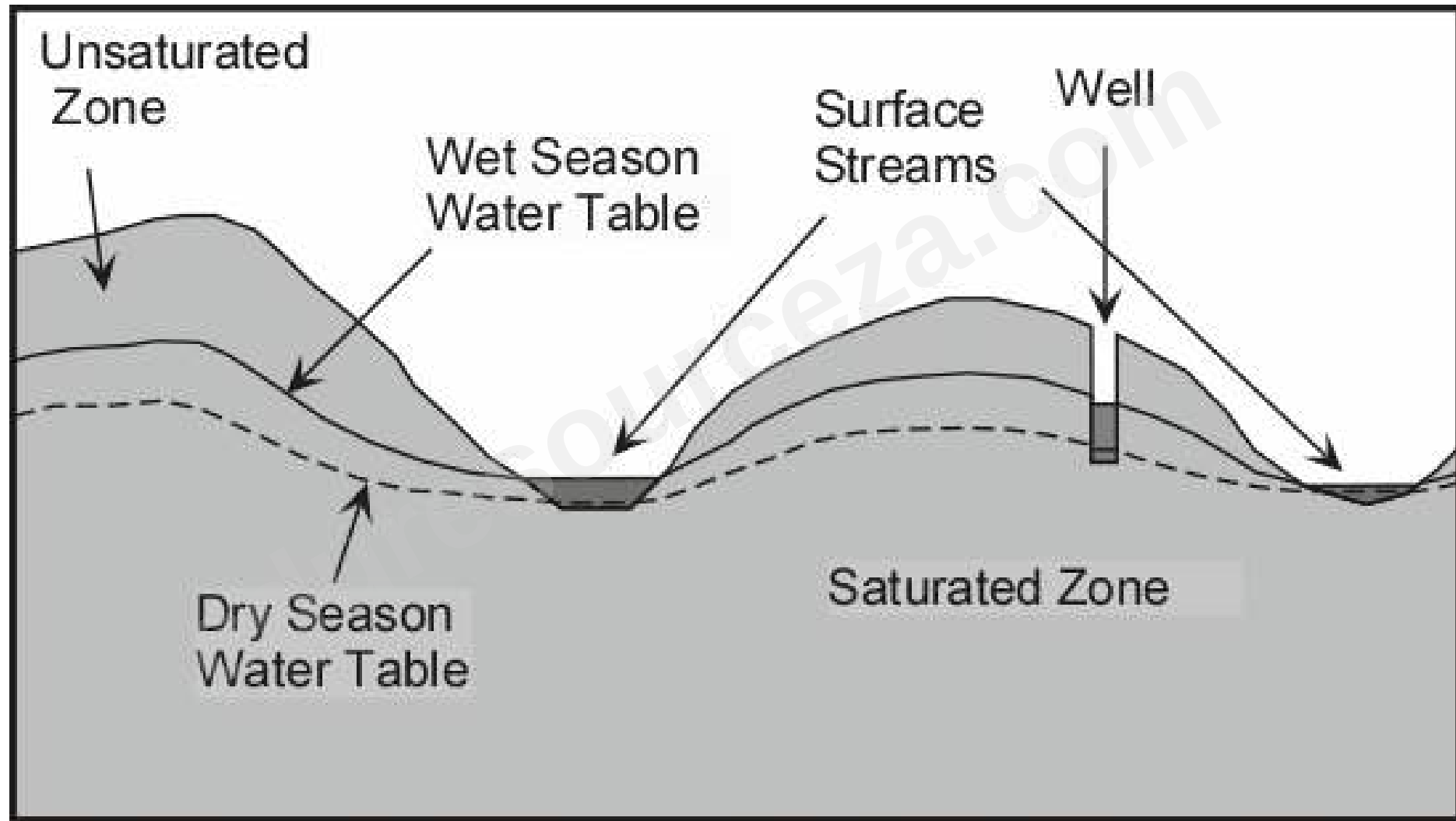


FIGURE 1: A map showing the river basins in South Africa.

Flows

- Overland flow = rainwater flowing over the surface
- Channel flow = water flowing in a river channel
- Throughflow = water flowing through the soil
- Groundwater flow = water flowing through underground rocks
- Baseflow = groundwater that seeps into a river





More definitions

- Infiltration – precipitation or water soaks into subsurface soils & moves into rocks through cracks & pore spaces
- Percolation – when water on the earth's surface in the run-off stage seeps underground

Class & Prep work

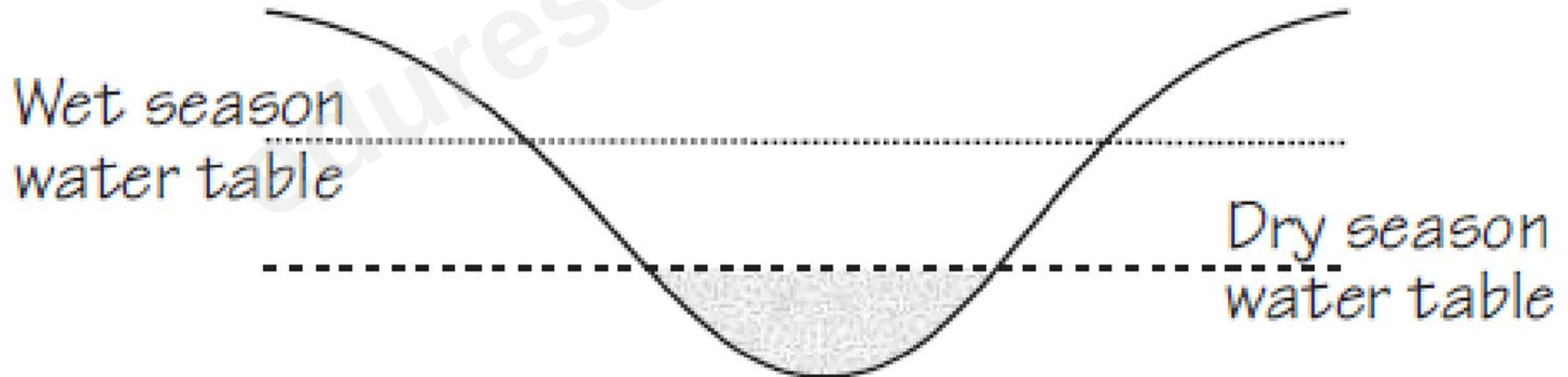
- Activity 2 p 128
- Activity 3 p 128

Types of rivers

- Permanent
- Periodic
- Episodic
- Exotic

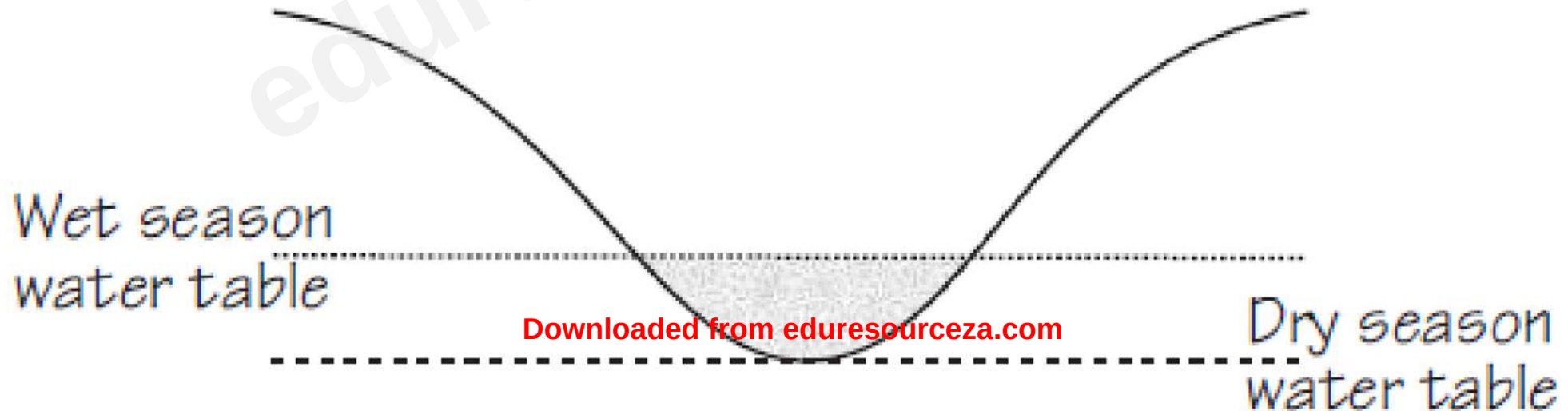
Permanent (Perennial)

- Receive groundwater all year (water table always lies above the bed of the river – baseflow) & flow all year round
- E.g. Tugela, Vaal & Crocodile



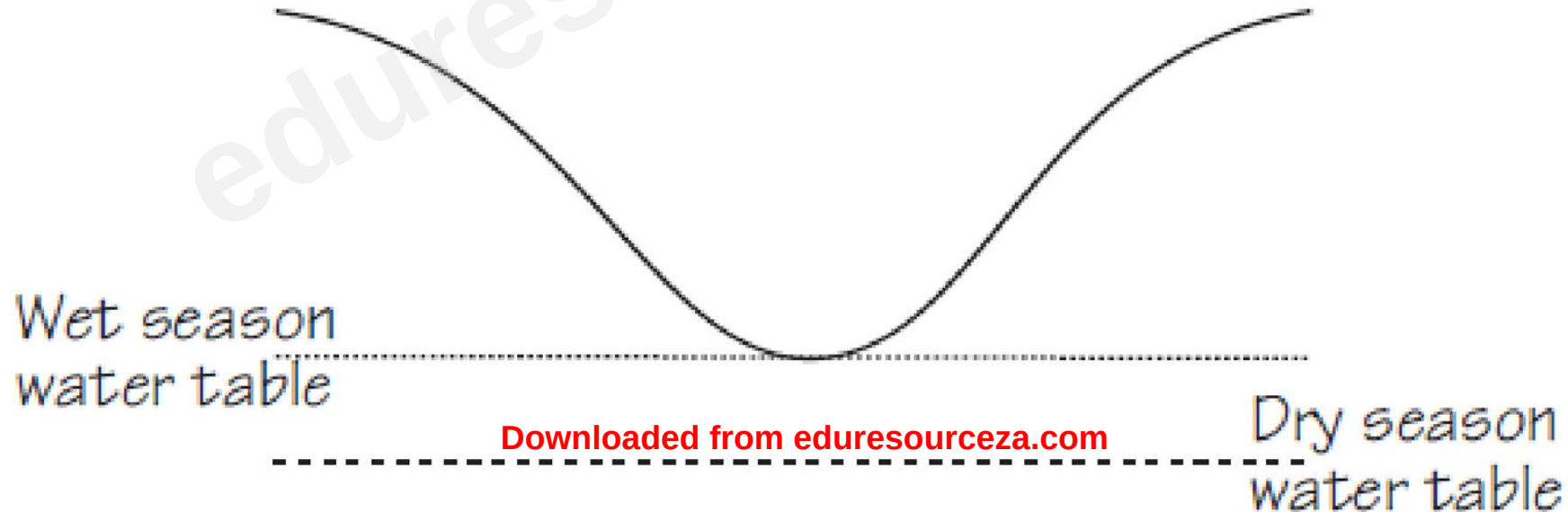
Periodic (Non-perennial)

- Receive groundwater only in the rainy season when the water table is above the riverbed
- These rivers are seasonal, only flowing for 5-6 months after a period of rainfall
- This is characteristic of most of SA's streams



Episodic

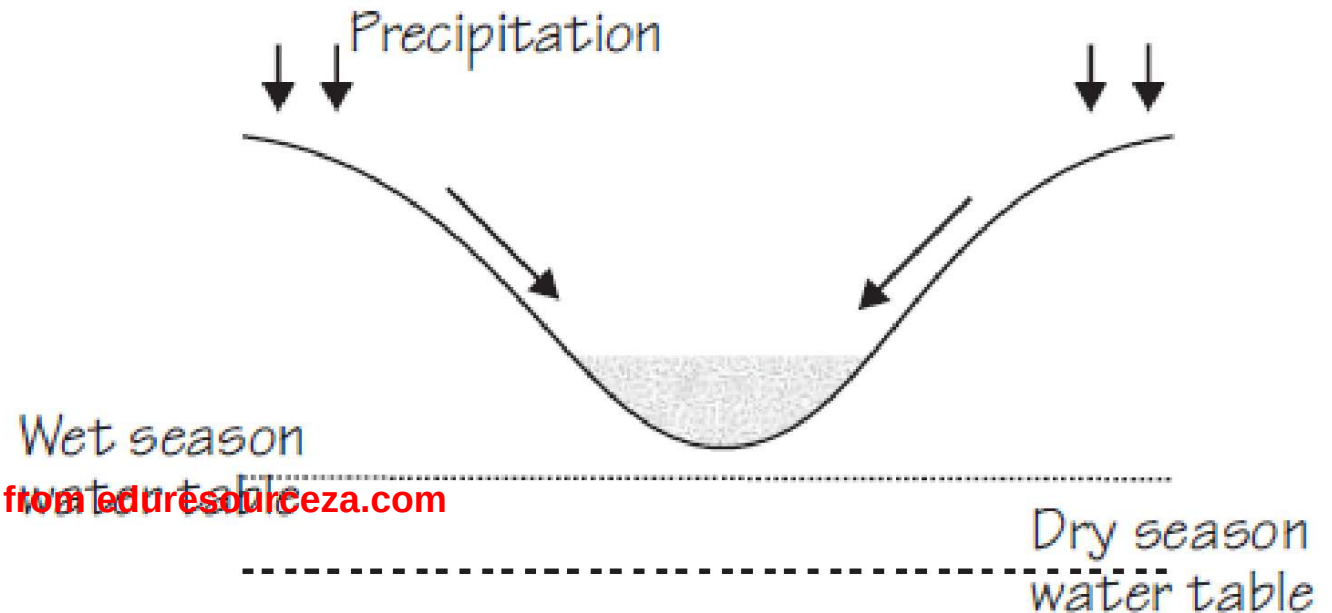
- Never supplied with groundwater
- Flow only after an episode of rain
- Water infiltrates river bed
- E.g. Swakop & Buffels



Exotic

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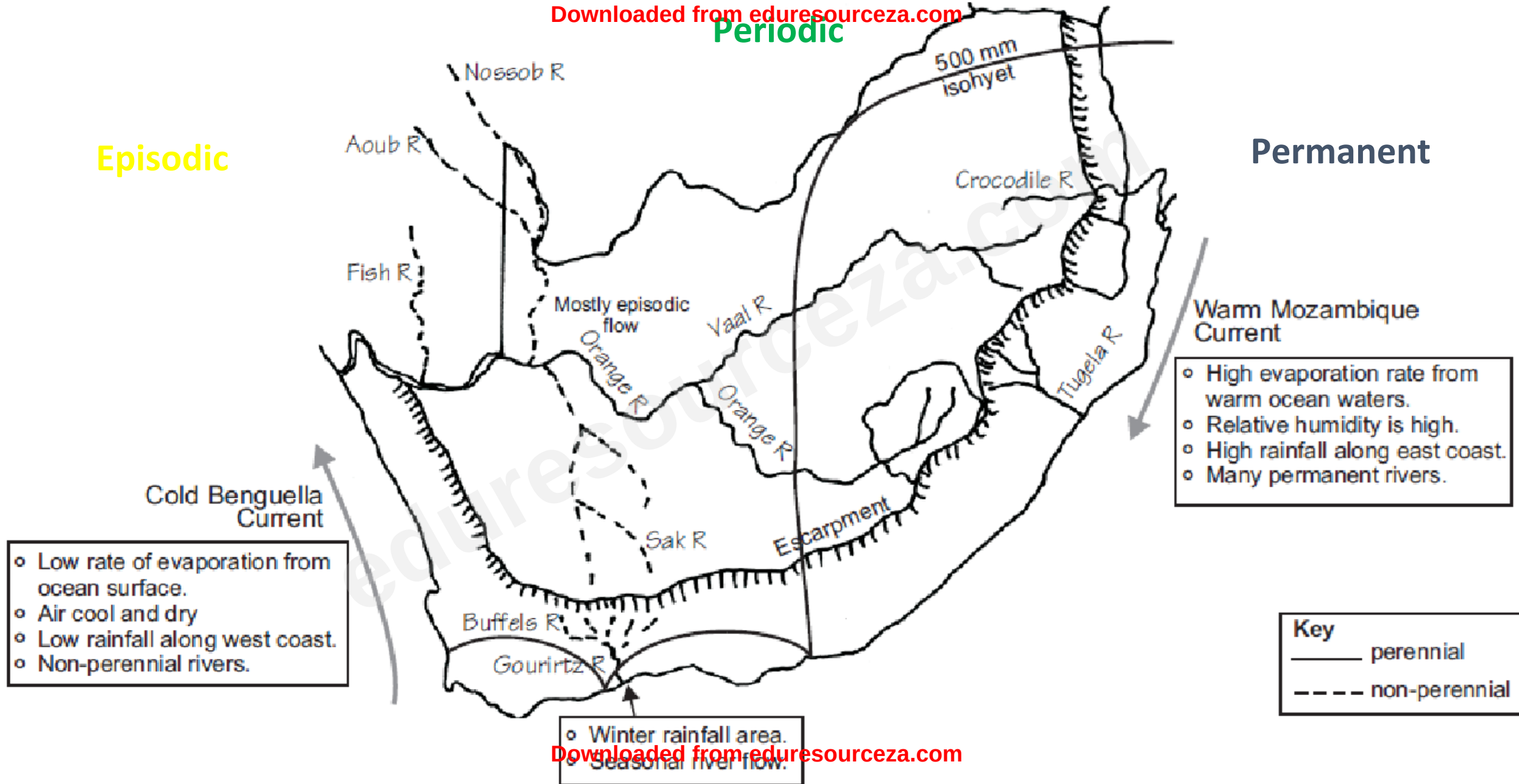
- Flow all year round
- Supplied with water where they rise but little water is added towards the sea
- They exhibit characteristics of their source rather than the areas through which they flow
- Groundwater does not contribute to baseflow in arid areas
- E.g. Orange (Gariep) & Nile

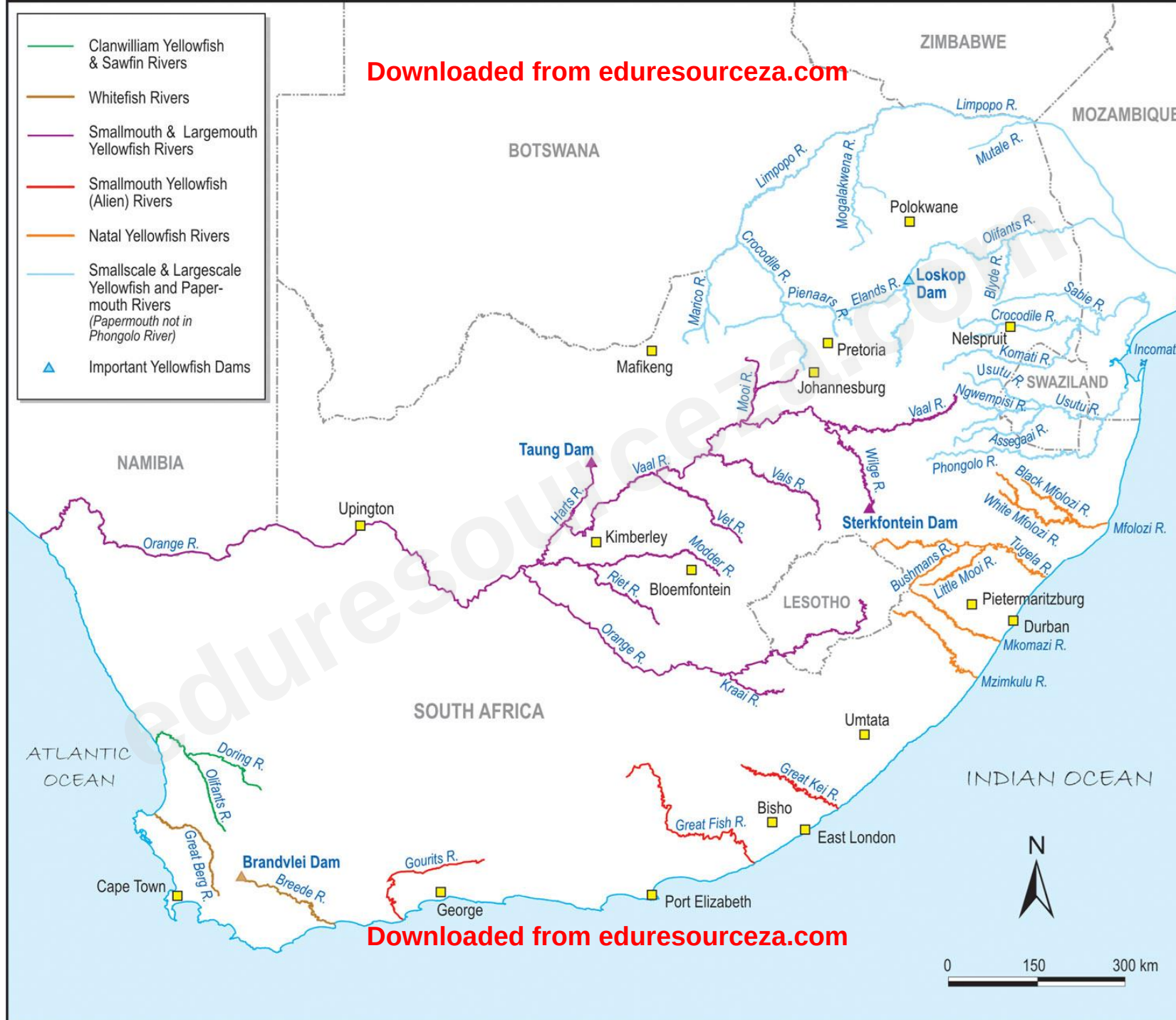


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Episodic

Permanent





Class & Prep work

- Activity 4 p 130

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Drainage patterns

- = the way in which rivers within a river system or network are arranged
- They are related to the geology & topography of the area

Drainage patterns that depend on the geology or topography of the area where they are found

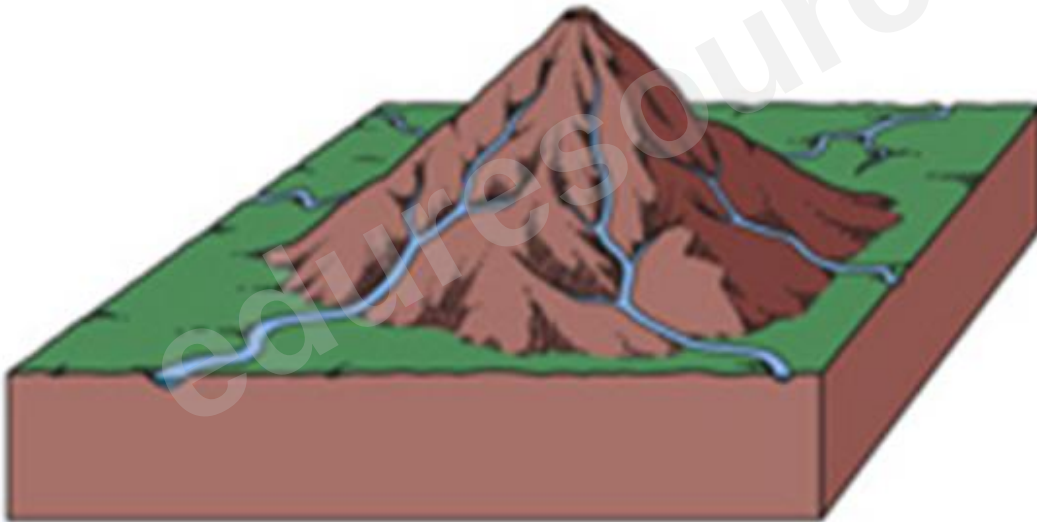
- These develop in less resistant rock, in joints & cracks, or where there is a steeper gradient

1. **Radial**
2. **Trellis**
3. **Rectangular**
4. **Centripetal**

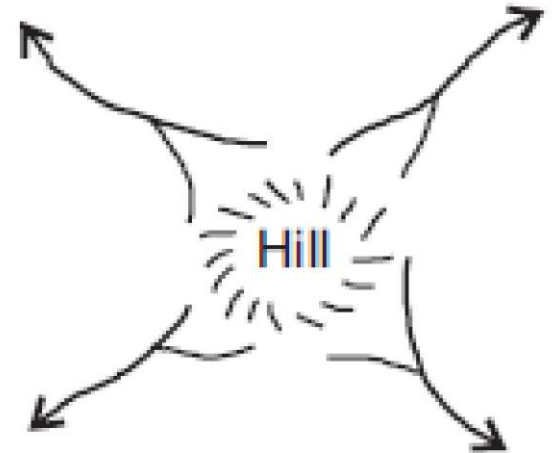
1. Radial = on a dome where streams flow outwards & downhill; looks like spokes of a wheel



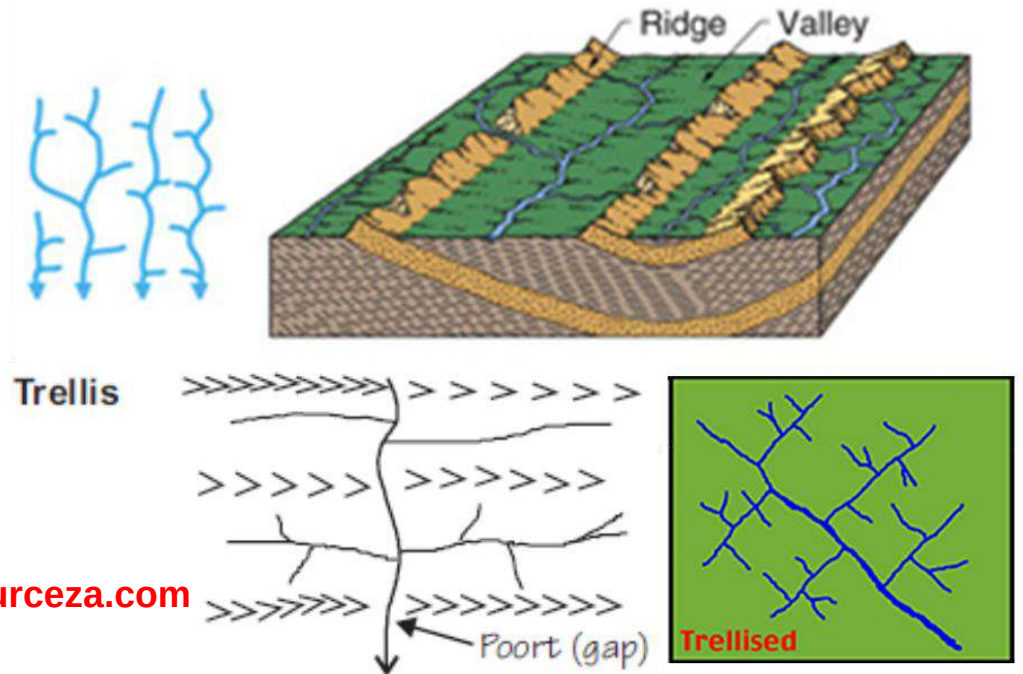
B Radial



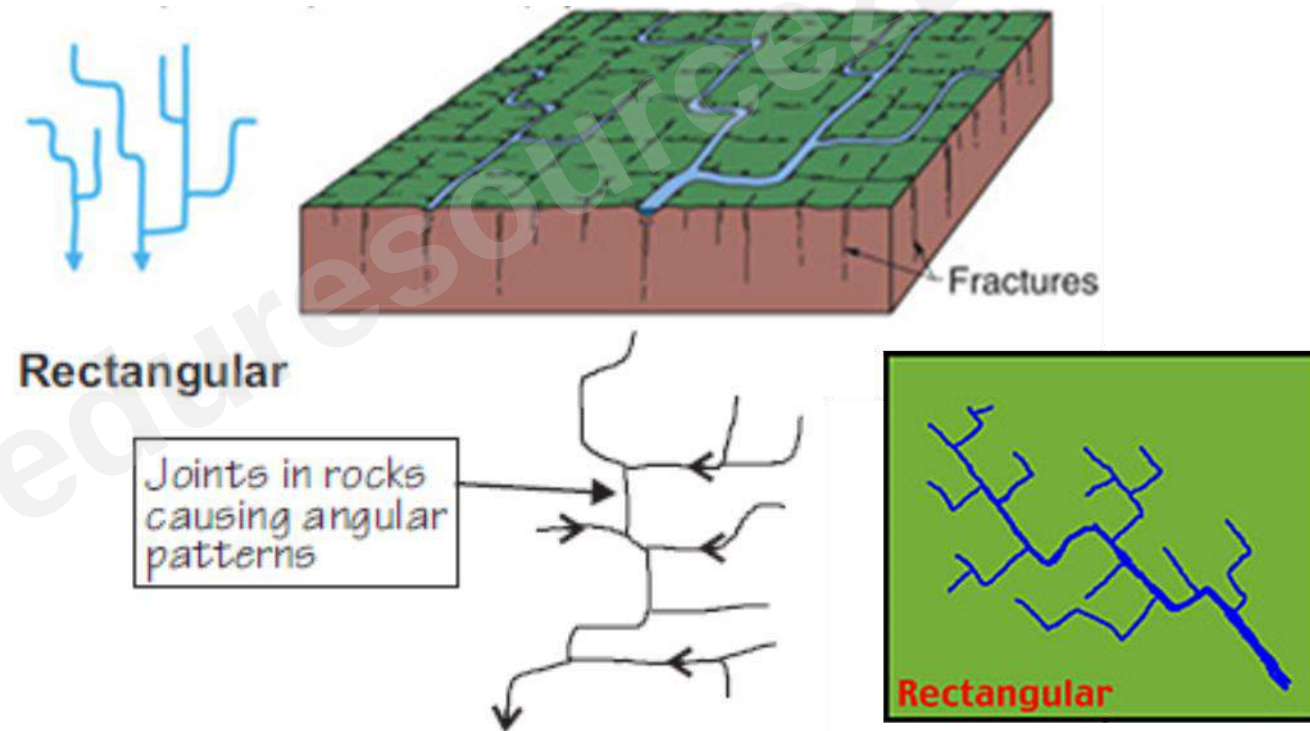
Radial



2. Trellis = forms on inclined strata unequally resistant to erosion or in areas where there are parallel fold mountains; streams develop in softer strata; shorter tributaries join main streams at right angles often cutting poorts or gaps through mountains

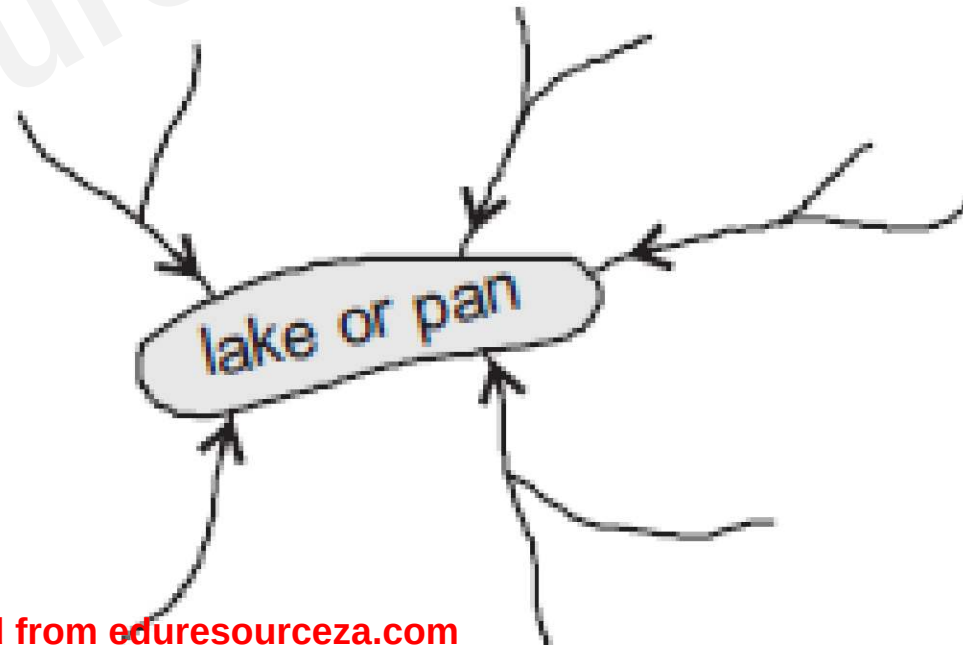


3. Rectangular = arises from joints/cracks in igneous rocks; streams develop right-angled bends where joints meet



4. Centripetal = streams flowing into a central pan or low-lying area

Centripetal



Patterns that develop independently of the rock structure or gradient

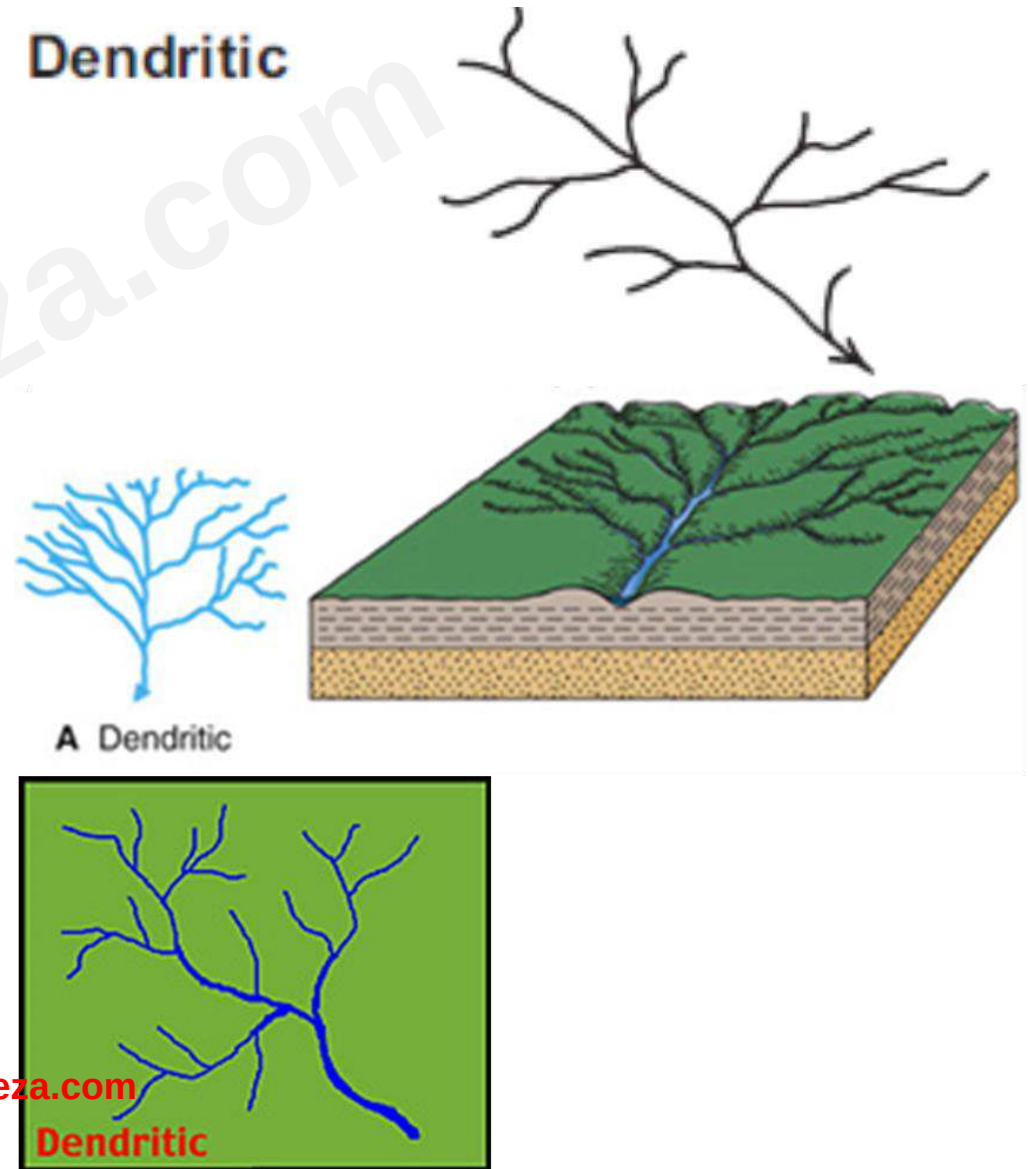
- There are no weaker areas in which water would erode a channel; gradient is uniform

5. Dendritic

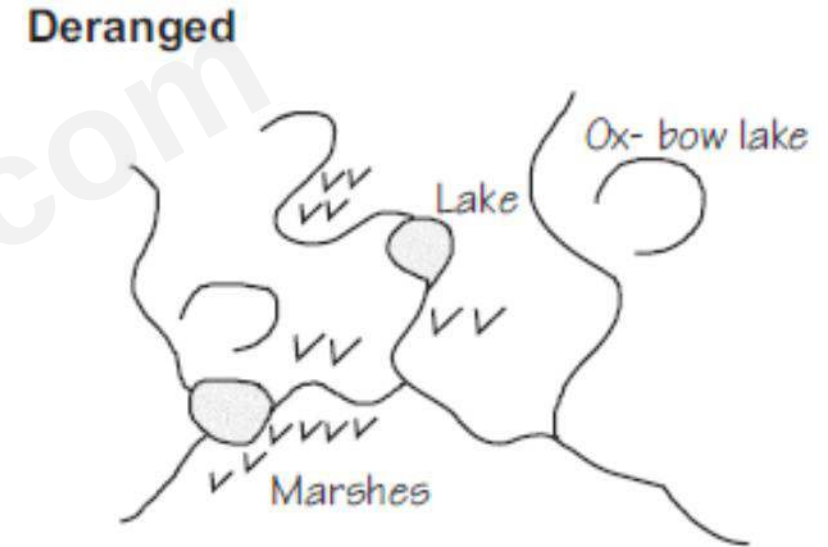
6. Deranged

7. Parallel

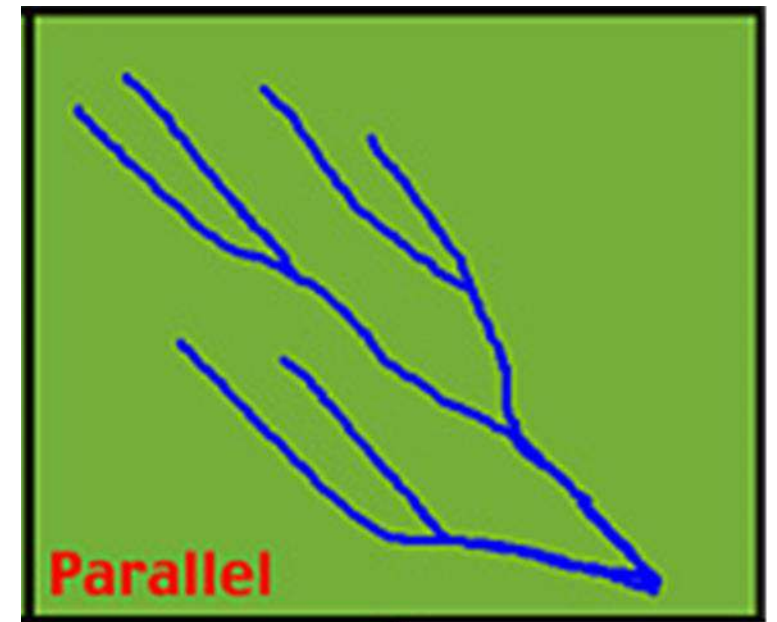
5. Dendritic = tree-like; tributaries appear like branches of a tree & join larger streams at acute angles; common; forms on rock of similar hardness in an area of similar gradient; rocks are massive igneous or horizontal sedimentary

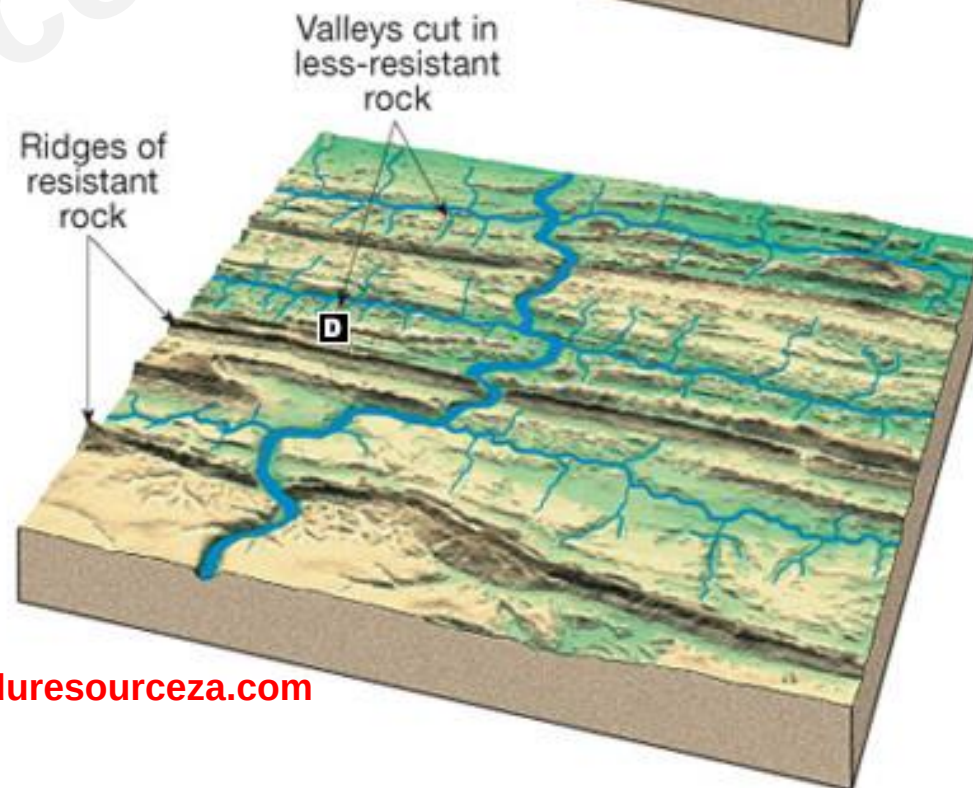
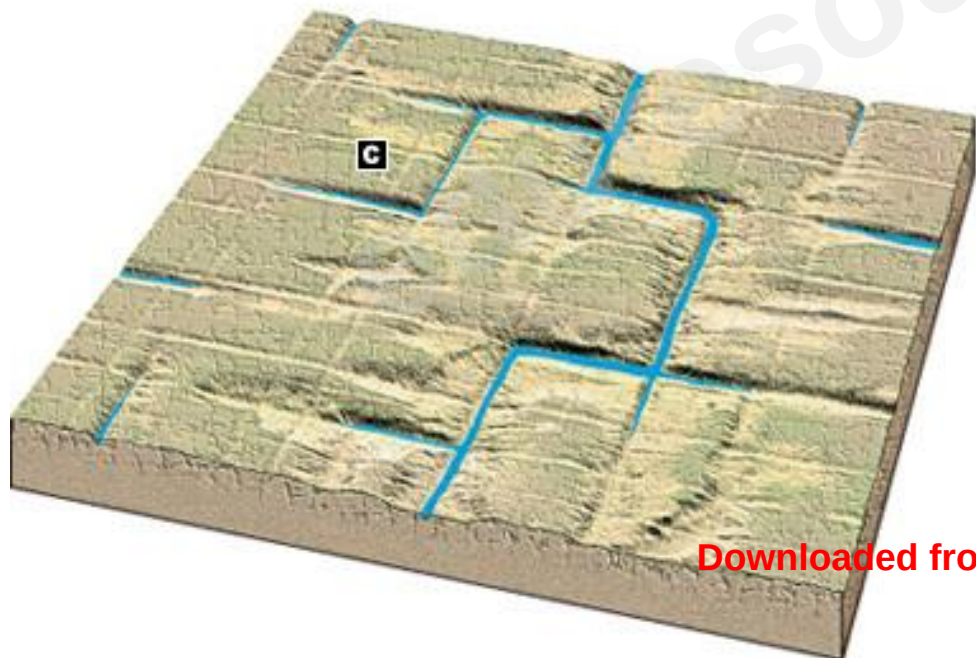
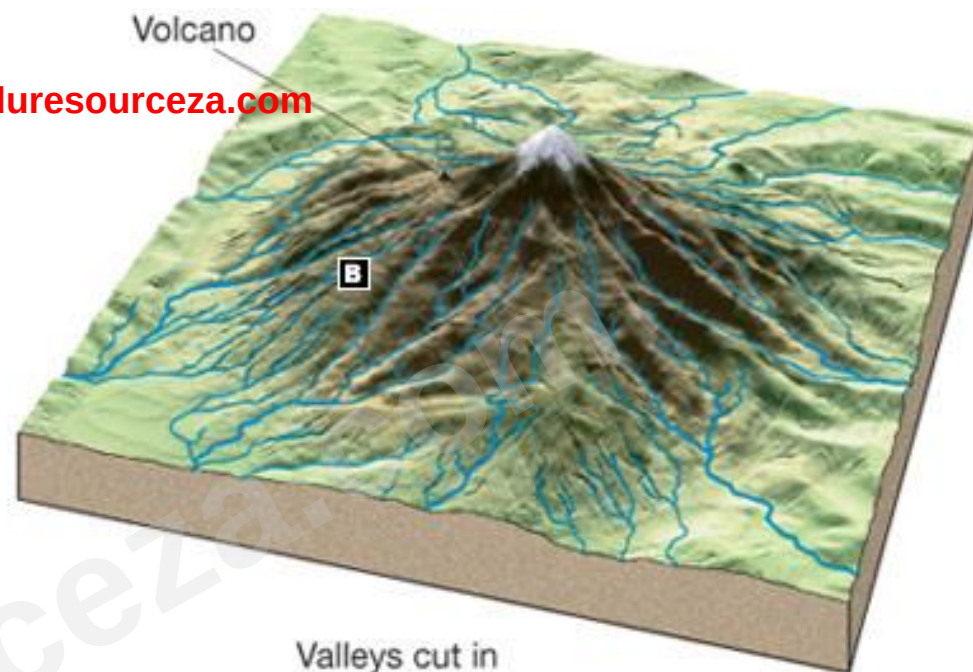
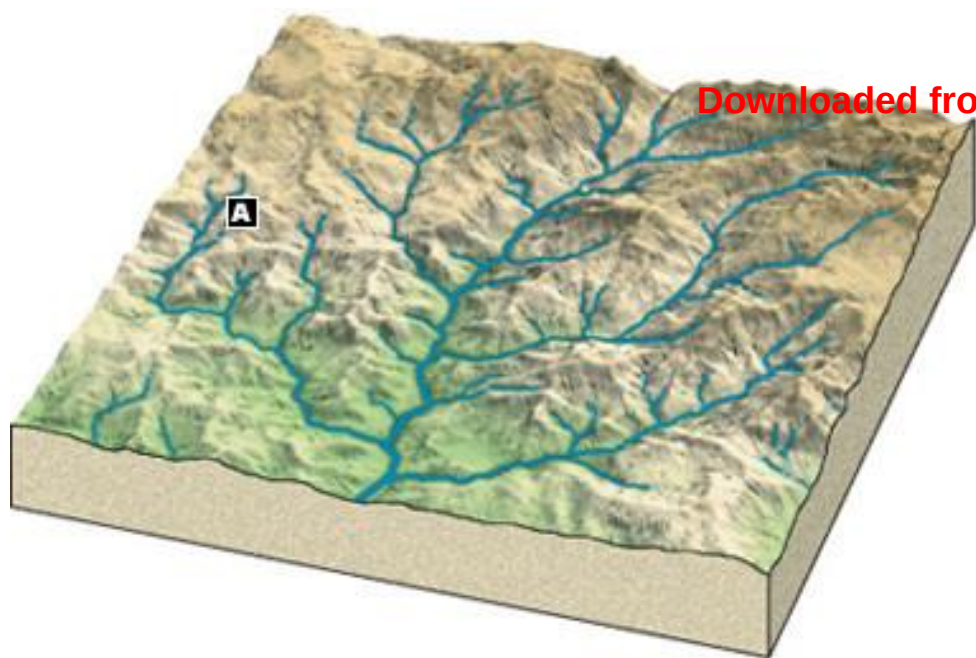


6. Deranged = develop on a land surface that was covered by an ice sheet or glacier, but that has since become exposed; landscape is made up of small streams, swamps & lakes; there is no apparent drainage pattern



7. Parallel = a surface slopes uniformly but is fairly steep; river & tributaries flow downslope nearly parallel to one another





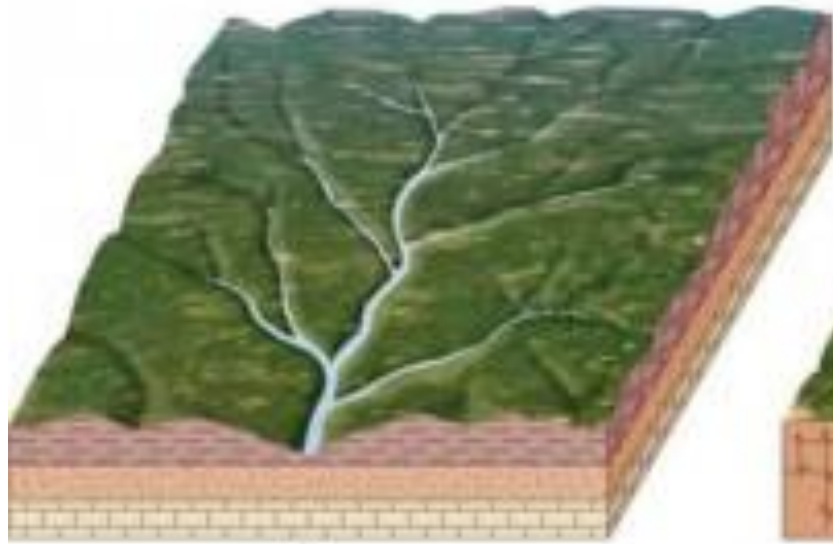
Class & Prep work

- Activity 5 p 133

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Spot test

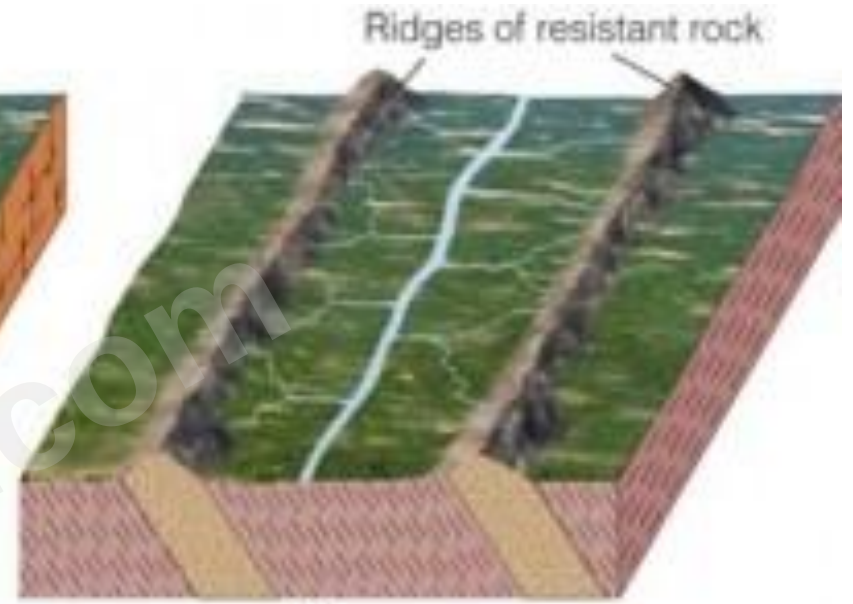
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(a)



(b)



(c)



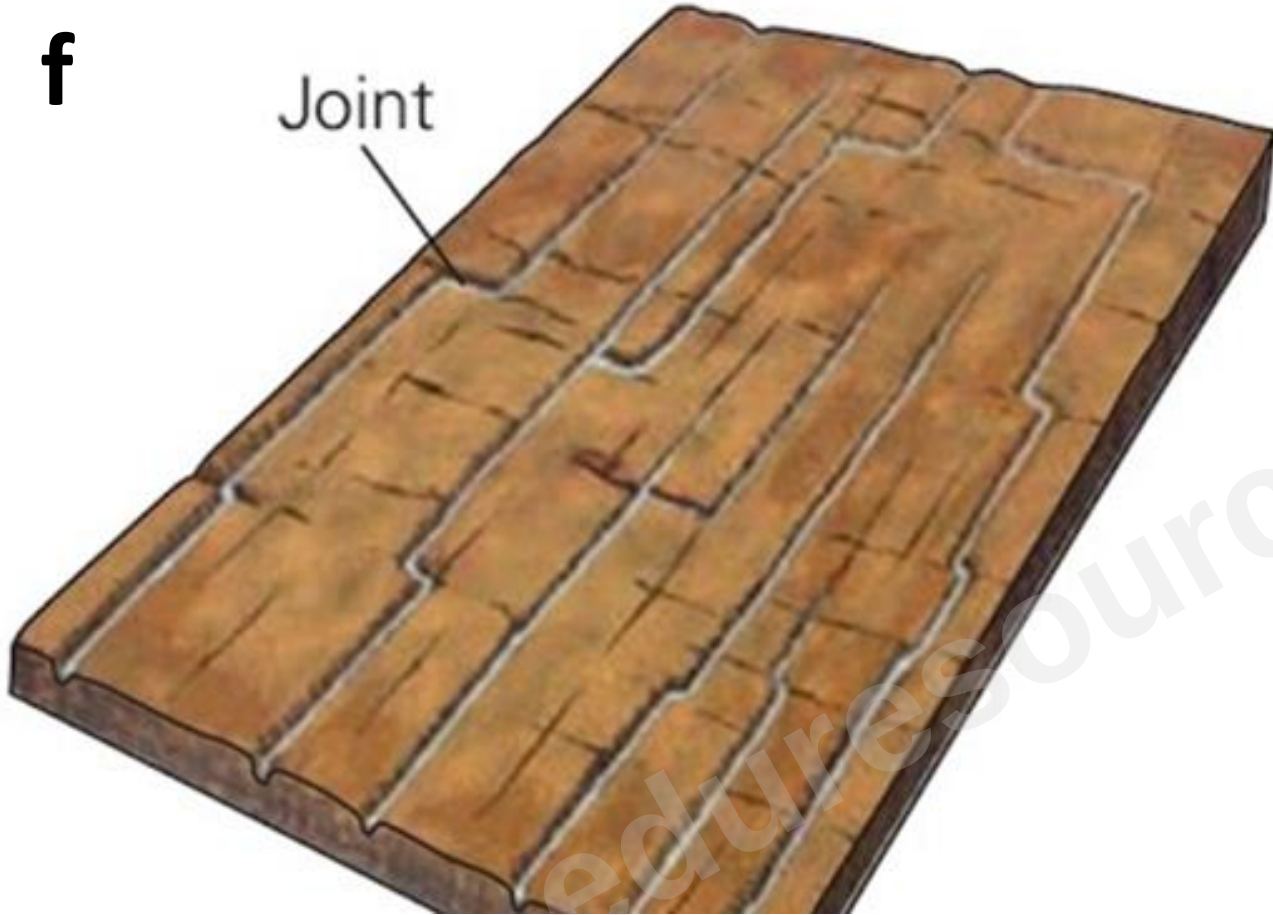
(d)



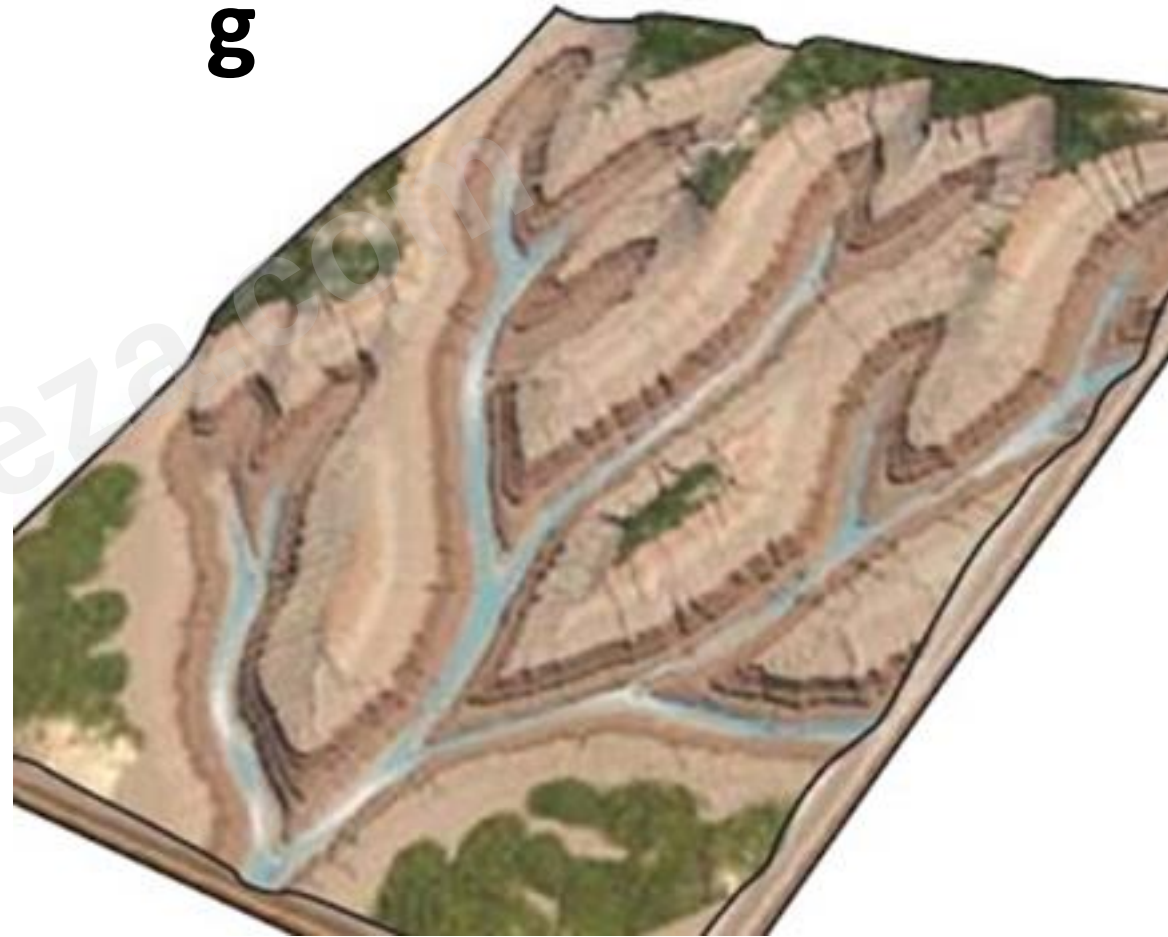
(e)

f

Joint

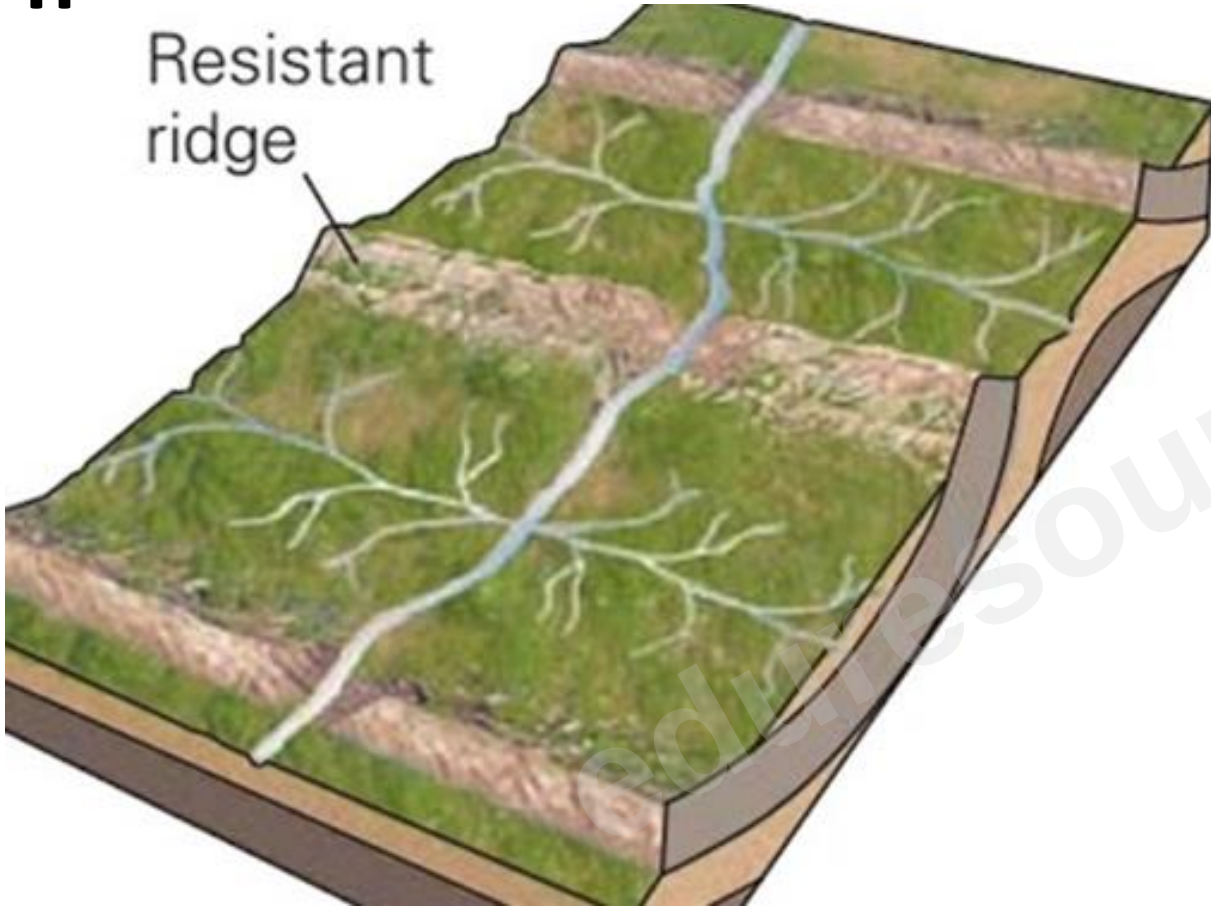


g



h

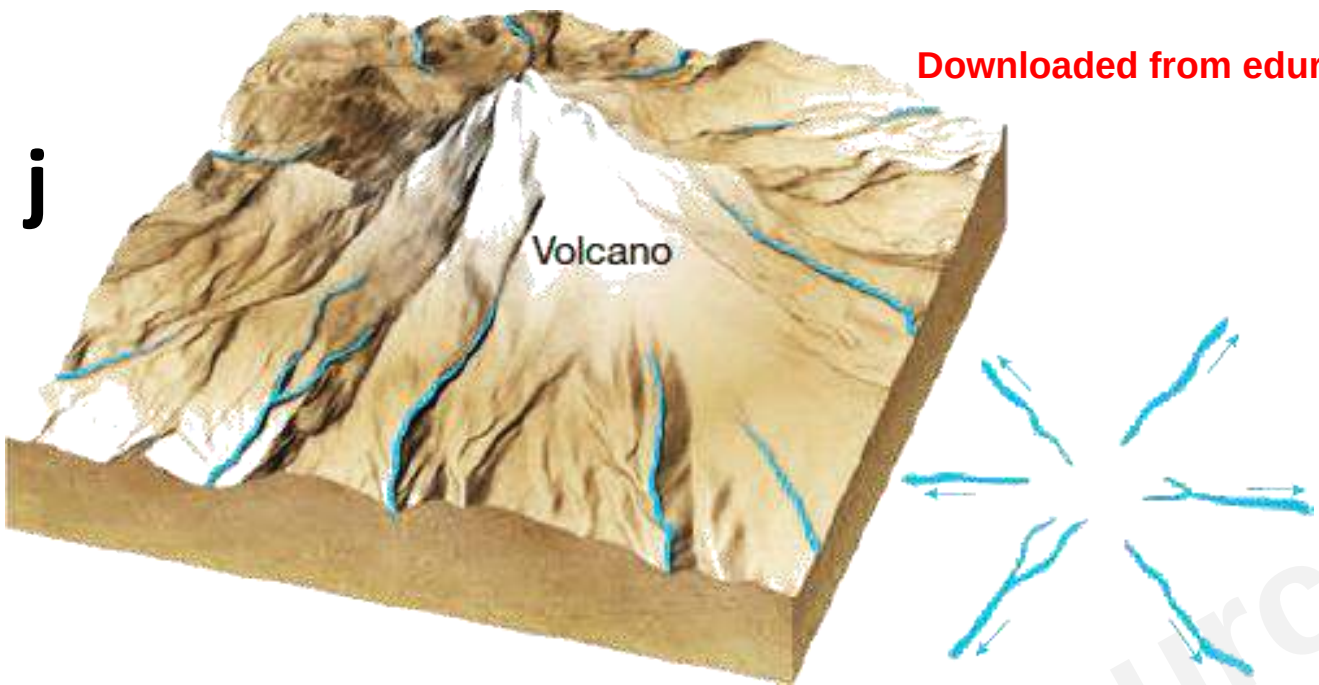
Resistant
ridge



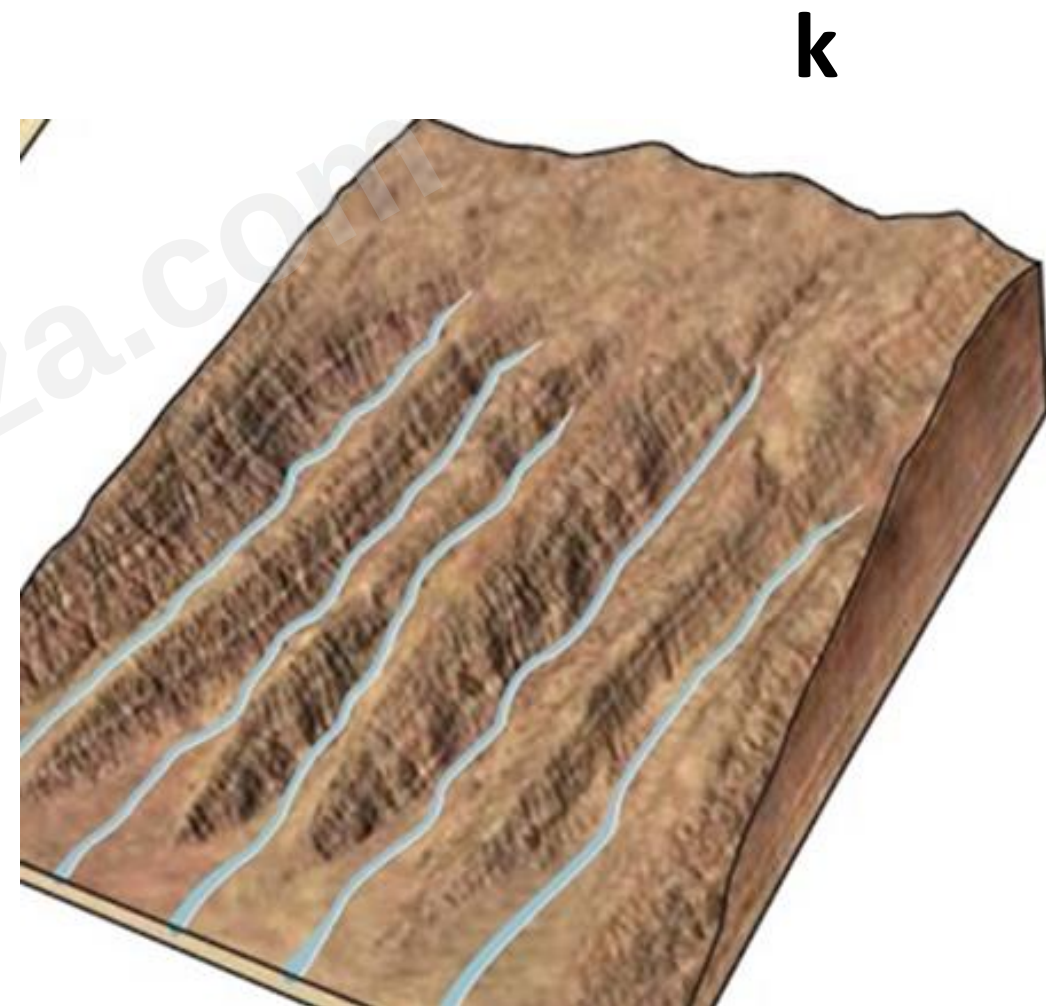
i

Volcano

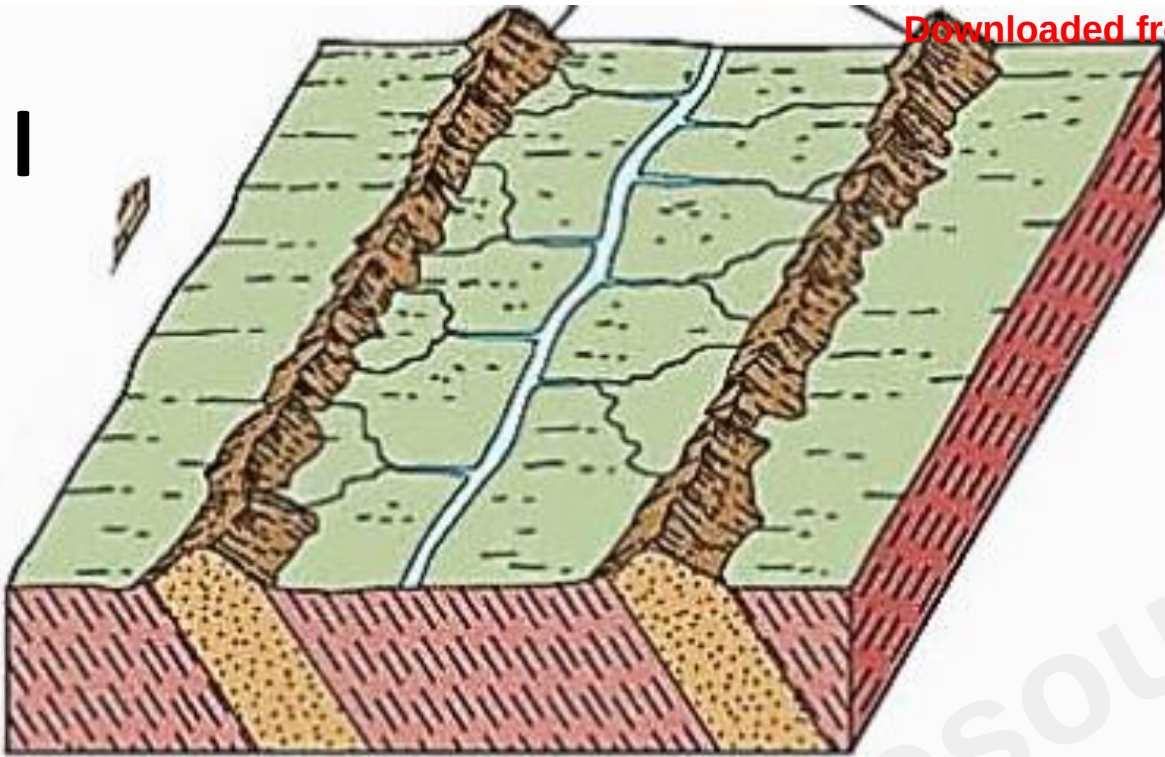




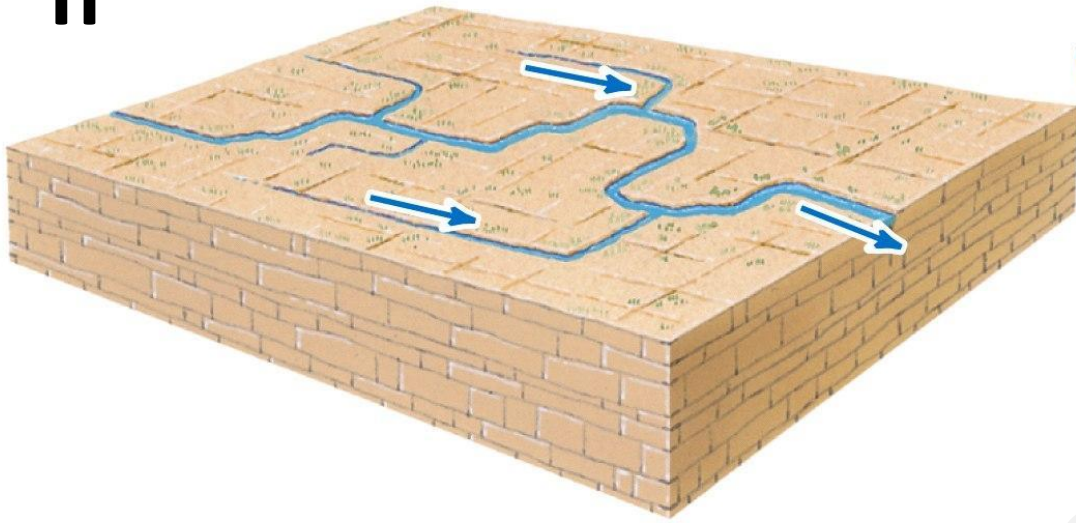
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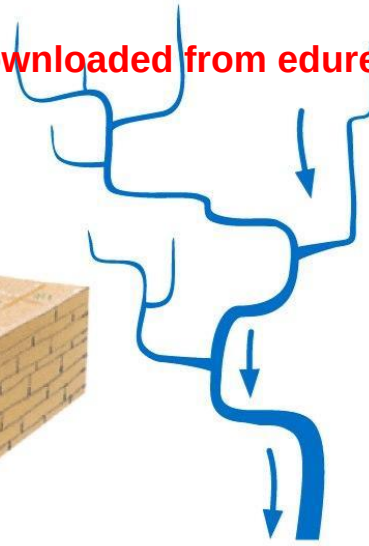
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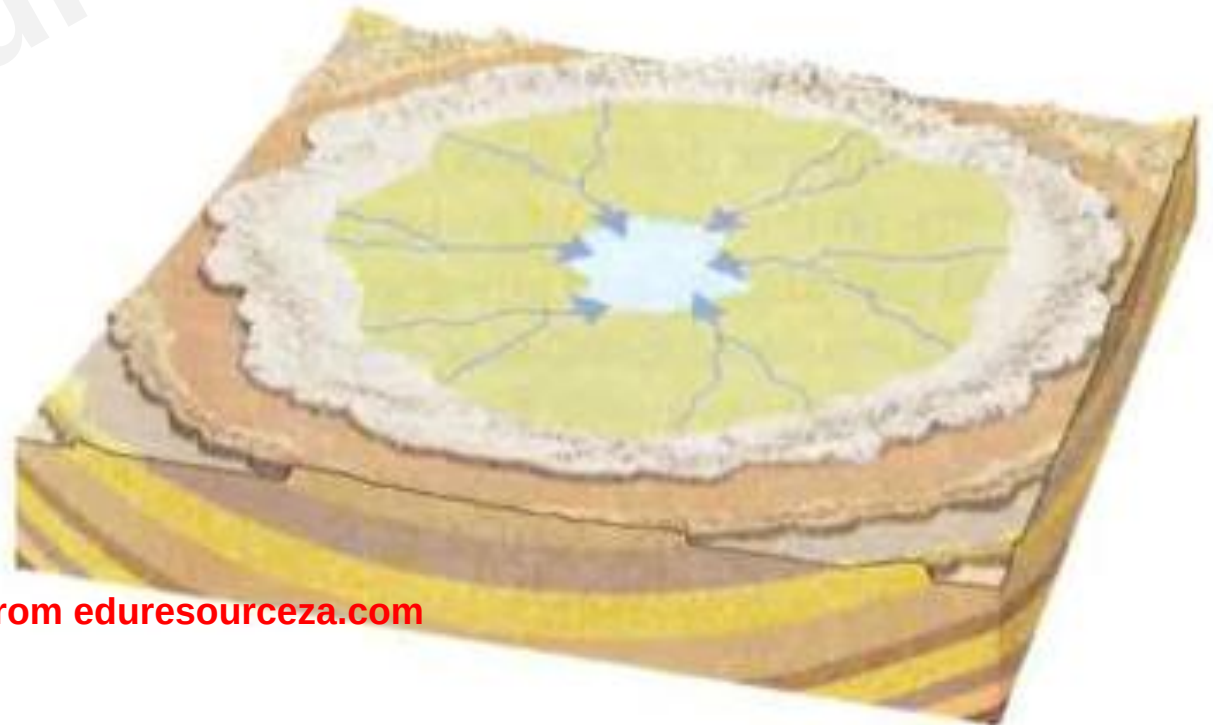
n



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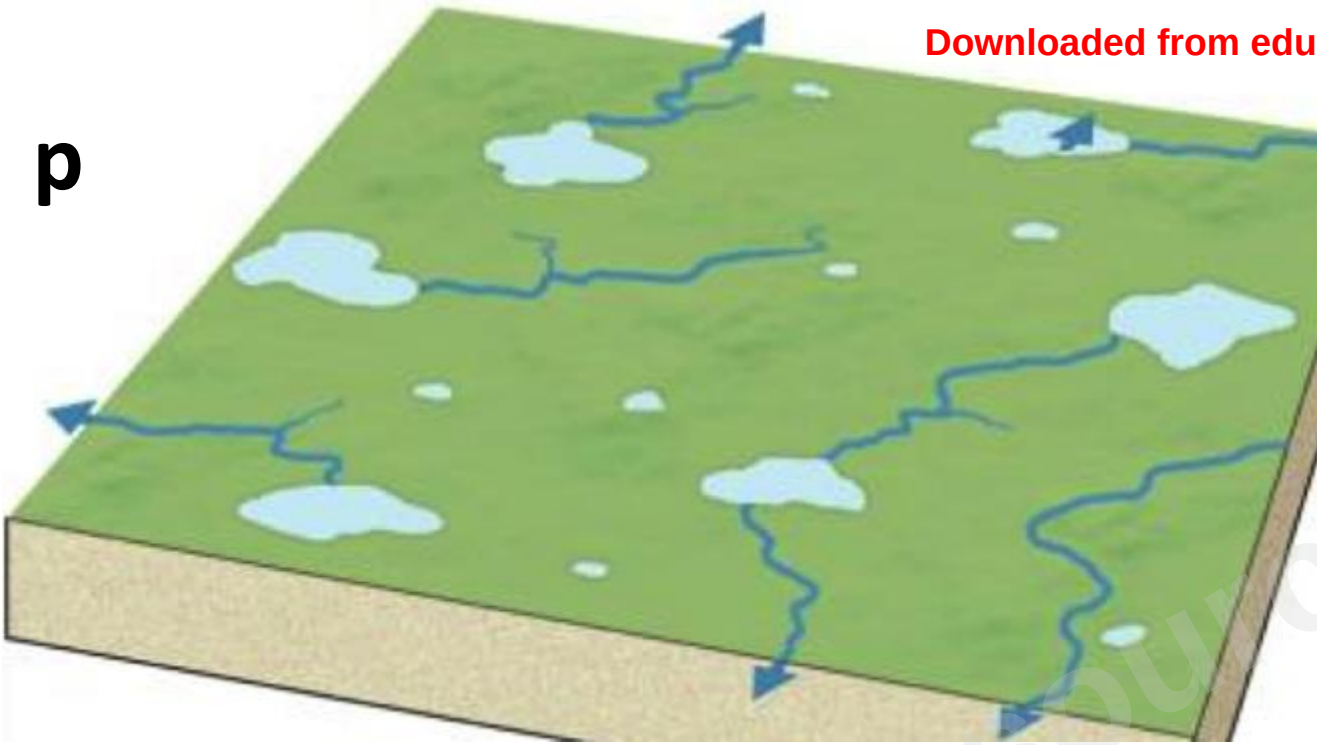
o



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p

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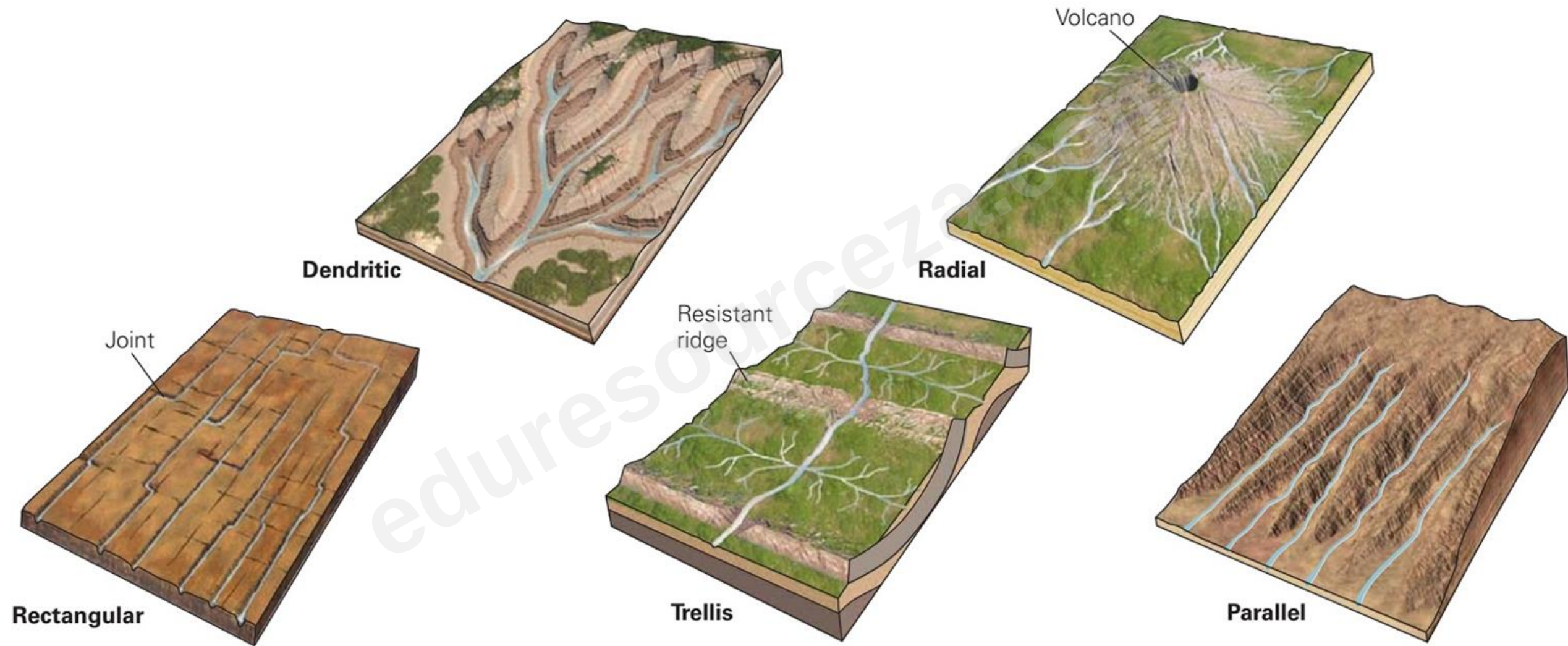


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Answers

- a) Dendritic
 - b) Rectangular
 - c) Trellis
 - d) Radial
 - e) Deranged
 - f) Rectangular
 - g) Dendritic
 - h) Trellis
 - i) Radial
 - j) Radial
 - k) Parallel
 - l) Trellis
 - m) Trellis
 - n) Rectangular
 - o) Centripetal
 - p) Deranged
- (16)



Drainage density

- = the total length of streams per unit area of a drainage basin
- *Drainage density* =
$$\frac{\text{total length of streams in the basin (km)}}{\text{total area of the drainage basin (km}^2\text{)}}$$
- It is influenced by runoff in the catchment area



a) Low drainage density
(Coarse texture)



b) Medium drainage density
(Medium texture)



c) High drainage density
(Fine texture)



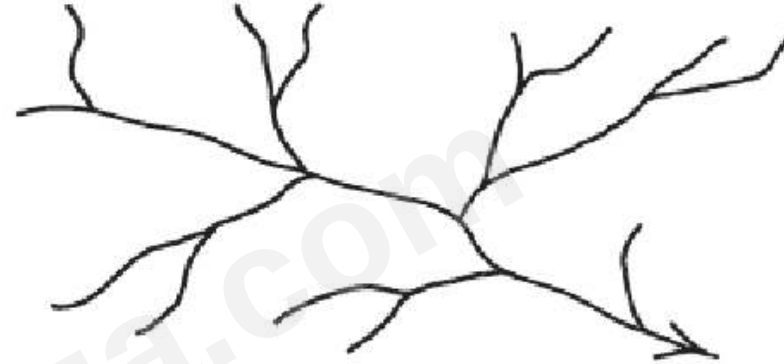
d) Very high drainage density
(Very fine texture)

Low density and coarse texture



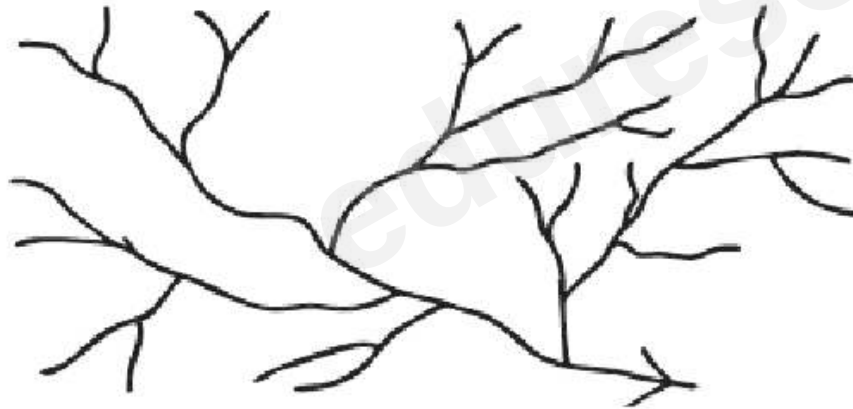
Few streams flowing in the drainage area.

Medium density and texture



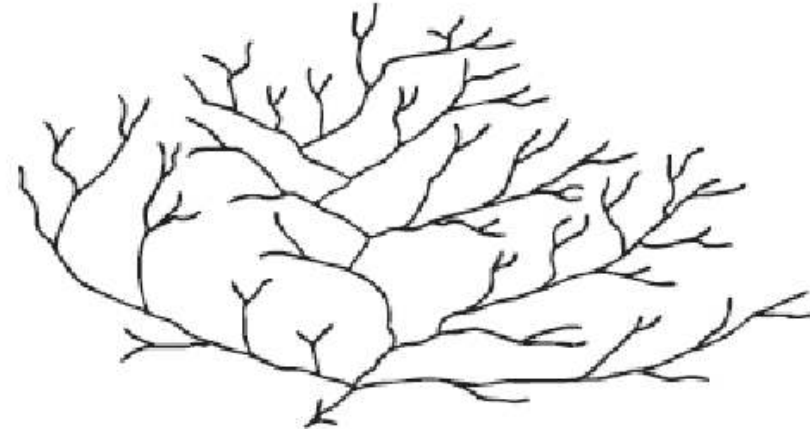
More tributaries in the drainage area.

High density and fine texture



Many 1st and 2nd order streams in the drainage area.

Extremely high density and very fine texture



Fine texture is characteristic of many small tributaries.

The drainage density and texture of various drainage basins

Factors influencing drainage density

- Evaporation rates
- Rainfall
- Infiltration rate
- Hardness of the rock (greater density in softer rock)

Class & Prep work

- Activity 6 p 134

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Stream ordering

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- Stream order = the category of a stream in a network determined by the order of the streams feeding into it
- Stream ordering is another way of describing streams within a network
- 1st order = lowest category with no other streams feeding into them (streams that lead from a source)
- Where two streams of the same order meet, a stream of a higher order is formed
- Where two streams of a different order meet, the stream retains the higher order of the two streams



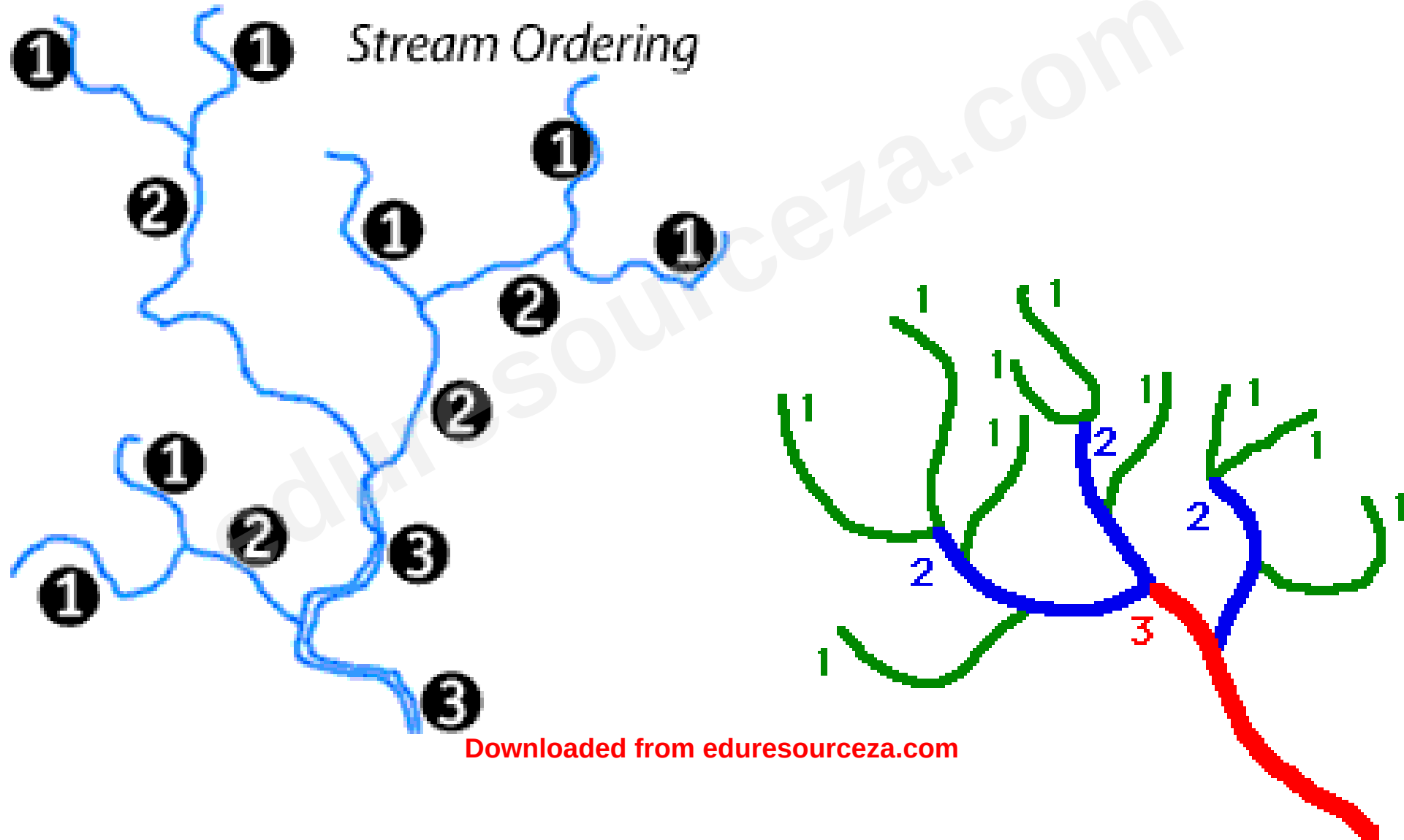
Note:

$1 + 1 = 2^{\text{nd}}$ order stream
$1 + 2 = 2^{\text{nd}}$ order stream
$2 + 2 = 3^{\text{rd}}$ order stream
$2 + 3 = 3^{\text{rd}}$ order stream
$3 + 3 = 4^{\text{th}}$ order stream

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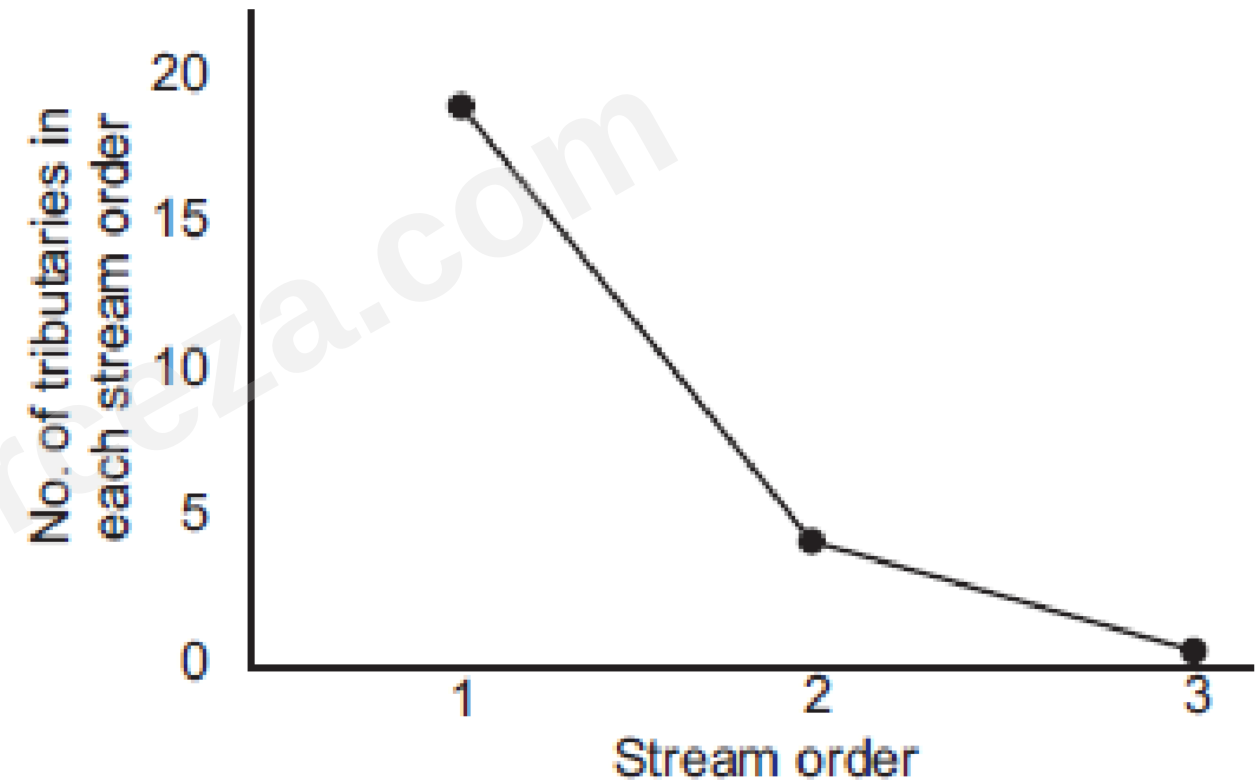
Stream ordering in a small sub-catchment area of the Tugela River

Stream order



Stream Order	No. of streams within an order
1	18
2	4
3	1

In this drainage area the lower the stream order, the greater the number of tributaries present.



Stream ordering for a sub-catchment area of the Tugela River

Class & prep work

- Activity 7 p 135
- Activity 8 p 136
- Activity 9 p 137

ATTRITION – material is moved along the river bed, collides with other material and breaks up into smaller pieces.

CORRASION is caused by fine material rubbing against the river bank. The action is rather like that of sandpaper.

EROSION

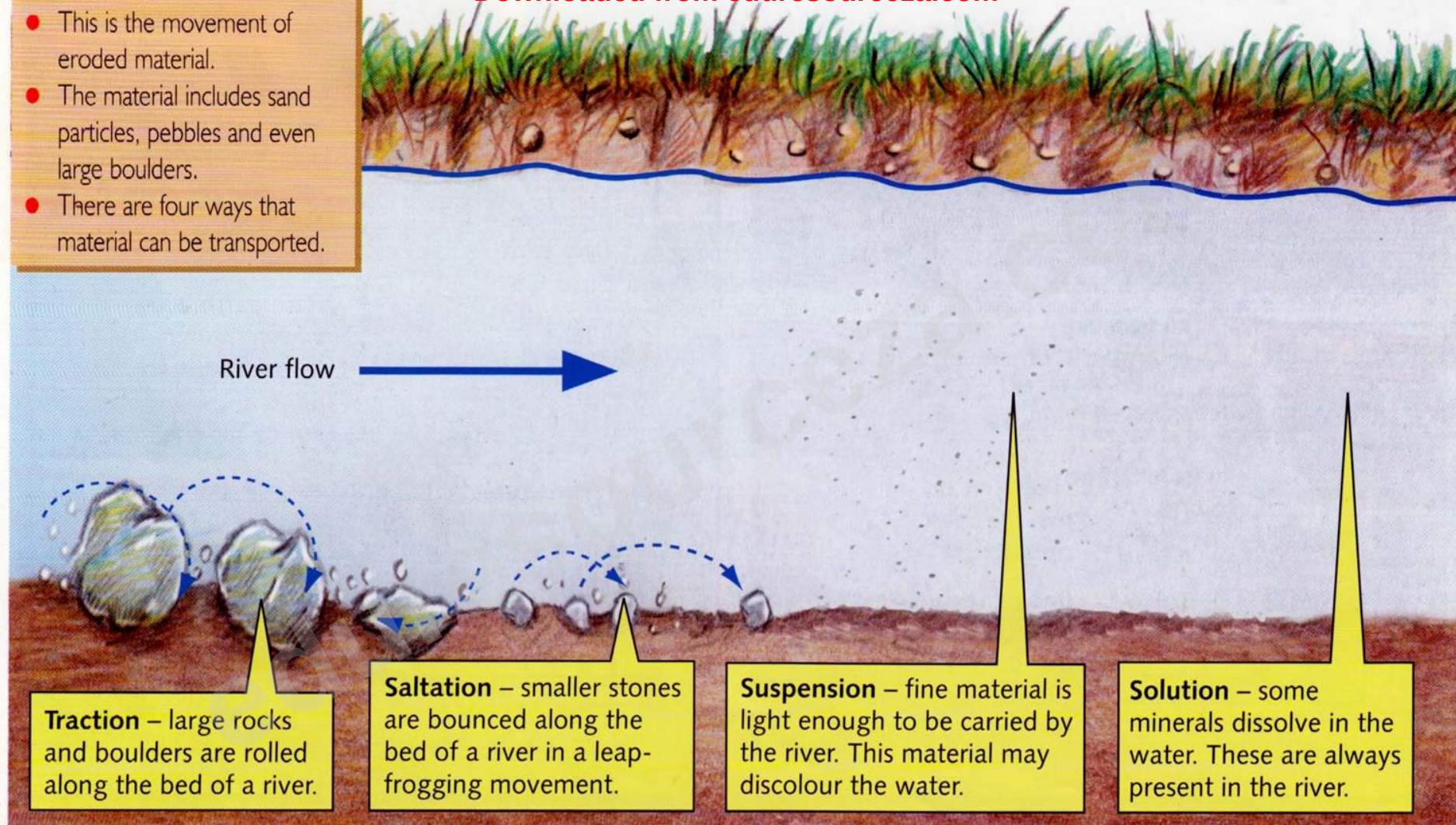
- This is the wearing away of the land.
- Most erosion occurs when a river is in flood. This is when it flows fastest and can carry huge amounts of material.
- There are four main types of erosion.

CORROSION is a form of chemical erosion. The banks and bed of the river are dissolved by acids in the water.

HYDRAULIC ACTION is the force of water hitting the banks of the river. It wears them away and causes them to collapse.

TRANSPORTATION

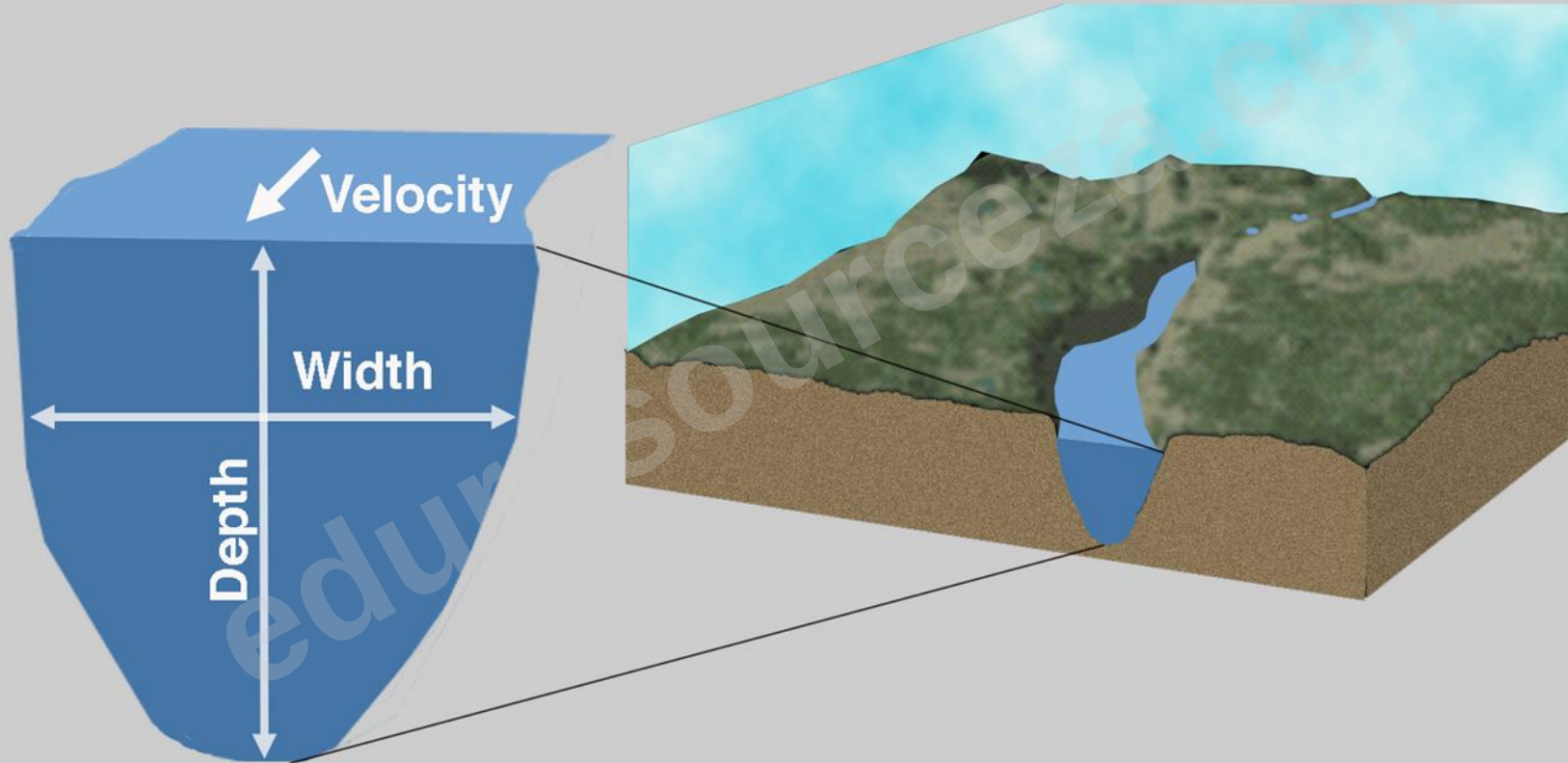
- This is the movement of eroded material.
- The material includes sand particles, pebbles and even large boulders.
- There are four ways that material can be transported.



Discharge of a river

- = the amount of water flowing in a river channel past a point in a given time
- Measured in **cumecs** = cubic meters per second
- Discharge figures are recorded on a storm **hydrograph** – they show the discharge pattern of a river
- The **way** the water flows, the **speed** at which the water flows & the **volume** of water flowing influence the discharge of a river system

$$\text{Discharge (m}^3\text{/s)} = (\text{width} \times \text{depth}) \times \text{velocity}$$



Freshwater 418,000 km³

Rivers 1,200 km³

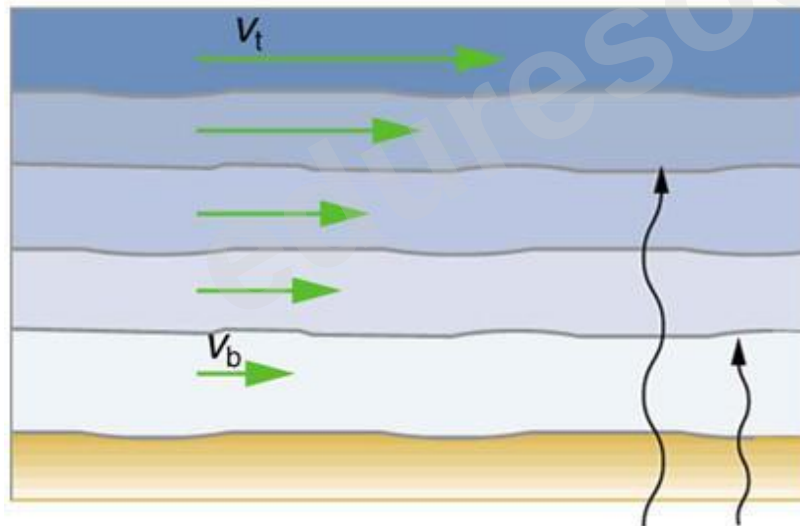
Major Rivers of the World

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

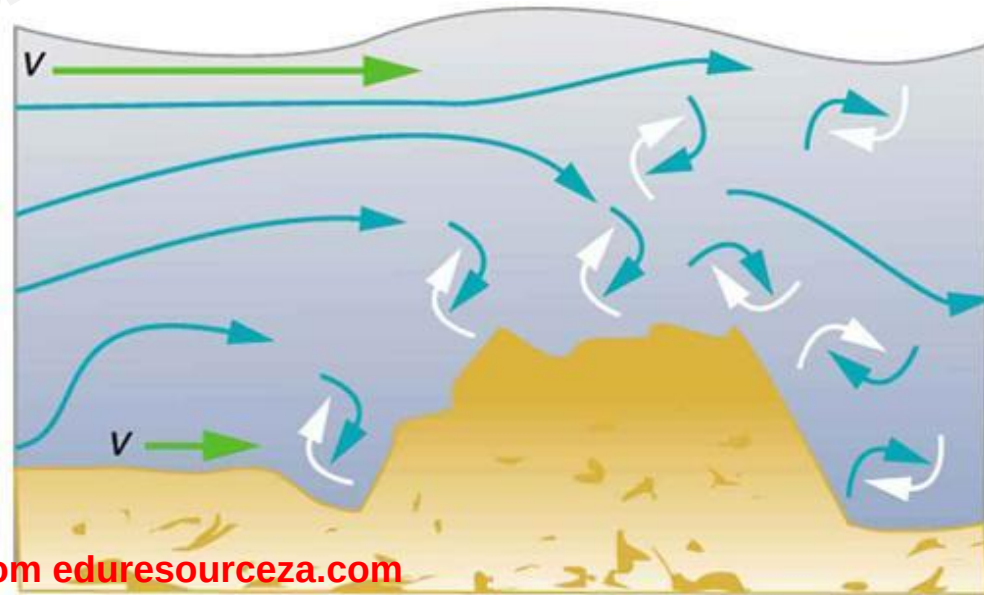
Laminar & turbulent flow

- **Laminar flow** = water flowing over a smooth surface, with little friction; flow speeds may be high; water flows in sheets & does not change levels
- **Turbulent flow** = water flowing in a bubbling motion; uneven river bed; water changes levels; internal friction; flow speed is reduced



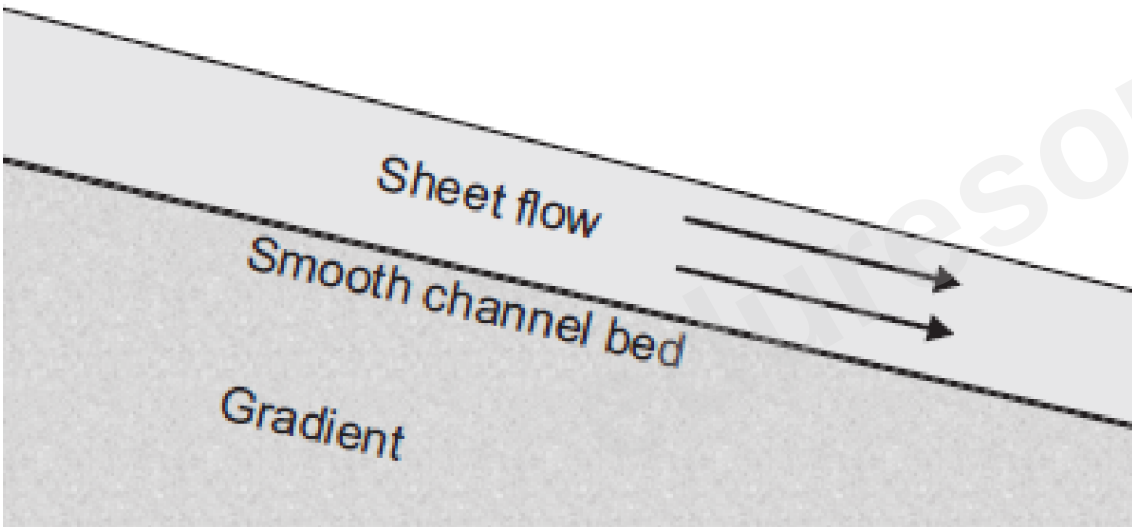
Friction between layers

(a)

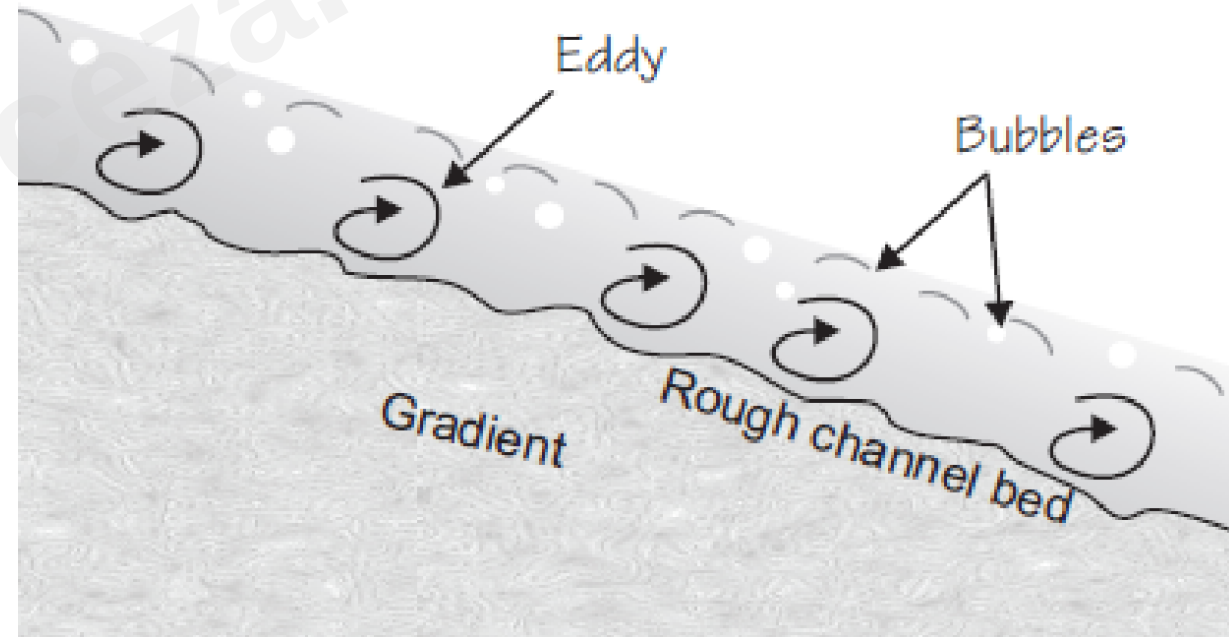


(b)

Laminar flow



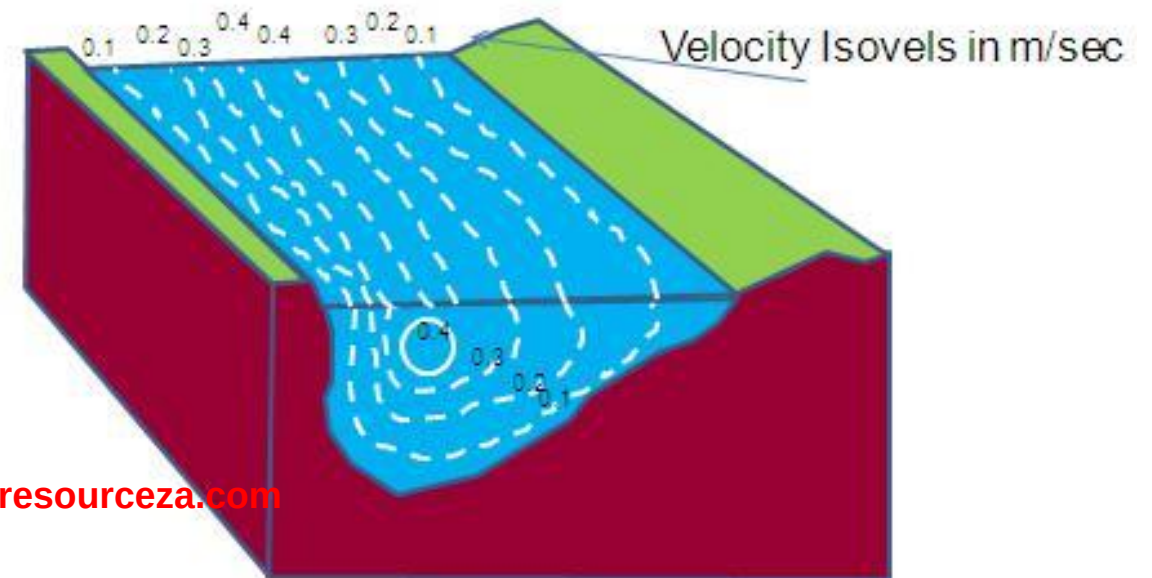
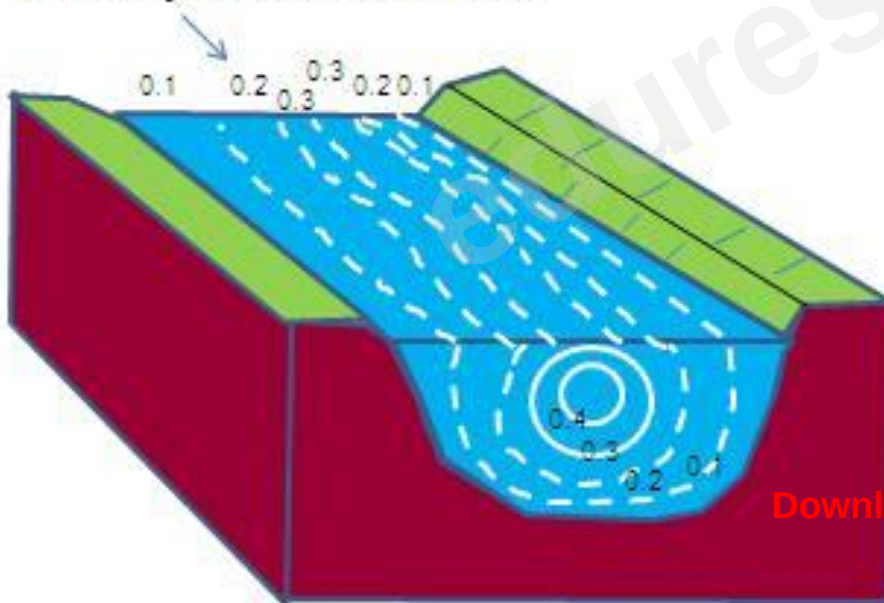
Turbulent flow



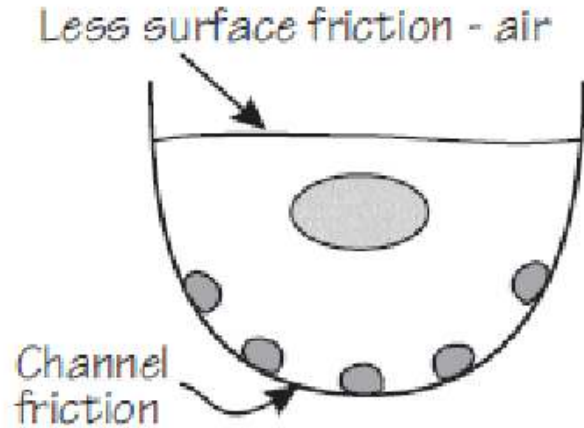
Flow speeds in a river channel

- The highest flow speeds in a straight river with a symmetrical channel are in the middle of the body of water just below the surface
- In a meandering river, flow speeds are highest towards the outer bank

Velocity Isovels in m/sec



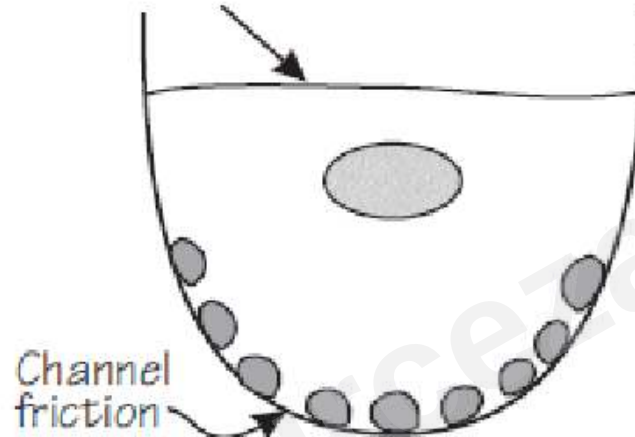
Narrow channel



- Less surface friction - air.
- Less channel friction - rough surface.
- Small volume of water.
- Slow moving water body.

Deep channel

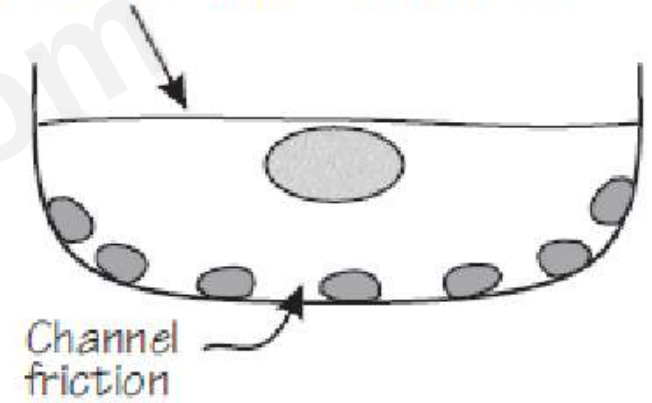
More surface friction - air



- More surface friction - air.
- Deeper channel increased channel friction.
- Large volume of water.
- Faster moving water.

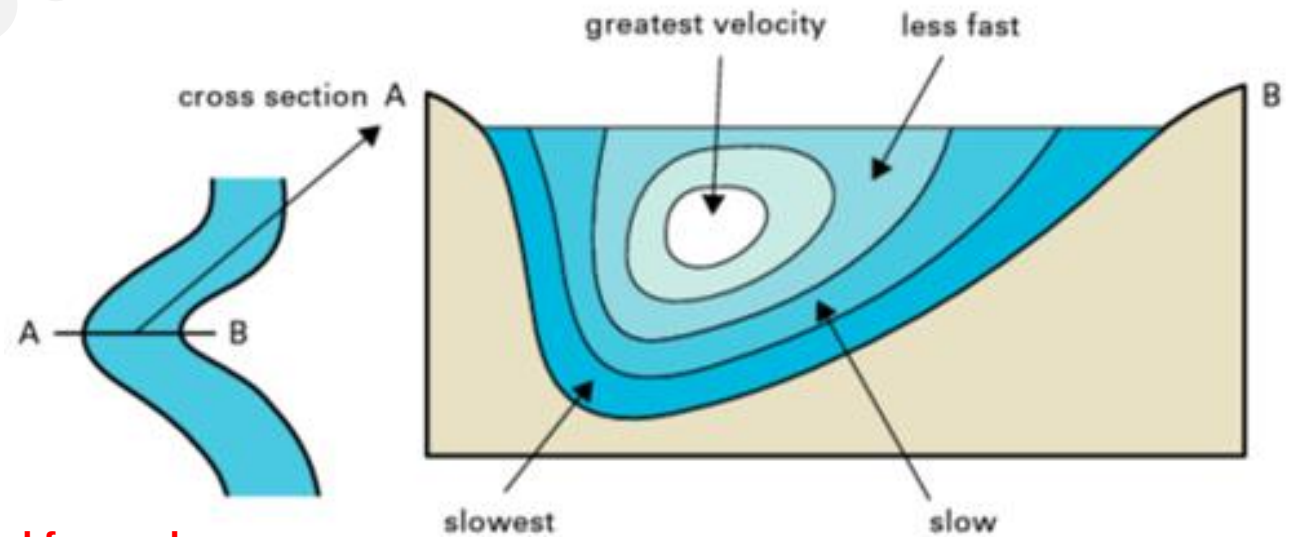
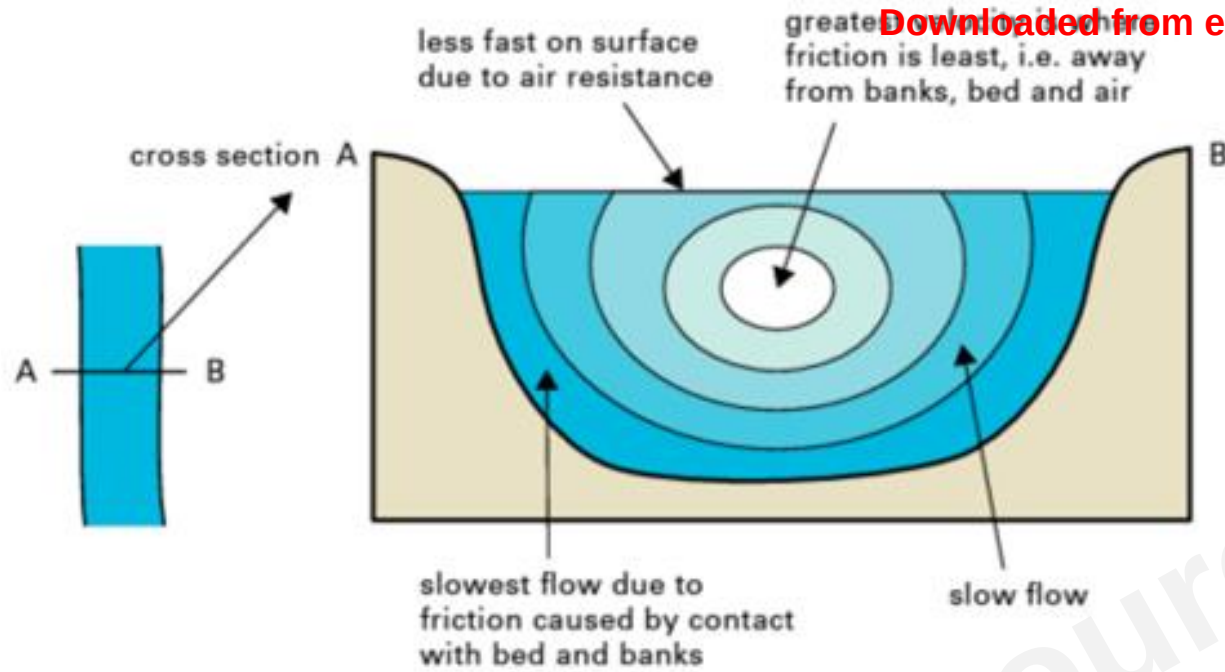
Wide, shallow channel

Greatest surface friction - air



- Greatest surface and channel friction.
- Broad, shallow channel creates greater friction.
- Fairly slow moving water.

 = area of fastest flowing water



Class & prep work

- Activity 10 p 139

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Flood hydrograph

Lag time:
Period of time between maximum precipitation and the peak flow.

Peak flow or flood peak:
When the river reaches its highest level (maximum amount of water).

Key:

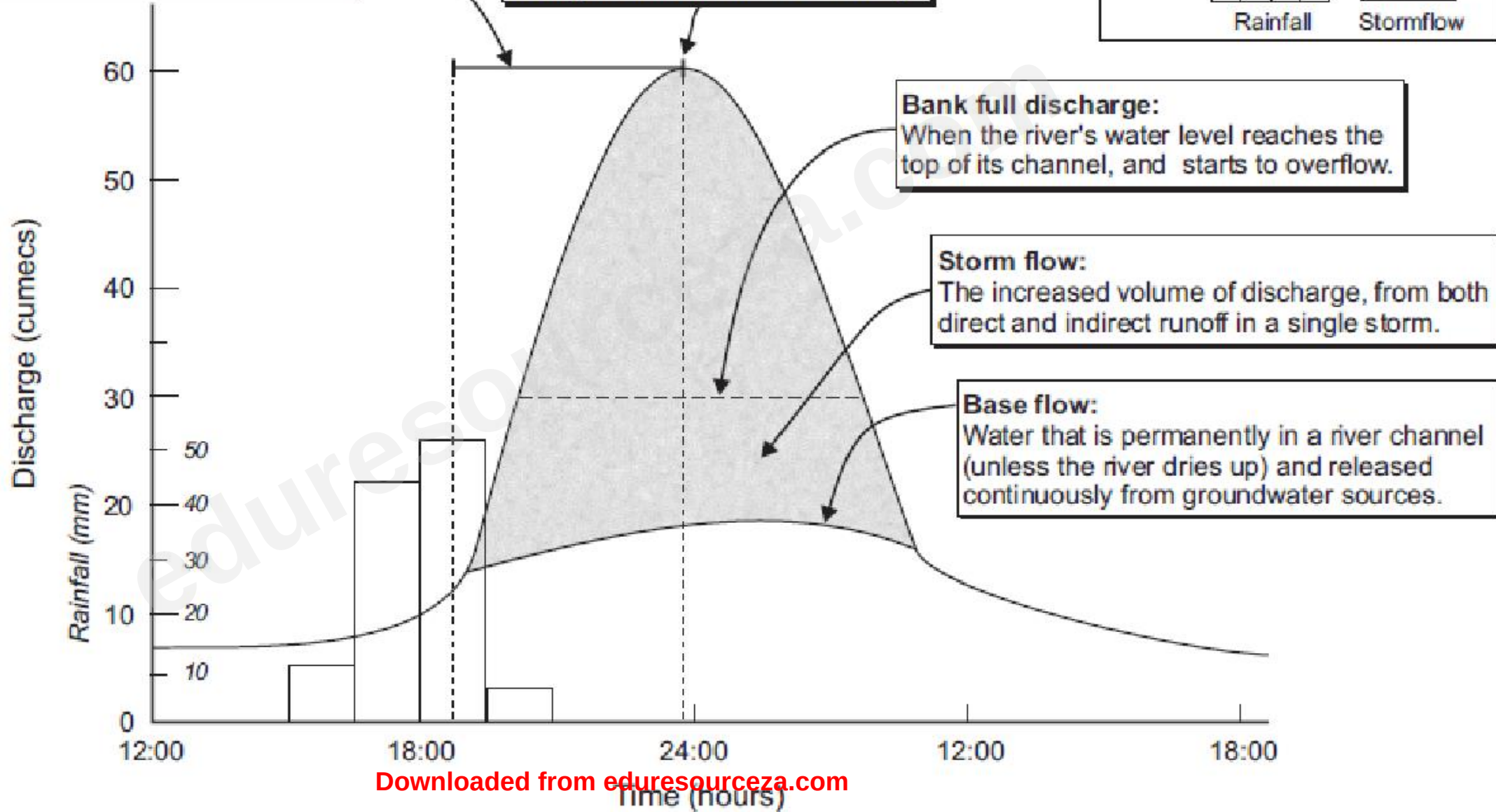
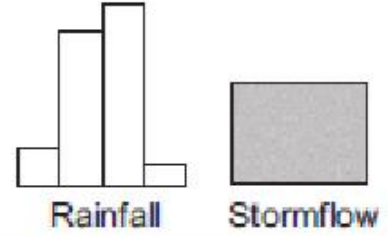
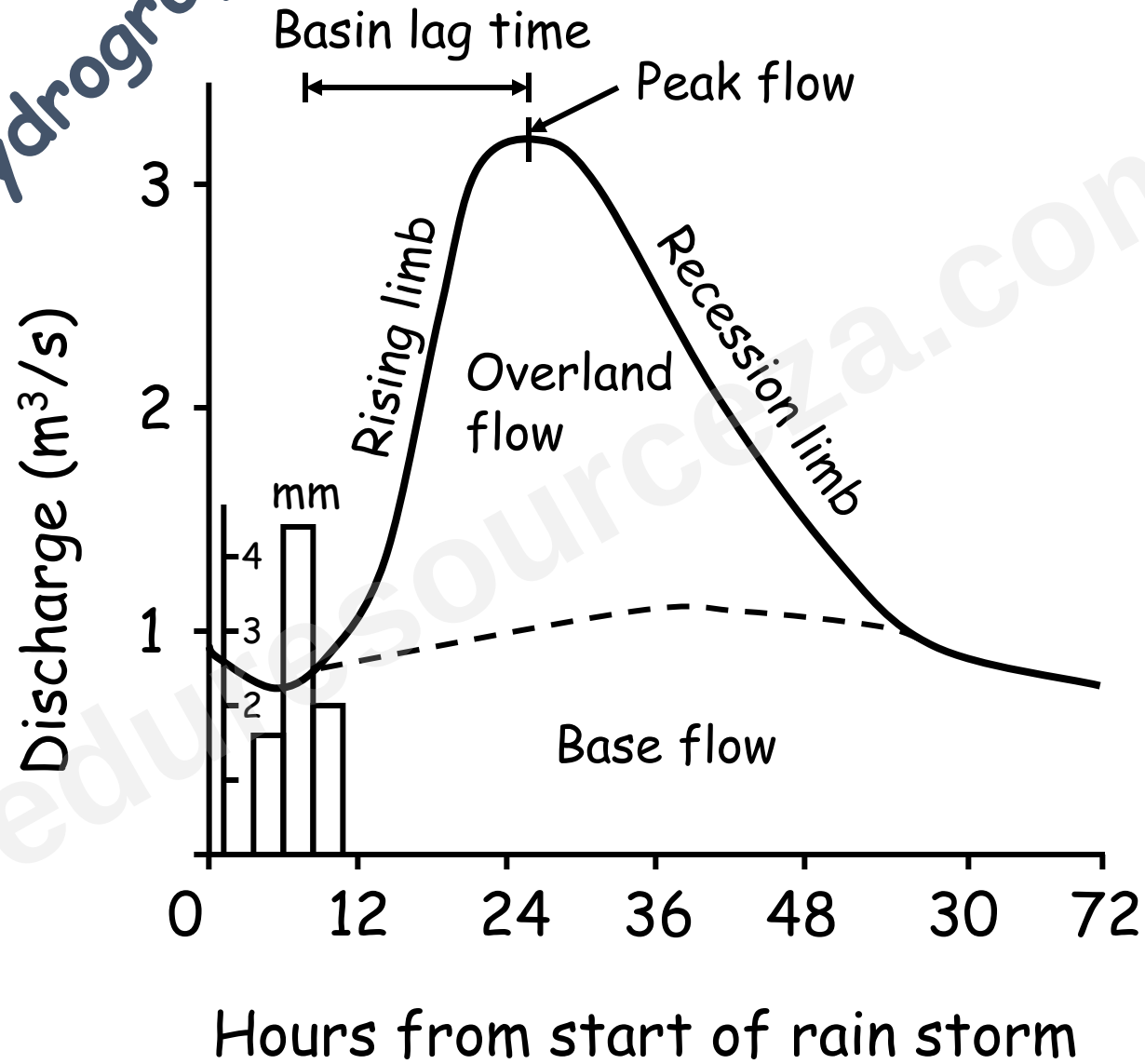


Diagram of storm hydrograph

Flood Hydrograph

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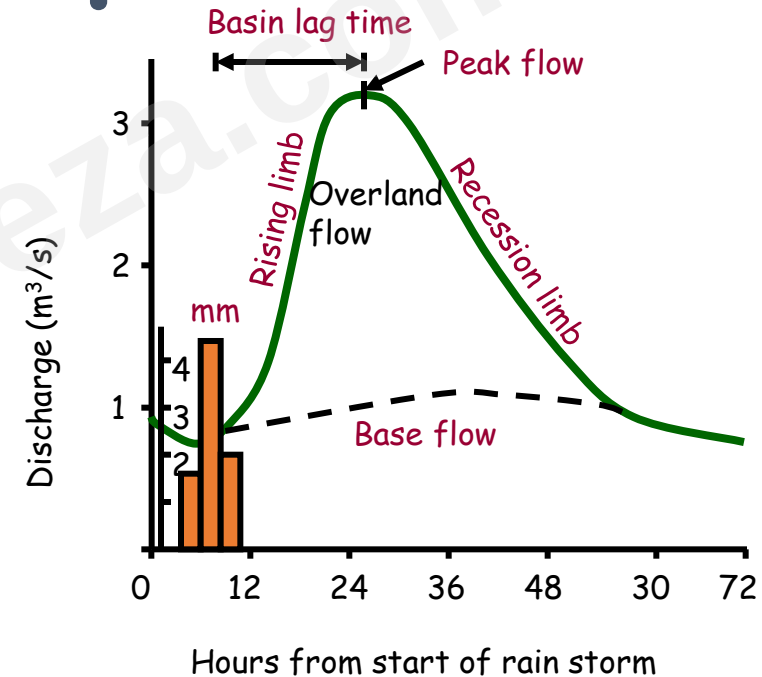


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Interpretation of Storm Hydrographs

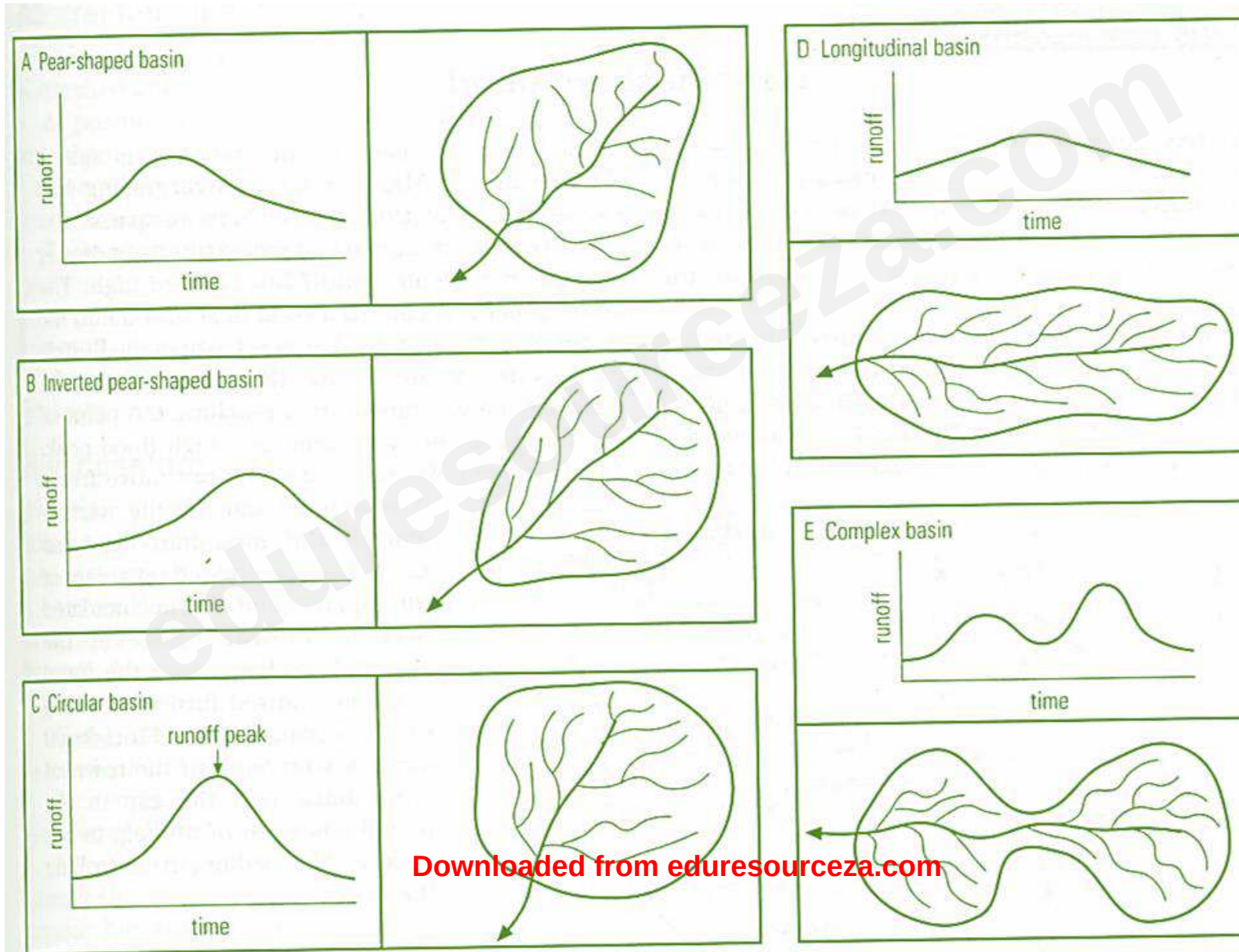
You need to refer to:

- Rising Limb
- Recession Limb
- Lag time
- Rainfall Intensity
- Peak flow compared to Base flow
- Recovery rate, back to Base flow

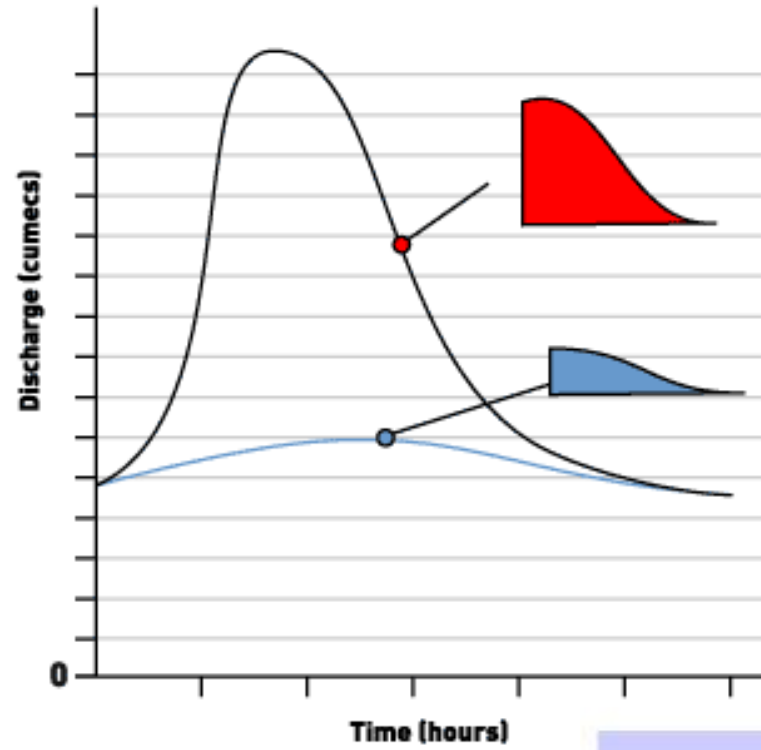


Shape of Drainage Basins & Discharge

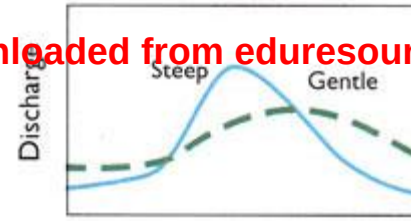
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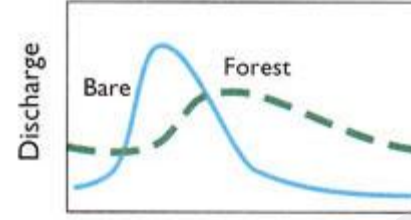
Influence of steepness



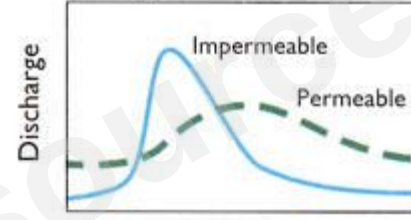
Valley side steepness



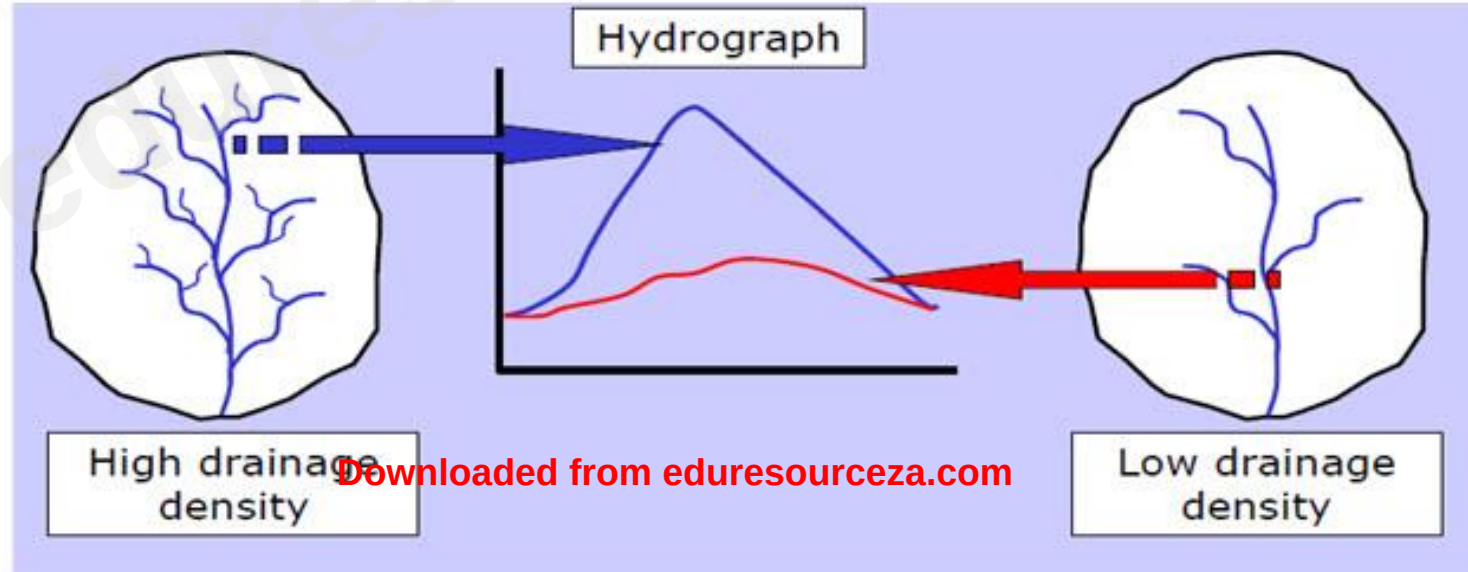
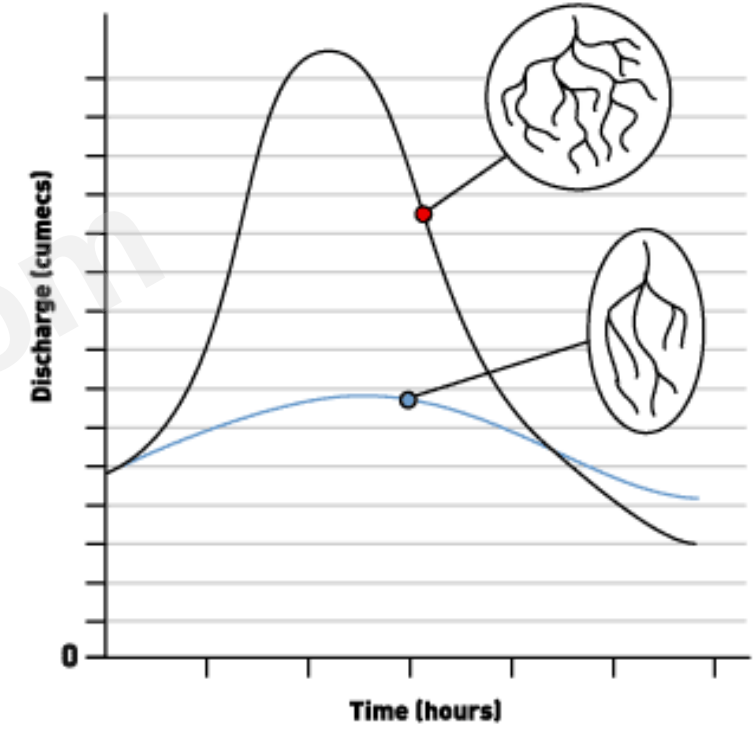
Vegetation

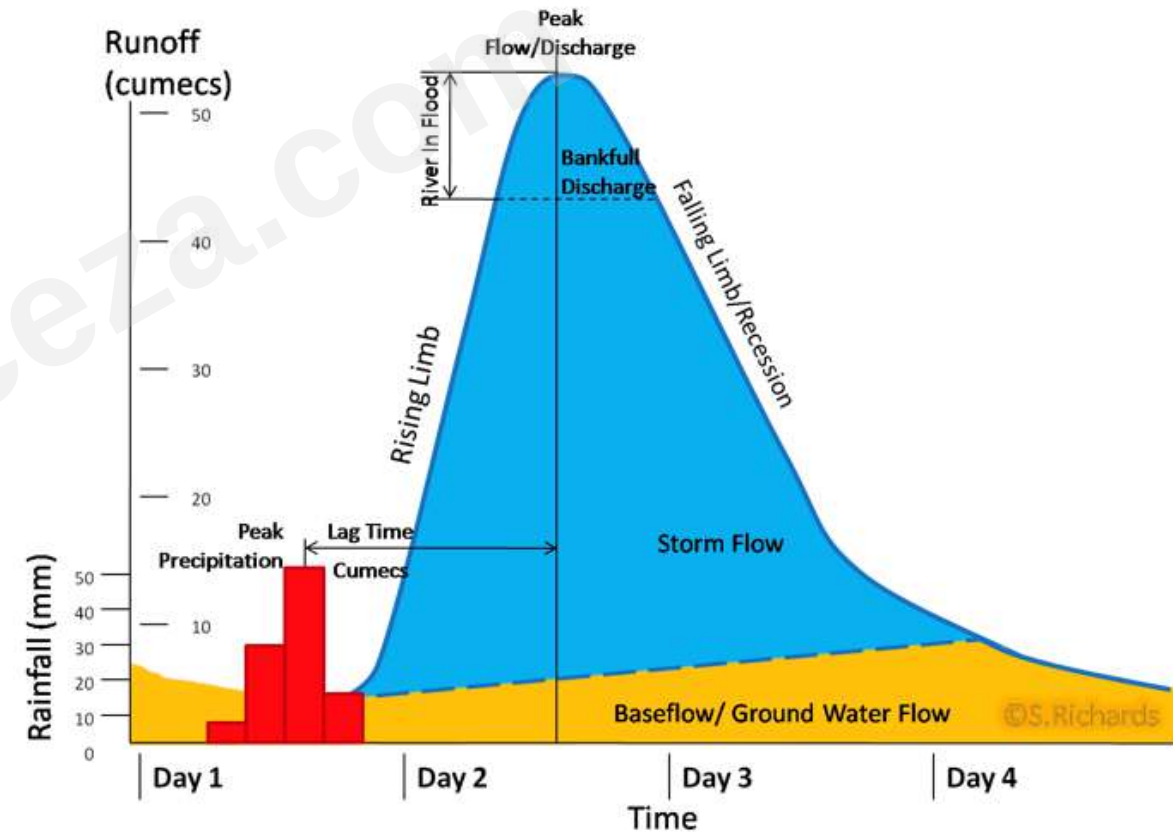
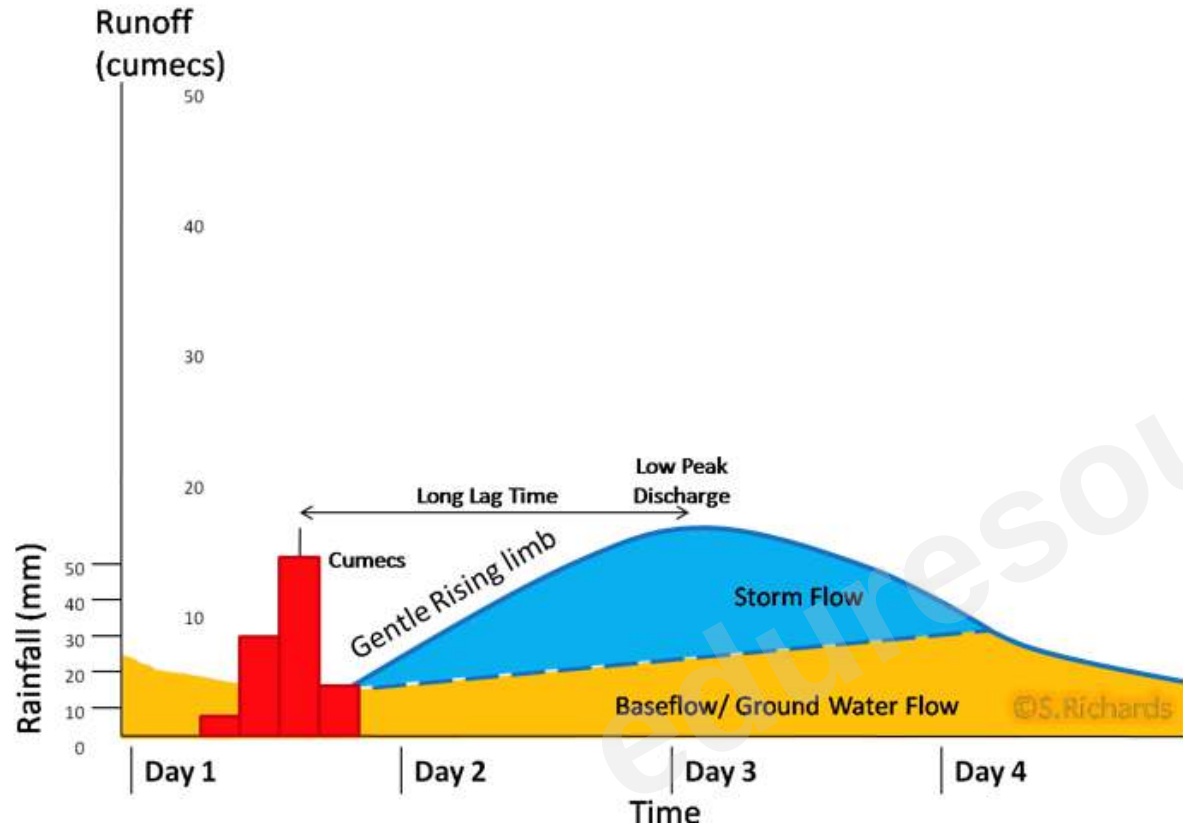


Soil type



Influence of basin shape





Factors influencing storm hydrographs

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Area

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- Large basins receive more precipitation than small therefore have a larger amount of **runoff**
- Larger size means longer **lag time** as water has a longer distance to travel to reach the trunk of the river

Area	Rock Type	Drainage Density
Shape	Soil	Precipitation / Temp
Slope	Land Use	Tidal Conditions

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Shape

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- . Elongated basin will produce a lower **peak flow** & longer **lag time** than a circular one of the same size

Area	Rock Type	Drainage Density
Shape	Soil	Precipitation / Temp
Slope	Land Use	Tidal Conditions

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Slope

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- . Channel flow can be faster down a steep slope therefore steeper **rising limb** & shorter **lag time**

Area	Rock Type	Drainage Density
Shape	Soil	Precipitation / Temp
Slope	Land Use	Tidal Conditions

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Rock Type

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. Permeable rocks mean rapid infiltration & little overland flow therefore shallow **rising limb**

Area	Rock Type	Drainage Density
Shape	Soil	Precipitation / Temp
Slope	Land Use	Tidal Conditions

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Soil

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- . Infiltration is generally greater on thick soil, although less porous soils eg. clay act as impermeable layers
- . The more infiltration occurs, the longer the **lag time** & the shallower the **rising limb**

Area	Rock Type	Drainage Density
Shape	Soil	Precipitation / Temp
Slope	Land Use	Tidal Conditions

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Land Use

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- . Urbanisation - concrete & tarmac form impermeable surfaces, creating a steep **rising limb** & shortening the **time lag**
- . Afforestation - intercepts the precipitation, creating a shallow **rising limb** & lengthening the **time lag**

Area	Rock Type	Drainage Density
Shape	Soil	Precipitation / Temp
Slope	Land Use	Tidal Conditions

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Drainage Density

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- A higher density will allow rapid **overland flow**

Area	Rock Type	Drainage Density
Shape	Soil	Precipitation / Temp
Slope	Land Use	Tidal Conditions

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Precipitation & Temperature

- . Short intense rainstorms can produce rapid **overland flow** & a steep **rising limb**
- . If there have been extreme temperatures, the ground can be hard (either baked or frozen) causing rapid **surface run off**
- . Snow on the ground can act as a store producing a long **lag time** & shallow **rising limb**. Once a thaw sets in the **rising limb** will become steep

Area	Rock Type	Drainage Density
Shape	Soil	Precipitation / Temp
Slope	Land Use	Tidal Conditions

Tidal Conditions

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- High spring tides can block the normal exit for water from a river, therefore extending the length of time the river basin takes to return to normal **base flow**

Area	Rock Type	Drainage Density
Shape	Soil	Precipitation / Temp
Slope	Land Use	Tidal Conditions

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Remember!

These influencing factors will:

- Influence each other
- Change throughout the rivers course



Overland flow

Volume of
water reaching
the river from
surface run off

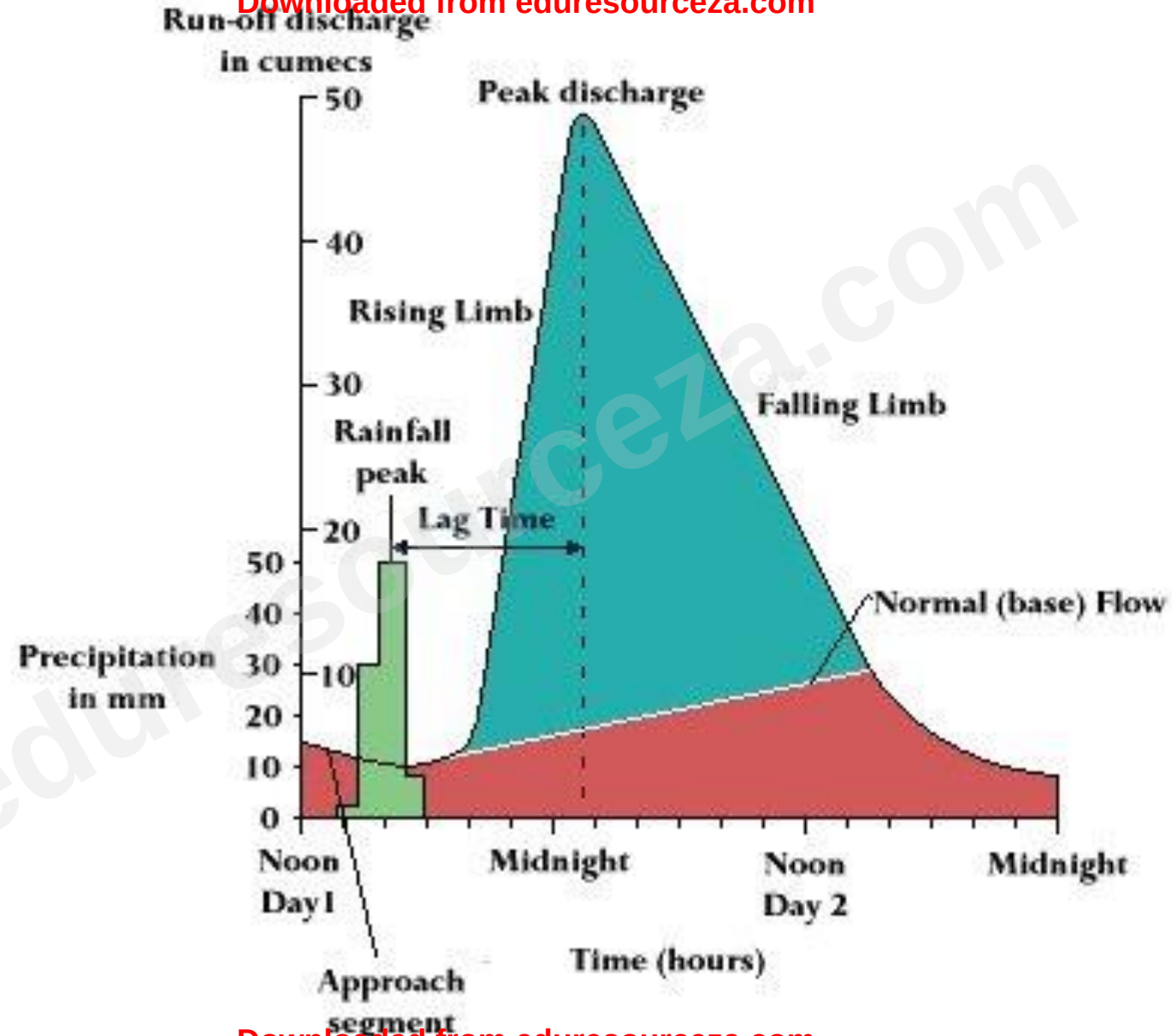
Through flow

Volume of water
reaching the river
through the soil and
underlying rock
layers

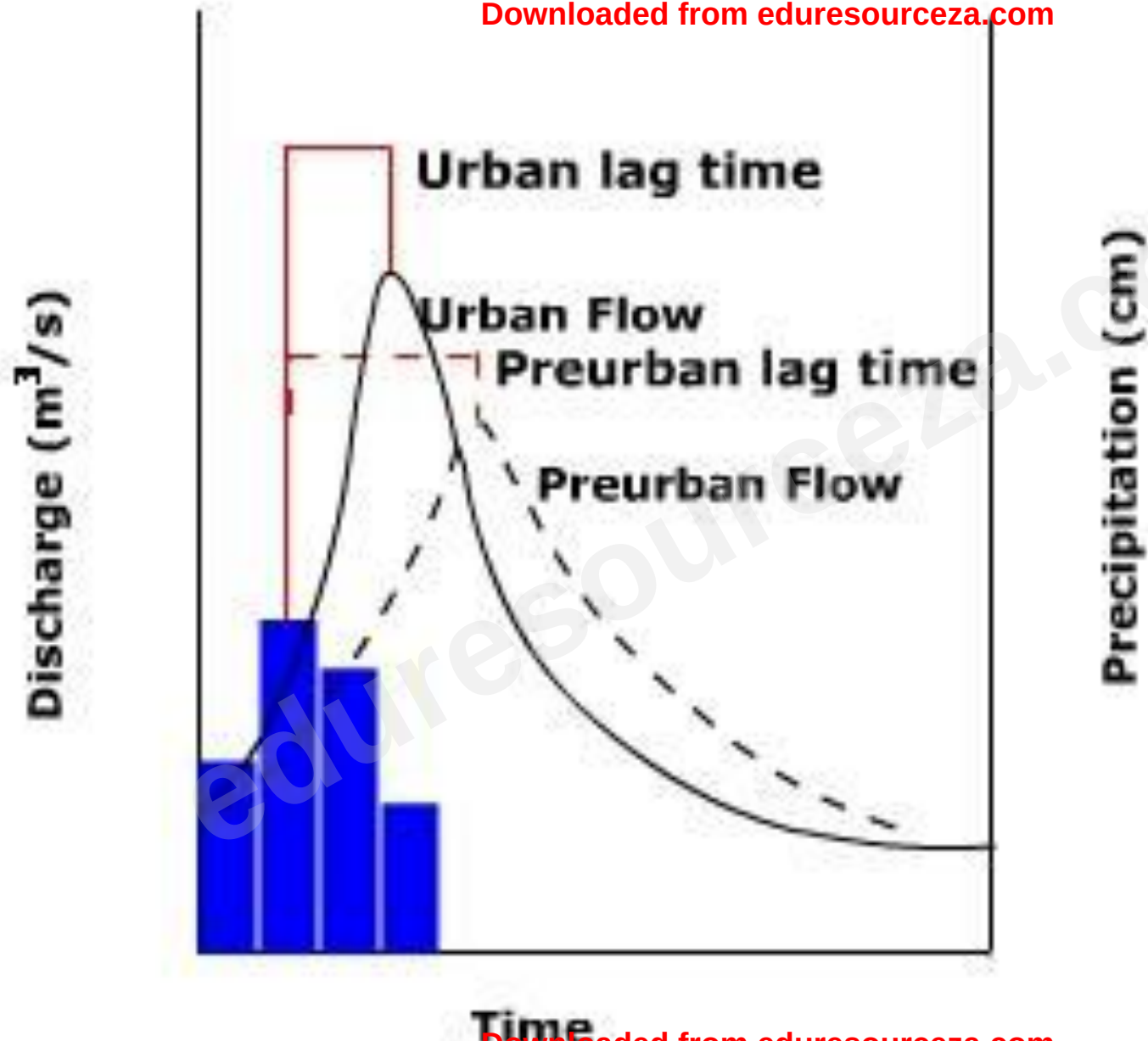


A flood hydrograph

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Value of Flow Hydrographs

- Agricultural land management
- Urban water management e.g. storm water
- Domestic / industrial use
- Flood precautions e.g. settlement planning
- Water resources protection
- Water infrastructure
- Sewerage farms

Value of Flow Hydrographs

- Public use of dams and rivers
- Water quality management
- Groundwater levels
- Impact of exotic flora on water levels e.g. Jacaranda trees
- Protect environmentally sensitive areas e.g. Sterkfontein caves
- Tourism

Fluvial processes

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Friction

- $\uparrow$ volume = $\downarrow$ friction
- Deeper, narrow channel has less friction per volume than a shallower, wide channel
- Rough, uneven channel has more friction (larger surface area in contact with ground)
- Efficient river = a river able to overcome friction & flow



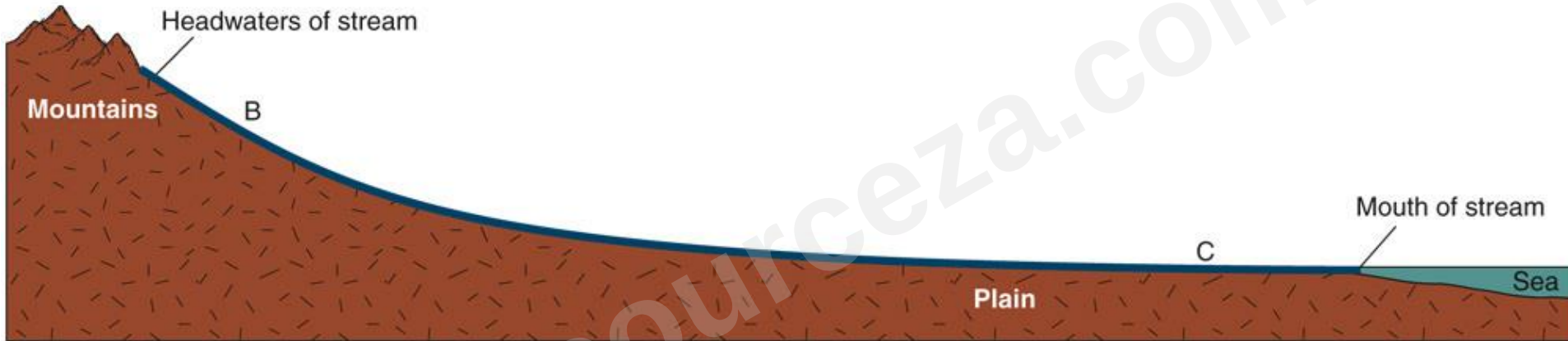
Energy of a river

- Gradient provides potential energy for a river
- $\uparrow$ slope elevation = $\uparrow$ PE
- Graded river = river in equilibrium with a concave longitudinal profile (no active erosion or deposition)
- Overgraded river = river with excess energy – will erode their channels
- Undergraded river = river that does not have enough energy to transport its load

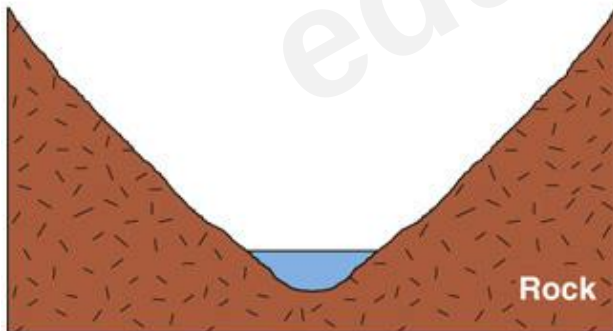
Fluvial processes

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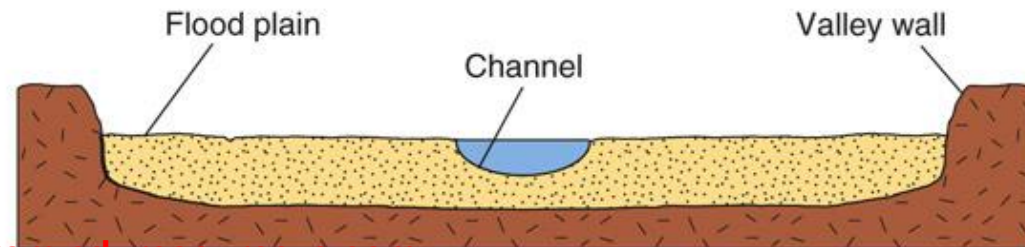
River profiles



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



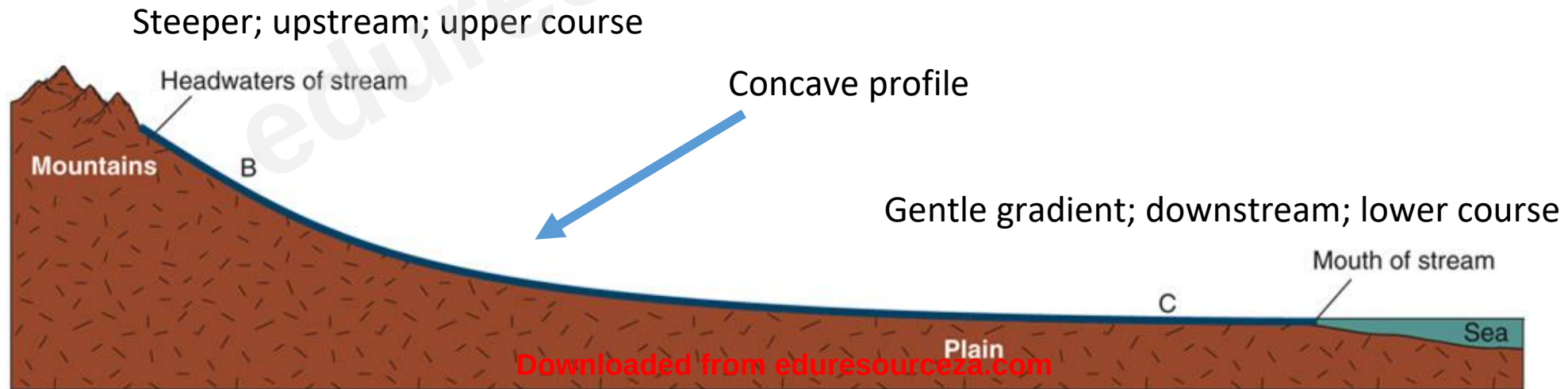
B Cross section of the stream at point B. The channel is at the bottom of a V-shaped valley cut into rock.



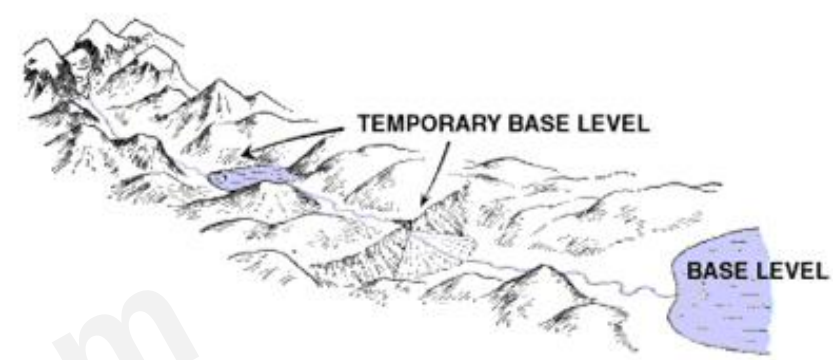
C Cross section at point C. The channel is surrounded by a broad flood plain of sediment.

Longitudinal profile of a river

- = a visual representation of the gradient down which the river flows from source to mouth
- In theory this profile is concave – not usually in reality

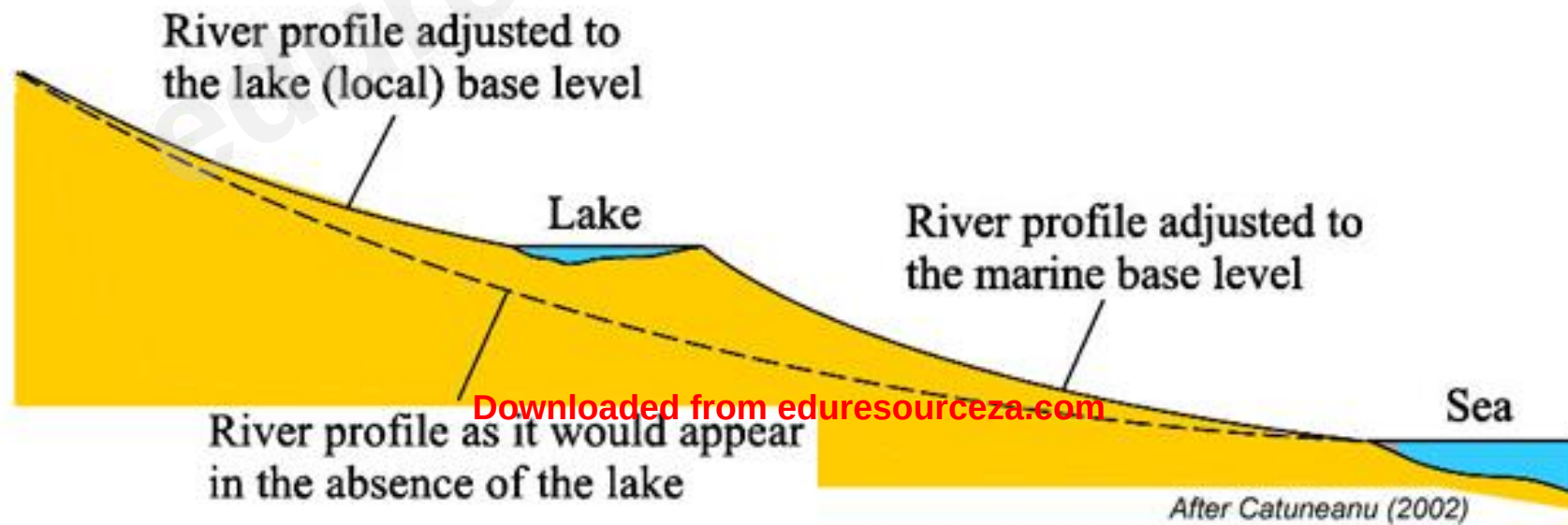


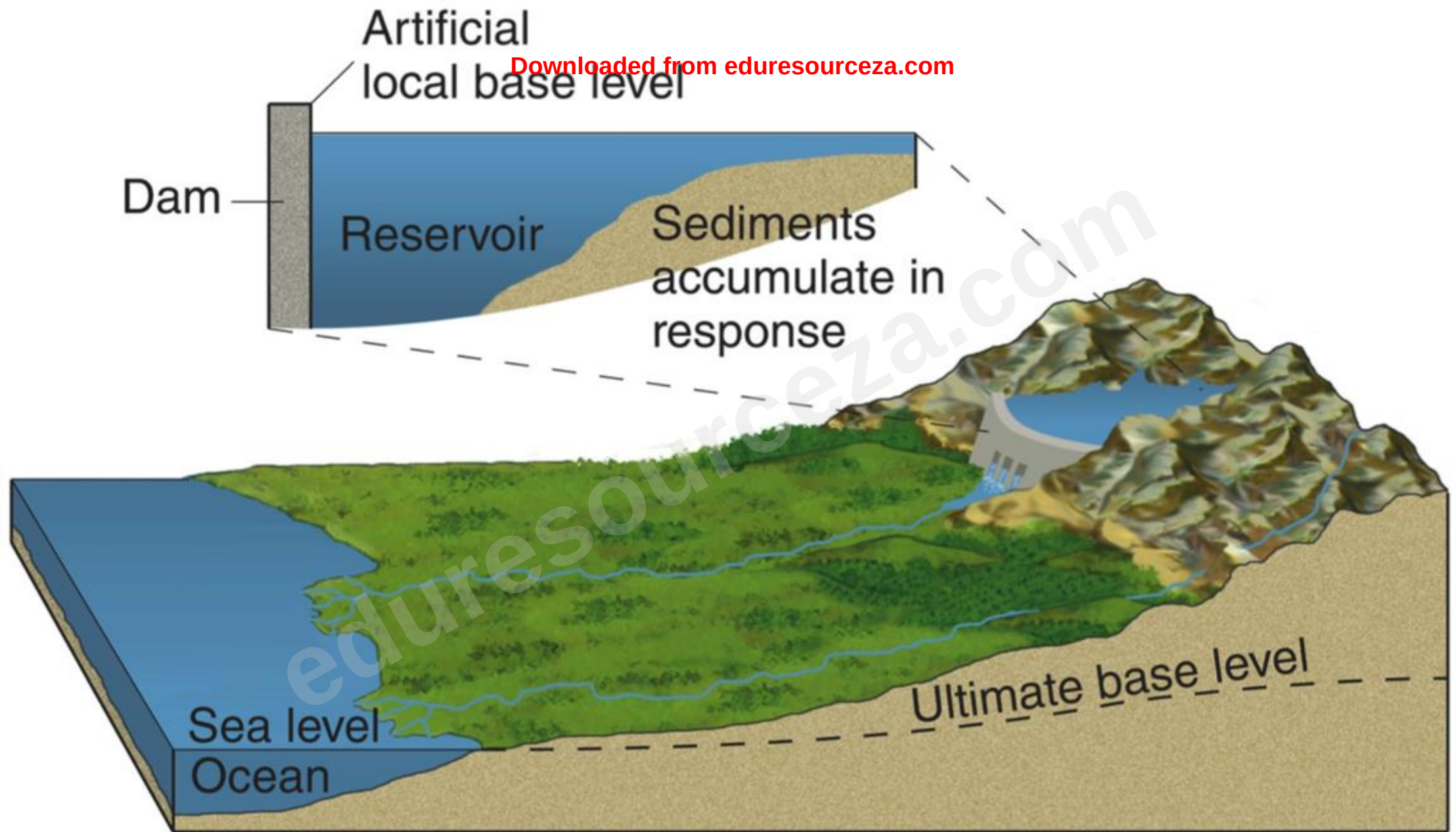
A Longitudinal profile (dark blue line) of a stream beginning in mountains and flowing across a plain into the sea.



Base levels

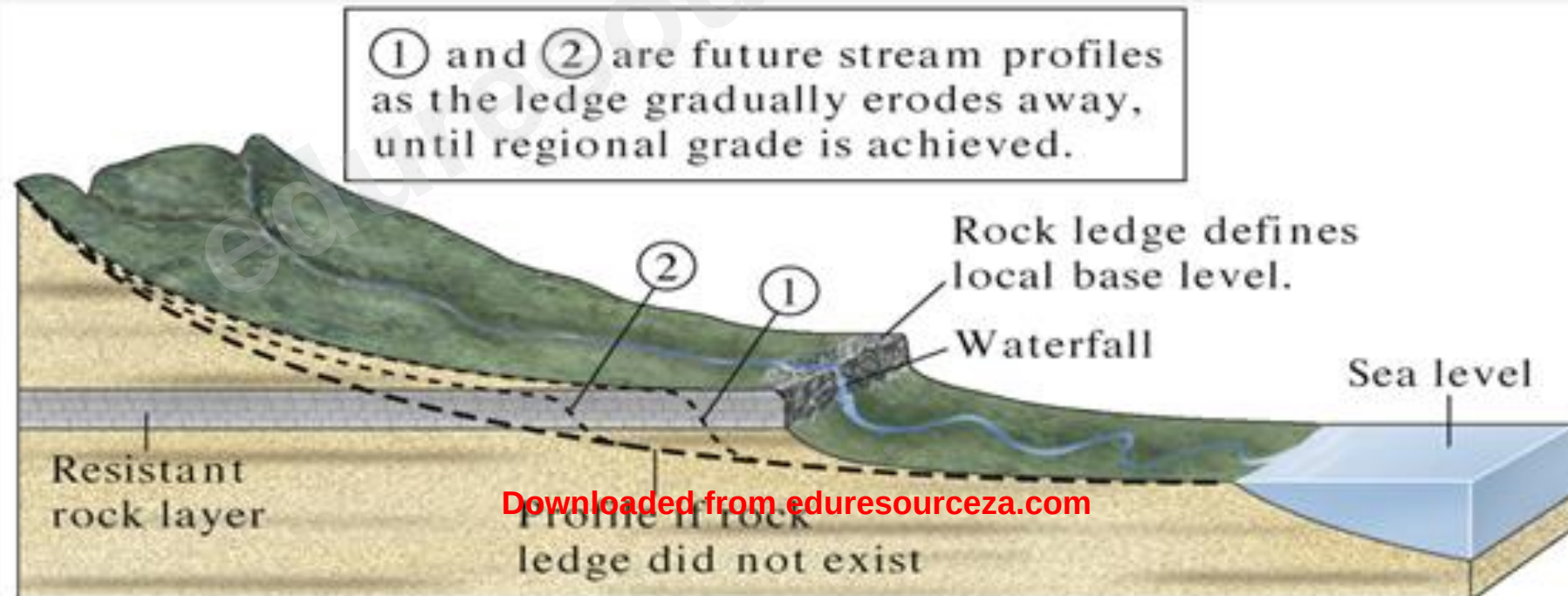
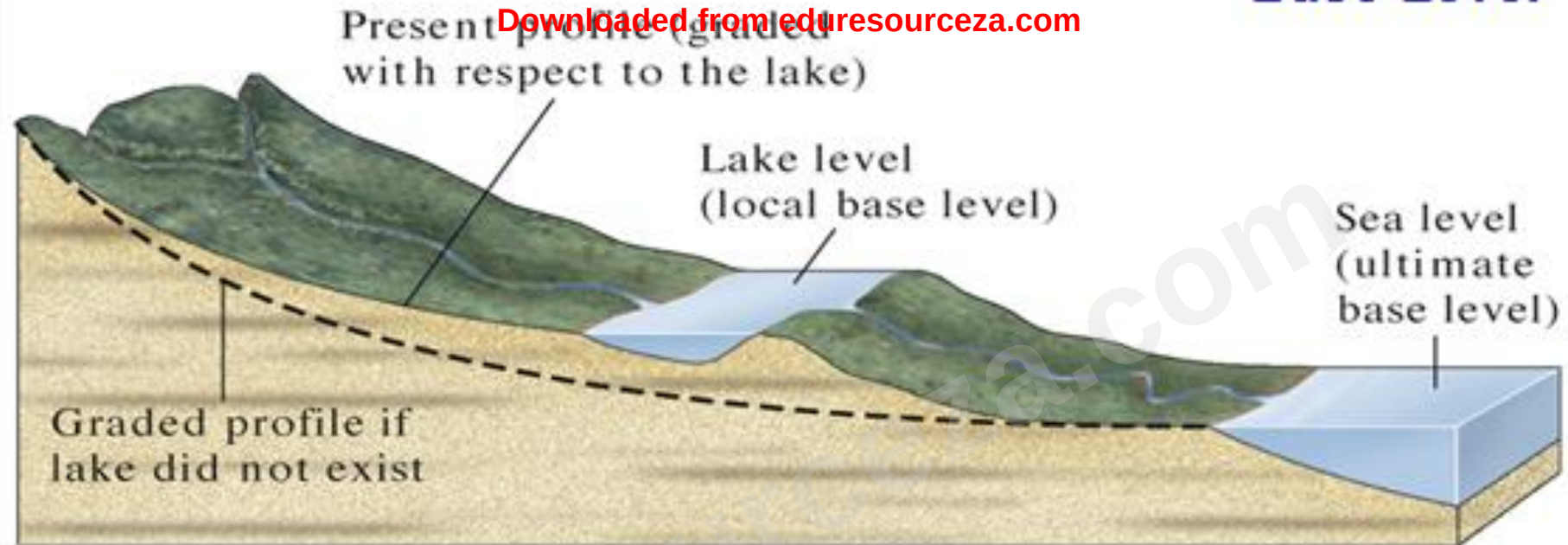
- **Temporary base levels** = changes in gradient along the course of a river due to **vertical** (downwards) erosion
- Rapids, waterfalls, lakes & dams are all temporary base levels
- **Permanent (ultimate) base level** = sea level – the lowest level to which a river will erode





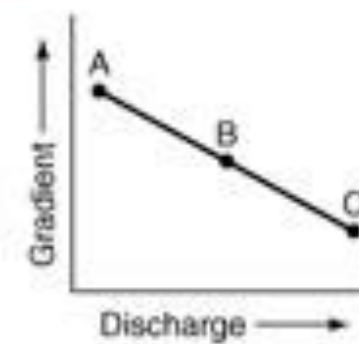
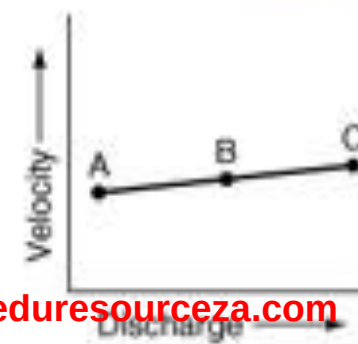
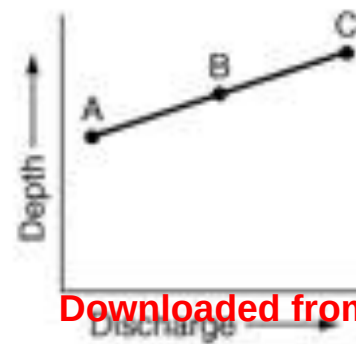
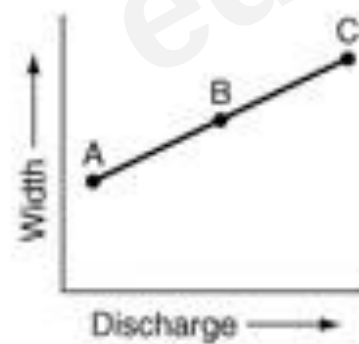
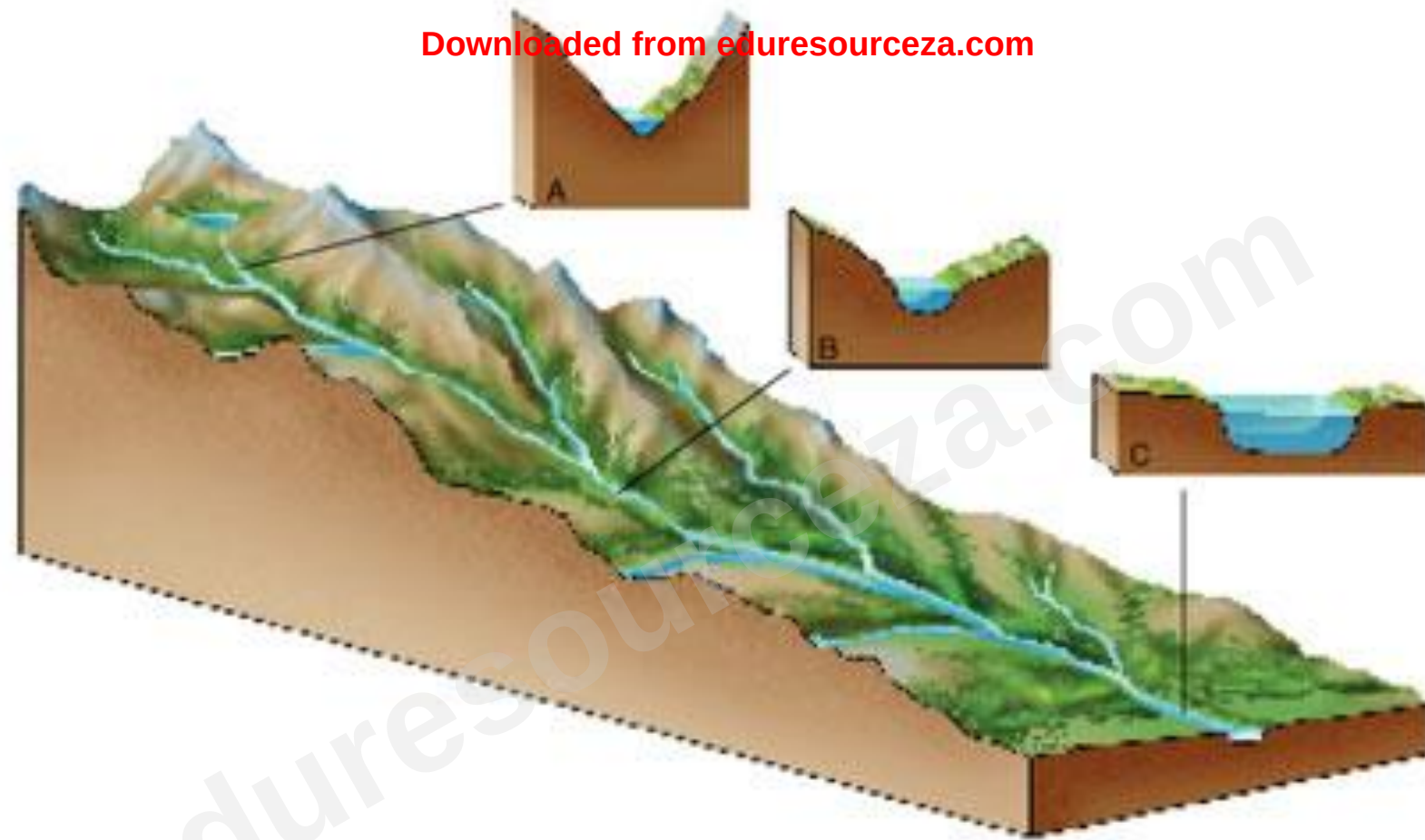
(a)

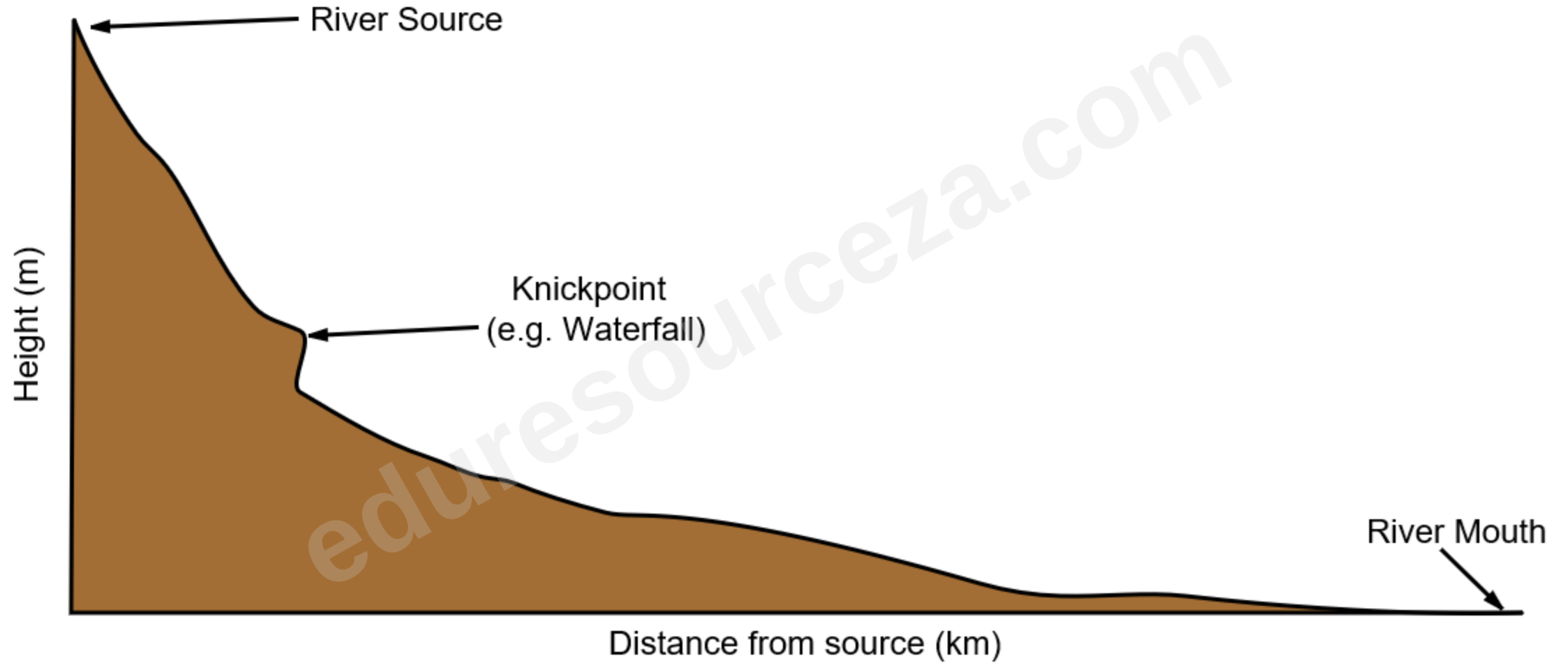
Base Level



Transverse profile

- = cross profile or cross section
- It is related to its gradient & longitudinal profile
- Steep gradient (upper course) = steep, deep, narrow, V-shaped
- Middle course = more opened V-shape
- Gradual gradient (lower course) = wide, shallow, open V-shape (U-shape)
- Upstream of a temporary base level (e.g. waterfall) the cross-profile is wider & more open as there is less vertical erosion
- Downstream of a temporary base level is a steep-sided gorge or ravine – high velocity & much vertical erosion





Class & prep work

- Activity 11 p 142

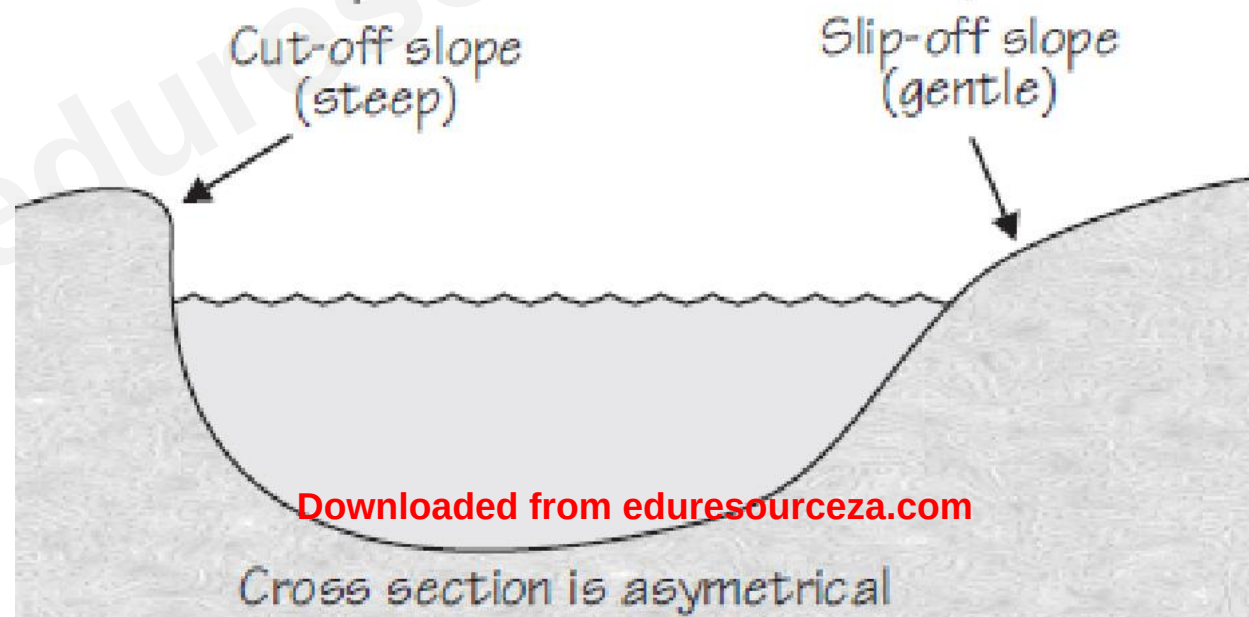
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Fluvial landforms – created by a river

- **Meanders** – bends in the river channel; they migrate laterally & downstream
- **Oxbow lakes** – erosion at the outer bend of the meander narrows the neck of land between meander loops; the river cuts through the narrow neck forming a straighter channel; water at the sides of the straighter channel flow slowly resulting in deposition; the old meander is blocked off
- **Floodplain** – flat valley floor; alluvium (fertile silt) is deposited
- **Natural levee** – raised banks of a river that form from deposition during flooding
- **Braided streams** – deposits of alluvium form islands in the middle of the channel, splitting the river into separate channels
- **Delta** – deposition near the mouth of a river; deposited material may build up & extend out into the sea; deposited material blocks the main channel resulting in distributaries

River meandering

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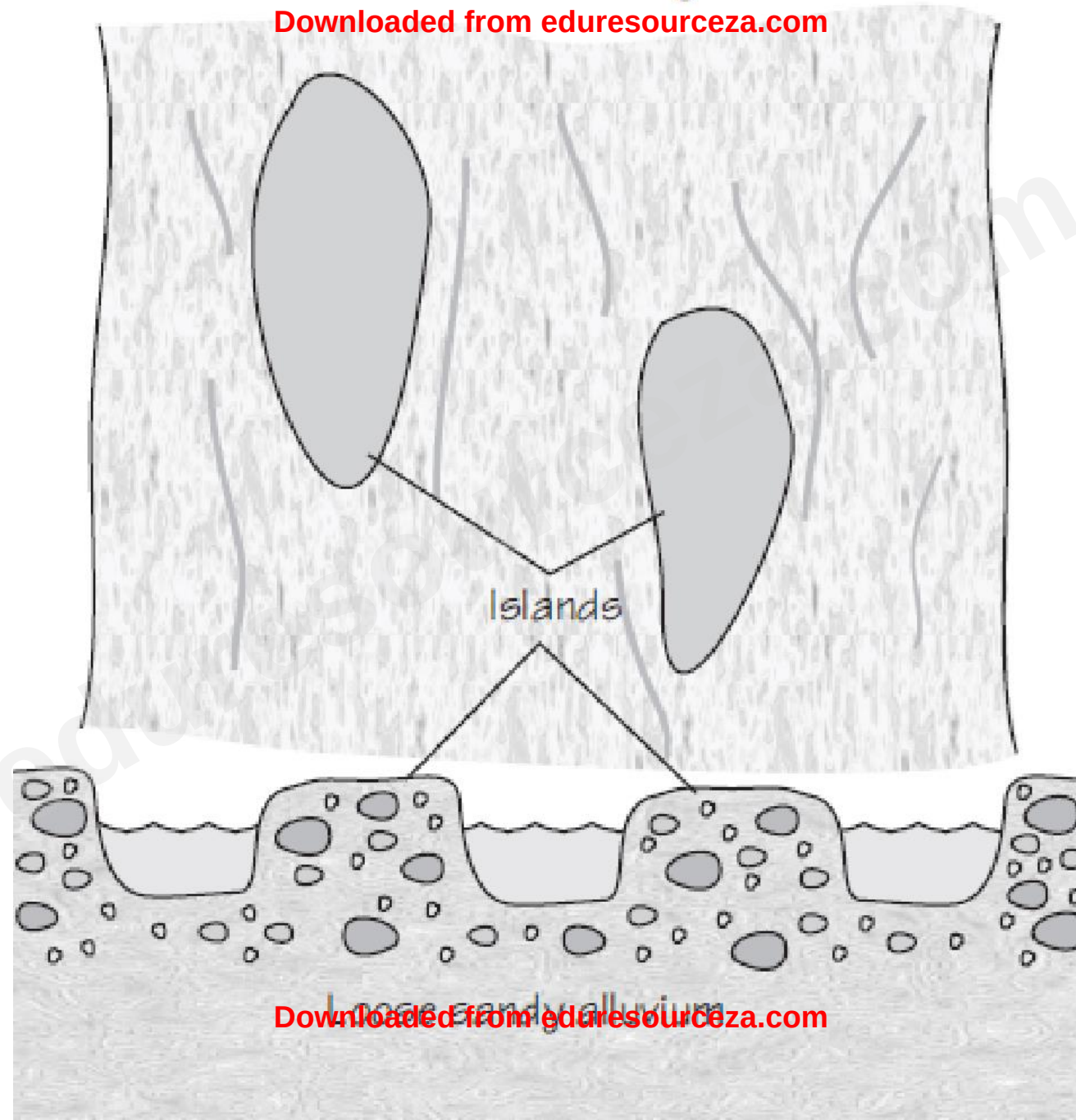


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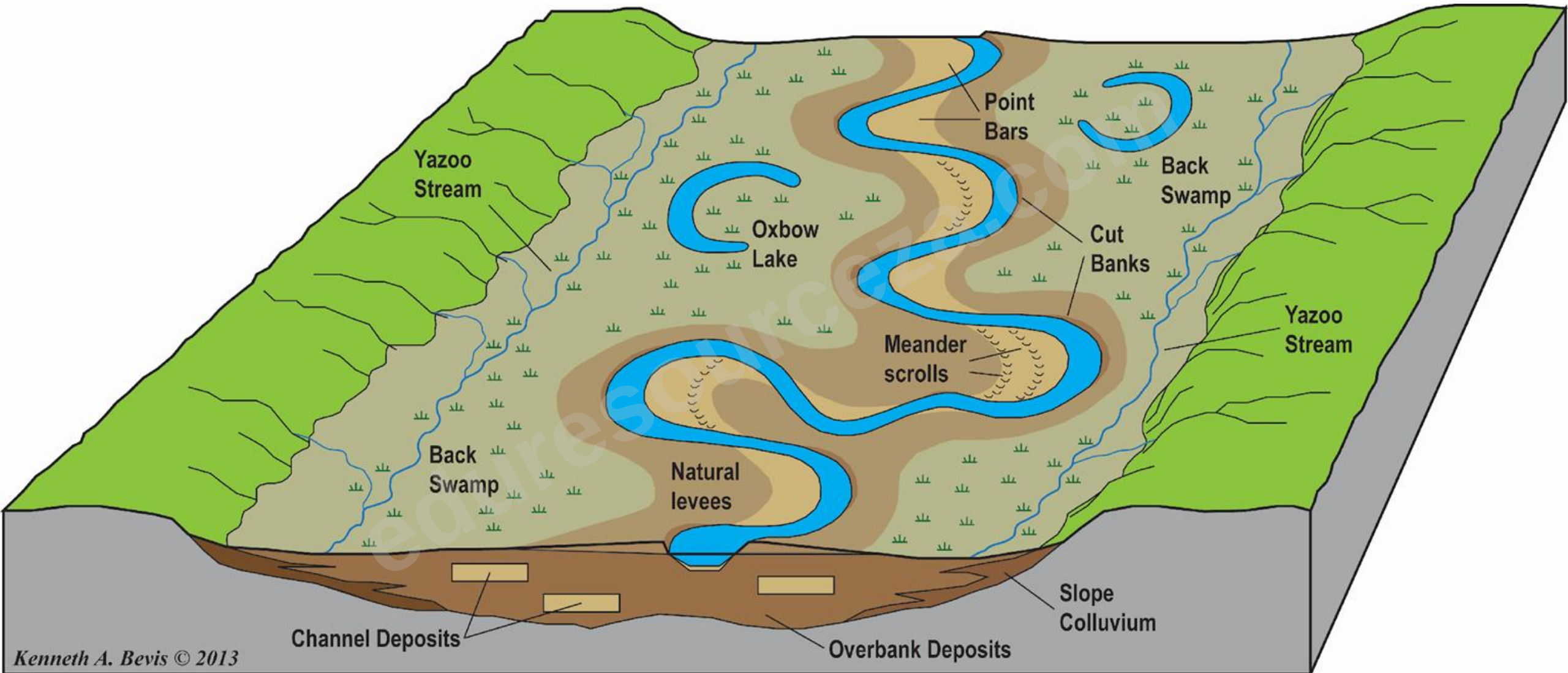
Cross section is asymmetrical

Stream braiding

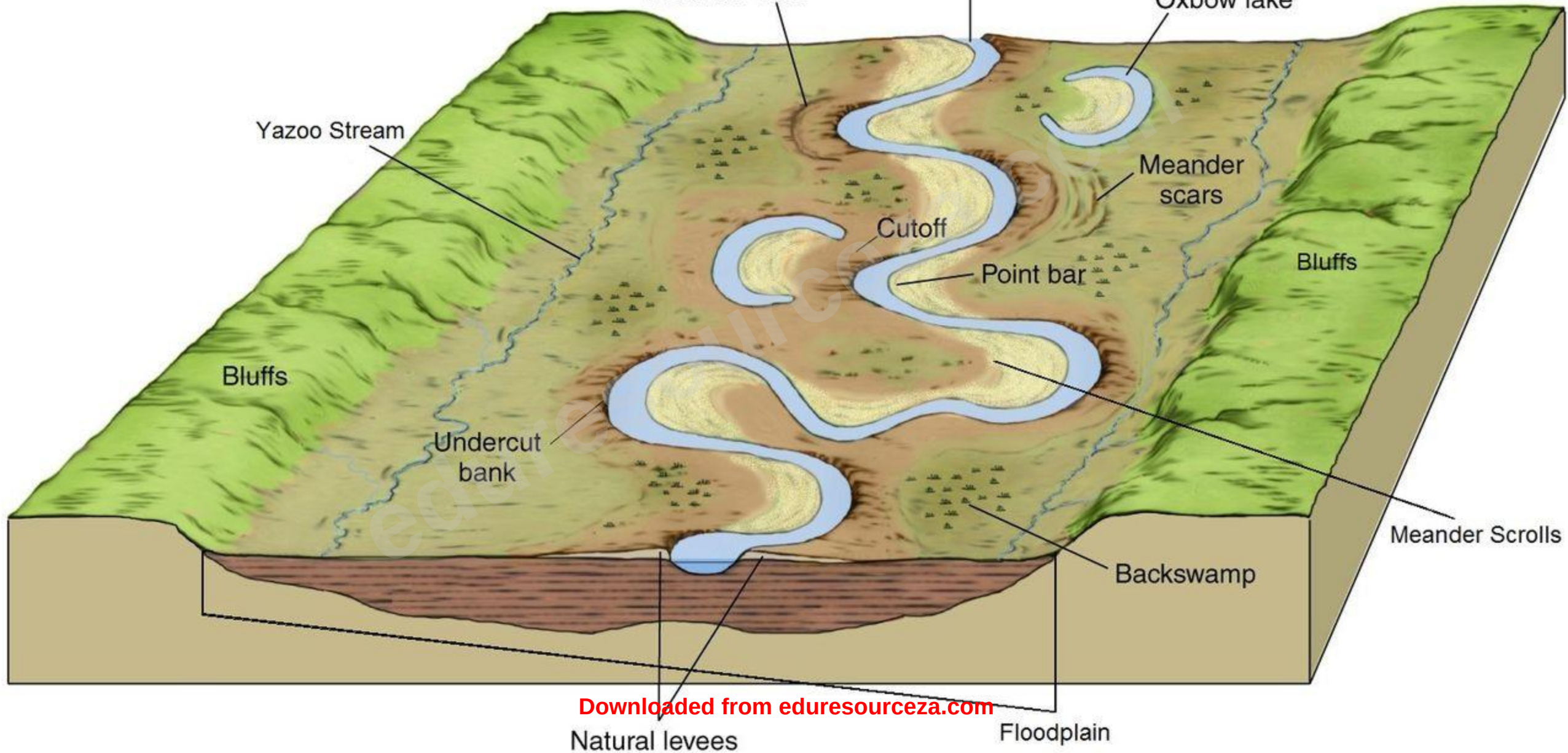
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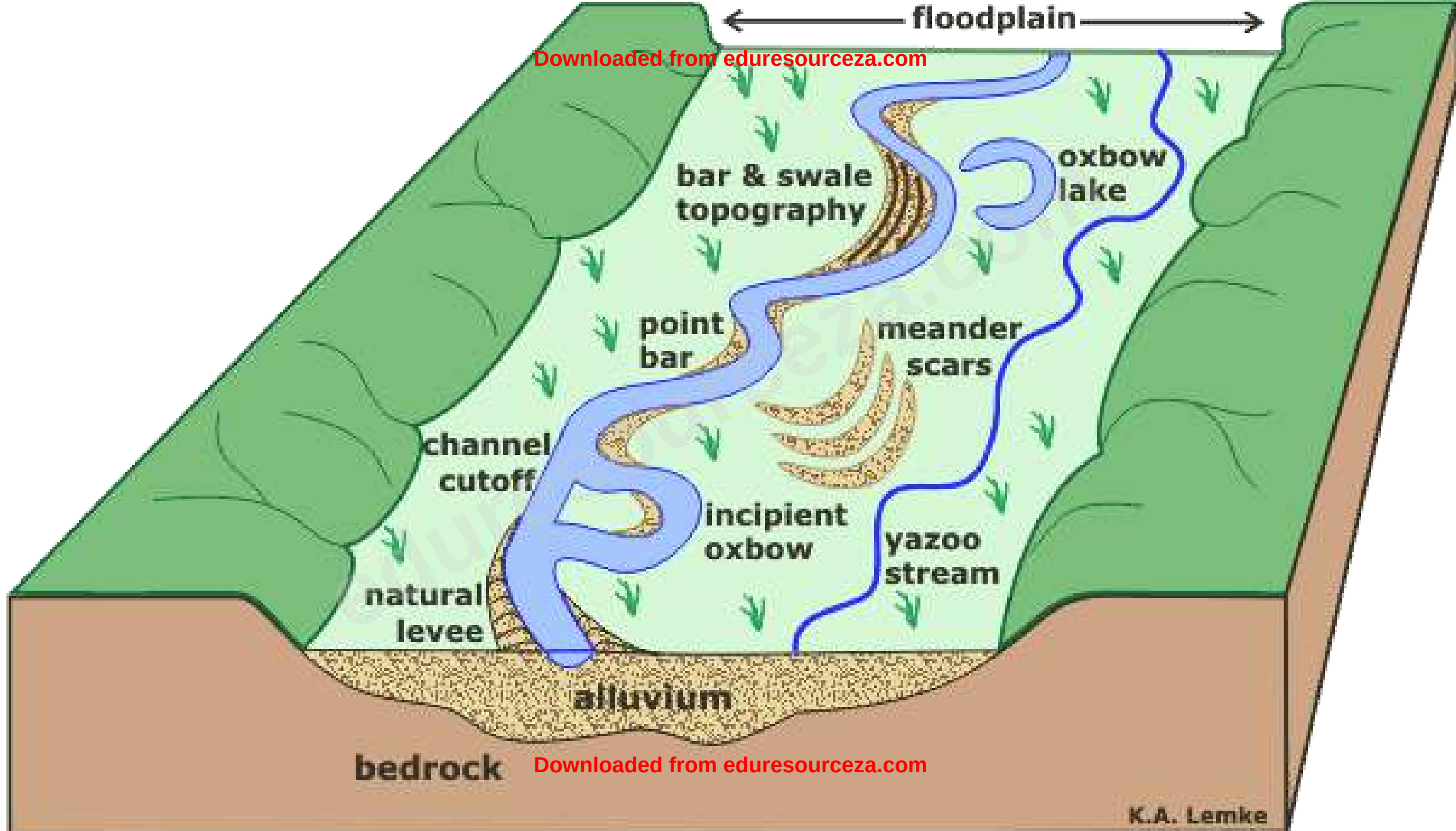
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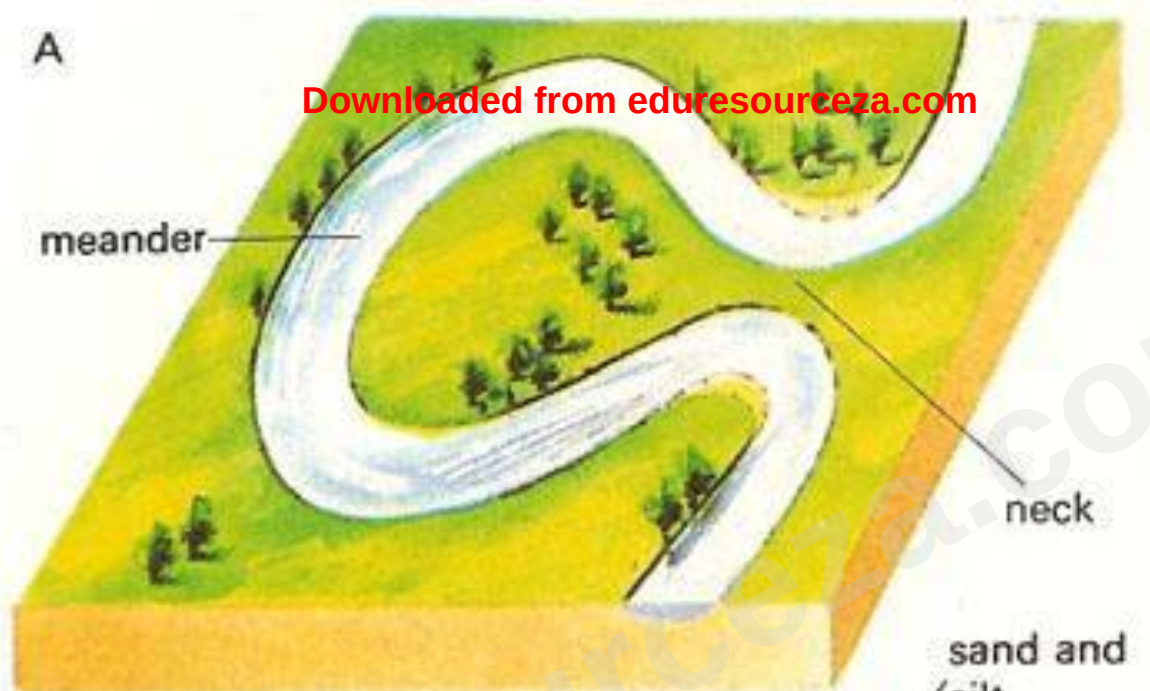


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Meandering, graded stream
Meander scar



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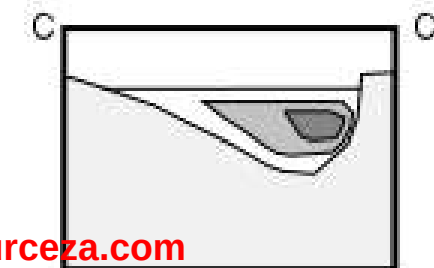
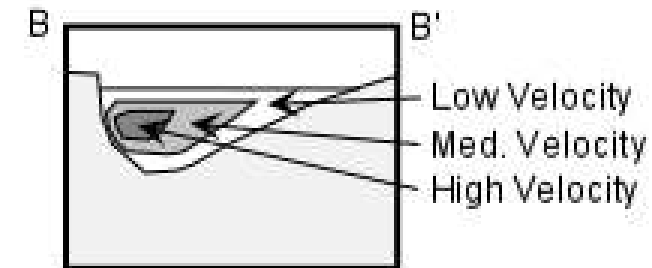
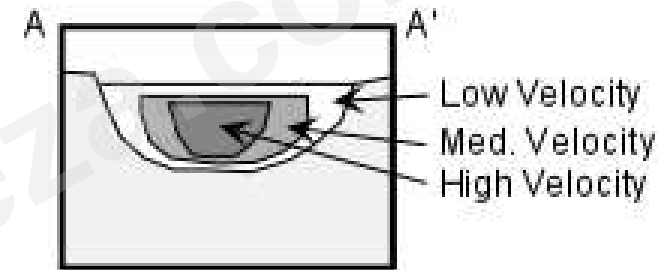
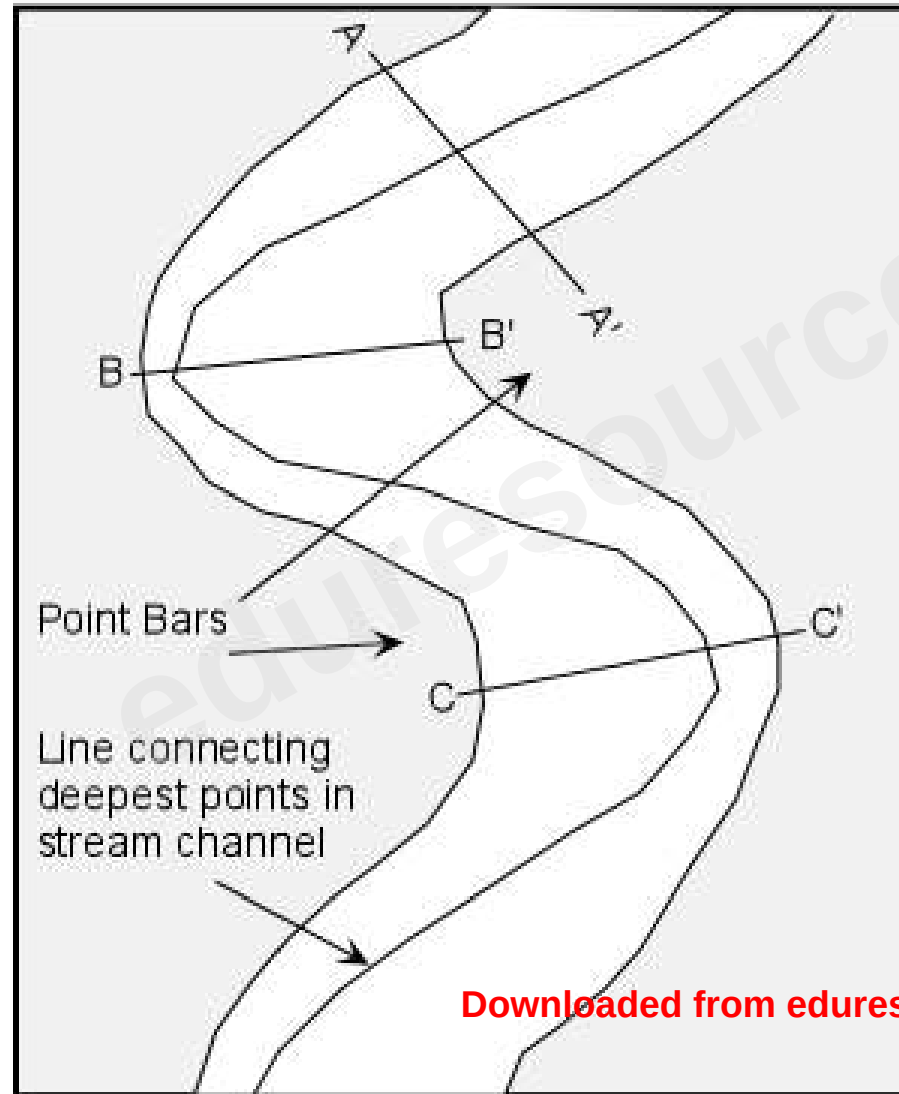




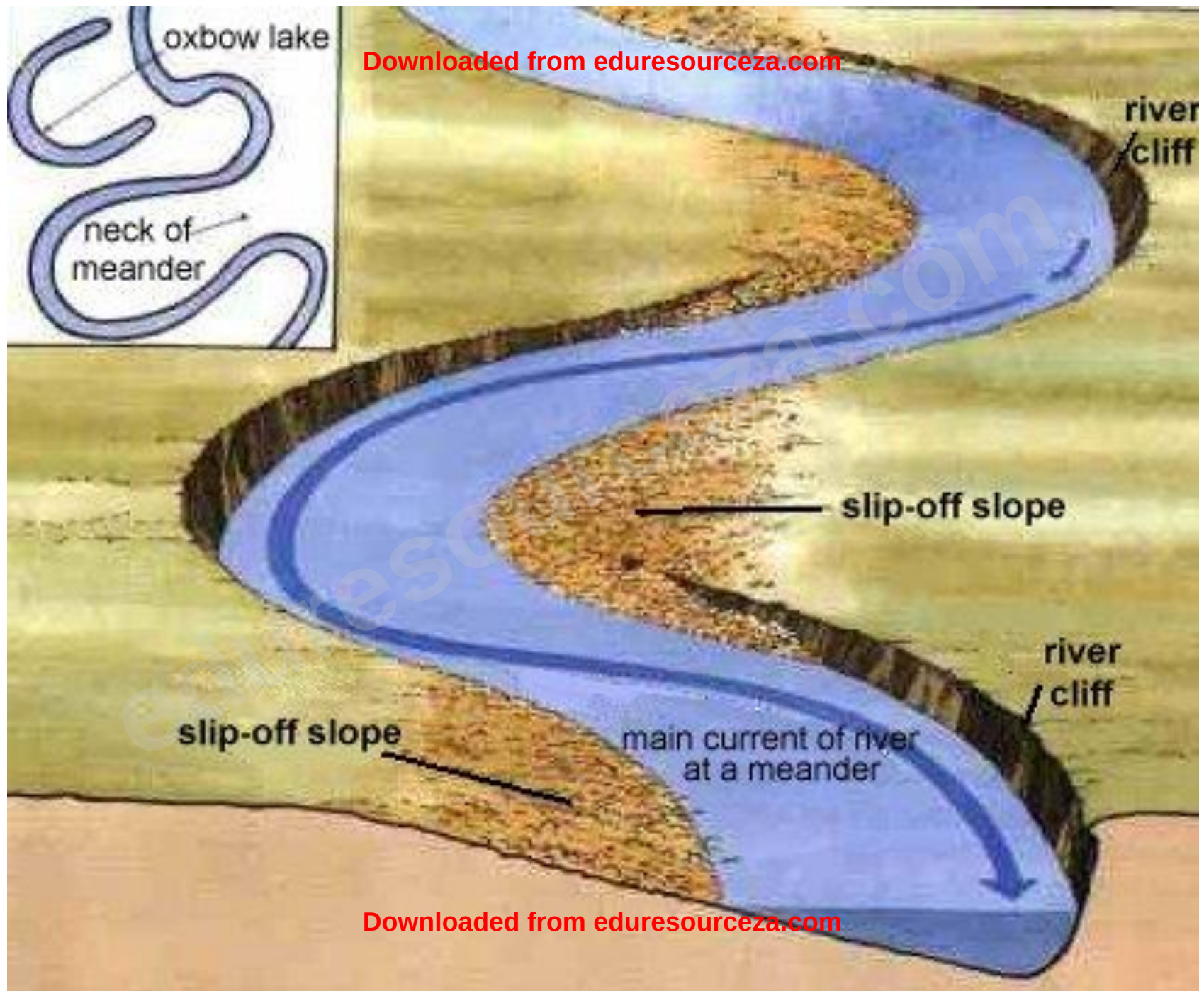
Asymmetrical transverse profile

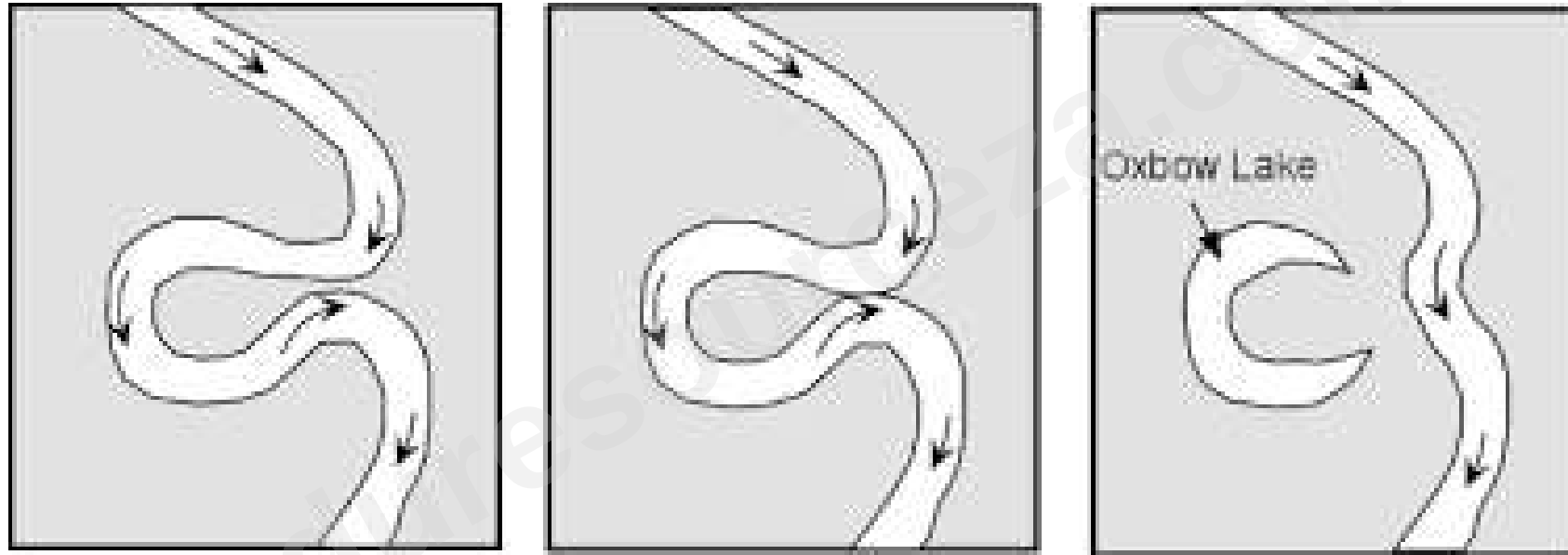
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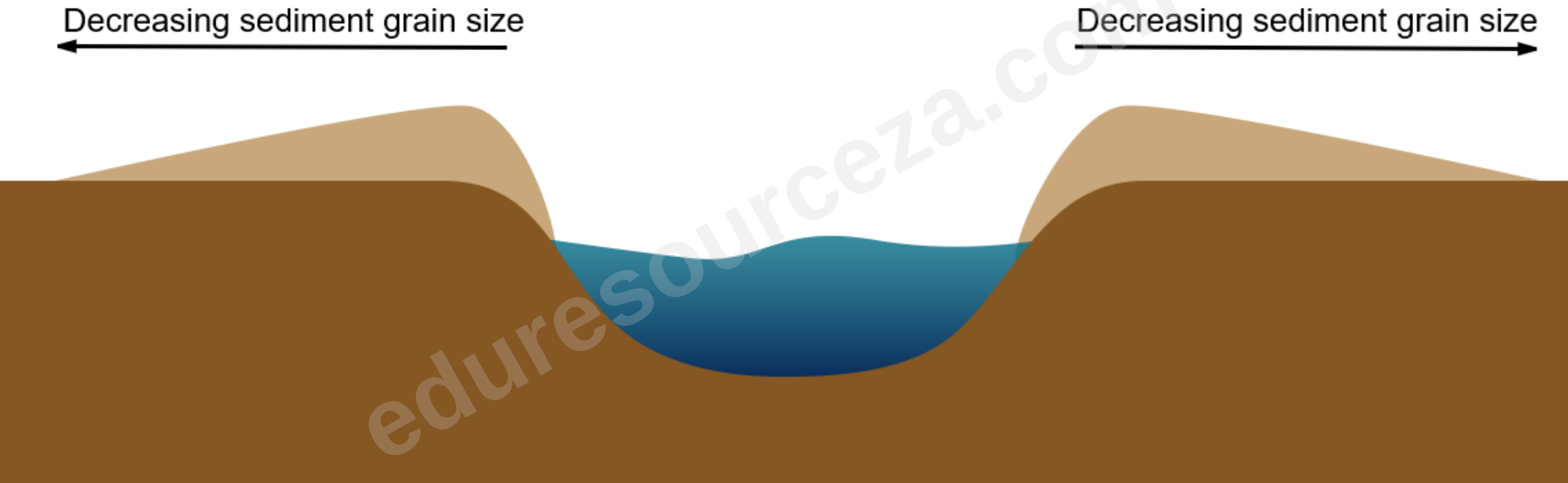
Meandering Channels

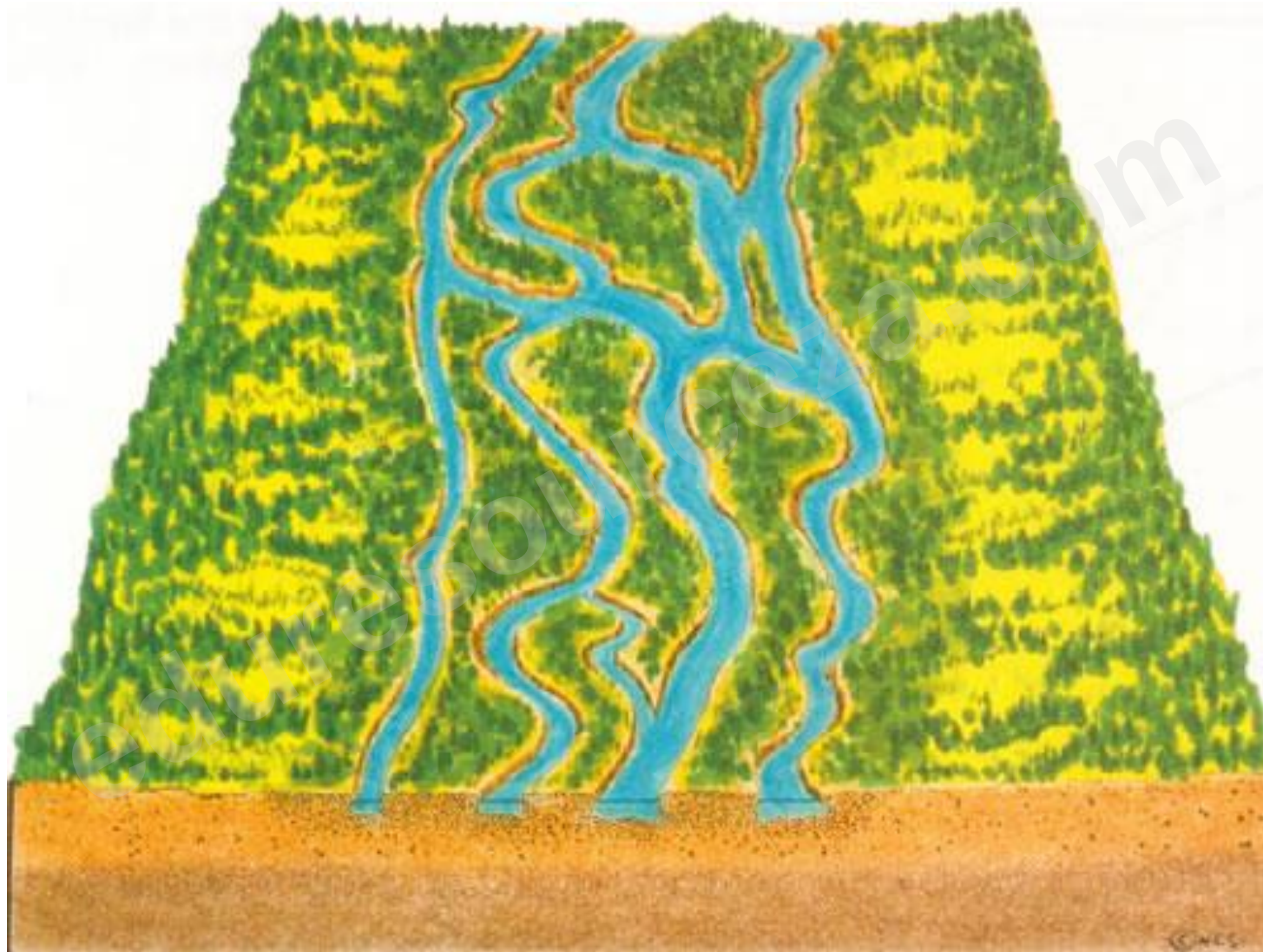


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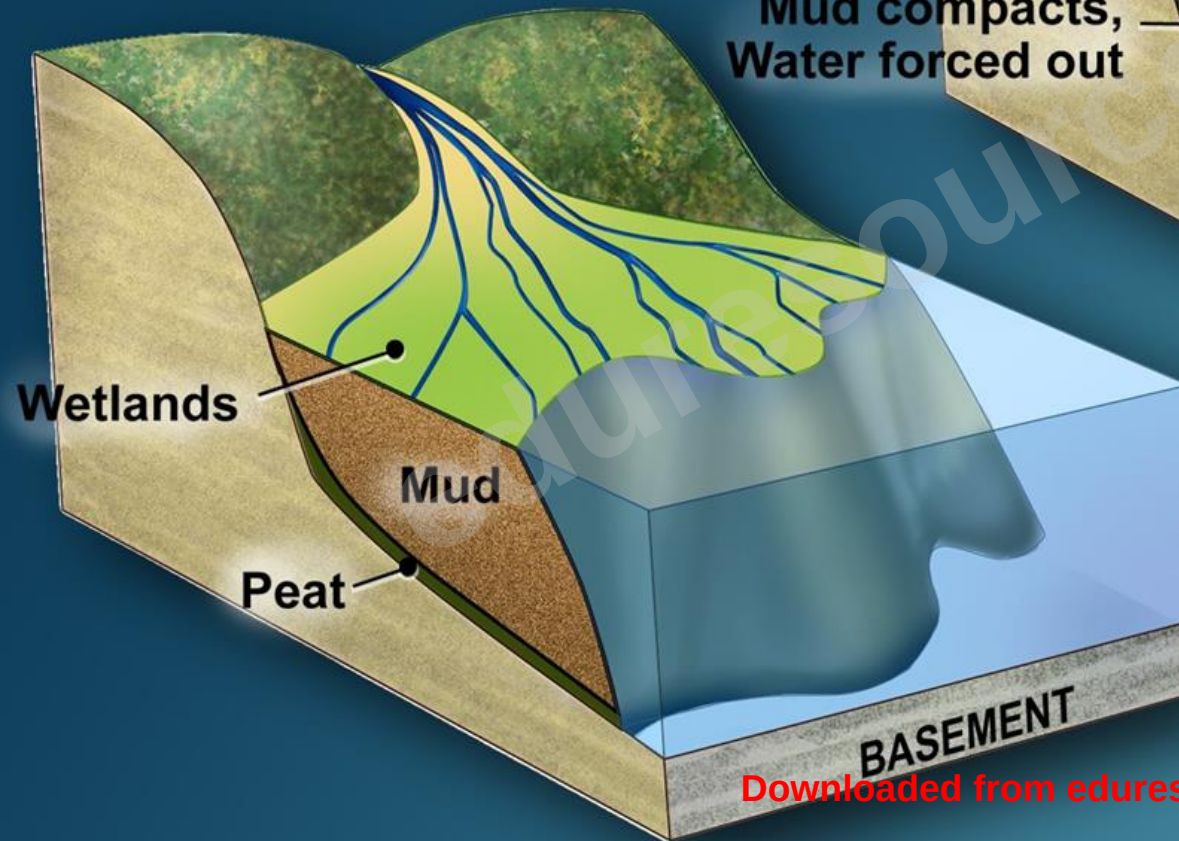




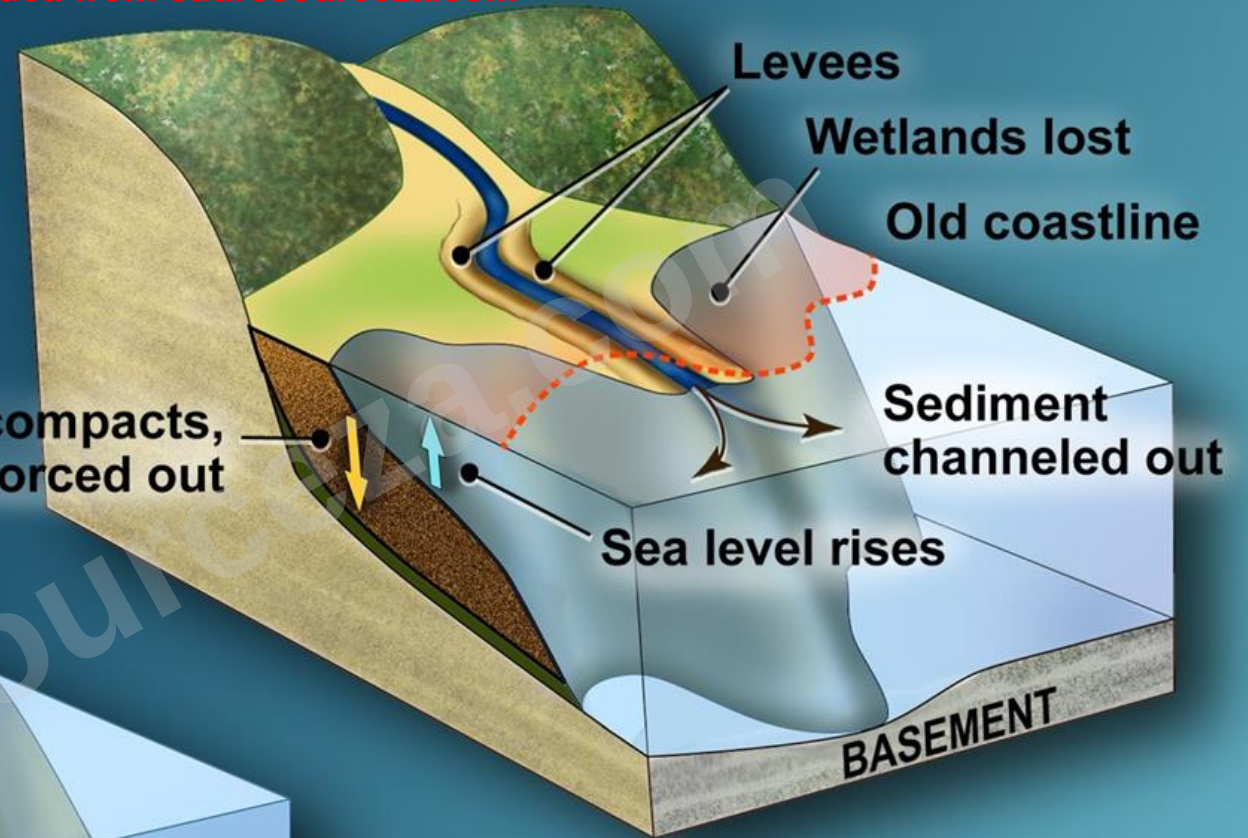
THE DELTA TODAY

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A FEW THOUSAND YEARS AGO



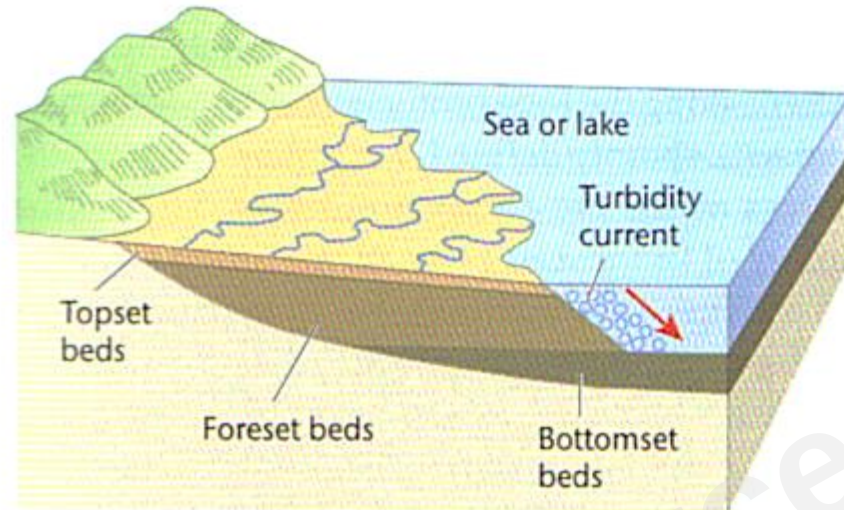
Mud compacts,
Water forced out



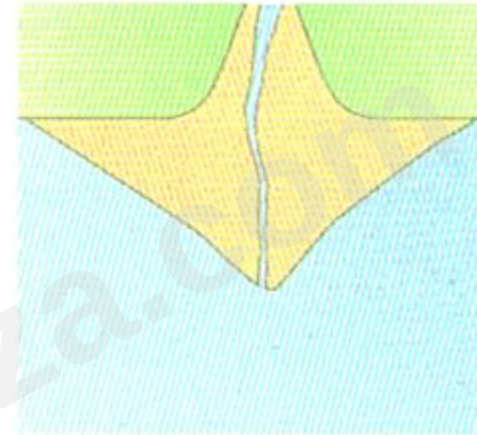
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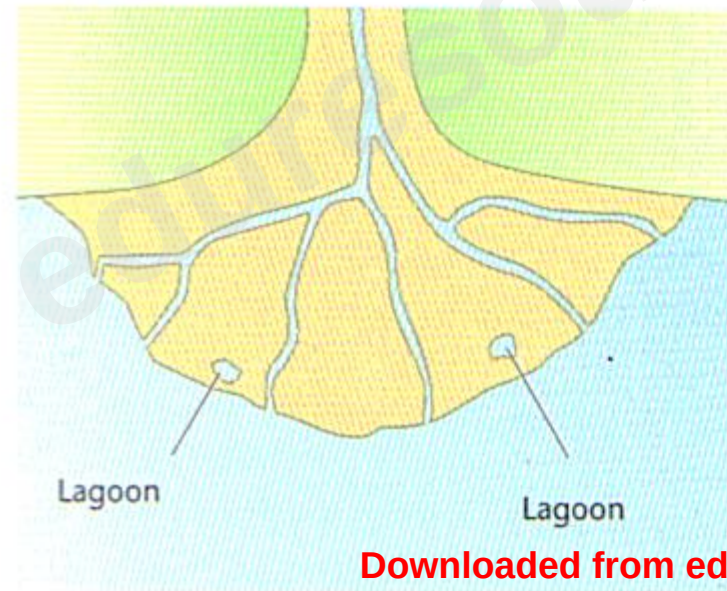
(a) Structure of a simple delta



(b) Cuspate delta



(c) Arcuate delta

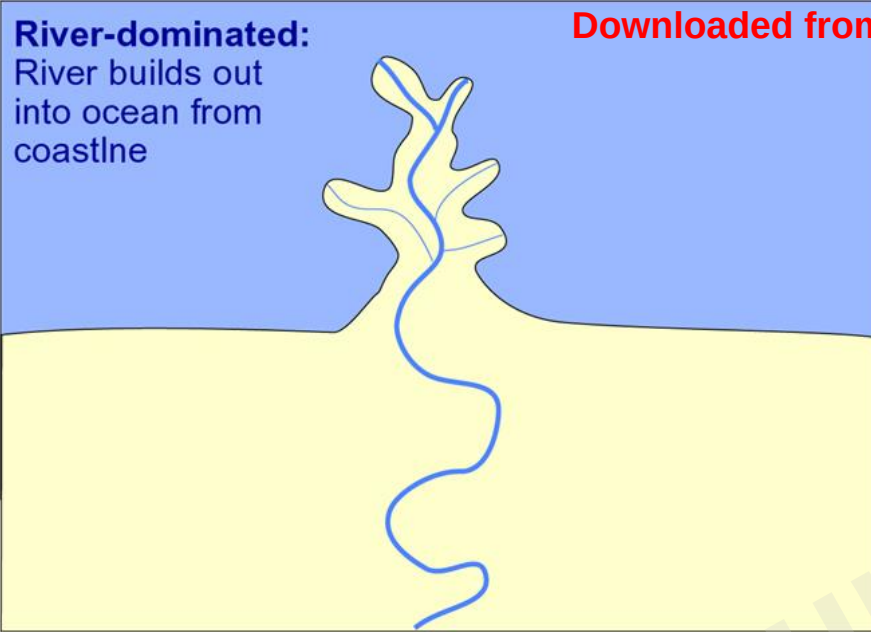


(d) Bird's foot delta



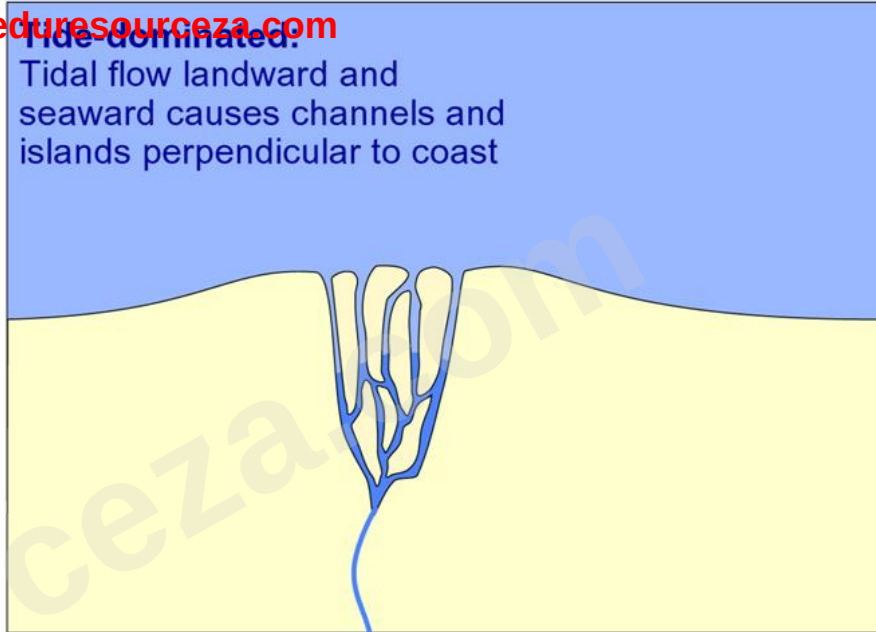
Morphologies of deltas

River-dominated:
River builds out
into ocean from
coastline

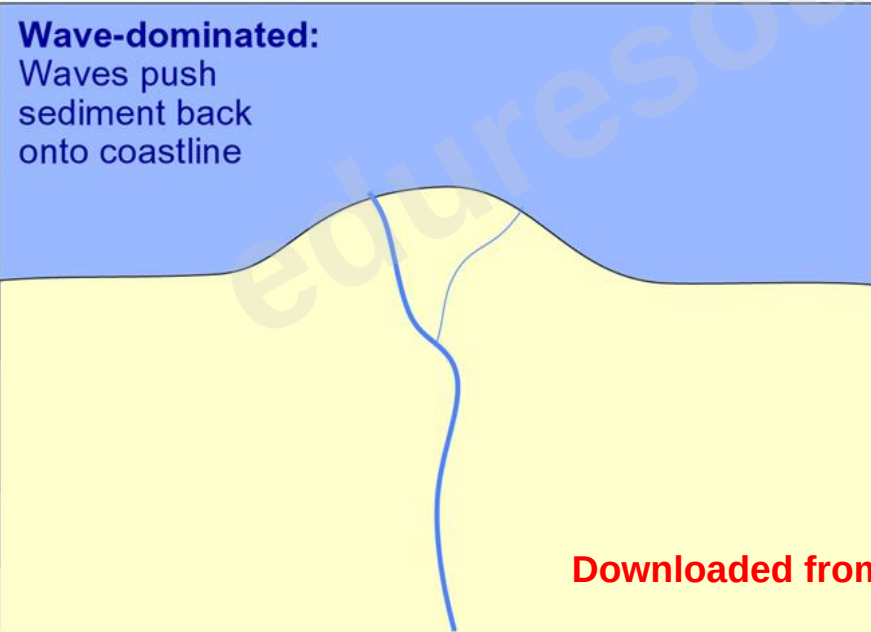


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Tide-dominated:
Tidal flow landward and
seaward causes channels and
islands perpendicular to coast

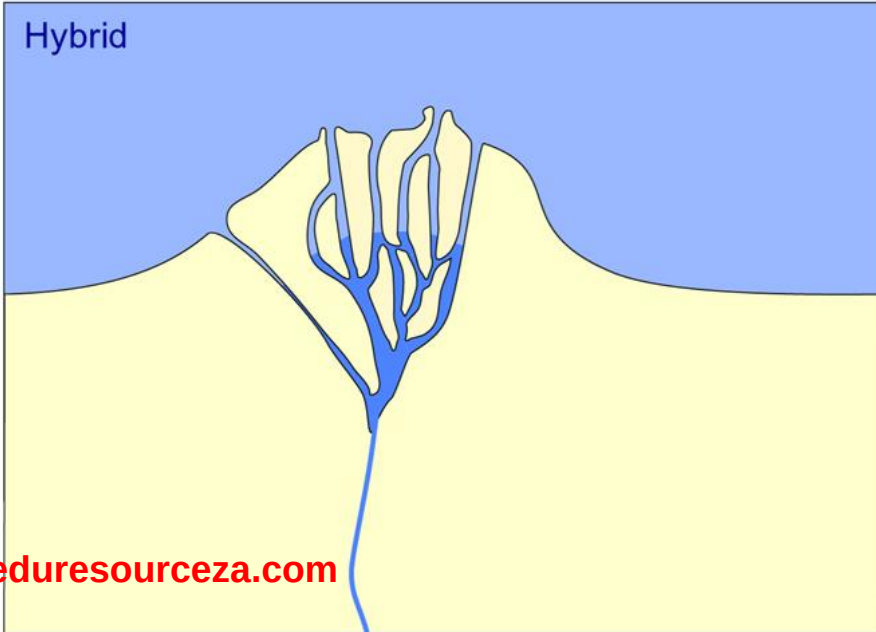


Wave-dominated:
Waves push
sediment back
onto coastline



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Hybrid

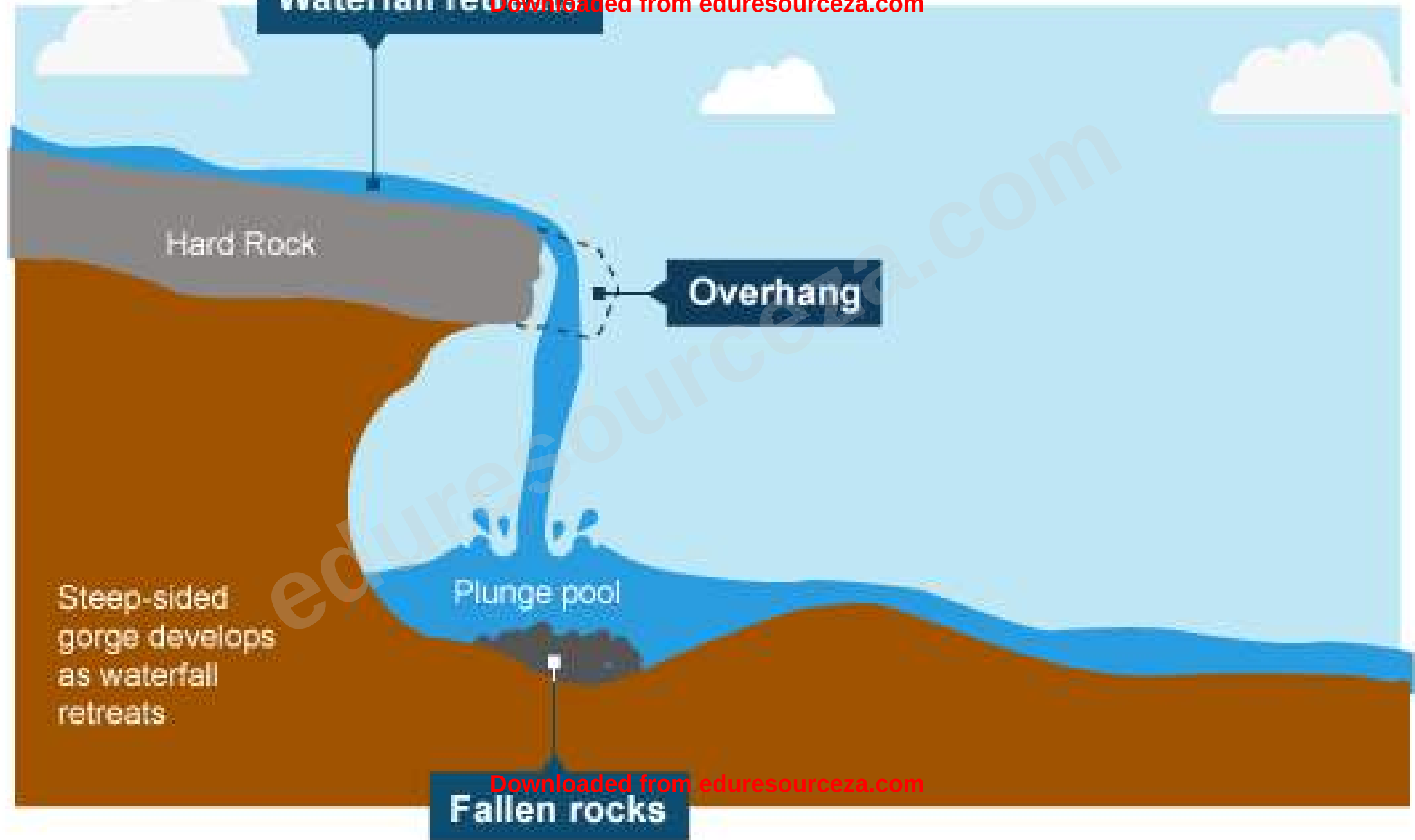


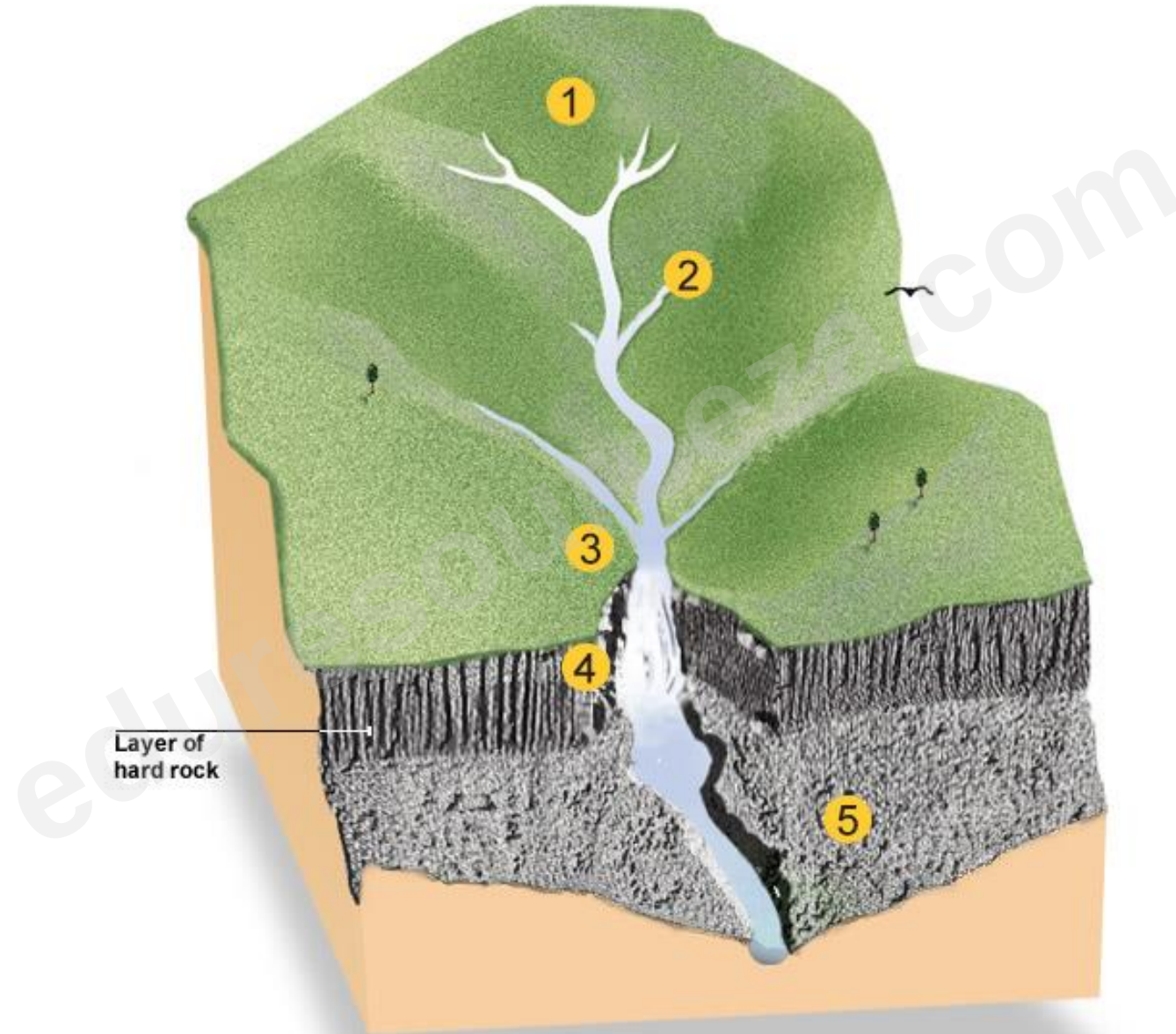
Fluvial landforms

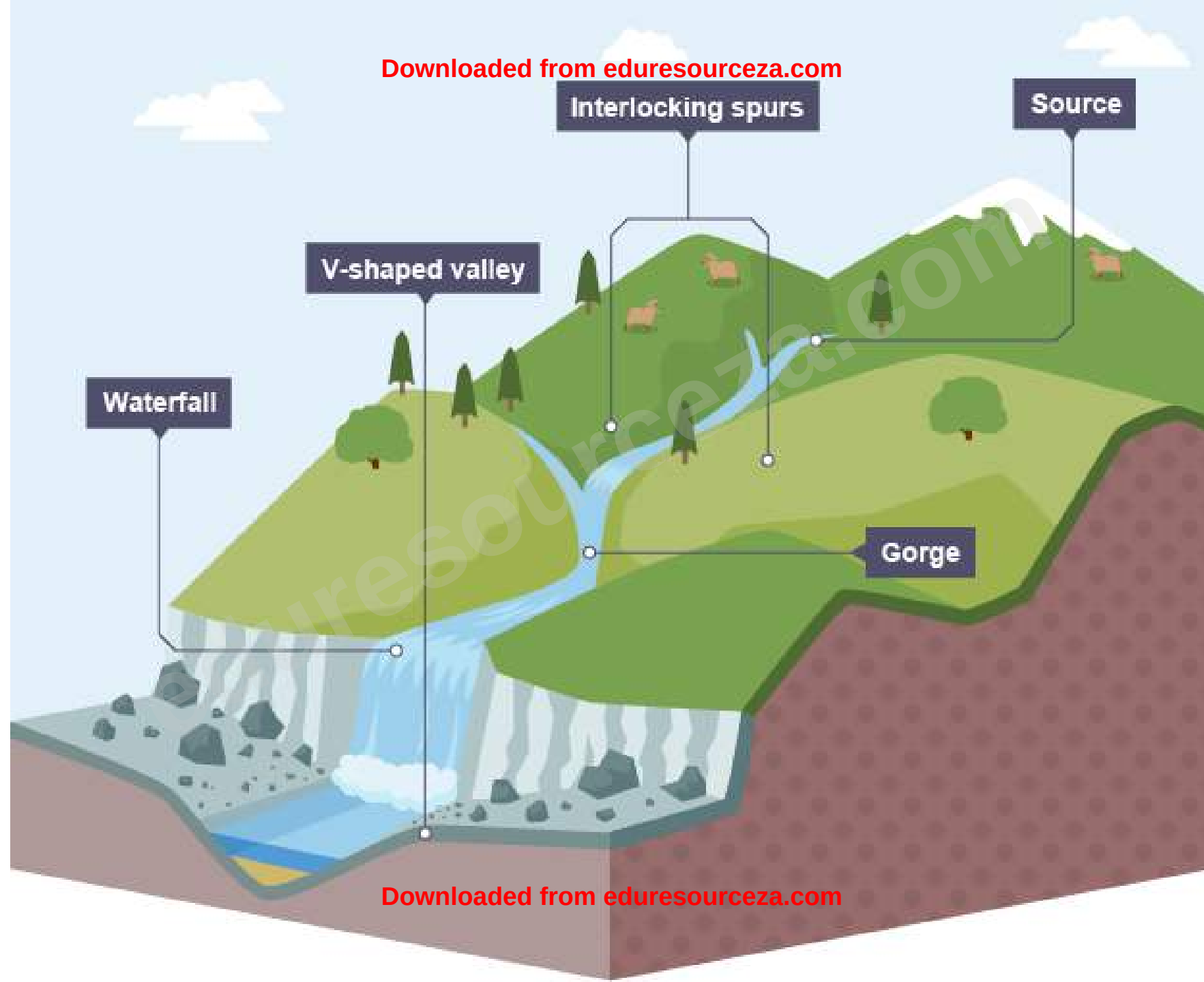
- **Waterfall** – river crosses a horizontal layer of resistant rock, or a layer of resistant rock dipping upstream & flows down a steep gradient
- **Rapids** – resistant layer of rock inclined downstream causes slight changes in gradient & turbulent flow

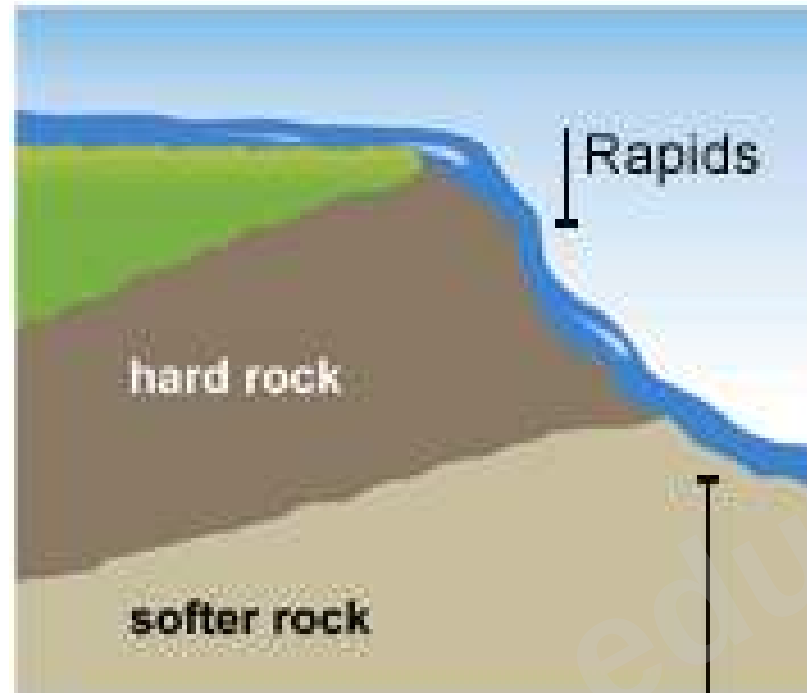
Waterfall retreats

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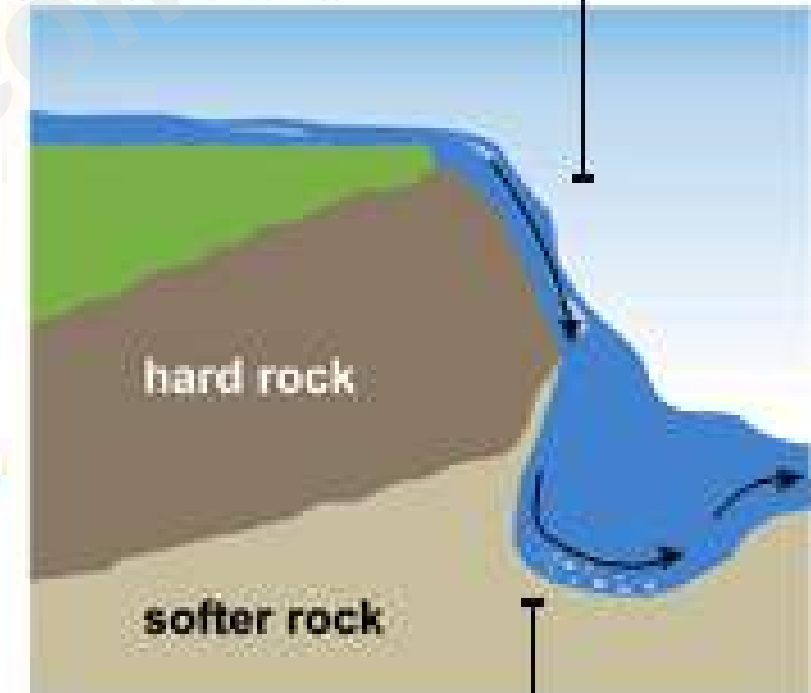


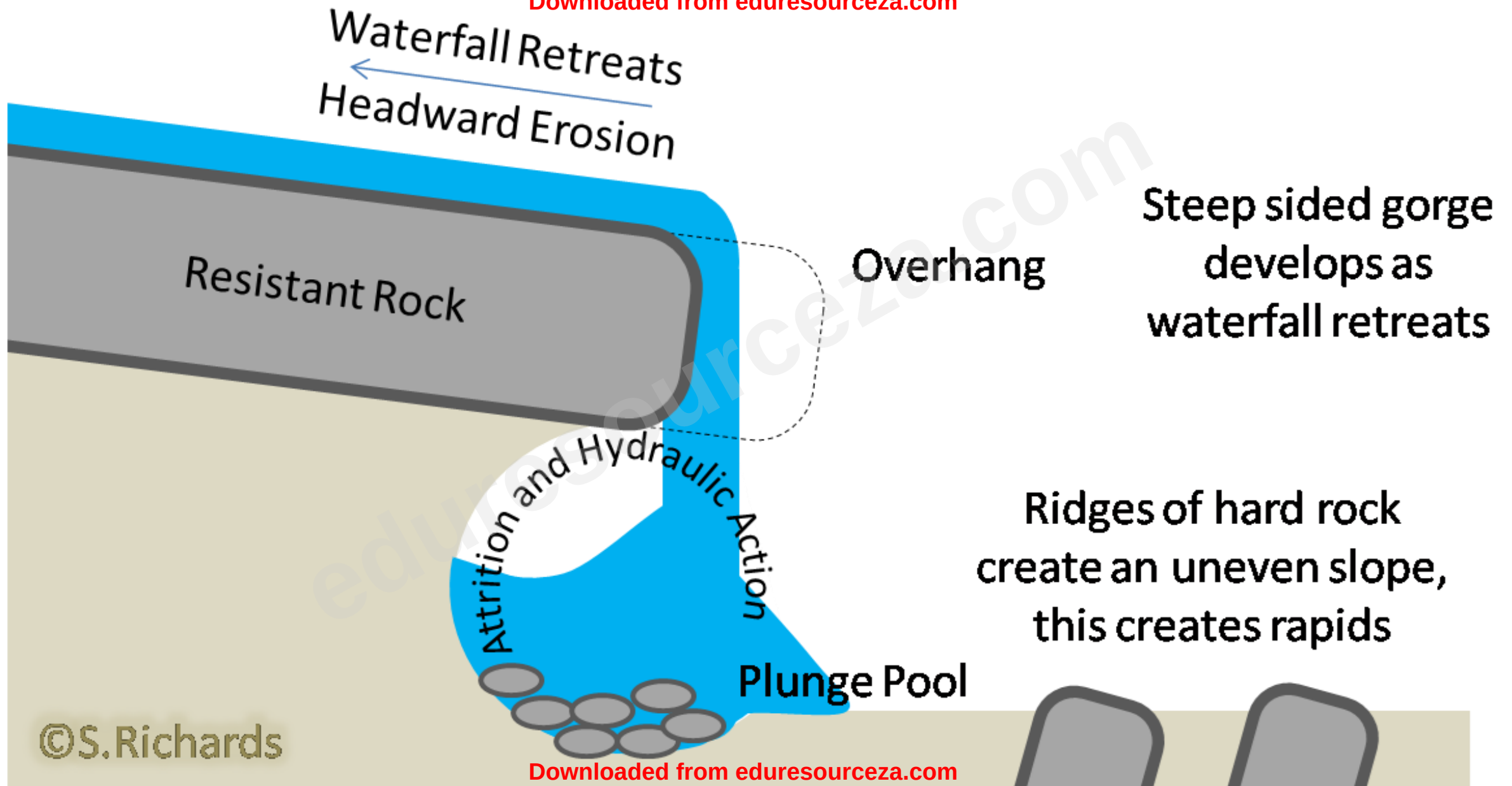


Softer rock erodes more quickly



Gorge cut as waterfall moves back



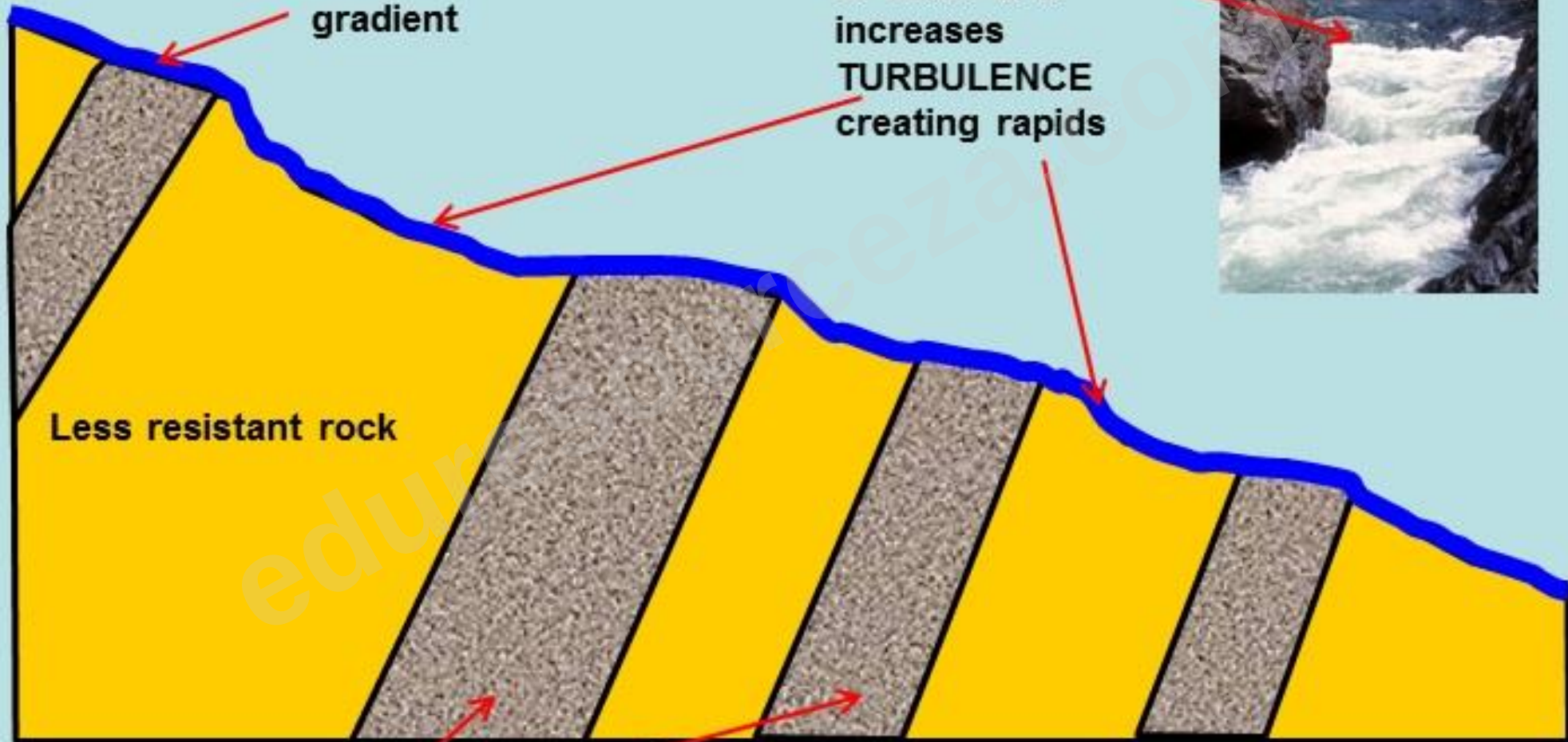


River Rapids

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Faster erosion rates
steepen gradient .
This speeds up flow
of water and
increases
TURBULENCE
creating rapids

Rock eroded at a
slower rate so lower
gradient

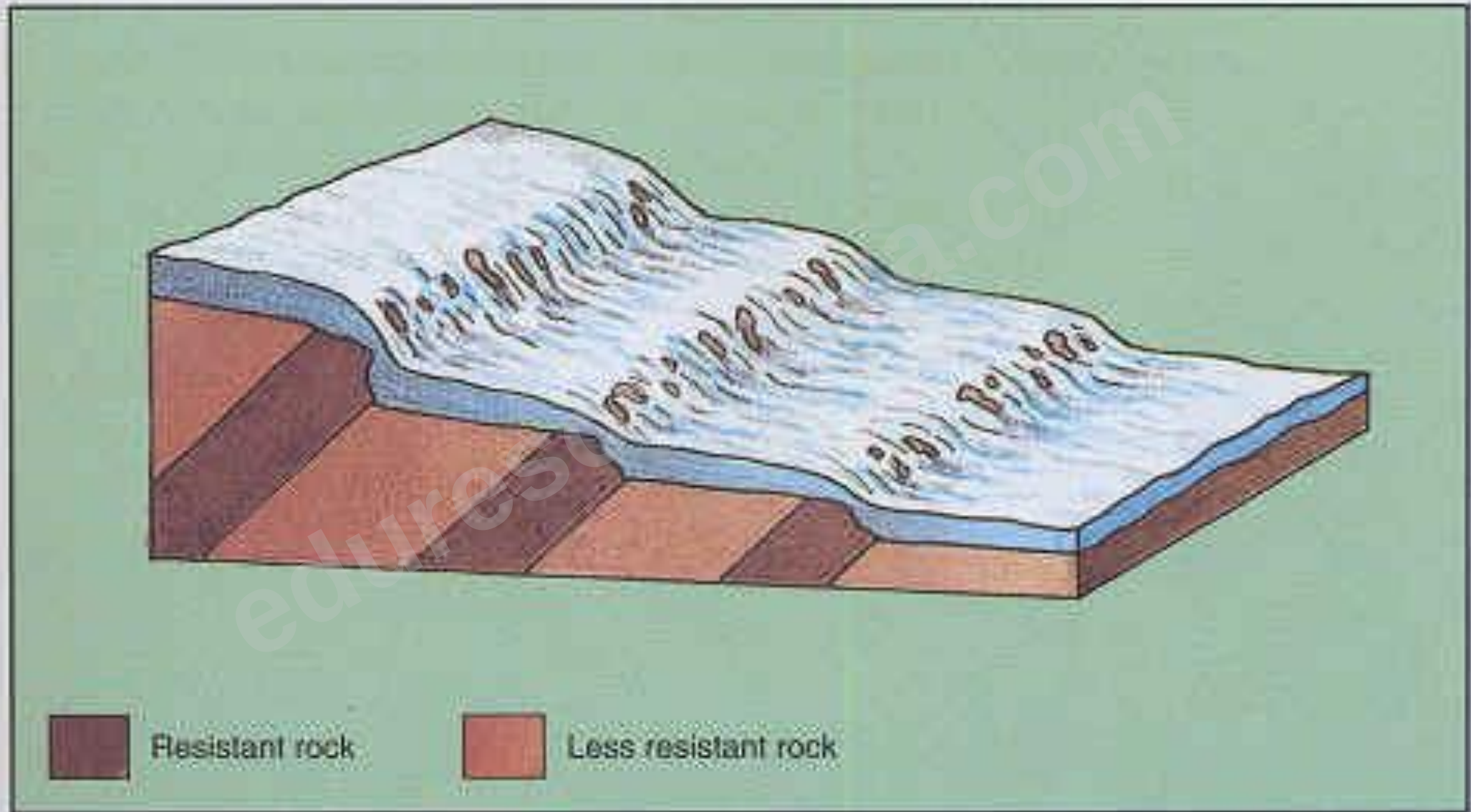


Less resistant rock

Bands of more
resistant rock

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By Rob Gamesby



Meandering







The Mbashe River winds its way through the Transkei region of the Eastern Cape.



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Braided



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More terms

- Hydraulic action – force of flowing water loosening pebbles, stones, sand & silt from the sides & bed of the channel
- Abrasion – particles carried by the river scratch & wear away the river bed & channel sides
- Traction – boulders & large rocks are pushed & rolled along the river bed
- Saltation – smaller rocks & stones are bounced along the river bed
- Suspension – silt & small particles are carried within the flow of the water

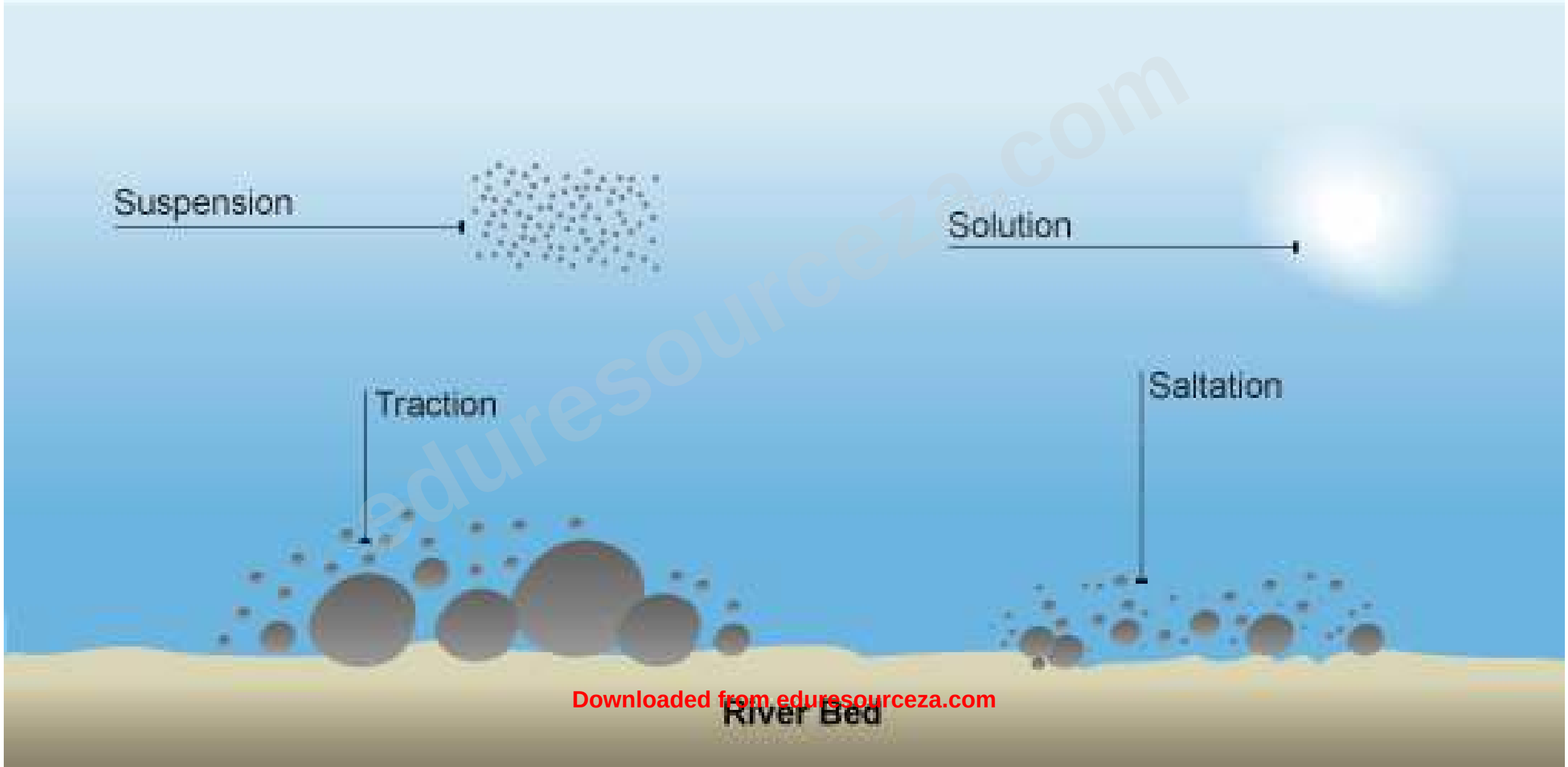
Suspension

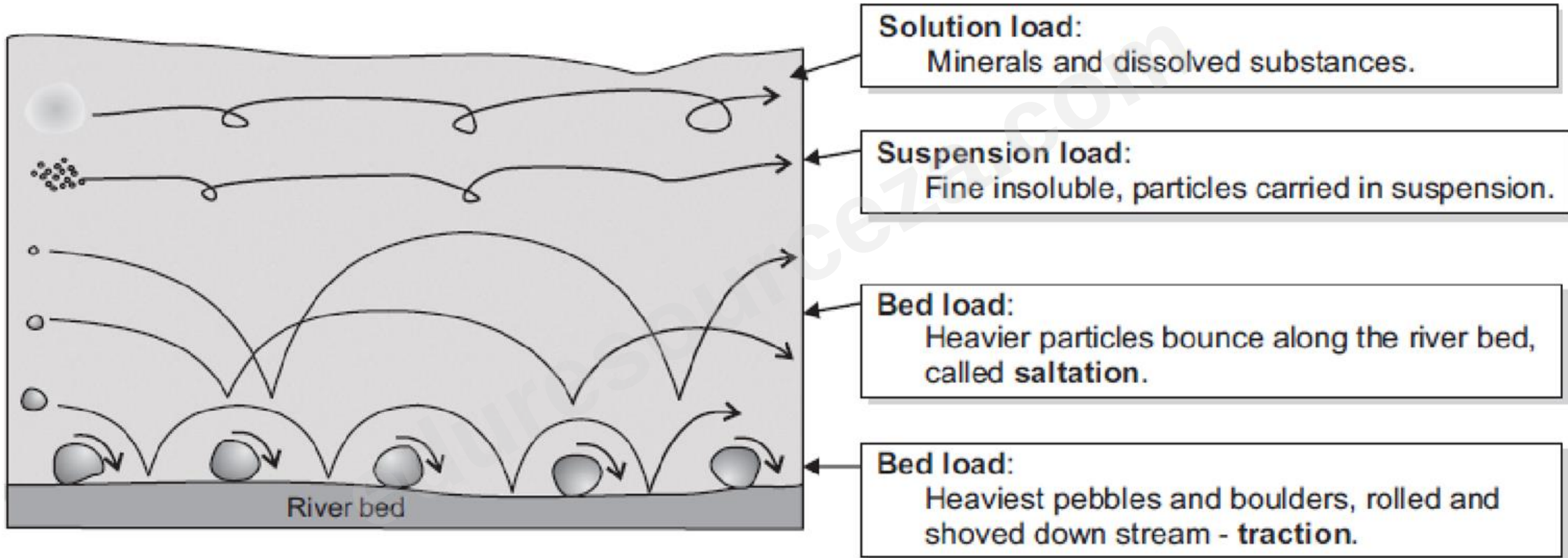
Solution

Traction

Saltation

River Bed

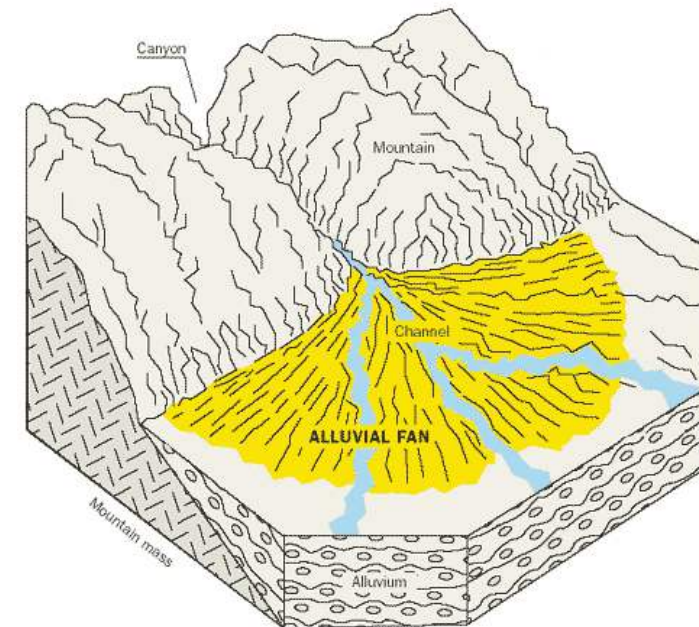




The river load

More terms

- Headward erosion – a river lengthens its course by cutting back upstream above its original course
- Alluvial fans – deposition as a river flows off the mountains onto the flatter plains; deposition is in the shape of a fan
- Sheetflow – water flowing downslope in thin sheets
- Mass movement – movement downslope of weathered material
- Distributaries – a single channel divides into a number of smaller channels that do not rejoin



Pothole scouring



Time-lapse videos

- <https://earthengine.google.com/timelapse/>

Class & prep work

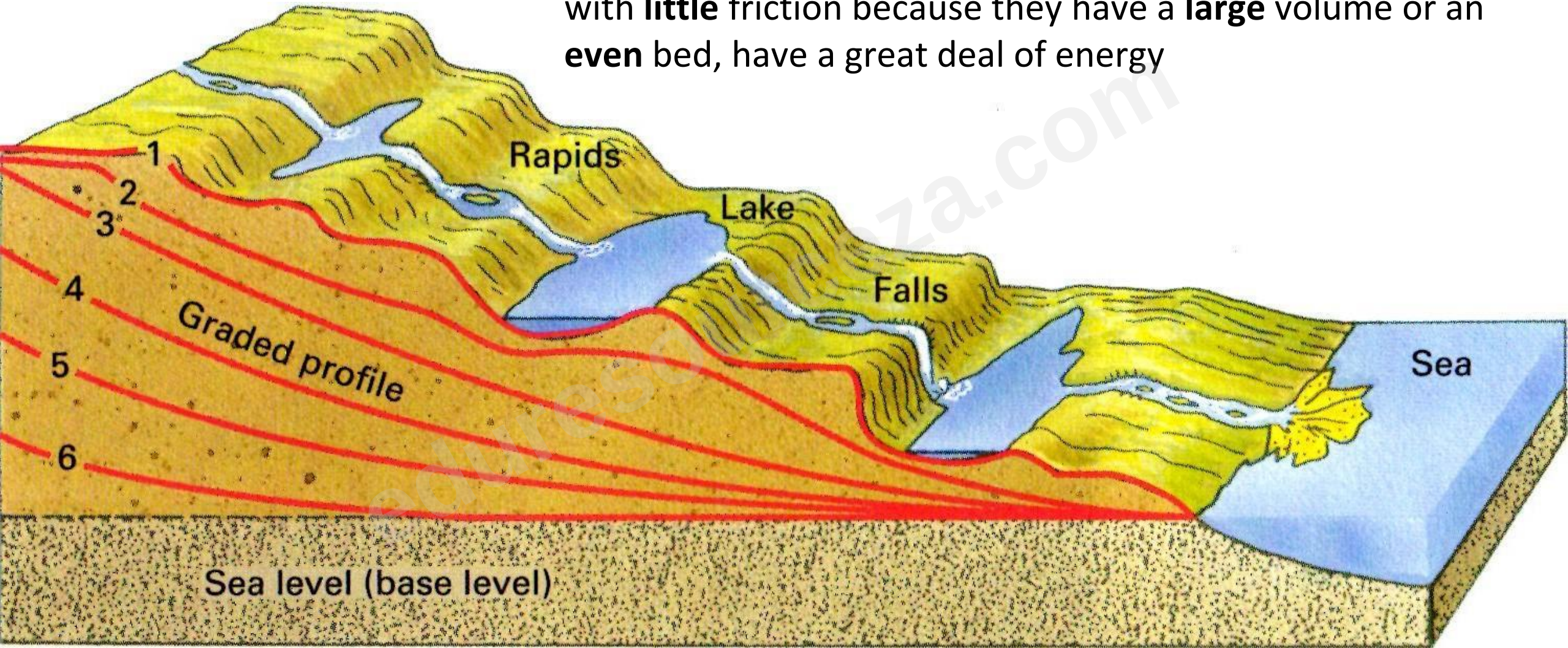
- Activity 12 p 148

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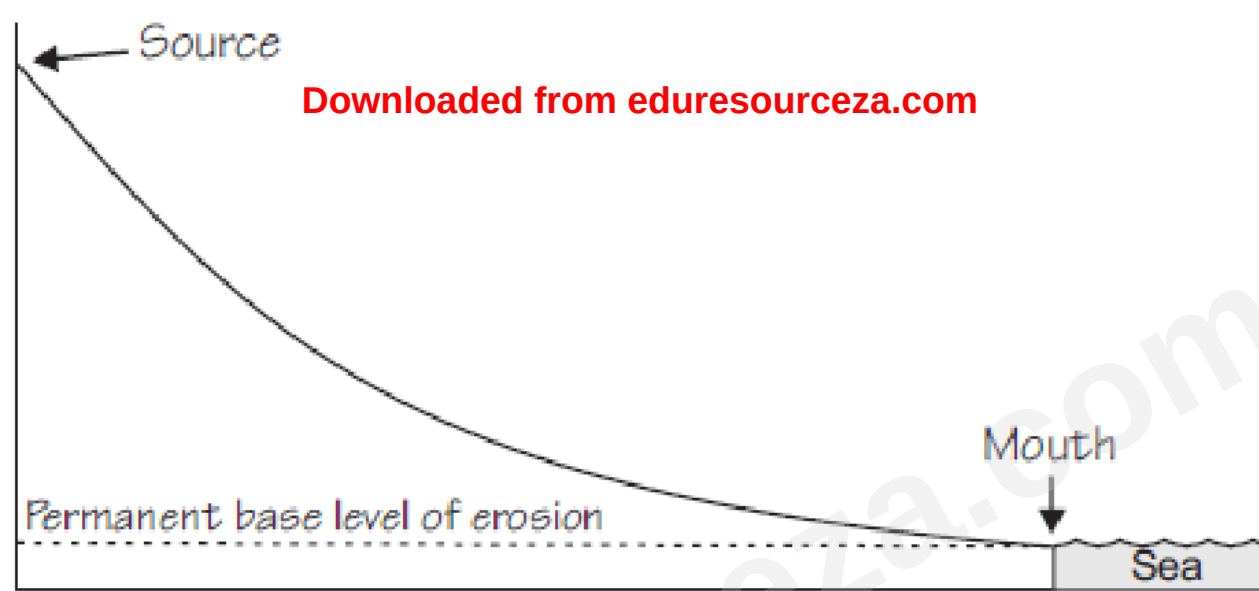
River grading

- Energy of a river is dependent on **velocity** of flow which is related to **gradient** & amount of **friction** in the river
- **Graded river** – a river that has reached equilibrium between gradient, volume & channel shape so that the river has just sufficient energy to flow, with erosion rates in balance with deposition rates
- Upper course – small volume, uneven bed, turbulent flow, small channel, more friction, steep slope
- Lower course – large volume, large load, even bed, laminar flow, large channel, less friction, gradual gradient

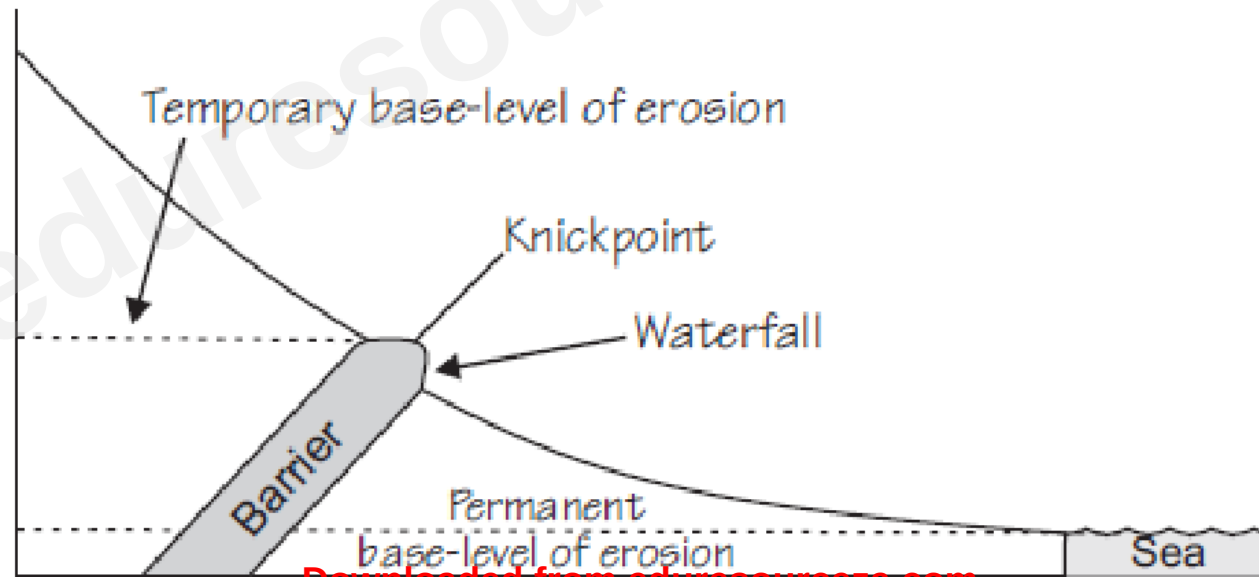
Overgraded – rivers flowing down a **steep** gradient, or rivers with **little** friction because they have a **large** volume or an **even** bed, have a great deal of energy



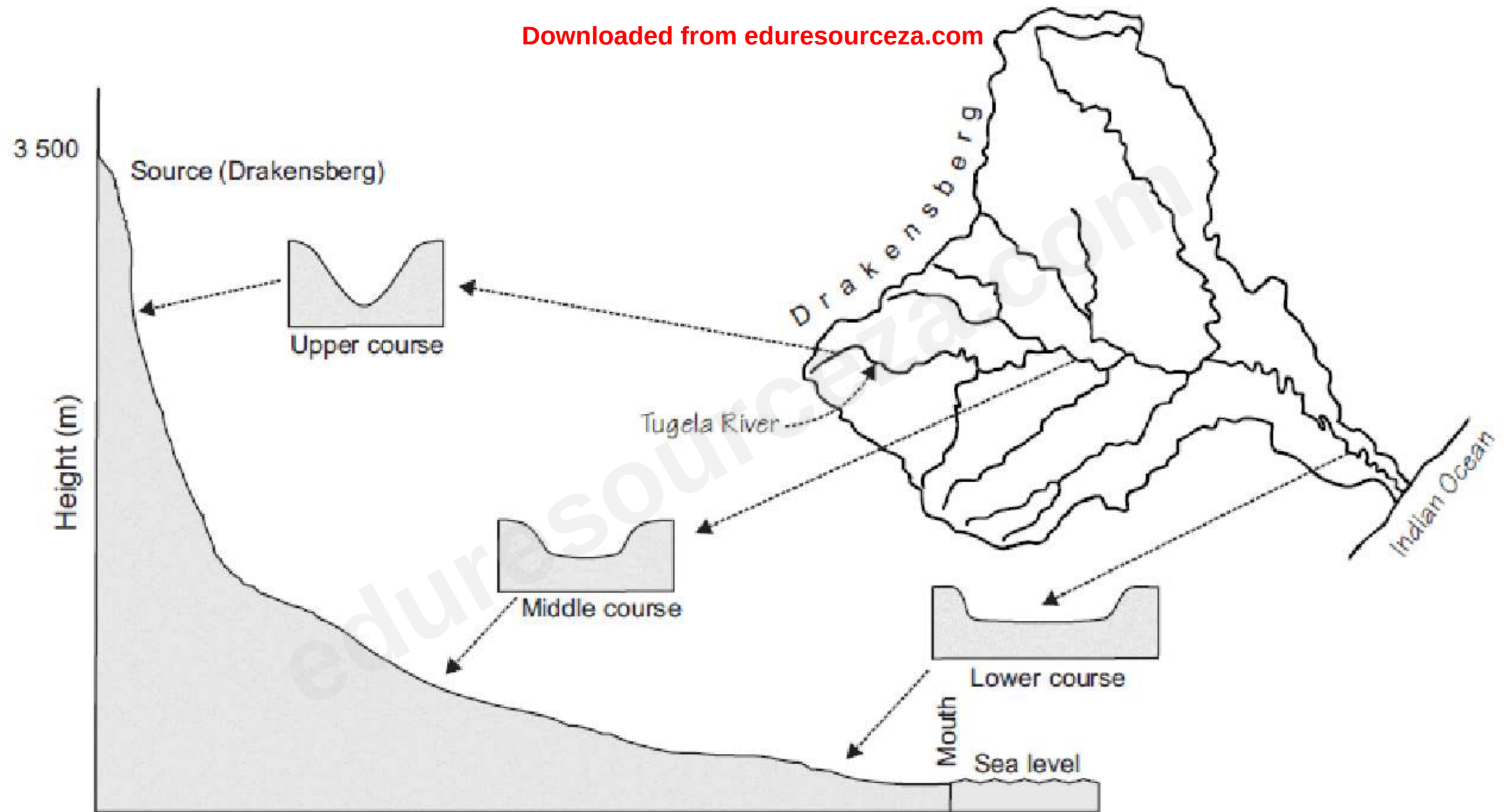
Undergraded – if the volume **decreases** or the gradient **lessens** or friction **increases** a river does not have enough energy to flow & **deposits** its load



A smooth, graded profile



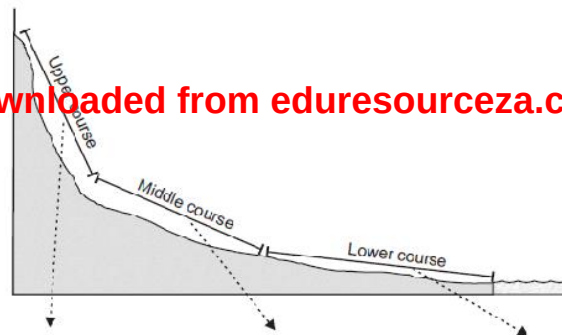
***An uneven, ungraded profile,
caused by a waterfall creating a knickpoint***



Distance
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Longitudinal profile of the Tugela River

The cross section of a river shows the shape of the river channel. This is often compared along the longitudinal profile. Various factors may influence the shape of the cross section.

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River channel feature	Upper Course	Middle Course	Lower Course
Cross section			
	 Deep, narrow	 Wider	 Broad, flat
Work performed by running water	Vertical erosion	Lateral erosion is dominant over vertical erosion	Deposition
Gradient	Very steep	Gentler, less steep	Gentle or flat
Volume	Low volume, with little load	Load and volume increased as channel widens	Increased volume and suspended load
Flow	Turbulent, fast, swift flowing water	Less turbulent, more laminar in places	Laminar
Characteristic features of course	• Cascades • Waterfalls • Rapids • Gorges or ravines	• River begins to meander • Floodplain starts to develop • Alluvial fans • Interlocking spurs	• Marshes • Wide meanders • Levees • Oxbow lakes • Wide floodplains • Braiding
Significance for Humans	• Storage dams* • Hydro-electric power • Ports and gaps used for transport routes • Recreation such as hiking, punting, canoeing, fishing	• Irrigation schemes • Road and rail construction easier, as gradients are not as steep	• Ports • Navigation • Very fertile soils suitable for agriculture • Densely populated • Good water • flat land • fertile soil

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Class & prep work

- Activity 13 p 150

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Rejuvenation of rivers

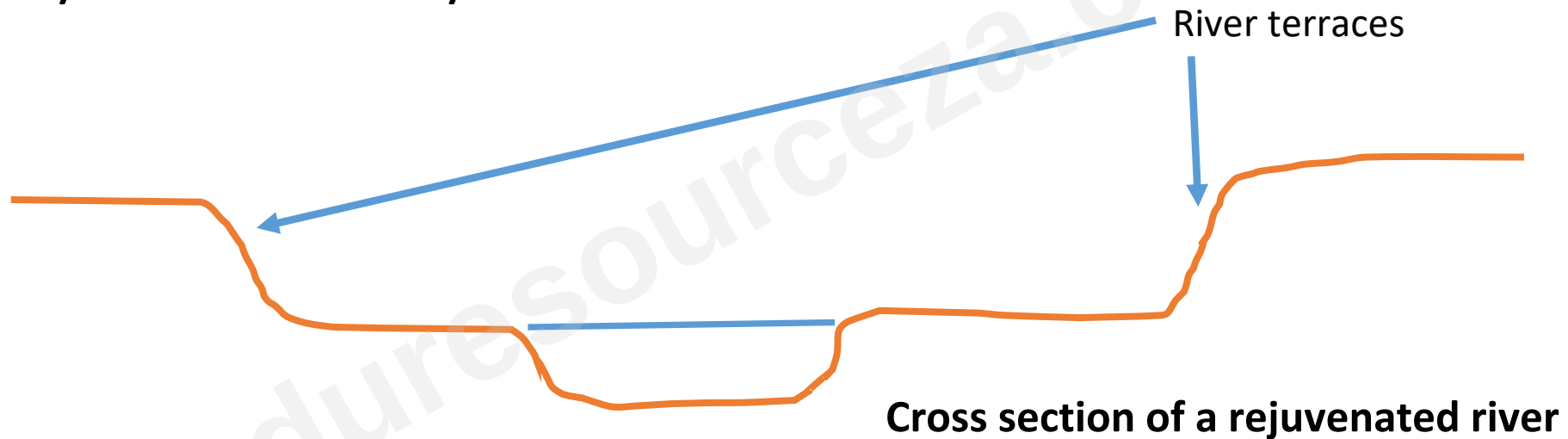
- **Rejuvenated** rivers receive **additional energy** & begin to erode vertically
- **Aging** rivers **lose energy** & begin to deposit their loads
- A river is rejuvenated as the speed, erosive power & carrying capacity (transported load) of the river increases

Rejuvenation process

- The permanent base level is altered causing a sharp change in gradient along the river's course – by isostatic uplift or a drop in sea level
- Knickpoint = a sharp change in gradient – knickpoint waterfalls develop
- This results in increased amounts of energy
- Vertical erosion increases
- Added water volume also rejuvenates

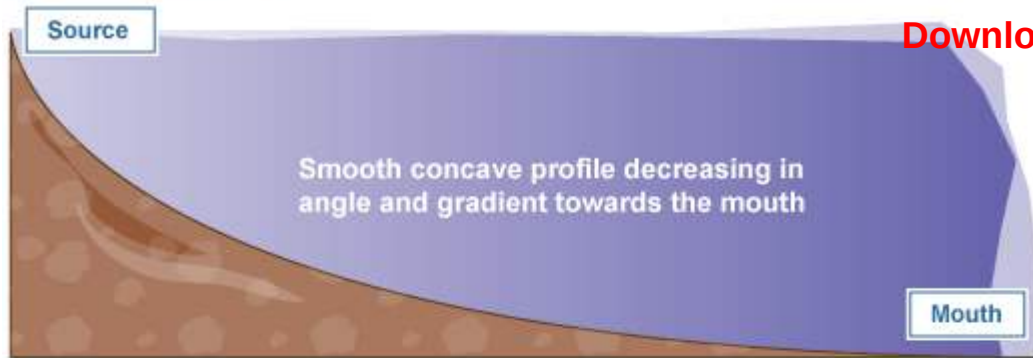
Fluvial landforms resulting from rejuvenation

- A valley within a valley results



- **Entrenched** or **incised** meanders (between steep valley sides) & **ingrown** meanders (cuts sideways into the bank forming an overhang) result

The graded profile

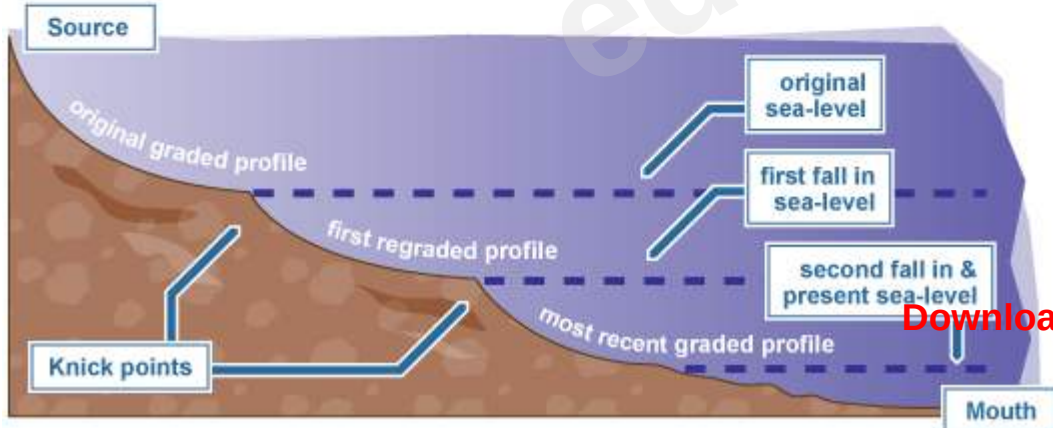


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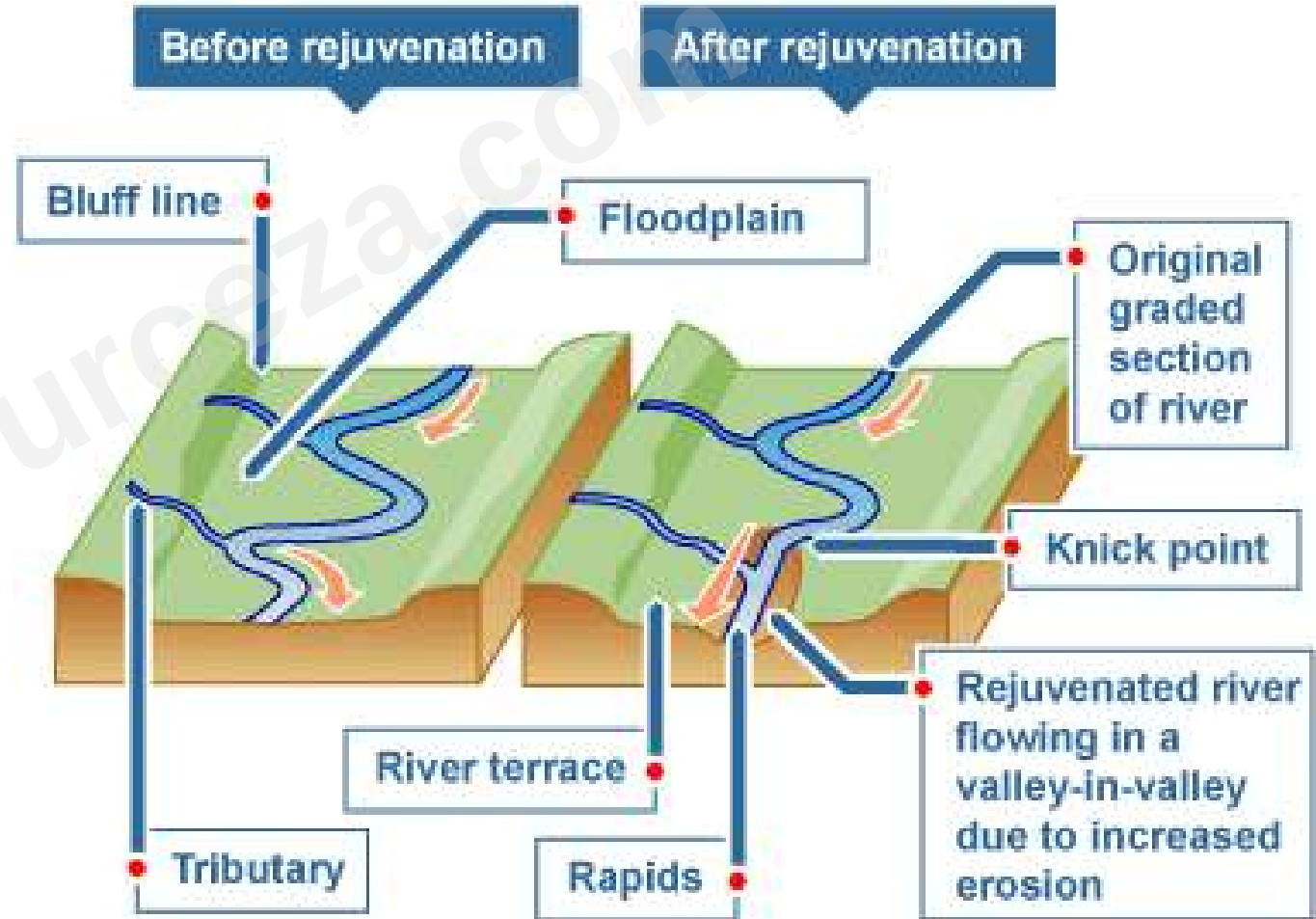
Irregularities in the long profile



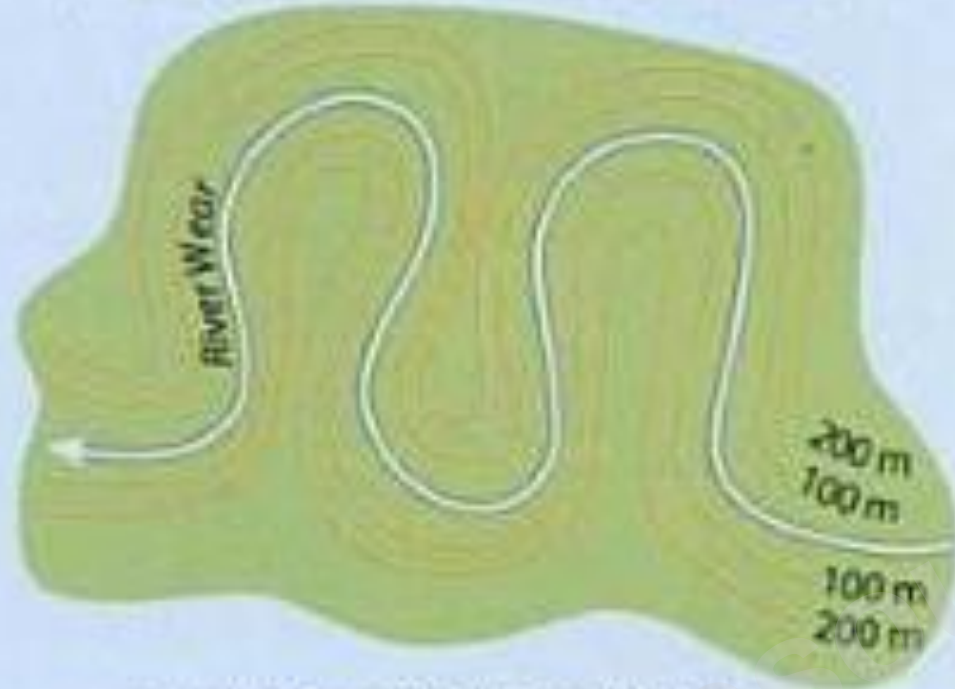
Rejuvenation



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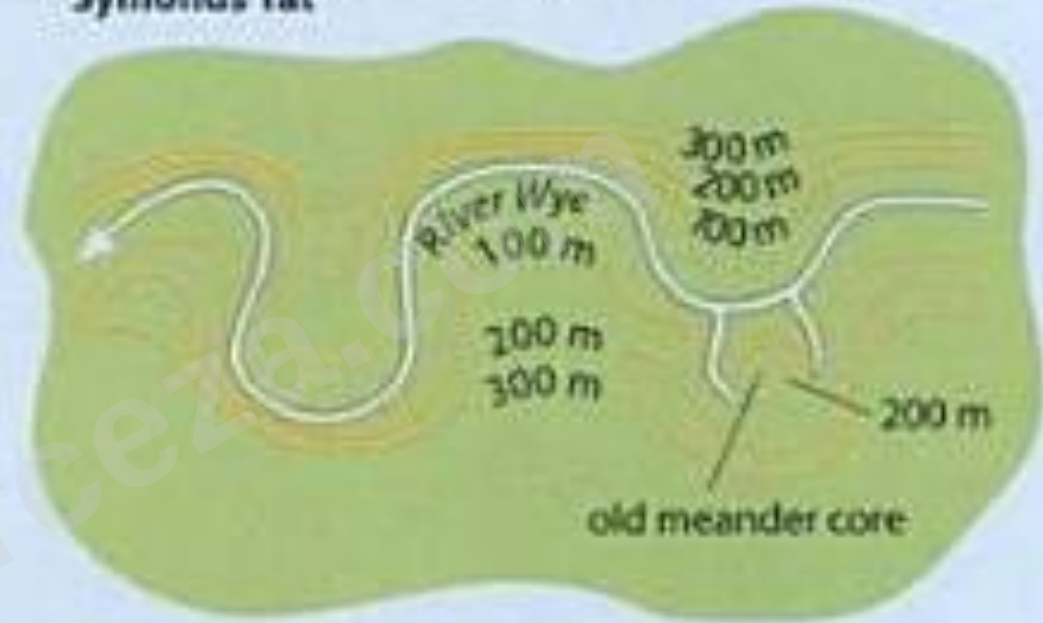
a entrenched meanders: R. Wear, Durham



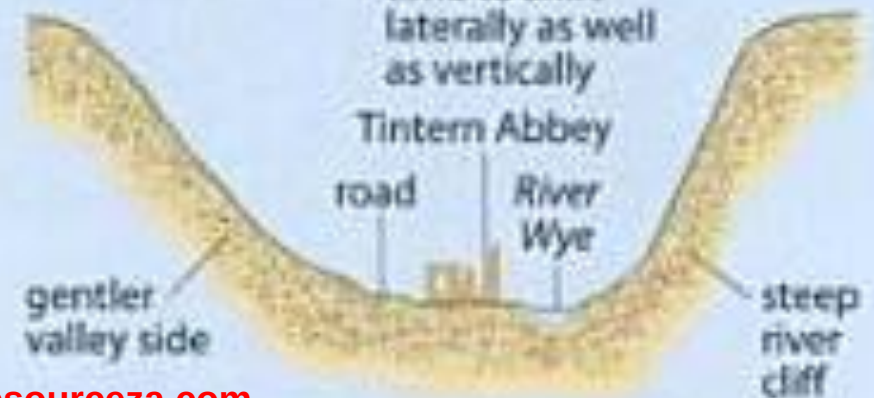
cross-valley profile: River Wear has cut vertically



b long, low meanders: R. Wye, Tintern Abbey to Symonds Yat

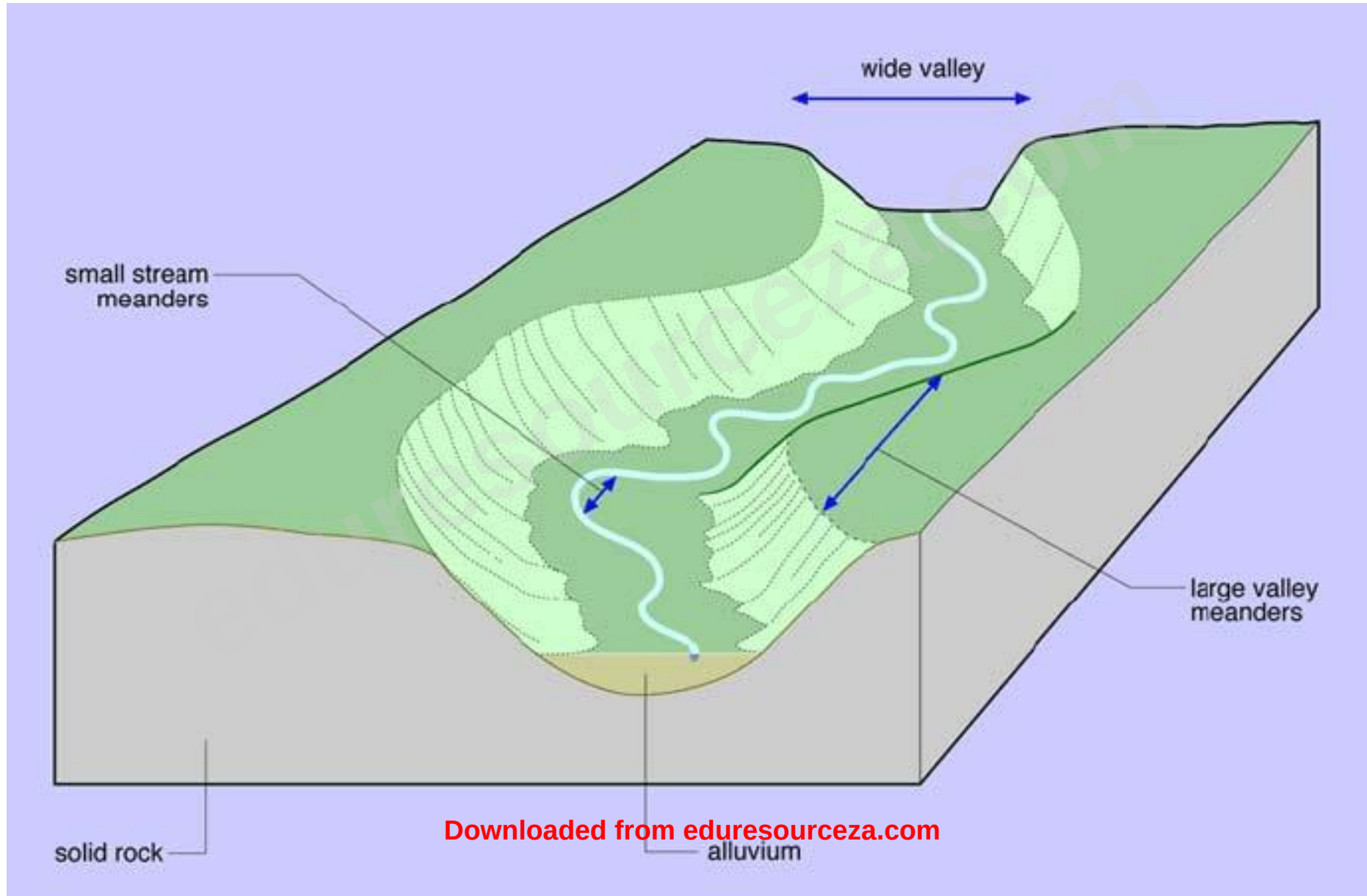


cross-valley profile: River Wye had time to shift laterally as well as vertically



Incised meander

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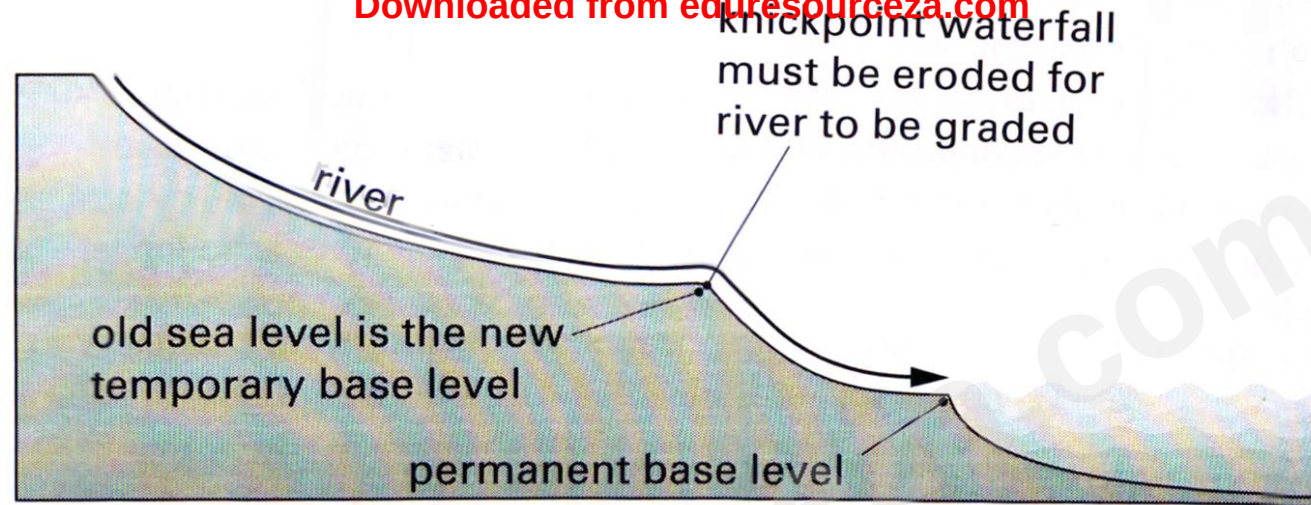
Class & prep work

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1.

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Rejuvenated river – longitudinal profile

2.

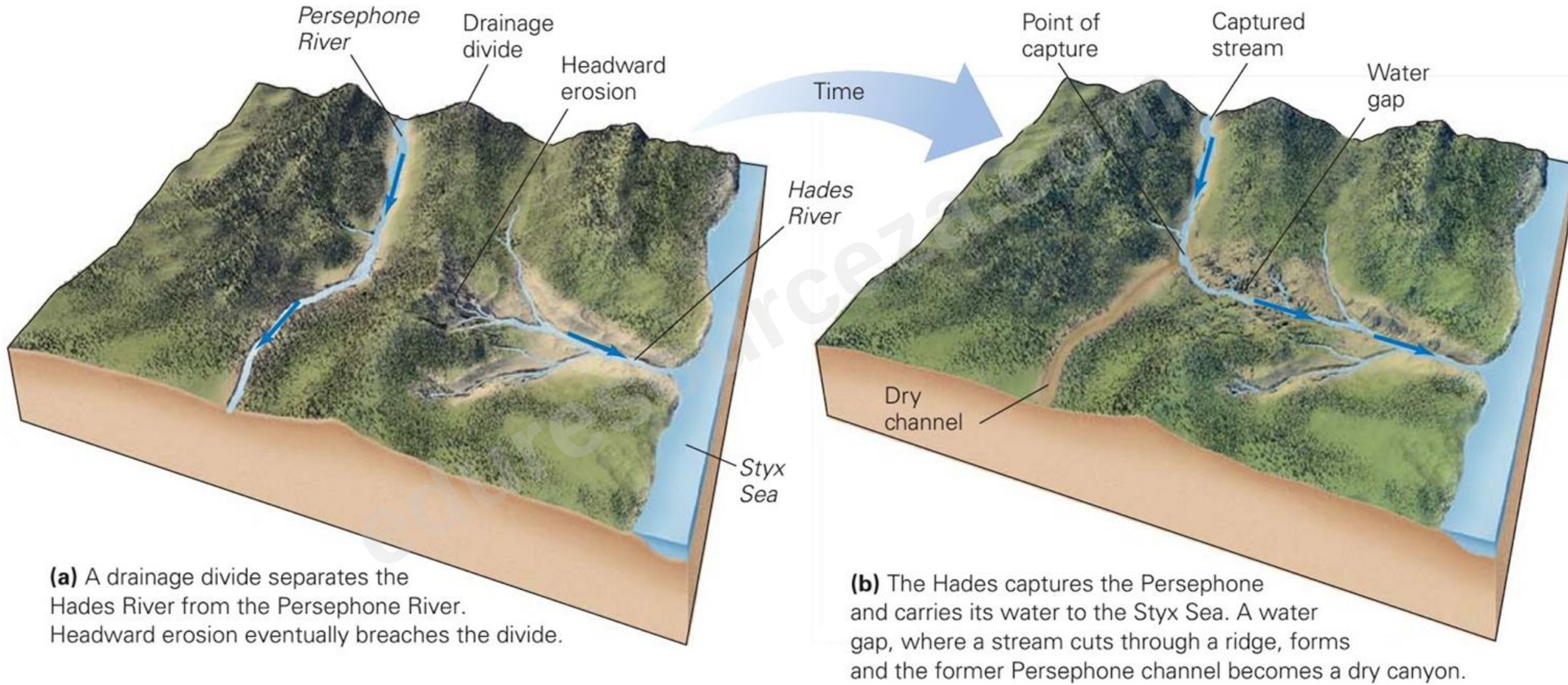


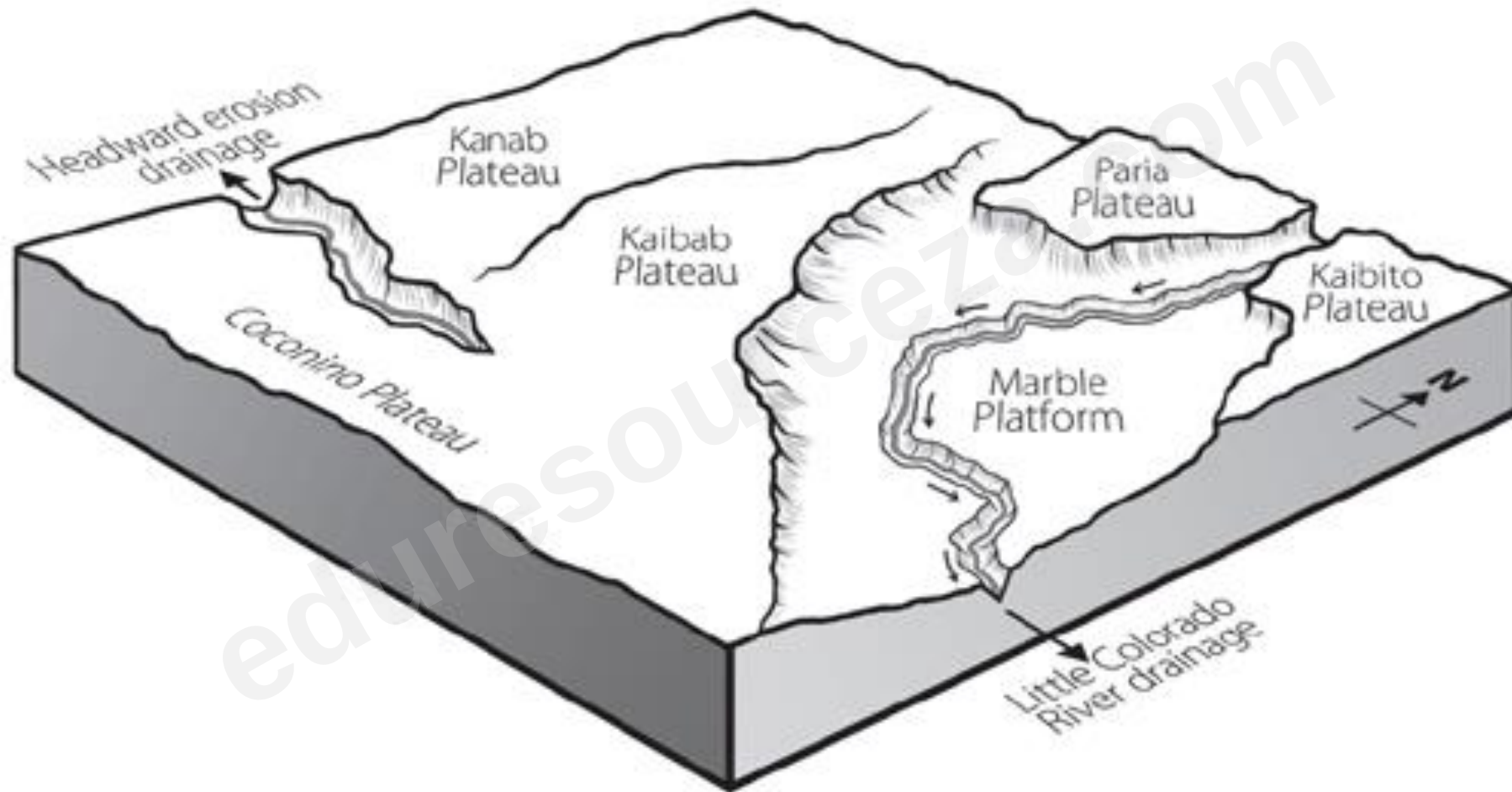
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Cross profiles before rejuvenation and after rejuvenation

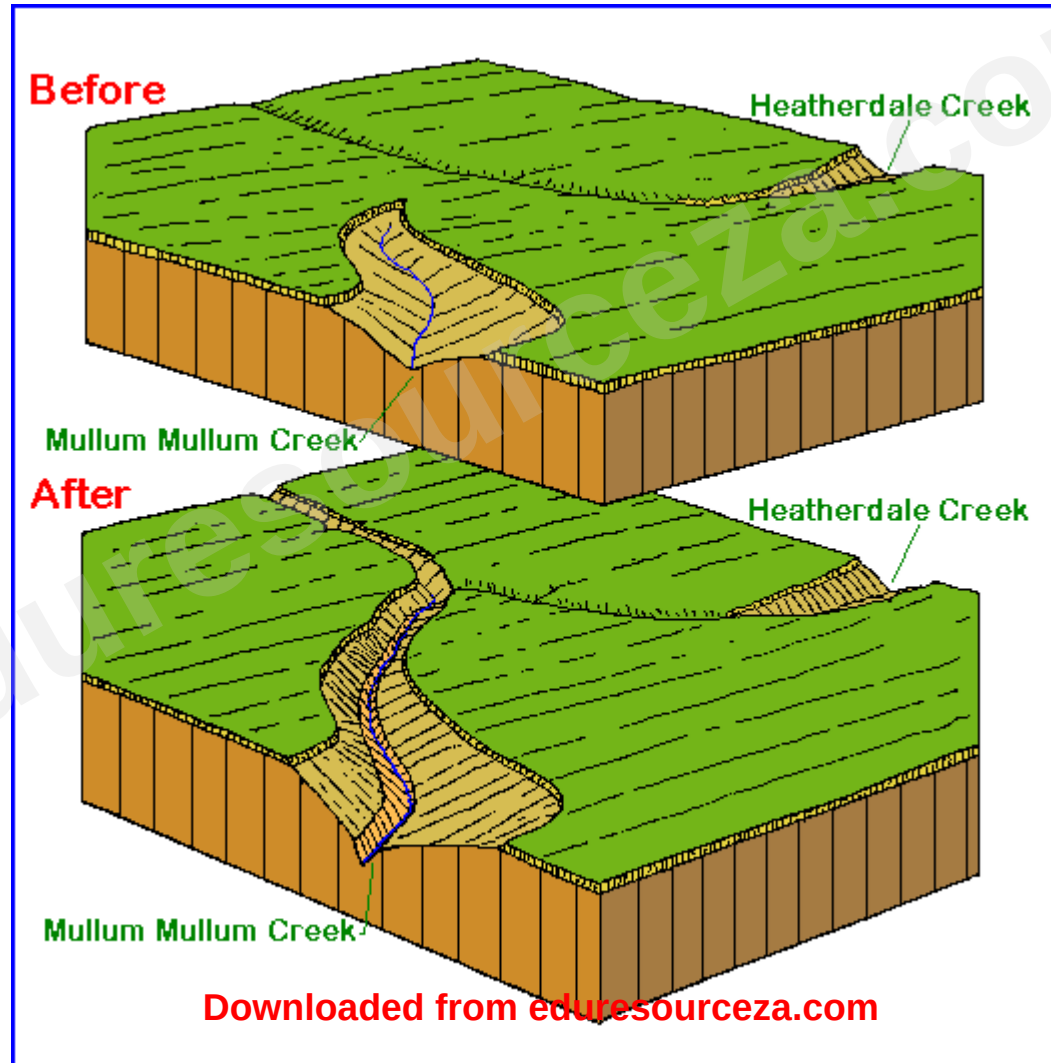
River capture (stream piracy)

- River capture = more energetic streams meet the courses of other rivers & divert their flow into other drainage basins
- A river that flows down a steeper gradient & has a larger volume or flows over weaker strata, has more energy & can become a captor stream
- By headward erosion the more energetic river erodes through the watershed & captures the water of the less-energetic river flowing at a higher level
- Headward erosion = the lengthening of a river course at its source due to the erosion of the watershed
- At the point of capture, the captured river changes direction & flows into the lower-lying river
- The discharge of the captor increases, which gives it more energy
- This results in rejuvenation, enabling more vertical erosion





River Capture



Possible knickpoint
waterfall

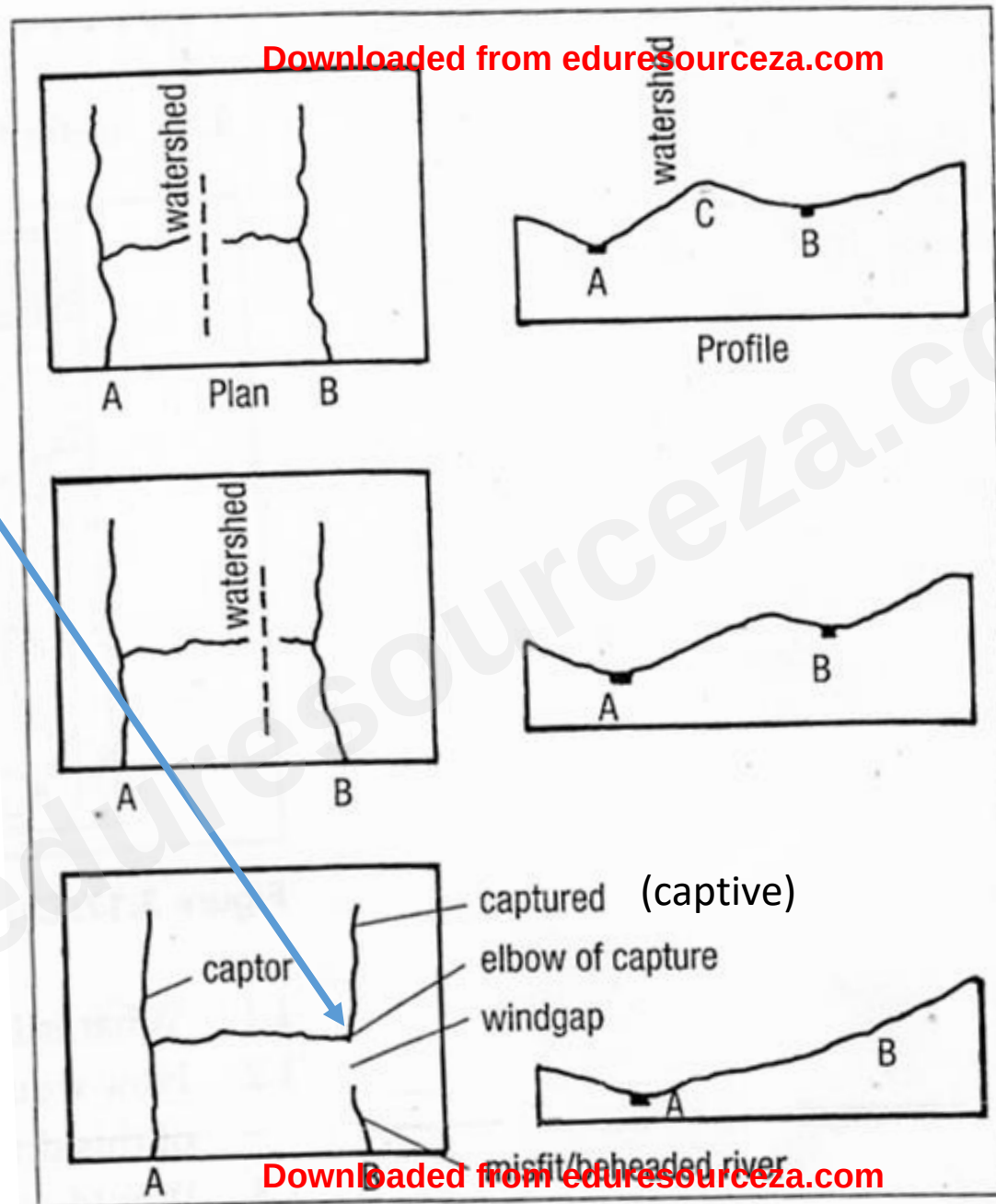
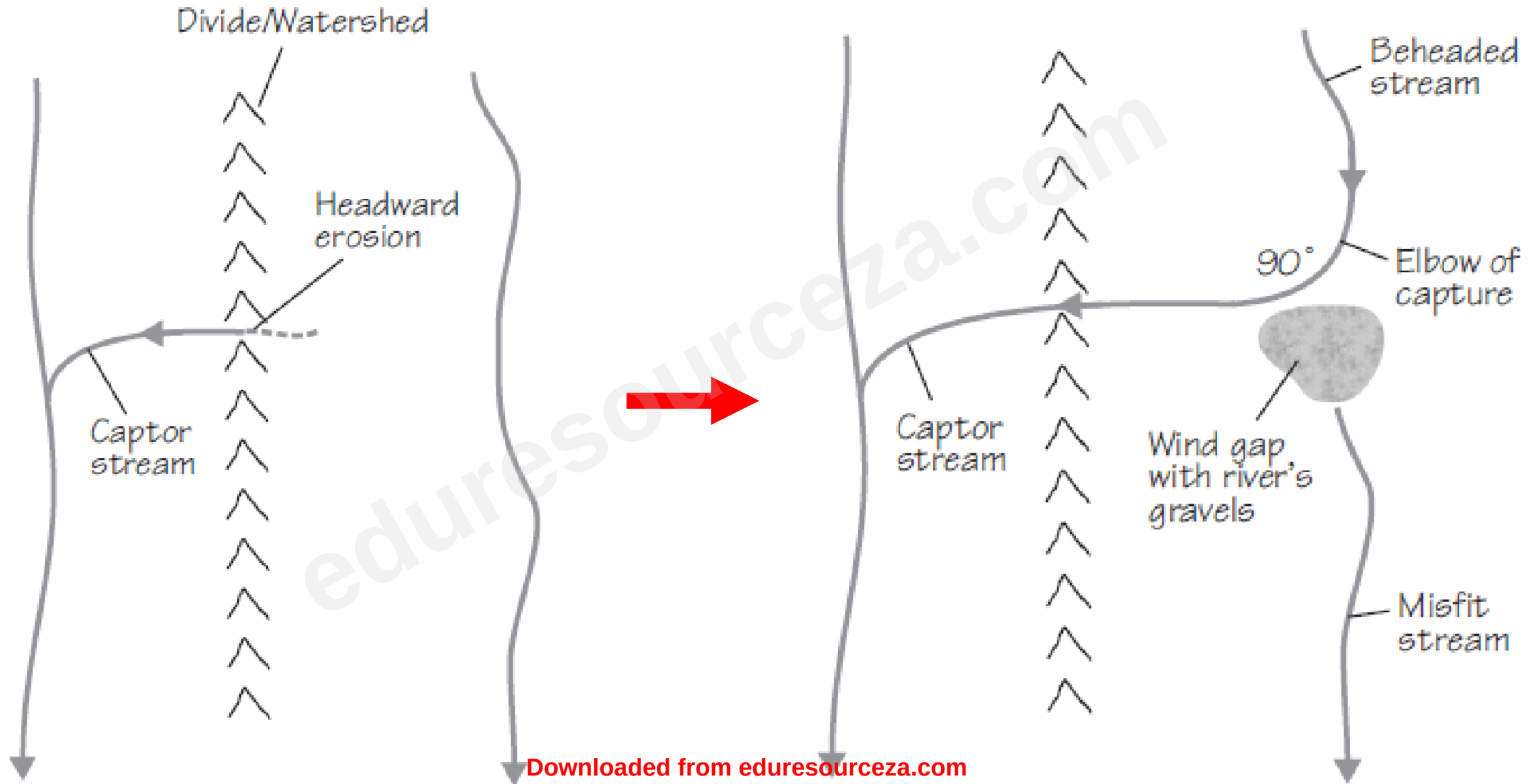
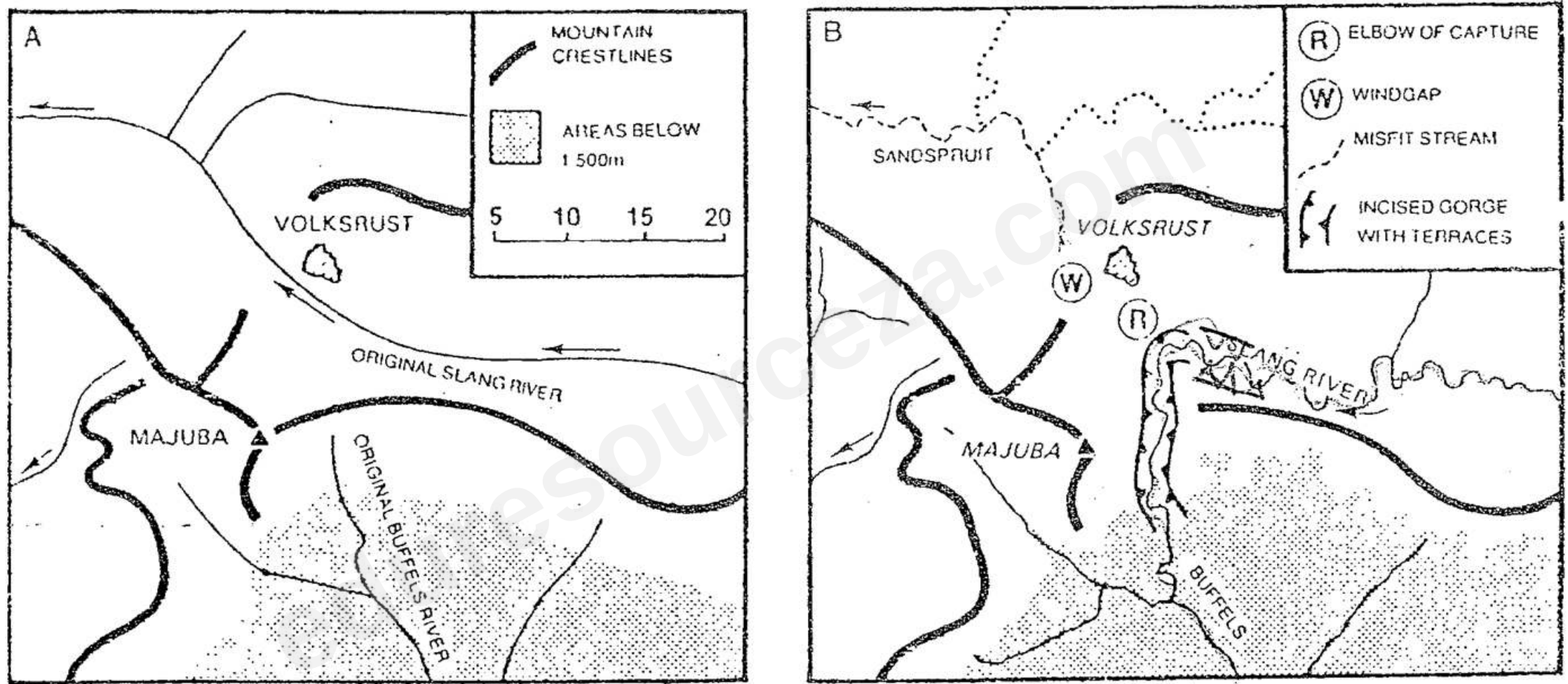


FIGURE 3.30: Features of river capture





The westward-flowing Slang River, near Volksrust on the Highveld, was intercepted by a rapidly headward-eroding tributary of the Buffels River: A is a reconstruction of the original drainage prior to the capture, B represents the present position. B displays the four classical features of stream capture: an elbow of capture (R), a windgap (W), a misfit stream (Sandspruit) and the incised ravine along the present course of the Buffels ending in a knickpoint in the Slang River.

Activity

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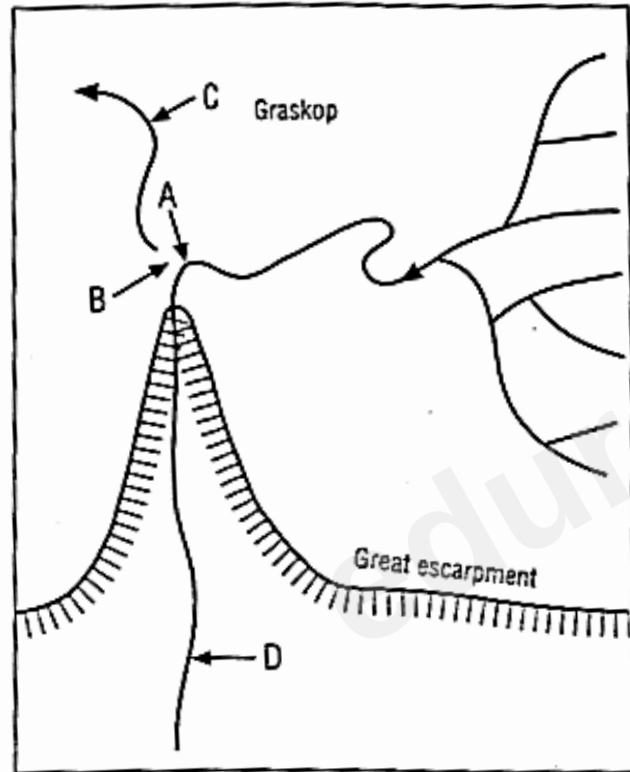


Figure 3.18: River capture

3. Refer to Figure 3.18 which shows river capture.
- 3.1 Identify the features of river capture labelled A, B, C and D.
- 3.2 With reference to Figure 3.18, explain how river capture took place here.
- 3.3 What impact will river capture have on the volume and velocity of river D?

$$4 \times 2 = (8)$$

$$3 \times 2 = (6)$$

$$2 \times 2 = (4)$$

$$\text{Total} = 60$$

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ACTIVITY 15 *Identifying river capture* (LO1; AS4/LO3; AS1)

The diagrams below show a region before and after river capture took place.

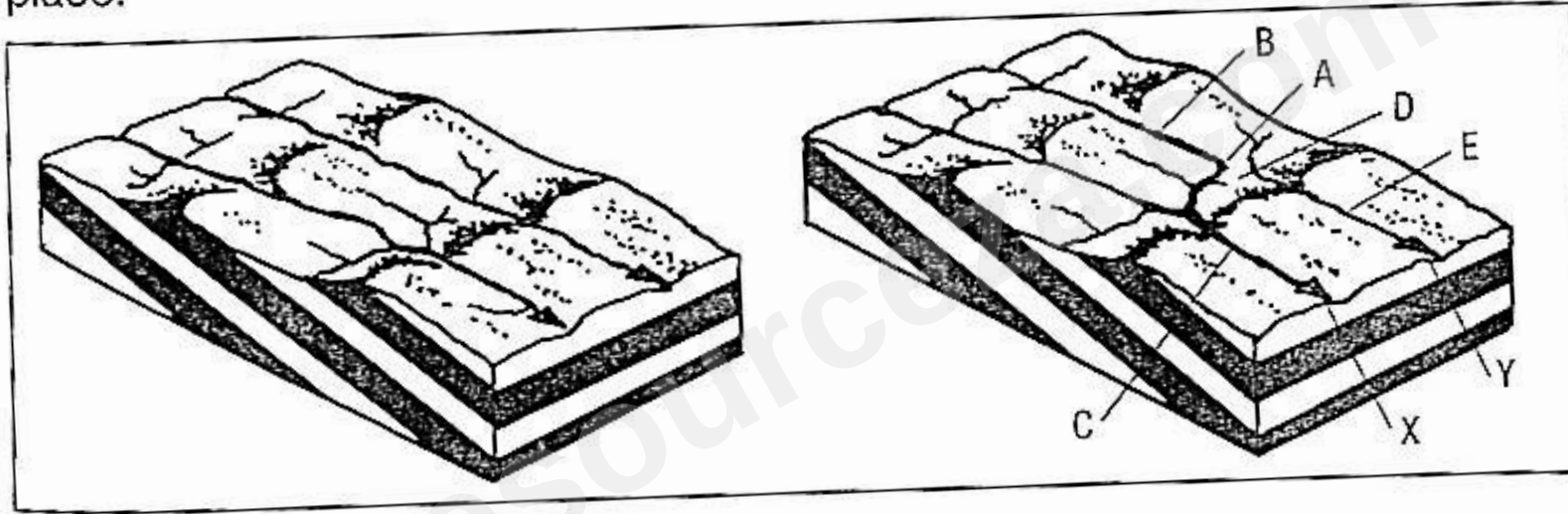


FIGURE 3.31: River capture

- 1 Identify the features of river capture labelled A, B, C, D and E.
- 2 Explain how river capture took place in this region.
- 3 Describe and account for the flow characteristics of rivers X and Y after river capture has occurred.
- 4 What impact will river capture have on the ecology of the area along river Y?

Results of capture

- The beheaded stream has lost some of its water & it now flows in a valley that is larger than it should be
- It loses energy & becomes undergraded & deposits some of its load
- The captor forms a deep valley with its additional energy
- It is overgraded & the river erodes a deep valley that retreats upstream through headward erosion

Abstraction

- Abstraction = the lowering and recession of a watershed
- Rivers flowing down a steeper slope will erode the slope quicker than rivers flowing down a more gradual slope
- Sheetflow & mass movements cause greater erosion on the side of the watershed with the steeper gradient
- The side of the watershed is eroded until both sides have the same gradient
- It may be associated with river capture

Abstraction

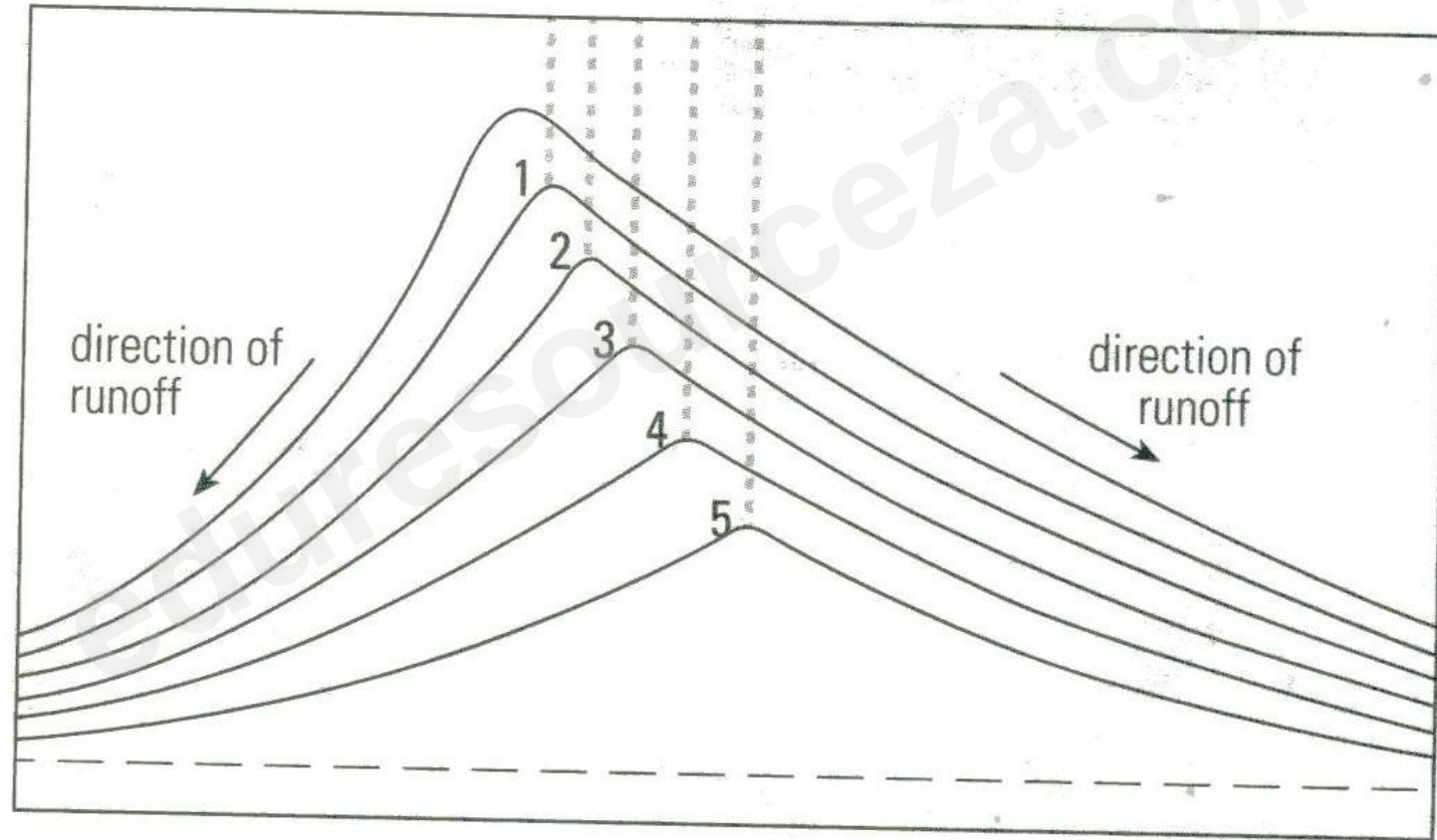
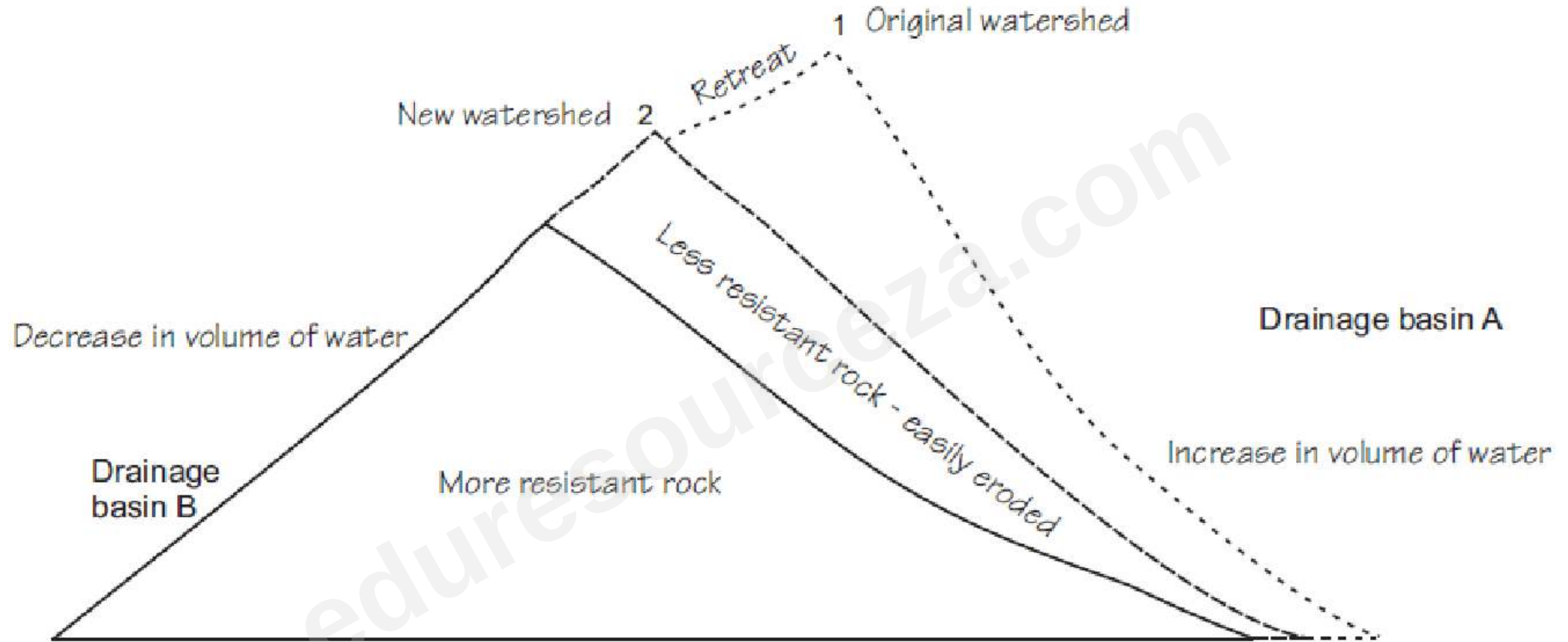


Figure 5.22 Abstraction



- Drainage basin A has a steep gradient with less resistant rock.
- Headward erosion occurs in the area between 1 and 2.
- The water from the area between 1 and 2 will no longer flow into area B but now flows into the catchment area of A.

Class & prep work

- Activity 15 p 154

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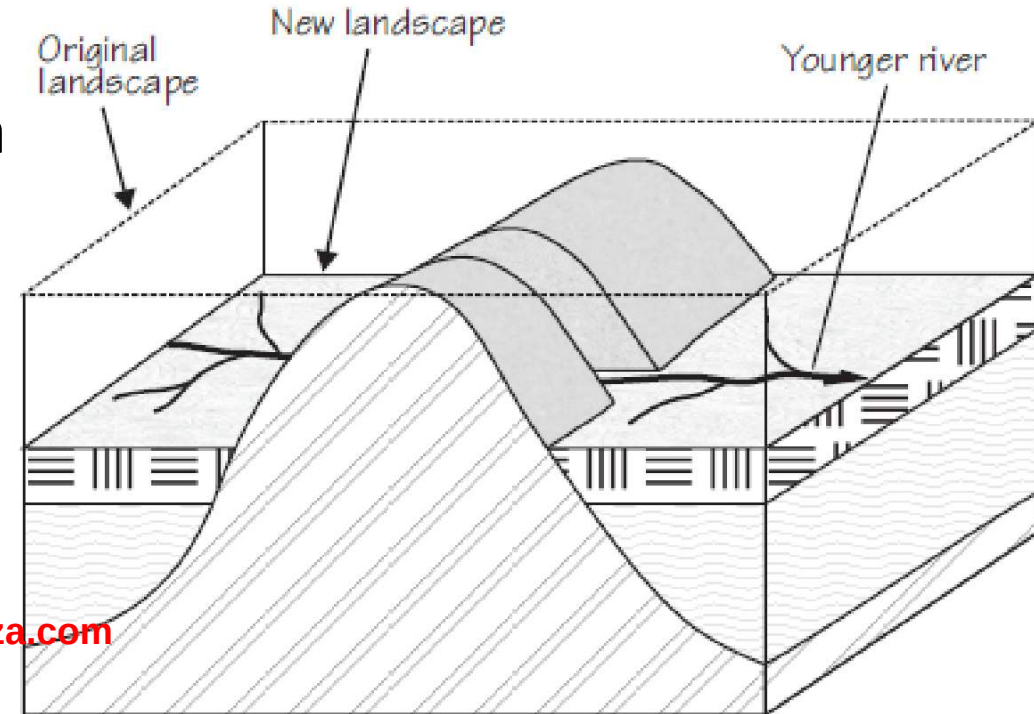
Superimposed & Antecedent drainage patterns

- They do not relate to the rock structure & relief of the area in which they occur

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Superimposed drainage pattern

- Older layers of **horizontal strata** are exposed at the earth's surface because of **erosion**.
- The river now develops its course on this older landscape.
- The river pattern does not match the structure of the underlying surface.
- Rivers are **superimposed** (placed on top) on a landscape that is older than the river itself.
- Superimposed streams are **younger** than the landforms (structures) that they cut through.
- Rivers have **inherited** their courses from the former overlying layers.
- SA e.g.'s Vaal, Crocodile & Apies Rivers



1 Stream course established on flat-lying younger rocks



2 Younger rocks eroded

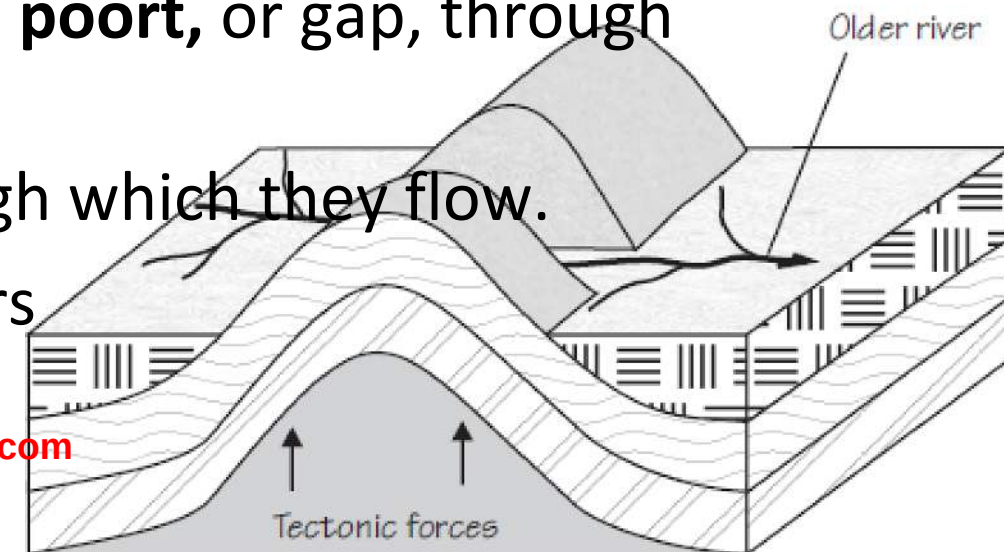


Vaal River near Parys

- <https://www.google.co.za/maps/place/Parys/@-26.8554576,27.3609478,56640m/data=!3m1!1e3!4m5!3m4!1s0x1e943e6ab093a237:0xee46bd9b1b1d23e8!8m2!3d-26.9110891!4d27.4908738>

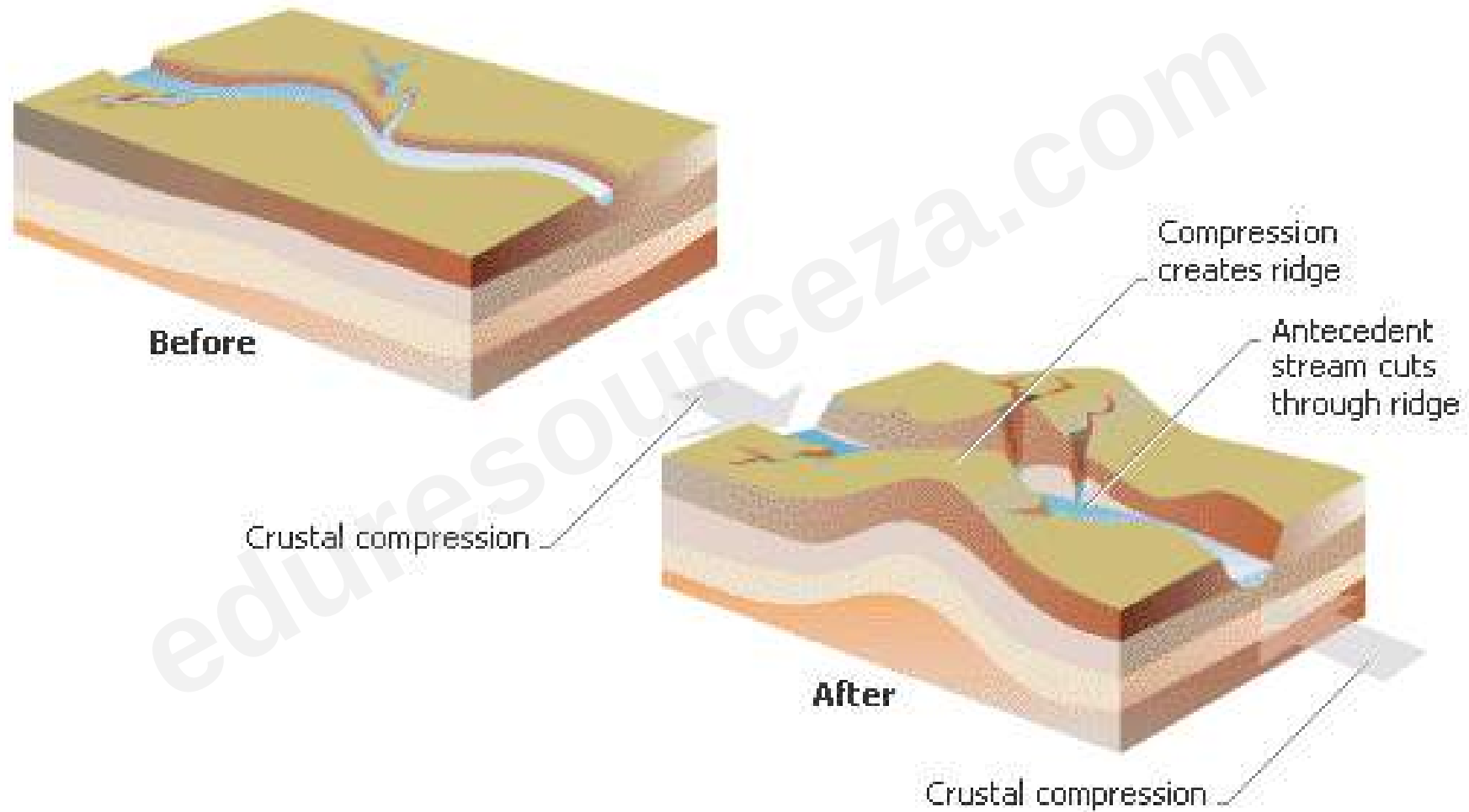
Antecedent (existed before) drainage pattern

- An area of the crust is **raised** because of **folding** or **faulting** (tectonic forces).
- The river develops its course on a former landscape.
- The river was able to erode fast enough to keep pace with the **uplifting landscape**.
- The stream is able to erode through the **folded structures** or **resistant rocks**.
- Rivers maintain their original course by cutting a **poort**, or gap, through the new folded mountain.
- These rivers are **older** than the structures through which they flow.
- E.g. Gariep (Orange), Indus & Brahmaputra Rivers

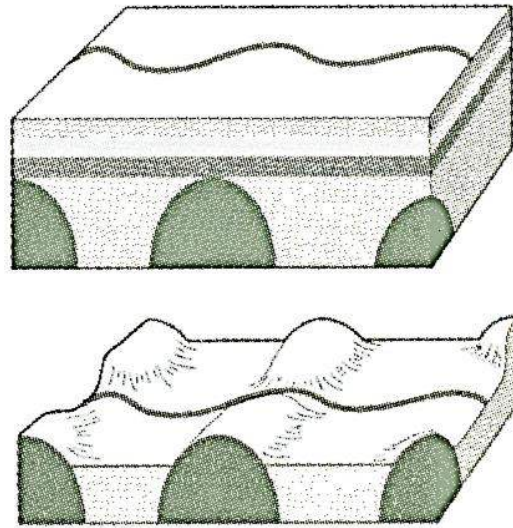


Indus & Brahmaputra Rivers

- <https://www.google.co.za/maps/place/Brahmaputra/@26.9900421,92.9067337,797828m/data=!3m1!1e3!4m5!3m4!1s0x39fd9fc3227c912d:0xf5bd18ec4b8cba8e!8m2!3d26.4746671!4d92.5347513>

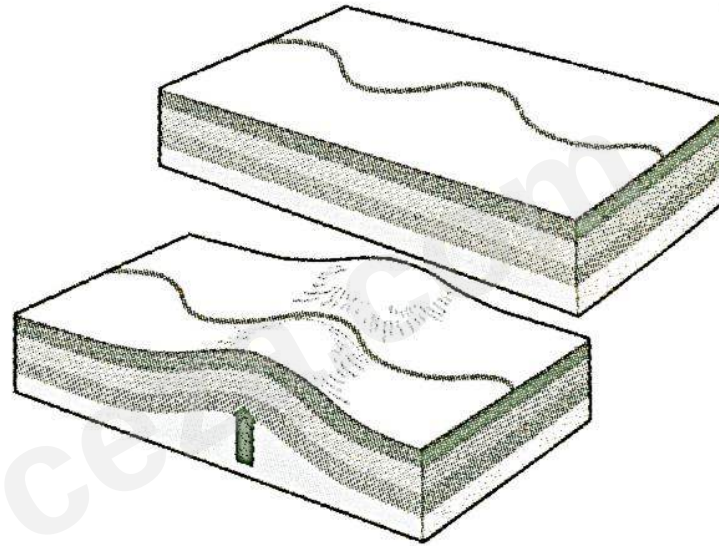


Superimposed drainage



- A river flows over an area where sediment covers a previously formed landscape.
- The river removes the sediment and then continues to flow over the uncovered landscape.
- The river will erode into the exposed structures creating gaps or poorts.
- The river is therefore younger than the features it flows over and erodes into.

Antecedent drainage



- The river developed first.
- The area then underwent change as a result of faulting, folding, or warping. As these tectonic movements occurred, the river continued in its same course eroding at the same rate that uplift occurred.
- The river eroded gaps and poorts.
- The river is therefore older than the structures it flows over.

Class & prep work

- Activity 16 p 157

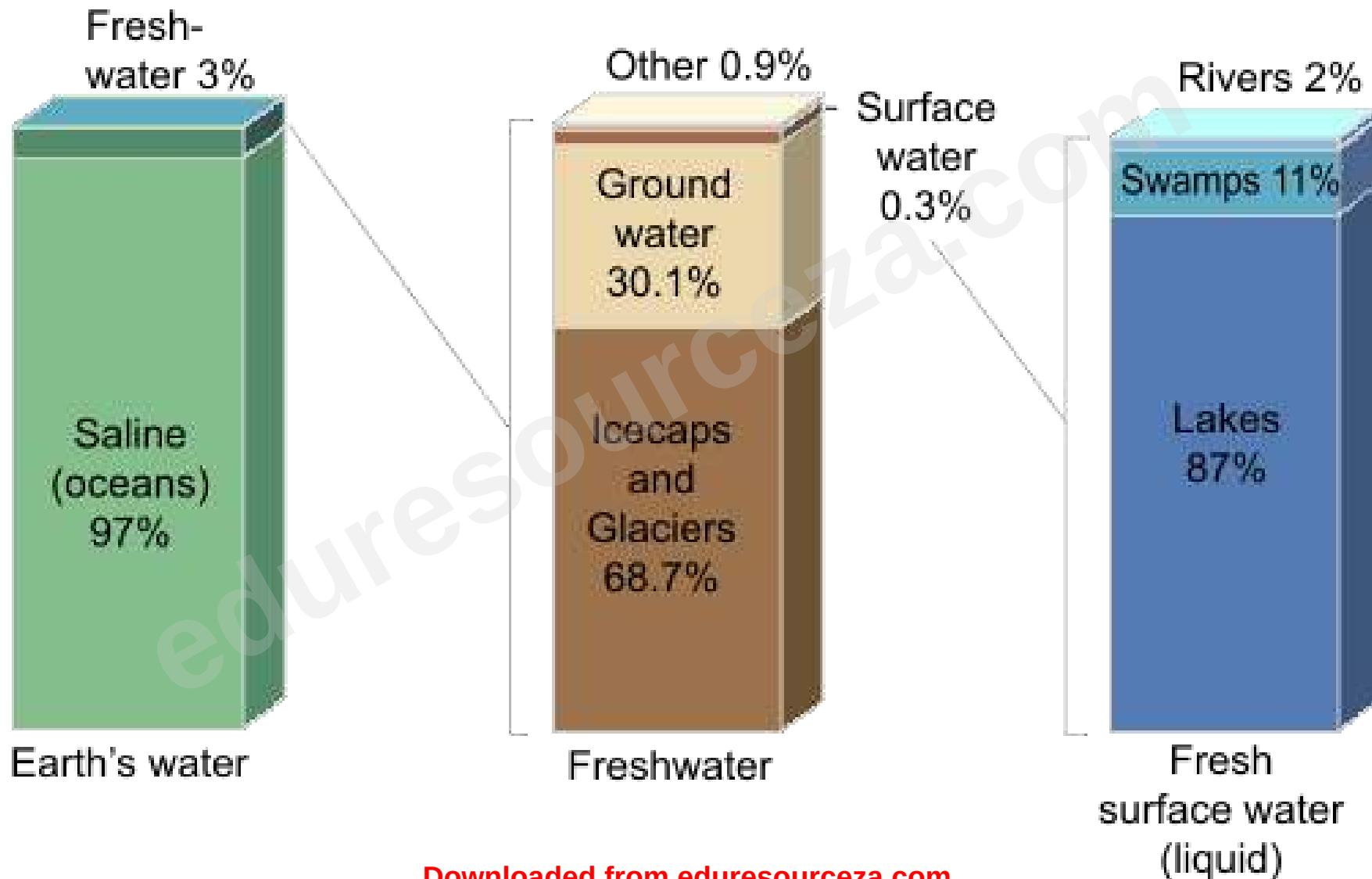
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Importance of managing drainage basins & catchment areas

- Only 2 % of Earth's water is fresh & suitable for human use
- SA is a 'water-scarce' country receiving just over half of the world average
- More & more water is needed as development occurs
- Drainage basins collect & store water which makes their management important

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Distribution of Earth's Water



Importance of water sources & wetlands & why they should be managed

- Human health – free of disease
- Agriculture, industry, business, development, hydroelectricity
- Food
- Recreation, tourism, cultural activities & settlement
- Riparian zone for wildlife
- Wetlands remove harmful bacteria & reduce water acidity, filter sand, acts as a sponge holding water reducing flood damage, wildlife habitat
- Integrated Water Resources Management = policy that groundwater, rivers & wetlands need to be managed **together** as well as land that surrounds water
- A drainage basin consists of inputs, stores, flows & outputs

Impact of people on drainage basins & catchment areas

- Volume & nature of water flow
- Land surfaces over which water flows before it reaches rivers
- Quality of water that is underground, that flows over land & that flows in the river

Think, Pair, Share

- Think: How do the following affect a river: boreholes, mining, overgrazing, nutrients & pesticides, urban surfaces, wetland destruction, water removal, mismanaged sewage, water transfer schemes, dam construction, alien plant species, alien fish
- Pair
- Share

Catchment & drainage basin management

- Legislation to control underground water usage
- Legislation to control discharge into rivers
- Vegetation clearing control & control of alien vegetation
- Avoid construction & settlement on flood plain
- Care taken when altering river channels to prevent flooding
- Environmentally sustainable practices
- Conservation of water resources
- Manage entire drainage basin
- Conserve wetlands
- Investigate properly before new dams are built
- Maintain vegetation in riparian zone

SA drainage basin management

- Department of Water Affairs & Forestry (DWAF) is responsible for rivers
- National Water Act provides for the establishment of Catchment Management Agencies that manage & develop catchments
- Department of Environmental Affairs & Tourism (DEAT) runs a wetlands conservation programme – Ramsar site = a wetland identified as being internationally important
- Working for Water projects by various Water Boards – employ locals to clear alien vegetation & rehabilitate wetlands

Ramsar sites

- <https://rsis.ramsar.org/>

The River Health Programme in SA

- DWAF together with DEAT & the Water Research Commission introduced the River Health Programme (RHP) in 1994
- Information is collected & reported about a river's health
- Suggestions are made to achieve the desired health
- The RHP uses indicators & icons to report on a river

RIVER HEALTH PROGRAMME CONCEPTS



Aquatic invertebrates

South African
Scoring System
(SASS)



Fish Communities

Fish Assemblage
Integrity Index
(FAII)



Riparian vegetation

Riparian vegetation
index
(RVI)

Natural

No measurable modification

Good

Biodiversity largely unmodified

Fair

Sensitive species lost or less abundant

Poor

Population dynamics disrupted

RHP

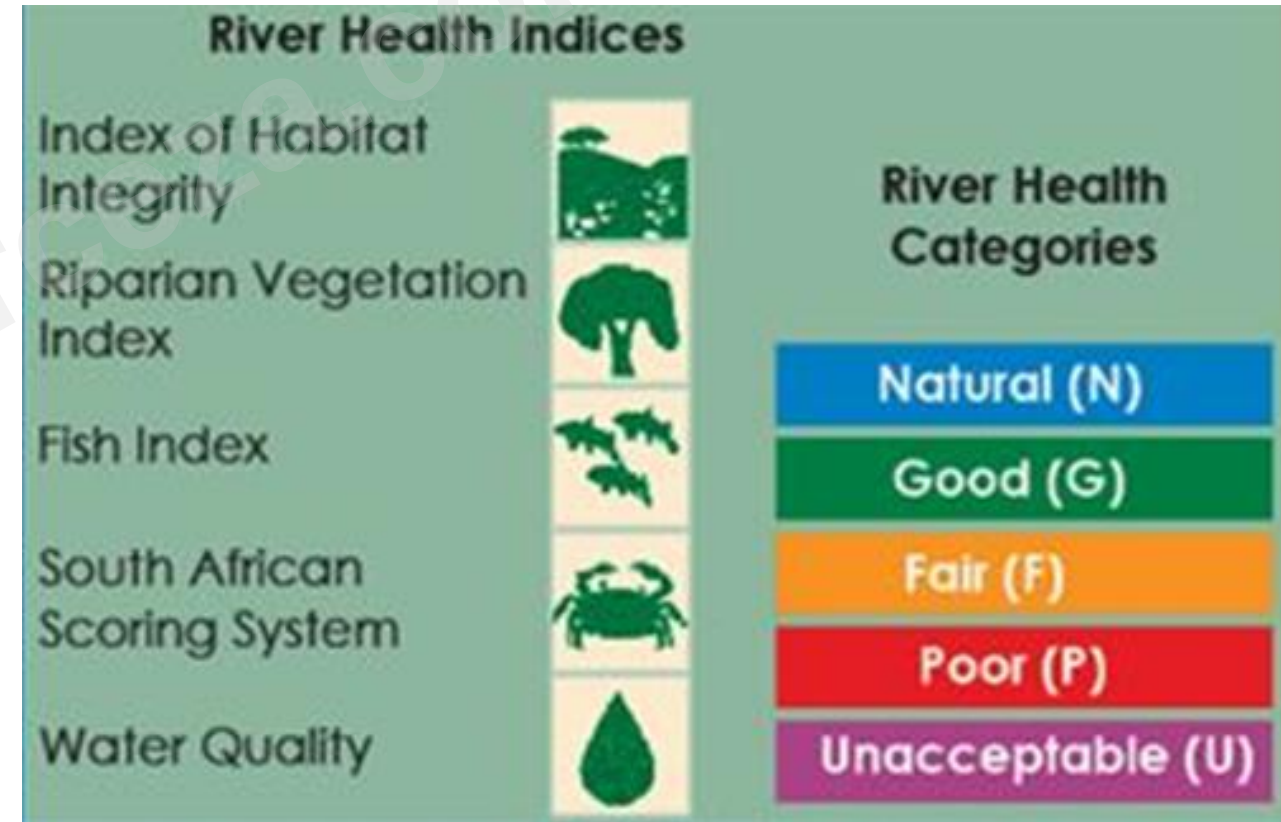
IHI = assesses the diversity of habitats & impact of disturbances e.g. removal of water & channel modification

Geomorphological index (GI) = assesses channel condition due to impacts of weirs & dams & channel stability in relation to banks & beds

RVI = indicates the status of vegetation around the river & human influence on that vegetation

Fish Assemblage Integrity Index (FAII) = variety & quantity of fish

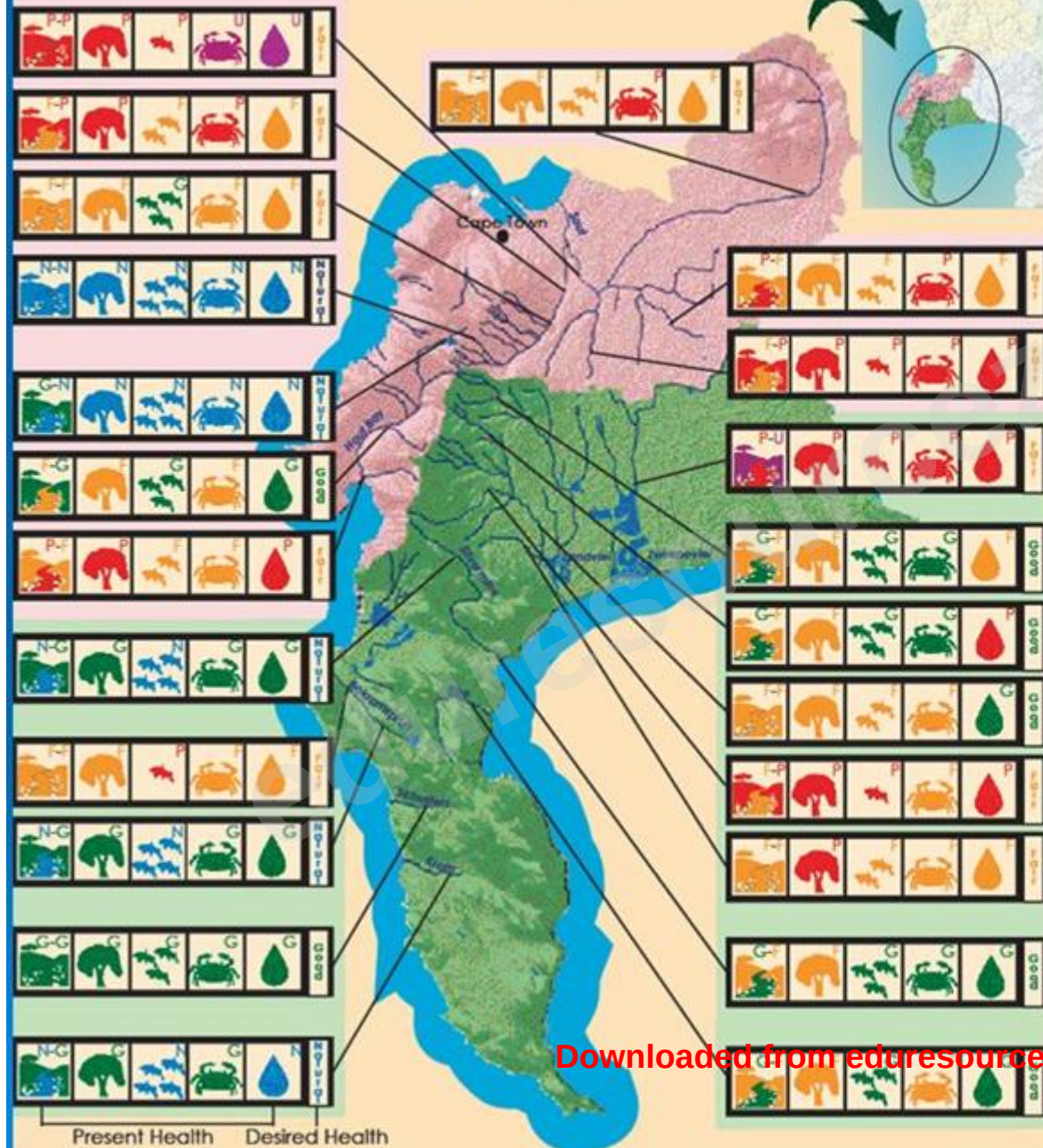
SASS = assesses changes in structure & composition of aquatic invertebrates as this indicates short-term changes in water quality



SOUTHERN AND CENTRAL RIVERS

PRESENT STATE

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River Health Programme – Example of River Assessments

River Health Indices

Index of Habitat Integrity



Riparian Vegetation Index



Fish Index



South African Scoring System



Water Quality



River Health Categories

Natural (N)

Good (G)

Fair (F)

Poor (P)

Unacceptable (U)

Case Study – Buffalo River System & drainage basin RHP assessment

- Activity 19 p 164

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Bifurcation ratio (R_b) (Latin – *furca* = fork)

- = a dimensionless number denoting the **ratio** between the **number of streams of one order & those of the next-higher order** in a drainage network
- It looks at the relationship of streams of different orders e.g., if a drainage basin has 7 first order streams, 4 second order streams & 2 third order streams, then to calculate the R_b you divide the number of first order streams by the number of second order streams ($7/4=1,75$), then divide the number of second order streams by the number of third order streams ($4/2=2$). You then add together the results ($1,75+2=3,75$) & divide by the total sets of values ($3,75/2=1,875$). The drainage basin therefore has a bifurcation ratio of 1,88.

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Stream order	Number of stream segments	R_b
1	7	---
2	4	1,75
3	2	2
4	1	2
	Average	$(1,75+2+2)/3$ $= 1,58$

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Stream orders – Bifurcation Ratio

Stream Order (u)	No. of Stream Segments (Nu)	Bifurcation Ratio (Rb)
------------------	-----------------------------	------------------------

1	139	
---	-----	--

2	46	
---	----	--

3	11	
---	----	--

4	3	
---	---	--

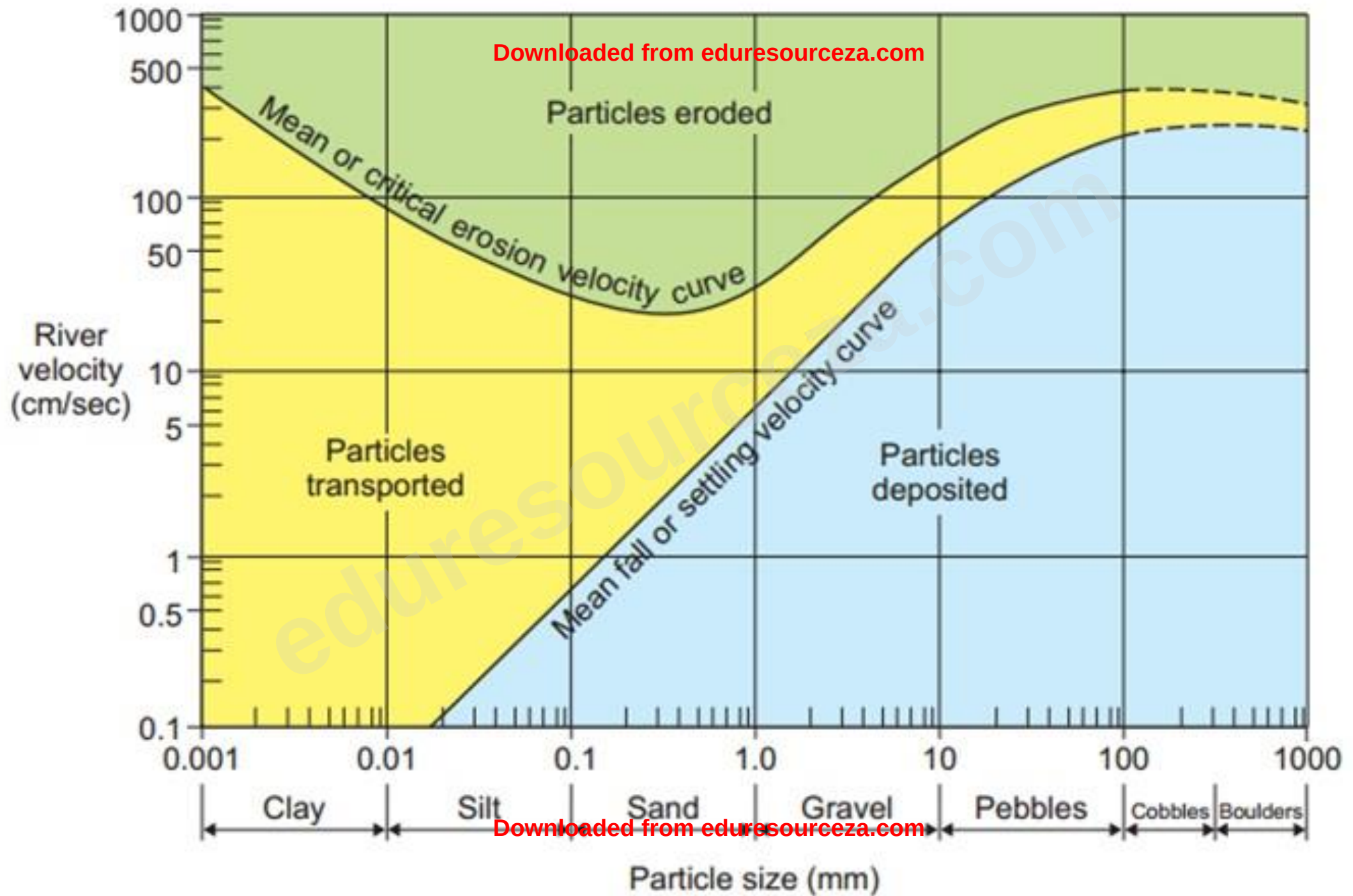
5	1	
---	---	--

Usefulness of the bifurcation ratio

- It helps in interpreting the shape of the basin & deciphering the runoff behaviour
- The R_b varies from a minimum of 2 in “flat or rolling drainage basins” to 3 or 4 in “mountainous or highly dissected drainage basins”
- It may be a useful measure of flood proneness – the higher the R_b , the shorter will be the time taken for discharge to reach the outlet, & higher will be the peak discharge – leading to a greater probability of flooding
- It correlates positively with drainage density i.e., a high R_b indicates a high drainage density
- Higher R_b also suggest that the area is tectonically active
- The R_b can also show which parts of a drainage basin is more likely to flood, comparatively, by looking at the separate ratios

Hjulström curve

- = a special type of graph which shows how a river's velocity affects its competence & its ability to erode particles of different sizes

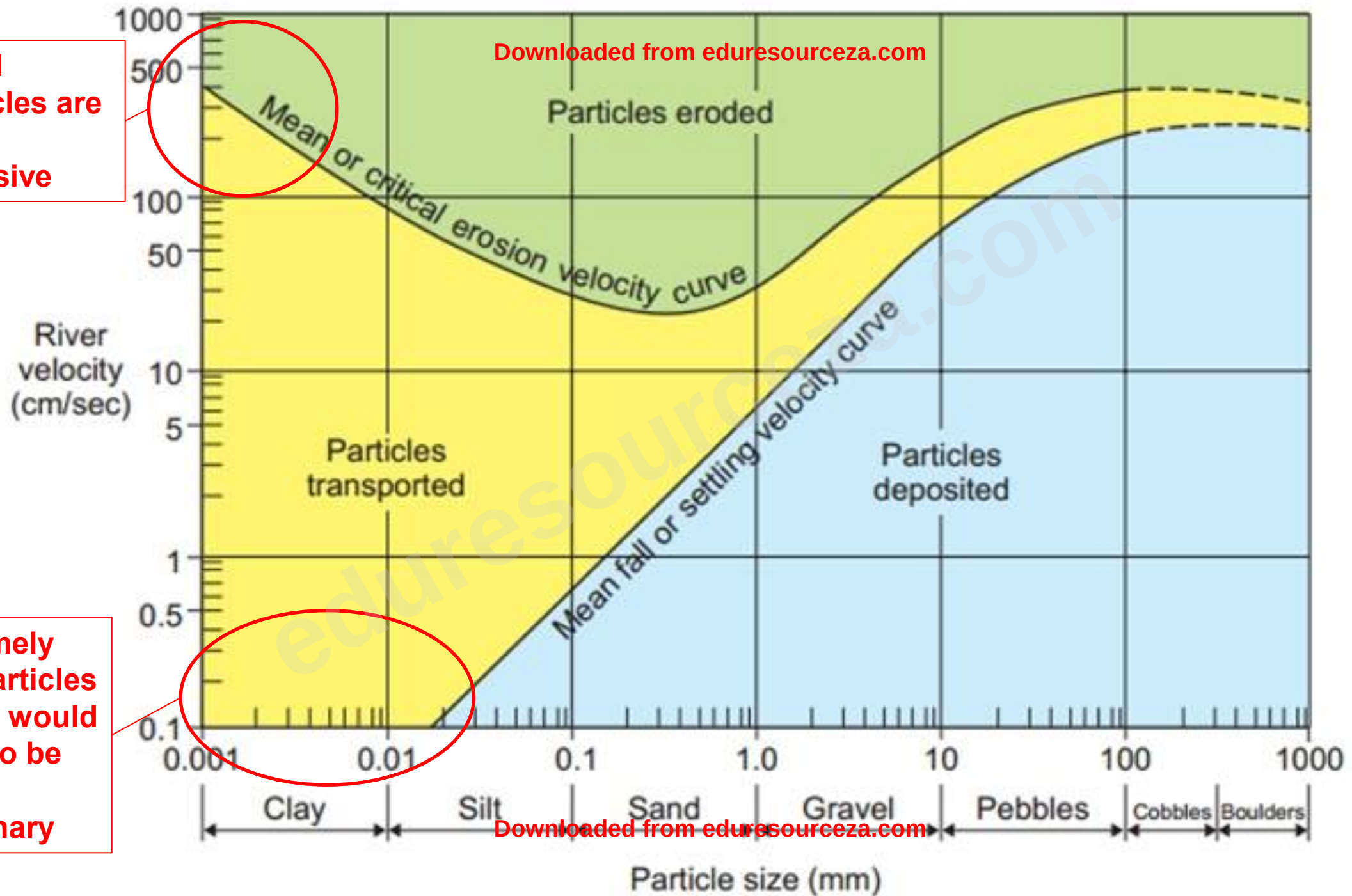


Two curves of the Hjulström graph

- **Critical erosion velocity** curve – shows the minimum velocity needed to transport and erode a particle
- **Mean settling velocity** curve – shows the minimum speed that particles of different sizes will be deposited by a river
- The shaded areas between the curves show the different processes that will be taking place for particles that lie in those shaded areas – erosion, transportation, deposition
- As an example, a river flowing at 10 cms-1 will erode & transport large clay, silt & sand particles but will deposit gravel, pebble and boulder particles
- Conversely, a river flowing at 100 cms-1 will erode & transport large clay particles, silt, sand & most gravel particles. It will transport all but the largest of pebbles & will deposit boulders.
- To read the curve, draw a horizontal line from the velocity you are trying to read
- Two interesting things to note:
 - Clay sized particles don't seem to have a mean settling velocity. This is because these particles are so fine that a river would have to be almost perfectly stationary in order for them to fall out of solution.
 - Small particles seem to have an erosive velocity that's the same as the velocity for larger particles. This is because smaller particles are cohesive, they stick together, making them harder to dislodge & erode without high velocities.

Small particles are very cohesive

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Extremely fine particles – river would need to be nearly stationary

Class & Prep work

- Exam Practice p 166-167
- Practise geographical skills & techniques p 168-169

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Revision Questions

- Define the terms; drainage basin, watershed, and drainage texture
- Differentiate between the following terms:
 - Drainage pattern and stream pattern
 - Antecedent and superimposed drainage
 - Abstraction and headward erosion
 - Grade and gradient
 - Temporary and permanent base levels of erosion

Answers

- Drainage basin: the area drained by a river and all its tributaries
- Watershed: The highlying area separating drainage basins
- Drainage density/texture: This is the ratio between the total length of streams and the area drained by them

Answers

- Drainage pattern: the shape of the stream network in a drainage basin

Stream pattern: the shape of an individual stream segment within a stream network

Answers

- Antecedent drainage: when a river has maintained its original direction of flow across later tectonic topography

Superimposed drainage: Drainage pattern contrary to structure, created by erosion of layers originally above hard rock strata.

Answers

Abstraction: Where drainage basin A expands at the expense of drainage basin B, because A has one or more of the following characteristics; a steeper slope, more runoff or softer rock

Headward erosion: the process whereby a stream lengthens its course upstream. This results in abstraction.

Answers

- Grade: State of balance where there is no deposition or erosion occurring. The full energy of the river is being used to transport the river load. Signs of a graded river are:
 - No recently collapsed river banks
 - No deposition on river channel floor

Gradient: the slope of the river bed

Answers

- The lowest level to which the river can erode
- Temporary: a lake
- Permanent: the sea