Rivers and Alluvial Rivers

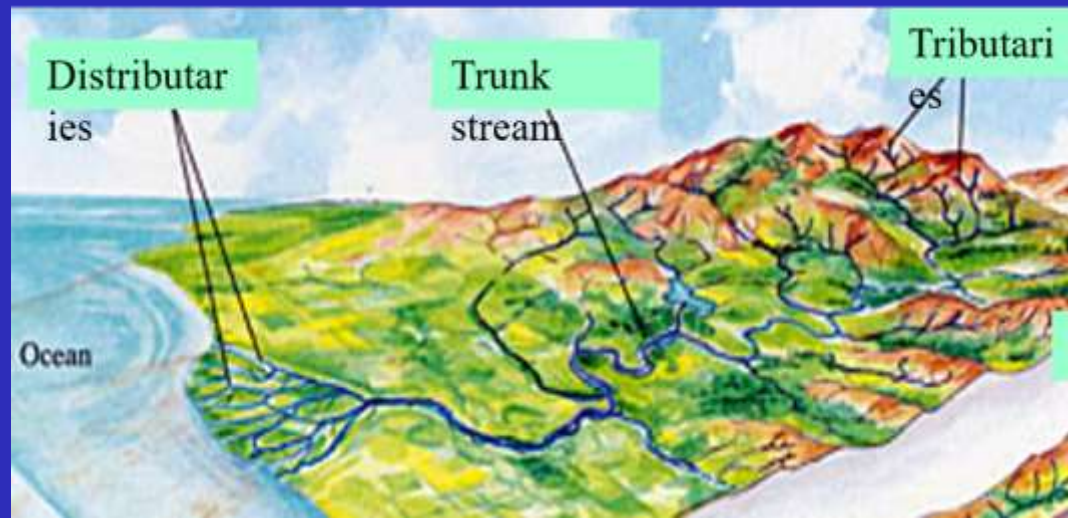
Rivers and streams are channelized flows of *water and sediment* transport within definable boundaries (banks). Overland flow on the other hand, is used for non-channelized flows of water, usually less than a few centimeters deep but very widespread. Surface runoff at first travels as overland flow, and then later as channelized flow as a river or stream.

A river system can be divided into three subsystems:

Collecting system (branches) -- consisting of a network of tributaries in the headwater region, collects and funnels water and sediment to the main stream.

Transporting system (trunk) -- the main trunk stream, which functions as a channel way through which water and sediment move from the collecting area toward the ocean. Erosion and deposition also occur in a river's transporting system that makes the river pattern.

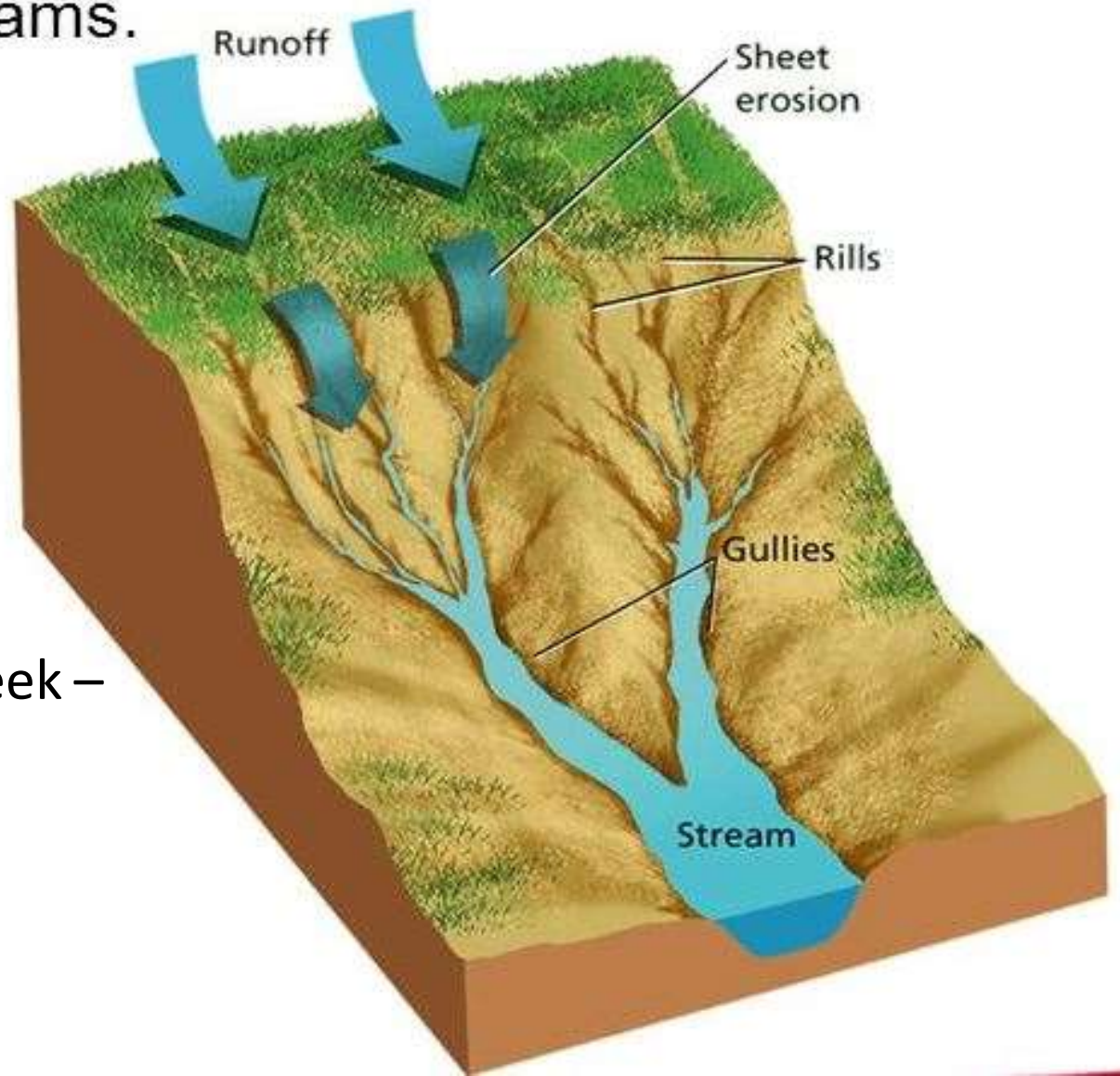
Dispersing system (roots) -- consists of a network of distributaries at the mouth of a river (delta), where the sediment and water are dispersed into an ocean, or a lake.



River as a tree – the trunk is the main river

Rivers and Alluvial Rivers

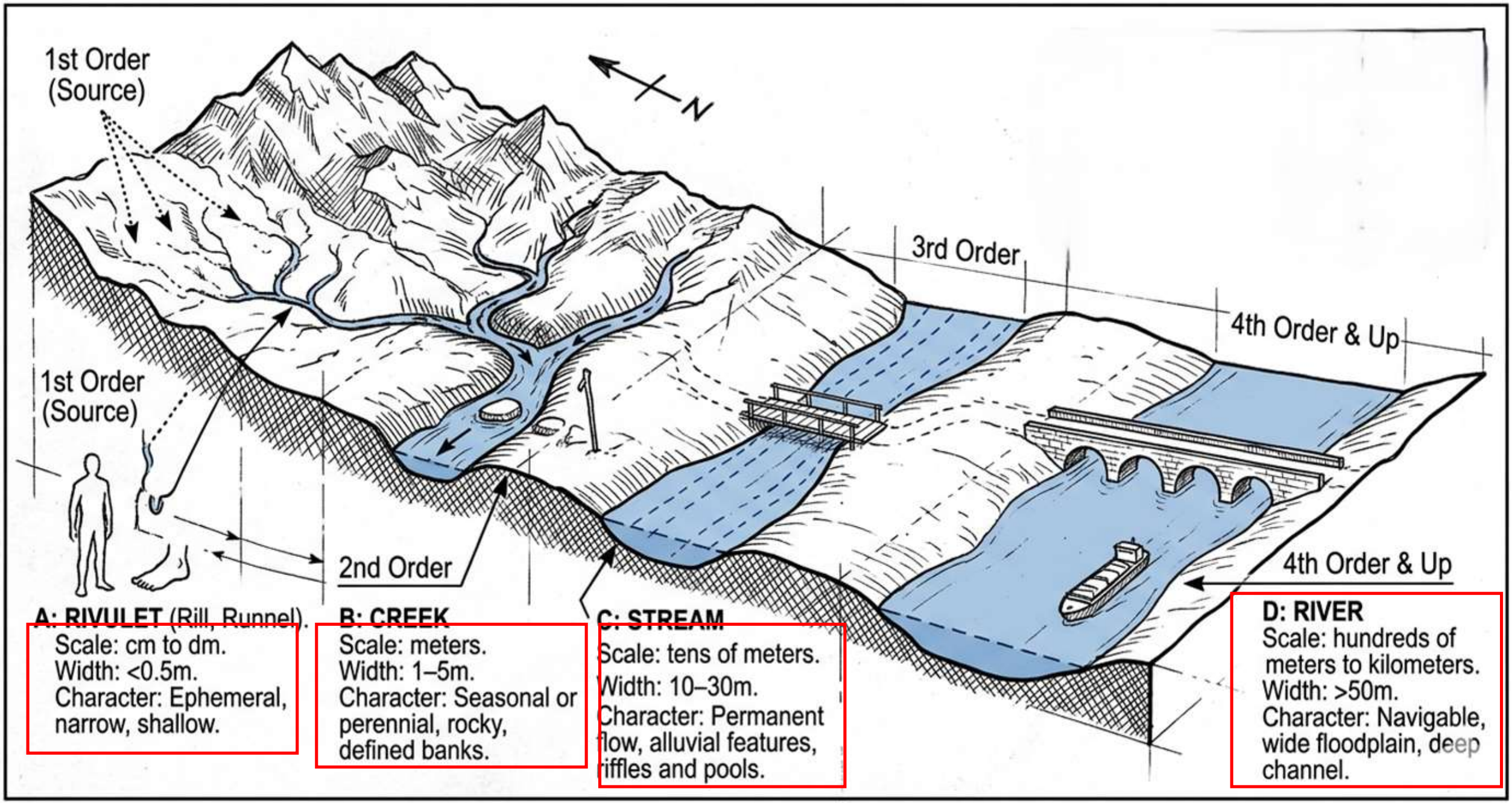
Water flowing across the land runs together to form rills, gullies, and streams.



Overland flow/sheet flow and stream/channelized flow

Rills/Rivulet –Gullies – Stream/Creek – River

COMPARATIVE SCALE AND CLASSIFICATION OF FRESHWATER FLOWS



Conceptually the river system can be divided into three main zones:

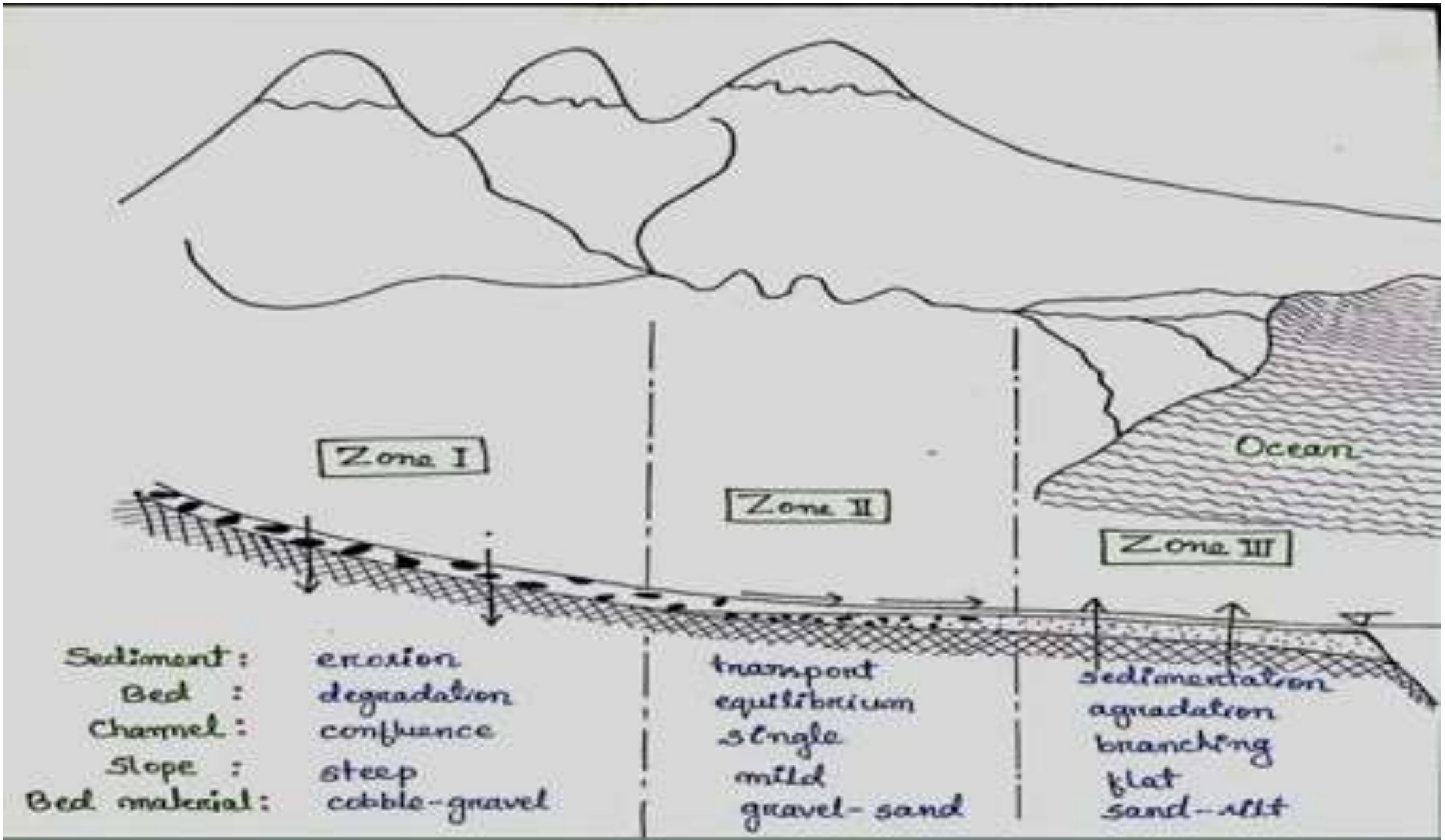
1. An ***erosional zone*** of runoff production and sediment source
2. A ***transport zone*** of water and sediment conveyance, and
3. A ***depositional zone*** of runoff delivery and sedimentation

In the first or upper zone the erosional process predominates and the stream and riverbeds are generally degraded. The streams join together at confluences and their slopes are generally steep. The bed material is characteristically composed of boulders, cobbles or gravels.

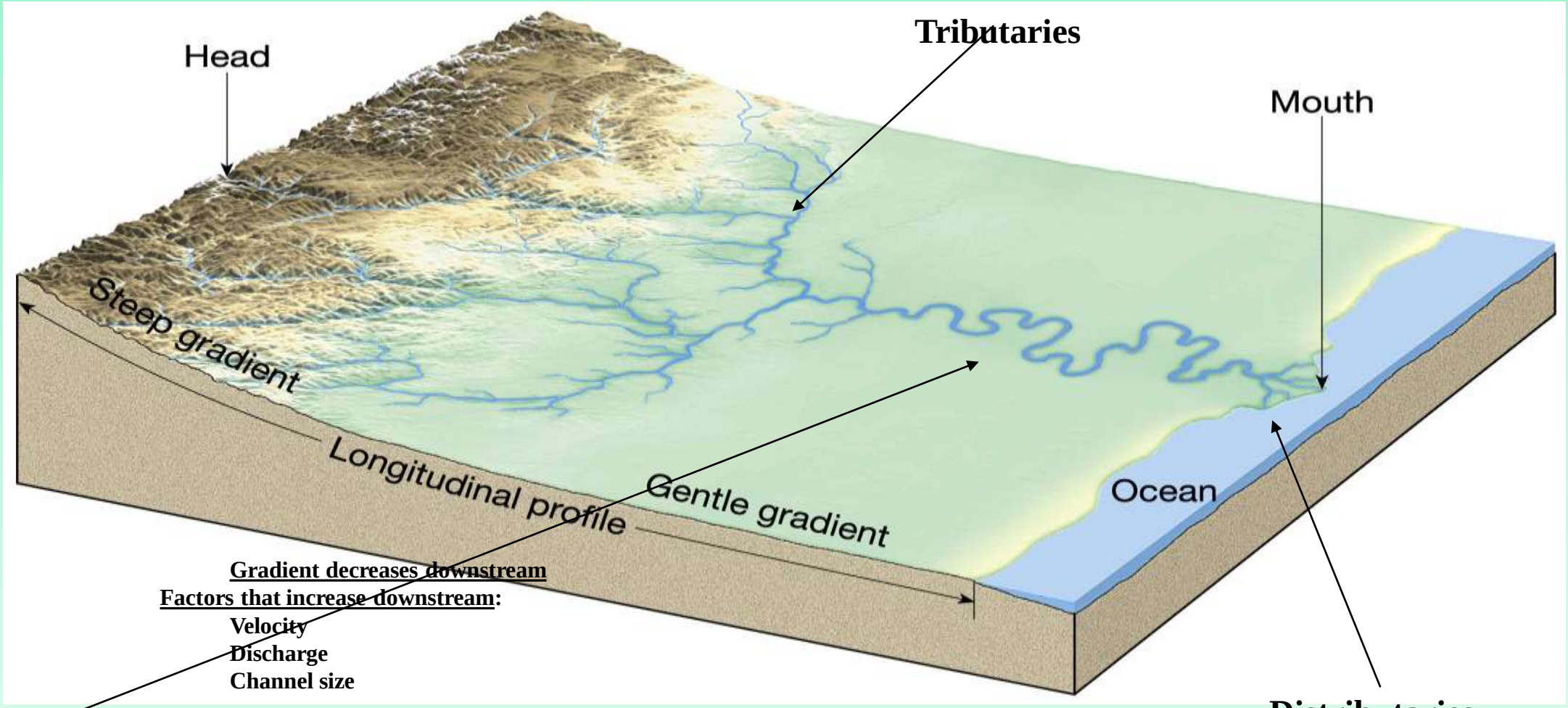
The second (middle) zone is characterized by near equilibrium condition between the inflow and outflow of water and sediment. The bed elevation in this equilibrium zone is fairly constant and the river generally flows in a single channel- there are few confluences or branching (unlike in the last zone) and the sediment material generally composes of gravels and sands of various sizes.
The depositional/lower zone is characterized by net sedimentation and riverbed aggradations.

There is branching of the river into channels and the slope of these channels is rather flat. The bed material generally composes of fine sand to silt and clay.

Long-profile of a River



Rivers <u>convert potential energy (elevation) to kinetic Energy</u> (motion/velocity). Most of the energy is lost to friction, but 2-4% of total potential energy is converted to work of erosion and transportation.



<u>Gradient decreases downstream</u>
<u>Factors that increase downstream</u>:
Velocity
Discharge
Channel size

Trunk Stream

Distributaries And Delta

Some definitions related to river:

- **Tributary :** a stream flowing into or joining a larger stream
- **Distributary :** numerous stream branches into which a river divides when it reaches the valley/delta
- **Upstream :** moves toward headwater (up the section of river)
- **Downstream :** moves toward mouth of river (down the section of a river)
- **Delta :** a large, roughly triangular body of sediment deposited at the mouth of a river before it goes to sea/lake
- **Levee/Terrace/Ridge :** elevated area beside the river bank before it enters the floodplain
- **Floodplain :** area adjacent to the river banks that is flooded with a return period of 1.5 to 2 years
- **Thalweg** : The imaginary line connecting the deepest points along the longitudinal profile of a river

The type of river mouth (outfall) will depend on the relative importance of sea (lake) and river:

- Streams carrying both large flow and sediments to the sea form **deltas**. Deltas are generally triangular in shape with multiple channels.

- Streams with less flow ans sediment load to the sea with strong tidal currents create **estuaries**. They have no definite shape but are generally narrower than delta. Sediment depositions are both riverine and marine and there is strong tidal influence.



Differences between Delta and Estuary

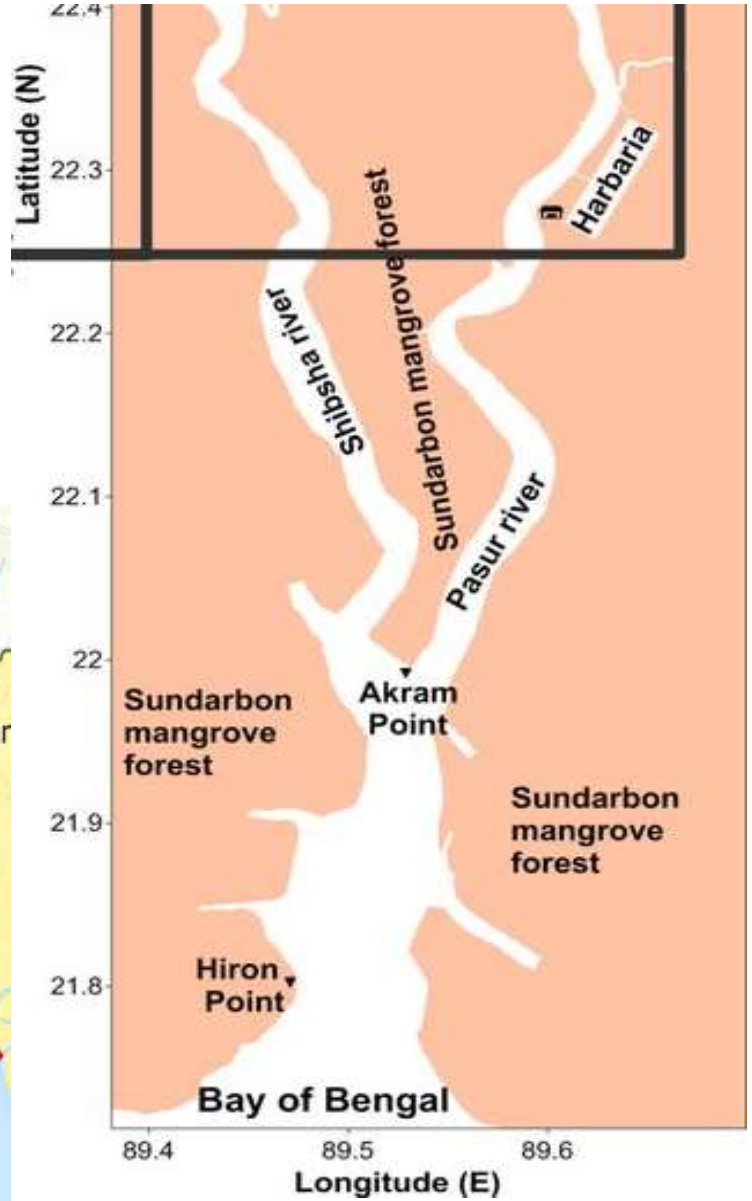
Feature	Estuary	Delta
a. Dominant Force:	Tidal energy (Sea)	Upland flow (River)
b. Primary Process:	Erosion- Tides wash silt away	Deposition- Silt settles at the mouth
c. Physical Shape:	Funnel-shaped/wide opening	Triangular or fan-shaped
d. Land Formation:	Does not form new land	Builds new land seaward
e. Water Type:	Brackish (mix of fresh/salt)	Mostly Freshwater (at deposition point)
f. Soil Fertility deposits:	Low; saline and marshy	High; rich in alluvium
Examples:	Estuaries of SW coastal Region	Delta of Lower Meghna



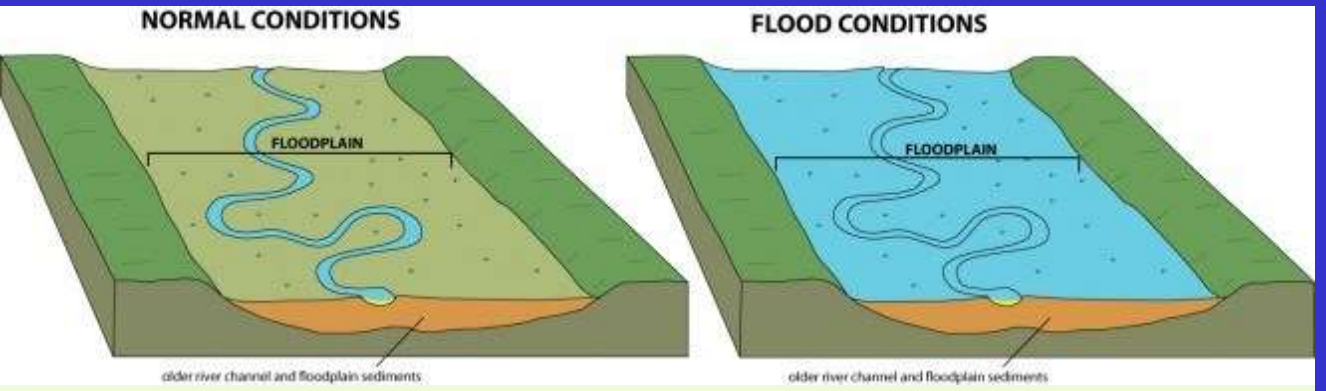
Lower Meghna Delta

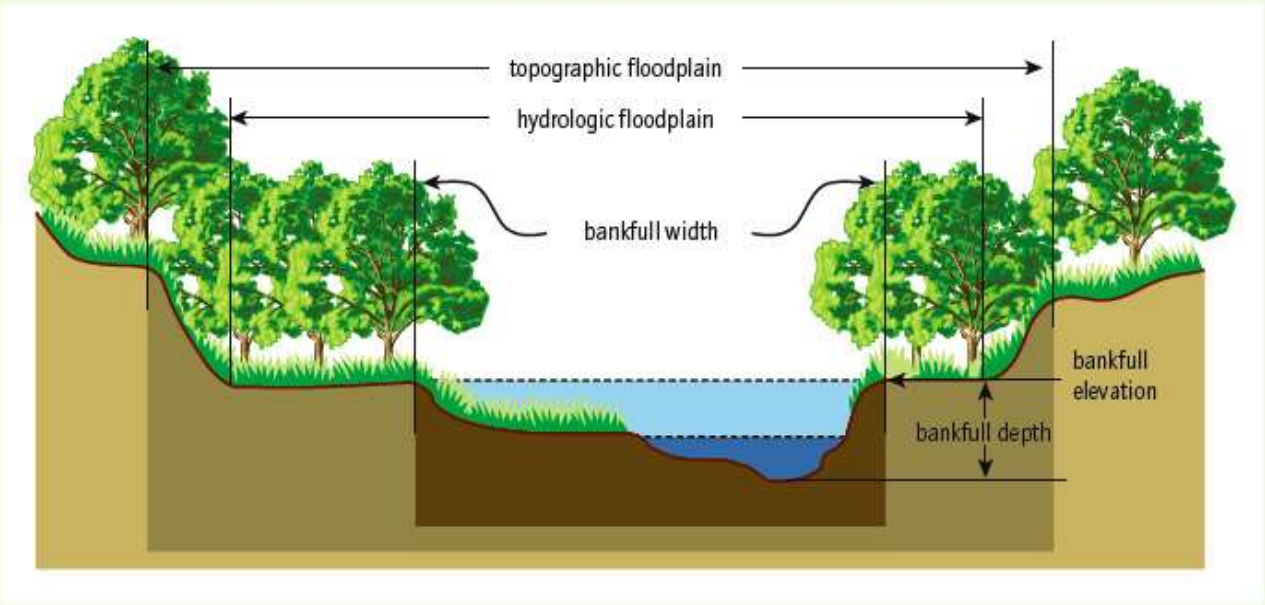


SW Estuaries

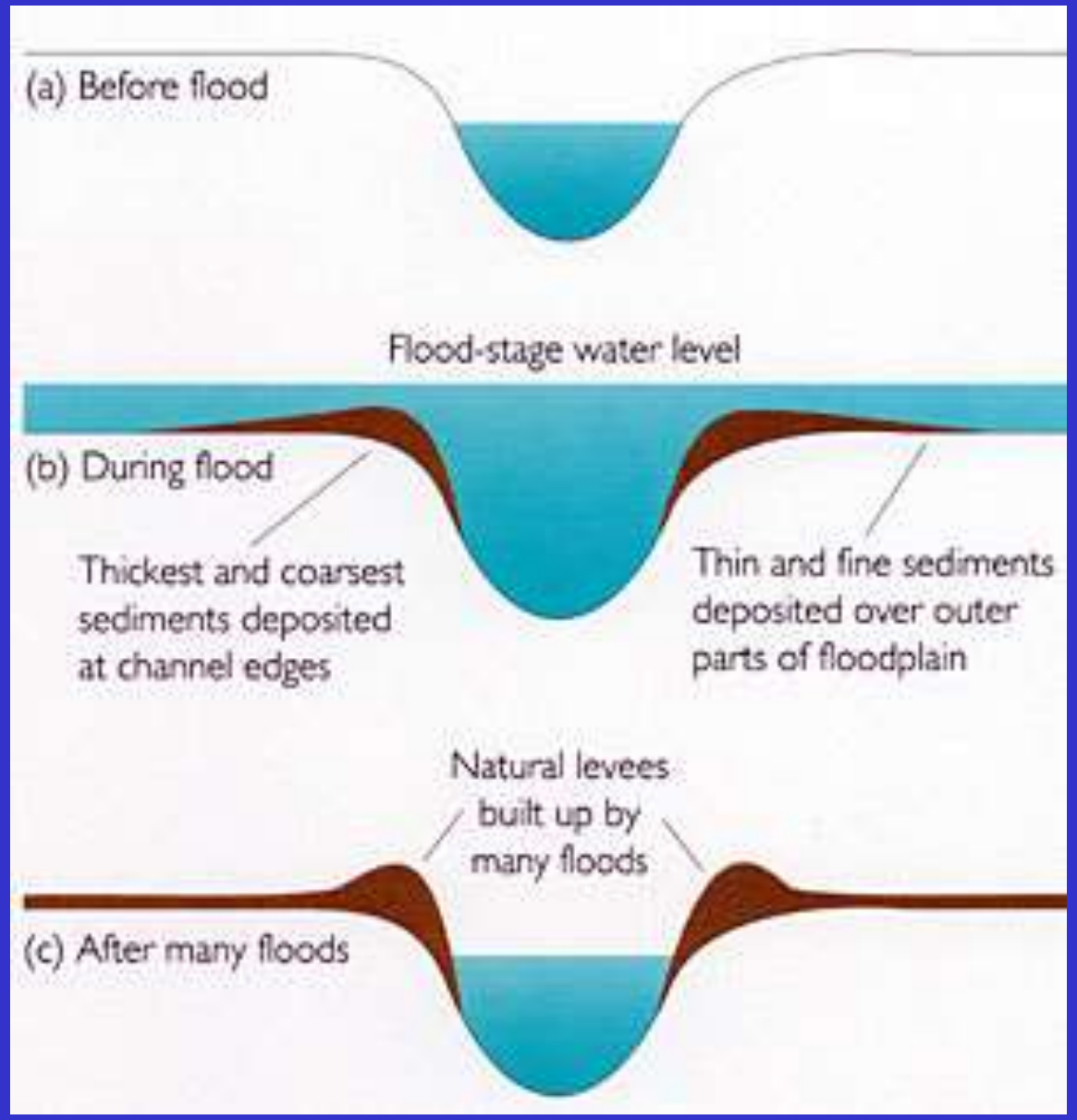


Floodplain

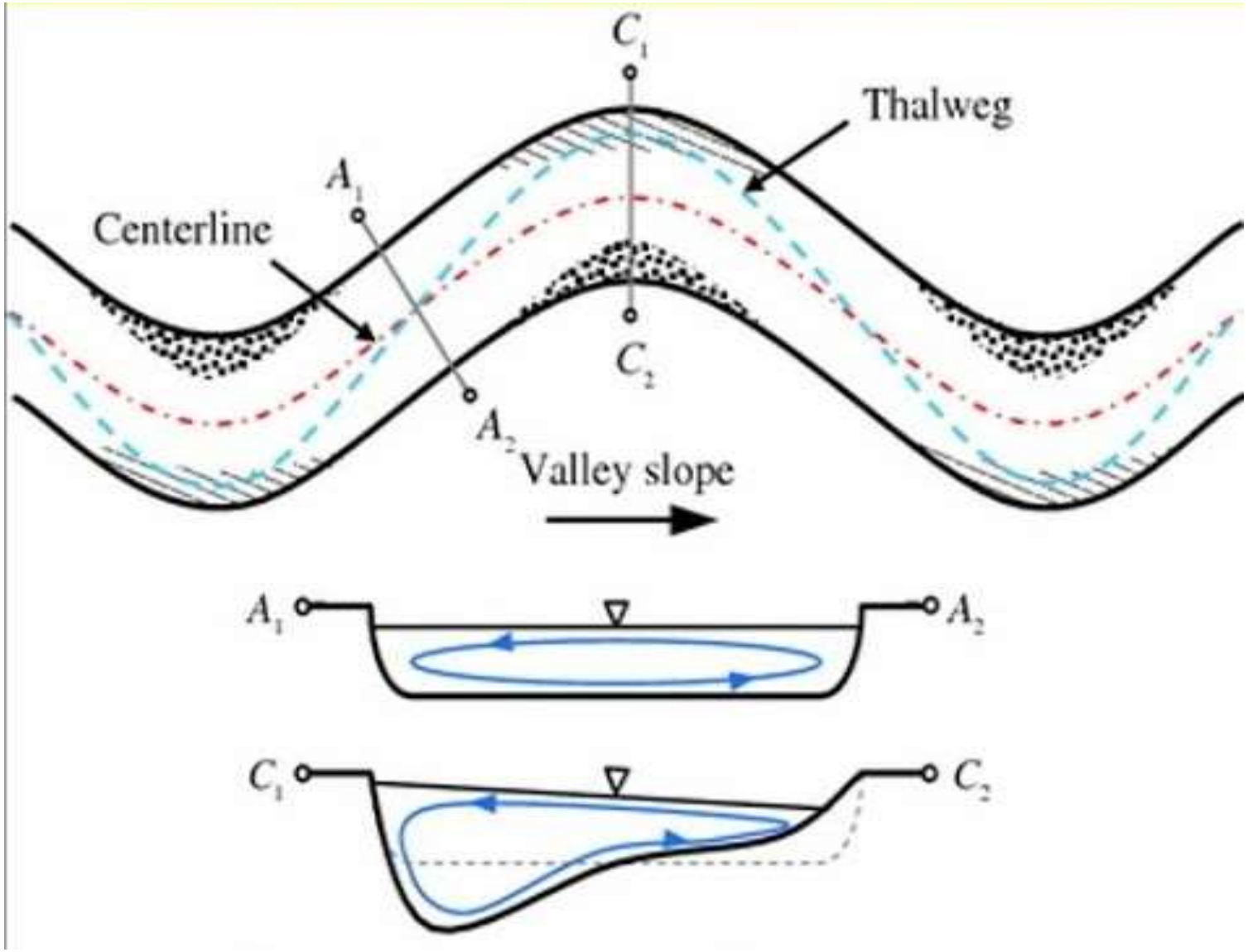




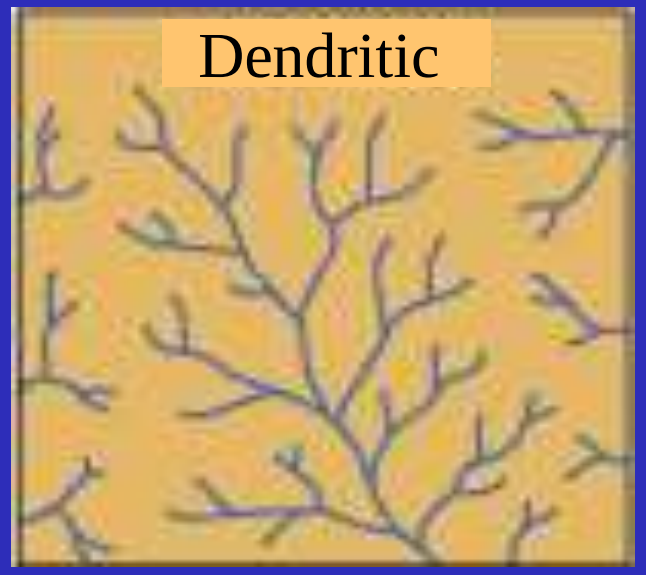
Natural Levees/Terrace/Ridge



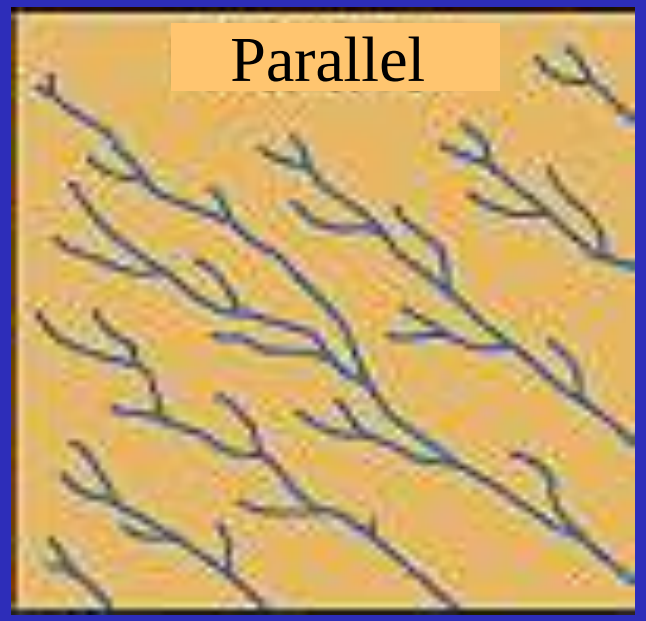
Thalweg



Drainage Pattern (collection system/zone of erosion)

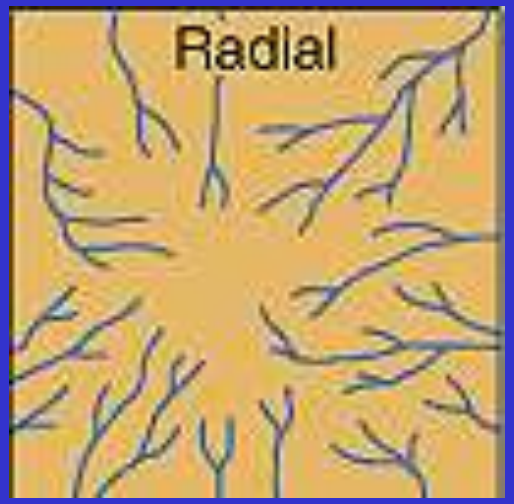


- Irregular branching pattern (tree like) in many direction.
- It is common in massive rocks and in flat lying strata



- Parallel or sub-parallel drainage formed on sloping surface.
- Common in terrain with homogeneous rocks.
- Development of parallel rills, gullies or narrow channels are commonly seen on gently sloping surface

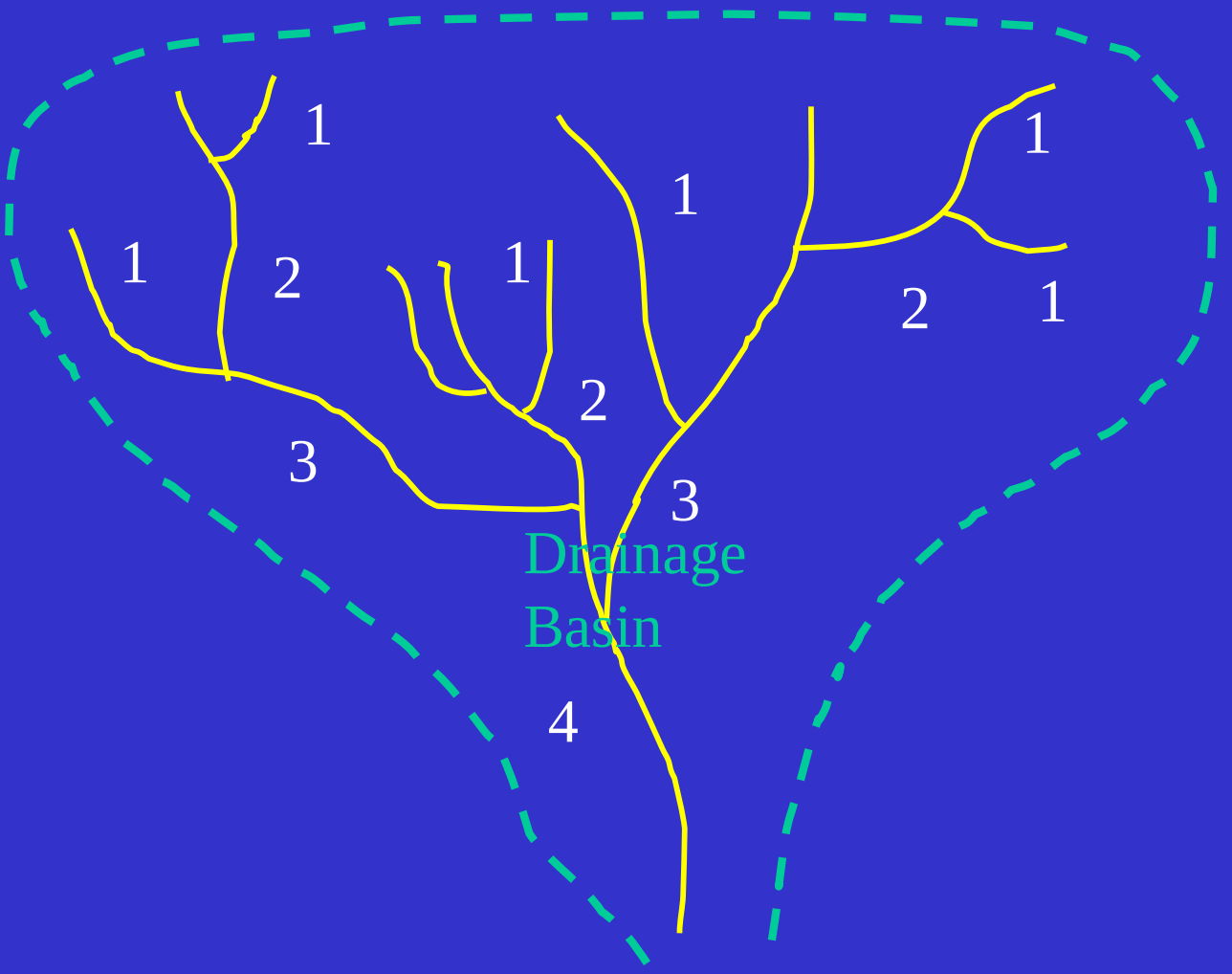
- **Streams radiates out from the center of the topograhic high**
- **common in Volcanic terrain**

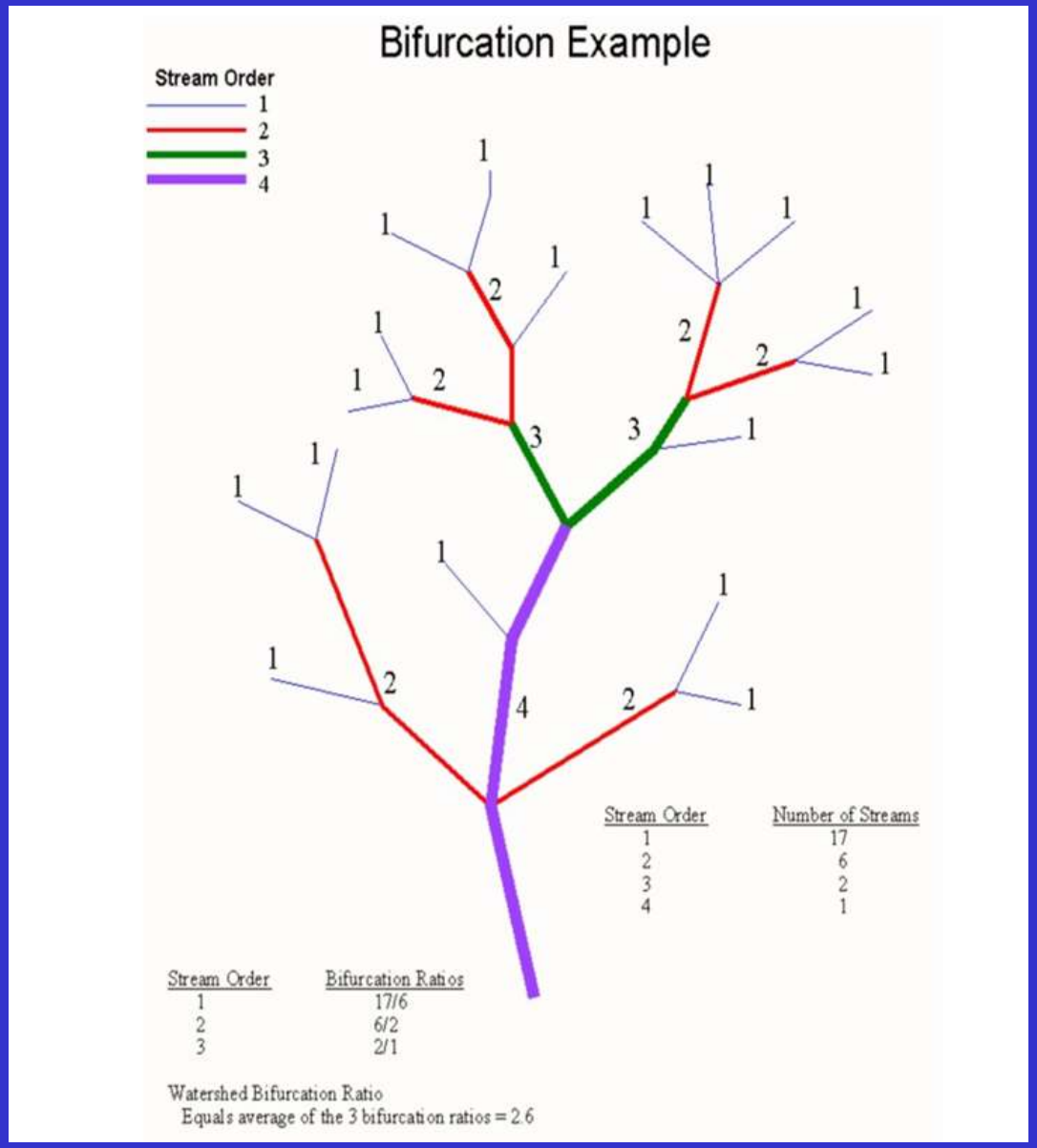




Rectangular arrangement of channels in which principal tributary streams are parallel and very long, like vines trained on a trellis. This pattern is common in areas where the outcropping edges of folded sedimentary rocks, both weak and resistant, form long, nearly parallel belts.

Stream Order



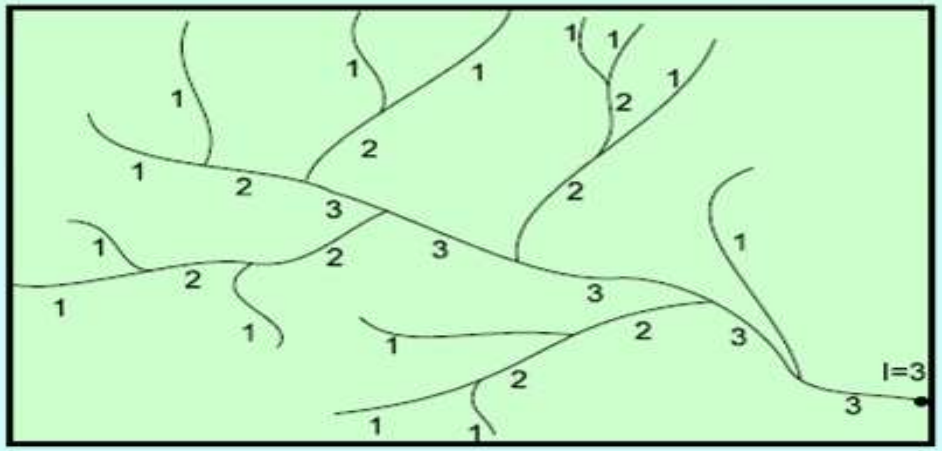


Stream Order

Drainage Patterns

- watersheds are typically characterized by one main drainage channel and a series of tributaries that ultimately drain into the main channel
- the concept of **stream order** was developed in order to quantify the drainage network
- the smallest tributaries of the watershed are classified as Order 1
- the segment where 2 first-order streams meet is classified as Order 2
- order 3 stream segments exist where two Order 2 streams meet
- this classifying continues until the main channel at the watershed outlet has been classified

The Mississippi River is Order 12 at its mouth



Rivers can be classified in several ways:

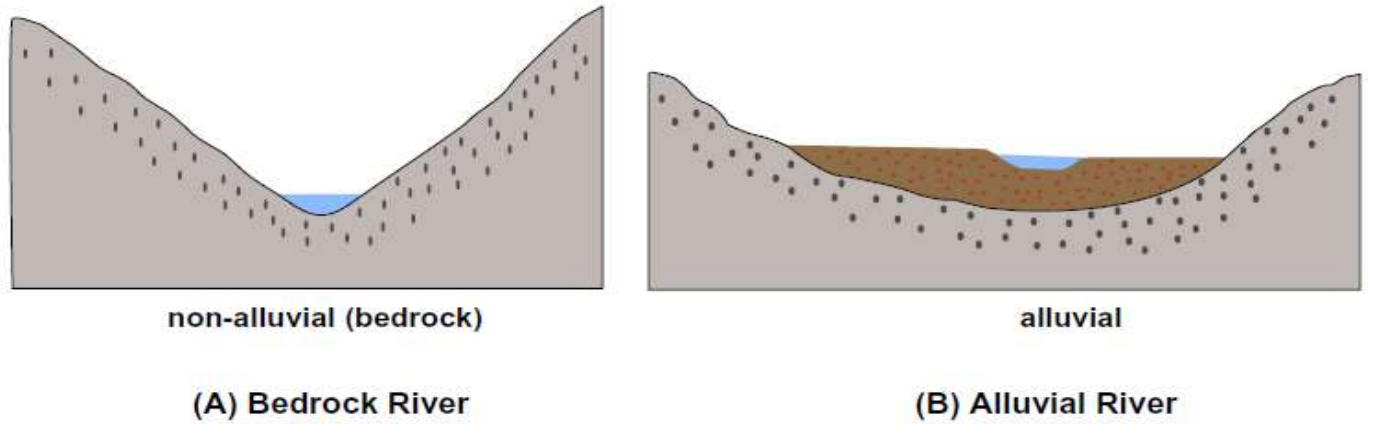
- by the nature of their substrate
- by the percentage of time they flow
- by their relationship to the groundwater table
- by the kind of sediment load/dominant particle size of the sediment they carry
- by their morphology/Planform

Nature of Substrate

Depending upon the nature of the material through which the river flows, there are two major categories of rivers: *bed rock and alluvial*.

Some rivers, especially small rivers in mountainous areas, flow directly on bedrock. Such rivers are called *bedrock rivers, or non-alluvial rivers*. Such rivers are generally fixed in position and is stable over a long period of time.





Other rivers, especially large rivers, flow on a bed of sediments they have deposited and can continue to transport. Such rivers are called *alluvial rivers* and are subjected to major pattern change and to significant change in channel position as the sediment (called alluvium) is eroded, transported and deposited and as the sediment load and the discharge changes.

An **alluvial river** is river in which the bed and banks are made up of mobile sediment and/or soil. Alluvial rivers are self-formed, meaning that their channels are shaped by the magnitude and frequency of the floods that they experience, and the ability of these floods to erode, deposit, and transport sediment. For this reason, alluvial rivers can assume a number of forms based on the properties of their banks; the flows they experience; the local riparian ecology; and the amount, size, and type of sediment that they carry.

Alluvial rivers are streams with well defined geometric cross-sections, longitudinal profile and slope that change with time depending upon the discharge, material of the bed and banks and quantity and quality of the sediment carried by the river.
Such rivers are free to change their dimensions depending upon the hydraulic conditions, type of bed and bank materials and the sediment load the river is carrying.

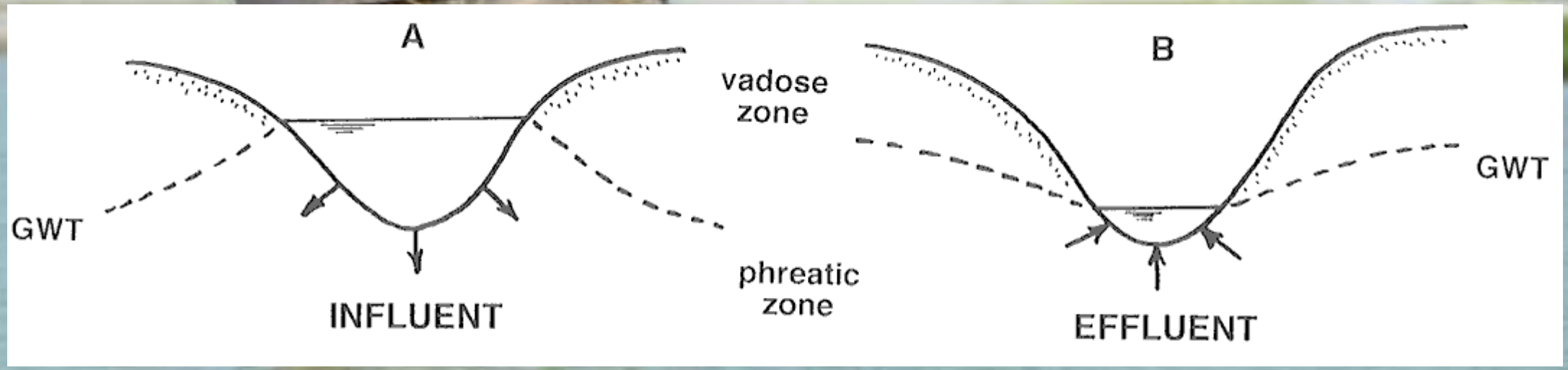
Thus these rivers are morphologically unstable.

Relationship to Groundwater Table

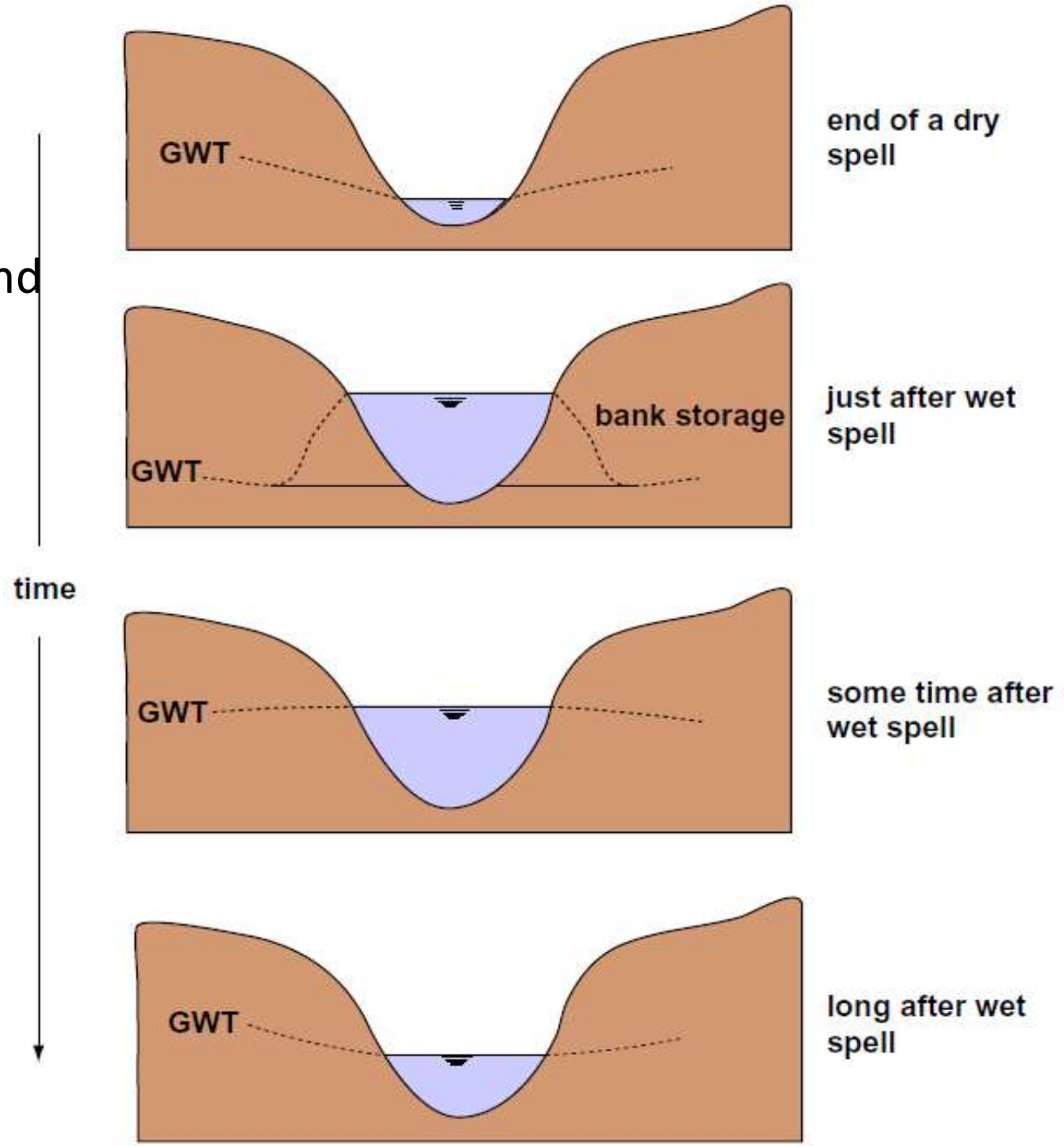
If the water surface in the river lies above the local groundwater table in the river banks, then the river loses water to its banks. Such a river is said to be an *influent river.*

On the other hand, if the water surface in the river lies below the local groundwater table in the banks, then the river gains water from its banks. Such a river is said to be *effluent river.*

An effluent river is also called a gaining river, because it is gaining water from the adjacent substrate, and an influent river is called a losing river.



A perennial river can be both influent or effluent depending upon season and along the longitudinal profile.



Percentage of Time the River Flows

Some rivers show a flow of water all the time, even long after the last rainstorm in the watershed. Such a river is called a *perennial stream*.

Other rivers flow for only a short time after a rainstorm, and for the rest of time, usually most of the time, their beds are dry. Such a river is called an *ephemeral stream*.

Some rivers lie between these two extremes: during the wetter part of the year they flow as a perennial stream, whereas during the drier part of the year they flow as an ephemeral stream. Such a river is called an *intermittent stream*.

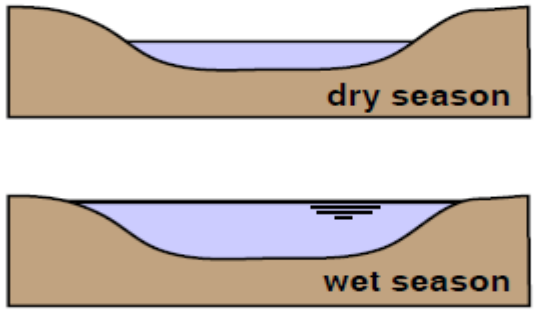
Rivers by Sediment Load

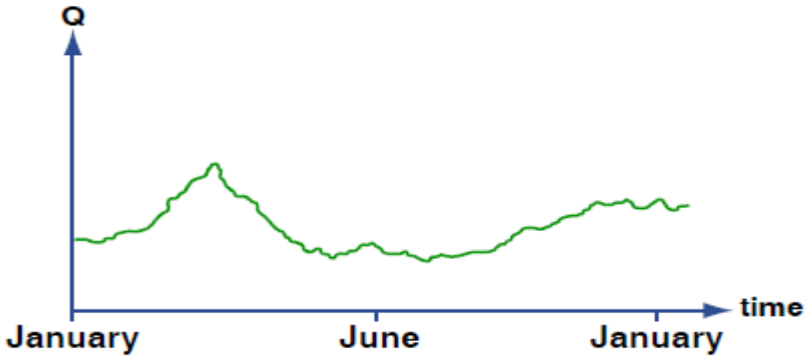
Some rivers, especially those whose sediment sources consist mostly of coarse sand and gravel, are carried mostly as bed load. Such rivers are called, *bed-load rivers*.

On the other hand, the sediment sources of some rivers are mainly clay, silt, and fine sand. The sediment load of such rivers is mainly suspended load. Such rivers are called *suspended-load rivers*.

Finally, in a great many rivers both bed load and suspended load are important; such rivers are called *mixed-load rivers*.

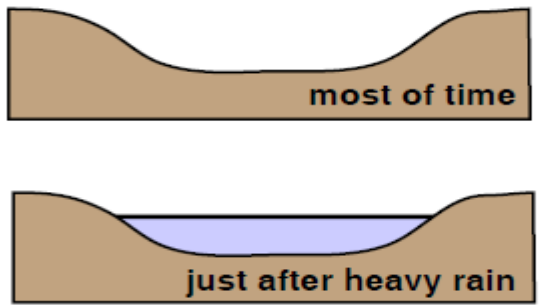
PERENNIAL

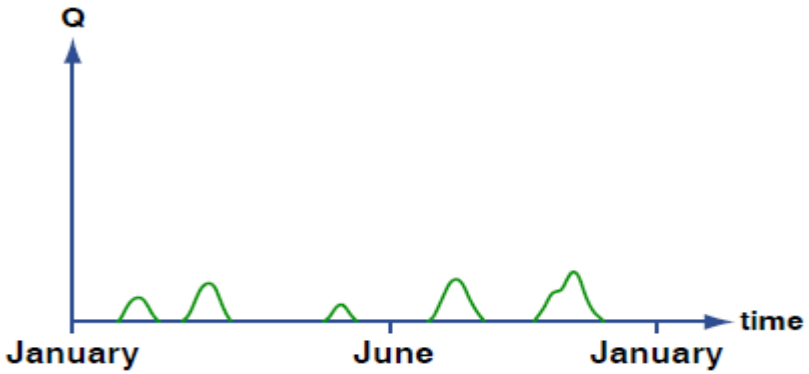




perennial

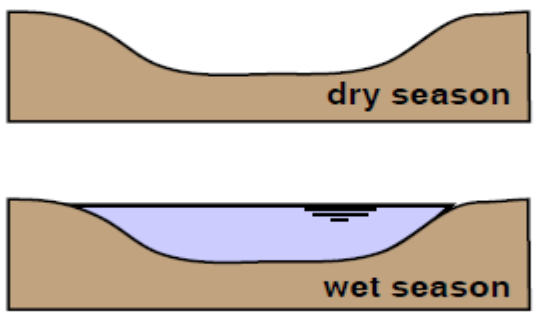
EPHEMERAL

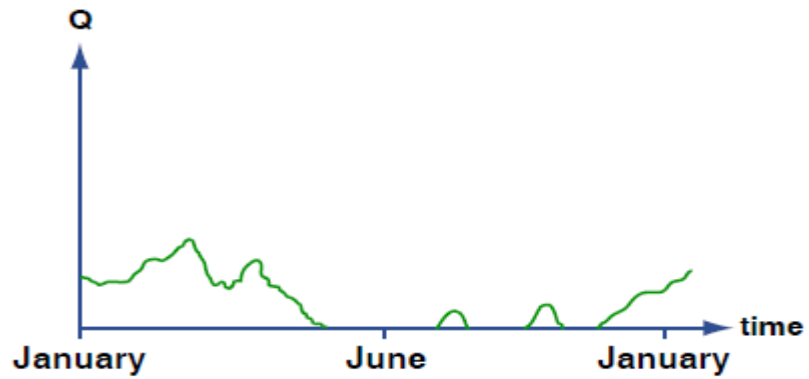




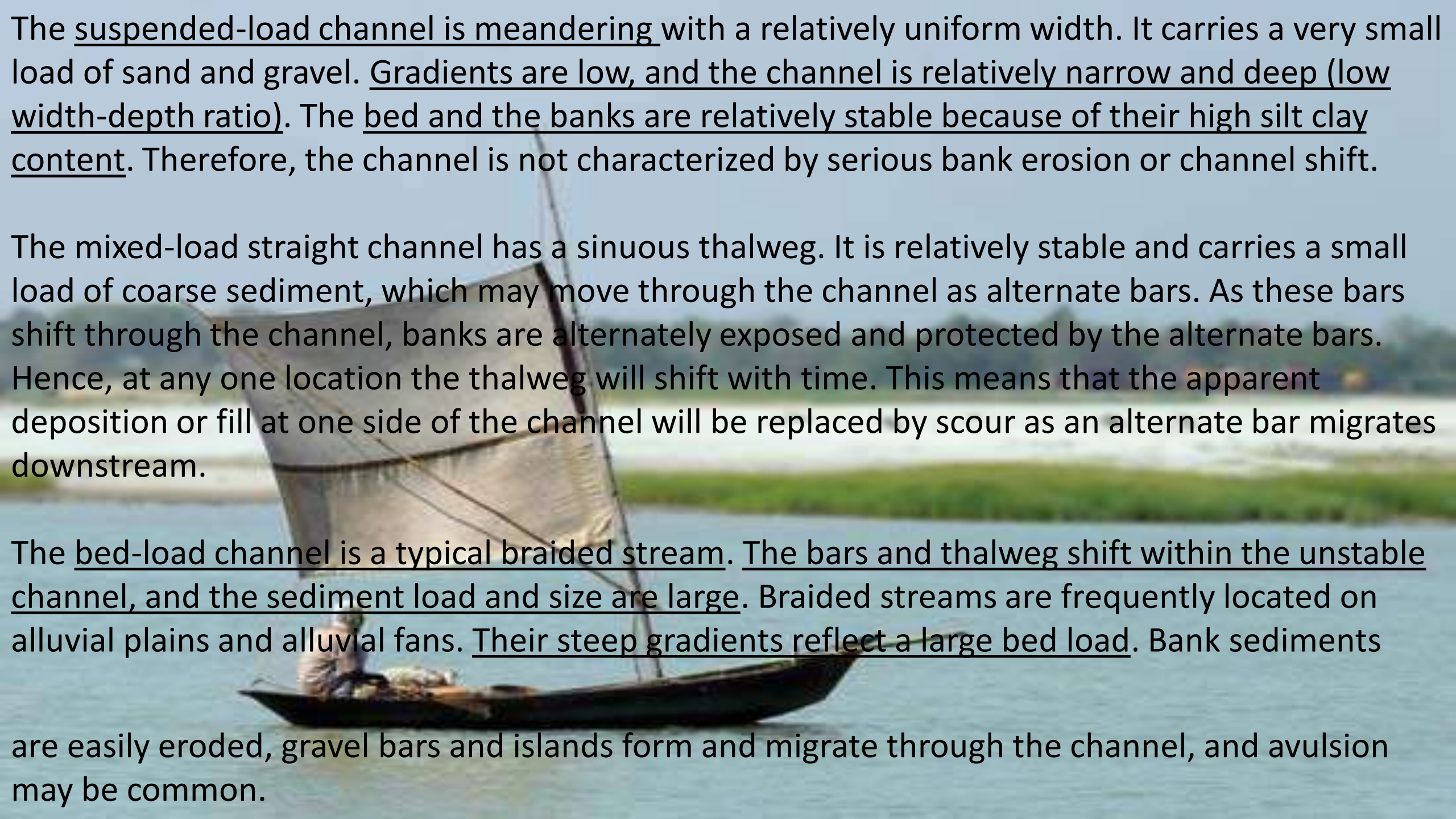
ephemeral

INTERMITTENT





intermittent



The suspended-load channel is meandering with a relatively uniform width. It carries a very small load of sand and gravel. Gradients are low, and the channel is relatively narrow and deep (low width-depth ratio). The bed and the banks are relatively stable because of their high silt clay content. Therefore, the channel is not characterized by serious bank erosion or channel shift.

The mixed-load straight channel has a sinuous thalweg. It is relatively stable and carries a small load of coarse sediment, which may move through the channel as alternate bars. As these bars shift through the channel, banks are alternately exposed and protected by the alternate bars. Hence, at any one location the thalweg will shift with time. This means that the apparent deposition or fill at one side of the channel will be replaced by scour as an alternate bar migrates downstream.

The bed-load channel is a typical braided stream. The bars and thalweg shift within the unstable channel, and the sediment load and size are large. Braided streams are frequently located on alluvial plains and alluvial fans. Their steep gradients reflect a large bed load. Bank sediments

are easily eroded, gravel bars and islands form and migrate through the channel, and avulsion may be common.

Table 1 Classification of stable alluvial channels (after Schumm 1977)

Type of channel	Bed load (% of total load)	Type of River	
		Single channel	Multiple channel
Suspended load (Meandering river)	<3	Suspended-load channel. Width-depth ratio <10; sinuosity >2.0; gradient relatively gentle.	Anastomosing system
Mixed load	3–11	Mixed-load channel. Width-depth ratio >10, <40; sinuosity <2.0, >1.3; gradient moderate. Can be braided.	Delta distributaries Alluvial plain distributaries
Bed load (Braided river)	>11	Bed-load channel. Width-depth ratio >40; sinuosity, <1.3; gradient relatively steep. Can be braided.	Alluvial fan distributaries

Morphology/Pattern

The morphology (study of forms) of rivers, especially in plan view is the most common way to classify rivers. Two characteristics are used in the classification of rivers by morphology/pattern: sinuosity and multichanneledness.

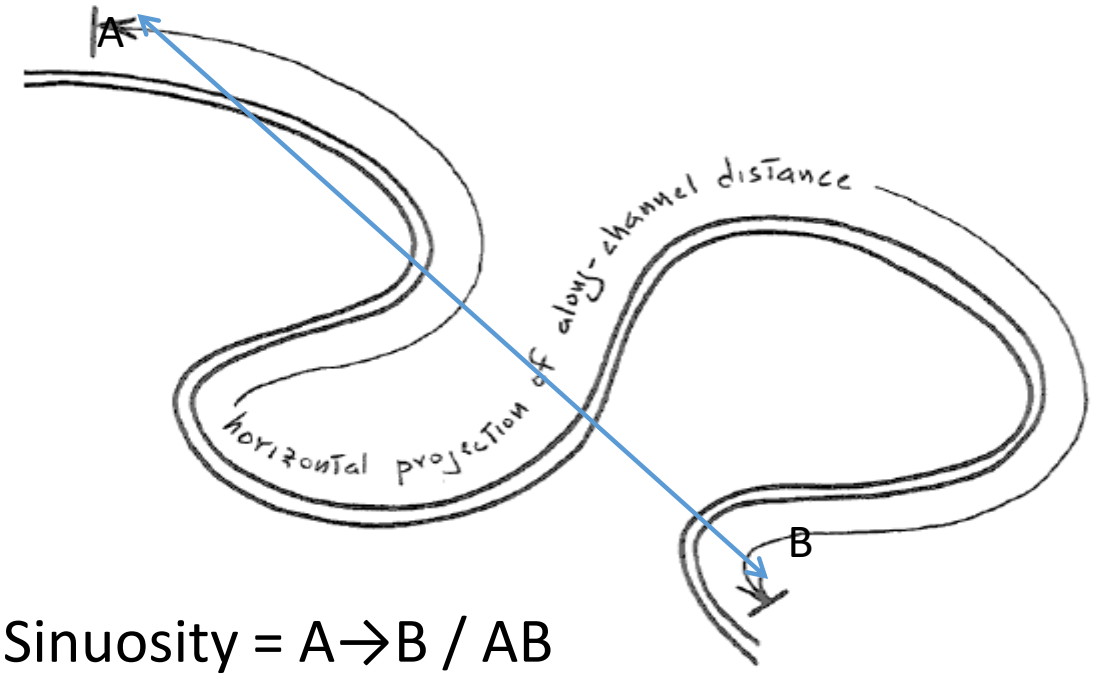
Sinuosity can be defined with respect to two arbitrary points along the river as the ratio of the along-channel distance between the two points and the straight-line distance between the points. The minimum sinuosity, for a straight river, is 1; the more sinuous the river, the greater its sinuosity. Very sinuous rivers can have values of sinuosity approaching 4.

Multichanneledness reflects the number of individual flow channels shown by a river in a cross-section across the entire river system.

Many rivers have only one channel, except perhaps where an occasional island divides the channel into two. Other rivers show a large number of channels, all of about the same size and nature, separated by numerous bars and islands.

On the basis of morphology/planform, rivers are classified as *straight, braided and meandering*.

Sinuosity is a measure of straightness of rivers.



Sinuosity = A→B / AB

	Single channel	Multi-channel
LOW SINUOSITY	STRAIGHT	BRAIDED
HIGH SINUOSITY	MEANDERING	ANASTOMOSING

Straight rivers—those with sinuosity not much greater than 1—are surprisingly uncommon in nature. In fact, it's hard to keep rivers straight: humans straighten them out for their own purposes, and the rivers try to become sinuous again, by erosion and deposition on the banks.

Both *braided rivers* (low-sinuosity, multichanneled) and *meandering rivers* (high sinuosity, single-channeled) are very common.

Anastomosing rivers (high-sinuosity, multichanneled) are much less common.


Soyanipara ছয়ানীপাড়া
Z4801
Z4017
Z4801
Bangladesh
N
70 mi
Google Earth
Image Landsat / Copernicus

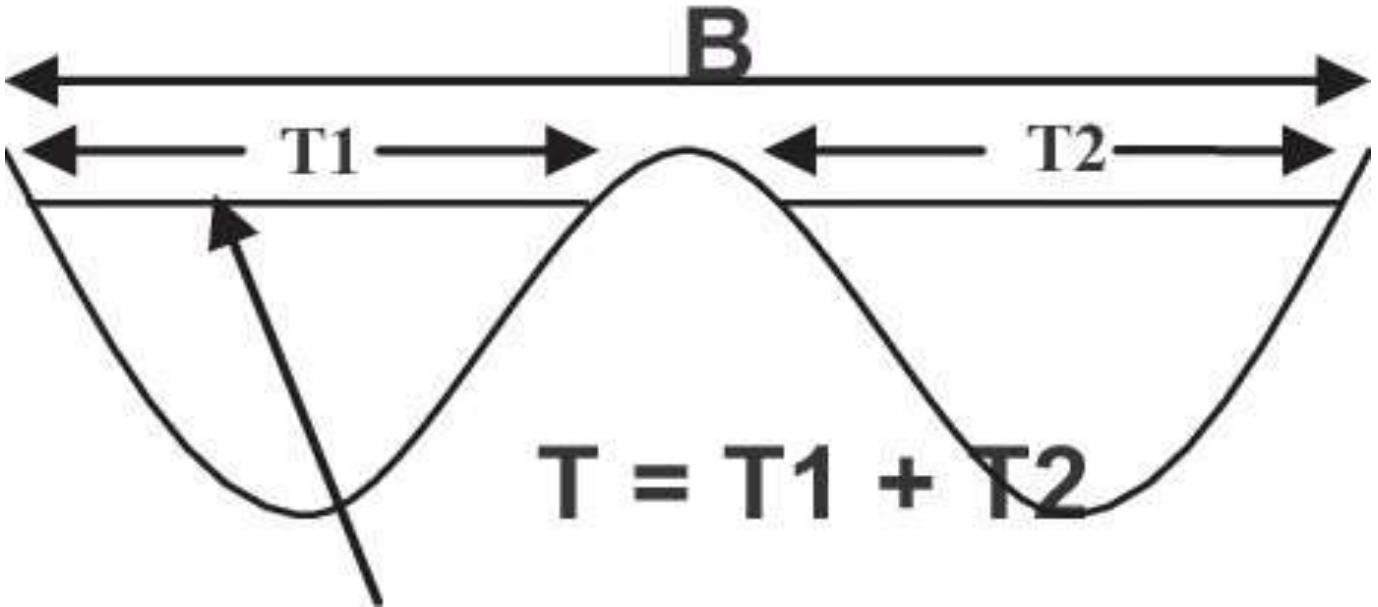
Planform Index (PFI)

Definition sketch of Plan Form Index (PFI) reflects the percentage of actual flow width in a channel and its lower value is indicative of higher degree of braiding. For providing a broad range of classification of the braiding phenomenon, the following threshold values for PFI are proposed by Sharma (2004).

$$PFI = [\sum T / B] \times 100 / N$$

where T is the top width of the channels, B is the total flow width and N is the number of channels. The lower the value of PFI the higher is the degree of braiding.

Highly Braided: PFI < 3 Moderately Braided: 20 > PFI > 3 Low Braided: PFI > 20



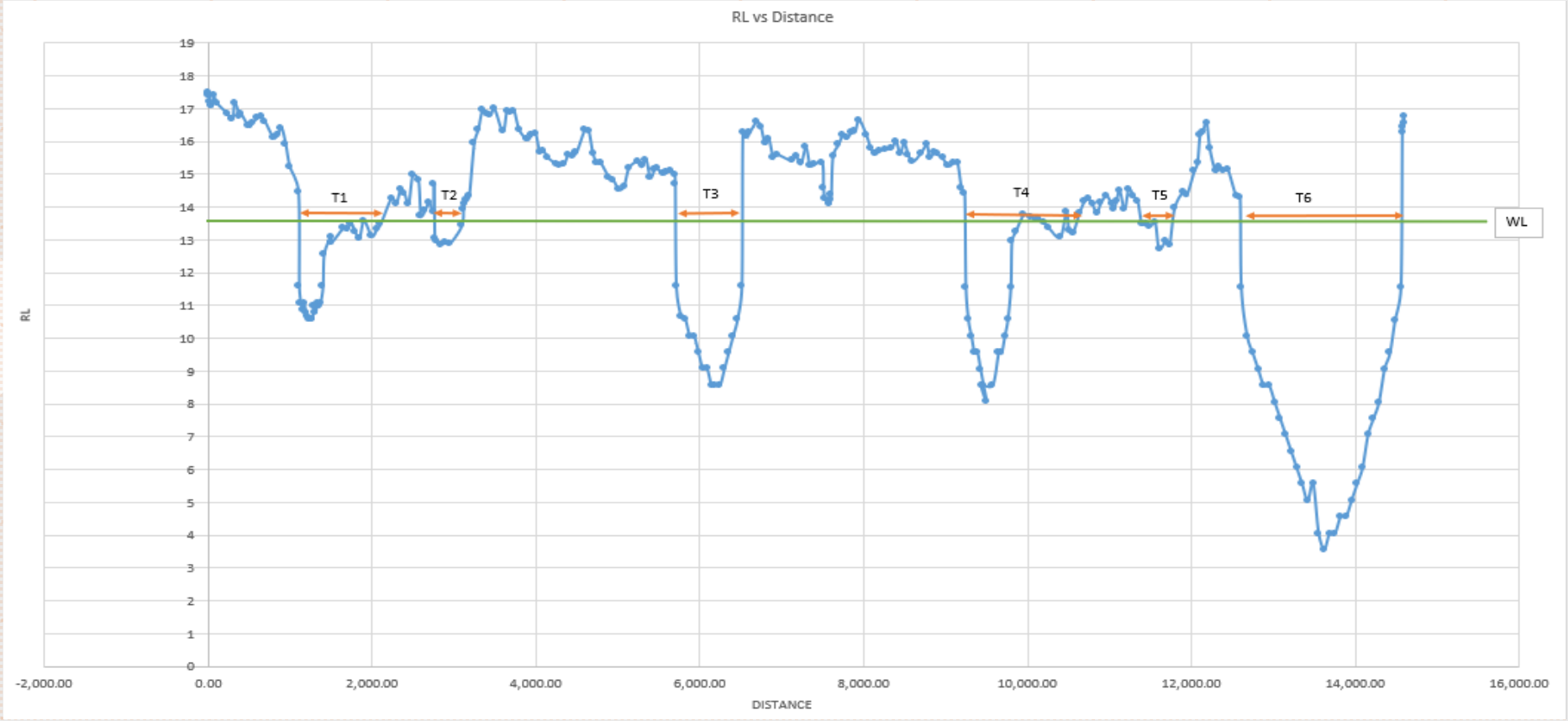


Fig : Cross section at RMJ11 of Jamuna in the year 2005

Here, T1=1125 m, T2 =400 m, T3= 812 m, T4= 1387 m, T5= 400 m, T6= 1965 m
B= 14,600 m
N=6

PFI = (1125+400+812+1387+400+1965)/14600 * (100/6) = 6.95

PFI of Jamuna River

Year	Planform Index
2005	6.9
2006	12.2
2008	5.5
2010	18.2
2011	4.3
2012	5.5