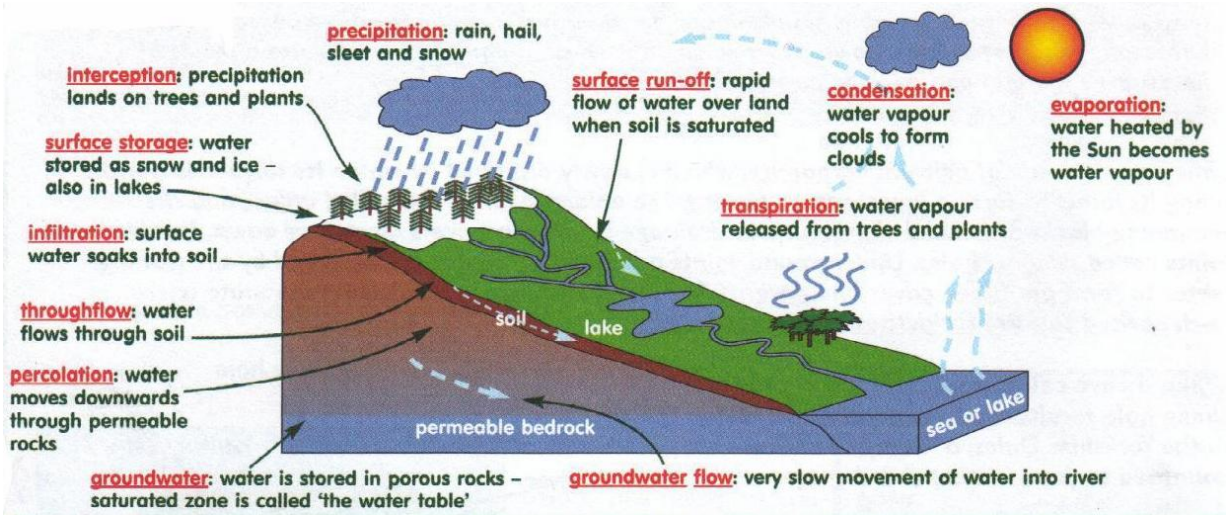
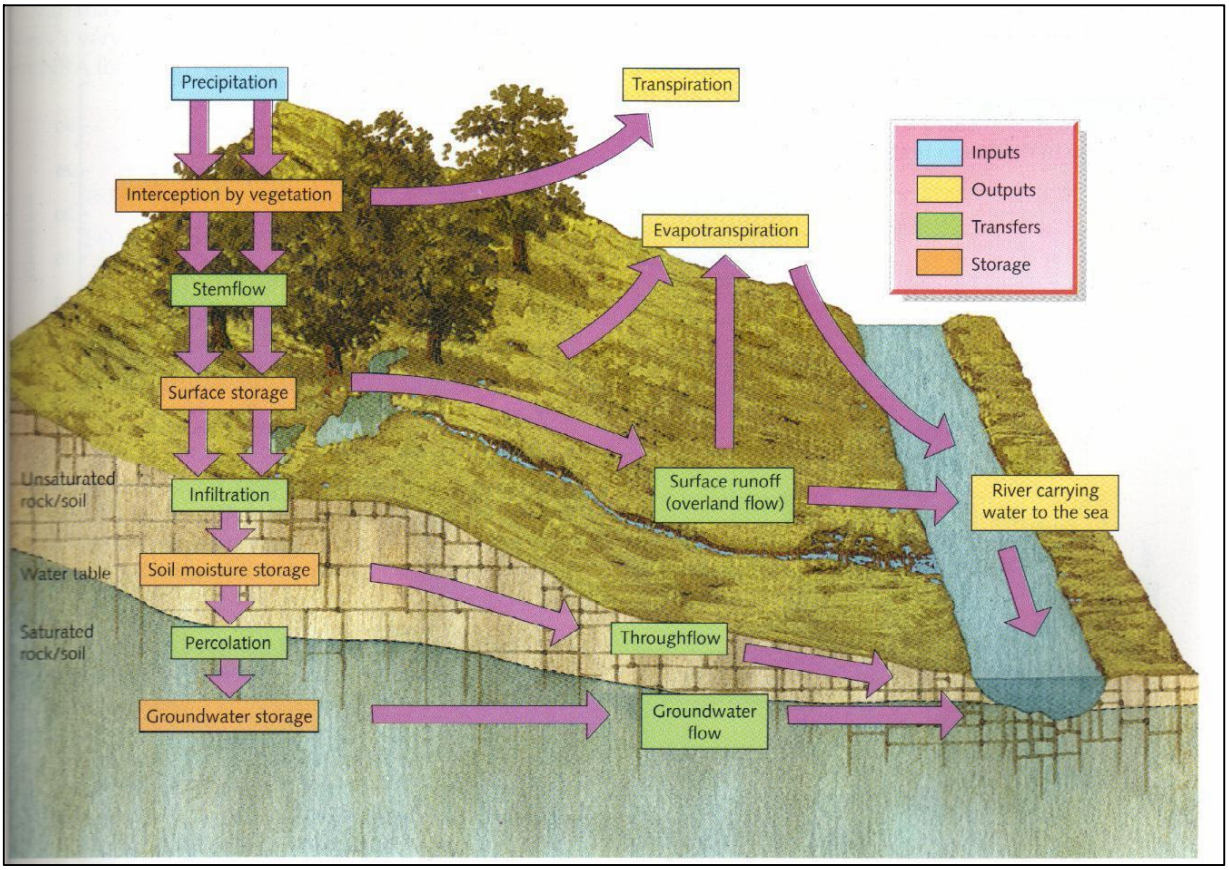
WATER CYCLE: A RIVER BASIN SYSTEM

The Water Cycle is the constant movement of water between the SEA, LAND and ATMOSPHERE

PRECIPITATION falling on land finds its way back to the sea following a number of different routes in a **RIVER BASIN SYSTEM**

The system has **INPUTS**, **STORES**, **PROCESSES** and **OUTPUTS**

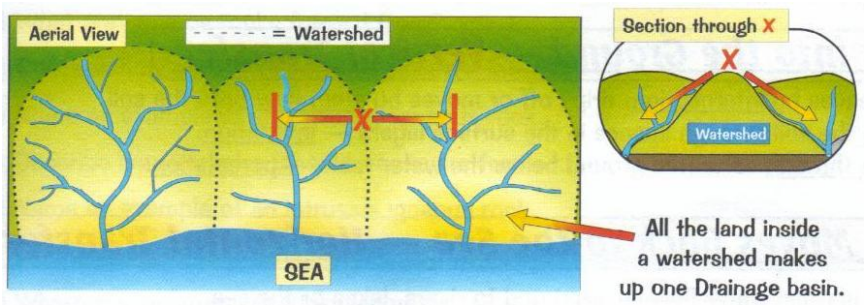




DRAINAGE BASINS

A Drainage Basin is a land area drained by a River

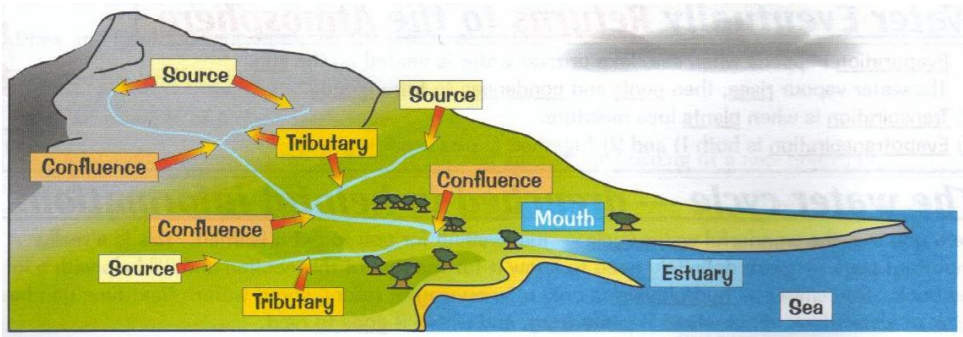
DRAINAGE BASIN land provides water source for the main river and tributaries
size depends on river size e.g. Amazon basin covers most of Brazil
Catchment Area/D.B. is area from which river and tributaries collect rainwater
Watershed is high ground separating drainage basins



DRAINAGE BASINS work as a SYSTEM

RIVER BASIN FEATURES

Source	where river starts (usually upland area)
Tributary	is a stream that joins the main river
Confluence	a point where two rivers meet
Mouth	where river flows into the sea
Estuary	where mouth is low enough to let the Sea enter – causes deposition (mud banks)



RIVERS AND VALLEYS

Rivers flow in Linear Features called VALLEYS

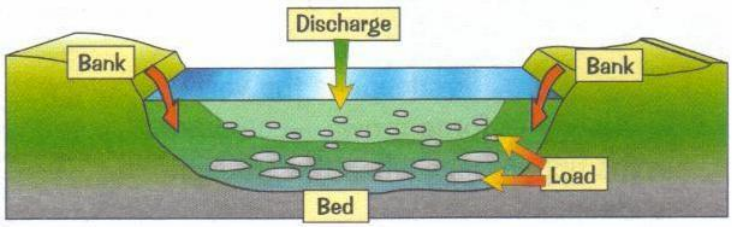
A river flows from an upland source to the mouth where it enters the sea

The river channel widens as it follows its course to the sea, and the amount of water it carries – **DISCHARGE** – increases as other streams and rivers join it

A river's energy is linked to its velocity – the speed of flow in one direction. High velocity means high energy – e.g. during floods or when the river's gradient is steep

Rivers with lots of energy wear away the **CHANNEL BANKS** producing the **LOAD** – sand, stones

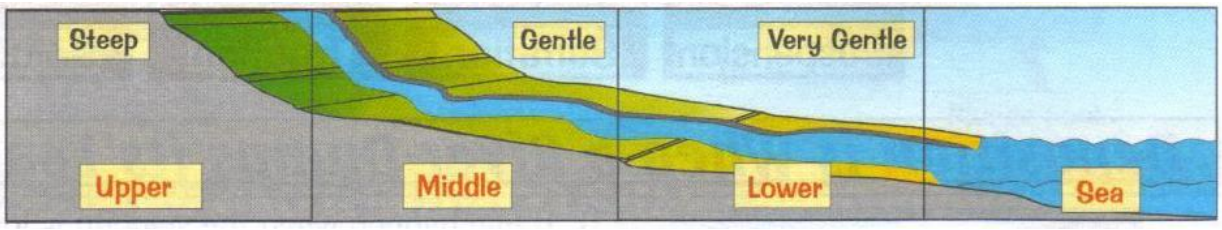
When a river has little energy, the load is deposited on the **BED** and **BANKS**



LONG PROFILE OF A RIVER

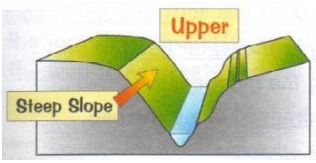
RIVER VALLEY LONG PROFILE is a cross-section from source to mouth

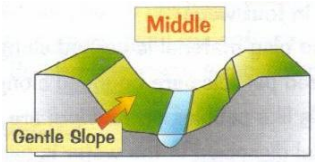
UPPER Course	MIDDLE Course	LOWER Course
river gradient is steep	gradient is much more gentle	gradient is very gentle, almost flat

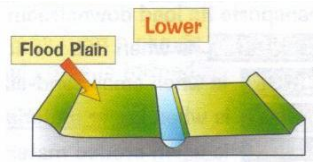


RIVER VALLEY CROSS-SECTIONS shape of valley changes from source to mouth
Erosion is key in UPPER course
Deposition is key in LOWER COURSE

Upper Course	Middle Course	Lower Course
-narrow V-shaped valley	-wider U-shaped valley	-wide valley
-steep valley sides	-gentle valley sides	-flat valley
-river erodes vertically	-river erodes vertically and laterally	-river erodes laterally and deposits bedload
-bedload: angular boulders/rocks	-bedload: smoother stones/pebbles	-bedload: smooth sand and silt







DISCHARGE
is the amount of water in the river. It increases from source to mouth. This is because tributaries add more water to the main channel. As discharge increases width/depth must also increase

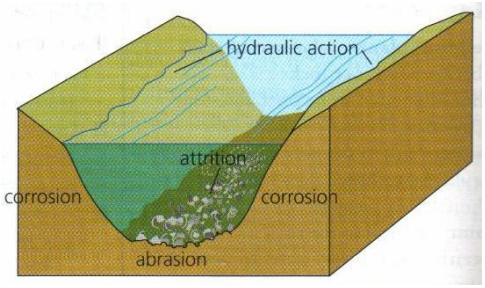
VELOCITY
also increases from source to mouth. As the discharge of the river increases, there is less friction from the river bed and banks. This means the water is able to flow faster, even though the gradient becomes more gentle

EROSION

EROSION is when the RIVER WEARS LAND AWAY

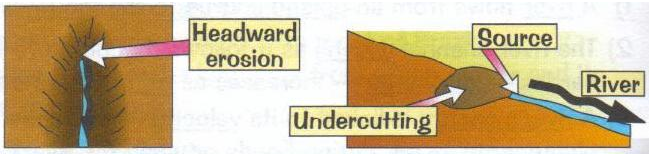
Rivers erode in four main ways:

ATTRITION	is where stones and pebbles carried by the river smash into each other, breaking them into smaller pieces and making them rounder
CORRASION / ABRASION	occurs when stones and pebbles carried by the river wear away the river channel (sandpaper effect)
HYDRAULIC ACTION	is when the force of the water wears away at softer rocks such as clay, can also weaken rocks along bedding planes/joints
SOLUTION	is when river water dissolves (calcium carbonate in) chalk and limestone

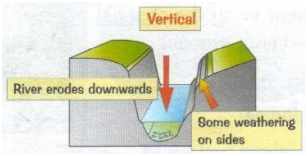


River Erosion is:

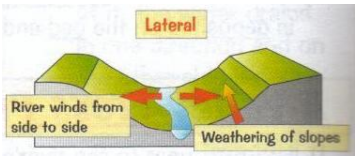
HEADWORD
is when the furthest point upstream, the valley head, is worn away by rainwash, undercutting or soil creep



VERTICAL
deepens the valley as the water force grows – common in the upper stage when the gradient is steep



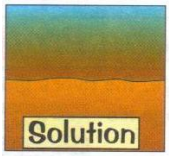
LATERAL
widens the valley, combined with weathering of the sides – it's common in middle and lower stage valleys



TRANSPORTATION

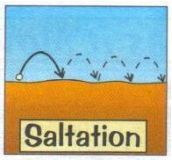
A River transports its load (eroded material) downstream in four main ways:

SOLUTION
is when eroded material
dissolved in the water is carried away

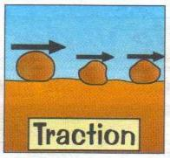


SUSPENSION
is when fine silt and clay material
is carried along in the water itself

SALTATION
is when small sand-sized
particles are bounced along the river bed

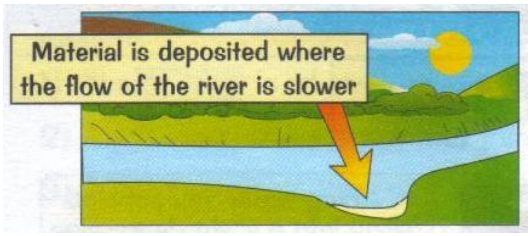


TRACTION
is when larger materials like pebbles
or boulders are dragged along the bed



DEPOSITION

DEPOSITION is when a River Dumps its Load



When a river slows down it loses energy and deposits its load

A river loses energy when discharge falls or when it reaches the sea
It can also happen when a river's load is increased e.g. after a landslide

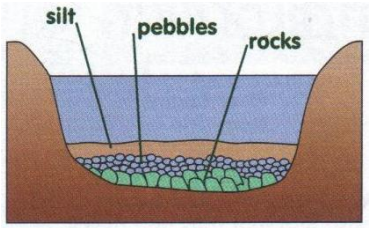
Deposition can form deltas where a river enters a sea or lake

4 STAGES OF DEPOSITION

1. Large material by the river is deposited in the higher reaches (UPPER COURSE)
2. Gravel, sand and silt carried as bedload or in suspension are laid down in the lower reaches (LOWER COURSE)
3. Fine particles of suspended silt and clay are laid down in estuaries and deltas
4. Dissolved load is not deposited but carried out to sea and stays in solution

All the stuff the river transports and deposits is called **sediment**

The **heaviest** material is always deposited **first**



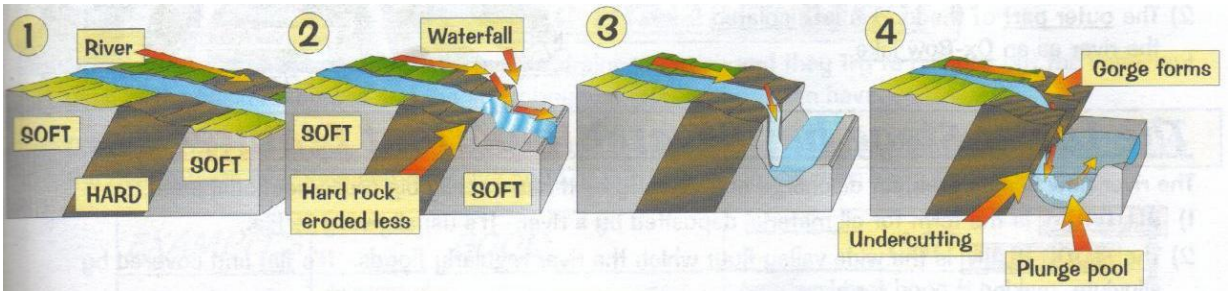
RIVER FEATURES: WATERFALLS & GORGES

Waterfalls are found at steep parts of the River Bed

STAGES OF FORMATION

1. Hard rock won't erode very easily when river reaches it, any softer rocks on the downstream side are eroded more quickly
2. This means that the river bed gets steeper where it crosses the hard rock and a waterfall forms, followed by an outcrop of overhanging rock
3. Overhang eventually collapses and waterfall moves upstream
4. At the foot of the waterfall the water wears away the softer rock to form a plunge pool
5. As the waterfall retreats, it eats its way upstream and a gorge (steep sided valley) is formed

Waterfalls can form when the hard rock is horizontal, vertical or dips upstream (rock slopes down as you go downstream)



RIVER FEATURES: MEANDERS & OX-BOW LAKES

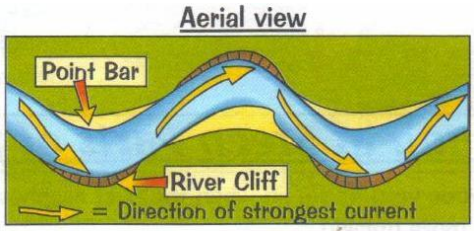
Meanders commonly occur in the Middle-Lower Course of the River's Long Profile

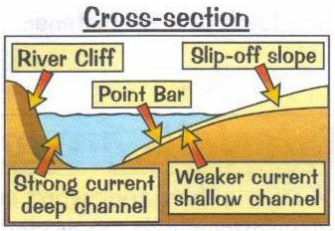
A Meander is a curve or loop in a river
An Ox-Bow lake is a horseshoe-shaped lake by the side of a river

MEANDER: STAGES OF FORMATION

1. River has large discharge, gentle gradient and lateral erosion
2. River develops winding pathway with large bends
3. Over time the course of the meander migrates downstream

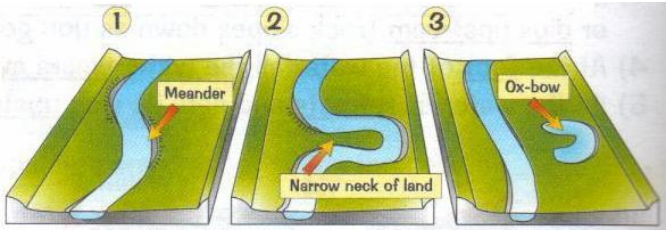
4. Current is fastest on the outside of the meander curve because the river is deeper there – on the inside it's shallow so the current is slower
5. River cliffs are found on the meander's outer edge where the river causes more erosion
6. Point bars are on the inner edge where sandy material is deposited by the slower-moving river – above river level they are slip-off slopes





OX-BOW LAKE: STAGES OF FORMATION

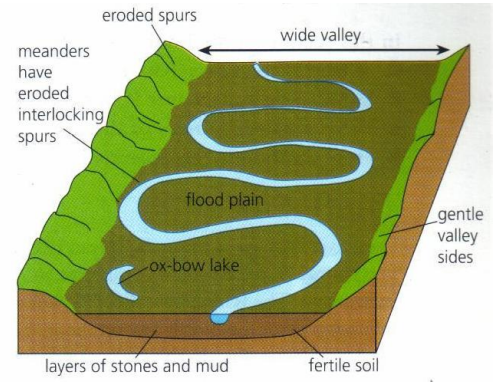
1. Meander loops become so wavy that they are inefficient
2. The rivers easiest path is straight across (in times of flood) so it breaks through narrow neck of land
3. Outer part of loop is left isolated from the river as an Ox-Bow Lake
4. Over time the lake becomes a marsh and then completely dries up



RIVER FEATURES: FLOODPLAINS & LEVEES

FLOODPLAIN

The Floodplain is the wide valley floor which the river regularly floods. The river erodes laterally wearing away interlocking spurs and widening the valley. It is flat and covered by alluvium, making it good farmland. Annual floods deposit layers of alluvium (silt) on the valley floor – floodplain is gradually raised

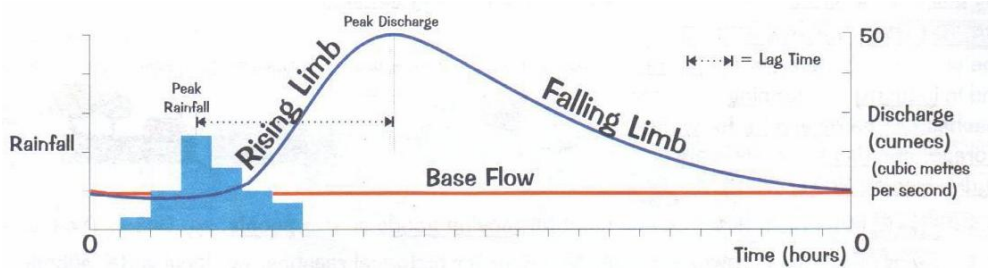


LEVÉES

Levées are raised river banks either side of the river channel, made of coarse river load material, deposited during floods

FLOODING: THE STORM HYDROGRAPH

Hydrographs show the relationship between precipitation and the change in river discharge (volume of water flowing per second) over a short period of time after a storm. It is used to work out when a flood might be coming



BASE FLOW	is the normal discharge of the river
RISING LIMB	represents the increase in discharge after the storm
FALLING LIMB	represents the decrease in discharge
LAG TIME	is the amount of time between peak rainfall and peak discharge

The river is likely to flood when the graph is steep. This is because there is a rapid increase in discharge over a short period of time and the river system is unable to transport it away

FACTOR	STEEEPER GRAPH 	GENTLER GRAPH 
Total Rainfall	High	Low
Intensity of Rain	High (runs off)	Low (soaks in)
Wetness of Ground	Saturated (runs off)	Dry (soaks in)
Rock Type	Impermeable (run off)	Porous (soaks in)
Ground Cover	Bare Soil (runs off)	Vegetated (soaks in)
Slope Angle	Steep (runs quickly)	Gentle (runs slowly)

FLOODING: CAUSES

Flooding is a natural process, but it may also be caused by people:

Precipitation	heavy rainfall over a few days ➔ saturates soil ➔ surface run-off
Flash Flood	hot dry area ➔ ground baked hard by sun ➔ intense burst of heavy rainfall ➔ water cannot infiltrate ➔ very rapid run-off
Snowmelt	temperatures rise ➔ snow melts ➔ stored precipitation is released
Deforestation	fewer trees ➔ reduced interception and transpiration ➔ increased surface run-off
Urbanisation	concrete, tarmac and drains laid ➔ surface becomes impermeable ➔ rapid increase in surface run-off (also building bridges into rivers)

FLOODING: IMPACTS

The impacts of flooding will be more severe in LEDCs than MEDCs

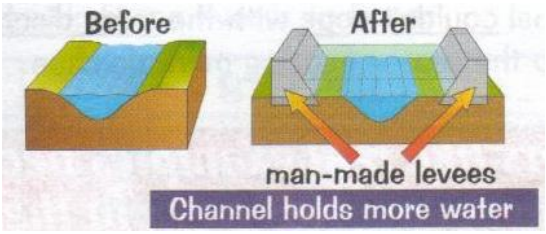
- Buildings and Property washed away or damaged by mud
- People and Animals drowned in fast-flowing water
- Transport interrupted – airports closed, road and rail networks submerged
- Crops ruined – soil saturated for months afterwards, preventing new planting
- Sewage contaminates drinking water supply – diseases such as cholera spread
- Economic impacts on individuals, industries, insurance companies and governments

- Positive Impacts of flooding include – deposition of fertile silt, washing away of pollutants and replenishing groundwater

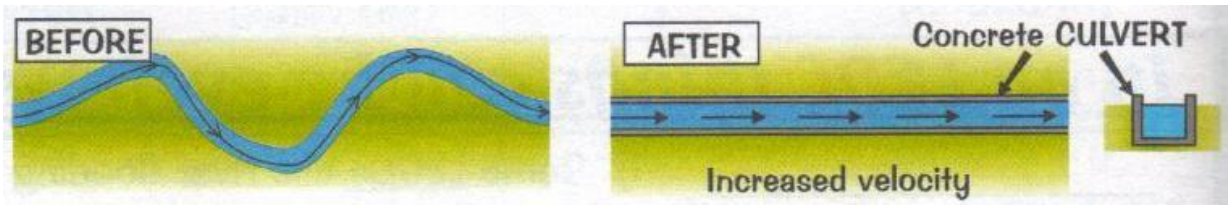
FLOODING CONTROL: HARD STRATEGIES

HARD STRATEGIES

Dams & Reservoirs	built in the upper valley, can control the discharge of the river (benefits include HEP and leisure facilities)
Levées	increase the height of river banks, floodwater is contained



Straightening Meanders (or lining channels)	increases speed of river to remove flood water quickly

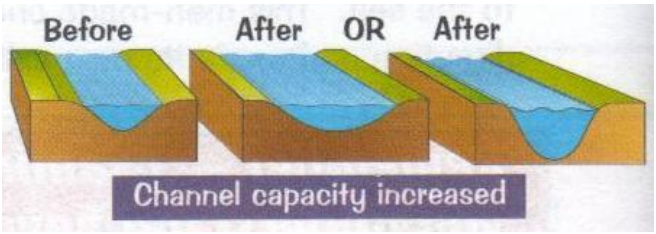


Spill ways

over flow

channels allow river to flood low-value or unused land

Changing the River Shape	increasing the capacity of the river channel means it can hold more water in a flood



FLOODING CONTROL: SOFT STRATEGIES

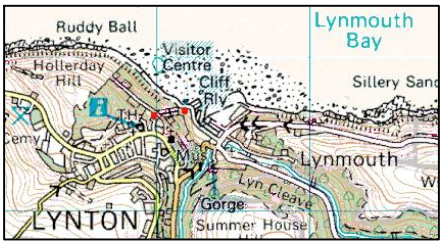
Flood Control using **SOFT ENGINEERING** involves using natural drainage basin processes to reduce flooding

Prediction	considering previous flood data, geology, soil, drainage and precipitation help predict when new flooding will hit
Flood Warning Systems	give people time to remove possessions and evacuate area
Afforestation	planting trees increases interception and evapotranspiration, reducing run-off
Pasture Land	leaving land to pasture gives continuous plant cover (also added plants and grass areas reduce flooding impacts)
Sandbagging	attempts to flood-proof homes and buildings
Insurance	spreads the cost of flood damage
Zoning	prevents new building in areas at risk from flooding – in UK based on Environment Agency flood risk maps

Sustainable Urban Drainage Systems (SUDS) reduce the flow and amount of urban damage by directing rainwater into the soil, slow draining channels or ponds

THE RIVER LYN & THE LYNMOUTH FLOOD – 1952

One of the worst floods in living memory in Britain was that which devastated the North Devon town of Lynmouth in 1952



- August of that year had been very wet and left the ground saturated
- An estimated 230mm of rain fell in a freak storm lasting 14 hours, and there was immediate surface run-off into the river causing a flash flood

- The channel of the West Lyn had been narrowed at Lynmouth by the building of hotels and other tourist amenities
- The already narrow arch of the road bridge had become blocked

- The river, too swollen to be contained within its channel, flowed down the main street of the town – following the path of least resistance

- Over 100 000 tonnes of boulders were left in the main street after the waters drained away – one boulder found in the basement of a hotel weighed **7.5 tonnes**.
- Elsewhere rocks of up to 10 m^3 had been moved by traction

IMPACTS OF THE FLOOD

- 34 people killed
- 90 houses and hotels destroyed
- 130 cars and 19 boats destroyed beyond repair

←Lynmouth **THEN**

Lynmouth **NOW**→

MASS MOVEMENT

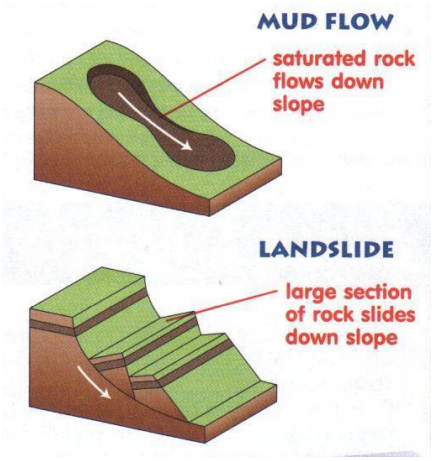
Mass Movement is when rock and soil move down a slope
Rapid mass movement is a **HAZARD** for people – both at the top and bottom of the slope

SOIL CREEP is the very slow movement of soil down a slope
caused by **throughflow** and **run-off**
results in bent trees and fences

MUD FLOW rapid movement of clay
rock weakened by heavy rain
behaves like a liquid

LANDSLIDE rapid movement of rock along a curved slip plane
occurs when rock can no longer support its own weight
heavy rainfall can saturate and weaken rock
building on slopes can weaken rocks by adding extra weight
earthquakes are often a key cause

ROCK FALL very rapid fall of cliff material (**Avalanche**) loosened by weathering (can be caused by loud noises, or accumulation of fresh snow)
fallen material (**Scree**) accumulates at foot of cliff – forms **Scree Slopes**



ABERFAN DISASTER 1966
Spoil heaps containing 90 years of waste rock (man-made hills) on a slope concern that these were unstable.
On 21st October heavy rain saturated a spoil heap.
This combined with the erosion underneath it by a small river made the slope steeper.
2million tonnes of rock flowed downhill destroying a farm, 20 houses and a school.
116 children and 28 adults were killed