GCSE GEOGRAPHY Y9 2017-2020

PAPER 1 – LIVING WITH THE PHYSICAL ENVIRONMENT

SECTION C PHYSICAL LANDSCAPES IN THE UK

Student Name: ____ **Class:** ___________

Specification Key Ideas:

Key Idea	Oxford text book
UK Physical landscapes	P90-91
• The UK has a range of diverse landscapes	
Coastal landscapes in the UK	P92-113
• The coast is shape by a number of physical processes	P92-99
• Distinctive coastal landforms are the result of rock type, structure and physical processes	P100-105
• Different management strategies can be used to protect coastlines from the effects of physical processes	P106-113
River landscapes in the UK	P114-131
• The shape of river valleys changes as rivers flow downstream	P114-115
• Distinctive fluvial (river) landforms result from different physical processes	P116-123
• Different management strategies can be used to protect river landscapes from the effects of flooding	P124-131

Scheme of Work:

Lesson	Learning intention:	Student booklet
1	UK landscapes & weathering	P10-12
2	Weathering	P12-13
3	Coastal landscapes – waves & coastal erosion	P14-16
4	Coastal transport & deposition	P16-17
5	Landforms of coastal erosion	P17-21
6	Landforms of coastal deposition	P22-24
7	INTERVENTION	P24
8	Case Study: Swanage (Dorset)	P24-25
9	Managing coasts – hard engineering	P26-28
10	Managing coasts – soft engineering	P28-30
11	Managed retreat	P30-32
12	Case Study: Lyme Regis (Dorset)	P32-33
13	INTERVENTION	P33
14	River landscapes	P34-35
15	River processes	P35-36
16	River landforms	P36-41
17	Case Study: River Tees (County Durham)	P42-44
18	INTERVENTION	P44
19	Factors increasing flood risk	P44-45
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21	Managing floods – hard engineering	P48-50
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24	Case study – soft engineering	P54-55
25	Case Study: Managing floods at Banbury (Oxfordshire)	P55-57

26	Fieldwork preparation 1	P58
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AQA GCSE GEOGRAPHY(8035)

3.1.3 Section C: Physical landscapes in the UK In this section, students are required to study **UK physical landscapes** and two from **Coastal landscapes in the UK**, **River landscapes in the UK** and Glacial landscapes in the UK.

3.1.3.1 UK physical landscapes
The UK has a range of diverse landscapes.
An overview of the location of major upland/lowland areas and river systems.

3.1.3.2 Coastal landscapes in the UK
The coast is shaped by a number of physical processes.
Wave types and characteristics.
Coastal processes:
- weathering processes – mechanical, chemical
- mass movement – sliding, slumping and rock falls
- erosion – hydraulic power, abrasion and attrition
- transportation – longshore drift
- deposition – why sediment is deposited in coastal areas.

Distinctive coastal landforms are the result of rock type, structure and physical processes.
How geological structure and rock type influence coastal forms.
Characteristics and formation of landforms resulting from erosion – headlands and bays, cliffs and wave cut platforms, caves, arches and stacks.
Characteristics and formation of landforms resulting from deposition – beaches, sand dunes, spits and bars.
An example of a section of coastline in the UK to identify its major landforms of erosion and deposition.

Different management strategies can be used to protect coastlines from the effects of physical processes.
The costs and benefits of the following management strategies:
- hard engineering – sea walls, rock armour, gabions and groynes
- soft engineering – beach nourishment and re-profiling, dune regeneration
- managed retreat – coastal realignment.

An example of a coastal management scheme in the UK to show:
- the reasons for management
- the management strategy
- the resulting effects and conflicts.

3.1.3.3 River landscapes in the UK
The shape of river valleys changes as rivers flow downstream.
The long profile and changing cross profile of a river and its valley.
Fluvial processes:
- erosion – hydraulic action, abrasion, attrition, solution, vertical and lateral erosion
- transportation – traction, saltation, suspension and solution
- deposition – why rivers deposit sediment.

Distinctive fluvial landforms result from different physical processes.
Characteristics and formation of landforms resulting from erosion – interlocking spurs, waterfalls and gorges.
Characteristics and formation of landforms resulting from erosion and deposition – meanders and ox-bow lakes.
Characteristics and formation of landforms resulting from deposition – levées, flood plains and estuaries.
An example of a river valley in the UK to identify its major landforms of erosion and deposition.

Different management strategies can be used to protect river landscapes from the effects of flooding.
How physical and human factors affect the flood risk – precipitation, geology, relief and land use.

The use of hydrographs to show the relationship between precipitation and discharge.
The costs and benefits of the following management strategies:

- hard engineering – dams and reservoirs, straightening, embankments, flood relief channels
- soft engineering – flood warnings and preparation, flood plain zoning, planting trees and river restoration.

An example of a flood management scheme in the UK to show:

- why the scheme was required
- the management strategy
- the social, economic and environmental issues.

GLOSSARY

9. UK Physical Landscapes

Key Term	Definition
Cross-section	an imaginary 'slice' through a landscape which helps to visualise what we cannot see
Geology	the rock type that forms the landscape
Landscape	an extensive area of land regarded as being visually and physically distinct
Relief	the height of the land and the different landscape features created by changes in height
Resistant rock	tough rock such as granite and slate
River system	the complete river network from its source to mouth
Spot height	indication of land height, usually represented on OS maps as black dots with height above sea level written alongside

10. Coastal landscapes in the UK

Key Term	Definition
Abrasion	(1) rocks carried along a river wear down the river bed and banks (2) the sandpaper effect of glacial ice scouring a valley floor and sides
Adaptation	actions taken to adjust to natural events such as climate change, to reduce damage, limit the impacts, take advantage of opportunities, or cope with the consequences
Aerial photo	an image taken from above ground-level looking down on a landscape, they can either be (1) *Vertical* – looking directly down to the ground or, (2) *Oblique* – looking sideways
Arch	a wave-eroded passage through a small headland. This begins as a cave which is gradually widened and deepened until it cuts through
Attrition	rocks being carried by the river smash together and break into smaller, smoother and rounder particles
Backwash	water that flows back towards the sea after the swash has moved up-shore
Bar	where a spit grows across a bay, a bar can eventually enclose the bay to create a lagoon
Barrier beach	coastal landform that runs parallel to the coastline, often created when offshore bars are driven onshore by rising sea levels

Bay	a wide coastal inlet, often with a beach, where areas of less resistant rock have been eroded by the sea
Beach	a zone of deposited material that extends from the low water line to the limit of storm waves
Beach nourishment	adding new material to a beach artificially, through the dumping of large amounts of sand or shingle
Berm	a low ridge on a sandy beach created by swash, usually marks the high tide line
Biological weathering	a type of weathering caused by flora and fauna, such as plant roots growing in cracks in the rock or animals burrowing into weak rocks
Carbonation	weathering of limestone and chalk by acidic rainwater
Cave	a large hole in a cliff caused by waves forcing their way into cracks in the cliff face
Cavitation	the explosive force of air trapped in the cracks of rock
Chemical weathering	the decomposition (or rotting) of rock caused by a chemical change within that rock
Cliff	a steep high rock face formed by weathering and erosion
Coastal management	strategies used to defend coastal environments, divided into three different approaches: *hard engineering*, *soft engineering* and *managed retreat*
Coastal realignment	the establishment of a new coastline as part of managed retreat, often allowing flooding to occur over low-lying land to protect farmland, roads and settlements
Concordant coastline	a straight coastline with a single rock running parallel to the coast
Constructive waves	a powerful wave with a strong swash that surges up a beach
Corrosion	chemical erosion caused by the dissolving of rocks and minerals by sea water
Deposition	occurs when material being transported by the sea is dropped due to the sea losing energy
Destructive waves	a wave formed by a local storm that crashes down onto a beach and has a powerful backwash
Discordant coastline	an indented coastline made up of headlands and bays formed when different rocks reach the coast
Dune	deposit of sand which has been blown inland by onshore winds
Dune fencing	fences constructed on sandy beaches to encourage the formation of new sand dunes to protect existing dunes
Dune regeneration	building up dunes and increasing vegetation to prevent excessive coastal retreat
Erosion	wearing away and removal of material by a moving force, such as a breaking wave
Fault	a crack or line of weakness in rock
Fetch	the distance of open water over which the wind can blow

Freeze-thaw weathering	a common process of weathering in a glacial environment involving repeated cycles of freezing and thawing that can make cracks in rock bigger
Gabions	steel wire mesh filled with boulders used in coastal defences
Geological structure	the way that layers of rock are folded or tilted
Grid reference	a map reference that indicates a location using numbered vertical and horizontal lines that run up and down, and increase in value from bottom to top of the map
Groyne	a wooden barrier built out into the sea to stop the longshore drift of sand and shingle, and allow the beach to grow
Headland	a rocky coastal promontory (highpoint of land) made of rock that is resistant to erosion: headlands lie between bays of less resistant rock where the land has been eroded by the sea
Hydraulic power	process where breaking waves compress pockets of air in cracks in a cliff; the pressure may cause the crack to widen, breaking off rock
Jurassic Coast	a 154km stretch of coast in East Devon and Dorset which was made a World Heritage Site in 2001 because of its geological importance
Landform	a physical feature of the Earth’s surface
Landslide	the movement of rock, earth or debris down the slope of a hill. Also known as a *landslip*
Longshore drift	transport of sediment along a stretch of coastline caused by waves approaching the beach at an angle
Marram grass	type of grass that is adapted to windy, exposed conditions and is used in coastal management to stabilise sand dunes
Mass movement	downhill movement of weathered material under the force of gravity
Mechanical weathering	physical disintegration or break up of exposed rock without any change in its chemical composition, i.e. freeze–thaw
Mudflats	areas of fine sediment deposits which over time can develop in saltmarshes
Mudflow	when saturated soil and weak rock flow down a slope
OS map	highly accurate maps drawn by Ordnance Survey, the national mapping agency for Great Britain
Recurved end	strong winds or tidal current cause the end of a spit to become curved
Reprofiling	increasing the height and width of beaches by dumping and shaping of dredged sand or shingle
Rock armour	large boulders deliberately dumped on a beach as part of coastal defences

Rockfall	a fragment of rock breaks away from the cliff face, often due to freeze-thaw weathering
Rotational slip	slump of saturated soil and weak rock along a curved surface
Salt weathering	a weathering process where salt crystals grow and expand in the cracks and holes of rock, creating pressure which eventually causes fragments of rock to break away
Saltation	hopping movement of pebbles along a river or sea bed
Saltmarshes	important natural habitats often found in sheltered river estuaries behind spits where there is very little flow of water
Scree	accumulation of fragments of weathered rock
Sea wall	concrete wall aiming to prevent erosion of the coast by reflecting wave energy
Sliding	loose surface material becomes saturated and the extra weight causes the material to become unstable and move rapidly downhill
Solution	the dissolving of rocks such as limestone and chalk by sea water
Spit	depositional landform formed when a finger of sediment extends from the shore out to sea, often at a river mouth
Stack	isolated pillar of rock left when the top of an arch has collapsed
Suspension	small particles carried in river flow or sea water, i.e. sands, silts and clays
Swash	the forward movement of a wave up a beach
Traction	heavy particles rolled along the sea bed
Transportation	the movement of eroded material
Tsunami	huge waves caused by earthquakes
Wave refraction	wave energy is reduced in bays as the water gets shallower
Waves	ripples in the sea caused by the transfer of energy from the wind blowing over the surface of the sea
Wave-cut platform	rocky, level shelf at or around sea level representing the base of old, retreated cliffs

11. River landscapes in the UK

Key Term	Definition
Abrasion	rocks carried along a river wear down the river bed and banks
Aerial photo	an image taken from above ground-level looking down on a landscape, they can either be (1) Vertical – looking directly down to the ground or, (2) Oblique – looking sideways
Alluvium	a sediment deposited by a river when it floods

Attrition	rocks being carried by the river smash together and break into smaller, smoother and rounder particles
Benefits	financial savings made by preventing flooding, along with any environmental improvements
Channel	the main water course
Channel straightening	removing meanders from a river to make it straighter
Confluence	where a tributary joins a larger river
Costs	the financial cost of a scheme, and any negative impacts on the environment and on people's lives
Course	the path of the river from its source to mouth
Cross profile	a cross section of a river channel or its valley
Dam	a barrier built across a valley to interrupt river flow
Deposition	occurs when material being transported by the sea is dropped due to the sea losing energy
Discharge	quantity of water that passes a given point on a stream or riverbank within a given period of time
Drainage basin	an area of land drained by a river and its tributaries
Embankment	artificially raised river banks often using concrete walls
Estuary	tidal mouth of a river where it meets the sea – wide banks of deposited mud are exposed at low tide
Flash flood	a very sudden flood event resulting from a torrential rainstorm
Flood	where river discharge exceeds river channel capacity and water spills onto the floodplain
Flood relief channel	artificial channels that are used when a river is close to maximum discharge; they take the pressure off the main channels when floods are likely
Flood risk	the likelihood of a flood event occurring in a certain area
Flood storage areas	water is deliberately allowed to flood wetlands to reduce the risk of flooding further downstream
Flood warnings	providing reliable advance information about possible flooding
Floodplain	relatively flat area forming the valley floor either side of a river channel that is sometimes flooded
Floodplain zoning	identifying how a floodplain can be developed for human uses
Flow control	specially designed aperture (opening) in a river channel which controls the rate of flow downstream. Excess water is stored behind the structure in a reservoir
Gorge	a narrow steep-sided valley – often formed as a waterfall retreats upstream

Gradient	the height and angle of a slope
Hydraulic action	power of the water eroding the bed and banks of a river
Hydrograph	a graph which shows the discharge of a river, related to rainfall, over a period of time
Interlocking spurs	outcrops of land along the river course in a valley
Knick point	a step or drop in a river's bed which often cause waterfalls
Lateral erosion	erosion of river banks rather than the bed – helps to form the floodplain
Levee	raised bank found on either side of a river, formed naturally by regular flooding or built up by people to protect the area against flooding
Load	material transported by a river
Long profile	the gradient of a river, from its source to its mouth
Meander	a wide bend in a river
Mouth	the end of a river, usually where a river joins the sea
Mudflats	areas of fine sediment deposits which over time can develop in saltmarshes
Ox-bow lake	an arc-shaped lake on a floodplain formed by a cut-off meander
Plunge pool	a deep and turbulent area of water where the river 'plunges' over a waterfall
Pools and riffles	alternating sequence in the course of a river or stream that carry coarse sediment, where shallow fast-flowing sections are called *riffles* and deeper slower-moving sections are called *pools*
Precipitation	moisture falling from the atmosphere – rain, sleet or snow
Prediction	using historical evidence and monitoring, scientists can make predictions about when and where a hazard may happen
Reservoir	A large natural or artificial lake used as a source of water supply
River restoration	modifying the course of a river to return it to its natural state
Saltation	hopping movement of pebbles along a river or sea bed
Saltmarshes	important natural habitats often found in sheltered river estuaries behind spits where there is very little flow of water
Solution	dissolved rocks and minerals often derived from limestone or chalk
Source	the start of a river
Suspension	small particles carried in river flow or sea water, i.e. sands, silts and clays
Thalweg	the course of the fastest flow (velocity) within a river
Time lag	the time in hours between the highest rainfall and the highest (peak) discharge
Traction	where material is rolled along a river bed or by waves

Transportation	the movement of eroded material
Tributary	a small stream that joins a larger river
Velocity	rate of the river flow
Vertical erosion	downward erosion of the river bed
V-shaped valley	steep-sided valley
Waterfall	a step in the long profile of a river usually formed when a river crosses over a hard (resistant) band of rock
Watershed	the edge of the river basin
Wetlands	saturated areas of land, often found on river floodplains

Notes:

Lesson 1 – UK Landscapes

The UK's relief and landscapes

Relief is a term used to describe the physical features of the landscape. This includes: height above sea level, steepness of slopes & shapes of landscape features.

The relief of an area is due mainly to its geology – the rocks that form the landscape. Tough, resistant rocks such as granite and slate form some of the UK's most dramatic mountain ranges such as those in Arran (Scotland). Weaker rocks such as clays and limestone often form low-lying plains and gently rolling landscapes.

Arran mountains

South Downs clay lowlands

The UK's landscapes

A landscape is an area whose character is the results of the action and interaction of natural and human factors. In the UK a wide variety of rock types are responsible for creating our varied landscapes.

The UK's river systems

The UK has an extensive river system. Most rivers have their source in the mountain ranges or hills and flow to the sea.

Key features of the UK

Landscapes of the UK

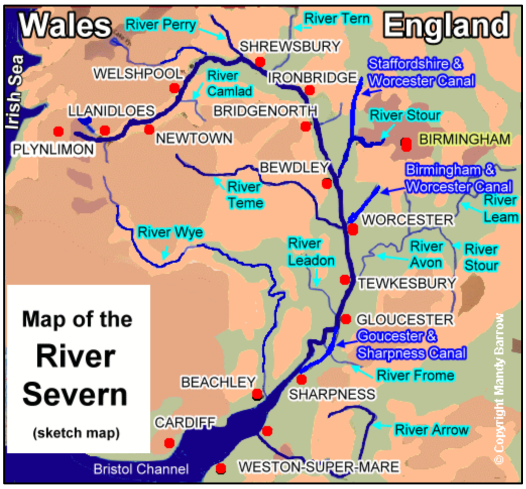
The Lake District

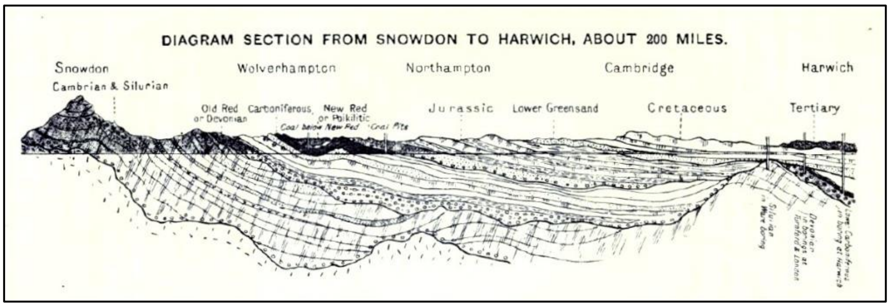
The Cheviot Hills – border of England & Scotland

Cumbrian mountains

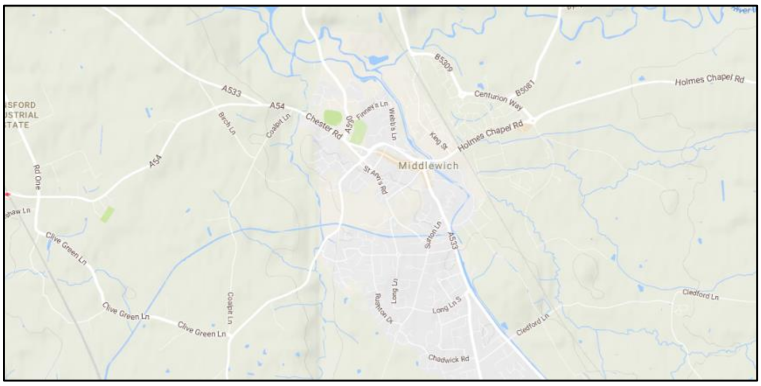
The Pennines

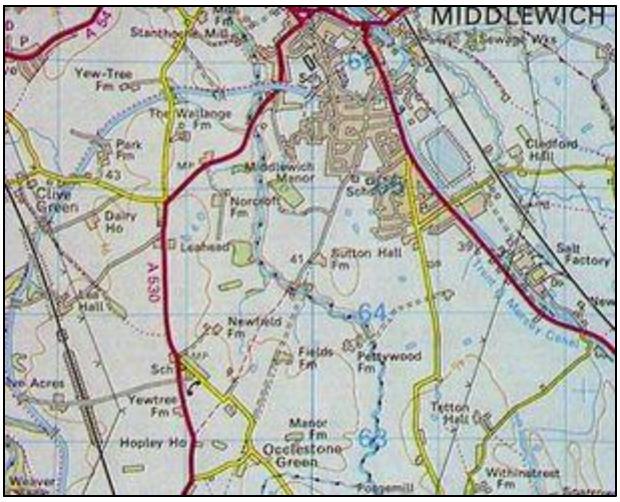
Dartmoor





Maps of Middlewich

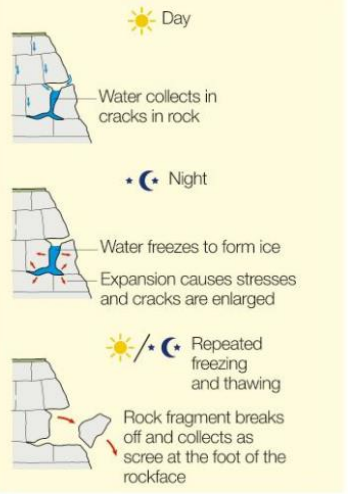




The department has OS maps of Middlewich that you can refer to.

<u>Lesson 2 - Weathering & Mass Movement</u>

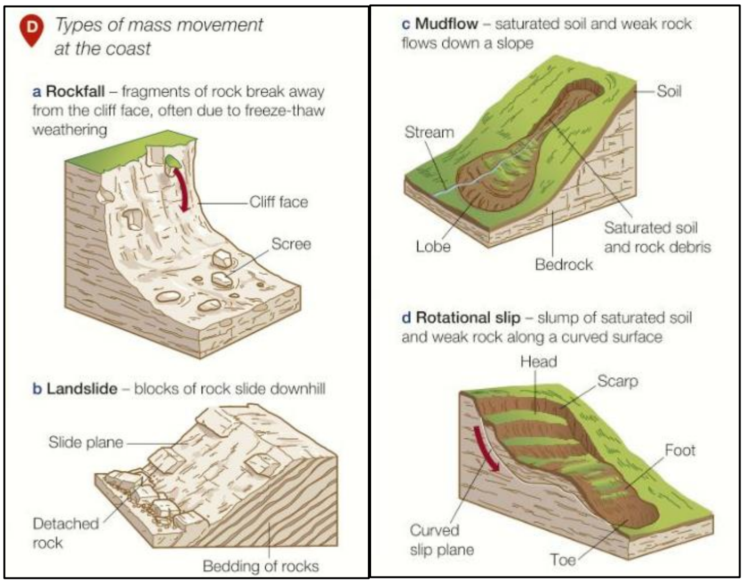
Cliffs collapse because of different types of weathering. This is the weakening or decay of rocks in their original place on, or close to, the ground surface. It is mostly caused by weather factors such as rainfall and changes in temperature.



B *The process of freeze-thaw weathering*

Weathering process	Description
Freeze-thaw (mechanical)	Look at diagram **B**. • Water collects in cracks or holes (pores) in the rock. • At night this water freezes and expands and makes cracks in the rock bigger. • When the temperature rises and the ice thaws, water will seep deeper into the rock. • After repeated freezing and thawing, fragments of rock may break off and fall to the foot of the cliff (*scree*).
Salt weathering (mechanical)	• Seawater contains salt. When the water evaporates it leaves behind salt crystals. • In cracks and holes these salt crystals grow and expand. • This puts pressure on the rocks and flakes may eventually break off.
Carbonation (chemical)	• Rainwater absorbs CO_2 from the air and becomes slightly acidic. • Contact with alkaline rocks such as chalk and limestone produces a chemical reaction causing the rocks to slowly dissolve.

Mass movement is the downward movement or sliding of material under the influence of gravity. Diagram D describes some of the common types of mass movement found at the coast. Both mass movement and weathering provide an input of material to the coastal system. Much of this material is carried away by waves and deposited further along the coast.



Rockfall at Beachy Head 2001


A Rockfall at Beachy Head, Sussex

Photo A shows a rockfall that happened at Beachy Head in East Sussex. During the wet winter of 2000 the chalk rock became saturated with water. The water froze during the winter. In April 2001 this caused a rockfall – a huge slab of chalk broke away and collapsed into the sea.

Source 1 – British Geological Survey - This landslide occurred at 14.30hrs on 3 April, 2001 and destroyed the landmark known as the 'Devil's Chimney' (Figures 3 and 4). The landslide followed three days of preliminary subsidence and detachment movements amounting to a displacement of a few metres.

A deep tension crack, probably penetrating the entire thickness of the Seaford Chalk Formation, developed following pre-existing joints. The separated block tilted seaward further opening the tension crack and increasing the vertical stresses at its base. Debris and water were able to enter the fissure over many years, before the final slide where failure occurred. This failure is thought to have occurred in two stages separated by a few days or hours.

The Devil's Chimney before and after the cliff collapse.

Source 2 – Wikipedia – Belle Tout Lighthouse - By 1999 the erosion of the cliffs was threatening the foundations of the building and drastic steps had to be taken to stop it from falling into the sea. On 17 March 1999 in a remarkable feat of engineering work the Belle Tout was moved 17 metres (56 ft) away from the cliff face. The 850-ton lighthouse was moved using a pioneering system of hydraulic jacks which pushed the building along four steel-topped concrete beams that were constantly lubricated with grease, work undertaken by the engineering firm Abbey Pynford. The site should now be safe for many years and has been designed to enable further moves as and when they are required.

Cliff Collapse at Scarborough 1993

In 1993, 60m of cliff slipped onto the beach near Scarborough in North Yorkshire, taking with it part of the Holbeck Hall Hotel. The hotel was left on the cliff edge and had to be demolished.

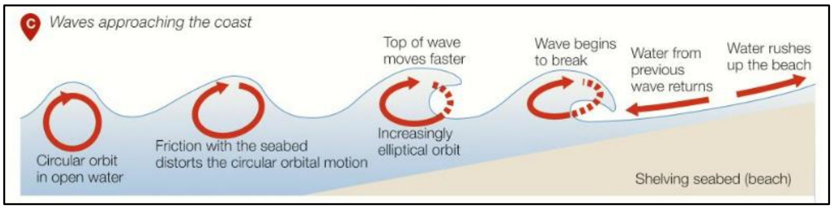
Lesson 3 Coastal Landscapes – Waves & Coastal Erosion

Wave Types & Their Characteristics

Waves are formed by the wind blowing over the sea. Friction with the surface of the water causes ripples to form and these develop into waves. The distance the wind blows over the water is called the *fetch.* The longer the fetch the more powerful the wave.

Waves can also be caused by undersea earthquakes or volcanic eruptions. These are called tsunamis.

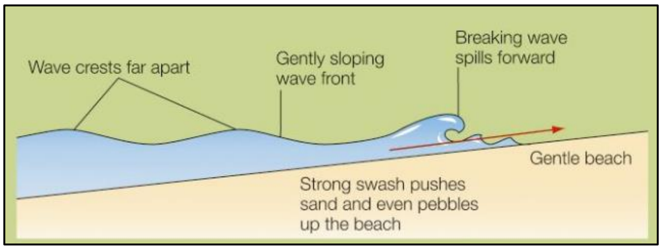
When waves reach the shore there is a forward movement of water as the waves break and surge up the beach. Friction with the seabed causes the wave to change shape and eventually the wave crest rises up and then collapses on the beach. Water rushing up the beach is called *swash* and water flowing back to the sea is called *backwash.*



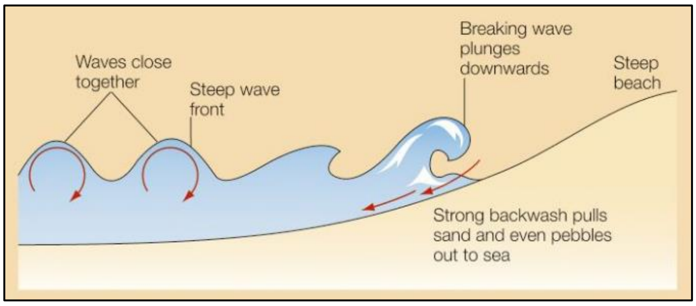
A Surfing at Newquay, Cornwall

There are two types of waves – *constructive* and *destructive.*

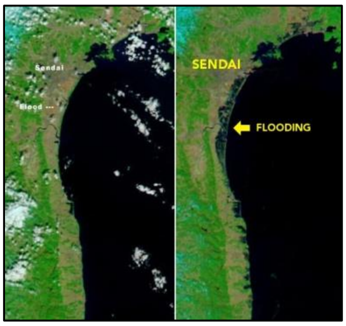
Constructive waves
* low waves that surge up beach
* powerful swash
* carry & deposit large amounts of sediment
* 'construct' the beach making it bigger
* preferred by surfers due to longer rides
* formed by storms out to sea



Destructive waves
* formed by local storms close to shore
* can 'destroy' the beach
* closely spaced
* can 'interfere' with each other creating chaotic swirling water
* high and steep before plunging down on beach
* little forward motion (swash)
* powerful backwash
* gradually removes sediment from beach



Japanese Tsunami 2011 – Source – The Telegraph



DEATH TOLL: A total of 12,431 people were confirmed dead by Japan's National Police Agency, while 15,153 were missing.

NUMBER OF PEOPLE EVACUATED: More than 163,000 people were in shelters around the country following evacuation, the National Police Agency said. The government has set up an evacuation area around Tokyo Electric Power Co's quake-stricken nuclear plant in Fukushima 150 miles north of Tokyo, with a 12-mile radius. More than 70,000 people lived in the largely rural area within the zone. It is unclear how many of them have been evacuated, but most are believed to have left. Another 136,000 people were within a zone extending a further six miles in which residents are recommended to leave or stay indoors.

A total of 164,059 households in the north were without electricity, Tohoku Electric Power Co said.

At least 170,000 households in eight prefectures were without running water, the Health Ministry said.

At least 46,027 buildings have been destroyed, washed away or burnt down, the National Police Agency of Japan said.

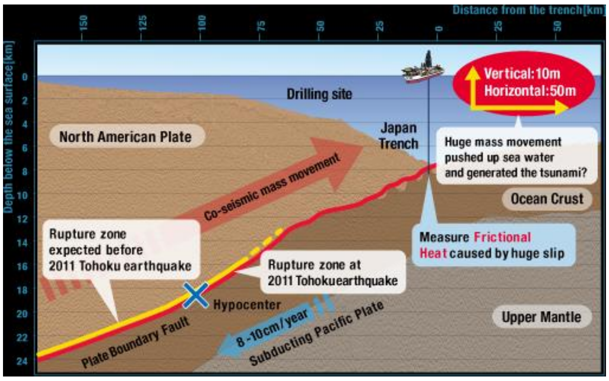
The government has estimated damage from the earthquake and tsunami at 16-25 trillion yen. The top estimate would make it the world's costliest natural disaster.

The estimate covers damage to roads, homes, factories and other infrastructure, but excludes lost economic activity from power outages and costs arising from damage to the Fukushima nuclear power plant, as well as the impact of swings in financial markets and business sentiment. The yen initially spiked to a record high against the dollar after the quake, prompting the first joint intervention by the Group of Seven rich nations in 11 years to help shield Japan’s export-reliant economy.

Japan's reconstruction spending will almost certainly exceed that of the 1995 quake in Kobe, when the government needed extra budgets of more than 3 trillion yen. The government may need to spend more than 10 trillion yen in emergency budgets for post-quake disaster relief and reconstruction, with part of them possibly covered by new taxes, Deputy Finance Minister Mitsuru Sakurai signalled on Thursday.

According to the Foreign Ministry, 134 countries and 39 international organisations have offered assistance.

Figure 1. Rikuzen-takata City before and after the disaster*



Coastal (Marine) Processes – Coastal Erosion

Erosion causes the removal of material and the shaping of landforms. There are 5 key processes of coastal erosion.

Solution- dissolving of soluble chemicals in the rocks e.g. limestone.

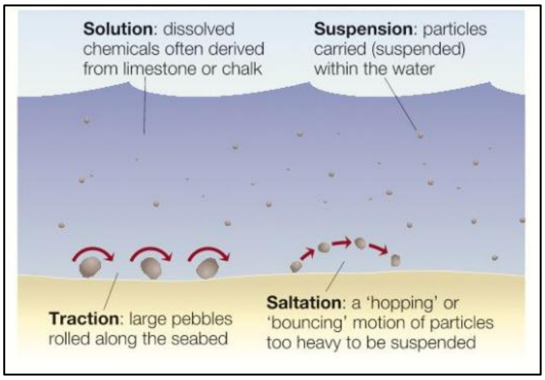
Hydraulic power/action – the power of the waves as they smash onto a cliff, tapped air is forced into cracks & holes in the rock eventually causing the rock to break apart. The explosive force of trapped air operating in a crack is called *cavitation.*

Attrition – rock fragments carried by the sea knock against each other causing them to become smaller and more rounded.

Abrasion – This is the 'sand-papering' effect of pebbles grinding over a rocky surface or platform often causing it to become smooth.

Corrasion – fragments of rock are picked up and hurled by the sea at a cliff. The rocks act like tools scraping and gouging to erode the rock.

<u>Lesson 4 Coastal transportation & deposition</u>



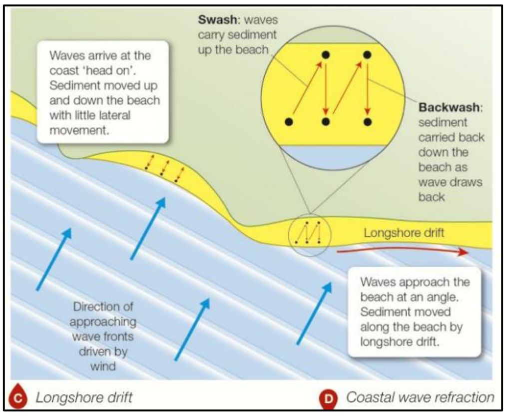
There are 4 different ways that sediment can be carried by the sea – depending on the size of the sediment. These are solution, suspension, saltation and traction.

Longshore Drift

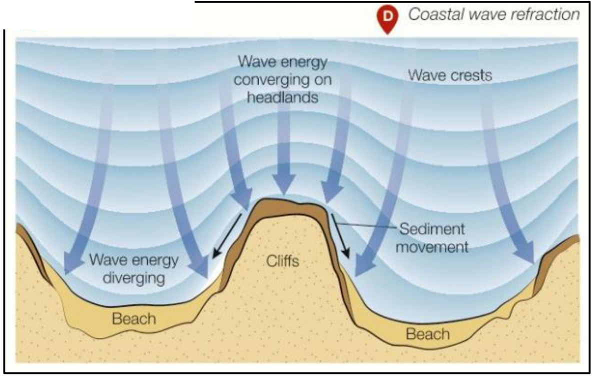
The movement of sediment along a beach depends on the direction that waves approach the coast. If waves approach 'head on'; the sediment simply moves up and down the beach. However; if the waves approach at an angle, sediment will be moved *along* the beach in a *zig zag* pattern. This is called *longshore drift* (diagram C)*.* Longshore drift creates landforms such as beaches and spits.

Coastal Deposition

Deposition takes place in areas where the flow of water slows down. Waves lose energy in sheltered bays and where water is protected by spits or bars. Here sediment is deposited. This is why we find beaches in bays.



C Longshore drift
D Coastal wave refraction



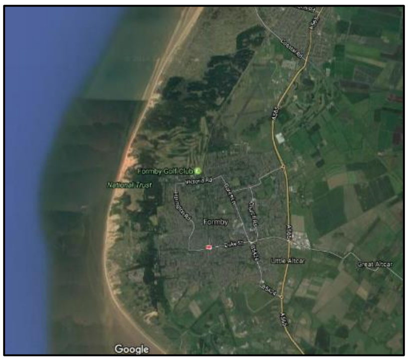
D Coastal wave refraction

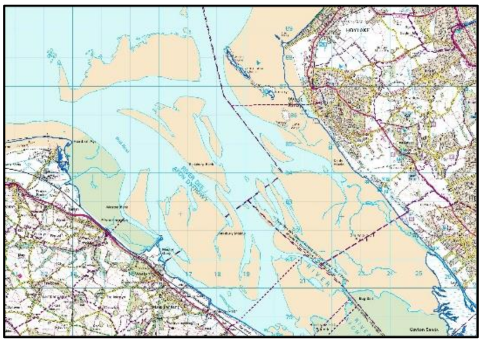
Wave refraction is where the energy of waves is reduced in bays – see diagram D.

Mudflats and salt marshes are often formed in sheltered estuaries behind spits where there is little flow of water.

Local coastal locations where deposition occurs

Formby Beach, Lancashire | Cleveleys Beach, Lancashire | River Dee mudflats





Lesson 5 – Landforms of Coastal Erosion

A *landform* is a feature of the landscape that has been formed or sculpted by processes of: erosion, transportation or deposition.

Some rocks are tougher and more *resistant* than others. Rocks such as granite, limestone and chalk from impressive cliffs and headlands because they are more resistant to erosion.
Softer rocks such as clays and sands are more easily eroded to form bays or low-lying stretches of coastline.

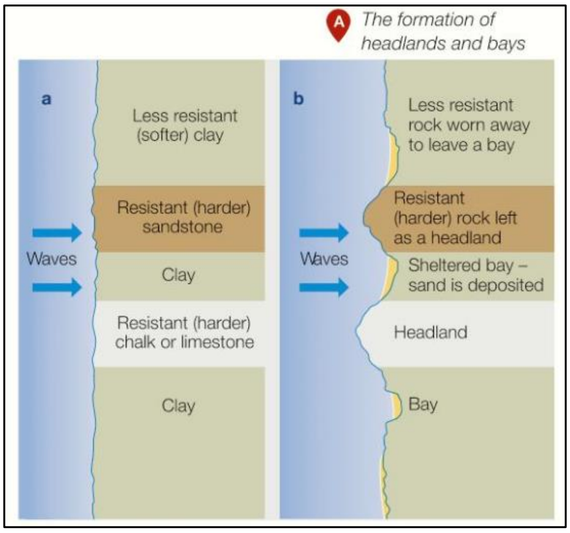
Remember!

- A cliff, a river meander or a delta *are* all landforms.
- A process such as longshore drift is *not* a landform.
- A geological feature such as a joint in a rock outcrop is *not* a landform.

If you are in any doubt, check with your teacher!

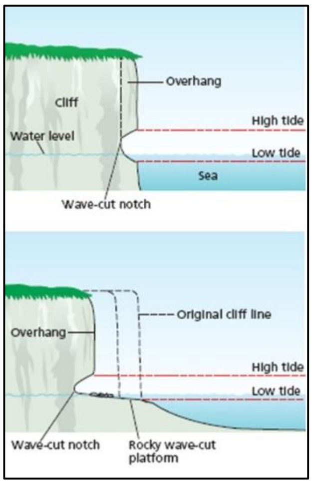
Geological structure includes the way that layers of rock are folded or tilted. This can be an important factor in the shape of cliffs. *Faults* are cracks in rocks. Enormous tectonic pressures can cause rocks to ‘snap’ rather than fold (bend) and movement happens on either side of the fault. Faults form lines of weakness in rocks, easily carved out by the sea.

Headlands and Bays

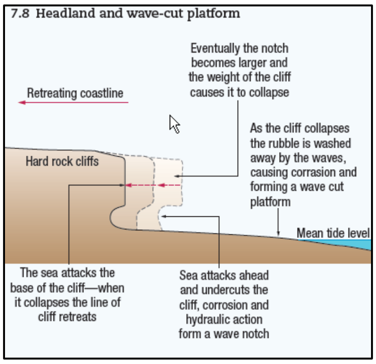


Different types of rocks are eroded at different rates. Weaker rocks erode more easily to create *bays*. As bays are sheltered, deposition takes place and a sandy beach forms.
The more resistant rocks are eroded more slowly. They stick out into the sea as *headlands*. Erosion dominates here so there are no beaches. Most erosional landforms are found at headlands. Headlands and bays are formed due to differential erosion. This indented coast is called a discordant coastline.

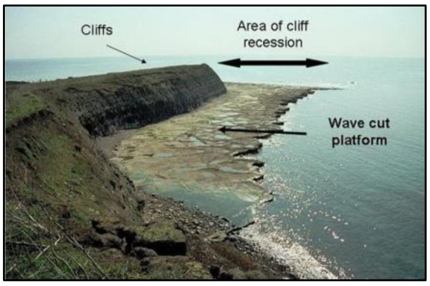
Cliffs and Wave-Cut Platforms



Waves break against the base of a cliff and erode at the *high tide mark*. This erosion forms a *wave-cut notch*. Over a long period of time – usually hundreds of years – the notch will get deeper and deeper, *undercutting* the cliff. Eventually the over-hanging cliff can no longer support its own weight and it collapses.



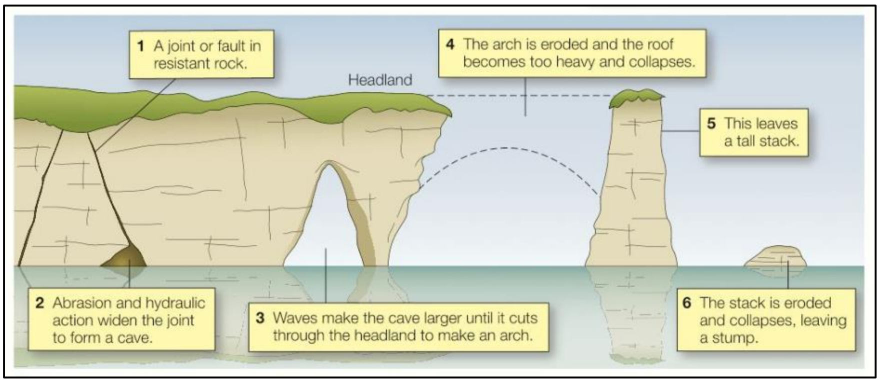
This process repeats itself over time and gradually the cliff *retreats* backwards. In its place a gently sloping rocky platform called a *wave-cut platform* forms. This is typically smooth due to abrasion, however in places there may be rock pools.



Caves, arches and stacks

Faults are vulnerable to erosion. Waves erode the cliffs along lines of weakness such as faults to form *caves*. Over time erosion may lead to two back-to-back caves breaking through a headland to form an *arch*. Gradually the arch is enlarged by erosion at the base and weathering processes on the roof. Eventually the roof will be worn away and collapse to form an isolated pillar of rock called a *stack*.


Old Harry, the Jurassic Coast



Activity - Coastal Erosion landforms

This accompanies the animation **Skills-pod 04: Interpreting photos – Landforms**.

Look carefully at the photo below of Lulworth Cove in Dorset, southern England.

1. Identify **two** geomorphic processes which have helped to create the landscape in the photo. *[2 marks]*

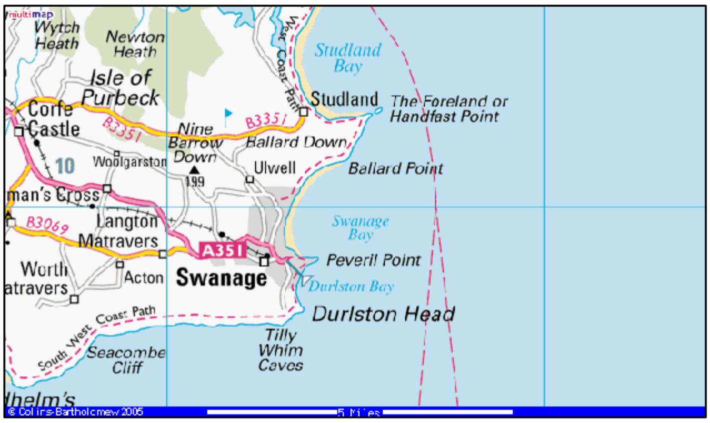
2. Using evidence from the photo, add annotations to the photo to explain how Lulworth Cove was formed. *[7 marks]*

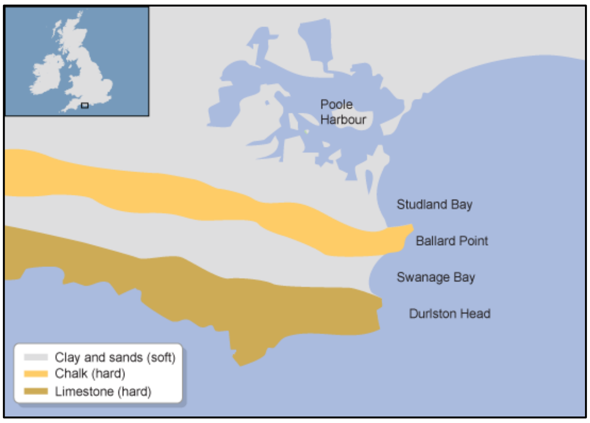
3. Identify **one** further piece of information which would help to provide a better understanding of how this landscape was formed. *[1 mark]*

[10 marks]

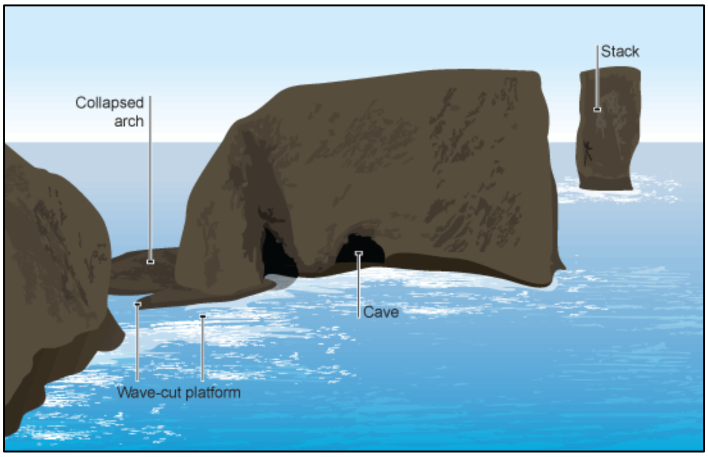
Swanage

Along the coastline of the Isle of Purbeck in Dorset, there are both discordant and concordant coastlines. The discordant coastline has been formed into Studland Bay (soft rock), Ballard Point (hard rock), Swanage Bay (soft rock) and Durlston Head (hard rock). After Durlston Head, the strata stop alternating and the coastline is made up of hard rock. This concordant coast has fewer features.





Old Harry Rocks, Swanage, Dorset



<u>The Foreland</u>

There are three main features found in The Foreland:

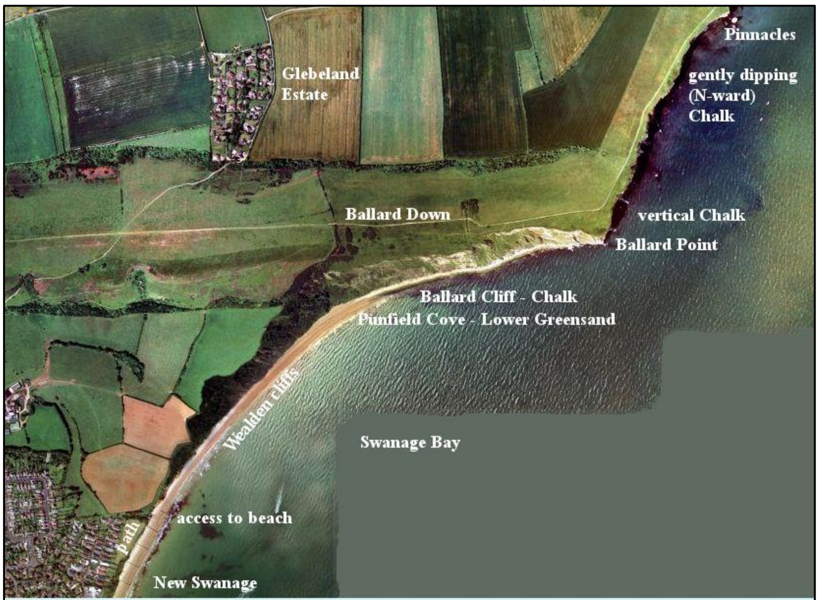
- <u>Natural Arch</u>

  The Natural Arch can be found at 056,824. They are formed from caves and develop at opposite sides of the headland to join up. It is also caused by destructive waves. Arches are made from resistant permeable rock and are tall and vertical. As waves continue to erode the base of the arch, its roof becomes too heavy to be supported and collapses leaving part of the cliff isolated.
- <u>Stacks</u>

  Old Harry (found at 058,827), and Old Harry's Wife (found at 058,826), were both stacks but now Old Harry's Wife is a stump. They are both near the Natural Arch. A stack is a steep sided rocky heap located offshore from coastal cliffs and natural arches. They are formed from resistant permeable rock and formed when the rock above the arch became too heavy to be supported and so collapsed. Old Harry can be said to be like a 'tall pillar'. The geometric processes which have formed this feature are corrasion, destructive waves and hydraulic action. These processes will carry on colliding against the stack (Old Harry), until eventually the stack collapses leaving a stump (Old Harry's Wife)
- <u>Wave-Cut Platforms</u>

  There could be a wave-cut platform forming at The Foreland at 056,826. Waves erode rocks along the shore line by hydraulic action, corrosion and corrasion. A notch is slowly formed at the high water mark which may develop into a cave. Rock above the notch becomes unstable with nothing to support it and so collapses. The coastline retreats over many years as this process continues to form a wave-cut platform. The actual size and angle of the cliff will depend on the local rock and its hardness.

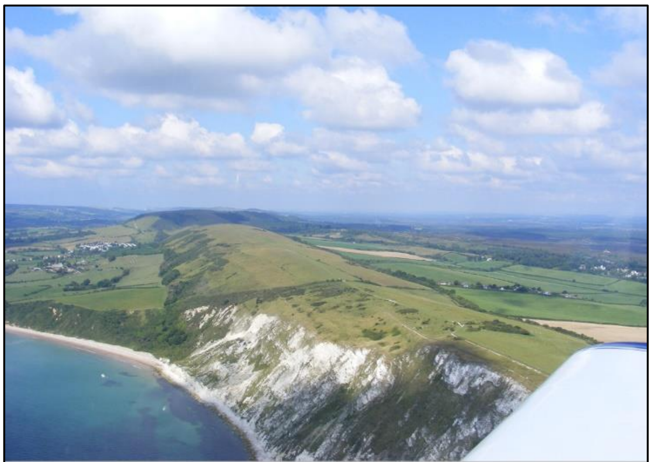
Ballard Cliff



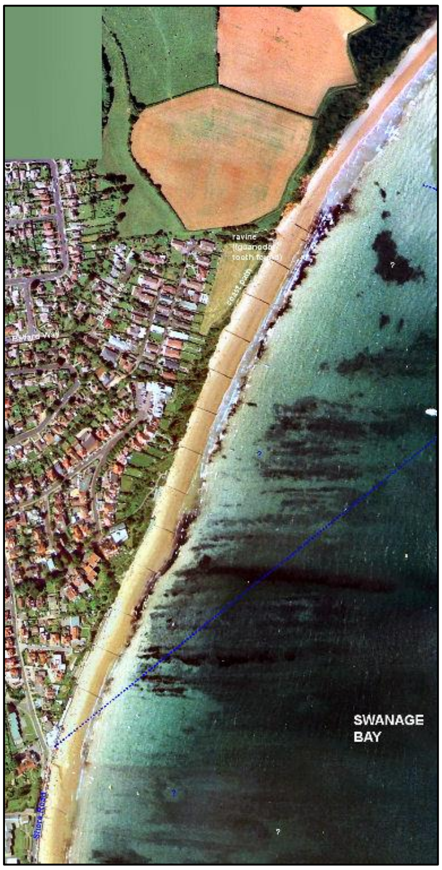
Location aerial photograph for the northern part of Swanage Bay and Ballard Cliff.
Modified after Live Search. Ian West, 2009.

The Wealden Cliffs of the northwestern part of Swanage Bay. Ballard Down, of Chalk, is in the background. The Wealden exposures are not as good as they were in the past because of the growth of vegetation and extension of the town northward. However there is still a reasonable section surviving of the clays and sands of this upper part of the Cretaceous Wealden Group. Photograph from Swanage Pier, 14th August 2009. Ian West (c) 2009.

Wealden Cliffs



Alan Holiday aerial photograph: 23rd July 2011.
BALLARD DOWN OF CHALK (FOREGROUND) IS OUT OF ALIGNMENT WITH NINE BARROW DOWN (PURBECK HILL BEYOND), SWANAGE, DORSET.
This has always been shown on the geological maps as a result of displacement on the Ulwell Gap Fault, which was believed to run through the caravan site in the middle distance. However, the 2000 edition of the BGS map, surprisingly, omits this fault. The view is westward and the Chalk dips steeply northward (to the right). Just southwest of the Chalk cliffs is Punfield Cove, where the Lower Greensand crops out. Unfortunately, it is now covered with bushes. Alan Holiday (c) 2011. (Ian West website).



Lesson 6 - Landforms of Coastal Deposition

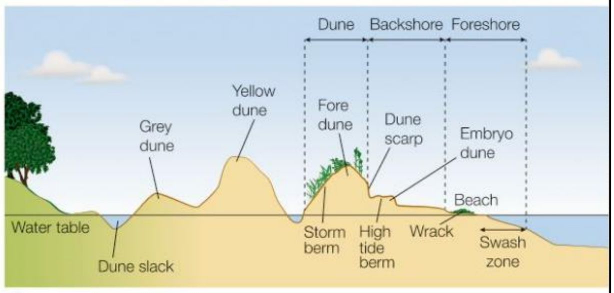
There are 4 main depositional landforms found at the coast – beaches, sand dunes, spits and bars. You may also see a tombolo – this is a bar which connects an island to a mainland.

Beaches

* deposits of sand or shingle (pebbles)

* sandy beaches are mainly found in sheltered bays – constructive waves have strong swash and build the beach

* Many beaches have pebbles not sand – in southern England the strong waves wash sand away leaving pebbles which come from nearby eroded cliffs or are washed ashore from out to sea



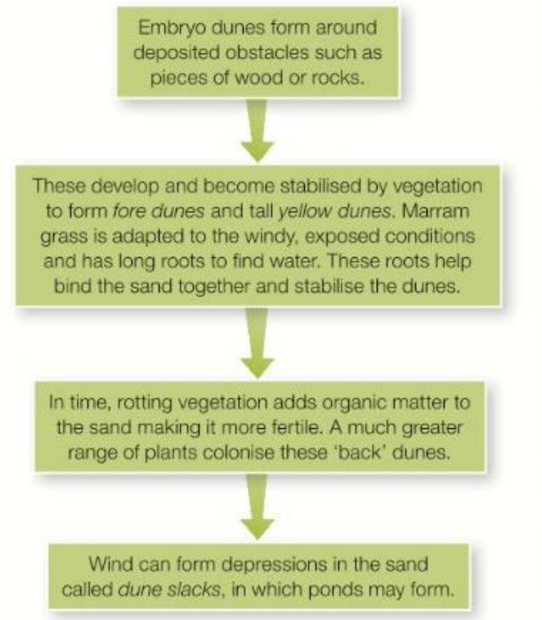
B A beach profile

A beach profile shows a cross-section through a beach – look at the *berms,* which are ridges on the beach.

Seaweed and rubbish are often deposited at the high tide mark.

Sand dunes

These are formed by sand, that is deposited on the beach, being blown inland by onshore winds to from dunes. Sand dunes change over time. Vegetation colonises the dunes and helps to stabilise them.



C Development of sand dunes

Spits

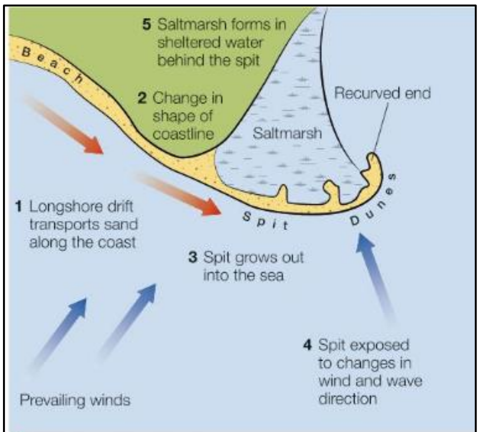
A spit is a long narrow finger of sand or shingle jutting out into the sea from the land. They form on coasts where there is longshore drift and a change in shape of the coastline.

A sharp bend in the coast, such as an estuary, allows sediment to be deposited out into the sea, building up an extension from the land.

Strong winds or tidal currents can cause the end of the spit to curve – this is called a hook or recurved end. A spit may have a number of hooks showing the previous positions of the spit.

Salt marshes often form in the sheltered water behind the spit, where deposits of mud develop. These are gradually colonised by plants and wildlife.

D Hurst Castle Spit, Hampshire



E The formation of a spit

Bars

Bar at Slapton Ley, Devon

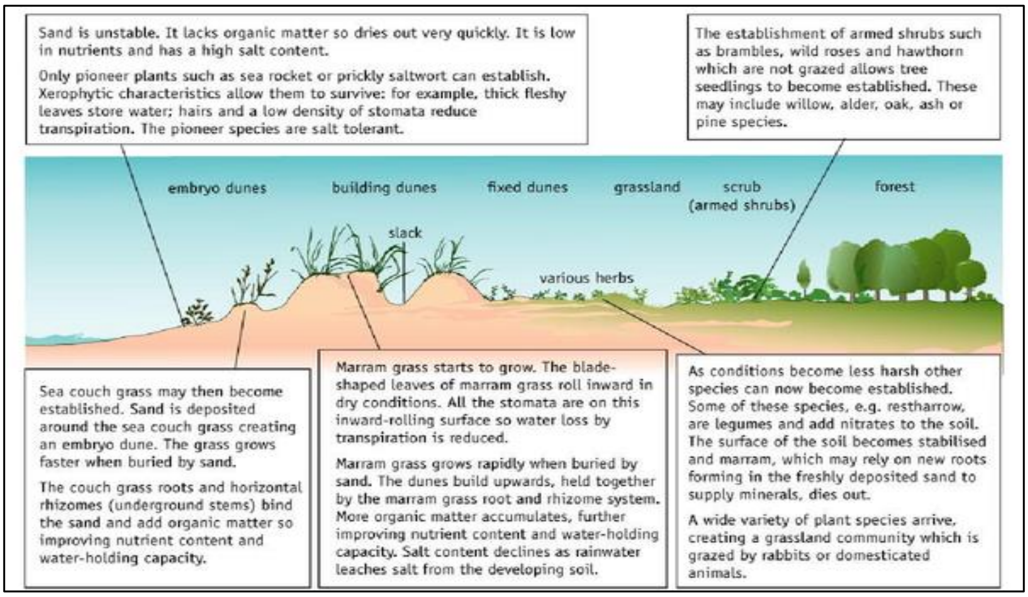
Sometimes longshore drift causes a spit to grow right across a bay forming a bar. Freshwater is trapped behind it forming a lagoon.

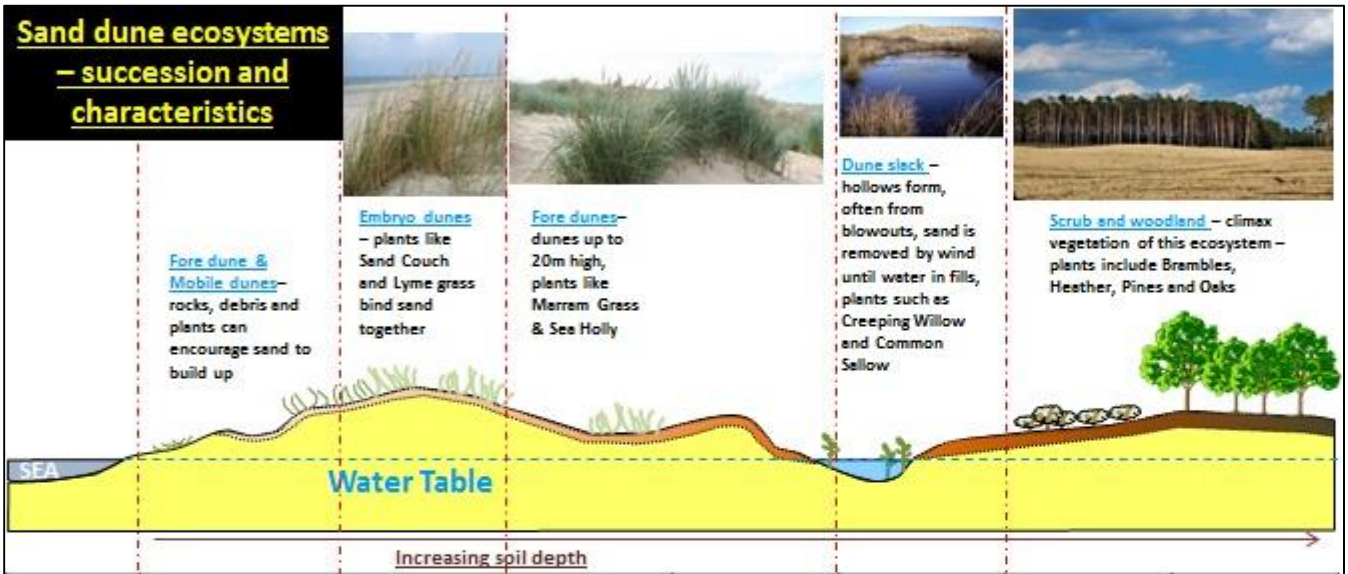
Occasionally an *offshore bar* forms further out to sea. Here waves deposit sediment due to friction on the gently sloping sea bed. The offshore bar causes waves to break some distance from the coast.

In some parts of the UK offshore bars have been driven onshore by rising sea levels following the end of the last ice age 8000 years ago. This forms a *barrier beach* such as Chesil Beach in Dorset.

Extension - Tombolos

Can you explain their formation using a labelled diagram?



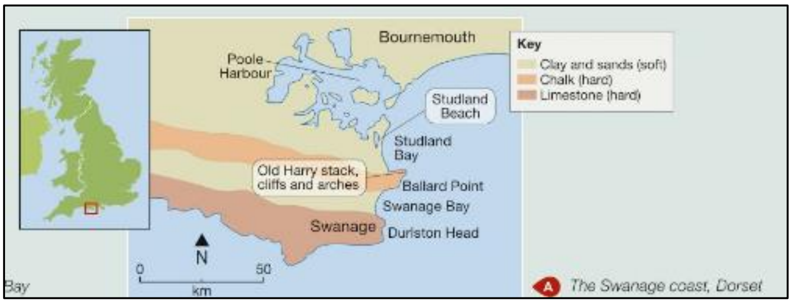


Location/type of dune	Strand line	Embryo dunes	Fore dunes	Fixed dunes	Dune slack	Dune scrub	Woodland
Approximate distance from sea (m)	0-20	20-80	80-150	150-300	300-500	Variable	Variable
pH at surface of soil	8.5	8.0	7.5	7.0	6.5	6.0	6.0
Soil colour		Yellow		Yellow and grey		Grey	Brown
% Humus	<1	2.5	5		20	>40	
% Calcium Carbonate	10	8	8	5	1	<0.1	
Age (years)	-	0-50	50-100	100-150	150-250	250+	250+

Lesson 7 - INTERVENTION

Lesson 8 – Case study: Swanage

Location



A The Swanage coast, Dorset

Swanage is a seaside town in Dorset on the south coast of England. It is located in a sheltered bay and has a broad sandy beach. It is found on the *Jurassic Coast,* which is a World Heritage Site due to its geological importance. The rocks in this area were formed 145-200 million years ago in the Jurassic period.

Geology

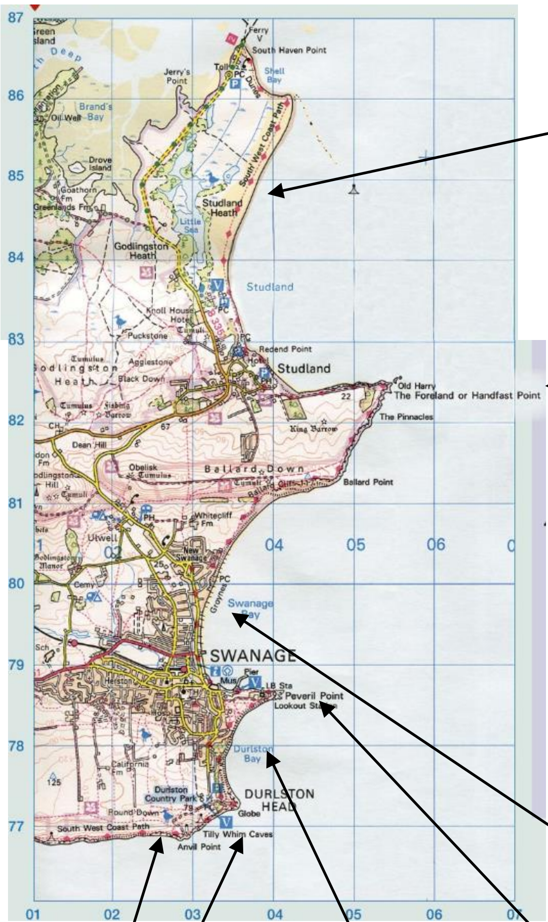
Different rock types have had a major influence on the formation of this coastline. The rocks have been folded and tilted so that different bands of rock are found along the coast. There are alternating bands of hard and soft rock which create headlands and bays.

This indented coast is called a discordant coastline – see lesson 3 for a reminder!

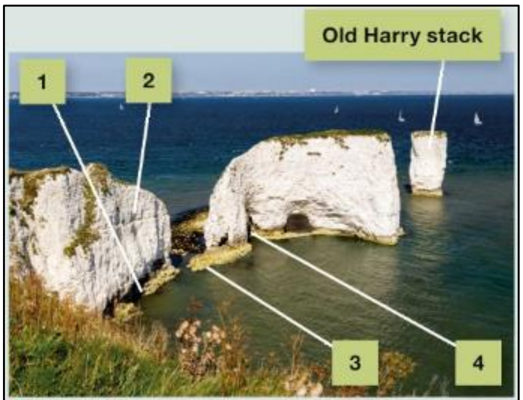
To the north of Swanage lies Poole Harbour, one of the UK's largest natural harbours. A lot of deposition has taken place here. Two spits have formed – on each side of the bay.

Studland has a number of depositional features including lagoons, saltmarshes and sand dunes.

Using the OS map extract you can locate many well-known local landforms such as Ballard Point, Swanage Bay, Old Harry, Peveril Point and Durlston Head.



B Aerial view of the coastline between Ballard Point and the Foreland



C The Foreland and Old Harry

Lesson 9 – Managing Coasts – Hard Engineering

Why do coasts need to be managed?

Coastal management tries to find a balance between the forces of nature and the needs of people. People who live and work at the coast can be affected by coastal erosion and flooding. As sea levels are predicted to rise, coastal defences will become more expensive. In some places, the coasts may outweigh the benefits and the coastline may be left undefended.

Coastal Management Options

Hard engineering – building artificial structures to control natural processes
Soft engineering – less intrusive, more environmentally friendly methods working with natural processes
Managed retreat – controlled retreat of the coastline, often allowing flooding of some low-lying land

Comparing Coastal Management Methods & Costs

Hard engineering

This includes sea walls, wooden and rock groynes, rock armour and gabions. Today hard engineering methods are less common due to the high cost of building and maintaining them. They interfere with natural coastal processes which can cause destructive knock-on effects elsewhere. They also look unnatural.

Rock armour

Description: Piles of large boulders dumped at the foot of a cliff. The rocks force waves to break, absorbing their energy and protecting the cliffs. The rocks are usually brought by barge to the coast.

Cost: £200000 per 100m

Advantages:
- Relatively cheap and easy to maintain.
- Can provide interest to the coast.
- Often used for fishing.

Disadvantages:
- Rocks are usually from other parts of the coastline or even from abroad.
- Can be expensive to transport.
- Do not fit in with the local geology.
- Can be very obtrusive.

C Rock armour at Walton on the Naze, Essex

Sea wall

Description: Concrete or rock barrier against the sea, placed at the foot of cliffs or at the top of a beach. Has a curved face to reflect the waves back into the sea.

Cost: £5000–£10000 per metre

Advantages:
- Effective at stopping the sea.
- Often has a walkway or promenade for people to walk along.

Disadvantages:
- Can look obtrusive and unnatural.
- Very expensive and high maintenance costs.

Gabions

Description: Wire cages filled with rocks that can be built up to support a cliff or provide a buffer against the sea.

Cost: Up to £50000 per 100m

Advantages:
- Cheap to produce and flexible in the final design.
- Can improve drainage of cliffs.
- Will eventually become vegetated and merge into the landscape.

Disadvantages:
- For a while they look very unattractive.
- Cages only last 5–10 years before they rust.

D Gabions at Thorpeness, Suffolk

Groynes

Description: Timber or rock structures built out to sea from the coast. They trap sediment being moved by longshore drift and enlarge the beach. The wider beach acts as a buffer to reduce wave damage.

Cost: Timber groynes £150000 each (at every 200m)

Advantages:
- Create a wider beach, which can be popular with tourists.
- Provide useful structures for people interested in fishing.
- Not too expensive.

B Groynes at Eastbourne, Sussex

Disadvantages:
- By interrupting longshore drift they starve beaches further along the coast, often leading to increased rates of erosion elsewhere. The problem is therefore shifted rather than solved.
- Groynes are unnatural and rock groynes in particular can be unattractive.

	Timber Revetments Source: Scottish Natural Heritage
Appropriate locations	High value sites suffering modest and periodic erosion.
Costs	Moderate (£2000 to £50,000/100m frontage length).
Effectiveness	Provide good protection if only occasionally exposed to waves. 5-30 year life.
Benefits	Normally acceptable to the public. Less expensive than seawalls or rock revetments
Problems	Limited life, particularly where exposed to wave action. Visually intrusive. Alters beach-dune processes as sand interchange is disrupted.

Artificial headlands are rock structures built along the toe of eroding dunes to protect strategic points, allowing natural processes to continue along the remaining frontage. This is significantly cheaper than protecting a whole frontage and can provide temporary or long term protection to specific assets at risk. Temporary headlands can be formed of gabions or sand bags, but life expectancy will normally be between 1 and 5 years.

	Artificial Headlands Source: Scottish Natural Heritage
Appropriate locations	Rapidly eroding dunes with important backshore assets at discrete intervals along the shore.
Costs	Moderate, but low maintenance (£20,000-£60,000/100m of structure, plus minor works for unprotected frontages).
Effectiveness	Good temporary or long term protection for protected length. Allows natural processes to continue elsewhere. Can be used with other low cost methods. Unlimited structure life for rock headlands.
Benefits	Provides local protection with minimum disturbance to dune system as a whole. Can be modified or removed at later date.
Problems	Visually intrusive. Do not control erosion along the whole frontage. Structures may interfere with longshore transport, particularly on sand-gravel beaches, and may require periodic extension or relocation landward to avoid outflanking.

Gabions 	This is where rocks and boulders are encased in wired mesh. They absorb the energy from waves.	Cheap and efficient.	Shorter life span than a sea wall. Visually unattractive.	£100/m
Off-shore breakwater	These are large concrete blocks and boulders located off shore to change the direction of waves and reduce longshore drift. They also help absorb wave energy.	Beaches retain natural appearance.	Difficult to maintain, unattractive, does not protect the cliffs directly and does not stop beach material from being eroded.	

Technique	Description	Advantage	Disadvantage	Approximate Cost
Groynes	Groynes are wooden barriers constructed at right angles to the beach to retain material. Material is trapped between these groynes and cannot be transported away by longshore drift. Groynes encourage a wide beach which helps absorb energy from waves, reducing the rate of cliff erosion.	Cheap, retain wide sandy beaches and do not affect access to the beach.	Beaches to the south of the defences are starved of beach material due to their affect on long shore drift.	£7000 each
Sea Walls	Sea walls are usually built along the front of cliffs, often to protect settlements. They are often recurved which means waves are reflected back on themselves. This can cause the erosion of material at the base of the sea wall.	Provide excellent defence where wave energy is high, reassures the public and long life span.	Expensive, can affect beach access, recurved sea walls can increase the erosion of beach material.	£3000-4000/m
Reventments	Traditionally these have been wooden slatted barriers constructed towards the rear of beaches to protect the base of cliffs. Energy from waves is dissipated by them breaking against the reventments. In recent times concrete reventments such as accropodes have been used in places such as Scarborough.	Less beach material is eroded compared to a sea wall. Cheaper and less intrusive than a sea wall.	Short life span and unsuitable where wave energy is high.	£2000/m
Rock armour / boulder barriers	These are often large boulders placed along the base of a cliff to absorb energy from waves.	Cheap and efficient	Unattractive, dangerous access to beach, costs increase when rock is imported.	£3000/m

<u>Lesson 10 - Soft engineering</u>

These methods try to work with natural processes. They tend to be cheaper than hard engineering though they can require more maintenance. They are sustainable and are the more preferred option today.

When beach replenishment takes place, bulldozers are used to shape the sediment. This is called *reprofilling*.

Beach nourishment

Description: The addition of sand or shingle to an existing beach to make it higher or wider. The sediment is usually obtained offshore locally so that it blends in with the existing beach material. It is usually transported onshore by barge.

Cost: Up to £500 000 per 100 m

Advantages:
- Relatively cheap and easy to maintain.
- Blends in with existing beach.
- Increases tourist potential by creating a bigger beach.

Disadvantages:
- Needs constant maintenance unless structures are built to retain the beach.

Dune regeneration

Description: Sand dunes are effective buffers to the sea but are easily damaged and destroyed by trampling. Marram grass can be planted to stabilise dunes and help them to develop. Fences can be used to keep people off newly-planted areas.

Cost: Cost: £200–£2000 per 100m

Advantages:
- Maintains a natural coastal environment that is popular with people and wildlife.
- Relatively cheap.

Disadvantages:
- Time-consuming to plant the marram grass and fence areas off.
- People don't always respond well to being prohibited from accessing planted areas.
- Can be damaged by storms

C *Dune regeneration at Chichester, West Sussex*

Dune fencing

Description: Fences are constructed on a sandy beach along the seaward face of existing dunes to encourage new dune formation. These new dunes help to protect the existing dunes.

Cost: £400–£2000 per 100m.

Advantages:
- Minimal impact on natural systems.
- Can control public access to protect other ecosystems.

Disadvantages:
- Can be unsightly especially if fences become broken.
- Regular maintenance needed especially after storms.

D *Dune fencing at Formby, Merseyside*

Technique	Description	Advantage	Disadvantage	Approximate Cost
Beach nourishment	Beaches are made higher and wider by importing sand and shingle to an area affected by longshore drift.	Cheap, retains the natural appearance of the beach and preserves the natural appearance of the beach.	Off shore dredging of sand and shingle increases erosion in other areas and affects the ecosystem. Large storms will require beach replenishment, increasing costs.	£20 /cu.m
Managed retreat	This is when areas of coast are allowed to erode. This is usually in areas where the land is of low value.	Managed retreat retains the natural balance of the coastal system. Eroded material encourages the development of beaches and salt marshes.	People lose their livelihood e.g. farmers. These people will need to be compensated.	Depends on amount of compensation that needs to be paid to people affected by erosion.

Case study: tourism in Studland Bay Nature Reserve

Studland Bay is located in the Isle of Purbeck in Dorset and is popular with **tourists**. It can be accessed by ferry from the desirable area of Sandbanks in Poole during the summer. It is only a few minutes drive from the resort of Swanage and most visitors arrive by car.

Studland Bay is a good example of a place where **conflict** can occur between interest groups.

The issues

- The nature reserve is an area of **sand dunes**. These are dynamic, but often unstable and vulnerable environments.
- Areas such as this are home to rare species of plants and birds.
- The area is attractive to tourists because of the dunes and the wide, sandy beach. The beach can get very **crowded** in summer months.
- Visitors need somewhere to park and also demand other **facilities**, such as paths and public toilets.
- Tourists bring their **problems** such as litter and fire hazards (caused by barbecues and cigarette ends).

How is the area managed?

- Vulnerable areas and areas recently planted with marram grass (which is used to stabilise the dunes) are **fenced off** to limit access and damage.
- **Boardwalks** have been laid through the dunes to focus tourists onto specific paths.
- **Car parks** have been provided and people are not permitted to drive onto the beach.
- **Fire beaters** are positioned within the dune area in case of a fire.
- Facilities including a shop, café, toilets and litter bins are provided near the car parks to focus tourists into one area.
- Information boards **educate** visitors about the environment and how they can help to protect it.

<u>Lesson 11 – Managed Retreat</u>

Managed retreat is a deliberate policy of allowing the sea to flood or erode an area of relatively low-value land.

It is a form of soft engineering as it allows natural processes to take place.

In the long term, managed retreat is a more sustainable method than spending large sums of money trying to protect the coast with hard engineering methods.

As sea levels continue to rise, managed retreat is likely to become an increasingly popular choice for managing the coastline.

Medmerry Managed Retreat, near Chichester, West Sussex

Aerial photo **B** shows a stretch of coastline on the south coast of England near Chichester. This flat, low-lying coast is mainly used for farming and caravan parks. For many years the land was protected by a low sea wall but this is now in need of repair. Building a new sea wall to protect the area against future sea-level rise was a very expensive option.

Given the relatively low value of the land, it was decided to allow the sea to breach the current sea defences (photo **A**) and flood some of the farmland that was previously protected. You can see in the photo how this has happened .

The Medmerry scheme cost £28 million and the controlled breaching of the old sea defences took place in November 2013. In the future, this scheme will:

- create a large natural saltmarsh to form a natural buffer to the sea
- help to protect the surrounding farmland and caravan parks from flooding
- establish a valuable wildlife habitat and encourage visitors to the area.

B *Managed retreat at Medmerry, West Sussex*

You can see on photo **B** that embankments have been constructed inland to give protection to farmland, roads and settlements. This alteration of the coastline is called *coastal realignment*.

Coastal monitoring & adaptation

Most of the UK's coastline does not need expensive coastal defences. The coastal land may be low-value farmland, forest or moorland. Here the coastal zone is left alone – the 'Do Nothing' approach.

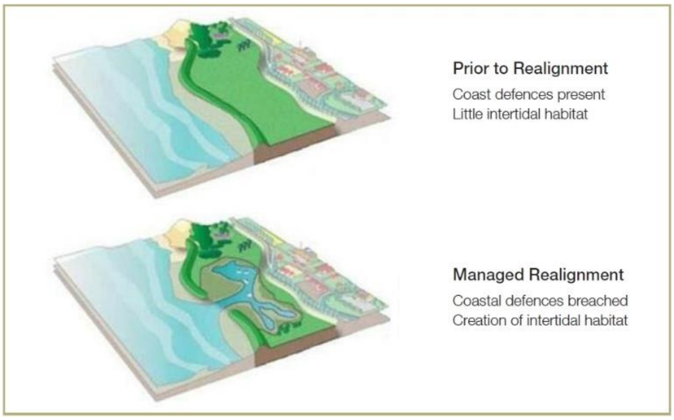
People who live or work here have to adapt by moving inland. This might involve moving mobile homes on a holiday park, a path or a fence.

These stretches of coastline are monitored by scientists. This helps to reduce possible conflict between managing the coast and meeting the needs & views of local people.

This monitoring involves studying coastal processes, mass movement and human activity to ensure safety.

If conditions change then a new approach might be needed, for example if the risk of flooding increases and threatens homes.

Some people think that managed retreat does not account for the longer-term impact on coastal trade, tourism, infrastructure and businesses, as well as rehousing costs.



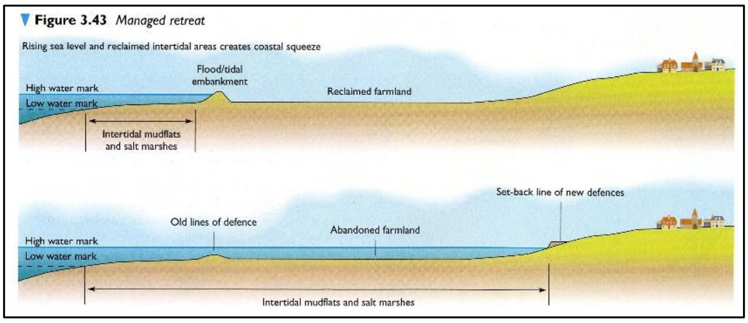


Figure 3.43 *Managed retreat*

Lesson 12 - Case Study – Lyme Regis

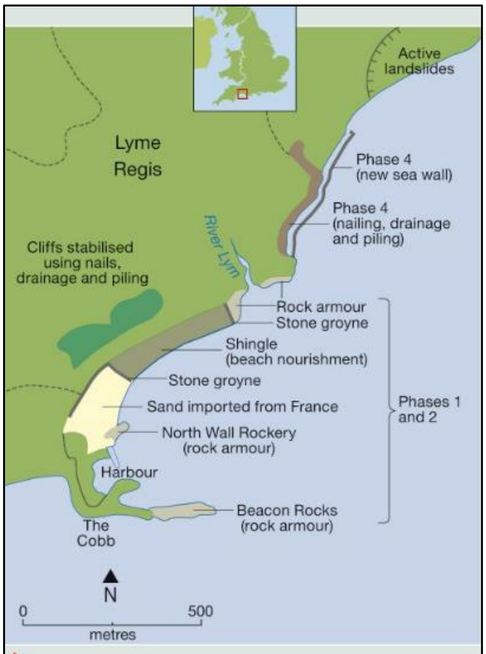
Location

Lyme Regis is a coastal town on the south coast of England – on the Jurassic Coast. The coast is famous for the fossils found there. It attracts many visitors especially in the summer when the population swells from 4000 to 15 000.

Issues

- The town was built on unstable cliffs
- Powerful waves from the south west are rapidly eroding the coastline
- Many properties have been destroyed or damaged
- The foreshore has been greatly eroded
- The existing sea walls have been breached repeatedly

Lyme Regis Environmental Improvement Scheme



A *Coastal management at Lyme Regis*

Phase 1 Date: 1990s (completed 1995)
- New sea wall and promenade constructed to the east of the mouth of the River Lim.
- In the winter of 2003–2004 a £1.4 million emergency project was completed to stabilise the cliffs. Hundreds of large nails were used to hold the rocks together as well as improving drainage and re-profiling the slope of the beach.

Phase 2 Date: 2005–2007

Extensive improvements made to the sea front costing £22 million. These included:
- construction of new sea walls and promenades
- creation of a wide sand and shingle beach to absorb wave energy and increase use of the shore; shingle dredged from the English Channel and sand imported from France
- extension of rock armour at The Cobb (map **A**) and the eastern end of the sea front, to absorb wave energy and help retain the new beach.

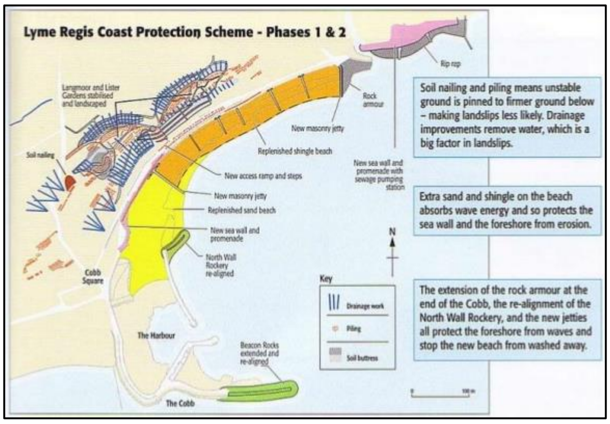
Phase 3 Not undertaken.

The initial plan to help prevent landslips and coastal erosion to the west of The Cobb were shelved. It was decided to leave this stretch of coast alone as the costs outweighed the benefits.

Phase 4 Date: 2013–2015

This final phase focused on the coast east of the town (photo **B**). It cost £20 million and involved:
- constructing a new 390m sea wall in front of the existing wall (photo **C**) to provide additional protection
- extensive nailing, piling and drainage to provide cliff stabilisation to protect 480 homes.

- Set up by West Dorset District Council in the early 1990s
- Aimed to provide long-term coastal protection & reduce threat of landslips
- Engineering works were completed in 2015
- Consultation meetings were held with property owners, fishermen and environmentalists

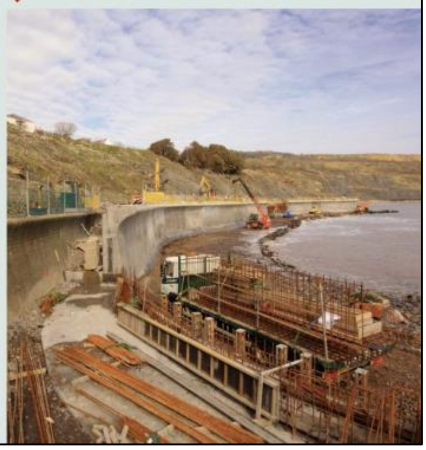


Benefits

- Long-term protection against destructive coastal erosion and landslips.
- More sand and shingle on the beach.
- It will be possible to walk along the whole beach even at high tide.
- A new promenade along the seafront.
- Calmer conditions for boats in the harbour and bay.
- Better access to the public gardens, including ramps for people using wheelchairs and prams.
- Re-landscaped public gardens with more walks.
- Improvements to roads.
- A more secure future for the town's people and businesses.

B *The Jurassic Coast east of Lyme Regis in 2013 before Phase 4 began*

C *Phase 4 coastal defence works at Lyme Regis*



How successful has the management scheme been?

Positive outcomes ✓	Negative outcomes ✗
• The new beaches have increased visitor numbers and seafront businesses are thriving. • The new defences have stood up to recent stormy winters. • The harbour is now better protected, benefiting boat owners and fishermen.	• Increased visitor numbers have led to conflicts with local people who think traffic congestion and litter have increased. • Some people think the new defences have spoilt the natural coastal landscape. • The new sea wall may interfere with coastal processes and affect neighbouring stretches of coastline, causing conflicts elsewhere. • Stabilising cliffs will prevent landslips that may reveal important fossils – a potential conflict.

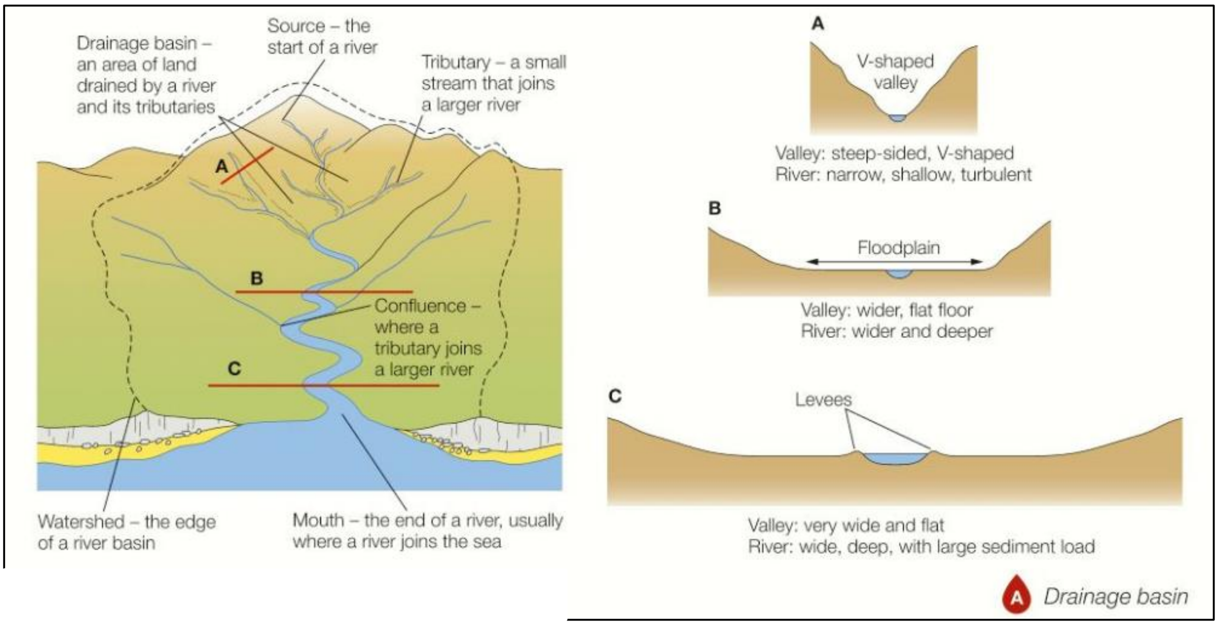
<u>Lesson 13 - INTERVENTION</u>

Lesson 14 – River Landscapes

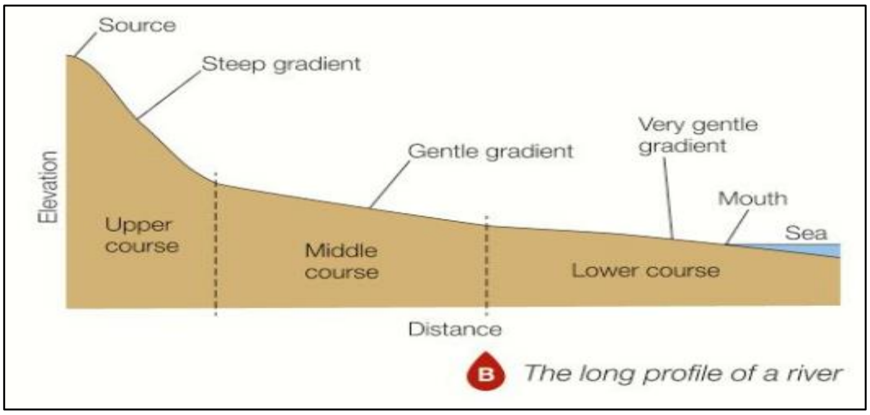
Changes in Rivers and Their Valleys

What is a drainage basin?

This is an area of land drained by a river and its tributaries. The long profile of a river changes as you travel downstream.



A Drainage basin



B The long profile of a river

How does the cross profile of a river and it valley change downstream?

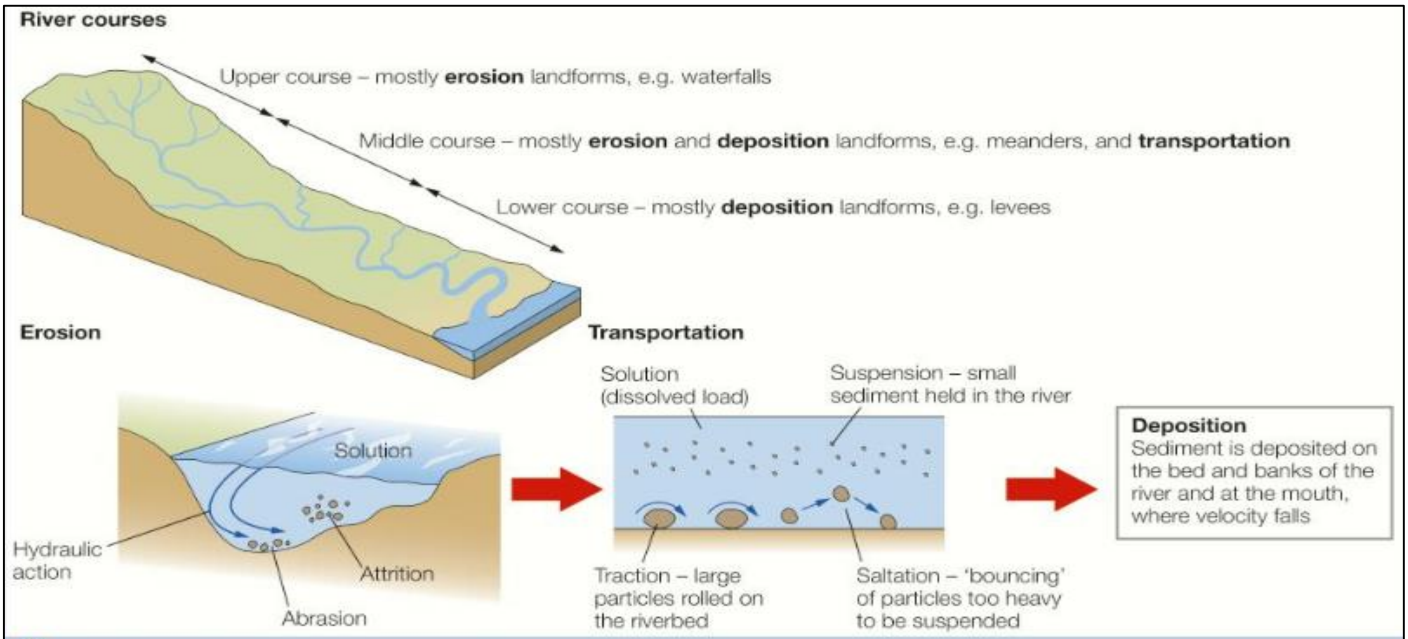
A cross profile is an imaginary slice across a river channel and its valley at a particular point.
As the river flows downstream it changes:

- Wider channel
- Deeper channel
- Wider valley
- Flatter valley
- Less steep valley sides

There will be variations due to geology, human activity and river management by people.

The changes are due to the amount of water flowing in the river. More water means a bigger river which can erode a wider and deeper channel. This in turn broadens and flattens the river valley. Weathering and mass movement make the valley sides less steep.

Lesson 15 - River (Fluvial) Processes



B River courses and fluvial processes

Rivers have the same three types of processes as coastal areas – erosion, transportation and deposition (see lesson 2).

Rivers have two types of erosion – vertical (downwards) and lateral (sideways).

Erosion – hydraulic action, abrasion, attrition & solution.

Diagram **B** shows the four processes of erosion that take place in a river:

- **Hydraulic action** – the force of the water hitting the river bed and banks. This is most effective when the water is moving fast and when there is a lot of it.
- **Abrasion** – when the load carried by the river repeatedly hits the bed or banks dislodging particles into the flow of the river.
- **Attrition** – when stones carried by the river knock against each other, gradually making the stones smaller and less rounded.
- **Solution** – when the river flows over limestone or chalk, the rock is slowly dissolved. This is because it is soluble in mildly acidic river water.

Transportation – traction, saltation, suspension & solution.

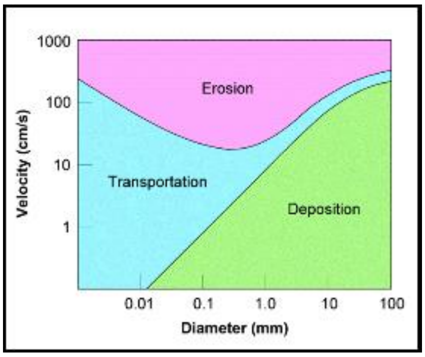
The size and amount of load that a river can carry depends on its *velocity* (rate of flow).

Deposition – occurs when velocity decreases and sediment is deposited.

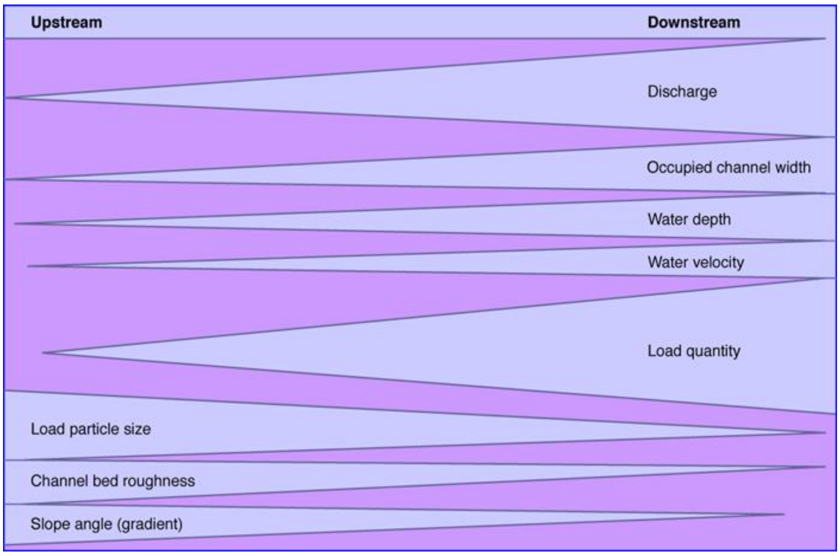
- Larger rocks are deposited in the upper course of the river – only transported short distances (traction) during periods of high flow.
- Finer sediment is carried further downstream (suspension) – deposited on river bed and banks when velocity is reduced due to *friction*.
- Large amount of deposition takes place at river mouth – river velocity reduced due to interaction with tides and very gentle gradient.

The Hjulstrom Curve:

The **Hjulström curve**, named after Filip **Hjulström** (1902–1982), is a graph used by hydrologists and geologists to determine whether a river will erode, transport, or deposit sediment.



The Bradshaw Model:



From upstream to downstream:

1. Discharge increases
2. Occupied channel width increases
3. Water depth increases
4. Water velocity increases
5. Load quantity increases
6. Load particle size decreases
7. Channel bed roughness decreases
8. Slope angle (gradient) decreases

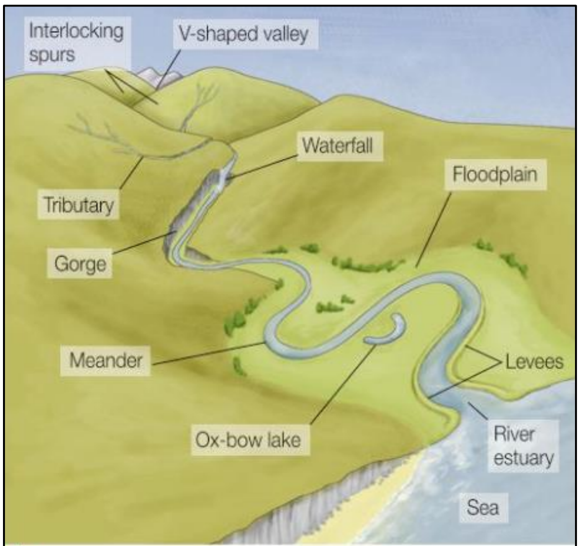
You will investigate this model on your field trip!

<u>Lesson 16 – River Landforms</u>

A typical river has distinctive landforms along its profile.
In the upper course – erosion – interlocking spurs, waterfalls & gorges.

In the middle section – erosion & deposition – meanders & ox-bow lakes.

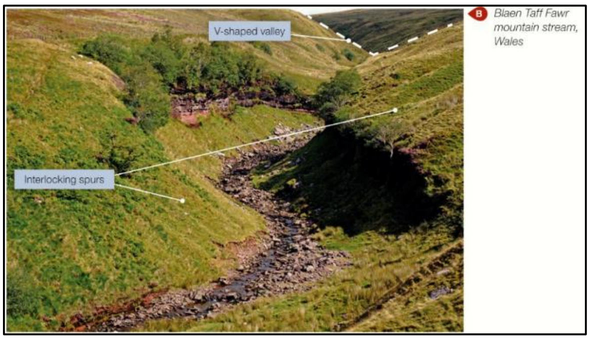
In the lower section – deposition – flood plain, levees & estuary.



A *River landforms from source to mouth*

River erosion landforms

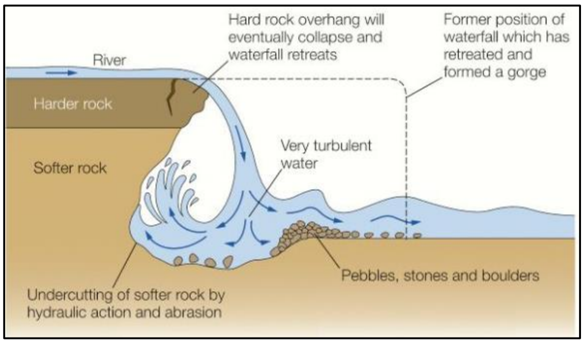
Interlocking spurs



These are fingers of land that jut out from the V-shaped valley sides – the river weaves its way around them.

As the river is near its source it is not powerful enough to cut through the spurs so has to flow around them.

Waterfalls

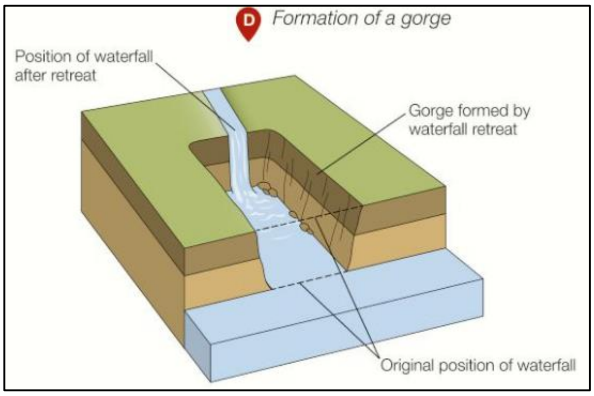


This is a 'step' in the long profile formed when a river flows over more resistant rock.
Waterfalls are most commonly formed when a river flows over a relatively resistant band of hard rock.
When a river plunges over a waterfall it forms a turbulent and deep *plunge pool*. Here erosion (hydraulic action & abrasion) combine to undercut the waterfall.
Eventually the overhanging rock collapses and the waterfall retreats upstream.
Over many years the retreating waterfall creates a steep-sided gorge.

Waterfalls can also form when a drop in sea level causes a river to cut down into its bed creating a step in the long profile. This step is called a *knick point* and is marked by a waterfall.

Waterfalls can also be found in glacial hanging valleys.

Gorges



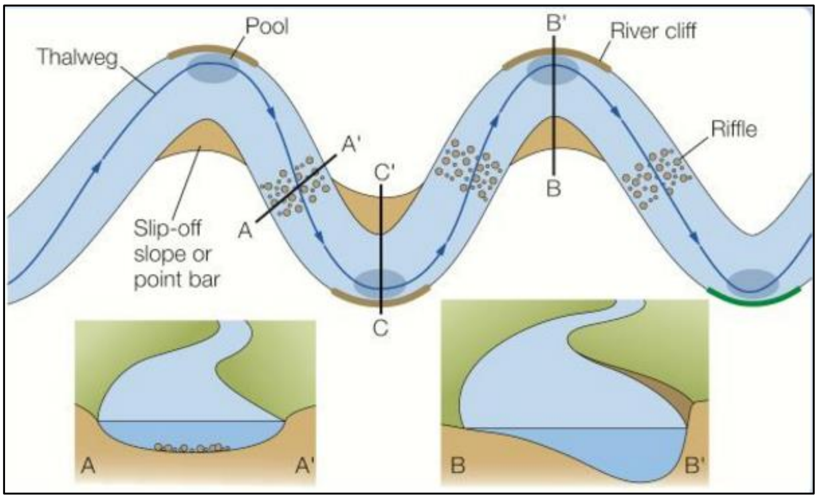
A narrow steep-sided valley usually found downstream of a waterfall. It is formed by the gradual retreat of a waterfall over 100s or even 1000s of years. Sometimes gorges are formed when huge quantities of melting glacial water poured off upland areas at the end of the last glacial period (8000 years ago) i.e. Cheddar Gorge (Somerset). Rarely gorges are formed by the collapse of underground caverns.

River Erosion & Deposition Landforms

Meanders

These are wide bends in a river found mainly in lowland areas. They are the most efficient channel for a heavily-laden river as it flows over fine sediment on very gentle slopes.

They constantly change size and shape due to the processes of lateral erosion and deposition in the river channel.



A Meanders on the River Cuckmere, East Sussex

The *thalweg* is the line of fastest flow within the river. It swings from side to side, causing erosion on the outside of the meander and deposition on the inside.

Over time this erosion causes the meander to *migrate* across the valley floor.

Pools & Riffles

Where streams carry coarse sediment, they can develop alternating sections of shallow fast-flowing water – riffles and deeper slower-moving water – pools.

These are easiest to see in low flow conditions.

The riffles have deposits of coarser gravel and the pools have deposits of finer sediment.

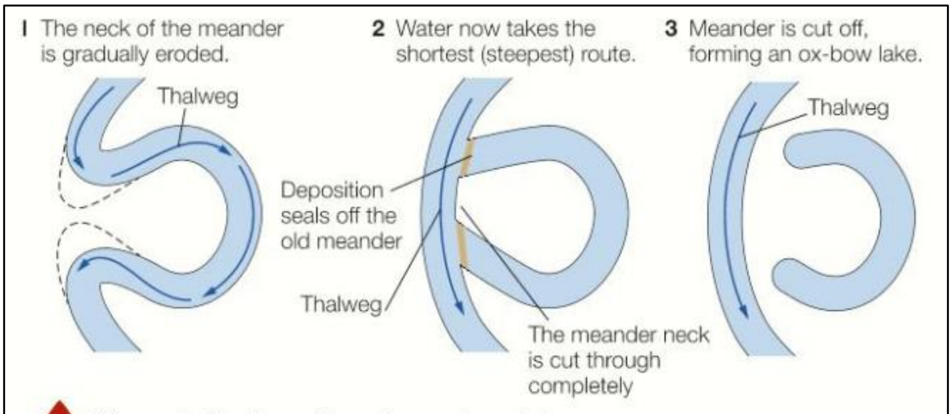
Pools develop close to the outside of the meander, where the thalweg is in high flow conditions and where most erosion takes place.

Riffles develop between meander bends where a drop in velocity leads to deposition of coarser sediment.

Ox Bow Lakes

As meanders migrate they can erode towards each other, eventually narrowing the neck of a meander until it is completely broken through. This usually happens during a flood.

A new straighter channel is formed. The old meander loop is cut off by deposition to form an ox-bow lake.



C Stages in the formation of an ox-bow lake

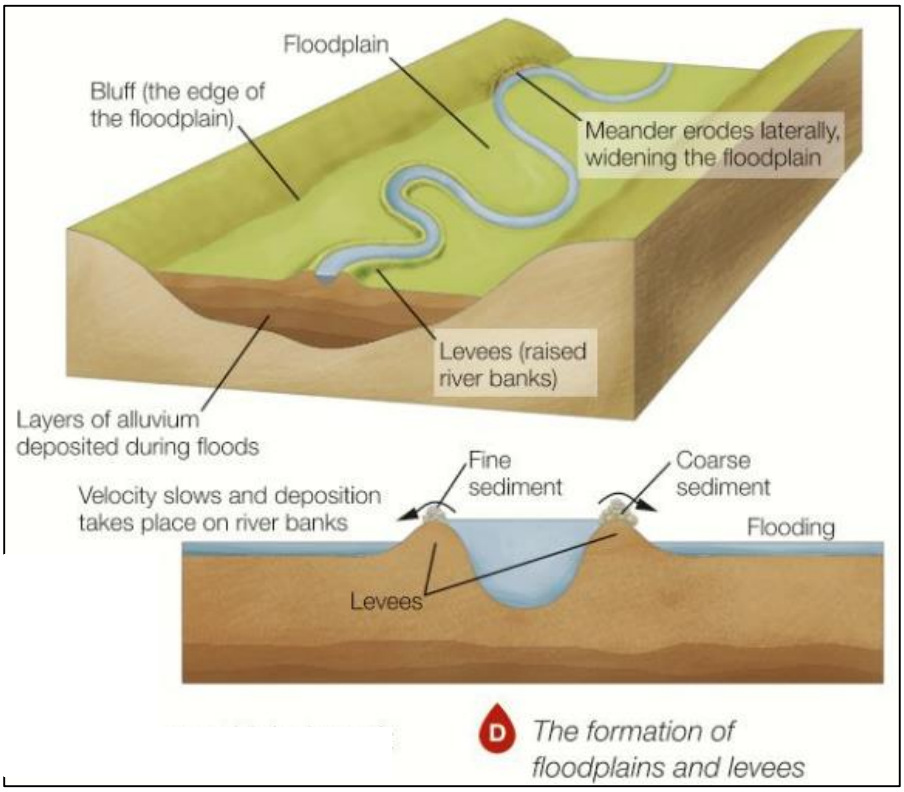
Floodplains & Levees

A floodplain is a wide flat area of marshy land on either side of a river, usually found in the middle and lower sections of the river.

Floodplains are made of *alluvium* – a sediment (silt) deposited by a river when it floods. The soils here are very fertile and excellent for farming.

There are two processes which create a floodplain:

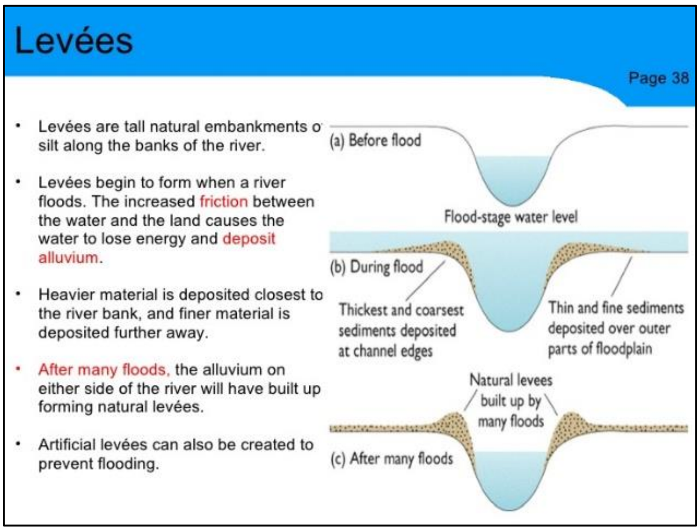
- Migrating meanders due to lateral erosion which erode the sides of the valley (bluff) widening the valley
- River floods which deposit silt creating a flat flood plain – many layers build up over time forming a thick deposit of alluvium



D The formation of floodplains and levees

A *levee* is a raised river bed found alongside a river in its lower course.

It is formed by flooding over many years. A ridge of sediment is deposited naturally to build up the levee.



During low flow conditions deposition takes place. This raises the river bed and reduces the capacity of the channel.

When flooding happens, water flows over the sides of the channel.

Here the river velocity decreases rapidly leading to deposition of sediment on the river banks.

First coarser sands are deposited then finer silt and mud. Gradually, after many floods, the height of the banks can be raised by up to two metres!

Estuaries

Estuaries are *transitional zones* where a river mouth opens into the sea. They are affected by both river and coastal processes. The main process found here is deposition.

During a rising tide river water is unable to be discharged into the sea. The river's velocity falls and sediment is deposited. At low tide these fine deposits form extensive *mudflats*. Over time mudflats can develop into *saltmarshes*.

UK Waterfalls

Hardraw Force (Hardraw Beck Yorkshire Dales)

Janet's Foss (Gordale Beck Yorkshire Dales)

Cauldron Snout (River Tees Northumbria)

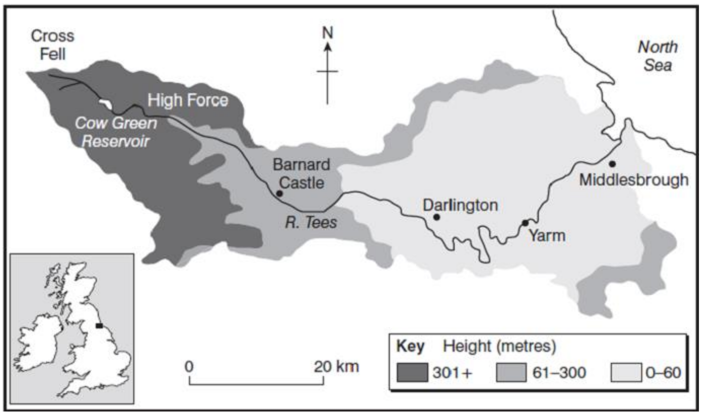
River Floodplains – Aerial photos

Lesson 17 – Case Study – The River Tees (County Durham)

A The location of the River Tees in north-east England

Location

The River Tees is an important river in the north east of England. Its source is high in the Pennines near Cross Fell (893m). From there it flows roughly east for around 128km to reach the North Sea at Middlesbrough.



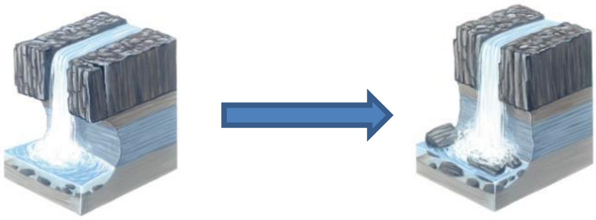
River landforms

There are a number of distinctive landforms along the profile of the River Tees. One of the most famous is High Force waterfall, near Forest-in-Teesdale. Here the river drops 20m into a turbulent plunge pool. The river then flows through a spectacular gorge downstream.

http://www.highforcewaterfall.com/

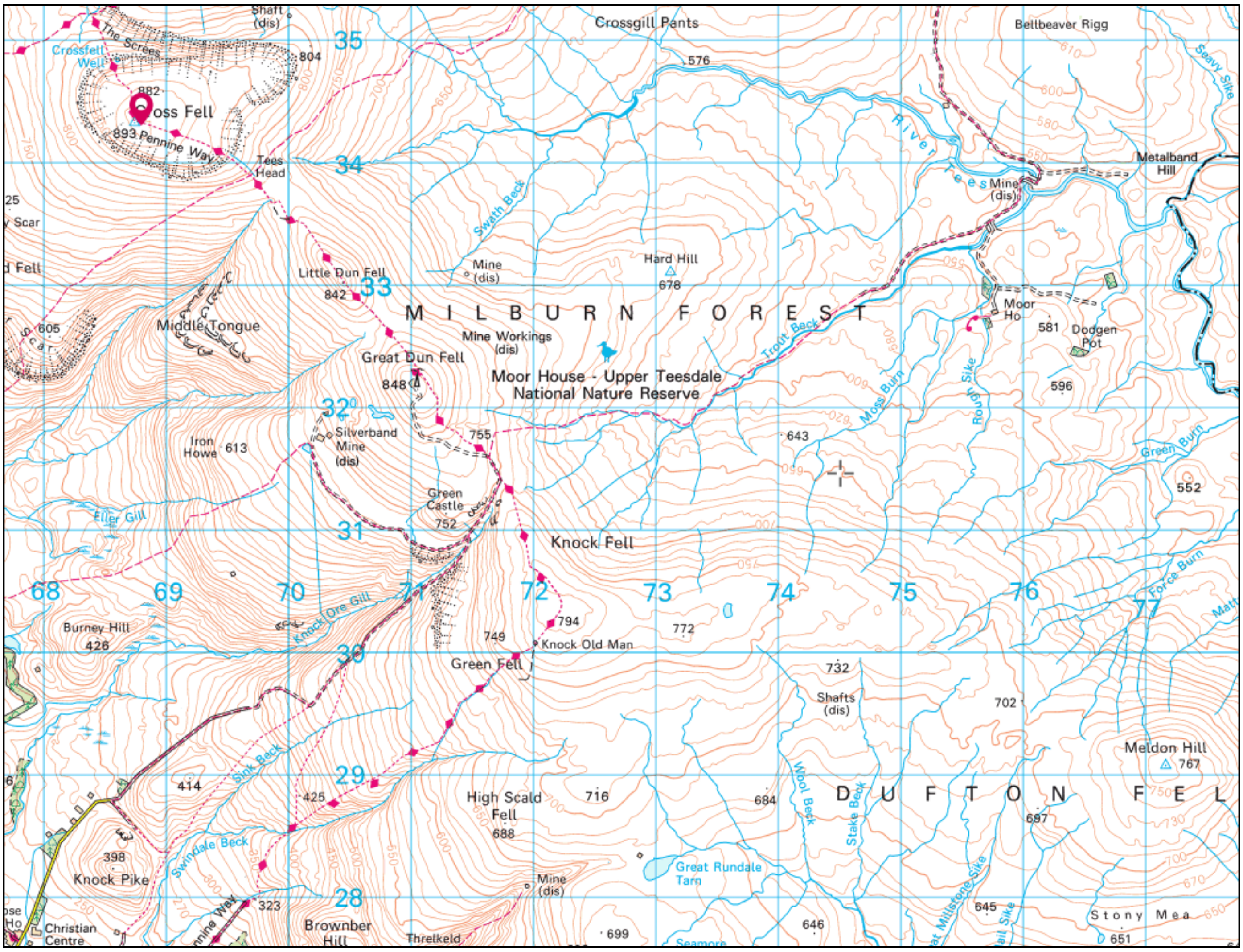
The waterfall formed due to a resistant band of igneous rock called dolerite (formed 295 million years ago), which cuts across the valley. This rock is known as Whin Sill and it is a lighter colour on the photo. As the river is unable to erode this tougher band of rock, the river has formed a step in its profile, which has formed the High Force waterfall.

The underling rock (darker colour) is Carboniferous limestone (formed 330 million years ago), which is undercut by the river as it flows over the waterfall. This forms an overhang which eventually collapses.

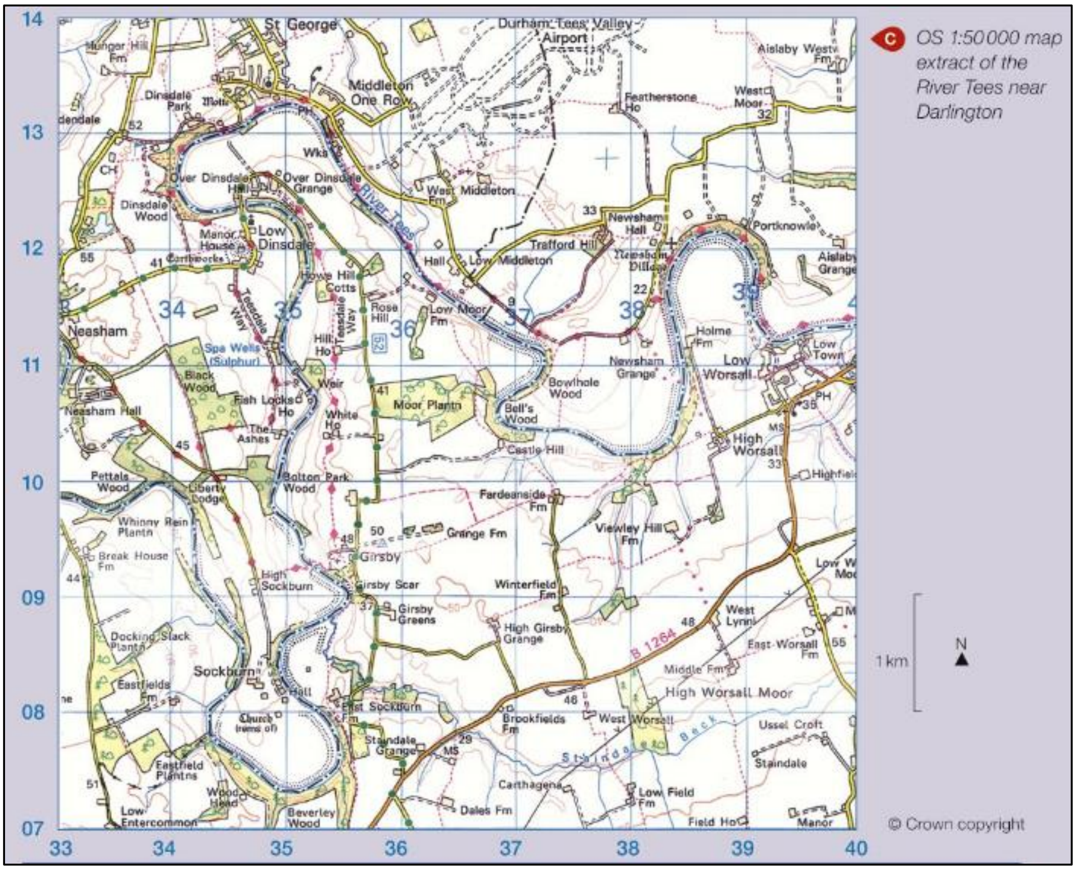


In the lower course of the River Tees, south of Darlington, the river flows over relatively flat low-lying land where there are good examples of meanders, levees and floodplains.

Source of the River Tees



Lower section of River Tees



OS 1:50 000 map extract of the River Tees near Darlington

© Crown copyright

Lesson 18 - INTERVENTION

Lesson 19 – Factors that Increase Flood Risk

What is flooding?

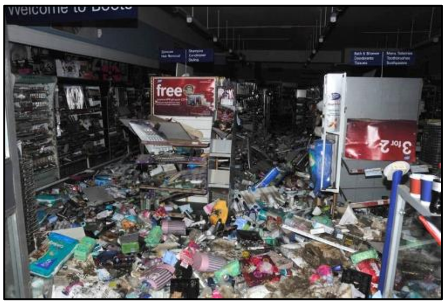
This is where land that is not normally underwater becomes inundated. A river flood occurs when a river channel can no longer hold the amount of water flowing in it. Water overtops the banks and floods the adjacent land – the floodplain.


A Cockermouth floods, 2009

Cockermouth suffered badly in the nationwide flood on 19 and 20 November 2009. Over 200 people needed to be rescued, with helicopters from RAF Valley, RAF Boulmer and RAF Leconfield retrieving about 50 and the remainder being rescued by boats, including those of the RNLI. Water levels in the town centre were reported to be as high as 2.50 metres (8 ft 2 in) and flowing at a rate of 25 knots. Many historic buildings on and adjacent to Main Street sustained severe damage, as did a number of bridges in and around the town. Recovery from the devastation was slow, with residents placed in temporary accommodation and some businesses temporarily relocated to Mitchells auction mart. By the summer of 2011 most of the damage had been repaired and buildings re-occupied, though some remained empty or boarded up.

Flooding occurred again in 2015 when the River Derwent burst its banks on December 5, with several hundred homes and businesses affected. Source: Wikipedia

http://www.visitcumbria.com/cockermouth-floods/



What causes flooding?

River floods usually occur after a long period of rain often during the winter.
The volume of water steadily increases causing river levels to rise. Eventually the river may overtop its banks to cause a flood.

Sudden flash floods can occur following torrential storms. These are called *flash floods*. They are more often associated with heavy rainstorms that occur in the summer.

There are physical and human factors that increase flood risk.

Physical factors

- **Precipitation** – torrential rainstorms can lead to sudden flash floods as river channels cannot contain the sheer volume of water flowing into them. Steady rainfall over several days can also lead to flooding in lowland river basins.
- *Geology (rock type) – impermeable rocks* (rocks that do not allow water to pass through them) such as shales and clays encourage water to flow overland and into river channels. This speeds up water flow and makes flooding more likely.
- *Steep slopes* – in mountain environments steep slopes encourage a rapid transfer of water towards river channels. This increases the risk of flooding.

Human factors (land use)

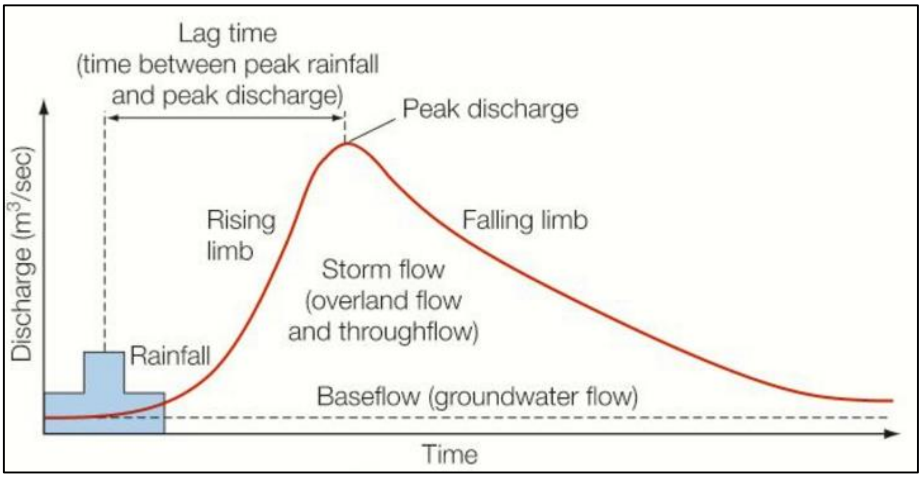
- *Urbanisation* – building on a floodplain creates impermeable surfaces such as tarmac roads, concrete driveways and slate roofs. Water is transferred quickly to drains and sewers and then into urban river channels. This rapid movement of water makes flooding more likely.
- *Deforestation* – much of the water that falls on trees is evaporated or stored temporarily on leaves and branches. Trees also use up water as they grow. When trees are removed much more water is suddenly available and transferred rapidly to river channels, increasing the flood risk.
- *Agriculture* – in arable farming, soil is left unused and exposed to the elements for periods of time. This can lead to more surface runoff. This is increased if the land is ploughed up and down steep slopes, as water can flow quickly along the furrows.

Lesson 20 - Hydrographs

A hydrograph is a graph that plots river discharge after a storm. River discharge is the volume of water flowing along a river – measured in cubic metres per second (cumecs).

A hydrograph shows how discharge rises after a storm, reaches its peak and then returns to a normal rate of flow.

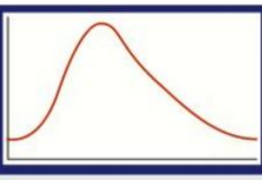
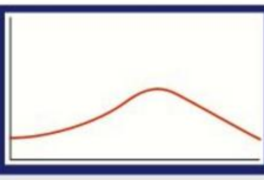
Flood hydrograph

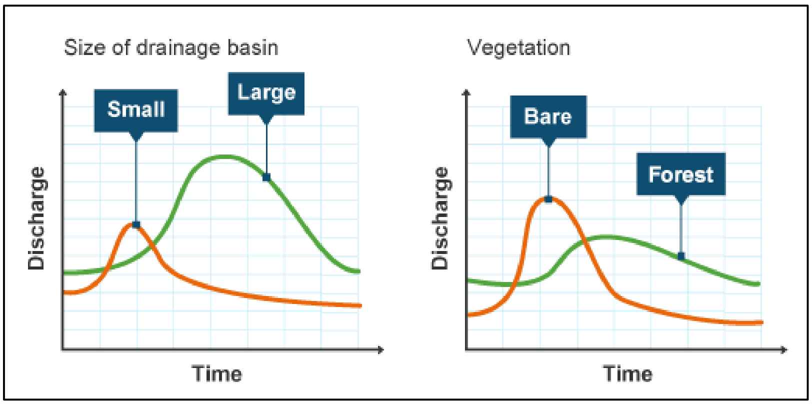


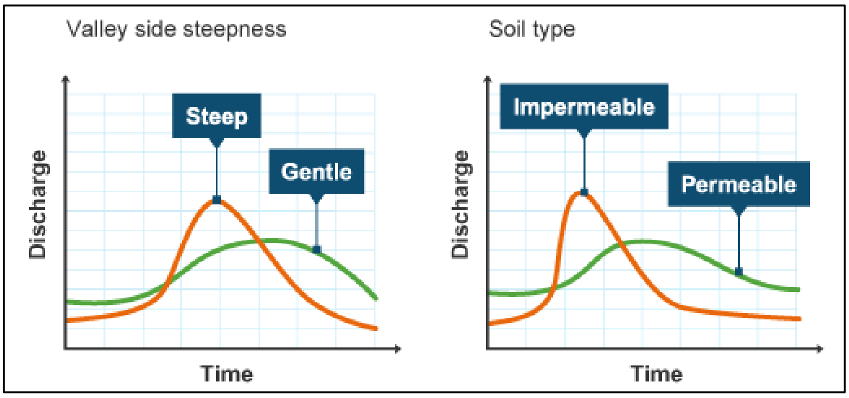
One of the most important aspects of a hydrograph is the *time lag*. This is the time in hours between the highest rainfall and highest (peak) discharge.
This shows how quickly water is transferred into a river channel and is a key factor in the flood risk.
The shorter the time lag the greater the risk of flooding.

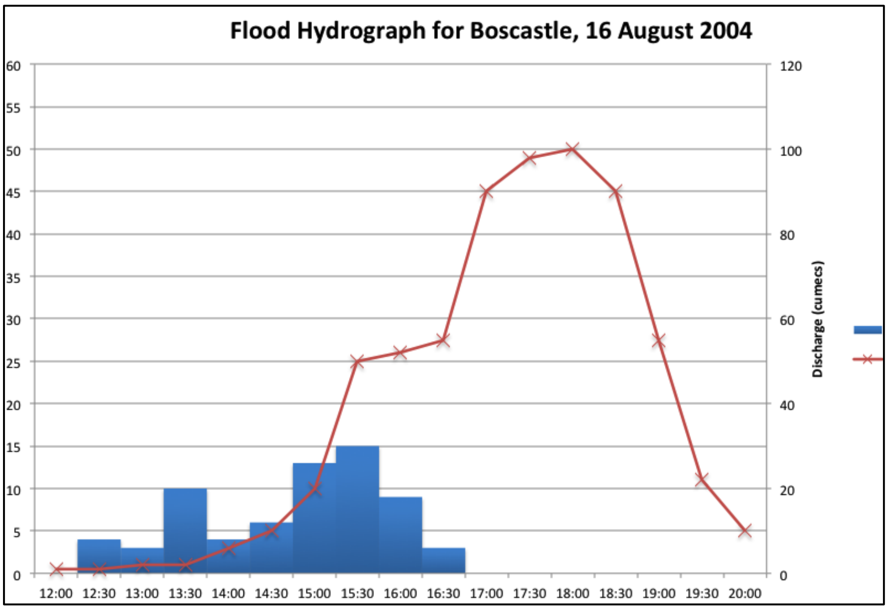
[Hydrographs]

What affects the shape of a hydrograph?

Drainage basin and precipitation characteristics	'Flashy' hydrograph with a short lag time and high peak 	Low, flat hydrograph with a low peak 
Basin size	Small basins often lead to a rapid water transfer.	Large basins result in a relatively slow water transfer.
Drainage density	A high density speeds up water transfer.	A low density leads to a slower transfer.
Rock type	Impermeable rocks encourage rapid overland flow.	Permeable rocks encourage a slow transfer by groundwater flow.
Land use	Urbanisation encourages rapid water transfer.	Forests slow down water transfer, because of interception.
Relief	Steep slopes lead to rapid water transfer.	Gentle slopes slow down water transfer.
Soil moisture	Saturated soil results in rapid overland flow.	Dry soil soaks up water and slows down its transfer.
Rainfall intensity	Heavy rain may exceed the infiltration capacity of vegetation, and lead to rapid overland flow.	Light rain will transfer slowly and most will soak into the soil.


Size of drainage basin
Small
Large
Discharge
Time
Vegetation
Bare
Forest
Discharge
Time


Valley side steepness
Steep
Gentle
Discharge
Time
Soil type
Impermeable
Permeable
Discharge
Time


Flood Hydrograph for Boscastle, 16 August 2004
60
55
50
45
40
35
30
25
20
15
10
5
0
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100
80
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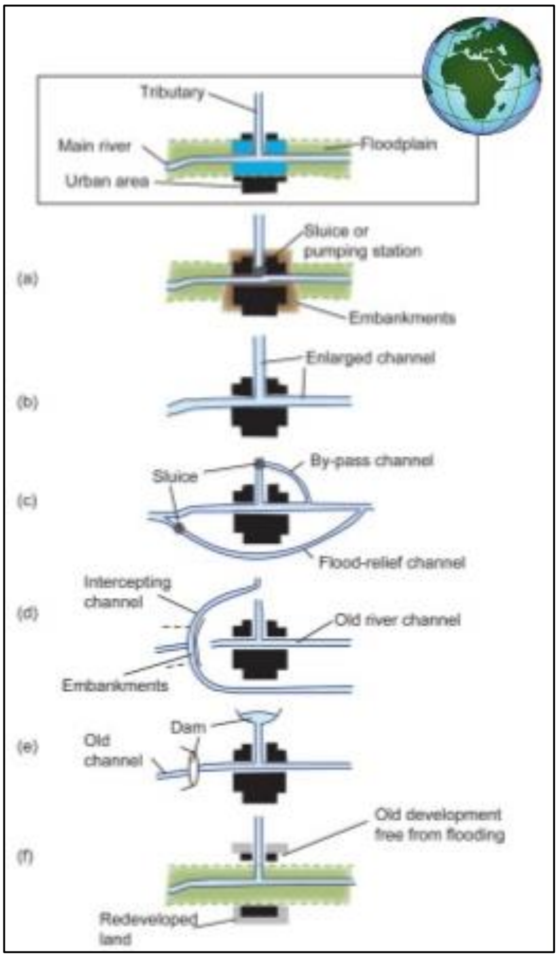
Discharge (cumecs)
12:00 12:30 13:00 13:30 14:00 14:30 15:00 15:30 16:00 16:30 17:00 17:30 18:00 18:30 19:00 19:30 20:00

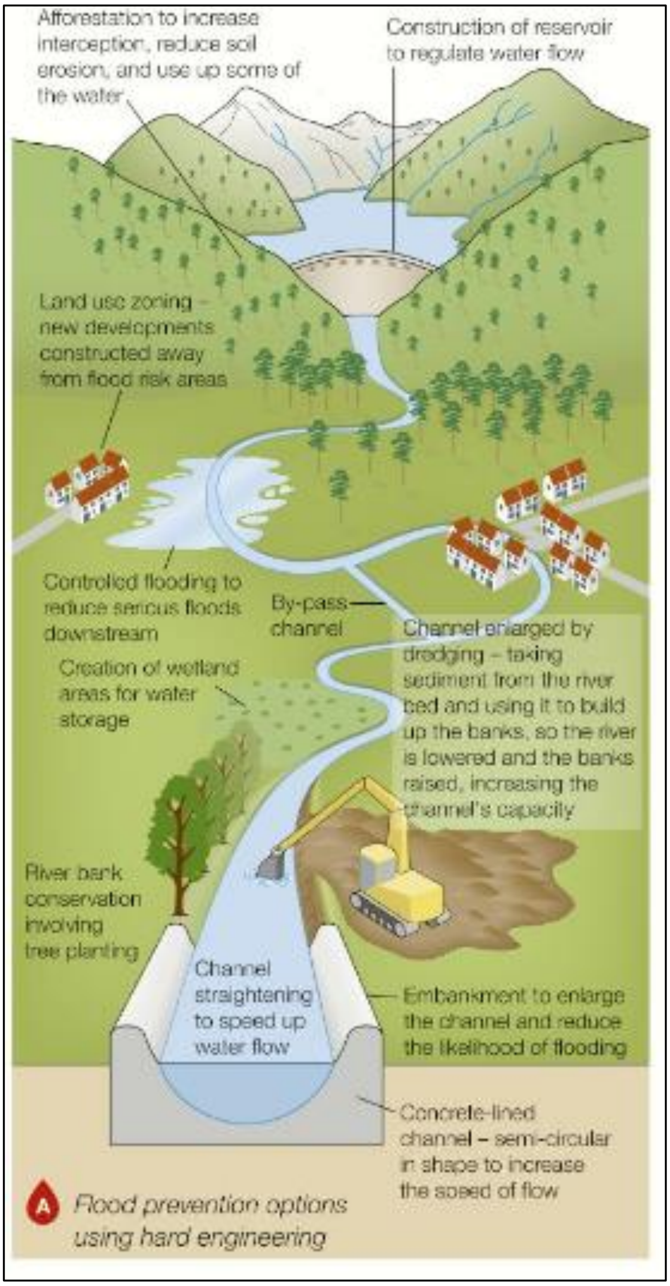
Lesson 21 – Managing Floods – Hard Engineering

Hard engineering involves using man-made structures to prevent or control natural processes from taking place.
(See lesson 6 re. coastal defences)
This is an expensive form of flood management – individual projects can cost several million pounds. This is the preferred option for protecting expensive property or land such as housing estates, railways or water treatment works. The costs have to be weighed against the benefits.

Costs – financial plus any negative impacts on the environment or people's lives.

Benefits – financial savings made by preventing flooding plus any environmental improvements.





Hard engineering

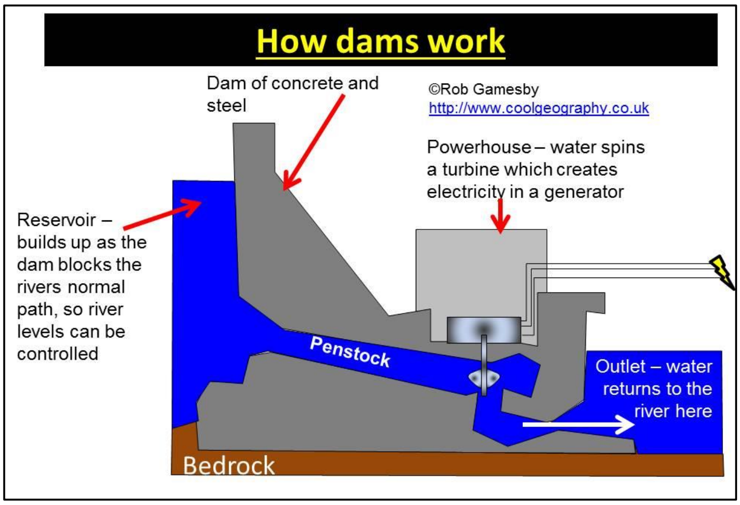
What are the arguments for and against hard engineering?

FOR	AGAINST
Reduction in flooding and therefore protects property	Can lead to destruction of habitats along river bank
Takes water away from towns more quickly	Can be visually intrusive
Increase in water supply e.g. on the Nile	It can dramatically increase peak discharge, duration and timing of floods downstream
Improved navigation e.g. Mississippi	Where meanders have been straightened, the river will try to re-establish itself
Allows energy to be created e.g. hydroelectric power on the Colorado	Straightening courses can lead to greater upstream erosion and downstream deposition

Dams and reservoirs

These are widely used around the world to control river flow and reduce the risk of flooding. Most dam projects are multi-purpose and have several functions:

- Flood prevention
- Irrigation
- Water supply
- Hydro-electric power
- Recreation



Dams can be very effective in regulating water flow. During periods of high rainfall, water can be stored in the reservoir. It can then be released when rainfall is low.

However dam construction can be controversial as they are very expensive and the reservoir often floods large areas of land. Many people may have to be moved from their homes.

Clywedog reservoir, Llanidloes, Wales

The Clywedog reservoir (photo **B**) was constructed in the 1960s to help prevent flooding of the River Severn. Its concrete dam is over 70 m high and 230 m wide and the reservoir stretches for nearly 10 km. It has been in continuous use since 1967, filling up in the winter and gradually releasing water in the summer to retain a constant flow. Although some flooding has continued to affect settlements further downstream, Clywedog has undoubtedly prevented catastrophic floods.

B *The Clywedog dam and reservoir*

Other hard engineering methods include channel straightening, embankments and flood relief channels.

Channel straightening

River straightening involves cutting through meanders to create a straight channel. This speeds up the flow of water along the river. Whilst river straightening may protect a vulnerable location from flooding, it may increase the flood risk further downstream. The problem is not really solved but shifted somewhere else!

In some places straightened sections of river are lined with concrete. This speeds up the flow and prevents the banks from collapsing, which can cause the channel to silt up. But the concrete channels create a very unattractive and unnatural river environment and can damage wildlife habitats.

Embankments

An embankment is a raised riverbank. Raising the level of a riverbank allows the river channel to hold more water before flooding occurs.

Hard engineering structures involving concrete walls or blocks of stone are frequently used in towns or cities to prevent flooding of valuable property. Sometimes mud dredged from the river may be used. This is cheaper and more sustainable and looks more natural.

Flood relief channels

A flood relief channel is a man-made river channel constructed to by-pass an urban area.

During times of high flow, sluice gates can be opened to allow excess water to flow away into the flood relief channel and reduce the threat of flooding.

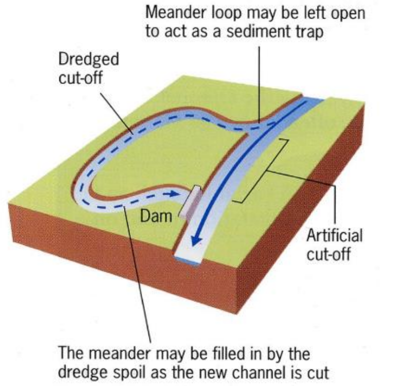


Figure 6.2 Realigning the channel
(*Source*: Knapp et al, 1989)

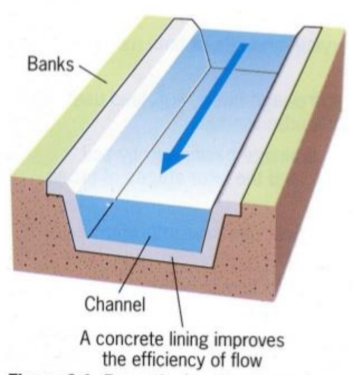
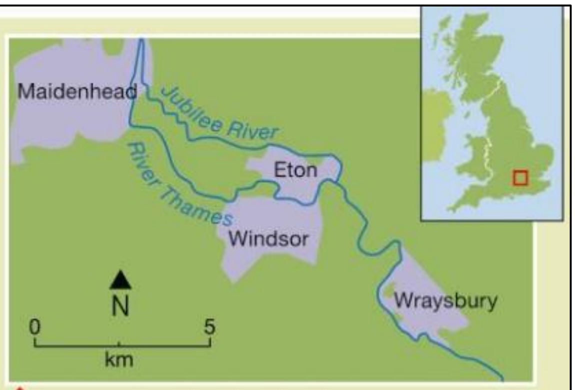


Figure 6.1 Resectioning the channel
(*Source*: Knapp et al, 1989)

The Jubilee River, Maidenhead

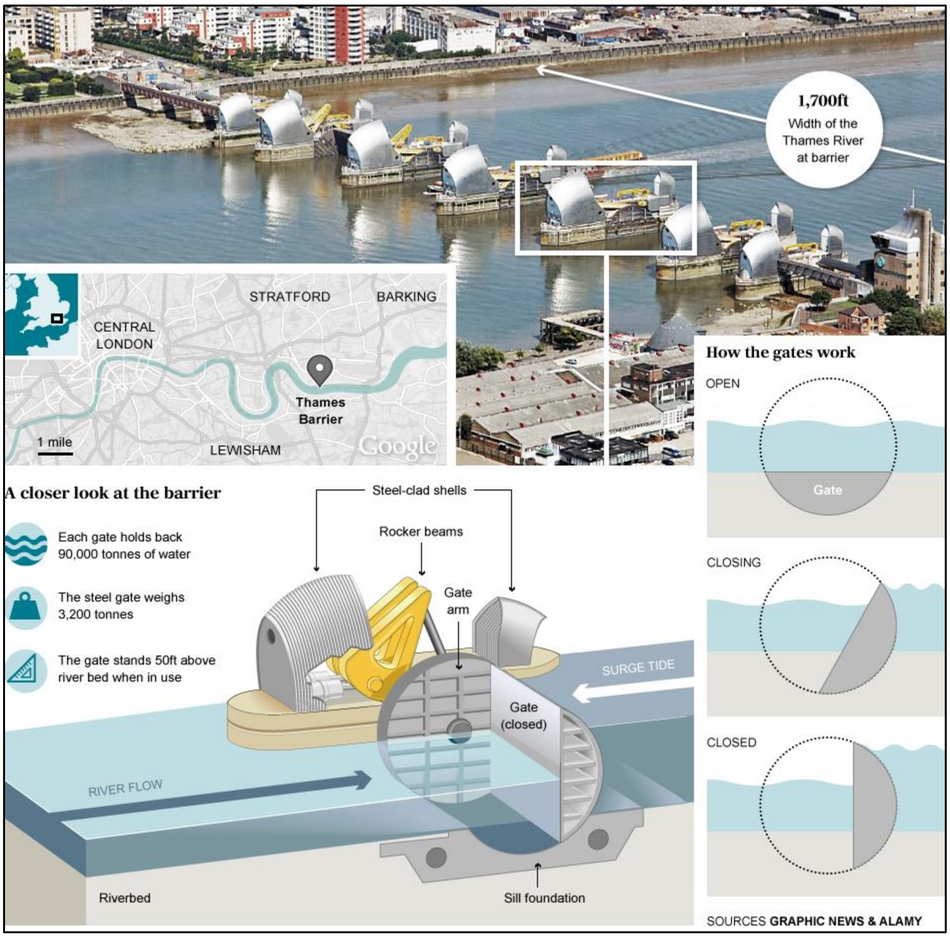
In the UK a flood relief channel, named the Jubilee River, has been constructed on the River Thames near Maidenhead in Berkshire (map **C**). The 11 km channel was opened in 2002. It cost £110 million to construct and with a length of nearly 12 km is the longest man-made channel in the UK. As well as reducing the risk of flooding for over 3000 properties, the Jubilee River has had a positive impact on the environment by creating new wetlands. It is also popular for recreational activities such as walking and fishing.



C *The Jubilee River*

Lesson 22 – Case study of hard engineering

Thames Flood Barrier



The Thames Barrier is one of the largest movable flood barriers in the world. The Environment Agency runs and maintains the Thames Barrier as well as London's other flood defences.

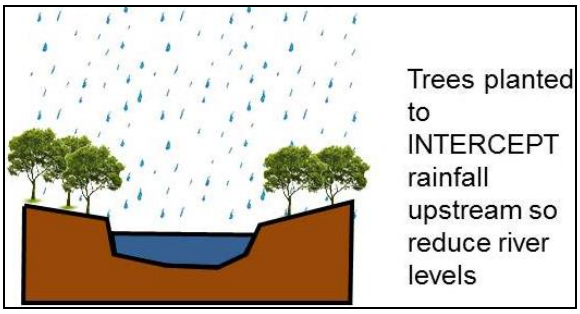
https://21stcenturychallenges.org/the-thames-barrier/

https://www.carbonbrief.org/risk-and-uncertainty-calculating-the-thames-barriers-future

http://www.telegraph.co.uk/news/weather/10646439/The-Thames-Barrier-has-saved-London-but-is-it-time-for-TB2.html

Lesson 23 – Managing Floods – Soft Engineering

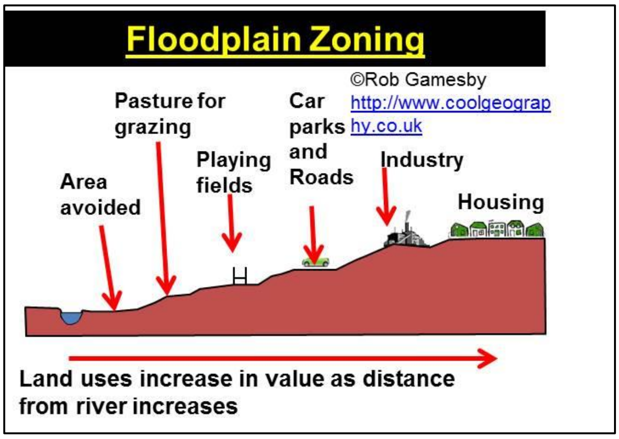
Soft engineering involves working with natural river processes to manage the flood risk.
It does not involve building artificial structures or trying to stop natural processes.
It aims to reduce and slow the movement of water into a river channel to help prevent flooding.
There are costs and benefits.



Afforestation
Planting trees to create a woodland helps to obstruct the flow of water and slow down the transfer of water to river channels. Water is soaked up by the trees or evaporated from leaves and branches. Tree planting is relatively cheap and has other environmental benefits.

Wetlands and flood storage areas
Wetland environments on river floodplains are very efficient in storing water. Wetlands are deliberately allowed to flood to form flood storage areas. Water can be stored to reduce the risk of flooding further downstream.

A Flood storage area, near Rye, East Sussex



Floodplain zoning
This restricts different land uses to certain zones on the floodplain. Areas close to the river and at risk from flooding can be kept clear of high-value land uses such as housing and industry. Instead these areas can be used for pasture, parkland or playing fields.
Floodplain zooming can reduce overall losses caused by flood damage. It can be difficult to implement on floodplains that have already been developed and can cause land prices to fall.

River restoration

Where the course of a river has be changed artificially, river restoration can return it to its original course. This uses the natural processes and features of the river, such as meanders and wetlands, to slow down river flow and reduce the risk of a major flood downstream.

Cheshire West plan 1 Warrington Flood defences Warrington Flood Defences 2

Restoration of the River Glaven, Norfolk

Preparing for floods

Rivers and drainage basins are monitored remotely using satellites and computer technology. Instruments are used to measure rainfall and check river levels.
Computer models are used to predict river discharge and identify areas at risk from flooding.

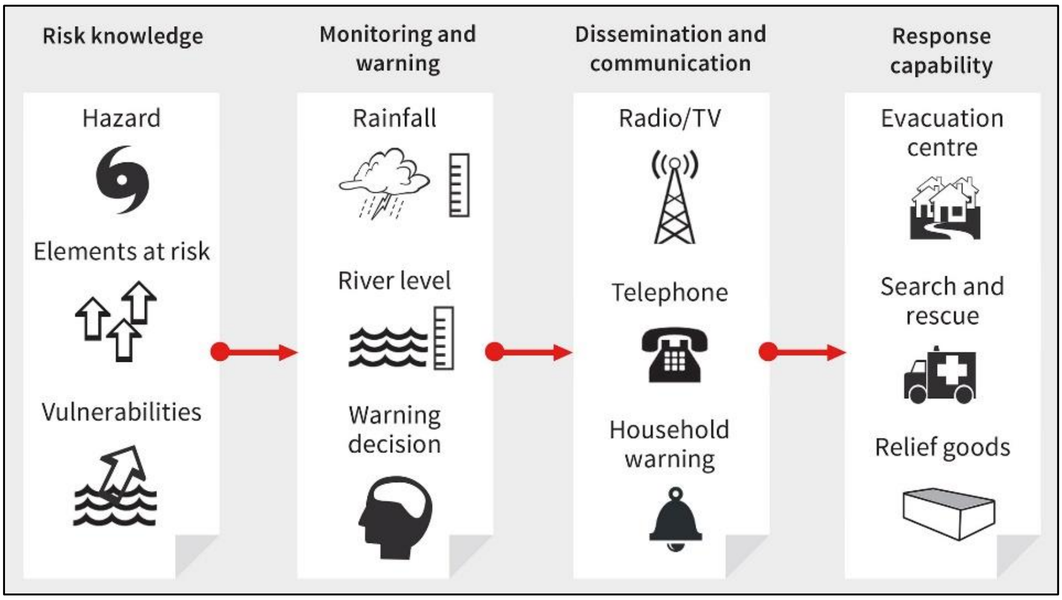
In England & Wales the Environment Agency issues *flood warnings* if flooding is likely. Warnings are sent to the emergency services and the public using social media, text and email. There are 3 levels of warning:

Flood Watch – flooding of low-lying land and roads is expected. People should be prepared and watch river levels.

Flood Warning – there is a threat to homes and businesses. People should move items of value to upper floors and to turn off electricity and water.

Severe Flood Warning – extreme danger to life and property is expected. People should stay in an upper level of their home or leave the property.

How the Environment Agency decides when to issue a warning and what type of warning to issue.



The EA's new flood warning codes

	Key Message	Timing	Actions	Channels
Awareness Raising	Be aware. Keep an eye on the weather situation.	▪ Daily forecasts of flooding on our website ▪ Communications with the media.	▪ Check the forecast on our website.	▪ Internet ▪ Media
FLOOD ALERT	Flooding is possible. Be prepared.	2 hours to 2 Days in advance of flooding.	▪ Be prepared for flooding. ▪ Prepare a flood kit.	▪ FWD ▪ Floodline ▪ Internet
FLOOD WARNING	Flooding is expected. Immediate action required.	Half an hour to 1 Day in advance of flooding.	▪ Act now to protect your property. ▪ Block doors with flood boards or sandbags and cover airbricks and other ventilation holes. ▪ Move family, pets and valuables to a safe place. ▪ Keep a flood kit ready.	▪ FWD ▪ Floodline ▪ Internet ▪ Sirens ▪ Loudhailers ▪ Media
SEVERE FLOOD WARNING	Severe flooding. Danger to life.	When flooding poses a significant threat to life and different actions are required.	▪ Be ready should you need to evacuate from your home. ▪ Co-operate with the emergency services and call 999 if you are in immediate danger.	▪ FWD ▪ Floodline ▪ Internet ▪ Sirens ▪ Loudhailers ▪ Media
Warning Removed	No further flooding is currently expected for your area.	Issued when a flood warning is no longer in force.	▪ Flood water may still be around and could be contaminated. ▪ If you've been flooded, ring your buildings and contents insurance company as soon as possible.	▪ FWD ▪ Floodline ▪ Internet

Lesson 24 – Soft engineering case study - Morpeth

Towns like Morpeth have suffered badly from flooding in the past. They now have their own website and Flood Action Group to support the community.

Environment Agency

National Flood Forum

Morpeth Flood Action Group

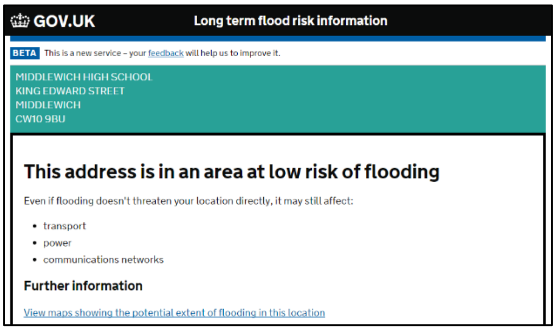
EA Morpeth blog

How Morpeth floods

The EA make maps identifying areas at risk of flooding. People living in these areas are encouraged to plan for floods. This might include:

- Planning what to do if there is a flood warning (i.e. move valuables upstairs)
- Using flood gates to prevent floodwater from damaging property
- Using sandbags to keep floodwater away from buildings

Middlewich High School is in an area with a low risk of flooding.


GOV.UK Long term flood risk information

BETA This is a new service – your feedback will help us to improve it.

MIDDLEWICH HIGH SCHOOL
KING EDWARD STREET
MIDDLEWICH
CW10 9BU

This address is in an area at low risk of flooding

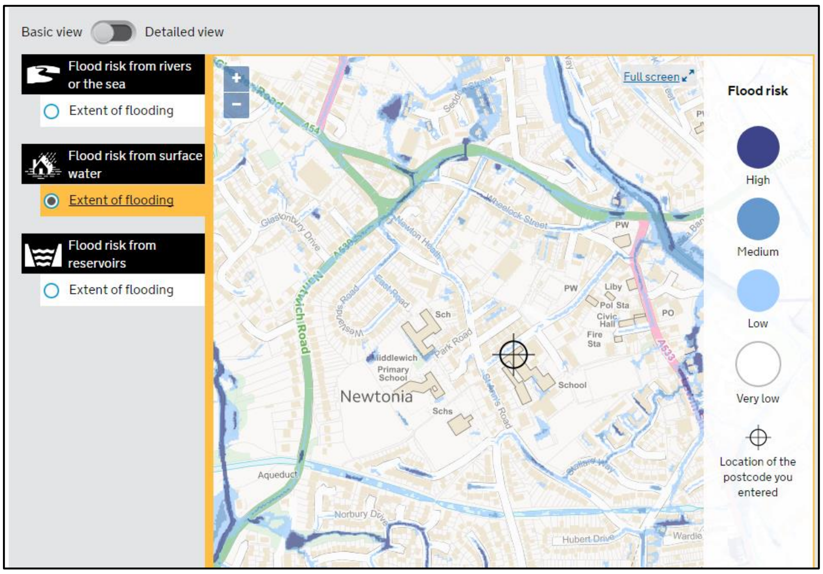
Even if flooding doesn't threaten your location directly, it may still affect:

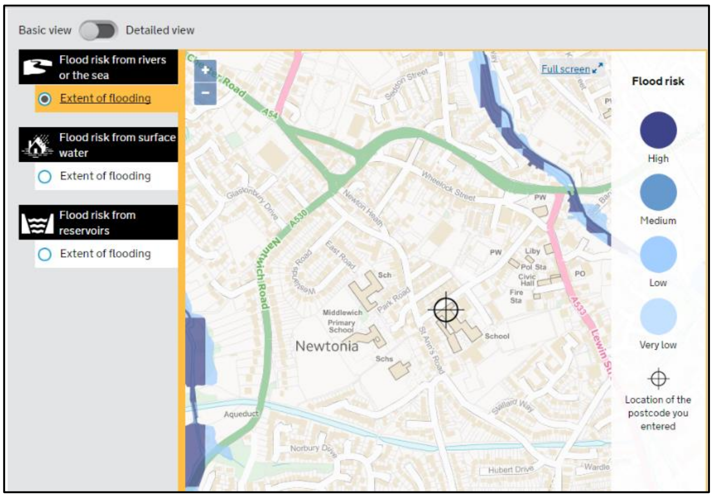
- transport
- power
- communications networks

Further information

View maps showing the potential extent of flooding in this location

What about where you live?





Local authorities and emergency services use these maps to plan responses to floods. For example, installing temporary flood barriers, evacuating people, closing roads and securing buildings and services.

Flood prediction is based on probability and one of the 'costs' is that places can become blighted by being 'at risk' from flooding. This can cause property values to drop and insurance premiums to increase.

Lesson 25 – Case Study – Managing Floods at Banbury

A The location of Banbury

Location

Banbury is a town in the Cotswold Hills about 50km north of Oxford. The population is about 45,000. Much of the town is built on the floodplain of the River Cherwell, which is a tributary of the River Thames.

History of flooding

Banbury has experienced many devastating floods. In 1998 flooding led to the closure of the town's railway station, shut local roads and caused £12.5 million damage. More than 150 homes and businesses were affected
In 2007 the town was hit again by floods that covered much of central and western England. Many more homes and businesses were affected as the river burst its banks after very heavy rain.


B Banbury station flooded in 1998

Flood Management in Banbury

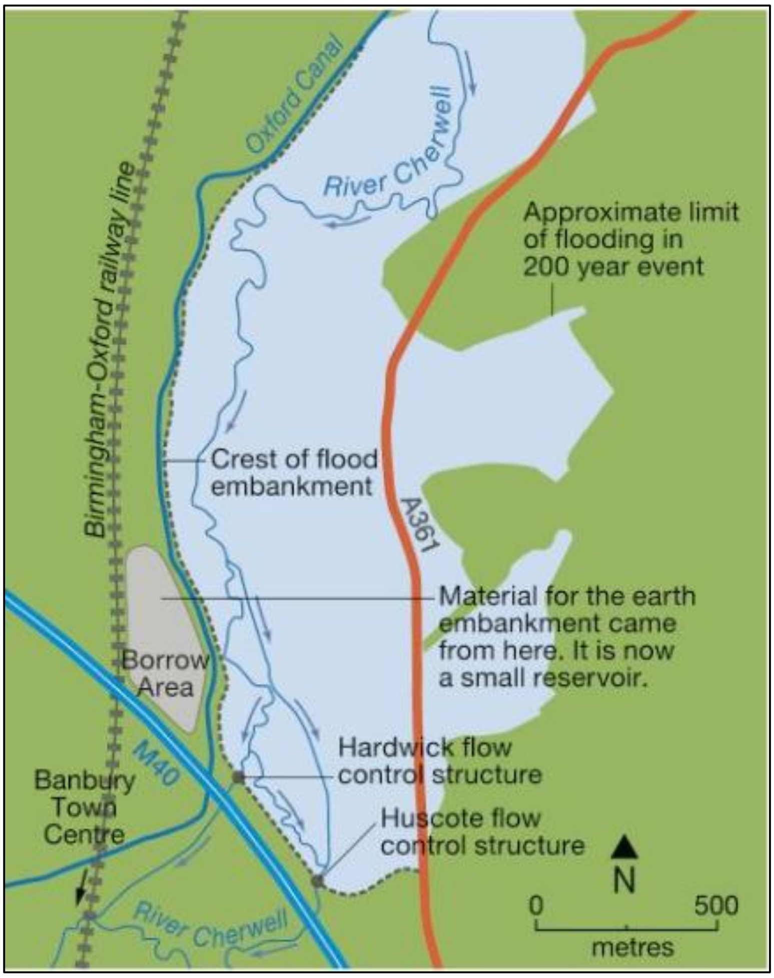
In 2012 Banbury's new flood defence scheme was completed. A 2.9km earth embankment was built parallel to the M40 motorway to create a flood storage area. The embankment has a maximum height of 4.5m. It is capable of holding around 3 million cubic metres of water – that's 1200 Olympic sized swimming pools!

The flood storage area is located mainly on the natural floodplain for the River Cherwell. It collects rainwater that otherwise would fill the river and cause it to flood.

Photo D shows one of the two flow control structures in the embankment. The specially designed aperture (opening) controls the rate of flow downstream towards Banbury. Any excess water backs up behind the structure, filling the reservoir rather than flooding Banbury. The design avoids the need to open and close flood gates.


D Flow control structure looking upstream towards the embankment

Map of Flood Storage Area at Banbury



Additional flood defences (part of the scheme):

- Raising part of the A361road in the flood storage area plus improvements to drainage beneath the road to prevent flooding
- New earth embankments and floodwalls to protect property and businesses, such as the motorsport business Prodrive
- A new pumping station to transfer excess rainwater into the river below the town
- The creation of a new Biodiversity Action Plan (BAP) habitat with ponds, trees and hedges to absorb and store excess water


New sheet-piled flood wall with concrete capping provides flood protection to football pitch at Banbury Utd - Courtesy of Black & Veatch

Scheme in operation Nov 2012

BBC news

Flood conference presentation

Costs and benefits?

Social	Economic	Environmental
• The raised A361 route into Banbury will be open during a flood, to avoid disrupting people's lives. • Quality of life for local people is improved with new footpaths and green areas. • Reduced levels of anxiety and depression through fear of flooding.	• The cost of the scheme was about £18.5 million. • Donors included Environment Agency and Cherwell District Council. • By protecting 441 houses and 73 commercial properties, the benefits are estimated to be over £100 million.	• Around 100 000 tonnes of earth were required to build the embankment. This was extracted from nearby, creating a small reservoir (map **C**). • A new Biodiversity Action Plan habitat has been created with ponds, trees and hedgerows. • Part of the floodplain will be deliberately allowed to flood if river levels are high.

Lesson 26 – Fieldwork preparation 1

Lesson 27 – Fieldwork preparation 2

Lesson 28 – Revision

Lesson 29 – Assessment

Lesson 30 – Assessment review