**3. Management issues and strategies**

**Dams and reservoirs**

* Examine the hydrological changes resulting from the construction of dams and reservoirs. Examine the costs and benefits of dams and reservoirs as part of multi-purpose schemes.

Hydrological changes from dams and reservoirs:

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| **CHANGES TO HYDROLOGY UPSTREAM OF DAMS** | **CHANGES TO HYDROLOGY DOWNSTREAM OF DAMS** |
| * **Increased evaporation** rates because reservoirs have a larger surface area than rivers. * An **increase in the amount of surface store** (reservoirs are an artificial store). * A **reduction in the velocity** of the river upstream. * **Increased sedimentation** can lower the depth of the river and the reservoir. Again this will reduce velocity and may also reduce storage capacity. | * **River discharge will decrease** because water is being held behind the dam. * **Erosion of riverbed** but no sedimentation. * Less **load transported** * **Salinity** of the water and the ground may increase. * **Increased velocity** * **Temperature** reduction, as water released from reservoirs is often colder (depth). * The water may also be **less oxygenated** than natural free flowing water. * The amount of depositional landforms may reduce. |

Dams are nowadays built as multipurpose schemes, meaning that they may provide renewable energy, prevent floods and create water storage.

Three Gorges Dam

* The multipurpose dam is located on the Yangtze river in central China
* Largest dam in the world

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| **ADVANTAGES** | **DISADVANTAGES** |
| * Reducing pollution (renewable) * It produces over 18,000 MW of clean renewable energy. * Protects over 10 million residents downstream from the risk of flooding. * Improved for navigation. * Creation of jobs * Tourist destination * Storage of water | * Sedimentation behind the dam stops alluvium reaching the floodplain downstream. * The increased river traffic is blamed for the extinction of the Yangtse river dolphin. Sturgeon threatened as it cannot reach its breeding grounds. * Risk of dam failure due to seismic activities. * The flooding of the reservoir forced over 1.3 million people to be relocated. * Fertile land was lost in the process of flooding * Cost: $70 billion |

**Floodplain management**

* Explain the stream channel processes (erosion, transport, deposition) and explain the resultant landforms found on floodplains. Examine the human modifications of a floodplain and their effect on the size and probability of floods. Evaluate the costs and benefits of alternative stream management strategies.

Stream channel processes:

* **Erosion:** Wearing away of bed, bank and load of a river.
* **Attrition:** Wearing away of load creating smaller, rounder particles.
* **Hydraulic Action:** Forces of air and water on riverbed, banks and in cracks.
* **Solution (Corrosion):** Removal of chemical ions, especially calcium, which causes rocks to dissolve.
* **Abrasion (Corrasion):** Wearing away of the bed and bank by the load.

Factors affecting erosion:

**Base level:** The lowest level that a river can erode (sea level or artificial bed).

* Load: Heavier and sharper increases erosion
* Velocity and discharge: Increase 🡪 greater erosion potential
* Gradient: Increase 🡪 greater erosion potential
* Geology: Soft, unconsolidated rocks like sand or gravel are easily eroded
* PH: Rates of solution are increased when water is more acidic
* Human impact: Deforestation, dams and bridges interfere with a river’s natural flow and can increase the rate of erosion
* Clear water erosion: Power of water
* Vertical erosion: Rather up course, above base level with larger load particles
* Horizontal (lateral) erosion: Middle and lower course, nearer to base level. Smaller load particles means more suspended load.

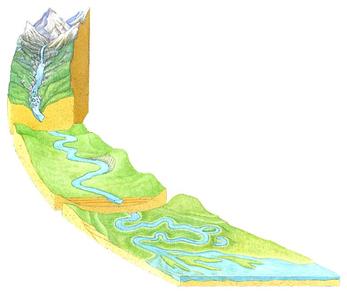
Transportation types & deposition:

**Capacity** is theamount of debris a stream can carry and **competence** the diameter of the largest particle. **Critical erosion velocity** is the lowest velocity, at which debris can be moved. Hjulström curve shows required velocities to transport and deposit.

* Suspension: Small particles held up by turbulent river flow
* Saltation: Heavier particles bounce or bump along the river bed
* Solution: Chemical load carried dissolved in water
* Traction: Heaviest material dragged or rolled along river bed
* Flotation: Leaves or twigs carried on the river surface

Deposition occurs as a river slows and loses energy. This occurs as a river floods a floodplain, enters the sea or during low-flow conditions. Large particles are deposited before smaller ones. Features of deposition include deltas, levees, slip-off slopes, oxbow lakes, braided channels and floodplains.

River landforms:

****Landforms can be classified as 1. Erosional, 2. Erosional and depositional and 3. Depositional.

**Upper course:**

Section nearest to source. Load is biggest and most erosion is vertical. Landforms are made by erosion and include waterfall, gorges, rapids and valleys.

**Middle course:**

Section between mountains and flat land with a hilly environment. Valley floors widen, increased horizontal erosion. Landforms include meanders.

**Lower course:**

Section closest to mouth. River is travelling flatter and the load is smaller and smoother. High horizontal erosion as its near the base level. Landforms include meanders, oxbow lakes and levees.

**Alluvial river:** Any river, carrying load.

**Fluvial:** Anything found or made by a river e.g. landforms.

Fluvial landforms:

**Levees:**

* When a river floods, the contact to the floodplain reduces velocity and causes deposition. Over time, levees (raised banks) form.

**Meanders:**

* Bends of rivers, forming slip-off slopes (point bars) by deposition at the inside and river cliffs at the outside by erosion
* If meanders become cut off from the main river, **Oxbow lakes** form.

Human modifications:

Generally, urbanization increases the likelihood of floods. Human modifications usually result from urbanization and can be split into **hard engineering (**concrete) and **soft engineering** (natural modifications). Modifications include:

* **Sewer systems**: Artificial channels, which reduce lag time (more flooding).
* **Pollution**: Metals, waste and chemicals from transport, industry and housing.
* **Groundwater depletion**: Unsustainable use of groundwater.
* **Deforestation**: Often from urbanization, it involves reduced interception and transpiration. Mudslide risk and saturation increases as root uptake stops.

**Stream management strategies:**

1. **Reforestation** (Soft engineering):

Advantages: Natural; increases interception, transpiration and root uptake

Disadvantages: Only scalable to a certain degree. Trees lose leaves in autumn.

1. **Channel Enlargement** (widening/deepening) (Hard engineering):

Advantages: Increases bank full discharge and velocity

Disadvantages: Expensive, may not be possible everywhere.

1. **Dams** (Hard engineering):

Advantages: Storage of water

Disadvantages: Expensive, several non-beneficial side effects.

1. **Flood Proofing** (Soft engineering):

Advantages: Cheap, may be done individually.

Disadvantages: Only protects against weak floods

1. Channelization (Hard Engineering)

Advantages: Reduces friction, increases velocity and decreases bank erosion.

Disadvantages: Expensive and bad for ecosystem. Flood may occur downstream.

**Ground water management**

* Explain the functioning and management of artesian basins and aquifers, distinguishing between natural and artificial recharge. Examine the environmental impacts of groundwater abstraction.

**Phreatic zone:** The area of ground that is permanently saturated.

**Aeration zone:** The area of land that is only partially saturated or completely unsaturated.

**Water table:** The boundary between saturated and unsaturated ground. The water table can move up or down.

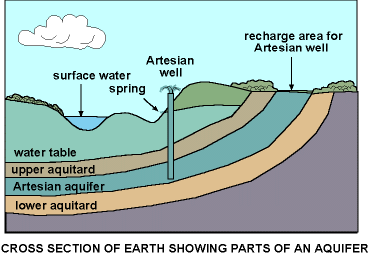
**Aquifer:** Rock that can hold water (porous).

**Aquitard:** A layer of rock that limits the movement of groundwater. It may be non-porous and has low hydraulic conductivity (e.g. clay).

**Aquiclude:** Rock that will not hold water or allow its movement (impermeable)

Artesian basins and aquifers:

**Artesian basin:** A confined aquifer containing groundwater under positive pressure. This causes the water level in the well to rise to a point where hydrostatic equilibrium has been reached (balance between pressure on and from the aquifer). An example is the Great Artesian basin in Australia

**Natural recharge:** The aquifer may be recharged from precipitation, infiltration and groundwater flow.

**Artificial recharge:** Leakage from irrigation channels, reservoirs or pumps.

If too much water is extracted, the pressure reduces and less water will rise naturally.

**Deficit (natural):** When evapotranspiration exceededs precipitation for a long time.

**Recharge (natural):** When precipitation exceeds evapotranspiration.

**Excess (natural):** When precipitation exceeds evapotranspiration for a long time, the ground saturates and the water table will move up.

**Usage (natural):** When evapotranspiration is greater than precipitation, the water table will move down.

**Groundwater abstraction:**

Ways of extraction include: Wells, springs, pumping, piping.

Environmental impacts:

* Lack of water for the ecosystem
* Natural flow of water may change, affecting the ecosystem

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| Causes of groundwater usage | Causes of groundwater recharge |
| * Irrigation * Drinking * Industries * Natural usage (ecosystem) * Interbasin transfer * Leakage into nearby aquifers | * Artificial recharge * Leakage into nearby aquifers * Interbasin transfer * Infiltration after precipitation |

Possible solutions to Groundwater depletion and pollution:

**Desalination:** Removing salt from seawater.

**Trade in virtual water:** Countries with excess water produce food requiring a lot of water for countries with a deficit to buy.

**Artificial stores:** Creating reservoirs to collect water.

**Recycling grey water:** Water may be reusable for watering plants.

**Drip irrigation:** Irrigation can be wasteful and water may evaporate.

**Cloud seeding:** Using chemicals to stimulate precipitation.

**Controls and cost regulation:** Leads to a decrease in usage.

**Recycling contaminated garbage:** Reduces pollution effect of landfills.

**Water treatment:** Recycling water by removing solid and chemical waste.

**Freshwater wetland management**

* Describe the role of wetlands as a water resource. Evaluate the effectiveness of the management strategies that have been adopted in a major wetland.

**Wetland:** Area of land, whose soil is saturated with moisture permanently or seasonally. Such areas may be swamps or marshes with saltwater, freshwater or brackish water (mixture).

Importance of wetlands:

* **Flood control:** Many wetlands are covered in vegetation, which can intercept precipitation, absorb rainwater and transpire. It reduces river velocities and acts as water storage and absorbent. Acts as stabilization against erosion.
* **Groundwater recharge:** Wetlands collect precipitation and river discharge, causing infiltration and percolation to recharge groundwater.
* **Tourism**
* **Environmental biodiversity:** Unique habitats for flora and fauna.
* **Water purification:** Wetlands help clean and purify water.
* **Storage of organic matter** (such as methane)

Example of a major wetland: Kissimmee River

Located in south central Florida, around 200 km long. To reduce floods, channels were built, which had large effects on the wetland ecosystem of the Kissimmee River.

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| **PROBLEMS CAUSED BY RIVER MANAGEMENT** | **THE RESTORATION AND ITS BENEFITS** |
| * The Kissimmee River floodplain dried up after channelization. * The reduction of the floodplain reduced waterfowl habitat by 90% * Wood stork populations now at one third. * Fishing, bird watching and hunting tourism declined after channelization * Pollution from the Kissimmee are flowing into Lake Okeechobee. | * The restoration project started in 1999 * The aim is to restore over 100km2 of river and wetland floodplain by 2015 * The river is being dechannelized by refilling the flood canal and reestablishing the old natural course of the river. * Restored sections now flood naturally * The nutrient loads in Lake Okeechobee should be reduced as more is absorbed in the wetland. * Wading birds have returned to the restored sections * Increased revenue from tourism * Reestablishment of natural ecosystem |

**Irrigation and agriculture**

* Examine the environmental impact of agriculture and irrigation on water quality: salinization, agro-chemical runoff, the pollution of groundwater and the eutrophication of lakes, rivers and wetlands.

The demand for agriculture is rising due to growing populations while the land for this use is declining due to urbanization and soil degradation. Irrigation increases agricultural land but also salinization due to increased evaporation. It also has effects on the water table and may help nations economically. Impacts of agriculture are:

* **Eutrophication:** Artificially added nitrates and phosphates cause excessive growth of algae in wetlands and lakes. It originates from agro-chemical runoff (fertilizers) and domestic sewage. They reduce oxygen content and sunlight and harm other species.
* **Salinization:** Unsustainable water extraction causes an increase in the salt content of the water, with harmful effects on wildlife.
* **Desertification:** Rising temperatures, drought, overgrazing or deforestation may cause fertile soil turning into desert. Correct irrigation methods may reduce this.

**Sprinkler irrigation** is often used on a large industrial scale. They respond directly to demand but may evaporate fast and need electricity to pump the water.

**Drip systems** are more efficient. They also respond to demand but less water is lost to evaporation. However, it is more expensive and not suitable for all types of crops.