

River Systems

Physical Geography Lecture - GEOG B1

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Hydrology

- **Hydrology** is the scientific study of the movement, distribution, and properties of water on Earth (and other planets), including the water cycle, water resources and environmental watershed sustainability.

The focus is on water at or below Earth's surface.

Fluvial

Fluvial - processes associated with rivers and streams and the deposits and landforms created by them.

- The term river is usually applied to the trunk, or main stream of a network of tributaries
- Stream is a more general term for water flowing in a channel.

When the stream or rivers are associated with glaciers, ice sheets, or ice caps, the term **glaciofluvial** or **fluvioglacial** is used.

Drainage basin

- A **drainage basin** is any area of land where precipitation collects and drains off in streams and comes together to form river systems to a common outlet, such as into a river, bay, or other body of water.

Fig. 15.1 - Amazon River Drainage Basin and mouth

A drainage basin is usually an open system with inputs of precipitation and regional geology.

The drainage basin includes all the surface water from rain runoff, snowmelt, and nearby streams that run downslope towards the shared outlet, as well as the groundwater underneath the earth's surface.

Drainage basins range in size from tiny to vast



Mississippi River Drainage Basin

Appalachian Mountains to the east and Rockies to the west

Drainage

- **Sheetflow** - an overland flow or downslope movement of water taking the form of a thin, continuous film over relatively smooth soil or rock surfaces.
- Drainage can also concentrate in rills, small scale grooves in the landscape. Rills can combine to form gullies, and then stream channels leading to a valley floor.



Clear
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Rills



Gullies



Valley

Drainage Divide

The high ground that separates two drainage basins is a drainage divide.

Fig. 15.3

- A **continental divide** is a drainage divide on a continent such that the drainage basin on one side of the divide feeds into one ocean or sea, and the basin on the other side either feeds into a different ocean or sea. *

*Or else is internal, or endorheic, not connected to the open sea



Where a continental divide meets an internal, or endorheic basin, such as the [Great Divide Basin](#) of [Wyoming](#), the continental divide splits and encircles the basin.

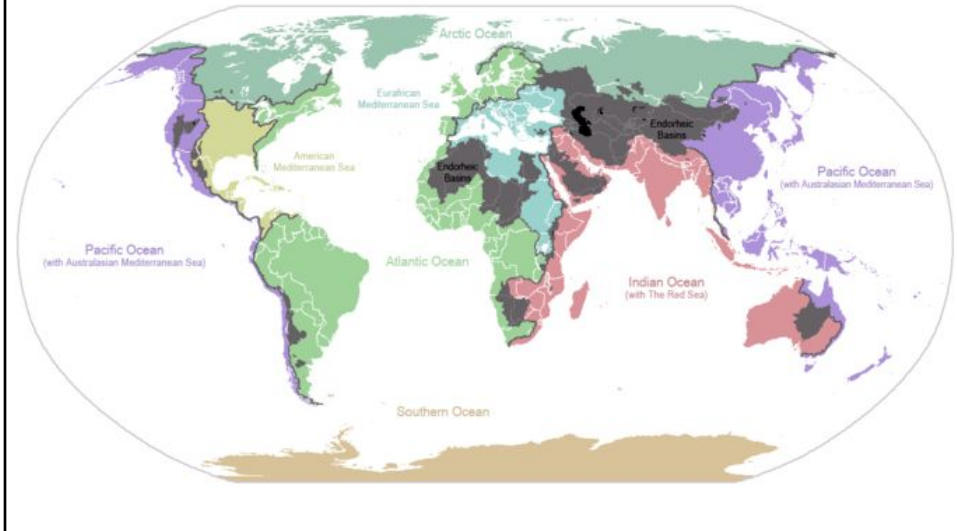
Internal drainage

- An endorheic basin is a closed drainage basin that retains water and does not let it flow to other outside bodies of water, such as oceans.* The water leaves the system through evaporation or subsurface gravitational flow.
- Such a basin may also be referred to as a closed or terminal basin or as an **internal drainage system**.

*The water instead converges instead into lakes or swamps, permanent or seasonal

Examples: Utah's Great Salt Lake, Dead Sea region in the Middle East, and the region around the Aral Sea and Caspian Sea in Asia

International Drainage Basins



Drainage basins don't follow political boundaries. Many basins cover multiple countries (like the Danube River - **Fig. 15.4**).

These rivers many economic functions: commercial transport, municipal water source, agricultural irrigation, fishing, and hydroelectric power. International struggles are under way to save the waters of many drainage basins from industrial waste, sewage, chemical discharges, agricultural runoff, and drainage from ships.

Drainage density

Drainage density is the total length of all the streams and rivers in a drainage basin divided by the total area of the drainage basin.*

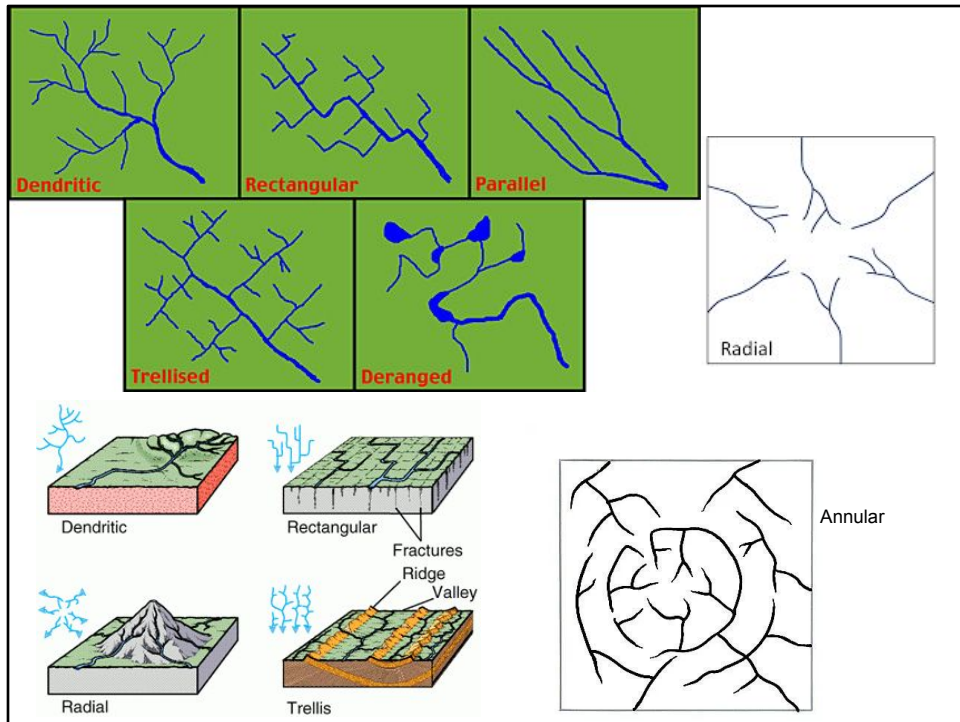
*It is a measure of how well or how poorly a watershed is drained by stream channels

Drainage density depends upon both climate and physical characteristics of the drainage basin. Soil [permeability \(infiltration difficulty\)](#) and underlying rock type affect the runoff in a watershed; impermeable ground or exposed bedrock will lead to an increase in [surface water runoff](#) and therefore to more frequent streams. Rugged regions or those with high relief will also have a higher drainage density than other drainage basins if the other characteristics of the basin are the same.

Drainage pattern

Drainage systems can fall into one of several categories known as **drainage patterns**. Drainage patterns depend on the *topography* and *geology* of the land.

- **Dendritic drainage pattern**
- **Parallel drainage pattern**
- **Trellis drainage pattern**
- **Rectangular drainage pattern**
- **Radial drainage pattern**
- **Deranged drainage pattern**
- **Annular drainage pattern**



Dendritic - most familiar - treelike pattern

Trellis - characteristic of dipping or folded topography

Radial - results when streams flow off a central peak or dome - like a volcanic mountain

Parallel - associated with steep slopes

Rectangular - formed by a faulted and jointed landscape - drainage is in a series of right angle turns.

Annular - occur on structural domes, with concentric patterns of rock strata guiding stream courses

Deranged - no clear geometry to the pattern no true stream valley forms - found in glaciated shield regions of Canada, northern Europe, and some parts of Michigan

Basic Fluvial Concepts

- **Gradient** - the channel slope of a stream *
- **Base Level** - the level below which a stream cannot erode its valley **
- **Discharge** - a stream's volume of flow per unit of time
 - **Discharge = depth x width x velocity**

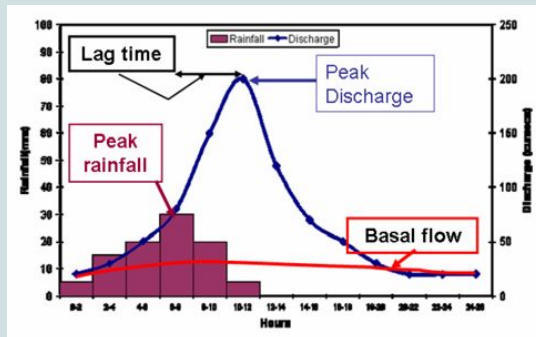
* Defined as the drop in elevation per unit distance - usually measured in meters per km, or feet per mile.

The ultimate base level is sea level. Regionally a large river or lake is likewise the **base level for tributary streams.

Hydrograph

Hydrograph - shows the changing rate of stream flow (discharge) over time.

Fig. 15.9



When rainfall occurs in some part of the watershed, the runoff is concentrated in streams and tributaries in that area.

The amount, location, and duration of rainfall determine the peak flow, the highest discharge that occurs during a precipitation event.

The nature of the surface in a watershed, whether permeable or impermeable, affects peak flow and the timing of changes recorded in the hydrograph.

Which leads us to the flash flood.....

Flash Flood

Flash flood - a sudden and short-lived torrent of water that exceeds the capacity of a stream channel - associated with desert and arid regions *

- Urban areas produce runoff patterns quite similar to those of deserts due to the sealed surfaces of the city drastically reducing infiltration.

Fig. 15.9 b

*In deserts, where surfaces have thin, impermeable soils and little vegetation, runoff can be high during rainstorms

Fluvial Processes

- **Erosion** - the process where water dislodges, dissolves or removes weathered surface material from one location, then transport it away to another location
- **Deposition** - the process where weathered material which has been eroded is laid down, or deposited

Stream Channel Processes

- **Hydraulic action** - a type of erosive work performed by flowing water alone - the motion of water against a rock surface produces mechanical weathering.
 - the ability of moving water (flowing or waves) to dislodge and transport rock particles *
- **Abrasion** - the process of rock and sediment debris in a river grinding and carving the streambed - like liquid sandpaper **

*A primary example of hydraulic action is a [wave](#) striking a cliff face which compresses the air in cracks of the rocks. This exerts pressure on the surrounding rock which can progressively crack, break, splinter and detach rock particles. This is followed by the decompression of the air as the wave retreats which can occur suddenly with explosive force which additionally weakens the rock. Cracks are gradually widened so each wave compresses more air, increasing the explosive force of its release.

**The intensity of abrasion depends on the hardness, concentration, velocity, and mass of the moving particles.

Abrasion can also happen with debris carried by wind and glaciers.

Sediment transport

- **Sediment transport** - when stream flow propels sand, pebbles, gravel, and even boulders downstream

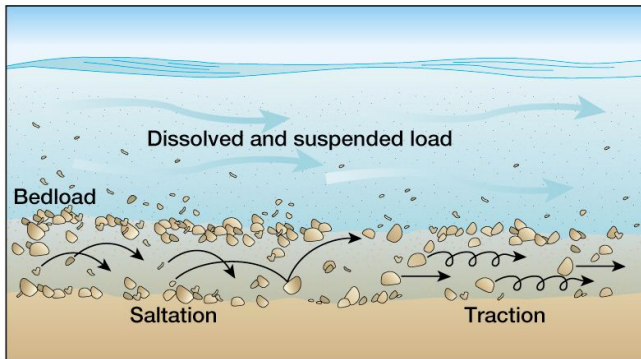
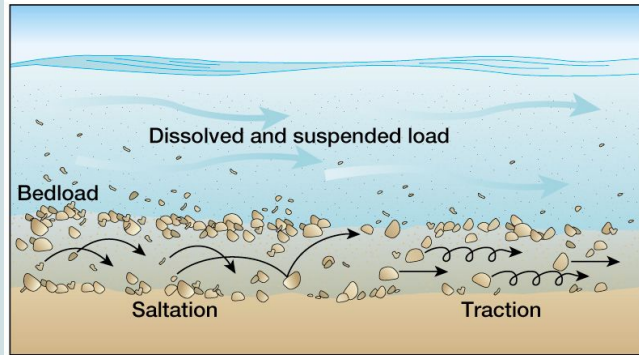


Fig. 15.13

Sediment transport occurs in natural systems where the particles are [clastic](#) rocks ([sand](#), [gravel](#), [boulders](#), etc.), [mud](#), or [clay](#); the fluid is air, water, or ice; and the force of gravity acts to move the particles along the sloping surface on which they are resting. Sediment transport due to fluid motion occurs in [rivers](#), [oceans](#), [lakes](#), [seas](#), and other bodies of water due to [currents](#) and [tides](#). Transport is also caused by [glaciers](#) as they flow, and on terrestrial surfaces under the influence of [wind](#).

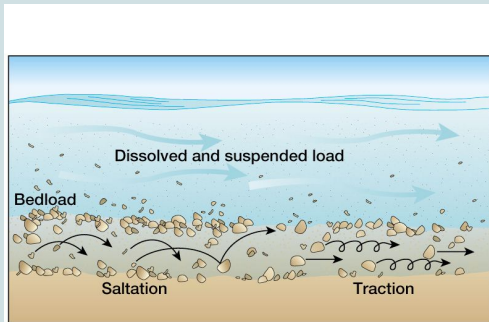
Dissolved load

- **Dissolved load** - material from chemical weathering, that is carried in solution by a stream



Suspended Load

- **Suspended load** -the portion of a stream's sediment uplifted by the fluid's flow in the process of sediment transportation. It is kept suspended by the stream's turbulence.

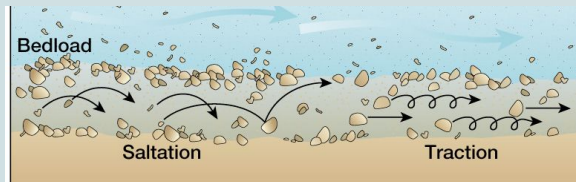


The suspended load generally consists of smaller particles, like Clay, Silt, and fine sands.

Bed load

Bed load - consists of the larger sediment which is transported by:

- **traction** - process of rolling or dragging sediment materials along the streambed
- **saltation** - refers to the way particles may bounce along in short hops and jumps *



*from the Latin saltim - which means “by leaps or jumps”

Particles transported by saltation are too large to remain in suspension but are not confined to the sliding and rolling motion of traction.

Stream Velocity

- Stream velocity, or speed, affect its ability to carry sediment.
- With increased kinetic energy in a stream, parts of the bed load are rafted upward and become part of a suspended load.
 - *Example: a flood*

As a flood flows build, it increases the stream's ability to erode and transport sediment.

Degradation / Aggradation

- **Degradation** - the process when a streambed erodes due to higher stream velocity
- **Aggradation** - the process of a stream bed being built up through the deposition of sediment
 - occurs when the velocity of a stream diminishes

Fig. 15.14

Effects of Dams on Sediment Transport

Dams disrupt natural river discharge and sediment transport - usually with detrimental effects on river systems.

- river bank beaches disappear
- fish migration disturbed
- depleting nutrients

pp. 434-435 - Focus Study 15.1
- Stream Restoration

Channel Patterns

Braided streams - consists of a network of small channels separated by small and often temporary islands called braid bars * **Fig. 15.15**

Meandering streams - a more sinuous (snakelike) form of channel pattern on a gradual slope - it weaves back and forth across the landscape

*Created when reduced discharge lowers a stream's transporting ability, such as after flooding.

Commonly occur in glacial environments where coarse sediment is plentiful and slopes are steep - like in New Zealand, Alaska, Nepal, and Tibet

There are also **anabranching** channels - when multiple large channels are present across a vast floodplain **Fig. 15.16**

and occasionally there are **straight channels** (**Fig. 15.17**), but these aren't as common and depend on the bedrock

Meandering Channel Erosion - I *

- **Undercut bank** - the outside bank of a bend in a stream, which is continually undergoing erosion due to higher velocity
 - shaped much like a small cliff, and are formed by the erosion of soil as the stream collides with the river bank.
- **Point Bar** - an area of sediment deposition on the inside of a meander bend due to lower stream velocity

*A **meander**, in general, is a bend in a [sinuous](#) watercourse or river. A meander forms when moving water in a stream erodes the outer banks and widens its valley, and the inner part of the river has less energy and deposits silt.

A [stream](#) of any volume may assume a *meandering* course, alternately [eroding sediments](#) from the outside of a bend and depositing them on the inside. The result is a *snaking* pattern as the stream meanders back and forth across its down-valley axis.

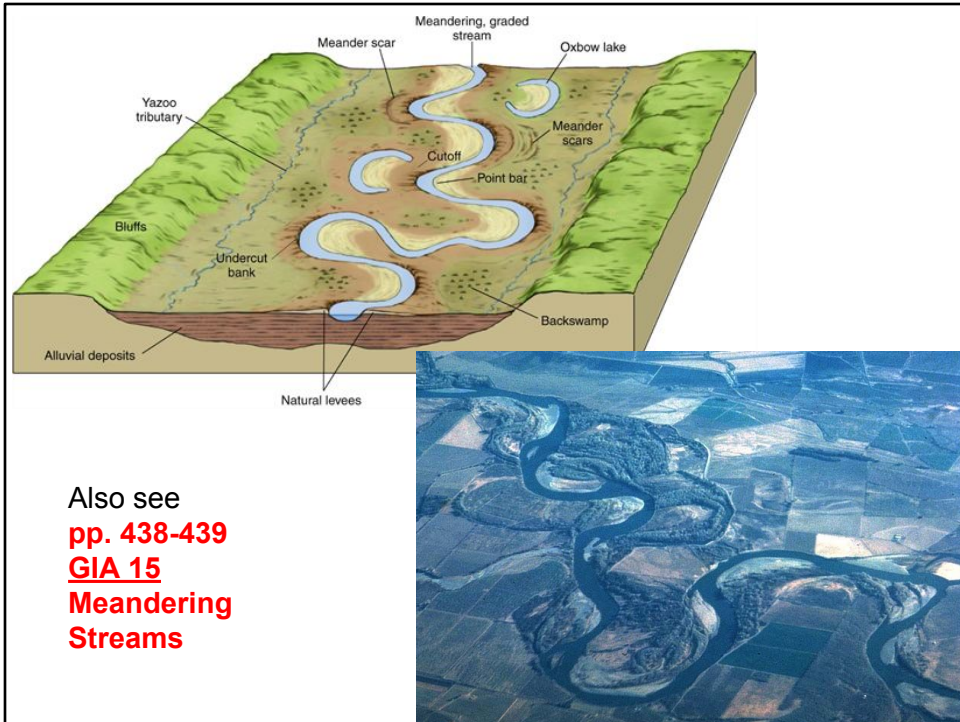
Meandering Channel Erosion - II

- **Cutoff** - formed when the river cuts through a narrow neck of a loop in a meander
- **Oxbow lake** - a horseshoe shaped body of water that forms when a wide meander from the main stem of a river is cut off, creating a free-standing body of water. *



*This landform is so named for its distinctive curved shape, resembling the bow pin of an oxbow.

An oxbow lake is known as a *billabong* in Australia



Graded stream

The tendency of natural systems is to move towards a state of equilibrium.....

- **Graded stream** - a stream in which the channel slope has adjusted, given the discharge and channel conditions, so that stream velocity is just enough to transport the sediment load

Tectonic Uplift

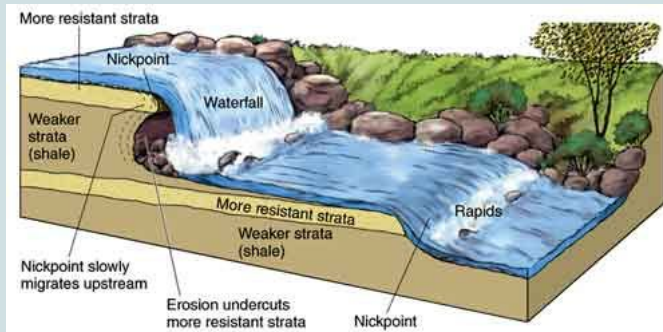
A graded stream can be affected by tectonic uplift that changes the elevation of the stream relative to its base level.

The lifting of the landscape would increase the stream gradient, thereby increasing erosional activity - degradation is rejuvenated.

Can lead to entrenched meanders - **Fig. 15.20**

Nickpoint

- **Nickpoint** - a part of a river channel where there is a sharp change in channel slope, such as a waterfall or lake. **Fig. 15.21 b & 15.22**



Depositional Landforms

Alluvium - the unconsolidated clay, silt, sand, gravel, and mineral fragments deposited by running water

- When this loose alluvial material is deposited it creates landforms such as bars, floodplains, terraces, and deltas.

When this loose alluvial material is deposited or cemented into a [lithological](#) unit, or [lithified](#), it is called an **alluvial deposit**.^[3]

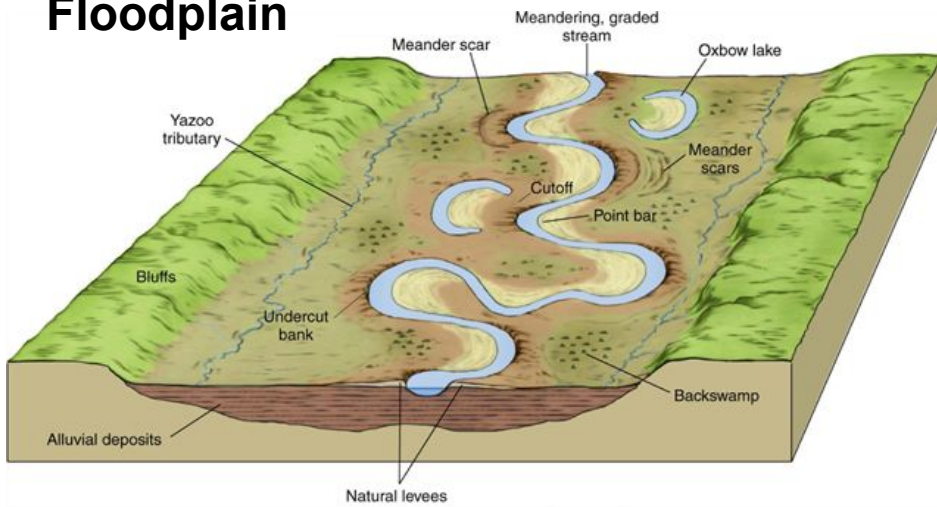
Floodplains

Floodplain - a flat, low-lying area adjacent to a river that stretches from the banks of its channel to the base of the enclosing valley walls and experiences recurrent flooding

- The area is inundated when the river overflows its channel during times of flooding.
- When the water recedes, it leaves behind *alluvial deposits* that mask the underlying rock.

Flood plains are made by a [meander](#) eroding sideways as it travels downstream. When a river breaks its banks and floods, it leaves behind layers of [alluvium](#) (silt). These gradually build up to create the floor of the flood plain. Floodplains generally contain unconsolidated sediments, often extending below the bed of the stream.

Floodplain



Focus on **alluvial deposits**, **Yazoo stream tributary**, and **natural levees**.....

Yazoo Stream / Natural Levee

- **Yazoo stream** - flows parallel to the main river in a floodplain, but are blocked from joining it by natural levees
- **Natural levee** - a long, low ridge that forms on both sides of a stream in a developed floodplain - a depositional product of river flooding

Alluvial Terrace

Level areas that appear as topographic steps above a stream, created by a stream as it scours with renewed downcutting into its floodplain



Alluvial fan

Alluvial fan - a fan- or cone-shaped deposit of fluvial sediment crossed and built up by streams.

- Typically found in arid and semiarid climates where canyon draining from mountainous terrain emerges out onto a flatter plain.
- Stream velocity decreases and sediment is deposited over and over again.



Well developed alluvial fans also can be a major source of groundwater. Some cities - San Bernadino, for example - are built on alluvial fans and extract their municipal water supplies from them

Bajada

Bajada - consists of a series of coalescing alluvial fans along a mountain front.



This bajada lies on the west side of Death Valley, CA

Playa

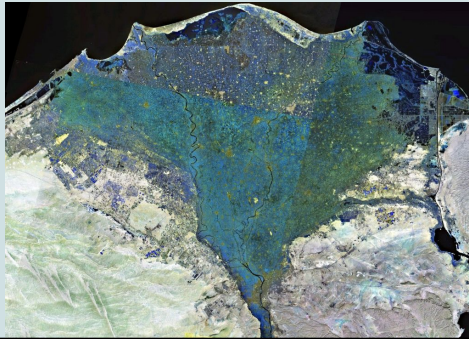
- **Playa** - as water evaporates from a temporary shallow lake left in a desert, a salty crust may be left behind on the desert floor



A **dry lake** is either a basin or depression that formerly contained a standing surface water body, which disappeared when evaporation processes exceeded recharge.

River Deltas

Delta - a landform that forms from deposition of sediment carried by a river as the flow leaves its mouth and enters slower-moving or standing water *



*This occurs where a river enters an [ocean](#), [sea](#), [estuary](#), [lake](#), [reservoir](#), or (more rarely) another river that cannot transport away the supplied sediment.

A delta is named for its characteristic triangular shape, after the Greek letter delta

Each flood deposits a new layer of alluvium over portions of the delta, extending it outward.

Fig. 15.27 - Ganges and Brahmaputra Rivers combined delta complex - largest in the world

Fig. 15.29 - Mississippi River Delta

Estuary

Estuary - a partially enclosed coastal body of brackish water with one or more fresh-water rivers flowing into it - has a free connection to the open sea.



Estuaries form a transition zone between river environments and maritime environments. They are subject both to marine influences—such as [tides](#), waves, and the influx of saline water—and to riverine influences—such as flows of fresh water and sediment. The inflows of both sea water and fresh water provide high levels of nutrients both in the water column and in sediment, making estuaries among the most productive natural habitats in the world.

Flood

Flood - a high water flow that passes over the natural bank along any portion of a stream or river

Human Management

- Flood probability
- Floodplain management



Flooding may occur as an overflow of water from water bodies, such as a [river](#), [lake](#), or ocean, in which the water overtops or breaks [levees](#), resulting in some of that water escaping its usual boundaries,^[3] or it may occur due to an accumulation of rainwater on saturated ground in an areal flood. While the size of a lake or other body of water will vary with seasonal changes in [precipitation](#) and snow melt, these changes in size are unlikely to be considered significant unless they flood [property](#) or drown [domestic animals](#).

Artificial Levee

Artificial levees -
earthen embankments,
often built on top of
natural levees

Fig. 15.30 & 15.31 & 15.32

<http://www.nad.usace.army.mil/portals/40/siteimages/NACCS/07.gif>

