Summary

Streams and Drainage Systems

- Streams are part of the hydrologic cycle and the chief means by which water returns from the land to the sea. They help shape the Earth's surface and transport sediment to the oceans.
- A stream's long profile decreases in gradient downstream.
- The discharge of a stream at any place along its course is equal to the product of its cross-sectional area and its average velocity. When a stream deepens because of an increase in discharge, its velocity also increases.
- As discharge increases downstream, stream width and depth increase, and velocity increases slightly.
- Streams experiencing major floods are capable of transporting large loads and moving large boulders. Exceptional floods can do a great deal of geologic work, but they have a low recurrence interval.
- World sea level constitutes the base level for most stream systems. A local base level, such as a lake, may temporarily halt downward erosion upstream.

- Straight channels are rare. Meandering channels form where gradients are low and the load is fine-grained. Braided patterns develop in streams with highly variable discharge and a large load to transport.
- Stream load is the sum of bed load, suspended load, and dissolved load. Bed load is usually a small fraction of the total load of a stream. Most suspended load is derived from erosion of fine-grained regolith or from stream banks.
- Streams that receive large contributions of underground water commonly have higher dissolved loads than those deriving their discharge principally from surface runoff.
- Sediment size decreases downstream because of sorting and abrasion of particles. The composition of a stream's load changes downstream as sediments of different compositions are introduced.
- Sediment yield is influenced by rock type and structure, climate, and topography. The greatest sediment yields are recorded in mountainous terrain with steep slopes and abundant runoff, and in small basins that are transitional from grassland to desert conditions. In moist climates, vegetation anchors the surface, thereby inhibiting erosion.
- Water that moves fast has higher energy and can transport a greater volume of sediment (carrying capacity) and larger particles (competence) than slow moving water with less energy.

- During floods, streams overflow their banks and construct natural levees, which grade laterally into silt and clay deposited on the floodplain. Terraces result from the abandonment of a floodplain as a stream erodes downward.
- Alluvial fans are constructed where a stream experiences a sudden decrease in gradient. The area of a fan is closely related to the size of the area upstream that supplies sediment to the fan.
- A delta forms where a stream enters a body of standing water and loses its ability to transport sediment. The shape of a delta reflects the balance between sedimentation and erosion along the shore.
- A drainage basin encompasses the area supplying water to the stream system that drains the basin. Its area is related to the stream's length and annual discharge.
- Stream systems possess an inherent orderliness, with the number of stream segments increasing with decreasing stream order.
- Drainage patterns are related to underlying rock type and structure, and often can reveal information about a stream's history.

Organizing principle

- Potential energy to kinetic energy
- Geometry
- Dynamics
- Deposition
 - Aggradation/Degradation

Geometry of Streams

- Stream Channels have many degrees of Freedom
- Cross-sectional shape
 - width/depth from 1 to >>1
- Long Profile is hyperbola
 - gradient: vertical drop divided by horizontal distance
- Velocity is maximum usually near midchannel at surface





Channel Patterns

- Meanders: common with:
 - Fine grained sediments
 - "Gentle" gradients
- Braided Channels:
 - Variable discharge
 - Easily eroded banks















Streamflow Dynamics

- Balanced condition of:
 - channel dimension
 - gradient
 - average velocity
 - discharge
 - Load
- Q = w * d * v
 - discharge = width x depth x velocity
- Vary load and discharge:
 - continuous adjustment to shape and gradient

- Change from headwaters to mouth:
 - discharge increases
 - width and depth increase
 - velocity increases
 - gradient decreases



Floods

Flood frequency

maximum discharge vs log(recurrence time)





Catastrophic Floods

- During the last glaciation the continental ice sheet covering western Canada created a huge lake in the vicinity of Missoula, Montana.
- The glacier-blocked lake contained between 2000 and 2500 km³ of water when it was filled and remained in existence only as long as the ice dam was stable.







Base Level

- The limiting level below which a stream cannot erode the land is called the **base level** of the stream.
- The base level for most streams is global sea level.



Stream Load

- Annual Worldwide Load
 - 18 billion tons of rock debris (82%)
 - 4 billion tons of dissolved material (18%)
- Suspended load: Fine grained
- Bed load: moves along stream bed
- Dissolved load
- "Competence" and "Carrying Capacity"





Suspended Load

- fine particles of silt and clay moving in suspension.
- particles remain in suspension in turbulent waters.
- They settle only where velocity decreases
 - in a lake or in the sea.





Downstream Changes in Particle Size

- Decreases in coarseness downstream
- Coarse bed load reduced in size by abrasion
 - no coarser than sand at ocean

Sediment Yield

- function of:
 - Rock type and structure.
 - Local climate.
 - Relief and slope
- In temperate eastern North America and Western Europe, vegetation cover is more or less continuous and erosion rates are low.





Depositional Features

- Floodplains
 - deposits from floods
 - natural levees
 - zoning problems
- Terraces
 - abandoned floodplains, now incised by a stream
- Alluvial fans
 - fan shaped deposit where stream leaves a steep mountain region
- Deltas
 - stream enters lake or sea
 - can be massive















- drainage basin: the total area that contributes water to the stream
- **Divide**: The line that separates adjacent drainage basins
- The arrangement and dimensions of streams in a drainage basin tend to be orderly.
- The smallest segments lack tributaries and are classified as first-order streams









Centripetal Streams converge toward a central depression, such as a volcanic crater or caldera, a structural basin, a breached dome, or a basin created by dissolution of carbonate rock.

Parallel

Radial

Trellised

Annular

Tampering with the Nile

- Ninety eight percent of the Nile's load is suspended sediment.
- Prior to construction of the Aswan Dam, an average of 125 million metric tons of sediment passed downstream each year.
 - The dam reduced this value to only 2.5 million metric tons.
 - Nearly 98 percent of the suspended sediment is now deposited in the reservoir behind the dam.

- Under natural conditions this sediment was carried downstream by floodwater, where much of it was deposited over the floodplain and delta, thus adding to the rich agricultural soils at a rate of 6 to 15 cm/century.
- Because the annual discharge of sediment has now been cut off, the coast has become increasingly vulnerable to erosion.

