Topic 8

Fluvial Processes and Landforms

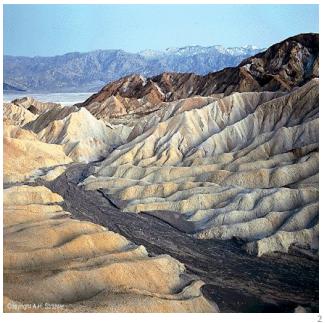
Drainage Basins, Density, and Patterns
Streamflow Characteristics
Fluvial Erosion, Transport, and Deposition
Channel Form and Floodplains
Rating and Flood Frequency Curves
Stream Hydrographs

KEY LEARNING CONCEPTS

Chapter 15

Fluvial Processes

- Most significant agent of landscape denudation
- Processes that erode, transport, and deposit material as a result of running water are referred to as _____
- Material deposited as result of fluvial processes called _____



Drainage Basins

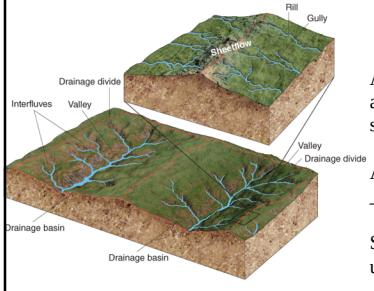
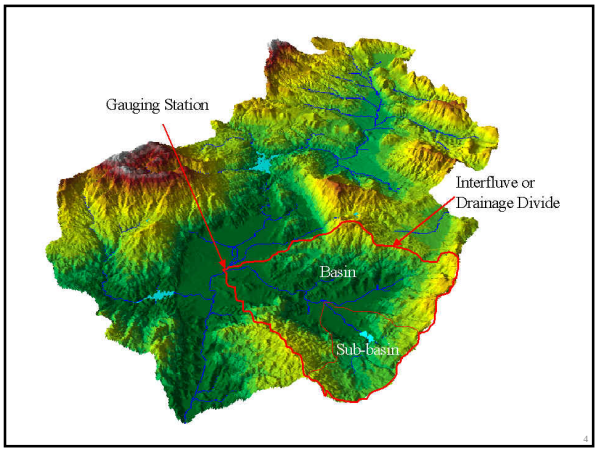


FIGURE 14.3 A drainage basin. A drainage divide separates the drainage basin and its watershed from other basins.

Area that contributes runoff and groundwater flow to a stream

Also called a _____ or _____

Separated by ridges or upland areas called _____ or _____



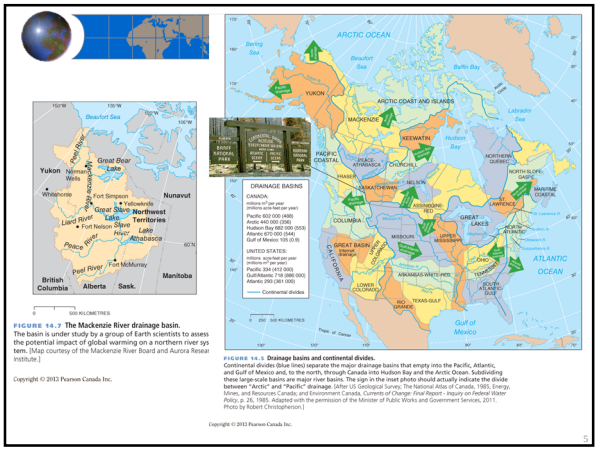
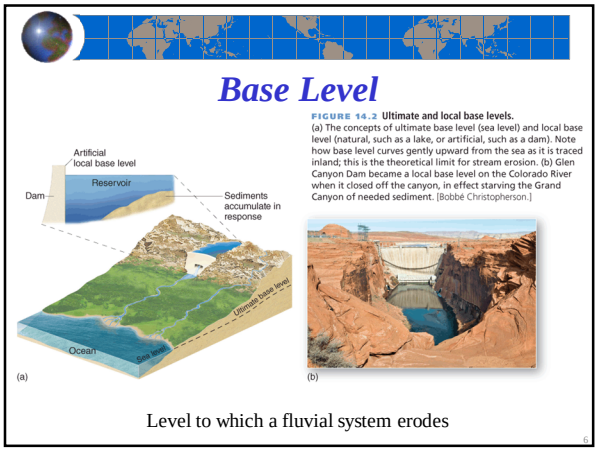


FIGURE 14.7 The Mackenzie River drainage basin. The basin is under study by a group of Earth scientists to assess the potential impact of global warming on a northern river system. [Map courtesy of the Mackenzie River Board and Aurora Research Institute.]

FIGURE 14.1 Drainage basins and continental divides. Continental divides (blue lines) separate the major drainage basins that empty into the Pacific, Atlantic, and Gulf of Mexico and, to the north, through Canada into Hudson Bay and the Arctic Ocean. Subdividing these large-scale basins are major river basins. The sign in the inset photo should actually indicate the divide between "Arctic" and "Pacific" drainage. [After US Geological Survey, The National Atlas of Canada, 1985, Energy, Mines, and Resources Canada; and Environment Canada, *Currents of Change: Final Report - Inquiry on Federal Water Policy*, p. 26, 1985. Adapted with the permission of the Minister of Public Works and Government Services, 2011. Photo by Robert Christopherson.]



Base Level

FIGURE 14.2 Ultimate and local base levels. (a) The concepts of ultimate base level (sea level) and local base level (natural, such as a lake, or artificial, such as a dam). Note how base level curves gently upward from the sea as it is traced inland; this is the theoretical limit for stream erosion. (b) Glen Canyon Dam became a local base level on the Colorado River when it closed off the canyon, in effect starving the Grand Canyon of needed sediment. [Bobbé Christopherson.]

Level to which a fluvial system erodes

Where do streams begin?

- A stream or (network of streams) initially develops as:
- _____ **flow** is concentrated by converging topography
- increased depth results in _____ **flow**
- causing entrainment of particles and incision
- micro-channels develop into **rills,** then **gullies,** and finally streams
- streams erode _____ either randomly or controlled by rock/sed structure

Drainage Density and Patterns

FIGURE CT 14.2.1 Two drainage patterns dominate this scene from central Montana, in response to local relief and rock structure. [Bobbé Christopherson.]

Drainage density is a measure of how efficiently a drainage basin collects and transports water

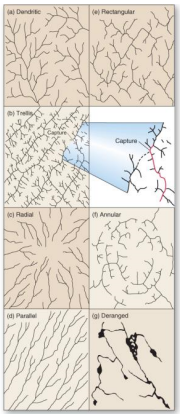
D_d = stream length / basin area

Ranges from 1.5 to 6 km/km^2

Common Drainage Patterns

Spatial organization or arrangement of stream segments in a basin

- Function of:
- slope direction
- surface and subsurface geology
  - folding, faulting, jointing
- anthropogenic influences



Deranged Drainage in Quebec

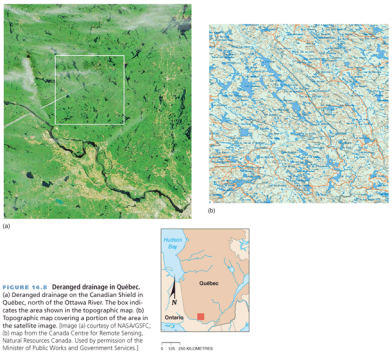


FIGURE 10.8 Derangrd drainage in Québec. (a) Deranged drainage on the Canadian Shield in Québec, north of the Ottawa River. The box indicates the area shown in the topographic map. (b) Topographic map covering a portion of the area in the satellite image. [Image (a) courtesy of NASA/GSFC; (b) map from the Canada Centre for Remote Sensing, Natural Resources Canada. Used by permission of the Minister of Public Works and Government Services.]

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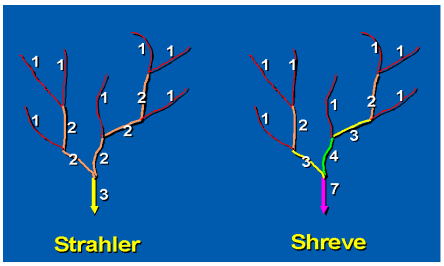
Stream Order



A way of quantifying and comparing drainage basins
- increases with basin area and segment length
- decreases with number of segments and gradient

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Streamflow Characteristics

- **Discharge** how much water (volume) passes by over a given period of time

Q = A x V OR (W x D) x V (ft^3/s or m^3/s)

- Varies significantly since velocity and area are highly variable
- Area changes as the water level rises and falls
- Velocity is a function of slope; generally decreases downstream

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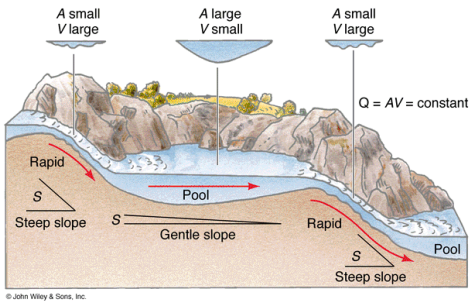
Streamflow Characteristics



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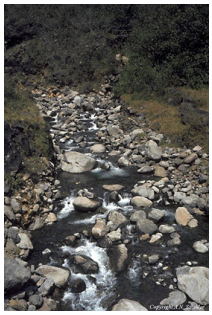
Fluvial Erosion

- Three processes:

1. **Corrosion**
2. **Abrasion**
3. **Hydraulic action**



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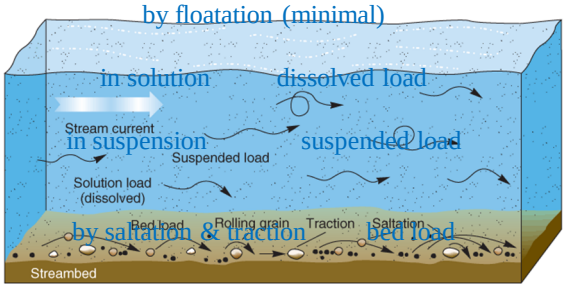
Stream Transportation



Streams transport <u>load</u> in FOUR different ways

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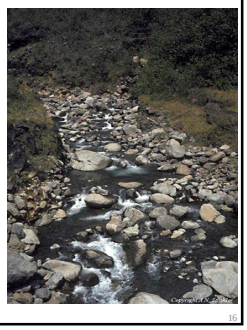
Competence and Capacity

- **Competence**
  - largest particles that can be transported
- **Capacity**
  - total amount of material (load) transported



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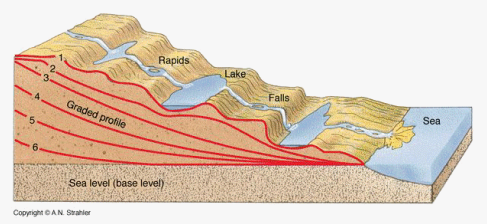
Graded Streams



Equilibrium between erosion, transport, and deposition

Gradient is adjusted to transport the load of the stream

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Nickpoints

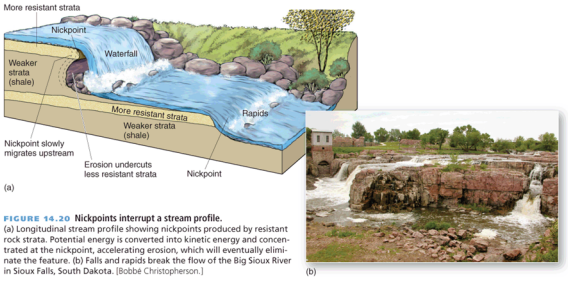

FIGURE 14.20 **Nickpoints interrupt a stream profile.** (a) Longitudinal stream profile showing nickpoints produced by resistant rock strata. Potential energy is converted into kinetic energy and concentrated at the nickpoint, accelerating erosion, which will eventually eliminate the feature. (b) Falls and rapids break the flow of the Big Sioux River in Sioux Falls, South Dakota. [Bobbé Christopherson.]

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Flow Characteristics

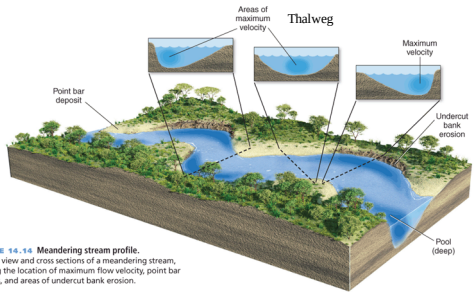

FIGURE 14.14 Meandering stream profile.
Oblique view and cross sections of a meandering stream, showing the location of maximum flow velocity, point bar deposits, and areas of undercut bank erosion.

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Channel Morphology: Meandering Streams

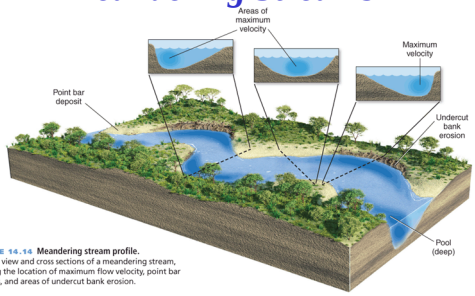

FIGURE 14.14 Meandering stream profile.
Oblique view and cross sections of a meandering stream, showing the location of maximum flow velocity, point bar deposits, and areas of undercut bank erosion.

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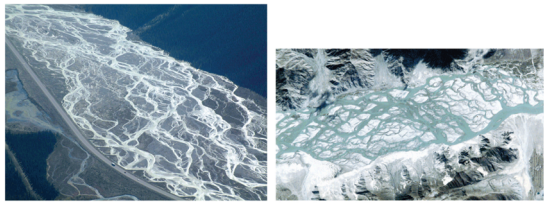
Channel Morphology: Braided Streams



(a) (b)

FIGURE 14.13 A braided stream.
(a) Sunwapta River, along the Icefields Parkway, southern Jasper National Park, Alberta. (b) A 15-km stretch along the braided Brahmaputra River channel some 35 km south of Lhasa, Tibet, in a narrow valley south of the Tibetan Plateau. These streams reflect excessive sediment load associated with glacial meltwaters filled with fine sediments, or "glacial flour." [Photos (a) Courtesy of the Geological Survey of Canada. Photo 2002-597 by Réjean Couture and Gianluca Bianchi Fasani. Reproduced with the permission of Natural Resources Canada. © 2012. (b) October 13, 2001, International Space Station astronaut, courtesy of Earth Science and Image Analysis Lab, JSC/NASA.]

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Evolution of a Meandering Stream

FIGURE 14.15 **Meandering stream development.** (a) Ikiliik River in Alaska. (b) Development of a river meander and an oxbow lake simplified in four stages. [(a) USGS.]

Stream Processes, Floodplains, and Oxbow Lake Formation

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Floodplains

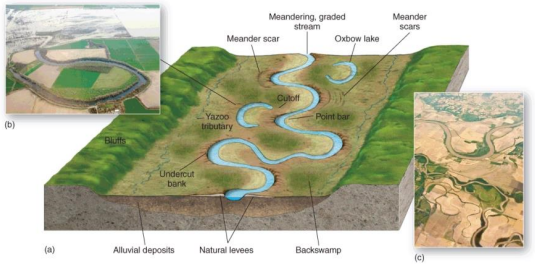

Figure 14.23

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Shifting Meanders

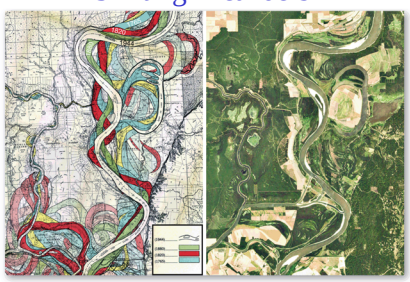

FIGURE 14.22 **The Mississippi River's shifting meanders through history.** The former river channels for 1765, 1820, 1880, and 1944 are noted for the portion of the river north of the Old River Cutoff. [Army Corps of Engineers, *Geological Investigation of the Alluvial Valley of the Lower Mississippi*, 1944; *Landsat*, NASA and UMD Global Land Cover Facility, http://glcf.umiacs.umd.edu/index.shtml.]

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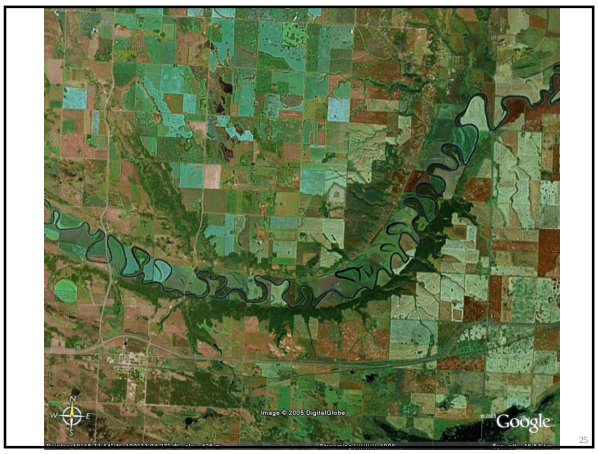
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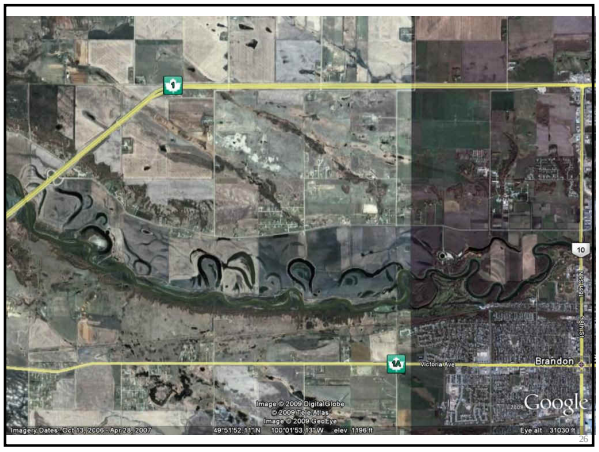
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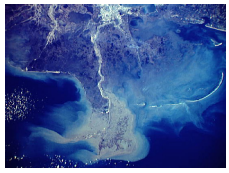
Alluvial Fans and Deltas

- Both produce fan shaped deposition features due to a sudden reduction in flow velocity as either:



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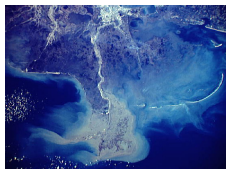
Alluvial Fans and Deltas

- Both produce fan shaped deposition features due to a sudden reduction in flow velocity as either:



a stream enters a larger body of water and forms a _____

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Alluvial Fans and Deltas

- Both produce fan shaped deposition features due to a sudden reduction in flow velocity as either:

a stream spills out into a valley where it forms an _____

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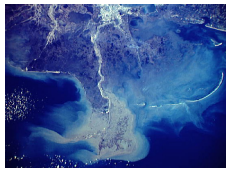
Alluvial Fans and Deltas

- Both may result in formation of distributaries
- Courser material deposited first, finer last



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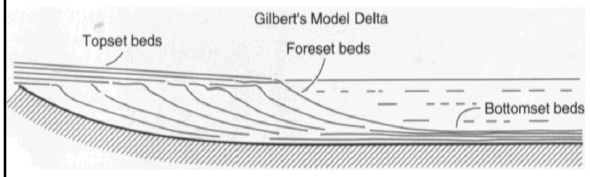
Alluvial Fans and Deltas



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Alluvial Fans and Deltas

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Stream Discharge Measurement

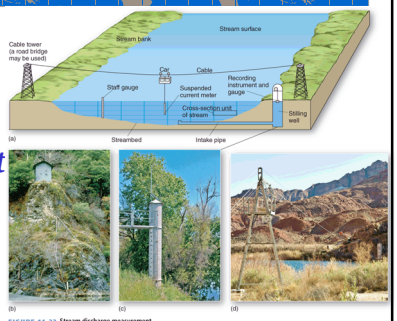

FIGURE 16.33 Stream discharge measurement. (a) A typical flow measurement installation may use a variety of devices. (b) An automated hydrographic station and (c) a stilling well sends telemetry to a satellite for collection by the USGS. (d) Lee's Ferry cable towers and cable from which current meters are lowered. [(b) California Department of Water Resources. (c) and (d) by Bobbé Christopherson.]

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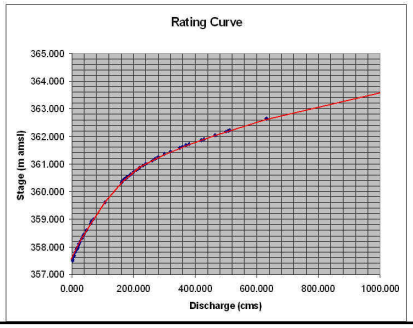
Discharge from Stage



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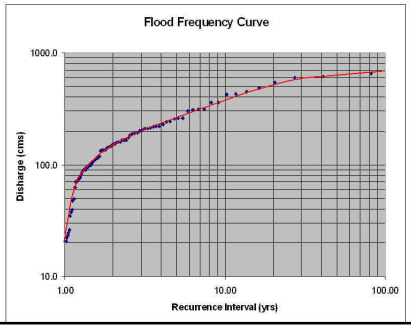
Recurrence Interval From Discharge



Stream Hydrographs

Graph of stream discharge over a specified period of time

Illustrates relationship between precipitation and stream flow

Base flow represents the groundwater contribution to stream flow

Area under curve represents runoff of precipitation

The "flashyness" or "peakedness" of hydrograph indicates response of stream to a precipitation event