EENS 111	Physical Geology
Tulane University	Prof. Stephen A. Nelson
Streams and Drainage Systems	

This page last updated on 02-Apr-2012

Streams

A ***stream*** is a body of water that carries rock particles and dissolved ions and flows down slope along a clearly defined path, called a ***channel***. Thus, streams may vary in width from a few centimeters to several tens of kilometers. Streams are important for several reasons:

- Streams carry most of the water that goes from the land to the sea, and thus are an important part of the water cycle.
- Streams carry billions of tons of sediment to lower elevations, and thus are one of the main transporting mediums in the production of sedimentary rocks.
- Streams carry dissolved ions, the products of chemical weathering, into the oceans and thus make the sea salty.
- Streams are a major part of the erosional process, working in conjunction with weathering and mass wasting. Much of the surface landscape is controlled by stream erosion, evident to anyone looking out of an airplane window.
- Streams are a major source of water, waste disposal, and transportation for the world's human population. Most population centers are located next to streams.
- When stream channels fill with water the excess flows onto the the land as a flood. Floods are a common natural disaster.

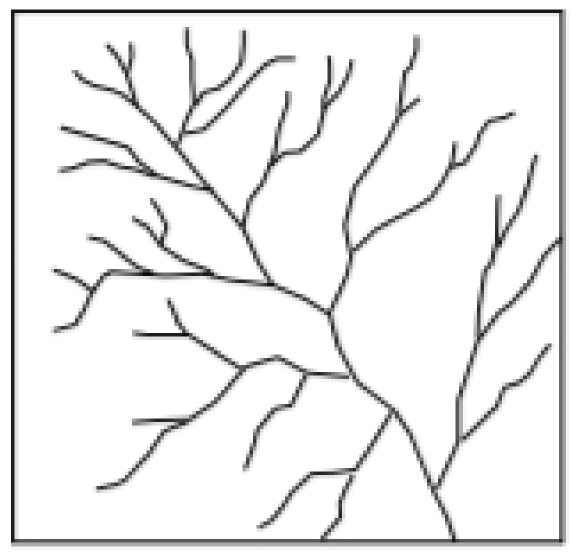
The objectives for this discussion are as follows:

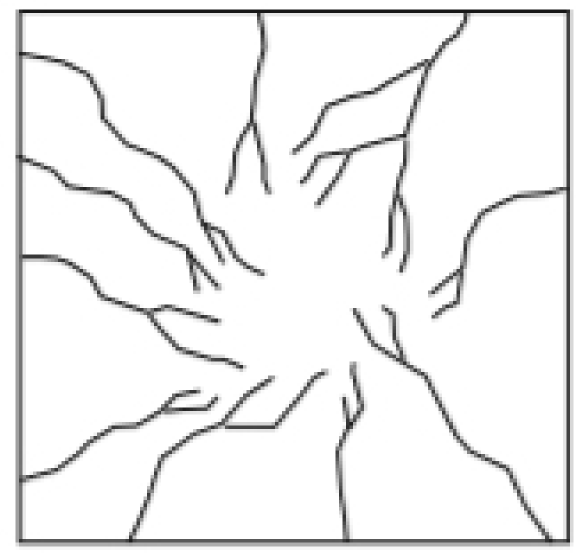
1. How do drainage systems develop and what do they tell us about the geology of an area?
2. How do stream systems operate?
3. How do streams erode the landscape?
4. What kinds of depositional features result from streams?
5. How do drainage systems evolve?
6. What causes flooding and how can we reduce the damage from floods?

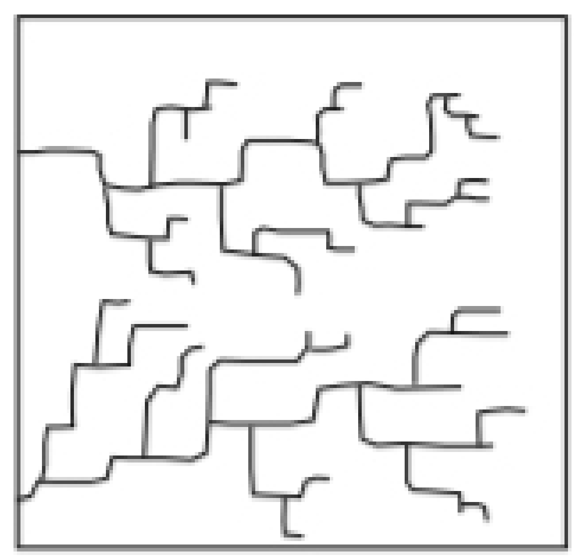
Drainage Systems

Development of Streams - Steamflow begins when water is added to the surface from rainfall, melting snow,and groundwater. Drainage systems develop in such a way as to efficiently move water off the land. Streamflow begins as moving sheetwash which is a thin surface layer of water. The water moves down the steepest slope and starts to erode the surface by creating small rill channels. As the rills coalesce, deepen, and downcut into channels larger channels form. Rapid erosion lengthens the channel upslope in a process called ***headward erosion***. Over time, nearby channels merge with smaller tributaries joining a larger trunk stream. (See figure 17.3 in your text). The linked channels become what is known as a ***drainage network***. With continued erosion of the channels, drainage networks change over time.

Drainage Patterns - Drainages tend to develop along zones where rock type and structure are most easily eroded. Thus various types of drainage patterns develop in a region and these drainage patterns reflect the structure of the rock.


Dendritic Drainage


Radial Drainage


Rectangular Drainage

- Dendritic drainage patterns are most common. They develop on a land surface where the underlying rock is of uniform resistance to erosion.
- Radial drainage patterns develop surrounding areas of high topography where elevation drops from a central high area to surrounding low areas.
- Rectangular drainage patterns develop where linear zones of weakness, such as joints or faults cause the streams to cut down along the weak areas in the rock.
- Trellis drainage patterns develop where registrant rocks break up the landscape (see figure 17.4a in your textbook).

Drainage Basins - Each stream in a drainage system drains a certain area, called a drainage basin (also called a catchment or a watershed). In a single drainage basin, all water falling in the basin drains into the same stream. A ***drainage divide*** separates each drainage basin from other drainage basins. Drainage basins can range in size from a few km^2, for small streams, to extremely large areas, such as the Mississippi River drainage basin which covers about 40% of the contiguous United States (see figure 17.5c in your text).

Continental Divides - Continents can be divided into large drainage basins that empty into different ocean basins. For example: North America can be divided into several basins west of the Rocky Mountains that empty into the Pacific Ocean. Streams in the northern part of North America empty into the Arctic Ocean, and streams East of the Rocky Mountains empty into the

Atlantic Ocean or Gulf of Mexico. Lines separating these major drainage basins are termed Continental Divides. Such divides usually run along high mountain crests that formed recently enough that they have not been eroded. Thus major continental divides and the drainage patterns in the major basins reflect the recent geologic history of the continents.

Permanent Streams - Streams that flow all year are called permanent streams. Their surface is at or below the water table. They occur in humid or temperate climates where there is sufficient rainfall and low evaporation rates. Water levels rise and fall with the seasons, depending on the discharge.

Ephemeral Streams - Streams that only occasionally have water flowing are called ephemeral streams or dry washes. They are above the water table and occur in dry climates with low amounts of rainfall and high evaporation rates. They flow mostly during rare flash floods.

Geometry and Dynamics of Stream Channels

Discharge

The stream channel is the conduit for water being carried by the stream. The stream can continually adjust its channel shape and path as the amount of water passing through the channel changes. The volume of water passing any point on a stream is called the ***discharge***. Discharge is measured in units of volume/time (m^3/sec or ft^3/sec).

$$Q = A \times V$$

Discharge (m^3/sec) = Cross-sectional Area [width x average depth] (m^2) x Average Velocity (m/sec).

As the amount of water in a stream increases, the stream must adjust its velocity and cross sectional area in order to form a balance. ***Discharge increases as more water is added through rainfall, tributary streams, or from groundwater seeping into the stream***. As discharge increases, generally width, depth, and velocity of the stream also increase.

Velocity

A stream's velocity depends on position in the stream channel, irregularities in the stream channel caused by resistant rock, and stream gradient. Friction slows water along channel edges. Friction is greater in wider, shallower streams and less in narrower, deeper streams.

In straight channels, highest velocity is in the center. In curved channels,The maximum velocity traces the outside curve where the channel is preferentially scoured and deepened. On the inside of the curve were the velocity is lower, deposition of sediment occurs. The deepest part of the channel is called the thalweg, which meanders with the curve the of the stream. Flow around curves follows a spiral path.

Stream flow can be either laminar, in which all water molecules travel along similar parallel paths, or turbulent, in which individual particles take irregular paths. Stream flow is characteristically turbulent. This is chaotic and erratic, with abundant mixing, swirling eddies, and sometimes high velocity. Turbulence is caused by flow obstructions and shear in the water. Turbulent eddies scour the channel bed, and can keep sediment in suspension longer