Chapter 13 and 14 Notes: Surface Water and Groundwater

I. The Hydrologic or Water Cycle

Water of the Earth = 100%

97% of the world's water salt

3% Freshwater = 2% Frozen (polar/glaciers)

1% available freshwater

.97% groundwater

.03% surface water

Precipitation

2 paths to follow

Surface Runoff

Groundwater

II. Surface Runoff

A. Surface runoff occurs when water flows across the surface of the ground from high elevations to lower elevations.

1. There are 5 factors that affect the rate of surface runoff as well as the amount of erosion.

   a. Climate: this is the most important factor in determining surface runoff. The greater the precipitation, the greater the amount of erosion by running water.

   b. Slope: the steeper the slope of the land, the faster the surface runoff occurs and the greater the erosion.

   c. Permeability: the measurement of the flow of water into the ground. Coffee filter/ Collendar

   If water flows very quickly into the ground, it will not be able to flow across the surface which causes erosion. Porosity/Water storage

   d. Volume: the greater the amount of liquid flowing across the surface, the greater the amount of erosion.

   e. Velocity: the faster the flow of water, the greater the rate and amount of erosion.

Competence: the size of particle a stream can move / carry (controlled by Velocity)

Capacity: the total amount of sediment that a stream can move / carry (controlled by Volume / Discharge)
B. Drainage Basins—when surface runoff flows from high elevations to lower elevations, it forms drainage basins.

1. Drainage basins are defined as a definite system of drainage channels carrying water out of a given area.

2. Every drainage basin has at least one river system draining it.

3. Drainage basins have several parts. A typical drainage basin is diagramed below.

4. The entire US is often considered to be divided up into three main drainage basins, each containing thousands of smaller drainage basins. The Rocky Mountains act as the main divide for the two main basins. For this reason, the Rockies are sometimes referred to as the continental divide. In the east, the Appalachian Mountains are the divide for this part of the US.

   a. Locally, we live in the Cumberland Valley Drainage Basin. Divides can be small also.
5. **Drainage basins are classified according to their shape.** All drainage basins fit into 1 of 3 shapes. The shape of the drainage basin depends on the topography of the land, and the rock type in a given area.

- **a. Trellis:** this shape is found in ridge and valley regions such as those found in central Pennsylvania within the Appalachian Mountains. **Perry County**

  Trellis Drainage - Top Down View

- **b. Dendritic:** this shape is found in hilly regions. The local streams in Cumberland Valley form this type of pattern. The channels look like the branches of a tree.

  Dendritic Drainage - Top Down View

- **c. Radial:** This shape forms when water flows away from a common point in all directions. The channels look like the spokes of a wheel. This type of drainage is found on volcanoes like the one forming the islands of Hawaii.

  Radial Drainage - Top Down View

**C. Weathering by Running Water** - weathering by water occurs when sediment is formed by running water.

1. **Abrasion by Running Water** - A mechanical weathering process which occurs when sediment is picked up by the running water and is forced against the sides of the channel or against other rocks breaking off more sediment.

2. **Hydrolysis by Running Water** - A chemical weathering process where water dissolves the minerals out of the rock and wears it away. Water is the universal solvent and is able to dissolve many minerals. In Cumberland Valley, the landscape is greatly affected by hydration. (More on this later)

**D. Erosion by Running Water** - occurs when running water picks up sediment and transports it from one place to another location. This process is diagramed below.

- **Solution Load** - Material carried by the river in solution. The particles are too small to see with the unaided eye. Some minerals, especially mineral salts, can be easily dissolved in water.

- **Mud / Clay**

- **Muddy Water**

- **Suspended Load** - Tiny particles carried in the current and eddies of a stream or river. The size of these particles depends on the rate and volume of flow of a river.

- **Sand Pebbles**

- **Bedload** - Sediment rolls and bounces along the bottom in a process called saltation. The size of the sediment moved by the river depends on the rate and volume of flow of the river.
E. Deposition by Running Water- deposition by running depends on the stage of river development the volume of water and the rate of flow of the water.

1. Water deposits sediments in the same way that the wind deposits sediments.

2. Water deposited sediments are well sorted. The largest and heaviest sediments are deposited first until finally the smallest clay particles are deposited last.

F. The Aging of Rivers- Rivers go through an aging process made up of different stages.

1. Youth Stage- a young river is marked by the following features.
   
   a. The slope of the drainage basin is at the steepest point it will ever be.
   
   b. The river channel is V shaped, narrow, deep, and straight.
   
   c. The current flows the fastest rate of any other stage. Waterfalls and rapids are common.

   d. Erosion is greater than deposition. This leads to few landforms associated with this stage of river development.

Diagram A

2. Mature Stage- This stage is marked by the appearance of well developed erosional features and the beginning of depositional features. The characteristics of this stage are as follows:

   a. The slope of the drainage basin is decreasing due to erosion.

   b. The channel is becoming wider and more shallow.

   c. The following erosional features are well formed:

      1. Undercut Bank- banks that overhang the river channel because the river has eroded out underneath them.

   d. The following depositional features are well formed:

      1. Delta- sediments that accumulate when a river enters a large body of water

      2. Alluvial Fans- sediments that accumulate on dry land in the shape of a fan. Alluvial fans form when a river drains on to dry land or from water washed off a levee.

      3. Flood Plain- every river floods as a regular part of its life cycle. (100 year) When a river over flows its banks, it carries and deposits sediments. The area over which a river deposits sediments during its flood periods is its floodplain.

   Distributaries: streams in a delta that distribute sediment at the mouth of a river
Undercut Bank

Delta

Alluvial Fan
e. Meandering begins to occur.

1. Meandering is the movement of a river channel across its floodplain. Meandering is the result of both erosion and deposition. Meandering occurs in the following way:

- **Path of Fastest Water**
- **Path of Slower Water**

Deposition occurs on the inside of curves because the slower moving water stays to the inside of a bend in the river.

Erosion occurs on the outside of curves because faster moving water moves to the outside of the bend of a river.

2. The constant erosion of the outside of curves and deposition on the inside of curves causes a river to meander across its floodplain.

f. The following features are formed by both erosion and deposition during the mature stage.

1. **Levees** - a mound of material on each side of a floodplain or along the river channel. The mounds can be due to the river cutting into its own floodplain. Excess sediments are also deposited on the side of the channel during flooding periods.

2. **Meanders** - bends or curves in the river channel as explained earlier.

3. **Abandoned meanders or meander scars** - meanders where the water has since dried up in them after the river changed its course and abandoned the old channel.

4. **Oxbow Lake** - abandoned meanders which remain full of water.

5. **Islands** - a body of land that is surrounded on all sides by water. These can be the result of either erosion or deposition.
3. The Old Age Stage - this stage of river development has developed the following characteristics:

   a. The drainage basin has been eroded nearly to sea level.

   b. The channel is very wide, very shallow, and the current is slow.

   c. Deposition is greater than erosion.

   d. Deltas and other depositional features are well developed.

4. Death - when a river erodes its drainage basin to sea level it stops flowing and dies.

Chapter 14
II. Groundwater Runoff

A. Groundwater is water in the ground near the surface. Groundwater can change the landscape as it moves through the ground.

B. As groundwater seeps through the limestone in Cumberland Valley, it dissolves calcium carbonate, CaCO₃ of the rock making it hard - contains many minerals in it. Soft water, such as rain, contains few or no dissolved minerals.

C. Groundwater can travel through the ground because much of the bedrock is porous - has tiny holes in it that allows water to seep through. Plants use some of water that enters the soil while the rest filters down.

1. There are two main zones that groundwater occupies within the soil and rock.

   a. Zone of Aeration - the upper zone of groundwater where the pore spaces are filled partly with air and partly with water. The groundwater trickles down to lower zone from here.

   b. Zone of Saturation - the water eventually reaches a rock layer where the pore spaces in the rock are too small to allow water to pass through or the pore spaces are not connected. This rock layer is said to be impermeable. At this point the water stops moving down. It collects above this impermeable rock layer to form the water table.

   1. The water table basically follows the shape of the landscape. It dips below valleys and rises up underneath mountains.

   2. Where the water table breaks the surface, natural ponds, lakes, and rivers are found.

2. Water will sink into the ground until it reaches an impermeable layer of rock such as shale. When it reaches the impermeable layer the water may flow along it until it finds its way back to the surface forming a spring much like the Boiling Springs. The water may also find another permeable layer and sink deeper.

Aquifer = underground source of water
Aquiclude = stops the flow of water
3. The diameter of a sinkhole, or cave entrance is associated with:

- Diabase (Won't dissolve)
- Limestone (Will dissolve)

Limestone forms Children's Lake.

**Permeable Rock**

**Water Table**

**Aquifer**

**Boiling Springs Lake**

**Artesian Spring**

**Impermeable Rock** Basalt type rock (Igneous) = Diabase

**Groundwater** - The movement of water through the ground as part of the hydrologic cycle.

**Aquifer** - A region of permeable material that is water soaked.

**Impermeable Rock** - Does not allow water to flow through it.

**Water Table** - The upper most level of water in an aquifer.

**Spring** - A natural flow of water from the ground.

**Artesian Spring** - A spring fed by ground water, with the water flows freely without pumping.

**Cave** - an opening beneath the surface of the earth formed by groundwater erosion. Caves often form in limestone because it is water soluble.
**Diagram A**

**Youthful Stage**

- High stream gradient (generally greater than 10 ft/m).
- Narrow V-shaped stream valley.
- Little or no floodplain developed.
- Low if any, meanders.
- Vertical erosion dominant.

**Mature Stage**

- Moderate gradient (generally less than 10 ft/m, possibly as low as 1 or 2 ft/m).
- Wide, flat-bottomed stream valley with well-defined valley walls.
- Floodplain well developed.
- Meanders common; individual meander loops may occupy the full width of the stream valley.
- Transportation and lateral erosion dominant.
- Very low gradient (generally less than 2 ft/m, often less than 1 ft/m).
- Extremely wide valley, perhaps with indistinct valley walls.
- Extreme floodplain, with features such as natural levees.
- Extreme meandering; a distinct meander belt may be developed.
- Deposition dominant.

**Rejuvenated Stage**

Tectonic uplift of a region or lowering of base level may cause the stream gradient to be steepened and an old age or mature stream may be thus rejuvenated. The characteristic feature to look for is the presence of entrenched meanders which show that the stream once achieved a low gradient, but that the gradient has since been steepened, reinitiating downcutting. Increased rainfall due to climate change may also initiate rejuvenation.

**Diagram B**

**Mature Stage**

- Regional dissection very incomplete, with broad uplands unaffected by erosion.
- Poorly developed drainage system.
- Few streams, mostly in the youthful stage, separated by broad, uneroded interstream divides.
- Local relief due to erosion is generally low.

**Middle Stage**

- Regional dissection advanced, few areas unaffected by erosion.
- Well-developed drainage system, with maximum number of tributaries.
- Many streams, mostly in the youthful stage, separated by narrow, rounded interstream divides.
- Master streams mature or old age.
- Local relief due to erosion is at its maximum development.

**Late Stage**

- Master stream drainage dominates the region, with the master streams in the old age stage.
- Fewer streams than in middle stage due to the merger of stream valleys as interstream divides are completely destroyed by erosion.
- Remaining interstream divides are broad and low.
- Local relief due to erosion is once again low, except where monadnocks (eroded remnants) remain.

**Diagram C**

**Old Age**

**Diagram D**

**Land uplifted**

**Rejuvenated Stage**