GROUNDWATER HYDROLOGY

- 1. Hydrologic Cycle and Water Distribution
- 2. Soil Horizons
- 3. Aquifers
- 4. Soil Texture
- 5. Porosity and Density
- 6. Saturation and Water Content
- 7. Hydraulic Head



1. Hydrologic Cycle and Water Distribution

All the rivers run into the sea, yet the sea is not full; unto the place from whence the rivers come, thither they return again"

Hydrogeology: What is it?

- Hydrologic cycle circulation of water in the environment
- Hydrogeology examines the relationships of geologic materials and flowing water



Global Hydrologic Cycle



Schematic representation of the hydrologic cycle.

Basin Hydrologic Cycle



FIGURE 1.4.1 Schematic view of the hydrologic cycle

WATER CYCLE

 Water is the basic element of nature. It covers 70% of the earth's surface. It provides life, eases out heat, drains harmful substances and mediates many day-to-day works. • Water needs to be replenished, purified and circulated again and again so that it can perform its functions. Nature does this job through a process called the water cycle. Also known as hydrologic cycle, the water cycle is a phenomenon where water moves through the three phases (gas, liquid and solid) over the four spheres (atmosphere, lithosphere, hydrosphere and biosphere) and completes a full cycle.

The water cycle has many effects:

- it regulates the temperature of the surroundings.
- It changes weather and creates rain.
- It helps in conversion of rocks to soil.
- It circulates important minerals through the spheres.

• It also creates the many geographical features present on earth like the ice caps of mountains, icebergs, the rivers and the valleys, lakes, and more.

• Hence it is quite important to understand and learn the processes of the water cycle.

Step 1: Evaporation

• The water cycle starts with evaporation. It is a process where water at the surface turns into water vapors. Water absorbs heat energy from the sun and turns into vapors. Water bodies like the oceans, the seas, the lakes and the river bodies are the main source of evaporation. Through evaporation, water moves from hydrosphere to atmosphere. As water evaporates it reduces the temperature of the bodies.

Step 2: Condensation

• As water vaporizes into water vapor, it rises up in the atmosphere. At high altitudes the water vapors changes into very tiny particles of ice /water droplets because the temperature at high altitudes is low. This process is called condensation. These particles come close together and form clouds and fogs in the sky.

Step 3: Sublimation

- Apart from evaporation, sublimation also contributes to water vapors in the air. Sublimation is a process where ice directly converts into water vapors without converting into liquid water.
- This phenomenon accelerates when the temperature is high or pressure is high. The main sources of water from sublimation are the ice sheets of the North Pole and the South Pole and the ice caps on the mountains. Sublimation is a rather slower process than evaporation.

Step 4: Precipitation

- The clouds (condensed water vapors) then pour down as precipitation due to wind or temperature change. This occurs because the water droplets combine to make bigger droplets. Also when the air cannot hold any more water, it precipitates.
- At high altitudes the temperature is low and hence the droplets lose their heat energy. These water droplets fall down as rain. If the temperature is very low (below 0 degrees), the water droplets fall as snow. Water also precipices in the form of drizzle, sleet and hail. Hence water enters lithosphere.

Step 5: Transpiration

• As water precipitates, some of it is absorbed by the soil. This water enters into the process of transpiration. Transpiration is a process similar to evaporation where liquid water is turned into water vapor by the plants. The roots of the plants absorb the water and push it toward leaves where it is used for photosynthesis. The extra water is moved out of leaves through stomata (very tiny openings on leaves) as water vapor. Thus water enters the biosphere and exits into gaseous phase.

Step 6: Runoff

- As the water pours down (in whatever form), it leads to runoff. Runoff is the process where water runs over the surface of earth.
- When the snow melts into water it also leads to runoff. As water runs over the ground it displaces the top soil with it and moves the minerals along with the stream.
- This runoff combines to form channels and then rivers and ends up into lakes, seas and oceans. Here the water enters hydrosphere.

Step 7: Infiltration

• Some of the water that precipitates does not runoff into the rivers and is absorbed by the plants or gets evaporated. It moves deep into the soil. This is called infiltration.

• The water seeps down and increases the level of ground water table. It is called pure water and is drinkable. The infiltration is measured as inches of water-soaked by the soil per hour.

Basin Hydrologic Cycle – GW/SW Interaction



Artesian Zone of Edwards Aquifer



 The artesian zone is a complex system of interconnected voids varying from microscopic pores to open caverns

 Located between two relatively less permeable layers that confine and pressurize the system

• Underlies 2100 square miles of land

Global Hydrologic Cycle – Schematic



Basin Hydrologic Cycle – Schematic



Basin Hydrologic Cycle – Quantitative Representation



2. Soil Horizons





Figure 15.1

3. Aquifers

Aquifers

Definition: A geological unit which can store and supply significant quantities of water.

Principal aquifersby rock type:UnconsolidatedSandstoneSandstone and CarbonateSemiconsolidatedCarbonate-rockVolcanicOther rocks

Occurrence of Ground Water



- Ground water occurs when water recharges the subsurface through cracks and pores in soil and rock
- Shallow water level is called the water table

Recharge

Natural

- Precipitation
- Melting snow
- Infiltration by streams and lakes

Artificial

- Recharge wells
- Water spread over land in pits, furrows, ditches
- Small dams in stream channels to detain and deflect water



Example Layered Aquifer System



Other Aquifer Features



Leaky and Perched Aquifers

- Leaky confined aquifer: represents a stratum that allows water to flow from above through a leaky confining zone into the underlying aquifer
- <u>Perched aquifer</u>: occurs when an unconfined water zone sits on top of a clay lens, separated from the main aquifer below



Soil Water Infiltration Movement of water into soil. Importance? - flood prediction - erosion - agriculture - water resources

Types of Porous Media



6. Saturation and Water Content

7. Hydraulic Head

Two Confined Aquifers with Different Heads

Groundwater will tend to flow from the top aquifer to the bottom aquifer.

We can't make any conclusion about horizontal head gradients from this picture.



Lecture 2 Reading Assignments

- 1. Hydrologic Cycle and Water Distribution
 - Bedient et al., pp. 1-6
 - Domenico & Schwartz, pp. 9-21
- 2. Soil Horizons
 - Bedient et al., pp. 15-18
 - Charbeneau, pp. 5-6
- 3. Aquifers/Soil Texture/Porosity and Density/Saturation and Water Content
 - Bedient et al., pp. 18-23
 - Charbeneau, pp. 2-12
- 4. Hydraulic Head
 - Bedient et al., pg. 24
 - Domenico and Schwartz, pp. 58-59
 - Freeze and Cherry, pp. 18-25

Note: Only reading in Bedient et al. is <u>required</u>. Other reading assignments are highly recommended and contain extended explanations that might be helpful for your understanding of the material.