Importance of groundwater

- **Groundwater** is water found in the pores of soil and sediment, plus narrow fractures in bedrock.
- Groundwater is the largest reservoir of fresh water that is readily available to humans.
- Earth’s fresh water supply is finite.
- Fresh water is necessary for survival and most human activities.
Distribution of groundwater

- **Zone of saturation** - The pore spaces are filled with water
- **Zone of aeration** - The pore spaces are filled with air.
- **Water table** – the upper limit of the zone of saturation
Distribution of Groundwater
The water table

Interaction between groundwater and streams

- Constitutes a basic link in the hydrologic cycle (The water cycle)
- Three types of interactions
  - **Gaining streams** – gain water from the inflow of groundwater through the streambed
  - **Losing streams** – lose water to the groundwater system by outflow through the streambed
  - A combination of the first two – a stream gains in some sections and loses in other areas
Gaining and losing streams

A. Gaining stream

B. Losing stream (connected)

C. Losing stream (disconnected)
Factors influencing the storage and movement of groundwater

**Permeability** – the ability of a material to transmit a fluid

- **Aquitard** – an impermeable layer that hinders or prevents water movement (such as clay)
- **Aquifer** – permeable rock strata or sediment that transmits groundwater freely (such as sands and gravels)
Features associated with groundwater

Springs

• Occur where the water table intersects Earth’s surface
• Natural outflow of groundwater
• Can be caused by an aquitard creating a localized zone of saturation which is called a perched water table
Springs may result from a perched water table
Features associated with groundwater

Hot springs

- Water is 6-9°C warmer than the mean annual air temperature of the locality
- The water for most hot springs is heated by cooling of igneous rock
Features associated with groundwater

Geysers

- Intermittent hot springs
- Water erupts with great force
- Occur where extensive underground chambers exist within hot igneous rock
- Groundwater heats, expands, changes to steam, and erupts
Old Faithful geyser in Yellowstone National Park
Features associated with groundwater

Wells

• To ensure a continuous supply of water, a well must penetrate below the water table
• Pumping of wells can cause
  – Drawdown (lowering) of the water table
  – Cone of depression in the water table
Formation of a cone of depression in the water table
Features associated with groundwater

**Artesian well** – a situation in which groundwater under pressure rises above the level of the aquifer

- **Types of artesian wells**
  - Nonflowing – pressure surface is below ground level
  - Flowing – pressure surface is above the ground

- **Not all artesian systems are wells, artesian spring also exist**
An artesian well resulting from an inclined aquifer
Problems associated with groundwater withdrawal

Subsidence

- Ground sinks when water is pumped from wells faster than natural recharge processes can replace it (San Joaquin Valley of California)
Ground subsidence in San Joaquin Valley
Problems associated with groundwater withdrawal

Saltwater contamination

- Excessive groundwater withdrawal causes saltwater to be drawn into wells, thus contaminating the freshwater supply
- This is primarily a problem in coastal areas
Saltwater contamination due to excessive well pumping

A.

Water table
Fresh groundwater

Salt groundwater
Ocean

B.

Pumped well
Cone of depression

Fresh groundwater
Salt groundwater
Ocean
Groundwater contamination

Common sources and types of contamination include:

• Sewage
• Landfills
• Highway salt
• Fertilizers
• Pesticides
• Chemical and industrial materials
Geologic work of groundwater

Groundwater dissolves rock

- Groundwater is often mildly acidic
  - Contains weak carbonic acid
  - Forms when rainwater dissolves carbon dioxide from the air and from decaying plants

- Caverns
  - Most caverns are created by acidic groundwater dissolving soluble rock at or just below the surface in the zone of saturation
Geologic work of groundwater

Caverns

• Features found within caverns
  – Composed of *dripstone* (*travertine*)
  – Calcite deposited as dripping water evaporates
  – Collectively, they are called *speleothems*
  – Includes *stalactites* (hanging from the ceiling) and *stalagmites* (form on the floor of a cavern)
Speleothems in Carlsbad Caverns National Park
“Soda straws” in Carlsbad Caverns National Park
Kartchner Caverns, Arizona
Geologic work of groundwater

Karst topography

- Forms when limestone is slowly dissolved away by slightly acidic groundwater.
- Some common features include
  - Irregular terrain
  - *Sinkhole* or sinks (formed by groundwater slowly dissolving the bedrock often accompanied by collapse)
  - Striking lack of surface drainage (streams)
Development of karst topography