Groundwater is an important natural resource:

- 30X more freshwater is stored as groundwater than in all streams and lakes combined,
- ~ 20% of the water used in the US is withdrawn from wells,
- More than half of the US gets its drinking water from groundwater sources

<table>
<thead>
<tr>
<th>World reservoirs of water</th>
<th>(%)</th>
<th>Average residence time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ocean</td>
<td>97.2</td>
<td>1000’s of years</td>
</tr>
<tr>
<td>Glaciers and ice</td>
<td>2.15</td>
<td>10-10,000’s years</td>
</tr>
<tr>
<td><strong>Groundwater</strong></td>
<td>0.61</td>
<td>1,000-10,000’s years</td>
</tr>
<tr>
<td>Lakes</td>
<td>0.017</td>
<td>10’s of years</td>
</tr>
<tr>
<td>Soil moisture</td>
<td>0.005</td>
<td>Days</td>
</tr>
<tr>
<td>Atmosphere</td>
<td>0.001</td>
<td>9 days</td>
</tr>
<tr>
<td>Rivers</td>
<td>0.0001</td>
<td>14 days</td>
</tr>
</tbody>
</table>

Groundwater is the water that lies beneath the ground surface, filling the cracks, crevices and pore space of rocks.

Where does groundwater come from?
Sources of groundwater come from rain and melting snow and ice as well as some rivers that lose water to the sediment they flow over.

Where is groundwater stored?
Groundwater is stored in cracks, pores and voids in soil and bedrock. It is NOT stored in underground lakes or rivers. Large underground voids and rivers are quite rare.
Groundwater

Groundwater is the water that lies beneath the ground surface, filling the cracks, crevices and pore space of rocks.

Where the pores are completely filled with water they represent the zone of saturation.

Where the pores are not completely filled with water they represent the vadose zone.

The boundary between the zone of aeration and the zone of saturation is called the water table.

Groundwater

Porosity – total volume of open pores/spaces in a rock or sediment.

Permeability – the ability of a rock or sediment to transmit water. It’s a measure of how “well connected” the pores are.

Specific yield – ratio of aquifer volume containing gravity water that is free to move in or out of pores.

Specific retention – volume of water held by capillary action.

Dynamics
Groundwater

Different rock and sediment types have different porosities and permeabilities. The best arrangement for storing and retrieving lots of groundwater is a rock or sediment body that has high porosity AND high permeability.

Metamorphic and igneous rocks:
- usually have very low porosity (<1% - unless fractured), make poor groundwater reservoirs

Sedimentary rocks:
- have porosities ranging up to 20%, make good groundwater reservoirs

Sands and gravels:
- have porosities that range up to 50%, make the best groundwater reservoirs.

Groundwater

A sediment or rock body that allows water to move through it at a useful rate is called an **aquifer**.

A sediment or rock body that DOES NOT allow water to move through at a useful rate is called an **aquitard**.

**Unconfined aquifers** are NOT overlain with aquitards and the water in the aquifer is not under pressure.
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**Wells and Springs**

**Wells**—are fed by water flowing from aquifers. They are not necessarily under pressure. Wells that tap into confined aquifers (under pressure) are called artesian wells.
Springs – are places where water flows naturally from rock or sediment onto the land surface. Some springs discharge where the water table intersects the land surface, but they also occur where water flows out from caverns or along fractures, faults, or rock contacts that come to the surface.

Hot Springs – are springs in which the water is warmer than human body temperature.

Geyser are a type of hot spring that periodically erupts hot water and steam. The hot water is near boiling.
Groundwater Problems

**Depletion and Subsidence** – withdrawing fluids from the ground leads to a reduction in resisting pressure. Overlying sediments begin to become compacted and slowly reduce thickness – collapse.

Subsidence of the land surface caused by the extraction of groundwater in the San Joaquin Valley, Ca. Signs on the pole indicate the positions of the land surface in 1925, 1955 and 1977. The land sank 9 meters (30 feet) in 52 years.

Groundwater Problems

**Contamination** – groundwater contamination occurs from many sources including agricultural chemicals, oil field liquids, landfills, homes, and UST's.
**Groundwater**

**Groundwater Problems**

**Saltwater Intrusion** – Coastal area problem as heavier salt water moves into coastal aquifers. Pumping fresh water from aquifers pulls salt water into wells rendering the water unfit for human consumption.

**Karst topography** – dissolution of the weak cement that holds some limestones together results in the formation of caves, sinkholes (surface depression resulting from dissolving of underlying rock and collapse of the surface) and solution valleys.
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