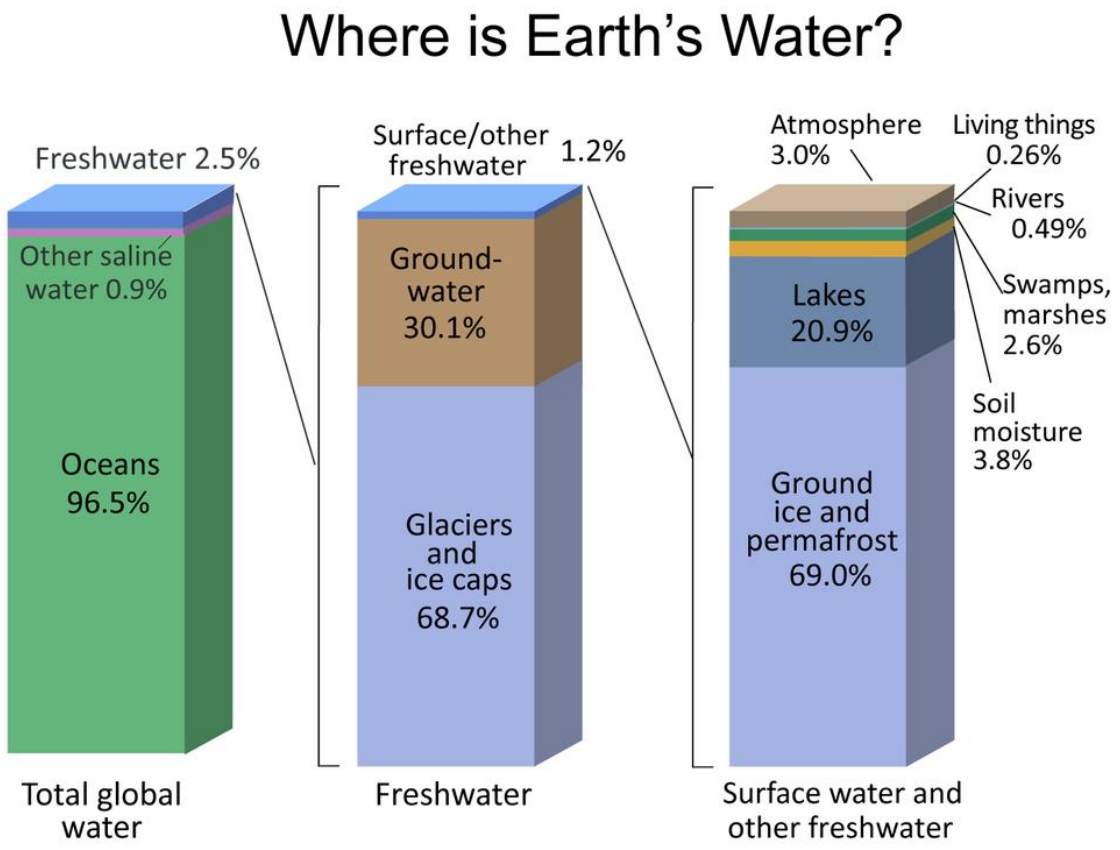
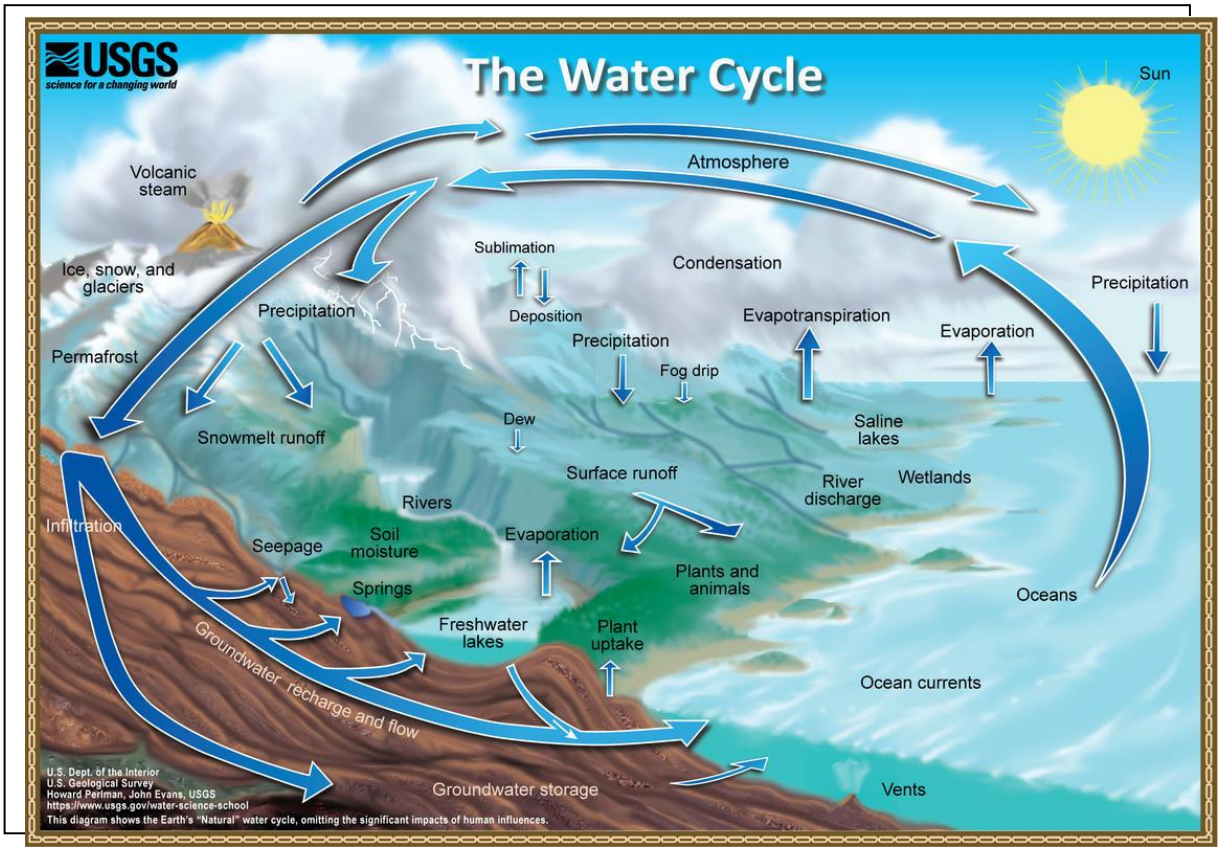
Occurence of Water: Surface and Groundwater

About 71 percent of the Earth's surface is water-covered, and the oceans hold about 96.5 percent of all Earth's water. Water also exists in the air as water vapor, in rivers and lakes, in icecaps and glaciers, in the ground as soil moisture and in aquifers, and even in our bodies.



Credit: U.S. Geological Survey, Water Science School. https://www.usgs.gov/special-topic/water-science-school
Data source: Igor Shiklomanov's chapter "World fresh water resources" in Peter H. Gleick (editor), 1993, Water in Crisis: A Guide to the World's Fresh Water Resources. (Numbers are rounded).

This bar chart shows how almost all of Earth's water is saline and is found in the oceans. Of the small amount that is actually freshwater, only a relatively small portion is available to sustain human, plant, and animal life.
• In the first bar, notice how only 2.5% of Earth's water is freshwater - the amount needed for life to survive.
• The middle bar shows the breakdown of freshwater. Almost all of it is locked up in ice and in the ground. Only a little more than 1.2% of all freshwater is surface water, which serves most of life's needs.
• The right bar shows the breakdown of surface freshwater. Most of this water is locked up in ice, and another 20.9% is found in lakes. Rivers make up 0.49% of surface freshwater. Although rivers account for only a small amount of freshwater, this is where humans get a large portion of their water from.



Water in our planet is available in the atmosphere, the oceans, on land and within the soil and fractured rock of the earth’s crust. Earth's water is always in movement, and the natural water cycle, also known as the hydrologic cycle, describes the continuous movement of water on, above, and below the surface of the Earth. Water is always changing states between liquid, vapor, and ice, with these processes happening in the blink of an eye and over millions of years.

Surface Water

Surface water is any body of water above ground, including streams, rivers, lakes, wetlands, reservoirs, and creeks. The ocean, despite being saltwater, is also considered surface water. Surface water participates in the hydrologic cycle, or water cycle, which involves the movement of water to and from the Earth’s surface. Precipitation and water runoff feed bodies of surface water. Evaporation and seepage of water into the ground, on the other hand, cause water bodies to lose water.

There are three types of surface water

Perennial: Perennial, or permanent, surface water persists throughout the year and is replenished with groundwater when there is little precipitation.

Ephemeral: Ephemeral, or semi-permanent, surface water exists for only part of the year. Ephemeral surface water includes small creeks, lagoons, and water holes.

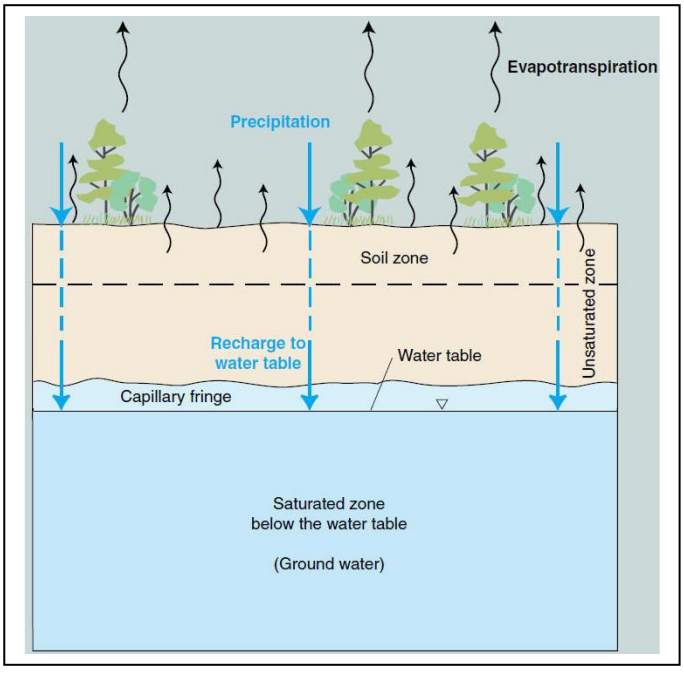
Man-made: Man-made surface water is found in artificial structures, such as dams and constructed wetlands.

Groundwater

Some water underlies the Earth's surface almost everywhere, beneath hills, mountains, plains, and deserts. It is not always accessible, or fresh enough for use without treatment, and it's sometimes difficult to locate or to measure and describe. This water may occur close to the land surface, as in along our coastal belt in Goa, or it may lie many hundreds of feet below the surface. Water at very shallow depths might be just a few hours old; at moderate depth, it may be 100 years old; and at great depth or after having flowed long distances from places of entry, the water may have been in the ground for several thousand years.

Groundwater is a part of the natural water cycle. Some part of the precipitation that lands on the ground surface infiltrates into the subsurface. The part that continues downward through the soil until it reaches rock material that is saturated is groundwater recharge. Water in the saturated groundwater system moves slowly and may eventually discharge into streams, lakes, and oceans. Some people believe that ground water collects in underground lakes or flows in underground rivers. In fact, ground water is simply the subsurface water that fully saturates pores or cracks in soils and rocks.

Vertical distribution of ground water



Schematic diagram showing vertical section from the land surface through the vadose zone, capillary fringe, and into an unconfin
1999, https://www.usgs.gov/media/images/groundwater-area-underground-where-openings-are-full-water, Public Domain.

Subsurface water can be divided in two broad zones
1. Vadose zone / (Unsaturated zone?*)
2. Saturated Zone

Vadose zone: The zone between the ground surface and the top of water table is known as the vadose zone. The vadose zone consists of the Unsaturated zone and Capillary zone.

The zone between the ground surface and the top of capillary fringe is called unsaturated zone (or, zone of aeration) which consists of voids (pores or interstices) partially filled with water and partially with air. Water is held at a pressure less than the atmospheric pressure in the unsaturated zone. Unsaturated zone can be further divided into 1. soil-water zone 2. intermediate zone

Capillary zone: Water rises a small distance into soil pores above the water table due to capillary forces that result from the adhesion of water molecules to subsurface solids and the cohesion of water molecules to one another. The zone between bottom of the unsaturated zone and top of the water table is called capillary zone, wherein most voids are filled with water but the water is held at a pressure less than the atmospheric pressure.

Saturated zone The zone extending from the water table to an impermeable layer is called saturated zone (or, zone of saturation), wherein all voids are completely filled with water. In this zone, water is held at a pressure greater than the atmospheric pressure, and hence it moves in a direction based on the contiguous hydraulic situation. Not all underground water is groundwater, rather only free water or gravitational water (the water that moves freely under the force of gravity into wells) constitutes the groundwater. “Groundwater is that portion of the water beneath the earth’s surface, which can be collected through wells, tunnels, or drainage galleries, or which flows naturally to the earth’s surface via seeps or springs”. (Bouwer, 1978).

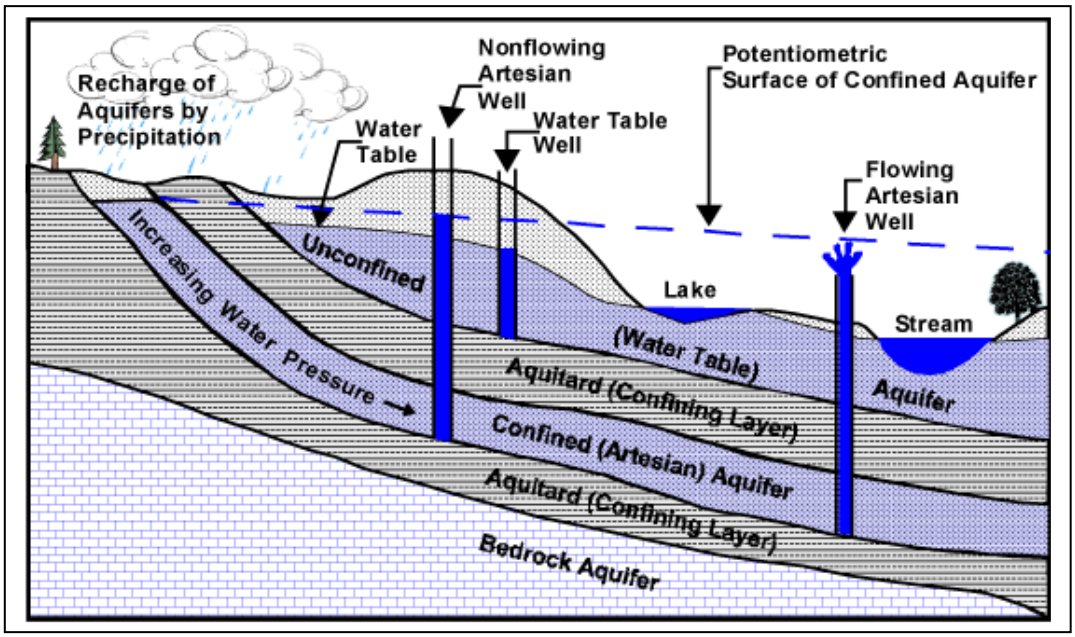
Aquifer

An aquifer is defined as a body of rock or unconsolidated sediment that has sufficient permeability to allow water to flow through it. E.g., Unconsolidated materials like gravel, sand, and even silt make relatively good aquifers, as do rocks like sandstone. Other rocks can be good aquifers if they are well fractured.

Aquifuge, Aquiclude, Aquitards

An aquifuge suggests that the material has no capacity to store or transmit water, it is impermeable. – e.g., unfractured hard Granite rock. An aquiclude is a saturated geologic unit that has some storage and transmission properties, however, for practical purposes, no transmission occurs- e.g., Clay- Highly porous but impermeable Aquitards are units that store water and are less permeable than aquifers, so they slow the transmission of water. E.g., Sandy clay – porous but less permeable All these are relative terms and act as confining layers.

Confined and Unconfined aquifer



Potentiometric surface and water table in an aquifer system

Potentiometric surface and water table in an aquifer system. , An Introduction to Geology , Salt lake community college, https://opengeology.org/textbook/wp-content/uploads/2016/07/wa-aquifer_types-1.gif, CCBY

Where groundwater is in direct contact with the atmosphere through the open pore spaces of the overlying soil or rock, then the aquifer is said to be unconfined. The upper groundwater surface in an unconfined aquifer is called the water table. The depth to the water table varies according to factors such as the topography, geology, season and tidal effects, and the quantities of water being pumped from the aquifer.

Unconfined aquifers are usually recharged by rain or stream water infiltrating directly through the overlying soil. Typical examples of unconfined aquifers include many areas of coastal sands and alluvial deposits in river valleys.

Confined aquifers, on the other hand, have layers of impermeable material above and below them – so they are contained within these layers. Groundwater in a confined aquifer is under pressure and will rise up inside a borehole drilled into the aquifer. The level to which the water rises is called the potentiometric surface. An artesian flow is where water flows out of the borehole under natural pressure.

Confined aquifers may be replenished, or recharged by rain or stream water infiltrating the rock at some considerable distance away from the confined aquifer. Groundwater in these aquifers can sometimes be thousands of years old.