

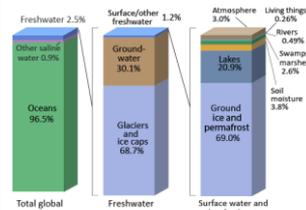
## Water on Earth

- Earth as a watery world: 71%
- Despite the need, fresh water is one of the rarest resources on Earth!



## Water on Earth

### Where is Earth's Water?

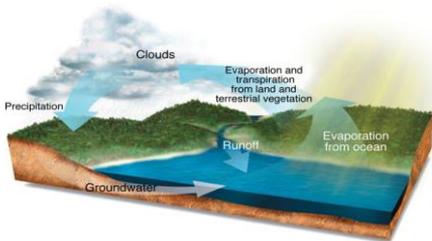


- About 97% of Earth's water is salty and not consumable.

- Of the freshwater, most is locked in ice caps and glaciers, leaving less than 1% in a useable form for humans.

Source: Igor Shiklomanov's chapter "World fresh water resources" in Peter H. Gleick (ed.), 1993, Water in Crisis: A Guide to the World's Fresh Water Resources. NOTE: Numbers are rounded, so percent summations may not add to 100.

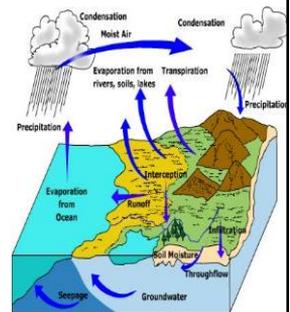
- Moreover, of the 1%, most of it is not readily available for human use.
- Instead, it is constantly moving through the seas, land, and air as part of the hydrologic cycle.



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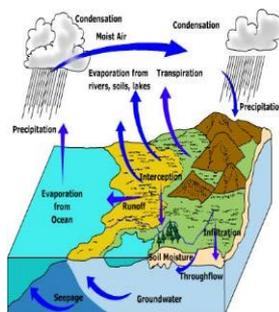
## Hydrologic Cycle

1. Heat from the sun causes water in oceans & other water sources to **evaporate**



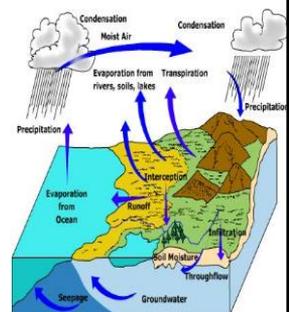
## Hydrologic Cycle

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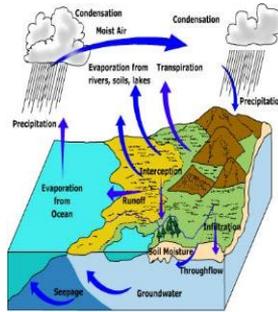
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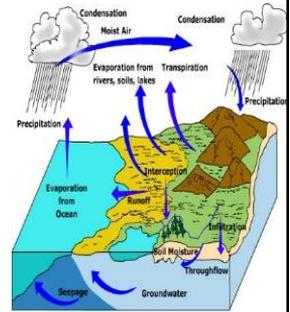
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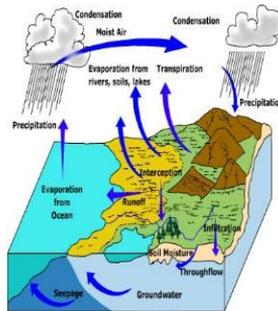
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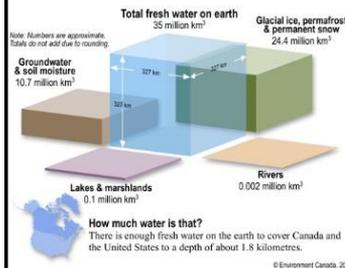
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**\*\*NOTE:** water can be **stored** in such areas as glaciers and groundwater (aquifers). Water may also be **transpired** from trees.

**Where on earth is all that fresh water?**  
There are about 35 million km<sup>3</sup> of fresh water on the earth. Here's where that water is found.

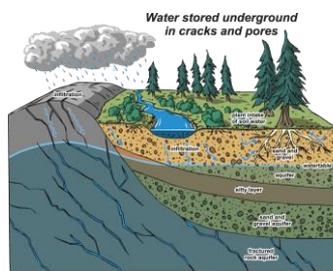


We get freshwater from two locations:

1. Groundwater
2. Surface Water

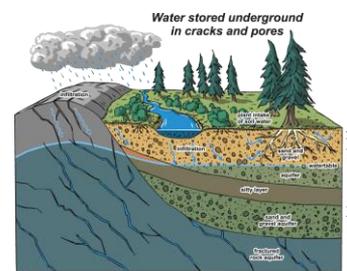
## Groundwater

- Is the water that **infiltrates** the soil and eventually reaches the water table
- The **water table** is the top part of the zone that is **saturated** with water.



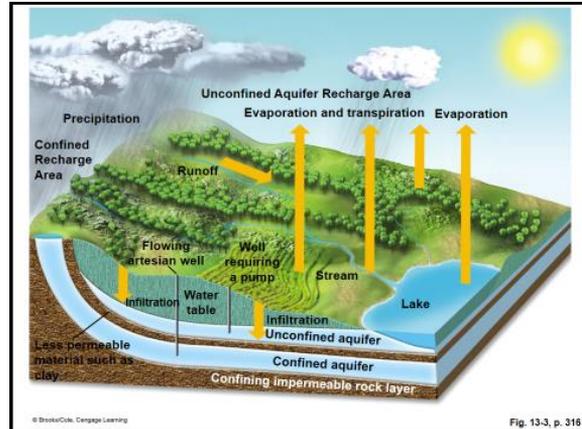
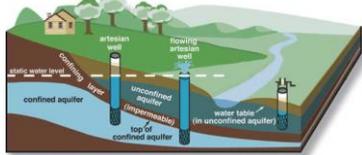
## Groundwater

- Comprising the water table are many **aquifers** (layers of rock and soil that store and/or transmit water).



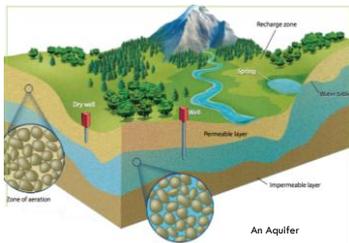
## Groundwater

- An unconfined aquifer is an aquifer with a permeable water table.
- A confined aquifer is bounded above and below by less permeable beds of rock, and its water is confined under pressure.



## Groundwater

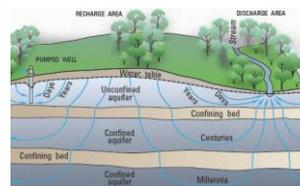
- Aquifers are an important source of freshwater to people who get their drinking water from wells.
- Due to the slow rate of recharge, groundwater is considered a non-renewable resource.



**Did You Know?** The average age of groundwater is 1400 years. Groundwater recharges very slowly.

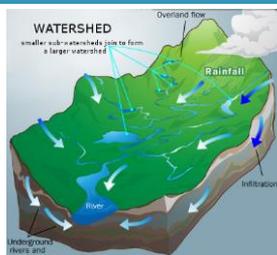
## Groundwater

- With time, groundwater eventually meets the surface where it discharges to streams, ponds, lakes, etc.

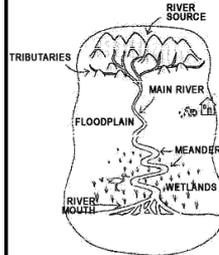


## Surface Water

- Is water that exists on the surface on the Earth
- Includes streams, rivers, lakes, ponds
- Occurs as a result of a watershed (an area of land that drains into a specific body of water)



## Parts of a Watershed



A watershed boundary (or divide) marks the outer-most limit of a watershed.

The main river is the primary channel within a watershed.

The river source is the beginning of the main river and it is often located in mountains.

A tributary is a smaller stream or river that eventually joins the main river.

### Parts of a Watershed

A **floodplain** is relatively flat land near the river which may flood during heavy rain or snowmelt.

**Wetlands** are low-lying areas saturated with water for long enough periods to support vegetation.

The **river mouth** is the place where the main river flows into a larger body of water, such as another river, a lake, or an ocean.

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### Surface Water

- Quantity** related to: climate, geology, geography, ground cover
- Quality** is related to human activities (i.e. deforestation, chemical usage, land management)

### Scarcity of Clean, Freshwater

- Freshwater scarcity is partially caused by a **growing population** and **climate change** but it is intensified by **management decisions**.

Our freshwater problems can be simplified as:

- Too little water (water withdrawal /consumption)
- Poor water quality (water pollution)

Today we'll discuss water withdrawal/consumption and leave pollution issues till later in the course.

### Water Usage

- Water is "**as vital to life as air**".
- What do we use water for?
  - Drinking and cooking
  - Washing
  - Manufacturing
  - Mining and energy
  - Agriculture

### Water Usage

- Water Withdrawal** – non-consumptive use
  - Temporarily** removes water from its source
  - E.g. power plants using water for cooling
- Water Consumption**
  - Does not return water to its original source

**Global Fresh Water Withdrawals**

Total global withdrawal approx 4,000 km<sup>3</sup>/yr in 2010

Category	Volume (km <sup>3</sup> /yr)	Percentage
Agriculture	2,800	70%
Municipal & Domestic	400	10%
Industrial Energy	800	20%
Mining	78	2%
Other	0	0.0%

**Agriculture uses 70% of water worldwide.**

That leaves 30% for everything else: drinking water, water for cooking, water for industry.

**Substantially more water required for meat**

Producing 1 kg of **grain** requires approximately 1,500 litres of water while 1 kg of **beef** requires 15,000 litres.

Product	Unit	Equivalent water in cubic metres
Bovine, cattle	head	4,000
Sheeps and goats	head	500
Meat bovine fresh	kilogram	15
Meat sheep fresh	kilogram	10
Meat poultry fresh	kilogram	6
Cereals	kilogram	1.5
Citrus fruit	kilogram	1
Palm oil	kilogram	2
Pulses, roots and tubers	kilogram	1

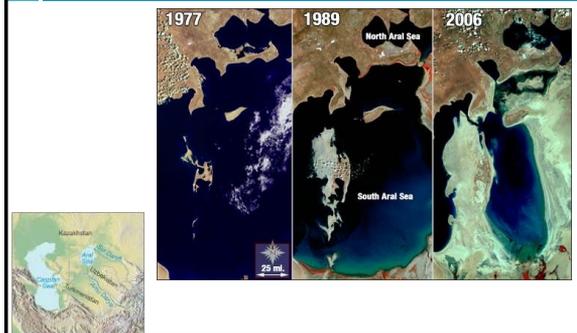
## Overdrawing Surface Waters

- Up to 30% of water from rivers and lakes can be withdrawn without overly affecting the ecosystem.



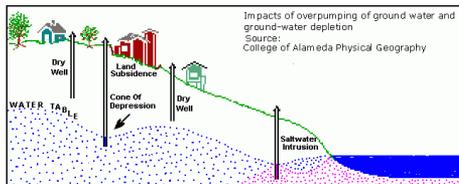
- However, in some places considerably more is withdrawn, resulting in:
  - Wetlands drying up
  - Estuaries becoming saltier
  - Habitat and biodiversity loss

## E.g. Aral Sea



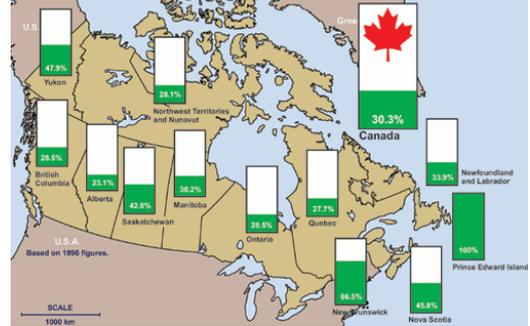
## Groundwater Depletion

- Happens due to sustained pumping (and slow recharge)
- End result is a lowered water table which leads to drying up of wells and increased costs to users



## Percentage of population reliant on groundwater

Municipal, domestic and rural only



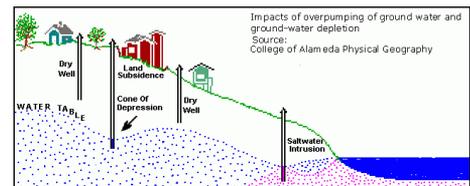
## Groundwater Depletion

- Sometimes when water is taken out of the soil, the soil collapses, compacts, and drops, resulting in land subsidence and/or creation of sinkholes.



## Groundwater Depletion

- Pumping can cause saltwater to migrate inland and upward, resulting in saltwater contamination of the water supply. This is referred to as salt water intrusion.



## Groundwater Depletion

- Surface water and groundwater are closely linked.
- Over pumping also decreases water in streams and lakes, thereby resulting in loss of wetland vegetation and wildlife habitat.



## Long Term Outlook



- Climate change is increasing frequency and duration of drought
- Increasing human population and demand for freshwater

## Stress on the World's Major River Basins

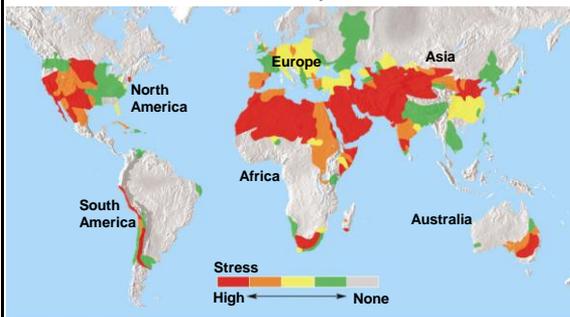


Fig. 13-6, p. 319