GLY 102

Introduction to Geology II

2020/2021 Session

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and

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Additional Textbooks

- Understanding Earth Sixth Edition Edition by John Grotzinger (Author), Thomas H. Jordan
- Principles of Geology: (Classic Reprint) Paperback – June 15, 2012 by Charles Lyell.
- System History - Text 3RD EDITION by Steven M. Stanley. W.H. Freeman, 2009

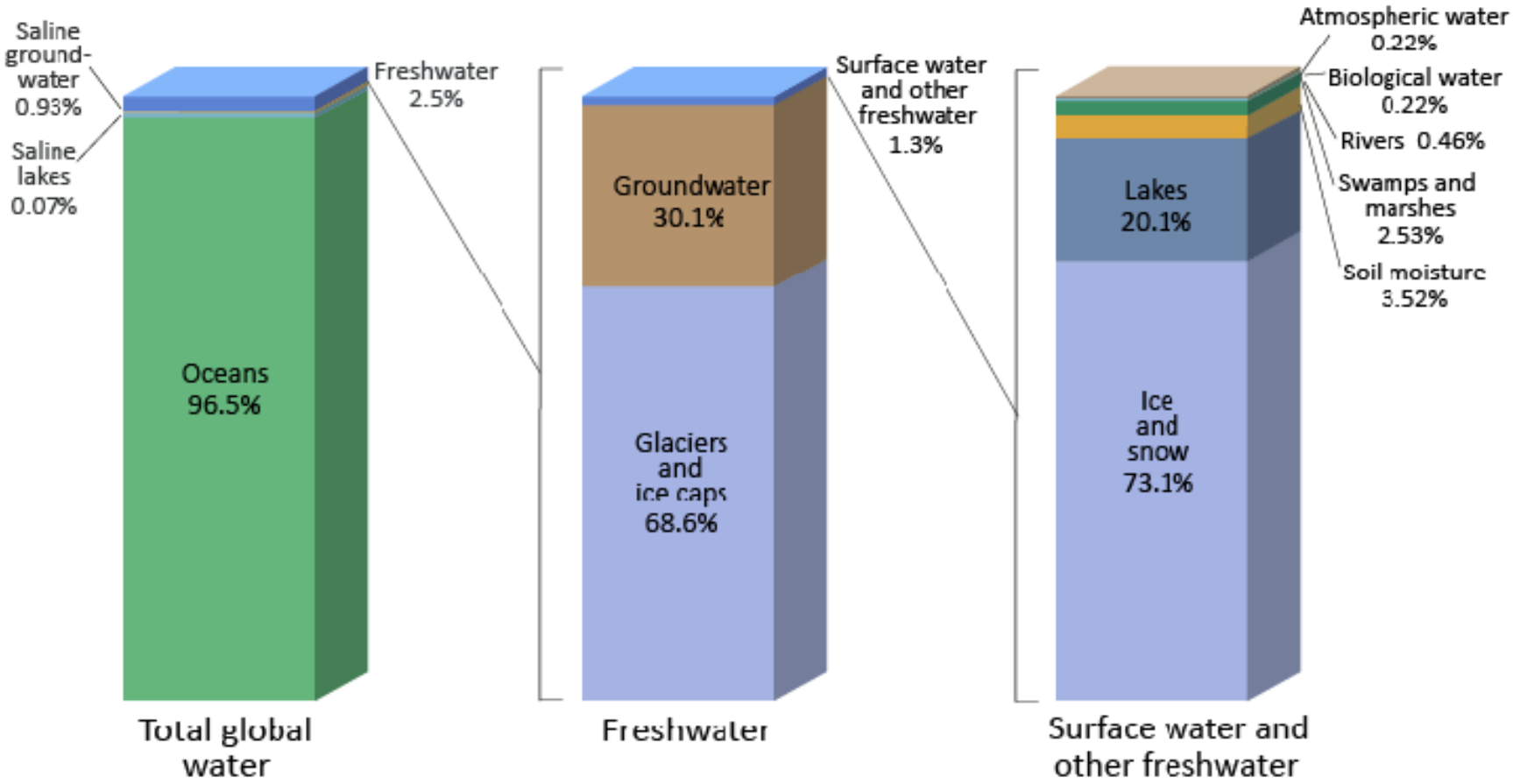
Hydrologic Cycle

Outline

- Water distribution in the World
- Water cycle
- Elements of water cycle
- Impacts
  - Human
  - Natural

Water on the Planet Earth

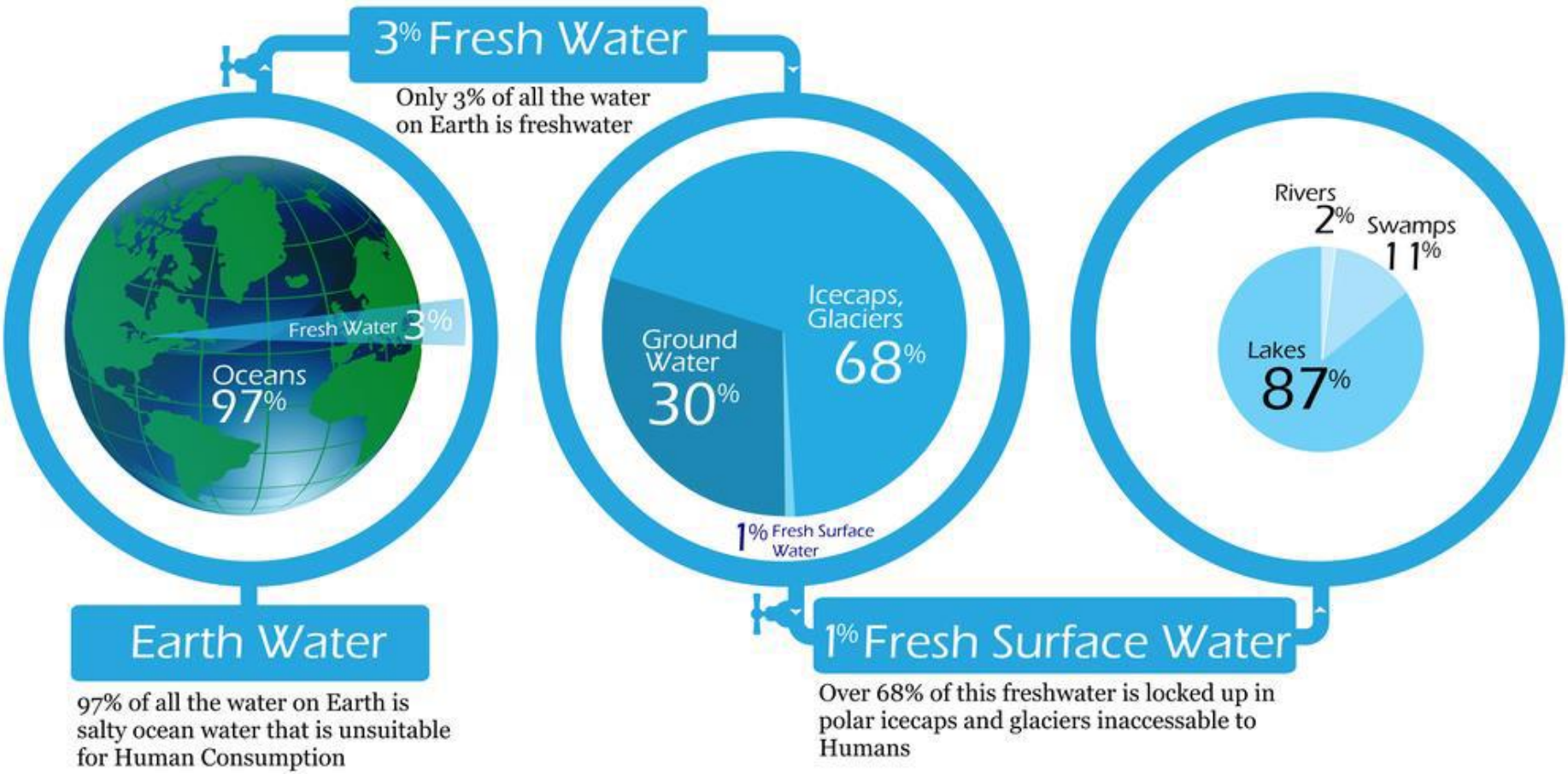
70% of the earth's surface is covered with water.



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.

http://ga.water.usgs.gov/edu/earthwherewater.html

Fresh Water on Earth



Hydrologic Cycle

Water can occur in three physical phases: solid, liquid, and gas and is found in nature in all these phases in large quantities. Depending upon the environment of the place of occurrence, water can quickly change its phase.

A number of cycles are operating in nature, such as the carbon cycle, the nitrogen cycle, and several biogeochemical cycles.

The *Hydrologic Cycle*, *also known as the water cycle*, *is one* such cycle which forms the fundamental concept in hydrology.

Hydrologic Cycle

Hydrologic cycle was defined by the National Research Council (NRC, 1982) the as “the pathway of water as it moves in its various phases to the atmosphere, to the earth, over and through the land, to the ocean and back to the atmosphere”.

This cycle has no beginning or end and water is present in all the three states (solid, liquid, and gas).

The hydrologic cycle, also known as global water cycle or the H_2O cycle, describes the storage and movement of water between the biosphere, atmosphere, lithosphere, and the hydrosphere.

Hydrologic Cycle

"The water cycle, also known as the hydrological cycle or the H_2O cycle, describes the continuous movement of water on, above and below the surface of the Earth."

Water is most commonly found in its liquid form, in rivers, oceans, streams, and in the earth.

Elements or Component s of Water Cycle

The hydrologic cycle can be subdivided into three major systems:

1. The oceans being the major reservoir and source of water;

2. The atmosphere functioning as the carrier and deliverer of water; and

3. The land as the user of water.

The amount of water available at a particular place changes with time because of changes in the supply and delivery.

Elements or Component s of Water Cycle

The major components of the hydrologic cycle are :

1. Evaporation,
2. Transpiration,
3. Sublimation, Condensation and Transportation
4. Precipitation (rainfall, snowfall, hale, sleet, fog, dew, drizzle, etc.),
5. Infiltration,
6. Percolation,
7. Moisture storage in the unsaturated zone, and
8. Runoff (surface runoff, interflow, and baseflow).

Evaporation and Transpiration of Evapotranspiration

Evaporation is the change of state of water (a liquid) to water vapor (a gas). On average, about 47 inches (120 cm) is evaporated into the atmosphere from the ocean each year.

Transpiration is evap-oration of liquid water from plants and trees into the atmosphere. Nearly all (99%) of all water that enters the roots transpires into the atmosphere.

Evaporation and Transpiration of Evapotranspiration

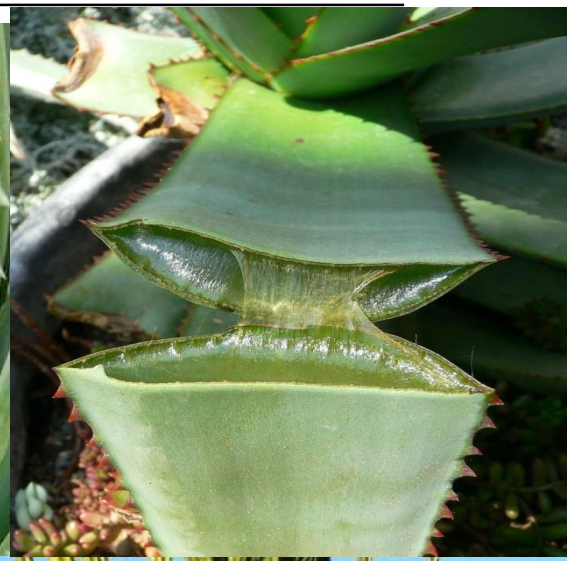
Temperature: Higher temperature → higher transpiration

Relative humidity: higher relative humidity → lower transpiration

Wind and air movement: Increased air movement → higher transpiration.]

Soil-moisture availability: **no moisture** → Less transpiration

Evaporation and Transpiration of Evapotranspiration



Evaporation and Transpiration of Evapotranspiration

Sublimation, Condensation, Transportation

Sublimation is the process where ice and snow (a solid) changes into water vapor (a gas) without moving through the liquid phase. Deposition is the reverse of sublimation. Water vapor (a gas) changes into ice (a solid) without going through the liquid phase. This is most often seen on clear, cold nights when frost forms on the ground.

Condensation is the process where water vapor (a gas) changes into water droplets (a liquid). This is when we begin to see clouds.

Transportation is the movement of solid, liquid and gaseous water through the atmosphere. Without this movement, the water evaporated over the ocean would not precipitate over land.

Precipitation

Precipitation is water that falls to the earth.

Most precipitation falls as rain but includes snow, sleet, drizzle, and hail. On average, about 39 inches (980 mm) of rain, snow and sleet fall each year around the world.

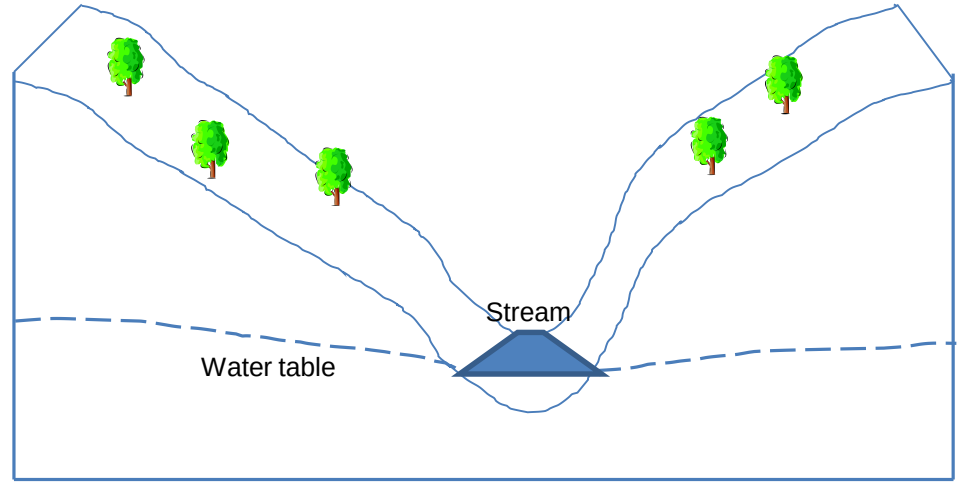
The standard instrument for the measurement of rainfall is the 203mm (8 inch) **rain gauge.** This is essentially a circular funnel with a diameter of 203mm which is kept in an open area, so that it collects the rain into a graduated and calibrated cylinder. The measuring cylinder can record up to 25mm of precipitation. The precipitation value in mm is referring to the amount of rain per square meter in one hour. One millimeter of rainfall is the equivalent of one liter of water per square meter.

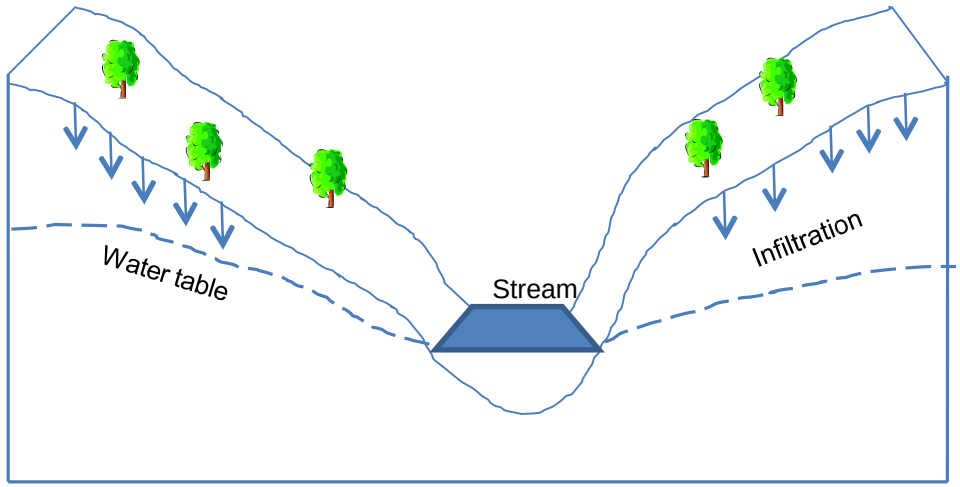
Intensity (- High intensity → runoff , - Low intensity → infiltration

Duration (- Soil Saturation)

Infiltration

Infiltration is the movement of water into the ground from the surface. Percolation is movement of water past the soil going deep into the groundwater.

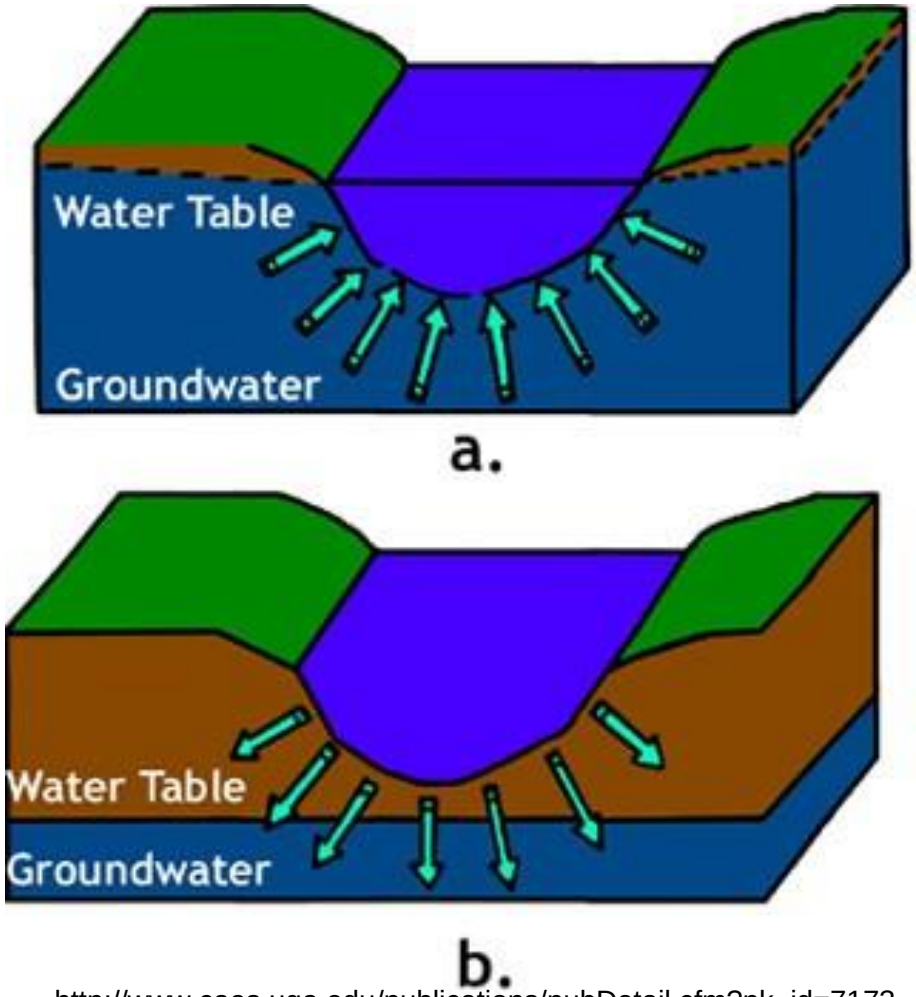




- Light rain
  - No runoff
  - Infiltration raises water table
  - Increase discharge

Groundwater

Groundwater is the flow of water under- ground in aquifers. The water may return to the surface in springs or eventually seep into the oceans.

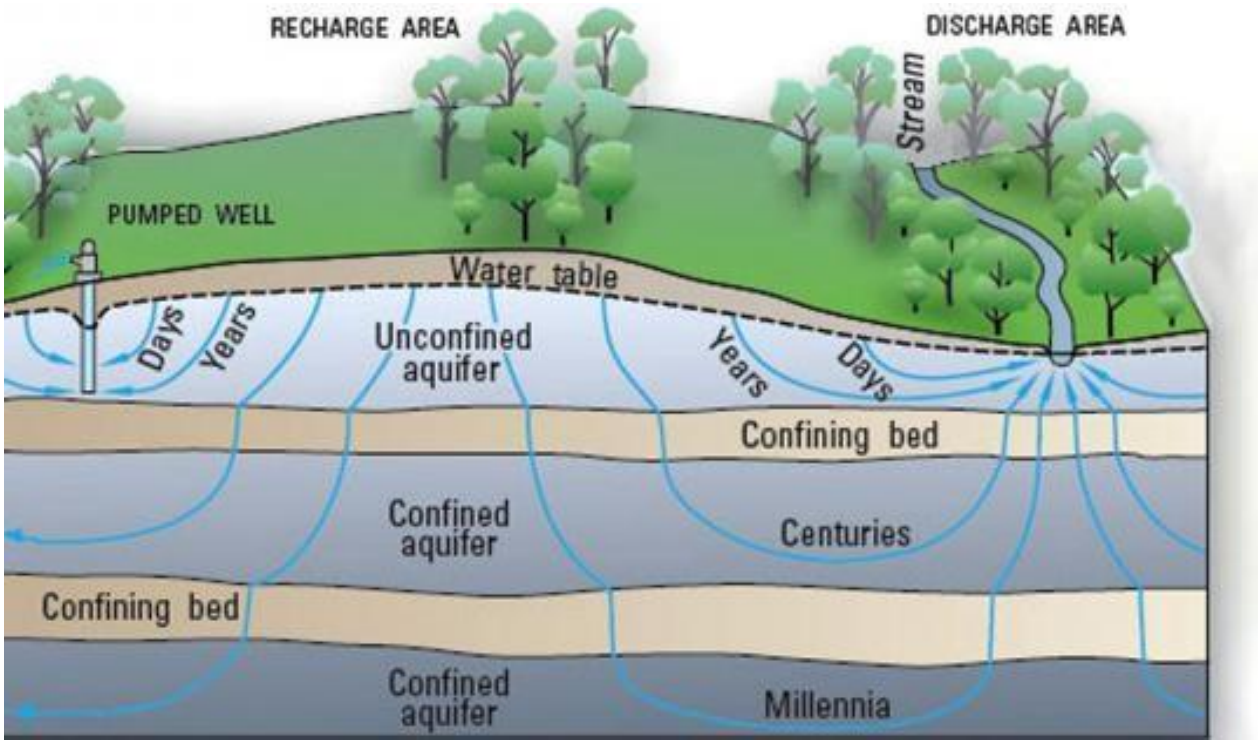


- From Infiltration
- Slow movement

http://www.caes.uga.edu/publications/pubDetail.cfm?pk_id=7173

Water Storage

- Deep groundwater
  - 46% fresh water
  - 54% saline
- Aquifer



http://earthy-moony.blogspot.com/2011/02/aquifers-and-aquitards.html

Water Storage: Aquifers

Aquifers are typically saturated regions of the subsurface that produce an economically feasible quantity of water to a well or spring (e.g., sand and gravel or fractured bedrock often make good aquifer materials).

An aquitard is a zone within the Earth that restricts the flow of groundwater from one aquifer to another. A completely impermeable aquitard is called an aquiclude or aquifuge. Aquitards comprise layers of either clay or non-porous rock with low hydraulic conductivity.

Water Storage: Aquifers

There are two types of aquifers;

Confined and Unconfined (with semi-confined being in between).

Confined aquifers are aquifers that are overlain by a confining layer, often made up of clay. The confining layer might offer some protection from surface contamination.

Unconfined aquifers are sometimes also called water table or phreatic aquifers, because their upper boundary is the water table or phreatic surface. Typically (but not always) the shallowest aquifer at a given location is unconfined, meaning it does not have a confining layer (an aquitard or aquiclude) between it and the surface.

Water Storage: Ice and Snow

- Ice and Snow
  - 90% Antarctica
  - ~10% Greenland Ice Cap

http://pubs.usgs.gov/fs/2005/3056/

Runoff

- Surface runoff is precipitation runoff over the landscape.
  - Affected by many factors:

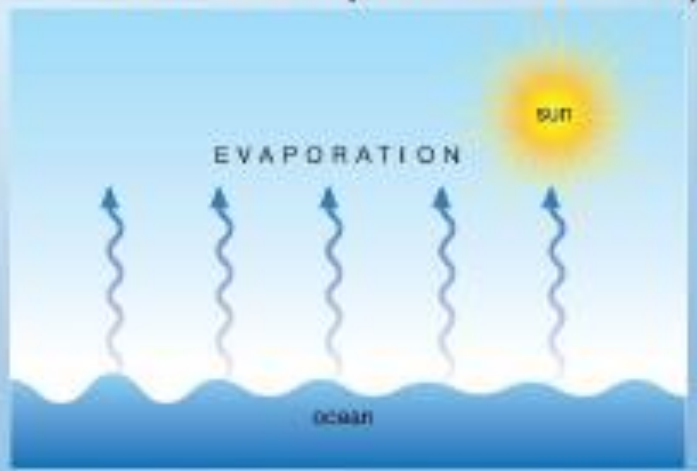
- Meteorological factors
  - Type of rain
  - Rain intensity
  - Rain amount
  - Rain duration
  - Rain distribution
  - Previous precipitation
  - …
- Physical factors
  - Land use
  - Vegetation
  - Soil type
  - Drainage area
  - Basin shape
  - Topography
  - Ponds, lakes
  - …
- Human factors
  - Urbanization
  - Impervious surfaces
  - Reservoirs
  - …

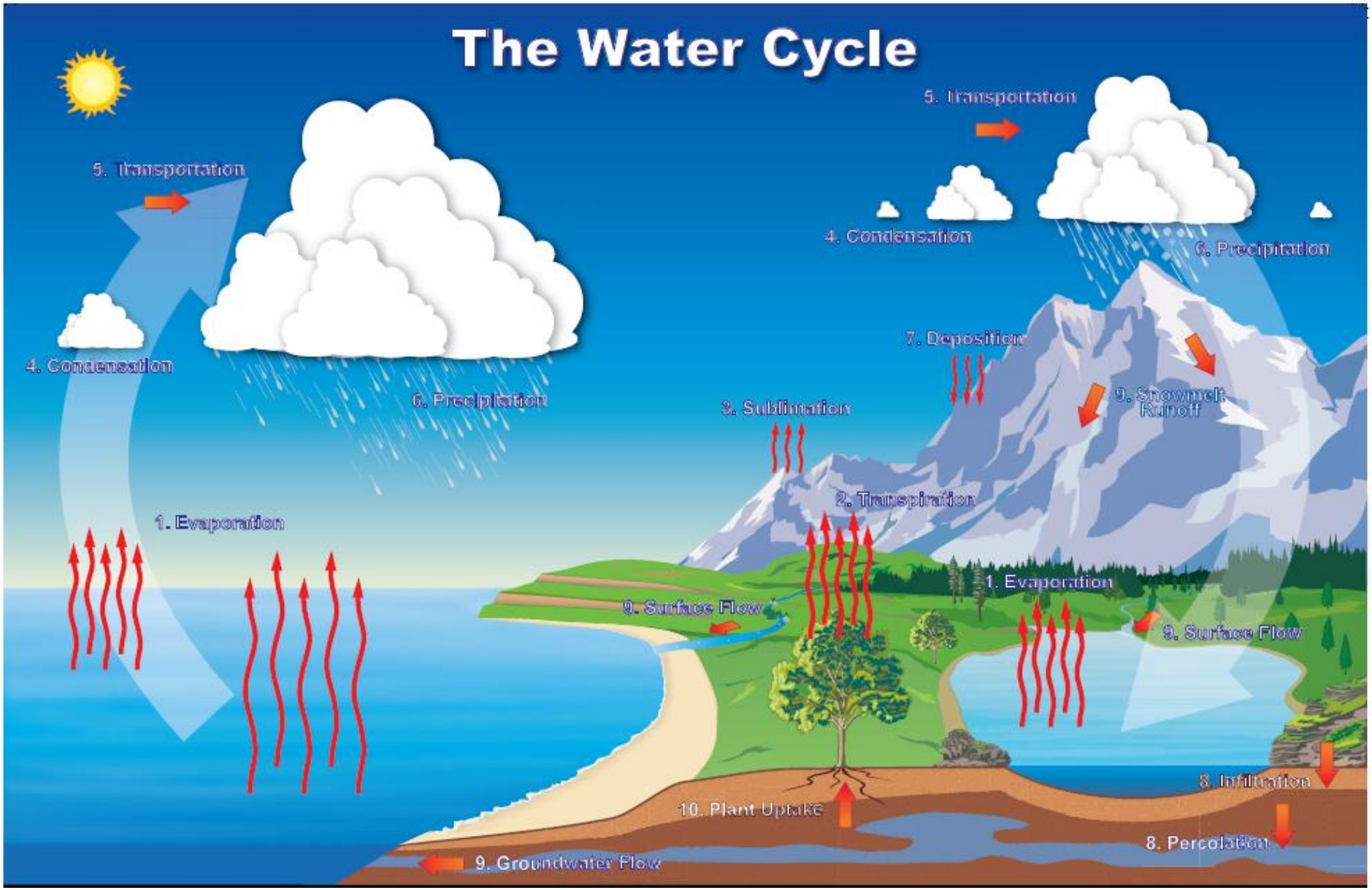
Hydrologic Cycle

TWO MAJOR FORCES DRIVE THE WATER CYCLE

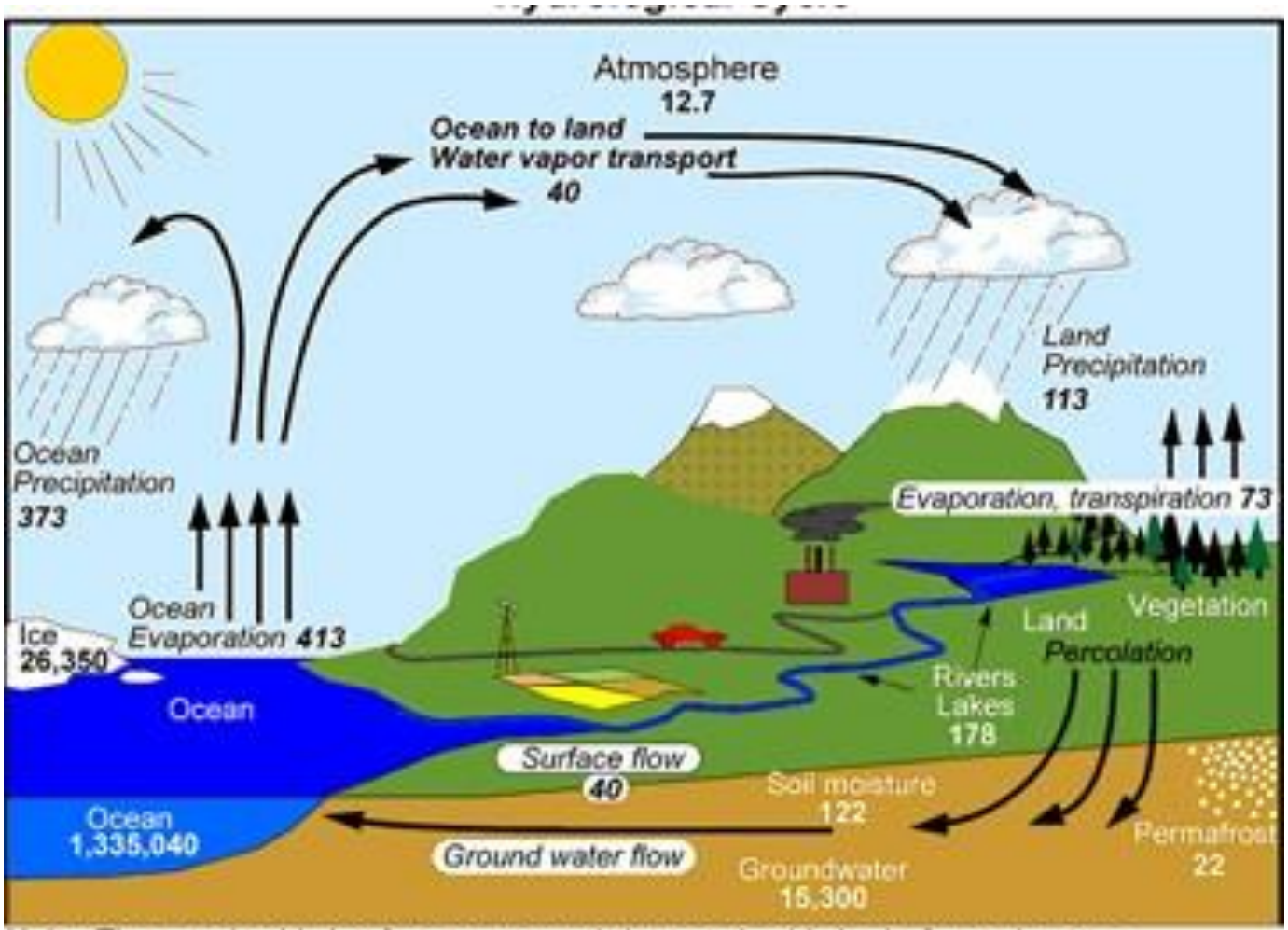
GRAVITY (PRECIPITATION)

SOLAR ENERGY (EVAPORATION)



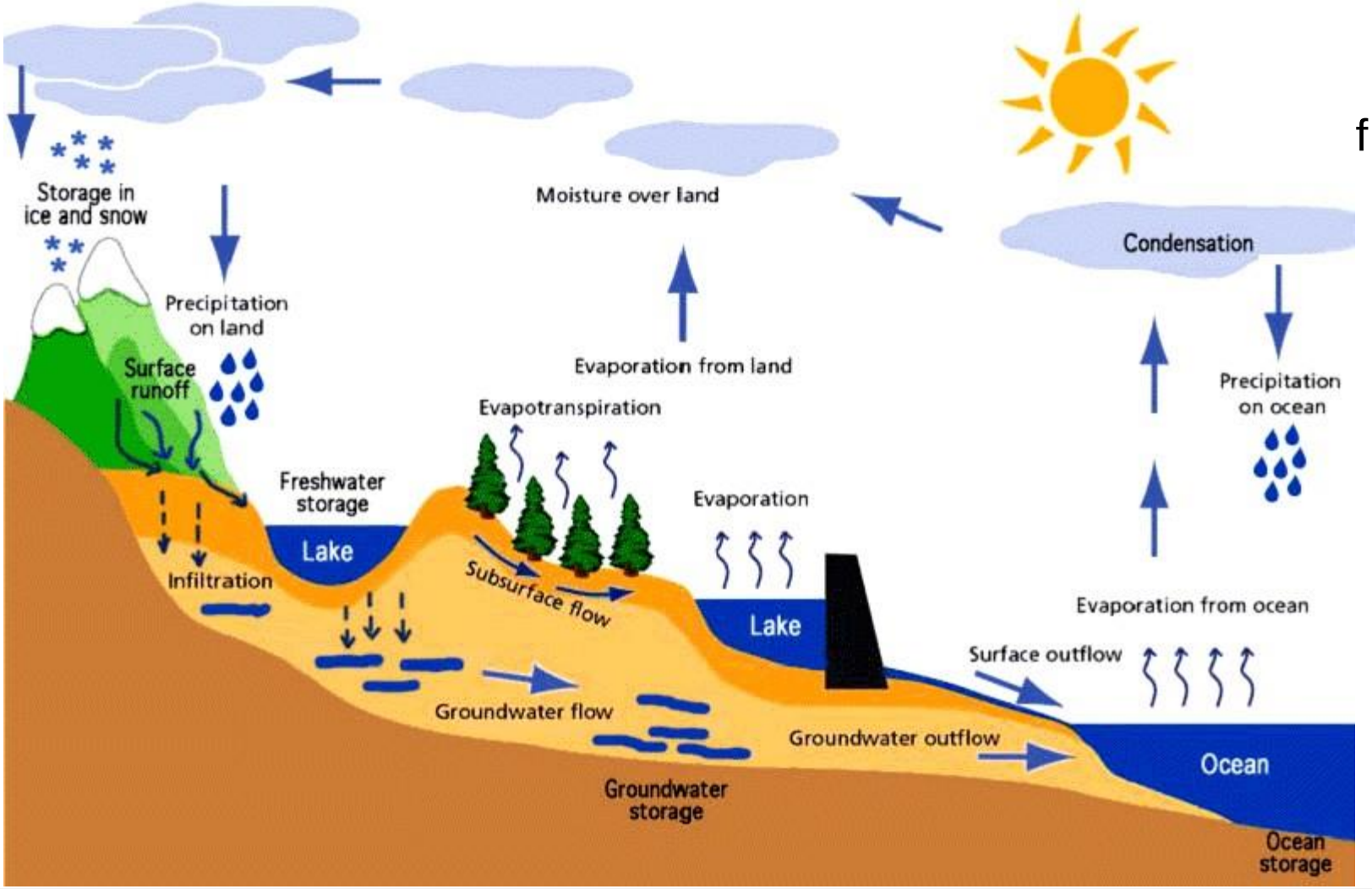

The Water Cycle
5. Transportation
4. Condensation
6. Precipitation
7. Deposition
3. Sublimation
9. Snowmelt Runoff
2. Transpiration
1. Evaporation
9. Surface Flow
10. Plant Uptake
8. Infiltration
8. Percolation
9. Groundwater Flow

Water Cycle



Units: Thousand cubic km for storage, and *thousand cubic km/yr* for exchanges

Water Cycle



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Human impacts on the hydrologic cycle

- Dams
- Irrigation
- Urbanization
- Water deviation
- Etc. etc. etc…

Human Impacts: Dams

- Electricity production
- Flood control
- Irrigation
- Etc, etc, etc…

- Increases evaporation
- Increases infiltration

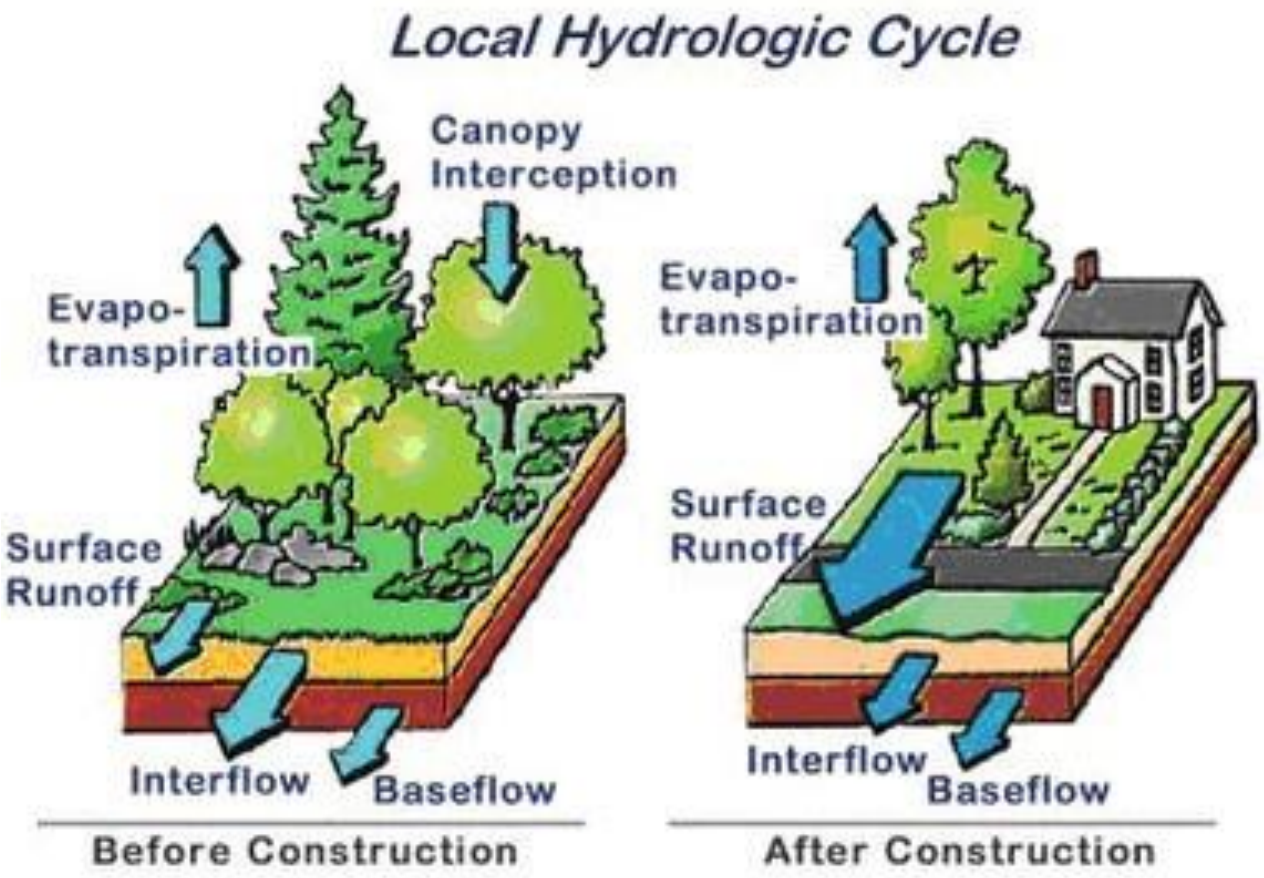
Human Impacts: Irrigation

http://ga.water.usgs.gov/edu/irsprayhi

Wikipedia

http://acarainstitute.wordpress.com

Human Impacts: Urbanization



http://www.oeconline.org/our-work/rivers/stormwater/stormwater%20report/impacts

Don’t want to talk about this (Ganges)

http://shipbright.wordpress.com

Natural Impacts on the Hydrologic Cycle

- Natural climate oscillations
- Temperature
- Precipitation
- Evapotranspiration