

RWater Module 1

Understanding the Hydrologic Cycle

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Learning Goals

The *Hydrologic Cycle* (often called the water cycle) is the vertical and horizontal movement of water in either vapor, liquid, or solid form between the earth's surface, subsurface, atmosphere, and oceans. Hydrologic analyses and water resources managements are mostly based on watersheds. So, in-depth understanding of how the water moves when it rains over a watershed is very much essential in order to more effectively use the associated hydrologic data sources and analytical tools. In this module, students will learn:

- i. about the major components of hydrologic cycle
- ii. how to define a watershed
- iii. how to access flow records at a specific stream location using internet

The Hydrologic Cycle

Although the balance of water on Earth remains fairly constant over time, individual water molecules can come and go, in and out of the atmosphere. The water moves from one reservoir to another, such as from river to ocean, or from the ocean to the atmosphere, by the physical processes of i) evaporation and evapotranspiration, ii) condensation, iii) precipitation (rainfall/snowfall), iv) runoff, v) infiltration, vi) percolation, and vii) groundwater flow. In so doing, the water goes through different phases: liquid, solid (ice), and gas (vapor).

- The Sun, which drives the water cycle, heats water in oceans and seas. Water from free surface (lakes/ rivers/ oceans) evaporates into the air as water vapor. Ice and snow can sublime directly into water vapor. Again, water from plants and soil gets into the atmosphere through the process of Evapotranspiration.
- Rising air currents take the vapor up into the atmosphere where cooler temperatures cause it to condense into clouds.
- Air currents move water vapor around the globe; cloud particles collide, grow, and fall out of the upper atmospheric layers as Precipitation. Some precipitation falls as snow or hail, sleet, and can accumulate as ice caps and glaciers, which can store frozen water for thousands of years. Most of the precipitation falls back into the oceans or onto land as rain.
- The rainwater travels over the ground as Surface Runoff.
- Runoff falls into rivers or streams, then moves towards the oceans. The volume of water per unit of time in a river or stream is called the streamflow.
- Not all rainwater flows into rivers in form of runoff, part of it gets soaked into the ground by the process of Infiltration.
- Some portion of the infiltrated water stays close to the land surface and can seep back into streams or rivers as the Groundwater flow or Baseflow.

- The remaining portion of the infiltrated water goes deep into the ground by Percolation and replenishes aquifers. This is what we usually call the “groundwater recharge”. By definition, the “Aquifer” is an underground layer of water-bearing permeable rock or soil materials (gravel, sand, or silt) which stores freshwater for long periods of time. Aquifers can be tapped by inserting wells, through which water can be pumped over ground for human usage.
- Some groundwater finds openings in the land surface and comes out as freshwater springs.

In this way, the water returns to the ocean over time, from where our water cycle got started.

Hence, it is understandable that all these processes are connected with one another and a disruption in one of these processes may affect the whole cycle. Figure 1 shows all the major processes in a Hydrologic Cycle.

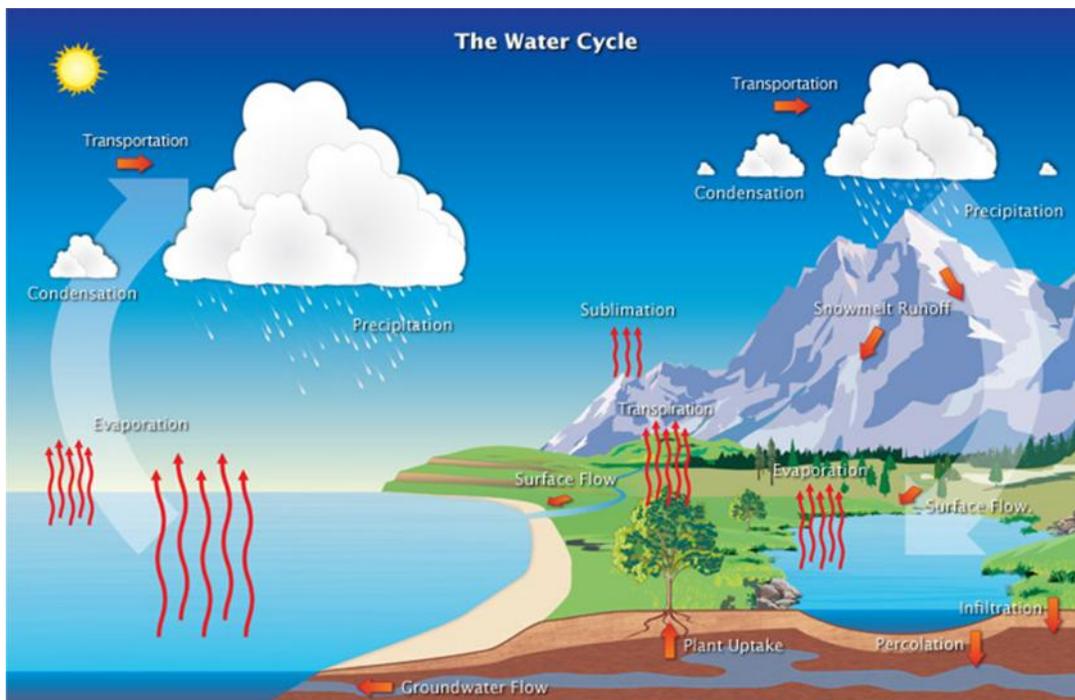


Figure 1. Source: <http://www.earthobservatory.nasa.gov>

Watershed

A watershed is a bounded area of land in which water naturally drains to a point. Think of a watershed boundary as the line that connects all the highest points of that area. This is some sort of an imaginary boundary that directs where the water will flow when it rains or snows. Water will flow down from those highest points towards the streams or rivers within that area, and this water will travel until it reaches the lowest point. This lowest point is the watershed outlet. Watershed can be large or small. Infact, your house backyard belongs to a specific watershed and one watershed can extend beyond many counties, states or even countries. One watershed can consist of multiple smaller sub-watersheds. Very large watersheds are often called “Basins”.

Figure 2 below schematically represents the concept of defining watershed and its boundary.

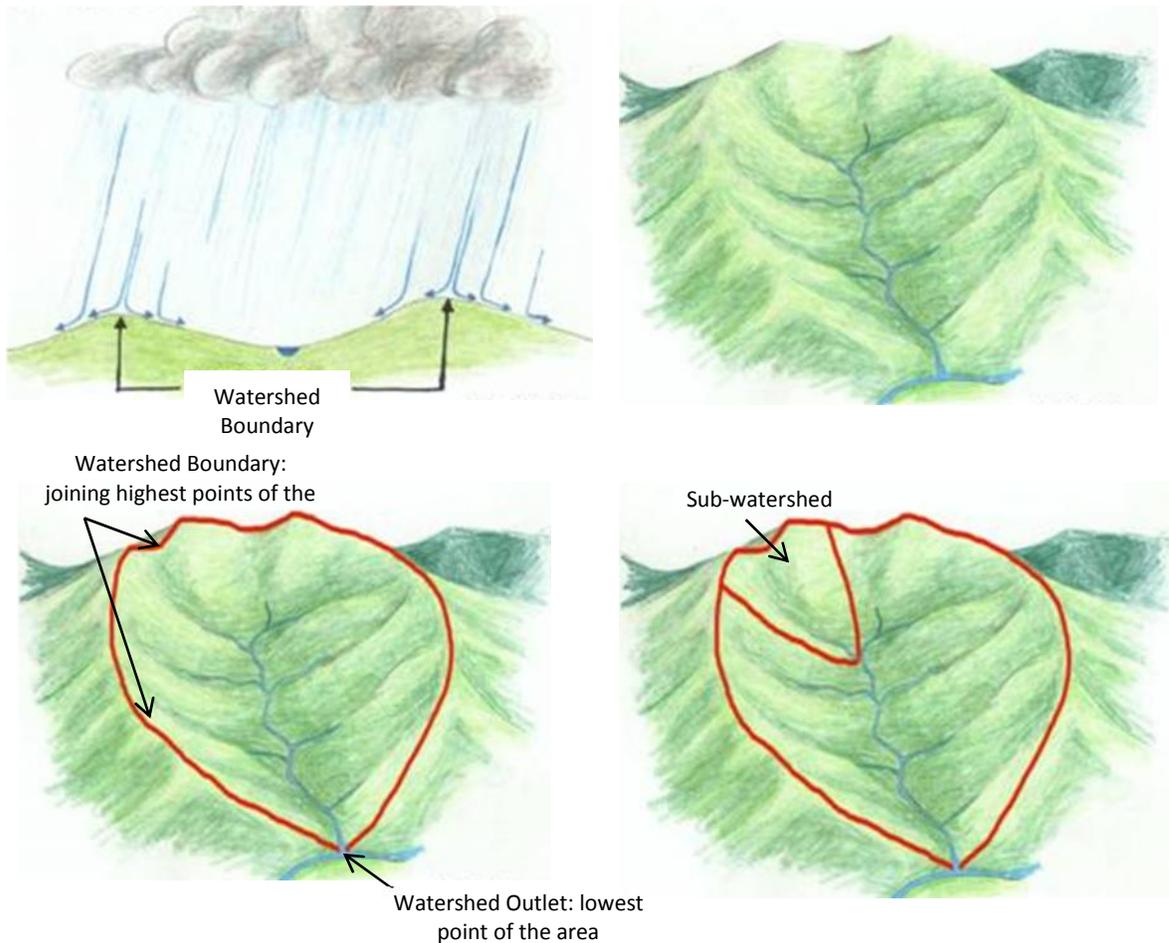


Figure 2. Source: <http://www.ces.ncsu.edu/>

Monitoring Streamflow in a Watershed

As seen in the figure above, a watershed holds tributaries of streams or rivers. All the rainwater falling over the surface within its boundary always drains through these tributaries towards the lowest point. These streams or rivers also get contribution from the groundwater. Hence, flow in a stream is the combined form of surface runoff and the baseflow.

Flow of water is always measured at a specific location along the stream. The United States Geological Survey (USGS) operates thousands of such gaging stations all over the USA, monitoring the streamflow.

- Go to this web link <http://waterdata.usgs.gov/nwis/rt> (see the screenshot below),
- Then select 'Daily streamflow' and 'State' from the drop down menu under 'Predefined displays' and 'Group table by' category.
- Now, click on the 'go' button and you can see all the gage stations sorted under each state.

You can access streamflow records (Daily Mean Streamflow, Annual Peak Streamflow etc.) from any of these locations for a specific date range.



Quiz

1. Rainwater falling over an watershed always drains to _____
 - a. a pond
 - b. lowest point of the watershed
 - c. ground
2. Infiltration is a process, through which
 - a. part of rainwater gets vaporized
 - b. rainwater flows towards the watershed outlet
 - c. water gets absorbed into the ground surface
3. Which one of the following is not a component of the hydrologic cycle?
 - a. Rainfall
 - b. Groundwater flow or baseflow
 - c. Watershed boundary
4. Surface Runoff is the portion of rainwater that
 - a. gets absorbed into the surface
 - b. travels over the ground to reach nearby stream
 - c. gets condensed to form clouds
5. Watershed boundary is
 - a. the boundary of a county
 - b. the boundary joining the highest points of an area which drains onto a point
 - c. line of hills that controls velocity of water movement