Practical Limnology: A Primer Series

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Chapter 1

Introduction: In this series, I will present topics in the field of limnology that are important to water quality, especially for Lake Keowee. The series will follow a logical order and each subsequent topic will build upon, or enhance, previous ones. In a sense, the series will be a detailed story of water and will use Lake Keowee and its watershed as the example.

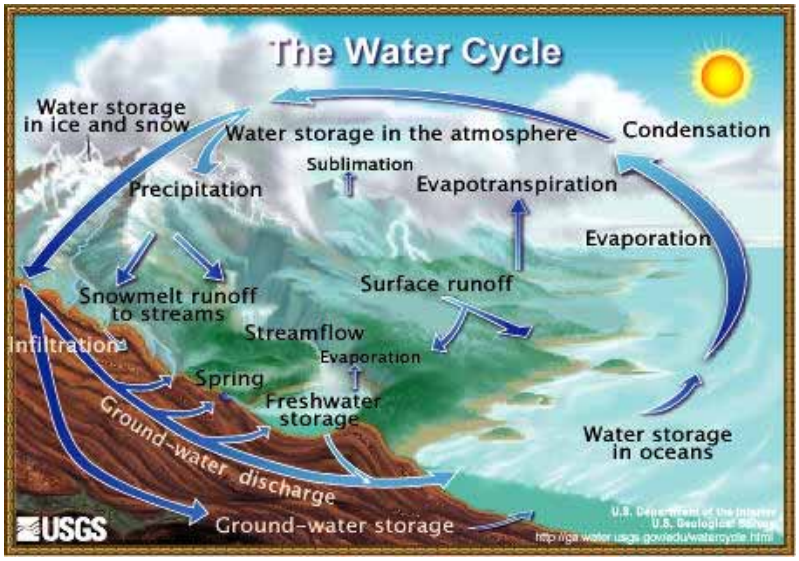
The field of limnology has been likened to 'inland oceanography' and a variety of other similes. It is the study of freshwater, whether in lakes or rivers, and encompasses every process in the watershed that affects both water quantity and water quality. In this sense, it is a field of 'ecosystem' science in that it involves interacting physical, chemical, and biological systems. The field of limnology much in common with other fields and employs them, such as: aquatic ecology, hydrology, geology, hydrodynamics, engineering, geochemistry, sedimentology, etc.

Lake Keowee is a complex system that is affected by many forces. The water in Lake Keowee is deposited as precipitation that is moved to this area by weather, powered by sunlight. The water in Lake Keowee moves in complex patterns that are determined by the type of forces on it and by the shape of the basin. The materials that are dissolved in the water or suspended as particles are moved with the water but each material may have its own unique source. The sources may be natural or man-influenced.

The flow of water through Lake Keowee and the motion of water within Lake Keowee are the product of many forces including the hydrologic cycle, the shape of the basin, the operation of Keowee Dam and of Jocassee Dam, and the operation of Oconee Nuclear Station. The supply and motion of the water are the most important single factor in understanding Lake Keowee and because these are physical processes, the place for this series to begin is with physical limnology. So we will.

The Hydrologic Cycle

Water is continually cycled through natural systems. Water for Lake Keowee mostly comes as discharge from the watershed that includes numerous tributary streams fed by runoff and groundwater, as well as Lake Jocassee and numerous smaller lakes. It arrives as water vapor and is deposited as precipitation. An excellent website in which to explore the hydrologic cycle is:
http://observe.arc.nasa.gov/nasa/earth/hydrocycle/hydro1.html



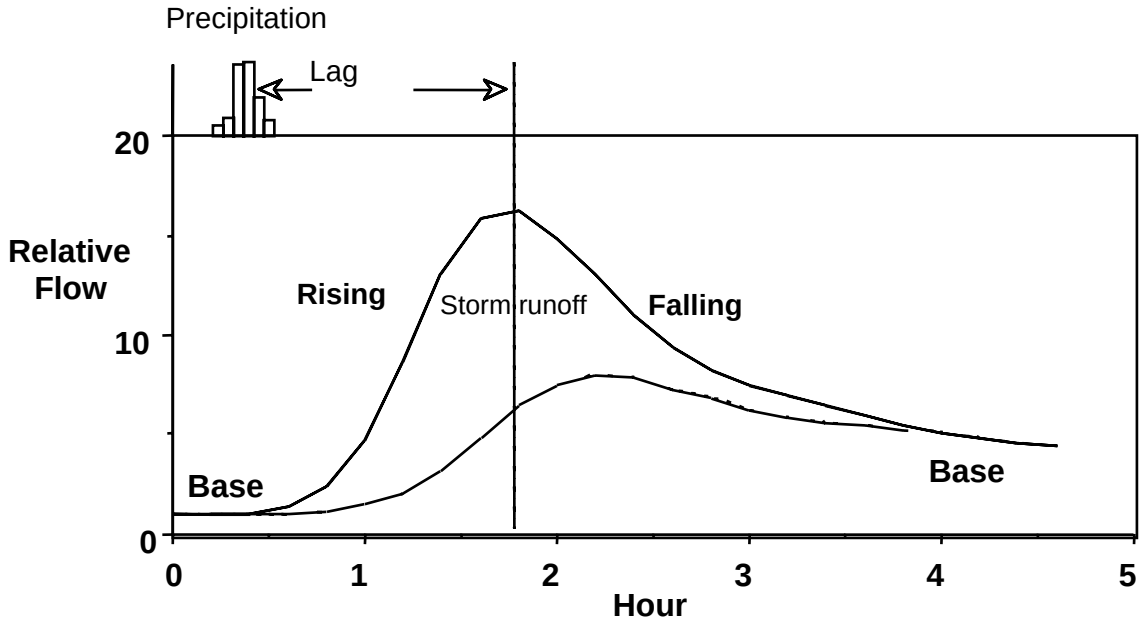
The above figure (from the USGS website) diagrams the hydrologic (water) cycle.

Water moves as it is evaporated from the land, streams, lakes, and ocean, and later precipitated over the Lake Keowee watershed. Much of the water in Lake Keowee originated in the Gulf of Mexico. In order to evaporate water, energy is required just as in the process of making steam. When the vapor condenses and is precipitated, energy is released just as in the thunderstorms we experience in the summer and fall. The energy required for the hydrologic cycle is almost entirely solar. Energy enters the system as sunlight, moves the water, and then energy exits the system as heat, eventually lost from the atmosphere to space. This simple cycle is actually very complex because so many types of energy transfers happen in so many places.

In the cycle diagrammed above, the energy of the sun is responsible for evaporation of water from surface waters. Water taken up in plants is also lost as vapor and this process is called ‘transpiration’. Together, evaporation and transpiration in the watershed combine to form ‘evapotranspiration’. Precipitation occurs in two primary forms, snow or sleet, and rain – both forms occurring in the Lake Keowee watershed but dominated by rain.

Precipitation that does not evaporate before it reaches the soils of the watershed can be absorbed by those soils thus recharging the groundwater, or it can run off the surface. Normally, if the rate of precipitation exceeds the ability of the soil to absorb the water, the excess is runoff.

Streams carry precipitated water from both surface runoff and from groundwater release. Streams flowing during long times between precipitations are flowing due to releases from groundwater. The variation of stream flow, or discharge as it is often termed, can be plotted graphically. This graph is called a ‘hydrograph’. A typical hydrograph is shown below.



Hydrograph of Single Storm

In this hydrograph are depicted a storm event in the watershed, the base flow due to groundwater discharge, and the rising and falling limbs of the storm hydrograph. The timing and intensity of the hydrographic response to a storm is determined by the intensity of the storm and the characteristics of the watershed. The hydrograph for a watershed that is well-forested and relatively undisturbed will respond more slowly, over a longer time, than for a watershed that contains large area of impervious surfaces such as in urban areas. Impervious surfaces include any land cover that does not absorb water: parking lots, roads, driveways, roofs, etc. In the Lake Keowee watershed, increased construction of impervious surfaces will change the hydrographic response of streams entering the lakes. Increased impervious surfaces will result in quicker hydrographic response and higher peak flows. Such a change would be important for many reasons that will be discussed in later additions to this series.

The next topic will be the sources and transfers of the energy driving this system. The combination of the energy transfers and the water movement set the stage for the most important characteristics of any lake. And for Lake Keowee this is also very true.