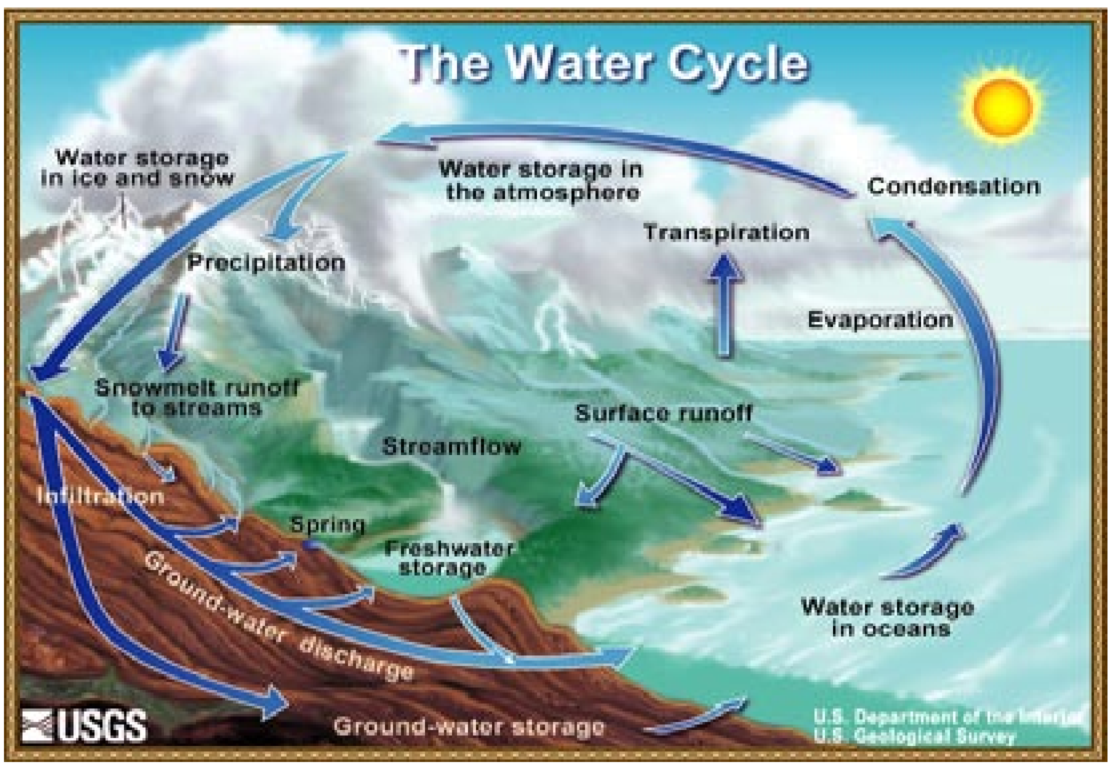
Chapter 2

Water Budgets

When trying to understand some aspects of hydrology, whether it is ground-water flow, springs, surface water, evaporation, water quality, or any other topic, one needs to first look at the whole system. In hydrology, all topics are dependent on each other.

For example, precipitation distribution affects runoff and ground-water recharge. Recharge affects ground-water levels in shallow aquifers. Ground-water levels can affect springs and contributions to surface water. Precipitation, geology, ground-water levels, and surface water can affect water quality, and these interactions and relations continue throughout a hydrologic system.

The term scientists use for the overall system is the Water Cycle. On a global scale, the water cycle can be simplified into a series of steps that a particle of water would follow from one natural state to another. The following diagram illustrates this process.



In this cycle, a water particle gets evaporated from the ocean. The particle contributes to cloud formation as condensation. The clouds move over the land surface, become cooled, and the water particle falls to the land surface as either rain or snow. The runoff or snowmelt either flows downgradient as surface water or infiltrates the ground and becomes ground water. Both the surface water and ground water ultimately discharge to the oceans, and the cycle starts all over again. Of course, this is a gross simplification of the real world water cycle, and water particles actually can follow a multitude of pathways that are all part of the water cycle.

For example, water that reaches the Earth as rainfall or snowfall can be evaporated back into the atmosphere before it has the chance to infiltrate or become runoff. Various interactions occur between ground water and surface water; water that infiltrates and becomes ground water can later discharge to the surface as springs or baseflow to streams and possibly reenter the ground-water system later in stream-loss areas or become evaporated and reenter the atmosphere. So water can take many different paths in the water cycle, but the overall concept is valid, that being water is always changing from one state to another, and the process is continuous.

This brings us to a discussion about water budgets. A water budget is a lot like a budget you might keep for your personal finances. Many inputs and outputs can affect the budget.

Let's look at a single basin in order to better understand water budgets. In a basin, certain natural water inputs exist. These include precipitation (rainfall and snowfall) and inflows by streams and ground water from other basins upgradient. The water outputs from the basin include ET (evaporation of surface water and transpiration from vegetation using water) and streamflow and ground-water flow out of the basin. These natural factors can affect affect a basin's water budget.

Of course, human influence such as ground-water pumpage, artificial recharge, manmade lakes and reservoirs, vegetation removal, surface paving of open fields, irrigation of crops, etc. can affect the natural water budget of a basin.

One way to look at water budgets is as a simple equation:

Water Budget = Inputs – Outputs +/- Changes in Storage

In a balanced system, the inputs would equal the outputs in quantity. However, it's the changes in storage that raise concerns. Going back to the personal finance example, if this was your savings account, your account would be in balance (no change) if your income equaled your bills paid each month. If you lower your income, not all the bills can be paid without dipping into savings. Likewise, if you get a nice promotion, then your bills get paid and your savings account grows.

The increase or decrease in your balance is the same as changes in storage in the water budget. If the precipitation and inflows of surface water and ground water equal the outputs from ET and outflows of surface water and ground water, then the water budget is balanced and storage does not change. However, if one component is changed, then the system is no longer in balance and storage changes.

Examples of what can change the storage include both natural and human impacts. During drought, precipitation decreases, which results in less input into the water budget for a particular basin. With less precipitation, it's probable that ground-water levels will decline. The ground-water level decline results in a change in water storage for the basin because less water is now held in the aquifers. Likewise, if climatic conditions changed and above-normal precipitation occurred for a few years, then more recharge to the aquifers would result, which would be an increase in basin water storage.

Human impacts, such as wells installed in aquifers in a basin for either public supply or irrigation, also could result in changes in storage because the balance of the water budget was altered. Often, water pumped for human consumption is transported out of the basin, so this water is effectively a loss in storage. Water pumped for irrigation usually stays within a particular basin, but much of that water is lost to ET when applied to surface crops. Therefore, the output side of the equation is increased with this activity and it results in a change in storage.

One thing to consider when looking at water budgets is the effect of scale. Many potential impacts on a water budget, such as annual variations in precipitation or ground-water pumpage for domestic uses, are so small compared to the total size of the basin and the ground-water system that the effects are practically unnoticeable. Also, so much water in Nevada is lost to ET that many changes in the inputs and outputs of a water budget are masked by slight changes in the amount of water lost to the atmosphere.

Because of the large scale of the basins and the small scale of the impacts, many of these effects are too small to measure. Also, because so much water is stored in aquifers in eastern Nevada, even large-scale ground-water pumpage might not be detectable in the short term (years or decades) because the water is coming out of storage and not directly from the inputs and outputs. In other words, the effects on springs, lake levels, and vegetation might not be detectable for a long time.