Chapter 17

Evapotranspiration

ET is the combination of evaporation and transpiration. Evaporation is the process of liquid water converting to vapor. Transpiration involves the uptake of water by plants and the subsequent release of vapor from the leaves. Because the two processes typically take place together in the same environment and each are difficult to quantify separately, the two terms are combined into ET.

Discharge for basins in Nevada typically consists of a combination of natural and man-induced components. Ground-water flow out of a basin, ground-water discharge in the form of springs, and ET are the natural components of the hydrologic budget, whereas pumpage of ground water for agricultural uses and human consumption make up the man-induced components. ET is part of the discharge side of the hydrologic budget, where recharge equals discharge, plus or minus a change in aquifer storage.

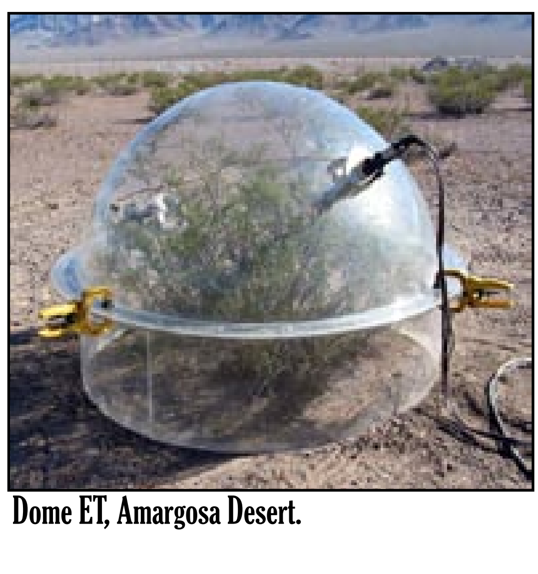
Evaporation takes place from surface-water bodies, soil moisture, and ground water to depths of several yards below land surface. Sometimes humans help increase the effects of evaporation by pumping ground water for irrigation. The amount of evaporation related to aerial irrigation (spraying) can be a significant proportion of the water withdrawn for this purpose.

Transpiration depends on plant type and density, soil characteristics, root depth, and climatic factors such as temperature, relative humidity, and solar radiation. In Nevada, xerophytes, such as many types of sagebrush, tend to transpire much less water than phreatophytes, which are plants with tap roots reaching the water table. Some studies have actually shown small cones of depression in the water table around phreatophytes because of the removal of ground water by the roots.

Measuring ET is not always easy. In earlier studies, ET was often considered the residual component in the water balance equation after accounting for the known quantities. What this means is that other factors, such as precipitation, streamflow, spring discharge, ground-water flow, pumpage, ground-water levels, and other variables affecting the water balance, were measured and quantified. The unknown, ET, was estimated as the difference between the known recharge and discharge components (plus or minus change in storage). Obviously, this technique does not allow for much confidence in the ET estimates.

Most studies now attempt to quantify ET as a measurable component to the equation. However, many different ways exist to do this, and like most science topics, disagreements and debates occur over which method is the best.

One method to quantify ET is to conduct laboratory experiments that measure transpiration rates for various plants and then apply that information to real world settings. For example, say that three types of plants exist in a certain basin. If the average transpiration for these plants was measured, and estimates of evaporation for bare soils and surface water were made, then aerial photos showing plant coverage could be used to make estimates of ET for the basin.



Dome ET, Amargosa Desert.

Measuring ET in the field can be accomplished using several methods. These methods include dome measurements, weighing lysimeters, and energy-budget calculations. Dome measurements and weighing lysimeters are the most direct methods for estimating ET.

The dome method involves placing a large plastic dome over a representative area of plants and soils. The actual amount of water released as ET is measured. This method provides a short measurement (minutes), so it essentially takes a "snapshot" of the ET.

Weighing lysimeters are, in their simplest form, containers of soil, buried flush with the ground surface, that are weighed periodically. Vegetation that ideally represents the surrounding area is planted in the lysimeter at land surface. Use of weighing lysimeters requires measurements of weight changes that result from ET (weight loss) or precipitation (weight gain).

Two other methods for measuring ET in the field involve the Bowen-ratio and eddy-correlation methods, which are based on energy-budget calculations associated with the process of ET. During the ET process, energy is used to convert water from liquid to vapor and transfer the vapor to the atmosphere.

In the environment, energy is partitioned by the energy budget into four principal components: (1) net radiation, the sum of all incoming and outgoing radiation; (2) subsurface heat, the amount of energy stored in the soil or water; (3) sensible heat, the amount of energy that heats the air directly above the soil, plant canopy, or water surface; and (4) latent heat, the amount of energy consumed by the process of ET.

Very sophisticated instrumentation is used to measure the four different energy components. The instrumentation is deployed in the field of study for up to several years. By solving the energy budget based on the measurements of the four energy components, estimates of ET can be derived.

It is important to have a good understanding of ET in order to make accurate assessments of water budgets for any given basin. For example, a USGS study was done in Ruby Valley National Wildlife Refuge in 2000 where in 1 year about 89,000 acre-feet (about 29 billion gallons) of water was lost to ET.

ET Station in Ruby Valley. Photograph by D.L. Berger, USGS.