

Groundwater Recharge

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What is Recharge?

The water balance of a system can be expressed as a relationship relating all of the inputs and outputs into or out of the system.

The major input to the land surface is typically precipitation (P). When precipitation falls on the ground there are several possible pathways the water can take;

- (1) It could travel across the ground surface as overland flow (O) moving toward a nearby ditch or stream (sometimes called runoff).
- (2) It could evaporate (E) back into the atmosphere directly from the soil surface, or from a ponded area of water (pond, lake, stream, etc.)
- (3) It could percolate into the soil and then be captured by plant roots to be transpired (T) back into the atmosphere.
- (4) It could percolate into the soil and then move laterally as interflow (I) through the soil zone toward a depression or water body.
- (5) It could percolate into the soil and become trapped in the pores between soil grains and remain there in storage (S) for some time, or
- (6) It could percolate down into the soil to the water table thus entering the aquifer to become groundwater (R). This process is called “recharge” and is essentially the amount of water left over after all of the surface and near surface processes have impacted the water.

Water balance relationships can be expressed as an equation $P - O - E - T - I - S = R$ which describes the water balance of water budget of a system. While each of the terms in the equation are important, **recharge, R** is extremely important to hydrologists and water managers in Nebraska as it is a measure of how much water will be added to the groundwater reservoir and thus be available for use as a resource.

The amount of recharge occurring at a given location is typically expressed as a depth of water across the watershed (similar to the way precipitation is expressed). For example, recharge may be said to be 3 inches for a given area. This means that if the volume of recharge water in a given watershed was spread out over the entire area of the watershed it would pond at a depth of 3 inches. Inherent in this usage, but not always expressed is a time constraint. That is to say, *recharge amounts are expressed over some time – typically a year*. So, recharge is 3 inches per year in the above example. When expressed as a volume (or depth) per time, the value is called the **recharge rate**.

Recharge within a watershed is a function of many different factors including (but not limited to) the amount, distribution and frequency of rainfall across the watershed, land cover and land use, the amount of bare soil, vegetation type, soil type and soil properties, etc. Thus, recharge is not a constant value in either space or time. Said another way, *recharge changes throughout the year and is different at various locations across a watershed*. Thus, the recharge rate can be a very difficult value to quantify.

Estimating Recharge

A number of methods exist for estimating the recharge rate of a given area. No one method is the standard, and each method has its own strengths and weaknesses. Some methods determine the actual amount of recharge at a given location over some measurement time, using soil

moisture sensors, isotopic or chemical tracers, or other soil-water/groundwater monitoring devices to track the movement of water through the soil zone and down to the watertable. These methods are often more expensive, much more labor intensive and are very site specific, but typically give more accurate values than other estimation methods. These methods can also be used to evaluate how the recharge rate changes in time and space.

Other methods estimate recharge over larger areas and longer timescales using a water-balance approach, but these may be subject to less accuracy than direct measurement methods and often need to make assumptions that may or may not be valid in all situations. For example, one common method used by water managers is to estimate R using a hydrologic model (SWAT for example). If the other parameters in the surface/shallow soil water budget are known, or can be measured or estimated with some accuracy using other methods, R can be calculated by difference or as the residual. Another common method is to use a numerical groundwater model (such as MODFLOW) to estimate R by adjusting the recharge input value in the model until groundwater levels calculated by the model match the aquifers measured water level values. One problem with this approach is that often changing other hard to determine parameters such as hydraulic conductivity and aquifer storage may also impact the calculated water levels.

The major problem with each of these longer-term water-balance estimation methods is that they typically compute a constant value over some longer period of time, for example 4 inches/year. While this value may be satisfactory for some watershed management problems, it may not be suitable for others, specifically short-term situations such as groundwater pumping, impacts of short-term drought, etc., as the methods do not typically account for the spatial and temporal variation in the recharge value within the watershed.