ground water

Guest Editorial/

It Is the Discharge

by John Bredehoeft

We all know the mantra *Keep It Simple*—the principle KISS. I have been thinking of another mantra for ground water—*It Is the Discharge.* Let me explain: In a recent conversation with one of my distinguished colleagues, he bemoaned our lack of understanding of ground water recharge. I keep thinking about that conversation. In a broad sense as hydrogeologists, we are hoping to understand how aquifer systems function, more particularly how much water is flowing through a particular system—the focus on recharge is simply one facet of the larger task. In studying the system, there are at least three aspects that we can focus on—(1) the recharge; (2) the aquifer itself as a transmission mechanism; and (3) the discharge from the aquifer.

One of the first principles of hydrogeology is that the recharge is balanced by the discharge before the system is perturbed. One tack commonly taken is to focus on the discharge and assume that recharge equals discharge. Of course, when we model a system in a virgin state, the mathematics demand conservation of mass, and the recharge, flow through the aquifer, and the discharge are balanced (or we do not have a solution to the problem). Often it is the capacity of the aquifer to transmit water that determines both the recharge and the discharge—the aquifer can accommodate only so much flow.

Generally, the recharge is the most difficult component of the ground water system to quantify, which brings me back to my colleague's comment—Shouldn't we be spending additional research effort to understand the recharge? My response is that it is more fruitful to examine the discharge. However, rarely do I hear hydrogeologists say that they are studying ground water discharge, especially in the academic community. Yet, the discharge is generally there to be observed—it occurs as springs, as base flow to streams, and as water for phreatophytes in the desert environment. There is a reason why hydrogeologists in Nevada still use the Maxey/Eakin method to estimate recharge, a method published in 1949—no one has come up with an improved procedure to estimate recharge even given 50+ years of further investigation. On the other hand, the methods of measuring phreatophyte discharge are greatly improved.

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Furthermore, human activities that impact a ground water system ultimately impact the discharge. It is usually the ground water discharge that is captured during ground water development. The USGS (1972) in *Definitions of Selected Ground Water Terms* published the following definition of *capture*:

> Water withdrawn artificially from an aquifer is derived from a decrease in storage in the aquifer, a reduction in the previous discharge from the aquifer, an increase in recharge, or a combination of these changes. The decrease in discharge plus the increase in recharge is termed capture.

Many aquifers can be analyzed mathematically as if they are linear systems; this includes all confined aquifers and even water table aquifers where the change in head, caused by a given stress, does not change the saturated thickness greatly. In this case, neither the recharge nor the discharge is of concern; rather, the changes in these quantities, caused by the stress—the capture, are of interest. In the linear mathematical system, if one knows (1) the geometry of the aquifer system, (2) its hydrologic properties (permeability and storage), and (3) the boundary conditions, one can determine the impact of a given stress on the system. Often it is the discharge that we end up capturing.

Even if the recharge is not of pragmatic concern, it still may be of interest—we would like to fully understand the ground water system. Other factors such as how contaminants are transported through the system sometimes depend upon the recharge.

I have no doubt that studying recharge will be high on the list of research topics for the future. I am also confident that the recharge is better understood through the discharge where there is an integrated and observable hydrologic signal, and that discharge is of much more pragmatic concern than recharge. Harold Thomas, the distinguished professor of Water Resources at Harvard, was working on the problem by studying stream hydrographs; unfortunately, he died before he could publish his ideas. I tried unsuccessfully to point out the importance of the discharge in commenting on a proposed National Academy of Sciences/National Research Council research agenda—my remarks had no impact. Still, my argument is—*It Is the Discharge*.

Editor's Note: Opinions expressed in the editorial column are those of the author(s) and do not necessarily reflect those of the National Ground Water Association or the staff of the journal.