IRRIGATION AND THE GROUNDWATER BUDGET: NO FREE LUNCH

William L. Bland[1]

Introduction

Irrigation is fundamentally the act of distributing water onto soil that is not quite wet enough to keep crop plants growing at their best. But as the old saying goes, there is no free lunch. We pay for irrigation in some obvious ways–equipment, energy–but also in some harder-to-count ways. Irrigation water has to come from somewhere–what are the impacts of this extraction? How much irrigation is too much?

Irrigation water comes from rivers, lakes, and groundwater. In Wisconsin groundwater is the main source of irrigation water, and it is groundwater pumping that is raising the most concerns. How do we understand the costs that irrigation imposes on the groundwater? First, a brief review of the basics of groundwater. Groundwater resides in near-surface layers of Earth, in the pores and cracks within and between materials such as sandstone, sand and gravel, and limestone. A significant body of such geological material with pores filled with water is called an *aquifer*. Water in soil, lakes, and rivers may become groundwater by percolating downward into an aquifer, in a process termed *recharge*. Groundwater can escape its dark confines by bubbling up to the surface as a spring, or seeping upward through the bottoms of lakes, streams and rivers, a process called *discharge*. When we try to track the rates of recharge, discharge, and changes to the amount of water stored in a aquifer we say that we are working out its *budget*. Some aquifers were filled many thousands of years ago and no longer undergo much recharge or discharge, while in other aquifers water is just passing through (slowly) from areas of recharge to areas of discharge. In the most common type of aquifer we call the upper boundary of the fully-full-of-water (saturated) pores the *water table*.

When we drill a new well and pump from it for irrigation (or manufacturing or drinking) we are adding a new discharge point to the aquifer. What is the impact of a new discharge? How much can we safely extract through it? This is one of the key questions surrounding the sustainability of irrigation.

An intuitive answer–that turns out to be wrong–is that the rate at which we extract water by pumping from an aquifer should not exceed the rate of recharge to the aquifer. One way to recognize that this is too simple an answer is to imagine the aquifer system before any wells are drilled into it. Water enters the aquifer as recharge, lingers a time as it moves slowly toward a discharge (there can be several), and finally is discharged to the surface (Fig. 1A). The amount of water stored in the aquifer, often reflected in the elevation of the water table, is the result of a balance between the inputs and outputs–recharges and discharges–of water. Add another discharge and this balance is upset. Imagine that an acquaintance proposes adding a new automatic deduction to your bank account–will this be alright as long as it is for less than your automatically deposited paycheck?

For your bank account and an aquifer a new discharge will begin to lower the balance/water table. If you do not make some adjustments this will eventually empty your bank account. In the case of groundwater aquifers what happens is the water table becomes deeper and changes shape in ways that decrease the water flows to other discharges. There's no free lunch, something's gotta' give, you can't get something for nothing...

---

[1] Professor, Dept. of Soil Science, 1525 Observatory Dr., Univ. of Wisconsin-Madison, WI, 53706

The impacts of reducing other discharges by pumping from a well depend on the situation. When the elevation of a water table drops, flow out a spring may slow, or even stop. We do not know how many springs have disappeared in the Madison area as a result of pumping by the city water utility. A more subtle impact occurs when discharge into a stream bottom is reduced by pumping in the vicinity (Fig. 1B). The average flow in the stream may just be slightly reduced, by a small enough amount that it is difficult to measure amidst the daily, monthly, and annual natural variation. The effects may not be of significance during months and years of high stream flow (because of rain and snow), but can be deadly at times when stream flow is naturally small. The situation in the Little Plover river near Stevens Point is a good example of this.

There is a saying in ecology (ascribed to various thinkers): “You can’t do just one thing.” It reminds us in a subtle way that there are always multiple implications for any one of our actions. Fortunately for humans Earth is bountiful, and we can do lots of things without causing damage–although, like every other species on Earth, we cannot help but bring about a bit of change. Irrigation (and every other extraction of water from rivers and groundwater) reduces some other discharge. If we are fortunate, the impacts will be so small that we hardly notice and, if the impact can be measured, no one else cares. When impacts are large, though, our choices about how we manage groundwater become everyone’s business, rightfully so.

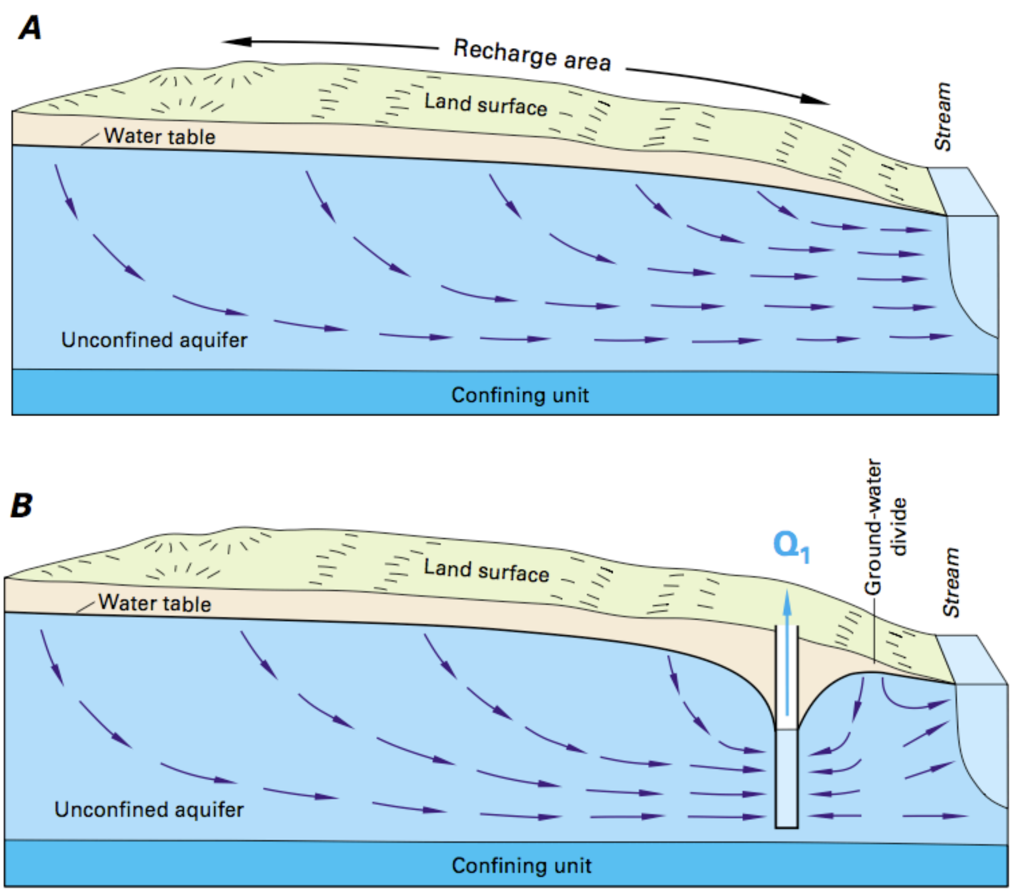

Figure 1. A. Schematic of groundwater recharge, flow, and discharge to a stream, in the absence of human intervention. **B:** When groundwater is extracted from a well this new discharge changes the water table and reduces discharge to the stream. *Source:* USGS circular 1186.