Net inflow –a key quantity for defining pathways towards sustainability in heavily stressed aquifers

*James J Butler[1], Geoffrey C Bohling[1], Donald O Whittemore[1], Blake B Wilson[1]

1. Kansas Geological Survey, University of Kansas, Lawrence, KS USA

The depletion of aquifers that support irrigated agriculture is a pressing problem across the globe. A frequently asked question is how to redirect these heavily stressed systems on to more sustainable paths. If alternative water supplies are not available, the only viable option for the near term (few to several decades) is to reduce pumping. The key issues therefore become how much should pumping be reduced to significantly extend the lifetime of an aquifer and what is the likelihood of attaining a sustainable state for the system. We have developed a new water-balance approach to glean insights into these issues and give water managers a convenient tool for application in seasonally pumped aquifers supporting irrigated agriculture. This approach, which can be used to assess the impact of pumping reductions and to chart pathways towards more sustainable states, shows that the response to pumping reductions heavily depends on the net inflow (all inflows to the aquifer minus all outflows except pumping) component of an aquifer’ s water budget, both in terms of its magnitude and how it changes with time in response to the reductions. The net inflow will decrease in response to pumping reductions; prospects for sustainability will depend on the proportion of the various components making up the net inflow (e.g., how much is natural recharge versus how much is irrigation return flow) and their sensitivity to the reductions. If a pumping reduction leads to a pumping rate that is above the net inflow at the time of the reduction, the aquifer lifespan can often be extended by a factor of two or more but depletion will be the final outcome. If a reduction results in a pumping rate equal to the net inflow, the aquifer lifespan will be extended further but again depletion will be the end result. In contrast, if a reduction results in a pumping rate below (>10-15%) the net inflow at that time, sustainability may be achievable. At the very least, there will be a lengthy period of apparent sustainability during which water levels remain above the level at the time of the reduction. In any case, the aquifer lifespan will be lengthened to such an extent that other options, such as large-scale water transfers, may become viable. These concepts will be demonstrated using examples based on data from an ongoing large-scale (256 km^2) experiment in pumping reductions in the High Plains aquifer in the state of Kansas in the central United States; the role of climate change will be incorporated into the analysis using regional-scale projections. These results indicate that field monitoring of net inflow and its changes through time must become a higher priority for the water resources community. As we have shown in earlier work (Butler et al., GRL, 2016), this can be readily done when reliable pumping and water-level data are available. Although efforts to parse out the individual contributors to net inflow will ultimately provide the clearest picture of what the future holds, many useful insights of practical importance can be obtained through greater attention to this quantity.

Keywords: aquifer sustainability, pumping reductions, net inflow, High Plains aquifer

