GROUNDWATER MONITORINGFOR MITIGATION: WILL IT WORK?

Monitoring of the hydrologic cyclical is a time honored and worthwhile endeavor. Society monitors rainfall, and compares it to past records to know if this is it a wet or dry year. We monitoring streamflow for similar purposes; for example, the first decade, in the 21st Century, of streamflow in the Colorado River is lower than any decade in the 20th Century.

Monitoring for a different purpose was introduced recently into the management of groundwater. Pumping groundwater ultimately diminishes the natural outflow from groundwater basins. For example: The Southern Nevada Water Authority (SNWA) is proposing to pump large quantities of groundwater from desert valleys north of Las Vegas, south of Ely, and transport the water in a large pipeline to Las Vegas. The most recent proposal was for pumping from three valleys: Cave, Dry Lake, and Delamar Valleys. Recharge from these valleys is believed to provide water for a large spring complex south of the three valleys: the Muddy River springs. The Nevada State Engineer in granting the SNWA permit request acknowledged that natural outflow from the groundwater system would be diminished. He insisted that the springs be monitored with the explicit instruction that should deleterious impacts be observed, there must be measures taken to mitigate the impacts. (A Nevada Court recently vacated the State Engineer's ruling in this hearing.)

The question is: Can one monitor a real groundwater system, with the idea of identifying the explicit impacts of pumping from individual wells or pumping centers, as the Nevada State Engineer implied, and which various Federal agencies bought into? It is virtually impossible. Let me explain why:

A Simple Monitoring Model

Scientists and engineers use computer models to investigate real systems, often to identify cause and effect. With that thought in mind, let's perform a simple modeling experiment to monitor the impacts of pumping.

Figure 1 is a hypothetical valley in the Great Basin:

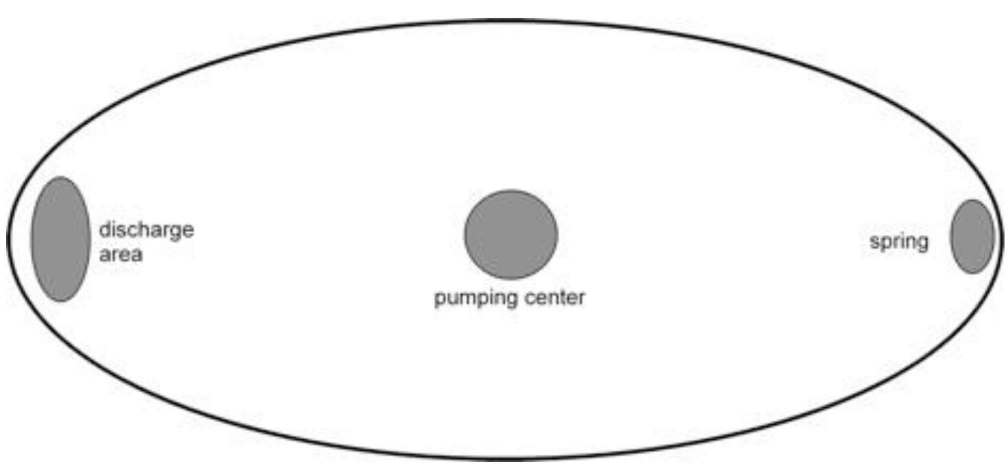

Figure 1. Schematic map of a hypothetical valley in the Great Basin: 50 miles long by 25 miles wide. Recharge occurs at the left extremity of the valley, and outflow from a spring at the right extremity of the

valley.

In the hypothetical valley recharge occurs at a rate of 100 cubic feet per second (cfs) and outflow occurs in a spring, before development, at the same rate.—the system is balanced, inflow equals outflow. The valley is highly permeable with aquifer properties like those encountered in many Great Basin valleys. We simulate pumping in the central part of the valley using a numerical groundwater model.

We initiate pumping at 100 cfs—the same rate as the recharge and the spring flow. The spring flow will decline as it is impacted by the pumping. Once the spring flow drops by 10% to 90 cfs we terminate the pumping. During this process we monitor the spring flow, shown in Figure 2.

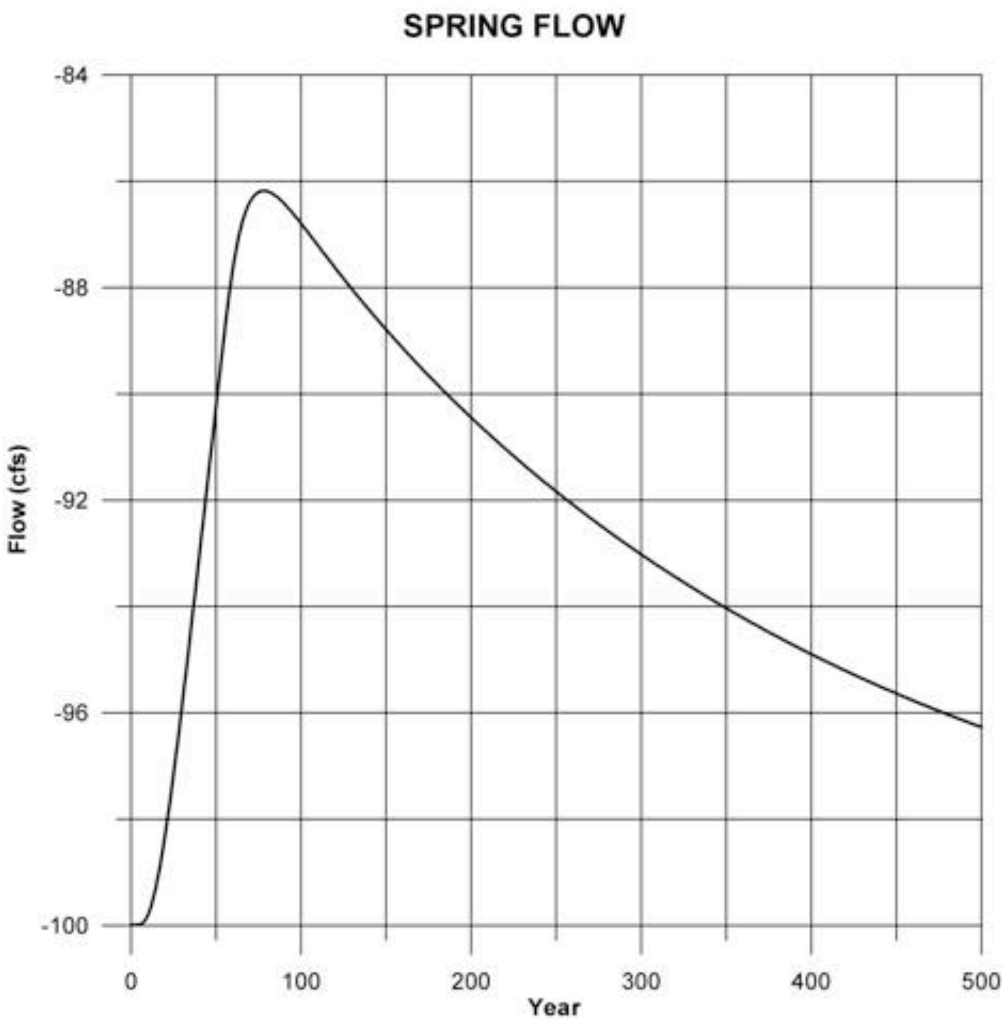

Figure 2. Simulated spring flow as a function of time. The pumping is stopped at year 50.

We see in Figure 2 that even though the pumping is stopped after year 50, the spring continues to decline at the same rate for another 15 to 20 years. It takes 25 years after pumping is stopped before the spring flow starts to recover. The spring flow recovery is very slow; even after an additional 450 years the spring has not recovered to its initial rate of 100 cfs, even though the recharge to the aquifer is at a constant 100 cfs throughout the entire period.

Most people are surprised that even though we stopped pumping after 50 year, the spring flow continues to decline, at the same rate, for another 20 years. We would be tempted to say that something else was happening in the basin that we had not accounted for, but our model, we know, accounts for everything. There are good hydrologic reasons why the spring flow continues to decline for such a long time after pumping was stopped—I will not bore the reader with these. It is enough to say that the pumping created a perturbation on the system; it takes some time for this disturbance to work its way through the entire system.

Recovery takes a long time because we are replenishing storage that was depleted during the pumping at only approximately 10%, or less, of the rate in which it was depleted during pumping. We depleted storage at a rate of approximately 100 cfs for 50 years. After pumping the spring flows at approximately 90 cfs, and we are recharging at 100 cfs. The difference, approximately 10 cfs is going into storage.

Monitoring in Real Life

In our model experiment we know the exact cause of the spring decline—pumping. Now let's imagine that we are monitoring the Muddy River springs where we think that recharge from Cave, Dry Lake, and Delamar Valleys support the outflow from the springs. The proposed SNWA pumping from these valleys ranges from approximately 50 to 100 miles from the spring complex. We start to pump in these valleys. Over time the spring discharge declines, as it undoubtedly will. An existing model of the system suggests that the impact on the spring might be delayed by more than 100 years, perhaps by as much as several hundred years.

We will try to sort out the cause of the spring decline. Undoubtedly, there will be wet and dry climate periods in the intervening years since pumping was initiated. There may be permanent climate change. Others will be pumping from the catchment. There is pumping within the spring complex for a nearby power plant, there is pumping in Coyote Springs valley, just to the north for a new resort, there is other pumping to the south. There will be proponents for each of these factors as the principal cause in the decline. Careful modeling might suggest cause and effect; but there will not be a consensus about using model results. Few will argue for totally stopping pumping, especially if large investments in infrastructure were made to support development. One can envision a horror story.

The Muddy River springs are the home of an endangered species, the Muddy River Dace. The fish breed in the springs that are higher in elevation in the complex. These will be some of the first springs to be impacted by a lowering of the water table in the area, caused by the pumping, that in turn reduces the spring flow. Ultimately a Federal Court, empowered by the endangered species act, my restrict all the pumping thought to impact the springs.

Once the genie of development is out of the bottle, especially with pumping in valleys that impact distant springs, it will be virtually impossible to return it to the bottle—the die will be cast. Adverse impacts will undoubtedly follow. These impacts will be difficult, if not impossible to mitigate. The idea of monitoring, with the intent to mitigate adverse impacts, sounds good; it is totally impractical, a screen behind which to hide politically driven decisions.