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Talk of the Town

Column: What is a groundwater-flow model?

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Recently the U.S. Geological Survey (USGS) published its Regional Groundwater-Flow Model of Aquifer Systems of Northern and Central Arizona. It is a computerized numerical model that simulates interactions among groundwater systems over much of northern Arizona, including the Prescott region and the Big Chino and Verde Valleys.

This long-awaited regional, peer-reviewed model was prepared in cooperation with the Arizona Department of Water Resources and Yavapai County for use primarily by water managers in Yavapai County. As both public and private entities put the model to use, we can expect to see statements, articles and debates about what the results mean or don't mean for our local water resources.

In this column we will provide an overview of what a numerical groundwater-flow model is and how it can be used, and we will say a bit about reliability. Most of this description was condensed, with permission, from a paper by William Meyer and Edward Wolfe titled "What is a Numerical Groundwater Model?" at http://vrbp.org/outreach.html.

An aquifer or groundwater system can receive natural or artificial recharge. Groundwater flows within the system and discharges from it. Groundwater naturally discharges from aquifers into springs and streams, and some can be consumed by vegetation with roots that reach to shallow groundwater. Groundwater is also discharged by pumpage from wells.

A numerical groundwater model is a computer model of a groundwater system that is used to simulate recharge to, the movement of groundwater within, and the discharge of water from the system under both natural and man-made conditions, such as pumping. This makes the model a predictive tool that allows evaluation of the probable consequences of human actions. The predictive capability depends upon the degree to which the model accurately simulates the groundwater system.

The movements of water into, through, and out of an aquifer are interdependent components of a groundwater system. A change in one of these components affects the others. Pumpage from wells necessarily changes the amount and movement of water within a groundwater system and reduces the natural discharge from that system, ultimately by an amount equal to the pumpage.

The purpose of model construction is almost always to allow us to predict the hydrologic effects of particular human stresses on the groundwater system. Water managers are most interested in predictions about water-level changes and changes in the amount and location of groundwater discharge to wells, springs or streams.

In order to refine and assess their predictive capability, most models are first constructed to simulate natural conditions; this process is referred to as model calibration. Following calibration, the model is then adjusted to reproduce known man-made changes; this process is referred to as model verification. The degree to which a model can be calibrated and verified provides the modeler with an indication of the predictive capability of the model.

Some information necessary to fully calibrate and verify a model is nearly always lacking, and this lack requires assumptions to be made during model construction. For instance, the distribution of rain gauges is generally insufficient to accurately portray the distribution and rate of groundwater recharge from precipitation and can at best only be estimated.

Even less information may be available on the distribution of those geologic factors that control the movement and storage of water within the groundwater system. In general, the larger the area simulated by a model, the more likely is the need for making assumptions that are incorporated into the model.

Despite these constraints, when the model's design appropriately simulates the groundwater system, the calibration and verification processes can be used to establish reasonable limits on the model's predictive capability. When these constraints are considered, a numerical groundwater model is, without question, the most effective tool available to evaluate the consequences of man-induced changes on the movement and storage of water in a groundwater system and the changes in the rates and location of groundwater discharge from it.

Previous conceptual models by the USGS and others showed us that pumping at the Big Chino Water Ranch would result in an eventual near-corresponding reduction in the Verde River flow, but not the time for the reductions to occur. The new USGS numerical model will be used to predict the magnitude of the reductions over time.

Please submit your comments and questions to info@cwagaz.org.

University of Arizona professor Michael Crimmins will present "Climate Change and Arizona: Past, Present, and Future" when he speaks to CWAG on June 11 from 10 a.m. to noon at the Granite Peak Unitarian Universalist Congregation, 882 Sunset.

John Zambrano is president of the Citizens Water Advocacy Group and is a retired environmental engineer.

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