Southwest
HYDROLOGY
The Resource for Semi-Arid Hydrology

Volume 4/Number 1 January/February 2005

Photo donated and copyrighted by Adriel Heisey, a photographer based in northern Arizona. More information about his work is available at www.adrielheisey.com.

Sustainability in an Era of Limits

Southwest Hydrology
University of Arizona - SAHRA
P.O. Box 210158-B
Tucson, AZ
85721-0158

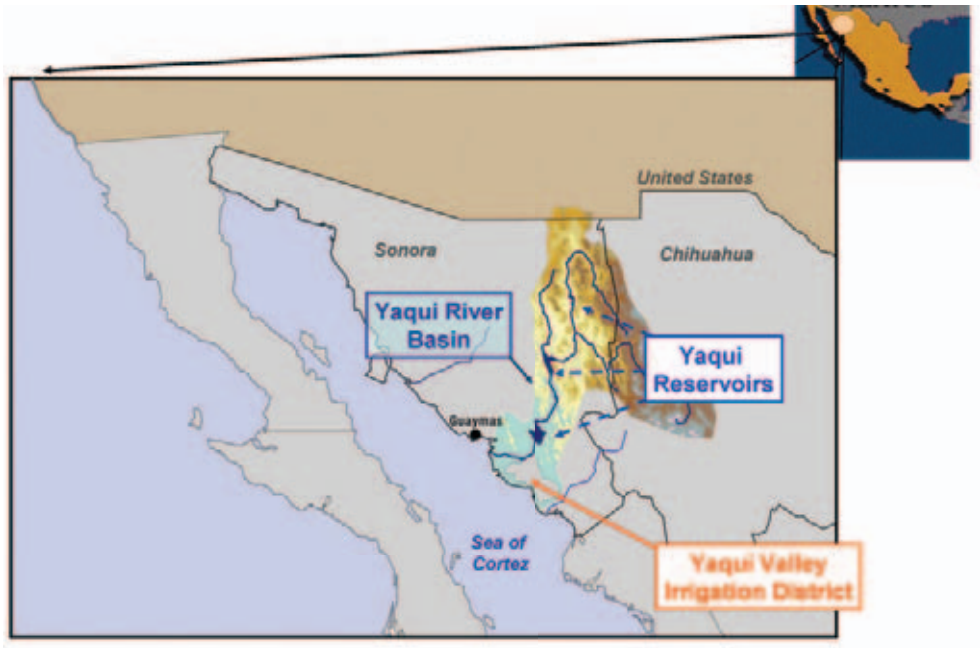
Address Service Requested

A publication of SAHRA, an NSF Science and Technology Center · The University of Arizona

Evaluating Increased Groundwater Use in the Yaqui Valley, Mexico

Lee Addams, Ph.D. *– International Research Institute for Climate Prediction, Columbia University*

Irrigated agriculture currently accounts for 77 percent of global water withdrawals, with that figure rising to 90 percent in developing countries. Although irrigated agriculture currently represents less than 20 percent of total farmland, it contributes 40 percent to the world's total food production (World Bank, 2004). Providing enough water for agriculture requires more efficient use of existing surface water and groundwater. In addition, innovative and reliable management solutions to improve the efficiency and dependability of water systems will be crucial for maintaining the food supply from irrigated agriculture (Rosegrant et al., 2002).



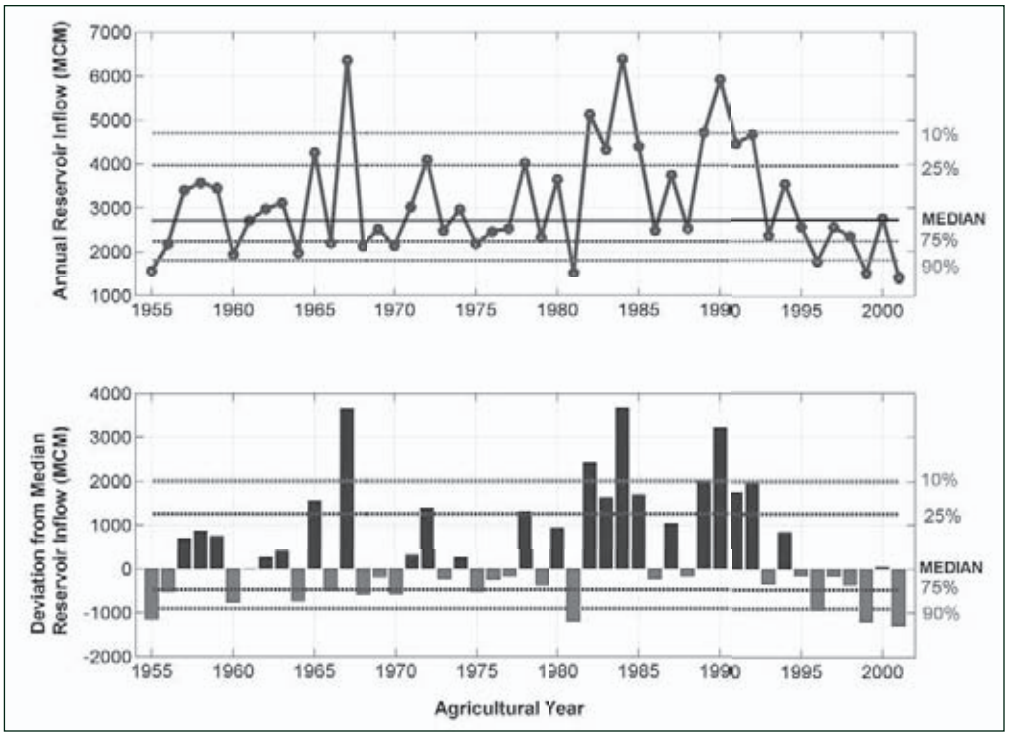
Map of the Yaqui River Basin, northwestern Mexico. The basin encompasses 72,000 km² in two Mexican states (Sonora and Chihuahua).

The Yaqui Valley, a semi-arid, irrigated coastal plain in Sonora, Mexico, approximately 500 miles south of the Arizona border (see map), provides much of the wheat grown in Mexico. During the past seven years, however, a severe drought has reduced Yaqui River discharge, with significant economic consequences for the agriculture that is dependent upon it. Although National Water Commission planners are separately working on improved, long-term operating rules for reservoir management, local farmers in the irrigation district are beginning to turn to groundwater and have secured international funding to effectively double the well capacity through new drilling (*La Tribuna*, 2003).

In principle, increasing the use of Yaqui Valley groundwater as a buffer to surface water variability seems like a good idea. In contrast to neighboring agricultural regions to the north and south (and much of the arid southwestern United States), the Yaqui Valley historically has underutilized groundwater resources because of the normally plentiful surface water supply of the river. Prior to the recent drought, Yaqui River water used for agriculture averaged 2,619 million cubic meters (MCM) (2.1 million acre-feet) per year compared with only 225 MCM (182 acre-feet) per year of groundwater, about 8 percent of the total.

To evaluate the potential benefits of increased groundwater use in the Yaqui Valley, an integrated hydrologic-economic-agronomic modeling framework was developed by researchers at Stanford University. The management model framework represented crop and water decision-making by farm subunits of the irrigation district as well as water distribution and well pumping decision-making by the irrigation district. Eight crops were available to each module, with the three major crops (wheat, maize, and safflower) also modeled for yield response to water and salinity. A spatially explicit groundwater flow model and a canal network simulator are linked to the management models. The economics of crop prices and production costs, including energy costs for pumping, significantly influence agricultural decision-making in this area and are also integrated into the modeling framework. Since surface water is essentially free for the irrigation district, the price of district-provided water depends on both the fraction of groundwater used by the district and the pumping costs that must be passed along to farmers.

The model was run using the two-level management-modeling framework to predict groundwater use behavior over the drought period from 1995 to 2003. Initial results showed that farmers would indeed use more well capacity to supplement declining reservoir allocations. However, even though total modeled extractions are "sustainable" in a resource sense, the model also showed that during years of extremely low surface-water availability, the cumulative groundwater drawdown resulted in exceptionally high pumping costs (and therefore water prices) during the "critical year." Only high-value crops (citrus and vegetables) could be profitably grown during such a situation. Using this insight, policy makers and lenders can consider the secondary economic assistance that may be needed to support crop diversification in the valley before drilling more wells. From these preliminary results, the model will be extended to answer related "what-if" scenarios of proposed infrastructure change, such as canal lining, as well as climatic variations.



Historical reservoir inflows (net runoff) for the Yaqui River Basin, 1955-2002. The most recent drought started in 1996.

Contact Lee Addams at addams@iri.columbia.edu. Visit yaquivalley.stanford.edu for more information on research in the Yaqui Valley.

References

La Tribuna, "Autorizan 70 Mdd al Distrito de Riego," May 12, 2003.

Rosegrant, M.W., X. Cai, and S.A. Cline, 2002. World Water and Food to 2025: Dealing with Scarcity. Washington, D.C., International Food Policy Research Institute.

World Bank, 2004. Water Resources Sector Strategy: Strategic Directions for World Bank Engagement. Washington, D.C., World Bank.

Southwest Hydrology HydroFacts

Increase in the cost of all goods and services in U.S., 1980-2003: 97%
Increase in the cost of water and sewer services in U.S., 1980-2003: 175%

Budget for NOAA's 2004 climate change research program: $70 million
Budget for 2004 climate change movie, "The Day After Tomorrow": $125 million

Maximum number of typhoons ever to hit Japan in one season prior to 2004: 7
Number of typhoons that hit Japan during 2004: 10

Fraction of water news articles, Aug. '01 to Oct. '04, from Africa containing the word "sustainable": 1 in 22
Fraction of water news articles, Aug. '01 to Oct. '04, from U.S. containing the word "sustainable": 1 in 200

Average annual population growth rate for U.S., 1970-2002: 1.1%
Average annual population growth rate for Albuquerque, Tucson, Phoenix and Las Vegas metropolitan areas: 1.9%, 2.9%, 3.9%, and 5.5%, respectively.

Gallons of water used to refine one gallon of crude oil: 44
Gallons of water used to manufacture one car, including tires: 39,090