Coupling Hydrologic, Economic, and Social Network Models to Improve Understanding of Surface Water-Groundwater Interactions for Protection of Instream Flows

PIs: Nicholas Brozović, John Braden, Ximing Cai, Stephen Gasteyer, and Albert Valocchi
University of Illinois at Urbana-Champaign

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In many regions of the world, agricultural, urban, and environmental water users share the same sources of water. In recent years, a major source of water conflict has been the increased extraction of groundwater from areas that are physically connected to rivers and streams, and the resulting loss of instream flows. The impacts of decreased instream flows include reduction of habitat for fish and migratory birds, changes in stream and riparian zone form and habitat, and decreases in water availability for dam and reservoir operation, recreation, and downstream uses. Although hydrologists have long conducted field studies of the physical aspects of groundwater-surface water exchange, little is known about the feedbacks operating between natural and human components of complex surface water-groundwater systems, which are uncertain, spatially variable, and may include nonlinear and threshold behavior. Two sites for studying surface water-groundwater systems where an understanding of the complex interactions between human and natural components is critical to effective policy design are the Kankakee River Basin in Illinois and the Republican River Basin in Nebraska and Kansas. As a result of groundwater pumping, both areas have experienced reduced stream flows that are of concern to policymakers. However, the two basins differ dramatically in terms of economics, institutions, history of management, stakeholder conflict, and current policies. The objectives of this research project are (1) to quantify the economic and social impacts of uncertainty in coupled surface water-groundwater systems; (2) to evaluate how variability in individual and social group behavior can affect modeling and policy design for surface water-groundwater systems; (3) to analyze the impacts of decision making processes on the development of socially acceptable surface water-groundwater management policies; and (4) to develop efficient and socially acceptable policies to manage surface water-groundwater systems in order to maintain instream water flows. The methods to be used in this study include numerical modeling and simulation, statistical analysis, the use of geographical information systems, interviews with stakeholders, and advanced visualization techniques. The research will address fundamental hydrologic and socioeconomic questions, while also integrating training and learning activities for K-12 and graduate students, as well as outreach activities to local and international stakeholders.

By integrating analysis of natural and human systems, this research will provide significant advances in the development and calibration of natural system models, which typically ignore all uncertainty arising from human interventions. The improved scientific models derived from this research will advance policy design that maintains or improves instream environmental conditions while improving economic prospects and minimizing the potential for stakeholder conflict. This project will provide practical information on how to improve water resource management and reduce stakeholder conflict in our two study areas. Research findings will also be of general interest in many parts of the world where coupled surface water-groundwater systems are the source of conflict. This project is supported by an award resulting from the FY 2007 competition in the Dynamics of Coupled Natural and Human Systems.