

Enhanced groundwater modelling methods for analyses in ecohydrology

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Abstract Water operations policy to support improved habitat for riparian and aquatic species is being implemented in many regions of the United States. Habitat-motivated outcomes include surface and groundwater hydrology metrics. The desired hydrological outcomes include specific seasonal hydrographs to support spawning and other fish needs; and, overbank flooding or maintenance of shallow groundwater conditions to support native riparian vegetation, providing nesting habitat or serving other ecological functions. Success in achieving surface water and groundwater metrics is dependent on multiple concurrent interactions, not only between surface water and groundwater within the hydrogeological setting of the near-river zone, i.e. river gains and losses, but also on evapotranspiration, which varies by plant group, season, and depth to groundwater; and, on regional groundwater boundary conditions, which may be influenced by climate, urban, or irrigation demand. Finally, the river bed itself may undergo change under different flow regimes, and present further uncertainty in extrapolating from historic hydrological relationships to future conditions. To improve understanding of hydrological relationships in the near-river zone and assess impacts of water operation alternatives on ecology-based hydrological metrics, a modelling approach has been developed that incorporates transient processes that potentially impact groundwater conditions and groundwater–surface water interactions. This approach has been applied to the evaluation of river restoration and water operation alternatives on the Rio Grande in New Mexico and the San Joaquin River in California, USA. Very high-resolution three-dimensional groundwater models are employed, with the width and depth of wetted river channel and flooded overbank areas set as flow-dependent boundary conditions, obtained from a companion surface water routing model. To incorporate variable water demand by vegetation, riparian plant functional groups are identified that can be separately assigned potential evapotranspiration rates, seasonally-varying rates of water use, and rooting depths. External transient processes, such as regional water demand, that impact the near-river groundwater zone are specified according to a hypothesized future condition. Model simulations illustrate the sensitivity of desired hydrological metrics to other elements of the ecosystem, and demonstrate the need to evaluate possible future scenarios not against static assumptions drawn from past observed conditions, but in light of physically-based transient system dynamics.

Key words riparian; groundwater; ecohydrology; modelling; conjunctive use; New Mexico; California; San Joaquin; Rio Grande