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SIMULATION OF WELLFIELD-OPERATION EFFECTS ON THE VULNERABILITY OF PUBLIC-SUPPLY WELLS TO CONTAMINATION

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ABSTRACT: Variations in hydraulic heads and gradients that result from episodic withdrawal rates and schedules can affect the vulnerability of public-supply wells to contamination from both natural and anthropogenic sources. Although withdrawal rates and schedules may be constrained by factors such as seasonal water demand and variable energy costs, their effects on vulnerability to contamination should be considered when water quality is a component of well-field optimization. If unacceptably high contaminant concentrations can be reduced by judicious pumping schedules, storage costs incurred by the temporal discordance of water demands and pumping schedules may be justified. Evaluation of different pumping schedules is facilitated by transient flow and contaminant transport simulations particular to individual hydrogeologic settings.Aquifer study sites in Albuquerque, New Mexico and Modesto, California contain both anthropogenic (VOC and/or nitrate) and natural (arsenic and/or uranium) contaminants. Although mitigation of vulnerability to anthropogenic contaminants from shallow sources is a goal at both sites, they differ in natural-contaminant source depths (deep vs. shallow) and dominant directions of vertical hydraulic gradients. Vulnerability to contamination can be characterized by the groundwater-age distribution measured for a supply well and associated implications for source depths of the withdrawn water. For the Albuquerque site, a local-scale transient groundwater-flow model was coupled with local grid refinement to a basin-scale flow model. A corresponding local-scale transport simulation of several tracers of young and old groundwater observed in both public-supply and observation wells enabled improved calibration of parameters representing hydraulic conductivity and effective porosity. For the Modesto site, an existing simulation was modified to simulate transient flow and transport from a distributed shallow source containing high alkalinity and associated uranium. The transport models for the two study sites were used to evaluate the effects of different pumping schedules on the concentrations of contaminants, from shallow and/or deep sources, simulated in the public-supply wells of interest.Although details of the sites differ, they each feature seasonal pumping cycles and long-screen production wells that serve as short circuits for contaminant migration during low-pumping cycles. Increasing withdrawals during low-pumping cycles could reduce flow from contaminated to previously uncontaminated aquifer depths within the screened interval.

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