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Reducing the impact of a desalination plant using stochastic modeling and optimization techniques

Client: Veolia Waters

Keywords: Pumping/injection tests, model calibration, contamination, geostatistics, tidal response test

Four out of 200 simulated (above) and estimated (below) log-diffusivity fields.

Summary: Water is critical for economic growth in coastal areas. In this context, desalination has become an increasingly important technology over the last five decades. It often has environmental side effects, especially when the input water is pumped directly from the sea via intake pipelines. However, it is generally more efficient and cheaper to desalt brackish groundwater from beach wells rather than desalting seawater. Natural attenuation is also gained and hazards due to anthropogenic pollution of seawater are reduced. In order to minimize allocation and operational costs and impacts on groundwater resources, an optimum pumping network is required. Optimization techniques are often applied to this end. Because of aquifer heterogeneity, designing the optimum pumping network demands reliable characterizations of aquifer parameters. An optimum pumping network in a coastal aquifer in Oman, where a desalination plant currently pumps brackish groundwater at a rate of 1200 m3/h for a freshwater production of 504 m3/h (insufficient to satisfy the growing demand in the area) was designed using stochastic inverse modeling together with optimization techniques.

The Monte Carlo analysis of 200 simulations of transmissivity and storage coefficient fields conditioned to the response to stresses of tidal fluctuation and three long term pumping tests was performed. These simulations are physically plausible and fit the available data well. Simulated transmissivity fields are used to design the optimum pumping configuration required to increase the current pumping rate to 9000 m3/h, for a freshwater production of 3346 m3/h (more than six times larger than the existing one). For this task, new pumping wells need to be sited and their pumping rates defined. These unknowns are determined by a genetic algorithm that minimizes a function accounting for: (1) drilling, operational and maintenance costs, (2) target discharge and minimum drawdown (i.e., minimum aquifer vulnerability) and (3) technical feasibility of the solution. Results show that the combined use of stochastic inverse modeling and optimization techniques leads to minimum side effects (e.g., drawdowns in the area are reduced substantially) and to a significant reduction of allocation and operational costs.