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Stochastic inversion of hydraulic tests for highly permeable unconfined aquifers – model development and application to an aquifer in the middle reach of the Wu River in central Taiwan

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The spatial distributions of transmissivity (T) and storage coefficient(S) in aquifers are important for accurately evaluating groundwater resources and predicting contaminant transport. To obtain aquifer parameters with great detail, much attention has been paid to improve the efficiency and capability on aquifer characterizations. Hydraulic tomography surveys (HTS) is a conceptually improved technique and has been recognized to be efficient for estimating high resolution aquifer parameters. Based on the concept of HTS, this study presents a stochastic inverse model for estimating transmissivity and specific yield (Sy) in highly permeable unconfined aquifers. A synthetic example is first employed to assess the accuracy of the developed inverse model. Several hydrogeological conditions, including aquifer types and the numbers of pumping/injection evens and the associated head observations, are considered in the test example to provide general insight into the characterization strategies for practical applications. The developed model is then applied to field-scale, cross-hole hydraulic tests in a highly permeable unconfined aquifer near middle reach of the Wu River in central Taiwan. For all the hydrogeological conditions in the synthetic example, the existing HTS model for confined aquifers is employed for comparison purpose. Results of the synthetic example show that the developed inverse model can reproduce well the predefined geologic features of the unconfined aquifer. The HTS models for confined and unconfined aquifers may lead to slightly differences in estimating T and Sy near pumping/injection wells if the same head observations are used for estimating aquifer parameters. For aquifers with high mean ln (T) (about 2000m2/day), the numbers of pumping/injection evens can be significantly reduced for both confined and unconfined HTS models. However, the increase of pumping/injection events can not improve much the estimation accuracy of highly variable T and Sy in aquifers. Based on the field test data from Wu River aquifer, we found high mean ln(T) (about 2500m2/day) but small variation of ln(T) (ln T variance = 0.005∼0.01) for the well field. However, the Sy distribution shows relatively high variation (ln Sy=0.01), especially near some well locations. Such results may be influenced by well clogging or unexpected failure of well bores.