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Reliable groundwater levels: failures and lessons learned from modeling and monitoring studies

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Adequate management of groundwater resources requires an a priori assessment of impacts of intended groundwater abstractions. Usually, groundwater flow modeling is used to simulate the influence of the planned abstraction on groundwater levels. Model performance is tested by using observed groundwater levels. Where a multi-aquifer system occurs, groundwater levels in the different aquifers have to be monitored through observation wells with filters at different depths, i.e. above the impermeable clay layer (phreatic water level) and beneath (artesian aquifer level). A reliable artesian level can only be measured if the space between the outer wall of the borehole (vertical narrow shaft) and the observation well is refilled with impermeable material at the correct depth (post-drilling phase) to prevent a vertical hydraulic connection between the artesian and phreatic aquifer. We were involved in improper refilling, which led to impossibility to monitor reliable artesian aquifer levels. At the location of the artesian observation well, a freely overflowing spring was seen, which implied water leakage from the artesian aquifer affected the artesian groundwater level. Careful checking of the monitoring sites in a study area is a prerequisite to use observations for model performance assessment. After model testing the groundwater model is forced with proposed groundwater abstractions (sites, extraction rates). The abstracted groundwater volume is compensated by a reduction of groundwater flow to the drainage network and the model simulates associated groundwater tables. The drawdown of groundwater level is calculated by comparing the simulated groundwater level with and without groundwater abstraction. In lowland areas, such as vast areas of the Netherlands, the groundwater model has to consider a variable drainage network, which means that small streams only carry water during the wet winter season, and run dry during the summer. The main streams drain groundwater throughout the whole year. We simulated groundwater levels with a steady-state groundwater flow model with and without groundwater abstraction for the wet and dry season, i.e. considering a high (all streams included) and low drainage density (only major streams), respectively. Groundwater drawdown maps for the wet and dry season were compiled. Stakeholders (farmers, ecologists) were very concerned about the large drawdowns. After a while and discussions with the Water Supply Company and stakeholders, we realised that we had calculated unrealistic large drawdowns of the phreatic groundwater level for the dry season. We learnt that by applying a steady-state model we did not take into account the large volume of groundwater, which is released from the groundwater storage. The transient groundwater model that we developed then, showed that the volume of groundwater released from the storage per unit of time is significant and that the drawdown of the phreatic groundwater level by the end of the dry period is substantially smaller than the one simulated by the steady-state model. The results of the transient groundwater flow model agreed rather well with the pumping test that lasted the whole dry season.