Groundwater Modeling and Ecosystem Management – The Case of Houthalen-Helchteren Military Domein

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The objective of this study was to use groundwater modeling as a tool for the management of a highly groundwater-dependent ecosystem. Management of such an ecosystem requires a profound knowledge on local hydrogeological conditions as groundwater availability is one of the main factors determining plant type and distribution.

Over the last decade the water table below a military proving ground in the North-East of Belgium has been successively lowered to improve on-site military operability and intensify agricultural use nearby. For this purpose a network of drainage canals had been constructed. Dewatering has lead to a gradual deterioration of the local ecosystem. As the area is part of the NATURA 2000 network (BE2200030) the ecosystem should be conserved in accordance with the Habitats Directive (92/43/EEC) and it has been agreed on among stakeholders to set up a management plan that focuses on ecosystem restoration by also taking military needs into consideration. It was decided to develop a groundwater model of the site to conduct a scenario analysis regarding the influence of the drainage network. This model can aid as decision support tool during restoration measures.

The study site is situated at 70-80 m asl on top of the Campine plateau covering roughly 2200 ha. The underlying unconfined aquifer has a thickness of about 200 m and consists of several layers of Quaternary and Tertiary sands and fine gravels with varying glauconite content and occasional local clay lenses.

A conceptual model was set up using data from regional models as well as local data from previous studies. Two problems being faced with were the lack of local data for hydraulic conductivity and the area being situated exactly on the water divide of two major catchments, the Meuse and the Scheldt.

Groundwater flow was modeled using MODFLOW-2005. The model comprises more than 900,000 cells and the modeling period was chosen from 1991-2010. Rivers and drainage canals were implemented using the DRAIN package. First, a three-layer steady state model was set up using annual long-term averages for recharge modeled with WetSpass. A sensitivity analysis was performed with ModelMate, identifying hydraulic conductivity as the most sensitive parameter. Calibration was done in UCODE-2005 using water level time series of 37 piezometers on-site. Hydraulic conductivities for layers 1-3 were estimated at 1.24, 1.38 and 1.02 m/d respectively, with layer three also containing a subzone of much lower conductivity. MAE and RMSE were determined at 0.87 and 1.13 m. Calibration results and errors were verified with the double constraint method (DCM), which showed similar values (MAE of 0.8 m and RMSE of 1.0 m).

Afterwards, a three-layer transient model was created using monthly recharge values over the entire modeling period. Observed and modeled water levels were in good agreement. As measured groundwater levels seemed to contain too little information, leading to equifinality, addtional soft observations on vegetation zones influenced by groundwater seepage was taken into account during model calibration.

Results from a number of scenarios with varying drainage network density were used as input for an ecological model that uses average lowest groundwater levels and compares estimated future ecosystem development with the actual state as well as a reference state. As such, scenario analysis helped with decision support regarding measures for ecosystem restoration.