Modelling of the groundwater flow in Baltic Artesian Basin

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Baltic Artesian Basin (BAB) is a multi-layered complex hydrogeological system underlying about 480'000 km2 in the territory of Latvia, Lithuania, Estonia, Poland, Russia, Belarus and the Baltic Sea. The model of the geological structure contains 42 layers including aquifers and aquitards from Cambrian up to the Quaternary deposits.

The finite element method was employed for the calculation of the steady state three-dimensional groundwater flow with free surface. The horizontal and vertical hydraulic conductivities of geological materials were assumed constant in each of the layers.

The Precambrian basement forms the impermeable bottom of the model. The zero water exchange is assumed through the side boundaries of BAB. Simple hydrological model is applied on the surface. The level of the lakes, rivers and the sea is fixed as constant hydraulic head in corresponding mesh points. The infiltration is set as a flux boundary condition elsewhere. Instead of extensive coupling with hydrology model, a constant mean value of 70 mm/year was assumed as an infiltration flux for the whole BAB area and this value was adjusted during the automatic calibration process.

Averaged long-term water extraction was applied at the water supply wells with large debits. In total 49 wells in Lithuania (total abstraction 45000 m3/day), 161 in Latvia (184000 m3/day) and 172 in Estonia (24000 m3/day) are considered.

The model was calibrated on the statistically weighted (using both spatial and temporal weighting function) borehole water level measurements applying automatic parameter optimization method L-BFGS-B for hydraulic conductivities of each layer. The steady-stade calculations were performed for the situations corresponding to undisturbed situation (1950-ies), intensive groundwater use (1980-ies) and present state situation (after 2000).

The distribution of piezometric heads and principal flows inside BAB was analyzed based on the model results. The results demonstrate that generally the flow is directed from southeast to northwest, but the more shallow aquifers show strong influence by local topography. There is an intensive transient flow in Cm aquifer system and this flow is separated from upper layers by thick aquitard O-S. About 25% of the aquifers volume is under free flowing artesian conditions.