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A hydrogeological study of the confined aquifers below the Boom Clay in NE-Belgium: combining a piezometric analysis with groundwater modelling

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For more than 35 years, SCKCEN has been investigating the possibility of high-level and/or long-lived radioactive waste disposal in the Boom Clay in north-eastern Belgium. This research, defined in the long term management programme for high-level and/or long-lived waste of ONDRAF/NIRAS, includes studying the regional hydrogeology of the aquifer systems surrounding the Boom Clay. In this context, a hydrogeological study of the confined aquifers below the Boom Clay was performed. To properly address the conceptual uncertainties related to the poorly characterized domain featuring large uncertainty in the forcing data, a combination of a piezometric data analysis and hydrogeological modelling was used.

The study area represents the confined part of the groundwater system located stratigraphically below the Boom Clay in NE-Belgium. This so-called deep aquifer system includes, with increasing depth, parts of the Oligocene aquifer, the Bartoon aquitard system and the Ledo-Paniselian-Brusselian aquifer. Due to the considerable pumping from these aquifers in combination with a limited recharge to the deep aquifer system, a gradual decrease in groundwater levels has been observed in more than 30-year piezometric records.

The analysis of the piezometry of the confined deep aquifer system allowed gaining more insight on the system response to the intensive pumping. Since the Oligocene aquifer has a significantly lower permeability compared to the Ledo-Paniselian-Brusselian aquifer, the Oligocene pumping triggers only local effects on groundwater levels. Hence, the regional effects (constant decrease of groundwater levels) in the Oligocene aquifer are presumably caused by pumping in the Ledo-Paniselian-Brusselian aquifer, whereby the hydraulically isolating Maldegem Formation (Bartoon aquitard) dampens these effects. The amount of this dampening is given by the spatial distribution of the hydraulic properties of the Maldegem Formation and/or its variable thickness. For the piezometers located in the Ledo-Paniselian-Brusselian aquifer, we see that although the pumping is concentrated in the south, it causes the water level to decrease far northwards, which implies a higher hydraulic conductivity of this aquifer than the Oligocene aquifer.

A transient hydrogeological model was constructed for the area in order to confirm the findings of the piezometric analysis and to analyze the regional flow processes occurring in the deep aquifer system. Since groundwater pumping is the most important process affecting the groundwater flow in the deep aquifer system, we reconstructed the pumping history in the Oligocene aquifer, the Bartoon aquitard system and the Ledo-Paniselian-Brusselian aquifer as far as possible into the past. The detailed geometry of the Oligocene aquifer and Bartoon aquitard system was introduced in the model, implying a variable thickness of the clay layers in these formations.

The model was calibrated using an automated calibration algorithm and is able to reproduce satisfactorily the general trends in the observed groundwater level data. The most sensitive parameters of the model are the pumping amount, the hydraulic conductivity of the Ledo-Paniselian-Brusselian aquifer and the vertical hydraulic conductivity of the clay layers in the Oligocene aquifer and the Bartoon aquitard system. The outcome of the hydrogeological modelling confirms the results of the piezometric data analysis and is further used for assessment of the regional flows in the deep aquifer system.