Comparison between a steady-state and a transient flow model and related radionuclide concentration predictions

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Radionuclide concentration predictions in aquifers play an important role in estimating impact of planned surface disposal of radioactive waste in Belgium, developed by the Belgian Agency for Radioactive Waste and Enriched Fissile Materials (ONDRAF), who also coordinates and leads the corresponding research.

Long-term concentration predictions are based on a steady-state flow solution obtained by a cascade of multi-scale models from the catchment to the detailed (site) scale performed in MODFLOW. To test the concept and accuracy of the groundwater flow solution and conservativeness of the concentration predictions obtained therewith, a transient model, considered more realistic, was set up in a sub-domain of the intermediate scale steady-state model. Besides the modelling domain reduction, the transient model was and exact copy of the steady-state model, having the infiltration as the only time-varying parameter. The transient model was run for a twenty-year period, whereas the results were compared to the steady-state results based on infiltration value and observations averaged over the same period. The comparison of the steady-state and transient flow solutions includes the analyses of the goodness of fit, the parameter sensitivities, relative importance of the individual observations and one-percent sensitivity maps.

The steady-state and transient flow solutions were subsequently translated into a site-scale transport model, used to predict the radionuclide concentrations in a hypothetical well in the aquifers. The translation of the flow solutions between the models of distinct scales was performed using the Local grid refinement method available in MODFLOW. In the site-scale models, MT3DMS transport simulations were performed to obtain respective concentration predictions in a hypothetical well, situated at 70 meters from the disposal tumuli. The equilibrium concentrations based on a constant source flux achieved using a steady-state solution were then compared to the equilibrium concentration evolution based on repeating transient flow solutions. This comparison confirmed that although a steady-state flow solution does not correspond to the reality of time-varying groundwater flows, the concentration predictions based the steady-state flow solution are conservative. Additional prediction scaled parameter sensitivity analyses deepen the understanding on the effects of the flow solution temporality on the concentration predictions.