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Simulation of seawater intrusion in three-dimensional confined aquifers

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A three-dimensional finite element model was developed for the simulation of the seawater intrusion in coastal confined aquifers by considering the development of a transition zone between freshwater and seawater and thus density-dependent flow and transport. For a detailed representation of the density-dependent flow, the model is based on a flow equation taking into account the change in the mass of the dissolved solids with time, due to the change in concentration. Furthermore the transport equation includes a coefficient, which introduces the effect of concentration change on the fluid density.

A Picard iterative scheme is used to solve the coupled nonlinear flow and transport equations. The Galerkin finite element method is used to solve the flow equation for the hydraulic head, the Darcy equation for the velocity field and the transport equation for the concentration.

The model was applied to obtain transient solution to Henry's two-dimensional problem, for comparison with existing solutions. Furthermore the effect of the element size and the time step size are studied on the development of numerical oscillations near the concentration front. The effect of various hydrogeological parameters as well as the aquifer dimensions are shown in non-dimensional diagrams, which can also be used to predict steady state concentration distributions.

In seawater intrusion problems the freshwater outflow portion of the seaward side boundary, where a second type boundary condition is required, is not known a priori and it may vary with time. In this model the outflow boundary is determined by using the direction of the velocities on the seaward side boundary, which are obtained from the finite element solution of the Darcy equation. Since the outflow boundary can be

determined during a model simulation the effect of the element size and the effect of various hydrogeological conditions were studied on the variation of the freshwater outflow boundary.

The model was also applied to a fully three-dimensional flow situation for the simulation of the seawater intrusion induced by a partially penetrating pumping well. The results show the influence of the position of the well in the vicinity of the coast and the position of the well screen on the seawater intrusion and the upconing processes.