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MOVEMENT OF DENSE PLUMES IN VARIABLY SATURATED POROUS MEDIA: NUMERICAL MODEL AND RESULTS

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Summary. Accidentally spilled leachate from sanitary landfills can have total dissolved solid concentrations up to 40,000 mg/L. As a result, leachate fluids have a significantly higher density than water found in both the unsaturated and saturated subsurface. Leachate spilled on the soil or released at the bottom of disposal sites will therefore be transported by variable-density flow through the unsaturated soil zone (vadose zone), and eventually reach the saturated groundwater zone (phreatic zone). To better understand plume transport in the subsurface, Simmons et al. (2002, Transp Porous Media) have performed laboratory experiments in a sand-filled glass tank under both fully saturated and variably-saturated flow conditions. In the present study, a new numerical model is developed to simulate the movement of dense fluid under variably saturated conditions. The new model is based on the existing HydroGeoSphere model, and it is validated for two-dimensional unsaturated-saturated variable-density flow and transport in porous media using the experimental results obtained by Simmons et al. (2002). Numerical simulations are performed that focus on the processes that occur at the capillary fringe and below the water table as dense contaminant plumes migrate through the unsaturated zone. The simulations indicate that (i) plume transport in the saturated zone is strongly controlled by the spatial grid, (ii) fingers begin to grow at the capillary fringe, and (iii) the position of the water table must be considered in contaminant studies. This study also illustrates how the results by Simmons et al. (2002) are used as a basis for the testing of variable-density (and variably-saturated) groundwater flow and solute transport numerical codes. An error analysis and a sensitivity test are conducted in order to obtain the appropriate spatial grid and transport parameters for successful code testing.