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Thermal Loading at a Potential Repository: Modeling the Thermal-Hydrological Response within the Unsaturated Zone at Yucca Mountain, Nevada

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Abstract

This paper presents a numerical study on the response of the unsaturated zone (UZ) system of Yucca Mountain to heat generated from decaying radioactive wastes emplaced at the proposed repository. The modeling study is based on the current thermal-hydrological (TH) mountain-scale model, which uses a locally refined 2D north-south cross section and dual-permeability numerical approach. The model provides a prediction of the mountain-scale TH response under the thermal-load scenario of 1.45 kW/m, while accounting for future climatic changes and the effects of drift ventilation. The TH simulation results show that ventilation of the repository drifts has a large impact on thermal-hydrologic regimes and moisture-flow conditions at the repository. In both cases, with and without ventilation, the TH model predicts dry or reduced liquid saturation near the drifts for over 1,000 years, during which liquid flux through the drifts is reduced to either zero or less than the ambient flux. Without ventilation, the model predicts higher temperatures at the repository, but no major moisture redistribution in the UZ except in the areas very near the heated drifts.

Keywords: thermal hydrological behavior, unsaturated zone flow and transport, radioactive waste disposal, drift ventilation, thermal and moisture distribution, liquid reflux