Evidence of Rapid Localized Groundwater Transport in Volcanic Tuffs Beneath Yucca Mountain, Nevada

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At Yucca Mountain, Nevada—the proposed location for a national high-level nuclear waste repository—radionuclides, if released from breached waste storage canisters, could make their way down through the unsaturated zone (where the repository would be located) into the underlying groundwater and eventually back to the biosphere (i.e., where they could adversely affect human health). The compliance boundary, 18 km south of the proposed repository, is defined as the location where a human being using groundwater would be maximally exposed to radionuclides outside of an exclusion zone set around the repository. It is thus important to predict how these radionuclides would be transported by the groundwater flow, and to predict both the concentration of and the rate at which any leaked radionuclides would arrive at the compliance boundary.

We recently conducted a study of groundwater flux in the saturated zone through the Crater Flat Group, in a wellbore 15 km south of the proposed repository. The Crater Flat Group, a sequence of ash-flow tuff formations, is laterally extensive beneath the footprint of the proposed repository. Because of its intense fracturing and high permeabilities, the Bullfrog tuff is the primary unit within the Crater Flat Group through which radionuclides would be transported, as indicated by groundwater models. In a new wellbore, NC-EWDP-24PB, we conducted flowing electrical conductivity logging (FEC), an open-wellbore logging technique, to identify flowing fractures prior to wellbore completion. While the FEC logs have identified transmissive zones, quantitative interpretation of the FEC results was difficult because differences in hydraulic heads in different flowing intervals created significant intraborehole fluid flow. The well was subsequently backfilled and completed with a distributed thermal perturbation sensor (DTPS), which introduces a thermal pulse to the wellbore and uses the thermal transient to estimate groundwater flux.

Corroborating FEC observations, the DTPS has identified two flowing intervals within the Bullfrog tuff that are each approximately 20 m thick and exhibit an average specific discharge of 50 m/yr. Assuming a fracture porosity of 1%, groundwater velocities are estimated to be on the order of 5 to 10 km/yr. While these results are for one borehole, heterogeneity in the flow system may play a significant role in determining regional groundwater flow. Additional data, including geochemical and isotopic, will be needed to provide a more complete picture of the origin of the groundwater in these fast flow paths, and aid in the determination of the lateral extent of the identified flowing intervals.

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