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A Field-Scale Modeling Study of Characterizing Hydraulic Properties for Water, Air and Heat Flow in the Unsaturated Zone of Yucca Mountain, Nevada

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Within the 500 to 700 meter thickness of unsaturated zone at Yucca Mountain, site of the proposed high-level nuclear waste repository, subsurface hydrologic processes occur in an arid environment within highly heterogeneous layers of anisotropic, fractured ash flow and air fall tuffs. Characterization of fluid flow and heat transfer through such a system has been a challenge due to the large-scale heterogeneity inherent in the mountain. Quantitative evaluation of water, gas, and heat flow is essential for design of the potential repository; although numerical modeling has played a crucial role this effort, accuracy and reliability of such model predictions are critically dependent on model parameters.

To meet the need for accurate hydrogeologic parameter estimates, the US Department of Energy has collected a large variety of data which must be synthesized. Available field data include: borehole liquid saturations and water potentials, pneumatic responses at different depths, in-situ temperature measurements, perched water data, geochemical data, air permeabilities and fracture properties. Laboratory data include: rock thermal properties, matrix porosities and permeabilities, and van Genuchten parameters. At LBNL, a methodology combining inverse modeling and direct model calibration has been used to derive a consistent set of field-scale hydrologic parameters. The parameter estimating process consists of synthesizing all available data of field and laboratory measurements using numerical modeling. It has been shown that it is possible to estimate physical ranges and uncertainties of hydraulic properties of the unsaturated zone through systematic inverse modeling analysis and direct model calibration efforts. Examples will be given to demonstrate this methodology, and its compatibility with field measurements.