Rainier Mesa (RM) is a tuffaceous, high-elevation plateau on the Nevada Test Site (NTS) that has been subjected to numerous nuclear tests between 1957 and 1992. Unlike other tests on the NTS located within or just above the saturated zone, tests at the RM T-tunnel complex were conducted within a variably saturated sequence of bedded and non-welded vitric and zeolitized tuff units, located approximately 500 m above the regional groundwater flow system. The low permeability and high porosity of the underlying zeolitized tuff units suggest the downward transport of radionuclides released from these tests are minimal through the tuff matrix. However, numerous faults observed to discharge water into tunnel drifts may serve as preferential pathways for radionuclide migration. Data collected from tunnel drifts indicate that faulting within the zeolitized tuff units is sparse with fractal clustering, and that connectivity between adjacent fault clusters is often weak to non-existent. The sparse fault density at RM, in conjunction with the extreme variability in the spatial distribution of faults, poses challenges not readily addressed by existing upscaling methods that upscale fracture properties as equivalent grid tensors. The unique fault statistics at RM has led to the development of a fracture continuum method designed to faithfully preserve flow and transport properties of the sparse fault networks. This method is based on selective mapping and upscaling of fault hydraulic and transport properties onto a continuum grid in support of dual-permeability simulations. Comparisons of global flow and random walk particle breakthrough between two-dimensional discrete fracture network and fracture continuum simulations demonstrate the utility of this method.