STOCHASTIC MODELING OF WATER FLOW THROUGH A VARIABLY-SATURATED, HETEROGENEOUS FIELD AT IDAHO NATIONAL LABORATORY: UNCERTAINTY ANALYSIS

Abstract

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Water flow through variably-saturated, heterogeneous field at the Idaho Nuclear Technology and Engineering Center (INTEC), Idaho National Laboratory (INL), which has been used to receive, store, and process spent nuclear fuel, is of great concern. Adequate flow models that can be used for reliable predictions are needed. In general, the performance and accuracy of a flow model depend largely on the accuracy of input data, which is affected by the spatial heterogeneity of geological materials (soil, rock) and the density of field samples.

The goal of this study was to examine the uncertainty associated with water flow through the vadose zone at the INTEC. Specific objectives were (i) to model the spatial distribution of basalt and the interbedding sediments using indicator kriging, (ii) to analyze the uncertainty in water flow as a function of the spatial distribution of sediment interbedding by applying sensitivity analysis on several key physical parameters (geological media classification; relative position of water sources; geostatistical model parameterization), and (iii) to assess uncertainty in water flow as affected by local random variability of the geological material using conditional

simulation.

Indicator kriging was use to characterize the subsurface geological media using specified probability cutoff. A two-component exponential empirical variogram model was determined based on the borehole data from the study site. TOUGH2, a comprehensive software package for three-dimensional numerical simulation of transport processes in porous and fractured media was applied to simulate water flow through variably-saturated, heterogeneous fields at study site based on the kriged stratigraphy. Multiple prediction runs were carried out to examine the uncertainty in subsurface water flow regime due to the uncertainty of (i) geological media (basalt and sediments) categorization, (ii) the relative location of water source to the impeding sediment interbeds, and (iii) geostatistical model parameters, specifically, the ranges of variogram model. Additionally, a total of 30 conditional simulations were made to evaluate the effect of random local variability on the water flow.

Results from the flow modeling indicate that all tested parameters affect the variably-saturated water flow to varying degrees. The uncertainties due to different geological media classifications were most sensitive. Similarly, the uncertainty due to uncertainty of relative locations of water source to interbeds was also significant. When the adjustment to the range values of the variogram model was minor, the resultant impact on water flow was not substantial. However, if the adjustment is significant, the impact may be considerable. Local random variability of the geological media may have great influence on certain characteristics of the water flow regime, in particular, the positions of flow peaks across flow bottom boundary as well as the peak values.