Assessing Recharge and Geological Model Uncertainty at the Climax Mine Area of the Nevada Test Site

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Hydrologic analyses are commonly based on a single conceptual-mathematical model. Yet hydrologic environments are open and complex, rendering them prone to multiple interpretations and mathematical descriptions. Considering conceptual model uncertainty is a critical process in hydrologic uncertainty assessment. This study assesses recharge and geologic model uncertainty for the Climax mine area of the Nevada Test Site, Nevada. Five alternative recharge models have been independently developed for Nevada and the Death Valley area of California. These models are (1) the Maxey-Eakin model, (2 and 3) a distributed parameter watershed model with and without a runon-runoff component, and (4 and 5) a chloride mass-balance model with two zero-recharge masks, one for alluvium and one for both alluvium and elevation. Similarly, five geological models have been developed based on different interpretations of available geologic information. One of them was developed by the U.S. Geological Survey for the Death Valley Regional Flow System (DVRFS) model; the other four were developed by Bechtel Nevada for the Yucca Flat Corrective Action Unit (CAU). The Climax mine area is in the northern part of the Yucca Flat CAU, which is within the DVRFS. A total of 25 conceptual models are thus formulated based on the five recharge and five geologic models. The objective of our work is to evaluate the conceptual model uncertainty, and quantify its propagation through the groundwater modeling process. A model averaging method is applied that formally incorporates prior information and field measurements into our evaluation. The DVRFS model developed by the U.S. Geological Survey is used as the modeling framework, into which the 25 models are incorporated. Conceptual model uncertainty is first evaluated through expert elicitation based on prior information possessed by two expert panels. Their perceptions of model plausibility are quantified as prior model probabilities, which are then updated by the site measurements of head and flux through inverse modeling. Posterior model probabilities of the models are then evaluated after the updating process, and used as weights in the summation of each model's mean predictions and associated predictive uncertainty. Deterministic simulation results using calibrated parameters are examined to investigate different model predictions of each alternative model. Parametric uncertainty of each model is assessed using Monte Carlo simulation, and the uncertainty is compared for each model to evaluate uncertainty bounds. Finally, the uncertainty bounds of model averaging, incorporating both parametric and conceptual model uncertainty, are evaluated and compared with those of individual models. It is shown that model averaging provides larger uncertainty bounds, indicating that more uncertainty is incorporated, rendering model predictions more scientifically defensible.