

Infiltration and Contaminant-Transport Modeling for a Uranium Mill Tailings-Disposal Facility.

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Contaminant fate and transport modeling of uranium was performed for a uranium milling and tailings-disposal facility. Prior to final closure and site reclamation, and in support of the site's groundwater-discharge permit, the operator is required to prepare an infiltration and contaminant-transport model in order to demonstrate the long-term ability of the tailings-cover system to adequately contain and control tailings contaminants and protect nearby groundwater quality of the uppermost aquifer.

Infiltration through the tailings-cover system was predicted with the variably-saturated flow-and-transport code HYDRUS-1D. Predictive modeling was used to evaluate different reclamation scenarios, and the cover design was optimized to minimize infiltration rates through the cover and reduce construction costs. The infiltration model demonstrated that a vegetated, evapotranspiration (ET) cover would significantly reduce infiltration relative to that of a conventional cover. Average model-predicted long-term infiltration rates were reduced from approximately 1.0×10^{-2} cm/day for the original cover design to 1.0×10^{-4} cm/day for the ET cover design.

Modeling of potential uranium transport from the tailings through the tailings-cell liner and into the vadose zone was performed with HYDRUS-1D. Retardation rates for uranium (VI) were calculated based on equilibrium soil-water partition coefficients (K_d) using the mass of hydrous-ferric oxide (HFO) present in the bedrock and the equilibrated solution compositions predicted with the geochemical code PHREEQC. Surface-complexation coefficients for uranyl and uranyl-carbonate were optimized to correlate with published sorption experiments. Neutralization of the infiltrating tailings-pore waters and sorption of solutes was determined with PHREEQC. The masses of HFO and calcite were determined for samples collected from the vadose zone. Through this method, a sorption value for the bedrock immediately beneath the tailings cells was estimated to be 8.47 kg/L. Assuming a volumetric moisture content of 7%, a retardation factor of 250 was calculated. Uranium, as a result of the solute's strong capacitance for sorption and resultant high-retardation coefficients, is predicted to migrate a limited distance (less than 1 m) below the liner system in 200 years; and is not predicted to be a threat to groundwater in the underlying perched aquifer.