Performance Assessment Transport Modeling of Uranium at the Area 5 Radioactive Waste Management Site at the Nevada National Security Site

Following is a brief summary of the assumptions that are pertinent to the radioactive isotope transport in the GoldSim Performance Assessment (PA) model of the Area 5 Radioactive Waste Management Site (RWMS), with special emphasis on the water-phase reactive transport of uranium, which includes depleted uranium (DU) products.

Source Term

The Area 5 PA model assumes activity disposed in trenches is well mixed within the native alluvium of the trench at the time the facility is closed. Waste containers and waste forms are assumed not to limit the release of radionuclides for transport.

Transport

In the Area 5 RWMS PA model, the pathways that are considered to bring radioactivity in the waste zone to the surface soils of the closure covers are (1) plant uptake, (2) burrowing animal activity, and (3) advection/dispersion/diffusion in the pore water. Water-phase transport is a minor component of the transport, which is dominated by plant uptake and burrowing animal activity. Because the soil column is mostly dry, upward water flux rates are extremely small, resulting in small advective/dispersive transport of radioactive isotopes in pore water of the unsaturated zone.

Reactive transport of radioactive elements in the Area 5 soil pore water are modeled using element-specific partition coefficients (Kds) that partition radioactivity between pore water and soil of the disposal cell, and solubility limits that control the solubility of elements in pore water. Geochemical modeling is not performed in the Area 5 RWMS GoldSim PA model; however, Kds and solubility limits were derived from previous geochemical modeling performed using Area 5 geochemical data.

Kds for uranium were developed based on geochemical modeling using the mineral characteristics of soil (alluvium) and the chemical characteristics of water at the site (Carle et al., 2002). In the GoldSim model, uranium Kd is represented with a lognormal distribution with a mean value of 0.8 milliliter per gram (taken from Figure 4.11, Page 4-19 of Carle et al., 2002). It is important to note that, in scientific literature, uranium Kds are seen to be highly variable, dependent on geologic media and waters (U.S. Environmental Protection Agency, Office of Air and Radiation, 1999).

Solubility limits for uranium used in the model were also determined based on site geochemical data using geochemical software (Cochran et al., 2001). In the Area 5 RWMS GoldSim model, uranium solubility limits are represented by a log-uniform distribution with a minimum value of 2e-6 moles per liter (mol/L) and a maximum value of 7e-3 mol/L. Uranium reacts with oxygen in the pore water to form a dioxide (UO_2), a trioxide (UO_3), and a large number of intermediate oxides, the most important of which is triuranium octoxide (U_3O_8). UO_2, UO_3, and U_3O_8 are relatively insoluble in water.

Depleted Uranium Studies Related to Disposal at the Nevada National Security Site

Two studies evaluated DU disposal at the Nevada National Security Site (NNSS): (1) *Final Programmatic Environmental Impact Statement for Alternative Strategies for the Long-Term Management and Use of Depleted Uranium Hexafluoride* (U.S. Department of Energy, 1999) and (2) *Assessment of Preferred Depleted Uranium Disposal Forms* (Croff et al., 2000). The second study evaluated four DU forms specifically (U_3O_8, UO_2, uranium tetrafluoride, and uranium metal). The study indicated that the proposed DU waste forms do not have characteristics that prohibit disposal at the NNSS.

References

Carle S. F., M. Zavarin, and G. A. Pawloski. 2002. *Geostatistical Analysis of Spatial Variability of Mineral Abundance and Kd in Frenchman Flat, NTS, Alluvium*. U.S. Department of Energy, Lawrence Livermore National Laboratory, UCRL-ID-150200, November 1, 2002.

Cochran, J. R., W. E. Beyeler, D. A. Brosseau, L. H. Brush, T. J. Brown, B. Crowe, S. H. Conrad, P. A. Davis, T. Ehrhorn, T. Feeney, B. Fogleman, D. P. Gallegos, R. Haaker, E. Kalinina, L. L. Price, D. P. Thomas, and S. Wirth. 2001. *Compliance Assessment Document for the Transuranic Wastes in the Greater Confinement Disposal Boreholes at the Nevada Test Site*. Sandia National Laboratories, SAND2001-2977, September 2001, Albuquerque, NM.

Croff, A. G., J. R. Hightower, D. W. Lee, G. E. Michaels, N. L. Ranek, J. R. Trabalka, 2000. *Assessment of Preferred Depleted Uranium Disposal Forms*, Oak Ridge National Laboratory, ORNL/TM-2000/161, June 2000, Oak Ridge, TN.

U.S. Department of Energy, 1999. *Final Programmatic Environmental Impact Statement for Alternative Strategies for the Long-Term Management and Use of Depleted Uranium Hexafluoride*, DOE-EIS-0269, April 1999.

U.S. Environmental Protection Agency, Office of Air and Radiation, 1999. *Understanding Variation in Partition Coefficient, Kd, Values, Volume II: Review of Geochemistry and Available Kd Values for Cadmium, Cesium, Chromium, Lead, Plutonium, Radon, Strontium, Thorium, Tritium (^3H), and Uranium.* EPA 402-R-99-004B. August 1999.