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DEFINING MODELING PARAMETERS FOR JUNIPER TREES ASSUMING PLEISTOCENE-LIKE CONDITIONS AT THE NTS

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ABSTRACT

This paper addresses part of Sandia National Laboratories' (SNL) efforts to assess the long-term performance of the Greater Confinement Disposal (GCD) facility located on the Nevada Test Site (NTS). Of issue is whether the GCD site complies with 40 CFR 191 standards set for transuranic (TRU) waste burial. SNL has developed a radionuclide transport model which can be used to assess TRU radionuclide movement away from the GCD facility. An earlier iteration of the model found that radionuclide uptake and release by plants is an important aspect of the system to consider. Currently, the shallow-rooted plants at the NTS do not pose a threat to the integrity of the GCD facility. However, the threat increases substantially if deeper-rooted woodland species migrate to the GCD facility, given a shift to a wetter climate. The model parameters discussed here will be included in the next model iteration which assumes a climate shift will provide for the growth of juniper trees at the GCD facility. Model parameters were developed using published data and wherever possible, data were taken from juniper and piñon-juniper studies that mirrored as many aspects of the GCD facility as possible.

I. INTRODUCTION

The GCD facility on the NTS consists of a series of drilled boreholes which are about 3 m in diameter and 36 m deep. During the mid-1980's the bottom 15 m of some of these boreholes were filled with wastes, including TRU wastes. The GCD facility was so named because the 21 m of fill placed on the wastes provides greater confinement than shallow land burial.[1] SNL currently is conducting a Performance Assessment (PA) to determine if the GCD facility meets three main objectives defined in 40 CFR 191: (1) the protection of human health; (2) the protection of ground water, and (3) the containment of TRU wastes. The containment requirement sets limits on the probability of exceeding a given total integrated discharge of specific isotopes into the "accessible environment" (land surface, surface waters, atmosphere, oceans, and any point in the subsurface lithosphere 5 km beyond the disposal site) over a 10,000 year period.

The containment standard of 40 CFR 191 requires that the disposal system does not exceed the upper bounds placed on the probabilities of a given release. Given this requirement, our goal is not to render a realistic model of the system's behavior, but to provide confidence that the actual release of the "true" system (given the uncertainty) will be less than the modeled release, and that the modeled release will be less than the containment standard. Therefore, conservative assumptions are used where there is model uncertainty; thus, the model is assumed to be conservative with respect to the real system.

Since some of the wastes are only 21 m beneath the land's surface, the PA considers a number of surface processes in modeling the fate of radionuclides. Upward diffusion, infiltration, erosion, subsidence and biologic uptake are among the more critical surface processes which may impact the GCD's long-term performance. Based on an earlier iteration of the PA, the relatively shallow burrowers and shallow-rooted plants of the current climate are not believed to facilitate radionuclide transport,[2] even though bioturbation by root invasion and animal burrowing is abundant in, and around the GCD facility.[3,4]

Paleobotanical evidence suggests that as recently as

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11,800-12,000 years ago juniper woodlands may have existed at the elevation of the GCD facility under a wetter and cooler climate.[5,6] Because we cannot know future climate, we make the conservative assumption that climate change will return these same deep-rooted juniper woodland communities to the GCD region in the future. By focusing on Pleistocene climate, future climate projections can be tied to a recent and relatively reliable empirical record. To model the effects of juniper trees growing at the GCD facility, modeling parameters are for: (1) radionuclide concentration ratios (CR), a measure of the amount of radionuclides taken up by a plant for a given level of radionuclides in the soil, (2) rooting depths, and (3) yearly biomass turnover. This paper documents the development of these three modeling parameters.

II. RESULTS

A. Concentration Ratios

We found no studies that had CRs for junipers, and very few studies that report CRs for trees. Additionally, only CRs for 3 of the 21 isotopes were found.[7,8] Given this lack of available data, the following criteria were used in the determination of CRs for junipers (Table 1): (1) a CR measured for an isotope of a given element was applied to all isotopes of that same element and (2) where no data for any isotope of an element exists, the maximum CR measured for all other elements was used (i.e., 0.02 for U^{238}); the only exception to this criterium was Ac^{227}, which was assumed to be more like Am^{241} than U^{238}, per Grogan (1985)[9].

B. Juniper Rooting Depths

Data from a number of studies were used to develop a rooting-depth probability distribution function (pdf).[10,11,12] Two aspects of juniper rooting were critical to the development of this pdf: (1) the maximum recorded rooting depth (61 m), which indicates that junipers can develop very deep roots and (2) the majority of junipers studied had roots that remained in the top few meters of soil. We believe, but have not proven, that this extreme difference in rooting depths is a result of rooting habits which maximize access to available water; deep roots develop in fractured rock to follow deep water movement, and shallow root systems develop in soils to maximize access to shallow water. The GCD facility is constructed in alluvial sediments, not fractured rock. Lacking information on juniper rooting depths in alluvial sediments, we developed a single pdf using all available data which includes both deep-rooted and shallow-rooted junipers. The resulting pdf is lognormal with 0.001 and 0.999 quantiles of 1 cm and 61 m, respectively.

C. Juniper Biomass Turnover Rates

To determine the amount of radionuclides released at the surface, the model also requires an estimate of biomass turnover (kg dry aboveground biomass/unit area/year). The development of this parameter was two-fold. First, we determined juniper biomass

Table I. Concentration ratios for trees.

ISOTOPE	CR[1]	ISOTOPE	CR[1]	ISOTOPE	CR[1]
Ac^{227}	5.0 E-4[2]	Pu^{239}	5.0 E-4[3]	Th^{230}	0.02[2]
Am^{241}	5.0 E-4[3]	Pu^{240}	5.0 E-4[2]	Th^{232}	0.02[2]
Cs^{137}	0.02[2]	Pu^{241}	5.0 E-4[2]	U^{233}	0.02[2]
Np^{237}	0.02[2]	Pu^{242}	5.0 E-4[2]	U^{234}	0.02[2]
Pa^{231}	0.02[2]	Ra^{226}	0.02[2]	U^{235}	0.02[2]
Pb^{210}	0.02[2]	Sr^{90}	0.02[2]	U^{236}	0.02[2]
Pu^{238}	5.0 E-4[2]	Th^{229}	0.02[2]	U^{238}	0.02[3]

[1]Concentration Ratio = $\frac{\text{pCi activity, g dry biomass}}{\text{pCi activity, g dry soil}}$ [2]assumed CR [3]measured CR

for a given area. Since junipers are perennial trees, this estimate was limited to foliage production and turnover because very little woody biomass is turned over relative to needles. Secondly, we estimated the percentage of that biomass that turns over annually. Using a compilation of data we derived foliage biomass from crown area.[13] Two crown dimensions (maximum and minimum crown diameter) provide a mean crown diameter which is used to calculate mean crown area based on the assumption that the crown is circular. The linear regression of foliage biomass [FB (kg)] on mean crown area [CA (m^2)] yielded this equation for estimating foliage biomass ($r^2 = 0.92$):

$$FB = (CA * 12.413) - 33.204.$$

Foliage biomass can be determined for any given area with this equation and a ratio of maximum crown cover to surface area for piñon-juniper woodlands in mesic sites that is approximately 0.50.[14] Annual biomass turnover is not known, so we assume it is equal to yearly foliage production which has been estimated to be 30% of foliage mass in the only study found that reported juniper foliage production.[15] For example, to estimate foliage biomass turnover for 10 m^2, first multiply 10 by 0.5 to obtain crown area (5 m^2), use this crown area to derive foliage biomass from the equation above (28.86 kg), then multiply this value of foliage biomass by 0.30, to arrive at an estimate of 8.65 kg foliage biomass turnover per 10 square meters per year.

III. SUMMARY

In conducting the PA for the GCD facility, we assume that junipers will return to the site, given a wetter climate and the fact that junipers have occurred at GCD elevations in the recent past. Here we have presented our efforts to provide modeling parameters for junipers for the next iteration of the PA.

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REFERENCES

1. Price, L.L, S. H. Conrad, D.A. Zimmerman, N.E. Olague, K.C. Gaither, W.B. Cox, J.T. McCord, and C.P. Harlan. 1991. Preliminary Performance Assessment of the Greater Confinement Disposal Facility at the Nevada Test Site, Nevada Operations Office, Las Vegas, NV (volumes 1-3).

2. Raytheon Services Nevada (RSN). 1991. Surficial geology of the Area 5 Radioactive Waste Management Site, Interim Report Review Draft, Las Vegas, NV.

3. Snyder, K.E., S.M. Parsons, and D.L. Gustafson. January 1993. Field Results of Subsurface Mapping at the Area 5 Radioactive Waste Management Site DOE/Nevada Test Site, Nye County Nevada.

4. Baer, T.A., L.L. Price, J.E. Emery, and N.E.Olague. 1994. Second Performance Assessment Iteration of the Greater Confinement Disposal Facility at the Nevada Test Site, Report to the U.S. DOE, Nevada Operations Office, SAND93-0089.

5. King, T.J. 1976. Late Pleistocene - early Holocene history of coniferous woodlands in the Lucerne valley region, Mojave Desert, California: Great Basin Naturalist, v. 36, pp. 227-238.

6. Davis, O. K. 1986. Palynological evidence for historic juniper invasion in central Arizona: a late-Quaternary perspective., *in* Proceedings- pinyon-juniper conference, R.L. Everett, ed. USDA General Technical Report INT-215, pp. 120-124.

7. Garten, C.T., J.R. Bondietti, R.L. Walker and T.G. Scott. 1987. Field studies on the terrestrial behavior of actinide elements in east Tennessee. CONF-841142, Office of Scientific and Technical Information, United States Department of Energy.

8. Dahlman, R.C., E.A. Bondetti and L.D. Eymann. 1976. Biological pathways and chemical behavior of plutonium and other actinides in the environment, *in* Actinides in the Environment, Friedman, A.M., ed., American Chemical Society, pp. 47-80.

9. Grogan, H.A. 1985. Concentration ratios for BIOPATH: selection of the soil-to-plant concentration ratio database, Swiss Federal Institute for Reactor Research, EIR-Bericht Nr. 575.

10. Tierney, G.D. and T.S. Foxx. 1987. Root lengths of plants on Los Alamos National Laboratory Lands. LA- 10865-MS, UC-48, National Technical Information Service, Springfield, VA.

11. Foxx, T.S. , G.D. Tierney, and J.M. Williams. 1984. Rooting depths of plants on low-level waste disposal sites. LA-10253, UC-70B, National Technical Information Service, Springfield, VA.

12. Young, J.A., R.A. Evans, and D.A. Easi. 1984. Stem flow on western juniper (*juniperous occidentalis*) trees. Weed Science, v. 32, pp. 320-327.

13. Miller, E.L., R.O. Meeuwig and J.D. Budy. April 1981. Biomass of singleleaf pinyon and Utah juniper. USDA Forest Service Research Paper, INT-273, Intermountain Forest and Range Experiment Station.

14. Lajtha, K. and J. Getz. 1993. Photosynthesis and water-use efficiency in pinyon-juniper communities along an elevation gradient in northern New Mexico. Oecologia, v. 94, pp. 95-101.

15. Mason, L.A. and S.S. Hutchings. 1967. Estimating foliage yields on Utah juniper from measurements of crown diameter. Journal of Range Management, v. 20, pp. 161-166.