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To: Timothy McCartin; Gordon Wittmeyer; Roland Benke; Sitakanta Mohanty; Andy Campbell; Bret Leslie; Christopher Grossman; David Esh; James Danna; James Firth; Richard Codell
Subject: Risk Insights for Biosphere
Attachments: biosphere.knowledgeable.riskinsights.wpd

Attached is my crack at the risk insights summary for the biosphere. It had to be done fairly quickly due to a large plethora of other milestones that had to be completed over the past 2 weeks. Anyway, I think it captures the current thinking but could be improved with more quality time. I am out for vacation from Friday 12/20 and will be back in the office on Monday 12/30.

It appeared from the last meeting that a single format was not yet agreed upon so I picked one from the existing writeups.

Enjoy!

Pat

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Function of the Biosphere

The biosphere is modeled as a final system abstraction in the total system performance assessment calculation. Conceptually, the biosphere is the environment where the reasonably maximally exposed individual lives. The biosphere functions to transfer radionuclides that enter from groundwater or airborne sources through a series of environmental pathways that lead to exposure of the reasonably maximally exposed individual. Submodels in the biosphere abstraction include the following:

1. The concentration of radionuclides in groundwater is calculated using the annual radionuclide flux from the saturated zone that is captured by the water supply well and the representative volume of water that is pumped. Conceptually, radionuclides released from the repository that are transported through the unsaturated zone to the saturated zone and from the saturated zone in a southerly direction 18 km to the compliance location are present in a groundwater plume that enters the location of the biosphere. The radionuclides in the plume are captured by a water supply well that supports the water needs of a community where the reasonably maximally exposed individual resides. The extent of plume capture is determined by the characteristics of the well and local hydrology. In present TPA modeling, the relevant input parameters cause all of the plume to be captured. Captured radionuclides are diluted into a pumping volume of 3000 acre-ft, specified by regulations in 10 CFR Part 63, to estimate the concentration of radionuclides in the pumped water.

2. The igneous activity disruptive event scenario provides another means for the soil in the biosphere to become contaminated with radionuclides. The estimated concentration of radionuclides deposited to soil from a postulated igneous event is the result of airborne dispersion modeling calculated outside the biosphere modeling as part of geosphere disruptive event modeling. The resulting pathway dose calculations in the biosphere are, however, part of the biosphere modeling and are conceptually the same as for the groundwater pathway except there is no irrigation related deposition or leaching and a more detailed model for mass loading of soil contamination to air for inhalation dose calculations is used. A recent addition to the igneous activity disruptive event modeling is related to redistribution of ash fallout from outlying areas into the biosphere where it can contribute to dose to the reasonably maximally exposed individual. Redistribution modeling has been recently included into TPA version 5 code and additional analyses are need to establish risk insights for redistribution [perhaps R. Benke or others could add any insights to this, if known].

3. Fate and transport of radionuclides through various biosphere pathways is modeled to estimate radionuclide concentrations in media (on the ground and in the air) and amounts of radionuclides ingested or inhaled by the reasonably maximally exposed individual. To generate these estimates, the contaminated groundwater is assumed to be used by the local community annually for drinking (at a rate specified by regulation in 10 CFR Part 63), domestic use, and production of crops and livestock. Radioactive material intakes are calculated directly from the consumption of contaminated drinking water. Once the soil is contaminated by irrigation, the transfer of radionuclides from the soil to plants and animal products is computed. Radionuclides can remain in the surface soil layer and be available for plant uptake, animal consumption, and resuspension or they can leach from the surface layer to deeper layers away from roots and wind disturbance where they no longer contribute to dose estimates. Direct exposure to the irrigation contaminated ground surface and inhalation of resuspended dust also contribute to dose. A fraction of the soil contamination that exists in the surface layer near the roots is transferred to plants as the plants utilize irrigation water. A fraction of the radionuclide concentration in the irrigation water also is deposited on the surface of crop leaves and is

available for human and animal consumption. The contaminated plant and animal products are eventually consumed by the reasonably maximally exposed individual leading to further intake of radionuclides.

4. Exposures to contaminated media and intakes of radionuclides from various biosphere pathways are converted to dose. Internal and external dosimetry modeling consistent with methods acceptable to the federal government (Environmental Protection Agency, 1988; 1993) is used to convert external radiation exposure and intake of radionuclides to an effective dose equivalent for comparison with regulations in 10 CFR Part 63. The effective dose equivalent is calculated for the reasonably maximally exposed individual assuming the reasonably maximally exposed individual has the metabolism and physiology of an adult in accordance with regulations in 10 CFR Part 63.

What Can Go Wrong?

There is a limit to what can go wrong with the biosphere modeling because key aspects of the groundwater concentration calculation and characteristics of the reference biosphere and reasonably maximally exposed individual are specified by regulation in 10 CFR Part 63. These key aspects include the specification of the 3000 acre-ft pumping volume, the 2 liter per day drinking water consumption rate, the specification of mean values for diet and living style based on local survey data, adult dosimetry, and the limitation on projections of changes in society, the biosphere, biology, human knowledge and technology. Prior process model sensitivity analysis results (LaPlante and Poor, 1997) show that consumption rates are important and highly variable parameters in the biosphere dose calculations. Fixing these parameters at mean values limits the range of possible doses that can be calculated. Following the use of mean values consistent with the regulatory requirements, TPA 4.1 results showed the total range of most biosphere dose conversion factor distributions was approximately an order of magnitude (Andersen, 2002).

The current values of mean consumption rates are taken from local surveys conducted by DOE (CRWMS M&O, 2000) and this information is not expected to change significantly in the future. Furthermore, the groundwater concentration calculation is also not expected to change significantly given the pumping volume specified by regulation and the plume capture results at a bounding level (i.e., the entire plume in the accessible environment is captured in current TPA modeling). The coefficients that convert intake to dose are limited to fixed values based on methods presently accepted by the U.S. government (e.g., ICRP 30) and are not expected to change in the near future. Given all the constants in the biosphere modeling, at present, the primary area where changes could occur are in uncertain parameters used in the pathway modeling that have not been fixed to mean values by regulation. These parameters are the primary source of uncertainty propagated through current biosphere calculations and include the partition coefficient's used in soil leaching calculations, the soil to plant transfer coefficients used for plant uptake of radionuclides, and to a more limited degree the crop interception fraction that determines the fraction of irrigated radionuclides that remain on the surface of crops. Issue resolution agreements presently exist with DOE concerning justification for these parameter values. Resolution of these agreements, therefore, has a potential to moderately impact the results of future biosphere dose calculations if selected values or distributions change, however, major changes to the parameter values are considered unlikely.

What is the Risk Associated with the Biosphere?

Biosphere dose conversion factors, the results of the biosphere pathway modeling, are factors that directly impact the magnitude of calculated doses. Therefore, changes to the biosphere modeling that impact the magnitude of dose conversion factors can have proportional impacts on total system performance assessment dose results. However, large changes in dose results are not expected from future refinements to the biosphere modeling. First, a significant portion of the total dose (about 50%) is from the drinking water pathway and this calculation is unlikely to change in the future due to fixed consumption rate in the regulation. Also, the biosphere parameters that are not fixed by regulation contribute, at present, about an order of magnitude total range in calculated dose conversion factor distributions. The most important of these parameters include the plant uptake factors, the distribution coefficients used in soil leaching, and to a more limited degree, the crop interception fraction. Simple perturbation tests using TPA 4.1 showed that expected dose results could be changed by a factor of 5 from the basecase result by using a high distribution coefficient value (99.9 percentile) and a factor of 2.5 between expected dose results using a mean distribution coefficient and the high value. Because distribution coefficients will likely continue to be sampled and include a range of values the impact on expected dose of changes to such an input parameter distribution would be much less. Similar perturbation tests with the plant uptake factors caused about a four fold increase in expected dose from the basecase value when high transfer factors (99.9 percentile values) were used. Tests on the potential impacts of crop interception fraction distribution changes suggested no more than a 35 percent increase in dose is possible from changing the parameter range to include all possible values. Given that the aforementioned tests were conducted with high point values rather than distribution changes (except the crop interception test), it appears likely the potential for changes in dose results from biosphere parameter changes would be within a factor of two at most.

For the igneous activity disruptive event scenario biosphere modeling, the important parameters relate to the inhalation dose calculation. These include the mass loading factor distribution and exposure duration parameters. The present range used for mass loading is fairly conservative and appears unlikely to change in a manner that would significantly increase dose. Additions to the TPA modeling to parse the exposure calculations for indoor and outdoor inhalation and external exposure should allow more precise testing of the risk significance of relevant parameters. A final area that presents potential for future changes in dose results is the redistribution of volcanic ash deposits. A simple model was added to the TPA version 5.0 beta code and this should allow future sensitivity testing to gain additional risk insights. The department of energy is also working on implementing a redistribution model. To date, the risk insights related to redistribution are limited.

The Biosphere, What's it Good For? (conclusion)

The biosphere modeling directly impacts the magnitude of doses calculated in a total system performance assessment, however, the potential for changes in the magnitude of doses is limited because many important aspects of the modeling are specified or constrained by regulation. Specific parameters that could be changed in the future have some impact on dose but is expected parameter changes would be unlikely to change results more than a factor of two. Areas of modeling related to the igneous activity disruptive event biosphere modeling (e.g., redistribution, new inhalation calculations) are relatively new so detailed risk insights remain to be developed. These areas appear to have some potential to change the magnitude of calculated doses.

Bulleted list of Risk Insights for Biosphere:

- Important aspects of the groundwater concentration calculation and characteristics of the reference biosphere and reasonably maximally exposed individual are specified by regulation in 10 CFR Part 63. These key aspects include the specification of the 3000 acre-ft pumping volume, the 2 liter per day drinking water consumption rate, the specification of mean values for diet and living style based on local survey data, adult dosimetry, and the limitation on projections of changes in society, the biosphere, biology, human knowledge and technology. Fixing these values limits the uncertainty that can be propagated in biosphere calculations and therefore limits the importance of the biosphere on total system performance assessment results.

- Prior process model sensitivity analysis results (LaPlante and Poor, 1997) show that consumption rates are important and highly variable parameters in the biosphere dose calculations. Fixing these parameters at mean values limits the range of possible doses that can be calculated.

- Given that selected important and uncertain parameters in the biosphere modeling have been fixed by regulation, the remaining influential parameters are limited to those where uncertainty is propagated in current calculations

- Following the use of mean values consistent with the regulatory requirements, TPA 4.1 results showed the total range of most biosphere dose conversion factor distributions was approximately an order of magnitude (Andersen, 2002).

- Parameters that are the primary source of uncertainty propagated in current biosphere calculations for the groundwater exposure scenario include the partition coefficient's used in soil leaching calculations, the soil to plant transfer coefficients used for plant uptake of radionuclides, and to a more limited degree the crop interception fraction that determines the fraction of irrigated radionuclides that remain on the surface of crops.

- For the groundwater exposure scenario, the drinking water pathway contributes about 50 percent of the total dose, the crop ingestion pathway about 40 percent, and the animal product ingestion about 10 percent. Direct exposure and inhalation amount to only a few percent to the dose.

- For the igneous activity exposure scenario, inhalation of resuspended ash material dominates the dose relative to other pathways. Key parameters are mass loading factors for indoor and outdoor exposures and the duration of exposure.

- Potential future changes in dose results could result from modeling the redistribution of volcanic ash deposits. A simple model was added to the TPA version 5.0 beta code and this should allow future sensitivity testing to gain additional risk insights.

References:

Andersen, J.W. Integrated Issue Resolution Status Report. NUREG-1762. Washington DC: U.S. Nuclear Regulatory Commission, July 2002 (section 3.3.14).

CRWMS M&O. “Identification of the Critical Group (Consumption of Locally Produced Food and Tap Water).” ANL–MGR–MD–000005. Revision 00. Las Vegas, Nevada: CRWMS M&O.

2000.

LaPlante, P.A., and K. Poor. Information and Analyses to Support Selection of Critical Groups and Reference Biospheres for Yucca Mountain Exposure Scenarios. CNWRA 97-009. San Antonio, TX: Center for Nuclear Waste Regulatory Analyses, August, 1997.

U.S. Environmental Protection Agency. External Exposure to Radionuclides in Air, Water, and Soil: Federal Guidance Report No. 12. EPA 402-R-93-081. Washington DC: U.S. Environmental Protection Agency, September, 1993.

U.S. Environmental Protection Agency. Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion: Federal Guidance Report No. 11. EPA 520/1-88-020. Washington DC: U.S. Environmental Protection Agency, September, 1988.