A Generic Safety Assessment Model for a Trench Type LILW Repository

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1. Introduction

A simple and effective model and a GoldSim [1] template program, by which a probabilistic safety assessment of a conceptual trench type repository system for low-level radioactive waste (LILW) disposal can be carried out, have been developed.

To quantify the exposure dose rates from the nuclide release and transport through the various pathways possible in the near- and far-fields of the LILW repository system, various scenarios are expected to be simulated, rather than assessed, in a straightforward manner rather exactly and conveniently with this GoldSim model, which was modeled and devised, as shown in Figure 1, as similarly done for different types of repositories in previous studies [2-10].

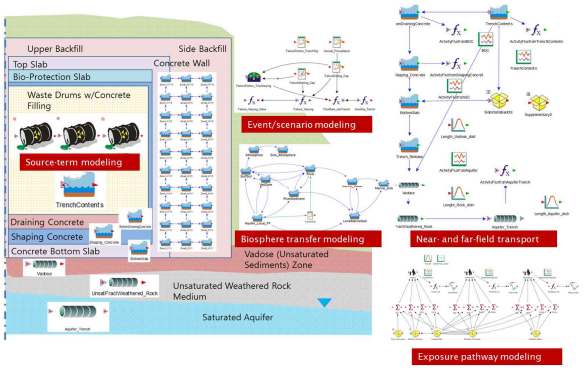

Fig. 1. Construction of a GoldSim Model.

2. Nuclide Transport Scenario and Modeling

The 200*l* storage drum packages for LILW, which amounts to a total of 125,000 packages, are assumed to be disposed of in a trench with multiple concrete barriers and then buffered and grouted with concrete. Impervious and multilayered trench covers for preventing water infiltration and some erosion, as well as nuclide release, are considered to be placed on the roof.

In such GoldSim modeling, as shown in Figure 1, a trench and its surrounding concrete barriers and geological media are discretized into several compartments.

The waste is to be disposed of in multiple concrete barrier boxes in the trench, as depicted in Fig. 1, and the inside is buffered by filling concrete.

For trench-type repositories at the surface or possibly a subsurface depth, normally and commonly, once leakage from a damaged radioactive waste package occurs through tiny holes, the nuclides will spread out into the buffer material surrounding the waste, and then into other possible barrier regions in and around the trench before being transported into the biosphere through various pathways in the natural far-field area.

In the case of transport into porous soil and weathered rock media under the repository, both of which are unsaturated, an aquifer is that probably exists in the far-field area of the repository could be one of the main pathways, through which the nuclides finally reach the human environment, by passing over the geosphere-biosphere interfaces for exposure to human bodies.

Through this study, the scenarios for nuclide release and transport mainly considered herein for a deterministic and probabilistic safety assessment are a conservative base case, under which nuclides are released by groundwater that normally flows along their own preferential pathways after release from the repository, as well as several possible cases that are not described herein. Any upward overflow pathways through the cover other are temporarily excluded in this study.

Two principal release pathways from the trench are suggested for a normal case, i.e., the side and base pathways, all of which simultaneously reach the unsaturated vadose zone under the trench for farther far-field transport. All releases from the trenches are then, in turn, later transported along with various unsaturated and saturated pathways including subsurface groundwater flow and aquifer pathways into the natural far-field region and biosphere.

Illustrative evaluations for a comparison among these scenarios, as well as the sensitivity of the travel distances, are made and demonstrated in Figs. 2 and 3.

The long-term confinement and release of nuclides from a near-field engineered barrier system rely on reliable waste packages, a concrete buffer, and concrete barriers of the trench. Therefore, the case of an imaginary disruptive event owing to an earthquake whose magnitude is over a certain value, which is large enough for a direct connection to an unsaturated vadose zone under the trench from inside, resulting in a bypass of the concrete barriers, and/or when the magnitude-to-distance ratios are over certain values for a flow increase in the entire repository system, is also postulated in view of the long-term safety in that it might be disruptive enough to reduce the performance of the repository. Under this scenario, the formation of a direct pathway and a sudden increase in the

groundwater flow are assumed. Two principal parameters, that is, the magnitude of the earthquake and the distance between a repository and its epicenter, are used for the scenario, which seems sufficient to characterize an earthquake. They are also assumed to follow the statistical behaviors of certain distributions well, despite a lack of evidence of such.

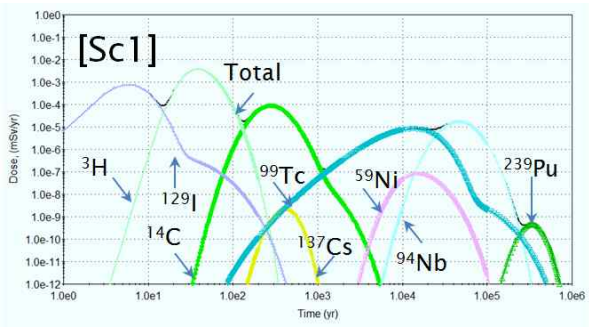

Fig. 2. Annual farming dose exposure rate for a normal case.

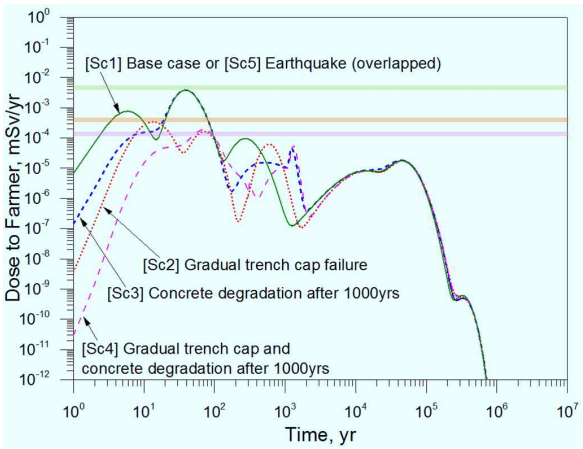

Fig. 3. Comparison of farming dose exposure rate for all scenarios.

3. Conclusions

A simple and effective model for a safety assessment of a conceptual trench repository system, in which an LILW that arises from a nuclear power plant and other sources, has been developed. The computer program based on this model has also been developed as a GoldSim template using the commercial GoldSim development tool. This program is ready for a total system performance assessment and is able to deterministically and probabilistically evaluate the nuclide release from a repository and farther transport into the geosphere and biosphere under various normal circumstances, disruptive events, and scenarios that can occur after a failure of waste packages with associated uncertainty.

Despite the conceptual design of a trench type LILW repository system, all parameter values associated with the repository system were assumed for the time being, and the generic model developed through this study should be helpful because the evaluation of such releases is very important, not only in view of the safety assessment of the repository, but also for the design feedback of its performance.

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