Progress in Nuclear Energy 53 (2011) 760–774

Contents lists available at ScienceDirect

Progress in Nuclear Energy

journal homepage: www.elsevier.com/locate/pnucene

Evaluation of nuclide release scenarios for a hypothetical LILW repository

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ARTICLE INFO

Article history:
Received 28 October 2010
Received in revised form
2 May 2011
Accepted 11 May 2011

Keywords:
GoldSim
LILW repository
Nuclide transport
Safety assessment
Scenario
Modeling

ABSTRACT

A program for the safety assessment and performance evaluation of a low- and intermediate-level radioactive waste (LILW) repository system has been developed. Utilizing GoldSim (2006), the program evaluates nuclide release and transport into the geosphere and biosphere under various disruptive natural and manmade events and scenarios that can occur after a waste package failure. We envisaged and illustrated these events and scenarios as occurring after the closure of a hypothetical LILW repository, and they included the degradation of various manmade barriers, pumping well drilling, and natural disruptions such as the sudden formation of a preferential flow pathway in the far-field area of the repository. Possible enhancement of nuclide transport facilitated by colloids or chelating agents is also dealt with. We used the newly-developed *GoldSim* template program, which is capable of various nuclide release scenarios and is greatly suited for simulating a potential repository given the geological circumstances in Korea, to create the detailed source-term and near-field release scheme, various nuclide transport modes in the far-field geosphere area, and the biosphere transfer. Even though all parameter values applied to the hypothetical repository were assumed, the illustrative results, particularly the probabilistic calculations and sensitivity studies, may be informative under various scenarios. (*GoldSim*, LILW, Nuclide transport, Safety assessment, Scenario).

1. Introduction

Until the past few years, the direct disposal of spent PWR and CANDU fuel, which are the only types of high-level radioactive waste (HLW), was the major disposal option in Korea. Recently, a repository system for LILWs has become a great concern due to the consideration of pyroprocesses for the treatment of PWR spent fuel, from which a part of plutonium and other TRUs are recovered and can be fabricated as the fuel of a sodium-cooled fast reactor, where plutonium and minor actinides are burned out together and reduced to HLWs. A repository solely for LILWs is also currently under construction in the Gyeongju area, and is anticipated to begin operation in 2012.

In the meantime, tools have been developed, by which safety assessments for LILW repositories arising in Korea have been made (e.g., Lee and Hwang, 2009; Lee et al., 2007; Lee, 2002; Ebashi et al., 2008). To quantify a nuclide release and transport through the possible pathways in the near- and far-fields of a repository system, as well as the dose rate within various exposure pathways in a biosphere system, reliable programs capable of an assessment of various possible release scenarios are required. The evaluation of such releases is very important not only in view of the safety assessment of a repository, but also for design feedback of its performance.

Very recently, as was similarly conducted for an HLW repository (Lee and Hwang, 2009), the development of a more effective safety assessment program for a complex LILW repository and its in-depth evaluation was implemented using *GoldSim*, which is a commercial Windows-based development tool. Using this program, nuclide transports into the near- and far-field areas of a repository, as well as farther transport into the biosphere, could be effectively modeled and conveniently evaluated under various release scenarios with an integrated graphical user friendly interface.

While a number of other models and programs have previously been developed for similar purposes, offering both deterministic and probabilistic calculations by utilizing such general purpose development tools as AMBER (2002), this new template program developed using *GoldSim* seems to be more flexible and easy to handle. This is particularly true for simulating such complex systems as a repository, where complicated nuclide transport behavior in various manmade and natural system components are associated with various release scenarios and disruptive features, events, and processes (FEPs).

For the *GoldSim* template program, various unit program modules have been separately developed, such as a source-term

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doi:10.1016/j.pnucene.2011.05.010

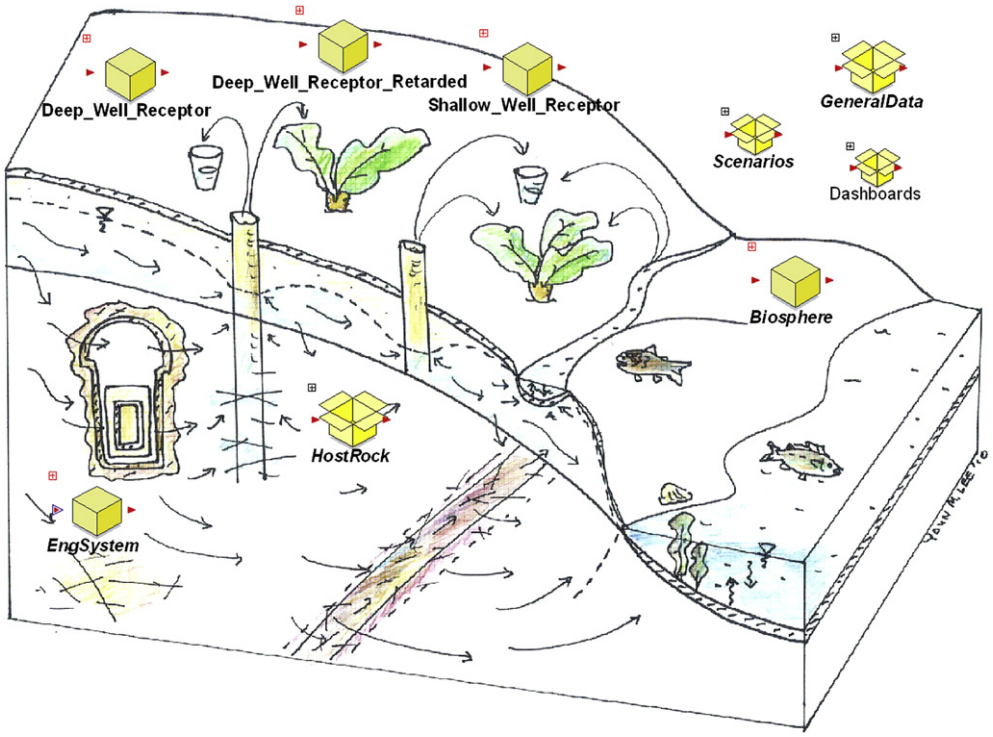

Fig. 1. A modeling scheme for the safety assessment of an LILW repository system using *GoldSim*.

evaluation module, detailed near- and far-field transport and biosphere assessment models, and various disruptive FEPs that can be caused naturally or through human activities. These modules were organically integrated together into a "total system performance assessment" (TSPA) program through which a safety assessment of a hypothetical repository, or even the actual Gyeongju repository, could be performed under a rather realistic approach by excluding as much conservatism as possible.

Evaluations of selected scenarios associated with LLW repositories are illustrated through this study.

2. Scenarios

Similar to the Gyeongju repository currently under construction, a hypothetical silo-type LILW repository located in crystalline host rock on a coastal hill is postulated.

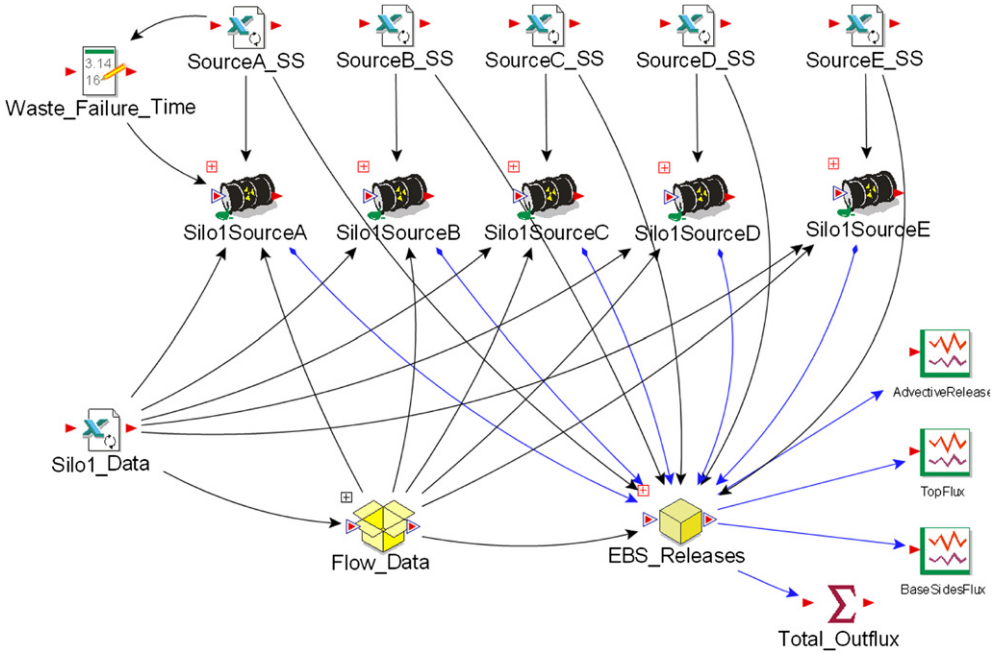

Fig. 2. Source-term modeling.