Criteria and Techniques for Field Characterization and Modeling Related to Selecting and Evaluating Performance of LILW Disposal Sites

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Argentina is faced with the challenging problem of developing technology for near-surface disposal and isolation of low- and intermediate-level radioactive waste (LILW). The preferred option for disposal of LILW (including both relatively short-lived and long-lived radionuclides) is to use disposal facilities that are near-surface—either above or below ground level [IAEA, 1985; 2001a; 2004]. How individual components of a waste disposal system perform (including waste forms, waste containers, engineered barriers and host environment) will determine system safety and the safety of the surrounding environment [IAEA, 1999]. The lack of appropriate engineering for the backfill, and for the selection of sealing and covering materials for trenches, vaults, and ditches, could result in the escape of radionuclides from the disposed wastes [IAEA, 1994a; 2001b]. Therefore, assessment and design of backfill, barriers, and cover materials are very important, both for preventing invasion of water into the disposal system, and for retarding radionuclides that could potentially migrate from the system into the atmosphere or groundwater [IAEA, 1982; 1994b; 2001a].

Many countries have spent substantial funds and resources in conducting research aimed at selecting LILW sites. These countries include: Argentina, Bulgaria, Canada, Croatia, Czech Republic, Finland, France, Hungary, Indonesia, Italy, Korea, Lithuania, Philippines, Russia, Slovenia, South Africa, Spain, Switzerland, Taiwan, Ukraine, and others. These collective efforts have not established a universal site-selection procedure [1983, 1994a], but they have been useful in providing some guidelines for site selection, characterization, monitoring, and risk assessment.

The overall objective of this presentation is to discuss a scientific and technical basis for near-surface disposal of LILW. The first part of this presentation will give a general worldwide overview of both proven and potential approaches to this type of radioactive waste using near-surface storage and disposal facilities, including:

(a) The key steps involved in a multiphase and multicriteria screening strategy for LILW disposal siting and characterization, based on geological and environmental considerations,

(b) Approaches to a repository design and examples of different types of engineered multiple-barrier systems for LILW sites. We will also briefly discuss what can cause failures in site selection and site performance, such as the rapid leaching of radionuclides from wastes and radionuclide releases due to flooding of disposal trenches by rainwater or a rising water table, and the release of gaseous effluents into the atmosphere. There could also be other problems associated with the past failures, which can be attributed to inadequate characterization of the site, unsatisfactory performance of engineered barriers, and inadequate control of the nature and inventory of radionuclides.

(c) A review of geological features and the experience in designing and performance assessment of LILW storage and disposal facilities at El Cabril, Spain, and Centre de l'Aube, France, which are currently considered as analogues for the storage and disposal facilities in Argentina. In this review, we will discuss the geological and hydrogeological conditions of these sites, and the concept of near-surface disposal of LILW based on three confinement barriers: the packages containing the waste, the repository structures (repository modules and underground monitoring drifts), and lithological layers.

In the second part of the presentation, we will discuss:

(a) Conceptual models of the normal and disruptive evolution of the LILW sites, which take into account the processes by which radionuclides could migrate and be brought into contact with the environment or with human beings. These processes include, for example, infiltration of surface water, groundwater intrusion, subsequent migration of contaminated water (leachate), inadvertent intrusion, and escape of radioactive gas. Investigations of these processes are also important for the selection of the potential host-rock candidates.

(b) Advanced methods of site characterization and monitoring, including minimally invasive geophysical methods (e.g., seismic, radar, electrical) using surface and single- and cross-borehole measurements, geochemical methods (stable and radioactive isotopic analyses) to control the environmental conditions of storage facilities and surrounding areas. We will indicate the need for controlling microbiological conditions for near-surface disposal facilities, which could affect, for example, corrosion of metal drums.

(c) An integrated modeling approach to assess coupled hydrogeological and biogeochemical processes in the rock/sediment–water systems. We will emphasize the need for incorporating models of heterogeneity in the host rock/sediment system, future climate changes, and uncertainty evaluation [Neuman, 2003] into coupled microbial and reactive transport models for predictions of environmental conditions and risk assessment [IAEA, 2004].

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