THE TRANSITION FROM STORAGE TO PERMANENT DISPOSAL OF LOW- AND INTERMEDIATE-LEVEL WASTES AT THE CHALK RIVER NUCLEAR LABORATORIES

D.G. Hardy and D.F. Dixon
Atomic Energy of Canada Limited
Chalk River Nuclear Laboratories
CHALK RIVER, Ontario, Canada
KOJ 1J0

ABSTRACT

A program is underway at CRNL to evolve from a policy of storage of low-level and intermediate-level radioactive wastes to one of permanent disposal. The approach being investigated is to sort the wastes into several categories graded according to their hazardous lifetime and to dispose of each category in a repository best suited to isolate and contain that waste until it no longer poses a radiological hazard. The disposal concepts selected for detailed study include an improved sand trench (IST), an intrusion-resistant shallow land burial (SLB) facility and a shallow rock cavity (SRC). The concept(s) adopted will depend on safety and economic criteria. The construction of a prototype SLB facility is being planned to better assess its operation, short-term performance and economics. The paper outlines the rationale, the strategy and the R&D work involved in the disposal program.

INTRODUCTION

Storage of radioactive wastes began at the Chalk River Nuclear Laboratories (CRNL) in 1946[1-3]. The total volume of these largely low- and intermediate-level wastes now exceeds 85,000 m^3 and is increasing at an annual rate of about 3000 m^3. The wastes are located in shallow ground storage facilities in areas with controlled access. Environmental monitoring is carried out to ensure compliance with safe practices. However, storage is an interim measure; the eventual intent is to increase the isolation of a large proportion of these wastes, through retrieval if necessary, to permanently dispose of them. Atomic Energy of Canada Limited (AECL) has embarked on a plan to safely dispose of past, current and future wastes for which CRNL is responsible, in repositories that will require no long-term human commitment for control of access, environmental monitoring and corrective action[4,5]. This paper outlines the rationale, the strategy and progress to date in the program for proceeding from storage to permanent disposal of low- and intermediate-level wastes at CRNL.

CRNL SITE DESCRIPTION

The CRNL property, encompassing an area of 37 km^2, is situated on the Ontario side of the Ottawa River about 180 km northwest of the city of Ottawa. The region is sparsely populated; it is unsuited to agriculture and is largely covered with forest of small commercial value. The climate is classified as cold, snow-forest with a warm summer but no distinct dry season. Annual precipitation averages about 835 mm (equivalent rain) of which approximately 20% falls as snow.

The topography is typical of the Canadian Shield, consisting of gently rolling hills (mainly glacially eroded bedrock) interspersed with a number of small lakes and marshes. The bedrock, a Precambrian complex of pink and grey granitic gneiss, is heavily folded and faulted with a fracture density about average for the Canadian Shield . In many areas glacial till deposits and other sediments are covered by extensive sand deposits which, particularly at the higher elevations, drifted into deep dunes before vegetation stabilized the topography.

The upland sand dunes have been, and are being, used successfully for the storage of radioactive wastes in shallow ground storage units and offer the best prospect for disposal of much of the CRNL wastes by shallow land burial. To achieve greater isolation of wastes containing a higher proportion of long-lived radioisotopes, disposal in bedrock 50 to 200 m below the surface may be necessary.

WASTE CLASSIFICATION AND STORAGE

The wastes stored at CRNL are composed of approximately 80% low-level wastes (LLW), 15% intermediate-level wastes (ILW) and 5% high-level wastes (HLW). These classifications are based on the following handling requirements:

LLW - require neither shielding nor cooling,

ILW - require shielding and confinement but not cooling,

HLW - require both shielding and cooling or planned heat dissipation.

Currently, about 50% of the waste is generated on-site from the operation and maintenance of research reactors, laboratories and hot cell facilities, from radioisotope production and from the decontamination and dismantling of radioactive facilities and associated equipment. The other 50% comes from many other Canadian users of radioactive materials, such as medical institutions and universities, industrial producers and users of radioisotopes, nuclear fuel manufacturers and one small power reactor. Radioactive wastes from all other Canadian power reactors are managed by the utilities at the reactor sites .

At CRNL most of the LLW, consisting mainly of such items as contaminated paper, mop heads, plastic trash, discarded supplies and equipment, was buried directly in sand trenches above the water table. The other LLW and most of the ILW containing fission or activation products are stored in buried concrete structures, either in concrete-lined rectangular trenches, or in cylindrical, reinforced concrete bunkers. The ILW consists of ion exchange resins and filters from research reactor cooling systems, Co-60 sources, hot cell wastes, redundant equipment and other wastes requiring shielding.

HLW in the form of irradiated experimental fuel and in-core components containing long-lived activation products and ILW arising mainly from radioisotope production are stored in concrete tile holes vertically embedded in free-draining dune sand.

THE NEED FOR DISPOSAL

With continued land-use control, maintenance and environmental monitoring the wastes could safely remain in the storage facilities for many years to come; however, the level and type of radioactivity in some of the wastes will require their isolation beyond the life of the storage facilities and/or beyond the 100 years or so that institutional controls can be assured. Thus disposal is needed, but not necessarily for all wastes. Some of the short-lived LLW may never be retrieved from storage if it can be shown that its radioactivity will decay to very low levels within the institutional control period or if its isolation can be sufficiently enhanced by engineered barriers added near the ground surface.

The recovery and disposal of stored wastes imposes a burden on future generations in terms of the cost and occupational exposures for handling wastes they did not produce. Our view is that the generation that produces the waste should provide for its disposal. Indeed, there are distinct advantages to initiating the disposal option for LLW and ILW as soon as possible. Sending current wastes directly to disposal will eliminate the interim steps of their transfer to storage and later recovery, with the attendant cost savings and reduction in the radiological exposures of operating personnel. In addition, storage facilities will not have to be built and later abandoned when the wastes are transferred to disposal.

DESIGN CONSIDERATIONS

Disposal Options

The choice of which disposal option or options to select depends upon a number of factors, the most important of which are:

- waste types, quantities and conditioning,
- geological and environmental conditions, and
- economic, social and regulatory conditions[8].

The option(s) selected will depend upon many aspects of each factor and upon the complex interrelationships between all factors. Since the geological and environmental conditions are restricted to those that exist on the CRNL property, the dominating technical factor is that of waste category.

Not only must the disposal of radioactive wastes satisfy health and safety considerations, but it also must be cost effective. The greater the depth of burial, the more assured the isolation, but also, the greater the cost. Thus it is necessary to optimize by matching the depth of burial with the duration of the waste hazard. Similar considerations apply to the provision of engineered barriers, i.e. barriers designed to isolate the wastes from man and/or to impede the movement of radioactive contaminants from the waste repository to man.

Waste Categories

The initial design strategy is to sort the waste into several categories graded according to their hazardous lifetime[a] and to dispose of each category in the repository best suited to isolate and contain that waste until it no longer poses a radiological hazard. Once the waste categories are defined, the objective is to design affordable repositories to meet all necessary safety criteria. There may be as many waste repository designs as waste categories, or the optimum economic approach may be to place all wastes in one or two suitable repository designs.

Based on present knowledge, it appears that the majority of the LLW and ILW stored at CRNL may be assigned to the following three categories, graded according to hazardous lifetime:

(1) Wastes with hazardous lifetimes of less than about 150 years,

  - dominated by radioisotopes with half-lives of less than about 15 years, e.g. Ru-106, Ce-144, Fe-55, Co-60, H-3,
  - containing low levels of radioisotopes with half-lives of intermediate length, e.g. Cs-137 and Sr-90,
  - with strict limits on radioisotopes with long half-lives, e.g. C-14, Ra-226 and actinides.

(2) Wastes with hazardous lifetimes of less than about 500 years,

  - dominated by radioisotopes with half-lives of about 30 years, e.g. Cs-137 and Sr-90,
  - with strict limits on radioisotopes with long half-lives, e.g. C-14, Ra-226 and actinides.

(3) Wastes with hazardous lifetimes of greater than 500 years,

  - dominated by the longer-lived radioisotopes,
  - with limits on some radioisotopes, e.g. Ra-226 and actinides.

Intrusion Resistance

Some provisions must be made in the design of the repositories to reduce the probability of inadvertent intrusion. Direct exposure to the wastes could result from activities such as excavation for sub-surface structures (e.g. basements), laying a pipeline, drilling for a well, farming, or the use of excavated material from the repository in construction or as fill.

The probability of intrusion can be reduced by a combination of active and passive barriers. Institutional control may be regarded as the active barrier.

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[a] The hazardous lifetime of a radioactive waste is that period of time over which some form of protection against radiation dose to humans is needed. The definition is somewhat dependent on local conditions as well as radiological characteristics.

This can include human surveillance and the provision and maintenance of signs, markers, fences and locked gates to alert casual intruders concerning the hazards present and to discourage access to the controlled areas. Such practices have been, and continue to be, successful in avoiding entry to the CRNL waste storage areas. Institutional control also includes monitoring to measure, and if necessary, to restrict through corrective action, any release of radionuclides from the controlled areas. However, reliance on institutional control for a period much beyond 100 years cannot be assured. On this basis, a repository containing category 1 wastes may require isolation for 50 years beyond the assured institutional control period.

The number and character of passive barriers required will depend on both the radiological characteristics and hazardous lifetime of the waste. Such barriers should be robust enough to discourage intrusion by making it too costly. A combination of natural and engineered barriers can be used in the repository cover, augmented perhaps by robust waste package design.

Resistance to Contaminant Release

Water is the major potential medium for the leaching of radionuclides from the waste packages and for transporting the released radionuclides from the repository to the human environment. Therefore, control of surface water and groundwater in and around the repository is of paramount importance.

For shallow ground repositories steps can be taken to exclude water from the facility and to permit it to flow out quickly if it does intrude thus curtailing waterborne releases. At CRNL this approach can be taken by locating the near-surface repositories in free-draining dune sand with the repository base some distance above the recorded water table, by using permeable materials in the bottom of the repository, by providing a water resistant cover to divert infiltrating precipitation away from the waste, and by contouring the surface so as to direct runoff away from the repository.

The design life of a water-resistant cover should be matched to the hazardous lifetime of the waste. Concrete caps, waterproofed with the application of coatings such as bitumen or epoxy and perhaps covered with a heavy plastic membrane, can be used for near-surface trenches containing category 2 wastes. Infiltration into rock cavities can be controlled by grouting the cracks in the rock. If the cavities are located above the regional groundwater systems, water accumulation in them can be avoided by providing a passive (e.g. underground) drain system. Rock cavities may also be located below the water table, preferably in either a hydraulically quiescant or a recharge zone having very low, and downward, groundwater velocity, to allow time for significant decay of the radionuclides to occur before they reach the biosphere.

In some cases the repository covers, whether natural (e.g. earth, rock), or man-made (e.g. concrete, plastic), may provide insufficient assurance that water will not enter the repository and transport unacceptable quantities of radionuclides to the biosphere. Multiple barriers may be necessary to provide this assurance. These barriers could include immobilization of the waste in a leach-resistant matrix, placement in a corrosion-resistant container and the use of backfill materials formulated to retard the movement of radionuclides. The required number and quality of the barriers depends on the hazardous lifetime of the wastes and on the site conditions.

The stability and compaction resistance of the waste and waste containers are of considerable importance for trenches where the cover could collapse (e.g. with unconsolidated covers). Poor compaction resistance can lead to subsidence of the cover to form a depression in the surface resulting in enhanced collection and infiltration of water through the waste. Compaction resistance is of less importance when the cover is self-supporting.

THE DISPOSAL CONCEPTS

The foregoing factors have led to the consideration of the following disposal concepts for CRNL, one for each of the three LLW and ILW waste categories:

(1) an improved sand trench (IST) for LLW with a hazardous lifetime of less than about 150 years,

(2) an intrusion-resistant, shallow land burial (SLB) facility for LLW and ILW with a hazardous lifetime of less than about 500 years, and

(3) a shallow rock cavity (SRC) for LLW and ILW with a hazardous lifetime of greater than 500 years.

Some of the HLW may qualify for disposal in an SRC, but most of it, especially irradiated nuclear fuel components, may continue to be stored, and then transferred to the national nuclear fuel waste repository, located elsewhere in Ontario, when that facility comes into operation[9,10].

The provision of three different disposal facilities for LLW and ILW may not be economic or necessary, perhaps only two or even one type will be eventually built. The final choice will depend on safety and economic considerations. Each of the concepts is described in the following sections.

Improved Sand Trench (IST) Concept

The potentially suitable locations for the IST are in the several upland, free-draining sand dune deposits on the CRNL property. The trenches would be excavated in the sand with their bases 1 to 2 metres above the water table. The bottom of the trench may be covered with a layer of clay/sand formulated to retard the migration of radionuclides, but permeable enough to let infiltrating water escape. The waste packages could be placed on the trench floor with the clay/sand mixture tamped between layers of packages. The cover above the waste might be composed of, for example, layers of sand, gravel, boulders, cobbles, gravel, a heavy plastic sheet, gravel, sand and topsoil. The resulting mound, planted with vegetation to stabilize the topography, would be contoured to direct precipitation runoff away from the repository. Some of these simple features (e.g. contouring, buried plastic membranes, vegetation) are being applied to some of the existing storage trenches in sand at CRNL to demonstrate their effectiveness.

Intrusion-Resistant Shallow Land Burial (SLB) Concept

The reference design of the *SLB concept* is a trench approximately 100 m long by 20 m wide by less than 10 m deep with a usable depth of at least 6 m[11]. It would be located in free-draining dune sand with the base above the recorded water table. The design features reinforced concrete walls and a one-metre thick, self-supporting, reinforced concrete cap to discourage the intrusion of humans, animals, plants

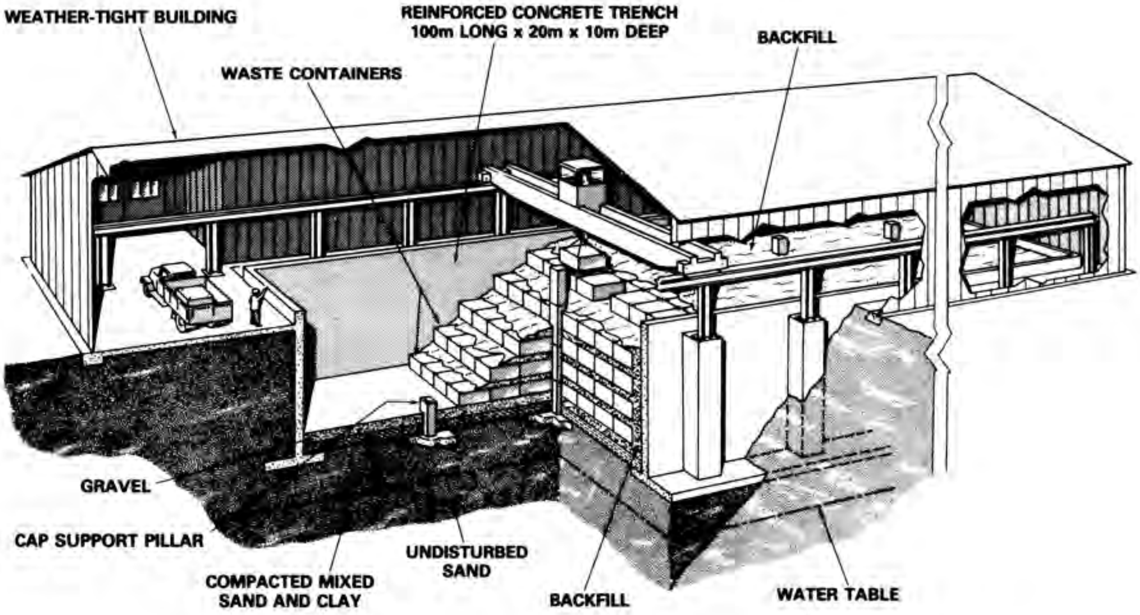

Fig. 1. Intrusion-resistant shallow land burial facility during the operational phase with the weather-shield building in place.

and infiltrating precipitation. To avoid the "bathtub effect" should the cap ever develop leaks, the trench bottom would be permeable, composed of a 0.5 m thick layer of gravel and a 0.5 m thick layer of clay/sand mixture to absorb released radionuclides.

The waste containers would be stacked on the gravel floor and the clay/sand mixture may be tamped into place between layers of containers. Although the usable part of the repository structure would enclose a space of 12,000 m^3, it may contain as little as 7000 m^3 of waste containers; the rest would be backfill.

During operation, the facility and a vehicle unloading bay would be covered with a weather shield, probably a pre-engineered, rigid frame building (Fig. 1). Placement of waste packages within the facility could be accomplished with an overhead crane operating on rails within the weather shield. The intent is that both the weather shield and crane would be capable of being dismantled and relocated over a second SLB unit after the first had been filled and capped.

When the waste and backfill were in place the remainder of the facility would be filled with compacted sand prior to installation of the concrete cap. Protection against moisture intrusion could be enhanced by using, for example, construction joint sealants, an epoxy or bituminous coating on the outside of the concrete, and/or heavy polymeric sheet on top of the cap but under the soil cover. When the weather structure had been removed the facility would be buried, probably under about 1.5 m of soil, to locate the concrete cap below the freeze/thaw zone. The soil cover would be contoured to direct surface water away from the facility and it would be planted with vegetation to resist erosion and stabilize the topography (Fig. 2).

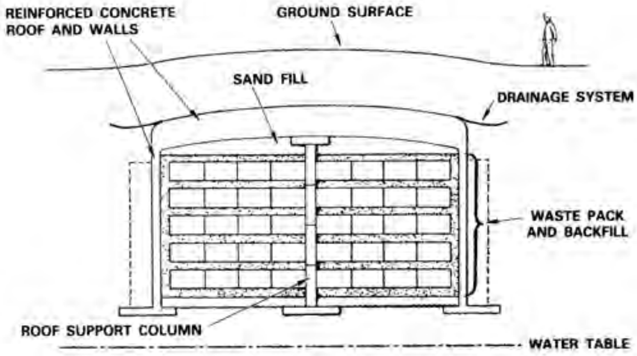

Fig. 2. Intrusion-resistant shallow land burial facility after closure.

Shallow Rock Cavity (SRC) Concept

Since it is expected at least some of the ILW (e.g. parts of those arising from radioisotope production and future decommissioning of some radioactive

CRNL facilities) will need disposal with longer-term isolation than can be provided by an SLB, a mined SRC concept is being investigated[4]. A preliminary survey indicates that such a repository could be located under one of two rock ridges on the CRNL property. Emplacement cavities would be below the weathered zone of rock (perhaps 50 m thick), but probably no deeper than 200 m.

Earlier design studies[12] aimed at national requirements examined SRCs with capacities ranging from 200,000 to 800,000 m^3; present indications suggest that a capacity of from 60,000 to 160,000 m^3 may be adequate for CRNL. These SRCs may be multi- or single-level and would contain several cavities of the same or different size. The maximum size of waste cavity is technically dependent on rock properties (e.g. strength, in-situ stress, jointing, fractures), but is governed to a large extent by economics related to waste emplacement rate, total capacity and the practical aspects of waste handling. Single cavity volumes of 10,000 to 20,000 m^3 appear likely. The waste content of the cavities would probably be between 50 and 70%, the rest would be backfill. If a repository were to be located in the highest ridge, which rises 100 m above the Ottawa River, access could be provided through a sloping tunnel from the base of the ridge.

A rock cover 50 m in depth could serve as an effective intrusion barrier; however, the bedrock is highly fractured and may not form a reliable barrier to water flow or radionuclide migration. In that case, control of releases would be provided by the engineered barriers such as waste form, waste container, backfill material and crack grouting.

Although there is no extensive R&D support program at CRNL for this type of repository, a great deal of relevant technology would be available from the major research program which has been underway for several years at AECL's Whiteshell Nuclear Research Establishment (WNRE) at Pinawa, Manitoba to develop the technology for a similar but much larger and deeper repository for high level nuclear fuel waste[9,10].

WASTE VOLUME REDUCTION AND IMMOBILIZATION

A major component of the waste disposal strategy is the development of economic waste conditioning methods to reduce the large volume of LLW and to produce a stable, well-defined waste form which would resist leaching of the contained radionuclides. These functions are provided by the CRNL Waste Treatment Centre (WTC). The WTC contains an incinerator and baler for low-level solid waste, an ultrafiltration/reverse-osmosis (UF/RO) system for concentrating low-level aqueous wastes and equipment for immobilizing the residues in a bitumen matrix[13,14]. The first two units are fully operational while the last two are being commissioned and are expected to be in operation during 1985.

WASTE CHARACTERIZATION

The objective of the waste characterization program is to sort wastes into categories which can be matched to one of the disposal concepts capable of containing that category of waste for its hazardous lifetime. Initial testing of a prototype waste characterization system at the WTC indicates that a good estimate of the radionuclide content of an incinerator charge could be obtained by selectively gamma-ray monitoring the 10% of the waste charge which was found to contain greater than 90% of the gamma-ray activity[15]. This work also suggests that alpha- and beta-emitting radionuclides can be estimated with acceptable confidence from the gamma-ray isotope signature of the waste feed. Based on the success of the prototype monitor, a dual-detector, demonstration monitor has been installed in the WTC to characterize both incoming raw waste in bags and the processed output (ash and bales).

RESEARCH AND DEVELOPMENT IN SUPPORT OF DISPOSAL PROGRAM

Continuing R&D programs have been underway for many years to determine the key factors affecting the release and transport of radioactive contaminants from the waste to the human environment. Data and understanding are needed to predict the likely pathways for radionuclide migration and to describe their movement in space and time along those pathways. A brief summary, highlighting the R&D programs, follows.

Environmental Research

An extensive body of environmental information has been accumulated for the CRNL property, especially in the areas of upland sand deposits, over the last 40 years as a result of an active and continuing environmental research program. Field and laboratory studies have contributed greatly to our understanding of the geology, geophysics, hydrogeology and groundwater chemistry of the area. For instance, the migration of subsurface radioactive plumes from several liquid injection sites on the property have been closely followed over many years[16,17]. These plumes enable direct measurements to be made of the distribution, mobility and the chemical/physical speciation of many radionuclides. Analytical models, developed to predict the migration of radionuclides in unconsolidated materials, have been successfully compared to field measurements and laboratory tests.

A limited amount of rock drilling and some geophysical studies have been done at CRNL. Some drilling was done in connection with the Nuclear Fuel Waste Management Program to study groundwater flow through rock fractures and to develop geophysical investigation techniques[10]. These data and methods, together with the extensive generic data obtained at other locations in the Canadian Shield, will be invaluable in planning the site characterization program for the SRC concept.

Engineered Barrier R&D

Experiments are underway to study the leaching behaviour of waste forms (e.g. bituminized wastes) and to measure the transport of contaminants from simulated wastes through backfill materials, particularly clay/sand mixtures. Laboratory experiments have shown that alkaline groundwater which has been in contact with concrete (which is being considered for waste packages and repository enclosure) will lower the release and transport rates of radionuclides from bituminized wastes[18]. Full-scale lysimeter tests containing simulated waste products in SLB repository field conditions are planned to start in 1985.

One problem reported with some bituminized wastes, i.e. those containing dry ion-exchange resins and anhydrous salts, is swelling of the product when immersed in water accompanied by an increase in radionuclide release[19]. However, tests at CRNL[18] have shown that a confining pressure of less than 7 kPa prevents the swelling and radionuclide release. Thus, proper containment and backfilling should resist water take-up and swelling in bituminized wastes.

Two clay materials are being tested for possible use as backfill materials at CRNL: one is an illite clay which can be obtained in the region and the other, sodium bentonite, is also being investigated by WNRE for the nuclear fuel waste repository. Mixtures containing up to 10% clay and local sand are being tested to find a suitable formulation in terms of cost and performance.

Various aspects of container materials and design are being studied. Metal and concrete containers are receiving the most attention, with the focus on durability and corrosion resistance. A study is underway to determine the optimum size and wall thickness for concrete overpacks. If used, the overpacks would be designed to contain unpackaged wastes or a number of smaller waste packages (e.g. drums, bales, etc.) to simplify handling and emplacement at the repository, to reduce the exposure of operating personnel by providing some shielding and to provide a barrier against water access and leaching of the radionuclides.

A second objective of the barriers development program is to provide models and parameters for the safety analysis. The REPOS computer code is being developed to simulate one-dimensional radionuclide transport from immobilized waste through engineered barriers. This code helps to provide an understanding of radionuclide movement through the repository, the mechanisms involved in the transport and to predict the long-term movement of radionuclides from within the repository system.

SAFETY ASSESSMENT CAPABILITY

The objective of the safety assessments is to estimate the total effect the proposed disposal facilities will have on man and the environment. This involves analysis of the combined mechanisms that can affect the isolation and containment features of the repository concept, including the characteristics of the waste form, waste container, backfill, repository design, the geologic surroundings and the biosphere.

Two different time intervals are involved, pre-closure and post-closure. The pre-closure phase covers the construction and filling of the facility, and its closing and sealing when full. The post-closure period is much longer; it begins when the facility has been sealed and lasts until the potential hazards to the public have diminished to very low levels. Both phases require an assessment of risk to the general public, but for the pre-closure phase the prime concern is for the workers who handle and emplace the waste.

The assessment process begins with predictions from scenarios that result in the release of radionuclides from their containment, and then couples such scenarios with analysis of pathways by which the nuclides might travel through the environment to irradiate man, either externally or through intake. The impact of radionuclide release from the repository on man will be assessed by means of a number of mathematical models. They are compounded from theory and experimental observation; their sophistication is consistent with the detail of the data available and the extent of the understanding of the processes involved. The resulting computer codes are based on a systems approach which link together a set of sub-models representing the main components of the disposal system, i.e. the repository, the geosphere and the biosphere.

Two codes are being used to perform the safety assessments for the SLB facility. The first is a simple deterministic code called COSMOS for analyzing the effect of the most significant radionuclides[20]. Preliminary results using the COSMOS code for a flooded, but intact, SLB facility indicate that the exposures to man resulting from Cs-137 release (one of the radionuclides being modelled) are extremely small and tend to peak at about 1000 years after closure.

The principal safety assessment tool will be the computer program SYVAC (SYstems Variability Analysis Code)[21,22]. This code is being developed for the fuel waste repository by WNRE and is being modified at CRNL for the SLB assessment. SYVAC is a probabilistic code in which uncertainty in data and variations in space and time are allowed for by defining the input parameters as distributions rather than as single values. By running the code for many different values from each distribution, the consequences (dose to man) can be obtained in the form of a frequency distribution to show the probability of the various consequences including the most probable.

PRIORITIES AND SCHEDULE

Since a bulk of the wastes stored at CRNL is believed to have a hazardous lifetime of less than 500 years, the SLB concept is receiving most of the current development effort. The immediate objective of the waste disposal program is to develop the SLB technology and to demonstrate its suitability as soon as practicable for as large a fraction of the CRNL waste as is appropriate. This objective is believed to be achievable by developing, constructing and operating one or two prototype SLB units before proceeding with the construction of "standard" units. The tentative schedule calls for construction of the first prototype during 1987-88, operation for four years and closure of the facility in 1992. The prototype would provide relevant cost data and would be invaluable in the design of the "standard" units by providing operating information on such items as the waste handling system, use of the weather shield and on closure technology.

The IST is given second priority. Further analysis of the concept is required to determine if such a facility is economic and if it can meet all of the safety criteria. If the decision is to proceed, a prototype could be ready to receive wastes in 1990.

Because the volume of CRNL wastes with long hazardous lifetimes (>500 years) is small, there is no immediate need for an SRC facility, nor is a large SRC R&D effort warranted at this time.

SUMMARY

Radioactive wastes have been successfully stored at CRNL for almost 40 years. To avoid encumbering future generations with the responsibility for looking after these wastes, and to avoid the costs and radiation exposures associated with double handling of current wastes, CRNL has embarked on a program to evolve from waste storage to waste disposal.

The strategy involves sorting the wastes into several categories graded according to their hazardous lifetimes and to dispose of each category in a repository suited to isolate and contain that waste until it no longer poses a radiological hazard to man. The disposal concepts selected for study include an improved sand trench (IST), an intrusion-resistant shallow land burial (SLB) facility and a shallow rock cavity (SRC) for wastes with hazardous lifetimes of <150, <500 and >500 years respectively. The IST and the SLB would be located in the upland, free-draining dune sand deposits while the SRC would be located under one of two rock ridges on the property. Which option or options will actually be built will depend on safety and economic criteria. As a first stage, construction of a prototype SLB facility is planned to better assess its operation, short-term performance and economics.

Important components of the program are the commissioning and operation of the Waste Treatment Centre to volume reduce and immobilize low-level solid and aqueous wastes in bitumen, the development of a practical waste characterization monitor, environmental research to characterize potential waste disposal sites, the development and optimization of engineered barriers and the development of computer codes to assess the safety of the various disposal concepts.

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