A Review of Low-Level Radioactive Waste Management Technology in the Canadian Nuclear Industry

T.J. Carter and P.K.M. Rao
Ontario Hydro
Toronto, Ontario
Canada
M5G 1X6

Abstract
Canada's low-level radioactive wastes (LLW) (generated primarily from the CANDU nuclear fuel cycle, radioisotope research, and industry) have a wide range of physical forms and radionuclides, and are currently managed either by producers or by the Atomic Energy of Canada's Chalk River Nuclear Laboratories (CRNL), which operates a national collection and management service for small producers. The processing and storage methods are generally well established. Substantial research and development is in progress for a gradual transition to disposal methods, including a shallow land burial (SLB) demonstration facility at CRNL. With a federal policy that encourages producers to propose disposal methods, the stage is now set for a transition from the current interim methods to long-term methods of LLW management.

Résumé
Au Canada, les déchets faiblement radioactifs sont surtout des sous-produits du cycle du combustible nucléaire CANDU ainsi que des activités de recherche et de fabrication de radio-isotopes. Ces déchets se présentent sous une grande variété de formes physiques et de radionucléides. Leur gestion est actuellement assurée par les producteurs eux-mêmes ou encore par les Laboratoires nucléaires de L'Energie Atomique du Canada à Chalk River, qui offrent un service de cueillette et de gestion aux petits producteurs de tout le pays. Les méthodes de traitement et de stockage sont généralement bien établies. Des travaux importants de recherche et de mise au point sont actuellement en cours afin d'assurer une transition graduelle vers des méthodes d'évacuation, y compris une installation de démonstration d'enfouissement à faible profondeur aux Laboratoires nucléaires de Chalk River. Grâce aussi à la politique du gouvernement fédéral encourageant les producteurs à proposer des méthodes d'évacuation, le Canada est maintenant prêt pour une transition sans heurts des méthodes actuelles provisoires à des méthodes à long terme de gestion des déchets faiblement radioactifs.

Introduction

Low-level radioactive wastes (LLW) generated in Canada broadly fall into one of the following categories:

a) those produced by the Canadian nuclear industry (e.g., in the uranium fuel production and power generating stages of the nuclear fuel cycle, and nuclear research and radioisotope processing facilities); and
b) those produced by a large number of licensed radio-isotope users (such as hospitals and laboratories) and a number of non-nuclear industries dealing with naturally radioactive feedstocks in their operations.

Electric utilities with nuclear generating stations in Ontario, Quebec and New Brunswick; uranium refiners; fuel fabricators; and Atomic Energy of Canada Limited (AECL) produce category a) wastes, which account for the major portion of the low-level wastes in Canada. AECL's Chalk River Nuclear Laboratories (CRNL) provide a national fee-based radioactive waste collection and storage service for those institutions that produce only small volumes of wastes, such as the over 5,000 licensed users of radioisotopes (category b). The wastes from industrial generators arising from processes that use raw materials containing naturally occurring radionuclides (abrasives manufacturing, specialty metal alloy production, etc.) make up the rest of category b). Not included here, are the uranium mine and mill tailings, which are locally managed by the mining industry. Table 1 summarizes the LLW arising in Canada.

There are no licensed low-level radioactive waste disposal facilities in Canada, although studies are in progress, and long-term plans are likely to be implemented in several organizations over the coming decades. The Low Level Radioactive Waste Management Office (LLRWMO) of AECL is spearheading analysis of the need and alternatives for establishing disposal facilities in Canada.

Low-level waste management in the Canadian nuclear industry has reached maturity in two important phases:

Keywords: radioactive wastes, processing, storage, disposal.

Table 1: Canada's Low-Level Waste Volume Projections (Based on Ref. 1)

	LLW projections (m^3) to year 2025
Category (a)	
Canadian nuclear industry	
Refining	65,000
Fuel fabrication	14,800
Utilities	156,500
Isotopes and research	61,200
Category (b)	
Other producers (institutional / industrial)	
Licensed users	12,900
Industries using naturally radioactive feedstocks	57,100
Total	367,500

These exclude about 1.2 million m^3 of wastes, primarily contaminated soils at several 'historic' sites, CRNL site and waste management sites of Eldorado Resources Limited at Welcome and Port Granby, Ontario.

Some compaction of the wastes at the source is assumed, as is carried out by the producers normally.

a) in the interim management of the diverse waste sources; and
b) in the technological research and development in support of plans for disposal of LLW.

This paper will review Canadian low-level radioactive waste management technology and outline Canadian efforts in developing low-level waste disposal systems.

Sources and Character of Low-Level Wastes

Technologies used in the various phases of LLW management share the common objective of safe containment of radioactivity. Waste properties differ widely across the industry and generally have been well characterized. Table 2 summarizes LLW characteristics.

The fuel production stages of the nuclear fuel cycle, which include uranium refining and fuel fabrication processes, yield uranium-contaminated materials and residues. Eldorado Resources Limited, the federally owned refiner, produces the major component of these wastes, which are currently managed in storage facilities near the plant at Port Hope, Ontario. Wastes from Canada's two fuel fabricators, Canadian General Electric and Westinghouse Canada, are sent to CRNL for storage.

Wastes in the power generating stages of the nuclear fuel cycle make up the major ongoing volume component of nuclear industry wastes. Ontario Hydro, which has a committed nuclear program of 13,600 MWe, is by far the major producer of these wastes; the other

Table 2: Characterization of Canada's LLW (1984 Statistics Compiled by Ontario Hydro for LLRWMO, Ref. 2)

Source / physical classification	*Major radionuclides (and half-life (a))*	*Typical radioactivity concentration Ci / m^3*
Category (a) – Canadian nuclear industry		
1 Refining	U-natural	up to 5×10^{-2}
	U-depleted	
2 Fuel fabrication	U-natural	up to 0.00013
	U-238	
3 Utilities		
Low-level (non-incinerable)	H-3 (12.3)	1×10^{1}
	C-14 (5730)	5×10^{-6}
	Co-60 (5.3)	1×10^{-2}
	Sr-90 (28.6)	1×10^{-3}
	Cs-137 (30.2)	3×10^{-3}
Low-level (incinerable)	Co-60 (5.3)	2×10^{-3}
	Sr-90 (28.6)	8×10^{-4}
	Cs-134 (2.1)	5×10^{-4}
	Cs-137 (30.2)	2×10^{-3}
Intermediate-level resins	H-3 (12.3)	2×10^{0}
	C-14 (5730)	2×10^{2}
	Co-60 (5.3)	4×10^{0}
	Sr-90 (28.6)	1×10^{-1}
Intermediate-level filters	Co-60 (5.3)	Direct measurements not yet available
	Cs-137 (30.2)	
Irradiated core components (retubing)	Fe-55 (2.7)	3×10^{4}
	Co-60 (5.3)	6×10^{3}
4 AECL research	Co-60 (5.3)	9×10^{-2}
	Cs-134 (2)	15×10^{-3}
	Cs-137 (30.2)	2×10^{-2}
Low-level (non-incinerated)	H-3 (12.3)	5×10^{-3}
	C-14 (5730)	2×10^{-5}
	Sr-90 (28.6)	1×10^{-6}
	Tc-99 (2)	2×10^{-5}
	Cs-137 (30.2)	1×10^{-6}
	Mixed fission products (MFP)	7×10^{-2}
	Activation products (MAP)	17
Low-level (incinerated)	Co-60 (5.3)	7×10^{-1}
	Cs-134 (2)	1×10^{-1}
	Cs-137 (30.2)	4×10^{-1}
Intermediate-level	H-3 (12.3)	12×10^{-2}
	Co-60 (5.3)	134
	Sr-90 (28.6)	14×10^{-3}
	Cs-137 (30.2)	3×10^{-2}
	Ra-226 (1600)	2×10^{-2}
	Am-241(432)	1×10^{-2}
	MFP	5×10^{3}
	MAP	8×10^{2}
Sealed sources	Sr-90 (28.6)	
	Cs-137 (30.2)	
	Am-241(432)	

Table 2 (Continued)

Source / physical classification	*Major radionuclides (and half-life (a))*	*Typical radioactivity concentration Ci / m³*
Category (b) – Institutional / industrial		
Institutional	H-3 (12.3)	<100
	C-14 (5730)	3×10^{-3}
	Sr-90 (28.6)	5×10^{-4}
	Cs-137 (30.2)	0.3
	Ra-226 (1600)	9×10^{-5}
	Am-241(432)	0.2
	Co-60 (5.3)	1.3
Industrial	Ra-226 (1600)	1.5×10^{-4}
	Th-230 (7.7×10^4)	1.5×10^{-4}
	Th-232 (1.4×10^{10})	1×10^{-3}
	U-natural	2.1×10^{-4}
	H-3 (12.3)	<0.1
	C-14 (5730)	0.2
	Co-60 (5.3)	<0.1
	Cs-137 (30.2)	<0.1
	Ra-226 (1600)	<0.1

contributors are the provincial electric utilities of Quebec and New Brunswick. The wastes are classified as 1) low- and 2) intermediate-level wastes. Both these subcategories are non-heat-generating, and are hence 'low-level,' although intermediate-level wastes require shielding. Low- and intermediate-level wastes consist, essentially, of all radioactive wastes produced in CANDU nuclear generating stations (NGS), other than those contained in the irradiated fuel. These wastes primarily consist of

a) housekeeping wastes, such as paper and plastic sheeting, temporary floor coverings, used protective clothing, rubber gloves and plastic suits, mopheads, rags and other cleaning materials, and contaminated hardware;
b) spent ion exchange resins and filters from purification systems; and
c) large irradiated and contaminated core components, arising from rehabilitation and retubing of reactors.

These wastes are mostly contaminated with short-lived radionuclides, such as Co-60, Cs-137, Sr-90, and H-3, with a particular segment of the waste (resins) containing C-14, a radionuclide with a half-life of 5,730 years.

The nuclear research laboratories at the Chalk River Nuclear Laboratories in Ontario, the Whiteshell Nuclear Research Establishment in Manitoba, and AECL's radioisotope processing facility in Ottawa are the major contributors of the remaining wastes from the Canadian Nuclear Industry. These consist of contaminated materials from laboratories, maintenance and purification wastes from research reactors, and wastes from isotope processing. These are not altogether different from the utility wastes in radiological character.

Institutional and industrial (category b) wastes consist of a wide range of radionuclide materials, such as sealed sources used in industrial equipment such as gauges, industrial radiography cameras, and static electricity eliminators; contaminated materials (i.e., animal carcasses, scintillation vials, liquids, filters, syringes, wipes and gloves from medical applications of radioisotopes); and residues from abrasives manufacturing or speciality metal alloy industries, which process raw materials containing naturally occurring (incidental) radionuclides. While the institutional wastes are handled by CRNL's national collection and storage service, incidental wastes from the industries are generally managed by the producers themselves.

Waste Management Technology

The major technologies in the management of LLW include

a) processing;
b) transportation;
c) storage; and
d) disposal.

Producers segregate wastes 'at the source,' taking into consideration the physical / radiological properties of the waste, to facilitate the application of the above technologies.

Processing

Processing of wastes is undertaken to reduce the volume and / or produce a wasteform more suitable for packaging, storage, and eventual disposal. For example, some 90 per cent of low-level utility waste is processible, either by mechanical compaction or incineration. Compaction results in a volume reduction ratio of about six, while incineration provides a volume reduction ratio of about 75.

Processing of LLW by incineration and baling has been adopted by Ontario Hydro [3] and Chalk River Nuclear Laboratories [4], the two major producers in the Canadian Nuclear Industry. Ontario Hydro has been operating a Waste Volume Reduction Facility (WVRF) at the Bruce Nuclear Power Development (BNPD) since 1977.

With waste sources that rapidly increased in number in the 1970s, due to an expanding nuclear program, Ontario Hydro put into service in-station waste management systems for collection, segregation, and packaging of wastes, as well as a centralized waste management site at the BNPD consisting of an incinerator, baler / compactor system, and a central maintenance facility that carries out laundering, decontamination, and other 'active' maintenance operations in support of nuclear stations [5]. AECL has constructed a Waste Treatment Centre (WTC) to process and condition CRNL's LLW. The WTC is composed of an incinerator and baler for solid wastes, an ultrafiltration and reverse-osmosis system for the concentration of aqueous wastes, and equipment for immobilizing the ash and solids from the

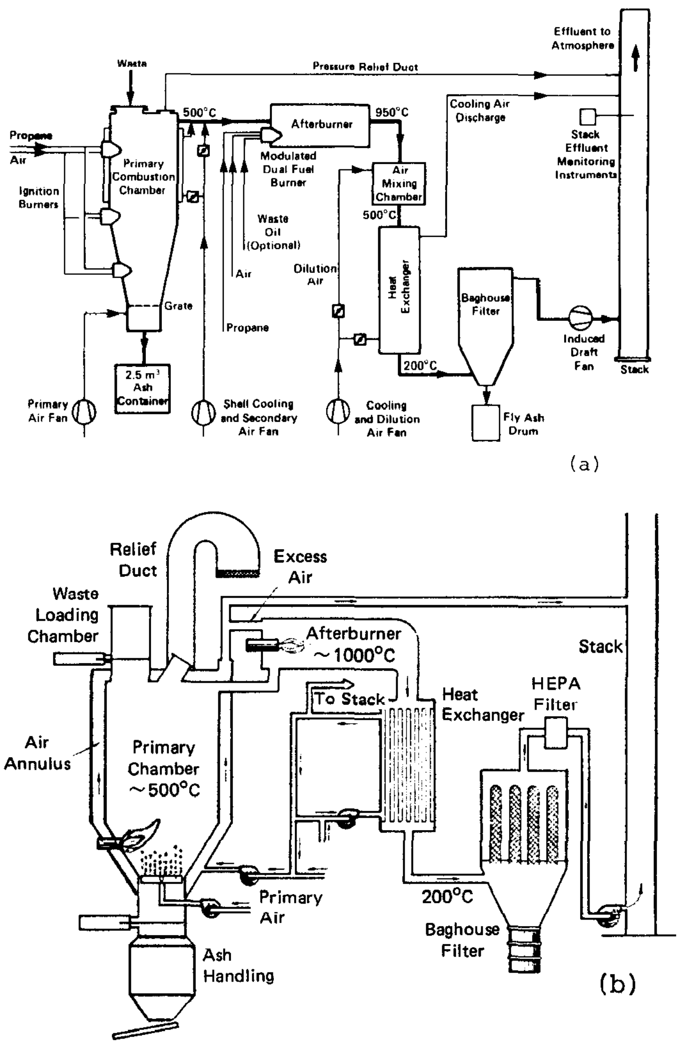

Figure 1: LLW Incinerators in Canada (a) Ontario Hydro (b) CRNL.

waste concentrates into a bitumen matrix. The goal is to produce a final-conditioned waste which is in a stable, compact, and leach-resistant form suitable for both storage and disposal. By combining several processes in a full-scale integrated system, the WTC serves to develop waste conditioning methods, improve the management of CRNL site wastes, demonstrate waste processing technologies, and generate performance and cost data for other Canadian nuclear facility owners.

Incineration Technology

Ontario Hydro's nuclear program currently generates about 6,000 m^3 unprocessed low-level waste per year, and this quantity is expected to increase to over 8,500 m^3/yr by 1992. Approximately 65 per cent of this volume is classified as incinerable. The Ontario Hydro system, like the CRNL system, utilizes a controlled air batch-pyrolysis technique (Figure 1), in which the combustion air quantity is starved in the primary chamber to about 30 to 50 per cent stoichiometric. The pyrolysis effluent from the combustion chamber is then fully oxidized in an afterburner. The dry off-gas clean-up system consists of an off-gas cooling stage and a one-step filtration stage in a baghouse; no polishing filtration is employed [3].

Although the Ontario Hydro incinerator is a working prototype that has required modifications during its operating life, it has, nevertheless, become one of the most productive incineration systems in the nuclear industry. To the end of 1985, over 20,000 m^3 of low-level waste has been processed in over 55,000 operating hours. Waste with a contact dose rate of up to 0.6 mSv / h is incinerated. Typically, solid waste with a specific gross gamma activity of 0.02 to 0.08 GBq / m^3 has been processed. Incinerator ash, which has a specific activity ranging from 0.08 to 8 GBq / m^3 is 'dumped' into 2.5 m^3, rectangular galvanized steel containers, which are then placed in the storage structures. Contact fields on most of the ash containers are between 0.1 to 0.2 mSv / h. Radioactive emission experience with the incinerator has been very satisfactory, with particulate gamma activity on the order of 70 KBq released through the stack for each m^3 of waste burned.

CRNL's incinerator, which also uses a starved-air batch pyrolysis process, is a more advanced version of the production unit operated by Ontario Hydro. It has improvements in control, process versatility, and the use of corrosion-resistant materials. It is designed to process batches of up to about 1,300 kg of solid waste in a nominal 24-h cycle. Particulate beta-gamma stack releases have remained less than 37 KBq per burn.

Transportation

Transportation of low-level waste is carried out in accordance with IAEA transportation regulations enforced by the Atomic Energy Control Board. Most wastes, such as the bulk LLW, contaminated soils, etc., qualify – depending on their radioactivity – either as LSA (low specific activity) or type A wastes. Waste materials with higher concentration of radioactive contaminants, such as intermediate-level wastes, require transportation in accident-resistant type B packages. The classification of transportation packages (as LSA, type A, or type B) is carried out in accordance with transportation regulations.

The infrastructure is now available in the Canadian nuclear industry to design, test, and commission transportation packages for low-level wastes, and for radioactive materials with higher levels of radioactivity – such as irradiated fuel and cobalt-60.

Storage

Ontario Hydro Experience

Currently, all radioactive waste materials are stored at BNPD, in a retrievable manner, in facilities having design lifetime of 50 years [6]. No radioactive materials are placed directly in soil; either in-ground or above-ground engineered structures are used.

The storage site consists of 19 acres (0.8 km^2) and a variety of storage facilities built on relatively impermeable glacial till deposits. Ontario Hydro has been developing the BNPD Radioactive Waste Operations Site for the last fifteen years [7]. To date, 37,000 curies (as stored) of radioactive wastes are estimated to be stored at the site. Among the storage facilities are

a) reinforced concrete trenches used for the storage of the low-level wastes;
b) in-ground structures, called 'tile holes' (used to store filters and ion-exchange resins that contain a higher level of radioactivity), including newer versions that employ borehole augering technology to allow faster construction, lower costs, and greater depths;
c) two above-ground prefabricated, prestressed concrete superstructures, called 'low-level storage buildings' (LLSB's), now being used for storage of low-level wastes with radiation fields less than 10 mSv / h;
d) double-walled, above-ground reinforced concrete structures, called 'quadricells,' used primarily to store intermediate-level resins, with a secondary role of storing highly radioactive core components.

AECL Experience

The CRNL facilities are located in elevated and well drained deposits of sand [8]. The radioactive waste is generally placed above the water table, to reduce the likelihood of contact with water. Close to 100,000 m^3 of solid radioactive wastes are stored or buried at the CRNL property. Eighty per cent is LLW, 15 per cent is intermediate-level, and five per cent is high-level waste. The LLW is generally buried unprotected in sand trenches, well above the water table. Solid wastes with higher radioactivity are stored, retrievably, above the water table in engineered concrete structures, ranging in diameter from 0.15 to 6.0 m, and in depths of up to 5 m. Each structure is fitted with a removable, weatherproof shielding cap, and protrudes less than a metre above grade.

Others

Two other Canadian utilities (Hydro Quebec and New Brunswick Power) have local sites for management of low-level wastes. These utilities employ designs similar to the engineered storage facilities of Ontario Hydro and CRNL. Eldorado Resources Limited, the major refining industry, operates its own storage facilities a few miles from its Port Hope plants. These facilities primarily consist of above ground waste emplacement schemes or shallow burial. Industries using materials in production processes that are incidentally radioactive (e.g., abrasives industry) generally store the waste materials at the plant sites.

Present Research and Development into Disposal

The above methods of storage are considered interim in that at least some of the wastes will be radioactive beyond the timeframe of storage and will require disposal. Disposal, by definition, is a permanent method of management, without the intention of retrieval, and does not rely for its success on perpetual institutional controls and monitoring.

The Chalk River Nuclear Laboratories have taken the lead in developing and demonstrating a disposal capability for low-level wastes in Canada [9]. Three concepts selected for study by CRNL include

a) 'improved sand trench' (IST) for wastes that need isolation up to about 150 years;
b) intrusion-resistant 'shallow land burial' (SLB) for wastes that require isolation up to about 500 years;
c) 'shallow rock cavity' (SRC) for wastes that need isolation for more than 500 years.

Based on knowledge of the radiological characteristics of the stored wastes, it is anticipated that the bulk of the waste could be disposed of in the SLB Facility (Figure 2). The other two concepts are considered potential complements to SLB.

The SLB is about 100 m long by 20 m wide by less than 10 m deep, with the top of the wall near the surface and the bottom above the water table. Once filled it will be covered with a self-supporting, water-shedding, concrete roof (and perhaps other water-shedding barriers), then buried under a relatively thick ground-cover to prevent erosion, and thus stabilize the topography. Continued engineered storage of LLW wastes is considered the essential ingredient in Ontario Hydro's plans. Programs are well advanced in the research and development of disposal technologies for those long-lived or higher-radioactivity wastes that will require disposal. Decisions on acquisition and proponency for a disposal facility have not been made up to this stage [10].

Eldorado Resources Limited (ERL) have been evaluating disposal facilities for their currently stored refinery wastes and for their ongoing production of LLW. Near-surface burial in glacial till, and intermediate-depth burial concepts in the local limestone geology, have been researched for application in the regions surrounding their Port Hope refining operations.

Responsibilities and Other Issues in LLW Management

Although the responsibilities of the provincial and federal governments in the area of low level-waste management is still a subject for discussion, some of the jurisdictional aspects are becoming clearer in Canada. Of importance are the following:

a) The federal government has established the Low-Level Radioactive Waste Management Office (LLRWMO) of Atomic Energy of Canada Ltd, in Ottawa, as the agency to discharge federal responsibilities in the area.

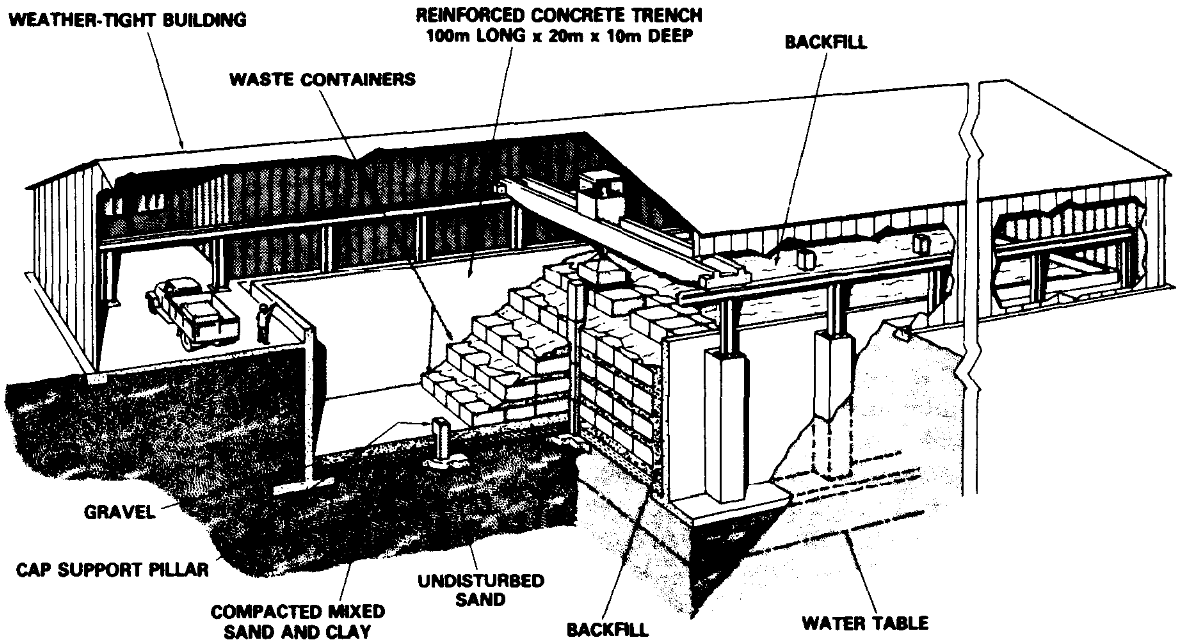

Figure 2: CRNL shallow land burial (SLB) facility.

b) The federal government accepts residual responsibility for LLW, i.e., responsibility for the wastes for which no person or company can be held responsible.
c) The federal government has adopted the principle (Federal Policy on LLW, 1986) that the primary responsibility for the management of radioactive wastes, including disposal, must rest with the producers of such wastes, and that the costs of waste management should be borne by those benefitting from the activities responsible for the generation of wastes [11].

The producers are accountable for ensuring that the wastes are properly isolated over their hazardous lifetime. This could include the development of sole- or joint-use disposal facilities and sites. The federal government may accept residual responsibility,

1. as in the case of cleanup and disposal of historic wastes, wastes from small producers, or companies no longer in business; and
2. as in the long-term stewardship of disposal sites after they have been closed and the producer's responsibility has been terminated.

One of the tasks undertaken by the LLRWMO is to establish, or to ensure the establishment of, low-level radioactive waste disposal facilities that could be used by institutions, such as universities and hospitals (small producers), on an ongoing basis. These low-volume producers are those who would otherwise be unable to establish their own facilities.

The benefits from the nuclear industry are diffused throughout society, while the perceived detriments from waste facilities are local to host communities. The Federal Policy on LLW management recognizes that the ideal democratic principle – that preference should be given to courses of action resulting in greater good for the greater number of people – is not widely accepted by residents who live near a proposed waste facility. Recent opposition from potential recipient (host) communities to relocation of contaminated materials / soils from past operations are cases in point. Although many factors (such as human health and safety, environmental protection, and general societal concerns) are taken into consideration by any proponent, it is absolutely essential that co-operation and participation of the public, and local and senior levels of government be sought in the necessary decision-making processes. In some cases, it is anticipated that an area that hosts a disposal facility may obtain 'offsets' for accommodating the facilities.

Summary

The Canadian nuclear industry has reached maturity in the interim management of all the waste segments produced not only by the nuclear industry, but by over 5,000 of the nation's institutions for which the Chalk River Nuclear Laboratories provide a service in collection and storage of their LLW. With the ultimate aim of providing for safe isolation of radioactivity over the hazardous life of LLW, the industry is involved in comprehensive technological research and development for disposal systems. CRNL has taken the lead in demonstrating the disposal capability in Canada, by commitment to a shallow burial facility (SLB) at the CRNL site.

Lastly, policies and regulations critical to acquisition of new waste management sites are emerging in Canada. These should facilitate transition from the current interim waste management practices to methods providing permanent isolation of LLW. Co-operation and participation by the public and different tiers of government is considered an absolutely essential ingredient in the decision-making process.

Acknowledgements

The authors wish to acknowledge Dr D.H. Charlesworth of the Chalk River Nuclear Laboratories, and Dr D.J. Cameron of the Low-Level Radioactive Waste Management Office for their generous support in the preparation of this paper. The material presented in this paper is a review of studies, research and development, and ongoing waste management programs of a number of agencies whose contributions have been crucial for low-level waste management in Canada.

References

1. *Cameron DJ* et al. An analysis of the need for low-level radioactive waste disposal in Canada and the alternatives for establishing disposal facilities. Low-Level Radioactive Waste Management Office, AECL Research Company, 275 Slater Street, Ottawa, Ontario K1A 1E5. Paper published in the Int Conf on Radioactive Waste Management, Winnipeg, Canada, September 7–11 1986.
2. *Green BJ.* Waste sources, volumes and characteristics compiled by Ontario Hydro for the Low Level Radioactive Waste Management Office, 1985.
3. *Krochmalnek LS, Kohout R.* Management of combustible radioactive wastes in Ontario Hydro. Int Conf in Radioactive Waste Management, Winnipeg, Canada, September 9–11 1981.
4. *Beamer NV.* Experience with low-level waste incineration at Chalk River Nuclear Laboratories. Waste Management '84, Proceedings, Vol. 2, 1984; 205–12.
5. *Carter TJ.* Radioactive waste management practices at a large Canadian utility. IAEA Seminar on the Management of Radioactive Waste from Nuclear Power Plants – Karlsruhe, FRG, October 5–9 1981.
6. *Rao PKM.* Ontario Hydro's options for long-term management of radioactive wastes. Inf Conf in Radioactive Waste Management, Winnipeg, Canada, September 9–11 1986.
7. *Carter TJ, Rao PKM.* Fifteen years of radioactive waste management at Ontario Hydro. Waste Management '85, Tucson, Arizona, March 1985.
8. *Heystee RJ, Rao PKM.* Canadian experiences in characterization of two low-level and intermediate-level radioactive waste management sites. IAEA Seminar on the Site Investigation Techniques and Assessment Methods for Underground Disposal of Radioactive Wastes, Sofia, Bulgaria, February 6–10 1984.
9. *Dixon DF.* A program for evolution from storage to disposal of radioactive wastes at CRNL. Report AECL-7083, October 1985.
10. *Isaac HN, Rao PKM.* Management of low- and intermediate-level nuclear wastes at Ontario Hydro. Paper presented at the International Symposium on Alternative Low-Level Waste Technologies, at The Westin Hotel, Chicago, Illinois in co-operation with Waste Management '86, February 27–March 1 1986.
11. Federal Policy on the Management of Low Level Radioactive Wastes, Energy, Mines and Resources Canada. (For further information contact: J. Howieson, Advisor, Radioactive Waste Management, Energy, Mines and Resources Canada), April 25 1986.