NUCLEAR WASTE MANAGEMENT ORGANIZATION
SOCIÉTÉ DE GESTION DES DÉCHETS NUCLÉAIRES

Choosing a Way Forward

The Future Management of Canada's Used Nuclear Fuel

Final Study

Errata

On page 81 of the Final Study: Choosing a Way Forward Inuit Tapiriit Kanatami (ITK) should be included in the list of Aboriginal organizations which argue that the NWMO Aboriginal Dialogues "are not 'consultation' as required by their interpretation of the law."

VISION, MISSION AND VALUES

VISION

Our vision is the long-term management of Canada's nuclear waste in a manner that safeguards people and respects the environment, now and in the future.

MISSION

The purpose of the NWMO is to develop collaboratively with Canadians a management approach for the long-term care of Canada's used nuclear fuel that is socially acceptable, technically sound, environmentally responsible and economically feasible.

VALUES

The fundamental beliefs that will guide us in our work include:

INTEGRITY

We will conduct ourselves with openness, honesty and respect for all persons and organizations with whom we deal.

EXCELLENCE

We will pursue the best knowledge, understanding and innovative thinking in our analysis, engagement processes and decision-making.

ENGAGEMENT

We will seek the participation of all communities of interest and be responsive to a diversity of views and perspectives. We will communicate and consult actively, promoting thoughtful reflection and facilitating a constructive dialogue.

ACCOUNTABILITY

We will be fully responsible for the wise, prudent and efficient management of resources and be accountable for all of our actions.

Choosing a Way Forward
The Future Management of Canada's Used Nuclear Fuel

Final Study

Minister
Natural Resources Canada
Ottawa, Ontario
K1A 0A6

November, 2005

Dear Minister,

On behalf of the Nuclear Waste Management Organization (NWMO), we are pleased to submit to you our completed study of proposed approaches for the long-term management of nuclear fuel waste.

We submit this report in compliance with sections 12 and 13 of the *Nuclear Fuel Waste Act*.

Further to the requirement of the *Act*, we include in our study the NWMO's recommendation as to which of the proposed approaches should be adopted.

Consistent with our obligations under section 12, we include with this report the comments of the Advisory Council to the NWMO.

In fulfillment of our obligations under section 24 of the *Act*, we are also making this report available to the public.

Respectfully submitted,

K. E. Nash

Ken Nash
Chairman

E Dowdeswell

Elizabeth Dowdeswell
President

Foreword

Three short years ago the NWMO took on the mission of developing collaboratively with Canadians a management approach for the long-term care of Canada's used nuclear fuel. We envisaged an approach that would be socially acceptable, technically sound, environmentally responsible and economically feasible. We were under no illusion that developing a response to this complex issue would be simple. It is after all an unprecedented test of society's ability and willingness to protect people and respect the environment, now and in the future.

Choosing A Way Forward is the fourth major report that we have published over the course of our study. We made a commitment to share our thinking as it evolved and was shaped by our investigations and interaction with Canadians. The first three documents articulated the issues, tested thoughts and reported back what we were hearing. This one reflects a synthesis of a diversity of perspectives from engagement with citizens and specialists and proposes a course of action. We believe our conclusions are responsive to the state of current knowledge and our understanding of the values of those who contributed to the dialogue.

In recommending an Adaptive Phased Management approach, we propose a responsible path forward that intends to meet rigorous standards of safety and security for people and the environment. It embraces the precautionary principle. It is grounded in concepts of continuous learning and adaptive management. We believe this is the strongest possible foundation for managing the risks and uncertainties that are inherent in the very long time-frames over which used nuclear fuel must be managed with care.

In a fundamental way our proposal advances a collaborative process in which citizens always play a legitimate role in making decisions, while at the same time creating conditions for productive movement forward. The nature of the waste, the inevitable uncertainties about performance years into the future, and the care that will be required over many generations, strongly suggest an ethical approach that integrates a continuing understanding of values.

Part One of this report presents our recommendation and outlines the factors that influenced us in reaching our conclusions. Part Two states our legislative requirements and identifies where we demonstrate accountability in meeting the spirit and intent of our founding legislation – the *Nuclear Fuel Waste Act*. Parts Three, Four and Five describe the journey we undertook with Canadians to arrive at this point – the engagement and the assessment. The document concludes with a statement from our Advisory Council.

While the NWMO alone is responsible for the conclusions it has drawn, we took inspiration from those many individuals who have shared their views and perspectives. We count on your enduring vigilance and involvement. Those who participated in specific activities over a period of time, in particular the Roundtable on Ethics and the Assessment Team, deserve special recognition for their essential contributions. Others, such as our international advisors provided informal but important critique and validation.

I particularly want to acknowledge the thoughtful guidance that we have received from our Advisory Council, the encouragement and support of our Board and the unstinting diligence and enthusiasm of the NWMO staff. All were dedicated to a common mission and prepared to synergistically challenge prevailing assumptions.

We were profoundly aware of the imperative to earn the trust of Canadians. Trust matters. To work through and address such a potentially divisive and difficult issue as what to do about the long term management of used nuclear fuel we must trust in each other and our collective ability to come together constructively and cooperatively. The NWMO was motivated to behave ethically and with integrity, to honour our commitments and obligations and to align our interests with the values of Canadians, as best we could. But earning trust takes time. We commit to inviting and valuing all perspectives as we move forward. The path ahead will reflect respect for citizens and the environment and create a capacity and strength to address the obstacles which will inevitably present themselves along the way.

We acknowledge that there will always be some uncertainties. But we are confident that we know enough to take the first steps. We also know that we must do so with flexibility to allow for new knowledge and societal change over time. We are convinced that it is now time to act decisively.

Elizabeth Dowdeswell, President
November 2005

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Chapter 1 / A Responsible Path: Our Conclusions

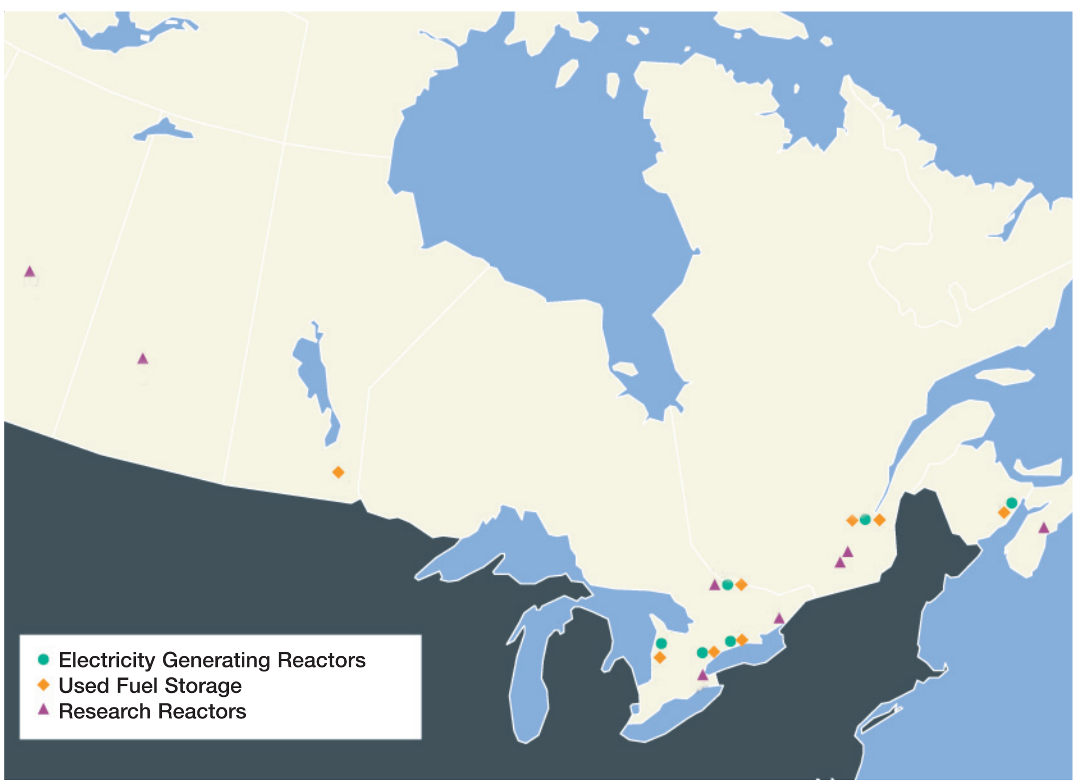
1.1 / Introduction

For decades Canadians have been using electricity generated by nuclear power reactors. When used nuclear fuel is removed from a reactor, it is highly radioactive and requires proper shielding and careful handling to protect humans and the environment. Although the radioactivity decreases with time, used fuel will remain a potential health risk for a very long period, likely hundreds of thousands of years or longer. Consistent with evolving international experience and the regulatory regimes governing management of used nuclear fuel, the NWMO has taken the position that used fuel will need to be contained and isolated from people and the environment essentially indefinitely. (Further elaboration of our understanding of the nature of the hazard is presented in Appendix 3.)

Canada's used fuel is now safely stored on an interim basis at licensed facilities at the reactor sites located in Ontario, Québec and New Brunswick and at the AECL facility in Manitoba. There are also small amounts at several nuclear research facilities throughout Canada. (See Figure 1-1) We currently have about two million used fuel bundles, and we expect to have about 3.7 million bundles if each of the electricity generating nuclear reactors has an average operating life of 40 years. (A more complete status report of the amount and location of Canada's used nuclear fuel can be found in Appendix 4.)

Like many other countries with nuclear power programs, Canada has yet to decide what to do with its radioactive used fuel over the long term. Thirty-two countries operate more than 400 nuclear power reactors. Some have chosen to construct a deep geological repository and are at different stages of site selection. Others are studying the most appropriate approach or have postponed consideration for the time being. (Appendix 6 provides additional information.)

Figure 1-1 Nuclear Reactor Sites in Canada



Notwithstanding considerable research about the science, technology and engineering of possible storage and repository approaches, the task of implementation has proven challenging.

In Canada, an intensive and lengthy period of deliberation was undertaken by the Seaborn Panel. The Panel's specific mandate was to conduct an environmental assessment of an AECL proposal for deep geological disposal. In 1998, they provided insight and direction on key issues that had to be addressed in order to move the decision-making forward. With respect to the AECL disposal concept they concluded that:

- From a technical perspective, safety of the AECL concept has been on balance adequately demonstrated for a conceptual stage of development, but from a social perspective, it has not; and

- As it stands, the AECL concept for deep geological disposal has not been demonstrated to have broad public support. The concept in its current form does not have the required level of acceptability to be adopted as Canada's approach for managing nuclear fuel wastes.

On the matter of criteria for safety and acceptability they concluded that:

- Broad public support is necessary in Canada to ensure the acceptability of a concept for managing nuclear fuel wastes; and

- Safety is a key part, but only one part, of acceptability. Safety must be viewed from two complementary perspectives: technical and social.

A paper documenting the legacy of the Seaborn Panel in pointing to the imperative to consider the ethical and social domains as well as the technical questions on one of the approaches under NWMO's review can be found at www.nwmo.ca (background paper #2-8).

The Government considered and responded to the Seaborn Panel Report, and in November 2002 brought into force the *Nuclear Fuel Waste Act* (an Act respecting the long-term management of nuclear fuel waste)(*NFWA*) . (See Appendix 2). As required by that federal legislation, the Nuclear Waste Management Organization (NWMO) was established. Our immediate task was to research, consult widely and make recommendations to the federal government about an appropriate long-term management approach for used nuclear fuel. The precise description of the NWMO's mandate follows in Chapter 2. This report, *Choosing A Way Forward*, documents our process and presents our conclusions and recommendation.

1.2 / The Foundation

This study was built on a firm foundation – a mission statement integrating the elements of sustainable development; a preeminent focus on safety and security; a perspective that takes a long view; a framework of ethics and values; and a recognition of the requirement for citizen engagement.

The NWMO Mission

The purpose of the NWMO is to develop collaboratively with Canadians a management approach for the long-term care of Canada's used nuclear fuel that is socially acceptable, technically sound, environmentally responsible and economically feasible. In a complex sociotechnical system an integrated perspective is essential.

A socially acceptable management approach is one which has emerged from a process of collaborative development with citizens. It must take into account the best available knowledge and expertise, and be responsive to the values and objectives which are most important to citizens. A solid grounding in knowledge, and a fundamental responsiveness to citizens, form the foundation for public confidence.

An environmentally responsible management approach is one in which physical, chemical and biological stresses on the environment, including cumulative effects over long periods of time, and the potential consequences of failure of any part of the containment system, are within the natural capacity of environmental processes to accept and adjust to, thus ensuring the long-term integrity of the environment.

A technically sound management approach is one which is informed by the best technical and scientific knowledge and experience available in Canada and around the world, and which is practicable given our current state of knowledge. At a minimum it must ensure: public health and safety; worker health and safety; security of nuclear materials and the facilities that manage them; and environmental integrity. As well, the approach must meet international safeguards and non-proliferation obligations.

An economically feasible management approach is one that ensures that adequate economic resources are available, now and in the future, to pay the costs of the selected approach. The selected approach ought to provide high confidence that funding shortfalls will not occur to threaten the assured continuation of necessary operations.

Safety & Security

Our primary motivation is safety – to protect people and the environment from highly radioactive used nuclear fuel. We are not confused or conflicted about this objective and common vision. More recently a specific focus on security from harmful acts, events and situations has assumed a higher profile. We must ensure that our security systems and safeguards are compliant with Canada's nuclear non-proliferation policy and international agreements.

While many Canadians use the words safety and security interchangeably, there are widely accepted definitions and understandings on which our laws are based. Essentially nuclear safety deals with accident, whereas security deals with intentional malicious actions perpetrated by a human adversary. The former requires proper operating conditions, prevention of accidents and protection of workers, the public and the environment from undue radiation hazards. Security requires measures to prevent loss or theft or unauthorized transfer of radiation sources or radioactive material.

Canada's commitment to nuclear non-proliferation, that is, to prevent the spread of nuclear weapons to states, is evident in its acceptance of international safeguards. The objective is to detect any diversion of nuclear material from peaceful activities and requires material protection, control and accounting.

We do not live in a risk-free world. A technical method cannot be practically demonstrated over thousands of years prior to implementation. It can only be predicted with greater or lesser confidence. Complex mathematical calculations and numerical analyses alone are not likely to generate required societal confidence.

That said, we must continue to build confidence that the management of used nuclear fuel will meet or exceed rigorous safety and security goals. Scientific and technical work must be, and be perceived to be, of the highest quality. Technically, a compelling case for safety must involve multiple barriers and redundant systems that maintain their integrity over exceedingly long periods of time. Over the long term, it would be imprudent to rely on a human management system alone with its changing forms of institutions and governance.

From a social perspective, safety and acceptability are intertwined. Society as a whole, and not science alone, needs to judge the benefit or harm. While science can speak to the probability of the occurrence of an event, science cannot speak to social tolerance for its occurrence. What poses risk, how the risk should be measured, and what is considered relevant for measurement are all decisions which are influenced by societal considerations. That is precisely why the NWMO study has been a socially directed process.

The Long View

Perhaps the most significant feature of this issue is the time dimension. Nuclear fuel waste remains a potential health, safety and security hazard for many thousands of years, so the relative performance of any option must look out to these geological time frames. Any decision taken today will be implemented over a number of decades, at least. Undoubtedly the program will encounter major changes in science and technology, institutions, values, political perspectives, and economic and financial considerations.

We are contemplating designing and licensing a system to last for periods longer than recorded history. That could lead to paralysis, encouraging the postponement of making a decision, particularly since any decision will be controversial and politically complex. Furthermore, the technology used to store nuclear fuel waste today is safe, adequate and affordable for some period of time and there appears to be no imminent safety or environmental crisis forcing a decision.

However, the *NFWA* reflects the sentiments and values of Canadian society: namely that this generation of citizens which has enjoyed the benefits of nuclear energy has an obligation to begin provision for managing that waste. That is consistent with the "polluter pays" principle. Used fuel already exists. This generation does not want to leave as a legacy the burden of providing for and funding the management of the used fuel we have created. We should not bequeath hazardous wastes to future generations without also giving those generations the capability to manage the waste in a safe and secure way.

We do not know what technologies may be available to succeeding generations, or what they may choose to do with the wastes that we have generated. We also do not know what the capacity of future generations will be to take an active role in managing this waste. In light of these uncertainties, our obligation is to give them a real choice and the opportunity to shape their own decisions while at the same time not imposing a burden which they may not be able to manage. This means avoiding approaches that are irreversible or overly dependent on strong institutions and embracing those that are precautionary. In essence the precautionary principle places the burden of proof on us to ensure that greater benefit of the doubt will be given to health and the environment. It means planning conservatively by setting aside the financial resources to ensure that future generations will have genuine choice. It means making a commitment to continuous learning today to assist decision making tomorrow.

What we can do is plan for the foreseeable future, act responsibly and confidently with the best science and technology in hand. What we must not do is pretend that we have all the answers for all time. A measure of humility will be essential as we move cautiously but surely toward the goal one step at a time.

Ethics and Values

Given the longevity of the hazard of used nuclear fuel, it is imperative that we consider explicitly how we might meet our obligations to future generations and the environment. Given the nature of the hazard, it is imperative that we consider matters of 'equity' or fairness within the current generation.

We believe that ethics should be embedded in our work. Consequently, ethical principles guided the manner in which we worked and the way in which we assessed the options and determined our recommendation. Intergenerational equity and fairness became much more than matters of academic discussion.

The most important ethical choices to be made are in fact values-based decisions and as such require the involvement of society at large. An ethical process is one that requires engagement of a broad cross-section of society in an informed dialogue on the core human issues to be addressed. An ethical outcome or recommendation is one which is responsive to the values and concerns of society at large.

Ethical questions may not have unambiguous or definitive answers. With no ethical absolute, and in the face of uncertainty, past attempts to resolve them through technical arguments have not been satisfactory. There are inevitable trade-offs among competing objectives. Which objectives are primary? Nonetheless we found common ground. This generation must accept responsibility, not leaving a legacy of waste for future societies. This generation should not make irrevocable decisions, depriving future generations of genuine choice. For this and future generations safety must not be compromised. These declarations are fine in theory, but equally important is how we act on them.

Part of the answer lies in incorporating a future perspective, thinking carefully about how the world might change and how future societies might behave. Another factor is in the design itself – choosing a technology that is capable of providing the requisite level of safety, fully funding future costs, anticipating and mitigating potential environmental and socio-economic impacts and planning for the creation and transfer of knowledge over time. Finally, in a democratic society, the inclusiveness and integrity of the process by which decisions are taken are key.

Citizen Engagement

The NWMO began its study with the understanding that technical and scientific specialists can help us understand the technical adequacy of each of the management approaches available to Canada. They can also help us understand the impacts any approach may have on the environment, and whether the approach is affordable (economically feasible). However, scientific and technical evidence and analysis, while essential, cannot be the sole basis of our choice.

The views of Canadian society in judging benefits or risks, and assessing the social implications of various approaches for long-term management, are critical to the development of a socially acceptable recommendation. Canadians expect that the best scientific and technical knowledge must be brought to bear in identifying and understanding the source and nature of risk and the ways in which safety can be assured. However, the decision as to whether safety has been assured to a sufficient degree to warrant implementation is a societal one. Canadians will be influenced by social notions of what constitutes risk and the safety threshold to be met.

We set aside traditional notions of consultation as they have too often in the past resulted in one-way conversations. We have consistently tried to design processes of dialogue to encourage listening and learning, and genuinely engage those who are interested in this matter. We have tried to be responsive to a variety of views and perspectives. We have been transparent, making all of our information available, at all stages of the process. As can be seen in Part Three of this report, thousands have helped us in the search for societal direction and common ground.

The goal of our Aboriginal dialogues, designed and conducted by Aboriginal peoples, was to build the necessary foundation for a long-term, positive relationship. We have begun the process of learning how to integrate the insights and knowledge of Aboriginal peoples into our work. There is substantive knowledge about the land and ecology in any given location, stemming from long contact with the land. But Aboriginal Tradional Knowledge is also about ways of developing and maintaining effective and respectful relationships – between young and old, within a community, between communities.

We have gained insight from previous attempts at siting facilities for other purposes from managing the wastes in mining communities, and from engagement processes that resulted in positive and continuing benefit to communities. Reactor-site communities were particularly helpful in articulating the current reality. And, whenever possible we tried to catch a glimpse of the future through the eyes of youth.

Sustained engagement with people and communities, whether they welcome, oppose or seek modifications to our observations and conclusions, is vital. We commit to continue building relationships as decisions are taken and implementation begins.

1.3 / An Important Question of Context – the Future of Nuclear Power

Our report would be incomplete if we did not refer to the impassioned arguments we heard about energy policy and the future of nuclear power.

For some it was a technical matter. Knowing the volume and type of waste might be a key element in the choice of technical option. They wanted to make sure that the options were tested against a variety of scenarios ranging from early phase-out to expansion of nuclear power. They sought assurance that an option chosen today would be robust enough to meet the needs of tomorrow, whatever those needs might be. Furthermore, in the choice of options to consider, some felt that source reduction and elimination should be a first step in any waste management program.

There were suggestions to assess the full life cycle of nuclear materials, from mining through to the management of all forms of waste. Some proposed that such an analysis would show that nuclear energy improves the quality of life and may lead to an overall reduction of stress on the environment. Others suspect that if the real costs and benefits of the full lifecycle were tallied nuclear energy generation would be abandoned.

There were some who argued that from a social and ethical perspective it is important to frame the issue very broadly. They wanted to examine the very activity that gives rise to the waste in the first place. While some worried that the identification of a long-term management approach would serve as a de facto licence for the expansion of nuclear energy without adequate public discussion, others acknowledged that it was important for the current economic viability of the industry that decisions be taken.

In this report, the NWMO has not examined nor is it making a judgment about the appropriate role of nuclear power generation in Canada. We suggest that those future decisions should be the subject of their own assessment and public process.

Used fuel exists today and will continue to be produced to the end of the lives of Canada's existing nuclear facilities. The focus of our study is to recommend a responsible path forward for addressing the used fuel that requires management for the long term. Our study process and evaluation of options were intended neither to promote nor penalize Canada's decisions regarding the future of nuclear power.

1.4 / The Technical Possibilities

Sound science and technology must be the starting point for any examination of alternative management approaches. For about four decades, various countries have been investigating numerous technical methods. Deep geological repositories have been the subject of intensive study in Canada, and are in an advanced state of scientific and technical understanding internationally. Storage technologies have been demonstrated at reactor sites for many years.

Our assessments have confirmed that there is reason to be confident that all three technical methods or concepts identified in the *NFWA* are credible and could be designed to be safe for the near term, from a technical perspective. Furthermore, our regulatory regime would demand a comprehensive safety case before licensing.

The word "disposal" has come to mean permanence and irretrievability in the minds of the public, and that raises questions about our stewardship of the waste. For that reason we do not use the word disposal. Yet to others the word "storage" implies a temporary approach that avoids taking a decision, and places a burden on future generations. For purposes of this report we have defined storage as a method of managing the waste in a manner that allows access under controlled conditions for retrieval or future activities while disposal is conclusive without any intention of retrieval or further use.

Additional options that had at some point received international attention were reviewed and found to be lacking in meeting important criteria such as proof of concept or legality. Members of the public had a particular interest in reprocessing of used fuel, as it seemed to be related to desirable environmental concepts of recycling and reuse. Partitioning and transmutation were also of interest for the possibility of reducing the volume and toxicity of the waste to be managed. For a variety of reasons outlined in Chapter 5, we believe that these options are unlikely to be economic, practical or desirable in Canada at this point in time.

For each of the three specific technical methods identified in the *NFWA*, engineering design concepts and cost estimates were developed for the Joint Waste Owners: Ontario Power Generation Inc., NB Power Nuclear, Hydro-Québec and Atomic Energy of Canada Ltd. These design concepts and cost estimates were validated by a third party and are fully described and assessed in Chapters 6 and 8. A brief description of these conceptual designs follows.

Option 1: Deep Geological Disposal in the Canadian Shield

This option involves placing the used nuclear fuel deep underground, relying on natural and engineered barriers to isolate the used fuel from humans and the surface environment over its hazardous lifetime. A deep geological repository would be located in the Canadian Shield at a nominal depth of 500 to 1,000 metres. Fuel would be transported from the existing interim storage facilities at nuclear reactor sites to this central site where it would be packaged in corrosion resistant containers. Over a period of about 30 years, these containers would be placed in rooms excavated deep in the rock. Performance of the repository would be monitored during placement of the used fuel after which the underground excavations would be backfilled and sealed. After closure, maintenance, inspection and security-related operations would be minimal. Such a facility would be designed to be passively safe over the long term, and not rely on institutional controls to ensure safety.

This concept was researched in depth by Atomic Energy of Canada Limited from 1978 to 1996, and reviewed by the Seaborn Panel under the *Federal Environmental Assessment and Review Process Guidelines Order* (1984). The original concept has been further developed based on underground research and experience both in Canada and internationally. It now incorporates provisions for extended monitoring as well as the technology to retrieve used fuel after placement in the repository. Note that the only time we refer to disposal as a possible Canadian approach is in reference to this specific AECL proposal.

Option 2: Storage at Nuclear Reactor Sites

Currently, when used nuclear fuel is removed from reactors it is placed in wet storage for about seven to ten years to reduce its heat and radioactivity. It is then transferred to containers for dry storage in a facility at the reactor site. The design life of the concrete and steel storage containers is about 50 years, although the expected life is estimated to be at least 100 years.

This option for used fuel management would involve either the expansion of existing dry storage facilities or the construction of new, long-term dry storage facilities at each of the seven storage sites in Canada. Over time, used fuel would have to be transferred from the existing interim storage facilities to newly designed storage containers and facilities at the reactor sites with various components designed to last between about 100 and 300 years. We project that storage facilities would need to be completely refurbished or replaced about every 300 years.

This option would require an indefinite cycle of replacement and refurbishing activities, as facilities would be renewed at the reactor sites. Processing buildings, which would also require ongoing maintenance, inspections and security systems, would also be needed for fuel loading and on-site transfer.

Option 3: Centralized Storage, Above or Below Ground

Centralized extended storage would involve creating new, long-term storage facilities at a central location. Conceptual designs have been developed for a storage facility built above or below ground, with options including: casks and vaults in storage buildings, surface modular vaults, casks and vaults in shallow trenches, and casks in rock caverns.

The used fuel would be transported from the seven interim storage sites in Canada to this new central facility.

The various components of the storage facility would have design lives between 100 and 300 years. It is projected that the storage facility would need to be completely refurbished or replaced every 300 years or so. This option for used fuel management would require an ongoing program of regular replacement and refurbishing activities, as the facility would be renewed indefinitely at the central site. Processing buildings, which would require ongoing maintenance, inspections and security systems, would also be needed for fuel loading and on-site transfer.

1.5 / The Evolution of Another Approach

The NWMO recommends an alternative approach – Adaptive Phased Management.

In defining and evaluating the three mandated options, it became clear that each possessed some unique strengths, but also some important limitations. They are not necessarily mutually exclusive. For example, even a timely decision to pursue development of a geological repository would require decades of continued storage before such a facility could be put in operation, followed by additional decades for complete transfer of the fuel. Or, a decision to choose long-term storage at the reactor sites would not preclude future generations from making a subsequent decision to move the fuel to some centralized location, provided funds were made available. As well, potential sites for a deep repository may be found in regions beyond the Canadian Shield in other geotechnically suitable rock formations, such as Ordovician sedimentary rock basins.

Furthermore, Canadians have expressed two complementary objectives. They are prepared to assume responsibility now for dealing with used fuel that has been created, but they also want to preserve the ability of future generations to do what they see as being in their best interests.

The insights from the assessments led us to search for an approach that might better meet Canadian objectives than any of the three options taken in isolation. The challenge of taking the long view demanded by this issue caused us to explore how we could build in sequential decision-making which would preserve flexibility during implementation in the coming years.

Adaptive Phased Management consists of both a technical method and a management system. The key attributes of the approach are:

- Ultimate centralized containment and isolation of used nuclear fuel in an appropriate geological formation;
- Phased and adaptive decision-making;
- Optional shallow storage at the central site prior to placement in the repository;
- Continuous monitoring;
- Provision for retrievability; and
- Citizen engagement.

A more detailed technical description of Adaptive Phased Management can be found in Chapter 6.

The approach builds on the best features of the three approaches outlined in the *NFWA*, and implements them in a staged or phased manner over time. Table 1-1 illustrates three potential phases of concept implementation: preparing for central used fuel management; technology demonstration and optional central shallow storage; and long-term containment, isolation and monitoring in the repository. Each of the three phases has a number of key activities and decision points. While we do not know the precise duration of these activities or the outcome of future decisions, we can provide an indication of a representative schedule for implementation based on the conceptual design work and previous analysis of the three options for used fuel management under study. (See Figure 1-2).

Table 1-1 **Option 4: Adaptive Phased Management**

Representative Conceptual Design Activities for Adaptive Phased Management	
Concept	A staged management approach with three phases of implementation: • Phase 1: Preparing for Central Used Fuel Management • Phase 2: Central Storage and Technology Demonstration • Phase 3: Long-term Containment, Isolation and Monitoring **Phase 1 (approximately the first 30 years):** Preparing for central used fuel management would comprise the following activities: • Maintain storage and monitoring of used fuel at nuclear reactor sites. • Develop with citizens an engagement program for activities such as design of the process for choosing a site, development of technology and key decisions during implementation. • Continued engagement with regulatory authorities to ensure pre-licensing work would be suitable for the subsequent licensing processes. • Select a central site that has rock formations suitable for shallow underground storage, an underground characterization facility and a deep geological repository. • Continue research into technology improvements for used fuel management. • Initiate the licensing process, which triggers the environmental assessment process under the *Canadian Environmental Assessment Act*. • Undertake site characterization, safety analyses and an environmental assessment for the shallow underground storage facility, underground characterization facility and deep geological repository at the central site, and to transport used fuel from the reactor sites. • Obtain a licence to prepare the site. • Develop and certify transportation containers and used fuel handling capabilities. • Obtain a licence to construct the underground characterization facility at the central site. • Decide whether or not to proceed with construction of a shallow underground storage facility and to transport used fuel to the central site for storage. • If a decision is made to construct the shallow underground storage facility, obtain a construction licence and then an operating licence for the storage facility. **Phase 2 (approximately the next 30 years):** Central storage and technology demonstration would comprise the following activities: • If a decision is made to construct shallow underground storage, begin transport of used fuel from the reactor sites to the central site for extended storage. • If a decision is made not to construct shallow underground storage, continue storage of used fuel at reactor sites until the deep repository is available at the central site. • Conduct research and testing at the underground characterization facility to demonstrate and confirm the suitability of the site and the deep repository technology. • Engage citizens in the process of assessing the site, the technology and the timing for placement of used fuel in the deep repository. • Decide when to construct the deep repository at the central site for long-term containment and isolation. • Complete the final design and safety analyses to obtain the required operating licence for the deep repository and associated surface handling facilities. There may be a need for transportation containers and facilities to produce them; processing facilities to load the fuel into transportation containers; production facilities for storage containers; and processing facilities to transfer the fuel from transportation to storage containers.

Table 1-1 (cont'd) Option 4: Adaptive Phased Management

Representative Conceptual Design Activities for Adaptive Phased Management	
Concept (cont'd)	**Phase 3 (beyond approximately 60 years):** Long-term containment, isolation and monitoring would comprise the following activities: • If used fuel is stored at a central shallow underground facility, retrieve and repackage used fuel into long-lived containers. • If used fuel is stored at reactor sites, transport used fuel to the central facility for repackaging. • Place the used fuel containers into the deep geological repository for final containment and isolation. • Decommission the shallow underground storage facility. • Continue monitoring and maintain access to the deep repository for an extended period of time to assess the performance of the repository system and to allow retrieval of used fuel, if required. • Engage citizens in on-going monitoring of the facility. • A future generation would decide when to decommission the underground characterization facility and any remaining long-term experiments or demonstrations of technology, and when to close the repository, decommission the surface handling facilities and the nature of any postclosure monitoring of the system. There may be a need for production facilities for used fuel containers; processing facilities to transfer the fuel from storage to the deep repository; and production facilities for sealing materials. The current owners of used fuel would continue to be responsible for its interim management at the reactor sites. The NWMO would assume management responsibility of the used fuel when it is transported from the reactor sites to the central facility for long-term management.
Location	The central facility for the shallow rock cavern, underground characterization facility and deep repository could be located in a suitable rock formation such as the crystalline rock of the Canadian Shield or in the Ordovician sedimentary rock basins. These two rock types cover a vast amount of land reaching several provinces and territories. A specific location would need to be identified and approval would be required from the Canadian Nuclear Safety Commission for the construction and operation of the facility. This would also involve an environmental assessment.
Transportation Requirements	The operation of a central facility would involve moving the fuel from existing reactor site storage facilities in certified transport containers to the central site over a period of approximately 30 years. Transportation would require an emergency response plan and adherence to security provisions. The mode of transportation (road, rail or water) would depend on factors such as the location of the central facility. The timing of transportation would depend on whether or not a shallow underground storage facility has been constructed at the central site and other factors. Based on a projected used fuel inventory of 3.6 million fuel bundles, the number of transportation shipments of used fuel from the reactor sites to the central facility would be: • Road: about 53 road shipments/month for 30 years, or • Rail: about 5 rail shipments/month + about 36 road shipments/month for 30 years, or • Water: about 2 water shipments/month + about 36 road shipments/month for 30 years

Table 1-1 (cont'd) Option 4: Adaptive Phased Management

Representative Conceptual Design Activities for Adaptive Phased Management	
Containers	Storage containers at reactor sites would consist of the existing casks, vaults and silos. Containers for long-term isolation in a deep repository are based on a 100,000-year design life. These durable containers are designed to withstand long-term environmental effects such as climate change and glaciation. Facilities would exist at the central site for repackaging the used fuel.
Storage Design Life	Storage containers at the central underground storage facility are based on the existing design of the dry storage container or equivalent with a 100-year design life.
Land Requirement	The land requirement for the surface buildings and associated facilities would be about 2 kilometres x 3 kilometres, or about 600 hectares (1,480 acres). The surface building dimensions would likely be a small fraction of the total land area. The footprint of the shallow underground storage facility would be about 515 metres x 450 metres, or about 23 hectares (57 acres). The footprint for the deep geological repository would be about 1.35 kilometres x 1.36 kilometres, or about 183 hectares (452 acres). The actual size of the deep geological repository would depend on a number of factors such as number of fuel bundles and their heat output, depth of the repository and site-specific factors such as thermal conductivity of the rock mass.
Underground Facility	During the Phase 2 extended storage period, the used fuel would be placed in a series of shallow rock caverns excavated at a nominal depth of 50 metres below surface. During the Phase 3 long-term isolation period, the used fuel would be placed in a network of horizontal access tunnels and rooms excavated in stable rock at a nominal depth of 500 to 1,000 metres below surface. Used fuel containers would be placed within the rooms or in boreholes drilled into the floor of the rooms. Used fuel containers are assumed to be placed in the deep repository over a 30-year operating period.
Repository Sealing System	Clay-based materials would be used to surround and protect the containers, to fill the void spaces in the repository, to limit the movement of groundwater and dissolved material, and to protect workers during container placement operations. These are referred to as sealing systems, and involve materials such as high-performance concrete and swelling bentonite clay.
Geosphere Barrier	The geosphere, or host rock, provides the principal barrier between the used fuel containers and the surface environment. Both the Canadian Shield granite and the Ordovician sedimentary rock basins are examples of naturally occurring geological formations which have long-term stability, good rock strength, and low groundwater flow. Large areas exist with sufficient depth below the surface and lacking in mineral resources that they are very unlikely to be disturbed by erosion or accidental drilling.

Table 1-1 (cont'd) Option 4: Adaptive Phased Management

Representative Conceptual Design Activities for Adaptive Phased Management	
Monitoring	Used fuel would be monitored in the central shallow rock caverns and in the deep repository. During Phase 2, monitoring would be straightforward over the estimated 30-year period since the storage containers are readily accessible. During Phase 3, monitoring over an estimated 240-year period would require more effort and technology since the long-term isolation containers would be backfilled and sealed within the placement rooms. Monitoring would be conducted to confirm the long-term safety and performance of the repository system. Until a decision is made to backfill and seal the access to the deep repository, monitoring would take place in-situ at repository depth. After closure of the deep repository around 300 years, postclosure monitoring of the facility could take place from the surface.
Retrieval	Used fuel would be retrievable at all times. The technology to retrieve used fuel containers from a deep geological repository would need to be further developed and demonstrated at the site. During Phase 2, used fuel retrieval would be straightforward over the estimated 30-year period since the storage containers are readily accessible. During Phase 3, used fuel retrieval over an estimated 240-year period would require more effort and technology since the long-term isolation containers would be backfilled and sealed within the placement rooms.
Illustrative Implementation Schedule	A government decision in 2006 to select this management approach would see an underground characterization facility and possibly a central shallow underground rock cavern storage facility ready by about 2035. The deep geological repository could then ready by about 2065. Following a decision by the federal government, the following activities with their **illustrative** timelines would be undertaken: • Siting of central facility (about 20 years) • Design and construction of the underground characterization facility and the optional shallow underground storage caverns, if required (about 10 years) • Transportation to central facility (over about 30 years) • Placement in deep geological repository (over about 30 years) • Extended monitoring (up to 300 years) • Decommissioning and closure (over about 25 years) • Postclosure monitoring (indefinite) There would be a need to obtain a licence at each phase and demonstrate continuous compliance with the licence (under regulatory oversight).

Table 1-1 (cont'd) Option 4: Adaptive Phased Management

Representative Conceptual Design Activities for Adaptive Phased Management	
Decommissioning	Once a societal decision was made and the necessary approvals were obtained, decommissioning would commence and all underground access tunnels and shafts would be backfilled and sealed. Surface facilities would be decontaminated and dismantled. Closure activities include removal of monitoring instruments and returning the site to greenfield conditions.
Costs	The cost of the Adaptive Phased Management approach is conservatively estimated to be about $24 billion (2002 dollars), including interim used fuel storage and retrieval from reactor sites, transportation costs to the central facility, extended storage in underground caverns, technology research development and demonstration in the underground characterization facility and placement of used fuel in a deep geological repository. These costs include the development and demonstration of the technology to retrieve used fuel from the deep repository, but not the costs to perform retrieval operations from the deep repository. The present value cost based on current long-term economic factors is approximately $6.1 billion (2004 dollars). (www.nwmo.ca/assessments) These costs include construction and operation of the shallow underground storage facility at the central site. If, however, the used fuel remains at reactor sites prior to operation of the deep repository and is not first placed in shallow storage, these costs would be reduced to about $21 billion (2002 dollars) with a present value of about $5.1 billion (2004 dollars).

Figure 1-2 Activity Flowchart for Adaptive Phased Management

Government Decision to proceed with Adaptive Phased Management

PHASE 1

Collaboratively develop a siting process and engagement program with people and communities from areas potentially affected, including Aboriginal peoples. Incorporate insights from all NWMO work. Consult with regulatory authorities for pre-licensing work.

Implement the Engagement Program, initiating the Siting Process to **select** a preferred site (stakeholder consultations, feasibility studies and site characterization) from candidate sites. Conduct some Design and Safety Assessment activities in parallel.

Conduct further site characterization and design of central facilities. Initiate the licensing process. With public engagement and safety analyses, perform an environmental assessment that includes shallow rock cavern storage, the underground characterization facility and deep geological repository, and apply for Site Preparation Licence.

With Engagement Program, **decide** whether or not to construct centralized storage facility, and transport used fuel to the central facility.

Obtain Construction Licence for underground characterization facility.

If **yes**, obtain Construction Licence for shallow underground storage.

If **no**, maintain used fuel storage at reactor sites. Transport used fuel to central site in Phase 3.

PHASE 2

Operate underground characterization facility to demonstrate technology, support design and licence for deep repository. Confirm the suitability of the site for a deep repository.

Obtain Operating Licence for shallow rock cavern storage and regulatory approval to transport used fuel. Transport, re-package (as required) and store used fuel in shallow rock caverns.

Through the Engagement Program, prepare final design and **decide** when to construct the deep repository and ancillary facilities. Obtain Construction Licence for deep repository.

PHASE 3

Obtain Operating Licence for deep geological repository. Transport used fuel, as required. Package and place used fuel in deep repository and begin extended in-situ monitoring.

Used fuel is now fully placed in repository. Monitoring will continue until a future society is sufficiently confident that the used fuel will remain contained and isolated.

Decide when to close and decommission deep geological repository.

Close access tunnels and shafts. Postclosure monitoring may be implemented if desired.

That is a very brief sketch of our recommended approach. What follows is the story of why we arrived at that conclusion.

1.6 / The Assessment

As required by the *NFWA*, we have undertaken a comparison of the benefits, risks and costs of each management approach with those of the other approaches, taking into account economic regions in which the approach might be implemented, as well as ethical, social and economic considerations associated with it.

The framework for this comparison emerged from dialogue with citizens over the course of our study. It is designed to capture the objectives that Canadians who participated in the study believe are important in assessing the appropriateness of any management approach for used nuclear fuel for Canada. These key objectives are: fairness; public health and safety; worker health and safety; community well-being; security; environmental integrity; economic viability; and adaptability. The comparison was also intended, as much as possible, to be responsive to the values and ethical principles which citizens suggested should drive decision-making. It was also informed by the knowledge and expertise of specialists.

Our process reflected the lessons learned by the Seaborn Panel about the need to incorporate both technical considerations and social and ethical considerations and the explicit direction in the *NFWA* to treat ethical and social considerations as a key component of any assessment. Social and technical notions of safety and risk were treated in a holistic and integrated way throughout the assessment.

The roadmap for the assessment is described in Chapter 8. It was an iterative process beginning with 10 key questions derived from our conversations with Canadians and the commissioning of background papers, and proceeding through the development of an ethical and social framework; an examination of future scenarios; a multi-attribute analysis; a formal comparative assessment of costs, benefits and risks and continued engagement exercises to validate each step of the process.

Our analysis suggested that:

- Taken individually, no one of the management approaches specified in the *NFWA* perfectly addresses all of the objectives which citizens said are important to address, particularly when both the near term (the next 175 years) and the longer term are considered;
- Each of the three approaches has distinct advantages and limitations in light of our comprehensive framework;
- A management approach which incorporates the most significant advantages of each approach, supported by a phased decision-making process designed to actively and collaboratively manage risk and uncertainties, is expected to perform better on our objectives than the other three approaches; and
- The process of implementation will be a test of the degree to which any of the approaches would ultimately address citizen objectives, values and ethical principles. Therefore, the requirements for an implementation plan form an essential part of our recommendation.

The storage options, Option 2 – Storage at Nuclear Reactor Sites and Option 3 – Centralized Storage, are expected to perform well over the near term (at least within the next 175 years). However, the existing sites were not chosen for their technical suitability as permanent storage sites. Furthermore, the communities hosting the nuclear reactors have an expectation that the used nuclear fuel will eventually be moved.

The NWMO believes that the risks and uncertainties concerning the performance of these storage approaches over the very long term are substantial in the areas of public health and safety, environmental integrity, security, economic viability and fairness. A key contributing factor in this expected performance is the extent to which the storage approaches rely on strong institutions and active management to ensure the safe and effective performance of the management system. The NWMO expects that these institutions and capacity for active management will be strong over the foreseeable future, but uncertain over the very long term. The NWMO believes that the type of responsible and prudent approach that Canadians have said is required dictates that we not rely on the existence of strong institutions and active management capacity over thousands and tens of thousands of years. On this basis, the NWMO does not suggest either of the storage options as a preferred approach for the long term.

Deep Geological Disposal in the Canadian Shield, Option 1, is judged to perform well against the objectives in the very long term because of the combination of engineered and natural barriers to isolate the used fuel. A key weakness, however, is its lack of adaptability, which is an important objective in the minds of citizens. Over the short term, the approach is judged to be less flexible in responding to changing knowledge or circumstances either concerning the performance of the system itself over time, or more broadly to innovations in waste management technologies. There is some uncertainty about how the system will perform over the very long term because we cannot obtain advance proof of the actual performance of the system over thousands of years. Also, this approach provides comparatively little opportunity for future generations to influence the way in which the used fuel is managed. Its lack of adaptability is a weakness that may ultimately affect the performance of the system over time on the other objectives such as public health and safety and environmental integrity.

We believe that our preferred approach, Adaptive Phased Management, builds upon the advantages of each of the three approaches studied but in addition has important attributes that respond to Canadian concerns and aspirations.

- This approach is designed to be highly adaptive in the near term, the period in which it is reasonable to believe there will be strong oversight institutions and active management capacity. It entrenches an explicit and planned process of social learning and action. Over this period, new learning and technological innovation is easily incorporated into the management plan. Some social uncertainties, such as the role of nuclear generation in the energy mix in Canada's near future, may be resolved. Some technical uncertainties, such as whether evolving technologies (i.e., transmutation) will become practicable, are also likely to be reduced. Some uncertainties over the performance of aspects of the deep geological system are also expected to be reduced with further research, testing and experimentation, particularly at the location where such a facility might be sited;

- This approach clearly identifies the technology associated with a deep geological repository as the appropriate end point. It does not rely upon human institutions and active management for its safe performance over the long term. The approach plans for and puts in place a safe and secure containment option for the used nuclear fuel at each point in the process. It provides real options and contingency plans should implementation through the phases not proceed as planned. In particular it provides the option of more robust and secure interim storage in shallow underground caverns located centrally at the site of the deep repository;

- The approach provides opportunity for citizens, including future generations (at least over the next 300 years), to influence the way in which the fuel is managed;

- The approach provides for research and collaborative decision-making in determining the manner and timing of movement through realistic and manageable phases; and

- The approach suggests a process through which confidence in the technology and supporting systems can be developed before moving to the final phase.

Finally, our analysis indicates that some important issues are not fully addressed through the selection of the management approach itself. They will need to be considered through the collaborative decision-making process, which should accompany the implementation of any approach. These issues include the design of a fair siting process and the determination of safety thresholds that would need to be met before moving to the next phase of implementation.

Dialogue with Canadians has highlighted that an optimal balance must be found between flexibility in the near term, which allows for new learning, and the implementation of an approach which isolates and contains the used fuel in a way which does not require active care by people over the very long term. Adaptive Phased Management is such a balance. Dialogue with Canadians has also highlighted that an optimal balance needs to be struck between moving cautiously, to allow for new learning and social confidence, and sustaining sufficient momentum to carry forward with the implementation of the approach to its completion. Should the implementation period be too protracted, there is a risk that future generations will lose interest and/or otherwise abandon the approach mid-way through implementation with negative impacts on public health and safety as a result. In recommending a stepwise implementation process, which involves potentially affected communities of interest at each major point of decision-making, the NWMO believes that public acceptability will be enhanced, thus expediting implementation.

1.7 / Further Reflection

When we tested this assessment and the NWMO's resulting *Draft Study Report* recommendation with the public, we heard that fundamentally our approach is both reasonable and appropriate. Indeed contributors gave us some solid direction for the implementation phase. (For a comprehensive summary of the input we received, see Chapter 4.) Nevertheless, a number of comments and questions arose, which deserve further reflection and clarification.

Is Adaptive Phased Management not really the same as Option 1, Deep Geological Disposal?

When the two approaches are looked at only through a technical lens, it may appear as if there is nothing new. The end point is a centralized deep geological repository. There the similarity ends.

First, Adaptive Phased Management is both a technical method and a management system. It is really the latter component that we believe is most responsive to citizens and to the times – the way in which a technical method is implemented, the way in which decisions are taken, the provisions for monitoring and review and the scope for ongoing societal involvement. The emphasis is on adaptability. Through a phased process with explicit decision points, new knowledge and technology can be accommodated as can the societal change that will be inevitable over time.

Contingencies against unforeseen events, either natural or man-made, are built in and funded to ensure that it is this generation that is assuming financial responsibility. In particular, an **optional** step of providing shallow underground storage at the central site, could respond to calls for enhanced security or the need or wishes of the reactor-site communities to move the used fuel more quickly. The expansion of possible geotechnical sites will provide greater opportunity to balance the wide range of societal objectives, without compromising safety. At all times the used fuel and the facility would be monitored, with the potential for retrievability of the used fuel preserved.

Finally, these two approaches were derived in very different ways. The disposal option was developed almost exclusively by scientific, technological and engineering specialists. Adaptive Phased Management evolved through a process of engagement with citizens, including specialists. As such, it is built to respond to a broader set of considerations and values, to recognize common ground and to balance competing objectives. Consequently, citizen engagement in monitoring and making decisions about safety and risk are a permanent feature of the recommended approach.

Why such a long timeframe?

Some have been concerned that there will be a loss of momentum – that the recommended approach is really postponing decisions and placing the burden on future generations. They pointed out that an approach that provides the greatest amount of procedural fairness may make the project more vulnerable to future political expediency, loss of technical expertise and financial resources. They want to accelerate the process.

There is no fixed timeframe in our proposal. The timeline for implementation which was contemplated in the *Draft Study Report*, that is three phases that would see the used fuel placed in a repository within 60 to 90 years, was intended to be 'illustrative' only. Assigning nominal time frames was required in order to develop conservative cost estimates. The timeline, particularly in the first phase, did take into account what we know and have experienced with siting, environmental assessment, licensing and construction processes. There are technical requirements that will take time. Although we can learn from other countries, this type of deep geological repository has yet to be constructed and begin operations anywhere. There is no benchmark.

There is no question that an implementation process that meaningfully involves potentially affected citizens, communities of interest and Aboriginal peoples in decision-making may affect the pace and manner of movement through the phases. Nevertheless we believe that this is responsive to the direction we have received during our study and is a requirement for social acceptance. A multi-party process is the most likely way to receive the social licence to proceed.

It should not be assumed that undue costs and time delays are being introduced into the process. Flexibility and adaptability are important in order for confirmatory research, new learning and perhaps new technologies to surface and be used to refine the path forward. A series of smaller steps acknowledges obstacles and unplanned issues that would challenge a rigid process. This process is designed to be resilient and self-correcting, building confidence to tackle further challenges. Flexibility is also driven by the search for the balance we need to strike between taking responsibility for the waste we have created while not foreclosing options for future generations.

Adaptive Phased Management is flexible and can certainly be accelerated should conditions warrant. It will proceed as expeditiously as societal circumstances and successful technology demonstration allow. We believe that momentum will build when the government makes its decision about an appropriate approach. We believe that the financial and technical resources required will be assured early. The first decades will be the most financially intensive. Site selection will always be a contentious process. During our study we have already begun to build the necessary relationships and affirm the principles that are required to make steady progress.

Isn't the optional step of shallow storage just a waste of time and money?

We provide for the option of building a shallow rock cavern storage facility at the chosen site for the deep repository for several reasons. The first is to provide a contingency in the event of unplanned circumstances. For example, there may be a need to move the used fuel from one or several of the current interim storage facilities before the safety of the deep repository has been sufficiently demonstrated. The shallow facility, located at the central site to minimize additional transportation of the used fuel, might then be used to safely and securely store this fuel in the interim period. The fuel will remain easily accessible and monitorable, and enjoy some incremental security advantage over current interim facilities because the shallow storage facility would be built in ground.

Secondly, it provides for flexibility in the timing of movement of the used fuel from the reactor sites, accommodating regional differences in priorities and the status of particular operations. For example, we understand that the waste owners may have different business planning assumptions about when the used fuel is moved away from their respective reactor sites.

Furthermore, this is an option. Within the first phase of the plan a specific decision will be required as to whether or not to exercise the option. That decision will occur at a time when there will be greater certainty about Canada's nuclear program. We will also have the benefit of further progress in the repository programs in such countries as Sweden and Finland. Additional research on suitable geological formations, both in Canada and in Europe, will be available. Perhaps we can even hope for a world less vulnerable to terrorist threats.

Why not keep the used fuel at the reactor sites and avoid the risks associated with transportation?

The locations of the nuclear power reactors were chosen for reasons specific to the effective and efficient operations of a power plant. These requirements are not the same as those for very long-term storage of used fuel at a deep underground repository, particularly with respect to environmental and security imperatives. Furthermore, from the perspective of fairness, citizens of reactor-site communities did not anticipate or agree that they would assume stewardship of the used fuel permanently. They accepted the need to store the fuel for an interim period of time.

The level of risk associated with a breakdown of institutional oversight and the complexity of managing the used fuel in the very long term is compounded by the existence of seven sites. We expect that centralization over time will mitigate that risk.

The NWMO acknowledges the concerns of many citizens about the transportation of used nuclear fuel. We need to demonstrate the safety of any transportation system to their satisfaction before beginning to transport used nuclear fuel to a centralized long term management facility. We understand that decisions on risk and safety are societal ones.

On the basis of the discussions we have had with regulatory authorities and waste management organizations in Canada and in other countries and the background research we have commissioned, we believe that used nuclear fuel can be transported safely. The design of the transport container, which is the main safety feature in used fuel transport, is subject to high safety standards and rigorous and extensive testing. A range of accident scenarios has been considered and the regulations are under constant review. Radioactive materials have been transported around the world for 40 years. In that time, there have been no accidents that resulted in the release of significant amounts of radioactivity.

Obviously adequate effort, resources, preparation, oversight and continued vigilance will be necessary requirements of any implementation plan.

1.8 / The NWMO's Commitment to Implementation

The long process of designing, building and operating a used nuclear fuel management facility can serve as a bridge to the kind of future that is sought by a community. Ultimately, quality of life, as perceived by the residents, will be a measure of whether or not the NWMO has been able to align its plans and actions with the community's vision.

Any management approach, no matter how well conceived, will fail if it is not also well executed. The process by which a management approach is implemented, and the institutions and systems which are put in place, will be important determinants of the overall effectiveness of the approach and the extent to which it is and continues to be responsive to societal needs and concerns. Just as considerable investment has been made in examining and understanding the technical management options, it will now be essential to demonstrate an investment in the process of implementation.

Over the course of dialogues with the general public, Aboriginal peoples and specialists alike, many focused their comments on the features they believe should be part of the implementation plan that accompanies the management approach selected. Indeed, as we report in Chapter 4, much of the common ground that we uncovered in our study relates to principles and expectations for how decisions will be taken, how citizens will be involved, and how any management approach will be implemented and monitored over time.

Roles and Responsibilities

Canada has an extensive system of governance to oversee the long-term management of used nuclear fuel. This governance framework involves many participants including governmental and regulatory agencies, the waste owners, the potentially affected communities and the NWMO, all of whom will participate in the ongoing decisions, implementation and operations. Figure 1-3 summarizes some of the more significant legislation and highlights key roles and responsibilities.

We draw particular attention to the Canadian Nuclear Safety Commission (CNSC) which is responsible for regulating the use of nuclear energy and nuclear materials to protect the health, safety, and security of Canadians, to protect the environment, and to ensure that Canada's commitments on the peaceful use of nuclear energy are respected. Canada's regulatory framework will provide for the safe, secure construction and operation of the facilities and transportation of the used nuclear fuel, demanding that standards are met or exceeded. Canada's regulatory framework also implements the international obligations made to the International Atomic Energy Agency (IAEA) under *Canada's Safeguards Agreement* pursuant to the international nuclear non-proliferation regime and the *Joint Convention on the Safety of Spent Fuel Management and the Safety of Radioactive Waste Management*.

Figure 1-3 Governance Framework for the Long-Term Management of Used Nuclear Fuel: Roles & Responsibilities

Government of Canada
Responsible for:
- Making the decision on the long-term management approach for used nuclear fuel.
- Developing policy, regulating, and overseeing producers and owners of waste to ensure that they comply with legal requirements and meet their funding and operational responsibilities.

Natural Resources Canada
Responsible for:
- Recommending a management approach to the Government of Canada from the options in the NWMO study.
- Administering the *Nuclear Fuel Waste Act*, and monitoring the NWMO and the nuclear fuel waste owners to ensure compliance with the *NFWA*, especially with respect to socio-economic effects.
- Approving the funding formula and annual deposits to the trust funds, ensuring trust funds are established, and required deposits are made by the nuclear fuel waste owners.
- Reviewing NWMO's reports and making public statements.
- Interacting with Aboriginal populations to meet government fiduciary responsibilities related to the *NFWA*.

Canadian Nuclear Safety Commission (CNSC)
Responsible for:
- Regulating the use of nuclear energy and nuclear materials to protect health, safety, security and the environment, and to respect related international obligations.
- Ensuring that Canada's international obligations are met, including safeguard agreements with the International Atomic Energy Agency (IAEA), and the *Joint Convention on the Safety of Spent Fuel Management and the Safety of Radioactive Waste Management*.
- Ensuring, prior to licensing, that environmental effects are carefully reviewed through environmental assessments, as required under the *Canadian Environmental Assessment Act*.
- Making determinations on licence applications brought forward by the NWMO for siting, constructing, operating, modifying and decommissioning the long-term management facilities.
- Undertaking ongoing compliance and enforcement of statutory requirements and current licence requirements and conditions, and taking enforcement actions on incidents of non-compliance.

Transport Canada
Responsible for:
- Establising and enforcing requirements to promote public safety during the transport of dangerous goods including radioactive material (in coordination with the CNSC).
- Approving Emergency Response Assistance Plans prior to transport.

Canadian Environmental Assessment Agency
Responsible for:
- Administering the *Canadian Environmental Assessment Act* with which the CNSC must comply before proceeding with each licence application from the NWMO.

Provincial Governments/Regulators
Responsible for:
- Shareholders/owner accountabilities for provincial nuclear power corporations.
- Enforcing provincial statutes that contribute to the regulatory framework that the NWMO must meet.

Major Nuclear Fuel Waste Owners
Responsible for:
- Establishing trust funds to finance the implementation of the long-term management approach selected by government.
- Establishing and maintaining a Nuclear Waste Management Organization.

Currently Canada's owners of used nuclear fuel are: Ontario Power Generation Inc. (owns approximately 90 percent of the used fuel), Hydro-Québec, NB Power Nuclear, and Atomic Energy of Canada Limited.

Figure 1-3 (cont'd) Governance Framework for the Long-Term Management of Used Nuclear Fuel: Roles & Responsibilities

Nuclear Waste Management Organization (NWMO)
Responsible for:
- Preparing the study of long-term management options.
- Consulting with the general public and Aboriginal Peoples.
- Implementing the management approach selected by Government, carrying out the associated managerial, financial and operational activities.
- Reporting regularly to the Minister of Natural Resources Canada and the public.

Advisory Council to the NWMO
Responsible for:
- Examining and providing written comments on the NWMO's study of management approaches and subsequent triennial reports submitted to the Minister of Natural Resources Canada.
- Providing ongoing guidance to the NWMO.

Host Communities
Responsible for:
- Contributing to the design of the implementation plan to ensure it will best meet the needs of the community.
- Participating in implementation of the plan to ensure community needs are met, and in particular, decisions which affect the pace and manner of moving through the phases of work.
- Participating in the design and implementation of measures to address socio-economic and cultural effects of NWMO activities.

Affected Aboriginal Peoples
Responsible for:
- Contributing to the design of the implementation plan to ensure the needs of those impacted will best be met.
- Participating in implementation of the plan to ensure the needs of those impacted are met, and in particular, decisions which affect the pace and manner of moving through the phases of work.
- Participating in the design and implementation of measures to address socio-economic and cultural effects of NWMO activities.

The NWMO will be required to apply to the CNSC for licences to prepare a site, construct, operate, modify, decommission and, when appropriate, abandon a nuclear fuel waste management facility. For centralized options, the NWMO will also be required to obtain a licence to transport waste fuel. In operating a nuclear waste repository, the NWMO will be required to demonstrate at regular intervals that it is meeting all applicable regulations. The necessary decommissioning plan forms the basis for the financial guarantee, which is required to ensure that funds will be available to implement the decommissioning plan and to avoid placing any financial burden on future generations.

The CNSC is defined as a federal authority under the *Canadian Environmental Assessment Act* (*CEAA*) and as such must ensure the requirements of the Act are met before it can proceed to licensing under the *Nuclear Safety and Control Act* (*NSCA*). Transport Canada promotes public safety during the transport of dangerous goods, including nuclear materials and establishes the requirements for emergency response.

After a decision is taken by the Government of Canada, the NWMO will become the implementing agency. It will be directed and governed by the provisions of the *NFWA*, and be subject to a number of federal, provincial and international acts and regulations. It will continue to operate as a not-for-profit corporation.

As required by the *NFWA*, Canada's three nuclear energy corporations, Ontario Power Generation Inc., NB Power Nuclear and Hydro-Québec, established the NWMO in 2002. It is under the governance of the Board of Directors that the NWMO will carry out the managerial, financial and operational activities to implement the long-term management of nuclear fuel waste. The three member corporations confirmed the objectives of the NWMO and clarified the roles and responsibilities of the member corporations in furthering those objectives. (See Chapter 11.) This includes provisions for cost-sharing the NWMO's annual operating budget up to an annual maximum.

Our founding legislation required the NWMO's governing body to appoint an Advisory Council, and provided specific direction on its membership and responsibilities. The Advisory Council has an ongoing responsibility to examine and to provide written comments on the triennial reports that the NWMO must submit to the Minister of Natural Resources Canada. As set out in the *NWFA*, council membership will change over time as the project proceeds from a study on management options, to a concept chosen by government, and then, to a site-specific project in a known location and region. Once an economic region has been identified for implementing the approach selected by the Government, representatives nominated by those local and regional governments and Aboriginal organizations will be added to the Council.

Canada's four waste owners, currently Ontario Power Generation Inc., NB Power Nuclear, Hydro-Québec and Atomic Energy of Canada Limited, are responsible for establishing trust funds to finance the implementation of the management approach selected by government. Nuclear energy corporations will continue to have the management responsibility of the used fuel while it remains in interim storage at nuclear reactor sites. Nonetheless, it will be essential to have close collaboration among the nuclear corporations, the NWMO and the current host communities so that implementation decisions taken with respect to the long-term management approach seek to avoid or minimize disruptive impacts on the current host communities.

Financing

Financial surety for the management approach means determining what costs can reasonably be expected to occur over the life of the project, along with some contingency for unexpected events, and putting in place the financial mechanisms to ensure the necessary money will be available when it is required. The NWMO will design a system that collects and protects enough funding to ensure that the entire cost of the project can be covered under a variety of social and economic circumstances and within the required time-frame.

Canada has a robust system of legal and regulatory oversight, covering all aspects of the nuclear industry. The standards that have been developed to provide financial surety for the long-term management of used nuclear fuel share many elements of design and implementation with other nations around the world. The CNSC has required financial guarantees, including for decommissioning, of nuclear facility operators as a condition of licensing. We anticipate that similar guarantees may also be required of the NWMO in the future. Decommissioning and waste management guarantees have been provided by all waste owners. Details are provided in Chapter 11.

The issue of liability and insurance provisions for damages to health, environment and property, arising from nuclear materials was a risk consideration that emerged during the engagement process. It is recognized that there are anticipated changes to the *Nuclear Liability Act* that will provide further direction to the NWMO on matters of liability.

The following financial details are addressed in legislation and regulations:

- Methods for collecting and managing funds that will meet the cost estimate forecasts in an equitable manner and within reasonable time-frames;
- Methods for adjusting the rate and size of funds that are collected should circumstances change over time;
- Reasonable determinations of cost estimates, derived financial obligations and forms of financial surety provided;
- Contingency programs that will allow all financial obligations to be met even when unexpected events significantly affect the Canadian market;

- A reporting methodology to verify that appropriate financial practices are implemented and that on-going adjustments are made to both cost estimates and the financial guarantees to ensure they are accurate; and

- Setting limits on liability and insurance requirements for various licensed operations.

The *NFWA* sets out requirements for the establishment of trust funds for the long-term management of Canada's nuclear fuel waste. Trust fund contributions made by each producer will be reviewed as part of the Annual Report to the Minister. Contributions will be continually adjusted to reflect improved projections of overall costs and number of fuel bundles to be produced by each waste owner.

Each waste owner has established an individual trust fund that is held and managed by an independent financial institution. As specified by the *NFWA*, deposits currently totalling $770 million, continue to be made by all four bodies. Experience in other countries has demonstrated the importance of safeguarding these large funds so that they will be preserved for the intended purpose. In Canada the legislation built in explicit provisions that will ensure that these trust funds are maintained securely, reported on and used only for the intended purpose.

A funding formula has been developed to set out the respective percentage of the estimated total cost of management of nuclear fuel waste that is to be paid by each nuclear energy corporation and Atomic Energy of Canada Limited, along with an explanation of how those respective percentages were determined. For all options involving a centralized facility, the overall objective is to share actual costs of long-term management based on the number of fuel bundles. That is, each waste owner would pay the same costs for each fuel bundle subject only to owner-specific costs such as transportation. For storage at nuclear reactor sites, costs would be borne by the waste owner at each specific site. For shared facilities at a central location, costs would be shared based largely on the number of fuel bundles to be managed. In addition, cost-sharing will reflect each waste owner's use of the facility, transportation requirements, and the timing of shipment of the used fuel to the central facility.

The total NWMO costs are presented in two formats – 2002 constant dollars and 2004 present value. A conservative costing of the recommended approach, Adaptive Phased Management, is estimated to be $6.1 billion present value or $24 billion 2002 constant dollars. As required by the legislation the costs of the impact of natural or other events that have a probability of occurring, such as earthquakes, global warming or glaciation have been built in to either the design or research costs.

The NWMO will have an ongoing obligation to assess the accuracy of the cost estimate for the selected management approach, and the sufficiency of contributions to cover cash flow obligations for the life of the project.

The NWMO's Intentions

The richness and the sincerity of the contributions to our study motivate us to make a commitment that complements our recommendation to the Government of Canada. The NWMO will be responsible for implementing the approach chosen and how it does so will be a reflection of its accountability to those who participated in this process.

The NWMO must be prepared to move forward in a timely way to implement the Government's decision. Implementation of any management approach will stretch out for many decades, as the project moves through phases of elaborating the management design, identifying candidate sites, building relationships with affected communities and organizations, evaluating sites for adequacy, characterizing the site, undertaking environmental assessments and regulatory approvals, constructing, monitoring and transporting the used fuel.

As we look ahead to the short-term horizon our activities in the first three years will be focused on a number of fronts. These include initiating the siting process, managing community impacts, furthering technical and scientific research, refining the financial requirements and making the appropriate institutional and governance transition.

In designing implementation plans it is the intention of the NWMO to:

- Communicate a clear decision-making path that assigns accountability;
- Continue to give priority to the values of citizens, including Aboriginal peoples;
- Build on the relationships that we have established;
- Seek to continue real dialogue;
- Focus our engagement on potentially impacted communities of interest;
- Assign importance to societal consideration in the site-selection process;
- Recognize contributions and costs borne by the community through appropriate mitigation measures; and
- Seek to ensure access to the knowledge and resources required to make decisions and sustain operations.

In Chapter 16 we present possible typical schedules of activities associated with each management approach. These can only be fully defined upon a government decision on a management approach. Under the NWMO's leadership, the detailed implementation plans will be designed through dialogue with the many communities of interest who will have important roles to play in overseeing and participating in implementation. We expect to hear a diversity of voices as we seek advice and receive direction on the design of the process and the issues to be explored. Implementation plans will not be static. They must continue to evolve. The unprecedented time horizon brings with it a need for continuous learning, and a commitment to collaboratively define and periodically assess indicators of progress as a means of facilitating adaptation to evolving conditions.

Siting

Although the NWMO is not proceeding with site selection as part of this study, in our public dialogues there was intense interest in the major considerations and principles that might influence our next steps in the site-selection process. We elaborate on these technical and social dimensions in Chapter 9. Safety and security will be fundamental considerations.

The NWMO is committed to seeking an informed, willing community to host the long-term management facility. We do not wish to proceed with siting against the wishes of the local community. Rather, it is against the backdrop of the community's own vision for its future that we would proceed. It is the potential host community that will be best positioned to determine how to ascertain whether it has the permission and trust of its people.

We believe that the objective of fairness would best be achieved if the site-selection process is focused within the provinces that are directly involved in the nuclear fuel cycle. We therefore intend to focus the site-selection process in Ontario, New Brunswick, Québec and Saskatchewan. We recognize that communities in other regions and provinces may come forward with interest in possibly hosting the centralized facility. Such expressions of interest will also be considered. The NWMO will respect Aboriginal rights, treaties and land claims.

The NWMO is committed to developing and implementing a siting process collaboratively with potentially impacted communities of interest. The siting process, and the engagement process which will support it, needs to be the subject of a specific NWMO dialogue immediately following any government decision which involves the centralization of used nuclear fuel.

We propose that the siting process seek to:

- Be open, inclusive and fair to all parties, giving everyone with an interest in the matter an opportunity to have their views heard and taken into account;
- Ensure groups most likely to be affected by the facility, including through transportation, are given full opportunity to have their views heard and taken into

account, and are provided with the forms of assistance they require to present their case effectively;

- Include special attention to Aboriginal communities that may be affected. In particular, the NWMO will respect Aboriginal rights, treaties and land claims;

- Be free from conflict of interest, personal gain or bias among those making the decision and/or formulating recommendations;

- Be informed by the best knowledge – in the natural sciences, the social sciences, Aboriginal Traditional Knowledge, and ethics – relevant to making a decision and/or formulating a recommendation;

- Be in accord with the precautionary approach, which first seeks to avoid harm and risk of harm. If harm or risk of harm is unavoidable, place the burden of proving that the harm or risk is ethically justified on those making the decision to impose it;

- Ensure, in accordance with the doctrine of informed consent, that those who could be exposed to harm or risk of harm (or other losses or limitations) are fully consulted and are willing to accept what is proposed for them;

- Take into consideration, in so far as it is possible to do so, the costs, harms, risks, and benefits of the siting decision, including not just financial costs but also physical, biological, social, cultural, and ethical costs (harm to our values); and

- Ensure that those who benefited most from nuclear power (past, present and perhaps future) are bearing the potential costs and risks of managing used fuel and other nuclear materials.

Governance and Institutions

The enduring nature of the NWMO will enable the insights gained and relationships established during the organization's study phase to provide a foundation for implementation. Our vision and values will continue to guide us as we strive to gain the confidence of Canadians. As the organization prepares itself to take on many and varied tasks over decades it will need to redesign itself. A key aspect of redesigning the institution for the transition to a new role will be acquiring the necessary skills and expertise to fulfill new responsibilities.

From the outset the Board has been mindful of adopting best practices in governance in this special purpose organization, funded by waste producers to fulfill their obligations under the *NFWA* with oversight by the federal government. In preparing for its implementation mandate, the Board and member organizations are currently reviewing the future governance of NWMO, including the membership and composition of the Board of Directors. This was a matter frequently discussed during the NWMO's public engagement.

In recognition of their experience in the first phase, the NWMO will be seeking the views of the Advisory Council regarding future membership and composition of the Council. In light of the future role and expanded responsibilities of the NWMO, reviewing the range of expertise and the terms of reference of the Advisory Council may be desirable.

Governance is a big word. During our public engagement sessions governance and decision-making were prominent topics of discussion. That does not surprise us. Meeting obligations to future generations, long-term stewardship, protecting human health and the environment from hazard and mitigation of risk and uncertainty are not responsibilities to be taken lightly.

Citizen Engagement

Our study has begun a process of dialogue and engagement with specialists and citizens that should continue through the decision-making and implementation stages. Knowledge, experience, values and society's priorities may well change over the period of implementation. In fact, continuous learning and adaptation are integral to Adaptive Phased Management.

Of most importance is that engagement can contribute to an informed citizenry and culture of watchful vigilance. We expect that only through successful engagement and collaborative decision-making in the early stages of implementation can we begin to build trust and confidence in the process. Ultimately, it will be essential in maintaining the momentum for action.

A continuum of engagement activities will be needed to support the decisions being taken at each step. (These steps are outlined in Chapter 13) We must communicate a clear decision-making path with accountabilities. Implementation must involve the identification and adoption of roles and responsibilities within communities of interest, government and industry. We must provide assurance that commitments made will be met, and that contingency plans are known and available should they be required.

Ethically, engagement should ensure that those who most directly could be exposed to harm or risk of harm are involved. We must understand concerns of regions and communities that are affected directly and indirectly. These communities will become active players and problem solvers. Communities must be informed and equipped with resources to participate in discussions and decision-making. Their participation must be based on an understanding of potential risks and the means to manage them, including those from transportation. Communities in the vicinity of any future facility must have opportunities for genuine involvement. They should be informed of issues and participate in decision-making, as well as monitoring. A special responsibility is owed to potentially impacted Aboriginal peoples. Effective engagement is based on principles of openness, transparency, integrity and mutual respect. (A set of understandings is further elaborated in Chapter 13.)

We will build on best practices and the relationships that we have established. Through a diverse engagement program we have sought to come to know and develop an ongoing dialogue with many communities of interest. This has laid the foundation for a longer-term relationship that will be essential as Canada moves through the phases of decision-making and implementation. The dialogue we have begun will continue and grow in the years to come. Our engagement with the Canadian public and with Aboriginal peoples is just beginning.

Addressing Social, Economic and Cultural Effects

Implementation presents a significant opportunity to recognize and support a host community's vision for its social, cultural and economic aspirations. It is the host community that must lead the development of a strategy to manage the changes introduced by hosting the facility. The NWMO has an important role to play in providing the resources and support necessary to address socioeconomic impacts.

There will be a broader set of interests beyond the immediate host community. All potentially affected parties must be afforded fair and equitable treatment in engagement with the NWMO, in assessing potential significant socio-economic effects, and in managing those effects. Reactor-site communities will figure prominently regardless of which management approach is selected. Continued secure storage of the used nuclear fuel at the existing reactor sites is an integral and essential component of Adaptive Phased Management.

Of particular note are Aboriginal communities. We are committed to building a relationship with them based on a recognition of Aboriginal values, mutual trust and respect.

It will be important to design implementation in such a way as to avoid or minimize disruptive impacts on the many affected communities. Where adverse impacts cannot be avoided, implementation must recognize the contributions and costs borne by the community through appropriately designed mitigation measures. Risks can be mitigated not only by a variety of physical design features, but through institutional, informational and social measures. Chapter 14 discusses the nature of potential socio-economic effects and the wide variety of measures available to address them.

The NWMO is committed to a collaborative process of decision-making. Fairness requires that interested citizens understand and participate in making key decisions about how to manage socio-economic effects, through full and deliberate engagement during the different stages of decision-making and implementation. That will require developing the capacity for community oversight and empowering the community to have influence in the process.

Research and Intellectual Capability

We see continuous learning and adaptability as integral to successful implementation plans.

A program that will evolve over a long period of time will have many opportunities for improvements to increase performance, enhance effectiveness, improve understanding, and address societal concerns. However, to realize these benefits, there needs to be a vibrant and robust research and development effort during management program development and execution.

While the role for research and issues of intellectual capacity were not explicitly required to be part of our study, we believe that there are many important reasons to pursue such a program. This was validated in our engagement process. Citizens and specialists alike spoke of the need for a significant and ongoing investment so that Canada will have the benefit of leading-edge technological innovation while ensuring that institutional memory and capacities of the nuclear workforce not be eroded.

Such a research and development program could guide the program's scope and content, including:

- Enhanced scientific understanding to improve confidence in predictions, reduce uncertainties, and to evaluate potential program improvements;
- The ability to confirm performance during and after program operations;
- The obligation to citizens to clearly demonstrate an ongoing capability to manage the enterprise and to respond to their concerns and desires;
- The ability to make mid-course corrections in response to new information or societal decisions;
- Preparation for facility siting, design, licensing, development, and operations; and
- Assurance of adequate human capacity to manage the program throughout its existence.

In Chapter 15 we provide examples of some areas of research that we believe would be appropriate under any of the four management approaches and comment upon the type of expertise and capabilities that will be required.

For the NWMO to be a successful "learning organization" it will need to commit to acquiring and incorporating new knowledge, be willing to re-evaluate decisions, maintaining the option to change course and be prepared to act on that new knowledge. As participants in the engagement process noted, beyond the required technical expertise, additional research and development should be conducted on a range of non-technical issues of importance as well, including ethics, socio-economics, stakeholder involvement, and public attitudes. It will be important to involve external parties in identifying research of relevance and interest. The research program work should most often be competitively determined and the work carefully peer reviewed. Finally, much work can be done in collaboration with other countries and international organizations.

1.9 / The Recommendation

The following is the NWMO's recommendation to the Government of Canada. With a decision about the basic approach the NWMO will then be able to move forward to meet the objective of safely managing Canada's used nuclear fuel for the long term. We seek to implement the management approach selected by government consistent with the intentions articulated in the previous section of this report.

NWMO's Recommendation

Our recommendation for the long-term management of used nuclear fuel in Canada has as its primary objectives safety – the protection of humans and the environment – and fairness to this and future generations.

Therefore we recommend to the Government of Canada Adaptive Phased Management, a risk management approach with the following characteristics:

- Centralized containment and isolation of the used fuel in a deep geological repository in a suitable rock formation, such as the crystalline rock of the Canadian Shield or Ordovician sedimentary rock;
- Flexibility in the pace and manner of implementation through a phased decision-making process, supported by a program of continuous learning, research and development;
- Provision for an optional step in the implementation process in the form of shallow underground storage of used fuel at the central site, prior to final placement in a deep repository;
- Continuous monitoring of the used fuel to support data collection and confirmation of the safety and performance of the repository; and
- Potential for retrievability of the used fuel for an extended period, until such time as a future society makes a determination on the final closure, and the appropriate form and duration of postclosure monitoring.

The Nuclear Waste Management Organization would implement this comprehensive approach, in compliance with the *Nuclear Fuel Waste Act* (*NFWA*) of 2002, and would:

- Meet or exceed all applicable regulatory standards and requirements for protecting the health, safety and security of humans and the environment;
- Provide financial surety through funding by the nuclear energy corporations (currently Ontario Power Generation Inc., Hydro-Québec and NB Power Nuclear) and Atomic Energy of Canada Limited, according to a financial formula as required by the *NFWA*;
- Seek an informed, willing community to host the central facilities. The site must meet the scientific and technical criteria chosen to ensure that multiple engineered and natural barriers will protect human beings, other life forms and the biosphere. Implementation of the approach will respect the social, cultural and economic aspirations of the affected communities;
- Focus site selection for the facilities on those provinces that are directly involved in the nuclear fuel cycle;
- Sustain the engagement of people and communities throughout the phased process of decision and implementation; and
- Be responsive to advances in technology, natural and social science research, Aboriginal Traditional Knowledge, and societal values and expectations.

1.10 / Concluding Thoughts

The observations made and conclusions reached in this report have evolved from synthesizing the views and aspirations of people, and rigorously examining technical and engineering information. There is a vast amount of accumulated knowledge. What shaped our thinking was a focus on the time dimension of the issue and the pre-eminent requirement of ensuring safety and security for people and the environment over time. We were concerned about fairness in the distribution of costs, benefits and responsibilities within and across generations. We were guided by a mission statement that calls for consideration of social acceptability, environmental responsibility, technical soundness and economic feasibility. We engaged citizens openly and honestly in defining the questions and discussing the possibilities.

Canadians are prepared to take responsibility for the long-term management of our used nuclear fuel. Our recommendation proposes a path to achieve that goal through a risk management approach of deliberate stages and periodic decision points.

- It commits this generation of Canadians to take the first steps now to manage the used nuclear fuel we have created;
- It will meet rigorous safety and security standards through its design and process;
- It allows sequential decision-making, providing the flexibility to adapt to experience and societal change;
- It provides genuine choice by taking a financially conservative approach, and providing for capacity to be transferred from one generation to the next;
- It promotes continuous learning, allowing for improvements in operations and design that would enhance performance and reduce uncertainties;
- It provides a viable, safe and secure long-term storage capability, with the potential for retrievability of used fuel, which can be exercised until future generations have confidence to close the facility; and
- It is rooted in values and ethics, and engages citizens allowing for societal judgments as to whether there is sufficient certainty to proceed with each following step.

We believe that our approach is both responsive and responsible. It is responsive to what we understand to be the values and expectations of Canadians in providing safe and secure isolation of the used fuel for the very long term. It also brings to bear responsibly the knowledge, expertise and wisdom of a variety of specialist communities to help us understand the choices. There is no single formula or lens through which to approach this public policy challenge. It demands the wisdom of Aboriginal elders, the expertise of natural and social scientists and engineers and the informed interest of citizens.

We are resolute in our belief that the knowledge we have today is more than adequate to start down this path, yet humble enough to acknowledge that the future will unfold in ways that may redirect the path to our end goal. We have an ethical obligation to act.

Part Two

Response to Legislated Study Requirements

2

Chapter 2 / Response to Legislated Study Requirements

The *Nuclear Fuel Waste Act* (*NFWA*) (an Act respecting the long-term management of nuclear fuel waste) was brought into force by the Government of Canada in November 2002. The purpose of the *NFWA* is to provide a framework to enable the Government of Canada to make, from the proposals of the NWMO, a decision on the management of nuclear fuel waste that is based on a comprehensive, integrated and economically sound approach for Canada.

The *NFWA* provides explicit direction on parameters that must be included in the NWMO study of management approaches. In this chapter, we discuss these specific parameters and how we sought to address them in undertaking our study.

The *NFWA* is provided in Appendix 2.

2.1 / Review of Study Requirements

In conducting its study, the NWMO has responded to each of the legislated requirements of the *NFWA*. Parts Three, Four and Five seek to make transparent our interpretation of the study requirements and how we discharged our obligations.

As a guide for readers, a locational index is provided in Table 2-1. The table itemizes each section of the *NFWA* that invokes a requirement for our study, and indicates where the requirement is addressed in the chapters that follow.

In many instances, the chapters refer interested readers to additional information available in the appendices to this report and/or supplementary reports that are publicly available for review on the NWMO website: **www.nwmo.ca**.

Table 2-1 **Guide to Study Requirements in the *Nuclear Fuel Waste Act***

Study requirements of the *Nuclear Fuel Waste Act* (*NFWA*)	Where these requirements are addressed in the NWMO Study Report
The Study	
12. (1) Within three years after the coming into force of this Act, the waste management organization shall submit to the Minister a study setting out	With the submission of this study to the Minister of Natural Resources Canada, the NWMO is fulfilling its requirement under section 12 (1).
(a) its proposed approaches for the management of nuclear fuel waste, along with the comments of the Advisory Council on those approaches; and	(a) Chapter 5 presents the four approaches for the management of nuclear fuel waste proposed by the NWMO for study. Chapters 6 and 7 provide detailed descriptions of the four approaches. In addition, the NWMO considers implementation plans to be a key component of what constitutes the overall management approach. Implementation characteristics corresponding to the four management approaches are outlined in Part Five of the study, in Chapters 9 through 16. The comments of the Advisory Council on the management approaches studied by NWMO are included in the Council's report, provided at the end of this study report.
(b) its recommendation as to which of its proposed approaches should be adopted. *(The NFWA defines "nuclear fuel waste" as irradiated fuel bundles removed from a commercial or research fission reactor.)*	(b) Chapter 1 presents the NWMO's recommendation on which of the management approaches should be adopted.
12. (2) Each of the following methods must be the sole basis of at least one approach:	Part Four reports on the methods that formed the basis for the management approaches in our study. The detailed descriptions of the management approaches studied by the NWMO, and the underlying technical methods, are presented in Chapter 6. As required by the *NFWA*, we studied individual approaches that had as their sole basis the three technical methods specified for study under the *NFWA*:
(a) deep geological disposal in the Canadian Shield, based on the concept described by Atomic Energy of Canada Limited in the Environmental Impact Statement on the Concept for Disposal of Canada's Nuclear Fuel Waste and taking into account the views of the environmental assessment panel set out in the Report of the Nuclear Fuel Waste Management and Disposal Concept Environmental Assessment Panel dated February 1998;	(a) Deep geological disposal in the Canadian Shield, as defined in the *NFWA*, formed the basis of "Option 1" in the NWMO's study.

Table 2-1 (cont'd) **Guide to Study Requirements in the *Nuclear Fuel Waste Act***

Study requirements of the *Nuclear Fuel Waste Act* (*NFWA*)	Where these requirements are addressed in the NWMO Study Report
The Study (cont'd)	
(b) storage at nuclear reactor sites; and *(c) centralized storage, either above or below ground.*	(b) Storage at nuclear reactor sites formed the basis of "Option 2" in the NWMO's study. (c) Centralized storage, either above or below ground, formed the basis of "Option 3" in the NWMO's study. While we were required by the *NFWA* to study approaches based on the three methods listed above, the *NFWA* allowed us to consider additional management approaches. Consequently, the NWMO studied a fourth management approach, Option 4: Adaptive Phased Management. This approach involves many features of the three technical methods prescribed for study in the *NFWA*.
12. (3) The study must include a detailed technical description of each proposed approach and must specify an economic region for its implementation.	Chapter 6 provides detailed technical descriptions of each proposed approach. Supplementary reports on the detailed technical descriptions for the management approaches are available on the NWMO website. Chapter 7 addresses economic regions for implementation. For each of the four management approaches studied, the NWMO specifies regions that we believe would be potentially suitable locations for implementation. The NWMO acknowledges that decisions on locating a facility will ultimately be based on extensive study of site-specific characteristics of a technical, environmental, scientific and social nature.
12. (4) Each proposed approach must include a comparison of the benefits, risks and costs of that approach with those of the other approaches, taking into account the economic region in which that approach would be implemented, as well as ethical, social and economic considerations associated with that approach.	Part Four outlines how the NWMO responded to the legislated requirement for a comparative analysis of each of the proposed management approaches. As background context to the assessment: • Chapter 5 describes how the NWMO considered the range of possible management options, and selected four management approaches to be the focus of the comparative study. • Chapter 6 describes the salient features and distinguishing characteristics of each of the four approaches studied. • Chapter 7 addresses the economic regions that would be associated with implementation of each of the four approaches. The comparative assessment of benefits, risks and costs is presented in Chapter 8. The first part of Chapter 8 reviews how the NWMO developed the assessment framework that was used to conduct the comparative assessment: • The chapter outlines the collaborative process of identifying the key questions and objectives for the assessment of management approaches, and the methodologies used to assess the four approaches. • We describe how ethical, social, economic and other considerations were embedded into the assessment to form important points of focus in the analysis.

Table 2-1 (cont'd) Guide to Study Requirements in the *Nuclear Fuel Waste Act*

Study requirements of the *Nuclear Fuel Waste Act* (*NFWA*)	Where these requirements are addressed in the NWMO Study Report
The Study (cont'd)	
	• We review how our assessment was further informed by taking into account the economic regions in which the approaches could be implemented. Chapter 8 concludes with a presentation of the NWMO's findings from its comparative assessment of costs, benefits and risks for the four management approaches. The findings of the comparative assessment are presented against each of the objectives established by the NWMO to guide our review. All of the supporting reports, papers and assessment studies are available for review on our website. (www.nwmo.ca)
12. (5) Each proposed approach must include a description of the nuclear fuel waste management services to be offered by the waste management organization under section 7. Section 7 of the *NFWA*: *7. The waste management organization shall offer, without discrimination and at a fee that is reasonable in relation to its costs of managing the nuclear fuel waste of its members or shareholders, to* *(a) Atomic Energy of Canada Limited, and* *(b) all owners of nuclear fuel waste produced in Canada that are neither members nor shareholders of the waste management organization* *its nuclear fuel waste management services that are set out in the approach that the Governor in Council selects under section 15 or approves under subsection 20(5).*	Chapter 12 addresses the issue of services to be provided by the NWMO to other waste owners, beyond the nuclear energy corporations (which are presently Ontario Power Generation, NB Power Nuclear and Hydro-Quebec).

Table 2-1 (cont'd) **Guide to Study Requirements in the *Nuclear Fuel Waste Act***

Study requirements of the *Nuclear Fuel Waste Act* (*NFWA*)	Where these requirements are addressed in the NWMO Study Report
The Study (cont'd)	
12. (6) Each proposed approach must include an implementation plan setting out, as a minimum,	Part Five presents implementation plans for each of the four approaches considered. Eight chapters address the elements of implementation required under the *NFWA*, as well as additional elements of implementation that the NWMO considers essential. With regard to elements of implementation that we were required by the *NFWA* to address:
(a) a description of activities; *(b) a timetable for carrying out the approach;*	(a) (b) Chapter 16 describes the activities and timetables associated with implementation of each of the four management approaches.
(c) the means that the waste management organization plans to use to avoid or minimize significant socio-economic effects on a community's way of life or on its social, cultural or economic aspirations; and	(c) Chapter 14 addresses social, economic and cultural effects, and the means by which the NWMO proposes to avoid or minimize significant adverse socio-economic effects on a community's way of life or on its social, cultural or economic aspirations. The NWMO also addresses the objective of seeking sustained long-term positive impacts for communities.
(d) a program for public consultation.	(d) Chapter 13 addresses the programs for public consultation that would form part of the implementation plans. In this chapter, we discuss how we propose to build an engagement strategy to accompany the implementation of the management approaches. We also address other elements of implementation, beyond the minimum requirements specified in the *NFWA*. • Chapter 9 presents what the NWMO believes to be the underlying foundation for implementation. We suggest some overarching principles to guide our implementation processes. We provide some elaboration on the process of siting, and our intent to seek a willing host community. Finally, we descibe some early "next steps" in our implementation workplan. • Chapter 10 outlines the broad scope of institutions and governance that exist to oversee, monitor and contribute to the sequential decision-making processes as implementation unfolds. • Chapter 11 addresses the important financial aspects of implementing and maintaining the management approaches. • Chapter 15 addresses the significance that research and intellectual capacity will have for the continuous learning and adaptability that are integral to implementation plans.

Table 2-1 (cont'd) Guide to Study Requirements in the *Nuclear Fuel Waste Act*

Study requirements of the *Nuclear Fuel Waste Act* (*NFWA*)	Where these requirements are addressed in the NWMO Study Report
Consultation	
12. (7) The waste management organization shall consult the general public, and in particular aboriginal peoples, on each of the proposed approaches. The study must include a summary of the comments received by the waste management organization as a result of those consultations.	Part Three presents our response to this requirement of the legislation. • Chapter 3 describes how the NWMO approached Canadians. We outline how the NWMO invited a continuous dialogue, engaging the general public, Aboriginal peoples, nuclear site communities and many interested individuals and organizations with insights to share. We describe our support of Aboriginal organizations to design and deliver engagement programs within their own communities. We discuss many components of our engagement program, through which we solicited and benefited from comments on the management approaches and the related implementation considerations, as well as the study process and the assessment methodology used in our analysis. • Chapter 4 is a summary of comments received by the NWMO as a result of those consultations. We report on comments received on each of the management approaches that had been the focus of our public engagement to date, and on the broader issues concerning implementation that have arisen in our work, including insights from Aboriginal peoples. Detailed reports on comments from specific dialogues are available on our website, as are the many electronic submissions we received. All provided important guidance as we conducted our assessment, developed a recommendation and formulated implementation plans. • The comparative assessment of the management options and the formulation of our recommended approach, (described in Part Four) were guided by input received from Canadians. • The implementation timetables and plans (described in Part Five) also drew from the insights provided from our dialogue with Aboriginal peoples and the general public.

Table 2-1 (cont'd) Guide to Study Requirements in the *Nuclear Fuel Waste Act*

Study requirements of the *Nuclear Fuel Waste Act* (*NFWA*)	Where these requirements are addressed in the NWMO Study Report
Financial Aspects	
13. (1) The study must set out, with respect to each proposed approach, a formula to calculate the annual amount required to finance the management of nuclear fuel waste. The report must explain the assumptions behind each term of the formula. The formula must include the following terms: *(a) the estimated total cost of management of nuclear fuel waste, which must take into account natural or other events that have a reasonable probability of occurring;* *(b) the estimated rate of return on the trust funds maintained under subsection 9(1);* *(c) the life expectancy of the nuclear reactors of each nuclear energy corporation and of Atomic Energy of Canada Limited; and* *(d) the estimated amounts to be received from owners of nuclear fuel waste, other than nuclear energy corporations and Atomic Energy of Canada Limited, in return for services of management of nuclear fuel waste.*	Chapter 11 discusses the formula to calculate the annual amount required to finance the management of nuclear fuel waste and explains the assumptions behind each term of the formula. The Chapter also addresses the specific requirements for the funding formula as set out in 13 1(a) through (d).
13. (2) The study must set out, with respect to each proposed approach, the respective percentage of the estimated total cost of management of nuclear fuel waste that is to be paid by each nuclear energy corporation and Atomic Energy of Canada Limited, and an explanation of how those respective percentages were determined.	Chapter 11 addresses the respective percentages of the estimated total cost of each management approach that would be paid by each nuclear energy corporation and Atomic Energy of Canada Limited. An explanation of how the percentages were determined is provided.
13. (3) The study must set out the form and amount of any financial guarantees for the management of nuclear fuel waste that have been provided by the nuclear energy corporations and Atomic Energy of Canada Limited under the Nuclear Safety and Control Act.	Chapter 11 sets out the form and amount of financial guarantees provided by the nuclear energy corporations and Atomic Energy of Canada Limited under the *Nuclear Safety and Control Act*. Chapter 11 also addresses other aspects of financial surety, including legislated provisions in the *NFWA* for the establishment of trust funds.

2.2 / Our Interpretation of "Management Approach"

In determining how the NWMO would articulate "management approaches" for consideration in its study, we were guided by the *NFWA* which defines "management" of nuclear fuel waste as the "long-term management by means of storage or disposal, including handling, treatment, conditioning or transport for purpose of storage or disposal." Our interpretation of what is meant by "management approach" is further detailed through the components of implementation plans, required under Section 12 of the *NFWA*. In effect, Table 2-1 describes the various steps taken to assess and recommend a long-term management approach for used nuclear fuel.

Consistent with the *NFWA*, and building upon discussions with Canadians, the NWMO sees the management approach as including both a technical method and an overarching management system. The technical method involves a type of technology, such as continued reactor-site storage or a repository deep in the ground, along with the required support infrastructure that would include transportation systems. The management system includes the institutions, governance, financial arrangements, and managerial and legal frameworks designed to oversee and guide the implementation and operation of the technical method through its operating life. Together, these elements comprise a comprehensive management approach.

In developing the management approach, it is clear that more than technical input is required: not only must technical design attributes be considered, but also the process of implementation – how decisions are taken, how they are reviewed, and the scope of ongoing public involvement. Thus, the design process must consider fully the ethical, social, cultural, environmental and economic dimensions. It must be sensitive to the impacts the approach may have on Canadians' way of life and their aspirations. In bringing together the best insights related to both substantive and process issues, the design of a management approach must draw not only on "western" science (social and natural), but also on Aboriginal Traditional Knowledge. Only through a fully developed management approach may we seek to earn the confidence of Canadians.

2.3 / Study Contributions of the Advisory Council to the NWMO

The Advisory Council to the NWMO was established by the NWMO in 2002, as required by the *Nuclear Fuel Waste Act* (*NFWA*). Membership of the Advisory Council is presented in Appendix 1.

The *NFWA* mandates the Advisory Council to examine and provide to the NWMO its independent written comments on the NWMO study and the management approaches considered in the study. The *NFWA* directs the NWMO to include the independent comments of the Council in our final study that we submit to the Minister of Natural Resources Canada and make public.

In addition to fulfilling this statutory responsibility, the Advisory Council agreed to provide the NWMO with arms-length guidance throughout our three-year study period. Some of these important contributions are discussed below.

The Advisory Council structured its meetings to reflect this dual sense of accountabilities.

Independent Review and Comments

Council members, respecting the Council's statutory responsibility to provide comments on the NWMO study, were conscious of preparing for and reflecting this independence in their operations. For example, the Council:

- Requested regular briefings and progress reports from NWMO management on the findings from public engagement, research and analysis;
- Sought supplementary information from the NWMO, to fully understand key aspects of the study;
- Sought opportunities to meet with invited guests as a means of understanding the breadth of perspectives on the issue of long-term management of used nuclear fuel;

- Attended some of the NWMO's public engagement sessions, to witness the range of comments expressed by Canadians;

- Regularly convened "in camera" sessions for private deliberation amongst members without the presence of NWMO management; and

- Devoted significant time to discussing and preparing its independent comments, through numerous private sessions.

From its inception, the Advisory Council was committed to providing a high level of transparency in its operations.

- The Council requested that formal minutes be taken at its meetings, and directed that the minutes of the Council proceedings be made public through posting on the NWMO website (www.nwmo.ca/advisorycouncil). Background on the Council membership is also maintained on the website.

- The Advisory Council developed a Tracking Matrix, to provide transparency in the nature of the NWMO/Advisory Council interaction over the three-year study period. This Tracking Matrix serves as a joint record of accountability for the Advisory Council and the NWMO.
  - > The Tracking Matrix identifies areas on which the NWMO sought Advisory Council advice, and reports on how the Advisory Council responded; and
  - > It also identifies areas in which the Advisory Council made suggestions or requests of the NWMO, and reports on the NWMO's response.

- The Advisory Council Tracking Matrix is available for review on the NWMO website, at www.nwmo.ca/actracking.

- In January 2005, the Advisory Council published on the website a statement on how it intended to fulfill its legislative mandate by providing independent comment. This early statement signaled the range of considerations that members would be considering in assessing the NWMO study. (www.nwmo.ca/acstatement)

In accordance with the *NFWA*, the Advisory Council provided its written comments on the NWMO study. We enclose these comments at the back of this final study report.

Ongoing Guidance to the NWMO

The second key role of the Advisory Council is one of providing counsel to the NWMO.

Our study of management approaches was enriched by their guidance in many ways. For example:

- We sought Council advice on how to structure our work so that we would make the most effective use of the three-year study period. We benefited from early Advisory Council reviews of our draft workplans and proposed areas of activities in each year of the study;

- We sought the Advisory Council's advice as we developed engagement plans. The Council provided advice on how to achieve effective and full engagement with Aboriginal peoples and the general public;

- We reviewed with the Advisory Council findings from each phase of public engagement, analysis, and assessment, as we considered the implications for our comparative assessment of management approaches;

- We asked the Advisory Council to review drafts of each of our three milestone documents, to suggest opportunities to enhance the clarity, completeness and balance in the reporting of the study findings, including the key issues from the general public and Aboriginal peoples. We asked the Council to advise on the structure and format of the documents, to ensure the documents are effective tools for public engagement; and

- We sought the advice of the Advisory Council on our organization's communications. As part of this, Council members reviewed and commented on NWMO's annual reports from the perspective of ensuring a full and accurate depiction of Council and NWMO activities for the preceding year.

The Tracking Matrix provides an account of the Advisory Council's input into the range of issues on which the NWMO sought guidance. From the NWMO's perspective, the richness of the Council's contributions was broadly based. We share some of our general observations:

The Advisory Council directed significant time and effort to advising us on our engagement activities. Drawing from their respective backgrounds and experiences, Council members advised us on the breadth, focus and structure of engagement plans to support a meaningful dialogue with Canadians. The Council reviewed carefully the findings from all of the NWMO's engagement activities. The decisions of many Council members to attend some of our public engagement sessions, to hear first-hand the range of issues and concerns, is further evidence of the importance assigned by the Advisory Council to the role of public engagement and input in the NWMO study.

Of particular note, was the Advisory Council's focus on the NWMO's engagement with Aboriginal peoples. The Council elected to establish a Sub-Committee on Aboriginal engagement, as a standing committee charged with reviewing and guiding the NWMO's implementation of its Aboriginal engagement program with national and local Aboriginal organizations. The Sub-Committee advised the NWMO on the design of some NWMO-led dialogue initiatives, and reviewed the reports from all of the Aboriginal dialogues. Sub-Committee members sought to ensure that the contributions of Aboriginal Traditional Knowledge would be reflected in the NWMO study.

The Advisory Council considered carefully how the NWMO would be fulfilling its obligation under the *NFWA* to take into account social and ethical considerations, among other factors. Council members followed closely the work of the NWMO's Roundtable on Ethics, and the way in which the NWMO incorporated ethics into its study.

The Advisory Council followed with diligence the analytical review of management options. Members discussed the NWMO's assessment of management approaches through each phase of analysis and public dialogue, and the methodological processes underpinning our analysis. Technical discussions were led by Council members to delve into particular areas of interest. In addition to the regular reports provided by the NWMO, Council frequently tabled information requests with the NWMO. The Council received weekly updates on activities in other jurisdictions. Through briefings, site visits and international meetings, members devoted significant personal time to monitoring closely the way in which other jurisdictions were proceeding with their plans for the long-term management of used fuel.

The Advisory Council urged us bring to bear the vast insights gained over previous years through Canada's study of the long-term management of used nuclear fuel, including the findings of the Seaborn Panel. At the same time, the Council reminded us to recognize and report transparently the remaining areas of uncertainty, and topics on which further social and technical research will be required.

Finally, the Advisory Council contributions to our study reflected the members themselves. Their decisions to devote personal time to meeting more frequently, with the NWMO and privately, than we had envisaged is evidence of their commitment. The nine individuals, with such a diversity of backgrounds and expertise, demonstrated an unwavering commitment to meet, discuss, advise and reflect on our study.

Drawing from their illustrious careers in federal and provincial government, municipal politics, academia, community involvement, non-profit organizations and the private sector, members led a full and intense discussion which resulted in strong contributions throughout our study. Through their questions and challenge, they brought rigour to our process, encouraging our further reflection and, ultimately, greater clarity in the study outcome. The intensity and thoughtfulness evident in the Council dialogue was an important reminder in itself of the value of a broadly-based Advisory Council.

The Advisory Council fulfilled its legislated mandate, and more. For its ongoing assistance and advice the NWMO is grateful. The study and the organization have benefited immensely. At the same time, we recognize the Council must reserve a place for its independent judgment of our work. In its report provided at the back of this document, the Advisory Council provides, in its own words, an account of its activities and its observations on how the NWMO has discharged its mandate over the past three years.

Part Three

What Canadians Said

3

Chapter 3 / How We Approached Canadians

Early on the NWMO adopted as its mission "to develop collaboratively with Canadians a management approach for the long-term care of Canada's used nuclear fuel that is socially acceptable, technically sound, environmentally responsible and economically feasible." This statement is reflected in how we approached Canadians, both in the way we asked for input and then used that input to shape the study.

We began with the understanding that technical and scientific experts or specialists can help us understand the **technical adequacy** of each of the management approaches. They can also help us understand the impacts any approach may have on the **environment**, and whether the approach is affordable (**economically feasible**). However, we understood that it is necessary to move beyond the technical and scientific communities to include the voices of a much wider range of citizens in order to judge the fourth element of our mission, **social acceptability**.

Scientific and technical evidence and analysis, while essential, was not the sole basis of our decision-making. We understood that the views of Canadian society, in judging benefits or risks, and assessing the social implications of various approaches for long-term management, are critical to the development of a socially acceptable recommendation. Canadians expect that the best scientific and technical knowledge is brought to bear in identifying and understanding the source and nature of risk and the ways in which safety can be assured. However, the decision as to whether safety has been assured to a sufficient degree to warrant implementation is a societal one, and will be affected by social judgements of what constitutes risk and safety and thresholds to be met.

We expected the management approach that may be regarded by Canadians as socially acceptable would be the one which factors in the best scientific and technical knowledge available, and is most responsive to the key values and objectives articulated by citizens who participated in our process of collaborative development. This process of working collaboratively with citizens to develop a management approach for Canada was designed to ensure that not only the best scientific and technical knowledge was brought to the study, but also that the values and objectives of citizens were identified and understood, and formed the road map for both the study and recommendation. The social and ethical considerations expressed by citizens were fundamental building blocks for the study.

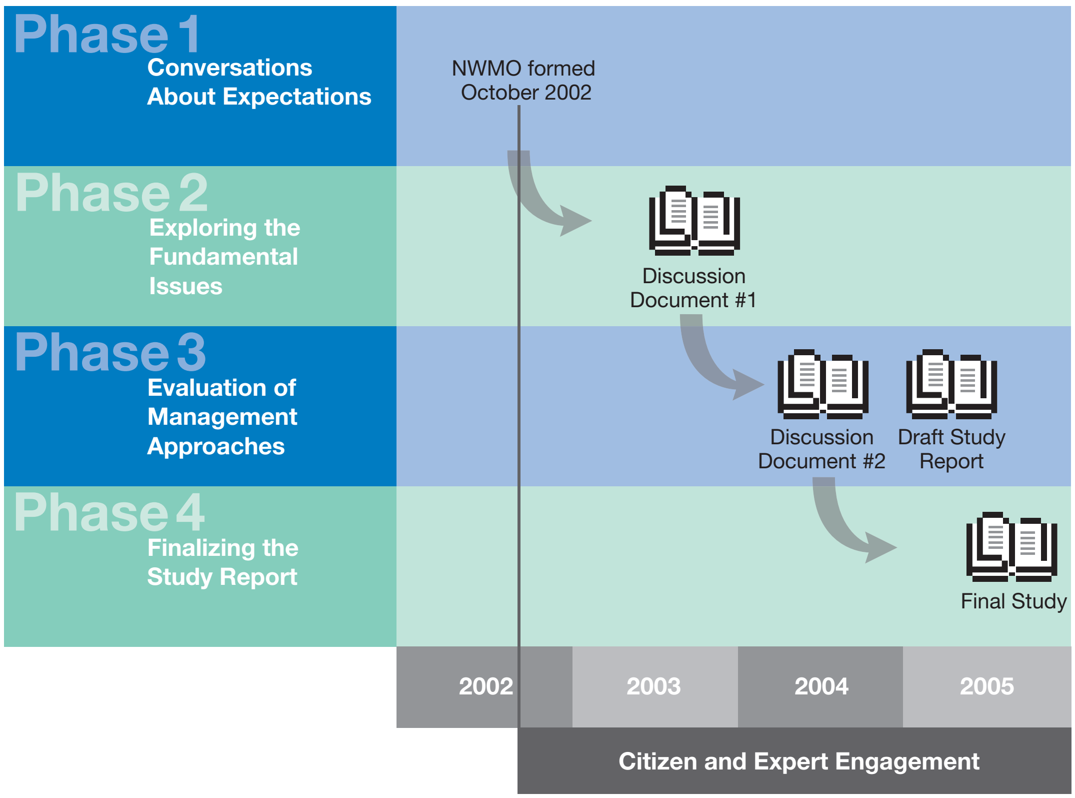
At its simplest, our study process involved asking Canadians to list the values and objectives against which a management approach should be assessed, and then engaging them in a dialogue to assess the approaches against that list. The study was designed so that the approach which emerged as most responsive to these values and objectives would be judged the most socially acceptable of the options studied.

In this collaborative development process, our role was to act as a facilitator of dialogue in an open forum where, as much as possible, all interested Canadians had access to information and the opportunity to put forward their views. The study process was designed so that as many perspectives as possible were considered and used to shape each major decision point.

3.1 / A Responsive Study Process

The three-year NWMO study was designed as a dialogue conducted over four phases as illustrated in Figure 3-1. Each of the four phases focused on a key decision point, and the direction of Canadians was elicited through dialogue before proceeding to the next key decision and phase of work. The four phases were supported by a series of milestone documents to share what we heard from Canadians, how this shaped our thinking, and to elicit public feedback to shape and direct subsequent steps in the study. Through these documents, we sought to make transparent our deliberations, to "think out loud," and to elicit comments and direction.

Figure 3-1 NWMO Study Plan



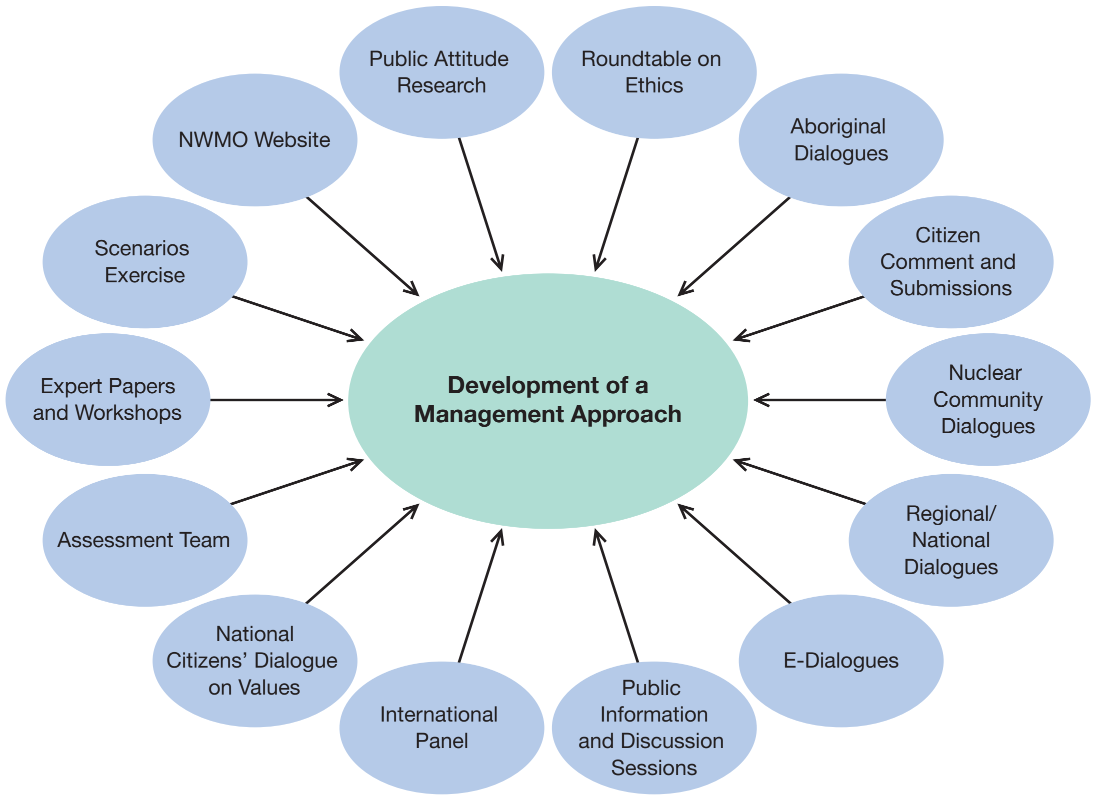
The dialogue process sought direction from Canadians at each of the following points:

- Identifying the questions to be asked and answered in the study, and the key issues to be addressed in the assessment of the management approaches;
- Confirming the range of technical methods to be considered in the NWMO study;
- Assessing the risks, costs and benefits of each management approach through the assessment process; and
- Designing the overarching management structure and implementation plans for each management approach considered in the study.

For this public policy issue, we understood that all Canadians may have an interest. We learned early on, from public attitude research, that the public attaches high importance to this issue, once it is brought to their attention, and expects to play an important role in the study. However, we also learned that most have little knowledge about the issue, and little interest in becoming personally involved. Recognizing that many people would not involve themselves in a discussion about used nuclear fuel, although the inclusion of public input is considered key to a credible study process by the public, we tried to deliberately include a diversity of voices. In this way we attempted to ensure that a broad range of social and ethical considerations were raised for consideration.

We sought this societal direction in part through a dialogue with citizens about the values and objectives that ought to drive decision-making on a waste management approach and the concerns that needed to be addressed. We also sought societal direction through a dialogue with specialists focused on understanding the current state of scientific knowledge related to the long-term manage-

Figure 3-2 Development of a Management Approach
The NWMO has attempted to use a wide variety of techniques to bring a diversity of voices to the study.



ment of used nuclear fuel, and the practicable options available to meet the values and objectives which citizens judge to be important.

Over the course of the dialogue, a broad range of engagement and dialogue techniques were used, including traditional and more innovative approaches. In order to elicit the range of social and ethical considerations which citizens bring to bear on this issue, we used nation-wide surveys, focus groups, issue-focused workshops and roundtables, e-dialogues and deliberative surveys, and public information and discussion sessions. (See Figure 3-2.) Through agreements initiated by the NWMO, 15 national, regional and local Aboriginal organizations conducted a range of dialogue initiatives, which they designed to meet the needs and preferences of Aboriginal participants.

Some of these techniques were used to ensure that we heard from a statistically representative cross-section of citizens, including those who would not otherwise involve themselves in the study. Some of these techniques elicited the concerns of those who are directly interested in the issue. Others provided for more in-depth conversation among those with specialized knowledge. Throughout, our website served as a platform, not only for making publicly available all reports commissioned by the NWMO, but also to share what was said and invite submissions and comment from Canadians on any of these topics. Each dialogue initiative was conducted, and reported on, by third parties in order to ensure the accuracy and transparency of the reporting.

In order to explore the state of scientific knowledge (both natural science and social science) related to the long term management of used nuclear fuel, and the practicable options from which to choose, we commissioned a series of background papers, each prepared by a specialist in that field and peer reviewed.

Specialists also prepared illustrative conceptual engineering designs and cost estimates for each of the short listed options in the study. These conceptual designs formed the basis for much of the broader public discussion.

The process through which the NWMO sought to elicit societal direction at each major step was designed to be responsive to what Canadians said an appropriate study process should embody:

- The study process must be grounded in knowledge and expertise;
- The study must solicit and consider a wide range of perspectives;
- The NWMO should "think out loud" and engage citizens in dialogue at multiple points in the process;
- The process must be fair, transparent and trustworthy;
- The process must make information accessible to members of the public who currently know little about this issue; and
- The process must use a variety of methods to engage citizens.

The NWMO study process is briefly outlined, by phase, in the following section. To August 31, 2005, more than 50,000 people expressed interest in our study by visiting our web site. We conservatively estimate that more than 18,000 citizens contributed,[1] including more than 500 specialists in scientific (natural and social sciences) and technical disciplines related to the management of used nuclear fuel.

3.2 / The Road Traveled – the NWMO's Process of Collaborative Development with Canadians

Phase 1 – Conversations About Expectations

The NWMO began by listening to Canadians about their expectations and objectives for the study. We asked them to tell us:

- How should the study be conducted?
- What questions should be asked and answered in the study? and
- Which options should be investigated and included in the study?

As part of this 'listening and learning', we launched a number of initiatives, including a set of early conversations with Canadians, to begin to appreciate expectations both for the process to be used and the issues to be explored in the study. These initiatives are discussed further in Table 3-1. We also commissioned a series of papers by specialists and convened workshops to initiate some focused discussions on specific topics. (See Table 3-2.)

One of the major initiatives we launched in this phase was a Scenarios Exercise. Given the very long time-frames over which used nuclear fuel remains hazardous to people and the environment, decisions we make today will surely have repercussions for generations to come. Although we cannot know what future societies will look like, we can try to anticipate what they may look like by envisioning a broad range of possibilities. Envisioning possible futures that we might attempt to plan for in the decisions we make today was the objective of the Scenarios Exercise.

[1] This estimate is based on the sum of: the number of unique visitors who visited the NWMO web site more than once (9,925), plus the number of citizens who were randomly selected and participated in public attitude research (3 nation wide surveys (2,600 x3) and 54 focus groups (8 x 54)). This figure does not include authors of papers which appear on the NWMO website, submissions, or participants at open houses, dialogue sessions, e-dialogues, Aboriginal dialogues, or web surveys since we are unable to confirm how many of these participants may have also visited the website more than once.

In partnership with Global Business Networks, we convened a Scenarios Team consisting of 26 individuals drawn from a range of interests and locations across Canada. Four workshops of several days each were held over the course of several months. At the end of the exercise, the group had described four detailed scenarios for the time-frame of 25 years from now, 12 much less detailed scenarios for the 175-year time-frame, 16 sets of conditions for the 500-year time-frame, and a number of simple "what-ifs" for the 10,000-year time-frame. A sub-set of these scenarios later came to form an important component of the assessment of approaches.

People needed good information as a foundation to become involved in the study. We commissioned a series of papers by specialists, which were peer-reviewed and then posted on our website. We asked more than 100 specialists from a wide diversity of disciplines to help us understand the state of scientific and technical knowledge in Canada and abroad on issues related to the study. These specialists also helped us to understand that although there is much that we know, there are still some areas of uncertainty.

This was the first step in creating an information foundation for the study. Over the course of the study, as information gaps were identified through public dialogue, additional expert papers were commissioned and workshops convened. Our information base expanded as Aboriginal peoples began to contribute their knowledge, wisdom and insight to the study. Citizens from communities that currently store used nuclear fuel shared their experiences 'living' with used nuclear fuel. The information foundation was also augmented by other citizens from the perspective of public values, objectives and experience.

Table 3-1 Phase 1: What We Did to Identify Expectations for the Study

- **Face to face meetings.** We traveled across the country for face-to-face conversations with more than 250 individuals and groups involved in this issue including: people from communities that are currently storing used nuclear fuel; political representatives at all levels of government; Aboriginal leaders; nuclear power plant workers, youth, environmental organizations, industry specialists, faith communities, government agencies and parliamentarians;

- **Letters and submissions.** We encouraged letters, submissions and comments from interested Canadians, through regular mail and through the NWMO website (via formal submissions or deliberative surveys);

- **Key Concepts exploration.** We commissioned a series of papers designed to describe key concepts often used in the exploration of difficult public policy issues, to help guide and inform our examination and assessment of used fuel management approaches. These papers suggested important questions for the study to ask and answer. The concepts explored included: risk and uncertainty; security; the precautionary approach; adaptive management; and sustainable development;

- **Traditional Knowledge Workshop.** We convened a workshop involving a variety of traditional knowledge holders to explore the contributions of Aboriginal Traditional Knowledge to our study;

- **Technical Methods exploration.** We commissioned background papers from specialists to describe the range of technical methods available, and the practicability and promise which each holds;

- **Future Scenarios exploration.** We conducted a major scenarios exercise, which included a series of four workshops. A diverse group of individuals drawn from many interests was brought together with the task of identifying a range of plausible futures and conditions which might need to be faced in managing used nuclear fuel over the long term, and the questions those scenarios raise for the study;

- **Roundtable on Ethics.** We convened a roundtable of specialists in ethics, who met over the course of the study to help identify the ethical issues associated with the long-term management of used nuclear fuel and the conduct of the study;

- **Nuclear Host Community workshop.** We convened a workshop with opinion leaders in communities that currently host interim storage facilities to explore ways to facilitate effective and responsive dialogue at the community level;

- **Aboriginal dialogues.** We began the process of creating agreements with national Aboriginal organizations and some regional and local organizations to design and implement their own dialogue processes as a means of providing input to the NWMO's study;

- **Sustainable Development workshop.** We convened a workshop with senior practitioners in sustainable development to discuss what might be the key environmental questions that need to be addressed respecting the management of used nuclear fuel;

- **Science and Technology workshop.** We convened a workshop of 50 scientific and technical specialists to discuss the key technical questions that need to be addressed respecting the management of used nuclear fuel, as well as the range of technical methods available, their promise and practicability;

- **Public attitude research.** We undertook public attitude research with a representative cross-section of Canadians, including: 14 focus groups; and a nation-wide telephone survey involving 2,600 Canadians; and

- **Political Representatives briefing.** We conducted meetings with political representatives at all levels of government in Canada, and with international agencies involved in this issue.

Reports of these initiatives can be viewed at **www.nwmo.ca/backgroundpapers** and **www.nwmo.ca/dialoguereports**. A detailed listing is contained in Appendix 11.

Table 3-2 Phase 1: What We Did to Create the Information Foundation for the Study

Approximately 70 papers were commissioned on the following topics:

- **Social and Ethical Dimensions.** The papers were designed to suggest social and ethical dimensions of managing radioactive waste;
- **Health and Safety.** The papers were designed to provide information on the status of relevant research, radiological protection technologies, standards and procedures to reduce radiation and security risk associated with radioactive waste management;
- **Science and Environment.** The papers were designed to provide information on the status of relevant research on ecosystem processes and environmental management issues, including: research into our understanding of the biosphere, subsurface biosphere and geosphere; natural and anthropogenic analogues; chemical toxicity potential; and implications of climate change and of microbiological factors on the long-term management of used nuclear fuel;
- **Economic Factors.** The papers were designed to provide insight into the economic factors and financial requirements for the long-term management of used nuclear fuel, including: an examination of economic regions; status of financing systems for high-level radioactive waste management around the world; examination of economic considerations and analytical tools for the economic assessment of approaches;
- **Technical Methods.** The papers were designed to provide general technical descriptions of the three methods for the long-term management of used nuclear fuel as defined in the *Nuclear Fuel Waste Act*, as well as other possible methods and related system requirements. These include: overview of reactor site storage, centralized storage, geological repository systems, other potential management options; the status and economic and radiological implications of reprocessing, partitioning and transmutation of used nuclear fuel; transportation systems, storage, disposal and transportation containers, transportation issues and considerations; exploration, from a geoscientific perspective, of the suitability of other geomedia beyond that specified in the *Nuclear Fuel Waste Act* for implementation of a deep geological repository concept; and potential design changes associated with implementation in other geomedia;
- **Conceptual Engineering Designs and Cost Estimates for Alternative Management Approaches.** The NWMO received and posted to the website a series of technical and engineering reports from the Joint Waste Owners: Ontario Power Generation, Hydro-Québec, NB Power Nuclear and Atomic Energy of Canada Limited. The Joint Waste Owners commissioned engineering consulting firms to develop preliminary conceptual engineering designs for the three technical methods identified in the *Nuclear Fuel Waste Act*, and to develop associated transportation infrastructure and cost estimates for those designs. Upon receipt of this material, the NWMO commissioned a third-party review of the work, including examination of the key engineering design assumptions and cost estimation process; and
- **Institutions and Governance.** The papers were designed to outline the current legal, administrative and institutional requirements that may be applicable to the long-term management of used nuclear fuel in Canada, including legislation, regulations, guidelines, protocols, directives, policies and procedures of various jurisdictions. These include: a compendium of current legislation, regulatory documents, treaties, guidelines, and plans; status of Canadian expertise and capabilities; review of the *Canadian Environmental Assessment Act* process, Canadian Nuclear Safety Commission licensing process, the Non-Proliferation Treaty; Nuclear Liability; methodologies for assessing used nuclear fuel options; and education and training in nuclear waste management in Canada and abroad.

These background papers can be viewed at **www.nwmo.ca/backgroundpapers**. A detailed listing is contained in Appendix 11.

Phase 2 – Exploring the Fundamental Issues

The second phase of the study was launched with the release of our first discussion document *Asking the Right Questions?* We reported back to Canadians what we had heard, and on this basis how we planned to proceed with the study. This discussion document identified:

- Our plan to break the study into 'bite-sized pieces', each of which would form the focus of a broad dialogue with Canadians and be the subject of a discussion document;
- A list of 10 questions which we heard that Canadians want asked and answered in the study, and which should set the agenda for the study; and
- The short list of technical methods that we heard hold the most promise, drawn from a list of 14 technical methods, representing the range of choices considered internationally for the management of used nuclear fuel.

We launched a number of initiatives to engage citizens and specialized groups in discussion on four questions: Have we described the problem correctly? Have we identified appropriate ways to deal with the problem? Are we asking the right questions? Is our proposed decision-making process understandable and appropriate?

One of the most significant initiatives was a National Citizens Dialogue on Values. (See Table 3-3.) From the outset, we identified the need for the study to be driven by the values of Canadians. To gain a more in-depth understanding of citizens' values, and to identify them explicitly, we launched a collaborative research project with the Canadian Policy Research Networks.

A representative cross-section of citizens from coast to coast participated in the dialogue. In total, 462 Canadians gathered in 12 cities across Canada between January and March 2004, to talk with each other about the key characteristics they feel are important in a long-term management approach. This 'deliberative' dialogue identified one over-arching requirement and six 'fundamental values,' which later came to form foundation elements in the assessment framework.

A second major focus of activity in this phase of the study was the development of an Assessment Framework reflecting the values and concerns of Canadians. This framework was needed to undertake a rigorous comparative analysis of alternative management approaches. A multi-disciplinary Assessment Team assembled by the NWMO created the framework, based on the 10 questions outlined in our first discussion document. The team was asked to apply the framework, in a preliminary manner, to the short list of options specified in the *Nuclear Fuel Waste Act*.

The Assessment Team conducted its work over a six-month period, meeting as a group for a full week once each month. The framework and the preliminary assessment were major inputs to our second discussion document. They were subjects of extensive dialogue with Canadians in Phase 3.

Table 3-3 Phase 2: What We Did to Explore the Fundamental Issues

- **Discussion Document.** The NWMO reported on what it had heard to date, how it incorporated what it had heard in its work going forward, and sought clarification and correction, with the release of its first discussion document, *Asking the Right Questions?* (**www.nwmo.ca/askingtherightquestions**);

- **National Citizens' Dialogue on Values.** We held an in-depth exploration of values through a National Citizens' Dialogue with a cross-section of citizens, to identify and explore the values which we share as Canadians, and which should drive decision-making on this issue;

- **Letters and submissions.** We received letters, submissions and comments from interested Canadians through regular mail and through the NWMO's website (via formal submissions or deliberative surveys).

- **Dialogue workshops.** We convened workshops with citizen groups and organizations involved in this issue and individuals and organizations with an interest in public policy at both national and regional levels (National Stakeholder and Regional Dialogues);

- **Aboriginal dialogues.** We sought advice and guidance through dialogues designed and implemented by Aboriginal Peoples. (**www.nwmo.ca/aboriginaldialogues**);

- **Youth forum.** We convened a workshop with young people involved in the nuclear industry (Roundtable Dialogue with Youth at the International Youth Nuclear Congress);

- **Public attitude research.** We commissioned public attitude research with a representative cross-section of Canadians, including: six focus groups and a nationwide telephone survey involving 2,600 Canadians;

- **Workshops and meetings upon request.** We held a number of workshops and meetings to outline our work to date, answer questions and receive comment upon request of various interested individuals and groups;

- **Political Representatives briefing.** We held ongoing meetings with political representatives at all levels of government in Canada, and with international agencies involved in this issue; and

- **Preliminary Assessment paper.** We created a multi-disciplinary team to develop an assessment framework based on the direction that had emerged from dialogue with Canadians, and to apply this framework in a preliminary way to the management approaches under study. The framework and preliminary assessment were subjects of extensive dialogue in Phase 3. (**www.nwmo.ca/assessments**)

Reports of these initiatives, unless otherwise indicated, can be viewed at **www.nwmo.ca/dialoguereports**.
A detailed listing is contained in Appendix 11.

Phase 3 – Evaluating Management Approaches

The third phase of the study was launched with the release of our second discussion document *Understanding the Choices*. Through this document we reported to Canadians what we had heard in the previous phase, and how we planned to proceed with the assessment of approaches. This discussion document:

- Reported on further learning about the values and priorities of Canadians concerning the long-term management of used nuclear fuel, and insights from dialogues convened around the first discussion document;
- Provided more complete descriptions of the approaches that had become the focus of the study; and
- Outlined a proposed framework to be used for the assessment of management approaches, composed of citizen values, ethical principles and specific objectives. This framework was designed to build on the 10 questions that had been identified through conversations with Canadians and largely confirmed through subsequent dialogue.

With the release of this document, we asked Canadians if the proposed assessment framework was sufficiently comprehensive and balanced. (See Table 3-4.) That is, did the framework reflect the values and objectives of Canadians? We also asked interested Canadians to help apply the framework to the approaches and identify the relative strengths and limitations of each of the approaches. In dialogue leading up to the second discussion document, we had begun to hear that the way in which any management approach is implemented is very important, perhaps as important as the approach itself. For this reason, we also posed the following question to Canadians, "Are there specific elements that you feel must be built into an implementation plan?"

To continue the dialogue, we collaborated with the independent consulting firm DPRA Canada, to organize a series of 120 public information and discussion sessions in 34 locations, including every province and territory, across Canada. These sessions were advertised broadly to invite all interested Canadians to meet with us, learn about the study, and contribute to the assessment of the approaches.

We also reconvened some of the individuals and groups who had met to discuss our first discussion document. These National and Regional Stakeholder Dialogue workshops convened by the independent consulting firm Hardy, Stevenson and Associates Ltd., brought together people from specialized organizations and groups, such as environmental groups, learned societies, the nuclear industry, faith communities and others involved in this issue.

Finally, we further explored the strengths and limitations of the approaches under study by commissioning a group of specialists to use the framework outlined in the second discussion document, and modified through dialogue, to conduct a rigorous assessment of the management approaches under study. This additional and complementary assessment work, conducted by independent consultants well known in this area (Golder Associates Ltd., Gartner Lee Ltd.), extended the assessment to include consideration of illustrative economic regions in which each of the approaches might be sited and more formal quantification of risk.

Table 3-4 Phase 3: What We Did to Further the Assessment of Management Approaches

- **Discussion Document.** The NWMO reported on what it had heard to date, how it had incorporated what it had heard in its work, and sought clarification and correction, with the release of its second discussion document, *Understanding the Choices*. (**www.nwmo.ca/understandingthechoices**);
- **Public information and discussion sessions.** We convened a series of 120 public information and discussion sessions across Canada, which invited interested Canadians to meet to discuss the second discussion document;
- **Letters and submissions.** We received letters, submissions and comments from interested Canadians through regular mail and through the NWMO website (via formal submissions or deliberative surveys);
- **Aboriginal dialogues.** We sought advice from Aboriginal Peoples through dialogues they designed and implemented. (**www.nwmo.ca/aboriginaldialogues**);
- **E-Dialogues.** We commissioned three e-dialogues on the difficult topic of risk and uncertainty as it applies to the long-term management of used nuclear fuel. These involved two learned panels, and a series of e-roundtables among graduate students and other young people;
- **Nature of the hazard workshop.** We convened a workshop which brought together a variety of individuals with knowledge in natural science, social science and Aboriginal Traditional Knowledge, to discuss how the nature of the hazard inherent in used nuclear fuel might best be characterized;
- **Dialogue workshops.** We convened a series of workshops with citizen groups and organizations involved in this issue (National Stakeholder and Regional Dialogues);
- **Nuclear Host Community meetings and workshops.** We convened a series of meetings and workshops with individuals in communities that currently host nuclear waste management facilities;
- **Public Policy Roundtable.** We convened a roundtable with key public policy analysts and opinion leaders;
- **Political Representatives briefing.** We held ongoing meetings with political representatives at all levels of government in Canada, and with international agencies involved in this issue;
- **Public attitude research.** We commissioned public attitude research with a sampling of Canadians, including 10 focus groups, as well as deliberative surveys on our website;
- **Open Houses.** We held open houses in communities that currently host interim storage facilities.
- **Workshops and meetings upon request.** We held a number of workshops and meetings to outline our work to date, answer questions and receive comment upon request of various interested individuals and groups;
- **Comparative Assessment of Costs, Benefits and Risks papers.** We commissioned a team of specialists to use the Assessment Framework developed by the Assessment Team, based on direction which had emerged from public dialogue, to conduct a rigorous and integrated assessment of the management approaches under study with respect to economic regions. (**www.nwmo.ca/assessments**);
- **Supplementary Risk Study.** We commissioned specialists to supplement the analysis with additional work to examine the management approaches from the perspective of risk. (**www.nwmo.ca/assessments**); and
- **Discussion Document.** The NWMO outlined its thinking on its proposed recommendation to government, its thoughts on how this recommendation is responsive to the advice and guidance of Canadians, and sought comment before formulating its final recommendation with the release of this document, the *Draft Study Report – Choosing a Way Forward*. (**www.nwmo.ca/draftstudyreport**)

Reports of these initiatives, unless otherwise indicated, can be viewed at **www.nwmo.ca/dialoguereports**.

Phase 4 – Finalizing the Study Report

With the release of the *Draft Study Report*, the fourth and final phase of our study began. (See Table 3-5.)

In this phase, we continued our dialogue with interested Canadians, specifically to receive comment and suggestions and to hear concerns about the NWMO's proposed recommendation. This dialogue surfaced issues of both substance and clarification as input to the refinement of the final recommendation and report. We outline the insights from the dialogue in the refinement of the final recommendation and report in the next chapter.

Among the significant initiatives in this phase of work was the convening of workshops with interested individuals, citizen groups and organizations who had been involved in earlier phases of the study. These workshops, convened by the independent consulting firm Stratos, were designed to discuss and hear comment and direction concerning the NWMO's planned recommendation and report.

Table 3-5 Phase 4: What We Did to Finalize the Study

- **Dialogue workshops.** We convened workshops with interested Canadians who had previously contributed to our study in five provinces – New Brunswick, Québec, Ontario, Manitoba and Saskatchewan – to examine and comment on the *Draft Study Report*;
- **Letters and submissions.** We received letters, submissions and comments from interested Canadians through regular mail and through the NWMO website (via formal submissions or deliberative surveys);
- **Aboriginal dialogues.** We sought advice and guidance from Aboriginal peoples at the national, regional and local levels, as their dialogue process continued;
- **Nuclear host community workshops.** We convened a workshop with opinion leaders in communities that currently host interim storage facilities;
- **Elders' forum.** We convened a gathering of 22 Aboriginal elders and 19 youth supporters to discuss the draft recommendation and work going forward;
- **On-line public forum.** We convened an electronic forum to answer questions and hear discussion and comment about the *Draft Study Report*;
- **Public attitude research.** We commissioned public attitude research with a representative cross-section of Canadians, including: 24 focus groups and a nationwide telephone survey involving 2,600 Canadians;
- **Workshops and meetings upon request.** We held a number of workshops and meetings to outline our recommendation, answer questions and receive comment upon request of various interested individuals and groups;
- **Open houses.** We held open houses in communities that currently host interim storage facilities for used nuclear fuel.
- **Political representatives briefings.** We held ongoing meetings with political representatives at all levels of government, and with international agencies involved in this issue; and
- **Final Report.** This phase culminates with the delivery of this report and recommendation to the Government of Canada on a preferred approach for the long-term management of used fuel.

Reports of these initiatives can be viewed at **www.nwmo.ca/dialoguereports**. A detailed listing is contained in Appendix 11.

Chapter 4 / What People Told Us

During almost three years of dialogue with Aboriginal peoples, the public and specialists, the NWMO received very specific direction on both the way in which we should assess the management approach options, and the advantages and limitations of each as judged by interested Canadians. After reviewing each of the three options which formed the focus of the study, many suggested to us that an additional option should be considered, an option that would attempt to capitalize on the advantages of the other three. We heard that the way in which a management approach is implemented is as important to its acceptability as the technology used. We received very specific direction on the requirements of an appropriate implementation plan. Finally, we received comment on a preliminary description of the Adaptive Phased Management approach which is recommended in this report. This chapter closes with a brief discussion of how the NWMO has responded to the issues and concerns raised in the design of the approach which is recommended in this document.

4.1 / Dialogue 1 – Asking the Right Questions?

What is Important in a Management Approach?

We asked citizens to help us understand the values and objectives which any used nuclear fuel management approach for Canada should address. The following is a summary of what people told us. It is compiled from the consultants' reports of findings from dialogue activities, and submissions to our website.

Basic Points of Debate

Over the course of our dialogue with Canadians much common ground has emerged. This common ground reflects a set of values and objectives that we as citizens appear to share and which can form a basis on which to move forward on this issue. We also heard people actively debate some questions which, for them, are fundamental to the choice of a management approach for used nuclear fuel. Around these questions, the common ground is less apparent.

We report below on some fundamental questions on which we heard the views of Canadians diverge. For the most part, these questions are beyond the mandate of our study. However, the divergence of view on these questions infuses many of the comments we heard about the management approaches. The differences in perspective on these questions are important influencing factors, which the study must recognize, although it cannot directly address.

Some have suggested that this divergence is a result of the imperfect distribution of knowledge among those who have engaged in the study. If all had the same level of knowledge and understanding, the argument goes, the diversity of opinion would be much reduced. They suggest that public education and communication will bring us together.

Others have suggested the source of divergence is more fundamental, and reflects real and substantial differences in perspective. Our efforts to both create a balanced portrayal of information and to broadly communicate this information to the interested public, leads us to believe that the divergence in perspective on these issues, specifically the future of nuclear energy in Canada, is substantial and warrants further exploration in a separate public policy forum.

Should the nuclear generation of electricity be continued?

From the inception of our study, a number of people told us that the assessment of management approaches needs to be undertaken in the context of a broader public policy debate about energy. Nuclear energy as a way of generating power, some argue, needs to be fully assessed in comparison with other ways of generating power. Others go further in arguing that discussions about the long-term management of nuclear fuel waste cannot be reasonably separated from discussion about the rest of the nuclear fuel cycle, including the mining of uranium ore.

Many of those who advocate for such a broad framing of the issue suspect that nuclear energy generation would be abandoned if the costs and benefits of the full life cycle were examined. For these people, until such an assessment is made, concern about the appropriateness of nuclear energy will continue to be a stumbling block to the discussion of waste management approaches.

Not all Canadians we spoke with shared this view. Many took an opposite view, and suggested that an assessment of energy generating methods would show nuclear energy to be a responsible choice, a form of energy that improves the quality of life of people around the world today and will continue to do so in the future. These Canadians did not see the nuclear energy question as an issue that must be addressed before waste management approaches are considered.

Finally, some suggested that since waste exists, it must be dealt with, irrespective of the future of nuclear power in Canada. For these people, the question of whether nuclear generation should continue is irrelevant to our study.

Do we have sufficient knowledge to proceed with decision-making?

All those with whom we spoke agree that Canada, and other countries, have assembled a large body of knowledge to help inform decision-making on the long-term management of used nuclear fuel. This is particularly the case when we compare the body of knowledge on this issue with the amount of knowledge that supports many other kinds of social decisions that we make with relative ease. We have a large group of scientific and technical specialists in Canada, many of whom are internationally renowned, to help us make wise decisions on this issue. Our knowledge is substantial. On this we have heard broad agreement.

Where we have heard active debate is on the question of whether this large body of knowledge is sufficient to proceed with decision-making now, particularly whether it is sufficient to make a decision on an 'ultimate solution' which will have implications for many generations to come. It is the time dimension of this issue, the fact that the used nuclear fuel must be effectively contained and isolated from people and the environment for a very long period of time, which gives rise to an important question. Given the long period of the hazard, and the fact that we have much knowledge although some uncertainties remain, what does a cautious approach dictate? And, what does responsible action require?

It is important to note that those who are most closely involved in the design of the management options and who have been at the forefront of scientific and technical exploration and testing, are confident in both the safety of the various technical methods for managing the fuel, assuming they are operated as designed, and our capacity to proceed with whichever Canadians may judge to be appropriate.

For which vision of the future should we be planning?

It is apparent that some have a more optimistic perspective on what the future holds than do others. This is evident in how Canadians have viewed the appropriateness of each of the approaches. If you feel that social structures may collapse in the future, you are more likely to consider a management approach that does not rely on social institutions to contain and isolate the material than on approaches that require institutional oversight. Similarly, if you believe that science will discover new and better management approaches in the future, then you are less likely to want to seal used nuclear fuel away and make it inaccessible. It is apparent from our conversations with Canadians that there is no one single view of the future that we all share, and feel should be the focus of planning.

The Common Ground: An Assessment Framework

With the release of our first discussion document, we concluded that we had identified the range of questions (see the "10 Questions" outlined in Figure 4-1) which should be asked and answered in the study.

With the release of our second discussion document, we largely heard that, using the 10 questions as a foundation, we had identified the range of values and objectives that should be considered in assessing options and identifying a preferred approach.

In general, dialogue participants from across the country expressed comfort with the breadth and depth of the values, ethical principles and objectives which make up the Assessment Framework and which should drive the assessment of the options. Participants found that the framework is balanced, and did a good job of reflecting what Canadians view as the important considerations for selecting a long-term approach for the management of used fuel.

Many participants told us they were pleased to see that the societal values and ethical considerations were being applied alongside the more conventional technical and financial considerations. For many this was viewed as a positive step forward, and begins to address one of the key findings of the Seaborn Panel's report that the long-term management solution must not only be technically feasible but also socially acceptable. There also appeared to be widespread recognition among participants that finding a long-term solution for the management of used fuel is both controversial and difficult. As a public policy issue this is a complex and multi-dimensional challenge and the development of an Assessment Framework that incorporates all considerations will provide a foundation for a more complete and more objective assessment of options. Several participants noted that the inclusion of societal values and ethical considerations was a significant improvement over other past efforts to manage used nuclear fuel.

While there is much common ground on what is important for a management approach in terms of values, ethical principles and objectives, it is apparent from our dialogues with Canadians that we don't all agree what fulfillment of that value, principle or objective would look like. This forms part of the social dilemma to be addressed in the selection of a management approach, and is outlined in more detail in the commentary that follows. This commentary is designed to briefly highlight what participants in dialogues said about each of the elements of the framework.

Citizen values which should inform the selection of a preferred approach:

Safety from harm

An overarching requirement. First and foremost, human health and the environment must be as safe as possible from harm, now and for the future.

Safety from harm was identified by participants as being the most important value. Regardless of which management approach is selected, people told us that the approach must, to the greatest extent possible, ensure that no harm is done. People had various definitions for safety, but most expressed very clearly and strongly that safety for all people (public and workers), and for our environment is critical. They said safety must be assured for both today and the future.

As will become evident in the discussion of the perceived advantages and limitations of the management approaches, there were different interpretations of how to best achieve safety. Some participants felt that the used fuel should remain at the reactor sites, where it is above ground and easily accessible. In this way, society would be constantly reminded of the used fuel, and monitoring and safeguards would be easily maintained, thus ensuring a high level of safety to people and the environment. At the other end of the spectrum, some participants felt that because of uncertainty regarding the stability of future society and the potential lack of commitment of future societies to properly manage the used fuel, the best way to ensure safety would be to place the used fuel in a repository below ground and to seal it for all time.

Responsibility

We need to live up to our responsibilities to ourselves and to future generations, and deal with the problems we create.

People told us that responsibility is an important value to guide the selection of a management approach. There appeared to be a consensus that we have an obligation to take action now to properly care for and manage the used fuel. However, there was no agreement as to what type of action Canada needs to take.

For many, taking responsibility means ensuring that we fully understand the nature of the waste management challenge, assess a full range of options, ensure that the necessary studies, procedures and protocols are in place, confirm that the current interim storage of wastes is safe and reliable, and ensure that the funds are in place to accommodate any future action for the long-term management of the used fuel. This does not include taking responsibility for a final decision now, but suggests leaving it to future generations to determine. For these people, our responsibility is to ensure that the conditions are in place to accommodate any future decision without placing future generations at risk from a safety or a financial perspective.

Others felt very strongly that it is our generation's responsibility to make a final decision that will ensure the long-term management of used fuel. We have the knowledge and capacity now to take this action, and we should use it. This includes selecting a management approach that completely addresses the final management of used fuel, and doing this within a relatively short period of time. From this perspective, our responsibility is to ensure that we resolve this matter and not leave it as a burden for future generations.

Adaptability

We need to build in capacity to respond to new knowledge.

People told us that adaptability is very important. One of the significant themes that emerged is that people generally are optimistic that society will continue to learn and discover new ways to do things. Of particular importance is that the selected management approach anticipates and is able to accommodate the potential for new information and technological advancement. No management approach should preclude consideration of new information, and any strategy must allow for a change in approach if any new information means that the used fuel can be better managed.

Some participants suggested that technological advancement might mean that the used fuel can efficiently and effectively be re-used as a future energy source. In anticipation of this, the selected management approach must allow for the used fuel to be accessible and retrievable. Thus, we should not make a decision today that would preclude the possibility of applying new knowledge for managing this material. Several suggested that part of our responsibility is to investigate and research emerging technologies and to assess their potential for the future management of used fuel.

Stewardship

We have a duty to use all resources with care and to conserve, leaving a sound legacy for future generations.

Participants talked to us about the need to use our resources wisely to ensure that they will be available for possible future use. Some suggested that stewardship means that Canadians have a responsibility to manage used nuclear fuel in other countries that has been produced by Canadian nuclear technology. A minority went as far as to suggest that full stewardship would imply that Canada should provide support and assistance to less fortunate countries for the proper management of their used fuel. Others, including the majority of participants in Aboriginal dialogues, argued strongly that our responsibility extends only to the used nuclear fuel that we have created and used in Canada.

Accountability and Transparency

Governments are ultimately accountable for the public good concerning safety and security, but must involve citizens, experts and stakeholders in any decision-making. Honour and respect must be shown for all.

Participants consistently commented on the importance of being able to have confidence that those entrusted with the responsibility of protecting the public interest are doing a good job. Decisions must be made in the long-term public interest, and not for political expedience or short-term profit. These decisions must involve the public. To be accountable, any individual or organization must be seen to be focused on the public interest and open to scrutiny.

Consistently throughout the dialogue, concern was expressed by some participants about the track record of the nuclear industry and government in terms of accountability and transparency. Many examples were brought forward of incidents in which the industry and/or government have acted in what is perceived to be a self-interested and secretive manner. For these participants, this is a key area in which trust must be built before proceeding with any approach for the long term management of used nuclear fuel. The fact the Board of Directors of the NWMO is composed only of waste producers causes some to question the extent to which such an organization can be fully accountable to the public interest.

Knowledge

We need to continue to invest in informing citizens, and in increasing knowledge, to support decision-making now and in the future.

Participants suggested that knowledge is also of great importance. In order for Canada to make a wise decision on the future management of used fuel, Canadians need to be aware and informed. Some participants identified the need to build awareness and public understanding of the challenges associated with used nuclear fuel management. Others commented that with the many demands that face most Canadians, it would likely be very difficult if not impossible to raise awareness of and knowledge about this issue.

Overall, participants suggested that complete, objective and balanced information and research must be provided. The potential for new knowledge and learning, including from Aboriginal Traditional Knowledge, needs to be recognized and accommodated in our recommendation to government.

Inclusion

The best decisions reflect broad engagement and many perspectives; we all have a role to play.

Participants identified the active involvement by all interested parties in the development and selection of a management approach as a fundamental requirement. Many felt that the selection of a management approach for used fuel should not be made in isolation by experts and politicians. The development of the approach must allow for all Canadians to provide views and opinions.

Ethical principles which should inform the selection of a preferred approach:

Respect for Life

in all its forms, including minimization of harm to human beings and other sentient creatures; Respect for People and Cultures.

Participants in the dialogues were largely unanimous in identifying Respect for Life as the most significant ethical principle to guide decision-making. Many equated this principle with the Safety From Harm value. Both suggest that whatever action is taken to manage the used fuel, it must respect all forms of life.

From the perspective of many participants, demonstrating Respect for People and Cultures is intimately related to demonstrating a respect for life more generally.

Respect for Future Generations

of human beings, other species, and the biosphere as a whole.

No ethical principle generated more discussion among participants than that of Respect for Future Generations. Many suggested that we should not prejudge the needs and capabilities of the future. Rather than acting in a paternalistic way, we should leave the choice of what to do with the used fuel for them to determine. There was a strong sense among some of the participants that the used fuel may represent a potential resource for future generations, and the decisions and actions taken by this generation should not foreclose future opportunities. In this context, our generation would show respect for the future by ensuring that the used fuel is properly cared for but remains available for possible future use.

Others, although fewer, argued that the principle clearly means that this generation must take all the necessary action to not leave to future generations a burden or a problem that we created. In particular, because of uncertainty about the stability of future societies and uncertainty regarding their technological and financial capabilities, we need to make a final decision to ensure that the used fuel created by this generation is fully and properly managed.

Justice

across groups, regions and generations; Fairness – to everyone affected and particularly to minorities and marginalized groups.

Most participants linked the principles of Justice and Fairness together. Some suggested that fairness and justice are difficult to define in the context of this issue, and are subject to multiple interpretations. How is fairness to be determined? Who determines it? What is geographic fairness? Is it possible to be fair (equally fair) to everyone who may be affected by the decision? And, how do we make sure that those who are most vulnerable, that is minorities and marginalized groups, are not unfairly burdened by any decision made? In this context some participants suggested that regardless of the selected management approach there will be some who will benefit and some who will bear the costs.

Some participants suggested that, when all the values, principles and objectives are taken into consideration, some difficult trade-offs will have to be made. When making these trade-offs, many expect that fairness cannot be assured. In particular, they suggested that in order to ensure safety from harm, fairness might need to be compromised.

Sensitivity

to the differences in values and interpretation that different individuals and groups bring to the dialogue.

Many participants commented on the importance of a wide cross-section of Canadians being engaged in decision-making on this issue, and the importance of understanding and considering the views, opinions and concerns that all people have regarding the future management of Canada's used fuel.

Objectives which should inform the selection of a preferred approach:

Public Health and Safety

To ensure public health and safety.

Public health and safety was uniformly considered the most important of the objectives, and has been the focus of discussions throughout the study. For many participants, this is the key issue to be addressed and other values and objectives are only important to the extent that they contribute to ensuring the health and safety of individuals and the population. Some participants told us that public health and safety necessarily encompasses 'worker health and safety' and 'community well-being.' Others told us that 'security' and 'environmental integrity' are also an integral part of a broader notion of safety, a notion focused on keeping the used fuel contained, and ensuring people are not harmed. Participants in focus groups in particular identified this as the only "must have" element of a management approach.

Fairness

To ensure fairness (in substance and process) in the distribution of costs, benefits, risks and responsibilities, within this generation and across generations.

Consistent with discussion of the ethical principle of the same name, Fairness was viewed as an important objective against which any management approach should be measured. It was the subject of much discussion and difference of view, about how fairness should be judged.

Worker Health and Safety

To ensure worker health and safety.

Many dialogue participants commented on the importance of Worker Health and Safety, and the need to consider separately the health and safety of the public and the health and safety of workers. Generally, participants felt it is appropriate that the standard of judgment for these two be different since workers willingly and appropriately take on greater risk as a result of their occupation.

Community Well-Being

To ensure community well-being.

Many participants struggled with the question of what constitutes a "community." Participants suggested that it should not be defined as just the community that might host a management facility, but should include any community of interest or group of individuals that might be affected either directly or indirectly by the management approach. This would include communities along potential transportation routes, the current reactor site communities, and any community, organization or group (i.e., an environmental group) that may be affected from an ecological, economic and social perspective. Participants in the Aboriginal dialogues expressed particularly strong concern about the need to define "community" broadly. There was also much discussion, without resolution, concerning how we might balance the needs and demands of different "communities" when these demands inevitably conflict.

Security

To ensure security of facilities, materials and infrastructure.

Participants felt that security is an important objective. Many saw security as what is required to respond to the citizen value of Safety from Harm and also to the ethical principle of Respect for Life. As such, it is an important companion to safety.

Participants offered a range of opinions as to how security is best assured in discussion of the different management approaches.

Environmental Integrity

To ensure environmental integrity.

In talking about the objective of Environmental Integrity, many people told us they consider this a necessary component of ensuring public health and safety. For many, it is not conceivable that we would be able to achieve Public Health and Safety without Environmental Integrity.

Economic Viability

To design and implement a management approach that ensures economic viability of the waste management system while simultaneously contributing positively to the local economy.

Participants commented on the importance of ensuring that adequate funding be in place to implement the approach, regardless of the management approach selected. Many commented, however, that management costs should not drive the selection of an approach at the expense of the other objectives, particularly public health and safety and community well-being.

Adaptability

To ensure a capacity to adapt to changing knowledge and conditions over time.

As discussed in the context of the citizen value of Adaptability, there was much discussion of the need to treat adaptability as an objective for any management approach. It is viewed as being a fundamental requirement. Some participants expressed optimism that as a society we will continue to learn and develop new technology. As a result, the future may well hold the key to a better solution over the long term for the management of the used fuel. The approach that is selected must recognize and accommodate the potential for new knowledge to influence the final solution.

Some participants commented that adaptability is important in that it allows for contingencies within a management approach that can both anticipate and address changing conditions, the significance of which are unknown to us today. The potential for climate change and future societal breakdown were often cited as two examples of changing conditions that need to be considered in the assessment of management approaches.

Figure 4-1 **What is Important in a Management Approach: Inputs for the Assessment**

10 QUESTIONS

Institutions & Governance
Does the management approach have a foundation of rules, incentives, programs and capacities that ensure all operational consequences will be addressed for many years to come?

Engagement and Participation in Decision-making
Does the management approach provide for deliberate and full public engagement through different phases of the implementation?

Aboriginal Values
Have Aboriginal perspectives and insights informed the direction, and influenced the development of the management approach?

Ethical Considerations
Is the process for selecting, assessing and implementing the management approach one that is fair and equitable to our generation and future generations?

Synthesis and Continuous Learning
When considered together, do the different components of the assessment suggest that the management approach will contribute to an overall improvement in human and ecosystem well-being over the long term? Is there provision for continuous learning?

Human Health, Safety, and Well-being
Does the management approach ensure that people's health, safety and well-being are maintained (or improved) now and over the long term?

Security
Does this method of dealing with used nuclear fuel adequately contribute to human security? Will the management approach result in reduced access to nuclear materials by terrorists or other unauthorized agents?

Environmental Integrity
Does the management approach ensure the long-term integrity of the environment?

Economic Viability
Is the economic viability of the management approach assured and will the economy of the community (and future communities) be maintained or improved as a result?

Technical Adequacy
Is the technical adequacy of the management approach assured and are design, construction and implementation of the method(s) used in the management approach based on the best available technical and scientific insight? By method, we mean the technical method of storage or disposal of the used fuel.

ETHICAL AND SOCIAL FRAMEWORK

- Citizen and Aboriginal values and concerns
- Ethical principles
- Future scenarios
- Societal context

ANALYSIS

Key Objectives

Fairness
Public Health and Safety
Worker Health and Safety
Community Well-being
Security
Environmental Integrity
Economic Viability
Adaptability of the Approach

TECHNICAL INFORMATION

- Background papers
- Engineering designs and cost estimates

Early Insight from the Aboriginal Dialogues

Aboriginal peoples are an important community of interest for this study, as reflected in specific direction to the NWMO through the *Nuclear Fuel Waste Act* (*NFWA*) to seek the comment of Aboriginal peoples. Over the years, Aboriginal leaders have consistently asked to have the opportunity to study the question of management of nuclear waste and to be part of the related decision-making processes. They have pointed out the strongly held values of Aboriginal peoples regarding the environment. They have also expressed a concern that Aboriginal peoples may be unfairly called upon to shoulder a responsibility for an issue that was not of their making and for which they have received few past benefits. There has been a real fear that depressed Aboriginal communities would be specifically targeted and attempts made to offer short-term financial and employment benefits that in the long term would be replaced by environmental and social problems of a far greater magnitude.

We have heard from Aboriginal leaders that the best way of moving forward will be found when Aboriginal Traditional Knowledge and "western" scientific thinking are brought together into the deliberations as respected partners. We have been urged to take the long view and at a minimum to think of the impact of our actions seven generations hence.

The goal of our Aboriginal dialogue is to build the needed foundation for a long-term, positive relationship between the NWMO and the Aboriginal peoples of Canada. As such, the Aboriginal dialogues reflects the beginning of an ongoing process of engaging with Canada's Aboriginal community.

From inception, we followed a strategy of providing support to Aboriginal organizations to design and implement dialogue processes which in their view would work most effectively. Initially, we established agreements with national organizations as a means of achieving the broadest exposure possible. As the study progressed we established agreements with more and more regional and local organizations to strengthen direct contact at the local level. All of this stands as experience to draw upon in the years ahead.

Over the course of these meetings, some individuals and groups suggested that the pace of our study did not leave sufficient time to allow participants to digest the complexity of the issue. Some argued for a higher level of resources to enhance their capacity and to allow for more independent technical expertise to be at their disposal. Yet others voiced concern that we have not adequately drawn on, and provided information about, previous involvement by First Nations with the uranium and nuclear industry. The observations summarized below are drawn from the many reports that Aboriginal groups have filed with us. These reports are all available in their entirety on the NWMO website. (www.nwmo.ca/aboriginal dialogues)

Many of the observations and insights offered during the various elements of the Aboriginal dialogues are similar to those gathered during our broader public dialogue. In particular:

- The highest priority concern expressed is for safety and security for people and the environment.

- The issue of fairness in the distribution of costs, benefits, risks and responsibilities was often mentioned; the particular expression of this in the Aboriginal dialogues is described further below.

- Many Aboriginal participants spoke in favour of reducing the use of energy in general and nuclear energy in particular. They argued that the waste management issue cannot be fully resolved without a broad discussion of energy policy and the long-term role of nuclear energy. Further, they suggested there is a need to address the full cycle of nuclear materials from mining through long-term management of waste, including low and intermediate level radioactive wastes. An underlying issue here was a concern that resolution of the used-fuel management issue would open the door for expansion of nuclear energy.

- Significant concern was expressed about the risks associated with transportation.

- Many also voiced a discomfort with the make-up of the NWMO Board, arguing that its composition by appointees from the waste owners diminishes the credibility of the organization.

- Waste importation is not acceptable to most Aboriginal peoples and there is concern that this is not explicitly rejected in the *Nuclear Fuel Waste Act*. Some concern was expressed that the North American Free Trade Agreement might force Canada to import nuclear waste from the United States, and this could be extended to bring in waste from other countries. Some called for a specific law against implementation.

- Many were supportive of maintaining a capacity for retrievability in the hopes that ways of reducing the risk or further using the used fuel would be discovered in the future. They also confirmed the need to leave options open so future generations could re-visit today's decision and make decisions that were right for them.

- The need for education and more transfer of knowledge about the issue of long-term management of used nuclear fuel was a strong theme. Many called for a more effective balance of perspective from within and outside the nuclear industry than had been noted to date. The Elders' Forum called for creation of a scholarship to support long-term Aboriginal knowledge and skill enhancement on this issue. They also emphasized the need to focus learning and exchange activities at the grass roots level.

- There is a belief that more research is needed on such topics as the nature and extent of associated risks, the nature of potential costs and benefits (social, cultural, environmental, economic), methods for eliminating the hazardous nature of nuclear fuel waste, development of alternative energy sources, and improving and demonstrating the performance of storage containers. As well, there are calls for conducting research and monitoring of international research efforts concerning advanced technologies for the reprocessing, partitioning and transmutation of wastes as well as Traditional Knowledge and its application.

A number of contributions were also offered that reflect a special perspective that derives from the particular history, experience, and concerns of Canada's Aboriginal community.

The Issue of "Consultation"

This is a complex legal issue concerning how Aboriginal peoples see "consultation" under the Canadian Constitution. The Assembly of First Nations, the Métis National Council, Congress of Aboriginal Peoples, Ontario Aboriginal Métis Association, Union of New Brunswick Indians, the Federation of Saskatchewan Indian Nations, the East Coast First People's Alliance, the Western Indian Treaty Alliance, and the Atlantic Policy Conference of First Nation Chiefs all argue that our Aboriginal dialogues are not "consultation" as required by their interpretation of the law.

Fairness in the Distribution of Costs, Benefits, and Risks

The Aboriginal community is concerned that the costs, benefits and risks related to this issue be fairly distributed. Many suggested that urban dwellers will argue that a more northern and rural location, where most Aboriginal communities are found, would be a preferable site for waste management facilities because it would be considered "remote" from concentrations of population and therefore safer. However, in their view this kind of attitude unfairly characterizes the north as "empty" of people when in fact it is the home of Aboriginal peoples and other northerners.

Many Aboriginal peoples feel that few if any benefits realized by nuclear energy have accrued to them. In fact, some feel they have been negatively impacted by components of the nuclear fuel cycle, such as uranium mining. For them, the idea that traditional Aboriginal territory would be targeted for hosting a waste management facility is both unfair and unacceptable.

However, others see the potential for gain from a waste management facility in terms of long-term economic and social stability and have expressed an interest in perhaps further exploring the idea. But, they need to be assured the safety and security for people and the environment can be maintained; this is a non-negotiable requirement.

In addition to the above perspectives, concern was expressed that financial leverage may be used to persuade an economically depressed Aboriginal community to accept the used nuclear fuel. This would be unfair and inappropriate.

Trust and Integrity

Some expressed a deep suspicion towards government, the nuclear industry, the power utilities, the Nuclear Waste Management Organization, and this Dialogue. Many Aboriginal peoples commented on their experiences with various industries and government, saying they had lost trust in these institutions, and in some cases even feared harm would come to their communities and traditional territory from a nuclear waste management system.

However, others argued that it was now time to re-engage but on the right foot, to contribute to finding the needed strategy for managing used nuclear fuel over the long term, and working collaboratively based on mutual respect and integrity. As part of this concern, the need to include all components of the Aboriginal community was voiced.

Recognition of Aboriginal Rights, Treaties and Land Claims

Many participants in the Aboriginal dialogues expressed concern that the *NFWA* does not mention, and that we have not made explicit, reference to respecting Aboriginal rights, treaties and land claims. For these individuals, a first step in establishing the needed trust would be a formal commitment on the part of the NWMO to respect Aboriginal rights, treaties and land claims.

Aboriginal Traditional Knowledge

In September 2003, we convened a workshop to examine how Aboriginal Traditional Knowledge could be brought to bear on our task. In subsequent phases of the Aboriginal dialogues, the results of the workshop were extended as participants added insight.

We have learned that Aboriginal Traditional Knowledge includes both an understanding of nature and of human relationships. It sees humans as part of the environment and spirituality a component of all relationships.

It honours the wisdom of elders, whether they be from Aboriginal or non-Aboriginal communities. It looks to collective benefits for both the short and long term, and uses the concept of considering implications of today's actions for at least seven generations. Table 4-1 offers two perspectives on the nature and breadth of Aboriginal Traditional Knowledge that came to us through the Dialogues.

Table 4-1 Perspectives on the Nature & Breadth of Aboriginal Traditional Knowledge

The Centre for Indigenous Environmental Resources in Winnipeg identifies four aspects of Traditional Wisdom and Knowledge:

- **Process related insight.** This is about who talks, when to talk, how to talk, and the appropriate protocols for relationship building and decision-making;
- **Special knowledge related to the land.** This is site specific, and can be held by not only indigenous people but also by anyone who has long lived on the land;
- **Values.** These reflect the special importance of the environment, recognition that humans are part of that environment and a commitment to a holistic perspective that sees the encompassing system as much as the component parts; and
- **Spirituality.** This serves as a weave across everything, but there is no single expression.

In work commissioned by the Métis National Council, Métis Traditional Knowledge is described as "a complexity of inherent and intrinsic wisdom" held and expressed in four realms, or four "wisdoms" that include:

- **Wisdom of Life –** encapsulates the wisdom of Métis women, as nurturers of life;
- **Wisdom of Earth –** encapsulates the wisdom of Traditional Resource Users, offering the complementary wisdom to Western scientific knowledge; touching on the ecological, geological and biological sciences from a Métis, applied perspective;
- **Wisdom of Community –** Métis community collective wisdom, gathered through dialogue, social interaction, relationships among family and friends, relationships in business; and
- **Wisdom of the Spirit –** encapsulates the Traditions and Culture of the Métis Nation, including adornment (sash), music (fiddle), dance, visual and performing arts.

Participants in our Aboriginal Traditional Knowledge Workshop identified five values or principles associated with Traditional Management Practice:

Honour the wisdom that can be garnered from speaking to the elders in both the Aboriginal and non-Aboriginal community.

Respect the opinions and suggestions of all who take the time to provide insight into the process.

Conservation, particularly as it applies to consumption of electricity.

Transparency, particularly when NWMO (the producer of the problem) has to suggest the solution.

Accountability so those responsible (whether for the concept or delivery) are held to high account by the public for actions, given the nature of the problem.

These principles served as significant influence on development of the NWMO assessment framework, particularly the ethical principles.

Applying these principles (for example in any NWMO process) would involve the elders and wisest speaking first, praying for assistance to make good decisions, constantly growing and evolving with new insights, involving the whole community, and considering the consequences of decisions we make today on seven generations into the future. It would recognize that people are part of and guardians of the land, understand and apply the consequences of breaking traditional law, and ensure strong accountability is integrated into the management strategy. This would involve consideration of the biophysical, economic, social, cultural and spiritual aspects of the environment while maintaining an emphasis on interrelationships.

Traditional Knowledge provides rules for protecting the land while using it; clarifying and enhancing relationships amongst users; assisting in the development of technologies to meet the subsistence, health, trade and ritual needs of local people; and helping to create a world view that incorporates and makes sense of all of these in the context of a long-term, holistic perspective in decision-making.

Many Aboriginal peoples expressed a frustration that they did not see in the work of the NWMO, a concrete reflection of Aboriginal Traditional Knowledge. They pointed out that an intellectual understanding of another culture is not the same as respecting that other culture, accepting differences and applying the insights from it.

From another perspective, a number of Aboriginal peoples expressed that the treatment of Aboriginal Traditional Knowledge by the NWMO serves to create a sense of paternalism. From their point of view there seems to be a calculated overemphasis that masks any sense that Aboriginal peoples have insight and knowledge simply as people in their own right.

For the NWMO, with its roots in western culture, there is still much to learn about Aboriginal Traditional Knowledge and how it can be respectfully and effectively integrated into decision-making processes.

The Issue of Responsibility

There were two distinct aspects of "responsibility" expressed in the Aboriginal dialogues. First, there is an absolute consensus that Aboriginal peoples have a special relationship with the "land" and a strong commitment to honour and protect the environment is attached.

Quite distinct from that sense of responsibility is the attitude of Aboriginal peoples towards the issue of managing used nuclear fuel. On this topic, the Aboriginal community is split. On the one hand, some pointed out that Aboriginal peoples were not involved in the decision of whether or not to proceed with the creation of used nuclear fuel in the first place, and thus the responsibility for addressing the used fuel issue is not theirs.

However, others spoke of the responsibility of Aboriginal peoples and all Canadians to manage these wastes because of the overarching implications for people, regardless of origins, and the environment. They signalled a desire to play a part in designing the management strategy. Even though nuclear fuel waste was not created by Aboriginal peoples, they see the need for action sooner rather than later to address the issue.

Continuity of Engagement

Regardless of positions taken on the work of the NWMO, there was a consistent call for an ongoing effective engagement program to help design and implement the way forward. There was some call for creating an independent oversight capacity for Aboriginal peoples covering any plan that is put into effect. All emphasized the need for information that is culturally and linguistically appropriate to ensure effective engagement and a dominant theme was an emphasis on the need to engage directly with the local communities that might be affected by any management strategy.

Many said that there is a need to involve Elders because of their wisdom and experience, and young people since they will be the ones addressing this matter in the future. There was a call for "building bridges for young people to develop their views, to carry traditional ways in new and different ways."

A majority of the participating Aboriginal groups, either formally or informally, expressed concerns that representation of Aboriginal peoples within NWMO teams and as staff people is inadequate. They would like to see this addressed as we proceed to implementation.

4.2 / Dialogue 2 – Understanding the Choices

The Advantages and Limitations of the *Nuclear Fuel Waste Act* Options

We asked Canadians to help us understand the advantages and limitations of the three management approaches under study, as they saw them. The following is a summary of what people told us about the strengths and limitations of each of the management approaches identified in the *Nuclear Fuel Waste Act*. This summary is compiled from the individual reports from dialogue activities concerning our second discussion document, including: workshops; information and discussion sessions; Aboriginal dialogues; e-dialogues; public attitude research; and submissions to our website.

Option 1: Deep Geological Disposal in the Canadian Shield

The management approach is:

- Long-term management of used nuclear fuel through containment and isolation in a deep geological repository in the granitic rock of the Canadian Shield;
- Used nuclear fuel is transported from the nuclear reactor sites to a central location for long-term management;
- The deep geological repository is based on the concept described by Atomic Energy of Canada Limited in the Environmental Impact Statement on the Concept for Disposal of Canada's Nuclear Fuel Waste, and modified to take into account the views of the Environmental Assessment panel as reported in February 1998;
- Following an interim period of monitoring, the repository is closed, without the intent to retrieve the used fuel.

Strengths of the Approach

Several advantages were suggested concerning this management approach including: the opportunity to isolate the used fuel from people and the environment in a permanent or definitive way, and the opportunity to remove the burden of management from future generations.

Many participants identified the potential of this management approach to provide high levels of safety to both people and the environment. Those that held this view indicated that the placement of the used fuel bundles at depths of 500 to 1,000 metres, in a highly stable and consistent geological setting, has the potential to provide the greatest certainty that the used fuel will not cause harm over the long term. Except for the possible future development of cost-effective and proven technologies that would completely neutralize the used fuel, this management approach was suggested by many to be the best opportunity to isolate or remove the used fuel from human beings and the environment.

Many participants felt that through proper siting, site-specific studies, and appropriate engineering and construction, the used fuel could be placed and left for the long term without contaminating ground or surface water. Through the multiple barriers and passive containment associated with this approach many felt it would be safer than the storage options. Additionally, the fact that the used fuel would be sealed underground is seen to greatly minimize the potential for access by terrorists who wish to either sabotage the repository or use the used fuel for an undesirable purpose. Some also suggested the robustness of this approach against accidental human intrusion as an additional advantage.

For some participants, an advantage of this approach is that it allows for a permanent solution now as opposed to storage approaches which "defer a final solution to the future." Developing the repository, whether it is used immediately or at some time in the future, would be a proactive and responsible action taken by this generation to resolve the issue surrounding the management of the used fuel. In other words, some considered this approach fairer to future generations than the other two approaches. Some suggested the approach could be modified to allow for retrievability and additional monitoring. This, in order to allow future generations the option to retrieve the fuel for another purpose or to permanently seal the repository at an appropriate time.

Some participants suggested the deep geological disposal management approach is more cost-effective than the other two management approaches. While the preliminary cost estimates for all three methods are generally similar, over the long term deep geological disposal is more cost-effective since it avoids the ongoing maintenance, monitoring and administrative costs associated with the long-term storage options. For this method, costs are relatively well known and time limited. Funding of the approach would not require trust funds designed to be available for thousands of years, as would the storage approaches. Therefore, with this option financial surety is greater.

Many participants suggested that "proper siting" of a deep geological facility would involve locations away from large population centres. As with the centralized storage method, there is an opportunity to select a site that would maximize economic and human benefits, and involve impacted communities in site selection and facility design. Some participants, including some in the Aboriginal community, suggested that this option has the potential to bring long term, stable jobs and income to a community.

Limitations of the Approach

Overall, the limitations of this approach as seen by participants, focus on the need to transport waste potentially long distances and on the fact that because the method is designed to ensure the waste is sealed and isolated it is relatively more difficult to monitor and retrieve the waste.

For many participants, transportation of the used fuel, whether by road, rail or water, was viewed as a very significant limitation of this management approach. For some participants, transportation related risk was considered to be so significant that this alone should make deep geological disposal or centralized storage unacceptable. Participants expressed concern about the potential for radiation exposure and/or surface and groundwater contamination due to a transportation related accident or spill.

Many participants suggested that maintenance of road and rail facilities in rural and northern areas would be a concern. If roads were not well maintained, this could increase the potential for accidents. Concern was also expressed about whether or not there would be adequate emergency preparedness and response personnel and equipment to respond to any accident or spill in rural and northern areas.

Many participants also expressed concern that the transportation of used nuclear fuel would offer an easy target for terrorists who wanted to sabotage or attempt to acquire the used fuel for some undesirable purpose.

As part of the conversation on this issue, some participants in the dialogues raised an alternative perspective for considering the transportation issue that some other participants found helpful. The suggestion was that the risk of moving used fuel, and its potential to cause harm in the event of an accident or sabotage, needed to be placed into context. In particular, the risk associated with the transportation of used fuel should be compared to experience in the management of other dangerous goods that are transported daily across this country. Such a comparison, it was suggested, would demonstrate that transportation of this material, with appropriate equipment, procedures and emergency preparedness and response programs in place, offered minimal real risk and may well have less risk than the transport of other dangerous materials that occur on a regular basis.

Participants suggested that it might be difficult to win the support of surrounding communities for any site that is selected as well as communities along transportation routes. Some said there is a risk of widespread public protest and municipal opposition which may make it difficult to develop and implement either a deep geological disposal or centralized storage management approach.

Some participants expressed concern about the safety of the facility itself. As a first of a kind project, there is no definitive proof that the concept will perform as promised. These participants suggested there is no location at which this method has yet been implemented and demonstrated to work. For some participants, even the current deep geological initiatives in Sweden and Finland were not considered as sufficient proof of concept. They were concerned that if an accident or breach does occur, it would be difficult, perhaps impossible, to take the necessary action to contain radioactivity. Furthermore, monitoring of the performance of the method would be difficult and unreliable. It might not be possible to detect and correct any problems within the repository in time.

Some participants suggested that since one cannot guarantee long-term safety, committing to this management approach as the final fate for the used fuel would be an irresponsible action. Because long-term safety is unknown, future generations may be placed at risk and left a significant financial and management burden.

Some participants took issue with the deep geological disposal approach in that sealing away the used nuclear fuel would deprive future generations of the opportunity to use the remaining energy within the fuel bundles, and take advantage of new technologies to make the used fuel safe and secure. Retrieval from a deep geological disposal facility is expected to be costly and potentially risky from a health and safety perspective.

Some also felt that this method is irresponsible because it reflects an inappropriate "out of sight, out of mind" attitude. Storing the waste on the surface, on the other hand, symbolizes our explicit duty to take care of the waste we have created. Similarly, for some the lack of a requirement for institutional control is a disadvantage of this approach because attention to the facility may diminish over time and with this a decline in institutional vigilance.

Some participants said it is misleading to believe that the number of sites in which used nuclear fuel is stored will be reduced, at least in the short term. Since the used fuel will still need to be stored at the seven existing sites for a period of time before it can be moved, the development of a deep geological disposal or centralized storage facility will mean that Canada would have eight locations containing used fuel, one more than the seven required for the storage at reactor sites approach. This additional site, some argue, increases the potential risk.

Participants in locations removed from the reactor sites, particularly some of the participants attending discussion sessions in Northern Ontario, opposed the deep geological disposal management approach on the basis of fairness. These participants stated that the reactor communities, which have received the economic benefits of nuclear power generation, should now bear the responsibility for the care and management of the used fuel. To site a disposal facility in Northern Ontario, which some suspect would be the likely location for a deep geological disposal facility on the Canadian Shield, it is argued would be unfair because these communities have not received any direct benefits from nuclear power. For similar reasons residents of Arctic areas, particularly the Inuit, are opposed to storing or transporting nuclear waste in the Arctic. Many participants across Canada recognize the potential for economic, social and cultural unfairness should a northern community end up hosting a management facility. Many called for careful assessment of these implications and the collaborative development of a plan and an agreement to address them.

Many participants in the Aboriginal dialogues suggested that deep burial was repugnant to their sense of the earth which they consider sacred. However others struggled with this, recognizing that leaving it where it is would also pose risk to the environment. Yet others expressed the view that returning the waste to the earth is both safe and consistent with their values. Some participants simply expressed a concern that it would bring significant environmental degradation with little associated benefit. Concern about groundwater quality, rock integrity, and earthquakes was often cited. Finally, some participants opposed this option on the basis of their past experiences with buried chemical waste and/or mine sites that had been abandoned and contaminated the surrounding environment.

Option 2: Storage at Nuclear Reactor Sites

The management approach is:

- Long-term management of used nuclear fuel in storage facilities, at or just below surface, at each nuclear reactor site in Canada; and
- Storage facilities are maintained, rebuilt and operated in perpetuity at each reactor site.

Strengths of the Approach

Overall, the strength of this approach, as seen by participants, focuses on an understanding that this technology exists today, it involves minimal transportation, and it allows the used fuel to be easily accessed and monitored.

Most participants in our dialogues felt strongly that regardless of the management approach that is selected, it must allow the potential for future generations to have access to the used fuel. Some of these participants favoured easy accessibility so that future generations could use the used fuel as an energy source. Others expressed faith in technological advancement producing new technologies that will neutralize the used fuel and render it harmless. For those holding either view, storage at the reactor sites offered an advantage over the two other management approaches. Many suggested that since we don't know what solutions may be developed in the future, there is still much to learn regarding nuclear energy technology. Making a final decision should be deferred for a reasonable period of time. If the used fuel were to be used in the future for either purpose, then storage of some type would be preferred to final disposal.

Similarly, many commented on the "flexibility" of the option as an advantage. The approach is seen to be the most flexible of the three because the used nuclear fuel is easily accessible.

A significant advantage cited by most participants is that there is no need to transport the used fuel to another location. Many expressed concern about the risks of transporting used fuel. For them, the potential for exposure to radiation from a transportation accident is a significant limitation of the other two management approaches. The fact that this approach would require no off-site transport is therefore viewed as a major advantage.

Some argued that existing storage facilities at the reactor sites have been proven safe with little potential to cause harm to people or the environment. Further, the reactor site communities have considerable familiarity and experience with all aspects of the nuclear industry. As a result, the community will likely be less concerned or fearful of the long-term storage of this material and therefore may be more likely or willing to accept this management approach. Some participants in the Aboriginal dialogues argued that leaving used nuclear fuel at the reactor sites raises fewer environmental justice issues than the other approaches.

Some participants also considered long-term storage at reactor sites to be fair in that there is no need to determine a location for the management facility. Some commented that the reactor communities have benefited from the operation of the nuclear power plants through jobs and other economic and community benefits. It was suggested that it would only be right that those communities also take on the burden of caring for and managing the used fuel. Some also commented that these communities, because of the presence of nuclear power plants, possess knowledgeable and competent management, scientific and security expertise that will be available to provide the high levels of oversight necessary to ensure the safety of the used nuclear fuel.

Because storage is on the surface, many said it has the advantage of being easier to monitor. It provides more certainty in terms of knowledge because the technology is well understood. As well, the environmental characteristics of the existing sites are well known.

Some also suggested that since "it doesn't put all eggs in one basket" if there is an environmental problem it would be easier to fix the individual site affected. In this way it is seen to be a method with greater adaptability.

Some participants in the Aboriginal dialogues favoured long-term storage at reactor sites, provided that waste be stored near population centres rather than in a "remote" location in order to ensure continued attention.

Limitations of the Approach

Overall, the limitations of this approach, as seen by participants, focus on the active management role that future generations would be expected to perform, and uncertainty that these future generations would be willing or able to do so. Fairness is also a concern to the extent that existing host communities did not agree to long-term management when the facilities were sited.

Many participants expressed the view that long-term storage of used fuel at the reactor sites was impractical. While it was suggested that short-term storage for the next 50 to 100 years might be acceptable, committing to this management approach for a period of thousands of years did not make sense. For this management approach to succeed, one needs to assume that future generations would be willing to take on the responsibility for oversight, monitoring and maintenance. For many participants, this is a highly questionable assumption.

Some participants felt that the costs for this management approach are too open-ended and therefore potentially excessive. In the event that future technological solutions do not materialize, the ongoing costs to manage the used fuel may become too much for future society to bear. Pressure to reduce funding for the maintenance of this management approach or to redirect funding to other priorities was considered to be real possibilities, which in turn would undermine the long-term safety of the management approach.

Contrary to the optimistic views expressed by some participants that future societies will thrive and technology will offer potential for more acceptable used fuel management solutions, some participants offered a pessimistic view. In particular, participants cited potential political and social instability and change as significant limitations of this approach. It was suggested that history is full of examples of civilizations that have either disappeared or significantly changed over time. Our current form of government, economic and social institutions cannot be guaranteed to exist for several hundreds, let alone thousands, of years. Because of this uncertainty, many felt that it would be irresponsible to not determine a final solution for the management of the used fuel. Leaving used fuel in storage over the long-term could well place both people and the environment at risk.

Some participants felt that the selection of this approach would be an abdication of our responsibility to take the necessary action to properly manage the used fuel. In their view, selecting this approach would be "not making a decision" since the final decision would be deferred to the future.

Some suggested that because this management approach would mean that there would be multiple storage sites, the potential exists for uneven application of procedures and risk management measures across the sites. This might compromise safety. In effect, participants said that the more sites that require management, the greater the potential for error or breach. Due to the multiple sites, it may also be more difficult to assure security.

Some participants also noted that the reactor sites are all located on bodies of water that serve as sources of drinking water, recreation and economic opportunities. The development of long-term storage facilities in close proximity to these water bodies represents an additional potential risk to people and the environment. In the very long term, sites adjacent to tidal water may be vulnerable to glaciation or if sea level rise occurs.

Finally, some participants commented that the initial siting decision for nuclear power plants and the acceptance of those communities did not extend to these sites being used for long-term storage of used nuclear fuel. Some participants felt that these locations do not offer the appropriate conditions for long-term management of used fuel. Requiring these communities to continue storing the used fuel over the long term would be unfair.

Option 3: Centralized Storage

The management approach is:

- Long-term management of used nuclear fuel in a storage facility, above or below ground, at a central site in Canada;
- Used nuclear fuel is transported from the nuclear reactor sites to the central location for long-term management; and
- The storage facility is maintained, rebuilt and operated in perpetuity at this central site.

Strengths of the Approach

Overall, the strengths of this approach, as identified by participants, are similar in some respects to those raised concerning long-term storage at reactor sites, and deep geological disposal.

One of the significant advantages identified with this approach, similar to deep geological disposal, is that used nuclear fuel would be removed from the existing reactor sites and put in a single location, specifically selected and built for the purpose of long-term storage. A single location would be easier to monitor and, particularly if built below the surface, would be more secure than multiple sites. It would also be more cost efficient.

Many participants suggested that, similar to deep geological disposal, an advantage of this approach is the opportunity to remove the used nuclear fuel from population centres and to a more remote location.

As with the deep geological disposal approach, the development of a centralized storage facility offers the potential for jobs, investments, purchasing of goods and supplies, and other economic benefits to residents, businesses and municipal governments who might be involved in the new facility.

The siting of a centralized storage facility, many participants suggested, may be easier than the siting of a facility for deep geological disposal because this approach does not rely on the geological conditions of a site in order to contain and isolate the used nuclear fuel. When compared to deep geological disposal, which would require highly specific siting requirements, centralized storage could be established in many different settings.

Because of this potential siting flexibility, some participants felt that the chances of there being a willing host community for the centralized storage facility would be greater than for a deep geological facility. Some suggested that the facility might also be located in an area that had clearly enjoyed the benefits of nuclear power, which would make such a siting decision fairer.

As with storage at the reactor sites, centralized storage would meet the preference of many participants for a management approach that is flexible, and that can adapt to new knowledge and events. With this approach, there would be no final fate decision; the stored used fuel would be accessible and retrievable either to take advantage of new nuclear waste management technologies or for future use as an energy source.

The used nuclear fuel would also be easily monitored. From the perspective of some participants, an advantage of this approach is also that it keeps the used fuel visible. In addition to visibility, the requirement for on-going attention and care would therefore allow future generations to actively manage the material to ensure safety, and would ensure high standards of management and monitoring are maintained over time. It would also serve as an incentive to spur research into emerging technologies for the future management of the used fuel.

Limitations of the Approach

Overall, the limitations of this approach, as identified by participants, are similar in some respects to those raised concerning both long-term storage at reactor sites and deep geological disposal.

This approach, like reactor site storage, requires future generations to maintain the commitment to manage, and care for the used fuel. Some participants repeated their skepticism that future generations would continue to fund and manage the used fuel. They believe the ongoing commitment to the approach cannot be guaranteed over time. The stability of future society, government institutions, and societal values and priorities are highly questionable.

The continued and periodic repackaging required by this approach was suggested as presenting an increased health and safety risk to workers, and to the public at large should there be a lapse in diligence.

As an above ground facility, the approach is considered to be more vulnerable to security threats. It is also more vulnerable to the long-term implications of climate change, and glaciation.

For those participants who feel there is an urgent need to develop a final solution for the management of the used fuel, centralized storage possesses the same drawbacks as the reactor site storage approach. Considering the long time period over which the used fuel would remain a hazard to people and the environment, this management approach does not provide the final solution which some participants seek. Rather, it "defers to the future" final decisions about how the used fuel will be managed. Integral to this is the potential that the siting decision would need to be made twice, doubling any unfairness in the siting process. Lack of action on a final solution by our generation "would be irresponsible."

Many participants wondered whether a willing host community could be found for a centralized storage facility. Even if a community did express willingness to accept a facility, it was felt that surrounding areas and communities along transportation routes are likely to be less willing or even be opposed.

Many participants expressed concerns about the transportation of the used fuel to a centralized storage location. Many communities along a transportation route could be affected. Public anxiety over risks associated with transportation may make it difficult or impossible to implement the approach.

Finally, some participants felt that centralized storage might represent the greatest potential for risk to people and the environment of the three management approaches. By bringing all the used fuel to one central location, the potential impact from a catastrophic event (terrorism, sabotage or meteor strike) would be much greater than any comparable event at a facility managing less used fuel, or with deep geological disposal. In this regard, if centralized storage is selected, most participants favour shallow burial of the storage facility over surface storage.

Striking the Right Balance

As participants described advantages and limitations for each of the approaches under study, they also recognized that deciding among the approaches would be difficult. This is because no one of the approaches fully meets all the values and objectives that had been identified as important for a management approach for Canada. They identified which aspects of the decision required a difficult choice.

Balancing Security with Accessibility

Some participants argued for the importance of sealing used nuclear fuel underground, as the deep geological disposal approach would provide the best means of achieving safety and security. The used nuclear fuel would be more effectively isolated from people and the environment, and it would also be more secure from human intrusion. However, it makes retrieving and monitoring the waste difficult.

A number of participants argued for keeping the waste accessible, which is a feature of the storage approaches. Accessibility makes it easy to monitor the waste, and quickly take corrective action should a problem occur. It allows for implementation of new technologies or access if a new use for the waste is found. However, this accessibility would make keeping the waste secure more difficult.

Choosing among the methods, involves choosing between maximizing security or maximizing accessibility to the used nuclear fuel.

Balancing the Minimization of Transportation with the Removal of Used Fuel from Population Centres

Many participants expressed concern about the prospect of transporting used nuclear fuel. For many, an important limitation of the centralized storage approach and the deep disposal approach is the requirement that used nuclear fuel be transported, potentially for substantial distances, to the site. They expressed concern that an accident may result in the release of radioactive material, posing a risk to the health of people and the environment. Concern was also expressed that transport shipments may provide a target for terrorists. Concern about transportation was expressed in all dialogues and all parts of the country. It was also a particular concern raised by Aboriginal peoples.

Many of the same participants also expressed concern about storing used nuclear fuel over the long term near large population centres, as the reactor site storage approach would involve. For these participants, an important advantage of the centralized storage approach and the deep geological disposal approach is the opportunity to remove the waste from current reactor sites to a more remote location, away from population centres.

Some Canadians feel used nuclear fuel should be removed from population centres, while others would like to see handling and transportation of the waste be minimized to reduce possibility of accident. An additional challenge is to allow for the inevitable migration of population over the very long period of time involved.

Choosing among the methods involves choosing between minimizing the transport of used fuel and maximizing the remoteness of any waste management facility.

Balancing Timely Decision-Making with Future Flexibility

Most participants told us they feel strongly that the generation which enjoyed the benefits should implement a solution and not transfer this problem to future generations. Some of these participants argued that we have the knowledge and capacity today to put in place a definitive solution that would relieve the burden of managing this waste from future generations. It would be irresponsible not to take this definitive action now, they said.

Other participants argued that the action we take today should not preclude future generations making their own decisions. Although we have much knowledge today, continued research may surface new or better options in the future. It would be irresponsible to put in place a management approach today which precludes future generations from taking advantage of "inevitable" new learning in the future.

Choosing among the methods, involves choosing between implementing a definitive solution today or building in flexibility to allow future generations to influence the way in which the material is managed.

Balancing Fairness to Current Host Communities with Fairness to Future Host Communities

Over the course of the dialogues participants wrestled with the issue of fairness concerning the siting of any facility which may ultimately be required. Many expressed the perspective that it would be unfair to expect a community that had not received any benefit from nuclear energy to become the site of a long-term waste management facility. Many said that although current reactor site communities may have received the greatest benefit from nuclear energy, they should not be expected to host a long-term management facility because it goes beyond the terms of their original agreement to host the existing interim management facility.

Participants in the Aboriginal dialogues, as well as other participants living in northern areas, articulated similar concerns, saying that locating a facility in the "north" would be unfair given that few benefits have accrued to them.

Choosing among the methods, involves balancing consideration of the fairness to current host communities with consideration of the fairness to future host communities.

Expanding the Options

After looking at the strengths and weaknesses of each of the options individually, many participants suggested that an 'obvious' additional approach be considered, one that builds on the advantages of the various approaches. These participants variably referred to this hybrid approach as: centralized storage at a long-term geologically suitable location, fully retrievable deep geological disposal, convertible geological storage, underground centralized storage, and, centralized storage at a deep geological disposal site.

The hybrid approaches suggested tend to share the following characteristics:

- Extended storage of used fuel at the reactor sites, for a definite period of time. The used fuel is currently safely stored in these facilities, and would continue to be so for some time to come;
- Consolidating the used fuel at one central location, on the surface or in shallow underground storage as a preliminary step;
- A period of learning. Emerging technologies may offer potential to either neutralize the radionuclides in the used fuel or allow for the safe and cost-effective reuse of the waste. It would also allow us to learn from the experience of other countries that are in the process of implementing long-term used fuel management approaches. In addition, there may be greater certainty about the future of nuclear power in Canada;
- Development of a deep geological repository either to be used for deep underground centralized storage or as final disposal, if needed;
- A period of relatively easy access and retrievability; and

- Staged decision-making. After a definite period of time, decide whether to continue to store the used fuel at the surface or shallow underground, or whether and when to place it in a deep geological storage or disposal facility.

Hybrid approaches tended to be a focus of discussion among participants who see value in the management approach being both flexible and adaptable, and ultimately definitive.

Participants who see less value in adaptability were less likely to suggest such a hybrid approach. As discussed earlier, some participants expressed the view that prompt implementation of the deep geological disposal approach would best ensure the safe management of the used nuclear fuel, and additional research is unlikely to surface better management approaches or new uses for the fuel. Participants with this view were more likely to see a hybrid approach as potentially introducing unnecessary delays, uncertainty and costs in implementation.

A Matter of Implementation

Throughout the NWMO dialogues, participants talked to us about the type of implementation plan that should accompany any management approach selected. They recognized that the decision-making and implementation processes for Canada's used nuclear fuel will involve at least many decades. They said it will be important that a management approach be implemented in a way that continues to be responsive to the values and objectives of Canadians.

We heard from dialogue participants that any management approach for Canada should have the following characteristics:

- Begin the initial steps toward implementation now;
- Ensure that safety for people and the environment is the primary consideration, including security and safeguards performance;
- Ensure implementation in as fair a way as possible;
- Accommodate new learning;
- Provide for a staged approach that provides for ongoing reviews and adjustments to decisions;
- Provide opportunities for future generations to influence the implementation;
- Prepare future generations for their responsibilities;
- Monitor emerging research and technical developments in Canada and internationally, including opportunities to reduce the inherent hazard associated with used nuclear fuel;
- Communicate clearly the decision-making process and authorities;

- Ensure that the system of governance combined with the capacity to deliver is trustworthy, accountable and inclusive;
- Involve democratic and accountable institutions, accessible to citizens;
- Ensure that citizens are informed, and have a voice at each stage in the process;
- Engage and understand concerns of regions and communities that are affected directly and indirectly;
- Build a good understanding of potential risks and the means to manage them, including those related to transportation;
- Include a "community commitments" plan that would include monitoring, economic benefits and property value protection agreements for any host community. This should be established before beginning siting of any facility;
- Develop contingency plans including those for emergencies. In addition to ensuring that all communities have trained personnel, ensure equipment and financial resources to support all emergency response in the host community and along transportation routes;
- Provide surety that sufficient funds will be secured, protected and available to fund the long-term management approach selected by government;
- Ensure that the amount of money spent is commensurate with the risk this material poses vis-à-vis other problems our society needs to address;
- Develop a monitoring program, which encompasses quality control and quality assurance standards in collaboration with impacted communities; and
- Be sensitive to the broader and dynamic policy context.

4.3 / Dialogue 3 – Choosing a Way Forward

After listening to Canadians about the strengths and limitations of the three options, and hearing interest in the notion of a fourth option which combines the strengths of each of the three options, the NWMO developed the Adaptive Phased Management approach and launched a dialogue with Canadians about its appropriateness.

With the release of the *Draft Study Report*, the NWMO outlined its intention to recommend Adaptive Phased Management as the preferred approach to the Government of Canada. In the three months of dialogue which followed, and through a variety of dialogue initiatives, people told the NWMO that the Adaptive Phased Management approach is a reasonable and appropriate approach for Canada. However, there are two elements of the approach which were the most questioned: the provision for shallow centralized storage as an option on the path to a deep repository; and, the extended time period of implementation.

As identified at the beginning of this chapter, many participants continued to voice their strong belief that any recommendation about long-term management approaches must be developed in the context of a discussion of the future of nuclear energy. Similarly, we were urged to turn to history to draw lessons from Canada's experience in developing the full nuclear fuel cycle.

The discussion which follows draws from the summary of dialogue initiatives prepared by the independent consulting organizations which conducted them on behalf of the NWMO. The discussion also draws upon the large number of meetings and dialogue sessions designed and implemented by Aboriginal organizations as part of the study. These reports can be viewed in their entirety at **www.nwmo.ca/dialogue reports**.

Overall Appropriateness of Adaptive Phased Management Approach

Overall, the Canadians who engaged in our dialogues considered the Adaptive Phased Management approach to be appropriate and reasonable for Canada.

The approach contains a number of design elements that provide people with the comfort they need to accept Adaptive Phased Management as an appropriate approach. First, the approach represents action toward a solution. For most participants, it is not appropriate to continue to stockpile used fuel with no long-term solution and there is a widespread desire to see action now. Additional design elements which provide comfort include:

- The approach can take advantage of future scientific advancements (impacting the treatment of the waste and, to a lesser extent, its method of storage);
- The waste will be monitored;
- The waste will continue to be retrievable long into the future;
- The waste will be centrally located and isolated from contact with people and the environment; and
- The lack of certainty and "guaranteed" safety of many design elements are balanced by flexibility, interim decision making, and ongoing public involvement.

A minority of those who participated in dialogues, and many Aboriginal peoples, disagreed with the nature of the NWMO recommendation, arguing in support of continued surface storage at nuclear reactor sites or centralized storage, either above or below ground. For the most part these individuals prefer further interim measures pending a cessation of nuclear power or at least a debate on the future of nuclear energy. As well, a small number of participants noted that they did not see a material difference between the NWMO's draft recommendation of Adaptive Phased Management and the Deep Geological Disposal in the Canadian Shield option.

We were urged by some to portray the recommendation not as a solution, but rather as the best way to move ahead, given our current knowledge.

Appropriateness of Individual Elements of Adaptive Phased Management Approach

In order to understand the strengths and limitations of the Adaptive Phased Management approach, Canadians were asked to comment on individual elements of the approach. The discussion which follows summarizes what we heard about: the foundation principles on which the Adaptive Phased Management approach is built; the individual process elements associated with the approach; and, the technical elements fundamental to the approach.

Foundation Principles

The Canadians who engaged in our dialogue told us the foundation principles of the approach are appropriate. In these principles, the NWMO is seen to have reflected the common ground of Canadians. (See Table 4-2.)

As an illustration of the perceived appropriateness of the principles, in a nation-wide survey of 2600 Canadians an overwhelming majority agreed that the principles the NWMO has used as the basis from which to build the Adaptive Phased Management approach are appropriate. Nine in ten or more agreed:

- First and foremost the management approach should keep the waste safe and secure.
- The approach should be built on the best technical and scientific knowledge and expertise available in Canada and around the world.
- The approach should ensure that the companies who created the waste have set aside enough funds to pay the costs of managing the waste.
- The approach should be fair to future generations, as well as distribute costs, benefits and responsibilities fairly across communities and regions.

- The approach should be responsive to the values and objectives that are important to citizens.

Process Elements

The Adaptive Phased Management approach contains process elements fundamental to many dialogue participants' belief that the approach is appropriate and reasonable for Canada. While many suggested they lack the information and expertise to assess whether the technical elements are sufficient to provide long-term safe storage, they were reassured of the adequacy of the overall approach on the basis of several of its process elements. Continuous learning, flexibility, and the ability to monitor and retrieve the waste tend to be embraced as essential design elements in order that safety be protected.

Adaptive and/or Flexible

Almost universal among the participants in our 24 focus groups was their strong faith in future science to discover a better way to manage the used fuel than disposing of it underground. Many participants even suspected that the NWMO may never be required to implement Phase 3 of the Adaptive Phased Management approach. The fact that the approach allows for continuous learning, or keeping up to date with the latest technologies, and adaptation long into the future was a very strongly supported design element.

In the six dialogue workshops, each typically lasting one full day and an evening, most participants identified adaptability and/or flexibility as a strong process element. Many interpreted flexibility as a sign of prudence, caution and evidence that the NWMO was not putting all its eggs in one basket, but was prepared to continue to look for and integrate improvements while reacting to the unexpected. Flexibility is a feature that helps them have confidence in the approach. Many of the reports from dialogues among Aboriginal peoples also suggest that an approach which attempts to build in, at a fundamental level, flexibility and adaptability is more appropriate than an approach which does not.

However, there was also a significant number of participants in these dialogue workshops for whom "flexibility" was an indication of indeci-

Table 4-2 Agreement with Foundation Principles for the Management Approach

FOUNDATION PRINCIPLES	% who agree with the statement
Should be safe and secure to protect people and the environment	98
Must take advantage of the best technical and scientific knowledge and expertise available in Canada and around the world	97
Must be fair to future generations	97
Must be responsive to the values and objectives that are important to citizens	96
Must ensure that the companies who created the waste have set aside enough funds to pay the costs of managing the waste	96
Must be fair in how it distributes costs, benefits and responsibilities to different regions and communities	90

Question: The NWMO adopted several principles to guide the recommended option for the long term management of used nuclear fuel waste, please tell me whether you strongly agree, agree, disagree or strongly disagree with each of these principles. Table shows percent who 'strongly agree' or 'agree'. From a telephone survey of 2600 Canadians. (Veraxis July 2005) sion, the potential for delay and a license for future decision makers to allow for incomplete implementation. These individuals wanted to be assured that flexibility would be accompanied with clear timelines to see the project through. This was especially true for those cynical of government and institutions.

When asked, as part of our nation-wide survey, how important this element would be to any appropriate approach for Canada, nine in ten or more said it is important, and therefore appropriate:

- 92 percent said it is important that the approach be 'flexible enough to adapt to new learning, and new developments in science and technology', assigning a score of six to nine on a nine point scale of importance;

- 90 percent said it is important that the approach be 'flexible enough to respond to the needs and concerns of society as these may change over time', assigning a score of six to nine on a nine point scale of importance.

Phased Implementation

A large majority of participants in all the dialogues expressed general comfort with the fact that the proposed approach is to be implemented in a phased manner, citing the view that it is both pragmatic and appropriate to take decisions in a staged, adaptive manner. Some participants embraced the phased character as a sign of clear milestones and evidence that a deliberate schedule would be followed. Participants also identified that each phase ends with clear decision points, leaving future generations with appropriate choices of how and when to proceed. Participants suggested phased decision-making has the following positive attributes:

- Provides opportunities for continuous learning from the experiences of other countries, leading to adjustments in design details;

- Provides opportunities for future generations to be proactively engaged in the management of the used nuclear fuel;

- Allows for the emergence of new technologies and approaches that might make geological containment and isolation unnecessary;

- Provides time for development and implementation of appropriate regulatory regimes and governance structures;

- Allows for decisions to move as quickly or as slowly as necessary; and

- Provides time for capacity building and informed decision-making among youth, potential host communities, and involved others and avoids predetermined outcomes that might undermine community support.

Participants supporting this key aspect often attached a proviso that phased decision-making and adaptive management not lead to a protracted implementation process that risks not being completed. They suggested that delays in implementation could have serious negative consequences, including:

- Risk that project intent is lost or changed, or the project itself is shelved entirely at a future date;

- Risk that existing reactor sites become *de facto* permanent storage sites;

- Risk that the interim shallow underground storage facility at the central site becomes the *de facto* permanent storage facility, rather than the deep repository;

- Loss of existing technical expertise on used fuel management;

- Increased risk of cost overruns; and

- Increased risk of political or environmental crises.

In order to minimize the risk of these consequences, participants suggested the NWMO undertake to:

- Place greater focus and emphasis on identifying activities that will need to take place during the first decade of implementation, and begin implementation as soon as possible;

- Identify and outline the short-term, discrete decision points (e.g. what they are, what must be decided, when, by whom, with what implications)

- Design decision points to coincide with the electoral cycle;

- Recommend dates/upper time limits by which key milestones must be met; and

- Bring youth – the future generations – into the decision-making process.

A small minority of participants in these dialogues were opposed to a phased implementation approach, arguing that the deep repository technology is well in hand and preferring fixed milestones for implementation.

In our nation-wide survey, eight in ten or more suggested it is important for the approach to be implemented in a phased manner:

- 84 percent said it is important that the approach 'include phased decision-making', with a score of six to nine on a nine point scale of importance.

In short, although a phased approach is considered appropriate by most participants in our dialogue, it is apparent that people want reassurance that implementation of this type of process will not lead to disorganization, stalemate and an inability to carry through to completion. Transparency and accountability related to implementation, participants told us, are also areas for which reassurance and confidence need to be established.

An Extended Timeframe for Implementation

Most participants told us they consider the idea of an extended timeframe for implementation to be appropriate. However, there was much discussion in the dialogues about just how long this timeframe ought to be and how to ensure that momentum can be maintained through to full implementation.

An extended timeline for implementation is seen as a signal that a cautious and considered approach to the management of used nuclear fuel is being taken, with sufficient time for new learning and technologies. An extended timeline is "pragmatic" in that it recognizes the many issues that will need to be addressed, and the difficulty in pre-judging the time needed to achieve informed consent by a willing host community and/or Aboriginal peoples.

Reports from Aboriginal dialogues suggest that design features such as flexibility, continuous learning adaptability and implementation over an extended timeframe, as fundamental drivers of the waste management approach, are preferred over an approach which does not embrace these considerations as its platform for action.

The presentation of the Adaptive Phased Management approach in the *Draft Study Report* suggested that implementation may extend over a period of as much as 300 years. For most participants, however, a timeframe of 300 years is difficult to comprehend. In the same way that many had trouble imagining a problem that would last thousands of years, many had trouble imagining a solution that would take 300 years to implement. Few who participated in the dialogues picked up on the fact that the deep repository would be fully implemented by year 90, with the remaining years in the timeline filled by ongoing monitoring and accessibility. However, for some even 90 years was too long a period for implementation of the deep geological repository.

Many felt that a less protracted timeline should be possible. This included those who said that a site could be chosen and built more quickly, as well as those who recommended doing away with the optional step of centralized shallow storage. These individuals tended to be among those who are convinced of the safety and security of the deep geological repository and are ready to proceed with it. The desire of some for a condensed timeline also reflects a concern that a long timeline is a license for inaction (by government, the industry) and further delay (by interest groups and the industry) and risks abandonment of the project by a future society. Over the course of the dialogue participants suggested there are risks in not moving as quickly as possible, including:

- Technical knowledge and expertise necessary to implement the management approach might be lost;
- Financial risks will be greater as the long-term sustainability of existing nuclear utilities is uncertain;
- Political interest and will to act may be more difficult to incite and sustain over the longer term;
- Existing storage facilities may become full, leaving no place to store the used fuel, and were never designed to safely secure the used fuel over an extended period; and
- Institutional and social capacities could decline rather than expand over even the short to medium term, putting the safety and security of the public and the environment at risk.

Participants told the NWMO it will be important to put mechanisms in place to minimize and/or address these risks.

Technical Elements

Participants in the dialogues were asked to comment on the appropriateness of each of the technical elements of the Adaptive Phased Management approach.

The Ultimate Goal of a Deep Geological Repository

The vast majority of participants in the dialogues embraced the suggestion that used nuclear fuel should be dealt with in one single location. There were some who suggested that greater security would be achievable if the waste was stored in multiple locations, but these participants were a small minority.

The vast majority of participants in the dialogues felt that the deep geological repository was an appropriate end goal to work toward. Their belief that this is a reasonable end point was qualified by strong feeling that this solution is not ideal (as compared to a neutralization or recycling solution). It was also qualified by the need for an assurance that the deep repository would only be arrived at through the kind of process identified by the NWMO as part of the Adaptive Phased Management approach. Particularly important are assurances that the waste will be monitored and retrievable, and that continuous learning will be applied on an ongoing basis.

People who participated in the dialogue workshops suggested that a deep geological repository is appropriate as an end goal on the following basis:

- Is known to be technically sound, as concluded by AECL and the Seaborn Panel;
- Provides for institutional control through centralized storage;
- Allows for protection of human populations and the environment by providing storage at depth, multiple barriers, and chemical isolation;
- Is the most cost effective option;
- Provides the greatest levels of security in both the medium and very long time periods;

- Is technically practicable because Canada has large areas of suitable geological formations; and
- Best addresses the public's primary concerns related to safety and security of present and future generations.

Some participants who supported this aspect of the recommendation stressed their support was contingent on finding a technically appropriate site within a willing host community. Others said they supported the recommendation insofar as it addressed only the used nuclear fuel arising from existing Canadian nuclear reactors.

Support for this aspect of the recommendation was not universal. A minority of participants and many Aboriginal peoples suggested they do not accept deep geological storage, in part, because they object to the use of nuclear power. These individuals fear that any long-term storage solution will make it easier for proponents of nuclear power to justify an ongoing nuclear power generation program. However, not all opponents of nuclear power took this view. Many individuals who would like to see an end to nuclear power generation also found the Adaptive Phased Management approach to be reasonable and appropriate for the waste that currently exists.

Some also expressed concern that "out of sight" will mean "out of mind". These individuals tended to be the most optimistic that science will achieve a neutralization or recycling solution, but feared that the necessary effort to achieve that solution will not be made when a storage option exists. Some also expressed concern that "out of sight" could result in less rigorous application of safety and monitoring of the waste. Finally some participants, including many Aboriginal peoples, explained their opposition to this element of the approach as an objection to placing this very hazardous material in the ground, Mother Earth.

In short, for most participants a deep geological repository is an appropriate end state for the used nuclear fuel, with important provisos including implementation of many of the process elements discussed earlier.

Transportation to a Central Location

Transportation to the central location required by this approach is seen as the technical element which has the potential to affect the greatest number of people. Like all other elements of the recommended approach, participants sought assurances that public safety will be protected. Participants also suggested that transparency will be particularly important on this issue, as will assurances that the combination of technical and precautionary elements will provide the absolute highest achievable standard of safety.

A very small minority of participants expressed a very high level of concern about transportation of used nuclear fuel to the point of favouring surface storage at existing reactor sites as a means of avoiding or limiting the transportation of used nuclear fuel.

The Rationale for the Provision for Shallow Rock Cavern Storage

Of all the technical elements of the Adaptive Phased Management approach, the provision for centralized shallow rock cavern storage as an optional stepping stone on the path to implementation of a deep geological repository received the greatest questioning. Many questioned its purpose and necessity. Participants wondered whether this facility was necessary citing reasons of cost, the potential for time delay and the fear that this may become the (insufficient) final option in an effort to cut corners at a later stage. Among other comments expressed were a concern that the facility is not deep enough to be safe and secure, and a concern that the additional handling of the fuel which this step would involve would unduly increase risk of contamination and accident.

In the focus groups, those who questioned the value of provision for this facility tended to be the same participants who took issue with the inclusion of flexibility in implementation. They also tended to be the individuals who thought the siting process and initial licensing (for construction) could be accelerated and were more prepared to accept the deep geological disposal option (Option 1) as an appropriate management approach. Some others felt that the "go slow" approach which provision for this facility would allow was appropriate and added to their sense of comfort with the NWMO's proposed recommendation. These tended to be the individuals for whom the process elements of flexibility in the manner of implementation, continuous learning and adaptability were especially important. For them, the provision for the optional shallow storage facility provides additional evidence of careful decision making, monitoring of the waste and containment facilities and a prolonged period in which to seek better solutions.

Participants in the dialogue workshops also offered very mixed views about this aspect. Many called on the NWMO to clarify the rationale and justification for this provision. Others commented that the provision for the optional shallow underground storage was prudent since it would allow more time for citizens to understand the issues and develop confidence in the approach before proceeding, and more time to explore new waste management technologies and/or uses for the fuel. Participants who supported this aspect of the recommendation did so by noting:

- Early centralization will increase security over the used nuclear fuel;
- As an activity undertaken in parallel with the development of the deep geological repository, it will minimize the time required until all the material is located safely in the deep geological repository;
- It will allow for demonstration of the required technologies and raise public confidence;
- It will assist in site identification activities as fewer sites will have appropriate formations for both shallow storage as well as permanent, deep geological isolation;
- It will allow for more timely decommissioning and clean up should decisions be taken not to refurbish existing nuclear reactor faculties;
- It will provide citizens with a familiar and comfortable analogue to the current approach to the management of household wastes (i.e. collection, centralization, and final disposal); and
- It provides a relatively low-cost mechanism for building capacities and confidence and improving decision-making with respect to ultimate deep geological containment and isolation.

A minority of participants objected to the provision outright, arguing that centralized shallow storage was unnecessary and could work against the NWMO's long-term goals with respect to security and environmental integrity in managing the used nuclear fuel:

- Used nuclear fuel is currently being safely stored at existing reactor sites;
- The technological know-how already exists to ensure confidence in a deep geological repository approach, while a comparable body of knowledge on shallow storage would need to be developed at the expense of time and additional financial resources;
- This approach may maximize rather than minimize used fuel handling and related public and occupational exposures; and
- Concern that this could lead to the worst possible outcome – used nuclear fuel abandoned in unsuitable containers, in unsuitable formations, out of view, and forgotten about by future generations.

The Rationale for Alternate Geological Media

A large minority of participants in the dialogue workshops specifically questioned the NWMO's proposal that geological media other than the rock of the Canadian Shield, in particular forms of sedimentary rock, may be appropriate for the deep repository. A few raised questions and concerns with respect to the areas of Canada the NWMO has identified as geologically appropriate. Some participants said that

Ordovician sedimentary rock should not be considered because insufficient research has been conducted, particularly in comparison with research already completed on granite-type formations such as the Canadian Shield.

Retrievability of the Waste

Technical design features that allow the waste to be retrieved were important to almost all participants and a fundamental source of assurance that the waste would be appropriately handled through the Adaptive Phased Management approach. Most participants supported this aspect of the recommendation noting that:

- The used fuel must be accessible if monitoring indicates that problems exist;
- The used fuel is a potential energy resource for future generations; and
- Future technologies could emerge to better manage the used fuel.

A small minority of participants indicated they did not support the provision for retrievability, arguing that:

- A lasting solution would put the used fuel effectively out of reach for all time;
- Used fuel should not be retrieved for reuse. Retrieval for the purposes of reprocessing, partitioning and transmutation will increase rather than decrease the generation of hazardous radioactive materials and the risk to public and workers;
- This provision increases costs unnecessarily. It makes the deep geological repository more expensive and more technically difficult to construct and operate; and
- Controlling access to the repository would be more difficult and an ongoing concern.

Monitoring

Participants' support for continuous monitoring of the used fuel over extended periods of time was nearly universal. Given the importance participants placed on maintaining the ability to monitor the used fuel over time, several commented that the NWMO needs to elaborate on the nature and extent of monitoring which it envisions in the implementation of the Adaptive Phased Management approach. Participants said monitoring is an important aspect of the recommendation for the following reasons:

- Is essential to ensure the long-term protection of human and ecological health;
- Will provide the public with assurances that the facility continues to be safe;
- Will allow future generations to measure and assess their stewardship over the used nuclear fuel;
- Will allow for continuous learning and provide for well-informed decision-making; and
- Is a precondition to future retrieval of the material, regardless of the intended purpose.

A small minority of participants objected to long term monitoring, particularly if it were to be intrusive in nature. They argued that intrusive monitoring may detract from the integrity of the storage system and is, in fact, unnecessary given that breaches of containment are very unlikely.

Comment on Implementation Requirements of Adaptive Phased Management Approach

Participants in the dialogue generally identified five issues as important to appropriate implementation of Adaptive Phased Management or any management approach selected:

- Governance
- Citizen engagement
- Siting
- Research and intellectual capability
- Financing.

Many participants suggested there are interrelationships among issues of siting, governance and citizen engagement. They said that proper resolution of outstanding issues in these areas would be essential to building and maintaining trust and achieving successful outcomes as the process moves forward.

Governance

Many participants asked who would oversee implementation of the project and how Canadians would be assured that it was being done safely. In general, they expressed a desire to know how governance would be applied. There is concern about who has authority and who gets to make the decisions. They suggested these are critical questions which will need clear and compelling answers.

In this context, concern was expressed that the Government should not be left to manage the implementation. There were numerous suggestions that this work was too important to be subject to the risk that comes with changes in political leadership, or subject to the politics and fortunes of political parties. However, the same individuals often argued that ultimate accountability must lie with the government.

Similarly, it was clear that participants did not want implementation to be managed by the nuclear energy producers. There was concern that management by the producers would lead to a tendency to seek ways to cut costs to the detriment of safety. Some participants were also concerned that the nuclear energy producers could eventually be privatized, further weakening the extent to which implementation would be applied with the public's best interest in mind.

Governance of the NWMO and related decision-making processes were issues of major importance to many in the dialogue workshops. Participants suggested it is important to know what roles the following groups will play in decision making: citizens in potential host communities; local governments; Aboriginal peoples; cottage associations; business associations; communities on transportation routes; citizens of broader regional administrative bodies or districts; and citizens of the province under consideration. Many participants were critical of the current composition of the NWMO Board of Directors. Several noted that sound corporate governance principles include the need for independent directors.

Reports from Aboriginal dialogues include strong calls for Aboriginal participation in NWMO governance processes, as well as appropriate consultation as is due to them and outlined in the Constitution.

Several participants were concerned about decision-making processes at the federal and provincial levels following a government decision on an approach. They wanted reassurance action will in fact be taken.

Over the course of dialogue, participants identified a number of questions and considerations that they believe the NWMO will need to address in the future concerning governance and decision-making including:

- In practice, how will members of a potential host community express consent: through elected bodies or plebiscite?

- How can a community have a strong voice given the limited powers and jurisdiction of municipal governments as compared to the provincial and federal governments?

- What level of input, consent, or assurance should be given to adjacent communities and those along the transport route?

- How will conflicts between competing interests within and between communities be addressed?

- What type of community and intervener funding will be needed, including the hiring of independent experts?

- Will a contract or agreement be signed with the community or will special legislation be passed that would offer legal recourse to the host community and other affected communities?

In the electronic forum which was conducted following the release of the *Draft Study Report*, concern was also expressed about who would be responsible for impacts if there were transportation accidents or failure of containment at the central site.

Citizen Engagement

There was a widespread desire to maintain transparency and sustained citizen engagement and education throughout implementation in order to ensure proper accountability. These are considered crucial to build public confidence and support in implementing the NWMO recommendation, and to allow informed decision-making by communities. Citizen engagement is seen by many as a check and balance to ensure that the waste is not "out of mind" and that appropriate decisions are made throughout. It was felt that rigorous timelines and proper safety are more likely to be achieved when citizens remain engaged.

Many people encouraged the NWMO to, as much as possible, explicitly lay out how it intends to continue the process it has begun with its study through to the implementation of the management approach itself.

Siting

There was general agreement that a willing community should be sought to host the waste with the caveat that any willing host community must also be proven to be technically appropriate. There was a universal expectation that any region or community that accepts the waste will receive incentives in the form of jobs, and financial compensation, but that finding a willing host would be very challenging. There was some belief that an area could be found that is sufficiently remote to not be in anyone's community. Participants in Aboriginal dialogues suggested, with their traditional territories in mind, there is no such place.

Among key issues of concern to participants in the dialogue workshops in particular were how the boundaries of "willing host communities" will be defined, and how the "willingness" of the community would be measured. Participants widely called on the NWMO to provide sufficient time and resources to build the capacities of potential host communities to make informed decisions.

Participants stressed the importance of initiating siting related activities without delay, following government decision on an approach. One of the first tasks recommended for NWMO attention was the development of a clear, transparent, and agreed set of criteria for assessing the suitability of potential sites. Participants advised the NWMO to look carefully at lessons learned from past siting exercises involving hazardous waste and low-level nuclear waste.

Many participants expressed concern that the NWMO will be unable to identify a willing host community. A few suggested, in part for this reason, that the waste stay at the existing reactor sites and/or that the NWMO explore creating a new purpose-built (and therefore willing) community around a suitable geological location on Crown lands.

Reports from Aboriginal dialogues underline the high level of concern which many Aboriginal peoples have that their territory and traditional way of life will be impacted by any site that is selected, and that this impact will not be appropriately recognized, factored in to decision-making and addressed.

Research and Intellectual Capability

There was some feeling in the focus groups that it is not enough to be responsive to advances in technology, but that implementation should also include ongoing funding of advanced research to seek a recycling, reuse or neutralization solution that would make deep geological storage unnecessary. These people wanted assurance that, even though the Adaptive Phased Management approach represents responsible action today, a search for a better solution will continue to be a priority.

Participants at four of the six Dialogue workshops placed particular importance on issues related to research and intellectual capacity. They argued that implementation of the NWMO recommendation will require knowledge and expertise be available over a very extended period, and therefore a significant and ongoing investment in both the natural and social sciences. Participants also noted that the institutional memory and capacities of the nuclear workforce are eroding, many knowledgeable individuals have left the industry and/or are about to retire and there are few new entrants. They said it will be important for the NWMO to outline an appropriate research and intellectual capability development program to support the proposed recommendation.

Financing

Dialogue participants were concerned about whether sufficient funds can be set aside and/or preserved to fully fund implementation of the approach. They supported the NWMO's approach to making conservative cost estimates, so that availability of funds will not unduly influence future choices. And they acknowledged the financial surety provisions established through the *NFWA* but noted that much needs to be done for the public to have confidence that sufficient resources will be available for full implementation of the approach.

Participants were especially concerned about the availability of sufficient financing to allow for complete implementation should the nuclear utilities not be sustainable over the longer term, should a future government decide to use the monies in the trust funds for other purposes, or should the funds set aside not fully cover the implementation costs. A number of Aboriginal participants also suggested that there is inadequate proof of financal surety over the long term and expressed doubt in the comprehensiveness of the cost estimates. Participants also expressed concern that sufficient funds be set aside to include activities such as research and development, citizen dialogue and engagement, host community capacity building in support of informed consent, and mitigation for host communities.

Some participants were of the view that the Adaptive Phased Management approach and phased decision-making, accompanied with the need to build capacities for long-term monitoring and stewardship by a willing host community, make it particularly difficult to project future financing needs.

Additional Comment Concerning the Importation of Waste

Finally, throughout the dialogues participants regularly made the point that they did not want to see Canada become the 'dumping ground' for nuclear waste from other countries. They wanted some assurance that 'just because Canada develops a very good solution, it will not mean that our governments would be willing to provide a North American or global repository'.

Summary Findings from Nationwide Telephone Survey

In the nation-wide telephone survey of 2,600 Canadians conducted by the NWMO after the release of the *Draft Study Report*, we invited comment on the nature of the draft recommendation. Respondents were read a list of fourteen elements of the Adaptive Phased Management approach and asked how important they considered each to be. Responses, which are summarized in Table 4-3 below, indicate that each of the elements of the Adaptive Phased Management approach is considered important. The research indicates that elements which involve meeting scientific and technical criteria and taking advantage of technological innovation are considered of primary importance. For instance, 95% said that it is important that any location chosen for the centralized facility must meet scientific and technical criteria, and 93% said that it is important that the approach be able to adapt to new learnings in science and technology. Similarly, 94% said that it is important the approach include monitoring of the used fuel over an extended period of time.

Community input and meeting social requirements are also high priorities. Ninety-one percent of respondents said that it is important that the approach be implemented in collaboration with the community in which the used fuel management facility will be located. Ninety percent said it is important that the site selected meet social and ethical requirements. On-going public participation is key as 88% said that the process should seek to site the facility only in willing communities and 87% said that ongoing public involvement is important.

While still considered of high importance by a large majority of respondents, the elements that ranked comparatively lower than others are those that specify a long time frame for disposal and continued access for retrieval.

There are no significant differences between residents in communities currently storing used nuclear fuel and residents in the rest of Canada. Support for these management attributes is high across both populations for all measures.

The research indicates there are few differences among population sub-groups on the potential benefits of, or concerns about, the proposed approach and on the importance placed on the fourteen management approach elements.

In past public attitude research on the topic of the management of used nuclear fuel, differences have been noted in opinion between men and women, between Northern and Southern Ontario residents, and between supporters and opponents of nuclear energy. In this research, slight differences were also noted. Women tend to attribute significantly higher importance than men to the process of decision making and to the management approach responding to social, ethical and community concerns. For instance, women are significantly more likely than men to say the following are important elements:

- Phased decision making;
- Having a long time frame for implementation;
- Involving the public;
- Being flexible enough to respond to the needs and concerns of society as they may change over time;
- Providing future generations with choice in how the approach is implemented;
- Being willing to locate the facility in a willing community;
- Focusing the site selection process on the provinces that are directly involved with nuclear waste/power;
- Requiring the site to meet social and ethical criteria;
- Requiring the site to collaborate with the site community on major decisions;
- Ensuring the repository contributes in a positive way to the community in which it is located.

Table 4-3 **Summary Rating of the Importance of Elements of the Approach**

REACTION TO CHARACTERISTICS OR ATTRIBUTES OF THE APPROACH	% who consider the characteristic important
Requires the site to meet scientific and technical criteria	95
Includes monitoring of the used fuel over an extended period	94
Flexible enough to adapt to new learning, and new developments in science and technology	92
Requires decisions about the site to be made in collaboration with the community where the repository is sited	91
Requires the site to meet social and ethical requirements	90
Provides future generations with genuine choice in how the approach is implemented	90
Flexible enough to respond to the needs and concerns of society as these may change over time	90
Will seek to locate the facility in a community that is willing to accept it	88
Ensures the operation of the repository contributes in a positive way to the community in which it is located	87
Involves the public at each step	87
Focuses the site location process on the provinces that are directly involved with nuclear energy and nuclear fuel – Saskatchewan, Ontario, Québec and New Brunswick	85
Includes phased decision making	84
Includes opportunity to retrieve the used fuel over an extended period	74
Has a long time-frame for implementation	73

Question: Now I would like to learn your reaction to different characteristics or attributes of the approach. On a scale of one to nine where one means not at all important and nine means extremely important, how important is it to you that this approach...
Table shows percent who rate the characteristic 6, 7, 8, or 9 on a 9 point importance scale.
From a telephone survey of 2600 Canadians. (Veraxis July 2005)

However, it is not the case that women dismiss scientific and technical considerations at the expense of social ones. Women and men both tend to place high importance on the following elements:

- Being flexible enough to adapt to new learning, and new developments in science and technology;
- Including monitoring of the used fuel over an extended period of time;
- Including the opportunity to retrieve the used fuel over an extended period of time;
- Requiring the site to meet scientific and technical criteria.

Focusing on Ontario residents, the province in which most of the used nuclear fuel is created and currently stored, residents of Northern Ontario appear to be significantly less supportive of things nuclear than are residents of Southern Ontario. They are also more likely to believe, incorrectly, that the task of the NWMO is to situate the waste in Northern Ontario. Nonetheless they tend to place importance on similar elements of the Adaptive Phased Management approach as do Southern Ontario residents.

There are also small differences in perspective associated with attitudes to nuclear energy. Those who are more opposed to nuclear energy generation place a greater value on involving the public at each step, on requiring that the waste management process meets social and ethical criteria and on requiring decisions about where to locate the site be made in collaboration with the community where the repository is located.

Among the other question areas included in the survey, respondents were asked to react to a number of statements which have been made by participants in earlier NWMO dialogues. The research indicates:

- Eighty percent of Canadians agree that 'since our generation was the one which caused the nuclear waste, we should be the ones to decide on and implement an approach to manage it'.
- Believing that we should act now to decide on management strategies is not incompatible with the belief that 'since nuclear waste remains hazardous for a long time, we should let future generations decide how they wish to deal with it'. Fifty-seven percent of Canadians agree that we should let future generations decide.
- Half of those who believe we should begin implementation now also believe that future generations should have the chance to decide how they wish to deal with it. Roughly speaking, more than 40% of Canadians believe both views. Twenty-five percent think we should be the ones to decide on and implement an approach and not allow future generations a decision role.
- Canadians are relatively optimistic about the ability of science and technology into the future. Just over half of Canadians (55%) believe that 'scientific research will soon produce a technology that will render nuclear waste safe by eliminating its radioactivity and allowing it to become part of the natural environment again'. Forty percent disagree.
- Canadians feel relatively confident in the long-term ability of our society to manage nuclear waste. Just over one-third of Canadians (35%) believe 'that future societies will be less able to deal with this waste than we are today'. Conversely, a strong majority of Canadians (62%) have faith in the ability of future societies.

Perspectives from Aboriginal Peoples

Reaction voiced in the Aboriginal dialogues to the NWMO's Adaptive Phased Management approach varied from cautious support by some, hesitation to make comment by others, and opposition from yet others.

Cautious Support with Caveats

The Inuit Tapiriit Kanatami (ITK), Métis National Council (MNC), the Ontario Métis Aboriginal Association, La Ronge Community Workshop, Northern Saskatchewan, and the Western Indian Treaty Alliance all signalled qualified support for an Adaptive Phased Approach. For the ITK, the appeal of the approach comes from the long-term phasing, the time provided for further discussion while the waste is held at reactor site locations, and an overall focus that is away from Inuit lands. They are not committed to eventual deep isolation and containment. For the MNC, it "best reflects the Métis world view" and concern for human health, environmental security, security at the site, responsibility for the site, transportation, and cost efficiency of concept. However, they strongly emphasized that implementation should be results driven, not timeline driven. Through the OMAA dialogue and prior to knowledge of the proposed fourth option, a majority indicated support for continued reactor site storage followed by centralized storage with deep burial last. With review of Adaptive Phased Management, OMAA was supportive. They noted that it "allows for scientific progress, easy retrieval, and highlights environmental issues." Further, they found that it "seems to take the process along a path that Traditional Knowledge would approve." In the La Ronge Community Workshop which included Métis, First Nations, municipal, and mining company participants, general support was reported. The Western Indian Treaty Alliance argued strongly for a simple approach that would move to deep isolation and containment as soon as possible.

Within this envelope of cautious support, the majority argue for a limit to the production of nuclear waste and a shift to other forms of energy.

No Comment

A number of Aboriginal organizations did not feel they were in a position to make a proper evaluation of the recommended approach. These included the Assembly of First Nations, Atlantic Policy Conference of First Nation Chiefs, Union of New Brunswick Indians, and Federation of Saskatchewan Indian Nations. Some of these also argued that full "consultation" had not yet taken place and therefore they were unwilling to offer an assessment of Adaptive Phased Management.

Opposition

Two organizations voiced opposition to Adaptive Phased Management, the Native Women's Association of Canada (NWAC) and the Congress of Aboriginal Peoples (CAP). NWAC's opposition is based on 1) lack of awareness on behalf of Aboriginal peoples in the communities that may be directly impacted, 2) the risks outweigh benefits for a remote community, 3) transportation poses unknown risks, 4) incorporation of Traditional Knowledge is as yet unknown, 5) waste importation may occur, 6) there is no assurance that the amount of waste will ever be limited, 7) there is no discussion of pursuing alternative energy options, and NWMO is "suspect" because it is driven by the waste producers themselves. In the case of CAP, they see the recommendation as a simple reworking of the AECL deep disposal concept which they find not proven from a safety perspective and unacceptable.

Additional reaction precipitated by the NWMO's study was voiced in the Aboriginal dialogues in passage of a number of resolutions. The Inuit Tapiriit Kanatami passed a resolution, in June 2004, in opposition "to the storage/disposal and transport of nuclear fuel waste in areas adjacent to Inuit owned lands, on Inuit co-managed lands and land governed by Inuit Land Claim Agreements". The Nishnawbe Aski Nation, in July 2005, passed a resolution "that the Nishnawbe Aski Nation Chiefs in Assembly declare the lands and communities of the Nishnawbe Aski Nation a 'Nuclear Waste Free Zone' ".

A report summarizing the NWMO's Aboriginal dialogues is found on our website at www.nwmo.ca/aboriginaldialogues. The report reviews the overall goals and objectives, the evolving context and role of the Aboriginal community in this country, the 15 national and regional/local organizations that participated, the observations that they offered, and the lessons learned as input for continued dialogue in the future.

Perspectives from Communities Currently Storing Used Nuclear Fuel

The NWMO received several submissions on the *Draft Study Report* from organizations and elected representatives of communities where used nuclear fuel is currently stored including the Canadian Association of Nuclear Host Communities. Some of these submissions were supported by formal council resolutions. General agreement was expressed with the assessment undertaken by the NWMO that none of the three original management options identified in the *NFWA* completely achieves the objectives set out by the NWMO or as expressed by Canadians. General agreement was also expressed that Adaptive Phased Management, if implemented properly and in a timely manner, will provide a technically effective, flexible and balanced approach for the long-term management of Canada's used nuclear fuel. However, some concerns were expressed about the way in which the approach might be implemented.

These concerns focus on three areas: the extended length of time the used nuclear fuel will remain in these communities before being moved to a centralized facility; the need to clarify the role these communities will play in implementation decision-making; and, the manner in which potential impacts on these communities associated with the implementation of the approach will be addressed:

- There is a concern that based on the expected timetable for implementation of the Adaptive Phased Management approach, used nuclear fuel may be kept at these sites for as long as 90 years if a decision were made not to proceed with a centralized shallow storage facility before implementing the deep repository. This would have the used fuel remain at these sites for a much longer period than originally expected.

- There is a concern that these communities will not be appropriately recognized nor compensated for the extended storage of the used fuel in their community involved in the Adaptive Phased Management approach. Compensation is expected based on potential impacts and risks in implementing the recommended approach, including costs associated with emergency preparedness, security measures, municipal infrastructure (roads, water, sewer, etc.) and community impacts.

- There is a concern that adaptability and phased decision-making may lead to delay in removing the used fuel from the communities. There is a concern that difficulties in finding a willing host community in a timely manner, and/or opposition to transportation may derail implementation indefinitely. In the worst case, there is concern that delayed or deferred decision-making could result in storage at existing reactor sites as the default long-term management approach.

- There is a concern that existing reactor sites may not have the capacity to store current and future used nuclear fuel waste for the extended periods which may be involved with this approach.

Communities have, therefore, said it is important that:

- A detailed implementation schedule be developed with key milestones/decision points clearly identified, and the Government of Canada, the waste owners and the NWMO should formally commit to adhering to this schedule. This is suggested as a means to ensure that the used nuclear fuel does not remain at the existing reactor sites for an indefinite period of time or that on-site storage becomes the management approach by default. The NWMO should identify and assess the factors that may delay or defer key milestones and decision points, as well as appropriate contingency plans and mitigation measures.

- These communities be afforded full opportunity and necessary resources to participate in implementation, including discussions concerning mitigation measures, and/or mechanisms for addressing socio-economic effects in the implementation of the approach.

- The NWMO confirm and document that the existing reactor sites have adequate storage capacity for current and future used fuel inventories over the extended period of storage required by the approach. The NWMO needs to assess the impact of any delays on the capacity for used nuclear fuel storage at existing reactor sites.

- More stringent monitoring practices be implemented at the interim storage facilities during this extended storage, especially as these facilities age.

- Transportation issues be studied and addressed in greater detail as planning and implementation work continues.

- Monitoring of international developments continue that may permit improvements in Canada's plans for used fuel management.

- The NWMO study acknowledges that the siting process is linked to a broader discussion of the future of nuclear energy.

Formal Resolutions from Other Communities and Organizations

Within the period of the NWMO's study, a number of other communities adopted formal resolutions focused on opposition to the transportation of nuclear waste near or through their community. These communities are: the City of Temiskaming Shores; and, the City of North Bay. These communities are also on record supporting "the creation of an independent commission involving the public and all levels of government (municipal, provincial and federal) to re-examine our nation's radioactive waste management options and report to each level of government, including a body of the federal Parliament, on its findings".

Among other communities of interest, Nuclear Waste Watch – a coalition of more than 30 environmental organizations – has indicated that it does not support proceeding with the Adaptive Phased Management Approach. Key among its reasons is the assertion that no commitment should be made to a long-term management approach before a commitment is made to the early phase-out of nuclear power.

4.4 / The NWMO's Observations

The question of what constitutes 'responsible action' in the long-term management of used nuclear fuel has been central to the complex and, at some times, impassioned discussion we have had with Canadians. We have heard participants in our dialogues propose values and objectives to guide our decision-making and serve as a platform for moving forward. As a true product of collaborative development, these values and objectives reflect the common ground of individuals and groups with many diverse perspectives on this issue. They suggest the terms and conditions of a collective journey to implement a long-term management approach for Canada which acknowledges both the areas in which we all agree and are prepared to proceed quickly and the areas in which greater confidence needs to be gained before, or over the course of, proceeding.

We have heard that people wish to proceed. In fact, they expect to immediately begin the process of implementing a long-term management approach for Canada. While some are very comfortable to move quickly to implement a final or definitive solution, we have heard from others they are only prepared to proceed with caution. These people would like the opportunity to learn more, understand better, and build greater confidence in decisions before they are taken, particularly if these decisions are difficult to reverse.

We believe that the evidence of common ground that has emerged from the dialogues provides the foundation for the Adaptive Phased Management approach to be taken. This approach has a clear direction and end in mind, which has built in to it flexibility to further explore the areas where citizens wish to gain greater confidence. At each point in the process, the safety of people and the environment needs to be demonstrated, and contingency plans put in place. A clear and appropriate decision-making process guides the journey, and strong and independent oversight will help ensure that we continue to progress towards our goal. It was this understanding, and the detailed guidance from dialogue participants as highlighted in this chapter, which formed the foundation for our recommended approach.

In the dialogues following the release of our *Draft Study Report* most dialogue participants, with the exception of those who feel no long-term approach is appropriate without first phasing out nuclear power, told us that overall the Adaptive Phased Management Approach is a reasonable and appropriate approach for Canada. However, we also heard that more information needs to be provided about elements of the approach, some important questions need to be answered, and some concerns about the approach addressed. In this final report, we attempt to respond to many of these requests, questions and concerns. We also lay out a process through which remaining questions and concerns will be collectively explored and addressed through implementation. The discussion of the Adaptive Phased Management approach in this report also incorporates the numerous suggestions and guidance for implementation provided through the dialogue.

Part Four
The Assessment

4

Chapter 5 / Technical Methods Considered in Our Study

Section 12(2) of the *Nuclear Fuel Waste Act* (*NFWA*) specifies three technical methods to be the basis of approaches considered by the NWMO. The *NFWA* also allows us to consider other management approaches.

5.1 / Our Initial Screening of the Options

For about four decades, various countries have been investigating many possible methods to manage used nuclear fuel and other long-lived highly radioactive wastes over the long term.

In our first discussion document, *Asking the Right Questions?*, we reviewed 14 different options that have been considered internationally in recent years. We categorized them in three ways:

- Methods requiring review as specified by the *NFWA*;
- Methods receiving international attention; and
- Methods of limited interest.

These options were subject to review by our Assessment Team and by Canadians who offered views and perspectives through technical workshops, formal comments and discussion in public dialogues. In the sections below we highlight our general findings concerning these three categories of methods for managing used nuclear fuel.

Methods Requiring Review

The *NFWA* requires that we study, at a minimum, management approaches based on the following individual technical methods:

- Deep geological disposal in the Canadian Shield;
- Storage at nuclear reactor sites; and
- Centralized storage, either above or below ground.

While we do not intend to dismiss future options and possibilities, it is clear that the three long-term management methods specified in the *NFWA* are of immediate interest to Canada. These three methods are also being assessed in detail and, in some cases, being implemented in other national radioactive waste management programs around the world.

Methods Receiving International Attention

We looked at the following methods currently receiving international attention:

- Reprocessing, partitioning and transmutation;
- Placement in deep boreholes; and
- The international used nuclear fuel repository concept.

These options were screened out of our comparative assessment for reasons outlined below. Our Assessment Team noted, however, that Canada may wish to maintain some interest in each of these options by undertaking research and/or tracking related international developments.

Reprocessing, Partitioning and Transmutation

Reprocessing is the application of chemical and physical processes to used nuclear fuel for the purpose of recovery and recycling of fissionable isotopes. Partitioning involves a further series of physical and chemical processes to separate various isotopes from used nuclear fuel for further conditioning, treatment or long-term management. Transmutation involves the transformation of radioactive isotopes from used nuclear fuel into non-radioactive or stable isotopes by bombarding the target isotopes with neutrons or other particles.

Reprocessing used nuclear fuel and partitioning and transmutation technologies were considered in light of ongoing international work to understand their potential for managing used nuclear fuel over the long term. Our research into these areas was further motivated by the high level of interest registered by Canadians in knowing more about the possibility of "recycling" or "reusing" used fuel, practices that we have come to expect in many other areas of our life. Intrigued by international work on transmutation as a potential for reducing the long-term hazard of used nuclear fuel, Canadians expressed a desire for us to report back on our findings and determinations concerning these options.

It is unlikely that Canada would need to implement reprocessing in the near future. Canada is a leader in uranium mining and our uranium reserves are far from being depleted. The cost of reprocessing used nuclear fuel is high and is not about to be exceeded in the near future by the cost of mined natural uranium.

While some countries including the United Kingdom, France, Russia and Japan continue to reprocess used fuel, other countries such as the United States, Germany and Switzerland have issued a ban or moratorium on reprocessing.

For a number of reasons, reprocessing as a management approach for used nuclear fuel is considered to be highly unlikely as a viable scenario for Canada at this time.

The necessary facilities are expensive, and inevitably produce residual radioactive wastes that could be more difficult to manage than used nuclear fuel in its un-reprocessed form. Reprocessing also requires a commitment to a continuing nuclear fuel cycle, and it potentially separates out material that could be used in the production of nuclear weapons in the course of the process.

Reprocessing is usually carried out on a commercial scale. If in the future a decision is made to further process CANDU fuel for the purpose of reducing the volume of high-level radioactive waste and toxicity of the fuel, there would need to be significant advances in the area of partitioning and transmutation which is still in an early development stage.

Partitioning and transmutation introduces the requirement for reprocessing at the back-end of the nuclear fuel cycle. It also necessitates a commitment to the continued use of nuclear energy by current and future generations. While it might reduce the volume and the toxicity of the used nuclear fuel to be managed, it would not avoid the need for long-term management of the residual high-level radioactive wastes that would be produced.

Partitioning and transmutation continues to be the subject of international study, particularly in France, where substantial funds have been committed to examining its feasibility as a complementary option for managing used fuel in the future. Based on this research, the scientific and technical foundation is not yet sufficiently advanced for implementation and long-term management of the residual radioactive materials would still be required. In a recent report, the French *Office parlementaire d'évaluation des choix scientifiques et technologiques, Assemblée nationale* noted that, "transmutation at an industrial scale is not foreseeable at best before 2040."

The possibility of transmuting various radioactive isotopes has only been demonstrated in the laboratory. It is too soon to demonstrate that it would be commercially feasible with the volume of used nuclear fuel which exists in Canada.

The NWMO recommends keeping a "watching brief" on the findings concerning partitioning and transmutation.

Systematic monitoring of this technology and other areas of evolving scientific research will continue to be an important function of the NWMO, to stay abreast of current developments concerning the long-term management of used nuclear fuel.

For a fuller discussion on this topic, see Appendix 9, and NWMO background papers on reprocessing, partitioning and transmutation, available at www.nwmo.ca/partitioningandtransmutation and www.nwmo.ca/implicationsrpt.

Placement in Deep Boreholes

Deep borehole placement of radioactive waste has been examined in a number of countries, including Sweden, Finland and Russia. The concept would involve placing used fuel packages in very deep boreholes drilled from the surface to depths of several kilometres, with borehole diameters typically less than one metre. The packages would be stacked on top of one another in each borehole, separated by layers of sealing material such as bentonite or cement. Boreholes could be drilled in many types of rock.

Monitoring and retrieval of used fuel packages in deep boreholes would be very difficult. Furthermore, a number of significant technical questions remain regarding the mechanical integrity of the used fuel packages under high stress and temperature conditions both during and after placement, necessitating significant further research and development. Deep borehole placement is currently viewed as a possible method for the disposal of small quantities of radioactive waste but would be difficult to implement as a management option for large quantities of used nuclear fuel.

International Repository Concept

The NWMO looked at the concept of an international repository (or even a regional repository), both in the case where the repository would be located in another country and where Canada would be the host. The assessment of an international repository option would have to include all the attendant costs, benefits, and risks of the particular site and related infrastructure (including transportation) and this would be linked to all of the implicated societies and cultures. While the transboundary movement of used fuel would not be against any international treaty, in some cases it might violate the self-sufficiency principle which guides the radioactive waste management activities of most countries with substantial nuclear reactor programs (i.e., those who produce the used fuel will assume full responsibility for its long-term management). The international repository option might become more attractive for some countries over the next few years, but it is not a decision that would be made solely by Canada. It will be important for Canada to continue to monitor developments in this area of radioactive waste management.

Methods of Limited Interest

The NWMO found eight methods to be of limited interest (see Appendix 9). We screened these methods out as potential options based on the following criteria:

- Contravention of international treaties (e.g., the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter); and/or

- Insufficient proof-of-concept to undertake an adequate assessment at the conceptual design level.

Further rationale for screening out these methods is provided in Appendix 9.

Our judgement of these methods is consistent with assessments undertaken in other countries. We recognize, however, that Canada may wish to maintain interest in some of these methods by undertaking research and/or tracking related international developments.

The NWMO has received additional suggestions from Canadians on long-term management options for used nuclear fuel, but they too did not become a focus of our work due to insufficient proof of concept.

5.2 / Methods Considered in Our Study

From our initial review of 14 options, we narrowed the choices to four, which became the focus of our study.

As required by the NFWA, we studied individual approaches based on each of the three technical methods specified for study:

Option 1: Deep geological disposal in the Canadian Shield;

Option 2: Storage at nuclear reactor sites; and

Option 3: Centralized storage, either above or below ground.

In addition, we have studied a fourth option, Adaptive Phased Management, which in part involves many features of the three technical methods listed in the *NFWA*.

These four options are described in detail in the following chapter.

Findings of the comparative assessment of the four options are summarized in Chapter 8.

Chapter 6 / Technical Descriptions of Approaches

The *Nuclear Fuel Waste Act* (*NFWA*) required the NWMO to develop detailed technical descriptions for each management approach the organization studied.

6.1 / The Development of Technical Designs

The three methods outlined in the *NFWA* are well understood and are each considered from a technical perspective to be credible and viable. Used fuel storage technologies have been demonstrated for many years at reactor sites where used fuel is cooled and then safely managed in interim storage facilities. Deep geological disposal has been the subject of intensive study in Canada for many decades, and is in an advanced state of scientific and technical understanding internationally.

Deep Geological Repository

In 1978, the governments of Canada and Ontario established the Canadian Nuclear Fuel Waste Management Program to study and advance the technology for storage, transportation and permanent disposal of Canada's nuclear fuel waste. Since that time, the research and development program has been primarily directed at developing the technology for deep geological disposal in the crystalline rock of the Canadian Shield. Although crystalline rock was the primary focus of the disposal research and development program in Canada, the 1977 study by Kenneth Hare recognized, based on studies and experience in other countries, that there are other potentially suitable rock types, including sedimentary rock and salt.

Conceptual designs have also been developed for the transportation of used nuclear fuel. The status of these systems in Canada and abroad have been summarized in background papers available online at www.nwmo.ca/backgroundpapers.

Since 1978, Canada has invested more than $800 million in used fuel technology development. Ontario Power Generation Inc. (OPG), on behalf of the nuclear fuel waste owners, has been ensuring that Canada has the capability to implement a deep geological repository program, should the federal government choose this technology. OPG has been managing the technology development program since 1996, addressing the technical issues raised during the federal review of Atomic Energy of Canada Ltd.'s (AECL's) 1994 disposal concept. These issues were reported on by the Seaborn Panel in 1998 and were derived primarily from the findings of their Scientific Review Group (1995) and others during the federal review. Progress has been documented in a series of annual reports. Key technical and design changes to the Canadian concept include a more robust long-lived used fuel container capable of withstanding the effects of glaciation, and design improvements for monitoring and retrieval of used fuel in a deep geological repository. (See repository technology development reports at www.nwmo.ca/repositorytechnology).

In 2004, OPG's Deep Geologic Repository Technology Program had an annual budget of $7.6 million. The main objectives of the research and development program were to further develop safety assessment, geoscience and engineering methods, models and tools required to assess the feasibility and safety of the deep geological repository concept. OPG is maintaining the technical expertise to initiate a siting program, as required. Research and development is also being conducted by technical experts at AECL and Canadian universities, as well as by the consulting community in Canada and abroad. Typically, over 30 technical reports and publications are produced each year in research areas such as:

- Used fuel container development;
- Copper corrosion modelling and experimental studies in crystalline rock and in sedimentary rock;
- Sealing material properties and behaviour under repository conditions;
- Rock mass characterization and monitoring instruments and methods;
- Repository design development (e.g., in-floor, in-room, long-tunnel placement);

- Modeling climate change for evaluating deep geological repositories;
- Modeling regional groundwater flow and transport in Canadian Shield;
- Potential impacts from long-term climate change, glaciation modeling and permafrost studies;
- In-situ transport studies and geosphere model development;
- Used fuel dissolution studies and vault model development;
- Evolution of a deep geological repository in crystalline rock;
- Evolution of a deep geological repository in sedimentary rock;
- Postclosure safety assessment studies and safety model development; and
- Canadian contribution to international waste management studies and analyses.

These research and development activities are designed to improve understanding of the expected evolution of a deep geological repository over very long periods of time (around one million years) and to provide confidence in the safety case for placing used nuclear fuel in such a repository.

Formal co-operation and information sharing agreements are in place between OPG and radioactive waste management organizations in Sweden (SKB), Finland (Posiva) and Switzerland (Nagra). These countries are considering used fuel repository concepts and geomedia (i.e., crystalline rock and/or sedimentary rock formations) similar to the Canadian repository concept. Several of the programs are advanced with respect to repository design, siting and approvals. Finland and Sweden plan to have repositories in service by 2020. In the event that the Government of Canada selects an approach with a deep geological repository, these countries are about 15 to 20 years ahead of a Canadian facility. Our country can learn from the siting and repository development experiences elsewhere. Appendix 6 provides an overview of activities in other jurisdictions.

Representatives from Canada participate in the international radioactive waste management program of the OECD Nuclear Energy Agency. Members of this group include waste owners and national regulators from all the major nuclear energy countries. In December 2003, OPG signed a five-year agreement with SKB to participate in research and repository technology demonstration activities at the Äspö Hard Rock Laboratory (HRL) in Sweden. Canadian participation in international co-operation projects such as Äspö enhances the technology base in Canada and helps improve our understanding of key processes in a deep repository.

Storage Technology

Facilities for interim wet and dry storage of used fuel have been well researched, designed, constructed, licensed and operated both in Canada and internationally for many decades. All of the nuclear waste owners (OPG, Hydro-Québec, NB Power Nuclear and AECL), have designed, developed and implemented licensed interim storage technology at the reactor sites in Canada. For example, there are licensed dry storage facilities at the Pickering and Bruce Power nuclear generating stations, and a licence to construct a dry storage facility at Darlington was issued by the Canadian Nuclear Safety Commission on August 11, 2004. While these facilities have been designed for interim storage for approximately 50 years, conceptual designs for long-term storage have been developed and submitted to the NWMO. (See conceptual design reports at www.nwmo.ca/conceptualdesigns). The waste owners are also conducting studies into the integrity of used fuel bundles under storage conditions over hundreds of years.

Internationally, many decades of research into the science and engineering aspects of storage and repositories have advanced our understanding of these different technical methods for used fuel management. Today, storage and repositories both represent viable, safe options from a technical perspective for the management of used nuclear fuel.

6.2 / Engineering Concepts for the NWMO Study

The conceptual engineering designs adopted for study by the NWMO were commissioned by the Joint Waste Owners: Ontario Power Generation Inc., Hydro-Québec, NB Power Nuclear and Atomic Energy of Canada Limited.

Consulting firms were asked to develop preliminary conceptual engineering designs and cost estimates for the three technical methods identified in the *NFWA*, and also to develop associated used fuel transportation infrastructure and cost estimates for those designs. Three possible modes of travel were considered: (1) road; (2) rail, which requires road shipments from the rail/road transfer facility to the central facility; and (3) water, which requires road shipments from the water/road transfer facility to the central facility. The conceptual designs and cost estimates include the following work elements: siting, safety assessment, security, safeguards, system development, public affairs, facility design and construction, facility operation, environmental assessment and monitoring, decommissioning and closure. These conceptual designs were intended to be "typical" of these technical options, and were not intended to be fully developed project plans or recommendations. The conceptual engineering designs are available online at www.nwmo.ca/conceptualdesigns.

Cost summary reports are available at www.nwmo.ca/costsummaries.

The reference conceptual designs and cost estimates were based on a 2001 projected used fuel inventory which assumed that the Pickering, Bruce and Darlington reactors in Ontario would operate for an average lifetime of 40 years, the Point Lepreau reactor in New Brunswick would operate for 25 years, and the Gentilly reactor in Québec would operate for 30 years. Under this assumption, the current fleet of commercial nuclear reactors in Canada would produce a used fuel inventory of approximately 3.6 million bundles. If all existing nuclear reactors operate for an average lifetime of 40 years, the projected used fuel inventory would be 3.7 million bundles, which is less than a three percent difference from the reference used fuel inventory associated with the conceptual designs and cost estimates for the various management approaches. Sensitivity analyses of cost estimates have also been conducted for average reactor lifetimes of 30 years and 50 years.

The NWMO commissioned a third-party review of this body of work to examine the appropriateness of key engineering design assumptions and the cost estimation process. The review concluded that both the designs and the cost estimates have been prepared with an appropriate estimating methodology and they are suitable for the options review and directional decision-making requirements of the NWMO. (www.nwmo.ca/engineeringreview and www.nwmo.ca/costreview)

The NWMO also had the possibility of considering and presenting other approaches for the long-term management of Canada's used nuclear fuel.

Following significant analytical work and input from the public, we identified an additional option for study. We present Option 4: Adaptive Phased Management (our recommended approach) as an adaptive risk management approach that draws on many of the features of the other three options, and which we believe would ensure a high degree of safety and security for the long term, while providing the flexibility and adaptability that Canadians have said is essential.

The initial high-level description of Option 4 is based on the conceptual engineering designs for storage at nuclear reactor sites, centralized storage and a deep geological repository. Option 4 was submitted to engineering consulting firms to review the technical feasibility of the concept and to develop a preliminary cost estimate for the approach. Their reports are available at www.nwmo.ca/assessments.

Distinguishing features of each of the four methods studied are shown in the following tables.

References to implementation timelines in the sections below should be considered as possible timelines, assumed for conceptual design, cost estimating and concept analysis purposes only.

Option 1: Deep Geological Disposal in the Canadian Shield

Option 1: Deep Geological Disposal in the Canadian Shield

The management approach:

- Long-term management of used nuclear fuel through containment and isolation in a deep geological repository in the crystalline rock of the Canadian Shield;
- Used nuclear fuel is transported from the nuclear reactor sites to a central location for long-term management;
- The deep geological repository is based on the concept described by Atomic Energy of Canada Limited in the 1994 Environmental Impact Statement on the Concept for Disposal of Canada's Nuclear Fuel Waste, and modified to take into account the views of the environmental assessment panel as reported in February 1998; and
- Following an interim period of monitoring, the repository is closed, without the intent to retrieve the used fuel.

A deep geological repository relies on natural and engineered barriers to isolate the used fuel from the surface environment over its hazardous lifetime. Within the disposal concept, a repository is a facility deep underground where used fuel is placed for final containment and isolation. The concept is illustrated in Figure 6-1.

During the period 1978 to 1996, Atomic Energy of Canada Limited (AECL) researched the idea of a deep geological repository for used CANDU fuel, under the Canadian Nuclear Fuel Waste Management Program. Subsequently, the Seaborn Panel reviewed that concept under the *Federal Environmental Assessment and Review Process Guidelines Order* (1984). The Panel listened to a broad range of stakeholders, including members of the public. In its final 1998 report, the Panel recommended technical changes to the AECL concept to address their comments. Since then, the Joint Waste Owners have continued researching and advancing the original concept.

The approach described here is based on the AECL design and further developed taking into account recommendations of the Seaborn Panel, as well as further repository conceptual design experience in Canada and internationally. The main changes to the 1994 AECL conceptual design include:

- Selection of copper (instead of titanium) as the reference corrosion barrier for used fuel containers with a 100,000 year design life (consistent with the reference repository containers selected for the Finnish and Swedish radioactive waste management programs);
- Inclusion of an inner steel vessel to the copper used fuel container to provide the necessary structural support so that the container can withstand the effects of glaciation and other environmental effects;
- Selection of 100 percent bentonite (instead of 50 percent bentonite / 50 percent sand) as the reference buffer sealing material surrounding the container to address the issue of microorganisms in the repository and to remove the potential of microbiologically influenced corrosion of the copper container;
- Development and selection of a larger (324 bundle instead of 72 bundle) used fuel container to enable a more practical rate of placement of containers in a deep repository;

- Development of three conceptual designs for used fuel container placement in a deep repository: (1) in room, (2) in floor borehole and (3) horizontal tunnel, in order to enable flexibility of repository design to accommodate site-specific conditions;

- Inclusion of an underground characterization facility at the site of the deep repository to conduct site-specific research, development and technology demonstration prior to operation of the deep geological repository;

- Continued monitoring of used nuclear fuel for an extended period of time (up to 70 years) after placement of used fuel containers in the deep repository; and

- Development of an engineering design to retrieve used fuel from a deep repository of used fuel. Container retrieval technology is currently being demonstrated at the Äspö Hard Rock Laboratory in Sweden.

The illustrative timelines and activities associated with the concept are summarized in Table 6-1.

The detailed technical description of the conceptual designs used in the NWMO assessment is provided at: www.nwmo.ca/geologicaldisposal.

Figure 6-1 Deep Geological Disposal in the Canadian Shield

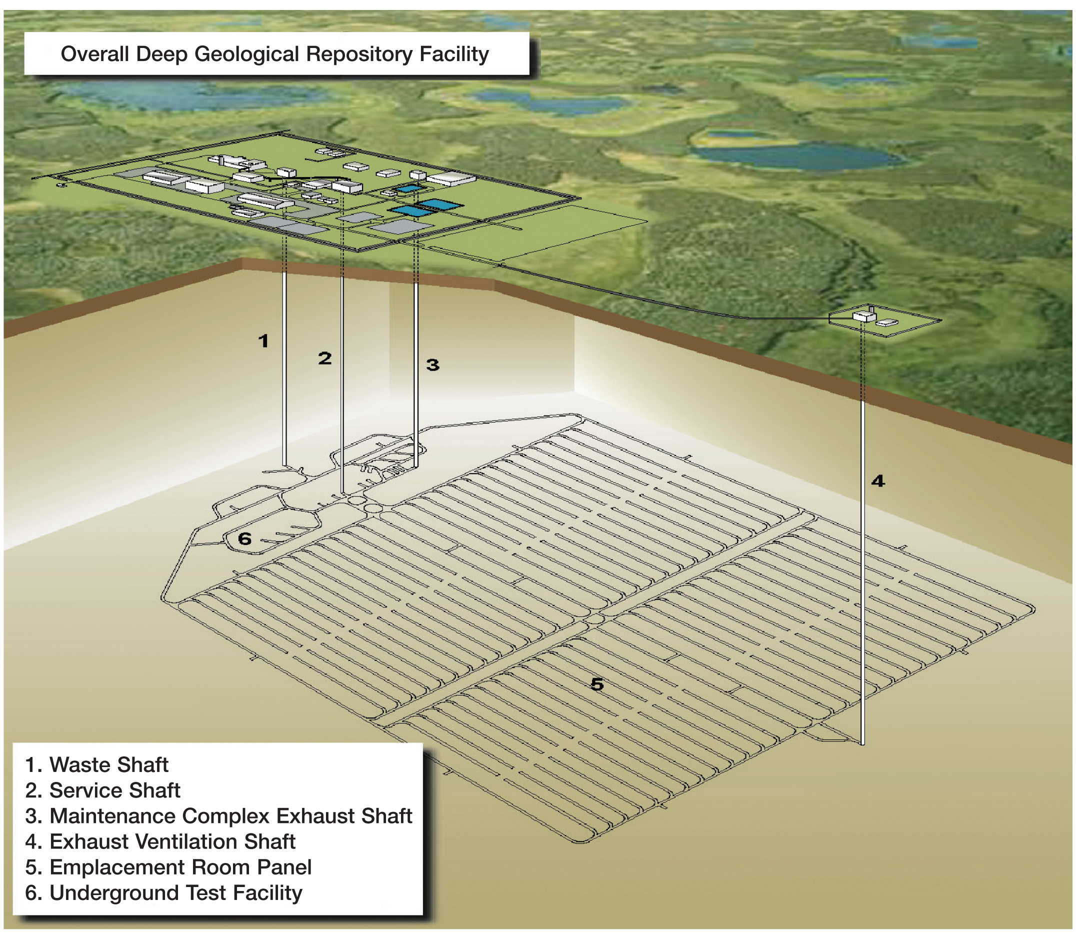


Table 6-1 **Option 1: Deep Geological Disposal in the Canadian Shield (modified AECL concept)**

Representative Conceptual Design Activities for Deep Geological Disposal in the Canadian Shield	
Concept	A long-term management approach based on a central deep geological repository located in the Canadian Shield at a nominal depth of 500 to 1,000 metres below surface. Used fuel would be transported from existing interim storage facilities at nuclear reactor sites, to a central location. At the central facility, the used fuel would be transferred into corrosion-resistant containers that would be placed in rooms excavated deep in the rock over a period of about 30 years. There would be a need for transportation containers and facilities to produce them; processing facilities to load the fuel into transportation containers; production facilities for deep repository containers; processing facilities to transfer the fuel from transportation to deep repository containers; and production facilities for sealing materials. Once all of the used fuel is transferred to the deep repository, it would be monitored over time prior to final backfilling, sealing and closure of the facility. Following closure of the deep repository, maintenance, inspection and security-related operations would be minimal. Such a facility would be designed to be passively safe over the long term and not rely on institutional controls to ensure safety. The current owners of used fuel would continue to be responsible for its interim management at the reactor sites. The NWMO would assume management responsibility of the used fuel when it is transported from the reactor sites to the central facility for long-term management.
Location	The facility would be located in the crystalline rock of the Canadian Shield, a vast rock formation stretching across parts of several provinces and territories. A specific location would need to be identified and licences would be required from the Canadian Nuclear Safety Commission for the construction and operation of the facility. This would also involve an environmental assessment.
Transportation Requirements	The operation of the centralized facility would involve moving the fuel from existing reactor site storage facilities in certified transport containers to the central site over a period of approximately 30 years. Transportation would require an emergency response plan and adherence to security provisions. The mode of transportation (road, rail or water) would depend upon the location of the central facility and other factors. Based on a projected used fuel inventory of 3.6 million fuel bundles, the number of transportation shipments of used fuel from the reactor sites to the central facility would be: • Road: about 53 road shipments/month for 30 years, or • Rail: about five rail shipments/month + about 36 road shipments/month for 30 years, or • Water: about two water shipments/month + about 36 road shipments/month for 30 years
Containers	At the central facility, used nuclear fuel would be placed in durable corrosion-resistant containers. This type of container can be designed to last a minimum of 100,000 years, and is capable of withstanding the hydraulic pressures of glaciations. Facilities would exist at the central site for repackaging the used fuel.
Storage Design Life	None. Concept does not include new storage facilities.

Table 6-1 (cont'd) Option 1: Deep Geological Disposal in the Canadian Shield (modified AECL concept)

Representative Conceptual Design Activities for Deep Geological Disposal in the Canadian Shield	
Land Requirement	The land requirement for the surface buildings and associated facilities would be about two kilometres x three kilometres, or about 600 hectares (1,480 acres). The surface building dimensions would likely be a small fraction of the total land area. The footprint for the deep geological repository would be about 1.35 kilometres x 1.36 kilometres, or about 183 hectares (452 acres). The actual size of the deep geological repository would depend on a number of factors such as number of fuel bundles and their heat output, depth of the repository and site-specific factors such as thermal conductivity of the rock mass.
Underground Facility	A network of horizontal tunnels and rooms would be excavated in stable rock about 500 to 1,000 metres below the surface. Used nuclear fuel would be packaged in durable containers and placed within the rooms or in boreholes drilled into the floor of the rooms. Used fuel containers are assumed to be placed in a deep repository over a 30-year operating period.
Repository Sealing System	Clay-based materials would be used to surround and protect the containers, to fill the void spaces in the repository, to limit the movement of groundwater and dissolved material, and to protect workers during container placement operations. These are referred to as sealing systems, and involve materials such as high-performance concrete and swelling bentonite clay.
Geosphere Barrier	The geosphere, or host rock, provides the principal barrier between the used fuel containers and the surface environment. The crystalline rock of the Canadian Shield is a naturally-occurring geological formation which has long-term stability, good rock strength, low groundwater flow, and is sufficiently below the surface and lacking in mineral resources that it is very unlikely to be disturbed by erosion or accidental drilling.
Monitoring	The facility would be monitored for an extended period of time to confirm the performance and safety of the system prior to final sealing, decommissioning and closure of the repository. Extended monitoring of the used fuel containers, sealing systems, rock around the repository, underground water flows and the natural environment would be conducted to confirm the long-term safety and performance of the system. In addition, some preventive maintenance might be required. For costing purposes it was assumed that extended monitoring at repository depth would occur over approximately 70 years, although it could be shorter or longer.
Retrieval	The technology to retrieve used fuel containers from a deep geological repository would need to be further developed and demonstrated at the site.

Table 6-1 (cont'd) Option 1: Deep Geological Disposal in the Canadian Shield (modified AECL concept)

Representative Conceptual Design Activities for Deep Geological Disposal in the Canadian Shield	
Illustrative Implementation Schedule	A government decision in 2006 to develop a deep geological repository would see the new facility ready in 2035, at the earliest. Following a decision by the government, the following activities with their illustrative timelines would be undertaken: • Siting (which would take about 15 years); • Design and construction (about 15 years); • Operation (about 30 years to place the fuel plus 70 years of additional monitoring); • Decommissioning (about 12 years); and • Closure (about 13 years). There would be a need to obtain a licence at each phase and demonstrate continuous compliance with the licence (under regulatory oversight).
Decommissioning	Once necessary approvals were obtained, decommissioning would commence and all underground access tunnels and shafts would be backfilled and sealed. Surface facilities would be decontaminated and dismantled. Closure activities include removal of monitoring instruments and returning the site to greenfield conditions.
Costs	The cost of a deep geological repository for used nuclear fuel is estimated to be $16.2 billion (2002 dollars), including interim used fuel storage and retrieval from reactor sites, and transportation costs to the central facility. These costs include the development and demonstration of the technology to retrieve used fuel from the repository, but not the costs of performing the retrieval operations. The present value cost based on current long-term economic factors is approximately $6.2 billion (2004 dollars). (www.nwmo.ca/disposalcosts)

Option 2: Storage at Nuclear Reactor Sites

Option 2: Storage at Nuclear Reactor Sites

The management approach:

- Long-term management of used nuclear fuel in storage facilities, at or just below surface, at each nuclear reactor site in Canada; and
- Storage facilities are maintained, rebuilt and operated in perpetuity at each reactor site.

Figure 6-2 Example of Used Fuel Storage in Bays at Reactor Site

Figure 6-3 & 6-4 Example of Used Fuel Storage in Dry Storage at Reactor Sites – Surface Storage Building and Dry Storage Containers

Initially, used fuel is removed from the reactor and placed in wet storage bays at the reactor site (see Figure 6-2). After a period of about seven to 10 years out-of-reactor, used fuel can be placed in dry storage at the reactor site, as illustrated in Figures 6-3 and 6-4. The long-term management approach builds on the current dry storage technology at the reactor sites.

The illustrative timelines and activities associated with the concept are summarized in Table 6-2.

The detailed technical descriptions, presented for the conceptual designs, are provided at: www.nwmo.ca/reactorstorage.

Table 6-2 **Option 2: Storage at Nuclear Reactor Sites**

Representative Conceptual Design Activities for Storage at Nuclear Reactor Sites	
Concept	Long-term storage at existing reactor sites would involve the expansion of existing dry storage facilities or the establishment of new, long-term dry storage facilities at each of the seven used fuel storage sites in Canada. In the latter case, used fuel would be transferred from the existing interim storage facilities to newly designed storage containers and storage buildings for long-term management. Storage would require an ongoing program of regular replacement and refurbishing activities, as facilities would be renewed indefinitely. Processing buildings would also be required to load the fuel and provide for its on-site transfer. The storage facilities would require ongoing maintenance, inspections and security systems. The current owners of used fuel would continue to be responsible for its interim management at the reactor sites. The NWMO would assume management responsibility of the used fuel when it is transferred to the long-term storage facilities at the reactor sites.
Location	Long-term storage would need to be established at the seven licensed Canadian reactor sites: • Whiteshell Laboratories, Manitoba • Bruce Nuclear Power Station, Ontario • Pickering Nuclear Power Station, Ontario • Darlington Nuclear Power Station, Ontario • Chalk River Laboratories, Ontario • Gentilly Nuclear Power Station, Québec • Point Lepreau Nuclear Power Station, New Brunswick This would involve identifying specific storage locations at each reactor site, and obtaining the necessary licences from the CNSC for the construction and operation of the facility, and potential environmental assessments.
Transportation Requirements	No off-site transportation of used fuel is required for extended storage at nuclear reactor sites. There are both surface and below-surface design options for reactor site storage, involving the use of casks, vaults and/or silos. The alternative conceptual designs considered reflect the different methods currently used for interim storage at each location in Canada.
Containers	There are both surface and below-surface design options for reactor site storage, involving the use of casks, vaults and/or silos. The alternative conceptual designs considered reflect the different methods currently used for interim storage at each location in Canada.
Storage Design Life	Eventually the storage containers and buildings would need to be replaced. This would involve construction of new storage buildings, transfer of the used fuel from the long-term storage containers to new packages, and transfer of the containers to the new building. The old buildings and waste storage containers would need to be refurbished or demolished. These activities would take approximately 30 years, and repackaging of the fuel storage system is assumed to be repeated every 100 years. Based on current design assumptions, complete refurbishment of all components of the storage facility would be required every 300 years. For design purposes, the assumed service lives for the various storage facility components are: • Casks 100 years • Fuel module 300 years • Fuel basket 300 years • Trench chamber 200 years • Storage building 100 years • Processing building 50 years It is recognized that new designs may make possible extended service lives of the facilities.

Table 6-2 (cont'd) Option 2: Storage at Nuclear Reactor Sites

Representative Conceptual Design Activities for Storage at Nuclear Reactor Sites	
Land Requirement	The land requirement for the surface storage buildings and associated facilities would vary for each reactor site depending upon the number of fuel bundles and the design of the storage facility. The maximum land requirement is expected to be less than about 200 metres x 200 metres, or about four hectares (10 acres).
Underground Facility	One of the possible reactor site concepts involves storage slightly below ground, in shallow trenches.
Repository Sealing System	None. There would not be a deep repository to be sealed.
Geosphere Barrier	Geosphere would not be used to provide a significant long-term isolation barrier.
Monitoring	Once all the used fuel from the reactor site was placed in the long-term storage facility, it would require ongoing monitoring to ensure that facility was being safely maintained, and to ensure preventive maintenance and repair is completed as required.
Retrieval	Storage would be designed to allow the safe retrieval of used fuel at any point during the life of the facility.
Illustrative Implementation Schedule	A government decision in 2006 to adopt storage at nuclear reactor sites, followed by immediate implementation would mean facilities at each site would be ready between 2016 and 2020. (The range reflects the different design options at the various reactor sites.) The long-term storage facilities would likely require complete refurbishment or replacement by the year 2300. While the design of a new long-term storage facility may vary at each reactor site, following a decision by the government, the following activities with their illustrative timelines would be undertaken: • Siting and approvals (up to five years) • Design and construction (about five years) • Initial fuel receipt (transfer of fuel from existing interim storage to new long-term storage facilities would occur over a period of approximately 35 to 40 years) • Extended monitoring (beyond 50 years) • Building refurbishment and fuel repackaging (beyond 50 years) There would be a need to obtain a licence at each phase and demonstrate continuous compliance with the licence (under regulatory oversight).
Decommissioning	Storage facilities and their components would be decommissioned and replaced, depending on the service lives of the various storage components. The duration of the decommissioning activities is approximately 30 years for each facility repeat event (~ every 300 years).
Costs	Depending on the specific design, preliminary estimates suggest this approach would cost between $17.6 billion and $25.7 billion (2002 dollars) for one 300-year cycle. Regardless of the storage options selected, the costs for reactor site extended storage would continue indefinitely. The present value cost of the first repeat cycle is approximately $2.3 to $4.4 billion (2004 dollars) based on current long-term economic factors. The calculation of costs beyond 300 years requires the use of long-term economic forecasting with its inherent uncertainties. (**www.nwmo.ca/reactorcosts**)

Option 3: Centralized Storage, Above or Below Ground

Option 3: Centralized Storage, Above or Below Ground

The management approach:

- Long-term management of used nuclear fuel in a storage facility, above or below ground, at a central site in Canada;
- Used nuclear fuel is transported from the nuclear reactor sites to this central location for long-term management; and
- The storage facility is maintained, rebuilt and operated in perpetuity at this central site.

One example of a centralized above ground storage facility is shown in Figure 6-5.

The illustrative timelines and activities associated with the concept are summarized in Table 6-3.

The detailed technical descriptions presented for the conceptual designs, are provided at www.nwmo.ca/centralstorage.

Figure 6-5 Centralized Storage – Above Ground

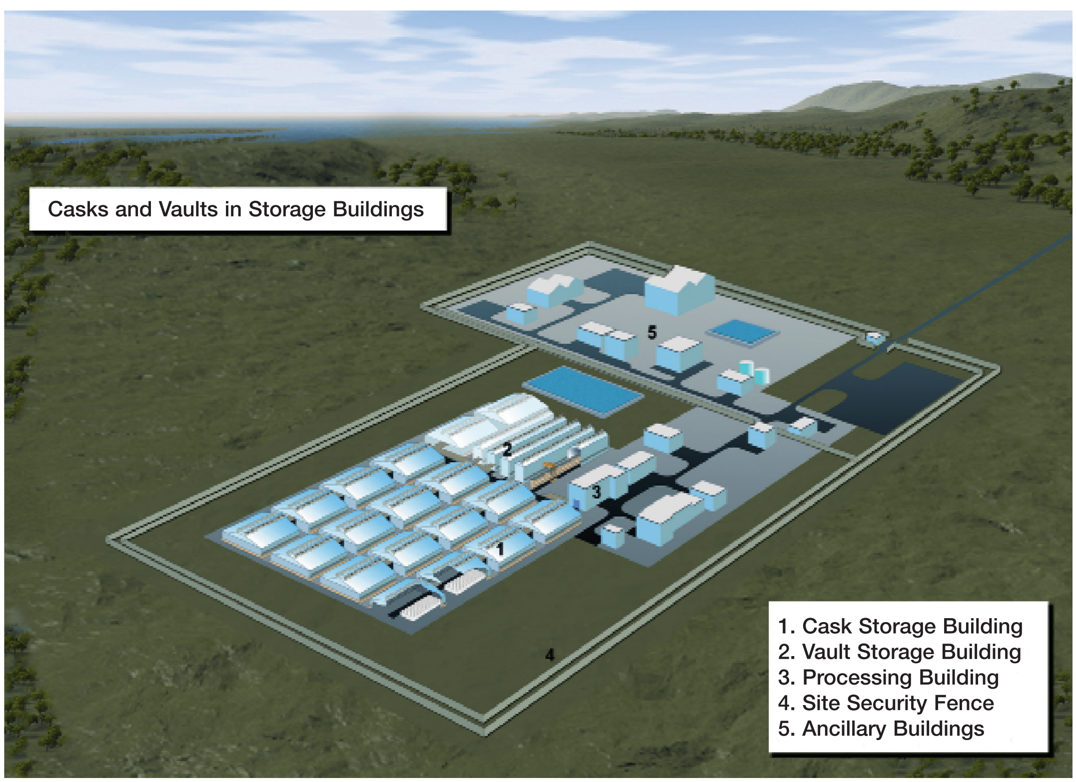


Table 6-3 Option 3: Centralized Storage, Above or Below Ground

Representative Conceptual Design Activities for Centralized Storage	
Concept	Centralized extended storage involves creating new, long-term storage facilities at a central location. Used fuel would be transferred from the seven interim storage sites in Canada to a newly designed facility. Conceptual designs have been developed for a central storage facility built above ground, or below ground. There would need to be transportation containers and facilities to produce them; processing facilities to load the fuel into transportation containers; production facilities for storage containers; and processing facilities to transfer the fuel from transportation to storage containers. Storage would require an ongoing program of regular replacement and refurbishing activities, as facilities would be renewed and expanded indefinitely. Once all the used fuel is transferred to the long-term storage facilities, ongoing maintenance, inspections and security systems would be required. The current owners of used fuel would continue to be responsible for its interim management at the reactor sites. The NWMO would assume management responsibility of the used fuel when it is transported from the reactor sites to the central facility for long-term management.
Location	Centralized storage could be built at a nuclear reactor site, but for assessment purposes, it is conservatively assumed that the central storage facility would be located at an undeveloped site, and the facility would be expanded as needed. A specific location would need to be identified, and approvals would be required from the CNSC for the construction and operation. This would also involve an environmental assessment.
Transportation Requirements	The operation of a centralized long-term storage facility would involve moving the fuel from existing reactor site storage facilities in certified transport containers to the central site over a period of approximately 30 years. Transportation would require an emergency response plan and adherence to security provisions. The mode of transportation (road, rail or water) would depend upon the location of the central facility and other factors. Based on a projected used fuel inventory of 3.6 million fuel bundles, the number of transportation shipments of used fuel from the reactor sites to the central facility would be: • Road: about 53 road shipments/month for 30 years, or • Rail: about five rail shipments/month + about 36 road shipments/month for 30 years, or • Water: about two water shipments/month + about 36 road shipments/month for 30 years

Table 6-3 (cont'd) Option 3: Centralized Storage, Above or Below Ground

Representative Conceptual Design Activities for Centralized Storage	
Containers	Four alternatives have been developed for the Joint Waste Owners as representative of a range of possible designs for the centralized long-term storage facility concept. In all cases, the used fuel would be contained in either concrete and steel casks or vaults. Two alternatives would use buildings on the surface. The other two alternatives would be underground. One option would be just below the surface and mounded over, while the other option would be about 50 metres below ground in bedrock. The four design alternatives for centralized storage are: • Casks and vaults in storage buildings. • Surface modular vaults. • Casks and vaults in shallow trenches. • Casks in rock caverns. Facilities would exist at the central site for repackaging the used fuel.
Storage Design Life	The storage containers and storage facilities are designed to last at least 100 years. Based on current design assumptions, complete refurbishment of all components, and repackaging of the entire fuel storage system is assumed to be repeated every 300 years. For design purposes, the assumed service lives for the various storage facility components are: • Casks 100 years • Fuel module 300 years • Fuel 300 years • Trench chamber 200 years • Storage building 100 years • Processing building 50 years It is recognized that new designs may make possible extended service lives of the facilities.
Land Requirement	The land requirement for the storage buildings and associated facilities would vary for each central storage alternative. For the surface storage alternatives, the land requirement would be about 1,080 metres x 865 metres, or about 93 hectares (230 acres). For the underground storage alternatives, the footprint of the storage caverns would be about 515 metres x 450 metres, or about 23 hectares (57 acres).
Underground Facility	No deep facility. The possibility exists to construct shallow rock caverns below the surface.
Repository Sealing System	None. There would not be a deep repository to be sealed.
Geosphere Barrier	Geosphere would not be used to provide a significant long-term isolation barrier.
Monitoring	The operation would require ongoing preventive maintenance and repair, as well as continuous monitoring to ensure that facility safety was being maintained.
Retrieval	The long-term storage facilities would be designed to allow safe retrieval of used nuclear fuel at any point during the service life of the facility. If the storage systems did not perform as expected, they could be repaired, or the fuel could be transferred to a new storage facility.

Table 6-3 (cont'd) Option 3: Centralized Storage, Above or Below Ground

Representative Conceptual Design Activities for Centralized Storage	
Illustrative Implementation Schedule	If the government decided in 2006 to adopt centralized storage, the storage facilities could not likely be ready for operations before 2023. Such facilities would require refurbishment or replacement by about the year 2300. Following a decision by the government, the following activities with their illustrative timelines would be undertaken: • Siting (up to 10 years) • Design and construction (about 10 years) • Initial fuel receipt (up to 40 years) • Extended monitoring (beyond 50 years) • Building refurbishment and fuel repackaging (beyond 50 years) There would be a need to obtain a licence at each phase and demonstrate continuous compliance with the licence (under regulatory oversight).
Decommissioning	Storage facilities and their components would be decommissioned and replaced, depending on the service lives of the various storage components. The duration of the decommissioning activities is approximately 30 years for each facility repeat event (~ every 300 years).
Costs	Depending on the specific design, preliminary estimates suggest this approach would cost between $15.7 and $20.0 billion (2002 dollars) for one 300-year cycle, including interim used fuel storage and retrieval from reactor sites and transportation costs. The present value impact of the first cycle is approximately $3.1 to $3.8 billion (2004 dollars) based on current long-term economic factors. The calculation of costs beyond 300 years requires the use of long-term economic forecasting with its inherent uncertainties. (www.nwmo.ca/centralstoragecosts)

Option 4: Adaptive Phased Management

Option 4: Adaptive Phased Management (Recommended Approach)

The management approach:

- Long-term management of used nuclear fuel through an adaptive path which provides for:
  > centralized containment and isolation of the used fuel in a deep geological repository in a suitable rock formation, such as the crystalline rock of the Canadian Shield or Ordovician sedimentary rock;
  > flexibility in the pace and manner of implementation through a phased decision-making process supported by a program of continuous learning, research and development;
  > provision for an optional step in the implementation process in the form of shallow underground storage of used fuel at the central site, prior to final placement in a deep repository;
  > continuous monitoring of the used fuel to support data collection and confirmation of the safety and performance of the repository; and
  > potential for retrievability of the used fuel for an extended period, until such time as a future society makes a determination on the final closure and the appropriate form and duration of postclosure monitoring.
- Used nuclear fuel is transported from the nuclear reactor sites to a central location for long-term management.

After significant analysis, public engagement and careful examination of the three options specified for study in the *NFWA*, the NWMO puts forward a fourth option – Adaptive Phased Management, as our recommended approach for long-term management of used nuclear fuel.

Adaptive Phased Management includes features from the other three technical methods. It proposes a path forward toward a determinate end point, the placement of used nuclear fuel in a deep geological repository for safe, secure long-term management. The approach builds on the continued development of the deep geological repository concept and takes into account the 1998 recommendations of the Seaborn Panel, as well as recent geological repository conceptual design experience in Canada and internationally.

The features of Adaptive Phased Management were drawn from the strengths of each of the other three options. The management approach is derived from a comprehensive comparative assessment of the options (as discussed in Chapter 8) and supported by the NWMO's engagement process (discussed in Chapter 4). Here we provide further information and rationale for these features of Adaptive Phased Management.

Centralized Containment and Isolation

Given the very long time period during which used nuclear fuel remains a potential health, safety and security hazard to humans and the natural environment, and based on our research in Canada and internationally, the NWMO has concluded that the most appropriate end point for used fuel should be containment and isolation. The appropriate location would be a deep geological repository in a suitable rock formation, such as the crystalline rock of the Canadian Shield or Ordovician sedimentary rock.

The rationale for a single centralized facility for long-term containment and isolation is based on a number of factors including cost, siting practicalities, safety, security and input from citizens. As discussed in Chapter 8, the costs to site, design, license and construct a facility to receive used fuel and place it in a deep geological repository are significant. It would not be cost-effective to develop multiple sites and facilities within Canada.

The risk of societal change and institutional breakdown over the long term would be mitigated by centralization. The management of one site is expected to be less complex than trying to provide security at several sites, although we recognize that our recommended approach will result in an additional site in Canada with used fuel while the material is being transported from the reactor sites to the central facility. The comparative analysis indicates that safety and security are improved with a central facility over the long term.

Potentially Suitable Host Rock Formations

The NWMO's rationale for including both the crystalline rock of the Canadian Shield and Ordovician sedimentary rock as potentially suitable host rock formations for a deep geological repository is given in our background paper *Adaptive Phased Management Technical Description*, which is available at **www.nwmo.ca/phasedmanagement** (background paper 6-18). In summary, the NWMO based its rationale on the following information:

- In 1977 the independent expert group chaired by Kenneth Hare identified several potentially suitable rock types in Canada for a deep geological repository for used nuclear fuel which included salt, crystalline rock, sedimentary rock and volcanic tuff. The Hare report indicated that the Canadian repository research and development (R&D) program should study several different rock types but that resources should not be spread too thinly. The report suggested that the primary R&D effort should focus on crystalline rock, but careful attention should be paid to work being conducted in other countries on other rock types.

- Since 1978, the Canadian repository R&D program has been primarily directed towards the crystalline rock in the Canadian Shield, including development of the Underground Research Laboratory by AECL near Lac du Bonnet, Manitoba. The potential suitability of the crystalline rock of the Canadian Shield for a deep geological repository has been extensively documented in AECL's 1994 Environmental Impact Statement and associated geoscientific and safety assessment reports. As well, there has been extensive documentation of the potential suitability of crystalline rock in other countries such as Sweden, Finland and Switzerland.

- Since the 1980's, there have been a limited number of Canadian studies on the potential for sedimentary rock as the host rock formation for a deep geological repository. The principal findings from these studies are that sedimentary rock formations have favourable geotechnical properties, they are relatively simple, homogeneous and thick, plus there are a large number of potential candidate sites for a deep repository.

- Several countries including Switzerland, France, Spain and Japan are studying both crystalline rock and sedimentary rock for their repository programs.

- From a geoscientific perspective, sedimentary rock formations such as the Ordovician (age 470 to 430 million years) have low hydraulic conductivity which means the flow of groundwater in the formations is very slow and the movement of dissolved material is dominated by diffusion. Also, sedimentary formations such as clay possess an ability to self-seal fractures and faults, and the clay minerals would retard the migration of many dissolved minerals.

- Ordovician sedimentary rock formations can be found in Canada at sufficient depth below surface and have sufficient thickness to meet technical siting criteria for a deep geological repository.

- In 2004, the NWMO commissioned a high-level review of potential changes to the conceptual design and costs of constructing a deep geological repository for used nuclear fuel in Ordovician sedimentary rock. The review found that construction of a deep geological repository in sedimentary rock is feasible and that the costs would be similar or less than a deep repository constructed in crystalline rock. (See background paper 6-13, *Conceptual Designs for Used Fuel Management in Sedimentary Rock*.)

There are several independent geoscientific arguments suggesting that Ordovician shales and limestones may provide a highly suitable environment to host a deep geological repository for used nuclear fuel in Canada. The prospect of successfully preparing a convincing safety case for a used fuel repository in Ordovician shales and limestones is substantial.

Based on the information available to the NWMO, both the crystalline rock of the Canadian Shield and Ordovician sedimentary rock are considered to be potentially suitable for a deep geological repository for used nuclear fuel. However, more research and development work on sedimentary rock needs to be completed to determine the suitability of these formations. The results from detailed site-specific characterization activities obtained during the site investigation, site selection and licensing phase would be required to confirm the technical suitability of any host rock formation for a deep geological repository.

Flexibility in the Pace and Manner of Implementation

Implementation of the Adaptive Phased Management approach is based on a series of steps or stages with key decisions supported by new knowledge, information, research and development. The NWMO does not consider “flexibility” to be an indication of indecision or an excuse to delay implementation. Rather, flexibility in the pace and manner of implementation recognizes that it is both pragmatic and appropriate to make these key decisions in an adaptive manner based on the best available information at the time of the decisions. Flexibility also provides Canadians with genuine choice with respect to how we arrive at the end point of Adaptive Phased Management.

In this chapter, we present one possible way of proceeding down the path of moving used fuel from nuclear reactor sites to an optional centralized underground storage facility in shallow rock caverns, followed by transfer to a final deep repository at the same site. At the same time, we acknowledge the potentially long timelines associated with implementation. During this period, there would be opportunities to adjust the timing as appropriate with the benefit of new information, continuous learning, monitoring of research and technological developments and discussion of timelines most appropriate for communities affected by the transition to long-term management.

Clearly, there are many **decisions** that may influence the implementation period for Adaptive Phased Management and the timelines for the key activities. Some of these decisions include:

- The selection of a preferred site for central, long-term management of used nuclear fuel.

- A decision about whether or not to construct an interim shallow underground storage facility at the central site and transport used fuel to the central facility while awaiting development of the deep repository.

- A decision about when to construct the deep geological repository and ancillary facilities.

- A decision about when to close the deep geological repository and decommission the surface facilities.

Further discussion of these decisions and the possible drivers for these decisions can be found in Chapters 13 and 16.

The **illustrative** and conservative timelines and activities associated with the concept are summarized in Table 6-4. Figures 6-6, 6-7 and 6-8 show three possible phases of implementation for Adaptive Phased Management.

It is important to note that the schedule and duration of activities for Adaptive Phased Management are illustrative for conceptual design, cost estimating and concept analysis purposes and would depend on a number of factors during implementation including the outcome of future decisions which cannot be know at this time. Other implementation schedules for Adaptive Phased Management are also possible and are discussed in Chapter 16. A detailed schedule of implementation activities and timelines would need to be developed following a decision by the Government of Canada on the preferred long-term management approach.

Provision for an Optional Shallow Underground Storage Facility

Adaptive Phased Management includes an option for shallow underground storage of used fuel at the central site while awaiting the development of the deep geological repository at the same site. This feature of the management approach is **optional** and one of the key decisions which must be made during the first phase of implementation is whether or not to proceed with this interim step of used fuel storage at the central facility.

For conceptual design, cost estimating and option comparison purposes, the NWMO has conservatively assumed that a decision is made to construct the shallow underground storage facility for used fuel. However, it is important to note that the factors which would influence the decision could be social, economic or technical (see discussion of key decisions for Adaptive Phased Management in Chapters 13 and 16). These include:

- A strong indication from some or all of the reactor site communities of a need to move used fuel off site, perhaps as a result of reactor decommissioning activities;

- Unforeseen developments that increase the desirability of centralizing used fuel for reasons of enhanced security;

- Unforeseen developments in technological innovation; and

- The time it takes to demonstrate the safety of the deep repository.

In simple terms, if there is an overriding need to move used fuel from the reactor sites to a central facility before the deep repository is operational, then the shallow underground storage facility would be constructed. If the need for storage at a central facility is not strong, then the storage facility would not be constructed and the used fuel would remain at the reactor sites until the deep repository is operational. Adaptive Phased Management would enable this choice to be made from social, technical and economic perspectives. The option of shallow underground storage provides a contingency in the event of unplanned circumstances.

Continuous Monitoring of Used Fuel

Used fuel will continue to be monitored throughout all phases of implementation of Adaptive Phased Management. Used fuel monitoring could be done over an extended period of time without affecting the integrity of the containment and isolation system. Monitoring would be done primarily to confirm the safety and performance of the management system, and to support various decisions during implementation. For example, the duration of in-situ monitoring of used fuel in the deep repository would affect the timing of the decision to close the deep repository and continue with postclosure monitoring from the surface.

Potential for Retrievability of Used Fuel for an Extended Period

Adaptive Phased Management enables used fuel to be retrievable at all times, both during storage and during placement in a deep geological repository. This feature of the approach has been provided to ensure that the used fuel is accessible should monitoring activities indicate that there are problems with the management system, or if there is a clearly justifiable reuse for the material, or should future technologies emerge to better manage used fuel over the long term.

A more detailed technical description of Option 4 is found in the NWMO background paper 6-18 *Adaptive Phased Management Technical Description*, which is available at **www.nwmo.ca/phasedmanagement**.

The detailed assessment of Option 4, based on conceptual designs, is available at **www.nwmo.ca/assessments**.

Table 6-4 Option 4: Adaptive Phased Management

Representative Conceptual Design Activities for Adaptive Phased Management	
Concept	A staged management approach with three phases of implementation: • Phase 1: Preparing for Central Used Fuel Management • Phase 2: Central Storage and Technology Demonstration • Phase 3: Long-term Containment, Isolation and Monitoring **Phase 1 (approximately the first 30 years):** Preparing for central used fuel management would comprise the following activities: • Maintain storage and monitoring of used fuel at nuclear reactor sites. • Develop with citizens an engagement program for activities such as design of the process for choosing a site, development of technology and key decisions during implementation. • Continued engagement with regulatory authorities to ensure pre-licensing work would be suitable for the subsequent licensing processes. • Select a central site that has rock formations suitable for shallow underground storage, an underground characterization facility and a deep geological repository. • Continue research into technology improvements for used fuel management. • Initiate the licensing process, which triggers the environmental assessment process under the *Canadian Environmental Assessment Act*. • Undertake site characterization, safety analyses and an environmental assessment for the shallow underground storage facility, underground characterization facility and deep geological repository at the central site, and to transport used fuel from the reactor sites. • Obtain a licence to prepare the site. • Develop and certify transportation containers and used fuel handling capabilities. • Obtain a licence to construct the underground characterization facility at the central site. • Decide whether or not to proceed with construction of a shallow underground storage facility and to transport used fuel to the central site for storage. • If a decision is made to construct the shallow underground storage facility, obtain a construction licence and then an operating licence for the storage facility. **Phase 2 (approximately the next 30 years):** Central storage and technology demonstration would comprise the following activities: • If a decision is made to construct shallow underground storage, begin transport of used fuel from the reactor sites to the central site for extended storage. • If a decision is made not to construct shallow underground storage, continue storage of used fuel at reactor sites until the deep repository is available at the central site. • Conduct research and testing at the underground characterization facility to demonstrate and confirm the suitability of the site and the deep repository technology. • Engage citizens in the process of assessing the site, the technology and the timing for placement of used fuel in the deep repository. • Decide when to construct the deep repository at the central site for long-term containment and isolation. • Complete the final design and safety analyses to obtain the required operating licence for the deep repository and associated surface handling facilities. There may be a need for transportation containers and facilities to produce them; processing facilities to load the fuel into transportation containers; production facilities for storage containers; and processing facilities to transfer the fuel from transportation to storage containers.

Table 6-4 (cont'd) Option 4: Adaptive Phased Management

Representative Conceptual Design Activities for Adaptive Phased Management	
Concept (cont'd)	**Phase 3 (beyond approximately 60 years):** Long-term containment, isolation and monitoring would comprise the following activities: • If used fuel is stored at a central shallow underground facility, retrieve and repackage used fuel into long-lived containers. • If used fuel is stored at reactor sites, transport used fuel to the central facility for repackaging. • Place the used fuel containers into the deep geological repository for final containment and isolation. • Decommission the shallow underground storage facility. • Continue monitoring and maintain access to the deep repository for an extended period of time to assess the performance of the repository system and to allow retrieval of used fuel, if required. • Engage citizens in on-going monitoring of the facility. • A future generation would decide when to decommission the underground characterization facility and any remaining long-term experiments or demonstrations of technology, and when to close the repository, decommission the surface handling facilities and the nature of any postclosure monitoring of the system. There may be a need for production facilities for used fuel containers; processing facilities to transfer the fuel from storage to the deep repository; and production facilities for sealing materials. The current owners of used fuel would continue to be responsible for its interim management at the reactor sites. The NWMO would assume management responsibility of the used fuel when it is transported from the reactor sites to the central facility for long-term management.
Location	The central facility for the shallow rock cavern, underground characterization facility and deep repository could be located in a suitable rock formation such as the crystalline rock of the Canadian Shield or in the Ordovician sedimentary rock basins. These two rock types cover a vast amount of land reaching several provinces and territories. A specific location would need to be identified and approval would be required from the Canadian Nuclear Safety Commission for the construction and operation of the facility. This would also involve an environmental assessment.
Transportation Requirements	The operation of a central facility would involve moving the fuel from existing reactor site storage facilities in certified transport containers to the central site over a period of approximately 30 years. Transportation would require an emergency response plan and adherence to security provisions. The mode of transportation (road, rail or water) would depend on factors such as the location of the central facility. The timing of transportation would depend on whether or not a shallow underground storage facility has been constructed at the central site and other factors. Based on a projected used fuel inventory of 3.6 million fuel bundles, the number of transportation shipments of used fuel from the reactor sites to the central facility would be: • Road: about 53 road shipments/month for 30 years, or • Rail: about 5 rail shipments/month + about 36 road shipments/month for 30 years, or • Water: about 2 water shipments/month + about 36 road shipments/month for 30 years.
Containers	Storage containers at reactor sites would consist of the existing casks, vaults and silos. Containers for long-term isolation in a deep repository are based on a 100,000-year design life. These durable containers are designed to withstand long-term environmental effects such as climate change and glaciation. Facilities would exist at the central site for repackaging the used fuel.

Table 6-4 (cont'd) Option 4: Adaptive Phased Management

Representative Conceptual Design Activities for Adaptive Phased Management	
Storage Design Life	Storage containers at the central underground storage facility are based on the existing design of the dry storage container or equivalent with a 100-year design life.
Land Requirement	The land requirement for the surface buildings and associated facilities would be about two kilometres x three kilometres, or about 600 hectares (1,480 acres). The surface building dimensions would likely be a small fraction of the total land area. The footprint of the shallow underground storage facility would be about 515 metres x 450 metres, or about 23 hectares (57 acres). The footprint for the deep geological repository would be about 1.35 kilometres x 1.36 kilometres, or about 183 hectares (452 acres). The actual size of the deep geological repository would depend on a number of factors such as number of fuel bundles and their heat output, depth of the repository and site-specific factors such as thermal conductivity of the rock mass.
Underground Facility	During the Phase 2 extended storage period, the used fuel would be placed in a series of shallow rock caverns excavated at a nominal depth of 50 metres below surface. During the Phase 3 long-term isolation period, the used fuel would be placed in a network of horizontal access tunnels and rooms excavated in stable rock at a nominal depth of 500 to 1,000 metres below surface. Used fuel containers would be placed within the rooms or in boreholes drilled into the floor of the rooms. Used fuel containers are assumed to be placed in the deep repository over a 30-year operating period.
Repository Sealing System	Clay-based materials would be used to surround and protect the containers, to fill the void spaces in the repository, to limit the movement of groundwater and dissolved material, and to protect workers during container placement operations. These are referred to as sealing systems, and involve materials such as high-performance concrete and swelling bentonite clay.
Geosphere Barrier	The geosphere, or host rock, provides the principal barrier between the used fuel containers and the surface environment. Both the Canadian Shield granite and the Ordovician sedimentary rock basins are examples of naturally occurring geological formations which have long-term stability, good rock strength, and low groundwater flow. Large areas exist with sufficient depth below the surface and lacking in mineral resources that they are very unlikely to be disturbed by erosion or accidental drilling.
Monitoring	Used fuel would be monitored in the central shallow rock caverns and in the deep repository. During Phase 2, monitoring would be straightforward over the estimated 30-year period since the storage containers are readily accessible. During Phase 3, monitoring over an estimated 240-year period would require more effort and technology since the long-term isolation containers would be backfilled and sealed within the placement rooms. Monitoring would be conducted to confirm the long-term safety and performance of the repository system. Until a decision is made to backfill and seal the access to the deep repository, monitoring would take place in-situ at repository depth. After closure of the deep repository around 300 years, postclosure monitoring of the facility could take place from the surface.

Table 6-4 (cont'd) Option 4: Adaptive Phased Management

Representative Conceptual Design Activities for Adaptive Phased Management	
Retrieval	Used fuel would be retrievable at all times. The technology to retrieve used fuel containers from a deep geological repository would need to be further developed and demonstrated at the site. During Phase 2, used fuel retrieval would be straightforward over the estimated 30-year period since the storage containers are readily accessible. During Phase 3, used fuel retrieval over an estimated 240-year period would require more effort and technology since the long-term isolation containers would be backfilled and sealed within the placement rooms.
Illustrative Implementation Schedule	A government decision in 2006 to select this management approach would see an underground characterization facility and possibly a central shallow underground rock cavern storage facility ready by about 2035. The deep geological repository could then ready by about 2065. Following a decision by the federal government, the following activities with their **illustrative** timelines would be undertaken: • Siting of central facility (about 20 years) • Design and construction of the underground characterization facility and the optional shallow underground storage caverns, if required (about 10 years) • Transportation to central facility (over about 30 years) • Placement in deep geological repository (over about 30 years) • Extended monitoring (up to 300 years) • Decommissioning and closure (over about 25 years) • Postclosure monitoring (indefinite) There would be a need to obtain a licence at each phase and demonstrate continuous compliance with the licence (under regulatory oversight).
Decommissioning	Once a societal decision was made and the necessary approvals were obtained, decommissioning would commence and all underground access tunnels and shafts would be backfilled and sealed. Surface facilities would be decontaminated and dismantled. Closure activities include removal of monitoring instruments and returning the site to greenfield conditions.
Costs	The cost of the Adaptive Phased Management approach is conservatively estimated to be about $24 billion (2002 dollars), including interim used fuel storage and retrieval from reactor sites, transportation costs to the central facility, extended storage in underground caverns, technology research development and demonstration in the underground characterization facility and placement of used fuel in a deep geological repository. These costs include the development and demonstration of the technology to retrieve used fuel from the deep repository, but not the costs to perform retrieval operations from the deep repository. The present value cost based on current long-term economic factors is approximately $6.1 billion (2004 dollars). (www.nwmo.ca/assessments) These costs include construction and operation of the shallow underground storage facility at the central site. If, however, the used fuel remains at reactor sites prior to operation of the deep repository and is not first placed in shallow storage, these costs would be reduced to about $21 billion (2002 dollars) with a present value of about $5.1 billion (2004 dollars).

Figure 6-6 Adaptive Phased Management: Phase 1 – Preparing for Central Used Fuel Management

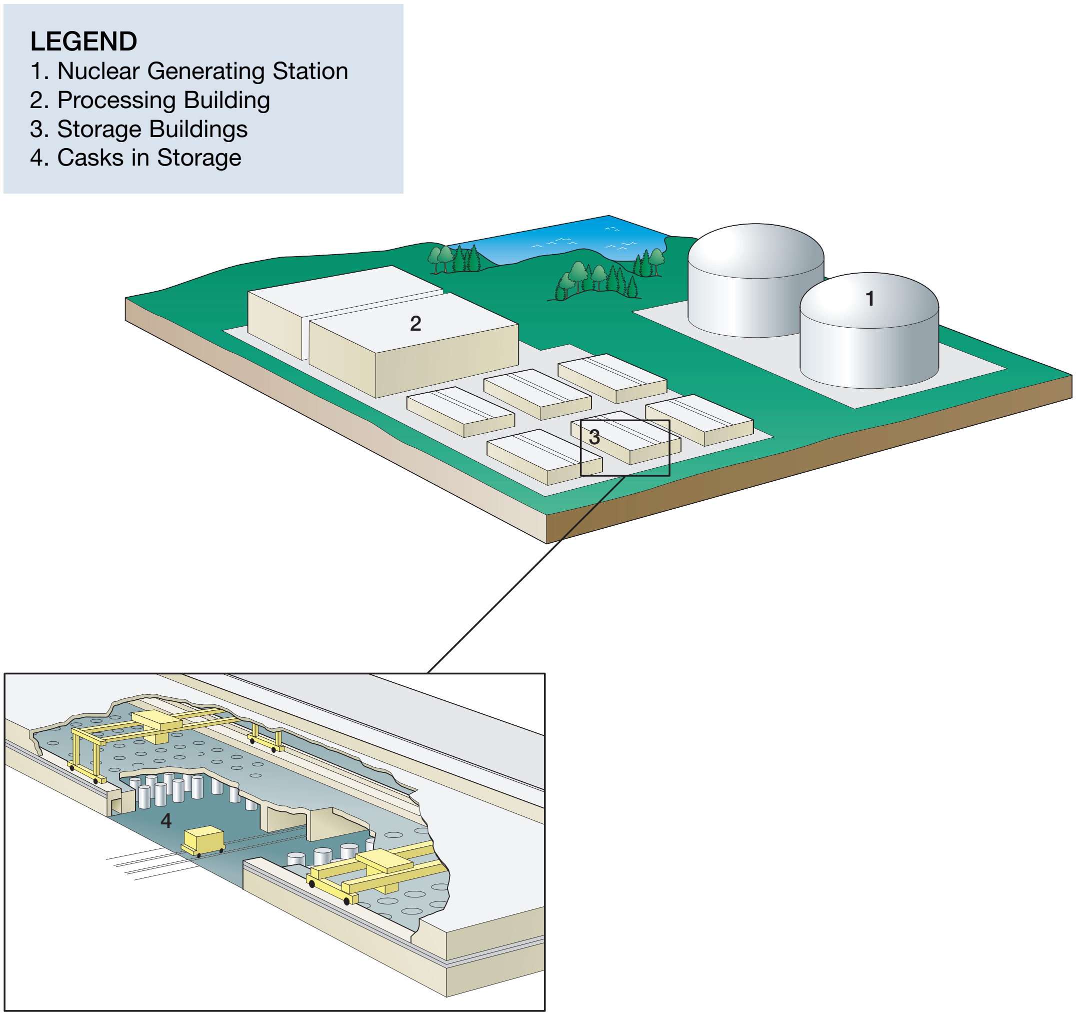


Figure 6-7 **Adaptive Phased Management: Phase 2 – Central Storage and Technology Demonstration**

LEGEND
1. Processing
2. Access Ramps
3. Shallow Rock Cavern
4. Casks in Cavern
5. Underground Characterization Facility
6. Service Shaft
7. Ventilation Shaft

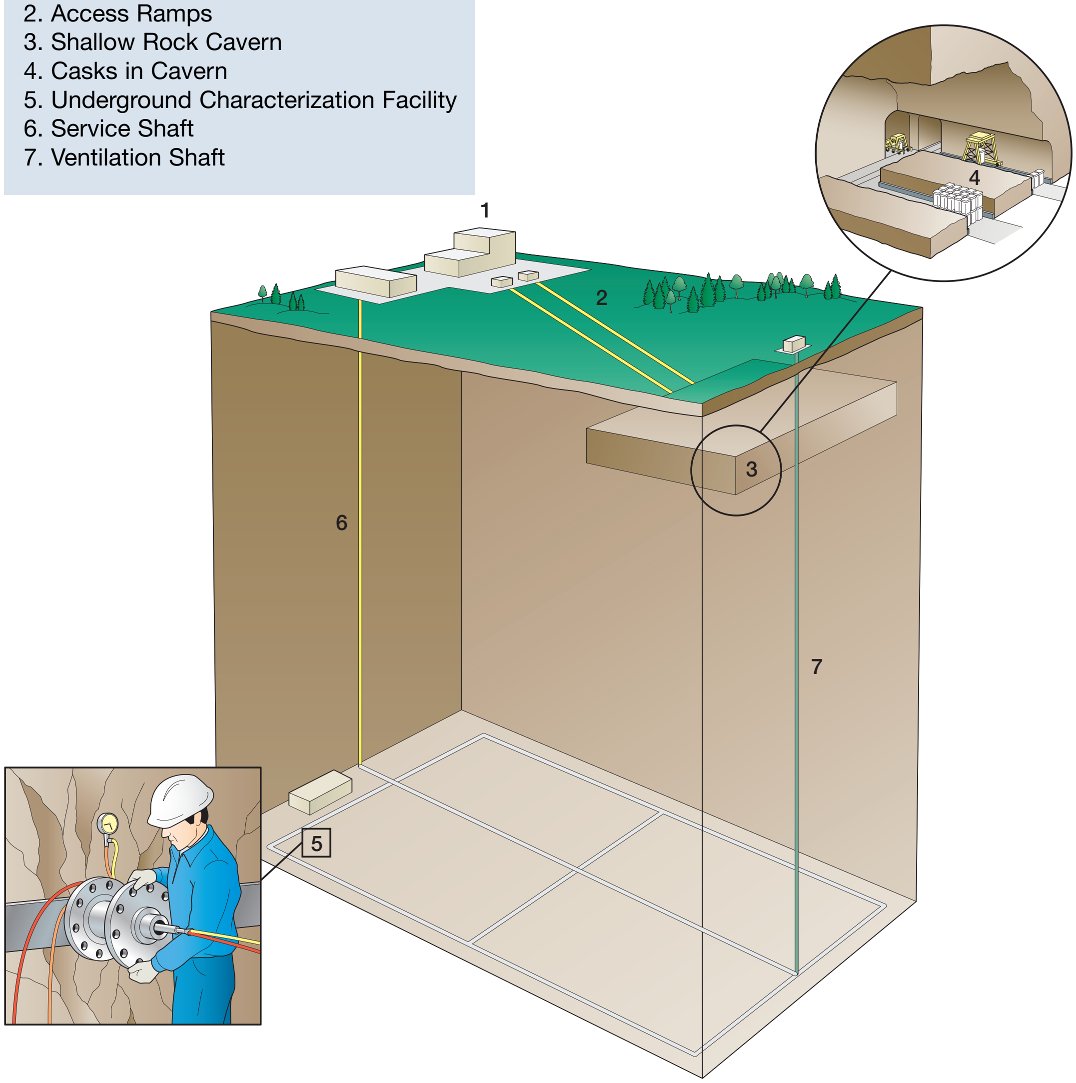
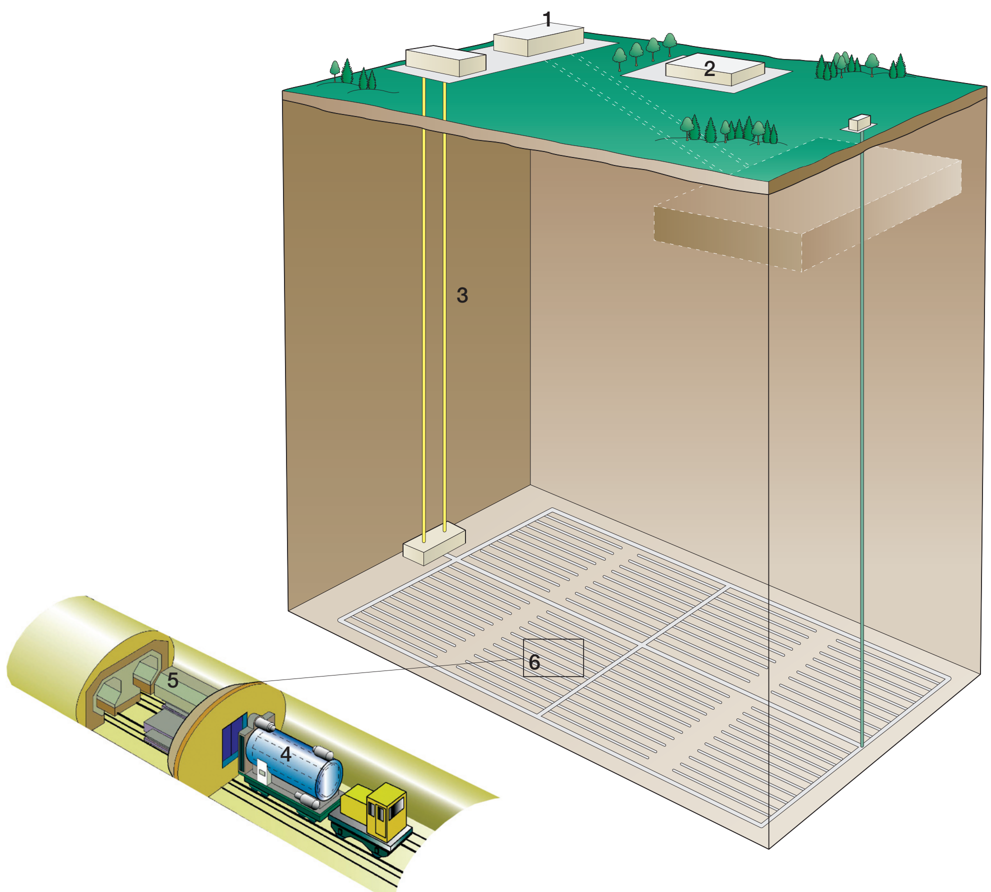


Figure 6-8 **Adaptive Phased Management: Phase 3 – Long-Term Containment, Isolation and Monitoring**

LEGEND
1. Repackaging Building
2. Sealing Materials Plant
3. Waste Shaft
4. Transport Cask
5. Jacketed Used Fuel Container
6. Placement Rooms



Chapter 7 / Economic Regions for Implementation

Although the NWMO is not proceeding with site selection as part of this study, we have an obligation under the *Nuclear Fuel Waste Act* (*NFWA*) to address economic regions for implementation of each approach studied.

The *NFWA* defines an 'economic region' as that described by Statistics Canada in its Guide to the Labour Force Survey, published on January 31, 2000. Economic regions are broad-based geographic units, generally composed of several census divisions within a province, used for compiling statistics and analysis of regional economic activity.

The 2000 Survey described 73 regions. Presently, there are 76 economic regions in Canada, including the Yukon, Northwest Territories and Nunavut.

Having listened to Canadians, we believe that the objectives of safety and fairness should be central in guiding decisions regarding location for the management approach. These objectives underlie our proposals regarding the specification of economic regions and our proposed siting considerations.

The *NFWA* does not require the NWMO to identify a particular region for implementing each management approach. This is appropriate for a number of reasons:

- Storage at nuclear reactor sites (Option 2) would, by definition, require implementation in a number of different regions. Similarly, centralized approaches (Options 1, 3 and 4) through their transportation requirements, would involve implementation in more than one region;

- Siting characteristics for any centralized facility would need to take into account, among other things, the suitability of a location in terms of its geotechnical and environmental characteristics. These characteristics differ vastly within regions, making it difficult to propose economic regions without site investigation. Screening out economic regions during the conceptual study phase, without the benefit of site characterization, would risk prematurely eliminating potential candidate regions from consideration; and

- Finally, we believe that the preferred site for any new facility must take into account many social, environmental, physical and technical factors that will determine its suitability for ensuring the objectives of safety and security. Narrowing the number of economic regions at this time may unduly remove communities that might otherwise wish to be considered as potential host locations.

7.1 / What We Can Learn from Economic Regions

The NWMO has done its best to specify regions that have potentially suitable locations for implementing different types of management approaches, and has done so to the extent practicable at this time.

It is useful to examine economic regions to understand how implementation might differ according to location. We examined in some depth the implications of situating a facility in different types of regions that reflect a diversity of human and biophysical characteristics. We looked at a range of economic regions, for purely illustrative purposes, as a means of understanding the costs, benefits and risks associated with locating a facility in regions with different physical, demographic and socio-economic features. We discuss this work in Chapter 8.

Through our analysis, we have seen that there is often as much variation within an economic region, as between regions, making it difficult to generalize about the suitability of one region over another.

A given economic region can exhibit vast differences in geology, environmental conditions, demographics and socio-economic composition. It is difficult to generalize beyond a certain point about the suitability of a particular region. For example, it is possible that an economic region might include areas of stable geology and areas that would be considered seismically unstable. In such cases, it would be inappropriate to exclude from consideration the region in its entirety.

Economic regions are not designed around meaningful boundaries for purposes of engaging in discussion about possible host communities. They do not reflect political or legal boundaries. Nor do they represent boundaries of traditional Aboriginal territories, or our country's ecozones. As a population, we do not organize our communities around the units of economic regions. We may have just as much or more in common with communities in neighbouring regions, as with communities located in other areas within our own defined economic region.

Ultimately, decisions on locating a facility will be made based on site-specific characteristics, and not economic regions. Following a government decision on a management approach, implementation planning will transition from this discussion of broad economic boundaries to one that considers specific siting characteristics defined for a fully specified project. Decisions will be guided by principles, objectives and processes that are developed collaboratively between the NWMO and interested locations. For further discussion on the proposed siting process, see Chapter 9.

7.2 / Specification of Economic Regions

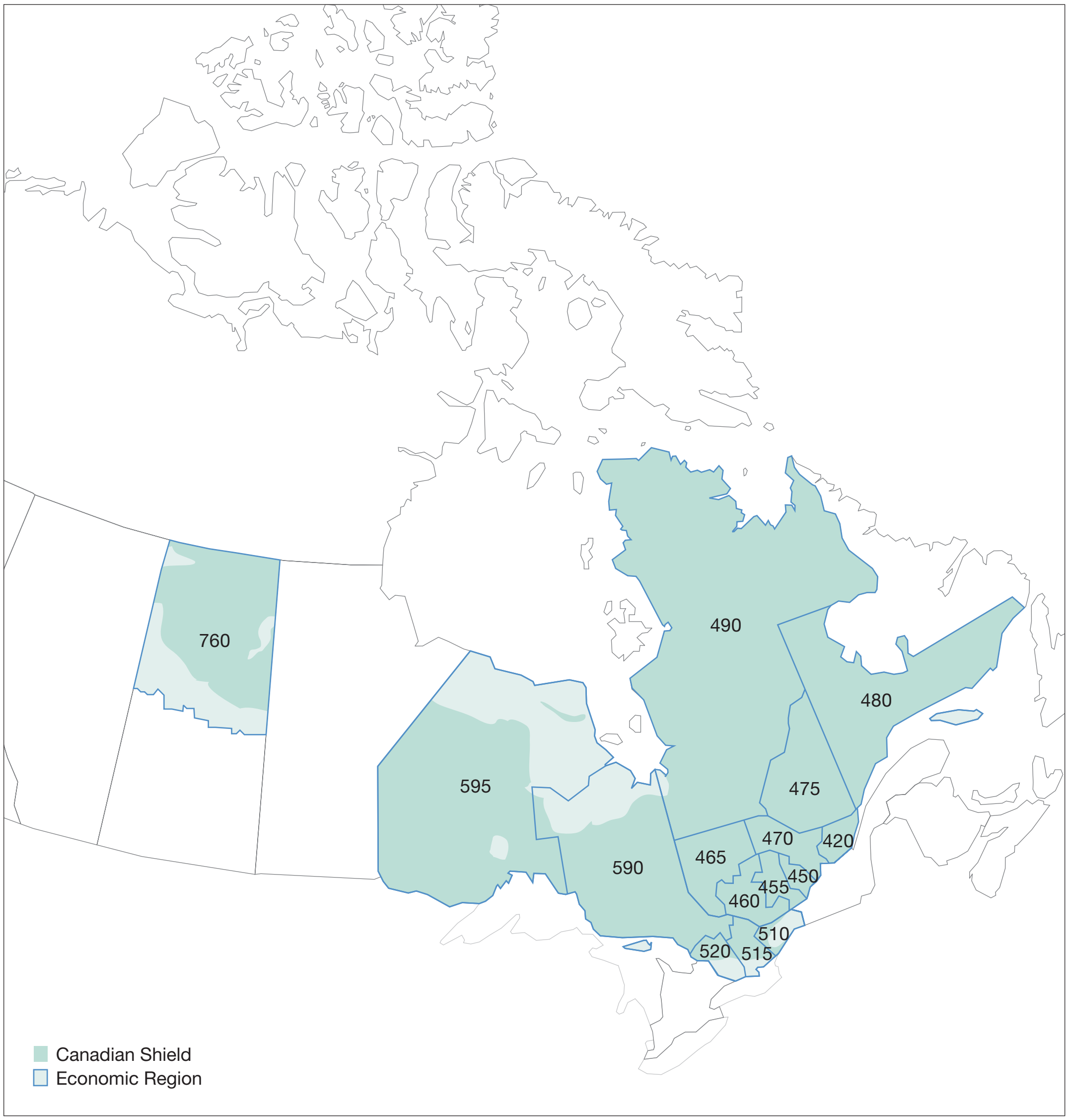
We believe that the objective of fairness would best be achieved if the site selection process were focused within the provinces that are directly involved in the nuclear fuel cycle.

Accordingly, in specifying economic regions for centralized facilities for initial consideration, we have proposed that the process of implementation be in the provinces that have benefited from activity associated with the nuclear fuel cycle.

This includes the three provinces that generate electricity from nuclear power and consequently create used nuclear fuel as a by-product (Ontario, New Brunswick and Québec), as well as Saskatchewan, which has benefited economically from mining the uranium that is used to make nuclear fuel. We believe that these provinces have a greater responsibility than do other provinces and territories to manage the waste stream arising from the nuclear process.

We recognize that communities in other regions and provinces, beyond the four nuclear provinces, may come forward with an interest in hosting a facility for the long-term management of used nuclear fuel. Provided that a site is shown to meet the established safety and other regulatory requirements, such regions would not be denied the opportunity to be considered as a potential host.

Figure 7-1 **Option 1: Deep Geological Disposal in the Canadian Shield-Map**



Option 1: Deep Geological Disposal in the Canadian Shield

The *NFWA* definition of disposal confines this approach to the economic regions lying in the Canadian Shield.

Thus, Option 1: Deep Geological Disposal in the Canadian Shield, brings the focus of potential implementation to the 21 economic regions which encompass the crystalline rock of the Canadian Shield, which stretches across six provinces and two territories. More specific examination of the regions, against siting principles and scientific and technical siting requirements, would determine the potential suitability of these regions for implementation of Option 1.

Figure 7-1 and Table 7-1 specify the economic regions that we propose be considered for possible implementation of Option 1: Deep Geological Disposal in the Canadian Shield.

Table 7-1 Economic Regions for Possible Implementation of Option 1

The economic regions specified below may be suitable for implementation of Option 1: Deep Geological Disposal in the Canadian Shield.

QUÉBEC:
420: Québec
450: Lanaudière
455: Laurentides
460: Outaouais
465: Abitibi-Témiscamingue
470: Mauricie
475: Saguenay-Lac St. Jean
480: Côte-Nord
490: Nord-du-Québec

ONTARIO:
510: Ottawa
515: Kingston-Pembroke
520: Muskoka – Kawarthas
590: Northeast
595: Northwest

SASKATCHEWAN:
760: Northern

Option 2: Storage at Nuclear Reactor Sites

Under Option 2: Storage at Nuclear Reactor Sites, used nuclear fuel would be stored at the sites presently hosting nuclear reactors. Therefore, implementation of long-term storage at nuclear reactor sites would be specified for the six economic regions in which the existing seven nuclear reactor sites are located.

Figure 7-2 and Table 7-2 specify the economic regions that would be considered for possible implementation of Option 2: Storage at Nuclear Reactor Sites.

Table 7-2 Economic Regions for Possible Implementation of Option 2

The NWMO proposes specification of the following economic regions for possible implementation of Option 2: Storage at Nuclear Reactor Sites.

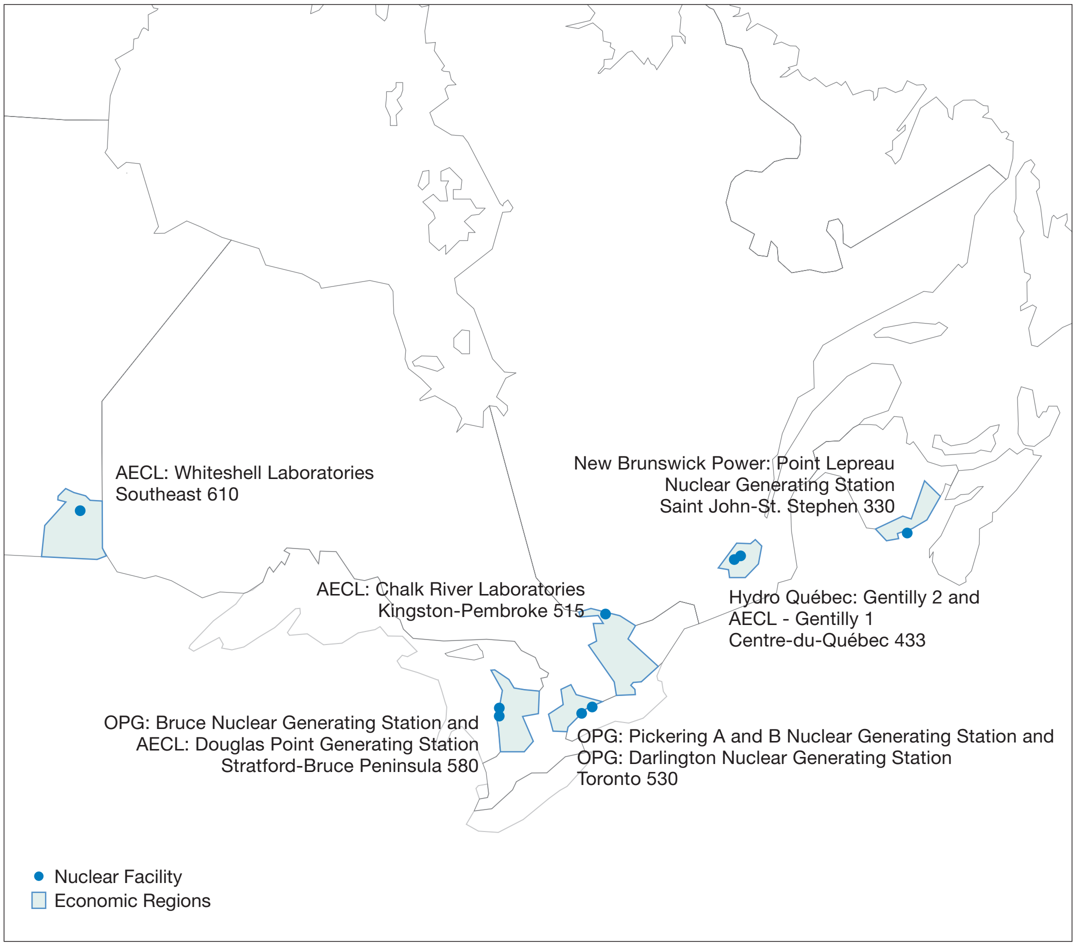
QUÉBEC:
433: Centre-du-Québec (Gentilly Reactors)

ONTARIO:
515: Kingston-Pembroke (Chalk River Laboratory Reactors)
530: Toronto (Pickering and Darlington Reactors)
580: Stratford-Bruce Peninsula (Bruce Power Reactors; AECL Douglas Point Reactor)

NEW BRUNSWICK:
330: Saint John-St. Stephen (Point Lepreau Reactor)

MANITOBA:
610: Southeast (Whiteshell Laboratories)

Figure 7-2 **Option 2: Storage at Nuclear Reactor Sites-Map**



Option 3: Centralized Storage (above or below ground)

The *NFWA* does not set out any criteria that would restrict the siting for Option 3 geographically. By its nature, centralized storage may be designed to be built above ground as well as slightly below ground surface anywhere in Canada.

Not reliant on specific geological requirements to enable safe operation of this type of facility, other than required soil characteristics to support the storage facilities and associated infrastructure, this concept offers considerable flexibility in siting. The starting point is the complete set of 76 economic regions in Canada.

More specific examination of the regions, against siting principles and scientific and technical siting requirements, would determine the potential suitability of these regions for implementation of Option 3.

Figure 7-3 and Table 7-3 specify the economic regions that we propose be considered for possible implementation of Option 3: Centralized Storage (above or below ground).

Option 4: Adaptive Phased Management

Phase 1 of Option 4 involves interim storage at nuclear reactor sites.

Phases 2 and 3 of this staged management approach would require selecting a site that would support a deep geological repository. The same site must also be suitable for shallow underground interim storage.

Sites to be considered would need to have the robust rock formations required to safely contain and isolate used fuel perpetually, as envisaged in the design concept.

Canada is fortunate in that its vast geological

Table 7-3 Economic Regions for Possible Implementation of Option 3

The economic regions specified below may be suitable for implementation of Option 3: Centralized Storage, Above or Below Ground.

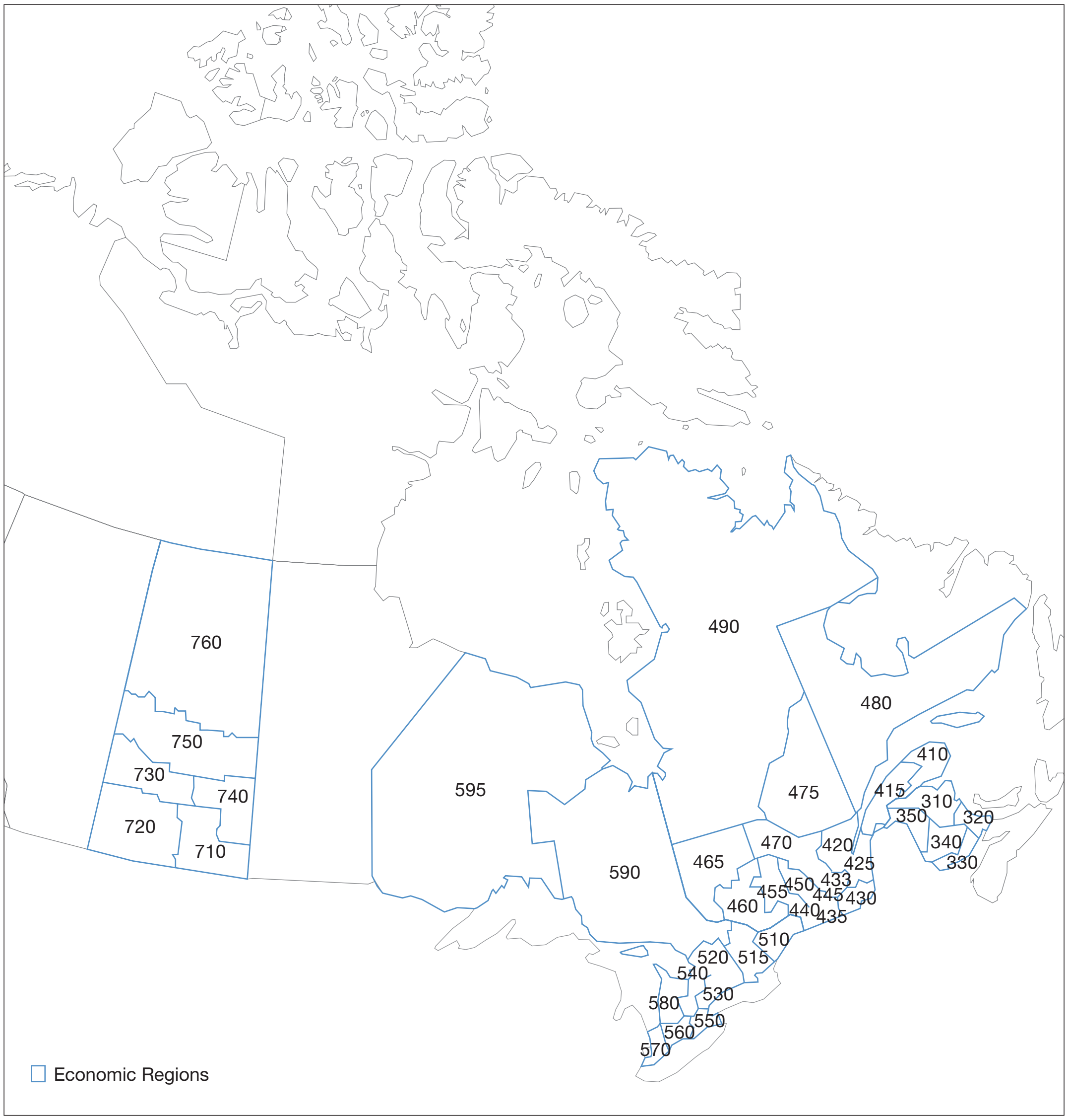
NEW BRUNSWICK:
310: Campbellton – Miramichi
320: Moncton – Richibucto
330: Saint John – St. Stephen
340: Fredericton – Oromocto
350: Edmundston – Woodstock

QUÉBEC:
410: Gaspésie – Îles-de-la-Madeleine
415: Bas-Saint-Laurent
420: Québec
425: Chaudière – Appalaches
430: Estrie
433: Centre-du-Québec
435: Montérégie
440: Montréal
445: Laval
450: Lanaudière
455: Laurentides
460: Outaouais
465: Abitibi-Témiscamingue
470: Mauricie
475: Saguenay – Lac-Saint-Jean
480: Côte-Nord
490: Nord-du-Québec

ONTARIO:
510: Ottawa
515: Kingston – Pembroke
520: Muskoka – Kawarthas
530: Toronto
540: Kitchener – Waterloo – Barrie
550: Hamilton – Niagara Peninsula
560: London
570: Windsor – Sarnia
580: Stratford – Bruce Peninsula
590: Northeast
595: Northwest

SASKATCHEWAN:
710: Regina – Moose Mountain
720: Swift Current – Moose Jaw
730: Saskatoon – Biggar
740: Yorkton – Melville
750: Prince Albert
760: Northern

Figure 7-3 **Option 3: Centralized Storage (Above or Below Ground)-Map**



resources present many options for locating a deep underground repository. Most notably, the 21 economic regions on the Canadian Shield may offer candidate sites. In addition, other rock formations such as the Ordovician sedimentary formations may prove to offer other robust sites for hosting a facility.

Figure 7-4 illustrates the economic regions that we believe present potentially suitable rock formations to support Phases 2 and 3 of implementation.

More specific examination of the regions, against siting principles and scientific and technical siting requirements, would determine the potential suitability of these regions for implementation of Option 4.

Table 7-4 specifies the economic regions that we propose be considered for possible implementation of Option 4: Adaptive Phased Management.

Table 7-4 Economic Regions for Possible Implementation of Option 4

<table>
<tr><th colspan="3">The economic regions specified below may be suitable for implementation of Option 4: Adaptive Phased Management</th></tr>
<tr><td>Economic regions at nuclear reactor sites:

Phase 1 Implementation</td><td colspan="2">Economic regions with rock formations potentially suitable for a centralized deep repository:

Phase 2 and 3 Implementation</td></tr>
<tr><td></td><td colspan="2">Economic regions with potentially suitable rock formations, within provinces associated with the nuclear fuel cycle:</td></tr>
<tr><td>List A:
6 Regions at Nuclear Reactor Sites

QUÉBEC:
433: Centre-du-Québec (Gentilly Reactors)

ONTARIO:
515: Kingston – Pembroke (Chalk River Laboratory Reactors)
530: Toronto (Pickering and Darlington Reactors)
580: Stratford – Bruce Peninsula (Bruce Power Reactors; AECL Douglas Point Reactor)

NEW BRUNSWICK:
330: Saint John – St. Stephen (Point Lepreau Reactor)

MANITOBA:
610: Southeast (Whiteshell Research Laboratory)</td><td>List B:
On the Canadian Shield:

QUÉBEC:
420: Québec
450: Lanaudière
455: Laurentides
460: Outaouais
465: Abitibi – Témiscamingue
470: Mauricie
475: Saguenay – Lac St. Jean
480: Côte-Nord
490: Nord-du-Québec

ONTARIO:
510: Ottawa
515: Kingston/Pembroke*
520: Muskoka – Kawarthas
590: Northeast
595: Northwest

SASKATCHEWAN:
760: Northern</td><td>List C:
On Selected Ordovician Sedimentary Formation:

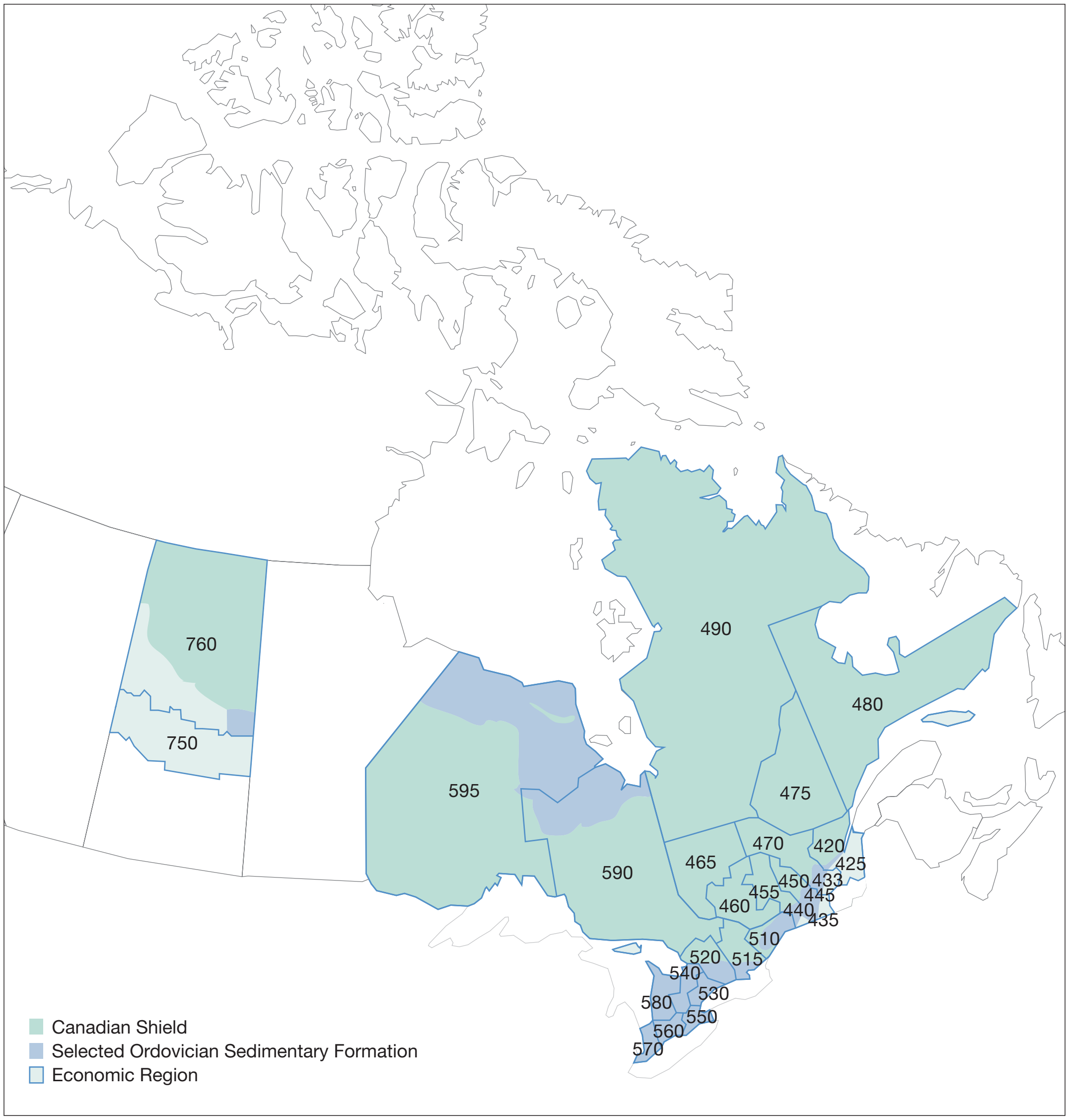
ONTARIO:
510: Ottawa**
515: Kingston – Pembroke*
520: Muskoka – Kawarthas**
530: Toronto*
540: Kitchener – Waterloo – Barrie
550: Hamilton – Niagara
560: London
570: Windsor – Sarnia
580: Stratford – Bruce Peninsula*
590: Northeast**
595: Northwest**

QUÉBEC:
420: Québec**
425: Chaudière – Appalaches
433: Centre-du-Québec*
435: Montérégie
440: Montréal
445: Laval
450: Lanaudière**
455: Laurentides**
460: Outaouais**
470: Mauricie**

SASKATCHEWAN:
750: Prince Albert
760: Northern **

* Economic Region already captured in List A.
** Economic Region already captured in List B.</td></tr>
</table>

Figure 7-4 Option 4: Adaptive Phased Management-Map



The NWMO specifies economic regions for implementation of:

- Phase 1: Regions presently hosting nuclear reactors
  > Economic regions with nuclear reactor sites.

- Phases 2 and 3: Regions with potentially suitable rock formations in the nuclear provinces, for example:
  > On the Canadian Shield; or
  > On selected Ordovician Sedimentary basins.

Although the NWMO has reviewed and identified a number of economic regions as required by the *Nuclear Fuel Waste Act*, we are not recommending the use of economic regions as the basis for siting a central facility for Options 1, 3 or 4.

Chapter 8 / Comparison of Benefits, Risks and Costs

In this chapter, we highlight the major exercises which the NWMO used to:

- Translate the direction of citizens into a concrete framework which could be used for assessment,
- Apply this framework to assess the used fuel management options, and
- Refine the assessment in light of comment and feedback by citizens.

Section 12(4) of the *Nuclear Fuel Waste Act* (*NFWA*) outlines the comparative assessment that the NWMO must undertake in considering the different management approaches. In response to the Act, Section 8.1 of this chapter describes the steps taken to develop the assessment framework within which we assessed the management approaches. Section 8.2 describes the systematic streams of analysis that we applied in examining the costs, benefits and risks of the management approaches and Section 8.3 reports on the results of our assessment. We conclude this chapter with a summary of the NWMO's assessment of the management approaches against the framework developed.

8.1 / Study Foundations: The Building of an Assessment Framework

The Challenge and Response

At the request of the federal and Ontario governments, and after a more than 20 year research program, a concept for the management of used nuclear fuel in Canada was developed by Atomic Energy of Canada Limited (AECL). This concept was subjected to a ten-year public environmental assessment and review process which, in 1998, culminated in a report known as the "Seaborn Report" after its chairman, Blair Seaborn. Among the key conclusions of the report were the following:

- "From a technical perspective, safety of the AECL concept has been on balance adequately demonstrated for a conceptual stage of development. But from a social perspective, it has not."
- "As it stands, the AECL concept for deep geological disposal has not been demonstrated to have broad public support. The concept in its current form does not have the required level of acceptability to be adopted as Canada's approach for managing nuclear fuel wastes."

The panel identified the absence of an ethical and social framework within which to assess options as an important issue.

The Government of Canada response to the report of the Panel articulated a policy framework for management of radioactive waste and provided direction for federal nuclear waste management policy, leading to the implementation of the *Nuclear Fuel Waste Act* (*NFWA*) in 2002. This Act put into law the requirement that the companies which produce used nuclear fuel must conduct a study of at least three options: deep geological disposal in the Canadian Shield; storage at nuclear reactor sites; and, centralized storage, either above or below ground. Importantly, among the requirements of this study was the following:

> 12. (4) Each proposed approach must include a comparison of the benefits, risks and costs of that approach with those of the other approaches, taking into account the economic region in which that approach would be implemented, as well as ethical, social and economic considerations associated with that approach.

Reflecting the lessons learned by the Seaborn Panel about the need to give weight to both technical considerations and social and ethical considerations in the determination of a management approach, and the explicit direction in the Act to treat ethical and social considerations as a key driver of any assessment, the

NWMO took upon itself a specific mission. This mission was to develop collaboratively with Canadians a management approach for the long-term care of Canada's nuclear fuel that is socially acceptable, technically sound, environmentally responsible and economically feasible. The NWMO has attempted to respond to these requirements by implementing a study, and assessment, which is broadly directed by the social and ethical concerns of citizens from its outset while being informed by the knowledge and experience of scientific and technical specialists in Canada and abroad.

As discussed in more detail in Chapter 3, we designed our study process to, as much as possible, be directed by the values, expectations and concerns of Canadians. To fully understand these values, expectations and concerns as they apply to the management of used nuclear fuel, the NWMO's study attempted to explore these considerations in an iterative way, with greater depth and detail as the study process and the NWMO's thinking evolved. As the core element of the study, the assessment of management approaches was also designed to be grounded in the values, expectations and concerns of Canadians while being informed by the knowledge and expertise of specialists. As reported in Chapter 4, this interplay between a broad dialogue with Canadians and the analysis of specialists began in 2002 and continued through to the writing of this report.

In practical terms, the NWMO attempted to develop a framework for assessment which integrates the broad range of social and ethical concerns with technical considerations. Early in the study, the NWMO's Roundtable on Ethics suggested that the best way of building such an integrated framework, which includes an appropriate treatment of ethical considerations, was to embed both ethical considerations and public values in the framework rather than separately from technical considerations. As the Seaborn Panel suggested earlier, and as the NWMO came to understand, social and technical notions of the core concepts of the assessment, such as what constitutes 'safety' and 'risk', are so intertwined they cannot be usefully separated for the purpose of development and application of an assessment framework. Social and technical perspectives on safety and risk, including the concept of 'social safety' as identified by the Seaborn Panel, must be treated in a holistic and integrated way throughout the assessment.

As a result, in the NWMO's assessment, ethical and social considerations have been considered in the context of the main substantive areas of the study. Ethical and social considerations factor into the determination of the objectives used in the assessment; for example community well-being, fairness and adaptability. They have also factored into the identification of the influences for performance of each objective; for example interspecies distributional fairness, intergenerational distribution of costs, and community social/cultural quality. Finally, ethical and social considerations factor prominently in the key dimensions of implementation; for instance accountability, continuous learning, engagement and participatory decision-making.

Roadmap for the Assessment

Three key inputs to the assessment emerged from the dialogue with Canadians early in the study process. As illustrated in Figure 8-1, these were:

- A set of ten key questions which should be asked and answered in the study;
- Elements of an ethical and social framework, including a list of citizen and Aboriginal values, a list of ethical principles suggested by the NWMO's Roundtable on Ethics, and a set of future scenarios identified from a multi-party scenario exercise as those which ought to be planned for in any decisions we make today; and,
- A body of technical and scientific (social and natural science) knowledge and expertise relevant to the long term management of used nuclear fuel.

Through further dialogue mid-way through the study, these inputs were:

- Distilled to a core list of eight key objectives designed to reflect the priorities and concerns of citizens as expressed in dialogue. These objectives are: fairness; public health and safety; worker health and safety; community well-being; security; environmental integrity; economic viability; and adaptability of the approach.

Using this foundation as guidance:

- A formal assessment framework was developed and applied in a preliminary way using a multi-attribute utility analysis methodology;
- Then a more formal comparative assessment of costs, benefits and risks was conducted using the same framework;
- This was supplemented by topical analysis, including a study on risk;
- An examination of implementation considerations emerged as a critical component of the analysis.

The assessment framework, and the preliminary assessment were the subject of dialogue with Canadians and resulted in additional comment and input to the more formal comparative assessment of costs, benefits and risks. Further dialogue and engagement assisted in the identification of the range of strengths and limitations of each management approach and important implementation considerations. The objectives, as they were elaborated over the course of the study, are described in detail in Appendix 8.

The discussion of the comparative strengths and limitations of the management approaches under study with interested Canadians continued with the release of the NWMO's *Draft Study Report* which included a preliminary description of the Fourth Option – Adaptive Phased Management approach. Through a number of major engagement activities with Canadians we invited comment on the appropriateness of the recommendation as input to our assessment.

Our analytical work was informed by a number of commissioned background papers and workshops. In total, we commissioned approximately 70 background papers to support our study. We engaged more than 115 scientific and technical advisors, and more than 94 advisors on governance, institutional and legal matters. As well, we engaged more than 300 knowledge specialists in public policy issues, the environment, Aboriginal Traditional Knowledge and social sciences. A list of these background papers and reports from workshops is provided in Appendix 11, and are available on the NWMO website.

The short list of options which became the focus of the assessment was the result of a preliminary screening of a longer list of options. A description of these options is contained in Appendix 9. The results of this preliminary screening, and the short list, were confirmed through dialogue as: Deep Geological Disposal in the Canadian Shield; Storage at Nuclear Reactor Sites; and Centralized Storage. This short list of options mirrors those specified in the *Nuclear Fuel Waste Act* as the ones which must be considered in the study.

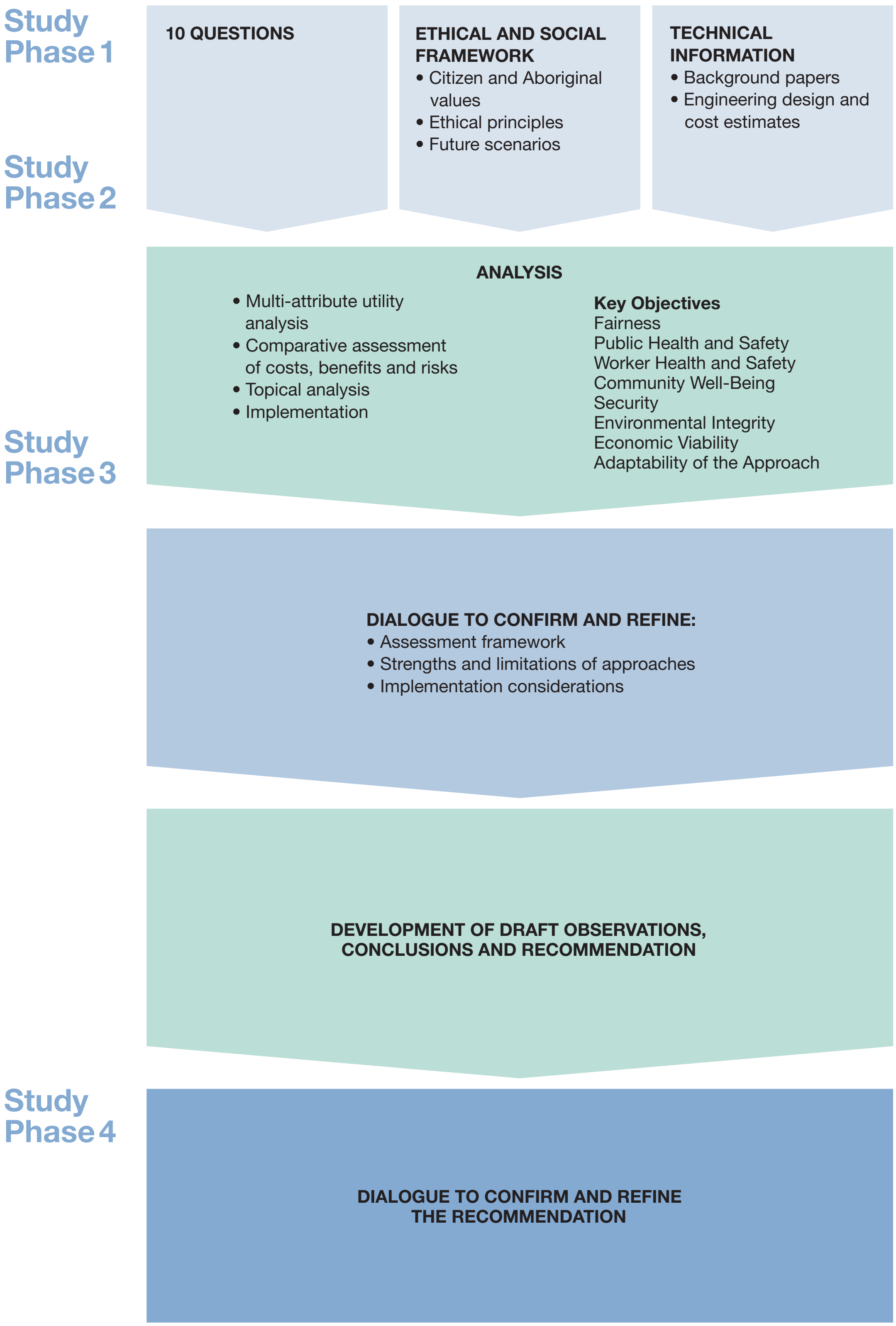
The multiple analytical processes and streams of analysis used in the assessment are discussed in more detail in Section 8.2.

8.2 / Streams of Analysis

The NWMO commissioned different, separate and complementary analyses to aid our understanding of the costs, benefits and risks of the management approaches in the study. For the purpose of all of these streams of analysis, the volume of used nuclear fuel which needs to be managed was assumed to be limited to the projected inventory from the existing fleet of reactors. In other words, the analyses were conducted using the facts as we know them at this time concerning the volume and nature of used fuel to be managed. It is possible that decision-makers may make decisions which cause the future to unfold in a way which is different from this 'reference scenario'. For this reason, this chapter concludes with a brief discussion concerning how well the preferred management approach might respond to a range of possible future scenarios in order to assess its robustness against such policy induced changes.

The basis for all of the assessments were the conceptual engineering designs for each of the management approaches and cost estimates prepared for the Joint Waste Owners, which were reviewed and validated by a third party and accepted by the NWMO.

Figure 8-1 **NWMO Assessment of Management Approaches**



Multi-Attribute Utility Analysis: Examining the Options Against Multiple Goals

The NWMO convened a group of individuals to work as an Assessment Team. These individuals were chosen for their diverse experiences and complementary skills in addressing complex public policy issues. Their skills ranged from environmental assessment and risk management to economic, financial and social policy analysis.

The team tackled a range of social, technical, environmental and economic aspects of used nuclear fuel management. They translated the 10 questions identified early in the study into a formal assessment framework that features eight objectives and a list of specific influencing factors based on the values and direction of Canadians identified through our engagement activities.

We asked the Assessment Team to develop and apply, in a preliminary way, a rigorous methodology for the assessment of management approaches. Consistent with the framework outlined in our first discussion document, the team selected a methodology that would allow for the integration of social and ethical objectives and principles, along with technical, economic, financial and environmental considerations.

The choice of the methodology was guided by the goals described above and influenced by a need to explicitly address multiple objectives in developing an approach for dealing with used nuclear fuel. These multiple objectives became evident in our first discussion document, *Asking the Right Questions? The Future Management of Canada's Used Nuclear Fuel*. The 10 questions listed in that report cover a broad range of objectives. Because of these multiple objectives, attention was restricted to a class of assessment methodologies known as "multi-objective" or "multi-criteria" decision tools, distinguished by their capacity to explicitly represent and work with multiple objectives.

Multi-attribute utility analysis (MUA) was selected because of its ability to aid in discriminating among options through a process of transparent deliberation. Multi-attribute utility analysis provides a step-by-step process for constructing and applying a decision model. It can be used to help identify a most preferred option, to rank options, to screen options down to a short list for more detailed analysis, or to distinguish acceptable from unacceptable choices. Many technical requirements (governing scoring, scaling, weighting, and aggregating) must be satisfied to ensure that rankings produced by the model logically flow from the judgments of the team. The evolved theory and long experience with MUA together provided a strong basis for the selection of this methodology.

Over the past two decades, numerous applications of multi-attribute utility analysis have been conducted in Canada, Great Britain, the United States and in many other countries, to assist decision-making in both the private and public sectors. A key characteristic of multi-attribute utility analysis (as well as other multi-objective approaches) is its emphasis on the judgments of the decision-making team that the analysis is intended to serve. The fact that multi-attribute utility analysis makes those judgments open and explicit was considered a strong advantage. Since the judgments and assumptions are represented as inputs to a decision model, interested parties can explore whether changes would alter conclusions.

The framework developed by the Assessment Team featured eight objectives: fairness; public health and safety; worker health and safety; community well-being; security; environmental integrity; economic viability; and adaptability. For each objective, factors that may influence the capacity to perform well against the objective were identified and mapped. The resulting "influence diagrams" created for each of the eight objectives, acted as a road map for the assessment. (See Appendix 8.) The focus of this analysis was on the objectives and factors that distinguished the management options from one another.

The team recognized that the management of used nuclear fuel must consider both a short and long-term perspective. Used nuclear fuel has the potential to affect humans and the environment for a very long period, likely hundreds of thousands of years or longer. No assessment of benefits, risks and costs can be complete without considering a range of time periods. Two time periods were used by the team for evaluating options:

Near Term, which was defined as roughly the first 175 years.

- The 175-year time horizon coincides with the seven generations concept that emerged from Aboriginal Traditional Knowledge as a target time horizon that we should use when considering the implications of today's decisions;

- It also coincides with the period during which site identification, development, licencing, operation and closure of a repository could occur. It represents a reasonable dividing line between the active period and the long-term, follow-on period;

- From a societal perspective, it is reasonable to assume the continuity of current institutional and economic structures and activities during this period;

- From a technical perspective, this time horizon marks the limit to which engineering predictions and the characteristics of human-made objects can be reasonably forecast. During such a period, environmental conditions, although undoubtedly changing, can be reasonably assumed to maintain some similarity to those of today; and

- From a scientific perspective, a period of about 175 years marks a defensible and fairly distinct division in the nature of the hazard to humans and biological life posed by nuclear fuel waste. It is the period when the used fuel bundles have been out of reactor for many decades and will have cooled substantially. By about this time, the short-lived radioisotopes, including many of the highly dangerous ones that account for most of the radioactivity contained in the waste when it is first removed from the reactor, will have decayed to insignificant levels. What will remain is the hazard from long half-life elements and isotopes that are present in much smaller quantities but remain dangerous for a very long time. During a 175-year period, the overall radioactivity of used fuel drops to about one-hundred thousandth of the level it was when removed from the reactors, but still poses a significant long-term hazard.

Long Term, which was roughly defined as the period beyond 175 years.

- In this time period, both Aboriginal Traditional Knowledge and future scenarios work conducted by the NWMO suggest it is not prudent to assume that social, institutional, or environmental conditions will closely resemble those of today;

- Although it is possible to predict the geological characteristics of rock with some confidence, the vagaries of environmental conditions above ground, combined with human-induced or natural stresses on the environment make any assessment of the human-ecological interactions extremely speculative; and

- The radioactivity of nuclear fuel wastes will continue to decline, but isotopes of iodine, chlorine, caesium, strontium and plutonium will remain radioactive and continue to pose health risks that continue to decline over time.

Three management options for used nuclear fuel were assessed using the framework. The individuals who comprised the Assessment Team did not assess each of the management options on the objectives in precisely the same way. In fact, the ranges in scores assigned by team members was quite wide, in most cases. The broad range of scores on many objectives reflected differing views among members of the Assessment Team concerning future environmental and social conditions in Canada, as well as questions regarding how well the approaches might actually perform.

The work of the Assessment Team also involved the conduct of a sensitivity analysis. This analysis included an assessment of the management approaches against plausible future alternatives. These scenarios were identified through a major NWMO scenarios exercise earlier in the study. Additional scenarios were considered by the NWMO. All are described in Appendix 10.

Through this assessment, the Assessment Team began to articulate strengths and limitations of each approach, and present this material as a basis for public discussion.

This analysis found that no single option on its own perfectly met all the objectives that Canadians said were important. The Assessment Team work brought into focus some of the difficult choices and trade-offs to be addressed as part of the assessment of the approaches.

The results of this assessment were published in our second discussion document in 2004, *Understanding the Choices* (www.nwmo.ca/understandingthechoices). Through this document, we sought public review of this assessment framework and we received comments that validated the appropriateness of the eight objectives. Accordingly, we adopted those objectives as the basis upon which we assessed the different management options. The full report of the Assessment Team is available at www.nwmo.ca/assessmentteamreport.

Broadening the Discussion of Strengths and Limitations

Given the intensive nature of the process used by the Assessment Team, the NWMO sought to broaden the discussion of the strengths and limitations of the approaches by involving interested Canadians in various parts of the process. This was used as a means of 1) exploring the appropriateness of the individual parts of the process; 2) increasing understanding of the process used so that members of the public would be better able to scrutinize, comment and add substantively to the discussion. As part of this effort, we attempted to replicate parts of the assessment process with various dialogue initiatives.

In the National and Regional Stakeholder dialogues, one full day of each two day session was devoted to familiarizing participants with the Assessment Team process and taking them through exercises which simulated some key aspect of the process. Approximately 90 individuals participated in these illustrative exercises. Additional sessions were conducted upon request.

In the nation-wide Public Information and Discussion sessions, to which all interested Canadians were invited, the objectives used by the Assessment Team and methodology were described, as well as the key findings concerning the relative advantages and limitations of each of the approaches which emerged from this assessment. Participants in these sessions were asked to comment on the appropriateness of the objectives, and the appropriateness and inclusiveness of the advantages and limitations which emerged from the assessment. Participants were encouraged to add to the list of advantages and limitations and suggest additional objectives which ought to be considered. More than 900 individuals participated in these sessions.

Focus groups and a nation-wide survey were also used to explore the appropriateness of the objectives used for the assessment. In total, more than 2800 individuals participated in this research.

Comparative Assessment of Costs, Benefits, and Risks

The assessment of the management approaches against the objectives was tested and enhanced using an expert multi-disciplinary team assembled by Golder Associates Limited and Gartner Lee Limited. These firms brought together a group of specialists knowledgeable in a range of scientific and engineering disciplines relevant to the long term management of used nuclear fuel and with direct experience in the field of nuclear waste management in Canada and/or abroad. This team included technical specialists as well as specialists in the natural and social sciences.

The objective of this work was to develop and implement a methodology to undertake a comparative assessment of benefits, risks and costs of the management approaches, taking into account illustrative economic regions and building off of the work of the Assessment Team.

Against the same eight objectives used by the Assessment Team, a comparison of the management approaches was undertaken on costs, benefits and on risks and uncertainty, looking at:

- Both near- and long-term time considerations; and
- Impacts of different site locations based on economic regions.

This assessment involved the following activities:

- Design and development of methods and tools for assessing the benefits, risks and costs of alternative approaches to the management of used nuclear fuel in Canada;
- Identification and development of background information for "illustrative" economic regions that would allow a comparison of the benefits, risks and costs for each approach with those of other approaches, taking into account the economic regions in which the approaches could be implemented. Note that the NWMO has not sought to select a specific site or single economic region for implementation of a management approach in this study. However, to meet the requirements of the legislation, we had to consider how the costs and benefits and risks might be affected when different types of economic regions are taken into account:
  - > Economic regions were selected for purposes of analysis which covered a range of physical and socio-economic conditions, illustrative of different regions of the country; and
  - > Illustrative economic regions were chosen to highlight how approaches might perform in regions with different physical and socio-economic foundations. Economic regions with different population densities, different distributions of economic activity and differing transportation requirements associated with implementing an approach were examined. This analysis was designed to highlight considerations that would arise in diverse economies, environments and population centres in an illustrative way for the analysis. It was not an attempt to pre-qualify or select sites for possible implementation.
- Examination of the numerous influencing factors for each of the eight objectives that were identified in the preliminary comparative assessment for further detailed analysis;
- Identification of measures and indicators for each of the influencing factors studied in detail for use in the comparative assessment. They were selected to allow the evaluation of the performance of the four approaches against each of the eight objectives, using quantitative measures for influencing factors where these are available and providing qualitative discussion on other influencing factors, where feasible;
- Analysis of the approaches across the applicable illustrative economic regions, using information from the chosen measures and indicators. For each option, the assessment looked at possible impacts, the consequence of impacts and the likelihood and timing when such an event might occur; and
- Assessment of the benefits, risks and costs using information from the above analysis. The analysis developed and applied appropriate and proven models that are capable of estimating effects within the social and environmental framework of the assessment, taking into account economic regions.

A detailed financial model of each management approach was developed to help assess "economic viability." These financial models describe the management phases and apply specific costs for labour and materials over a timeline extending out thousands of years. The models enabled testing of alternative costing assumptions. As well, the assessment of the community well-being objective was divided into two parts.

- First, economic relationships were modelled for 11 different illustrative economic regions. A unique input-output model was developed for each illustrative economic region, which enabled the study team to consider impacts on employment, income and taxes from the possible introduction of any of the management approaches. In addition, a qualitative assessment of other community values was conducted based on a combination of published literature and the study team's own extensive experience with nuclear and mining industry developments in both urban and rural regions of Canada; and

- The second part of the community well-being assessment involved application of the "Sustainable Livelihoods Framework" to each of the 11 illustrative economic regions. This framework allows an objective assessment of specific "capitals" including social, human, physical, financial, and natural. The intent of this quantitative analysis was to provide an indication of how each illustrative economic region ranks in its ability to adapt to the opportunities and challenges posed by the introduction of any of the management approaches.

The analysis introduced further information on how each approach was expected to perform against the eight objectives. It contributed further qualitative insights, to help broaden our understanding of costs, benefits and risks. Importantly, it included socio-economic analysis of the implications for the different types of economic regions that might host the facilities. This allowed us to consider how the location of a facility or facilities might affect benefits, risks, and costs. The detailed findings from this comparative assessment are available on our website. (**www.nwmo.ca/assessments**)

Topical Analysis

The NWMO assessment was also enhanced by a number of topical analyses. For instance, an analysis was conducted to estimate the potential risk associated with each stage of development of the options and main areas of potential risk were identified. Detailed findings from this and other topical analyses are available on our website. (**www.nwmo.ca/backgroundpapers**)

A Fourth Option Emerges

As we reflected on the assessment and listened to the commentary received from our engagement process with the general public and Aboriginal peoples, a fourth option began to emerge.

The three methods that we were required to study are well understood and are credible and viable from a technical perspective. Deep geological disposal is in an advanced state of scientific and technical understanding internationally. Used fuel storage technologies have been safely demonstrated for many years at reactor sites in Canada. However, as we listened to the public and Aboriginal peoples and considered the findings of our research, we understood that the most profound challenge does not lie solely in finding an appropriate technical method, but also in the manner in which the management approach is implemented.

The fourth option – Adaptive Phased Management – emerged from our observations.

With the emergence of the Fourth Option, work was then completed to extend the comparative assessment of costs, benefits and risks to the new hybrid option. Elements of the original conceptual engineering designs prepared for the Joint Waste Owners were used to create a preliminary design and cost estimate for the Fourth Option, which was used as the basis of the assessment.

8.3 / Assessment of Costs

Before presenting the findings from the assessment, the following discussion presents a comparison of costs of each of the management approaches, as required by the *Nuclear Fuel Waste Act*.

Table 8-1 presents the total (undiscounted) costs for each management approach as well as the present value cost for each management approach.

Cost estimates for Options 1, 2 and 3 were developed through work commissioned by the Joint Waste Owners – Ontario Power Generation Inc., Hydro-Québec, NB Power Nuclear, and Atomic Energy of Canada Limited. The Joint Waste Owners commissioned engineering consulting firms to develop preliminary conceptual engineering designs for the three technical methods identified in the *Nuclear Fuel Waste Act*, and also to develop associated transportation infrastructure and cost estimates for those designs. For each option specified in the Act, preliminary cost estimates were commissioned for siting, construction, operation, monitoring, closure and where applicable, closure and decommissioning of nuclear waste management facilities and for the transportation of used nuclear fuel. (www.nwmo.ca/costsummaries)

The NWMO commissioned a third-party review of this body of work for Options 1, 2 and 3. Independent consultants were asked to examine the key engineering design assumptions and cost estimation process. (www.nwmo.ca/engineeringreview) Their observations and conclusions were:

- All of the conceptual designs are credible, technically feasible and suitable for the intended purpose, which is to assess the options and arrive at a recommended approach;

- The conceptual designs are well developed and documented, and prepared in a manner consistent with established engineering practice; and

Table 8-1 Total Life Cycle Cost Estimates for Management Approaches

MANAGEMENT APPROACH	Total Cost (2002B$) (out to 350 years)	Total Cost (2002B$) (out to 1,000 years)	Present Value (Jan 2004 B$)
Option 1: Deep Geological Disposal in the Canadian Shield	16.2	16.3	6.2*
Option 2: Storage at Nuclear Reactor Sites			
Current Technology	17.6		2.3
New Above Ground Technology	25.7	68.4	4.4
New Below Ground Technology	21.6		3.6
Option 3: Centralized Storage			
Casks/Vaults in Storage Buildings	15.7		3.1
Surface Modular Vaults	20.0	47.0	3.8*
Cask/Vaults in Shallow Trenches	18.7		3.6
Casks in Rock Caverns	17.1	40.6	3.4*
Option 4: Adaptive Phased Management			
With Shallow Underground Storage	24.4	24.4	6.1*
Without Shallow Underground Storage	22.6	22.6	5.1*

JWO cost estimates are based on 3.7 million fuel bundles and an average reactor life of 40 years. Golder estimates are based on 3.6 million fuel bundles.
Estimates for Options 1, 2 and 3 out to 350 years were prepared by consultants for the Joint Waste Owners (www.nwmo.ca/costsummaries).
Estimates for Options 1, 2 and 3 out to 1,000 years were prepared by Golder Associates Ltd. and Gartner Lee Ltd. (www.nwmo.ca/assessments).
Estimates for Option 4 were prepared by Golder Associates Ltd. and Gartner Lee Ltd. (www.nwmo.ca/assessments).
*Present value calculations performed by Golder Associates Ltd. and Gartner Lee Ltd., are for 1000 year total estimates.
All remaining present value figures were ta en from Joint Waste Owners cost estimates using 350 year total cost estimates.
o te 1000 year cost estimates were produced from an illustrative sample of all possible management approaches, for comparative purposes only.

- Design details are consistent with the conceptual nature of the work and there is no reason to suspect that an appropriate final design could not be developed for an approach selected from the designs reviewed.

The third-party review of the cost estimates for Options 1, 2 and 3 concluded that they have been prepared with an appropriate estimating methodology and are suitable for the options review and directional decision-making requirements of the NWMO. (www.nwmo.ca/costreview) Specifically, the review of cost estimates included a professional opinion that the accuracy of these estimates was assessed as being within the range of plus or minus 33 percent including all the contingency allowances. These estimates were considered suitable for their purpose in assessing the magnitude of the cost of the scenarios and their alternatives.

Based on this work, the NWMO adopted these cost estimates for Options 1, 2 and 3, as thorough and reasonable cost estimates for the options based on a conceptual stage of design. A cost estimate for Option 4 was created by extracting costs from like activities in Options 1, 2 and 3.

Although definitive costs are not yet known, estimates include costs for:

- Public Health and Safety. Costs of radiation protection are accounted for in the economic costs of all approaches through facility designs and monitoring programs using today's technology and standards. There are no differences among economic regions;

- Worker Health and Safety. Costs for worker safety, including radiation protection and conventional occupational health and safety protection, are accounted for in the economic costs of all management approaches through facility designs and monitoring programs;

- Security. Costs for security are accounted for in the economic costs of all four approaches through facility designs and monitoring programs;

- Environment. Costs for environmental integrity are accounted for in the economic costs of the management approaches through facility designs and monitoring programs;

- Citizen engagement. Costs for public engagement and consultation are provided for in the cost estimates;

- Research. The cost estimates include provision for ongoing research; and

- Transportation costs. The incremental transportation costs for Deep Geological Disposal in the Canadian Shield, Adaptive Phased Management, and Centralized Storage (above or below ground) have a similar range, and vary across economic regions by up to about $1 billion (2002 dollars, not discounted). Incremental transportation costs are greater for economic regions located farther from the majority of the used nuclear fuel, which is in southern Ontario. There are no transportation costs associated with Storage at Nuclear Reactor Sites. A representative transportation cost for the other three approaches is in the range of $1.2 billion (2002 dollars, undiscounted).

The cost estimates used in evaluating each of the studied management approaches were prepared at a conceptual level, and do not include specific allocations for all labour requirements, ancillary facility operations or physical retrieval of placed fuel. The cost estimates include a contingency of approximately 20 percent, to cover possible changes in concept implementation. More detailed conceptual designs and cost estimates will be prepared during the normal course of implementation following a decision by the Government of Canada. These cost estimates and a more detailed discussion of provisions for financial surety are provided in Chapter 11.

We have reported on costs in two ways: present value and undiscounted total costs. Both convey key information for understanding the economic aspects of each option. For purposes of defining funding requirements an acknowledged and accepted practice is based on the use of present value estimates. For purposes of understanding socio-economic impacts, it is instructive to also look at the undiscounted cash-flow profiles for each management approach. In examining the projected timing and repeat cycles of investments associated with building, refurbishing and maintaining a facility, the magnitude of socio-economic impacts on communities from the project over time can better be appreciated. This assists in anticipating and planning for the benefits and challenges associated with managing those cyclical changes within the community hosting the facility.

Figures 8-2 to 8-6 illustrate the undiscounted cash-flow profiles for each management approach to Year 1000. These cash flows do not include costs for interim storage, retrieval and transportation.

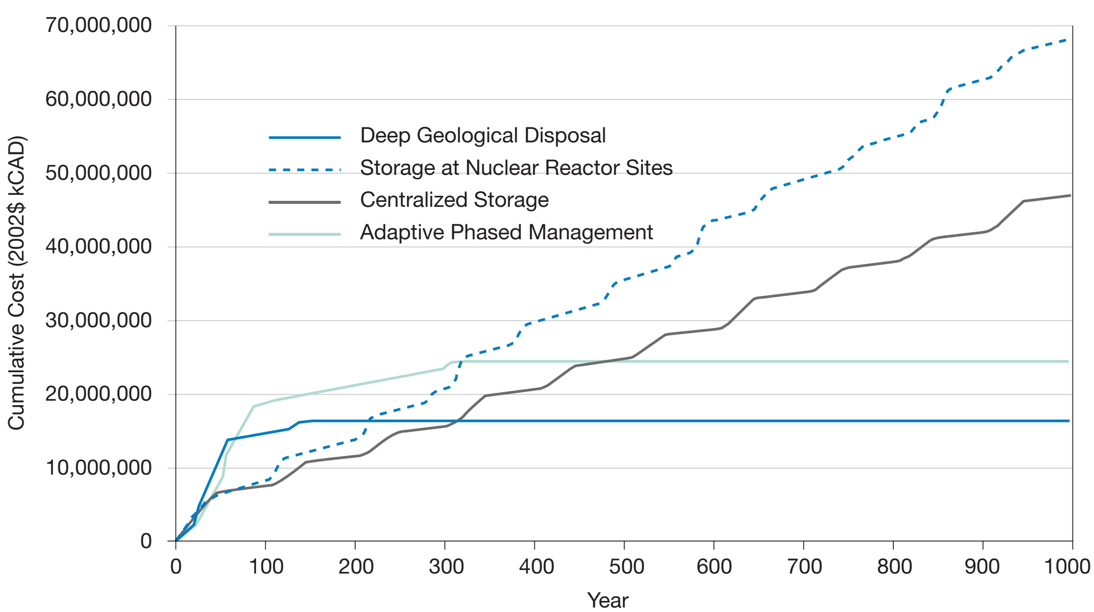
Key observations include:

- Option 1: Deep Geological Disposal in the Canadian Shield has the highest short-term cumulative cost ($10.1 billion in 2002 dollars, not discounted), up to Year 59, the time when all facilities (for all four approaches) are filled with used nuclear fuel, while Option 3: Centralized Storage (below ground) has the lowest cumulative cost ($2.6 billion in 2002 dollars, not discounted) for the same period.

- Option 4: Adaptive Phased Management has the highest cumulative cost ($16.95 billion in 2002 dollars, not discounted) up to Year 175 while Option 3: Centralized Storage (below ground) has the lowest cumulative cost ($6.6 billion in 2002 dollars, not discounted) for the same period.

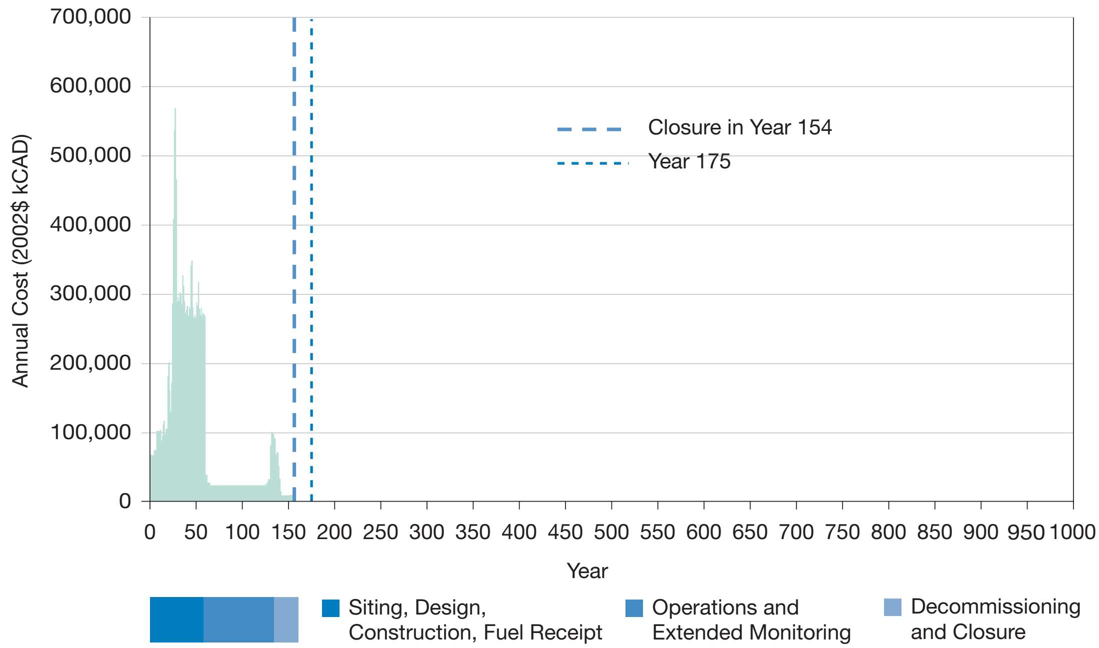
- Option 2: Storage at Nuclear Reactor Sites has the highest cumulative cost ($67 billion in 2002 dollars, not discounted) up to Year 1,000 (i.e., the "long-term" period selected for this study), while Option 1: Deep Geological Disposal in the Canadian Shield has the lowest cumulative cost ($12.7 billion in 2002 dollars, not discounted) over the same period.

Figure 8-2 Cumulative Costs: Options 1, 2, 3 and 4 (including Interim Storage, Retrieval and Transportation)



Note: No allowances for postclosure monitoring

Figure 8-3 Total Cash Flow: Option 1 – Deep Geological Disposal in the Canadian Shield (including Interim Storage, Retrieval and Transportation)



Note: No allowances for postclosure monitoring

Figure 8-4 Total Cash Flow: Option 2 – Storage at Nuclear Reactor Sites (New Above Ground Technology) (including Interim Storage, Retrieval and Transportation)

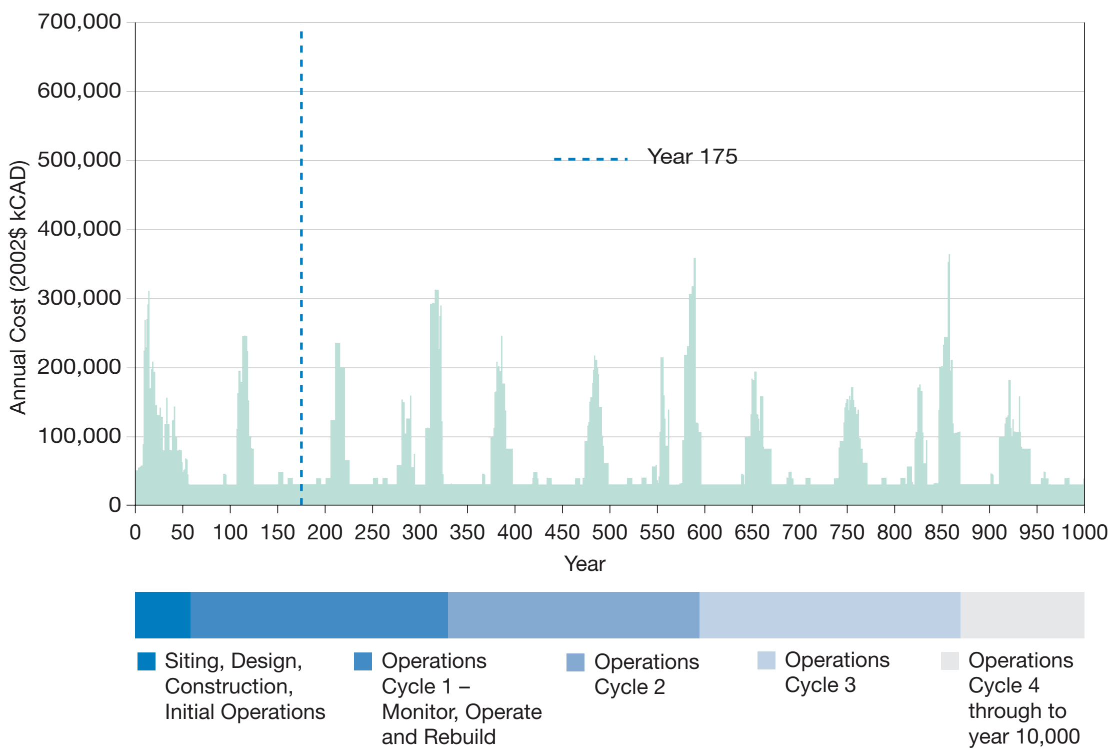


Figure 8-5 Total Cash Flow: Option 3 – Centralized Storage (Above Ground) (including Interim Storage, Retrieval and Transportation)

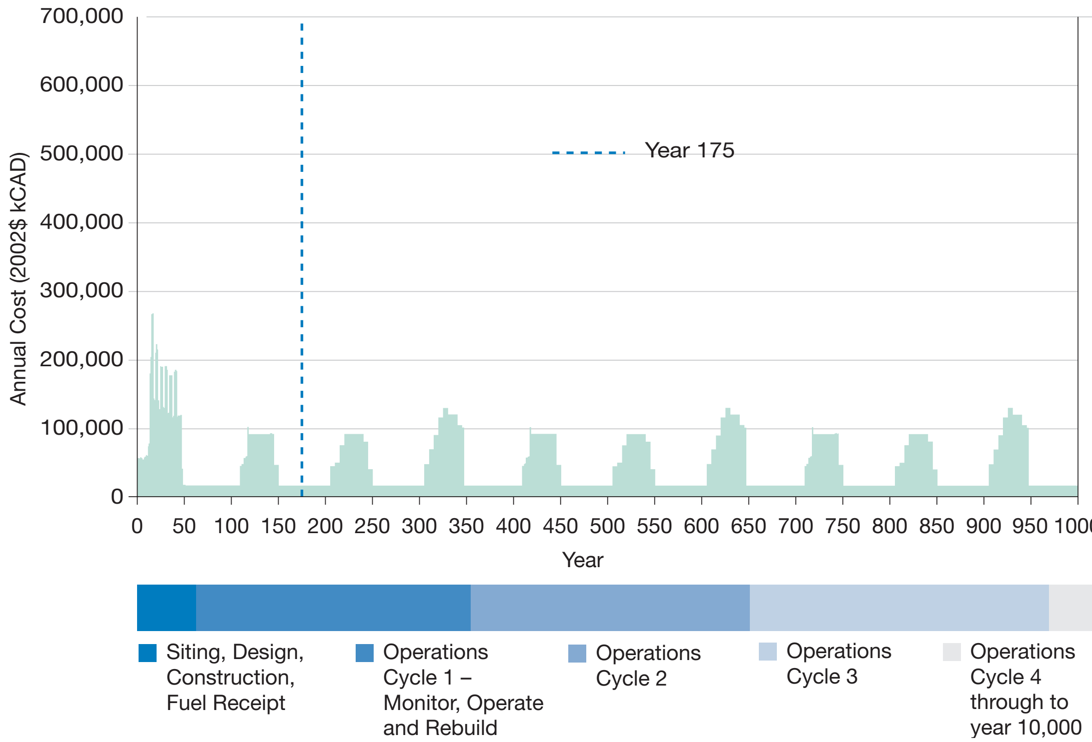
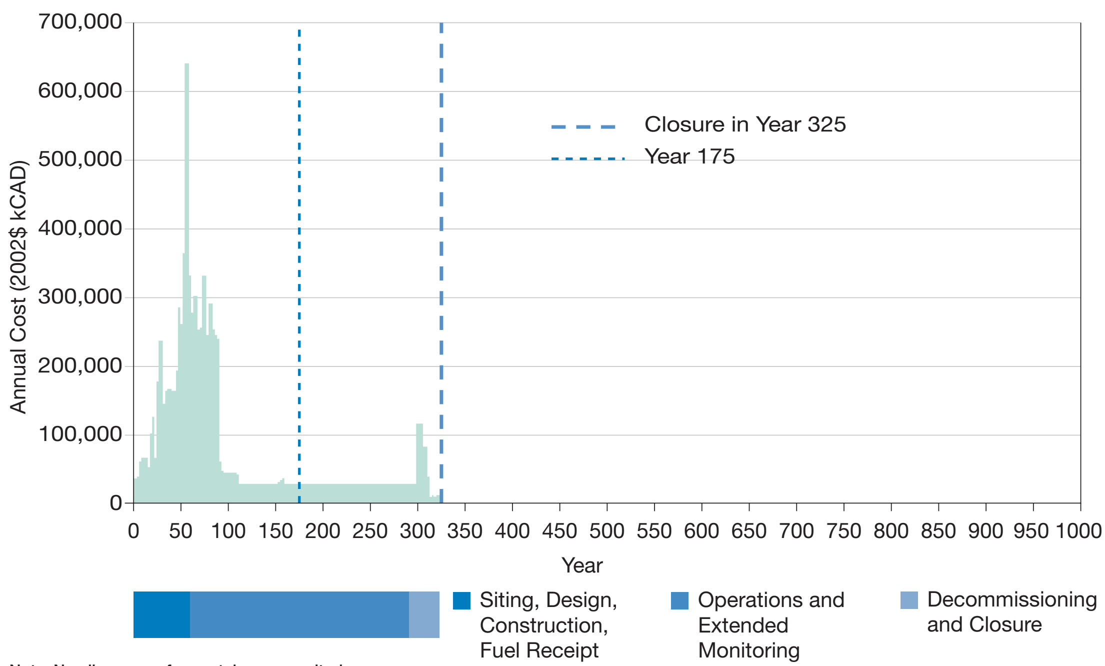


Figure 8-6 Total Cash Flow: Option 4 – Adaptive Phased Management (including Interim Storage, Retrieval and Transportation)



Note: No allowances for postclosure monitoring

8.4 / Our Assessment Findings

As required in the *NFWA*, we have compared the benefits, risks and costs of each management approach, taking into account economic regions in which that approach might be implemented, as well as ethical, social and economic considerations associated with that approach.

In this section, we present the key findings from our comparative assessment as we examined each of the four options against the eight objectives established for our study. We identify the benefits and areas of risk and uncertainty.

The assessment draws upon a wide variety of reports, background papers, dialogues and assessments conducted over the course of the study, all of which are available on the NWMO website. What follows is the NWMO's assessment of the options, informed by interpretation and conclusions of these reports, papers, dialogues and assessments.

Analysis of Objective 1 – Fairness

Our objective:
To ensure fairness (in substance and process) in the distribution of costs, benefits, risks and responsibilities, within this generation and across generations.
The selected approach should produce a fair sharing of costs, benefits, risks and responsibilities, now and in the future. In addition, fairness means providing for the participation of interested citizens in key decisions through full and deliberate public engagement during different phases of decision-making and implementation.

In our assessment of fairness, we considered issues of both substantive and procedural fairness.

Substantive fairness focuses on the content or substance of the approach. It includes consideration of how the costs and benefits associated with the approach would be distributed among different people and between humans and other species. It also includes consideration of intergenerational fairness. A key question for intergenerational fairness is the balance struck between the desire that the current generation take responsibility for resolving the problem once-and-for-all versus the desire not to overly constrain future generations by the choices we make today.

Procedural fairness focuses on the processes used and is mainly a function of the degree to which the approach would allow for the participation of concerned citizens in key decisions about how the approach would be implemented. This, in turn, depends in part on the opportunities for decision-making provided by the approach and the availability of information that would be helpful for driving those decisions.

Comparative Assessment

Table 8-2 presents our assessment of the relative benefits and risks and uncertainty for each of the four options studied.

Table 8-2 Fairness

	BENEFITS	RISKS & UNCERTAINTY
All approaches	All four management approaches have elements that support a strong claim to having distributed risks, costs, and benefits fairly across generations and within generations.	There are important but different uncertainties associated with each of the options in terms of intergenerational fairness.
Option 1: Deep Geological Disposal	Results in the eventual permanent placement of the used nuclear fuel, which reduces or may eliminate the necessity for long-term institutional and operational continuity and financial surety. As a consequence, after placement and closure, provision of long-term resources and funding are not required. It therefore places the responsibility on the current generation for ensuring that the long-term management facility is in place. It supports intergenerational fairness in limiting the burden on future generations to take further actions in managing the fuel. In the near term, provides the opportunity for public participation in locating the facility at a new central site. In the near term, it offers a significant economic boom to a host region and province. In the longer term, as a single centralized facility, it limits exposure to hazards and is designed to be passively safe which should limit overall risks and uncertainty.	In the longer term, provides little flexibility for future generations to influence the management of used nuclear fuel or to make fundamental changes without incurring considerable additional costs. Depending upon the economic region selected, could be in a region not having benefited from the production of nuclear energy. This risk is considered to be greater than for Option 3 and Option 4 because the requirement to site the facility in the Canadian Shield necessarily narrows the focus for siting which may result in a less fair distribution of the costs and risks. More communities will be affected since this option involves transportation of used nuclear fuel; however many if not all of these would likely have benefited from the power, at least indirectly. This risk is judged to be very small. In the short term, may be difficult to find an accepting host community or region. There is some uncertainty associated with how the system will perform over the long term. In the unlikely event of a breach of containment, it may be difficult for a future generation to detect the breach in a timely way and take corrective action. Although it offers a significant economic boom to a host region and province, this is expected to be followed by a rapid decline (bust) after construction of the deep repository and placement of fuel in it.

Table 8-2 (cont'd) Fairness

	BENEFITS	RISKS & UNCERTAINTY
Option 2: Storage at Nuclear Reactor Sites	In the short term, these communities have benefited from jobs and economic spin-offs associated with the nuclear plant and there is some element of fairness in having these same communities manage the waste from this activity while they receive benefits. Provides flexibility for future generations to influence the management of used nuclear fuel. It is easier to monitor human and environmental effects, to take corrective action, should it be required, and take advantage of new learning. Reactor site community residents have experience in living and working in communities with nuclear facilities. In the near term, the infrastructure, including skilled workers, and well-developed security systems, is in place to support nuclear facilities. No transportation of used nuclear fuel would be required, as the used fuel would remain next to where it is generated and so other communities would not be affected. The science and technology required are well in-hand. Offers financial and economic benefits to six economic regions simultaneously with the greatest benefit occurring in south-central Ontario, where the majority of used nuclear fuel is currently located.	Places responsibility on future generations to take responsibility for managing the used fuel consumed by this generation through the requirement to actively manage the waste to ensure safety over tens of thousands of years. Social, technological and moral liabilities are placed on future generations who will have to address the current generation's used nuclear fuel, and ensure the ongoing financial surety to safely manage the operations in perpetuity. With multiple sites to be managed, the potential costs and risks passed on to future generations could be higher than with one centralized facility. Creates obligations for existing reactor site communities for the ongoing, long-term management of used nuclear fuel. This function was not envisioned when the reactor sites were chosen initially, nor was it understood by the communities and businesses that have chosen to locate in the vicinity of these facilities. In order for future generations to receive some advantage from the ability to access the waste and make incremental improvements should they wish, it will be necessary to ensure strong institutions and financial surety mechanisms continue to be in place over the very long term. This is an area of high uncertainty. Other parts of the province, if not country, have benefited from nuclear power and would not be sharing equally in the costs of managing the used fuel. Few if any contingency plans/options should current site(s) become compromised. Even though the benefits accruing to the community are cyclical (following the pattern of ongoing facility replacement, which is required with this approach), these cycles are far enough apart that the host region(s) cannot avoid a "boom and bust" type cycle and the attendant costs.

Table 8-2 (cont'd) Fairness

	BENEFITS	RISKS & UNCERTAINTY
Option 3: Centralized Storage	Provides flexibility for future generations to influence the management of used nuclear fuel. It is easier to monitor human and environmental effects, to take corrective action, should it be required, and take advantage of new learning. The science and technology required are well in-hand. Provides the opportunity for public participation in locating the facility at a new central site. In the near term, provides for a facility that is purpose-built for long-term management. As a single centralized facility, it limits the exposure of populations to hazards. Provides flexibility for future generations to influence the management of used nuclear fuel. Provides more options where facility can be sited, since host geology is not a critical factor for this approach.	Places responsibility on future generations to manage the fuel consumed by this generation through the requirement to actively manage the waste to ensure safety over tens of thousands of years. Social, technological and moral liabilities are placed on future generations who will have to address the current generation's used nuclear fuel, and ensure the ongoing financial surety to safely manage the operations in perpetuity. In order for future generations to receive some advantage from the ability to access the waste and make incremental improvements should they wish, it will be necessary to ensure strong institutions and financial surety mechanisms continue to be in place over the very long term. This is an area of high uncertainty. Even though the benefits accruing to the community are cyclical (following the pattern of ongoing facility replacement, which is required with this approach), these cycles are far enough apart that the host region(s) cannot avoid a "boom and bust" type cycle and the attendant costs. Depending upon the community selected, it could be in a region not having directly benefited from the production of nuclear energy. This risk is considered to be less than for Option 1 because of the greater flexibility in siting the facility which may result in a fairer distribution of benefits, cost and risks. More communities will be affected since this option involves transportation of used nuclear fuel, however many if not all of these would likely have benefited from the power, at least indirectly. This risk is judged to be very small.

Table 8-2 (cont'd) Fairness

	BENEFITS	RISKS & UNCERTAINTY
Option 4: Adaptive Phased Management	Places the majority of responsibility on the current generation for ensuring that a long-term management facility is in place. Supports inter-generational fairness in limiting the burden on future generations to take further actions in managing the fuel. Responds to the sentiment of Canadian society, that the generations of citizens benefiting from nuclear power and creating the associated wastes have an obligation to provide a lasting means for managing that waste while at the same time preserving options for future generations to make decisions that they believe are in their own best interests. It calls for the construction of permanent facilities early in the implementation process in order to ensure that this generation has provided for viable long-term management facilities to reduce the burden on future generations. It calls for an extended period of flexibility in decision making in moving from current reactor site storage to eventual placement in a centralized deep repository and the potential sealing of this repository. This will leave room for future generations to influence the final stages of implementation, particularly over the period in which it is reasonable to expect that societal institutions will remain strong. Provides for an extended validation and optimization program, to enhance ultimate performance of the facility. Through proactive contingency planning, it ensures there are safe and secure storage facilities available for management of the used fuel at each point in the process. Implementation is phased, allowing for time to learn and benefit from new science and emerging findings on technology and to continue to gauge the risk and uncertainty in light of new knowledge associated with moving through the phases. This includes leaving the decision to a future society regarding the best time for closing and sealing the deep repository.	This approach attempts to balance the uncertainties and potential implications to fairness associated with Option 1 and with Option 3. It attempts to optimize flexibility in the near term, and ensure there is an option in place to contain and isolate the waste in the very long term, which does not rely upon human intervention. However, in so doing, it carries the risks of flexibility in the near-term period, although these risks are expected to be less than in the storage approaches because the period of risk is timed to coincide with the period in which it is reasonable to believe we are in the best position to actively manage this risk. In the very long term, it also carries the risks associated with the repository system, although these risks are expected to be less as a result of the planned extended period of technology investigation, testing and confirmation and the adaptive staging embodied in this approach. Depending upon the community selected, it could be in a region not having directly benefited from the production of nuclear energy. The flexibility of geologic media, some of which can be found closer to existing reactor sites, allows greater flexibility in siting and potentially a fairer distribution of benefits, costs and risks compared with Option 1. Transportation of the used nuclear fuel will involve more communities in the risk associated with the implementation of the approach. However, it is expected that this risk will be small. The fundamental importance of collaborative decision-making at multiple points in the implementation, which is embodied in this approach, is also expected to ensure that fairness issues associated with siting, as these are understood by those most directly affected, will be identified and explicitly addressed before any site decision is made.

Table 8-2 (cont'd) Fairness

	BENEFITS	RISKS & UNCERTAINTY
Option 4 (cont'd): Adaptive Phased Management	As a blend of a flexible centralized storage facility over the next 300 years, coincident with an extended period of proof of concept activities, and final placement of used nuclear fuel in a deep repository, this approach is judged to provide the fairest distribution of benefits and risks within this generation and across generations. Involves the creation of a long-term facility that could be located away from existing communities. Provides the potential for the location of this facility to maximize fairness since the restrictions on the host geology for the deep repository are substantially less than for Option 1.	

Summary Findings

Option 4 is judged to be the strongest of the options on the objective of fairness on both of its dimensions: substantive and procedural fairness.

Intergenerational Fairness

Concerning intergenerational fairness, all four management approaches have elements which support a strong claim to having distributed risks, costs, and benefits fairly across generations although there are important but different uncertainties associated with each of the options.

Option 1 provides for intergenerational fairness in placing the responsibility on the current generation – the generation benefiting from nuclear power – for ensuring that the long-term management facility is constructed and available to take the used fuel. Once the deep repository is closed, there are few if any requirements of future generations to ensure the continued isolation and containment of the waste. However, there is some uncertainty associated with how the system will perform over the very long term. In the unlikely event of a breach of containment, it would be difficult for a future generation to detect the breach in a timely way and take corrective action.

In contrast, Option 2 and Option 3, the storage options, provide for intergenerational fairness in offering a high degree of flexibility to future generations in terms of making their own decision about how best to manage the nuclear fuel. It would be easier to monitor human and environmental effects, to take corrective action should it be required, and take advantage of new learning. However, there is some uncertainty associated with whether societal capacity to actively manage the facility will endure for the thousands of years required with these approaches. Should this capacity not exist in the future, then the storage options will have left an unmanageable and unfair burden on future generations.

Option 4 provides some balance between these two potential contributors to intergenerational fairness, and for this reason is judged to be the strongest of the approaches on this dimension:

- It calls for the construction of facilities early in the implementation process in order to ensure that this generation has provided for viable long-term management facilities;

- It calls for an extended period of flexibility in decision-making in moving from current reactor site storage to eventual placement of used fuel in a centralized deep repository and in the potential sealing of this repository. This, in order to leave room for future generations to influence the final stages of implementation, particularly over the period in which it is reasonable to expect that societal institutions will remain strong;

- Through proactive contingency planning, it ensures there are safe and secure storage facilities available for management of the used fuel at each point in the process, including a facility which is designed to be passively safe should future societies be unable or unwilling to actively manage the used nuclear fuel; and

- Implementation is phased, allowing for time to learn and benefit from new science and emerging findings on technology. It also allows time to continue to gauge the risk and uncertainty in light of new knowledge associated with moving through the phases. In particular, a future society will determine the best time for closing and sealing the deep repository.

Interspecies Distributional Fairness

Concerning interspecies distributional fairness, all four management approaches are expected to be constructed and operated using best management practices. This is expected to minimize adverse effects on humans, non-human biota and the environment. In this respect, all four management approaches are judged to have a claim to be fair in terms of interspecies distributional fairness.

The key to ensuring interspecies distributional fairness is being able to prevent, effectively monitor, detect and mitigate adverse consequences in a timely manner. The question of whether one of the options is better than the others on this dimension, as with intergenerational fairness, requires judgment as to the magnitude of the uncertainties associated with: the capacity of future generations to actively manage a storage facility; and, the probability that a sealed deep repository will experience a major breach of containment.

It must be noted that Option 1 and Option 3, the approaches that involve the centralization of waste in a single facility, involve transportation and its associated risks and uncertainties. We expect that used nuclear fuel can be transported safety with little if any adverse effects to humans, non-human biota and the environment. We judge this to be a small incremental risk associated with these approaches. Option 4 attempts to provide a balance between the two major uncertainties mentioned above and for this reason is judged to be the strongest of the options on interspecies distributional fairness.

Distributional Fairness

Implementation of any of the four management approaches is expected to bring significant employment and income (wealth) benefits to the local host economic region, the host province, and to Canada as a whole. The degree of benefit does vary considerably between the four management approaches, as outlined in the previous tables. Although we believe it will be important for any management approach selected to be implemented in a way which contributes to the wealth of the host community and region, and all reasonable efforts should be made in this regard, we believe the wealth benefits associated with each of the options should not drive the selection of the management approach.

Many of the same factors pertaining to intergenerational and interspieces fairness have a similar impact in consideration of distributional fairness. Although flexibility for future generations is preserved with the storage approaches, the distribution of costs is highly skewed to future generations. For both the storage options, social, technological, and moral liabilities are placed on many future generations who will have to deal with the current generation's used nuclear fuel. With the Deep Geological Disposal approach, the distribution of costs is skewed toward current generations, however future generations are bequeathed a lesser ability to easily actively manage their risk through monitoring the used fuel and taking corrective action should it be required.

Transportation is a consideration in terms of the geographic distribution of benefits and risks. For the options which require transportation of used nuclear fuel to a centralized site, Option 1 and Option 3, communities along the transportation route(s) would be expected to incur some added risks but few, if any, benefits as transportation services and infrastructure may originate from outside these regions. However, these risks are limited in time duration and are expected to be very low. As such, this is not judged by the NWMO to be a determining factor.

The options which require centralization of the waste have the potential of involving a community which has not directly benefited from the production of nuclear energy but would be expected to incur some costs or risk associated with the long term management facility. Option 3 and Option 4, however, allow for a greater choice of sites because they can be built in a wider variety of geological media compared with Option 1.

Option 4, as a blend of a flexible centralized storage facility over the next 300 years, coincident with an extended period of proof of concept activities, and final placement of used nuclear fuel in a deep repository, is judged to provide the fairest distribution of benefits and risks within this generation and across generations.

Participation

Procedural fairness is influenced by the degree to which the approach would allow for the participation of concerned citizens in key decisions about how the approach would be implemented. This includes consideration of the opportunities for decision-making provided by the approach and the availability of information that would be helpful for driving those decisions.

Storage at reactor sites is viewed as least fair for several reasons. Perhaps most importantly, this storage approach would obligate existing reactor sites with on-going, long-term management of used nuclear fuel. This function was not envisioned when the reactor sites were initially chosen, nor was it understood by the communities and businesses that have chosen to locate in the vicinity of these facilities.

By contrast, the centralized approaches involve facilities that could be located away from existing communities, thus lessening the unfairness of involuntarily subjecting many people to additional risks. The opportunity for public participation in the locating of a centralized storage or deep disposal facility is seen to be a positive attribute with regard to fairness, assuming that the siting process will be a voluntary one. Option 4 shares the same benefits as Option 1 and Option 3, and is therefore judged to be among the strongest on this fairness dimension.

Analysis of Objective 2 – Public Health and Safety

Our objective:
To ensure public health and safety.
Public health ought not to be threatened due to the risk that people might be exposed to radioactive or other hazardous materials. Similarly, the public should be safe from the threat of injuries or deaths due to accidents during used nuclear fuel transportation or other operations associated with the management of used nuclear fuel.

In assessing the options against public health and safety, we considered many factors. We believe that any management system employed will result in direct or indirect risks to the health and safety of affected individuals or communities that must be fully acceptable according to current safety standards. The possibilities of unplanned events that could present unexpected risks or stresses must be considered, and appropriate contingency action provided. There should not be foreseeable outcomes of the approach that lead to greater risks to the public from the used nuclear fuel facility at any time in the future than is acceptable today.

The physical, chemical and radiological characteristics of used nuclear fuel, and their hazards, are well understood. Those hazards need to be managed to prevent unreasonable risk. Licensing requirements and compliance verification by the Canadian Nuclear Safety Commission will ensure that the effectiveness of any management approach will be monitored.

The public health and safety aspects of each approach were assessed under both the short (1 – 175 year) and long (greater than 175-year) time-frames. Risks were estimated under normal expected operating conditions and under "off-normal" scenarios in which members of the public might be inadvertently exposed to hazards associated with the various approaches.

Under normal operating conditions, risks associated with the following operations were considered: packing for shipment, transfer from old to new canisters, vehicle accidents, canister transport to dry storage and exposures during monitoring. Other risk scenarios considered included unanticipated deterioration of the natural and engineered barriers constructed to isolate the fuel, large-scale transportation accidents (e.g., the wreck of a train carrying used nuclear fuel), facility accidents, and unintended human intrusion.

Comparative Assessment

Table 8-3 presents our assessment of the relative benefits and risks and uncertainty for each of the four options studied.

Table 8-3 Public Health & Safety

	BENEFITS	RISKS & UNCERTAINTY
Option 1: Deep Geological Disposal	Radiological and non-radiological exposure to the public is expected to be well within current Canadian regulatory standards and norms with the performance and operation of the facility as designed. The public health and safety benefits, in comparison with the other options, are judged to be most pronounced in the very long term. The intrinsic geological features of the site, in combination with engineered features such as long-lived waste packages and material buffers are designed to isolate the used nuclear fuel from the accessible environment for the very long time periods that they remain hazardous. Not reliant on ongoing institutional control of the facility, it avoids risks that might otherwise be posed in the event of long-term societal instability. Deep underground placement reduces safety concerns both before and after closure because the materials would be difficult to access. Probability of unauthorized or inadvertent human intrusion into the closed repository is very low. Would allow for site selection solely on the basis of used nuclear fuel management and its public health and safety impacts. That is, the facility would be sited and designed to protect public health and safety. As well, the facility may be sited away from population centres and so fewer people would be potentially at risk. Although there does not currently exist a facility of this type in Canada or elsewhere, there has been a great deal of scientific and technical work completed on the design and operation of such a facility in both Canada and abroad. This work includes the study of the performance of natural analogues which have existed over the timeframes for which the facility would need to be effective.	There is some uncertainty regarding the performance of the system over the very long term because advance "proof" that such a system works is not scientifically possible. Detailed scientific studies, models and codes, and natural analogues, therefore, form the foundation of the assurances of performance. During normal and off-normal conditions in the near term, all potential exposures are expected during or just after placement of the fuel in the facility. Movement of radioactivity released from failed used fuel containers through the groundwater pathway is possible for hundreds of thousands of years into the future. However, predicted impact is well below applicable standards because of isolation provided by the host geological formation. Monitoring of system performance becomes more difficult once the used nuclear fuel is placed deep underground and as the site is backfilled and closed. In the unlikely event of a breach of containment sufficient to have an adverse environmental impact, the breach would be relatively more difficult to detect and address than in the storage options. Retrieval of the used fuel for corrective action is difficult and costly, involving similar risks to the public as used fuel placement. Transportation of the used nuclear fuel will be required and there is some risk to people along the transportation route because of conventional transport accidents. Robust containers are designed to ensure radiation containment in the face of a broad range of accident scenarios, covering both common and extreme events. Overall, radiation exposures for normal and off-normal transportation activities are considered very small. Risk of transport accidents depends on transportation distances and routes. Economic regions farther away from the sources of used fuel will potentially expose more members of the public to risk.

Table 8-3 (cont'd) Public Health & Safety

	BENEFITS	RISKS & UNCERTAINTY
Option 1: (cont'd) Deep Geological Disposal		Flexibility to address changing environmental conditions is low, however changing conditions are not expected to affect the performance of the system. Reversibility of decisions is difficult once the facility is closed. There is a lack of confidence by a substantial proportion of Canadians that enough is known to proceed with this option at this time, and that the waste can be transported safely. The probability of off-normal scenarios during the near term is very low. As well, with a negligible likelihood of human intrusion after the facility is closed, institutional controls would have to fail during the relatively short operational period for there to be even a risk of human intrusion and the resulting unacceptable risk to the public.
Option 2: Storage at Nuclear Reactor Sites	Radiological and non-radiological exposure to the public is expected to be well within current Canadian regulatory standards and norms with the performance and operation of the facility as designed. Movement of radioactivity is prevented through active management and institutional controls. The public health and safety benefits, in comparison with the other options, are judged to be most pronounced in the shorter term. In the short term, storage facilities are easy to monitor, making it easy to identify problems and take corrective action. Current capacity for effective management of facilities exists and has been demonstrated. The science and technology required are well in-hand. Existing processes have a record of ensuring protection of public health and safety and operating well within regulatory benchmarks in the near term. There is a reasonable expectation of the continuation of this performance over the near term.	In the long term, lacks the natural barriers afforded by placing the used nuclear fuel deep underground, and for this reason the safety of the facilities depends primarily on active management and maintaining institutional controls that prevent or restrict access. This may be increasingly difficult over the long term, because, for example, of the possibility that social instabilities might occur at some future time period; future societies may not be as safety conscious as we are today, safety operations may become lax over time, and/or the possibility of extreme natural or human induced events in the long term. Over the long term, the potential for events that might trigger exposure will increase. For example, there are risks that extreme natural events such as very high winds, rise in sea level, global warming or cooling, and earthquakes could damage the facilities, particularly given the location of some facilities in higher seismic zones and adjacent to large bodies of water.

Table 8-3 (cont'd) Public Health & Safety

	BENEFITS	RISKS & UNCERTAINTY
Option 2: (cont'd) Storage at Nuclear Reactor Sites	Each of these sites already houses nuclear installations, so there is nuclear expertise on site and in the existing communities. Ability to monitor and demonstrate the ongoing performance is high. Flexibility to adapt to changing conditions or new information is high. With the option of shallow below-ground storage, some safety concerns are diminished. No transportation of used nuclear fuel is required off the nuclear plant site, as the used fuel would remain where it is generated; therefore there are no off-site transportation related risks.	If the integrity of institutions is compromised as it may be in the future, the value of monitoring and flexibility is lost, and in fact becomes a liability. Storage at seven sites, rather than one central site, introduces possible risk to a greater number of people. As well, these reactor sites were selected for their suitability for reactor operation, not for very long term safe storage of used nuclear fuel. The fact that several of these sites are located near larger population centres further increases the potential risk to the public. The used nuclear fuel will remain hazardous well beyond the decommissioning and ultimate abandonment of the nuclear reactor site. Although corrective action is expected to be easier, alternative options (contingency plans) in the event of unplanned circumstances are very limited. Repeated repackaging cycles cause an associated risk of radiation exposure well into the future (greater than 10,000 years). The probability of off-normal scenarios during the near term is very low However, if institutional controls cannot be maintained for thousands of years, human intrusion into the facility is likely, with the resulting radiation exposures and unacceptable risk to the public.

Table 8-3 (cont'd) Public Health & Safety

	BENEFITS	RISKS & UNCERTAINTY
Option 3: Centralized Storage	Radiological and non-radiological exposure to the public is expected to be well within Canadian regulatory standards and norms with the performance and operation of the facility as designed. Movement of radioactivity is prevented through active management and institutional controls. The public health and safety benefits, in comparison with the other options, are judged to be most pronounced in the shorter term. In the short term, storage facilities are easy to monitor, making it easy to identify problems and take corrective action. Current capacity for effective management of similar types of facilities exists and has been demonstrated. The science and technology required are well in-hand. Existing processes have a record of ensuring protection of public health and safety and operating well within regulatory benchmarks in the near term. There is a reasonable expectation of the continuation of this performance over the near term. Ability to monitor the performance is high. Flexibility to adapt to changing conditions or new information is high. With the option of shallow below-ground storage, some safety concerns are diminished. Would allow for site selection solely on the basis of used nuclear fuel management and its public health and safety impacts. That is, the facility could be sited and designed to protect public health and safety. As well, the facility may be sited away from high population centres and so fewer people would be potentially at risk. Siting choices extend to both economic regions on the Canadian Shield and to areas of sedimentary rock in other regions, offering greater opportunities to limit transportation distances.	In the long term, lacks the natural barriers afforded by placing the used nuclear fuel deep underground, and for this reason the safety of the facilities depends primarily on active management and maintaining institutional controls that prevent or restrict access. This may be increasingly difficult over the long term, because, for example, of the possibility that social instabilities might occur at some future time period; future societies may not be as safety conscious as we are today; safety operations may become lax over time; and/or the possibility of extreme natural or human induced events in the long term. Over the long term, the potential for events that might trigger exposure will increase. For example, there are risks that extreme natural events such as very high winds, rise in sea level, global warming or cooling, and earthquakes could damage the facility. These risks would be mitigated in part by careful selection of the centralized site, and by the fact that there is only one facility. These risks would also be reduced were the facility to be located shallow underground. If the integrity of institutions is compromised as it may be in the future, the value of monitoring and of flexibility is lost and, in fact, becomes a liability. Transportation of the used nuclear fuel will be required and there is some risk to people along the transportation route because of conventional transport accidents. Robust containers are designed to ensure radiation containment in the face of a broad range of accident scenarios, covering both common and extreme events. Overall, radiation exposures for normal and off-normal transportation activities are considered very small. Risk of accidents depends on transportation distances and routes. Economic regions farther away from the sources of used fuel will potentially expose more members of the public to risk. Repeated repackaging cycles cause an associated risk of radiation exposure well into the future (greater than 10,000 years).

Table 8-3 (cont'd) Public Health & Safety

	BENEFITS	RISKS & UNCERTAINTY
Option 3: (cont'd) Centralized Storage		The probability of off-normal scenarios during the near term is very low. However, if institutional control cannot be maintained for thousands of years, human intrusion into the facility is likely, with the resulting radiation exposures and unacceptable risk to the public.
Option 4: Adaptive Phased Management	Radiological and non-radiological exposure to the public is expected to be well within Canadian regulatory standards and norms if the facility is built to specification and managed as designed. It allows time to establish confidence in both transportation and the efficacy of the deep repository concept, before proceeding with them. Allows for an extended validation and optimization program, so that full advantage can be taken of early repository system operation to justify confidence in performance or permit necessary additional measures to be taken during the period when institutional integrity is more certain. It allows a period of high flexibility in which new learning might be easily incorporated. It allows confidence to be established through a stepwise process, the pace of which can be adapted to mirror public confidence. In the long term, when institutional integrity is most uncertain, it offers important public health and safety advantages of multiple engineered and geological barriers for used nuclear fuel isolation. Being located deep underground, the radioactive materials would be contained and isolated and difficult to access. In the deep repository, the used fuel is protected by both robust natural barriers provided by the geological formation (crystalline or sedimentary rock), as well as the engineered barriers in terms of container design, buffer materials, etc. The facility can be sited and designed to protect public health and safety by minimizing the likelihood that material released would come into contact with the public. Siting choices extend to economic regions on the Canadian Shield and suitable areas of sedimentary rock, offering greater opportunities to limit transportation distances.	Additional fuel handling associated with an optional step of shallow underground storage represents a small increased risk compared to Option 1. Transportation of the used nuclear fuel will be required and there is some risk to people along the transportation route because of conventional road accidents. Robust containers are designed to ensure radiation containment in the face of a broad range of accident scenarios, covering both common and extreme events. Overall, radiation exposures for normal and off-normal transportation activities are considered very small. Risk of conventional road accidents increases with transportation distances. Economic regions farther away from the sources of used fuel will potentially expose more members of the public to risk. The probability of off-normal scenarios during the near term is very low. As well, with a negligible likelihood of human intrusion after the facility is closed, institutional controls would have to fail during the operational period for there to be even a risk of human intrusion and the resulting unacceptable risk to the public. The period of operation is somewhat longer than for Option 1, so the risk is greater. The period of operation is much shorter than for Options 2 and 3, so the risk is much lower. Due to the extended implementation period, there is a risk that the societal will to complete the implementation process may diminish to the point of threatening the safe operation of the management system. Compared with Option 2 and Option 3, this risk is small. Compared with Option 1, this risk is greater, although the NWMO judges the risk to be small.

Summary Findings

For all four options, public health and safety performance is expected to be well within Canadian regulatory standards and norms in the near term provided that the facilities are built and operated as designed. In all cases, public health and safety would be protected through the use of multiple barriers to contain and isolate the used nuclear fuel from the environment. These natural and/or engineered barriers will be enhanced by institutions and oversight focused on ensuring that standards are met for both radiological and non-radiological exposures. Over the near term, accessibility and flexibility, in combination with strong institutional control, is judged to be the approach which best protects public health and safety. It allows for continuous learning and incremental improvements to be made.

Over the long term, a passive system that can effectively contain and isolate the material without requiring institutional control is judged to be a better approach to safety than one that continues to rely upon institutions.

Over the long term, Options 1 and 4, which are expected to achieve passive safety through a combination of engineered and natural geological barriers are preferable to storage approaches which rely to a large extent on institutional control to maintain safety. The combination of robust engineered barriers, together with the geological barriers associated with placement deep underground, is more likely to effectively contain and isolate the used fuel for the thousands of years over which the material remains hazardous.

Storage options such as those envisaged under Options 2 and 3 have a strong track record of effective management and ensuring public health and safety to date. There is every reason to expect continuation of positive operating performance over the near term. The significant downside risk associated with these storage options relates to their reliance on ongoing institutional controls and societal oversight, which may not be reliable in perpetuity. Without the benefit of the multiple barriers, including geological barriers, these options require ongoing active management and monitoring to ensure public health and safety.

When both the near term and the long term are considered, Option 4 is judged to offer the greatest benefits in terms of public health and safety. In the near term, the staged management of this approach allows for continuous learning that enables us to address many areas of uncertainty and establish further confidence in the deep repository concept before proceeding. Option 4 allows for a high degree of flexibility in implementation, offering time to learn and observe emerging science and to incorporate new developments that may emerge over the next few decades. Contingencies are available at each point in the process to ensure effective containment and isolation of the used nuclear fuel. The approach envisages an option for interim centralized storage below ground, as a step along the implementation path. And the approach allows for future generations to make the determination when the deep repository is most appropriately closed and sealed, as the last step in providing permanent safety and security. Over the long term, the combination of natural geological and engineered barriers would be designed to ensure that public health and safety are protected even in the absence of institutional controls.

In order to best protect the health and safety of individuals and the public at large, we understand that an optimal balance needs to be found between flexibility in the near term, which allows for new learning, and the implementation of an approach which isolates and contains the used fuel in a way which does not require active care by people over the very long term. Option 4 provides such a balance. Dialogue with Canadians has highlighted that an optimal balance also needs to be struck between moving cautiously, to allow for new learning and building of social confidence, and sustaining sufficient momentum to carry forward with the implementation of the approach to completion. Should the implementation period be too protracted, there is a risk that future generations will lose interest and/or otherwise abandon the approach mid-way through implementation with negative impacts on public health and safety as a result.

There is some risk associated with each of the approaches studied that momentum will be lost in the face of public opposition and/or loss of will. In recommending a stepwise implementation process, which involves potentially impacted communities of interest at each major point of decision-making, the NWMO believes that public acceptability will be greater with the Adaptive Phased Management approach than for Option 1. Public acceptance will expedite implementation of the deep repository by matching the pace and manner of implementation to the pace at which society is prepared to proceed. In laying out a process in which key decision points have been mapped, along with the means to ensure those involved in the decision (potentially impacted communities of interest) have the required capacity and information to make the necessary decisions, and putting contingencies in place should unforeseen events be encountered, implementation will proceed in as efficient a manner as social conditions allow. Through provision of the decision-making process, and contingencies for multiple decision-making outcomes, the continued safe management of used nuclear fuel would best be assured though to completion of implementation.

Analysis of Objective 3 – Worker Health and Safety

Our objective:
To ensure worker health and safety.
Construction, mining and other tasks associated with managing used nuclear fuel can be hazardous. The selected approach should not create undue or large risks to the workers who will be employed to implement it.

In assessing options for impacts on worker health and safety, we considered a number of factors. The management system and the technologies used, the design, the construction methods and the operational and monitoring procedures should be such that, in addition to complying with good engineering practices and all industrial safety regulations, workers involved with the used nuclear fuel facility should not be subject to risks or harmful exposures, chronic or accidental, greater than those acceptable to Canadian or international authorities at the time of construction. Workers engaged in future monitoring or maintenance activities should not be subject to risks greater than those acceptable today.

Risks were separately estimated for two time periods. They were estimated based on normal, expected operating conditions and under "off-normal" scenarios in which workers might be inadvertently exposed to hazards associated with the various approaches. Under normal operating conditions, worker risks associated with the following operations were considered: construction, transportation, fuel handling, and monitoring. The main "off-normal" risk scenarios considered included an extreme construction accident, accidental radiological exposures and extreme fuel handling accidents.

Comparative Assessment

Table 8-4 presents our assessment of the relative benefits and risks and uncertainty for each of the four options studied.

Table 8-4 **Worker Health & Safety**

	BENEFITS	RISKS & UNCERTAINTY
Option 1: Deep Geological Disposal	Radiological and non-radiological risks to workers during operations and transportation are expected to be well within Canadian regulatory standards and norms with the performance and operation of the facility as designed. Minimal radiation exposure to workers over the long term. Avoids radiation exposure to workers from ongoing perpetual repackaging and handling of the fuel. Once the facility is closed, no additional worker activities required.	In the short term, would require the relatively higher risk tasks of mining and earth moving. The size of the workforce required to support implementation of this option, and the number of workers potentially at risk, is about three times higher than for Options 2 and 3 in the near term. However, much of the work would be mechanized and a relatively small number of workers would be directly involved in hazardous operations. In the short term, the risks to workers arise mainly from construction and transportation requirements, and are non-radiological in nature. Even though radiological exposures may well occur, based on the adoption of safe operating practices and robust oversight, they are unlikely to cause serious health consequences. Would involve transportation of used fuel, with the potential risks of traffic accidents and other dangers to drivers. The level of risk to workers through traffic accidents will be affected by the specific routes taken and transportation distance and therefore the choice of economic region selected for the deep geological disposal facility.
Option 2: Storage at Nuclear Reactor Sites	Radiological and non-radiological risks to workers during operations are expected to be well within Canadian regulatory standards and norms with the performance and operation of the facility as designed. Does not require off site transportation, thus avoiding the risks to workers associated with transport-related accidents. Involves minimal construction risks.	Produces worker risks during the refurbishment of existing facilities and construction of new facilities repeatedly as the containers degrade and the fuel must be repackaged. The risks are greater than with Option 1 and Option 4 because significantly more handling and packaging would be required. Some risk of injury is associated with the requirement for ongoing repackaging and handling of used fuel in perpetuity. Construction risks extend into the long term, due to the fact that the facility will need to be rebuilt every 300 years. Institutions must continue to function well to ensure that the safe practices that protect workers (and others) do not decline. As long as institutions remain effective, unacceptable risks to workers due to radiation exposure are unlikely. Has all of the on-site worker risks associated with the centralized storage approach plus would require continuing operations involving more workers at multiple sites with differing conditions.

Table 8-4 (cont'd) Worker Health & Safety

	BENEFITS	RISKS & UNCERTAINTY
Option 3: Centralized Storage	Radiological and non-radiological risks to workers during operations and transportation are expected to be well within Canadian regulatory standards and norms with the performance and operation of the facility as designed. Construction related work risk is less than for Option 1 and Option 4. The consolidation of the used fuel at a single site allows for process optimization and oversight to ensure worker safety, compared with Option 2.	Produces worker risks during the construction of the facility and repeatedly as the containers degrade and the fuel must be repackaged. The overall risks are greater than with Option 1 and Option 4 because significantly more used fuel handling and packaging is required. Some risk of injury is associated with the requirement for ongoing repackaging and handling of used fuel in perpetuity. Construction risks extend into the long term, due to the fact that the facility will need to be rebuilt every 300 years. Institutions must continue to function well to ensure that the safe practices that protect workers (and others) do not decline. As long as institutions remain effective, unacceptable risks to workers due to radiation exposure are unlikely. Would involve transportation of used fuel, with the potential risks of traffic accidents and other dangers to drivers. The level of risk to workers through traffic accidents will be affected by the specific routes taken and transportation distance and therefore the choice of economic region selected for the centralized storage facility.

Table 8-4 (cont'd) Worker Health & Safety

	BENEFITS	RISKS & UNCERTAINTY
Option 4: Adaptive Phased Management	Radiological and non-radiological risks to workers during operations and transportation are expected to be well within Canadian regulatory standards and norms with the performance and operation of the facility as designed. Minimal radiation exposure to workers over the long term. Avoids radiation exposure to workers from ongoing perpetual repackaging and handling of the fuel. Once the facility is closed, no additional worker activities required. Phased implementation, with possibility of interim underground storage in rock caverns would involve slightly more handling of the fuel than in Option 1, but less than with Options 2 and 3.	The size of the workforce required to support implementation of this option is about three times higher than for Options 2 and 3, in the near term. Would involve transportation of used fuel, with the potential risks of traffic accidents and other dangers to drivers. The level of risk to workers though traffic accidents will be affected by the specific routes taken and transportation distance and therefore the choice of economic region selected for the central facility. Siting choices extend to both economic regions on the Canadian Shield and suitable areas with sedimentary rock, offering opportunities to limit transportation distances and associated worker risk as compared to Option 1. Low levels of worker risk would continue through to the closure of the facility and the longer period of institutional control and monitoring as compared to Option 1. As well the optional step of shallow underground storage would involve some additional risk associated with construction and fuel handling.

Summary Findings

In all four options, radiological and non-radiological risks to workers during operations and transportation are expected to be well within Canadian regulatory standards and norms provided that the activities are conducted as planned. Options 1 and 4 offer the lowest risk to workers because these approaches limit risks to workers to finite periods of time during which the centralized facilities are built, the sites investigated, and used fuel is moved and placed into the facilities. Worker risk would be slightly higher under Option 4, which involves an expanded implementation timeline for additional monitoring and phased decision-making, as well as potentially an additional interim storage step, compared with Option 1.

In contrast, Options 2 and 3 require ongoing risks to workers because storage operations would continue in perpetuity, with ongoing requirements for repackaging and handling of used fuel. It is expected that up to 100 repackaging cycles would be required over a 10,000-year period.

The consolidation of the used fuel at a single site associated with Option 3 incrementally reduces the worker risks associated with Option 2, which would require ongoing operation and fuel handling at seven different locations. This is because with consolidation, fewer workers are involved with Option 3 and process optimization and oversight to ensure worker safety would be easier to achieve at a single site rather than at multiple sites.

Analysis of Objective 4 – Community Well-Being

Our objective:
To ensure community well-being.
Implications for the well-being of all communities with a shared interest (including host community, communities in the surrounding region and on the transportation corridor, and those outside of the vicinity who feel affected) should be considered in the selection and implementation of the management system and related infrastructure. A broad range of implications must be considered, including those relating to economic activity, environmental disruption and social fabric and culture.

The assessments with respect to community well-being considered both the likely economic impacts of the approach, and the potential effects on social and cultural qualities of affected communities. On the economic side, consideration was given to potential effects on property values, jobs and businesses. Potential social and cultural impacts include raising fears and concerns of citizens and the risk of community polarization (e.g., contrasting beliefs between those who support and those who oppose locating a facility near their community). Some residents may see living near a radioactive waste management facility as placing a stigma on their community.

Comparative Assessment

Table 8-5 presents our assessment of the relative benefits and risks and uncertainty for each of the four options studied.

Table 8-5 Community Well-Being

	BENEFITS	RISKS & UNCERTAINTY
All approaches	All four management approaches provide significant economic benefits. No matter which management approach is ultimately used, and no matter what site location is preferred, economic benefits accrue to all Canadians, but the host province and region stand to capture the majority of employment, income and tax benefits. All of the management approaches provide substantial economic benefits in terms of the creation of thousands of jobs, billions of dollars in new income and new tax revenue to all three levels of government. Well executed implementation will enable these benefits to be aligned with the realization of social, cultural and economic aspirations and support the long-term stability of the affected communities. Economic impacts would extend to enhancements to community infrastructure associated with supporting the facility, such as construction of improved roads and generation of higher-paying jobs.	Despite the very positive economic benefits resulting from all four management approaches, there are a variety of social and economic costs that are attendant with projects of this magnitude, particularly when sited in rural regions of Canada. “Boom and bust” cycles linked to each of the management approaches involve thousands of workers and billions of dollars in expenditures with likely temporary effects on: housing and land values; demand for social and physical infrastructure services from influx of short term and temporary workers; and local and regional government tax revenues. The analysis of eleven illustrative economic regions shows that there are distinct differences among regions in relation to capacity to adapt to the positive and negative “shock(s)” that are linked to all four management approaches. The more rural and remote regions, including some Aboriginal communities, have lower adaptive capacity. Should a facility be sited in such a region, adequate support would need to be given to these communities to ensure they are able to effectively participate in decision-making and ensure a full slate of benefits accrues to them. As well, Aboriginal communities and those who have chosen to live in less populated areas may be concerned about the development commercializing their way of life, and cultural disruption in general.

Table 8-5 (cont'd) Community Well-Being

	BENEFITS	RISKS & UNCERTAINTY
Option 1: Deep Geological Disposal	Is expected to be implementable with no adverse consequences to the community, assuming a decision-making process that involves affected communities, and appropriate mitigation measures are taken. Economic benefits are provided in the near-term. Significant expenditures on transportation required to support this option generate thousands of jobs and income that extend beyond the host region. If done well, siting can be achieved with community participation. With no significant operations required in the long term, the facility would not lead to the same repeat cycles of boom and bust associated with Options 2 and 3. Results in the eventual permanent placement of the used nuclear fuel, which reduces the necessity for long-term institutional and operational continuity and financial surety. In the near term (less than 175 years), both Option 1 and Option 4 provide the greatest income, employment and tax benefits by up to a factor of two compared to Storage at Nuclear Reactor Sites, and by up to a factor of eight compared to Centralized Storage (above or below ground). Option 1 and Option 4 are roughly equivalent in economic value in each illustrative economic region.	Creating a new facility in a new location may create more adverse impacts on communities than leaving the waste where it is. Requires transportation away from existing reactors and would likely raise concerns of communities along the transportation routes, particularly if the safety of transportation had not yet been established to the satisfaction of those communities. Communities on transportation routes would need to have concerns addressed. Over the long term, the limited opportunity to demonstrate system performance (for instance by monitoring and access) may be a source of lingering concern among some in the community.

Table 8-5 (cont'd) Community Well-Being

	BENEFITS	RISKS & UNCERTAINTY
Option 2: Storage at Nuclear Reactor Sites	Is expected to be implementable with no adverse consequences to the community, assuming a decision-making process that involved affected communities, and appropriate mitigation measures are taken. Economic benefits to the community are spread out over thousands of years. In the long-term, only Option 2 and Option 3 generate any significant economic benefits from ongoing maintenance and cyclical facility rebuilding. Consequently economic, employment and income generating benefits continue for thousands of years. This option is the only approach that simultaneously develops facilities at all seven current reactor sites. Benefits are more widely distributed across six regions/seven sites, with the regions managing the largest volumes of used fuel capturing the greatest share of benefits. The most urbanized region is likely to gain the most economic benefit in absolute terms. As with centralized storage, the required science and technology are well in hand. Further, the opportunity to monitor the performance and the flexibility to adapt to changing conditions is facilitated. Is expected to be implementable with no adverse consequences to the community, assuming a decision-making process that involved affected communities, and appropriate mitigation measures are taken.	Boom and bust cycles associated with Option 2 continue through the ongoing operation of the facilities, repeated cyclically with the repackaging and facility rebuilding required every 100 years and 300 years respectively. Requires continuing administrative controls and operations, including the necessary funding, for the thousands of years the used nuclear fuel remains hazardous. These reactor sites were selected for their suitability for reactor operation, not for very long-term storage of used nuclear fuel and therefore may not be ideal for this purpose. The used nuclear fuel will remain hazardous and will need to be secured well beyond the almost certain shutdown and ultimate abandonment of the nuclear reactor sites. Multiple sites would need to be secured, some located next to important bodies of water. Changing the role of the reactor storage sites from temporary to long term would involve significant facility upgrades – there is potential to polarize the more immediate community because some people may feel betrayed by the change of status of the facility from interim to long-term waste management. As well, the proximity of a facility that is acknowledged to involve risks may be a target for citizen legal action.
Option 3: Centralized Storage	Economic benefits to the community are spread out over thousands of years. In the long-term, only Option 2 and Option 3 generate any significant benefits from ongoing maintenance and cyclical facility rebuilding. Consequently economic, employment and income generating benefits continue for thousands of years. The extent of benefits captured locally depends upon the nature of the economic region hosting the facility.	Boom and bust cycles associated with Option 3 continue through the ongoing operation of the facilities, repeated cyclically with the repackaging and facility rebuilding required every 100 years and 300 years respectively. Centralized storage shares with the at-reactor storage option the key disadvantage of requiring effective and continuing administrative controls and operations, including the required funding, for thousands of years.

Table 8-5 (cont'd) Community Well-Being

	BENEFITS	RISKS & UNCERTAINTY
Option 3: (cont'd) Centralized Storage	As with storage at nuclear reactor sites, the required science and technology are well in hand. Further, the opportunity to monitor the performance and the flexibility to adapt to changing conditions is facilitated. If done well, siting can be achieved with community participation.	Creating a new facility in a new location may create more adverse impacts on communities than leaving the waste where it is. Requires transportation away from existing reactors and would likely raise concerns of communities along the transportation routes, particularly if the safety of transportation had not yet been established to the satisfaction of those communities. Communities on transportation routes would need to have concerns addressed.
Option 4: Adaptive Phased Management	Is expected to be implementable with no adverse consequences to the community, assuming a decision-making process that involved affected communities, and appropriate mitigation measures are taken. Phased implementation allows for a more gradual implementation period, and more opportunity for community adjustment than is possible with Option 1. Since this approach includes the potential for implementation in either granitic rock or sedimentary rock, there is a greater range of potentially suitable economic regions for implementation than is possible with Option 1. This approach, therefore, offers greater opportunity to limit the scope of adverse social, human, physical and financial impacts on the host community. Is most amenable to responding to changes that may occur over the implementation period, and thereby maintaining public confidence. Over the decades of program development and implementation, the selected approach will encounter changes in society, technology, economics, and the environment. These changes will be further influenced by the evolving political and institutional landscape and more. This approach is staged to include periodic sequential decision points that give greater opportunity for stakeholders, and specifically the affected communities, to participate in the design, and evaluation of the program status for progressive decision-making.	Creating a new facility in a new location may necessarily create more adverse impacts on communities than leaving the waste where it is. These adverse impacts are expected to be substantially less than for Option 1 due to the greater flexibility in siting the facility which Option 4 provides for. Requires transportation away from existing reactors and would likely raise concerns of communities along the transportation routes, particularly if the safety of transportation had not yet been established to the satisfaction of those communities. Communities on transportation routes would need to have concerns addressed. However, it is expected that the ongoing process of citizen involvement which this approach suggests would help ensure that transportation safety is appropriately examined and confidence is increased before transport of the used fuel begins in earnest. Over the very long term, the limited opportunity to demonstrate system performance (for instance by monitoring and access) may be a source of lingering concern among some in the community. However, this is expected to be substantially less than for Option 1 because of the extended period of confirmation of performance which this option involves. Need for continuing administrative controls and operations, including the necessary funding, for a longer period than for Option 1, although it is judged reasonable to believe that institutions will continue to remain strong during this period.

Table 8-5 (cont'd) Community Well-Being

	BENEFITS	RISKS & UNCERTAINTY
Option 4: (cont'd) Adaptive Phased Management	Explicitly recognizes, and plans for, the breadth of communities which will be impacted over the course of eventual implementation of a deep repository. In the near term (less than 175 years), both Option 1 and Option 4 provide the greatest income, employment and tax benefits by up to a factor of two compared to Storage at Nuclear Reactor Sites, and by up to a factor of eight compared to Centralized Storage (above or below ground). Option 1 and Option 4 are roughly equivalent in economic value to each illustrative economic region. However, the benefits of Option 4 are stretched out over a longer time period (i.e. 30 years longer than Option 1). If done well, siting can be achieved with community participation. With no significant operations required in the long term, the facility would not lead to the same repeat cycles of boom and bust associated with Options 2 and 3. Results in the eventual permanent placement of the used nuclear fuel, which reduces the necessity for long-term institutional and operational continuity and financial surety.	Creating a new facility in a new location may create more adverse impacts on communities than leaving the waste where it is. Requires transportation away from existing reactors and would likely raise concerns of communities along the transportation routes, particularly if the safety of transportation had not yet been established to the satisfaction of those communities. Communities on transportation routes would need to have concerns addressed.

Summary Findings

All four approaches are expected to provide significant economic benefits to all Canadians, host province, region and community.

For any approach, implementation plans must be designed collaboratively with the receiving communities to facilitate the community's social, cultural and economic aspirations and avoid or minimize adverse impacts. Although not the focus of this analysis, it is understood that a complementary collaborative effort will need to be undertaken with communities which currently host interim storage facilities in order to ensure that the manner and pace of movement of waste from the community meets their needs.

Centralized approaches, Options 1, 3 and 4, allow the invitation of a willing host community as part of the site selection process, and the opportunity to work closely with the selected community to design implementation in a way that is supportive and responsive to the priorities of the community.

Option 4, in presenting a staged and adaptive approach, allows the implementation path to be responsive to the expectations of Canadian society today and continued influence of future generations on the subsequent decisions to be taken concerning design and evaluation of program progress. Option 4 recognizes that a range of communities will be impacted, and seeks to build confidence through a stepwise implementation path.

Analysis of Objective 5 – Security

Our objective:
To ensure security of facilities, materials and infrastructure.
The selected management approach needs to maintain the security of the nuclear materials and associated facilities. For example, over a very long time-frame, the hazardous materials involved ought to be secure from the threat of theft, despite possibilities of terrorism or war.

An approach must provide for the security of both nuclear materials and the facilities that store or use them. The loss of nuclear material would pose health and safety risks to Canadians and others. The loss of nuclear material could also trigger concerns in relation to international safeguards and non-proliferation obligations. In this context, security and safeguards are fundamental requirements that go beyond protecting the health and safety of Canadians.

To assess security, the vulnerability of each approach to various risk scenarios was considered. The risk scenarios included terrorism and potential "insider" threats focused on theft, diversion, sabotage, and "seize and hold" strategies. The adequacy of contingency plans and the robustness of the approach under scenarios involving societal breakdown and civil disobedience were also considered.

Comparative Assessment

Table 8-6 presents our assessment of the relative benefits and risks and uncertainty for each of the four options studied.

Table 8-6 Security

	BENEFITS	RISKS & UNCERTAINTY
Option 1: Deep Geological Disposal	Expected to perform well within the security requirements reflected in Canadian regulatory standards, if built and operated as designed. In the near term, the high radioactivity of used fuel provides a "self-protecting" barrier against intruders, in combination with the heavy and large containers used to store used nuclear fuel in the interim period. Facility design and monitoring provide additional layers of further security. Once the used fuel is placed underground and the facility is backfilled and closed, the fuel is difficult to access, reducing the scope for theft, hostile intervention and dispersion of nuclear material. The size and weight of the heavy, large structures used for storing and transporting used fuel provide significant barriers to sabotage or theft. Even before closure, the limited access to the fuel and the 500-1,000 metre distance to surface provide considerable protection against security threats. Security is not reliant on ongoing active institutional oversight, an important feature for the long term, over which societal stability and institutional controls cannot be assured. Avoids the ongoing requirement for repackaging and handling and transportation once all the used fuel is placed in the deep repository, thereby limiting risks of security breaches and making the fuel significantly more secure for the longer term. Could be sited in a location designed to limit security risk to the general population, for instance away from large population centres and with community involvement.	Repackaging of used fuel, for transportation and perhaps placement in a deep repository, is required. However, substantially less repackaging of used fuel is required compared with storage options. Requires the identification and development of a site with potentially contentious community involvement. Public opposition to siting and transportation before confidence has been achieved may result in disruption in implementation and added security risk. Transportation risk and cost expected to be higher under conditions of low public confidence. Transportation to a central site would require additional safety measures for the movement of the used nuclear fuel from the nuclear reactor sites to the storage facility. Total number of trip-kilometres required to transport all used nuclear fuel by road to a facility vary considerably, depending on the site. Vulnerability of the used nuclear fuel is assumed to increase with increases in number of trip-kilometres. Therefore, there is a greater security risk during transportation for sites located longer distances from the majority of used nuclear fuel (i.e., longer distances from southern Ontario). For this approach, our analysis suggests that selection of any of a broad range of economic regions would involve similar numbers of large population centres (defined as greater than 50,000 inhabitants) along transportation routes as would the other centralized approaches and thus have a similar degree of security risk for this measure in the near term.

Table 8-6 (cont'd) Security

	BENEFITS	RISKS & UNCERTAINTY
Option 2: Storage at Nuclear Reactor Sites	Expected to perform well within security requirements as reflected in Canadian regulatory standards if maintained and operated as designed. In the near term, accessibility of fuel is low, offering security protection. The high radioactivity of used fuel provides a "self-protecting" barrier against intruders. This barrier continues for the first several hundred years. Facility design and monitoring provide additional layers of security provision. Robust, heavy, large containers and structures used for storing used fuel provide significant barriers to sabotage or theft. In the near term, while nuclear plants continue operations, security is enhanced by security infrastructure already in place. Nuclear plants offer years of experience in protecting facilities from unauthorized entry/access to fuel. With no requirements for off site transportation, this option avoids security risks associated with the transportation phase, and does not involve or require the cooperation of communities or the public outside of the host community.	After approximately 300 years, radiation levels decline such that the used fuel is no longer "self-protecting", making it more accessible to intruders. Managing the used fuel in surface facilities, at this point, requires significantly more physical protection resources than Options 1, 3 and 4 to ensure its long-term security. Security is heavily reliant on ongoing active management and institutional oversight and controls in perpetuity. Security risk could increase in the long term in the event of societal instability and resulting breakdown of institutional oversight. There is considerable uncertainty associated with the continuance of the societal infrastructure to ensure physical protection indefinitely. The level of the risk associated with a breakdown of institutional oversight, and complexity of managing it in the long term is compounded by the existence of seven sites, with several of the host economic regions including large population centres, as compared to a single central site. Requires ongoing repackaging of used fuel in perpetuity, providing repeated future opportunities for security risk. Strong physical protection would be required during the periodic repackaging operations required every 100 years and lasting approximately 30 years for each repackaging operation. As many as 100 repackaging cycles could be required over a 10,000-year period. Over the long term, the benefit from co-location at nuclear plants and the opportunity to benefit from shared oversight ceases once the nuclear plants are decommissioned. With the passage of time, it may be necessary to change current security standards and activities to account for changing world events. This may dramatically change future security requirements and the attendant costs.

Table 8-6 (cont'd) Security

	BENEFITS	RISKS & UNCERTAINTY
Option 3: Centralized Storage	Expected to perform well within security requirements as reflected in Canadian regulatory standards if built, maintained and operated as designed. In the near term accessibility of fuel is low, offering security protection. The high radioactivity of used fuel provides a "self-protecting" barrier against intruders. This barrier continues for the first several hundred years. Facility design and monitoring provide additional layers of further security provision. Robust, heavy, large containers used for storing used fuel provide significant barriers to sabotage or theft. The size and weight of the heavy, large structures used for transporting used fuel provide significant barriers to sabotage or theft. If central storage entails shallow underground storage, this offers an incremental security advantage over above ground facilities. Located at one central site, monitoring of the used fuel for the long term is facilitated, requiring fewer physical protection resources than would Option 2. Centralized storage, either above-ground or shallow below-ground, would allow for site selection on the basis of used nuclear fuel management and its safe and secure management, for instance away from large population centres and with community involvement.	After approximately 300 years, radiation levels decline such that the used fuel is no longer "self-protecting", making it more accessible to intruders. Managing the used fuel in surface facilities, at this point, requires significantly more physical protection resources than Options 1 and 4 to ensure the long-term security of the fuel. Security is heavily reliant on ongoing active management and institutional oversight and controls in perpetuity. Security risk would increase in the long term in the event of societal instability and resulting breakdown of institutional oversight. There is considerable uncertainty associated with the continuance of the societal infrastructure to ensure physical protection indefinitely. Requires ongoing repackaging of used fuel in perpetuity providing repeated future opportunities for security risk. Strong physical protection would be required during the periodic repackaging operations required every 100 years and lasting approximately 30 years for each repackaging operation. As many as 100 repackaging cycles could be required over a 10,000-year period. Requires the identification and development of a site with potentially contentious community involvement. Public opposition to siting and transportation before confidence has been achieved may result in disruption in implementation and added security risk. Transportation risk and cost expected to be higher under conditions of low public confidence. Transportation to a central site would require additional safety measures for the movement of the used nuclear fuel from the nuclear reactor sites to the central site.

Table 8-6 (cont'd) Security

	BENEFITS	RISKS & UNCERTAINTY
Option 3: (cont'd) Centralized Storage		Total number of trip-kilometres required to transport all used nuclear fuel by road to a facility varies considerably, depending on the site. Vulnerability of the used nuclear fuel assumed to increase in proportion to increases in number of trip-kilometres. Therefore, there is a greater security risk during transportation for sites located longer distances from the majority of used nuclear fuel (i.e. longer distances from southern Ontario). For this approach our analysis suggests that, selection of any of a broad range of economic regions would involve a similar number of large population centres (defined as greater than 50,000 inhabitants) along transportation routes as with the other centralized approaches and thus have a similar degree of security risk for this measure in the near term.
Option 4: Adaptive Phased Management	Expected to perform well within security requirements as reflected in Canadian regulatory standards if maintained and operated as designed. Accessibility of used fuel is low in both the near term and long term, offering protection from security breaches through hostile intrusion. In the near term, the high radioactivity of used fuel provides a "self-protecting" barrier against intruders, in combination with the heavy and large containers used to store used nuclear fuel in the interim period. Facility design and monitoring provide additional layers of security. The size and weight of the heavy, large containers used for transporting used fuel provide significant barriers to sabotage or theft. The optional phase of shallow underground storage prior to proceeding to the deep repository, offers enhanced barrier for physical protection during storage in the period leading up to final placement in the repository. A secure form of storage is ensured in the interim period should there be a delay in placement in the repository.	While offering more security than Storage at Nuclear Reactor Sites and Centralized Storage, the Adaptive Phased Management Approach is marginally less secure than Deep Geological Disposal in the Canadian Shield since it could involve additional repackaging of used fuel. As with Option 1 and Option 3, it would require additional safety requirements for the movement of the used nuclear fuel from the nuclear reactor sites to the storage facility. Total number of trip-kilometres required to transport all used nuclear fuel by road to a facility varies considerably, depending on the site. Vulnerability of the used nuclear fuel is assumed to increase in proportion to number of trip-kilometres. Therefore, there is a greater security risk during transportation for sites located longer distances from the majority of used nuclear fuel (i.e. longer distances from southern Ontario).

Table 8-6 (cont'd) Security

	BENEFITS	RISKS & UNCERTAINTY
Option 4: (cont'd) Adaptive Phased Management	Over time, declining radiation fields reduce the potential consequences of sabotage in the event of a security breach, but also reduce barriers to theft. For the long term, a combination of engineered and natural geological barriers deep underground provide enhanced security. Once the fuel is placed underground and the facility is backfilled and closed, the fuel is difficult to access, reducing the scope for theft, hostile intervention and dispersion of nuclear material. Even before closure, the limited access to the fuel and the 500-1,000 metres distance to surface provides considerable protection against security threats. Over the long term, security does not rely on ongoing active institutional oversight, an important feature for the long term, over which societal stability and institutional controls cannot be assured. Over the long term, avoids the ongoing requirement for repackaging and handling once all of the used fuel is placed in the deep repository, thereby limiting risks of security breaches and making the fuel significantly more secure for the longer term. Has the same high level of security in the long term as Option 1, as neither have repackaging events in the long term. The size and weight of the heavy, large containers used for transporting used fuel provide significant barriers to sabotage or theft. Could be sited in a location designed to limit security risk to the general population, for instance away from large population centres and with community involvement.	For this approach, our analysis suggests that selection of any of a broad range of economic regions would involve a number of large population centres (defined as greater than 50,000 inhabitants) along transportation routes. The flexibility in geologic media associated with this approach will provide more flexibility in siting which may allow transportation to be minimized. Requires the identification and development of a site with potentially contentious community involvement. Public opposition to siting and transportation before confidence has been achieved may result in disruption in implementation and added security risk. Transportation risk and cost expected to be higher under conditions of low public confidence. However, this approach provides for a longer period over which to establish and build confidence.

Summary Findings

All four options, if built and operated as designed, are expected to perform well within the security requirements of Canada's regulatory standards. Many aspects of security have been examined over the course of our analysis. Four particular aspects are briefly discussed below.

i) Fuel Accessibility

The less accessible the fuel, the stronger the contribution to ensuring the nonproliferation of weapons useable material. Access to the used fuel can be reduced by the actions of institutions, and the security mechanisms that they put in place and maintain, and through engineered and geological physical barriers that prevent access to the fuel.

Option 1 and Option 4, because they involve placing used nuclear fuel deep underground, and ultimately backfilling and sealing all routes to access the fuel, are inherently more secure than Option 2 and Option 3 over the long term. These two latter storage options keep and manage used nuclear fuel at or near the surface and rely upon security mechanisms in the form of robust containers and security fencing and personnel to prevent access. The storage of used fuel at or near the surface inherently poses additional security risk and demands additional security precautions. Security is heavily reliant on ongoing institutional management and controls, in perpetuity. Uncertainty over the availability of institutions and controls increases over time.

ii) Number of Repackaging Cycles

Repackaging of used nuclear fuel presents some risk of hostile attack for all four approaches. However, Option 1 and Option 4 do not require repackaging of used nuclear fuel once all used nuclear fuel is placed in the repository and are significantly more secure in the long term, compared with Option 2 and Option 3, which require as many as 100 repackaging cycles over a 10,000-year period.

While offering more security than Option 2 and Option 3, Option 4 is marginally less secure than Option 1 since it involves an additional repackaging event.

iii) Robustness of Physical Barriers

Of the four approaches, Options 1 and 4 offer the strongest physical protection of the used fuel and the management facilities against unintended security breaches through inadvertent intrusion or unauthorized intrusion. The combination of robust engineered barriers built into the design, the selection of the site, together with the geological barriers associated with placement of the fuel deep underground, is expected to enable secure isolation of the used fuel both in the near term and the long term. Protection against disruption or breaching of the barriers by intrusion is provided through these many barriers that isolate the used fuel, and is not reliant on ongoing effective institutional controls and active societal oversight over the very long term.

Of these two approaches, Option 4 offers additional advantages in that implementation allows for interim steps at each stage and contingency plans to ensure the security of the material should implementation not proceed as planned. Specifically, it allows for a centralized shallow underground storage facility in the period preceding the deep repository. The possibility of such intermediate steps would allow for timely centralization of the used fuel to a safe storage facility underground, while allowing for building confidence before emplacing the fuel in the final repository.

Option 4 has the same number and robustness of physical barriers as Option 1 following closure of the deep repository.

iv) Transportation Distance

Transportation of used nuclear fuel involves some inherent risk to security, although this risk is judged to be small. Option 2 requires no off-site transportation of used nuclear fuel, so there are no opportunities for attempted dispersion during transportation.

The options that require transportation to a central site, Option 1, Option 3 and Option 4, would require additional safety requirements for the movement of the used nuclear fuel from the nuclear reactor sites to the storage facility. For these three options, total number of trip-kilometres required to transport all used nuclear fuel by road to a facility is expected to vary considerably (by up to 15 times), depending on the site. Vulnerability of the used nuclear fuel is assumed to increase with the distance traveled.

Analysis of Objective 6 – Environmental Integrity

Our objective:
To ensure environmental integrity.
The selected management approach needs to ensure that environmental integrity is maintained over the long term. Concerns include the possibility of localized or widespread damage to the environment or alteration of environmental characteristics resulting from chronic or unexpected release of radioactive or non-radioactive contaminants. Concerns also include stresses and damage associated with new infrastructure (such as roads and facilities) and operations (e.g., transportation).

Assessing the degree of impact each approach would have on the natural environment required consideration of many factors, including the number and sensitivity of ecosystem elements that would potentially be affected, the likelihood of impact to each type of resource, and the significance of the potential consequences to affected resources. Many different types of valued and environmentally sensitive resources could be affected, including plants and animals, land, surface water, groundwater and the air (e.g., through air pollution created during the construction of a new facility). Also included in the assessment were various aesthetic impacts, such as noise, and visual changes to the natural scenery. As in the case of other objectives, it is necessary to consider not only the stresses that each approach would produce assuming that the approach performs as expected, it is also necessary to consider the possibility of risk scenarios which go beyond normal operating parameters. An important factor to be considered here is the impact of significant changes in environmental conditions associated with climate change and the impact these types of changes may have on the performance of the management system.

It is difficult to precisely forecast the environmental impacts of the various approaches. This is especially true in the cases of the geological repository and centralized storage approaches because the impacts of each approach depend greatly on where the new facilities would be located, something that is not yet known. The long time-frames involved complicate forecasts for all approaches.

Comparative Assessment

Table 8-7 presents our assessment of the relative benefits and risks and uncertainty for each of the four options studied.

Table 8-7 Environmental Integrity

	BENEFITS	RISKS & UNCERTAINTY
Option 1: Deep Geological Disposal	Under normal conditions, this approach is expected to be able to be constructed and operated without causing significant adverse effects on the environment in the near and long term. This is achieved by implementing standard mitigation measures and best management practices. This method is considered to deliver benefits over the very long term, since the used fuel is isolated from the environment. Provides significant advantages over surface-based facilities (Options 2 and 3) with respect to withstanding the effects of major environmental changes over the long term. The deep repository, isolated from surface water systems, provides a strong barrier against possible environmental events. Used fuel is placed deep underground. Once the facility is closed, it is not reliant on active management to ensure safety. With the multiple and robust barriers, the engineered facility together with the geological barrier of granitic rock, are designed to isolate the fuel from the environment, providing low likelihood of adverse environmental effects. The resilience of this management approach in providing a high level of protection of the environment is particularly critical in light of possible climatic changes and extreme natural events that may well be associated with the tens of thousands of years over which the used fuel must be managed. Some long-term environmental changes may be gradual, such as effects of climate change and rising surface water levels. Other effects may be episodic, such as earthquakes and seismic activities. Resilience of the facilities must also be considered for glaciation. Avoids the need for periodic repackaging of used fuel and associated risks to the environment. The site can be chosen to minimize environmental impact.	In the short term, the construction of the facility could produce adverse impacts on the environment. These impacts are expected to be localized and relatively short lived. Following closure of the repository, monitoring for potential environmental effects becomes more difficult than with surface based facilities. However, the likelihood of an adverse effect occurring even over the long term is low because of the physical and geological barriers built into this facility design. Used fuel retrieval or other corrective action is also difficult. Advance "proof" that such a system works is not scientifically possible because performance is required over thousands of years. Detailed scientific studies, models and codes and natural analogues, therefore, form the foundation of the assurances of performance. Requires transportation of the used fuel to the central facility over a 30-year period. The transportation routes would likely traverse multiple ecozones. With likelihood of transportation accidents low, transport is unlikely to carry with it large risks to the environment. In addition, risks associated with transportation would be lowest for sites that are located closest to the current reactor sites.

Table 8-7 (cont'd) Environmental Integrity

	BENEFITS	RISKS & UNCERTAINTY
Option 2: Storage at Nuclear Reactor Sites	Under normal conditions, this approach is expected to be able to be constructed and operated without causing significant adverse effects on the environment in the near and long term if implemented as designed and using standard mitigation measures and best management practices. Provides a robust management approach in the near term (first 175 years). Risk of occurrence of off-normal events is low in the near term. Avoids the construction of a deep repository and the potential environmental disruption associated with implementation. Also avoids involvement of a new potentially greenfield site. With facilities at or near surface, provides for ease of monitoring of facility performance. Anticipated problems are more readily identified and addressed. No transportation of used nuclear fuel would be required, as the used fuel would remain where it is generated. The science and technology required are well in-hand.	Protection of the environment for the long term is uncertain given that effective performance requires strong institutional control and oversight, and that is uncertain over the long term. Since the facilities are constructed at or near surface, they are unlikely to be able to withstand glacial events or major long-term environmental disruption from extreme weather events or other major climatic changes. With safety of the site reliant on ongoing active institutional control, social instability that jeopardizes refurbishment, monitoring and oversight, or leaves the site abandoned, would introduce significant environmental risk. These risks multiply in the long-term, with uncertainty over environmental patterns that may unfold over the tens of thousands of years for which the fuel requires isolation. Long-term risks are compounded, in light of the multiple (seven) sites at which facilities would exist. Adverse effects of off-normal scenarios may be most severe in those locations adjacent to large continuous bodies of water, as the impacts on the water resources could be far-ranging and could have international consequences.

Table 8-7 (cont'd) Environmental Integrity

	BENEFITS	RISKS & UNCERTAINTY
Option 3: Centralized Storage	Under normal conditions, this approach is expected to be able to be constructed and operated without causing significant adverse effects on the environment in the near and long term if implemented as designed and using standard mitigation measures and best management practices. Provides a robust management approach in the near term (first 175 years). Risk of occurrence of off-normal events is low in the near term. Avoids the construction of a deep repository and the environmental disruption associated with implementation. With facilities at or near surface, provides for ease of monitoring of facility performance. Unanticipated problems are more readily identified and addressed. Offers better and more predictable environmental performance than Option 2 both in near term and long term. One centralized facility reduces the range of environmental resources at risk. Siting of the new facility allows for it to be purposely located and built in such a way as to reduce environmental risks. The required science and technology are well in hand for the above ground storage design.	Protection of the environment for the long term is uncertain given that effective performance requires strong institutional control and oversight, and that is uncertain over the long term. The construction of the facility could produce adverse impacts on the environment. Since the facility is to be constructed at or near surface, it is less likely to be able to withstand glacial events or major long-term environmental disruption from extreme weather events or other major climatic changes without active institutional management. Below ground storage offers some advantages compared with surface facilities. With safety of the site reliant on ongoing active institutional control, social instability that jeopardizes refurbishment, monitoring and oversight, or leaves the site abandoned, would introduce substantial environmental risk. These risks multiply in the long term, with uncertainty over environmental patterns that may unfold over the tens of thousands of years for which the fuel requires isolation. Requires transportation of the used fuel to the central facility. The transportation routes would likely traverse multiple ecozones. With the likelihood of transportation accidents low, transport is unlikely to carry with it large risks to the environment. In addition, risks would be the lowest for sites that are located closest to the current location of the majority of the fuel.

Table 8-7 (cont'd) Environmental Integrity

	BENEFITS	RISKS & UNCERTAINTY
Option 4: Adaptive Phased Management	Under normal conditions, this approach is expected to be able to be constructed and operated without causing significant adverse effects on the environment in the near and long term if implemented as designed and using standard mitigation measures and best management practices. It allows a period of time of high flexibility in which new learning might be easily incorporated. It allows for decisions to be reversed, should this be required, and provides for a viable, safe and secure storage capability at each point in the process, even should there be delay before proceeding to the next stage of implementation. Over the long term, when most uncertain, not relying on ongoing institutional control of the facility, avoids risks that might otherwise be posed in the event of long-term societal instability. Being located deep underground, the radioactive materials would be contained and isolated from the environment. In the deep repository, the used fuel is protected by both robust natural barriers provided by the crystalline or sedimentary rock, as well as the engineered barriers in terms of container design, buffer materials, etc. Facility could be expressly sited and designed to minimize environmental impact. Extended implementation period allows more time to understand the environmental conditions through research at the underground characterization facility and used fuel placed in the optional shallow underground storage, before making the decision to move the fuel into the deep repository for long-term isolation. Over the decades of program development and implementation, the selected approach will encounter changes in society, technology, economics, and the environment. These changes are better accommodated by this adaptable approach.	In the short term, the construction of the facility could produce adverse impacts on the environment as the shallow storage in rock caverns is built, and later the deep repository is built at a depth of 500 to1,000 metres under ground. These impacts are expected to be localized and relatively short lived, compared with the storage options. The above ground facilities are less likely to withstand severe environmental events. However it is expected that such events are very unlikely during the period of above ground storage envisioned in this approach. These above ground facilities would require active institutional control, however social stability is expected to continue through the period of above ground storage envisioned by this approach. The step of shallow storage at a single purpose-built site would enhance robustness and surety of performance towards the end of this period. Following closure of the repository, at a time when society makes that decision, monitoring for potential environmental effects becomes more difficult than with surface based facilities. However, the likelihood of an adverse effect occurring even over the long term is low because of the physical and geological barriers built into this facility design. The extended period of technology development and testing is expected to increase the performance of the system and confidence in its performance. Requires transportation of the used fuel to the central facility. The transportation routes would likely traverse multiple ecozones. With the likelihood of transportation accidents low, transport is unlikely to carry with it large risks to the environment. Risks associated with transportation would be lowest for sites that are located closest to the current reactor sites. As well, the flexibility in geological media associated with this approach will provide more flexibility in siting which may allow transportation to be minimized.

Summary Findings

Under normal conditions, all four management approaches are expected to be able to be constructed and operated without causing significant adverse effects on the environment in the near and long terms if implemented as designed, using standard and proven mitigation measures and best management practices. For all options, a more detailed examination of environmental impacts will be required once potential sites have been identified.

The multiple barriers associated with Options 1 and 4, as discussed under "Public Health and Safety", also apply to environmental integrity. Site selection, engineered barriers and placement at depth in geologic media comprise robust management designs to protect environmental integrity. The performance of these barriers is not reliant on ongoing societal oversight to offer protection over the long term. A further benefit of Option 4 is the extended period over which the site and the facilities can be monitored, tested and refined, prior to final placement of the used fuel. This opportunity for active monitoring and study will allow us to learn, understand and adjust facility designs as may be appropriate over a staged implementation period.

Storage approaches, Options 2 and 3, offer the benefit of easy monitoring and access to the fuel to address any detected impacts. In the long term, however, these options introduce long-term risks. Monitoring and securing of the facilities is reliant on active institutional management and controls, over a time period in which we cannot be assured of ongoing social stability. Facilities sited at or near surface are also expected to be less resilient to long-term climatic changes and environmental conditions than facilities secured deep underground.

Analysis of Objective 7 – Economic Viability

Our objective:
To design and implement a management approach that ensures economic viability of the waste management system, while simultaneously contributing positively to the local economy.
Economic viability refers to the need to ensure that adequate economic resources are available to pay the costs of the selected approach, now and in the future. The cost must be reasonable. The selected approach ought to provide high confidence that funding shortfalls will not threaten the assured continuity of necessary operations.

Assessing the economic viability of the approaches required considering the likelihood that financial resources would be available to pay the costs, recognizing that these costs are uncertain and, especially in the case of the reactor site and centralized storage approaches would continue over a very long time.

Comparative Assessment

Table 8-8 presents our assessment of the relative benefits and risks and uncertainty for each of the four options studied.

Table 8-8 Economic Viability

	BENEFITS	RISKS & UNCERTAINTY
All approaches		Long-term management costs for the approaches (i.e., costs out to hundreds to thousands of years and beyond) are based on current technology costs and assumptions regarding frequency of events (e.g., repackaging). Such costs should be considered order-of-magnitude only – even assuming future generations choose to continue long-term storage using today's technology. It is not reasonable to assume that the financial markets of today will continue unchanged for the lifetime of the management approaches. Thus, elements related to interest rates, bond markets, financial institutions, and the ability to borrow are likely to change in the long term. However, it is reasonable to expect that financial markets will likely remain intact in the near term, including the time period to initially put the used nuclear fuel in place in a facility for any of the four approaches. During final design, siting, environmental assessment and licensing, modifications to the design or schedule could result in significant cost increases. For example, the licensing and approval process, add-ons, more restrictive standards and other possibilities unforeseeable to the designers may lead to costs in excess of original estimates and the allowable contingencies, although the contingencies which are provided for in the cost estimates are comparable or greater than those for comparable projects.
Option 1: Deep Geological Disposal	Higher initial costs and lower longer term costs provide greater financial surety. With respect to time dependence of estimate certainty and the provision of surety, this option has the most certain estimates, as the vast majority of costs would be incurred in the near term. It is also the easiest to develop surety for because the facility closes within 150 years. If one is only concerned about the ability to marshal the necessary financial resources to complete the management of used nuclear fuel, this method is best.	Although the burden of financial surety is placed mostly in the hands of the current generation, should new technologies arise or should other social and/or technology issues arise, then future generations may be burdened with our used nuclear fuel legacy to an even greater extent. Since this type of facility has not been previously constructed, there is potential for problems and delays, which would raise costs.

Table 8-8 (cont'd) Economic Viability

	BENEFITS	RISKS & UNCERTAINTY
Option 1: (cont'd) Deep Geological Disposal	This management approach places used fuel in a "final" state with relatively few financial requirements over the very long-term compared with the two storage options. This means that the burden of financial surety is placed mostly in the hands of the current generation. Provides higher confidence that funding shortfalls will not occur that would threaten the assured continuation of necessary operations compared with the two storage options.	There are additional significant uncertainties. There would be substantial costs incurred in finding and characterizing a central site. Transportation costs may be significant and could increase if there are major delays. Our analysis suggests that, the incremental transportation costs vary across the economic regions examined by up to $900 million (2002 dollars, not discounted). Incremental transportation costs are greater for economic regions located longer distances from the majority of the used nuclear fuel (i.e., southern Ontario). The potential incremental transportation costs are significant compared with the cost of the management approach in the near term.
Option 2: Storage at Nuclear Reactor Sites	There is more certainty over near-term costs because a modified version of the technology is known and currently used. No costs associated with off-site transportation.	Lower initial costs, and higher longer-term costs, create more uncertainty around financial surety. The cost estimates provided for storage approaches have a higher degree of uncertainty than those for Option 1 because they assume conditions far in the future. Although the current generation will set aside funds for the long-term management of the used fuel, this method imposes a liability on future generations for continued active management and appropriate oversight institutions and a burden to cover costs that are not anticipated and funded today. The need for major rebuilding operations and ongoing repackaging on a regular basis in perpetuity severely limits the current generation's ability to estimate costs and provide surety. Cost estimates are more uncertain the farther into the future they are projected. Uncertainty with respect to surety also increases.

Table 8-8 (cont'd) Economic Viability

	BENEFITS	RISKS & UNCERTAINTY
Option 3: Centralized Storage	There is more certainty over near-term costs because the technology is known and currently used.	Lower initial costs, and higher longer-term costs, create more uncertainty around financial surety. The cost estimates provided for storage approaches have a higher degree of uncertainty than those for Option 1 because they assume conditions far in the future. Although the current generation will set aside funds for the long-term management of the used fuel, this method imposes a liability on future generations for continued active management and appropriate oversight institutions and a burden to cover costs that are not anticipated and funded today. Although the approach might be less costly initially, there are significant uncertainties. There would be substantial costs incurred in finding and characterizing a site. Transport costs may be significant, and could increase if there are major delays. The need for major rebuilding operations and ongoing repackaging on a regular basis in perpetuity severely limits the current generation's ability to estimate costs and provide surety. Cost estimates are more uncertain the farther into the future they are projected.
Option 4: Adaptive Phased Management	Higher initial costs, and lower longer-term costs provide more financial surety than for Option 2 and Option 3. Adequate surety can be developed. Examples exist of select human organizations and their investments persisting for over 325 years. This approach provides for a long-term storage facility based on existing, passive technologies rooted in long-standing areas of human activity (mining, metallurgy). The approach balances the risks that the required financial resources will be available when needed with the benefits of new technology development and enhanced proof of concept for long-term isolation. It preserves opportunities for decision making to future generations for an extended period without compromising the responsibility of the current generation to provide for a long-term solution.	Spans a longer time period than Option 1, which increases risk of financial surety, but a much shorter period of time than Option 2 and Option 3 with, therefore, comparative greater expectation of financial surety. Since a deep repository type facility has not been previously constructed, there is potential for problems and delays, which would raise costs. The more measured approach to implementation associated with this approach may reduce this potential. There would be substantial costs incurred in finding and characterizing a central site. Transportation costs may be significant, and could increase if there are major delays. As with Option 1, transportation costs are expected to vary substantially with the site selected.

Summary Findings

All options require substantial funding to be provided by the owners of nuclear waste. In all cases, the *NFWA* would require contributions from each nuclear corporation against an approved funding formula and schedule, thus ensuring as much as possible that the generation that benefited from the nuclear power also sets aside the required amounts to fund the approach.

The options are differentiated by significant variation in cost (either total cost or present value). The options are differentiated by the timing of expenditures in both the near and long term.

The options are differentiated by the uncertainty associated with estimating the amount of funds required, and ability to protect these funds, to ensure availability for this purpose over the very long time period over which the approach requires expenditures.

Options 1 and 4 are judged to offer the most surety, requiring the majority of expenditures to be made in the near term (within the first 100 years). Over this period, we believe it is reasonable to be confident in the availability of strong institutions and, therefore, safekeeping of the funds that have been contributed for this purpose. Confidence is also higher since the period for which costs need to be estimated is shorter.

In contrast, Options 2 and 3 are judged to offer the least certainty both that estimates made now will be accurate for the long duration of implementation involved with these approaches and that funds set aside now can be protected for this purpose for the long period that they are to cover. This is because these approaches require used fuel repackaging and rebuilding of storage facilities every 100 to 300 years in perpetuity. Funding would need to be assured on an ongoing basis to support the refurbishment and maintenance that is essential to securing the safe storage of the used fuel. Looking out to the long term, over the thousands of years for which the fuel must be isolated from people and the environment, we face considerable uncertainty that introduces risk to financial surety. Over the long term we cannot predict the performance of financing instruments or the status of the financial and governmental institutions responsible for the safekeeping of the funds.

Analysis of Objective 8 – Adaptability

Our objective:
To ensure a capacity to adapt to changing knowledge and conditions over time.
The selected management approach should be robust in the face of new or unforeseen circumstances. The approach should provide flexibility to future generations to change decisions; not place burdens or obligations on future generations that will constrain them. The approach should be able to function satisfactorily in the case of unforeseen events.

There was much discussion on this objective by citizens during the dialogue following release of our second discussion document. Although there appeared to be broad agreement on the importance of this objective, some debate was raised concerning how best to characterize or define the objective. Should the adaptability of an approach be defined primarily on the basis of the flexibility in future decision-making that it provides? Should the adaptability of an approach be defined primarily on the basis of the robustness it provides in the face of changing environmental conditions?

We have proceeded in a way which understands that both of these are potentially important influences on the adaptability of a management approach even though the measures one might put in place to achieve flexibility might directly conflict with the measures one might put in place to achieve physical robustness. What is required to make an approach adaptable in the near term may not be the same as what is required to make an approach adaptable in the very long term. Given the long time-frames for which any management approach will need to effectively contain and isolate used nuclear fuel, the balancing of such tensions is integral to both understanding what adaptability means for this issue and assessing the approaches on it.

We have approached adaptation as a general strategy of systems for attaining or maintaining a goal in the face of changing environmental circumstances. "Adaptability" is defined as the set of characteristics of an option that are expected to make a management approach robust with respect to the widest range of possible social and environmental scenarios in the long term. To be "adaptable" is to be capable of responding well to changes in environmental and social conditions, over a wide range of such possible changes.

Assessing the adaptability of each approach required consideration of many factors, including whether there are opportunities to adapt to changing knowledge or circumstances during the period when the various stages of the project are being implemented. It also included consideration of the robustness of the operation of the option to contain and isolate the waste, and/or ease of taking corrective action to ensure continued containment and isolation, in response to a wide variety of expected challenges to system integrity over the very long term. These challenges might include extreme natural events, deficiencies in option performance as designed, and an availability of any institutional controls or systems that may be required.

Comparative Assessment

Table 8-9 presents our assessment of the relative benefits and risks and uncertainty for each of the four options studied.

Table 8-9 Adaptability

	BENEFITS	RISKS & UNCERTAINTY
Option 1: Deep Geological Disposal	Being able to offer an "immediate" solution in the near term is a benefit, since it does not handicap future generations in terms of cyclical or significant costs to manage. The need for adaptability in relation to financial surety is minimal. Higher initial costs and lower longer-term costs provide more financial surety. Results in the eventual permanent placement of the used nuclear fuel, which reduces or may eliminate the necessity for long-term institutional and operational continuity and financial surety. After placement and closure, provision of long-term resources and funding are not required. Is less susceptible to security breaches. This reduces the need for flexibility in relation to long-term monitoring and contingency planning. Is most robust in face of changing environmental conditions such as glaciation, climate change and societal instability. This approach removes the burden of making decisions about managing the waste. Over the long term, it is likely that institutions and governance will change. This approach minimizes the need for institutions and governance because actions are not required after the repository is closed. This assumes that predicted "normal" operating conditions prevail and that there is no need for interventions (i.e., used nuclear fuel retrieval or mitigation of adverse effects). However, analysis indicates that the cost of retrieval from a closed Deep Geological Disposal in the Canadian Shield facility will likely be less than the incremental cost to manage the two storage approaches over the long term.	There is some uncertainty over the performance of the system over the very long term because advance "proof" that such a system works is not scientifically possible since performance is required over thousands of years. Detailed scientific studies, models and codes, and the study of natural analogues therefore, form the foundation for the assurances of performance. Science, technology, and social values may change over time, which may make a change to the management approach desirable. Such change would be very difficult to accommodate once the repository is closed. Monitoring of system performance becomes more difficult as the used nuclear fuel is placed deep underground and as the site is backfilled and closed. As well, retrieval of the used fuel for corrective action becomes much more difficult, costly, and hazardous. Flexibility to address changing conditions is low, however changing conditions are not expected to affect the performance of the system. Reversibility of decisions is difficult once the facility is closed. Retrieval of the used fuel is not envisioned with this approach. Cost of retrieval is not included in the conceptual design cost estimates. Costs related to reversing adverse health or environmental effects are largely unknown. However, since it is more difficult to monitor environmental effects, after closure, it is reasonable to assume that it will take longer to discover adverse effects compared to the storage approaches that remain open for the very long term. As a result, there is greater risk of a higher potential remediation cost with this approach although the probability of adverse effects after closure is considered to be very low.

Table 8-9 (cont'd) Adaptability

	BENEFITS	RISKS & UNCERTAINTY
Option 2: Storage at Nuclear Reactor Sites	This approach provides greater ability to monitor performance and flexibility to adapt to changing conditions. Taking corrective actions when required is easier and less costly. The waste is easier to retrieve. No transportation of used nuclear fuel would be required, as the used fuel would remain next to where it is generated. The science and technology required are well in-hand.	In the longer term, a surface facility is less able and adaptable to withstand potential wide variations in environmental and social conditions. Requires ongoing active management and financial resources over the very long term with the associated institutional controls and governance. However, it is possible that new technologies may arise that are less costly and more effective in managing used nuclear fuel, thus lessening the risk and costs to future generations. Lack of contingency plan should there be a need to remove the waste from the site. Requires numerous periodic future interventions that will be influenced by future applicable governing laws, market forces/incentives, cultural/social values and norms, and the synthesis of continual learning. Although a benefit on one hand (e.g., one can leverage the best science of the day to repackage used nuclear fuel), it also poses some risk that the necessary support institutions and governance frameworks we now rely on will not be there in the very long term. This is compounded by the existence of seven individual sites. The adequacy of institutions and governance in the long term is a critical consideration. The cost or liability to future generations of ensuring the financial and institutional stability of overseeing agencies will be significant.

Table 8-9 (cont'd) Adaptability

	BENEFITS	RISKS & UNCERTAINTY
Option 3: Centralized Storage	This approach provides greater ability to monitor performance and flexibility to adapt to changing conditions. Taking corrective actions when required is easier and less costly. The waste is easier to retrieve. The science and technology required are well in-hand.	In the longer term, a surface or near surface facility is less able and adaptable to withstand potential wide variations in environmental and social conditions. Requires ongoing active management and financial resources over the very long term with the associated institutional controls and governance. However, it is possible that new technologies may arise that are less costly and more effective in managing used nuclear fuel, thus lessening the risk and costs to future generations. Lack of contingency plan should there be a need to remove the waste from the site. Requires numerous periodic future interventions that will be influenced by future applicable governing laws, market forces/incentives, cultural/social values and norms, and the synthesis of continual learning. Although a benefit on one hand (e.g., one can leverage the best science of the day to repackage used nuclear fuel), it also poses some risk that the necessary support institutions and governance frameworks we now rely on will not be there in the very long term. The adequacy of institutions and governance in the long term is a critical consideration. The cost or liability to future generations of ensuring the financial and institutional stability of overseeing agencies will be significant.

Table 8-9 (cont'd) Adaptability

	BENEFITS	RISKS & UNCERTAINTY
Option 4: Adaptive Phased Management	Offers twin benefits of developing a long term solution in a relatively short time frame, yet enables easy access and active monitoring capability in the meantime. The approach offers the benefit of an extended storage option that enables continued research and development and monitoring activities to "prove" the concept and design parameters to the satisfaction of multiple generations. If satisfied, future generations can decide to proceed with long-term isolation of the used nuclear fuel or implement an alternative approach at the time. This extended storage and monitoring period reduces the potential requirement for and the cost of retrieval from a "closed" long-term isolation facility. Allows for sequential decision making on whether, when and how fast used nuclear fuel is moved to final disposition. Provides a viable storage capability that can be adapted to facility progress and used fuel placement while providing flexibility for waste placement rates or potential retrieval. It is less dependent on institutions and governance in the long term because actions are not required after the fuel is placed in the repository other than long-term monitoring. A critical success factor in the decision-making process for selecting an appropriate used nuclear fuel management approach is providing opportunity for public stakeholders to influence the process. This approach sets in place an open and transparent process to continue over the long term in relation to monitoring and new knowledge about how best to deal with used nuclear fuel. It allows for both current and near current generations to participate before it is fully implemented.	As with Option 1, there is some uncertainty over the performance of the system, once the repository is closed, over the very long term because advance "proof" that such a system works is not scientifically possible since performance is required over thousands of years. However, the extended period of technology investigation, testing and confirmation, is expected to substantially reduce this uncertainty. As with Option 2 and Option 3, it requires on-going active management and financial resources with the associated institutional controls and governance. However, this is substantially less than for Option 2 and Option 3 and is expected to be limited to a period in which confidence in institutional integrity is reasonably high. Due to the extended implementation period, there is a risk that the societal will to complete the implementation process may diminish to the point of threatening the safe operation of the management system. Compared with Option 2 and Option 3, the risk is small. Compared with Option 1, this risk is greater, although NWMO judges this risk to be small. This is because the infrastructure and facilities for the geologic containment and isolation of the used fuel will be in place, operating and/or available for operation relatively early on, within the timeframe for which institutions are expected to be strong. This risk is, by design, constrained by the recommended implementation plan, and balanced by the potential to incorporate new learning which the flexibility of this approach, within the near term provides.

Summary Findings

Each of the four management approaches have some measure of adaptability, although the mechanisms they provide to achieve adaptability, and the degree and nature of adaptability over time, varies between the approaches.

In the near term, the storage options offer more accessibility to the waste, making it easier to monitor and access the waste to take corrective action if necessary, or to take advantage of new advances in waste management technologies. However, they also create long-term costs and institutional requirements that would burden future generations and would compete for resources with other valued objectives of the time. Should future generations not have the will or capacity (including knowledge and resources) to actively manage these facilities, the waste is vulnerable to the natural deterioration of the containment as well as a range of likely risk scenarios including climate change, human intrusion, and glaciation. Since the used fuel will be hazardous for hundreds of thousands of years, adaptability depends on the continued existence of institutions over this very long period, which is highly uncertain. Although in the short term these approaches are highly adaptable, taking into consideration both the near term and the longer term, they are judged to perform poorly on this objective.

The deep geological disposal concept takes the hazardous material out of the accessible environment making it less vulnerable to extreme events than the other approaches. Through the combination of natural and engineered barriers, the system is designed to isolate and contain the used fuel over the long periods for which it needs to be managed without requiring institutional care or intervention.

Over the long term, the system is designed to be robust in the face of a broad range of extreme events including severe climate change, human intrusion and glaciation. However, in so doing it makes it more difficult to monitor the used nuclear fuel and to detect problems and take corrective action in the unlikely event of a breach of containment. Note that over the very long term, there is some uncertainty over performance of the system because advance "proof" that such a system works is not scientifically possible since performance is required over thousands of years. It also makes it more difficult to take advantage of any advances in waste management technology that may become available in the future.

Over the very long term this approach is more robust in the face of extreme events, and is expected to perform better than the storage approaches. However, because it offers little opportunity for monitoring the performance of the system, for taking corrective action, or taking advantage of new technologies that may emerge during the period for which it is reasonable to believe that institutions and governance will remain strong, this approach is judged to be less adaptable than the Adaptive Phased Management approach.

Adaptive Phased Management offers a balance between the requirements for adaptability in the short term and in the long term. It offers the benefits of implementing an approach that in the long term does not require institutional control for effective performance, while providing for a period of easy access and active monitoring capability up to that point. It is less dependent on institutions and governance in the long term because actions are not required after the repository is closed other than long term monitoring. It offers the option of an extended storage period that enables continued research and development and monitoring activities to "prove" the concept and design parameters to the satisfaction of multiple generations. If satisfied, future generations can decide to proceed with long-term isolation of the used nuclear fuel or implement an alternative approach. It allows for both current and near term generations to participate in the selection and design of a long-term approach before it is fully implemented. It allows for sequential decision-making on whether, when and how fast used nuclear fuel is moved to final disposition, and it ensures there is a viable option available to reverse decisions made at each key decision point in the process. In this way it provides mechanisms to respond to changes in society, technology, economics, and the environment that will likely occur over the period of program implementation.

A Comment about Transportation

Throughout the course of our dialogues, many citizens expressed concern about the transportation of used nuclear fuel and questioned whether it can be accomplished safely. The NWMO acknowledges this concern and the need to demonstrate the safety of any transportation system to the satisfaction of citizens before beginning to transport used nuclear fuel to a centralized long-term management facility. We commissioned three background papers specifically to examine the state of knowledge and experience regarding the transportation of used nuclear fuel.[1] On the basis of these papers, and through further insight gleaned from discussions with nuclear waste management organizations and regulatory bodies in other countries, the NWMO believes that with sufficient effort, resources, preparation, oversight and continued vigilance, used nuclear fuel can be transported safely. This is for a number of reasons.

Robust containers. The design of the transport container for used nuclear fuel is the main safety feature in used fuel transport. The containers are designed to withstand expected accident conditions without breach of containment or without an increase in radiation level that could potentially endanger the general public and workers. Testing under accident conditions is done to ensure that a container meets rigorous requirements. Details of the tests and the acceptance criteria with regard to leakage and radiation fields are prescribed in regulations developed by the International Atomic Energy Agency (IAEA).

The severity of the acceptance tests, outlined in Table 8-10, particularly those for accident conditions, indicate the high safety standards to which used fuel packages are tested prior to being deemed transportation worthy. The regulations are under constant review to ensure that they are kept up to date with modern requirements and knowledge gained from any actual incidents or accidents – whether or not these accidents involved nuclear materials.

Used nuclear fuel containers are massive structures typically manufactured from forged steel. Because of the robustness of these containers, used nuclear fuel has been transported safely for over forty years internationally. The IAEA has also set standards for the physical protection of nuclear material and

[1] NWMO Background Paper: 6-6 - Wardrop Engineering. Status of Transportation Systems for High-level Radioactive Waste Management; 6-7 Amir Husain and Kwansik Choi. Status of Storage, Disposal and Transportation Containers for the Management of Used Nuclear Fuel; 6-8 – Gavin J. Carter. Review of the Fundamental Issues and Key Considerations related to the transportation of spent nuclear fuel.

Table 8-10 Test Requirements for Used Fuel Transportation Packages

CONDITIONS	TESTS
Normal transport conditions	• Water spray test: exposure to rainfall of approximately 5 cm/h for at least 1 hour is simulated • Free drop test, package is dropped a free distance of 0.3 m • Stacking test: a compressive load, equivalent to 5 times the mass of the package (container plus used fuel), is applied • Penetration test: a 6kg bar is dropped from a height of 1 m on top of the package
Accident transport conditions	• Free drop test: package is dropped a free distance of 9 m • Penetration test: package is dropped a free distance of 1 m onto a rigid vertical bar • Thermal test: package is exposed for 30 minutes to a hydrocarbon fuel/air fire with an average temperature of 800°C • Water immersion test: package is exposed to a 15 m (minimum) head of water for a duration of 8 hours (minimum).

Source: Background Paper 6-7, "Status of Storage, Disposal on Transportation Containers for the Management of Used Nuclear Fuel, Amir Husain and Kwansik Choi.

produced guidelines for member countries to plan for and respond to emergency situations.

Containers used within Canada must also be licensed by the Canadian Nuclear Safety Commission (CNSC) an independent agency of the Government of Canada which regulates the use of nuclear material. Canada has so far moved only a limited number of used nuclear fuel containers. However, three million tonnes of dangerous goods (including hazardous waste) in approximately 27 million shipments are successfully transported in Canada every year by road, rail and air. The CNSC works in conjunction with Transport Canada to ensure the safe transport of this material. The important role of the CNSC and Transport Canada in this area is more fully described in Chapter 10.

International experience. While used nuclear fuel has not been transported widely in Canada, government, regulators and commercial organizations around the world have extensive experience transporting radioactive and nuclear materials, and with regulating it for safety and security. Government and independent experts in many countries, most notably the United States, the European Union and Japan, as well as the IAEA, have also regularly examined and researched safety issues concerning radioactive material transport. A large body of technical data exists which can be drawn on by regulators, utilities, politicians and the public in preparing any future plans for the transportation of used fuel. This information has direct application and relevance because Canada, as a member of the IAEA, is obliged to meet the same level of international standards that have been the subject of this study and analysis.

Radioactive materials have been transported around the world for 40 years. In that time, there have been no accidents that resulted in the release of significant amounts of radioactivity. In the US, nearly 3000 shipments of commercial used fuel have been transported over 2.5 million km in the last 30 years. Approximately 4300 shipments (primarily by rail) are proposed within a 24-year period to the U.S. Yucca Mountain site beginning in 2010. The UK and France combined average 650 shipments of used fuel per year (primarily by rail), through countries much more densely populated than Canada. Sweden routinely moves used fuel by ship to a central storage facility. Used fuel and high level reprocessing waste has been transported by sea between Europe and Japan. The ships have covered 4.5 million kilometers transporting used fuel without an incident resulting in the release of radiation to an individual or the environment.

Studies have also been conducted to examine a range of "what if" scenarios and accident scenarios, including analyses of what would have happened if used nuclear fuel had been transported during some of the most severe hazardous material accidents. These studies have consistently shown that the levels of risk are very low whether used nuclear fuel is transported by land or sea.

In summary, the NWMO acknowledges the concerns of many citizens about the transportation of used nuclear fuel and the need to demonstrate the safety of any transportation system to the satisfaction of citizens before beginning to transport used nuclear fuel to a centralized long term management facility. The NWMO understands that decisions on risk and safety are societal ones. On the basis of the work which the NWMO has conducted during this study, including the commissioning of background papers, and the discussions it has had with nuclear waste management organizations in other countries, the NWMO believes that used nuclear fuel can be transported safely. Adequate effort, resources, preparation, oversight and continued vigilance are necessary requirements of any plan for transportation of used nuclear fuel and, therefore, must be critical elements of any implementation plan for a management approach.

Summary of our Assessment Findings

We reached our conclusions through an iterative process of several stages. Our analysis suggests:

- Taken individually, no one of the management approaches specified in the *NFWA* perfectly addresses all of the objectives which citizens said are important for any management approach for Canada to address, particularly when both the near term (the next 175 years) and the longer term is considered;
- Each of the three approaches specified for study in the *NFWA* has distinct advantages and limitations in light of this framework;
- A management approach which incorporates the most significant advantages of each approach, supported by a phased decision-making process designed to actively and collaboratively manage risk and uncertainties, is expected to perform better on our objectives than the other three approaches; and
- The process of implementation will be a test of the degree to which any of the approaches would ultimately address citizen objectives, values and ethical principles. Therefore, the requirements for an implementation plan form an essential part of our recommendation.

The storage options, Option 2 – Storage at Nuclear Reactor Sites and Option 3 – Centralized Storage, are expected to perform well over the near term (at least within the next 175 years). However, the existing reactor sites were not chosen for their technical suitability as permanent storage sites. Furthermore, the communities hosting the nuclear reactors have an expectation that the used nuclear fuel will eventually be moved.

The NWMO believes that the risks and uncertainties concerning the performance of the storage approaches over the very long term are substantial in the areas of public health and safety, environmental integrity, security, economic viability and fairness. A key contributing factor in expected performance is the extent to which the storage approaches rely on strong institutions and active management to ensure the safe and effective performance of the management system. The NWMO expects that these institutions and capacity for active management will be strong over the foreseeable future, but uncertain over the very long term. The NWMO believes that the type of responsible and prudent approach that Canadians have suggested is required dictates that we not rely on the existence of strong institutions and active management capacity over thousands and tens of thousands of years. On this basis, the NWMO does not suggest either of the storage options as a preferred approach for the long term.

Deep Geological Disposal in the Canadian Shield, Option 1, is judged to perform well against the objectives in the very long term because of the combination of engineered and natural barriers to isolate the used fuel. A key weakness, however, is its lack of adaptability, which is an important objective in the minds of citizens. Over the short term, the approach is judged to be less flexible in responding to changing knowledge or circumstances either concerning the performance of the system itself over time, or more broadly to innovations in waste management technologies. There is some uncertainty about how the system will perform over the very long term because we cannot obtain advance proof of the actual performance of the system over thousands of years. Also, this approach provides comparatively little opportunity for future generations to influence the way in which the used fuel is managed. Its lack of adaptability is a weakness that may ultimately affect the performance of the system over time on other objectives such as public health and safety and environmental integrity.

Adaptive Phased Management, Option 4, has been designed to build upon the advantages of each of the three approaches studied. It is designed to reduce uncertainties at each phase in the process and over time. Involvement of citizens in decision-making throughout all of the phases is important. The NWMO considers Option 4 to offer a preferred approach.

- This approach is designed to be **highly adaptive** in the near term, the period in which it is reasonable to believe there will be strong oversight institutions and active management capacity. It entrenches an explicit and planned process of social learning and action. Over this period, new learning and technological innovation is easily incorporated into the management plan. Some social uncertainties, such as the role of nuclear generated electricity in Canada's energy mix, may be resolved in the near future. Some technical uncertainties, such as whether evolving technologies (i.e., transmutation) will become practicable, are also likely to be reduced. Some uncertainties over the performance of aspects of the deep geological system are also expected to be reduced with further research, testing and experimentation, particularly at the location where such a facility might be sited;

- This approach also clearly identifies the technology associated with a deep geological repository as the appropriate end point. It does not rely on human institutions and active management for its safe performance over the long term. The approach plans for and puts in place a safe and secure containment option for the used nuclear fuel at each point in the process. It provides real options and contingency plans should implementation through the phases not proceed as planned.

- This approach is designed to ensure that **public and worker health and safety** are maintained over the long term. Radiological and non-radiological exposures to the public and to workers are estimated to be very small. The optional step of shallow underground storage of used fuel at the central facility is expected to add a slight increase in radiation exposure to workers if more handling and repackaging of the used fuel is required, although the exposure would be well below current regulatory levels. The flexibility and adaptability of the approach allows for new and continuous learning to be incorporated. This is expected to improve the safety and performance of the management system through the reduction of uncertainty. It allows confidence to be established in the safety and performance of the technology before proceeding along each step in implementation.

- Similarly, site selection, engineered barriers and placement at depth in geologic media comprise a robust management design to **protect environmental integrity**. The extended period over which the site and the facilities can be monitored, tested and refined, prior to final placement of the used fuel are designed to strengthen the environmental performance of the system. The opportunity for active monitoring and study will allow us to learn, understand and adjust facility designs as may be appropriate over a staged implementation period.

- Over the long term, the approach will keep the waste **secure**, since it involves strong physical protection of the fuel against unintended security breaches by placing used nuclear fuel deep underground, and ultimately backfilling and sealing all routes to access the fuel.

- The approach is designed to be **fair** in the distribution of the risks, benefits and uncertainties within this generation and across generations. As a blend of a flexible centralized storage facility in the near term, coincident with an extended period of proof of concept activities, and final placement of used nuclear fuel in a deep repository, the management approach provides a balance between the major uncertainties associated with the performance of the individual technologies taken in isolation, both in the near term and over time.

- **Community well-being** is a key consideration in the approach in the sense that the staged and adaptive process will allow the implementation path to be responsive to the expectations of Canadian society today and continued influence of future generations on the subsequent decisions to be taken concerning design and evaluation of program progress.

- **Economic viability**, and in particular financial surety, is taken into account in requiring the majority of expenditures to be made in the near term (within the first 90 years). Over this period, it is reasonable to be confident in the availability of strong institutions and, therefore, safekeeping of the funds that have been contributed for this purpose.

Adaptive Phased Management provides the option for more robust and secure interim storage in shallow underground caverns located centrally at the site of the deep repository;

- The approach provides opportunity for future generations to influence the way in which the fuel is managed;
- The approach provides for research and collaborative decision-making in the determination of the manner and timing of movement through the phases;
- The approach suggests a process through which confidence in the technology and supporting systems can be developed before moving to the final phase; and
- The approach suggests a process for putting multiple options in place should these be required as contingencies throughout the implementation process.

Finally, our analysis suggests that some important issues are not fully addressed through the selection of the management approach itself. They will need to be considered through the collaborative decision-making process, which should accompany the implementation of any approach. These issues include the design of a fair siting process and the determination of safety thresholds that would need to be met before moving to the next phase of implementation.

Dialogue with Canadians has highlighted that an **optimal balance** needs to be found between flexibility in the near term, which allows for new learning, and the implementation of an approach which isolates and contains the used fuel in a way which does not require active care by people over the very long term. Option 4 provides such a balance. Canadians have also said that an optimal balance needs to be struck between moving cautiously, to allow for new learning and social confidence, and sustaining sufficient momentum to carry forward with implementation of the approach to completion. Should the implementation period be too protracted, there is a risk that future generations will lose interest and/or otherwise abandon the approach mid-way through implementation with negative impacts on public health and safety as a result.

As suggested earlier, the NWMO believes there is some risk associated with each of the approaches studied that momentum will be lost in the potential face of public opposition and/or loss of political will. A stepwise implementation process, involving potentially impacted communities of interest at each major point of decision-making, will result in greater public acceptability. This public acceptance should expedite the implementation of the deep repository by matching the pace and manner of implementation to that at which society is prepared to proceed. In laying out a process in which key decision points have been mapped along with the means to ensure those involved in the decision (potentially impacted communities of interest) have both the capacity and information to make the required decision, and putting contingencies in place should unforeseen events be encountered, implementation should proceed in as efficient a manner as social conditions allow. Through the nature of the decision-making process, and contingencies for multiple decision-making outcomes, the continued safe and secure management of used nuclear fuel is best assured through to completion of implementation.

In recommending Option 4, the NWMO considers the risk of a loss of momentum to be small overall, particularly over the period leading up to the completed construction of the deep repository which is expected to be within 90 years or less. The infrastructure and facilities for geological containment and isolation of the used fuel will be in place, operating and/or available for operation relatively early on, within the timeframe during which institutions are expected to be strong. The risk of a loss of momentum is, by design, constrained by the recommended implementation plan, and balanced by the potential to incorporate new learning, which the flexibility of this approach provides in the near term.

8.5 / The Preferred Approach and Possible Future Scenarios

This assessment has been conducted, and our recommendation is being made, based on what we know today, specifically the number of used nuclear fuel bundles which have been produced to date and which are planned to the end of the current lives of existing nuclear plants. Other decisions may be taken in the near future which could significantly change the conditions in which the management approach will be called upon to operate.

Adaptive Phased Management may be sufficiently flexible and adaptable to respond to a range of future scenarios. A description of the scenarios considered, and the technical and cost implications of each are discussed in Appendix 10. These scenarios did not benefit from a comprehensive comparative assessment of any social and ethical factors.

Any decision which may impact the future of nuclear power in Canada may well be accompanied by changes in societal priorities and preferences concerning the manner in which used nuclear fuel should be managed. Since Adaptive Phased Management is by design marked by a sequence of steps and decisions, significant adjustments can be made at many points through the implementation process. Two brief examples follow for illustrative purposes.

Early Nuclear Phase Out

What if Canada decided to phase out nuclear power generation by 2012? First, there would be some practical implications. There would be less fuel to manage and transport to a central facility. Used fuel transportation could be completed more quickly, within a period of 20 years rather than 30 years. As well, the long term management facilities could be scaled back in size. From a technical perspective, with relatively minor adjustments to the design and scale of the central facilities, the Adaptive Phased Management approach could be adapted to meet the conditions in this scenario.

A phase out of nuclear power may be accompanied by a shift in societal priorities or other public policy. For example, in order to more quickly close out the nuclear fuel cycle there might be a desire to implement the deep repository more quickly. Should this scenario come to fruition within the first 30 years of implementation of the Adaptive Phased Management approach, flexibility exists to forego the optional step of shallow underground storage and proceed to implementation of the deep repository on an expedited timeframe. This is an example of how the flexibility which has been built in to the approach might be used to adapt to changing conditions. Under this scenario, it is expected that sufficient funds would be available under the proposed conservative funding formula to support an expedited timeframe for implementation, particularly if the shallow storage facility was not constructed or was constructed on a smaller scale.

Existing Reactor Refurbishment and Life Extension

What if each of the nuclear reactors in Canada operated longer than currently planned, to an average of 50 years? First, there would be a number of practical implications. There would be an increased volume of used nuclear fuel to manage and transport over a longer period of production. The used fuel transportation period and placement period would each be increased from 30 years to 40 years. As well, the size of the deep repository would need to be expanded. From a technical perspective, with relatively minor adjustments to the design and scale of the central facilities the Adaptive Phased Management approach could be adapted to meet the conditions in this scenario.

An extension of the life of existing plants may be accompanied by a shift in societal priorities or other public policy. For example, since operations will continue at each nuclear plant site for an extended period, there might be a desire to continue to keep used nuclear fuel at the existing reactor sites for the full extended duration of the plant operation, and then move directly to placement of the fuel in a deep repository. The flexibility built in to the approach could be used to respond effectively to these changing conditions by extending the period of reactor site storage and forgoing the step of centralized shallow storage. Cursory consideration of this scenario may suggest that in order to be robust against this scenario, the Adaptive Phased Management approach should be implemented at a site which is large enough to accommodate expansion and additional fuel should the need arise. Cursory consideration may also suggest that any discussions with communities expressing interest in hosting the centralized facilities include discussion of this scenario and the bounds of community interest in this light.

Part Five
Implementation

5

Chapter 9 / Foundation for Implementation

Over many years, much research has been directed to examining and understanding the technical management options presented by the different conceptual designs. Going forward, it will be essential that the NWMO demonstrate a continuing commitment to process. The process by which a management approach is implemented will be an important determinant of its overall effectiveness and the extent to which it is, and continues to be, responsive to societal needs and concerns.

The *Nuclear Fuel Waste Act* (*NFWA*) requires that our study address some specific aspects of implementation. In Chapters 9 through 16, we address each of these legislated requirements and expand our discussion to address additional considerations we believe to be integral to the overall implementation plan.

9.1 / Key Features of Implementation Plans

For any management approach selected, the decision-making and implementation processes will unfold over many years. As the NWMO proceeds with implementation, it will be important that implementation continue to be responsive to the values and objectives of Canadians. The manner of implementation will determine the effectiveness of any management approach, and the extent to which it reflects societal needs and concerns. Through implementation we will seek to build confidence.

In our dialogues with the general public, Aboriginal peoples and specialists alike, many people focused their comments on features they believe should be part of the implementation plan that accompanies the management approach selected. Indeed, as we reported in Part Three, much of the common ground uncovered in our study relates to principles and expectations for how decisions will be taken, how citizens will be involved, and how any management approach will be implemented and monitored over time. In the discussion on implementation that follows, we are guided by the considerable advice and sharing of views we benefited from over the course of the study.

As the NWMO assumes its role leading implementation of the management approach selected by government, we intend that our processes build upon the foundations established to date through the course of our study of management options.

Our intentions for the implementation plans are outlined below:

We will communicate a clear decision-making path that includes accountability. With our study we have begun what will be an ongoing process that unfolds through the decision-making and implementation processes. There will be a continuum of engagement activities appropriate to support decisions taken at each step. We must provide assurance that commitments made will in fact be met, and that contingency plans are known and available should they be required. Safety for people and the environment must remain primary considerations as implementation proceeds.

Aboriginal values and concerns are a priority. We will continue to pursue relationships with potentially affected Aboriginal peoples based on mutual trust, respect and integrity. We are committed to seeking an alignment between Aboriginal values and those reflected in our implementation plan. We will respect Aboriginal rights, treaties and land claims.

We will build on relationships that we have established. The three-year NWMO study provides a starting point for the much longer-term outreach and engagement that will be the centerpiece of implementation. Through a diverse engagement program, we have come to know many communities of interest and developed ongoing dialogues with them. Our engagement of the Canadian public and with Aboriginal peoples is just beginning. The dialogue we have begun will continue to grow in the years to come.

We will seek to continue real dialogue. From the inception of our study, we have endeavoured to engage Canadians in a dialogue that permits a rich conversation through which to shape each step of our work. Many participants expressed support for the process we initiated to formulate our recommendations. The dialogue must continue through the implementation phases. Although agreement between all participants may not always be forthcoming, effective dialogue facilitates a better understanding of different perspectives. Key is the creation of opportunities in which these important discussions may take place. This is an area in which process-related insights from Aboriginal Traditional Knowledge can be brought to bear to inform implementation.

We will focus our engagement on potentially affected communities of interest. We will encourage all parties with significant interest to participate so that we may understand their views and incorporate the broadest possible foundation of perspectives and knowledge into our implementation decisions. We want to understand concerns of citizens in regions and communities that are affected directly and indirectly. We also want such communities to become active players and problem solvers. The potentially affected communities of interest are broad, and will vary over time and across phases of implementation.

Our plans for engaging communities of interest will need to be developed iteratively and collaboratively with those most affected. Decision-making becomes increasingly more complex as more players demand an active role. Effective engagement is based on principles of openness, transparency, integrity and mutual respect, which imply a shared responsibility.

We will assign great importance to societal considerations in the site-selection process. We must continue to learn about, and adapt to, the requirements identified by communities of interest. In order to support effective participation, we must ensure that the citizens and communities potentially impacted by the selection of a site for the management facility are sufficiently resourced and informed to be equipped to participate in discussions and decision-making. Their participation must be based on an understanding of potential risks and the means to manage them. Communities of interest potentially affected by the facility must have opportunities for genuine involvement in implementation process.

We do not intend to site a facility without the support of the host community. We must seek to design and implement our activities to foster positive change over the long term. Should there be adverse impacts, we must recognize the contributions and costs borne by the community through appropriate mitigation measures designed in collaboration with them.

We will seek to ensure access to the intellectual capacity required to make decisions and to sustain operations. Monitoring of emerging research and technical developments internationally will be important. Skills and capacities of workers must be sustained to support the safe operation of the facilities over the period of time in which institutional control is required.

9.2 / Engaging Communities of Interest

Over the course of its study, the NWMO has attempted to involve a broad cross-section of communities of interest, because all citizens are potentially affected by any decision made regarding the long-term management of used nuclear fuel. As we move toward implementation, different perspectives will be identified by those who feel they will be differentially impacted. With implementation, our engagement must become more focused on the communities of interest potentially most affected at each phase of the process.

The determination of those most affected, and the nature of their involvement, must be the subject of dialogue in the months immediately following a decision by the Government.

In our dialogues, we were asked what we mean by "communities of interest". A "community of interest" is a group of people who share a common interest or purpose. The group may live in close proximity to each other, for instance, in a town – therefore, the town is a community of interest – or they may share a common concern or knowledge, and have come together to pursue specific interests. For example, Nuclear Waste Watch, an organization formed as a result of shared concerns about nuclear waste management and the NWMO study, is a community of interest. The Canadian Nuclear Society, an organization of engineering professionals working in the nuclear industry, is also a community of interest. An Aboriginal community represents yet another, as are communities that presently host Canada's nuclear reactors, and communities along a transportation route. Going forward, a willing host community that offers itself and is selected for

Table 9-1 Describing Affected Communities for the Four Management Approaches

MANAGEMENT APPROACH	COMMUNITIES OF INTEREST
Option 1: Deep Geological Disposal	Cities, towns, villages, municipalities and dispersed population in the vicinity of the site; the Aboriginal community within the affected traditional territory, transportation corridor communities, reactor site communities until all used nuclear fuel is re-located.
Option 2: Storage at Nuclear Reactor Sites	Reactor site cities, towns, villages, municipalities and implicated aboriginal people.
Option 3: Centralized Extended Storage	Cities, towns, villages, municipalities and dispersed population in the vicinity of the site; the Aboriginal community within the affected traditional territory, transportation corridor communities, reactor site communities until all used nuclear fuel is re-located.
Option 4: Adaptive Phased Management	Cities, towns, villages, municipalities and dispersed population in the vicinity of the site; the Aboriginal community within the affected traditional territory, transportation corridor communities, reactor site communities until all used nuclear fuel is re-located.
All management approaches	Professional organizations working in this area; academic institutions conducting research in related areas; research and/or implementing organizations in other countries involved in implementing a similar approach; civil society groups with an interest; regulatory bodies and government departments with an interest.

the long-term management facility will be a very important community of interest. The communities in the region that may be affected by the operation of the facility are similarly important.

Communities of interest include geographic communities, such as cities, towns, villages or municipalities. They also include governments, industries, and civil society. There are those in the international arena contributing to the development of our management approach (for example, by providing scientific or technical advice) or who may be influenced by what we do in Canada. They too are a community of interest. Communities of interest which are likely to be affected will vary over time as decisions about managing used nuclear fuel are made and implemented. Table 9-1 is a very preliminary reflection of the variety and breadth of communities of interest which may be impacted at one or more points in the implementation process.

A discussion of our engagement plans is continued in Chapter 13.

9.3 / "Consultation" with Aboriginal Peoples

On treaty lands, Aboriginal and treaty rights are defined and protected under s.35 of the *Constitution Act*, 1982. In addition, in 1987, the World Commission on Environment and Development (the Brundtland Commission) stated that tribal people must be given a decisive voice in the formulation of resource policy in their areas. Since then, a series of Supreme Court of Canada decisions has begun the process of formally clarifying the legal duty of consultation owed to Aboriginal peoples by the Crown.

Throughout our study, we have made best efforts to involve Aboriginal peoples in the dialogue. This activity is documented in full in Part Three of this report. We have heard from some that these discussions did not constitute "consultation" as they saw it. The nature of the specific obligation will be clarified as the Government makes its decision, and directly affected individuals and communities become more evident.

9.4 / The Site-Selection Process

Although site selection is not part of this study, many have asked that we elaborate on some of the major considerations and principles that might influence the site-selection process.

A Willing Host Community

The siting of the management facility will involve both technical and social dimensions that cannot be separated. Safety and security must be fundamental considerations. Technical and scientific factors associated with confirming the geology and suitability of the site are important, and regulatory processes will demand that a strong safety case be demonstrated. However, confidence in the technical aspects of a site alone is unlikely to be sufficient to provide the assurances that people seek in order to implement the project successfully. A dynamic process, implementation must unfold in an ethical way that continues to respect the social, cultural and economic aspirations of the affected community.

For this reason, the NWMO is committed to seeking an informed, willing community to host the long-term management facility.

Identification of a willing host community is central to building a foundation for collaboration and active involvement of the community in implementing the management approach. Implementation requires a host community that is well informed about the impacts, and is committed to working with the NWMO, shaping and directing key implementation decisions. Implementation presents a significant opportunity to build trust and cooperation, so that decisions taken support and make possible longer-term, sustained benefits for the community. It is against the backdrop of the community's own vision for its future that the NWMO would wish to proceed with implementation.

The NWMO does not intend to proceed with siting against the wishes of a local community. It is the potential host community that will be positioned to determine how to ascertain whether it has the permission and trust of its residents in order for the NWMO to proceed.

It is up to the potential host community to determine how it will demonstrate its willingness to host the facility. It will be up to the potential host community to establish how it will invite its citizens to express their views.

In deciding whether or not "willingness" has been demonstrated at a level sufficient to proceed with siting in a potential host community, the NWMO will consider a number of factors.

For example, a "willing host community" must be one which:

- Has provided an open, inclusive and fair opportunity for engagement and dialogue with residents of the community, allowing their views to be heard and taken into account;
- Has considered the potential benefits and costs, as well as areas of risk and uncertainty, associated with hosting the long-term management facility;
- Has considered the full range of impacts on the community's social and cultural aspirations, as well as economic considerations. During our public engagement we heard concerns that a community might be drawn to accept the facility for purposes of economic development alone. The NWMO will want to ensure that the community's willingness is not driven exclusively by economic development reasons, without due consideration to social and cultural impacts implicit in becoming the host community;
- Has, in considering the implications of hosting the facility, been well informed by the best available knowledge about the project and has carefully considered the decision of hosting the facility. It has received sufficient resources from the NWMO with which to develop its capacity to undertake this investigation, including access to independent advisors;
- Has determined how it will demonstrate community willingness to host the facility, and has arrived at its interpretation of willingness using indicators/process/judgement of its own design; and
- Has demonstrated a willingness to work closely with the NWMO throughout the implementation process. The NWMO will want to work collaboratively with the community to identify measures and manage socio-economic effects that may arise in the course of implementing, monitoring and operating the facility, in a way that supports the community's long-term vision. Societal considerations will assume great significance in a site-selection process, and the NWMO must continue to learn about, and adapt to, the requirements identified by the host community.

These issues are discussed further in Chapter 14.

Collaborative Design of a Siting Process

The NWMO will play the lead role in coordinating the site-selection process. We will initiate our plans for siting-related activities immediately following a government decision on a management approach.

During our dialogues, we heard that the engagement process that the NWMO establishes as part of the siting process will be a particular area of interest and concern. To build and maintain trust, we were advised that the siting process must provide extensive opportunity for public input.

The NWMO is committed to developing and implementing a siting process collaboratively with affected communities of interest.

The siting process, and the engagement process to support it, must be the subject of a specific dialogue immediately following any government decision which involves the centralization of used nuclear fuel.

During the collaborative design of a siting process, the NWMO will seek to develop, confirm and communicate the:

- Objectives of the exercise;
- Principles that would apply;
- Major steps in the site-selection process, including the process that will be used to determine suitability and confirm acceptability, at each step along the way;
- Factors and criteria to be applied and how they would be used;
- Processes and mechanisms to integrate Aboriginal Traditional Knowledge;
- Information sharing that would be undertaken and studies required at each stage; and
- Processes and mechanisms to engage and support potential willing host communities, from the initial solicitation of expressions of interest, to the identification of a preferred site.

We received many comments on the complex issues to be addressed as the NWMO initiates a siting dialogue to identify an informed, willing host community. We will need to determine how decisions are considered and made, and who is involved in those decisions. Examples of some of the issues are outlined below:

- How can the NWMO develop a fair, ethical and effective siting process, which benefits from the input of potentially affected communities of interest?
- What information does the NWMO need to provide clearly and transparently at the outset, to support these initial discussions about a siting process? What preliminary information on site requirements and criteria should be tabled to initiate a dialogue?
- What level of input, agreement or assurance should be sought from different communities of interest as a preferred site is identified? How will conflicts be addressed?
- What process should the NWMO use to invite expressions of interest from potential host communities?
- How will the boundary of "host community" be defined, for purposes of a specific community demonstrating its willingness? (The notion of "host community" may be defined in terms of geographical or political boundaries, but not always.)
- What time and resources are required for potential host communities to build their capacities to make informed decisions: What information and capacity building are required to enable consideration by potential host communities, as part of the process of inviting informed consent by a willing host community? Are there specific types of preliminary feasibility studies and analyses that will be required? What social and technical data are required to understand the community-specific impacts? What financial resources and independent expertise is required to support the community's consideration?
- How can the NWMO best support an iterative process of learning and exploration? How can potential host communities help shape the nature of the investigations? What is the most effective way for the NWMO to share findings of research as it collects data and understands the character of potentially suitable sites?
- What is required in establishing clear authorities to negotiate and implement agreements with an informed willing host community?

- What types of agreements should the NWMO enter into with potentially interested host communities, to support further collaborative investigations?

- What are appropriate timelines for convening these different phases of the site selection process?

In our public dialogues, participants advised that the NWMO look to lessons learned from past siting exercises involving nuclear waste and other hazardous substances. We were encouraged to look at best practices from specific experiences within Canada and abroad as we elaborate a siting process.

Siting Principles and Other Factors

Participants in our dialogues also provided preliminary insights as to some of the principles that they believe should be fundamental in a collaboratively-designed siting process. We have considered these comments, in setting out the discussion that follows.

We believe that the ethical obligations outlined below should shape the way in which we proceed with the site-selection process, as we seek a willing community to host the long-term management approach:

- Respect for life in all its forms, including minimization of harm to human beings and other sentient creatures;

- Respect for future generations of human beings, other species, and the biosphere as a whole;

- Respect for peoples and cultures;

- Justice across groups, regions, and generations;

- Fairness to everyone affected and particularly to minorities and marginalized groups; and

- Sensitivity to the differences of values and interpretations that different individuals and groups bring to the dialogue.

In order for the site to be acceptable, it would need to address scientific and technical siting factors to ensure that any facility is likely to protect human beings, including future generations, other life-forms and the biosphere as a whole into the indefinite future. Any facility would be subjected to regulatory oversight to ensure that the site is acceptable from a safety perspective.

Based on these principles, the siting process will seek to:

- Be open, inclusive and fair to all parties, giving everyone with an interest in the matter an opportunity to have their views heard and taken into account;

- Ensure groups most likely to be affected by the facility, including the transportation required, are given full opportunity to have their views heard and taken into account, and are provided with the forms of assistance they require to present their case effectively;

- Include special attention to Aboriginal communities that may be affected. In particular, the NWMO will respect Aboriginal rights, treaties and land claims;

- Be free from conflict of interest, personal gain or bias among those making the decision and/or formulating recommendations;

- Be informed by a synthesis of the best knowledge – in particular natural science, social science, Aboriginal Traditional Knowledge, and ethics – relevant to making a decision and/or formulating a recommendation;

- Be in accord with the precautionary approach, which first seeks to avoid harm and risk of harm. If harm or risk of harm is unavoidable, place the burden of proving that the harm or risk is ethically justified on those making the decision to impose it;

- Ensure, in accordance with the doctrine of informed consent, that those who could be exposed to harm or risk of harm (or other losses or limitations) are fully consulted and are willing to accept what is proposed for them;

- Take into consideration, in so far as it is possible to do so, the costs, harms, risks, and benefits of the siting decision, including not just financial costs but also physical, biological, social, cultural, and ethical costs (harm to our values); and

- Ensure that those who benefited most from nuclear power (past, present and perhaps future) are bearing the potential costs and risks of managing used fuel and other nuclear materials.

We believe that the objective of fairness would best be achieved if the site-selection process is focused within the provinces that are directly involved in the nuclear fuel cycle.

We therefore intend to focus the site-selection process in Ontario, New Brunswick, Québec and Saskatchewan. We recognize that communities in other regions and provinces may come forward with interest in possibly hosting the centralized facility. Such expressions of interest will also be considered.

The NWMO will respect Aboriginal rights, treaties and land claims.

Those potentially affected by the development of the management facility must be involved in discussions and be provided in advance with information and resources that enables them to participate effectively. The implementation process must seek ways to assist citizens in the host community to manage the resulting change caused by the project so they can pursue their economic, social and cultural aspirations. Effects management measures will need to be used to avoid or reduce the severity of negative socio-economic impacts of hosting the facility while nourishing those that enhance desirable socio-economic and cultural characteristics.

We are particularly sensitive to the role of potentially affected Aboriginal peoples. We are committed to building a relationship based on mutual trust, respect, and integrity. We are committed to seeking an alignment between Aboriginal values and those reflected in our management strategy.

We have begun the process of exploring and learning how to bring holders of Aboriginal Traditional Knowledge into the discussion and integrate their insights into our work. We have learned that Aboriginal Traditional Knowledge is broad. Well known, is that it includes substantive knowledge about the land and ecology in any given location, stemming from long contact with the land. But it also includes process knowledge, about developing and maintaining effective and respectful relationships – between young and old, within a community, and between communities. Thus, it can teach us about effective decision-making and management processes.

We will continue to engage with the Aboriginal communities that may be affected by our work, to share our knowledge and to learn from them. We believe, as we have been told, that the best way forward will be found by bringing together Aboriginal Traditional Knowledge with "western" science in a partnership.

Safety will be central to all decision-making processes. Regulatory processes overseen by the Canadian Nuclear Safety Commission (CNSC) will lead the reviews of site locations. Environmental assessment and licensing procedures will demand that the safety case be clearly demonstrated. The CNSC, together with Transport Canada, will demand strong safety cases for any required transportation associated with implementation. For any management approach adopted, specific siting requirements will be defined once a decision has been taken on a specific approach, and the project specifications fully elaborated.

The scientific and technical siting factors will include:

For Option 1: Deep Geological Disposal in the Canadian Shield

- Location in the Canadian Shield;
- Absence of known potential economic resources at depth;
- Sufficient surface area for receipt facilities and associated infrastructure;
- Seismically stable region with low known or projected frequency of high magnitude earthquakes;
- Low frequency of major groundwater conducting fracture zones, features or faults at repository depth;
- Geotechnically suitable host rock formation at least 200 metres below surface with a preference for a suitable host rock formation between 500 and 1,000 metres below surface for the deep geological repository;
- Geochemically suitable (e.g., reducing) conditions in groundwater at repository depth;
- Evidence of rock mass homogeneity and stability at repository depth;
- Low hydraulic gradient and low permeability; and
- Diffusion controlled transport of dissolved minerals at repository depth.

For Option 2: Storage at Nuclear Reactor Sites

- Location of storage facilities at nuclear reactor sites.

For Option 3: Centralized Storage, Above or Below Ground

- Competent soil or similar material to support the storage facilities and associated infrastructure;
- Sufficient surface area for storage facilities and associated infrastructure; and
- Seismically stable region with low known or projected frequency of high magnitude earthquakes.

For Option 4: Adaptive Phased Management

- Location in suitable rock such as the crystalline rock of the Canadian Shield or in the Ordovician sedimentary rock basins;
- Absence of known potential economic resources at depth;
- Sufficient surface area for receipt facilities and associated infrastructure;
- Seismically stable region with low known or projected frequency and magnitude of earthquakes;
- Low frequency of major groundwater conducting fracture zones, features or faults at repository depth;
- Geotechnically suitable host rock formation below surface for the optional shallow rock cavern vaults;
- Geotechnically suitable host rock formation at least 200 metres below surface with a preference for a suitable host rock formation between 500 and 1,000 metres below surface for the underground characterization facility and the deep geological repository;
- Geochemically suitable (e.g., reducing) conditions in groundwater at repository depth;
- Evidence of rock mass homogeneity and stability at repository depth;
- Low hydraulic gradient and low permeability; and
- Diffusion controlled transport of dissolved minerals at repository depth.

9.5 / Managing Implementation

Immediately following a decision by the Government of Canada on the selection of a management approach, the NWMO will assume its mandate as the implementing agency, as required under the *Nuclear Fuel Waste Act* (*NFWA*). We must be prepared to move forward in a timely way to implement the Government's decision.

Implementation of any management approach will stretch out for many decades, as the project moves through phases of elaborating the management design, identifying candidate sites, building relationships with affected communities of interest, evaluating sites for adequacy, characterizing the site, undertaking environmental assessments and regulatory approvals, constructing, transporting and monitoring the used fuel. In support of these activities, we intend to develop the details of our multi-year strategic plans collaboratively with the many communities of interest affected by our project, inviting input on the way in which we design and tailor the many facets of our implementation processes as well as programs for citizen engagement. As part of the implementation process, we will clarify the roles and responsibilities of the NWMO and the waste owners respectively, including areas in which we will work together. For example, the NWMO and the waste owners will commit to working closely with reactor site communities which currently host the used fuel and which must be actively involved in implementation plans.

As we look ahead to the short-term horizon for the NWMO, our activities in the first three years will be focused on a number of fronts. The siting process discussed in the previous section will be one important area of focus for the NWMO. Some additional areas of activity for the NWMO are presented below:

Managing Community Impacts

We will be developing a five-year strategic plan and budget to support implementation of the management approach. We will be tabling this strategic plan with the Minister of Natural Resources Canada at the conclusion of our third year of implementation, and making it public at the same time.

In formulating our detailed strategic plans for implementation, we will work collaboratively with communities of interest, to develop our approach to dialogue, decision-making and attention to socio-economic impacts that will feature fundamentally in implementation.

- We will seek input from the potentially affected communities of interest concerning the way in which they wish to be engaged in the process. We want to initiate an open dialogue with affected interests, both to invite comment on our progress to date, and to help shape our future plans;

- We will seek direction and input from potentially affected communities for how we should analyze possible socio-economic effects of our implementation activities on a host community's way of life or on its social, cultural or economic aspirations, and consider how best to manage those effects;

- Working with potentially impacted communities, we will undertake research into social and ethical considerations and impacts that will be encountered through implementation and ultimately, during operation of the management facility. We will continue research on adaptive management as it relates to ongoing social and technical decision-making, including research to support the identification and management of possible community impacts, including impacts on traditional Aboriginal lands. (See Chapter 15 for a fuller discussion on Research and Intellectual Capacity); and

- We will support the development of capacity in potentially affected communities, so that they may increase their understanding of implementation issues, and initiate their own investigations, as required. (See Chapters 13 and 14 for more discussion.)

Furthering our Social, Technical and Scientific Research

We will continue our technical and scientific research activities in a number of areas:

- Research will include site-specific investigations into the technical performance of the management system;
- We will continue to undertake research on the characteristics and performance of geology which is potentially suited to implementation of the selected management approach. While much is already known about crystalline rock, further research is required to understand the suitability and technical requirements in the case of sedimentary rock, proposed to be included for study in the case of the recommended Option 4 (Adaptive Phased Management); and
- We will continue to monitor and engage in research being undertaken internationally to further the understanding of social, technical and ethical considerations.

Our research plans will be discussed and developed collaboratively with the communities of interest.

For a fuller discussion of research requirements, see Chapter 15.

Refinement of Financial Requirements

There is important work that the NWMO must continue relating to the financial provisions for the management approach. Building on work undertaken to date, we must develop and refine the cost estimates and funding formula to support the financing of the long-term management approach.

The *NFWA* sets out some specific requirements that we must address and report on, in each NWMO annual report issued following the government's selection of a management approach. We must provide:

- Details on the financial guarantees;
- An updated estimated total cost estimate of the management approach;
- The budget forecast for the next fiscal year;
- The proposed formula for the next fiscal year to calculate the amount required to finance the management of nuclear fuel waste; and
- The amount of the deposit required to be paid during the next fiscal year by each of the nuclear energy corporations and AECL.

The NWMO submits annual reports to the Minister of Natural Resources Canada. They are made public at the same time. When we report this information in our first NWMO annual report following the government's decision, the funding formula and the amounts of the deposits proposed by the NWMO will be subject to approval by the Minister of Natural Resources Canada. Once the level of deposits is approved by the Minister, each nuclear energy corporation and AECL will adjust their annual contributions to their respective trust funds accordingly.

The financial requirements are discussed in more detail in Chapter 11.

Oversight of Implementation

The NWMO will experience organizational change as it transitions from a phase of study to one of implementation. The organization will require different expertise and capabilities. In the transition to implementation, the NWMO will continue to be guided by the vision and values, and the objectives and ethical principles that have been instrumental in guiding our work thus far.

The NWMO Board of Directors will ensure that a strong governance structure is in place to oversee implementation of the government's decision in compliance with the *NFWA*. The Board will seek to ensure that the NWMO is equipped to assume its new and expanded responsibilities. In this regard, the Board will provide the organization with annual funding commensurate with its broadened scope of responsibility. The Board will ensure that the NWMO's policies, practices and internal controls are appropriate to lead and manage implementation in accordance with best practices.

As part of its overall review of the future governance structure of the NWMO, the Board is currently reviewing its own membership and composition as appropriate for the evolving mandate of the NWMO. Similarly, the NWMO will review the terms of reference and membership of the Advisory Council to the NWMO. It will be important that the Council is appropriately constituted to bring a range of perspectives to its independent counsel to the NWMO on implementation issues.

For further discussion of the NWMO mandate and governance, see Chapter 10.

The *NFWA* sets out specific elements for implementation plans that are to be developed for each option in our study. In the chapters that follow, we address in turn, each of the elements required by the *NFWA*. We also address other elements that we believe are key to assuring procedural fairness, integrity and safety: governance and institutions (Chapter 10); financial surety (Chapter 11); and research and intellectual capacity (Chapter 15).

In many areas of implementation, our recommendations would be similar for all four management approaches. In other areas, we identify where implementation approaches differ, according to the option under review.

Our discussion of implementation activities and timetables in Chapter 16 presents possible schedules associated with each management approach. Detailed implementation plans will be developed through collaboration and dialogue, led by the NWMO, following the government's decision. Many individuals and communities of interest will have important roles to play in overseeing and participating in implementation. We look forward to advice and direction from a diversity of voices on how the process should be designed and what issues need to be explored.

Implementation plans will not be static. They will evolve. The unprecedented time horizon over which implementation will occur points to a requirement for continuous learning and a commitment to periodically assess progress and adapt to changing conditions.

Chapter 10 / Governance and Institutions

There is an extensive governance framework in place to oversee the long-term management of Canada's used nuclear fuel and to ensure this management continues to meet the needs of Canadians (as outlined in Figure 10-1).

The NWMO has committed to a collaborative process to guide implementation. At this early stage of development, we identify some of the participants who will be included in this process, and some key roles and responsibilities. The roles and responsibilities of other affected communities of interest will emerge through dialogue as part of the implementation process.

Following a decision on a management approach, implementation will be overseen by governmental and regulatory bodies. The NWMO will be required to comply with all applicable legislative and regulatory requirements. Chapter 10 summarizes some of the more significant governing legislation and highlights the key roles and responsibilities of the participants who will figure prominently.

For further discussion of the regulatory framework, see Appendix 5. Background papers available at **www.nwmo.ca/institutions**, present a more comprehensive listing of statutes and other laws of general application that may also be relevant.

Figure 1-3 Governance Framework for the Long-Term Management of Used Nuclear Fuel: Roles & Responsibilities

Government of Canada
Responsible for:
- Making the decision on the long-term management approach for used nuclear fuel.
- Developing policy, regulating, and overseeing producers and owners of waste to ensure that they comply with legal requirements and meet their funding and operational responsibilities.

Natural Resources Canada
Responsible for:
- Recommending a management approach to the Government of Canada from the options in the NWMO study.
- Administering the *Nuclear Fuel Waste Act*, and monitoring the NWMO and the nuclear fuel waste owners to ensure compliance with the *NFWA*, especially with respect to socio-economic effects.
- Approving the funding formula and annual deposits to the trust funds, ensuring trust funds are established, and required deposits are made by the nuclear fuel waste owners.
- Reviewing NWMO's reports and making public statements.
- Interacting with Aboriginal populations to meet government fiduciary responsibilities related to the *NFWA*.

Canadian Nuclear Safety Commission (CNSC)
Responsible for:
- Regulating the use of nuclear energy and nuclear materials to protect health, safety, security and the environment, and to respect related international obligations.
- Ensuring that Canada's international obligations are met, including safeguard agreements with the International Atomic Energy Agency (IAEA), and the *Joint Convention on the Safety of Spent Fuel Management and the Safety of Radioactive Waste Management*.
- Ensuring, prior to licensing, that environmental effects are carefully reviewed through environmental assessments, as required under the *Canadian Environmental Assessment Act*.
- Making determinations on licence applications brought forward by the NWMO for siting, constructing, operating, modifying and decommissioning the long-term management facilities.
- Undertaking ongoing compliance and enforcement of statutory requirements and current licence requirements and conditions, and taking enforcement actions on incidents of non-compliance.

Transport Canada
Responsible for:
- Establising and enforcing requirements to promote public safety during the transport of dangerous goods including radioactive material (in coordination with the CNSC).
- Approving Emergency Response Assistance Plans prior to transport.

Canadian Environmental Assessment Agency
Responsible for:
- Administering the *Canadian Environmental Assessment Act* with which the CNSC must comply before proceeding with each licence application from the NWMO.

Provincial Governments/Regulators
Responsible for:
- Shareholders/owner accountabilities for provincial nuclear power corporations.
- Enforcing provincial statutes that contribute to the regulatory framework that the NWMO must meet.

Major Nuclear Fuel Waste Owners
Responsible for:
- Establishing trust funds to finance the implementation of the long-term management approach selected by government.
- Establishing and maintaining a Nuclear Waste Management Organization.

Currently Canada's owners of used nuclear fuel are: Ontario Power Generation Inc. (owns approximately 90 percent of the used fuel), Hydro-Québec, NB Power Nuclear, and Atomic Energy of Canada Limited.

Figure 1-3 (cont'd) Governance Framework for the Long-Term Management of Used Nuclear Fuel: Roles & Responsibilities

Nuclear Waste Management Organization (NWMO)
Responsible for:
- Preparing the study of long-term management options.
- Consulting with the general public and Aboriginal Peoples.
- Implementing the management approach selected by Government, carrying out the associated managerial, financial and operational activities.
- Reporting regularly to the Minister of Natural Resources Canada and the public.

Advisory Council to the NWMO
Responsible for:
- Examining and providing written comments on the NWMO's study of management approaches and subsequent triennial reports submitted to the Minister of Natural Resources Canada.
- Providing ongoing guidance to the NWMO.

Host Communities
Responsible for:
- Contributing to the design of the implementation plan to ensure it will best meet the needs of the community.
- Participating in implementation of the plan to ensure community needs are met, and in particular, decisions which affect the pace and manner of moving through the phases of work.
- Participating in the design and implementation of measures to address socio-economic and cultural effects of NWMO activities.

Affected Aboriginal Peoples
Responsible for:
- Contributing to the design of the implementation plan to ensure the needs of those impacted will best be met.
- Participating in implementation of the plan to ensure the needs of those impacted are met, and in particular, decisions which affect the pace and manner of moving through the phases of work.
- Participating in the design and implementation of measures to address socio-economic and cultural effects of NWMO activities.

10.1 / The Government of Canada

The Government of Canada, in cooperation with the provinces and the owners and producers of nuclear fuel waste, has an important policy role to play in the long-term management of nuclear fuel waste. The federal government is responsible for developing policy and overseeing the producers and owners of nuclear fuel waste in order that they meet their operational and funding responsibilities in accordance with the approved long-term waste management plans. Government has put in place policies, legislation and regulations to provide direction and oversight for radioactive waste management.

In July 1996, the federal government announced its Policy Framework for Radioactive Waste. This Framework set out principles to govern the institutional and financial arrangements for radioactive waste management in Canada. It defines the roles of government and waste producers and owners:

- The federal government will ensure that radioactive waste disposal is carried out in a safe, environmentally sound, comprehensive, cost-effective and integrated manner;
- The federal government has the responsibility to develop policy, to regulate, and to oversee producers and owners to ensure that they comply with legal requirements and meet their funding and operational responsibilities in accordance with approved waste disposal plans; and
- The waste producers and owners are responsible, in accordance with the principle of "polluter pays," for the funding, organization, management and operation of disposal and other facilities required for their wastes. This recognizes that arrangements may be different for nuclear fuel waste, low-level radioactive waste and uranium mine and mill tailings.

The Canadian Parliament passed the *Nuclear Fuel Waste Act* (*NFWA*) in 2002. The *NFWA* assigns roles and responsibilities for the long-term management of nuclear fuel waste consistent with the government's Policy Framework for Radioactive Waste Management.

Under the *NFWA*, the federal government holds decision-making authority over the management approach selected for nuclear fuel waste. Its decision will be based on a comprehensive, integrated and economically sound approach for Canada. The *NFWA* is presented in full in Appendix 2.

Many agencies and departments of the federal government have related responsibilities. The key ones are identified in Figure 10-1.

10.2 / Natural Resources Canada

The federal Minister of Natural Resources Canada is responsible for administration of the *NFWA*. In administering this legislation, Natural Resources Canada has an important role in overseeing the long-term management of nuclear fuel waste.

Upon receipt of our study, Natural Resources Canada will initiate an inter-departmental review to invite comments from various departments, as well as the Canadian Nuclear Safety Commission. It is upon the recommendation of the Minister of Natural Resources Canada that the government will make its decision on the management approach from proposals put forward by the NWMO.

After the government decision, the Minister's oversight of the NWMO and the implementation process continues, under the various requirements of the *NFWA*. Provisions in the *NFWA* that make explicit the oversight of the Minister of Natural Resources Canada include the NWMO's reporting requirements to the Minister, and the Minister's review and approval authorities. Chapter 11 reviews the Minister's role in reviewing and approving financial provisions for the management approach.

10.3 / Canadian Nuclear Safety Commission

Any option chosen for the long-term management of used nuclear fuel will have to meet the regulatory requirements governing such facilities.

The Canadian Nuclear Safety Commission (CNSC) is the lead federal organization overseeing operations of the nuclear industry in Canada. The CNSC is an independent regulatory agency of the federal government, responsible for regulating the use of nuclear energy and nuclear materials to protect the health, safety, and security of Canadians, to protect the environment, and to ensure that Canada's commitments on the peaceful use of nuclear energy are respected.

The CNSC, operating within the mandate and authority of the *Nuclear Safety and Control Act*, regulates all activities relating to nuclear materials, equipment and processes within Canada. The requirements of the *NSCA*, as administered and applied by the CNSC, will oblige the NWMO to obtain licences for the site preparation, construction, operation, modification, decommissioning, and where applicable, abandonment of disposal/ storage facilities.

The CNSC's regulatory regime covers the entire nuclear substance lifecycle, from production, use, to final disposition of any nuclear substances. Of particular significance is the CNSC compliance program. Once a licence is issued, the licensed activities are monitored by the CNSC to ensure compliance with the regulatory requirements. Non-compliance is corrected using a set of graduated enforcement actions that range from verbal discussions and written notices to legal prosecution and revocation of licence.

The CNSC has established principles that it will take into account in making regulatory decisions concerning the long-term management of used nuclear fuel. The CNSC has issued a Draft Regulatory Guide, G-320, for public comment, which sets out typical ways to assess impacts that long-term waste management may have on the environment and on the health and safety of people in the long term. It is intended to assist licensees and applicants in assessing the long-term safety of storage and disposal of radioactive waste. Details are set out in Appendix 5.

In operating a nuclear waste repository, the NWMO will be required to demonstrate that it is in accord with regulations made under the *NSCA*. We will also be required to demonstrate compliance with the conditions of licence(s).

The CNSC regulates the safe transport of nuclear substances under the *NSCA* in coordination with Transport Canada, under the *Transportation of Dangerous Goods Act*. As part of this process, the CNSC: establishes package design requirements; reviews safety cases; ensures that the licensee provides the physical security that is required by the *NSCA*, by the regulations pursuant to the *NSCA*, and by licence conditions; and performs compliance inspections. For centralized options, we will be required to use a package design that will be certified by the CNSC, and obtain a licence to transport fuel waste materials to the centralized repository. Any shipment(s) of used fuel will require the NWMO (licensee, transporter) to file a transport security plan with the CNSC to ensure that the proposed security measures for any used fuel shipments are commensurate with any credible threat at the time of shipment(s).

In meeting its obligations under the *Canadian Environmental Assessment Act*, the CNSC is required to determine whether an environmental assessment must occur to assess the potential for significant environmental impacts. It is anticipated that the CNSC would require the NWMO to undertake an environmental assessment prior to deciding on licence applications for site preparation, construction, operation, modification, decommissioning or abandonment of a nuclear waste facility. The *Canadian Environmental Assessment Act* is the basis for the federal practice of environmental assessment to ensure that the environmental effects of projects overseen by the federal government are considered early in the project's planning stages. The Act is administered by the Canadian Environmental Assessment Agency. For further details concerning the relationship between the *Canadian Environmental Assessment Act* and the CNSC licensing process, see background paper 7-9. (**www.nwmo.ca/cnsc licensing**)

The CNSC, in applying the *NSCA* to determine the merits of any licence application within its purview, and thereby issue, renew, suspend, amend, revoke or replace a licence, will make determinations on whether or not an applicant has also fulfilled the legislative and regulatory obligations of the *Nuclear Liability Act*, the *Canadian Environmental Protection Act*, the *Canada Transportation Act* and its regulations, and other acts and regulations it deems appropriate. The CNSC works with provincial, national and international agencies in harmonizing the regulation of radioactive waste management in Canada.

The CNSC usually issues licences for short periods of time. These licences must be renewed as part of the ongoing regulatory process. Licensing decisions are revisited with each renewal application. In considering each licence application, the CNSC takes into account the history of performance and compliance of the licensee, and the design and implementation of the licensee's programs in the areas of operations, quality assurance, radiation protection, environmental protection, non-radiological health and safety, emergency preparedness, nuclear security, safeguards and public information. This process continues until a licence to abandon is granted. Each application triggers a determination of the need for an environmental assessment under *CEAA*. The potential long-term impacts from the management of the used fuel need to be taken into account at each licence decision.

The CNSC may require that operators of nuclear facilities provide financial guarantees to ensure that operations will take place in a responsible and orderly manner. In the event that the waste owners are unable to pay and adequate financial guarantees are not in place, responsibility would rest with the federal and/or provincial governments, as managers of last resort.

The CNSC requires that all nuclear facilities have a decommissioning plan in place. The plan identifies the end-state of the facility and site, identifies the activities to achieve that end state, and includes an assessment of the potential environmental effects of the proposed decommissioning program. This decommissioning plan forms the basis for the financial guarantee, which is required to ensure that there will be funds available to implement the decommissioning plan and to prevent any financial burden on future generations. Future financial burden could arise from the need for institutional controls and the long-term care and maintenance of the wastes.

International Responsibilities

The CNSC is responsible for implementing Canada's international nuclear non-proliferation safeguards and security obligations in collaboration with Foreign Affairs Canada.

The cornerstone of the international nuclear non-proliferation regime is the *Treaty on the Non-Proliferation of Nuclear Weapons* (*NPT*). The *NPT* establishes commitments to prevent the spread of nuclear weapons, promote cooperation in the peaceful uses of nuclear energy, and achieve nuclear disarmament. Canada is an original signatory to the *NPT* and has centered its own nuclear non-proliferation policy on the treaty's provisions.

Canada has in place a comprehensive safeguards agreement with the International Atomic Energy Agency (IAEA) pursuant to the NPT. Safeguards require accurate accounting of nuclear material and inspection activities which include various technical measures to provide assurance to the IAEA that the sensitive material remains in place. The safeguards agreement gives the IAEA the right and obligation to monitor Canada's nuclear-related activities and to verify nuclear material inventories and flows in Canada. The CNSC is responsible for implementing the *Canada/IAEA Safeguards Agreement and Additional Protocol*. Through its regulatory process, the CNSC performs compliance and auditing activities to ensure that all relevant licensees have in place measures, policies and procedures to comply with these international commitments. Safeguards are intended to provide assurance to the international community that Canada is not using nuclear material for the production of nuclear weapons or other nuclear explosive devices. These are serious obligations and non-cooperation has significant repercussions.

The NWMO, operating under the jurisdiction of the CNSC, will also be required to manage itself in accord with the *Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management*. Under the *Convention*, Canada must demonstrate that it is meeting international commitments to manage radioactive waste and spent fuel safely.

10.4 / Transport Canada

Transport Canada promotes public safety during the transportation of dangerous goods. The department is responsible for regulating all dangerous goods that are transported in Canada, including Class 7 materials (radioactive materials). Responsibility for the regulation of transport of radioactive material is shared with the Canadian Nuclear Safety Commission. Transport Canada and the CNSC both have primarily adopted IAEA Regulations for the Safe Transport of Radioactive Material.

For Class 7 shipments Transport Canada is primarily responsible for:

- Establishing and enforcing any transportation requirements for carriers, vehicles or other conveyances except for the radiation protection program for the carriers;
- Establishing requirements and undertaking compliance inspections for transportation aspects such as training, classification, documentation, marking, labeling and placarding, emergency response planning and notification of releases and incident reporting;
- Setting the requirements of the Emergency Response Assistance Plan and reviewing and approving them; and
- Undertaking compliance inspections primarily to ensure that the Transport of Dangerous Goods Regulations are met.

Transport Canada enforces the requirement for detailed Emergency Response Assistance Plans to be in place prior to the transport of dangerous goods such as radioactive waste. Prior to transporting any nuclear fuel, the NWMO would be required to complete and receive an approval from Transport Canada of an Emergency Response Plan that met the requirements of the department, providing details on the contents, containers, transport routes and emergency response plans in place.

Transport Canada plays a key role in the response to emergencies and crises when they occur. In the event of an incident involving dangerous goods, the Canadian Transport Emergency Centre (CANUTEC), operated by Transport Canada, can assist emergency response personnel. Canadian emergency preparedness necessarily includes all levels of government, agencies and non-governmental organizations.

The CNSC is the prime agency of the federal government entrusted with regulating all activities related to the use of nuclear energy and nuclear substances. Its primary responsibilities related to the packaging and transport of nuclear substances are:

- The packaging aspects such as setting the package design requirements and reviewing the safety case;
- Establishing and enforcing the radiation protection program for the carriers;
- Investigating in the event of a dangerous occurrence;
- Issuing licences for shipments that require a licence to transport in accordance with the Packaging and Transport of Nuclear Substances Regulations;
- All aspects of physical security measures of nuclear substances and prescribed equipment against sabotage or theft for all modes and phases of transport; and
- Compliance inspections to ensure that the Transport of Dangerous Goods Regulations and the Packaging and Transport of Nuclear Substances Regulations requirements are met.

10.5 / Provincial Governments and Regulators

Some aspects of siting, construction and/or operation of a central used fuel management facility may be determined to be governed by provincial legislation. The legislative areas listed below may be relevant. In many cases provincial legislation adopts the procedures and requirements of federal Acts and regulations. In some instances, the provincial and federal governments have adopted harmonized procedures.

- Transportation: Most provinces and territories include nuclear substances in legislation and regulations addressing the transportation of dangerous goods within that province or territory;

- Emergency preparedness: Responsibilities for nuclear emergency preparedness fall to several levels of government. In particular, the CNSC has requirements in its Class 1 Nuclear Facilities Regulations and Regulatory Guide G-225. Provincial governments are responsible for protecting public health and safety, property and the environment within their borders. Provincial emergency preparedness legislation often requires that a plan be formulated to address off-site responses to emergencies at nuclear facilities (e.g., *Ontario Emergency Management Act*); and

- Environmental assessment and approvals: Provincial legislation requiring the assessment of potential environmental effects of an activity, plan or program may apply to some aspects of our work. For example, in Québec, the *BAPE – Bureau d'audiences publiques sur l'environnement* (public environmental hearing board) which mainly oversees the provincial environmental assessment process, has a responsibility to inform and consult the population about questions relating to the quality of the environment or certain projects which could significantly affect the environment and cause public concern.

In addition, legislation governing endangered species; environmental protection; heritage protection or preservation; water resources protection; occupational health and safety; and/or labour relations may be determined to be relevant. Municipalities, which derive their authority from provincial legislation, may have requirements that may also be relevant.

Appendix 5 provides more detail on the Canadian regulatory framework relevant to the management of used nuclear fuel.

10.6 / Major Nuclear Fuel Waste Owners

The *NFWA* assigns specific responsibilities to the major owners of nuclear fuel waste.

It requires that Canada's nuclear energy corporations establish a nuclear waste management organization – the NWMO. The nuclear energy corporations are the corporations that own used nuclear fuel resulting from production of electricity by means of a commercial nuclear reactor. These corporations, currently Ontario Power Generation Inc., NB Power Nuclear and Hydro-Québec, must remain members or shareholders of the organization.

This governance model is similar to those in Finland and Sweden, where the nuclear waste owners have the responsibility to establish and fund the implementing organization with responsibility for used nuclear fuel management.

Under the *NFWA*, the major owners of nuclear fuel waste – the nuclear corporations and Atomic Energy of Canada Limited (AECL) – will finance the long-term management approach selected by the government, including costs of designing and siting the approved approach, implementing and finally, decommissioning the facilities. The *NFWA* requires a specific guarantee in the form of trust funds held by a financial institution into which the nuclear energy corporations and AECL deposit money each year for the long-term management of used nuclear fuel. Money in the funds can only be withdrawn by the NWMO, and only after a construction or operating licence for a long-term management facility has been granted by the CNSC. To date, $770 million has been deposited into these trust funds. The financial obligations of the waste owners, assigned by the *NFWA*, are further elaborated in Chapter 11.

10.7 / Nuclear Waste Management Organization (NWMO)

The Organization's Mandate

The *NFWA* prescribes two phases of work for the NWMO:

- The first phase of the legislated mandate included conducting the study on management approaches and proposing a recommendation to the government. This work is now complete.

- After the Government of Canada specifies an approach for the long-term management of used fuel, we will then implement the approach. We will be responsible for managing and coordinating the full range of activities related to the long-term management of used nuclear fuel. Some of the near-term implementation activities of NWMO are profiled in Chapter 9.

The enduring nature of the NWMO will enable the insights and relationships developed in the course of our options study to be carried forward and built upon in succeeding years during implementation. The vision and values that have guided us will not change. We expect to be held accountable to our values and to delivering on our commitments. We will be an organization in which Canadians can have confidence and trust.

The NWMO will have to adapt over time as its mandate progresses. The size and composition of the organization will change as the skills and competencies required in subsequent work phases evolve.

Continuous learning must inform our decision-making. The extent and the way in which we monitor emerging knowledge about managing used fuel and, where appropriate integrate it, will be essential in building confidence in the integrity of our work. We will review our own work from the past three years, to consider those programs and practices which worked well, and areas in which we might seek to improve. The research and development, elaborated in Chapter 15, will be essential in informing our implementation decisions. We have an opportunity to draw on the best knowledge nationally and internationally through independent third-party guidance and peer reviews of our proposed research plans.

The NWMO is established as a not-for-profit corporation. We are directed and governed by requirements set out in the *NFWA*. As we become an implementing organization, we will also be guided by other federal, provincial and municipal laws and regulations, as well as international treaties to which Canada is a party.

Governance

Consistent with the governance structure set out in the *NFWA*, the nuclear energy corporations – Ontario Power Generation Inc., NB Power Nuclear, and Hydro-Québec – established the NWMO in 2002.

The Board of Directors, currently comprised of members from those three corporations, is responsible for oversight of the corporation and taking a leadership role in the development of the corporation's strategic direction. The Board is also responsible for approving annual budgetary provisions to support NWMO operations.

To formalize their obligations to establish the NWMO, the three founding member corporations clarified their roles and responsibilities in furthering those objectives. Members agreed on provisions for cost-sharing our annual operating budget to ensure that we have a secure and ongoing source of funds to carry out our activities and operations.

The Board of Directors appointed a President and CEO, who is accountable for the operation of the company. The President is responsible for the organization's planning, program design and direction of day-to-day operations.

The Board of Directors has directed the NWMO to make public the minutes of its meetings to provide transparency in its operations.

The NWMO will carry out the managerial, financial and operational activities to implement the long-term management of nuclear fuel waste under the governance of the Board. The Board will ensure that the organization is equipped to fulfill its ongoing role as envisaged by the *NFWA*. From the initial establishment of the NWMO, the Board has been mindful of adopting best practices, and has endeavoured to establish the corporate foundation for the NWMO to transition into the next phase of its legislated mandate. As part of its planning for the second phase of the NWMO mandate, the Board will be addressing the underlying funding requirements and approving the NWMO's operating budgets. The Board will continue to oversee the effectiveness of the organization's governance practices and the integrity of its financial and administrative controls. The Board will propose amendments as appropriate to support the evolving roles and responsibilities of the NWMO.

As the organization prepares to assume its new implementation mandate, the NWMO has an opportunity to develop and adopt governance policies and practices that keep the organization consistent with leading governance practices, while recognizing the mandate of this special purpose corporation, which is funded by waste owners to fulfill their obligations under the *NFWA*, and under the oversight of the federal government.

The requisite skills and expertise of Board members will change over time as the organization's mission and operating environment evolve. After the government decision on a management approach, the organization will shift from a corporation undertaking a study, to an operational body. Related roles and functions associated with implementing and ultimately operating the management approach include, among other things: managing large financial provisions associated with the siting, construction and operation of facilities; stakeholder engagement and communications; broad-based technical and social research programs; implementation planning; and regulatory and governmental interface. This shift in the NWMO's responsibilities must be accompanied by a commensurate evolution in governance structures, including the membership, skills and qualifications of Board members, appropriate for the organization through different stages of its mandate.

During the NWMO's public engagement activities in the last three years, there have been many expressions of concern about the limitations of a Board composed entirely of nuclear waste owners. Expanding from an exclusively industry-based Board, to one which offers independent perspectives through unrelated (non-industry) directors, presents an opportunity for the NWMO to be responsive to public concerns, and to build trust and credibility with the Canadian public. The addition of independent directors would also be consistent with what has come to be accepted governance standards and best practices, where there is an overall drive to adopt and communicate high standards of governance to build the public trust.

In preparing for the NWMO's implementation mandate, the Board of Directors and the member organizations are currently reviewing the future governance of the NWMO, including the membership and composition of the Board of Directors.

Reporting

The NWMO has extensive reporting requirements to the Minister of Natural Resources Canada. These reporting requirements, outlined in detail in the *NFWA*, reflect the ongoing oversight role of the federal government that will remain in effect through subsequent phases of implementation and operation of the long-term used fuel management approach. Annual and triennial reporting requirements to the Minister, and to the Canadian public, provide important measures of ongoing accountability. The NWMO's reporting requirements are summarized in Figure 10-2.

Figure 10-2 **NWMO Reporting Requirements**

ANNUAL REPORTS	TRIENNIAL REPORTS
16. (1) The waste management organization shall, within three months after the end of each fiscal year of the organization, submit to the Minister a report of its activities for that fiscal year. 16. (2) Each annual report after the date of the decision of the Governor in Council under section 15 must include: (a) the form and amount of any financial guarantees that have been provided during that fiscal year by the nuclear energy corporations and Atomic Energy of Canada Limited under the *Nuclear Safety and Control Act* and relate to implementing the approach that the Governor in Council selects under section 15 or approves under subsection 20(5); (b) the updated estimated total cost of the management of nuclear fuel waste; (c) the budget forecast for the next fiscal year; (d) the proposed formula for the next fiscal year to calculate the amount required to finance the management of nuclear fuel waste and an explanation of the assumptions behind each term of the formula; and (e) the amount of the deposit required to be paid during the next fiscal year by each of the nuclear energy corporations and Atomic Energy of Canada Limited, and the rationale by which those respective amounts were arrived at. 17. (1) Each nuclear energy corporation and Atomic Energy of Canada Limited shall, either directly or through a third party, deposit to its trust fund maintained under subsection 9(1) its respective deposit specified in the annual report (a) if the Minister's approval under subsection 16(3) is not required, within 30 days after the annual report is submitted to the Minister under subsection 16(1); or (b) if the Minister's approval under subsection 16(3) is required, within 30 days after the date of that approval. 17. (2) Notwithstanding subsection (1), the Governor in Council may, on request by a nuclear energy corporation made before the expiration of the 30 day period referred to in that subsection, authorize the nuclear energy corporation to defer by one year all or part of its deposit required by that subsection, if the Governor in Council is of the opinion that the public interest requires that the money be used instead to repair the damage caused by an event that is not attributable to the corporation and is extraordinary, unforeseen and irresistible.	18. The annual report of the waste management organization for its third fiscal year after the fiscal year in which a decision is made by the Governor in Council under section 15, and for every third fiscal year after that, in this Act called the "triennial report", must include (a) a summary of its activities respecting the management of nuclear fuel waste during the last three fiscal years, including an analysis of any significant socio-economic effects of those activities on a community's way of life or on its social, cultural or economic aspirations; (b) its strategic plan for the next five fiscal years to implement the approach that the Governor in Council selects under section 15 or approves under subsection 20(5); (c) its budget forecast for the next five fiscal years to implement the strategic plan; (d) the results of its public consultations held during the last three fiscal years with respect to the matters set out in paragraphs (a) and (b); and (e) the comments of the Advisory Council on the matters referred to in paragraphs (a) to (d).

Figure 10-2 (cont'd) NWMO Reporting Requirements

OTHER REPORTING
22. (1) The waste management organization, every nuclear energy corporation and Atomic Energy of Canada Limited, as well as every financial institution that holds a trust fund, shall keep, at its place of business in Canada, records, books of account and other documents for at least six years after the end of the fiscal year to which they relate, in such form and containing such information as will enable the verification of the accuracy and completeness of the information that is required to be submitted or provided to the Minister under this Act. (2) No person shall make false entry or fail to make an entry, in a record, book of account or other document required to be kept under subsection (1). 23. (1) The waste management organization shall provide the Minister, within three months after the end of each fiscal year of the organization, with financial statements audited at its own expense by an independent auditor. (2) Every financial institution that holds a trust fund shall provide the Minister and the waste management organization, within three months after the end of each fiscal year of the trust fund, with financial statements relating to that trust fund, audited at its own expense by an independent auditor. 24. The waste management organization shall make available to the public (a) the study, reports and financial statements that it is required to submit to the Minister under this Act, simultaneously with submitting them to the Minister; and (b) financial statements provided to the waste management organization under subsection 23(2) as soon as practicable.

Advisory Council

The *NFWA* requires the governing body of the NWMO to appoint an Advisory Council. The *NFWA* assigned the Council specific responsibilities, and provides direction on the membership of the Advisory Council.

The *NFWA* requires that the Advisory Council provide its independent comments on our study and the management approaches. Early in 2005, the Council released its statement as to how it intended to discharge that legislated mandate. As required by the *NFWA*, the Council has prepared its independent comments, which are included with this study report.

The Advisory Council has an ongoing responsibility to examine and to provide written comments in the triennial reports that we must submit to the Minister of Natural Resources Canada. Specifically, the *NFWA* requires that the NWMO include in each of its triennial reports to the Minister, the Advisory Council comments on:

a) The NWMO's activities during the previous three years, including the NWMO's analysis of any significant socio-economic effects of the NWMO's activities on a community's way of life or on its social, cultural or economic aspirations;

b) The NWMO's strategic plan for the next five-year period;

c) The NWMO's budget forecast for the next five-year period; and

d) The results of the NWMO's public consultations held in the last three fiscal years with respect to items a) and b).

The Advisory Council's terms of reference for its next phase will be developed to reflect these obligations.

The NWMO Board of Directors appointed the Advisory Council in Fall 2002, consistent with the legislation. There are presently nine Advisory Council members, each appointed for four-year terms. Advisory Council members are profiled in Appendix 1.

Legislative direction concerning Council membership will continue to apply as we move into future phases of our mandate. Within the parameters of the *NFWA*, membership and the terms of reference will change as the project proceeds from a study on management options, to a concept chosen by government, and then, to a site-specific project in a known location and region.

Once an economic region is identified for implementing the approach selected by the government, the *NFWA* requires the Advisory Council to include representatives nominated by those local and regional governments and Aboriginal organizations.

In addition to meeting the requirements of the *NFWA*, the NWMO will be seeking the views of the Advisory Council on membership and composition for the next phase of the NWMO's mandate. The discussion will invite consideration of broadening Council representation and the range of expertise that will be desirable in light of the future role and expanded responsibilities of the NWMO.

10.8 / Host Communities

The NWMO anticipates an active role in implementation for potentially affected communities of interest. Communities likely to be most impacted will vary over time as we move through various stages of implementation.

The NWMO has suggested that the communities of interest which are potentially impacted by the implementation of the approach must be involved in the iterative determination of risk and safety assessment throughout the implementation process. This requires their involvement at a fundamental level of decision-making, the specifics of which will need to be made more concrete as implementation proceeds.

The NWMO has a legislated requirement under the *NFWA* to conduct public consultations as implementation proceeds. There are also regulatory processes that the NWMO must participate in which will require public consultation to support decision-making and approvals. We will ensure that all of these requirements are met. In addition, we intend to continue our engagement in a substantive way as we collaboratively design and implement the key processes and decision-making frameworks that will accompany siting and subsequent implementation steps.

A more detailed discussion of our proposal for engagement of communities of interest is provided in Chapters 9, 13 and 14.

Two communities of interest have been singled out for consideration in this chapter as key participants in any process going forward: the communities which currently host interim storage facilities and the community which would host the new central facility.

The NWMO has a responsibility to work with various communities of interest most affected by implementation to identify effective ways and means for them to participate in decision-making in the development and operation of the long-term waste management facility. Over the past decade, a number of innovative institutional arrangements have been developed to facilitate development of such community capacity. A number of examples are described in Chapter 14. Many of these involve formal agreements between the community or elements of the community and a project lead, like the NWMO.

10.9 / Affected Aboriginal Peoples

The Aboriginal community in Canada includes Indian, Inuit, and Métis people; status and non-status; on-reserve and off. In pursuit of their aspirations, they have created an array of organizations that range in focus and scale from the local community to the nation as a whole. The internal decision-making process is complex and varies significantly between the different Aboriginal groups.

National organizations have been created to address issues that fall under the mandate of the federal government or are otherwise national in scope. Similarly provincial, regional, or treaty organizations exist to address issues at the provincial, regional, or treaty level. In the case of First Nations who have land by treaty, the primary decision-making unit is the First Nation itself.

The NWMO is committed to respecting Aboriginal rights, treaties and land claims. Aboriginal and treaty rights are protected under s.35 of the *Constitution Act*, 1982. The nature of the specific obligations to consult will be clarified as the government makes its decision and directly affected individuals and communities become more evident. In addition to any legal obligation to consult, the NWMO will seek the active involvement of Aboriginal peoples that are potentially impacted by implementation.

The NWMO has suggested that all those most potentially affected by implementation must be involved in the iterative determination of risk and safety assessment throughout implementation. The NWMO recognizes that Aboriginal peoples may be affected by implementation decisions and will therefore need to play an important role in any collaborative process to determine risk and safety. Identification of specific roles and active involvement will be subject to discussion and agreement with Aboriginal peoples and communities who may be affected by implementation. In addition, certain roles fall from law and practice, the details of which will need to be resolved over time.

The NWMO is committed to engaging with potentially impacted Aboriginal peoples in a way that will lead to a long-term, positive relationship – in a manner that is meaningful to both Aboriginal peoples and to the NWMO. It follows that our commitment is to build a way of working with the Aboriginal community that respects their various decision-making processes. We must provide an effective means for Aboriginal peoples to actively participate in decision-making.

This chapter has profiled the extensive system of governance and oversight provided through Canada's governmental bodies and regulatory agencies. It has also identified some of the responsibilities of various organizations and communities of interest that will have important roles to play in the implementation phase.

The chapters which follow address many of the specific elements that will comprise the implementation plan for the management approach selected by government.

A more detailed discussion of our proposal for community engagement is provided in Chapters 9 and 13.

Chapter 11 / Financial Aspects

11.1 / Funding Formula

The *Nuclear Fuel Waste Act* (*NFWA*) requires the NWMO to address the financial aspects of the long-term management of used nuclear fuel. (See Table 11-1.)

The annual amount required to finance the long-term management approach, selected by government for used nuclear fuel, has two components:

(i) the annual amount required to be contributed to the trust funds set up in accordance with section 9(1) of the *NFWA*, available to the NWMO to fund activities for which a construction or operating licence has been issued under the *Nuclear Safety Control Act*; and

(ii) the annual amount required to be provided to the NWMO to fund its activities prior to receipt of a construction licence.

The funding formula, covering both pre-construction licence and post-construction licence time frames is comprised of several elements. These include:

(i) the total cost of NWMO facilities, including design, siting, licensing, construction, operation, decommissioning and monitoring;

(ii) the total transportation costs for used fuel, from reactor sites to NWMO facilities;

(iii) volume of used fuel produced by each waste owner;

(iv) expected rate of return on *NFWA* trust funds;

(v) shared costs; each waste owner will pay a percentage of all shared costs based on the volume of used fuel they have produced, as well as factors based on individual owner usage of facilities; and

(vi) owner specific costs; these cover items of transportation that vary between the waste owners, and are dependent on location.

The following table sets out the specific sections of the *NFWA* addressing the Funding Formula.

Table 11-1 Funding Requirements

***Nuclear Fuel Waste Act* reference:**

13. (1) The study must set out, with respect to each proposed approach, a formula to calculate the annual amount required to finance the management of nuclear fuel waste.

The report must explain the assumptions behind each term of the formula. The formula must include the following terms:

(a) the estimated total cost of management of nuclear fuel waste, which must take into account natural or other events that have a reasonable probability of occurring;

(b) the estimated rate of return on the trust funds maintained under subsection 9(1);

(c) the life expectancy of the nuclear reactors of each nuclear energy corporation and of Atomic Energy of Canada Limited; and

(d) the estimated amounts to be received from owners of nuclear fuel waste, other than nuclear energy corporations and Atomic Energy of Canada Limited, in return for services of management of nuclear fuel waste.

(2) The study must set out, with respect to each proposed approach, the respective percentage of the estimated total cost of management of nuclear fuel waste that is to be paid by each nuclear energy corporation and Atomic Energy of Canada Limited, and an explanation of how those respective percentages were determined.

(3) The study must set out the form and amount of any financial guarantees for the management of nuclear fuel waste that have been provided by the nuclear energy corporations and Atomic Energy of Canada Limited under the *Nuclear Safety and Control Act*.

Total Cost

The total life cycle costs for used fuel management are different for each management approach, ranging from $2.3 to $6.2 billion present value in 2004 dollars. The used fuel owners are responsible for accumulating funds to cover the total life cycle costs. Total life cycle costs include items (i) through (iii) listed below. These costs are managed by the used fuel owners and the NWMO separately as follows:

- Of the total life cycle costs, the used fuel owners are responsible for managing approximately $900 million to $1.4 billion of costs depending on the management approach selected. This includes:

  (i) interim storage and retrieval costs at each reactor site.

- The portion of the total life cycle costs that the NWMO is responsible for managing (total NWMO costs), ranges from $0.9 to $4.8 billion in present value 2004 dollars, depending on the management approach chosen. These include:

  (ii) NWMO facility: siting, design, licencing, construction, operation, decommissioning and monitoring. Costs incurred before a CNSC construction or operating licence is issued will be paid under terms of membership agreements or contractual agreements. Costs occurring after a construction or operating licence has been issued by the CNSC will be paid from the *NFWA* trusts; and

(iii) Used fuel transportation costs moving material from reactor sites to the NWMO facility. These will be paid from the *NFWA* trusts.

Those total NWMO costs are the basis upon which the funding formula is developed.

The estimated total life cycle costs, which include interim storage and retrieval, for management of nuclear fuel waste for Options 1, 2 and 3, those defined in the *NFWA*, are set out in the summary cost estimate reports commissioned by the Joint Waste Owners. (www.nwmo.ca/costreview) The NWMO has adopted these cost estimates which we believe represent thorough and reasonable cost estimates for the options based on the conceptual stage of design.

In the case of Option 4: Adaptive Phased Management, total life cycle cost estimates have been developed by Golder Associates Ltd., and Gartner Lee Limited, using consistent estimating assumptions (www.nwmo.ca/assessments).

We commissioned third-party reviews of the cost estimates. These reviews concluded that they have been prepared with an appropriate estimating methodology, including appropriate cost contingency allowances, and the cost estimates are suitable for our review and assessment of the magnitude of costs of alternative management options and development of a recommendation on a preferred approach.

Total costs, (full life cycle and NWMO) are presented in two formats, the first is termed '2002 constant dollars,' the second form is termed 'present value 2004.' The first format establishes a fixed point in time, in this case the year 2002, when costs for materials, labour and other requirements have established

Table 8-1 Total Life Cycle Cost Estimates for Management Approaches

MANAGEMENT APPROACH	Total Cost (2002B$) (out to 350 years)	Total Cost (2002B$) (out to 1,000 years)	Present Value (Jan 2004 B$)
Option 1: Deep Geological Disposal in the Canadian Shield	16.2	16.3	6.2*
Option 2: Storage at Nuclear Reactor Sites			
Current Technology	17.6		2.3
New Above Ground Technology	25.7	68.4	4.4
New Below Ground Technology	21.6		3.6
Option 3: Centralized Storage			
Casks/Vaults in Storage Buildings	15.7		3.1
Surface Modular Vaults	20.0	47.0	3.8*
Cask/Vaults in Shallow Trenches	18.7		3.6
Casks in Rock Caverns	17.1	40.6	3.4*
Option 4: Adaptive Phased Management			
With Shallow Underground Storage	24.4	24.4	6.1*
Without Shallow Underground Storage	22.6	22.6	5.1*

JWO cost estimates are based on 3.7 million fuel bundles and an average reactor life of 40 years. Golder estimates are based on 3.6 million fuel bundles.
Estimates for Options 1, 2 and 3 out to 350 years were prepared by consultants for the Joint Waste Owners (www.nwmo.ca/costsummaries).
Estimates for Options 1, 2 and 3 out to 1,000 years were prepared by Golder Associates Ltd. and Gartner Lee Ltd. (www.nwmo.ca/assessments).
Estimates for Option 4 were prepared by Golder Associates Ltd. and Gartner Lee Ltd. (www.nwmo.ca/assessments).
*Present value calculations performed by Golder Associates Ltd. and Gartner Lee Ltd., are for 1000 year total estimates.
All remaining present value figures were ta en from Joint Waste Owners cost estimates using 350 year total cost estimates.
o te 1000 year cost estimates were produced from an illustrative sample of all possible management approaches, for comparative purposes only.

benchmarks. These cost rates are then used throughout each year of activity of the management approach. The annual amounts are totaled and the result is an estimate of the total cost of the management approach if all prices remained constant at the year 2002 level.

The second format for costs is 'present value 2004.' For each year of implementation of a management approach, costs for labour, materials and other requirements are escalated at a forecasted rate of inflation. These inflation-adjusted costs are then discounted from the year of expenditure back through time, at a fixed rate, to the year 2004 to give the present value. The fixed rate, which includes an expected real rate of return, that is used to discount costs is the rate of annual earnings that could reasonably be expected to accrue to trust funds that are invested to cover the management approach costs (see Estimated Rate of Return later in this chapter for further details). The present value is then the total amount of money that needs to be set aside in 2004 to allow the funds to grow through the accumulation of investment earnings, taking into account inflation, so that the total cost of the management approach would be covered in the time frame required.

Table 11-2 presents total life cycle costs of used fuel and includes costs for interim storage, retrieval, facility design, construction, operation, decommissioning, monitoring, as well as fuel transportation, and is intended for purposes of comparing management approaches.

Table 11-3 below presents information on the

Table 11-3 Total NWMO Costs for Management Approaches, Excluding Interim Storage & Retrieval

MANAGEMENT APPROACH	Total Cost (2002B$) (out to 350 years)	Total Cost (2002B$) (out to 1,000 years)	Present Value (Jan 2004 B$)
Option 1: Deep Geological Disposal in the Canadian Shield	13.8	13.8	4.8
Option 2: Storage at Nuclear Reactor Sites			
Current Technology	15.6		0.9*
New Above Ground Technology	24.4	67.1	3.2
New Below Ground Technology	20.3		2.6*
Option 3: Centralized Storage			
Casks/Vaults in Storage Buildings	14.1		2.0*
Surface Modular Vaults	18.0	45.0	2.3
Cask/Vaults in Shallow Trenches	17.1		2.5*
Casks in Rock Caverns	15.5	39.0	2.1
Option 4: Adaptive Phased Management			
With Shallow Underground Storage	22.0	22.0	4.6*
Without Shallow Underground Storage	19.1	19.1	3.5*

"PV" denotes present value in billions of January 2004 Canadian dollars.
Data produced by Golder Associates Ltd. (GAL) and Gartner Lee Limited, (GLL). All values for Option 4 developed by GAL/GLL.
*PV values developed by GAL/GLL. All other PV values taken from JWO Cost Estimates, see References below.
JWO costs are for 3.7 million bundle scenarios, one operational cycle (approximately 350 years).
GAL/GLL costs are for 3.6 million bundle scenarios, three operational cycles (to year 1000).
GAL/GLL DGR calculations omit postulated $100K/annum monitoring costs beyond year 154 in order to be comparable to JWO numbers. Including additional monitoring costs to year 1000 would increase total cost by $86,400 K and present value by approximately $448K.

References:

(1) Joint Waste Owners (JWO 2004a. Costs of Alternative Approaches for the Long-Term Management of Canada's Nuclear Fuel Waste, Deep Geologic Disposal Approach. A Submission to the Nuclear Waste Management Office by Ontario Power Generation, Hydro-Quebec, New Brunswick Power, and Atomic Energy of Canada Limited.

(2) Joint Waste Owners (JWO), 2004b. Costs of Alternative Approaches for the Long-Term Management of Canada's Nuclear Fuel Waste, Reactor-Site Extended Storage Approach. A Submission to the Nuclear Waste Management Office by Ontario Power Generation, Hydro-Quebec, New Brunswick Power and Atomic Energy of Canada Limited.

(3) Joint Waste Owners (JWO), 2004c. Costs of Alternative Approaches for the Long-Term Management of Canada's Nuclear Fuel Waste, Centralized Extended Storage Approach. A Submission to the Nuclear Waste Management Office by Ontario Power Generation, Hydro-Quebec, New Brunswick Power, and Atomic Energy of Canada Limited.

4) Adaptive Phased Management Cost Estimate Summary Report, August 2005, produced by GAL/GLL for NWMO. See www.nwmo.ca/assessments.

total costs that will be incurred for the long-term management of used fuel by NWMO over the life time of each management approach, and includes facility design, construction, operation, decommissioning, monitoring as well as fuel transportation. These costs, covering activities occurring before and after a construction or operating licence has been issued by the CNSC, are the basis of the funding formula.

The *NFWA* requires that we take into account natural or other events that have a reasonable probability of occurring. For example, as set forth in the Conceptual Design for Option 1: Deep Geological Disposal in the Canadian Shield, the design requires that testing, and on-going research and development work have as an objective designing and placing a containment canister that is capable of enduring glaciation, within the time-frame in which the used fuel would continue to be a hazard.

Ongoing research and development will include further study, modelling and analyses of the potential impacts of climate change (e.g., global warming and glaciation) and other natural events such as earthquakes, which have already been factored into the designs of the deep repository, the shallow underground storage facility and surface facility.

Estimated Rate of Return

The cost estimates referenced above are in billions of 2002 constant dollars and January 2004 present value billions of dollars. The present value calculation is based on a discount rate of 5.75 percent, which assumes a 3.25 percent real rate of return over a projected long-term average increase in the Ontario Consumer Price Index of 2.5 percent.

These data will be updated after the Government decides on a management approach, and will be reported in the first NWMO Annual Report required after this decision. Historical information available through Statistics Canada and the Bank of Canada show that the yields of Canada long bonds have exceeded CPI (Ontario) by approximately 4.8 percent over the past 25 years.

Reactor Life Expectancy

For purposes of the cost estimates it is assumed that the average life expectancy of the used fuel owner's nuclear reactors will be 40 years. See Appendix 10 for further discussion.

Fund Contributions from Other Used Fuel Owners

Current cost estimates do not include any allowances for an amount of used fuel to be received from owners other than Ontario Power Generation Inc., Hydro-Québec, NB Power Nuclear and Atomic Energy of Canada Limited.

Should new nuclear energy corporations enter the Canadian market, they would contribute to the NWMO, an amount per fuel bundle generated, based on the full cost of the program on a present value basis. This would include payment for their share of fixed costs already incurred in order to become a member of the Joint Waste Owner (JWO) group of companies (currently comprised of OPG, HQ, NBP and AECL).

Table 11-4 Current Projected Fuel Bundles and Percentages by Waste Owners

COMPANY	NO. OF BUNDLES	PERCENTAGE OF BUNDLES
Ontario Power Generation Inc.	1,746,410	88.21
NB Power Nuclear	103,436	5.22
Hydro-Québec	99,245	5.01
Atomic Energy of Canada Limited	30,682	1.55*
Total	**1,979,773**	**100.0**

*This figure does not include research reactor used fuel.

Percentage of Total Costs Allocated to Each Waste Owner

The percentage of the estimated cost that is to be paid by each nuclear energy corporation and AECL will be largely based on projections of used fuel to be generated by each waste owner. However, other considerations will need to be factored in, such as the usage of the long-term facilities by individual waste owners, transportation requirements and the timing of used fuel shipments by respective waste owners to the long-term management facility.

- **For Option 1: Deep Geological Disposal, Option 3: Centralized Storage, or Option 4: Adaptive Phased Management**
  - **> The overall objective is to share actual costs of long-term management based on the number of fuel bundles. That is, each waste owner would pay equal costs for each fuel bundle subject only to owner specific costs such as transportation. Transportation costs are the responsibility of the NWMO and will be paid from *NFWA* trust funds, however these costs vary between the used fuel owners and depend on the distance the fuel must travel to the future NWMO facilities.**
- **For Option 2: Storage at Nuclear Reactor Sites**
  - **> Costs would be borne by the waste owner at each specific site. For shared facilities at a given location, costs would be shared based on each corporation's used fuel quantities at that location.**

Current projected fuel bundles and percentages by each used fuel owner to year-end 2005 are shown in Table 11-4. The percentage ownership by waste owner will differ from these in the long term due to differences in end of life projections. In addition to CANDU fuel, AECL also has an amount of research reactor fuel. (See Appendix 4.)

11.2 / Financial Surety

Financial surety has the objective of determining what costs can reasonably be expected to occur over the life of a project, along with some contingency for unexpected events occurring, then designing a system that collects and protects enough funding to ensure that the entire cost of the project can be covered under a variety of social and economic circumstance and within the required time-frame. Financial surety can exist in many forms and generally includes utilizing a variety of financial instruments from secured assets and trust funds to government-supported guarantees.

Canada has a robust system of legal and regulatory oversight, covering all aspects of the nuclear industry. The standards that have been developed to provide financial surety for the long-term management of used nuclear fuel share many elements of design and implementation with other nations around the world.

In addition to the requirements of the *NFWA* there are legislative and regulatory structures in place that also address financial surety concerning obligations and expected costs of the present and future used fuel inventory, (see Appendix 5 for further detail on regulatory statutes). The following legislation and regulations direct the level of financial surety that is required within Canada:

- The *Nuclear Safety and Control Act*, 1997;
- Canadian Nuclear Safety Commission Regulatory Guide, G-206, "Financial Guarantees For the Decommissioning of Licensed Activities" 2000;
- Canadian Nuclear Safety Commission Regulatory Guide, G-219, "Decommissioning Planning For Licensed Activities," 2000;
- The *Nuclear Fuel Waste Act*, 2002; and
- The *Nuclear Liability Act*. A discussion of this Act is provided later in this chapter.

The following list covers both specific and general requirements that are addressed in legislation and regulations listed above, with many areas being impacted by more than one statute or regulation. Areas addressed include:

- Methods for collecting and managing funds that will meet the cost estimate forecasts in an equitable manner and within reasonable time-frames;
- Methods for adjusting the rate and size of funds that are collected should circumstances change over time;
- Reasonable determinations of cost estimates, derived financial obligations and forms of surety provided;
- Contingency programs that will allow all financial obligations to be met even when unexpected events significantly impact the markets of the used fuel owners;
- A reporting methodology to verify that appropriate financial practices are implemented and that on-going adjustments are made to both cost estimates and the financial guarantees to ensure they are reasonable; and
- Setting limits on liability and insurance requirements for various licensed operations.

Trust Funds

Canada has developed legislation that specifically addresses the future financial obligations for managing used nuclear fuel distinct from all other decommissioning costs. The *NFWA* administered by Natural Resources Canada, sets out requirements for the establishment of trust funds for this purpose.

Trust Fund Requirements

Table 11-5 provides the specific sections of the *NFWA* dealing with trust fund requirements.

Table 11-5 Trust Fund Requirements

***Nuclear Fuel Waste Act* (*NFWA*) reference:**

9. (1) Each nuclear energy corporation and Atomic Energy of Canada Limited shall maintain in Canada, either individually or jointly with one or more of the other nuclear energy corporations or Atomic Energy of Canada Limited, one trust fund with a financial institution incorporated or formed by or under an Act of Parliament or of the legislature of a province, except in the case of a nuclear energy corporation, a financial institution in relation to which the nuclear energy corporation beneficially owns, directly or indirectly, more than ten percent of the outstanding shares of any given class of shares.

9. (2) The financial institution that holds a trust fund referred to in this section shall maintain in Canada all documents relating to that trust fund.

10. (1) Each body mentioned in this subsection shall, either directly or through a third party, no later than 10 days after the day on which this Act comes into force, deposit to its trust fund maintained under subsection 9(1) the following respective amounts:

(a) Ontario Power Generation Inc., $500,000,000;
(b) Hydro-Québec, $20,000,000;
(c) New Brunswick Power Corporation, $20,000,000; and
(d) Atomic Energy of Canada Limited, $10,000,000.

10. (2) Each body mentioned in this subsection shall in each year, either directly or through a third party, no later than the anniversary of the day on which this Act comes into force, deposit to its trust fund maintained under subsection 9(1) the following respective amounts:

(a) Ontario Power Generation Inc., $100,000,000;
(b) Hydro-Québec, $4,000,000;
(c) New Brunswick Power Corporation, $4,000,000; and
(d) Atomic Energy of Canada Limited, $2,000,000.

10. (3) subsection (2) ceases to apply on the day on which the Minister approves the amount of the deposit under paragraph 16(3)(a).

10. (4) Interest accumulates on any portion of a deposit not paid by the day referred to in subsection (1) or (2), at the prime rate plus two percent, calculated daily from the day referred to in subsection (1) or (2), as the case may be, to the day before the day of the deposit.

10. (5) Each body mentioned in subsection (1) or (2) shall, either directly or through a third party, deposit to its trust fund maintained under subsection 9(1), no later than 30 days after the date of the decision of the Governor in Council under section 15, the applicable amount referred to in subsection (1) or (2) plus an amount, if any, equal to the interest.

17. (1) Each nuclear energy corporation and Atomic Energy of Canada Limited shall, either directly or through a third party, deposit to its trust fund maintained under subsection 9(1) its respective deposit specified in the annual report

(a) if the Minister's approval under subsection 16(3) is not required, within 30 days after the annual report is submitted to the Minister under subsection 16(1); or
(b) if the Minister's approval under subsection 16(3) is required, within 30 days after the date of that approval.

17. (2) Notwithstanding subsection (1), the Governor in Council may, on request by a nuclear energy corporation made before the expiration of the 30 day period referred to in that subsection, authorize the nuclear energy corporation to defer by one year all or part of its deposit required by that subsection, if the Governor in Council is of the opinion that the public interest requires that the money be used instead to repair the damage caused by an event that is not attributable to the corporation and is extraordinary, unforeseen and irresistible.

Once a decision has been made by the federal government on the appropriate management approach for all nuclear waste owners, then the funding formula will allocate liabilities to each nuclear waste owner for their portion of the estimated total cost of the management approach. The funding formula, as presented in the NWMO's Annual Report, following a government decision on an approach, will be subject to Ministerial approval.

In accord with the requirements of the *NFWA*, Ontario Power Generation Inc. (OPG), Hydro-Québec (HQ), NB Power Nuclear (NBP), and Atomic Energy of Canada Ltd. (AECL), each established individual trust funds that are held and managed by independent third parties. The trusts were established in 2002.

Initial deposits as specified by the legislation have been made by all four used fuel owners. Subsequent deposits as specified have been made by each used fuel owner. As of November 15, 2004, the four corporations collectively had contributed $770 million, to the *NFWA* trusts. As of November 15, 2005, a further $110 million will be contributed through the annual provision, bringing the total contribution to $880 million.

The *NFWA* specifies that contributions to the trusts are to continue at the present rate until the first Annual Report on funding requirements is provided by the NWMO to Natural Resources Canada, after a decision has been made on which management approach is to be implemented.

Contributions will be continually adjusted to reflect updated projections of overall costs of the management approach and the number of fuel bundles to be produced by each used fuel owner. Trust fund contributions to be made by each used fuel owner will be presented as part of each Annual Report following the decision by the federal government. Further discussion on trust fund holdings is presented later in this chapter under Financial Guarantees.

Safeguarding the Trust Funds

Individual waste owners are providing large sums of money to dedicated trust funds that will ensure the money is in place to implement the long-term management of used fuel. Experience in other countries has demonstrated the importance of safeguarding these large funds, so that they will be preserved for the intended purpose. In Canada, the *NFWA* built in explicit provisions to ensure that these trust funds are maintained securely and used only for the intended purpose. See *NFWA* section 11 in Appendix 2.

Through its reporting practices, both as explicitly required within the Act, and as a condition of attaining a CNSC licence to construct and operate a waste management facility, the NWMO will have an ongoing obligation to assess the accuracy of the cost estimate for the selected management approach, and the sufficiency of funding contributions to cover cash flow obligations for the life of the project.

We will make regular determinations on the sufficiency of funding, changes to the cost estimate, or other material matters that would impact the provided financial surety and will provide this information to the CNSC, Natural Resources Canada and our Advisory Council.

As part of the ongoing federal oversight that will continue, the *NFWA* provides for ministerial review and approval of the funding formula and proposed deposits by each used fuel owner. The *NFWA* also specifies and limits who has authorization to withdraw from the trust funds, as is set out in Table 11-6 below.

Table 11-6 Authorized Withdrawals from *NFWA* Trusts

***Nuclear Fuel Waste Act* (*NFWA*) reference:**

11. (1) Only the waste management organization may withdraw moneys from a trust fund maintained under subsection 9(1).

11. (2) The waste management organization may make withdrawals only for the purpose of implementing the approach that the Governor in Council selects under section 15 or approves under subsection 20(5), including avoiding or minimizing significant socio-economic effects on a community's way of life or on its social, cultural or economic aspirations.

11. (3) The waste management organization may make the first withdrawal only for an activity in respect of which a construction or operating licence has, after the date of the decision of the Governor in Council under section 15, been issued under section 24 of the *Nuclear Safety and Control Act*.

11. (4) If the Minister is of the view that the waste management organization has with drawn moneys from a trust fund contrary to subsection (2) or (3), the Minister may require the Minister's prior approval in respect of any future withdrawal from a trust fund by the waste management organization.

Financial Guarantees

An important component of financial surety is financial guarantees. The Canadian Nuclear Safety Commission (CNSC) has required nuclear facility operators to provide evidence of financial guarantees as a condition of licensing their generation and storage facilities.

The CNSC, operating under the, *Nuclear Safety and Control Act* 1997 (*NSCA*), is the federal regulatory agency that oversees all licensing requirements for the site preparation, construction, operation, modification, decommissioning and abandonment of all Canadian nuclear facilities, including the licensing required for the management of used fuel facilities.

The *NSCA* provides that the CNSC is responsible for issuing, amending, revoking and regulating all licences in regard to all aspects of nuclear materials within Canada. Further, the *NSCA* provides that any licence, within the authority of the Commission, can contain any term and condition that the Commission deems appropriate in fulfilling its mandate.

Sections 24(5) and (6) of the *NSCA* specifically address issues of financial guarantees. Section 24(5) states:

A licence may contain any term or condition that the Commission considers necessary for the purposes of this Act, including a condition that the applicant provide a financial guarantee in a form that is acceptable to the Commission.

Financial guarantees are provided by each nuclear waste owner and AECL in accordance with CNSC Regulatory Guide G-206, Financial Guarantees for the Decommissioning of Licensed Activities (2000) and the Commission's Regulatory Guide G-219, Decommissioning Planning For Licensed Activities (2000).

The financial guarantees required under the *NSCA* have been provided by all waste owners. The waste owners are responsible for providing financial guarantees for all aspects of decommissioning, one component of which is used fuel management.

The *NFWA* trust funds are accepted by the CNSC as forming part of the financial guarantees that cover total liabilities held by the waste owners, and are provided as part of the waste owner's licencing requirements for the operation of their generating and waste storage facilities.

In addition to the trusts that were created under the *NFWA*, the nuclear waste owners have established segregated funds and financial guarantees that address CNSC licencing requirements for their facilities. The segregated funds deal with both decommissioning obligations and used fuel management liabilities. To provide clarity on the scale of the resources that are being allocated for dealing with nuclear liabilities a summary of the segregated funds along with *NFWA* trusts is provided in Table 11-7.

Financial guarantees covering all elements of decommissioning including used fuel management provided by Ontario Power Generation (this includes costs related to used fuel produced by Bruce Power), Hydro-Québec, NB Power Nuclear and Atomic Energy of Canada Limited are as follows:

Table 11-7 Summary Information on Nuclear Funding Guarantees

WASTE OWNERS	FUNDING INSTRUMENT	VALUE ($million)
Ontario	Ontario Nuclear Funds Agreement, Segregated Funds (note 1)	5,296
	Provincial Guarantee (note 2)	1,510
	NFWA Trust (note 3)	807
Hydro-Québec	Provincial Guarantee: Decommissioning Fund (note 4)	205
	Provincial Guarantee: Used Fuel Fund (note 4)	320
	NFWA Trust (note 5)	28
New Brunswick Power	Decommissioning Fund (note 6)	76
	Used Fuel Fund (note 7)	105
	NFWA Trust (note 7)	28
Atomic Energy of Canada	Federal Government Guarantee	Fully covered
	NFWA Trust (note 8)	15

Note 1. Source is OPG "Annual Report To the Canadian Nuclear Safety Commission to provide status of Decommisssioning Plans and Financial Gurantee for all Class 1 facilities owned by OPG", January 2005.
Note 2. Under the Provincial Guarantee Agreement, the total guarantee available is $1.51billion.
Note 3. Source is "OPG Consolidated Statement of Income, Three Months Ended March 31, 2005".
Note 4. Value taken from "Financing the Management of Nuclear Fuel Waste in Support of the Nuclear Fuel Waste Act Report" submitted to NWMO July 22, 2005, by the used fuel owners.
Note 5. Information taken from "Financial Statement of Hydro Quebec Trust for Management of Nuclear Fuel Waste, December 31, 2004".
Note 6. Information taken from "New Brunswick Power Annual Report 2003/2004". (http://www.nbpower.com/en/corporate/about/reports/reports.aspx)
Note 7. Values adjusted to reflect most recent submission by NB Power Nuclear to the CNSC (June 30, 2005)
Note 8. Value (rounded to nearest million), taken from "AECL Nuclear Fuel Waste Trust Fund Financial Statements December 31, 2004".
www.nwmo.ca/trustfunds

Ontario Power Generation Inc.
Effective July 31, 2003, OPG provided the CNSC with a Decommissioning Financial Guarantee that included a guarantee associated with used fuel arising from the operation of OPG-owned facilities, including the facility leased by Bruce Power.

- The value of the used fuel guarantee required changes over time based on new generation of used fuel;
- The guarantee covers a five-year period to year-end 2007 and is updated annually by means of an annual report provided to the CNSC;
- For year 2005, the value of the guarantee for used fuel management is approximately $4.5 billion stated in present value as of January 1, 2005 and $2.432 billion for the purpose of guaranteeing the funding of decommissioning and low- and intermediate-level waste management costs;
- The guarantee is satisfied by actual accumulation of funds within segregated funds under the Ontario Nuclear Funds Agreement (ONFA) between OPG and the Province of Ontario, the *NFWA* trust fund, and a Provincial Guarantee Agreement for the balance.
  - The Provincial Guarantee Agreement provides an unconditional and irrevocable guarantee to cover the difference between monies set aside by OPG in segregated and *NFWA* trusts and the total financial guarantee required by the CNSC.
  - The Provincial Guarantee Agreement covers approximately $1.51 billion in guarantee requirements, and will be reduced over time as funds are accumulated in trust funds.
- The Ontario Power Generation *NFWA* trust has $807 million as of March 31, 2005.

Hydro-Québec
Hydro-Québec has provided to the CNSC a financial guarantee of $525 million stated in present value as of January 1, 2013.

- The guarantee is in the form of an expressed commitment of the Province of Québec to Hydro-Québec, which provides a continuous guarantee of payment until December 31, 2013. The guarantee covers both decommissioning and used fuel; and
- The total guarantee is made up of $205 million for decommissioning and $320 million for used fuel, projected to be generated by the operation of Gentilly-2 until 2013.
- The Hydro-Québec *NFWA* trust has $28 million as of December 31, 2004.

NB Power Nuclear
NB Power Nuclear has provided a financial guarantee for the management of used fuel projected to be produced to the end of Point Lepreau Generating Station's current Power Reactor Operating licence (December 31, 2005).

- The financial guarantee is based on the present value of future costs to manage this fuel on an incremental fee for service basis;
- As of March 31, 2005 the present value of the long-term management costs was calculated at $96.8 million; a June 30, 2005 submission by NB Power Nuclear to the CNSC presents an updated estimate for the present value at $133.41 million. In light of the recent change in NB Power Nuclear's licence application, this value is being recalculated.

- At March 31, 2005 the used fuel fund contained $87 million and the *Nuclear Fuel Waste Act* fund contained $28 million.

Atomic Energy of Canada Limited

The AECL financial guarantee is in the form of an expressed commitment by the Government of Canada to the CNSC. No specific dollar values are quoted in the commitment letter.

- The AECL *NFWA* trust had $14.9 million as of December 31, 2004.

Annual Reporting

Section 16(2)(a) to (e) of the *NFWA* sets out all NWMO annual reporting requirements.

Each NWMO Annual Report to Natural Resources Canada will include:

(i) The form and amount of any financial guarantees that have been provided during the fiscal year by the nuclear energy corporations and Atomic Energy of Canada Limited;

(ii) The updated estimated total cost of the management of nuclear fuel waste;

(iii) The budget forecast for the next fiscal year;

(iv) The proposed formula for the next fiscal year to calculate the amount required to finance the management of nuclear fuel waste; and

(v) The amount of the deposit required to be paid during the next fiscal year by each of the nuclear energy corporations and Atomic Energy of Canada Limited.

Upon submission of the first Annual Report, following the government's selection of a management approach, the Minister has the opportunity to approve the funding formula and the deposits. A further opportunity arises with the submission of the first Annual Report after the issuance of a construction or operating licence.

If approval is withheld, a re-submission will be made as directed by section 16(4) of the *NFWA*. The timing for contributions to the trust fund is based on Annual Report submissions and Minister approval requirements. The Annual Report is due three months after the NWMO fiscal year-end, and contributions within 30 days after that. Ministerial approval is required to prolong that period.

Nuclear Liability

Liability and insurance provisions for damages to health, environment and property, arising out of the use of nuclear materials - are areas of risk addressed by the *Nuclear Liability Act*.

The federal *Nuclear Liability Act* establishes the legal regime for liability for third-party insurance and damage arising from nuclear accidents in Canada. The Act creates an obligation for nuclear operators to prevent injury to health, or damage to property, from nuclear material at the facility, and while it is being transported, until it enters another nuclear installation.

The CNSC determines which nuclear installations are covered under the *Nuclear Liability Act*, sets the basic insurance requirements for designated installations, and ensures that the operator of the nuclear facility maintains appropriate insurance coverage. Facilities for managing used nuclear fuel, as determined by the Canadian Nuclear Safety Commission (CNSC), are among the facilities covered under the Act.

Nuclear power plant operators designated under the *Nuclear Liability Act* by the Canadian Nuclear Safety Commission must maintain $75 million in mandatory insurance to cover third-party nuclear damages. The CNSC is authorized to license nuclear facility operators holding insurance below this maximum based on an assessment of the potential risks at a specific facility. Natural Resources Canada is presently leading a comprehensive review of the provisions of the *Nuclear Liability Act*, to identify possible revisions required to modernize the Act and bring it into line with prevailing international practices and standards. See Appendix 5 for further discussion on this Act.

The NWMO expects that in its capacity as an operator of a used fuel management facility in the future, it will become subject to the federal *Nuclear Liability Act*. For purposes of costing the conceptual designs for each of the four management approaches, we made provision for liability insurance based on past experience with waste management facilities. The most recent Decision by the CNSC regarding insurance for waste management facilities was used as the basis for estimating insurance costs within the JWO cost estimates for options 1, 2 and 3. The NWMO will adjust costs related to liability insurance as amendments are made to the *Nuclear Liability Act*, and as decisions are taken by the CNSC concerning NWMO liability.

Chapter 12 / Services Provided to Other Owners of Nuclear Fuel Waste

Section 12(5) of the *Nuclear Fuel Waste Act* (*NFWA*) requires the NWMO to identify any services to be provided to other waste owners, beyond the nuclear energy corporations which are, Ontario Power Generation, Hydro-Québec and NB Power Nuclear, specifically, those referred to in section 7 of the Act. For the *NFWA* see Appendix 2.

Services to AECL

Section 7(a) of the *NFWA* relates to the NWMO's requirement to offer its services to Atomic Energy of Canada Ltd. There are two time periods within which the NWMO will provide services to AECL, each period governed by distinct agreements. With respect to implementation in the pre-construction licensing period, costs to be covered by AECL will be set out in an NWMO commercial contractual agreement specifying obligations and costs.

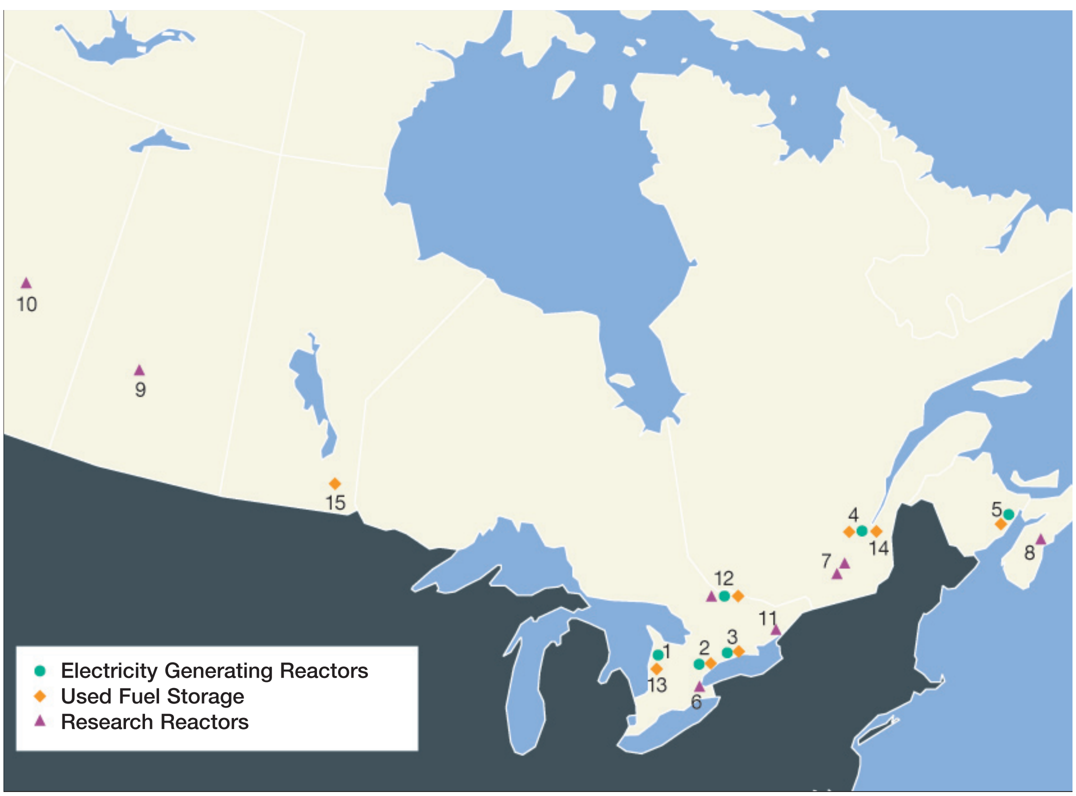
The second time period when the NWMO will offer AECL services will be after a construction licence has been issued. Again, a contractual agreement between AECL and the NWMO will then set out post-licence costs to be paid from AECL's *NFWA* trust fund. AECL will use our services, and pay for them from an allocated proportion of costs as set out in a funding formula approved by the Minister The services to be offered by the NWMO would be consistent with those offered to all other members.

Services to Others

Section 7(b) of the *NFWA* refers to two distinct groups. The first are the existing research reactors at various academic institutions across Canada. The second group would be made up of new market entrants.

Research reactors are located throughout

Figure 12-1 **Nuclear Reactor Sites and Used Fuel Storage Facilities in Canada**



Canada providing nuclear analysis and radionuclide production, as shown in Figure 12-1. Research reactors differ from commercial power reactors in size, power output and used fuel production. The nuclear fuel in a research reactor is typically 1 kg or less, and the reactor may operate for 20 years or longer before the fuel becomes waste requiring long-term management. The result being that the cumulative waste produced by existing research facilities is a very small portion of the entire used fuel inventory in Canada.

Tables 12-1 and 12-2 provide summary information on the location and nature of Canada's research reactors and their requirements for used fuel management services.

Table 12-1 Research and Isotope Producing Reactors in Canada

RESEARCH REACTOR	REACTORS	LOCATION (see map)
McMaster University (Pool-type research reactor)	5 MWt	Hamilton, ON (6)
École Polytechnique (SLOWPOKE-2)	0.02 MWt	Montréal, QC (7)
École Polytechnique (Subcritical Assembly)	0 MWt	Montréal, QC (7)
Dalhousie University (SLOWPOKE-2)	0.02 MWt	Halifax, NS (8)
Saskatchewan Research Council (SLOWPOKE-2)	0.02 MWt	Saskatoon, SK (9)
University of Alberta (SLOWPOKE-2)	0.02 MWt	Edmonton, AB (10)
Royal Military College of Canada (SLOWPOKE-2)	0.02 MWt	Kingston, ON (11)
AECL (Maple 1)	10 MWt	Chalk River, ON (12)
AECL (Maple 2)	10 MWt	Chalk River, ON (12)
AECL (NRU)	135 MWt	Chalk River, ON (12)
AECL (ZED-2)	0.0002 MWt	Chalk River, ON (12)

Table 12-2 Canadian Research Reactor Functions and Used Fuel Management Agreements

FACILITY OPERATOR	PURPOSE OF RESEARCH	TYPE OF NUCLEAR FUEL	FORECAST WASTE MASS	WASTE MANAGEMENT AGREEMENT
University of Alberta	Neutron activation analysis and radionuclide production	93% HEU U235	<1kg	Material to return to US supplier
Royal Military College	Neutron activation analysis and neutron radiography	19.89% LEU U235	1.15kg	Material to return to US supplier
Saskatchewan Research Council (SRC)	Neutron activation analysis of environmental samples	93% HEU U235	<1kg	Material to return to US supplier
Dalhousie University	Perform fundamental and applied studies in nuclear analytical chemistry	93% HEU U235	<1kg	Material to return to US supplier
McMaster University	Dedicated production facility manufacturing I-125 for use in nuclear medicine	(93%) HEU, (19.89%) LEU	135.6kg	Material to return to US supplier
École Polytechnique (SLOWPOKE-2)	Neutron activation analysis and radionuclide production	19.89% LEU U235	1.15kg	Material to return to US supplier
AECL (all research)	Historic & on-going research	multiple fuels	12% by mass of AECL CANDU fuel inventory	Material to be managed under *NFWA*, by NWMO

Note: Highly Enriched Uranium (HEU); Low Enriched Uranium (LEU); uranium-235 (U235).

The four management approaches under study by the NWMO have not identified services to be offered to waste owners other than NWMO Members (Ontario Power Generation Inc., NB Power Nuclear, Hydro-Québec) and AECL. Research reactors within Canada presently disposition used nuclear fuel in one of two ways. Under existing agreements, waste material is returned to the point of origin, under conditions licensed by the CNSC and Transport Canada. This means that the used fuel is returned to the institution or organization that originally provided the nuclear fuel for the research reactor. The NWMO would not provide services in this instance because the requirement for service falls under an alternative existing Agreement. In other cases, material is transferred back to AECL, to be temporarily stored at their Chalk River Laboratory and at some later date is to be returned to the original supplier in the United States.

In the event that there are new market entrants in the future, for research or commercial operations, the services and fees negotiated by the NWMO would be determined, at that time, by the nature of the waste owner's fuel, the volume of material to be managed and an allocation of costs in accord with existing member costs.

Chapter 13 / Continuing the Collaborative Process of Dialogue and Engagement

In a democratic society citizens have a right to know about and participate in discussions and decisions that affect their quality of life. Furthermore, citizens bring special insight and expertise which usually results in making better decisions. The NWMO's search for effective engagement, while based on the farsighted requirements of the *Nuclear Fuel Waste Act* (*NFWA*), reflects our belief that the challenge of managing used fuel over the long term demands engagement, genuine dialogue and deliberation.

A critical component of implementation, phasing and adaptation of any management approach is the continuing and evolving active engagement of both specialists and citizens. Engagement will enhance the NWMO's ability to progress effectively through each phase.

This is for a number of reasons. First, knowledge, experience, values and societal priorities may well change over the period of implementation. These kinds of changes will drive both the need to refine the approach and its implementation as well as uncover opportunities for doing so. It will be important to establish mechanisms to identify the need for change and examine the nature and consequences of any modifications to the approach which may be required.

Secondly, it is only as we move through implementation that it will be possible to fully understand those likely to be affected and identify which voices will need to be heard at each point in the process. It will be necessary to identify the "communities of interest" which are likely to be most affected at each phase of implementation, their capacity for engagement in the implementation process and any support they will require. Only through successful engagement and collaborative decision-making in the early stages of implementation will trust and confidence begin to be built in the process itself. The ability of the engagement process to identify, and effectively address, the difficult issues which will emerge over the course of implementation will be a key measure of success.

The *Nuclear Fuel Waste Act* (*NFWA*) requires that the NWMO set out a program for public consultation as part of an implementation plan for each approach. Although the specific details of a program for engaging communities of interest will need to be developed iteratively and collaboratively with those most affected, we provide the foundation for the program in this chapter.

13.1 / Setting the Context for Effective Engagement

The NWMO has heard from its dialogue with Canadians, and agrees, that in order for engagement to be effective, it will need to be based on the ethical principles identified through the study process. Implementation of these ethical principles would require that any engagement program:

- Be informed by the best knowledge – in particular from the natural and social sciences, Aboriginal Traditional Knowledge, and ethics – relevant to making a decision and/or formulating a recommendation;

- Ensure that those who most directly could be exposed to harm or risk of harm (or other losses or limitations) are involved in discussions and provided in advance with information and resources that enable them to participate effectively; and

- Take into consideration, in so far as it is possible to do so, the cost, harms, risks, and benefits of decisions which are taken, including not just financial costs but also physical, biological, social, cultural, and ethical costs (harm to our values).

Recognizing that all Canadians might have an interest in the matter of the long-term management of used nuclear fuel, the NWMO involved a broad cross-section of communities of interest in the course of its study. As we move to implement the decision of the Government of Canada, engagement will become more focused on the communities of interest which are potentially most affected at each phase of the implementation process. The determination of who those communities are and the nature of their involvement, will be the subject of dialogue in the period immediately following a decision.

In addition to the ethical principles, any engagement program will be built on the following understandings:

1. Judgments about acceptable risk and safety at each point in the process need to be made collaboratively with those most potentially affected.

The views of Canadian society in judging benefits or risks and assessing the social implications of various approaches have been important in developing a socially acceptable recommendation. Canadians expect that the best scientific and technical knowledge will be brought to bear in identifying and understanding the source and nature of risk and the ways in which safety can be assured. However, the decision as to whether safety has been assured to a sufficient degree to warrant implementation is a societal one, and will be affected by social notions of what constitutes risk, safety and thresholds to be met. This requires sustained engagement with people and communities.

In implementing any management approach selected by the Government of Canada, managing risk in a socially responsive way will require the involvement of those potentially affected at each point in the process in judgments about what constitutes acceptable risk and safety. Those communities of interest will be diverse, including specialists, citizen groups, individual citizens and waste producers. Mechanisms will need to be developed to involve them effectively in developing the assessment criteria for the phases of the project and evaluating progress against these criteria.

2. Detailed implementation plans need to be developed in an iterative and collaborative manner with those most potentially affected.

A commitment to continuous learning and adaptation to evolving conditions implies that implementation plans will not be static. They will need to evolve as the implementation process becomes more focused and localised. We anticipate that many communities of interest will have important roles to play at various points in the process, including the design of the process and the issues to be explored. Methods for engagement and timetables for implementation must be discussed and defined as part of the necessary collaboration and dialogue.

3. Addressing the needs and concerns of affected site communities is a key goal of engagement.

Once a willing host community has been identified, its vision of its social, cultural and economic aspirations will need to be recognized and supported as a key goal of the engagement program. The concerns of other communities of interest, such as those in surrounding regions must also be taken into account through any engagement program.

4. Transparency and openness in decision-making will be facilitated through the design and implementation of the engagement program.

In order to demonstrate the continued appropriateness of the engagement program as it evolves and the decisions which emerge from it, the engagement program will need to be operated in an open and transparent manner. Furthermore, although we expect the engagement process to become increasingly more focused on the communities of interest most directly affected, it is expected that others will continue to remain interested and engaged through the program.

5. Continuous learning and adaptation are also important goals of the engagement program.

The NWMO believes that continuous learning and adaptability are integral to successful implementation plans. A used nuclear fuel management program that will evolve over a long period of time will have many opportunities for improvements to increase performance, enhance effectiveness, improve understanding and confidence, and address societal concerns. To realize these benefits, there needs to be both a vibrant and robust research and development effort, and an engagement program which includes specific activities to consider new learning and incorporate it in decision making.

6. The engagement program should preserve and sustain a sense of urgency and momentum throughout implementation.

While taking the time to engage potentially affected communities of interest effectively, it will also be important to encourage implementation to proceed through the phases in as expeditious manner as full engagement will allow. It will be important to incorporate resiliency in the engagement process to allow for adjustments in course in the face of unplanned obstacles or problems which may arise.

7. The conditions for educational outreach and the development of an informed citizenry as well as a culture of vigilance should be enhanced through the engagement process.

There is an appetite for more knowledge and understanding about used nuclear fuel, the requirements for its management, and the activities of the NWMO among citizens across Canada. In virtually every dialogue held, the NWMO was told that we must take the task of education as a priority, increasing understanding within this generation of citizens and putting in place mechanisms to transfer knowledge to future generations. There must be a readily accessible opportunity for all citizens to access information, pose questions, have these questions answered, and develop confidence that the process which has been put in place will maximize safety and security and reflect the values and priorities of Canadians. As well, the efforts we make today to build an informed citizenry must contribute to a more informed citizenry in generations to come.

8. A special responsibility is owed to potentially affected Aboriginal peoples.

An engagement program must recognize the special obligation of government to Aboriginal peoples to consult on matters which may affect them, as laid out in legislation. Aboriginal and treaty rights are protected under s.35 of the *Constitution Act, 1982*. Since then, a series of Supreme Court of Canada decisions has begun the process of formally clarifying the legal duty of consultation by government owed to Aboriginal peoples. This process continues. Throughout our study, and as outlined in Chapter 3 and in more detail in Appendix 11, we have made best efforts to involve Aboriginal peoples in the dialogue. We have heard from Aboriginal peoples that these discussions did not constitute formal "consultation" as they saw it. The nature of the specific obligation will be clarified as affected individuals and communities become more evident.

9. 'Consultation' required by regulatory processes will be one among many components of the engagement program.

Over the course of implementation a number of regulatory decisions and approvals will be sought, each with specific requirements for public consultation. Two examples are approval under the *Canadian Environmental Assessment Act* (*CEAA*) of an environmental assessment for a preferred site and Canadian Nuclear Safety Commission (CNSC) approval and issuance of site preparation and construction licenses for a shallow rock storage cavern, an underground characterization facility and a deep geological repository. There may be additional requirements under provincial legislation, as outlined in more detail in Appendix 5. There are also regulatory requirements related to public information during all stages of implementation. The engagement program must ensure that the specific requirements of each of these processes are fully satisfied.

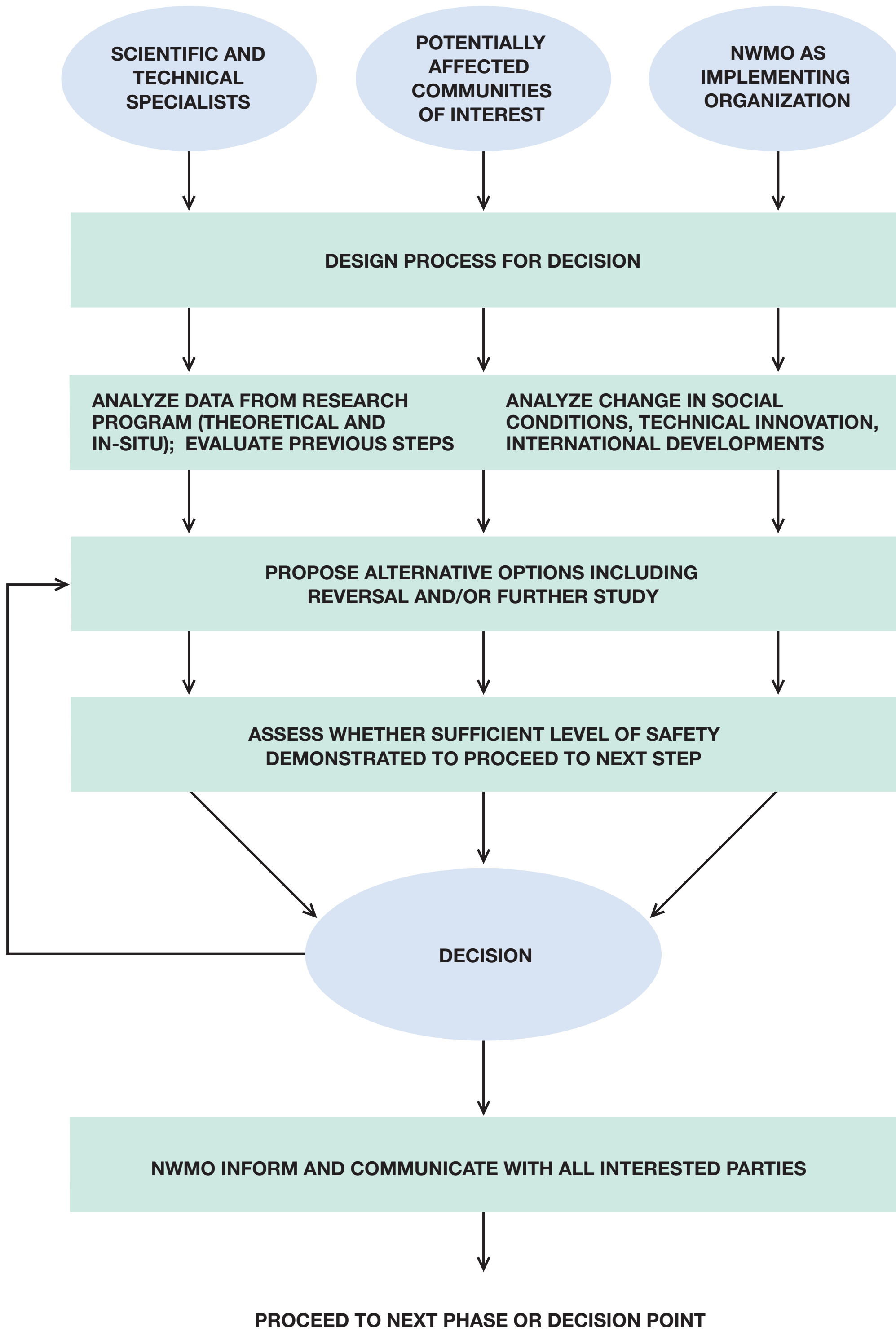
13.2 / Engagement as an Input to Decision-Making

The flow chart which follows (Figure 13-1) illustrates, at a conceptual level, the nature of the engagement which is being proposed for each of the decisions to be taken, regardless of the chosen management approach.

Implementation of the Adaptive Phased Management approach would involve decision points which would be the subject of public engagement. These decisions vary in complexity and some would likely involve a more elaborated series of decisions. The decision points for the Adaptive Phased Management approach include:

- Collaboratively develop a siting process and engagement program with people and communities from areas potentially affected, including Aboriginal peoples;
- Initiate the siting process to select a preferred site (including feasibility studies and site characterization) from candidate sites, including expressions of willingness from communities to engage in the site investigation process;
- Select a site;
- With public engagement and safety analyses, assess the project against the requirements of an environmental assessment, including shallow rock cavern storage, the underground characterization facility and deep geological repository;
- Decide whether or not to construct a central shallow underground storage facility;
- Decide when to begin transportation of used fuel from the reactor sites to the central site;
- Decide when to construct the deep geological repository and ancillary facilities;
- Decide when to begin to place waste in the shallow underground storage facility and/or deep repository;
- Decide the nature of active monitoring of the facility before closure of the facility;
- Decide when to close the deep repository; and
- Decide the nature and period of extended monitoring following closure of the repository.

Figure 13-1 **Illustrative Dialogue & Engagement Process for Each Decision Point**



Note: Loosely adapted from "One Step at a Time, the Staged Development of Geologic Repositories for High-Level Radioactive Waste", National Research Council of the National Academies, the National Academies Press, 2003.

By means of further illustration, Table 13-1 identifies the nature and breadth of contribution from the engagement program for each of the key implementation decisions of the Adaptive Phased Management approach.

Table 13-1 Engagement as an Input to Decision-Making

NO.	DECISION POINT	INPUTS
1	Identify candidate areas	• **From NWMO study:** Technical and societal siting principles identified through NWMO study process • **Research:** Advancement of Canadian and international research on characteristics and performance of appropriate geology • **Dialogue:** Results of dialogue with potentially affected communities, and other interested communities of interest, to determine an appropriate siting process and criteria • **Site-specific research:** Surface-based site characterization data • **'Acceptance/Confidence' achieved:** Expression of interest from potential communities for further feasibility studies and analyses.
2	Select preferred site	• **Dialogue:** Agreement from potential communities, and other directly affected communities of interest, for further feasibility studies and analyses • **Site-specific research:** Surface & subsurface site characterization data at potential sites; feasibility studies, including transportation studies; preliminary safety analyses to support technical feasibility and acceptability of sites; preliminary transportation analyses; preliminary engineering designs & cost estimates • **Application** of site evaluation & selection process – assessment against siting process and criteria developed collaboratively earlier • **'Acceptance/Confidence' achieved:** Agreement from preferred site community, and other communities of interest most directly impacted, to proceed with further studies, analyses, environmental assessment and licensing process.
3	Decide whether or not to construct central shallow underground storage facility	• **Site-specific research:** Detailed surface and subsurface site characterization data at the preferred site; further safety analyses, engineering design and cost estimating work; preliminary safety assessment report • **'Acceptance/Confidence' achieved:** Agreement from host community, and other directly affected communities of interest, to construct underground storage facility • **Meet regulatory conditions:** Environmental assessment approval; site preparation licence from CNSC • **Change in social conditions:** Strong indication from reactor site communities of a need to move waste off site; unforeseen developments that increase the desirability of centralizing the fuel for reasons of enhanced security • **Innovation in technologies:** Unforeseen developments in technological innovation.
4	Decide when to begin transportation of used fuel from the reactor sites to the central site	• **Dialogue:** NWMO to establish timelines through engagement with reactor site communities and the individual utilities. • **'Acceptance/Confidence' achieved:** That sufficient level of safety demonstrated to proceed with transportation, among directly impacted communities of interest • **Meet regulatory conditions:** The extent to which NWMO has finalized transportation plans to the satisfaction of regulatory and governmental authorities and the communities affected.

Table 13-1 (cont'd) Engagement as an Input to Decision-Making

NO.	DECISION POINT	INPUTS
5	Decide when to construct the deep geological repository	• **International experience:** Successful operation of deep geological repositories in other countries (e.g., Finland, Sweden, USA) • **Site-specific research:** Confirmation of site suitability for a deep geological repository – successful operation of underground characterization facility and tests of containment and isolation systems and technology demonstration; final safety analyses; final engineering designs and cost estimates; final safety case to support deep repository • **'Acceptance/Confidence' achieved:** Confirmation from host community, and other directly affected communities of interest, that safety has been sufficiently demonstrated and agreement to construct deep geological repository.
6	Decide when to close the deep repository	• **Operational performance and experience:** Successful operation of deep geological repository; in-situ monitoring data, engineering analyses and safety analyses confirm performance of repository • **Dialogue:** With host community, and other directly impacted communities of interest, concerning timing and manner of closure of the deep geological repository • **Change in social conditions:** Developments that might lead society to conclude that easy access to the used fuel is no longer a priority, for example: > review of latest international research findings suggest partitioning and transmutation or other used fuel treatment methods do not present a preferred waste management option; > Canada's activity in nuclear fuel cycle – level of nuclear operations and type of technology adopted – do not support economics or feasibility of using reprocessed fuel; and > Demand/supply for Canada's natural uranium reserves – natural sources of uranium appear to be sufficient to support Canada's nuclear operations, without reliance on reprocessed fuel > Unforeseen developments that increase the desirability of closing the repository or keeping it open • **Innovation in technologies:** Expected developments in technological innovation do not materialize • **'Acceptance/Confidence' achieved:** Confirmation from host community, and other directly impacted communities of interest, that passive safety performance of the repository, and/or the ability to retrieve the waste once the repository has been closed, and/or the effectiveness of remote monitoring to monitor the performance of the system once closed, has been sufficiently demonstrated to warrant closing of the repository.

13.3 / Incorporating Evolving Best Practices

How to achieve effective engagement in important public policy issues, and in nuclear waste management decision-making in particular, is a topic of much academic research and innovative experimentation. Over the course of its study, the NWMO in conjunction with a variety of independent contractors, tried a number of innovative approaches to engaging specialists and citizens. We benefited from academic research, including exploration of community based initiatives. There have also been advances in designing initiatives to broaden involvement in performance assessment, involving specialists and citizens in dialogue around a single table. This research and experience is the foundation upon which we will develop the tools and capacity to implement the range of engagement initiatives which implementation of the approach will require.

Internationally, there is also research and experimentation in engagement to draw upon. Specifically, advancements, successes and challenges experienced in Finland, Sweden, Japan, the United Kingdom, France, Germany and the United States will be monitored. As well, the work of the OECD's Forum for Stakeholder Confidence, and initiatives by the International Atomic Energy Agency, continue to provide important opportunities to share and learn from experiences of others.

These best practices will be documented and updated and made available to interested citizens and communities throughout the implementation process.

The NWMO has used a wide variety of means to disseminate information through its website, e-dialogues, national and local advertising, public information and discussion sessions, and media interviews and to create genuine opportunity for dialogue. However, we recognize that during implementation specific educational initiatives should be undertaken. As new tools and approaches are developed both in Canada and internationally, they will need to be reviewed, assessed and if appropriate adopted over the course of the implementation process.

13.4 / Comparing the Management Approaches

In our mission statement, we highlighted the importance of striving for social acceptability in the selection of any management approach. The way in which an approach is implemented, and specifically the process of engagement, is an important means to accomplish this goal.

How then do we see an engagement strategy differing among the four approaches studied? We recommend that no matter which management approach is ultimately selected by the Government, the essence of the engagement program outlined in this chapter should be applied.

However, we believe that the likelihood of successfully implementing this type of engagement is much higher with the preferred approach of Adaptive Phased Management than with the other approaches. This is because:

- The implementation of the non-preferred approaches is less amenable to being broken up into incremental pieces for the purposes of engagement;
- The non-preferred approaches are less able to address outcomes of engagement different from those planned and anticipated; and,
- There are few or no contingencies designed into the non-preferred approaches to accommodate major disruptions in implementation introduced through formal or informal engagement.

The type of comprehensive engagement outlined in this chapter is most anticipated and taken into account, by the Adaptive Phased Management process.

CHAPTER 14 / Addressing Social, Economic and Cultural Effects

Section 12(6)(c) of the *Nuclear Fuel Waste Act* (*NFWA*) requires the NWMO to specify the means that will be used "to avoid or minimize significant socio-economic effects on a community's way of life or on its social, cultural or economic aspirations."

The socio-economic dimension is key to the success of our strategy for managing used nuclear fuel. There are a growing number of experiences that offer innovative ways of bringing affected individuals, organizations, and communities into decision-making processes and addressing socio-economic and cultural effects in a way that ensures communities themselves remain in control of their own future. The result is an alignment between a given project and citizen values and priorities.

For communities and the NWMO, the way ahead must be marked by trust and integrity, not acrimony. Seen in this light, the effective management of socio-economic effects will pave the way for this project to provide real opportunity – an opportunity that brings an overall positive contribution – to people, their community, and the environment.

14.1 / The Context

NWMO's overall strategy for managing socio-economic effects consists of three key components:

1. **Seeking a willing community to host any long-term waste management facility;**
2. **Building with that community a strategy for long-term community sustainability; and**
3. **Working collaboratively and openly with all those potentially affected by implementation in a fair and equitable manner.**

Many considerations will come into play as we consider the definition of "host community". Community is not readily defined along geographic or political boundaries. A community may reflect shared perceptions and attitudes, and shared socio-economic foundations. It may be defined in part by behaviour patterns which individuals or groups of individuals hold in common, through their daily social interactions, the use of local facilities, participation in local organizations, and by involvement in activities that satisfy the population's economic and social needs. Arriving at an appropriate definition of "host community", and understanding its characteristics, values, goals and concerns, will be an important starting point for assessing and managing potential socio-economic and cultural effects.

Much of the discussion in this chapter focuses on the management of potential impacts in the communities closest to the central site – the willing host, recognizing that this is where effects are likely to be greatest and actions required, most significant. However, we recognize that there may be other areas potentially affected or implicated through the implementation process. We will ensure that all potentially affected are positioned to be active participants in decisions taken in implementing Adaptive Phased Management. All potentially affected parties must be afforded fair and equitable treatment, in engagement with the NWMO, in assessing potential significant socio-economic effects, and in managing those effects.

This includes paying particular attention to Aboriginal communities that may be affected. Implementation must respect Aboriginal rights, treaties and land claims, and be sensitive to the social, cultural and economic aspirations of those communities. We are committed to building a relationship based on mutual trust, respect and integrity, and seeking an alignment between Aboriginal values and those reflected in our management strategy.

Communities in which the used nuclear fuel is currently stored will also figure prominently in implementation, regardless of which management approach is selected. Our recommended approach, Adaptive Phased Management, involves continued storage of used nuclear fuel at existing interim storage facilities until such time as a new facility is available to receive the used fuel – whether a centralized shallow underground storage facility, and/or a deep geological repository in an appropriate geological formation. Continued secure storage of the used nuclear fuel at the existing reactor sites is an integral and essential component of Adaptive Phased Management.

The purposes of socio-economic and cultural effects management are to:

- ensure that people affected and their communities have the capacity to cope with change;
- ensure that good relationships are fostered between the proponent, a community and others involved in or affected by a project's development; and
- help to ensure that over the long term of any project, its consequences are contributing positively to a community's goals and aspirations.

Table 14-1 Categories of Measures to Address Impacts

Enhancement	refers to actions or measures undertaken with the objective to maximize the potential impacts deemed to be beneficial.
Mitigation	refers to actions or measures undertaken with the objective to avoid, or reduce the severity of adverse impacts.
Compensation	refers to actions or measures undertaken with the objective to redress or offset the unavoidable or residual adverse impacts of the management approaches. These measures can be impact-related, aiming to offset impacts to a level equivalent to pre-project conditions. Compensation measures may also be equity-related, intended to improve the community's share of benefits over costs. Equity-related compensation is often referred to as an incentive.
Monitoring and Contingency Measures	can take the form of policies or programs designed to ensure a timely and appropriate response to potential problems and unanticipated adverse impacts. These contingency measures may involve the application of mitigation, enhancement or compensatory measures.
Community Liaison Measures	are policies, programs or administrative procedures aimed at establishing and maintaining cooperative, non-adversarial relationships between the project proponent, project workers, the local community, and various levels of government in order to build commitment to the project and the effects management process, and to address some of the more intangible social impacts related to public risk perception.

Source: www.nwmo.ca/assessments

Historically, in the field of environmental assessment, measures taken to minimize or avoid adverse effects are generally referred to as "mitigation." Under the *Canadian Environmental Assessment Act*, "mitigation" refers to measures that serve to prevent, eliminate, reduce or control adverse environmental effects of a project, including restitution for any damage to the environment caused by such effects through replacement, restoration, compensation or any other means. In the field of socio-economic impact assessment, the concept of "mitigation" is broadened somewhat and is generally referred to as "socio-economic effects management". It includes not only measures to prevent, eliminate, reduce or control adverse environmental effects; and replace, restore or compensate for damages; but also measures to enhance positive effects and the implementation of practices and procedures for developing and maintaining trust or positive relationships with those affected. "Socio-economic effects management" involves the coordinated application of enhancement, mitigation, compensation, monitoring and contingency measures, and community liaison measures, as depicted in Table 14-1.

Through our discussions with Canadians and drawing from recent developments in Canada and abroad, we have found that a significant evolution in understanding continues to take place regarding how to best address social, economic and cultural implications of development. These insights are particularly important to apply to the development and operation of a facility to manage used nuclear fuel, given its unprecedented nature and time horizon.

At the very heart of this evolution is recognition that short-term solutions are rarely effective, and that mitigation of adverse effects, on its own, is also not adequate. Initiatives must be designed to seek positive contributions to the community that will continue over the long term. Further, the issue is not simply one of jobs, income, or tax revenues. More fundamentally, it is an issue of people's future and the degree of confidence that this future will unfold in a manner consistent with closely held values and priorities. This touches the heart of a community's culture. If synchronicity between a proposed project and people's values is not evident, the project may be seen as a threat to the fabric of community life, and be vehemently opposed.

We believe that such an alignment is possible. The key to success lies in how the citizenry are directly involved in the decisions that affect their current and future way of life. With involvement, trust can emerge; without it, trust is unlikely.

The NWMO is committed to a collaborative process of decision-making that includes:

- Working closely with communities to tailor programs for citizen involvement in the decisions that affect the community's way of life. Fairness requires that the NWMO provide for the participation of interested citizens in key decisions taken on managing socio-economic effects, through full and deliberate engagement during the different stages of decision-making and implementation; and

- Develop, with the host community, a community-oriented strategy for long-term sustainability. This requires working together to design measures appropriate to nourish the positive socio-economic and cultural effects, while avoiding or minimizing any negative effects.

We propose to involve people starting with the collaborative design and implementation of the process of engagement itself and extending through to collaborative design and implementation of measures to address socio-economic and cultural effects of NWMO activities. Collaboration is essential not only in the phase of inquiry and investigation, but also in decision-making throughout the life of the project.

Over the past number of years, effects assessment has evolved steadily to include a broader perspective. Table 14-2 describes a "sustainable livelihoods framework" that offers one way to approach potential community impacts in an integrated and comprehensive way, by considering the main factors that affect people's livelihoods. This framework invites consideration of the many aspects that are often included in the kind of sustainable development context that the NWMO has adopted.

In the context of siting, designing, constructing and maintaining a facility for the management of used nuclear fuel, it will be important to look at individual community characteristics to:

- Identify possible ways to support people and communities in building their livelihood assets;
- Identify ways to encourage responsive support from institutions and organizations; and
- Identify avenues that people and communities might choose to harness change for social and economic enhancement.

Having established an understanding of the ways in which a community may be impacted, it will then be possible to design and implement measures for assessing the capacity of the community to respond and the specific measures needed to manage effects, both in terms of enhancing positive effects and minimizing negative effects.

Table 14-2 The Sustainable Livelihoods Framework

The Sustainable Livelihoods Framework provides insight into the different dimensions of well-being, in terms of social, human, physical, financial and natural dimensions:

- **Social Capital**, consisting of networks and connectedness that increase people's trust and ability to work together;
- **Human Capital**, consisting of skills, knowledge, ability to work, and good health;
- **Physical Capital**, consisting of infrastructure and producer goods;
- **Financial Capital**, consisting of available stocks and inflows of money; and
- **Natural Capital**, consisting of natural resource stocks and intangible public goods – atmosphere, biodiversity; and divisible assets, such as trees, water and land.

The breadth of considerations covered by this framework is illustrative of the range of effects to be considered in implementation. In practice, the nature of the community effects and appropriate means of addressing those effects must be considered in the context of a specific site. Regions will differ significantly in their social, human, physical, financial and natural capitals.

People living in a community have a greater or lesser adaptive capacity based on the relative strength of the sustainable livelihood assets present in that location. The "adaptive capacity" of the residents or community to adjust to change, take advantage of opportunities presented by change, and/or cope with the consequences of change, will differ significantly depending upon the site selected for implementation. The measures required to manage those impacts will therefore differ according to the specific regions selected for implementation.

Investment in the community in terms of social, financial, physical and human capital may be required to ensure that it is equipped to participate in negotiations and decision-making, as well as participate in the benefits that emerge from increased employment activities. To ensure a fair process, early measures are required to build the capacity of people within such communities to effectively participate in discussions, dialogue and any required negotiations.

Note: Drawn from "Assessment of Benefits, Risks and Costs of Management Approaches for Used Nuclear Fuel by Economic Region", Golder Associates Ltd. and Gartner Lee Ltd., February 2005.

14.2 / What are Potential Socio-Economic Effects?

Socio-economic effects (or changes to the socio-economic conditions) are determined by many factors including:

- Existing or baseline conditions in an area such as the stability or the size of the local population;
- Key project or program factors that may create effects including estimated workforce requirements, infrastructure needs, and approach to decision-making;
- Changes to traffic patterns and economic flows within a region;
- The nature of the changes, including whether they are direct or indirect, of great or small magnitude, short or long duration, their significance and reversibility; and
- The community's own goals and aspirations and the degree that those affected have the opportunity and ability to participate in, and have some measure of control over, the outcome of decisions that will affect their lives and livelihood.

The socio-economic effects may vary according to the stage or phase of a project. For example, those produced during a site selection process may be completely different from those occurring during the operation of a specific facility. Identification and determination of socio-economic effects require dialogue with the people in the communities that may be affected.

Socio-economic effects ripple out across a community and region. There are direct effects from a project, such as the employment and wages earned. This in turn, creates indirect effects, such as the impact on goods and services purchased by that worker. In addition, there are tertiary effects. For example, if the work environment leads to the acceptance of a safety culture or an attitude towards co-workers that extends to the community, these are called tertiary effects. In this case, they would be educational in nature, and might lead to fundamental cultural changes. Tertiary effects are often much longer term in nature than direct and indirect effects, and for a project such as the long-term management of used nuclear fuel, they can be very significant indeed.

It is also important to think about socio-economic effects beyond the marketplace. These include effects on faith and cultural oriented activities, the wide range of volunteer activities, recreational activities, housework, and subsistence activities. These are activities that are essential to the fabric of community life. Yet, they often play little or no role in standard market-oriented economic analyses. However, in small communities, particularly Aboriginal communities, these aspects of traditional life carry great importance. The internal cultural and social structure of Aboriginal communities may be vulnerable to pressures that arise from development activities.

Social, economic and cultural effects may also be felt in areas far removed from the physical location of the new project or facility.

For example, the transportation of used nuclear fuel, away from existing reactor site communities to the chosen central host community could have implications for many communities of interest. Communities currently hosting used nuclear fuel may be impacted by decisions taken with respect to the timing and manner in which the used fuel is transported from their communities. The development of transportation plans concerning mode of transport, routes, security and safety measures, emergency preparedness may have implications for the reactor site communities currently hosting the used fuel, communities along the transportation route, and the central host community selected for the long-term management facility. All will have an interest in assuming active roles in engaging with the NWMO regarding the assessment of potential risks and community impacts, and in ensuring that potential effects are recognized and managed appropriately by the NWMO.

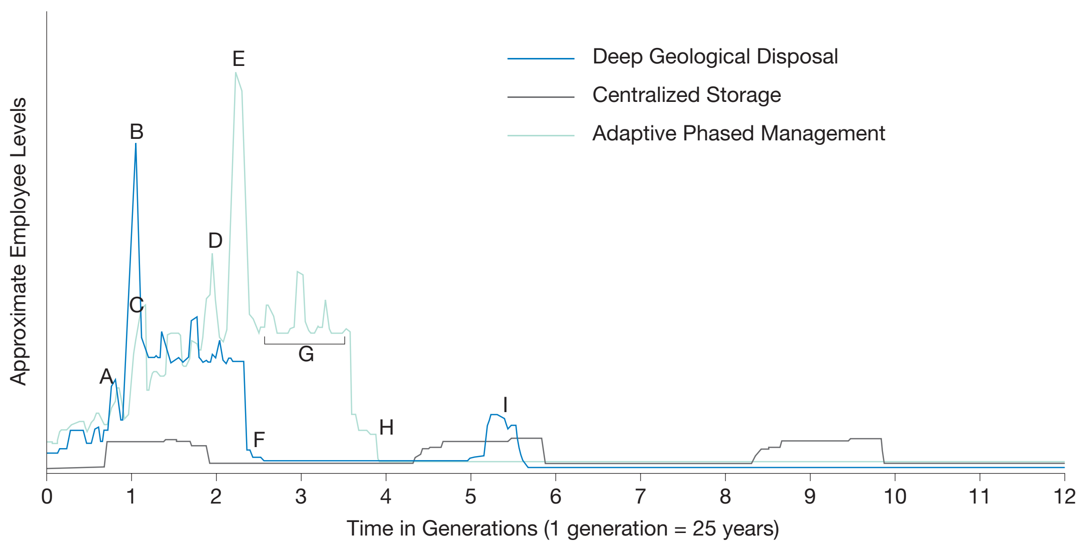
The linked issues of fairness and justice lie at the centre of many socio-economic concerns. If the distribution of costs, benefits, risks and responsibilities is perceived as fair and just, a sense of integrity emerges. Individuals, organizations and communities can open to many possibilities in the belief that their place will be respected. However, if a sense of unfairness arises, rather than a sense of integrity, it is bitterness, contempt, and even helplessness that come to dominate. Under these conditions, people lose any confidence that they can control their own future. It is for this reason that fairness and justice figure prominently in both the assessment process and the ongoing implementation strategy.

14.3 / The Particular Issue of Long-Term Community Sustainability

Long-term management of used nuclear fuel is without precedent in terms of the time-horizon over which socio-economic and environmental effects may be felt. The nature of the activity means that there will be rises and falls in the number of workers on site with a particularly dramatic peak occurring during any construction phase. In addition, the time over which these variations will be experienced on site varies significantly across the four options.

Figure 14-1 provides a conceptual schematic of the relative employment trends (NWMO plus contracted) for three of the four options: Deep Geological Disposal in the Canadian Shield (Option 1), Centralized Extended Storage (Option 3), and Adaptive Phased

Figure 14-1 Conceptual Schematic of the Relative Employment Trends for Each Option



A) Siting

B) Construction of deep repository

C) Construction of shallow rock caverns and underground research laboratory

D) Transport and emplacement of used fuel in shallow caverns, simultaneous R&D with the underground research laboratory

E) Construction of deep repository and packaging plant

F) Extended monitoring

G) Transfer of used fuel from shallow underground storage to repackaging plant, repackage, transfer to deep repository

H) Extended monitoring

I) Decommissioning

Note: The Reactor-site storage option is complex because it depends on how many workers will be shifted from continuing operations of the power producers.

Management (Option 4). Estimates for Storage at Nuclear Reactor Sites (Option 2) are not included because many of those involved would be drawn from existing operations of the power producers and just how this would be done is not known. It is not possible to specify exact numbers because of the many factors involved but it is possible to provide order-of-magnitude trends. For example, the highest peak shown (for Option 4) may reach to about 1,500 and the "average" level for Option 4 from generations one to four would be in the order of 500 people. The portion of these working on site will vary significantly depending on the phase of work.

Figure 14-1 serves to illustrate approximate variations of worker activity over time. Centralized Extended Storage involves a smaller work force that repeats every several generations in line with requirements for repackaging. Option 1: Deep Geological Disposal involves a single high peak during construction followed by a level of activity several times that of the Option 3: Centralized Storage lasting about a generation. Following closure, this level drops down to a low level.

For its part, Option 4: Adaptive Phased Management climbs to a peak during the time when construction of the deep underground facility overlaps with operation of the shallow-underground facility. However, what is notable in the case of Option 4, is that even though there are peaks that must be carefully managed, Option 4 builds gradually and extends over about four generations before dropping down to closure and monitoring conditions. This longer duration activity provides a greater window of opportunity for investment in social, human, physical, financial, and environmental capitals. In turn, with involvement in decision-making, there is heightened opportunity for management of socio-economic and cultural effects to be driven by community values and concerns.

Building a strategy to achieve this result in collaboration with any host community is an important task ahead for the NWMO. Direct, indirect, and tertiary effects will all have to be carefully considered over the full project life cycle.

Implementation presents the significant opportunity to understand the longer-term vision held by the community so that decisions taken in the implementation process may support and make possible longer-term, sustained benefits for the community. It is the willing host community that must lead the development of a strategy to manage the changes introduced by hosting the facility in a way that will support and sustain the achievement of the community's social, cultural and economic aspirations. While the NWMO has an important role to play in providing the resources and support necessary to address community impacts, it is only the community itself that can appreciate its vision, its values and aspirations for the future, all of which must drive decisions taken in implementation.

The NWMO will consider the range of anticipated costs, harms, risks, and benefits of the siting decision. We must consider not only financial costs, but also physical, biological, social, cultural, and ethical costs (harm to our values). Implementation provides an opportunity to avoid and mitigate negative socio-economic impacts. The implementation process must recognize the contributions and costs borne by the community through appropriately designed measures, developed with the community.

Ultimately, quality of life, as perceived by the residents, will be a measure of whether or not we have recognized and appropriately addressed the effects of this project on their community, and made possible sustained long-term enhancements. If implemented well, we will have designed and implemented our activities to foster positive change over the long term.

In particular, mechanisms will have be to considered that deal directly with the transition from high to low levels of activity. One possibility is to create a mechanism to ensure that resources for the use of the community are set aside during the high level of activities for drawing on during the low. This kind of thinking was behind development of such funds as the Alberta Heritage Fund, the Alaska Permanent Fund, and the Norwegian Petroleum Fund, amongst others. These kinds of financial mechanisms need to be reviewed to ascertain strengths and weaknesses and whether or not some form of such an approach might be useful in this case.

In sum, the various elements touched on above need to be brought together in a community-oriented strategy for sustainability that provides a blueprint for addressing socio-economic and cultural effects throughout the project life cycle. In building such a blueprint, suggestions may arise for modification to the level or duration of some of the technical aspects of the project to align the overall result with community priorities.

14.4 / Actions to Address Socio-Economic and Cultural Effects

We will work collaboratively to develop a siting process and engagement program with people and communities from areas potentially affected, including Aboriginal peoples. It is through a collaborative process that we would seek to identify any potentialy disruptive impacts of the long-term management approach on communities, and together develop appropriate contingency plans and effects management measures.

In the discussion below, we describe some traditional and some more innovative approaches to socio-economic and cultural effects management. We then discuss actions and measures to address potential socio-economic and cultural effects that may arise during different times of implementation of a long-term management approach for Canada's used nuclear fuel.

Traditional Approaches to Socio-Economic and Cultural Effects Management

The initiatives below are illustrative of the types of activities that have traditionally been considered and/or utilized in other exercises, and might be considered as the NWMO and communities address potential impacts. These illustrative measures are summarized in Table 14-3, and discussed more broadly in the background papers available at **www.nwmo.ca/assessments.**

Establishing and Maintaining Trust

It is important that implementation plans are responsive to the types of measures required for the affected community/ies to develop and maintain trust in the overall decision-making process. In this regard, it is important that NWMO seek to develop the capacity of the community, so that it is empowered and equipped to participate in the decision-making process, allowing community members to have influence over conditions that matter to people affected by the implementation and operation of the facility.

There may be a role for community agreements that can assist in establishing cooperative and positive working relationships between the NWMO and the community. Specific procedures for dispute resolution might be established to support decision-making processes during implementation.

Provision for active community involvement in project oversight and in the monitoring of socio-economic and environmental effects may be an important component of implementation. Opportunities for community oversight will be key to developing and maintaining trust during project implementation and operation. Community oversight measures are aimed at increasing community access to information, and providing more direct involvement in facility siting and routing, decision-making, design, and operations above and beyond regulatory controls. Developing and maintaining local advisory capacity will be important. Monitoring of socio-economic and environmental effects will play an important role in providing important information to enhance project implementation at the broadest level, but also in enabling the community to actively monitor, provide input and contribute to decision-making processes affecting their socio-economic status.

Decisions will involve many participants including citizens, and particularly Aboriginal peoples, from the affected communities. By developing important baseline understandings, and monitoring changes over time, the community will remain positioned to assume active roles throughout implementation. Through monitoring, the community may assist in identifying unintended effects and the appropriate contingency measures that may be required to mitigate adverse impact.

Table 14-3 Illustrative Measures for Addressing Socio-Economic and Cultural Effects

Establishing and Maintaining Trust	• Community Agreements • Alternative Dispute Resolution • Socio-Economic and Environmental Effects Monitoring • Community Oversight • Involvement of the Public and Aboriginal Peoples
Managing Community Change	• Impact Assistance Grants • Community Capacity Building • Property Value Protection • Community Infrastructure Development • Direct Financial Compensation and In-kind Replacement • Closure Planning
Enhancing Benefits	• Preferential Hiring • Employment and Training Support • Economic Development and Business Enhancement • Occupational Training • Employment Support Services • Off-Site Fabrication of Components • Co-Use and Acquired Property Management • Corporate Donations
Avoiding and Minimizing Adverse Effects	• Optimizing Facility Design • Commuting Programs for Workers • Provision of Temporary Accommodation • Managing Nuisance Effects • Improved Roadways and Access Routes

Source: www.nwmo.ca/assessments

Managing Community Change

A number of opportunities exist in the implementation process to assist affected communities in managing the change brought about by the project. Measures can be used to enhance community competence and adaptability to the changes brought about. A competent community may harness and enhance its resources, particularly those indigenous to the community. A competent community is skilled in problem solving and provides resources that aid the well-being of community members. Characteristics of a competent community include collaboration for integration of services and decision-making, which is facilitated by knowledge of other agencies and services, and participation by citizens in the functioning of organizations.

Community infrastructure development may be required in cases where there are insufficient levels of service to support the facility's construction and operation. Early community involvement in implementation and impact assistance grants can assist in minimizing adverse impacts on residents in terms of pressures placed on their community infrastructure as a result of the long-term waste management facility. Opportunities exist to help offset demonstrated or expected burdens imposed by the facility on the host community through compensation agreements, and through initiatives designed to protect property values. The provision of planning and technical assistance may build the capacity of a community to participate in implementation decision-making and ongoing monitoring of effects, so that the community may retain control over its future growth and development. The development of facility closure plans would also be important in minimizing the social and economic disruption for employees and the community as activity declines.

Enhancing Benefits

Community well-being can be supported by measures that seek to enhance the benefits available to the community as a result of the project implementation and operation. This can be achieved by measures designed to enhance the community's share of benefits from the project. Preferential hiring practices might be considered, to help ensure that local residents have the opportunity to fully participate in the project and share in the economic benefits. Employment, training and support programs may be considered, to enhance opportunities for local residents to participate in the project. A number of opportunities exist to enhance economic development and business activity, to provide local firms preference in the provision of goods and services required by the project, through such measures as preferential hiring; employment and training support; economic development and business activity enhancement; employment support services; and corporate donations.

Avoiding and Minimizing Adverse Effects

Where adverse effects are anticipated, measures can be taken to avoid or minimize the negative socio-economic impacts. Initiatives may seek to ensure the compatibility of the project within its socio-economic setting and manage the influx of population into a community. In general, this can be achieved through the implementation of best practices for facility siting and routing; facility design optimization and continual improvement; measures to facilitate local commuting and long-distance commuting; provision of temporary accommodation; nuisance effects management; access modifications and restrictions.

Exploring Innovative Ways of Addressing Socio-Economic and Cultural Effects

Over the past several decades, a range of innovative administrative arrangements have emerged to address socio-economic and cultural effects and simultaneously, to create a solid means for ensuring that affected interests are included in key project decision-making processes. Many of these innovations also provide surety to parties that responsibilities will be discharged in a way that is satisfactory to all concerned. An important task for the NWMO will be to review the experience of others within Canada and abroad, and to make that information available to interests throughout this process. This then will provide a strong basis for collaboratively designing the kind of administrative arrangements that will work best in the particular circumstances that are faced in this project.

Table 14-4 presents examples of how active community involvement and shared decision-making have been provided in other projects, with the necessary supporting resources and infrastructure.

Table 14-4 Innovations in Addressing Socio-Economic Effects

Innovative arrangements in Canada's North. Over the past several decades, and perhaps sparked by the innovative mid-1970s work of the Berger Commission on the Mackenzie Valley pipeline, Canada's north has seen a range of innovative instruments struck to address Aboriginal and northern concerns related to a range of resource developments. Co-management agreements, socio-economic agreements, impact and benefit agreements are some of the labels that have emerged. Mining, pipeline development, gas and oil developments, hydro-electric power developments have all played a part. Some of these arrangements have worked well, but some have not. In the Yukon, a new *Yukon Environmental and Socio-Economic Assessment Act* is setting a whole new standard for assessment. This body of knowledge needs to be carefully reviewed and the lessons learned brought to bear in a way that works for effective long-term management of used nuclear fuel.
The Stillwater Good Neighbourhood Agreement. In May 2000, a historic agreement was signed between the Stillwater Mining Company (SMC) of Montana and three not-for-profit organizations – the Northern Plains Resource Council (NPRC), Stillwater Protective Association (SPA), and Cottonwood Resource Council (CRC). All three of these organizations play a role in ensuring that quality of life in the region is maintained and improved. The agreement sets out to: (1) minimize the adverse impacts caused by company operations on the local communities, economies, and environment; (2) establish and maintain a mechanism of open lines of communication between the parties to ensure that concerns held by affected residents are addressed; (3) ensure that the community has the opportunity to participate in company decisions that may affect the local communities, economies, or environment (the nature of that participation varies depending on the issue); (4) bind the company and successors, partners, subsidiaries and affiliates for the life of mining operations; and (5) minimize future litigation by utilizing the processes and mechanisms established by the Agreement to resolve disputes.
The Antamina Mine's approach to community development and environmental protection. With an initial capital investment of $2.3 billion, Peru's Antamina Mine, which began production in 2001, is the largest "greenfield" mine development in history. Some 10,000 people were employed during the construction phase and 1,400 people are now permanently employed. Components of their innovative approach to community development and environmental protection include: (1) an explicit tripartite perspective involving the company, government, and society; (2) a comprehensive safety program based on building a culture of awareness through standards, training, inspections, audits, and continuous learning; (3) the adoption of internationally accepted principles of social responsibility based on (i) the need to obtain a "social licence" (defined as the consent or acceptance by the principal affected interests) to be able to operate in harmony with the local communities in the project's area of influence; (ii) triple bottom line reporting that includes economic and financial balance, environmental, safety, and health balance, and a social responsibility balance; and (iii) an extensive program of public engagement based on consultation and dialogue; (4) the use of collaborative community-company committees to address a range of environmental concerns and to serve in a monitoring and dispute resolution function; (5) participation by the company in a number or regional environmental working groups involving other companies, non-governmental organizations and local government; and (6) a number of special programs related to agriculture, education, and health.

Measures to Address Potential Socio-Economic and Cultural Effects by Project Activity

In addition to positive economic benefits resulting under any one of the four management approaches, there are a variety of social and economic costs that are attendant with projects of this magnitude. Further to the earlier discussion of potential socio-economic and cultural effects, and with consideration of the traditional and innovative approaches to effects management, Table 14-5 outlines some common socio-economic and cultural effects that may arise during different times of implementation for the four management approaches, and a discussion of possible means and measures to address them. They are offered as examples of changes that may occur, not predictions of what is likely to occur.

It is important to note that while current used fuel owners (Ontario Power Generation, Hydro-Quebec, NB Power Nuclear and AECL) will continue to have the legal ownership and management responsibility of the used fuel while it remains in interim storage at nuclear reactor sites, it is essential that there be close collaboration between the nuclear corporations, the NWMO and the current host communities so that implementation decisions taken with respect to the long-term management approach seek to avoid or minimize disruptive impacts on the current host communities.

It is through a collaborative process that we would seek to identify any potentially disruptive effects of the long-term management approach on reactor site communities, and together develop appropriate contingency plans and effects management measures. Formal mechanisms of public engagement and dialogue must continue. The NWMO must ensure that resources are provided for capacity-building within reactor site communities, to enable the current host communities to be active participants in decisions taken in moving the used fuel to the new facility. Current reactor site communities will continue to be important participants throughout implementation and until all used nuclear fuel is removed from those sites. In the event that a reactor site community were to be selected as the willing host for the new centralized long-term management approach based on any of the four options, it must be treated as a "new host community", afforded full consideration of costs, benefits and risks associated with its long-term contributions in hosting the management facility throughout all phases of implementation.

Table 14-5 Measures to Address Potential Socio-Economic Effects by Project Activity

Project Activity with order-of-magnitude estimates of time duration and employees on site	Potential Socio-Economic Effects and Measures Required
Transition to Decision	This period exists between the filing of the NWMO Study Report (November 2005) and the taking of a decision by the government. • Community debate may arise about the implications of the chosen management strategy and/or the acceptability of hosting a facility over the long term. This debate can be potentially divisive within a community, or serve to bring a community together in a strengthening way. • Effectively designed processes can lead to enhanced confidence building and capacity to participate through, for example, (1) continued development of community familiarity with issues through ongoing dialogue; (2) continued development of language capacity for Aboriginal peoples; (3) development of technical knowledge; (4) for the NWMO, a growth in capacity to include others in the dialogue, in particular Aboriginal peoples and Aboriginal Traditional Knowledge in deliberations. Local Advisory Capacity. Guidance on identifying and managing potential socio-economic effects could be sought from interests that may potentially be affected as well as from experts in the field. This input is essential in providing socio-economic-related insight to us concerning the area hosting the facility, benefiting from Aboriginal Traditional Knowledge, and serving as an ongoing focus of socio-economic and cultural-related work as implementation proceeds. Benefiting from International Experience. Opportunities might be sought to ensure an ongoing flow of information, research, insights and experiences from other countries that are studying and implementing long-term management approaches for used nuclear fuel. The insights available from other jurisdictions will be of interest not only to us, but also to the local area identified to host the Canadian facility. Generic Socio-economic Research. A comprehensive review of potential socio-economic effects and concrete experiences elsewhere, including successful implementation, might be conducted. This type of review might consider mechanisms that have been developed to address long-term community sustainability such as those mentioned in the previous section, as well as those mechanisms intended to ensure effective communication with communities of interest as the project proceeds. A review of the particular socio-economic needs, concerns, and issues (and ways of addressing them) of various special community groups including reactor-site communities and transportation route communities might be undertaken. In addition, consideration of approaches to dispute management might be useful, in light of the overarching importance of seeking fairness and justice in the implementation strategy.

Table 14-5 (cont'd) Measures to Address Potential Socio-Economic Effects by Project Activity

Project Activity with order-of-magnitude estimates of time duration and employees on site	Potential Socio-Economic Effects and Measures Required
Transition to Decision (cont'd)	Aboriginal-Specific Research, Development, and Training. Capacity-building might be advanced through research, development and training to support the active engagement of Aboriginal peoples affected by the implementation of the management approach for used fuel. Implementation might explore the nature of Aboriginal Traditional Knowledge and its applications for both process- and substantive-related issues of concern related to long-term management of used nuclear fuel. Consideration could be given as to how best to build innovative approaches for effective dialogue within the Aboriginal community and between the Aboriginal and non-Aboriginal elements of Canadian society using the long-term management of used nuclear fuel as a focus. There may be interest in reviewing ways of maintaining desirable aspects of a traditional life style and traditional economy while also participating in a wage economy.
Siting Process	In generic terms, this activity will begin in the "Transition to Decision" phase above. However, with the government decision, activity will begin to gather momentum and, over time, will become increasingly specific in terms of geographic location. • There may be community debate or other potential effects about the acceptability of entering into a feasibility study or site selection process. Depending on the nature of this discussion, the outcome can range from a strengthening of community cohesiveness to a significant rupture of cohesion. • Effectively designed processes can lead to enhanced confidence building and capacity to participate through (1) continued development of community familiarity with issues through ongoing dialogue; (2) continued development of language capacity for Aboriginal peoples; (3) development of social, cultural, economic, environmental, and technical knowledge; (4) for the NWMO, a growth in capacity to include others in the dialogue, in particular Aboriginal peoples and Aboriginal Traditional Knowledge in deliberations. • Community Resources for Capacity-Building: The NWMO has a responsibility to work with the various communities to negotiate effective ways and means for communities to assume and discharge any responsibilities that arise related to the long-term management of used nuclear fuel. Any implementation plan would be developed collaboratively with communities.
Site Characterization and Design; Environmental Assessment Process **Total time approximately 10 to 20 years**	From this point onwards, a specific site has been chosen while the final transportation corridors may still be under discussion. • Once the site(s) has been chosen, a significant responsibility would accrue to the host community in terms of its capacity to engage as a host. • Enhanced confidence building and capacity to participate could be provided through (1) continued development of community familiarity with issues through ongoing dialogue; (2) continued development of language capacity for Aboriginal peoples; (3) development of social, cultural, economic, environmental, and technical knowledge; (4) for the NWMO, a growth in capacity to include others in the dialogue, in particular Aboriginal peoples and Aboriginal Traditional Knowledge in deliberations.

Table 14-5 (cont'd) Measures to Address Potential Socio-Economic Effects by Project Activity

Project Activity with order-of-magnitude estimates of time duration and employees on site	Potential Socio-Economic Effects and Measures Required
Site Characterization and Design; Environmental Assessment Process (cont'd) **Estimated workers on site variable. Generally, about 25, could peak for short duration several times that amount**	• Communities may require assistance in coping with the economic and social change introduced by the project. Assistance would be essential to enable communities to effectively participate in the planning process and realize employment and income opportunities. • The long process of designing, building and operating a used nuclear fuel management facility can serve as a bridge to the kind of future that is sought by a community, but only if the community is resourced and equipped to assume a lead role in the collaborative assessment of impacts and the collective decision-making required, while supported by the NWMO. Communities affected by any future facility must have opportunities for genuine involvement, which enables them to become active players and problem solvers. Their participation must be based on an understanding of potential risks and the means to manage them. • The community must define the processes and resources required to support its informed and engaged consideration of implementation issues. The community must assume a leadership role in providing the opportunities for citizens to receive information, share knowledge, ask questions and discuss the issue. We expect that the community will have many demands relating to: opportunities to shape the nature of issues investigated at the site; active roles for the community in monitoring the site investigation; transparency in the sharing of findings of research and site assessments; opportunities for critical independent reviews; and input into decisions taken. The NWMO must ensure that communities are informed and sufficiently resourced to be equipped to participate in discussions and decision-making, as well as the monitoring and reporting of community conditions, including any changes that result from our activities.
Construction **Total time: up to several decades** **Estimated workers on site will range from about 600 to 800 for Option 1: Deep Geological Disposal and Option 4: Adaptive Phased Management** **Fewer workers will be required for Option 2: Storage at Nuclear Reactor Sites and Option 3: Centralized Storage** **Numbers may peak at higher levels for durations of a few years**	All four management approaches would provide economic benefits in terms of the creation of new jobs, new income and new tax revenue to governments. Well executed implementation would enable these benefits to be aligned with the realization of social, cultural and economic aspirations and support the long-term stability of the affected communities. • Implementation plans designed with the host community could seek to enhance the benefits to be captured from project construction and operation. • Such discussions might address hiring practices, to ensure some employment opportunities for local residents; employment and training support, allowing local residents, including Aboriginal peoples, to develop the necessary skill bases. • Local businesses might be assisted to recognize and capture new economic development opportunities, in ways that might be sustained following the completion of the capital-intensive phases of the project.

Table 14-5 (cont'd) Measures to Address Potential Socio-Economic Effects by Project Activity

Project Activity with order-of-magnitude estimates of time duration and employees on site	Potential Socio-Economic Effects and Measures Required
Construction (cont'd)	All four management approaches would generate some negative consequences, which could range from worker population growth and decline, community disruption or nuisance effects. The construction phase will be marked by a significant influx of workers and a heightened level of activity. As a result, significant socio-economic effects can occur and their careful management is crucial. For Option 1(Deep Geological Disposal) and Option 4 (Adaptive Phased Management), there will be fluctuations in activity levels above a relatively high base level. Particular attention will have to be paid to these peaks. Each of the following examples can lead to a significant contribution in the evolution of the community, or difficulties, depending upon how they are managed. • The influx of non-local workers may disrupt community cultural, social, and health conditions; Aboriginal communities may be particularly at risk. There may be a requirement for additional social services during and after peak project development, to help address stress on families and local businesses as they cope with possible job and economic declines. Other social stresses on families may arise, such as increased crime. • The influx of higher wage-earning workers into the community may affect local wage profile. • The demand for skilled trades or wage levels may result in movement of local workers from one industry to another. • The flow of dollars into the local economy may cause a rise in the level of economic activity during the construction period followed by a difficult drop if not carefully planned and orchestrated. • Infrastructure development can lead to improvements of local infrastructure: transportation, communication, education, health, recreation; however, demand for such infrastructure may push local community to build facilities which may be difficult to support in the absence of the construction activity that led to their creation in the first place. • An increase in demand for supplies and services may over-tax community infrastructure if not properly prepared for: water, sewer, waste disposal, utilities, emergency response, community and regional administrative services, recreation facilities, etc. All management approaches have the potential for significant increased demand for infrastructure services, such as roads, recreation facilities, water and sewage management, schools, social services and healthcare, to accommodate the large influx of workers during periods of construction and fuel placement. Following the project completion, out-migration from the community may place stress on local businesses and the community may experience a loss in tax base which makes it difficult to sustain the expanded infrastructure. • Vehicular traffic may be problematic for community if not carefully managed: noise, dust, traffic and visual impacts. • There may be an escalation in property values as economic activity and employment builds up to service the construction and operation phases of implementation. Housing and land values may then decline significantly upon the project completion.

Table 14-5 (cont'd) Measures to Address Potential Socio-Economic Effects by Project Activity

Project Activity with order-of-magnitude estimates of time duration and employees on site	Potential Socio-Economic Effects and Measures Required
Construction (cont'd)	• There may be changes in community character, such as the loss of a rural town atmosphere, and changes in rural/remote wilderness. There are a number of actions that can be taken to avoid or minimize negative effects on the community, to lead to better community relationships and a higher level of acceptance of the project in the community. A number of short-term initiatives are available to support the large influx of workers and vehicles required, such as measures to facilitate commuting, provision of temporary accommodation, actions to limit residents' exposure to nuisance effects, and development of access routes to limit traffic disturbances. For example: • There may be a need for property value protection measures. • With any management approach, there must be a plan developed that identifies the potential socio-economic consequences of eventual decommissioning and closure of the facility, and the ways and means for addressing any associated negative effects. These and other social issues would need to be addressed early on in the project planning stage. Communities must be well equipped to cope and adapt to the social and economic changes that are associated with such large projects. It is necessary to plan early as to how the host community can participate in the positive impacts made possible by the project, as well as how they will manage the inevitable economic swings caused by the project cycles. There are many measures that might be developed collaboratively with the host community, to recognize the community contributions and help to offset any negative circumstances precipitated by the development and operation of the facilities. Examples of measures that might be collaboratively developed, to provide for meaningful input of the public and Aboriginal peoples include: • community agreements; • formal roles for the community in oversight of the project; • active roles for the public in the monitoring of environmental and socio-economic effects; and • active community roles in the information exchange, discussions and decision-making around siting and transportation issues. The application of such measures will be very specific to individual communities. The NWMO will need to build, with the community, comprehensive public engagement processes that are responsible, responsive and effective means for providing community input. To be effective, and to establish and maintain trust of the local citizens, measures must be developed in close consultation with the community early in the project.

Table 14-5 (cont'd) Measures to Address Potential Socio-Economic Effects by Project Activity

Project Activity with order-of-magnitude estimates of time duration and employees on site	Potential Socio-Economic Effects and Measures Required
Operation: fuel transportation and emplacement, ongoing research and development **Total time: about 30 years** **Estimated workers on site: about a hundred**	In theory, during this phase, socio-economic effects should stabilize for approximately 30 years. Operations-related activities can introduce changes to the socio-economic characteristics of an area such as: • Workforce/labour changes, as construction-related workforce and labour are replaced with stable operating workforce for fuel placement activities. • Changes to local/regional spending for payroll, materials, services. • Infrastructure maintenance, including access routes maintenance. • Off-site service requirements, including water, sewer, waste disposal, utilities, emergency response, administrative, etc. • Physical attributes (noise, dust, traffic, visual effects, etc.) With its stability, there is significant opportunity in this phase to contribute to the evolution of community culture in a way that is consistent with community values and priorities.
Operation: post fuel placement **Duration of this phase is indefinite** **Estimated workers on site about 30 for security, monitoring and reporting**	The high level of activities has gone to be replaced by low level of continuous monitoring, regardless of the management option chosen. • Socio-economic and cultural effects will be at a consistent, but low, level.
Closure and Postclosure with Monitoring **Duration of this phase is indefinite** **During closure, the number of people on site would rise to about several dozen. Later, a few workers would be required for monitoring as long as it was maintained.**	For Centralized Extended Storage (Option 3) and Storage at Nuclear Reactor Sites (Option 2), this phase will never arise. For Deep Geological Disposal (Option 1) and for Adaptive Phased Management (Option 4), if and when a decision is made to permanently close the facility, a relatively short period of construction would bring workers onto the site, followed by a low level of activity for as long as monitoring is maintained. • A short initial period of decommissioning activity will be followed by reduced activity levels.

The NWMO has an ongoing legislative obligation under the *Nuclear Fuel Waste Act* to analyze any significant socio-economic effects of activities on a community's way of life or its social, cultural or economic aspirations. The discussion in this chapter has considered the range of possible impacts that may arise, and has offered some illustrative examples of how those effects might be managed. A more definitive and detailed discussion of these issues will be possible following: the decision by the government on a management approach; the selection of a central site for implementation; and articulation of a transportation plan. The NWMO will work with potentially affected communities to discuss how potential impacts and risks might be assessed, tracked, and addressed through measures designed collaboratively by the NWMO and the affected communities.

For any management approach selected, the decision-making and implementation processes will involve at least many decades. As we proceed, it will be important that a management approach be implemented in a way that continues to be responsive to the values and objectives of citizens affected by the implementation and operation of the facility. The unprecedented nature of the time horizon brings with it a need for continuous learning, and a commitment of the NWMO working with communities to define and periodically assess indicators of progress as a means of adapting to evolving conditions. During this period, there will be an opportunity to adjust the pathway as may be appropriate with the benefit of new information, continuous learning, monitoring of research and technological developments and discussion of timelines most appropriate for communities affected by the transition to long-term management.

Chapter 15 / Research and Intellectual Capacity

Although the *NFWA* does not require that the NWMO include research as part of the implementation plans, we address the issue in light of the significance that research and intellectual capacity have for the continuous learning and adaptability that are integral to implementation plans.

15.1 / The Important Role of Research

Regardless of the approach taken, activities to manage used nuclear reactor fuel would continue for a very long time. Any management program would be expected to apply the best practices available at that time. There is confidence in present best practices for safely handling used nuclear fuel and that such fuel can be properly managed into the future. However, a program that would evolve over a long period of time would have many opportunities for improvements to increase performance, enhance effectiveness, improve understanding, and address arising societal concerns. To realize these benefits, there needs to be a vibrant and robust research and development effort during management program development and execution, a period that would last many generations.

While the role for research and issues of intellectual capacity were not explicitly required as part of our study under the *NFWA*, we believe that there are many important reasons to pursue such a research and development program. Consequently, NWMO is responsible for ensuring that the research program is funded. The program's scope and content would be guided by:

The intrinsic need to embody the principles of continuous learning – The program for the management of used nuclear fuel would evolve over generations. Continuous learning would not just allow, but demand research and development to help assure focus on areas that warrant attention. Continuous learning also sets a standard for everyone associated with the program that excellence and integrity are the expected hallmarks. Program requirements are set not at minimally acceptable performance and regulatory compliance, but at meeting societal expectations to continually improve upon best practices and adapt to unfolding advances in related fields as the program progresses.

Increased understanding and capabilities that would surely come from research and development can measurably improve performance, reduce uncertainties and address residual concerns. Over time, it is easy to imagine, for example, major advances in geological understanding and predictions, together with improved man-made materials, engineered barrier system designs to isolate the waste, facility and transportation designs, and instrumentation to measure and confirm performance. Similarly, Canadian values and priorities may change, and the ability to adapt to changes would be necessary to maintain citizen confidence.

Preparation for facility siting, design, licensing, development, and operations – The long term management program would evolve through a number of important stages: developing a concept, identifying candidate sites, building relationships with affected communities and organizations, evaluating candidates for adequacy, finalizing designs, obtaining necessary licenses, building the necessary facilities and infrastructure, operating the system, eventually preparing for closure or steady state maintenance, and confirming post operational performance. These stages would occur over many decades. There would be many opportunities to improve system design, minimize costs, enhance schedules, reduce uncertainties, and assure regulatory and societal requirements.

Assurance of adequate human capacity to manage the program throughout its existence – The extended time-frame of any management program would present the challenge of sustaining an expert workforce to manage and operate the program. A healthy, properly sized, and focused research and development program would assure the continual refreshment of the qualified, trained staff required for effective program management. Exciting and cutting edge work attracts the best while assuring integration of program operations with advances in scientific and technological capabilities.

Enhanced scientific understanding to improve confidence in predictions, reduce uncertainties, and to evaluate potential program improvements – It is to be expected that research and development conducted over the course of the management program could be applied to markedly improve understanding and narrow the remaining uncertainties about anticipated performance over long periods of time. Program managers would be able to use this improved understanding to modify program elements where warranted, to improve expected performance and reduce unnecessary program schedule delays and costs. Of course, it is always possible that improved understanding may open up new questions about system performance, which would call for new avenues of research and development to address the new information.

The ability to confirm performance during and after program operations – Thorough confirmation of performance during development and initial operations and after the operational stage is complete are important steps. These confirmations serve to increase confidence in performance, meet regulatory compliance standards, identify any anomalies, and provide further assurance to the public and stakeholders that the implementers and regulators take their long term stewardship responsibilities seriously. Research and development programs would enhance capabilities to confirm performance through continual improvements, for example, in instrumentation, data acquisition techniques and methods, analytical and modeling capabilities, and computer simulations. Such improvements would be particularly valuable in a staged program.

The obligation to citizens to clearly demonstrate an ongoing capability to manage the enterprise and to respond to their concerns and desires – The management program for spent nuclear fuel is challenging both because of its long duration and because of the intense and widely varying views of the public and effected stakeholders. Citizens and their representatives want to be confident that responsible organizations would maintain the necessary capabilities to oversee and manage program development and implementation. A vibrant and well directed research and development program would help assure the staffing of a cadre of trained and experienced personnel focused on solving anticipated and emerging issues associated with the program throughout its duration.

The ability to enact mid-course corrections in response to new information or societal decisions – Because the management program would last for generations, it is possible, if not probable, that new scientific and technical information and capabilities, and perhaps changes in societal perspectives and desires, would lead to proposals for beneficial changes in program plans and implementation. In this regard, the research and development program would serve two important purposes. It would create the new information and capabilities that could serve as the rationale for subsequent decision making. It would also maintain the expertise and resource base to implement desirable changes.

There are many areas where new information and capabilities may lead to improvements in program implementation or modification of program goals. Some include the continuing development of advanced nuclear power plants, new fuel cycle processes and facilities; potential international or regional institutional changes to allow for multinational ownership or control of sensitive facilities; changes in international policies and treaties; and new developments in partitioning and transmutation of used nuclear fuel and in deep borehole management techniques.

The ability to adapt new capabilities developed external to the program that show the promise of improving program success – Over time, there would be marked changes in many areas of scientific, technical, and social science germane to the management program. One would expect significant advances in geosciences and biosciences and the development of new materials, improvements in computer codes and the modeling of natural and engineered systems, better instrumentation capabilities, new social science insights, and much more. Many of these advances would occur largely outside the program itself, but offer major potential benefits if adapted into the program. The research and development program would allow for identification and adaptation of such advances into the program as warranted.

The ethical obligation to undertake research on social impacts – The extended time-frame of any management program means that the period of potential social impacts itself is very long, longer than virtually any other program undertaken. For this reason, there is an ethical obligation to monitor impacts. It is important to have ongoing research on the ethical adequacy and social impact of the facility in order to be able to fully identify these impacts and appropriate responses.

15.2 / Research Requirements Common to all Management Approaches

Social and Technical Research Requirements

In the sections that follow, we provide examples of some of the areas of research that would be appropriate under any of the four management approaches.

As part of the implementation process, we would identify specific areas requiring study through ongoing engagement. Beyond the required technical expertise, additional research and development should be conducted on a range of non-technical issues of importance, including socio-economics, stakeholder involvement, and public attitudes. It would be important to involve external parties in identifying research of relevance and interest. Research funding should most often be competitively determined and the work carefully peer reviewed. Some topics that may require research include:

- Applying Aboriginal Traditional Knowledge – applies to both process issues (starting immediately) and substantive issues (when the site or sites are identified for more detailed assessment);
- Dispute management over the long term;
- Adaptive management as it relates to ongoing social and technical decision-making;
- How to monitor and assess community well-being;
- How to work with a community to ensure that cultural integrity is maintained in a way that works for the community;
- How to smooth out the economic boom and bust cycle in the adjacent region/community; what mechanisms can be created to address this in concrete terms; and
- Canada produces power using CANDU reactors which use different fuels than the more predominant Light Water Reactors used elsewhere in the world. Since the wastes residing within the used fuel represent the "source term" of radioactivity, it is important to have an indigenous program to identify issues of particular importance to Canada and assure that these are carefully addressed.

The scope of our program should be determined in conjunction with early bilateral and international program contacts to build upon the existing data and capabilities in other countries and international organizations. Formal working relations should be established as appropriate with waste management programs in other countries on problems of mutual interest. International collaboration has been a hallmark of radioactive waste management programs. Much of the work can be done collaboratively and information sharing and personnel exchanges can benefit all parties.

International exchanges of research findings make it possible for countries to allocate resources efficiently, sharing information on a wide range of technical considerations.

Human Resource Capacity

To ensure the safe management of used nuclear fuel, we must have access to a sufficient and sustainable number of trained and skilled personnel throughout the development and implementation of a radioactive waste management approach.

It can take a generation to build up appropriate expertise related to long-term used fuel management, but it can be lost very quickly. It would be important for us to canvass Canadian experience and capabilities and initiate a program to preserve knowledge already gained, and to organize a program with existing expertise, focused on issues of particular relevance to the programmatic choice coming out of the NWMO's November 2005 recommendations and subsequent government decisions.

The program should encourage the broad involvement of the Canadian academic community, with an emphasis on involving the next generation of leaders in research and development, graduate students, doctoral graduates, and young faculty.

We will require expertise and capabilities in a range of fields, including, but not limited to: socio-economics; ethics, finance, public engagement, Aboriginal Traditional Knowledge, siting and waste management technology. We must ensure that there is an adequate number of qualified personnel with ethical and socio-economic expertise to evaluate and conduct socio-economic impact assessments, manage community agreement negotiations and identify key ethical issues that may impact future generations. There must also be specialists qualified to manage the financial aspects associated with such a project. Furthermore, we would require trained personnel to develop and implement a comprehensive public engagement plan particularly during the initial siting phase, post government decision on the selected way forward for Canada. These specialists would also be required to ensure that the public's concerns are taken into account throughout the implementation process.

Depending on the management approach selected, many scientific disciplines would be required for implementation, among them earth sciences such as geology, hydrology, geochemistry, seismology, geomechanics and biosciences, as well as climatology, materials development and performance, and corrosion. Implementation may require program capabilities that merge earth sciences with engineering. A combination of experiments, analysis, modeling, simulation and computation are required for system design and even more so for performance assessments that would be the basis of licensing. Careful and sustained programs would have to be nurtured to develop this interdisciplinary need.

Areas of required technical capabilities and expertise include, but are not limited to: project management; risk, cost and benefit analysis; logistical studies; technology evaluations; institutional requirement analysis; code verification and validation; information research; quality assurance; environmental impact assessment; ecological sciences; and transportation equipment design, safety analysis and engineering design.

Expertise unique to used nuclear fuel management include: fuel waste characterization; waste-form behaviour; radiation shielding; radiological safety assessment; occupational radiation exposure management; material sciences and waste package design; and decontamination methods development and management. Many of these disciplines are specialized, so these skills may not be transferred over from other industries.

It is anticipated that the NWMO would not need to have this range of expertise fully covered with its in-house staff complement. Opportunities exist to contract for external support in many of these areas.

Monitoring of Research Internationally

Chapter 6 addressed the significant expenditures which have been made in Canada studying the long-term management of used nuclear fuel. In addition to commissioning its own research, the NWMO would benefit from monitoring findings of research activities under way in Canada and in other countries.

Over 30 countries have radioactive waste management programs and several (United States, Finland and Sweden) are close to implementing repositories for used nuclear fuel or high level radioactive waste (HLW). The level of funding for research and development activities varies from country to country. The Swedish (SKB) annual used fuel research and development budget is approximately $10 million while the United States (DOE) annual budget at Yucca Mountain is over $500 million ($US).

There are large international research programs such as the European Commission Sixth Framework Programme 2002 – 2006, with a radioactive waste management budget of 90 million Euros over the five-year period. Research areas under this program cover improvements of fundamental knowledge, development and testing of geological repository technologies, study of natural analogues and new and improved tools to model the performance and safety of geological repositories. There is also further work addressing partitioning and transmutation technology as well as concepts to produce less waste. France is particularly active in advancing the research and development program for partitioning and transmutation of used nuclear fuel wastes.

International research activities also include initiatives such as the Nuclear Energy Agency's Forum for Stakeholder Confidence, which enables a sharing of international experiences in planning and implementing engagement programs for long-term management approaches. The CARL project, an international social science research project, is investigating the effects of stakeholder involvement on decision-making in radioactive waste management.

The NWMO should keep a "watching brief" on a number of approaches and technical (and non-technical) developments in Canada and in other countries which, if successful, might lead to eventual improvement or modification of the Canadian program.

These may include, but are not limited to:

- Other waste management technologies such as reprocessing, partitioning and transmutation;
- Deep borehole disposal;
- International/regional initiatives regarding the fuel cycle, including used fuel storage and further disposition;
- Reprocessing and associated waste management;
- Engineered materials and barrier development;
- New instrumentation, particularly for performance confirmation;
- Modeling, simulation, and analytical techniques to evaluate long-term performance;
- Developments regarding evolving models for citizen engagement in decision-making; and
- Developments regarding social impact assessments.

15.3 / Research Specific to Individual Management Approaches

Canadians have said that regardless of the management approach eventually chosen by the federal government, there must be adequate resources dedicated to an ongoing research program associated with the long-term management of Canada's nuclear fuel waste. These resources should be allocated to keep Canadians abreast of new developments in radioactive waste management, both within Canada and internationally, to ensure that new knowledge and new developments can be incorporated into the solution for Canada's used nuclear fuel.

In the sections that follow, we provide examples of some areas of research that would be appropriate under different management approaches.

Option 1: Deep Geological Disposal in the Canadian Shield

Deep Geological Disposal involves transportation of the used fuel from each of the nuclear facilities currently in Manitoba, Ontario, Québec and New Brunswick to a central deep geological repository for permanent isolation of used nuclear fuel in Canada. Following a federal government decision to proceed with Deep Geological Disposal, it is expected that it would take about 30 years to site a geological repository and obtain an operating licence. This initial 30-year period would involve key decisions including selection of used fuel container and sealing system design, selection of host rock formation and selection of the preferred site for a geological repository and the transportation system to the central facility.

Research and development activities for Option 1 would be required to identify, characterize, engineer, analyze, study, demonstrate and select the appropriate repository technology and final site during the siting and design and construction phase. This research and development would include development of site screening criteria and the site selection process, technical and social site characterization, biosphere and geosphere evaluation, computer model development, repository engineering and safety assessment activities to support feasibility studies in potential host communities, and the selection of a final engineering design and preferred site to support the safety and environmental impact assessment documents and related licensing activities. It would include further study, modelling and analyses of the potential impacts of climate change (e.g., global warming and glaciation) and other natural events such as earthquakes, which have already been factored into the design of the deep repository and surface facilities. It would also include development of used fuel monitoring activities at repository depth, demonstration of used fuel container placement and retrieval technology at underground research facilities, vault sealing system development, security development work and further development of transportation technology, logistics and implementation schedule.

The research and development program follows the step-wise implementation of the deep repository concept with specific information designed to support the decision-making process. Examples of key decisions during the staged approach to implementation of Option 1 which would be supported by the research and development program include:

- Selection of design alternative (e.g., in-floor, in-room or long horizontal borehole placement of used fuel containers);
- Identification of the site selection process and site screening criteria;
- Selection of candidate sites for the repository from preliminary feasibility studies;
- Selection of the preferred host rock and depth for a repository;
- Selection of the preferred site for the repository;
- Decision to proceed with development of the underground characterization facility at the preferred site;
- Selection of the optimal transportation technology, route and logistics (timing);
- Identification of the repository monitoring system during used fuel container placement operations;
- Identification of the repository monitoring system after used fuel container placement operations;
- Identification of design improvements for the approach during implementation and re-licensing of the facility;
- Review of design from a safeguards perspective;
- Identification of the time period for extended monitoring of the repository (after container placement operations are complete); and
- Decision to decommission and close the facility.

The social and technical research and development program during the Siting and Design and Construction phase for Deep Geological Disposal would be between $10 million and $20 million per year. It is expected that the Canadian research and development program would continue its international collaboration and joint research and development program activities with other waste management organizations such as Posiva, SKB, and Nagra and seek opportunities to collaborate with other waste management organizations, as appropriate.

Option 2: Storage at Nuclear Reactor Sites

Storage at Nuclear Reactor Sites involves perpetual storage of used nuclear fuel at each of the nuclear facilities currently in Manitoba, Ontario, Québec and New Brunswick. Following a federal government decision to proceed with Storage at Nuclear Reactor Sites, it is expected that it would take three years to review the storage design alternatives and up to an additional seven years to obtain operating licences for the facilities, depending on the choice of storage technologies. This initial 10-year period is crucial for the identification, analysis and selection of the preferred storage alternative at each reactor site in Canada.

During the Siting and Design and Construction phase, research and development would be required to site, characterize, engineer, analyze, study and select the appropriate storage technology for each site. Used fuel storage technology has been developed in several countries and these technologies would be further reviewed to assess their feasibility in Canada. This research and development would support the safety assessment and environmental impact assessment documents and related licensing activities. It would include further study, modelling and analyses of the potential impacts of climate change (e.g., global warming) and other natural events such as earthquakes (which have already been factored into the design of the storage facilities). It would also include development of used fuel monitoring activities, long-term used fuel integrity studies and security development work.

The research and development program follows the step-wise implementation of the Storage at Nuclear Reactor Sites concept with specific information designed to support the decision-making process. Examples of key decisions during the staged approach to implementation of Storage at Nuclear Reactor Sites that would be supported by the research program include:

- Selection of reactor site storage design alternatives (e.g., existing or new technology);
- Identification of the optimum monitoring system period for used fuel examinations;
- Identification of design improvements for reactor site storage during implementation and re-licensing of the facilities; and
- Review of design from a safeguards perspective social and technical.

The research program during the Siting and Design and Construction phase for Storage at Nuclear Reactor Sites would be several million dollars for each site in Canada.

Option 3: Centralized Extended Storage

Centralized Storage, either above or below ground, involves transportation of the used fuel from each of the nuclear facilities currently in Manitoba, Ontario, Québec and New Brunswick to a central facility in Canada for perpetual storage of used nuclear fuel. Following a federal government decision to proceed with Centralized Storage, it is expected that it would take about 15 years to site a central facility and obtain an operating licence. This initial 15-year period would involve key decisions with respect to selection of used fuel storage design, location and transportation system to the central facility.

As with the Storage at Nuclear Reactor Sites, research and development would be required to identify, characterize, engineer, analyze, study and select the appropriate storage technology and final site during the Siting and Design and Construction phase. This research would address the engineering and safety assessment activities conducted to support the feasibility studies in potential host communities, development of site screening criteria and the site selection process, technical and social site characterization, selection of a final design and central site to support the safety and environmental impact assessment documents and related licensing activities. It would include further study, modelling and analyses of the potential impacts of climate change (e.g., global warming) and other natural events such as earthquakes (which have already been factored into the design of the storage facilities). It would also include development of used fuel monitoring activities, long-term used fuel integrity studies, security development work and further development of transportation technology, logistics and implementation schedule.

The research program follows the step-wise implementation of the Centralized Storage concept with specific information designed to support the decision-making process. Examples of key decisions during the staged approach for implementation of Centralized Storage which would be supported by the research program include:

- Selection of centralized storage design alternative (e.g., above or below ground);
- Identification of the site selection process and site screening criteria;
- Selection of candidate sites for centralized storage from preliminary feasibility studies;
- Selection of the preferred host rock, depth (if below ground) and site for centralized storage;
- Selection of the optimal transportation technology, route and logistics (timing);
- Identification of the optimum monitoring system period for used fuel examinations;
- Identification of design improvements for centralized storage during implementation and re-licensing of the facility; and
- Review of design from a safeguards perspective.

The social and technical research and development program during the Siting and Design and Construction phase for centralized storage would be about $5 million per year.

Option 4: Adaptive Phased Management

Option 4: Adaptive Phased Management involves transportation of the used fuel from each of the nuclear facilities currently in Manitoba, Ontario, Québec and New Brunswick to a central facility for an optional interim storage period, followed by used fuel placement in a deep geological repository for long-term isolation. Following a federal government decision to proceed with Adaptive Phased Management, it is expected that it would take about 30 years to site a central facility in suitable geomedia such as the Canadian Shield or in the Ordovician sedimentary rock basins and obtain an operating licence. This initial 30-year period would involve key decisions with respect to selection of used fuel container and sealing system design, selection of host rock formation and selection of the final site for a geological repository and transportation system to the central facility.

The research to date on sedimentary rock provides several independent geoscientific arguments suggesting that Ordovician shales and limestones might provide a highly suitable environment to host a deep geological repository for used nuclear fuel. However, more research and development work on sedimentary rock needs to be completed to determine the suitability of these rock formations.

The siting period would also continue the necessary research and development of the technology for used fuel storage, transportation and isolation. For example, containers and handling systems for extended storage of used nuclear fuel in shallow underground rock caverns may need a design update. Transportation systems for used fuel would need further development, testing and demonstration. And the mode of transportation: road, mostly rail or mostly water, may need further optimization to meet the needs of potential host communities for the central facility.

Research and development activities for a deep geological repository would be required to identify, characterize, engineer, analyze, study, demonstrate and select the appropriate isolation technology and final site during the siting phase. This research and development would address development of site screening criteria and the site selection process, technical and social site characterization, biosphere and geosphere evaluation, computer model development, repository engineering and safety assessment activities conducted to support the feasibility studies in potential host communities, and the selection of a final engineering design and preferred site to support the safety and environmental impact assessment documents and related licensing activities. It would include further study, modelling and analyses of the potential impacts of climate change (e.g., global warming and glaciation) and other natural events such as earthquakes, which have already been factored into the design of the deep repository, the optional shallow underground storage facility and surface facilities. It would also include development of used fuel monitoring activities at repository depth, demonstration of used fuel container placement and retrieval technology at international underground research laboratories, vault sealing system development, security development work and further development of transportation technology, logistics and implementation schedule.

Initially, the research and development would take place at surface laboratories and at international underground research laboratories at generic sites such as the Äspö Hard Rock Laboratory in Sweden. (Canada currently is participating in international research projects at Äspö). Later, the research and development would take place at the underground characterization facility at the preferred site in Canada.

The research and development program follows the step-wise implementation of the Adaptive Phased Management approach with specific information designed to support the decision-making process. Examples of key technical decisions for long-term isolation of used fuel which would be supported by the research and development program include:

- Identification of potentially suitable rock formations at candidate sites for a deep geological repository (e.g., crystalline rock, sedimentary rock);
- Identification of the site selection process and site screening criteria;
- Selection of candidate sites for a deep geological repository from preliminary feasibility studies;
- Selection of the preferred host rock and depth for the deep geological repository;
- Selection of the preferred site for the underground characterization facility and the deep geological repository;
- Selection of a long-term isolation design alternative (e.g., in-floor, in-room or long horizontal borehole placement of used fuel containers);
- Selection of the optimal transportation technology, route and logistics (timing);
- Identification of the repository monitoring system during used fuel container placement operations;
- Identification of the repository monitoring system after used fuel container placement operations;
- Identification of design improvements for a deep geological repository;
- Review of design from a safeguards perspective;
- Identification of the time period for extended monitoring of the deep geological repository (after container placement operations are complete) and any impacts on the integrity of the used fuel containers within the placement rooms; and
- Support for a decision to decommission and close the facility.

The cost estimates for the social and technical research and development program for Adaptive Phased Management provide between $10 million and $20 million per year during Phase 1 and about $30 million per year at the underground characterization facility during Phase 2. It is expected that the Canadian research and development program would continue its international collaboration and joint research program activities with other waste management organizations such as Posiva, SKB and Nagra and seek opportunities to collaborate with other waste management organizations, as appropriate.

Continuous learning through research and development and monitoring of emerging knowledge will be paramount to informed decision-making in implementing a long-term management approach for used nuclear fuel.

Each phase of implementation will require consideration of choices and decisions, with each step informed by the latest understanding of science, engineering, social sciences and the natural sciences. Research will be important in guiding decisions on technology for used fuel management, the detailed site investigations and in monitoring developments internationally in areas that may have relevance in confirming or proposing adjustments to the implementation path.

The NWMO believes that ongoing research and development should be a component of our annual business plans. Our research and development program should be reflected in the five-year strategic plans that are submitted to the Minister of Natural Resources Canada in the triennial reports. We should report regularly to the public on its key areas of investigation and how findings have impacted on decisions along the way.

The extent to which the NWMO monitors, considers and reflects emerging knowledge into its plans for managing used nuclear fuel would be essential to building confidence of the public.

We could be assisted by independent third party guidance on matters of such public interest, to confirm the areas of proposed research and our application of key research findings drawn nationally and internationally.

Chapter 16 / Description of Activities and Timetables

As required by the *Nuclear Fuel Waste Act* (*NFWA*), a description of activities and possible timetables are presented in this chapter.

It is important to note that the timetables are put forward as possible and typical implementation schedules only. They provide an indication of a representative schedule for implementation of each approach under study. They illustrate the time required to proceed through the various stages of siting, regulatory approvals and construction. Implementation schedules were based in part on siting experiences in other countries such as Finland and Sweden. The timelines form the basis of the cost estimates prepared for each management approach. They have not been optimized nor do they necessarily reflect the most appropriate schedules when technical and social considerations are taken into account. The actual timelines would need to be defined following a decision on a management approach by the federal government.

It is important to note that the regulatory regime would require licences to be obtained throughout various stages in the lifecycle of a waste management facility including site preparation, construction, operation, modification and decommissioning. Safeguarding used nuclear fuel is part of Canada's international obligations to the International Atomic Energy Agency under Canada's Safeguard's Agreement. Technical specifications and procedures for nuclear materials safeguards have been explicitly included in the conceptual designs for the waste management facilities and transportation systems. Safeguard measures include the use of seals, surveillance and nuclear material accountancy throughout all phases of implementation. As well, development of emergency response plans would need to be included and these would have to be submitted and approved. Canadian standards and regulations will continue to evolve taking into account requirements for international safeguards.

16.1 / Option 1: Deep Geological Disposal in the Canadian Shield

This section presents an estimated timetable for the implementation activities anticipated to site, design, construct, operate, monitor, decommission and close a deep geological repository for the placement of used fuel. The schedule and assumptions are based on the conceptual design and cost estimating reports prepared by consultants for the Joint Waste Owners. (See conceptual design reports at www.nwmo.ca/conceptualdesigns).

The deep geological repository program is often divided into two distinct periods: the preclosure period and the postclosure period. The preclosure period, which could last about 150 years, includes all activities from siting through to decommissioning and closure of all facilities related to the repository. After the

Figure 16-1 **Overall Work Schedule for Deep Geological Disposal in the Canadian Shield**

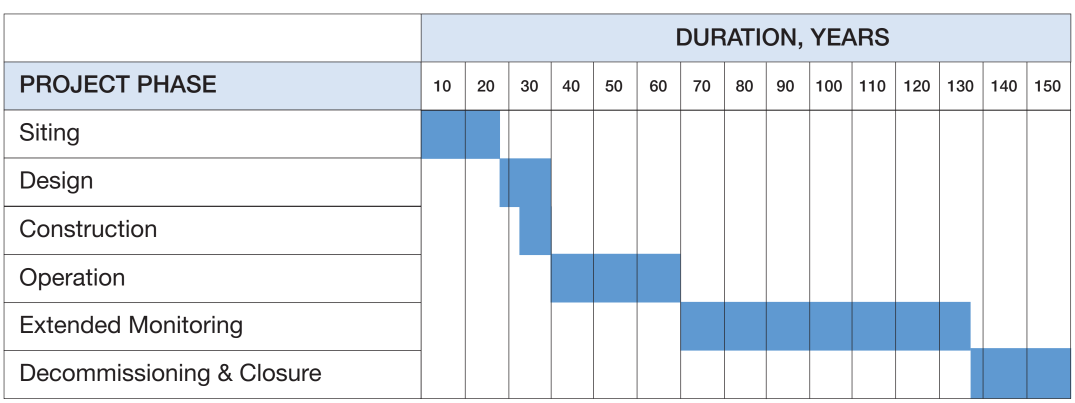


Figure 16-2 Activity Flowchart for Deep Geological Disposal in the Canadian Shield

Stage	Activity
Siting	Government Decision to proceed with Deep Geological Disposal in the Canadian Shield
	Develop an **Engagement Program** collaboratively with potential site, transportation route, aboriginal and non-aboriginal communities; incorporate insights from all NWMO work.
	Implement the **Engagement Program**, initiating the **Siting Process** to select preferred site (stakeholder consultations, feasibility studies, site characterization); **Design and Safety Assessment** activities in parallel.
	Conduct further site characterization and prepare **design** for underground characterization facility and **preliminary design** of deep geological repository.
	Perform an **Environmental Assessment** for the preferred site (including public engagement and safety analysis); obtain a **Site Preparation Licence** and a **Construction Licence** for the underground characterization facility, the deep geological repository and ancillary facilities; obtain Licence to Construct the underground characterization facility.
Design & Construction	**Construction and Commissioning** of the underground characterization facility.
	Begin site-specific Research & Development to confirm suitability of site.
	Collect data from underground characterization facility, conduct research to support design and operating licence for deep geological repository.
	Construct and Commission deep geological repository and ancillary facilities and obtain **Operating Licence** for deep geological repository and ancillary facilities.
Operation	Obtain **licence** to transport used fuel.
	Transport used fuel to site, **repackage** and **place** used fuel in deep geological repository.
Extended Monitoring	**Extended in-situ monitoring** from access tunnels.
Decommis-sioning & Closure	Obtain **Licence to Decommission** - and **close and decommission** deep geological repository.
	Close access tunnels and shafts, dismantle borehole monitoring.

extended monitoring period, it is assumed that the deep repository would be backfilled, sealed and the site closed, and that regulatory approval would be sought and obtained to "abandon" the site. The overall work schedule and activity flowcharts for Deep Geological Disposal in the Canadian Shield are presented in Figures 16-1 and 16-2, and described in detail below.

Siting Phase

The siting phase covers the time period in which a suitable location for a central deep geological repository in the Canadian Shield is being sought. It begins after a formal decision is made to start the process of finding a suitable site and would end when regulatory approval is received to construct the facility at the preferred site (estimated to be about 15 to 20 years).

During the siting phase, the current owners of used fuel would continue to be responsible for its interim management at the reactor sites. The NWMO would assume management responsibility of the used fuel when it is transported from the reactor sites to the central facility for long-term management.

The siting phase would involve developing a siting process that would include both public consultation and technical assessments on the basis of site characteristics. The acceptability of a site would be determined on the outcome of this siting process. The major components of the siting process would include initial public engagement, discussions and hearings, development and application of site screening criteria, an environmental assessment and the preparation of licence applications. Each of these major components necessarily includes both public involvement/participation and technical assessment and analysis.

The outcome of these public engagement activities would be coupled with the initial site characterization and screening to select a preferred site. Site characterization activities during the siting phase would involve an iterative process of investigation beginning with non-invasive surface-based feasibility studies at perhaps three candidate areas followed by more detailed surface and underground characterization via borehole drilling at select candidate sites and the final preferred site. These activities would provide an understanding of site-specific geosphere and biosphere conditions necessary to assess and communicate possible site suitability to host a deep geological repository.

During the siting phase, a preliminary conceptual deep geological repository design would be prepared for each site being evaluated. Design work would be completed for the surface and underground facilities primarily to establish the access, utility and infrastructure requirements. The design would include technical specifications for safeguarding the nuclear materials at the facility and during transportation. These requirements would be assessed during initial site screening to ensure that they could be met at potentially suitable site locations in the areas selected for detailed evaluation. Details of the environmental and deep geological repository monitoring program and the plan to incorporate this program into subsequent site evaluation activities would be developed. Following the selection of a preferred site, a preliminary deep geological repository design specific for the site would be completed prior to entering into the environmental assessment process and the licensing process.

Once an application for site preparation is made, or intent to apply is given, an environmental assessment would be required. The NWMO would be required to demonstrate, during the environmental assessment process, that there would be no significant adverse impact on the environment resulting from the construction, operation, decommissioning and closure of the deep geological repository (and during the postclosure period). The environmental assessment will require preparation of environmental assessment guidelines, site evaluations, a comprehensive survey to measure and record the current background conditions at the proposed site, a preliminary safety assessment, and environmental assessment technical studies and report.

The end point of the siting phase would be the receipt of a site preparation licence and a construction licence, the latter giving regulatory approval to begin construction of the deep geological repository facility on the preferred site. It is anticipated that the construction licence would be a staged licence, where the first stage is the construction of the underground characterization facility. Further construction activities would depend on acceptable results obtained from the site evaluation provided through operation of the underground characterization facility.

Design and Construction Phase

The construction phase (about 10 to 15 years) begins with the receipt of regulatory approval to begin construction and ends when commissioning of the facilities is completed prior to receiving the first formal shipment of used fuel for placement. It involves constructing the infrastructure and surface facilities needed to receive used fuel, the underground access ways and service areas, and a portion of the underground rooms for used fuel.

It is anticipated that the construction licence may be provided as a staged licence, initially providing approval for the construction of the underground characterization facility, and identifying specific requirements to be met prior to the start of full-scale construction of the facilities. A period of underground data gathering and evaluation in the underground characterization facility would be used to improve the definition of the geotechnical parameters and confirm suitability of the site, provide the basis for the detailed design of the deep geological repository, and validate licensing assumptions.

When the licence requirements have been met and the approval of the regulator obtained, construction of the full-scale deep geological repository facility and its ancillary facilities can begin. Provision is made in the design for concurrent excavation during the operations phase to provide further rooms in the repository at the required time.

Operation and Extended Monitoring Phase

The operation and monitoring phase (about 100 years) begins with regulatory approval to receive shipments of used fuel for placement under a licence to operate and ends with approval to begin decommissioning activities. This phase includes a 30-year period during which used fuel is placed into the deep geological repository rooms followed by a period of extended monitoring which is assumed to last up to 70 years. This phase ends when approval is given to initiate decommissioning of the deep geological repository facilities.

The application for an operating licence would include a final safety analysis report, consistent with the actual design built and in support of the conclusions of the environmental assessment report submitted. Also, the results of the commissioning program would be required prior to granting approval to operate. The licence would specify requirements, particularly in regard to health and safety and monitoring and the onus would be on the licensee to prove compliance. The licence may need to be renewed periodically as specified by the regulator.

The operation phase would involve receiving used fuel transported to the deep geological repository facility, sealing it in corrosion resistant used fuel containers, placing and sealing the used fuel containers in repository rooms, and constructing and preparing additional repository rooms. After the last used fuel container has been placed in the deep geological repository there would be an extended period of monitoring and assessing the conditions in the vicinity of the deep geological repository. The extended monitoring program makes use of the shafts and underground access tunnels while they are still available prior to deep geological repository sealing in the decommissioning phase. Extended monitoring activities would include environmental monitoring, monitoring used fuel container performance and monitoring rock mass behaviour. The monitoring data would be used to confirm the long-term safety assessment of the sealed deep geological repository and provide the basis for decommissioning and closure of the facility.

Decommissioning Phase

The decommissioning phase is the period (about 10 years) in the life cycle of the deep geological repository during which the surface facilities are decontaminated, dismantled and removed. The beginning of this phase is marked by regulatory approval of a licence to decommission. The underground facilities are decontaminated (if necessary) and dismantled, with tunnels and shafts backfilled and sealed. At the end of the decommissioning stage the site would be in a state suitable to allow public use of the surface. However, public access to certain areas would likely be restricted by maintenance of fencing securing ongoing monitoring activities.

Closure Phase

Closure activities (about 15 years) include dismantling the borehole monitoring instruments and sealing of the characterization and monitoring boreholes that are surface based and which may compromise the integrity of the deep geological repository system over the long term. The remaining surface facilities serving these ongoing monitoring activities would be removed together with all security measures, thereby fulfilling the objective to return the site to green field conditions. Final removal of all institutional control of the facility would require regulatory approval and the issuance of a licence to abandon the facility.

16.2 / Option 2: Storage at Nuclear Reactor Sites

This section presents an estimated timetable and a general description of the implementation activities anticipated for the long-term storage of used fuel at the reactor sites. (Currently, used fuel is being managed in interim storage facilities at the reactor sites). There are a variety of viable technical alternatives that could be followed at each of the sites requiring different maintenance considerations. Furthermore, different technical methods are currently used at the various sites; each could form the basis for a long-term storage plan.

This section does not attempt to provide a comparison of the technical alternatives, but rather identifies the phases of activity that would be required regardless of the method, or methods, selected. Figures 16-3 and 16-4 present the overall work schedule and activity flowchart for Storage at Nuclear Reactor Sites. Note that the estimated number of years per phase is not as clear cut as it may be for the other options that have central long-term management of used fuel at a single site because of the number of reactor sites and the different expected duration of phases for each reactor site.

The typical schedule and the following description of activities are based on information in the conceptual design and cost estimating reports prepared by consultants for the Joint Waste Owners. (See conceptual design reports at **www.nwmo.ca/conceptualdesigns**).

Figure 16-3 Overall Work Schedule for Storage at Nuclear Reactor Sites

	DURATION, YEARS														
PROJECT PHASE	10	20	30	40	50	60	70	80	90	100	150	200	250	300	350
Initial Licensing	■														
Design & Construction		■													
Operations: Initial Fuel Receipts		■	■	■	■										
Operations: Extended Monitoring						■	■	■	■	■	■	■	■	■	■
Operations: Building Refurbishment & Used Fuel Repackaging											■		■		■

Note: Extended Monitoring and Building Refurbishment/Used Fuel Repackaging activities continue in perpetuity, based on a 300-year cycle.

Figure 16-4 **Activity Flowchart for Storage at Nuclear Reactor Sites**

Phase	Activity
Initial Licensing	Government Decision to proceed with Storage at Nuclear Reactor Sites
	Develop an **Engagement Program** collaboratively with site, aboriginal and non-aboriginal communities; incorporate insights from all NWMO work.
	Implement the Engagement Process. Initiate the **Licensing Process** to determine the technical option and specific storage locations to be used at each site. **Prepare Letters of Intent** to the CNSC to prepare the sites and to constructing new storage facilities.
	Perform an **Environmental Assessment** for the preferred site (including public engagement and safety analysis); obtain a **Licence to Prepare Site** for the activities proposed.
	Obtain **Licence to Construct** for each storage complex including ancillary facilities.
Design & Construction	**Construct and Commission** storage and ancillary facilities.
	Obtain a **Licence to Operate** for each storage facility.
Initial Fuel Receipts	**Transfer** used fuel from current storage facilities, **repackage** as necessary, and **store** used fuel in new storage buildings; initiate **Extended Monitoring.**
Extended Monitoring	**Extended Monitoring**, security and limited maintenance continues for rest of timeline.
Refurbish-ment & Repackaging	Cask **refurbishment** – cycle repeats every 100 years Used Fuel module/basket **repackaging** – activity repeats every 300 years
Repeat Cycle	Cycle continues indefinitely.

The illustrative schedule of activities has been developed for the first 300-year cycle, although the time period for active management of used fuel at the reactor sites would continue indefinitely.

The estimated schedule for the first cycle assumes that new storage structures and possibly new dry storage technology would be implemented. New storage designs would need to be developed for each site including technical specifications for safeguarding the nuclear materials at the facilities. Emergency response plans may also need to be revised for each site. Due to the varying size of the facilities and the different fuel inventories at the sites, initial fuel receipt may continue at some reactor sites while construction is still occurring at others or extended monitoring may have begun at other reactor sites.

Initial Licensing Phase

This initial phase begins after a government decision is made to continue to manage the used fuel at the reactor sites and ends about 10-years later when all approvals have been received to construct the necessary storage structures and implement the selected long-term storage technology at the reactor sites.

This phase begins with an extensive NWMO review process of the alternatives to determine whether to continue using the existing interim dry storage facilities for long-term storage or to implement new dry storage technologies at some, or all, of the sites. Following this review, siting and conceptual design studies would be carried out at each reactor site, taking about one year to complete. When complete, letters of intent would be sent to the regulator to prepare sites and to construct new long-term storage facilities. This would initiate the provincial and federal environmental assessment process and an application for a licence to prepare the site and construct the facility.

During the environmental assessment process, the NWMO will be required to demonstrate that there would be no significant adverse impact on the environment resulting from the construction, operation and maintenance of the long-term reactor site storage facility. The environmental assessment will require the preparation of environmental assessment guidelines, site evaluations, preliminary safety assessment, preliminary decommissioning plan and environmental assessment technical studies and report. All of this would be done consistent with a public engagement plan approved by the regulator.

During the initial licensing phase, the owners of used fuel would continue to be responsible for its interim management at the reactor sites. The NWMO would assume management responsibility of the used fuel when it is transferred to the long-term storage facilities at the reactor sites.

Construction Phase

The construction phase is estimated to take about two to five years. It begins with regulatory approval to begin construction and ends when the facilities are commissioned and ready to receive used fuel from existing interim storage. It involves clearing of land, surface and/or underground excavation, construction of processing buildings, ancillary facilities, and construction of at least the first stage of the storage building. Provision is made in the design for construction and expansion during the initial fuel receipt phase to provide further storage capacity as required concurrent with interim storage.

Once commissioned, an application for a new or modified operating licence would be prepared to allow for the new buildings and structures to receive, process and store the used fuel. The application for an operating licence would include a preliminary decommissioning plan and a final safety analysis report, consistent with the actual design built and the anticipated activities. The final safety analysis results must also be consistent with the conclusions of the environmental assessment report.

Operations: Initial Fuel Receipt Phase

The initial fuel receipt phase begins with regulatory approval to receive transfers of used fuel for storage under an operating licence and ends with receipt of the last fuel transfer. The fuel transfer period is about 35 years. This phase may begin prior to completed construction of the entire storage complex, and additional storage capacity may be added in a staged manner as required. The length of this phase varies with the size of the used fuel inventory at each site.

There is a significant amount of activity during this phase. Depending on the technical alternative selected, the used fuel storage containers would require conversion in a processing building into a format appropriate for the long-term storage approach selected. The licence will specify requirements, particularly in regard to health and safety and monitoring and the onus would be on the licensee to prove compliance. Two particularly important requirements are environmental protection policies and procedures, i.e. an environmental management system, and effluent and environmental monitoring programs. The licence may need to be renewed periodically as specified by the regulator.

Operations: Extended Monitoring Phase

This phase commences at the end of initial fuel receipts and continues indefinitely throughout the reconstruction, refurbishment and repackaging phases described in the following subsection. This is a time of routine monitoring of the facility and the environment, as well as continued surveillance and security provision. The operating licence is expected to contain a combination of requirements related to monitoring, reporting, security and facility preparedness to respond to unacceptable monitoring results. Two particularly important requirements are environmental protection policies and procedures, i.e., an environmental management system, and effluent and environmental monitoring programs. This phase continues for as long as the long-term management facility is in existence.

Operations: Reconstruction, Refurbishment and Repackaging

Given that the used fuel storage facilities and principal containment structures have a finite life span, it would be necessary to move the used fuel from an ageing storage complex to new facilities, in addition to refurbishing and repackaging the storage casks and modules. Depending on the technical alternative chosen, this may be achieved by the staged building of additional storage capacity on the site, permitting the transfer of fuel containers from one storage location to another. Once the fuel has been transferred and the old storage units emptied, redundant storage structures and buildings would be demolished and new ones constructed.

There are two used fuel repackaging events that require consideration. One event, based on a 100-year service life of the storage casks, requires the removal of modules or baskets containing fuel from existing storage casks, and repackaging in fresh storage casks. The other repackaging event, occurring every 300 years based on the assumed service life of modules, module canisters and baskets requires the removal and transfer of fuel bundles to fresh modules, module canisters and baskets as required. The used fuel repackaging facility would perform functions relevant to the specific alternative chosen. It is assumed that the repackaging facility would comprise a shielded cell complex, housed within a large building, configured to perform the activities required for repackaging the used fuel.

The specific refurbishment requirements and the schedule and timing for the different technical alternatives are described in the conceptual design reports, available at www.nwmo.ca/conceptualdesigns.

16.3 / Option 3: Centralized Storage

This section presents an estimated timetable and a general description of the implementation activities anticipated to site, design, construct, operate, monitor and maintain a Centralized Storage facility for the long-term storage of used fuel. The Joint Waste Owners commissioned conceptual designs for four technical alternatives that could be followed in implementing the centralized storage concept, including above and below ground options, each with differing maintenance considerations; however the general schedule and phases are consistent for all alternatives.

Figures 16-5 and 16-6 present the overall work schedule and activity flowchart for Centralized Storage. This is based on the conceptual design and cost estimating reports prepared by consultants for the Joint Waste Owners. (See conceptual design reports at www.nwmo.ca/conceptualdesigns). The illustrative schedule of activities has been developed for the first 300-year cycle, although the time period for active management of used fuel at the reactor sites would continue indefinitely.

Siting Phase

The siting phase covers the time period in which a suitable location for a centralized storage facility is being sought. It begins after a formal decision is made to start the process of finding a suitable site and would end when regulatory approval is received to site and construct the facility at the preferred site (assumed to be about 15 years).

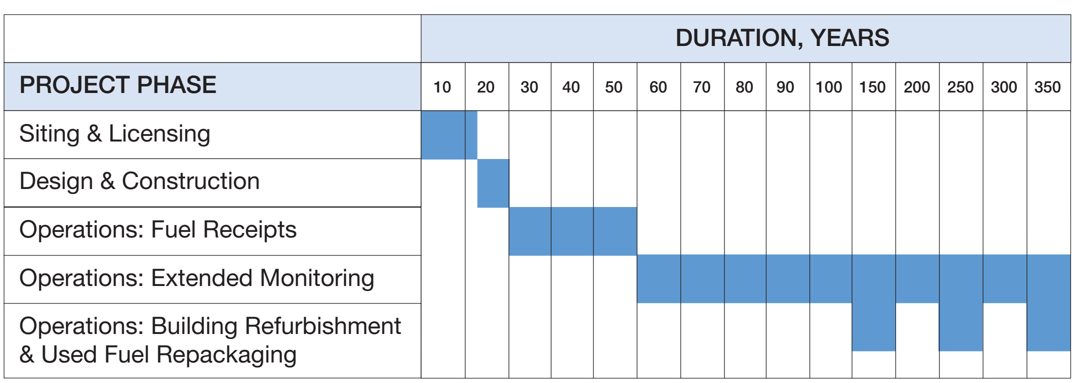
During the siting phase, the owners of used fuel would continue to be responsible for its interim management at the reactor sites. The NWMO would assume management responsibility of the used fuel when it is transported from the reactor sites to the central facility for long-term management.

The siting phase would involve developing a siting process that would include both thorough stakeholder consultations and technical assessments on the basis of site characteristics. The acceptability of a site would be determined on the outcome of this siting process. Key components of the siting process include initial public consultations and hearings, development and application of site screening criteria, an environmental assessment and the preparation of licence applications. Each of these major components necessarily includes both public involvement/participation and technical assessment and analysis.

The outcome of these public engagement activities would be coupled with the initial site characterization and screening to gain consensus toward selecting a preferred site. The approach would involve initial technical feasibility studies, followed by surface based characterization work, including subsurface exploration by borehole drilling carried out at perhaps two candidate sites in potential host communities prior to selecting a preferred site.

During the siting phase, a preliminary

Figure 16-5 Overall Work Schedule for Centralized Storage



Note: Extended Monitoring and Building Refurbishment/Used Fuel Repackaging activities continue in perpetuity, based on a 300-year cycle.

Figure 16-6 Activity Flowchart for Centralized Storage

Phase	Activity
Siting & Licensing	Government Decision to proceed with Centralized Storage.
	Develop an **Engagement Program** collaboratively with potential site, transportation route, aboriginal and non-aboriginal communities; incorporate insights from all NWMO work.
	Implement the **Engagement Program**, initiating the **Siting Process** to select preferred site (stakeholder consultations, feasibility studies, site characterization); **Design and Safety Assessment** activities in parallel.
	Perform an **Environmental Assessment** for the preferred site (including public engagement and safety analysis); obtain a **Licence to Prepare Site** for the activities proposed.
	Obtain **Licence to Construct** centralized storage complex including ancillary facilities.
Design & Construction	**Construct and Commission** central storage complex and ancillary facilities and obtain a **Licence to Operate** and **regulatory approval** to receive used fuel shipments.
	Obtain **regulatory approval** to transport used fuel.
Fuel Receipts	**Transport** used fuel to site, **repackage** as necessary, and **store** used fuel in storage complex Initiate **extended monitoring.**
Extended Monitoring	**Extended monitoring**, security and limited maintenance continues for rest of timeline.
Refurbish-ment & Repackaging	Cask **refurbishment** – repeat every 100 years Used Fuel module/basket **repackaging** – repeat every 300 years
Repeat Cycle	Cycle continues indefinitely.

conceptual design for centralized storage would be prepared for each site being evaluated. The design would include technical specifications for safeguarding the nuclear materials at the facility and during transportation. Following the selection of a preferred site, a comprehensive survey to measure and record the current background conditions at the proposed site would be conducted and a preliminary centralized storage design specific for the site would be completed prior to conducting the environmental assessment and preparing the application for a licence to prepare the site and construct the facility.

Once application for site preparation is made, or intent to apply is given, an environmental assessment will be required. The NWMO would be required to demonstrate during the environmental assessment process that there would be no significant adverse impact on the environment resulting from the construction, operation and maintenance of the centralized storage facility. The environmental assessment will require the preparation of environmental assessment guidelines, site evaluations, preliminary safety assessment, preliminary decommissioning plan and environmental assessment technical studies and report. All of this would be done consistent with a public engagement plan approved by the regulator.

Design and Construction Phase

The construction phase (about five years) begins with the receipt of a licence to begin construction and ends when the commissioning of the facilities is completed, prior to receiving the first formal shipment of used fuel for storage. It involves clearing of land, surface and/or underground excavation, construction of a processing building and ancillary facilities, and construction of at least the first stage of the storage complex. Provision is made in the design for concurrent construction and expansion during the fuel receipt phase to construct further storage capacity at the required time.

The application for a licence to operate is prepared during this phase. It will include a preliminary decommissioning plan and a final safety analysis report consistent with the actual design built and in support of the conclusions of the environmental assessment report submitted.

Operations: Fuel Receipt Phase

The fuel receipt phase (about 30 years) begins with regulatory approval to receive shipments of used fuel for storage under a licence to operate and ends with receipt of the last shipment. Following this would be an indefinite period of monitoring.

This phase of operations would involve receiving used fuel transported to the central site and sent to the storage complex. Fuel would arrive in existing storage casks, or be conveyed in transportation casks containing modules or baskets. Depending on the technical alternative selected, some fuel storage containers would require conversion in a processing building into a format appropriate for long term storage. During this phase, additional storage capacity would be constructed, expanding the storage complex in a staged manner.

Fuel receipt would be carried out entirely under an operating licence with specific requirements, particularly in regard to health and safety and monitoring. The onus would be on the licensee to prove compliance to these requirements. The licence may require periodic renewal as specified by the regulator.

Operations: Extended Monitoring Phase

This phase commences at the end of initial fuel receipts and continues indefinitely throughout the reconstruction, refurbishment and repackaging phases described in the following subsection. This is a time of routine monitoring of the facility and the environment, as well as continued surveillance and security provision. The operating licence is expected to contain a combination of requirements related to monitoring, reporting, security and facility preparedness to respond to unacceptable monitoring results. This phase continues for as long as the long-term management facility is in existence.

Operations: Reconstruction, Refurbishment and Repackaging

Given that the storage facilities and principal containment structures have a finite life span, it would be necessary to move the used fuel from an ageing storage complex to new facilities in addition to refurbishing and repackaging the storage casks and modules. Depending on the technical alternative chosen, this may be achieved by the staged building of additional storage capacity on the site, permitting the transfer of fuel containers from one storage location to another. Once the fuel has been transferred and the old storage unit emptied, the redundant building would be demolished and a new one constructed. This process is estimated to require 30 years.

There are two repackaging events that require consideration. One event, based on a 100 year service life of the storage casks (applicable to the alternatives Casks and Vaults in Storage Buildings, Casks and Vaults in Shallow Trenches, and Casks in Rock Caverns), requires the removal of modules (or in the case of Casks in Rock Caverns removal of baskets containing fuel from existing storage casks), and repackaging them in fresh storage casks. The other repackaging event, occurring every 300 years – based on the assumed service life of modules, module canisters and baskets – requires the removal and transfer of fuel bundles to fresh modules, module canisters and baskets as required. The used fuel repackaging facility would perform functions relevant to the specific alternative under consideration. It is assumed that the repackaging facility would comprise a shielded cell complex, housed within a large building, configured to perform the activities required for repackaging the used fuel.

The shielded cell complex is capable of allowing the opening of the storage casks, withdrawal of the modules and withdrawal of fuel bundles from the modules. The fuel bundles are transferred to 'fresh' modules, which would then be loaded into a new storage cask or a new welded canister. Alternatively, the shielded cell complex permits the opening of seal welded baskets and the withdrawal of the fuel bundles within. The fuel bundles are inserted into 'fresh baskets', and the basket assembly seal welded. The repackaging event for each alternative is assumed to require about 30 years. The specific refurbishment requirements and the schedule and timing for the different technical alternatives are described in the conceptual design reports at **www.nwmo.ca/conceptualdesigns**.

16.4 / Option 4: Adaptive Phased Management

The Adaptive Phased Management approach could be implemented in three major phases. In Phase 1, the used fuel continues to be stored and managed by the individual waste owners at the reactor sites until the necessary siting, approvals, and construction of a central long-term management facility have taken place. An engagement program would be collaboratively developed as a vehicle for various public inputs during implementation, and an oversight and reporting program would be instituted.

Phase 1 includes the option to construct shallow underground caverns for storage of used fuel at the central site while awaiting development of the deep repository. Also during the first phase, an underground characterization facility (UCF) would be constructed and site-specific research and development would be performed.

Phase 2 includes the option to transport used fuel from the reactor sites to the central location for interim shallow underground storage, demonstration of long-term isolation technology in the underground characterization facility and design and construction of the deep repository.

In Phase 3, the used fuel would be retrieved from storage, packaged into long-lived containers and placed in the deep repository. Extended monitoring would then occur until a decision is made to decommission the underground characterization facility and surface handling facilities and close the deep repository. This would be followed by a period of postclosure monitoring for as long as future societies decide is necessary.

Each of the three major phases of Adaptive Phased Management has key activities and decision points. While we do not know the precise duration of these activities or the outcome of future decisions, we can provide an indication of a representative schedule for implementation based on the conceptual design work and analyses of the three options for used fuel management described previously as well as international experience. Some of the key decisions which could affect implementation activities and the schedule include:

- The selection of a preferred site for central, long-term management of used nuclear fuel.

- A decision about whether or not to construct an interim shallow underground storage facility at the central site and transport used fuel to the central facility while awaiting development of the deep geological repository.

- A decision about when to construct the deep geological repository and ancillary facilities.

- A decision about when to close the deep geological repository and decommission the surface facilities.

Figures 16-7 and 16-8 present the overall work schedule and activity flowchart for Adaptive Phased Management.

Figure 16-7 Overall Work Schedule for Adaptive Phased Management

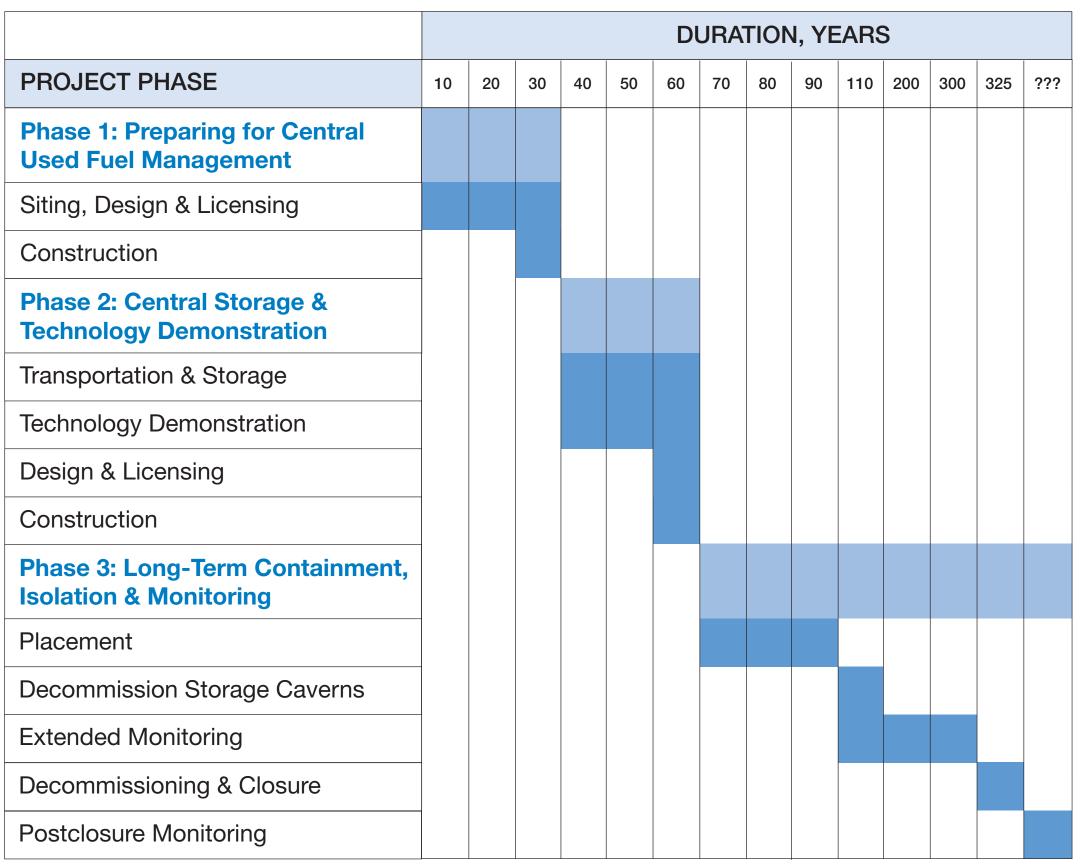


Figure 1-2 Activity Flowchart for Adaptive Phased Management

We have conservatively assumed for conceptual design, cost estimating and planning purposes that a decision has been made in Phase 1 to build the optional shallow underground caverns for centralized storage and that used fuel is transported from the reactor sites to the central facility beginning in Phase 2. Possible drivers which may affect the decision of whether or not to construct an interim shallow underground storage facility include:

- A strong indication from some or all of the reactor site communities of a need to move used fuel off site, perhaps as a result of reactor decommissioning activities;
- Unforeseen developments that increase the desirability of centralizing used fuel for reasons of enhanced security; and
- Unforeseen developments in new technological innovation.

Phase 1: Preparing for Central Used Fuel Management

Siting, Design and Licensing

In Phase 1, a suitable location for a shallow underground storage facility, an underground characterization facility and a deep geological repository would be sought, and licences obtained. The siting portion of Phase 1 would begin immediately after a formal decision is made to follow an Adaptive Phased Management approach, and it would end when a licence is received to construct a shallow underground storage facility and an underground characterization facility (estimated to be about 20 years).

During the siting phase, the owners of used fuel would continue to be responsible for its interim management at the reactor sites. The NWMO would assume management responsibility of the used fuel when it is transported from the reactor sites to the central facility for long-term management.

It is expected to take about 10 years to complete the feasibility studies and select a preferred site, followed by five more years to complete detailed site characterization and prepare safety reports, design reports and associated documentation required for licensing.

It is likely that the construction licence application for the deep geological repository would be submitted later in Phase 2 after confirming the suitability of the site and completing the safety analyses based on the final design of the facility.

The first activities in Phase 1 would be developing an engagement program and instituting an oversight and reporting program. The engagement program and siting process would be developed in collaboration with people and communities potentially affected including Aboriginal peoples. Based on input from this engagement program, a process would be developed and immediately implemented to determine site acceptability. The major components of the siting process would include public engagement and technical assessments. Other key activities in this phase include initial public consultations and hearings, development and application of site screening criteria, an environmental assessment, and the preparation of licence applications. Each of these components necessarily includes both public involvement/participation and technical assessment and analysis.

A preliminary conceptual shallow storage facility, an underground characterization facility, and a deep repository design would be prepared for the sites being considered. Design work would be completed sufficiently to establish access, utility, and infrastructure requirements as part of initial site screening of areas selected for detailed evaluation. The design would include technical specifications for safeguarding the nuclear materials at the facility for all phases of implementation and during transportation. Following the selection of a preferred site, a shallow underground storage design specific for the site and a preliminary design for the underground characterization facility and deep geological repository would be completed prior to conducting the environmental assessment and licensing processes.

The environmental assessment and application for a site preparation licence would need to consider the impacts from all facilities intended for the site, even if they would not be built for decades to come. The NWMO would be required to demonstrate during the environmental assessment process that there would be no significant adverse impact on the environment resulting from the construction, operation, decommissioning and closure of all facilities intended for the site.

The environmental assessment will require the preparation of environmental assessment guidelines, site evaluations, a comprehensive survey to measure and record the current background conditions at the proposed site, a preliminary safety assessment, and environmental assessment technical studies and reports. All of this would be done in concert with a public engagement plan approved by the regulator. A period of five years has been allocated to complete the environmental assessment and licensing process. Although there may be additional environmental assessments required in subsequent phases, we expect that they would be based on this major environmental assessment completed in Phase 1.

Construction

Assuming a decision has been made to build the shallow underground caverns for centralized storage, this facility and associated infrastructure plus the underground characterization facility would be built during Phase 1 construction (estimated to be about 10 years). This period begins with regulatory approval to begin construction and ends when commissioning of the facilities is completed; that is when shallow storage may receive used fuel and site-specific research and development may be performed at the underground characterization facility. If a decision has been made not to build the shallow underground caverns for centralized storage, then only the underground characterization facility and associates surface facilities and infrastructure would be constructed at the central site.

The underground storage areas of the central facility would be built as a series of shallow rock caverns excavated at a nominal depth of 50 metres below surface and accessible by ramp. The shallow underground caverns would be designed and constructed so that they would not compromise the integrity or safety of the natural geosphere barrier associated with the deep geological repository. As for the underground characterization facility, the underground access ways and service areas, and the underground rooms for used fuel would be constructed at a nominal depth of between 500 and 1,000 metres below surface and accessible by shaft. It is anticipated that the underground characterization facility may require modification or expansion during the operation phase depending on research findings.

Phase 2: Central Storage and Technology Demonstration

Transportation and Storage

Adaptive Phased Management includes the option to store used fuel in a shallow underground storage facility at the central site, while awaiting development of the deep repository. If this option is selected, then used fuel would begin to be transported from the reactor sites to the central site and placed in shallow underground caverns. If a decision has been made not to build the shallow underground caverns for centralized storage, then used fuel would remain at the reactor sites and be transported to the central facility during Phase 3. The decision about used fuel transportation would be influenced by the engagement program.

Used fuel transportation can only begin when the central facility has been granted an operating licence to receive, handle, and store used fuel shipments. As well, regulatory approval will be required for the transportation routes and methods, the emergency response plans, and the packages and transport containers that are designed and licensed for this purpose. It is estimated that transportation would continue for approximately 30 years.

The mode of transportation (road, rail or water) and the routes that would be utilized would depend on the location of the central facility, technical requirements and outcomes from the engagement process developed in Phase 1.

Technology Demonstration

Along with continued characterization of the site, further demonstration of the technology to contain and isolate used fuel in a deep geological repository would continue at the underground characterization facility. The NWMO has conservatively assumed a period of 20 years of research and demonstration at the underground characterization facility would be required to confirm the suitability of the site, to gain sufficient confidence in understanding the long-term issues and to prove the safety of isolating used fuel in a deep geological repository. Once a decision is made to proceed with developing the deep repository, site-specific research, long-term tests and technology demonstration at the underground characterization facility would continue in parallel with design and licensing activities for the deep repository.

Design and Licensing

It is estimated that a decision could be made to place fuel in a deep repository at or about Year 50. As with decisions on siting and transportation, this decision is subject to the engagement and oversight programs developed in Phase 1. A decision to place fuel in a deep repository would mark the beginning of another phase in which the design would be finalized and regulatory approvals would be sought for an operating licence for the deep repository and ancillary facilities. This period is expected to last about 10 years.

The final deep repository design would be based on underground data gathering and evaluation in the underground characterization facility which would be used to confirm the suitability of the site, provide the basis for the detailed design of the deep repository, and provide validation of assumptions made in the final safety analysis report. The repository design, which was initially prepared in Phase 1, may be updated depending on technical conditions and regulatory expectations at that time. With the licence requirements met and approval of the regulator obtained, this phase would end and construction of the deep repository and its ancillary facilities would begin.

Construction

The deep repository placement rooms would be constructed for the purpose of receiving used fuel. This activity formally begins with the decision to construct, and ends when the repository rooms and surface facilities have been commissioned to receive, process and store used fuel. Initial construction is expected to last about 10 years, although provisions are expected for concurrent excavation during Phase 3, providing additional rooms for used fuel at the required time.

An application for an operating licence would be made in parallel with construction activities, including a final safety analysis report. Also, the results of the commissioning program would be required prior to granting approval to operate.

Phase 3: Long-Term Containment, Isolation and Monitoring

Placement

Placement (estimated to be about 30 years) begins with regulatory approval under an operating licence for the deep repository and ends when the last fuel bundle has been placed and an extended monitoring program is initiated. Used fuel is assumed to be transferred from storage to the surface facilities for packaging into long-lived containers and then placed in a network of horizontal tunnels and rooms excavated in stable rock at a nominal depth of 500 to 1,000 metres below surface. The durable used fuel containers would be made of corrosion-resistant material and placed within the rooms or in boreholes drilled into the floor of the rooms. Used fuel containers are assumed to be placed in the deep repository over a 30-year operating period.

The operating licence will specify requirements, particularly in regard to health and safety and monitoring, and the onus would be on the licensee to prove compliance. Finally, the licensee may be required to report on the status of the facility and compliance with the licence and the used fuel management program in compliance with engagement programs and the oversight regime. The licence may require periodic renewal by the regulator.

Decommission Storage Caverns

After the used fuel has been removed from the optional shallow underground storage caverns, the underground facility would be kept open and available for used fuel storage, if required. After about 20 years, the shallow underground caverns are assumed to be decommissioned and closed.

Extended Monitoring

Extended monitoring begins after the used fuel is placed in the deep repository and ends when a decision is made to backfill and seal the deep repository, and approval is given to close and decommission the facilities. The extended monitoring program would take place in-situ at repository depth, making use of the shafts and underground access tunnels.

Extended monitoring activities would include environmental monitoring, monitoring used fuel container performance, and monitoring rock mass behaviour. The monitoring data would be used to confirm the long-term safety of the repository and provide the basis for decommissioning and closure of the facility. The time period for extended monitoring has been conservatively assumed to be about 210 years. After closure of the deep repository, postclosure monitoring of the facility would take place from the surface if necessary.

Decommissioning and Closure

Decommissioning activities include decommissioning of the underground characterization facility and any remaining long-term experiments or demonstrations of technology, plus decommissioning of the surface handling facilities. Decommissioning the repository begins when a decision is made to dismantle and remove underground equipment such as in-situ monitoring devices, backfill and seal the access tunnels and shafts, and the regulatory approval is granted to do so. This would be one of the last decisions that would need to be supported by the engagement program. Possible benefits of closing the repository, or leaving it open, would need to be determined at that time. During decommissioning the surface facilities would be decontaminated, dismantled and removed. It is estimated that final decommissioning activities would require about 25 years to complete. At the end of the decommissioning stage the site would be in a state suitable to allow public use of the surface. However, access may still be denied by maintenance of fencing to secure ongoing postclosure monitoring activities.

Postclosure Monitoring

After the closure of the deep repository and the decommissioning of all facilities at the central site, postclosure monitoring could take place at the surface. This would continue indefinitely until a decision was taken to end all activities associated with the deep repository.

Flexibility in Schedule for Implementation

Adaptive Phased Management allows flexibility in the pace and manner of implementation through phased decision making. In Figure 16-7 we have illustrated one possible implementation schedule which we believe is conservative and allows for genuine choice. In our illustrative timeline, the used fuel is fully transported from the reactor sites, and placed in the deep repository within 90 years, followed by an extended period of monitoring. However, other implementation schedules are possible, including an accelerated schedule. Implementation of Adaptive Phased Management could proceed faster or slower than the illustrative schedule outlined in this chapter and will depend on future decisions which cannot be known at this point in time.

We can predict with greatest accuracy the timelines for Phase 1. We have the benefit of Canadian experiences with other siting and environmental assessment processes. In addition, we are guided by the siting and regulatory experiences related to radioactive waste management facilities in Finland and Sweden. Our illustrative timeline for Phase 1, of 30 years, covers a period in which the following activities would take place:

- Continued research and development;
- Siting feasibility studies;
- Selection of a preferred site;
- Completion of detailed site characterization;
- Development and certification of transportation containers;
- Preparation of safety reports, facility design reports and associated documentation to support the environmental assessment, licensing and approvals process;
- A 10-year period of construction of the underground characterization facility and the optional shallow underground storage facility; and
- Citizen engagement associated with the activities noted above.

Based on our observations of other similar processes, we believe that 30 years is a reasonable timeline for Phase 1. However, should a decision be taken not to construct the optional shallow underground storage facility at the central site, then it is possible that construction of the underground characterization facility could be completed in five years, potentially shortening Phase 1 to 25 years.

In our illustrative timeline, Phase 2 activities would take place during years 30 through 60 in the implementation period. The activities taking in place in this period would include:

- Transport of used fuel from the reactor sites to the central site, where the used fuel is placed in the shallow underground storage facility;
- Research and testing at the underground characterization facility, to demonstrate and confirm the suitability of the site and the repository technology;
- Completion of the final design and safety analyses, to support the application for an operating licence for the deep repository;
- Construction of the deep repository; and
- Citizen engagement in the activities above.

It is possible that there may be a shorter period of demonstration of the long-term isolation technology in the underground characterization facility, enabling Phase 2 to proceed in 10 years, for example. This may be the case if the optional shallow underground storage facility is not constructed, and there are no unforeseen developments at the planned repository site. Used fuel would remain stored at reactor sites. Final repository design, licensing and construction activities would occur in parallel with site characterization and technology demonstration, resulting in all Phase 2 activities completed in 10 years, rather than the 30 year period reflected in our illustrative timeline.

During Phase 3 of our illustrative timeline, used fuel is transferred from the shallow underground storage facility to the deep repository over a period of 30 years. Under an accelerated schedule of implementation, without the optional shallow underground storage facility, used fuel would be moved from reactor sites to the central facility, repackaged into long-lived containers and placed in the deep repository. In both instances, a period of 30 years is required for the process of placing the used fuel bundles in the deep repository.

An accelerated implementation schedule may therefore enable all used fuel to be placed in the deep repository by year 65, rather than year 90, as depicted in our illustrative timeline.

An important component of Adaptive Phased Management, is the provision for ongoing monitoring after the used fuel is placed in the deep repository, to assess the performance of the repository system, and to allow for retrieval of the used fuel, if required. Even under an accelerated implementation schedule, we believe that a period of extended monitoring is an important provision. Decisions on the duration of this monitoring, the timing of closure of the facility and postclosure monitoring would be taken by a future generation.

Appendices

A

Appendix 1 / NWMO Profile

The Nuclear Waste Management Organization (NWMO) was established by Canada's nuclear electricity generators following passage of the *Nuclear Fuel Waste Act* in 2002 (See Appendix 2: *Nuclear Fuel Waste Act*). The legislation provides a framework for the Government of Canada to make a decision on the long-term management of used nuclear fuel. It requires the NWMO to investigate and develop an approach and present its recommendations to the government by November 2005.

The NWMO Board of Directors is currently composed of representatives of the major owners of used nuclear fuel: Ontario Power Generation Inc., Hydro-Québec and NB Power Nuclear. (www.nwmo.ca/directors)

The founding Chair was Richard Dicerni who retired from OPG in 2005. Stuart Groom served as a director until his retirement from NB Power in 2003. And René Pageau represented Hydro-Québec until he left the utility in 2004.

Current board members are:

- **Ken Nash (chair),** Vice President, Nuclear Waste Management – OPG.
  A mechanical engineering graduate from Salford University in the United Kingdom, Mr. Nash joined OPG's predecessor company, Ontario Hydro, in 1981 after working for British Nuclear Fuels Plc. on nuclear fuel design and nuclear waste management.

- **Laurie Comeau,** Manager, Personnel Safety and Environment, Point Lepreau Nuclear Generating Station – NB Power Nuclear.
  Mr Comeau's 24 year career in the nuclear industry has been focused on radiation safety, conventional safety, environmental monitoring, dosimetry, emergency preparedness, fire prevention and waste management.

- **Fred Long,** Vice President, Financial Planning – OPG.
  Mr. Long joined Ontario Hydro in 1976 after earning his Ph.D. in physics from McMaster University. He has held numerous positions in financial planning, financial policy and strategy, and operational audit.

- **Adèle Malo,** Vice President, Law and General Counsel; Vice President, Sustainable Development – OPG.
  Called to the Bar in 1989, Adèle Malo has practiced law with major corporations and law firms in Canada. She holds a Bachelor of Laws from the University of Windsor and a Master of Laws from the University of Cambridge.

- **Michel Rhéaume,** Licensing Manager, Gentilly-2 Refurbishment Project – Hydro-Québec.
  Mr. Rhéaume is a physics graduate of the Université du Québec à Trois-Riviéres. He began his career at Hydro-Québec in 1975 and has been a manager in: Health Physics, Emergency Preparedness, Environment, Nuclear Safety and Licensing and Nuclear Waste Management.

The NWMO has an arms-length Advisory Council composed of individuals knowledgeable in nuclear waste management issues and experienced in working with citizens and communities on a range of public policy issues. (www.nwmo.ca/advisorycouncil)

The Advisory Council has a legislative mandate to provide written comments on the NWMO study to the Minister of Natural Resources Canada. Its report is presented at the back of this study report. Throughout the study period, the Advisory Council has provided ongoing advice and guidance to the NWMO Board of Directors and its President.

Advisory Council members are:

- **Hon. David Crombie – Chairman**
  The Honourable David Crombie is the President and CEO of the Canadian Urban Institute and Chair of Ontario Place. He is a past mayor of the City of Toronto and a Privy Councillor. Mr. Crombie was the first Chancellor of Ryerson University and is the recipient of honorary doctorates of law from the University of Toronto and the University of Waterloo. Mr. Crombie is an Officer of the Order of Canada.

- **David Cameron**
  David R. Cameron is a Professor of Political Science at the University of Toronto and a Fellow of the Royal Society of Canada. He has held a number of senior government positions in both the federal and Ontario civil services. He continues to advise on a wide range of governmental issues.

- **Helen Cooper**
  Helen Cooper has devoted most of her professional career to strategic planning and development for broader public sector and not-for-profit organizations. She has practised as a mediator and adjudicator in dispute resolution and has taught courses in urban planning at both Queen's University and the University of Waterloo. She is a former mayor of Kingston, Ontario and a former president of the Association of Municipalities of Ontario.

- **Gordon Cressy**
  Gordon Cressy is the President of the Canadian Tire Foundation for Families. A past President of the United Way of Greater Toronto, he has held Vice-President positions at both the University of Toronto and Ryerson University. Mr. Cressy has a lengthy record of community involvement.

- **Frederick Gilbert**
  Frederick Franklin Gilbert is the President of Lakehead University in Thunder Bay, Ontario. He has had an extensive teaching, research and administrative career in the United States and Canada and has held several environmental and wildlife management public service appointments and positions. His research interests included resource management and the sustainable use of the natural environment.

- **Eva Ligeti**
  Eva Ligeti is the Executive Director of the Clean Air Partnership, a non-profit organization with a mandate to make Toronto more environmentally sustainable and a world leader in clean air. A lawyer, she served as Ontario's first Environmental Commissioner from 1994 to 1999.

- **Derek Lister**
  Derek Lister is the Chairman of the Chemical Engineering Department at the University of New Brunswick in Fredericton, where he also holds the Research Chair in Nuclear Engineering. His main research interests are in the areas of chemistry and corrosion associated with nuclear systems.

- **Donald Obonsawin**
  Donald Obonsawin is the President and CEO of Jonview Canada Inc. He has been Deputy Minister of seven Ontario government ministries over a 15-year period. He has also held senior positions with the federal departments of Indian Affairs and Northern Development and Health and Welfare Canada.

- **Daniel Rozon**
  Daniel Rozon is a retired Professor of Engineering Physics at l'École Polytechnique de Montréal. A fellow of the Canadian Nuclear Society, he is a specialist in reactor physics, with research interests in nuclear fuel management optimization. He was the director of the Nuclear Engineering Institute (l'Institut de génie nucléaire) for more than 15 years.

A Roundtable on Ethics, composed of experts in the field of ethics from a variety of disciplines, provided advice and feedback to the NWMO throughout its study. (www.nwmo.ca/ethicsroundtable) The Roundtable helped ensure the systematic integration of ethical considerations in the development and application of the framework used to assess the management options. Members are:

- **Andrew Brook**
  Andrew Brook is Professor of Philosophy and Director of the Institute of Cognitive Science at Carleton University. He is a graduate of the Universities of Alberta and Oxford and is a Past President of the Canadian Philosophical Association. Dr. Brook's research interests include: interdisciplinary cognitive research; Kant; consciousness; psychological and psychoanalytic explanation; environmental ethics; and ethics of nuclear waste management.

- **Wesley Cragg**
  Wesley Cragg is the George R. Gardiner Professor of Business Ethics, and Director of the Business Ethics Program at the Schulich School of Business at York University. He is also Chair and President of Transparency International, Canada. Dr. Cragg's areas of expertise include: business ethics, professional ethics; ethics and work; law and ethics; moral, social, political and legal theory.

- **George Erasmus**
  George Erasmus has made a lifelong contribution to the welfare and community of Canada's Aboriginal peoples. He has served as the president of the Indian Brotherhood of Northwest Territories/Dene Nation, and was twice elected as the National Chief of the Assembly of First Nations. Mr. Erasmus was co-chair of the groundbreaking 1996 Royal Commission on Aboriginal Peoples. He is President and Chairman of the Aboriginal Healing Foundation and is also currently Chief Negotiator for the Dehcho First Nations, in their land and governance process with the Federal Government.

- **David MacDonald**
  Ordained as a minister of the United Church of Canada, David MacDonald's long service to Canada has included: election to the House of Commons for the riding of Egmont, PEI for six terms beginning in 1965; Cabinet Minister; Fellow in Residence of the Institute for Research on Public Policy; President of the Futures Secretariat; Canadian Emergency co-ordinator/African Famine; and, United Church advisor on residential schools reconciliation and agreement.

- **Arthur Schafer**
  Arthur Schafer is the Director of the Centre for Professional and Applied Ethics at the University of Manitoba. He is also a Full Professor in the Department of Philosophy and an Ethics Consultant at the Health Sciences Centre in Winnipeg. A former Head of the Section of Bio-Medical Ethics in the Faculty of Medicine at the University of Manitoba, he is a recipient of many awards and honours. Professor Schafer has published widely in the fields of moral, social and political philosophy.

- **Margaret A. Somerville**
  Margaret Somerville is Samuel Gale Professor in the Faculty of Law, Professor in the Faculty of Medicine, and the Founding Director of the Centre for Medicine, Ethics and Law at McGill University. Widely published, a frequent participant in national and international conferences and consultations and all forms of media, she has been active in the worldwide development of bioethics and most recently was named the first recipient of the UNESCO Avicenna Prize for Ethics in Science. Dr. Somerville's areas of expertise include: bioethics; health law and ethics; medical law; torts; and criminal law.

The NWMO has also benefited from the informal and ongoing advice of a panel whose members have international experience in matters of resource development and Aboriginal concerns, environment and nuclear energy. Members are:

- **Justice Thomas Berger**
  From 1974 to 1977 Thomas Berger served as the Commissioner of the Mackenzie Valley Pipeline Inquiry, recommending a ten year moratorium on building a pipeline so that native land claims could be settled. He represented Vancouver – Burrard as a Member of Parliament in 1962-63 and was later an MLA and leader of the British Columbia New Democratic Party. Mr Berger served as a Justice of the Supreme Court of British Columbia from 1973 to 1983. He now practices law in Vancouver.

- **Dr. Hans Blix**
  Hans Blix was Director General of the International Atomic Energy Agency from 1981 to 1997 and was a member of Sweden's delegation to the United Nations from 1961 to 1981. In 2000 he was appointed Executive Director of the United Nations Monitoring, Verification, and Inspection Commission, supervising international inspections for weapons of mass destruction in Iraq until the inspections were suspended in 2003. A Swedish citizen, Dr. Blix has written several books on subjects associated with international and constitutional law.

- **Dr. Gustav Speth**
  James Gustav Speth is Dean of the School of Forestry and Environmental Studies at Yale University. He founded and was president of the World Resources Institute, co-founded the Natural Resources Defense Council, served as advisor on environmental issues for U.S. Presidents Carter and Clinton, and was Chief Executive Officer of the United Nations Development Program. In 2002, for his role in bringing the global warming issue to wide public attention, Dr. Speth was awarded the international environmental Blue Planet Prize.

Elizabeth Dowdeswell is President and CEO of the NWMO.

NWMO staff are:
Kathryn Shaver – Executive Director and Corporate Secretary
Gillian Adshead
Ginni Cheema
Jo-Ann Facella
Morrie Herman
Anthony Hodge
Elena Kapila
Michael Krizanc
Paul Lovie
John Neate (2003-04)
Pat Patton
Donna Pawlowski
Sean Russell

Appendix 2 / *Nuclear Fuel Waste Act*

NUCLEAR FUEL WASTE ACT [1]

Summary

This enactment implements a key component of the Government of Canada's 1996 *Policy Framework for Radioactive Waste* – that the federal government, through effective oversight, would ensure that the long-term management of radioactive waste is carried out in a comprehensive, integrated and economically sound manner. The key elements of the enactment include

(a) requiring the major owners of nuclear fuel waste to establish a waste management organization (referred to in this Summary as the "WMO") to carry out the managerial, financial and operational activities to implement the long-term management of nuclear fuel waste;

(b) requiring the major owners of nuclear fuel waste to establish trust funds and to make annual payments into those trust funds to finance the long-term management of nuclear fuel waste; and

(c) authorizing the Governor in Council to make a decision on the choice of approach for long-term management of nuclear fuel waste for Canada to be implemented by the WMO.

The enactment also requires that the WMO carry out public consultations, that the WMO's study and reports (which are submitted to the Minister) be made public, that the WMO establish an Advisory Council, whose comments on the WMO's study and reports are made public, and that the Minister make public statements on all of the WMO's reports.

Table of Provisions

[1] Canada Gazette, Part III, Volume 25, No. 2, Chapter 23. Ottawa, Friday, August 2, 2002, Statutes of Canada 2002.

NUCLEAR FUEL WASTE ACT	
49-50-51 Elizabeth II Chapter 23	
	An Act respecting the long-term management of nuclear fuel waste [Assented to 13th June, 2002] Her Majesty, by and with the advice and consent of the Senate and House of Commons of Canada, enacts as follows:
Short title	SHORT TITLE **1.** This Act may be cited as the *Nuclear Fuel Waste Act*.
Definitions	INTERPRETATION **2.** The following definitions apply in this Act.
"economic region"	"economic region" means an economic region described by Statistics Canada in its *Guide to the Labour Force Survey*, published on January 31, 2000.
"management"	"management", in relation to nuclear fuel waste, means long-term management by means of storage or disposal, including handling, treatment, conditioning or transport for the purpose of storage or disposal.
"Minister"	"Minister" means the Minister of Natural Resources or such member of the Queen's Privy Council for Canada as the Governor in Council may designate as the Minister for the purposes of this Act.
"nuclear energy corporation"	"nuclear energy corporation" means (a) Ontario Power Generation Inc., Hydro-Québec, New Brunswick Power Corporation, and any other body that owns nuclear fuel waste resulting from the production of electricity by means of a commercial nuclear reactor; (b) any successor or assignee of a corporation mentioned in paragraph (a); and (c) any assignee of Atomic Energy of Canada Limited, being the company incorporated or acquired pursuant to subsection 10(2) of the *Atomic Energy Control Act*, chapter A-19 of the Revised Statutes of Canada, 1970.
"nuclear fuel waste"	"nuclear fuel waste" means irradiated fuel bundles removed from a commercial or research nuclear fission reactor.
"prime rate"	"prime rate" means, for any day, the rate of interest charged by banks to their most credit-worthy borrowers for short-term business loans, as determined and published by the Bank of Canada for the month in which the day falls.
"waste management organization"	"waste management organization" means the corporation established under section 6, regardless of the actual name of that corporation.
Comprehensive, integrated and economically sound approach	PURPOSE OF ACT **3.** The purpose of this Act is to provide a framework to enable the Governor in Council to make, from the proposals of the waste management organization, a decision on the management of nuclear fuel waste that is based on a comprehensive, integrated and economically sound approach for Canada.
Binding on Her Majesty	APPLICATION OF ACT **4.** This Act is binding on Her Majesty in right of Canada or a province.
Application to nuclear energy corporations and AECL	**5.** This Act applies to a nuclear energy corporation and to Atomic Energy of Canada Limited only if it is the owner of nuclear fuel waste.

NUCLEAR FUEL WASTE ACT	
49-50-51 Elizabeth II Chapter 23 (cont'd)	
Incorporation and purpose	WASTE MANAGEMENT ORGANIZATION **6.** (1) The nuclear energy corporations shall establish a corporation, in this Act referred to as the waste management organization, whose purpose under this Act is to do the following on a non-profit basis: (a) propose to the Government of Canada approaches for the management of nuclear fuel waste; and (b) implement the approach that is selected under section 15 or is approved under subsection 20(5).
Participation in waste management organization	(2) Once the waste management organization has been established, every nuclear energy corporation shall become and remain a member or shareholder of it.
Not an agent of Her Majesty	(3) For all purposes the waste management organization is not an agent of Her Majesty in right of Canada.
Duty toward other owners of nuclear fuel waste	**7.** The waste management organization shall offer, without discrimination and at a fee that is reasonable in relation to its costs of managing the nuclear fuel waste of its members or shareholders, to (a) Atomic Energy of Canada Limited, and (b) all owners of nuclear fuel waste produced in Canada that are neither members nor shareholders of the waste management organization its nuclear fuel waste management services that are set out in the approach that the Governor in Council selects under section 15 or approves under subsection 20(5).
Advisory Council	**8.** (1) The waste management organization shall create an Advisory Council, which shall (a) examine the study referred to in subsection 12(1) and the triennial reports referred to in section 18 that are to be submitted to the Minister; and (b) give written comments on that study and those reports to the waste management organization.
Representation on Advisory Council	(2) The members of the Advisory Council shall be appointed by the governing body of the waste management organization. The governing body shall make all reasonable efforts to ensure that the Advisory Council's membership (a) reflects a broad range of scientific and technical disciplines related to the management of nuclear fuel waste; (b) reflects expertise, in matters of nuclear energy, (i) in public affairs, and (ii) as needed, in other social sciences; (b.1) reflects expertise in traditional aboriginal knowledge; and (c) includes representatives nominated by local and regional governments and aboriginal organizations that are affected because their economic region is specified for the approach that the Governor in Council selects under section 15 or approves under subsection 20(5).
Trust funds	FINANCING **9.** (1) Each nuclear energy corporation and Atomic Energy of Canada Limited shall maintain in Canada, either individually or jointly with one or more of the other nuclear energy corporations or Atomic Energy of Canada Limited, one trust fund with a financial institution incorporated or formed by or under an Act of Parliament or of the legislature of a province, except, in the case of a nuclear energy corporation, a financial institution in relation to which the nuclear energy corporation beneficially owns, directly or indirectly, more than ten per cent of the outstanding shares of any given class of shares.

NUCLEAR FUEL WASTE ACT	
49-50-51 Elizabeth II Chapter 23 (cont'd)	
Documents relating to trust funds	(2) The financial institution that holds a trust fund referred to in this section shall maintain in Canada all documents relating to that trust fund.
Initial deposit to trust funds	**10.** (1) Each body mentioned in this subsection shall, either directly or through a third party, no later than 10 days after the day on which this Act comes into force, deposit to its trust fund maintained under subsection 9(1) the following respective amounts: (a) Ontario Power Generation Inc., $500,000,000; (b) Hydro-Québec, $20,000,000; (c) New Brunswick Power Corporation, $20,000,000; and (d) Atomic Energy of Canada Limited, $10,000,000.
Subsequent deposits to trust funds	(2) Each body mentioned in this subsection shall in each year, either directly or through a third party, no later than the anniversary of the day on which this Act comes into force, deposit to its trust fund maintained under subsection 9(1) the following respective amounts: (a) Ontario Power Generation Inc., $100,000,000; (b) Hydro-Québec, $4,000,000; (c) New Brunswick Power Corporation, $4,000,000; and (d) Atomic Energy of Canada Limited, $2,000,000.
When obligation ceases to apply	(3) Subsection (2) ceases to apply on the day on which the Minister approves the amount of the deposit under paragraph 16(3)(a).
Calculation of interest	(4) Interest accumulates on any portion of a deposit not paid by the day referred to in subsection (1) or (2), at the prime rate plus two per cent, calculated daily from the day referred to in subsection (1) or (2), as the case may be, to the day before the day of the deposit.
Latest date for deposit	(5) Each body mentioned in subsection (1) or (2) shall, either directly or through a third party, deposit to its trust fund maintained under subsection 9(1), no later than 30 days after the date of the decision of the Governor in Council under section 15, the applicable amount referred to in subsection (1) or (2) plus an amount, if any, equal to the interest.
Withdrawals from trust funds	**11.** (1) Only the waste management organization may withdraw moneys from a trust fund maintained under subsection 9(1).
Condition for withdrawals	(2) The waste management organization may make withdrawals only for the purpose of implementing the approach that the Governor in Council selects under section 15 or approves under subsection 20(5), including avoiding or minimizing significant socio-economic effects on a community's way of life or on its social, cultural or economic aspirations.
First withdrawal	(3) The waste management organization may make the first withdrawal only for an activity in respect of which a construction or operating licence has, after the date of the decision of the Governor in Council under section 15, been issued under section 24 of the *Nuclear Safety and Control Act*.
Ministerial approval	(4) If the Minister is of the view that the waste management organization has withdrawn moneys from a trust fund contrary to subsection (2) or (3), the Minister may require the Minister's prior approval in respect of any future withdrawal from a trust fund by the waste management organization.

NUCLEAR FUEL WASTE ACT	
49-50-51 Elizabeth II Chapter 23 (cont'd)	
	STUDY BY WASTE MANAGEMENT ORGANIZATION
Study within three years	**12.** (1) Within three years after the coming into force of this Act, the waste management organization shall submit to the Minister a study setting out (a) its proposed approaches for the management of nuclear fuel waste, along with the comments of the Advisory Council on those approaches; and (b) its recommendation as to which of its proposed approaches should be adopted.
Methods to manage nuclear fuel waste	(2) Each of the following methods must be the sole basis of at least one approach: (a) deep geological disposal in the Canadian Shield, based on the concept described by Atomic Energy of Canada Limited in the *Environmental Impact Statement on the Concept for Disposal of Canada's Nuclear Fuel Waste* and taking into account the views of the environmental assessment panel set out in the *Report of the Nuclear Fuel Waste Management and Disposal Concept Environmental Assessment Panel* dated February 1998; (b) storage at nuclear reactor sites; and (c) centralized storage, either above or below ground.
Technical description, region	(3) The study must include a detailed technical description of each proposed approach and must specify an economic region for its implementation.
Comparison of risks, etc.	(4) Each proposed approach must include a comparison of the benefits, risks and costs of that approach with those of the other approaches, taking into account the economic region in which that approach would be implemented, as well as ethical, social and economic considerations associated with that approach.
Services to certain owners of waste	(5) Each proposed approach must include a description of the nuclear fuel waste management services to be offered by the waste management organization under section 7.
Implementation plan	(6) Each proposed approach must include an implementation plan setting out, as a minimum, (a) a description of activities; (b) a timetable for carrying out the approach; (c) the means that the waste management organization plans to use to avoid or minimize significant socio-economic effects on a community's way of life or on its social, cultural or economic aspirations; and (d) a program for public consultation.
Consultation	(7) The waste management organization shall consult the general public, and in particular aboriginal peoples, on each of the proposed approaches. The study must include a summary of the comments received by the waste management organization as a result of those consultations.
Financial aspects	**13.** (1) The study must set out, with respect to each proposed approach, a formula to calculate the annual amount required to finance the management of nuclear fuel waste. The report must explain the assumptions behind each term of the formula. The formula must include the following terms: (a) the estimated total cost of management of nuclear fuel waste, which must take into account natural or other events that have a reasonable probability of occurring; (b) the estimated rate of return on the trust funds maintained under subsection 9(1); (c) the life expectancy of the nuclear reactors of each nuclear energy corporation and of Atomic Energy of Canada Limited; and (d) the estimated amounts to be received from owners of nuclear fuel waste, other than nuclear energy corporations and Atomic Energy of Canada Limited, in return for services of management of nuclear fuel waste.

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Respective percentages	(2) The study must set out, with respect to each proposed approach, the respective percentage of the estimated total cost of management of nuclear fuel waste that is to be paid by each nuclear energy corporation and Atomic Energy of Canada Limited, and an explanation of how those respective percentages were determined.
Financial guarantees	(3) The study must set out the form and amount of any financial guarantees for the management of nuclear fuel waste that have been provided by the nuclear energy corporations and Atomic Energy of Canada Limited under the *Nuclear Safety and Control Act*.
Minister may consult public	**14.** (1) The Minister may engage in such consultations with the general public on the approaches set out in the study as the Minister considers necessary.
Revision of study	(2) If the Minister is of the opinion that the study fails in a significant way to meet the requirements of sections 12 and 13, the Minister shall direct the waste management organization to revise the relevant portions of it and submit the revised study to the Minister within the period that the Minister specifies.
Decision of Governor in Council	**15.** The Governor in Council, on the recommendation of the Minister, shall select one of the approaches for the management of nuclear fuel waste from among those set out in the study, and the decision of the Governor in Council shall be published in the *Canada Gazette*.
Obligation to submit annual reports	REPORTS BY WASTE MANAGEMENT ORGANIZATION **16.** (1) The waste management organization shall, within three months after the end of each fiscal year of the organization, submit to the Minister a report of its activities for that fiscal year.
Contents of annual report after section 15 decision	(2) Each annual report after the date of the decision of the Governor in Council under section 15 must include (a) the form and amount of any financial guarantees that have been provided during that fiscal year by the nuclear energy corporations and Atomic Energy of Canada Limited under the *Nuclear Safety and Control Act* and relate to implementing the approach that the Governor in Council selects under section 15 or approves under subsection 20(5); (b) the updated estimated total cost of the management of nuclear fuel waste; (c) the budget forecast for the next fiscal year; (d) the proposed formula for the next fiscal year to calculate the amount required to finance the management of nuclear fuel waste and an explanation of the assumptions behind each term of the formula; and (e) the amount of the deposit required to be paid during the next fiscal year by each of the nuclear energy corporations and Atomic Energy of Canada Limited, and the rationale by which those respective amounts were arrived at.
Minister's approval of formula and deposits	(3) The formula referred to in paragraph (2)(d) and the amount of each deposit referred to in paragraph (2)(e) are subject to the approval of the Minister when proposed in (a) the first annual report after the date of a decision of the Governor in Council under section 15 or subsection 20(5); and (b) the first annual report after the issuance, under section 24 of the *Nuclear Safety and Control Act*, of a construction or operating licence for an activity to implement the approach that the Governor in Council selects under section 15 or approves under subsection 20(5).
Grounds for refusing to approve	(4) If the Minister (a) is not satisfied that the formula referred to in paragraph (2)(d) will provide sufficient funds to implement the approach that the Governor in Council selects under section 15 or approves under subsection 20(5), or

NUCLEAR FUEL WASTE ACT	
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	(b) is not satisfied that the amount of each deposit referred to in paragraph (2)(e) is consistent with the formula referred to in paragraph (2)(d), the Minister shall refuse to give the approval referred to in subsection (3) and shall direct the waste management organization to revise the relevant portions of the annual report and submit the revised annual report to the Minister within 30 days.
Obligation to deposit	**17.** (1) Each nuclear energy corporation and Atomic Energy of Canada Limited shall, either directly or through a third party, deposit to its trust fund maintained under subsection 9(1) its respective deposit specified in the annual report (a) if the Minister's approval under subsection 16(3) is not required, within 30 days after the annual report is submitted to the Minister under subsection 16(1); or (b) if the Minister's approval under subsection 16(3) is required, within 30 days after the date of that approval.
Extension of time	(2) Notwithstanding subsection (1), the Governor in Council may, on request by a nuclear energy corporation made before the expiration of the 30 day period referred to in that subsection, authorize the nuclear energy corporation to defer by one year all or part of its deposit required by that subsection, if the Governor in Council is of the opinion that the public interest requires that that money be used instead to repair the damage caused by an event that is not attributable to the corporation and is extraordinary, unforeseen and irresistible.
Triennial report	**18.** The annual report of the waste management organization for its third fiscal year after the fiscal year in which a decision is made by the Governor in Council under section 15, and for every third fiscal year after that, in this Act called the "triennial report", must include (a) a summary of its activities respecting the management of nuclear fuel waste during the last three fiscal years, including an analysis of any significant socio-economic effects of those activities on a community's way of life or on its social, cultural or economic aspirations; (b) its strategic plan for the next five fiscal years to implement the approach that the Governor in Council selects under section 15 or approves under subsection 20(5); (c) its budget forecast for the next five fiscal years to implement the strategic plan; (d) the results of its public consultations held during the last three fiscal years with respect to the matters set out in paragraphs (a) and (b); and (e) the comments of the Advisory Council on the matters referred to in paragraphs (a) to (d).
Minister's statement	**19.** The Minister shall, within 90 days after receiving a report, issue a public statement regarding the report.
Tabling of reports in Parliament	**19.1** The Minister shall cause a copy of each report to be laid before each House of Parliament within the first fifteen sitting days of that House after the Minister has received the report.
	CHANGE IN APPROACH
New approach – technical difficulty	**20.** (1) If the waste management organization is unable, for technical reasons beyond its control, to implement the approach that was selected by the Governor in Council under section 15, the waste management organization shall so report in its triennial report and shall, in that report, propose a new approach.
New approach – technical innovation	(2) If a new technological method is developed that has been the subject of a scientific and technical review by experts from international governmental organizations that deal with nuclear matters and has received their support, the waste management organization may propose, in its triennial report, a new approach for the management of nuclear fuel waste that is based on that new method.

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Application of other provisions	(3) Subsections 12(3) to (7) and sections 13 and 14 apply, with such modifications as the circumstances require, in respect of an approach proposed under subsection (1) or (2). The approach must be accompanied by the comments of the Advisory Council on that approach.
Submission to Governor in Council	(4) If the Minister is satisfied that the new approach referred to in subsection (1) or (2) is technically and economically feasible in Canada, the Minister shall submit the new approach to the Governor in Council.
Decision of Governor in Council	(5) The Governor in Council may, on the recommendation of the Minister, approve an approach proposed under subsection (1) or (2), in which case the decision of the Governor in Council shall be published in the *Canada Gazette*.
	WITHDRAWAL BY BENEFICIARY
Withdrawals from trust funds	**21.** Notwithstanding subsection 11(1), the Governor in Council may, on the recommendation of the Minister, authorize a beneficiary of a trust fund to withdraw all or part of the balance in the trust fund if (a) the Governor in Council has approved an approach under subsection 20(5) and the total balance in the trust funds exceeds the estimated total cost of implementing that approach; or (b) the waste management organization has completed the implementation of an approach that the Governor in Council selected under section 15 or approved under subsection 20(5).
	RECORDS, BOOKS AND FINANCIAL STATEMENTS
Records and books to be kept	**22.** (1) The waste management organization, every nuclear energy corporation and Atomic Energy of Canada Limited, as well as every financial institution that holds a trust fund, shall keep, at its place of business in Canada, records, books of account and other documents for at least six years after the end of the fiscal year to which they relate, in such form and containing such information as will enable the verification of the accuracy and completeness of the information that is required to be submitted or provided to the Minister under this Act.
False entries, omissions	(2) No person shall make a false entry, or fail to make an entry, in a record, book of account or other document required to be kept under subsection (1).
WMO financial statements	**23.** (1) The waste management organization shall provide the Minister, within three months after the end of each fiscal year of the organization, with financial statements audited at its own expense by an independent auditor.
Trust fund financial statements	(2) Every financial institution that holds a trust fund shall provide the Minister and the waste management organization, within three months after the end of each fiscal year of the trust fund, with financial statements relating to that trust fund, audited at its own expense by an independent auditor.
	DOCUMENTS TO BE MADE PUBLIC
Documents to be made public	**24.** The waste management organization shall make available to the public (a) the study, reports and financial statements that it is required to submit to the Minister under this Act, simultaneously with submitting them to the Minister; and (b) financial statements provided to the waste management organization under subsection 23(2), as soon as practicable.

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	INSPECTION OF RECORDS AND BOOKS
Auditors	**25.** (1) The Minister may designate as an auditor for the purposes of this Act any person that the Minister considers to be qualified.
Powers of auditors	(2) For the purpose of ensuring compliance with this Act, an auditor may, during normal business hours, (a) enter any premises of a body referred to in subsection 22(1), after having given reasonable advance notice to the person in charge of the premises; and (b) inspect, make copies of, and take extracts from, any records, books of account and other documents that the auditor believes on reasonable grounds are required by subsection 22(1) to be kept.
Designation to be produced	(3) An auditor shall, if so requested either before or after entering any premises under this section, produce to the person in charge of the premises evidence of the auditor's designation by the Minister.
Duty to assist auditor	**26.** (1) Every person shall give all reasonable assistance to an auditor.
Prohibitions	(2) No person shall obstruct or hinder an auditor, or make a false or misleading statement, either orally or in writing, or provide false or misleading information, to an auditor.
	OFFENCES AND PUNISHMENT
Failure to deposit amounts	**27.** (1) If a nuclear energy corporation or Atomic Energy of Canada Limited fails to comply with subsection 10(5) or section 17, it is guilty of an offence and liable on summary conviction to a fine not exceeding $300,000 for each day on which the offence is committed or is continued.
Court order	(2) If a body is convicted under subsection (1), the court may, in addition to any punishment imposed under that subsection, order the body to deposit to its trust fund, on or before the date fixed by the court, the amount that it failed to deposit as required, plus interest on that amount at the prime rate plus two per cent calculated from the day on which the amount was required to have been deposited.
Failure to comply with court order	(3) If a body fails to comply with an order made under subsection (2), it is guilty of an offence punishable on summary conviction and liable to a fine equal to twenty per cent of the aggregate amount set out in that order.
Failure to submit study	**28.** (1) If the waste management organization fails to submit the study of its proposed approaches within the period set out in subsection 12(1), it is guilty of an offence and liable on summary conviction to a fine not exceeding $300,000 for each day on which the offence is committed or is continued.
Failure to submit revised study, annual report	(2) If the waste management organization fails to comply with a direction of the Minister made under subsection 14(2), or fails to submit the report of its activities within the period set out in subsection 16(1), it is guilty of an offence and liable on summary conviction to a fine not exceeding $100,000 for each day on which the offence is committed or is continued.
Failure to submit revised annual report	(3) If the waste management organization fails to comply with a direction of the Minister made under subsection 16(4), it is guilty of an offence and liable on summary conviction to a fine not exceeding $50,000 for each day on which the offence is committed or is continued.

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Withdrawals, making documents public	(4) If the waste management organization withdraws moneys from a trust fund without the Minister's approval where that approval is required under subsection 11(4), or fails to comply with section 24, it is guilty of an offence and liable on summary conviction to a fine not exceeding $100,000.
Auditors	(5) Every person who contravenes section 26 is guilty of an offence and liable on summary conviction to a fine not exceeding $100,000.
Other offences	(6) Every person who contravenes any other provision of this Act is guilty of an offence and liable on summary conviction to a fine not exceeding $50,000.
Offence by employee or agent	**29.** In a prosecution for an offence under this Act, it is sufficient proof of the offence to establish that it was committed by an employee or agent of the accused, whether or not the employee or agent is identified or has been prosecuted for the offence.
Due diligence	**30.** No person shall be found guilty of an offence under this Act if it is established that the person exercised all due diligence to comply with this Act or to prevent the commission of the offence.
Time limit for prosecution	**31.** Proceedings in respect of an offence under this Act may be instituted within but not later than two years after the time when the subject matter of the proceedings arose or the Minister became aware of the subject matter of the proceedings.
	COMING INTO FORCE
Coming into force	***32.** This Act comes into force on a day to be fixed by order of the Governor in Council. *[Note: Act in force November 15, 2002, see SI/2002-139.]

Appendix 3 / Nature of the Hazard

In order to understand the nature of the inherent hazard posed by used nuclear fuel which will need to be addressed by any management approach, the NWMO sought insight from a variety of specialists as well as interested citizens. A diversity of views has been expressed over the course of the NWMO's study, a diversity which tends to mirror that expressed internationally when this issue is discussed. In the pages which follow, the NWMO outlines its understanding of the nature of the hazard as the underpinning for its recommendation on a management approach. The discussion begins with an overview of some key facts, the interpretation of these facts by a multi-disciplinary group convened by the NWMO for this purpose, and concludes with a statement by the NWMO. The NWMO encourages learning and debate to continue to further develop understanding of the nature of the hazard posed by used nuclear fuel.

Some Key Facts

1. Canadian Used Nuclear Fuel – Characteristics

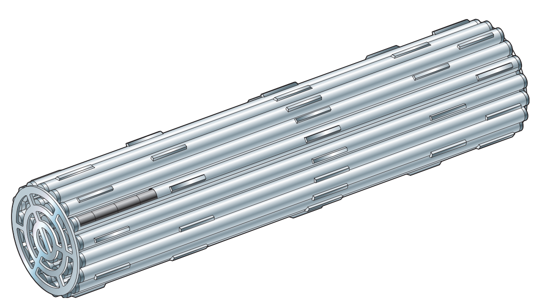
Most of the used nuclear fuel in Canada consists of used fuel which is generated at commercial nuclear power reactors in Ontario, Québec and New Brunswick. These 'CANDU' (Canadian Deuterium Uranium) reactors produce used fuel that is specific to this technology. There are also very small quantities of used fuel from research and isotope-producing reactors in Canada (*Asking the Right Questions?*, NWMO 2003). In many respects, these other nuclear fuel types are similar to CANDU fuel and are commonly used at other research facilities around the world. In the very near future, other fuel types may be introduced in Canada. For example, some Canadian nuclear utilities have proposed slight modifications to the composition of nuclear fuel through proposals to use slightly enriched uranium.

In a nuclear-powered electricity generating station, heat is produced by fission. Fission occurs within a fuel bundle when a neutron is absorbed by certain heavy elements (such as uranium-235 or plutonium-239). The characteristics and radionuclide content of used CANDU fuel for long-term management has been described in several reports such as AECL (1994) and Tait et al. (2000).

In the CANDU system used in Canada, each fuel bundle contains about 19 kg of natural uranium in the form of high-density uranium dioxide ceramic pellets. These pellets are sealed inside zirconium alloy tubes, about 0.5m long, arranged in a circular array 10 cm in diameter (see Figure A3-1). Energy is created in the nuclear reactor through the splitting of uranium atoms (fission) in a controlled chain reaction and the heat this process generates. This heat is removed by passing heavy water over the many bundles in the reactor. The heavy water then passes through boilers which transfer the heat to ordinary water, creating steam. The steam drives a turbine generator, producing electricity.

When an atom is split and neutrons are released, one neutron goes on to split another atom, and so on, keeping the nuclear reaction going. As this process continues, the concentration of fission products and actinides produced as a result of the nuclear reaction increases. The nuclear reaction begins to be impeded. At this stage, after about 12 to 18 months, the fuel is removed from the reactor both because of this build-up of fission products and actinides and the depletion of the fissionable material.

Figure A3-1 CANDU Fuel Bundle



Before entering the nuclear reactor, CANDU fuel (unirradiated or fresh fuel) consists primarily of ceramic uranium dioxide pellets. These pellets are composed of natural uranium which is approximately 99.28 percent uranium-238 and 0.72 percent uranium-235 (NWMO 2003). After leaving the nuclear reactor CANDU fuel (irradiated or used fuel) consists of approximately 98.58 percent uranium-238, 0.23 percent uranium-235, 0.27 percent plutonium-239 and very small amounts of hundreds of other radioactive fission products and actinides (see Table A3-1).

When the used fuel is removed from the reactor, it is highly radioactive. The radioactivity decreases substantially with time due primarily to the decay of short-lived radionuclides. The radioactivity of used fuel (Bq/kg U) decreases to about one percent of its initial value after one year, decreases to about 0.1 percent after 10 years and decreases to about 0.01 percent after 100 years (AECL 1994). After approximately one million years, the radioactivity in used fuel approaches that of natural uranium (AECL 1994; NWMO 2003; McMurry et al. 2003).

The fact that the total radioactivity of used fuel becomes comparable to the total radioactivity associated with a natural uranium ore deposit after a million years is considered by some people to be a useful benchmark. The total radioactivity of a used CANDU fuel bundle as a function of time out of reactor is illustrated in Figure A3-2.

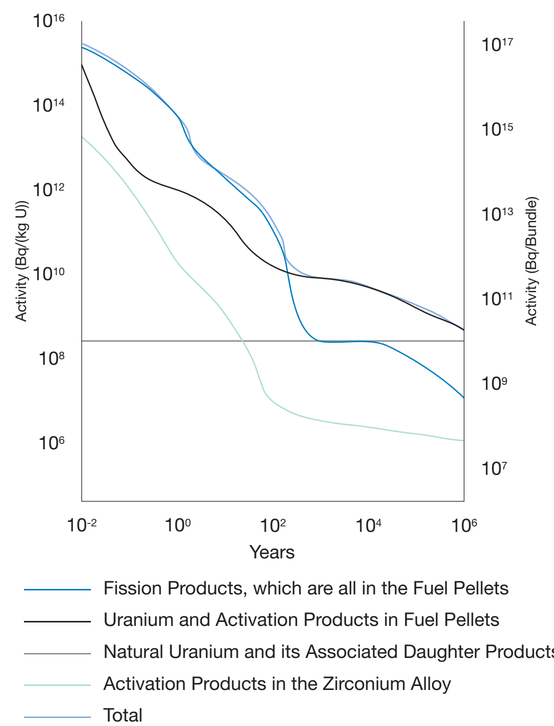
Radiotoxicity must also be considered. Note that the radiotoxicity of used fuel also becomes comparable to that of natural uranium ore on a one million year time frame.

Much of the emitted radiation is absorbed as heat by the fuel and surrounding materials. When a bundle is removed from the reactor, the heat output is about 37,000 watts (AECL 1994). The heat output drops to 73 watts after one year, five watts after 10 years and one watt after 100 years. After about 200,000 years, the decay heat from used fuel begins to approach that of natural uranium (McMurry et al. 2003).

Table A3-1 Composition of Fresh and Used CANDU Natural Uranium

COMPONENT	COMPOSITION OF UNIRRADIATED OR FRESH FUEL, %	COMPOSITION OF IRRADIATED OR USED FUEL, %
Uranium-235	0.72	0.23
Uranium-236	0	0.07
Uranium-238	99.28	98.58
Plutonium-239	0	0.25
Plutonium-240	0	0.10
Plutonium-241	0	0.02
Plutonium-241	0	0.01
Fission products	-	0.74

Figure A3-2 Total Activity of Used CANDU Fuel as a Function of Time Out of Reactor



2. Canadian Radiation Protection Regulations and Licences

The typical sources of radiation exposure are illustrated in Figure A3-3. They include radon gas from the earth's crust, radioactivity in the air, food and water, cosmic radiation and medical exposures such as dental x-rays.

The Canadian Nuclear Safety Commission (CNSC) public dose limit is the critical benchmark for public radiological safety analyses. The CNSC, which is responsible for regulating the use of nuclear materials, has set an annual radiation dose limit for members of the public of 1 mSv in one calendar year from the combined exposure to all activities which may result in radiation exposure, excluding natural background radiation and medical treatments (Radiation Protection Regulations under the *Nuclear Safety and Control Act*). For comparison, the average annual background radiation dose to members of the public in Canada from natural sources is approximately 1.7 mSv (R. Grasty et al. 2004). The total average annual background radiation dose to members of the public from natural and man made (anthropogenic) sources combined is approximately 3 mSv (Sutherland 2003).

The CNSC dose limit for nuclear energy workers has been set at the higher limit of 100 mSv in 5 years with an average of 20 mSv per year and an annual maximum exposure of 50 mSv.

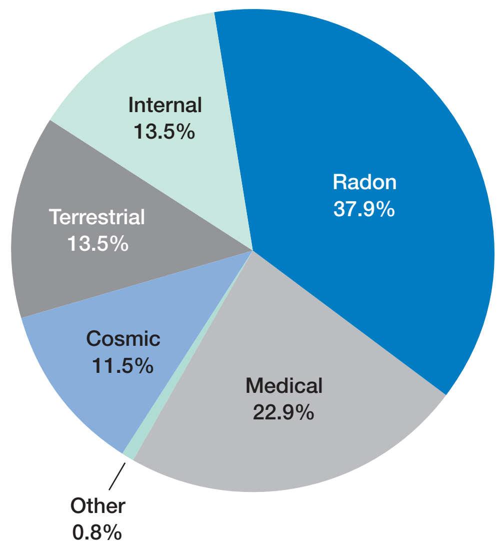
The CNSC's *Nuclear Substances and Radiation Devices Regulations* for uranium-238 requires a licence for possessing more than 1 x 10^7 Bq of uranium-238 in a non-dispersible form, which is equivalent to approximately one kg of uranium.

Measuring Radiation – Some Definitions

Bq or Becquerel
Standard international unit of radioactivity in a material reflecting the rate of decay of one atom per second.

Sv or Sievert
Standard international unit that indicates the biological damage caused by radiation. The biological damage depends on the type and energy of the radiation.

Figure A3-3 **Sources of Background Radiation Exposure in Canada**



Reference: Tammemagi, Hans and David Jackson, "Unlocking the Atom: the Canadian Book on Nuclear Technology". Hamilton: McMaster University Press, 2002.

3. Main Hazards

3.1 Radiotoxicity and Chemical Toxicity of Used Nuclear Fuel

Used nuclear fuel is a potential source of both external radiation and internal exposure to humans and the natural environment. The health effects from exposure to radiation have been studied over the years and documented in numerous publications such as BEIR (1990), ICRP (1991) and UNSCEAR (2000), which form the foundation for the development of international standards and regulatory regime. This work was summarized for the NWMO by Sutherland (2003). There is, however, some on-going debate on the potential biological effects of radiation on humans and non-human biota, and the health risks and dose models associated with low doses (e.g., see ECRR 2003). In particular, there is on-going debate on whether there are potential benefits from low doses of radiation (hormesis), whether the linear-no-threshold hypothesis for calculating risk is overly conservative, and whether or not regulations set to protect humans are sufficient to protect non-human biota.

The linear-no-threshold hypothesis is a conservative set of assumptions on which the

Table A3-2 Canadian Drinking Water Guidelines – Maximum Acceptable Concentration (Ref. Health Canada, April 2004)

RADIONUCLIDE	HALF LIFE (years)	INGESTION DOSE CONVERSION FACTOR (Sv/Bq)	MAXIMUM ACCEPTABLE CONCENTRATION (Bq/L)
Uranium-235	704,000,000	3.8×10^{-8}	4[a]
Uranium-238	4,470,000,000	3.6×10^{-8}	4[a]
Plutonium-239	24,100	5.6×10^{-7}	0.2
Radium-226	1,600	2.2×10^{-7}	0.6
Cesium-137	30.2	1.3×10^{-8}	10
Carbon-14	5,730	5.6×10^{-10}	200
Iodine-129	16,000,000	1.1×10^{-7}	1

[a] Note, the MAC for uranium based on chemical toxicity is 0.02 mg/L or about 0.5 Bq/L.

International Atomic Energy Agency's (IAEA) safety standards, the International Committee for Radiological Protection's (ICRP) recommendations, and CNSC regulatory oversight are based. The assumption is made that there are health risks associated with any exposure to radiation, even though it has not been proven that low doses are harmful (Sutherland 2003). This assumption may lead to an over-estimate of harm. However, it is considered the most defensible assumption on which to base safety standards by these international and Canadian authorities.

As part of the continuing debate, a report recently released by the U.S. National Academies' National Research Council supports the linear no-threshold (LNT) model of radiation health effects (BEIR June 2005). Also released in 2005 was the largest epidemiological study of low-dose radiation risk ever conducted. Carried out by the International Agency for Research on Cancer, the "International Collaborative Study" (IARC 2005) also appears to support existing radiation protection standards that assume even low doses (nuclear worker level doses, 19 mSv on average used in the study) can be harmful.

The hazard associated with used nuclear fuel from ingestion (for instance as dissolved in water) or inhalation (from dispersion in the air) depends on the exposure pathway, the dose associated with each radionuclide and the time the used nuclear fuel has been out of the reactor. A common index of radiotoxicity is based on the dose or risk calculated from ingestion (Mehta et al. 1991; OECD 2004). Similarly, drinking water guidelines are usually based on the water ingestion pathway (2 L/day), dose conversion factors for individual radionuclides and a dose limit set at 10 percent of the public dose limit (0.1 mSv in a calendar year).

Health Canada Guidelines for Canadian Drinking Water Quality were published in April 2004. The Health Canada maximum acceptable concentration (MAC) for selected radionuclides which are important in used nuclear fuel is listed in Table A3-2. The principal chemical in used fuel is uranium and the MAC for uranium is limited by its chemical toxicity value of 0.02 mg/L which corresponds to a radionuclide concentration of about 0.5 Bq/L.

The radiotoxicity analysis for used CANDU fuel suggests that this material is a potential internal exposure health risk for more than one million years (Mehta et al. 1991; AECL 1994). Similar analysis for used pressurized water reactor (PWR) fuel with enriched uranium-235 suggests that the radiotoxicity of used fuel becomes equal to the equivalent uranium ore after about 130,000 years (IAEA 2004). Other analysis suggests the time period is between 500,000 and one million years (OECD 2004).

3.2 External Radiation from Used Nuclear Fuel

The external radiation field from a CANDU bundle depends on time out of reactor and exposure distance from the fuel, which is typically measured from 0.3 to one metre from the source (Sutherland 2003). External radiation fields for various fuel ages are listed in Table A3-3 (Sutherland 2003). Exposure time to reach the public radiation dose limit of 1 mSv in a calendar year is also provided.

The analysis in Table A3-3 indicates that at 50 years, the external radiation dose from unshielded used nuclear fuel would present a significant health risk. At a dose rate of 1,150 mSv/h, unshielded nuclear fuel would give a potentially fatal dose of 5 Sv after about four hours of exposure. While the external radiation from used fuel declines rapidly with the passage of time, it could still be considered significant from a public dose perspective far into the future since exposure to million-year old fuel (or unirradiated fuel for that matter) could potentially reach the public dose limit of 1 mSv/a after about 110 hours.

4. Longevity

Based on the above discussion, one could conclude that used nuclear fuel poses a hazard which needs to be managed for one million years or more.

Discussion – Results of an NWMO Workshop

A workshop involving 16 specialists knowledgeable on various technical, environmental, health, social and ethical aspects of used nuclear fuel addressed the question "What is the nature of the hazard from used nuclear fuel?." After considering the information described above, workshop participants prepared a statement which is included here, and reproduced in the box following, as an additional component of the NWMO's description of the nature of the hazard.

Table A3-3 External Radiation from Used CANDU Fuel as a Function of Time

AGE OF USED CANDU FUEL (years)	UNSHIELDED EXTERNAL RADIATION FIELD AT 0.3 m (mSv/h)	EXPOSURE TIME TO REACH PUBLIC DOSE LIMIT OF 1 mSv/a
50	1,150	3 seconds
100	360	10 seconds
200	37	97 seconds
500	0.82	1.2 hours
1,000,000	0.009	110 hours

Figures shown for an average burn-up of 7,800 MW days per tonne of uranium.

A Participants' Statement on Characterizing the Hazard of Used Nuclear Fuel

A workshop addressing the question "what is the nature of the hazard from used nuclear fuel" was held in Toronto on February 10, 2005. The workshop involved 16 experts and other persons knowledgeable on various technical, environmental, health, social and ethical aspects of used nuclear fuel. This statement is the result of that workshop.

The Context

Note: This short section is written to reflect the wide-ranging discussion during the first session of the workshop in the morning, in so far as it provides context for the statement. Topics raised included:

Participants had differing views on the role of nuclear power in Canada.

Management solutions need to take account of possible changes in technology over time.

Prior informed consent is important to apply, including for Aboriginal communities.

There are three lines of inquiry when it comes to understanding the hazard. These are:

- *What is the inherent hazard of used nuclear fuel?*
- *How dangerous is it to human health and the environment?*
- *How can NWMO recommendations best protect human health and the environment from the hazards of used nuclear fuel?*

Inherent Hazard

Hazard can be considered generally as a source of danger or a possibility of being harmed. The inherent hazards of used nuclear fuel are primarily its radiotoxicity and its chemical toxicity.

Used nuclear fuel is inherently hazardous to human health and the environment. Maximum hazard exists in the short term, and while it does diminish over time, for practical purposes some hazard remains for an indefinite time.

The concept of indefinite time is in keeping with the premises of traditional knowledge and the need to ensure the health of all living beings. It reflects a recognition that there is scientific uncertainty.

There is a view among workshop participants that the containment and isolation of used nuclear fuel cannot be guaranteed for an indefinite period.

Pathways

The radiological hazard inherent in used nuclear fuel can negatively impact the health of humans, other organisms and ecosystems if it enters into the environment. It can then have impacts through external exposure to the body, or through internal exposure by lesions, ingestion or inhalation. The chemical hazard inherent in used nuclear fuel can impact humans, other organisms and ecosystems through dispersal and uptake into living organisms. Radiotoxicity and chemical toxicity depend on dose received.
The main potential pathways for internal exposure are through groundwater flow and subsequent entry into the food chain. A potential pathway for both external and internal exposure is through airborne transport of material.

Control and Protection

Used nuclear fuel needs to be contained and isolated as a response to the hazard it poses.

There remain different scientific interpretations of the health impact of low doses and dose rates of ionizing radiation. While experts differ over what may constitute a safe level of radiation exposure, it is consistent with international practice to act, in a conservative manner, as if there are health risks from any exposure to radiation.

Some experts say it may be useful to study the characteristics of natural uranium deposits to ensure long-term protection of life from the hazards of used nuclear fuel.

There is an established international system for radiation protection to regulate radiation exposure resulting from human activity. This has been used for several decades to protect workers and the public.

Participants suggest that NWMO make reference to the International Atomic EnergyAgency documentation of this system based on recommendations of the International Commission on Radiological Protection (ICRP) and scientific reviews carried out by the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR).

Participants suggest NWMO make reference to a table on external radiation from used nuclear fuel as a function of time. They further suggest that NWMO prepare some form of simple graphic information on potential health hazard from used nuclear fuel.

Some participants suggest that the NWMO make reference to recommendations of the European Committee on Radiation Risk (ECRR 2003) related to the health effects of ionizing radiation exposure at low doses for radiation protection purpose.

Some participants suggest that the NWMO make reference to the draft 2005Recommendations of the International Commission on Radiological Protection (ICRP).

Security

Security is required for used nuclear fuel because of the possibility that saboteurs could try to defeat the security measures of facilities and use the material to cause harm to people and the environment. Security concerns also relate to the diversion of used nuclear fuel toward the making of weapons.

Regulation, Standards and Oversight

Any approach for long-term management of used nuclear fuel will need to provide confidence that its implementation will meet or exceed regulatory requirements established by Canadian authorities, including the Canadian Nuclear Safety Commission, and it should be consistent with internationally recognized approaches. Canadian regulations generally follow international practices but Canadian law takes precedence.

Participants agree that the NWMO should include a short statement on the ethical and social framework which it has applied to its work, and on the perspectives of Aboriginal peoples.

Uncertainty

Much is known about the hazard associated with used nuclear fuel and its implications for long-term management approaches. However, given the long time periods involved, there are limitations to our knowledge and uncertainties associated with the environmental and human activity aspects of management approaches. A precautionary approach is appropriate.

The preceding statement, and an accompanying report, emerged from discussion among the following individuals:

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NWMO's Conclusion

Consistent with international standards and the regulatory regime governing management of used nuclear fuel in Canada, for the purposes of its study the NWMO has taken the position that used nuclear fuel will need to be contained and isolated from people and the environment essentially indefinitely.

The NWMO encourages learning and debate to continue to further develop understanding of the inherent nature of the hazard posed by used nuclear fuel. We recognize that international standards and domestic requirements may evolve with new learning. Any implementation plan for the long term management of used nuclear fuel will need to monitor evolution in understanding and/or requirements and be sufficiently adaptable to incorporate and respond to them. Any implementation plan will also need to include a substantial and continuing effort to increase the understanding of citizens on this issue.

References

AECL. 1994. Environmental impact statement on the concept for disposal of Canada's nuclear fuel waste. Atomic Energy of Canada Limited Report, AECL-10711, COG-93-1. Chalk River, Ontario.

BEIR. 1990. Health effects of exposure to low levels of ionizing radiation. Committee on the Biological Effects of Ionizing Radiation. National Research Council, National Academy Press. Washington, DC.

BEIR, 2005. Health Risks from Exposure to Low Levels of Ionizing Radiation: BEIR VII Phase 2 (2005). Board on Radiation Effects Research, The National Academies Press. Washington, DC.

ECRR. 2003. Recommendations of the European committee on radiation risk. The health effects of ionising radiation exposure at low doses for radiation protection purposes. Regulators' Edition.

Gierszewski, P., J. Avis, N. Calder, A. D'Andrea, F. Garisto, C. Kitson, T. Melnyk, K. Wei and L. Wojciechowski. 2004. Third case study – Postclosure safety assessment. Ontario Power Generation, Nuclear Waste Management Division Report 06819-REP-01200-10109-R00. Toronto, Ontario.

Government of Canada. 2000. Radiation protection regulations. Canada Gazette Part II, Vol. 134, No. 13, SOR/DORS/2000 203. 31 May 2000. Ottawa, Ontario.

Grasty, R., J.R. LaMarre. 2004. The annual effective dose from natural sources of ionising radiation in Canada. Radiation Protection Dosimetry 108(3), p.215-226.

IAEA. 2004. Implications of partitioning and transmutation in radioactive waste management. International Atomic Energy Agency Technical Report Series No. 435. Vienna, Austria.

IARC. 2005. Risk of cancer after low doses of ionising radiation – retrospective cohort study in 15 countries. British Medical Journal.

ICRP. 1991. 1990 recommendations of the International Commission on Radiological Protection. Annals of the ICRP 21(1 – 3). ICRP Publication 60. Pergamon Press, Oxford.

McMurry, J., D.A. Dixon, J.D. Garroni, B.M. Ikeda, S. Stroes-Gascoyne, P. Baumgartner and T.W. Melnyk. 2003. Evolution of a Canadian deep geologic repository: Base scenario. Prepared by Atomic Energy of Canada Limited. Ontario Power Generation, Nuclear Waste Management Division Report 06819-REP-01200-10092-R00. Toronto, Canada.

Mehta, K., G.R. Sherman and S.G. King. 1991. Potential health hazards of nuclear fuel waste and uranium ore. Atomic Energy of Canada Limited Report AECL 8407. Chalk River, Ontario.

NWMO. 2003. *Asking the Right Questions? The Future Management of Canada's Used Nuclear Fuel.*
(See www.nwmo.ca/askingtherightquestions)

NWMO. 2004. *Understanding the Choices. The Future Management of Canada's Used Nuclear Fuel.*
(See www.nwmo.ca/understandingthechoices)

OECD. 2004. The handling of timescales in assessing post-closure safety. Lessons learnt from the April 2002 Workshop in Paris, France. Organization for Economic Co-operation and Development, Nuclear Energy Agency Report NEA No. 4435, ISBN 92-64-02161-2. Paris, France.

Sutherland, J.K. 2003. Health aspects of high-level radioactive waste. Background Paper 3-2 prepared by Edutech Enterprises for the Nuclear Waste Management Organization.
(See www.nwmo.ca/backgroundpapers)

Tait, J.C., H. Roman and C.A. Morrison. 2000. Characteristics and radionuclide inventories of used fuel from OPG generating stations. Ontario Power Generation, Nuclear Waste Management Division Report 06819-REP-01200-10029-R00. Toronto, Ontario.

UNSCEAR. 2000. United Nations Scientific Committee on the Effects of Atomic Radiation. Sources and Effects of Ionizing Radiation. UNSCEAR 2000 Report to the General Assembly. United Nations. New York.

Appendix 4 / Status of Used Nuclear Fuel in Canada

In Canada, producers and owners of used nuclear fuel are responsible for its interim management. After seven to ten years in water-filled storage bays, used fuel bundles are transferred to dry storage facilities at the reactor sites.

The uranium mass of a CANDU fuel bundle is approximately 19.2 kilograms. As of December 31, 2004, Canada had 35,888 tonnes of uranium in its used nuclear fuel.

Electricity Generating Stations

Bruce Power operates six of eight reactors at the Bruce nuclear generating stations in Kincardine, Ontario. The company reported on March 21, 2005 that it had reached a tentative agreement with a negotiator appointed by the Province of Ontario for the potential restart of two additional units, one of which was shut down in October 1995, and the other in October 1997. Current operating licences for both Bruce A and Bruce B expire on March 31, 2009.

Ontario Power Generation Inc. (OPG) operates the Pickering nuclear generating stations in Pickering, Ontario. All four reactors at the Pickering B plant are in service. Estimated operating lives for these reactors range from 2013 to 2016. The current Pickering B operating licence expires on June 30, 2008.

Unit 4 at Pickering A was returned to service in September 2003. It had been shut down along with the other three Pickering A units in 1997. Unit 1 is planned to be returned to service in 2005. The pressure tubes at Pickering A were replaced between 1984 and 1993. As a result, OPG expects the operating life estimate for Units 1 and 4 to be extended to 2023. In August 2005, OPG announced that it would not refurbish Units 2 and 3 due to unexpected wear in the steam generators. The current operating licence for Pickering A expires on June 30, 2010.

Table A4-1 Storage of Used Nuclear Fuel as of December 31, 2004

Storage Location	Licensee	Bundles in Reactor(s)	Bundles in Wet Storage	Bundles in Dry Storage	Total Fuel Bundles
Bruce A	Bruce Power[1]	12,480	361,271		373,751
Bruce B	Bruce Power[1]	24,575	369,344	29,184	423,103
Pickering	OPG	36,744	382,332	135,927	555,003
Darlington	OPG	24,960	256,068		281,028
Douglas Point	AECL[2]			22,256	22,256
Chalk River	AECL[3]			4,853	4,853
Gentilly 1	AECL[4]			3,213	3,213
Gentilly 2	HQ	4,560	33,814	60,000	98,374
Pt. Lepreau	NBP	4,560	39,482	63,180	107,222
Whiteshell	AECL[5]			360	360
Total		**107,879**	**1,442,311**	**318,973**	**1,869,163**

1 OPG manages used fuel produced by Bruce Power which leases the Bruce reactors from OPG.
2 The Douglas Point Nuclear Generating Station in Kincardine, Ontario was shut down in 1986.
3 Chalk River Laboratories (CRL), near Deep River, Ontario is a nuclear research facility with test reactors, fuel inspection and other facilities. Most of the used fuel bundles in the CRL dry storage area are from the Nuclear Power Demonstration (NPD) reactor which was de-fueled in 1987. A quantity of non-standard fuel waste is also stored at the CRL.
4 Gentilly 1, at Becancour, Québec was shut down in 1977.
5 The dry storage facility at Whiteshell, Manitoba houses research reactor fuel rods and some used fuel bundles from the shutdown Douglas Point reactor.

OPG also operates four reactors at the Darlington nuclear generating station in Clarington, Ontario. The estimated operating life of these units ranges from 2018 to 2019. The current operating licence for Darlington expires on February 29, 2008.

Hydro-Québec operates one reactor at the Gentilly-2 nuclear generating station in Bécancour, Québec. The power plant is designed to operate until 2013. No decision has been taken on a company proposal to refurbish the plant, extending its life to 2035. The operating licence for Gentilly-2 expires on December 31, 2006.

NB Power Nuclear operates one reactor at the Point Lepreau nuclear generating station in Lepreau, New Brunswick. Its current operating licence expires on December 31, 2005. In July 2005, the Province of New Brunswick announced that it would proceed with the refurbishment of the Point Lepreau reactor beginning in 2008 and ending in 2009. The planned refurbishment of Point Lepreau could extend its service life for another 25 to 30 years beyond the refurbishment completion date.

The current inventory of used nuclear fuel in wet and dry storage at the nuclear reactor sites as of December 31, 2004 is listed in Table A4-1.

Projections of used fuel inventory in Canada can be made based on operational experience. When all of Canada's 22 CANDU reactors are operating, they generate about 16,000 MW and produce about 100,000 used fuel bundles per year, or about 6.25 bundles per MW year. The actual production of used fuel will depend on a number of factors such as reactor operational experience, decisions on refurbishment and life extension (e.g., Point Lepreau, Gentilly, Bruce A, Pickering A) and whether or not new reactors are constructed. Therefore, projections of used fuel inventory change as new information becomes available.

An estimate of the projected inventory of used fuel for each of the owners is given in Table A4-2. The original estimate was prepared in 2001 by the Joint Waste Owners for NWMO conceptual design and cost estimating purposes. The 2001 projected inventory assumed that the Pickering, Bruce and Darlington reactors in Ontario would operate 40 years, the Point Lepreau reactor in New Brunswick would operate 25 years, and the Gentilly reactor in Québec would operate 30 years. The total projected used fuel inventory was 3,557,451 bundles, which has been rounded up to 3.6 million bundles for conceptual design and cost estimating purposes.

In 2004, the Joint Waste Owners revised their projections based on a common 40-year average nuclear reactor life. This 2004 estimate is 3,665,094 fuel bundles or a rounded value of 3.7 million fuel bundles. The change in the reference scenario from about 3.6 million to 3.7 million fuel bundles (< 3%) would not have a significant impact on the conceptual designs for long-term management facilities. The larger value is more conservative from a design and cost perspective, but not materially different than the original estimate since the reference

Table A4-2 Projected Total Inventory of Used Nuclear Fuel

	Projected Total Used Fuel Inventory (number of bundles)	
Used Fuel Owner	**2001 Estimate**	**2004 Estimate**
Ontario Power Generation Inc.	3,274,431	3,274,412
Hydro-Québec	132,838	180,000
NB Power Nuclear	119,500	180,000
Atomic Energy of Canada Limited	30,682	30,682
Total	**3,557,451**	**3,665,094**
Total (rounded)	**3,600,000**	**3,700,000**

designs were prepared using the projected number of used fuel bundles rounded up to the nearest 100,000 bundles.

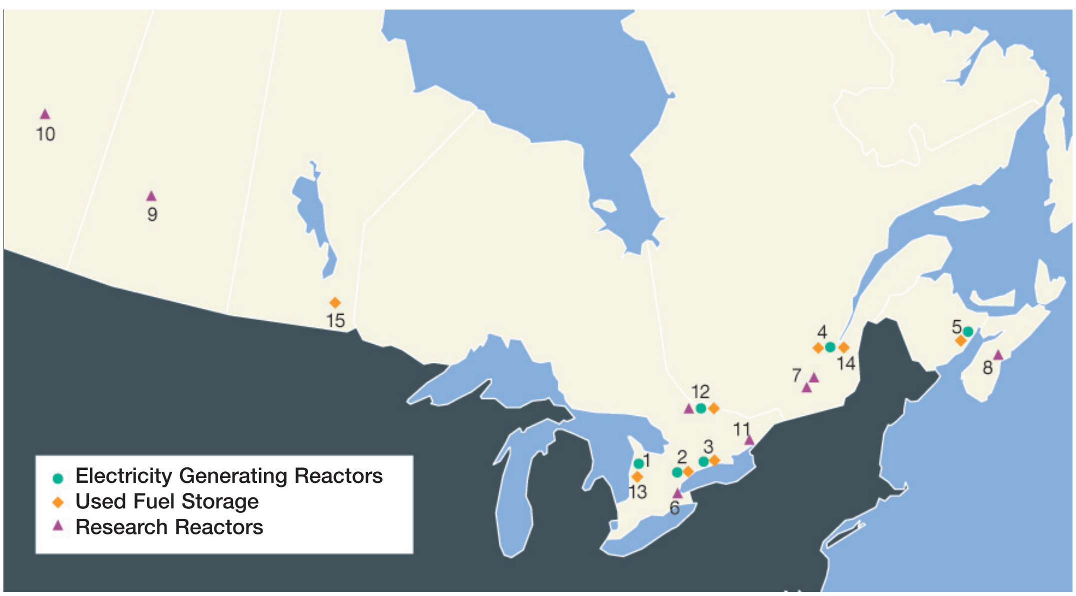
There continues to be uncertainty regarding the number of used fuel bundles that will eventually be produced in Canada. To address that uncertainty, the Joint Waste Owners have also prepared used fuel estimates for an average station life of 30 years (3.0 million bundles) and an average station life of 50 years (4.4 million bundles).

Research Reactors

Canada has a number of research and isotope-producing reactors. These include five SLOWPOKE reactors located at: École Polytechnique in Montréal, Dalhousie University in Halifax, Royal Military College in Kingston, the Saskatchewan Research Council in Saskatoon, and the University of Alberta in Edmonton. SLOWPOKE reactors, which use U-235 enriched fuel, can operate on one fuel charge for 20 to 40 years. The total mass of U-235 fuel in a SLOWPOKE reactor core is about one kilogram. Used fuel from some of these research reactors has been shipped to the AECL site at Chalk River, Ontario.

AECL has operated research reactors to support nuclear R&D and/or produce

Figure A4-1 **Nuclear Reactor Sites in Canada**



1. Bruce Nuclear Generating Station – Kincardine, ON
2. Pickering Nuclear Generating Station – Pickering, ON
3. Darlington Nuclear Generating Station – Clarington, ON
4. Gentilly 2 Nuclear Generating Station – Bécancour, PQ
5. Point Lepreau Nuclear Generating Station – Lepreau, NB
6. McMaster University – Hamilton, ON
7. École Polytechnique – Montréal, PQ
8. Dalhousie University – Halifax, NS
9. Saskatchewan Research Council – Saskatoon, SK
10. University of Alberta – Edmonton, AB
11. Royal Military College – Kingston, ON
12. AECL CRL – Chalk River, ON
13. AECL Douglas Point – Kincardine, ON
14. AECL Gentilly 1 – Bécancour PQ
15. AECL Whiteshell Labs – Pinawa, MB

medical isotopes since 1945. At Chalk River Laboratories (CRL), AECL operates the NRU, MAPLE 1 and MAPLE 2 production reactors, and a low-power ZED-2. The NRX reactor is shut down. Non-operating low-power reactors at CRL include PTR and ZEEP. AECL operated two reactors, WR-1 and SLOWPOKE Demonstrator (SDR) at its Whiteshell site in Manitoba. Both are shut down.

Used fuel from Canada's SLOWPOKE and AECL reactors is divided into about 70 different types, each with its own characteristics. AECL has long-term management strategies applicable to all used fuel arising from these research reactors.

McMaster University in Hamilton operates a pool-type reactor. Used fuel from this reactor is returned to its manufacturer in the United States.

The amount of used nuclear fuel from a research reactor, such as the SLOWPOKE, is typically about a kilogram or less, which is a very small amount compared to the approximately 19.2 kilograms of uranium in a single CANDU fuel bundle. Nevertheless, research reactor fuel is an important component of Canada's used fuel inventory and it will be incorporated into the long-term management approach.

Appendix 5 / Regulatory Framework

The legal and administrative arrangements governing nuclear energy have evolved considerably since the industry's inception immediately after World War II. The Government of Canada has legislative authority over the development and control of nuclear energy in Canada. The industry is regulated both through laws of general application and through specially focused regulations, policies and licence provisions. Consultation and cooperation among provincial, national and international agencies is essential to promote harmonized regulation and consistent national and international standards and achieve conformity with the measures of control and international obligations to which Canada has agreed concerning radioactive waste.

Federal Legislation

Canada has in place a comprehensive network of laws, regulations and policies that provide the legal basis for mitigation, preparedness and prudent risk management of nuclear installations and radioactive substances.

Nuclear Fuel Waste Act

The aim of the *Nuclear Fuel Waste Act* (*NFWA*) is to provide the necessary framework for choosing and then implementing a long-term management approach for nuclear fuel waste in Canada that is comprehensive, integrated and economically sound. It has five major sections addressing: the creation and function of the waste management organization; financing; the study produced by the waste management organization; reports, approvals and inspections; and offences and punishment. (See Appendix 2 for the *NFWA*.)

The *NFWA* requires the establishment of the NWMO to propose to the Government of Canada approaches, including its preference, for the long-term management of nuclear fuel waste and to implement the approved approach. The NWMO is to present its study to the Minister of Natural Resources Canada within three years of the act coming into force. The Minister may seek public comment on the study, or request the NWMO to undertake further work, before providing a recommendation to the government.

Once the government decides on the approach for long-term management of used nuclear fuel the NWMO is required to implement that approach. Changes with respect to reporting and financing take effect.

Nuclear Safety and Control Act

The Canadian Nuclear Safety Commission (CNSC) is the regulatory body established by the federal government to license nuclear facilities and to regulate the use of nuclear energy and materials to protect health, safety, security and the environment and to respect Canada's international commitments on the peaceful use of nuclear energy. The CNSC operates and enforces regulations under the *Nuclear Safety and Control Act* (*NSCA*). The CNSC is the nuclear energy and materials "watchdog" in Canada. The Commission is responsible for regulating nuclear power plants, nuclear research facilities and many uses of nuclear materials, including the use of radioisotopes for the treatment of cancer, and the operation of uranium mines and refineries.

The CNSC mandate involves:

- Regulating the development, production and use of nuclear energy in Canada;
- Regulating the production, possession and use of nuclear substances, prescribed equipment and prescribed information;
- Implementing measures respecting international control of the use of nuclear energy and substances, including measures respecting the non-proliferation of nuclear weapons; and
- Disseminating scientific, technical and regulatory information concerning the activities of the CNSC.

Requirements of Licensees

All current nuclear facilities – including provisions for nuclear waste management – must be licensed by the CNSC. The CNSC requires licence applicants to conduct detailed analyses of the anticipated effects on the environment, and on human health, safety and security of the proposed licensed activity. It also requires applicants to conduct a public information program that provides this information to persons living in the vicinity of the site in a clear and understandable manner.

As part of the review process, the CNSC evaluates the detailed submissions of the applicant, including the public information program. In addition, and to facilitate openness and transparency, the CNSC makes decisions on the licensing of major nuclear facilities through a public hearing process. The CNSC notifies and encourages individuals and organizations to attend public hearings, and to make submissions orally or in writing. Advance notice of the hearings is published in newspapers and notice of hearings and meetings is posted on the CNSC website (**www.nuclearsafety.gc.ca**). A detailed record of proceedings, including the reasons for decisions of the Commission, is made available to the public shortly after the proceedings. The CNSC also administers the *Nuclear Liability Act*, including designating nuclear installations and prescribing basic insurance to be carried by the operators.

To transport used nuclear fuel, a proponent (the consignor) must obtain a licence that contains, in addition to the information required by the Packaging and Transport of Nuclear Substances Regulations of the *Nuclear Safety and Control Act*, a detailed transportation security plan. The information required for the plan includes, but is not limited to:

- A threat assessment;
- Proposed security measures; and
- Arrangements for a response force.

Before a licence is issued, the security plan submitted with the licence application is reviewed by CNSC staff to ensure compliance with the regulations and a "best-practices" approach to the security arrangements.

CNSC Regulatory Documents

As the federal regulator, the CNSC executes licensing decisions made by the Commission or its designates and continually monitors licensees to ensure they comply with safety requirements that protect workers, the public, and the environment and uphold Canada's international commitments on the peaceful use of nuclear energy. The requirements are set out through the *NSCA*, its associated regulations, licences and directives provided by the CNSC. The CNSC also offers instruction, assistance and information on these requirements in the form of regulatory documents, such as policies, standards, guides and notices. Compliance is verified through inspections and reports.

CNSC Regulatory Policy P-290, Managing Radioactive Waste

Regulatory policies are documents that describe the philosophy, principles or fundamental factors which underlie the CNSC's approach to its regulatory mission. They provide direction to CNSC staff and information to stakeholders.

Regulatory Policy P-290 "Managing Radioactive Wastes" describes the philosophy that underlies the CNSC's approach to regulating the management of radioactive waste and the principles that are taken into account when making a regulatory decision concerning radioactive waste management. It is intended to promote the implementation of measures to manage radioactive waste so as to protect the health and safety of persons and the environment, provide for the maintenance of national security, and achieve conformity with measures of control and international obligations to which Canada has agreed; and to promote consistent national and international standards and practices for the management and control of radioactive waste.

When making regulatory decisions concerning the management of radioactive waste, the CNSC will consider the extent to which the owners of the waste have addressed the following principles:

- The generation of radioactive waste is minimized to the extent practicable by the implementation of design measures, operating procedures and decommissioning practices;

- The management of radioactive waste is commensurate with its radiological, chemical and biological hazard to the health and safety of persons and the environment and to national security;

- The assessment of future impacts of radioactive waste on the health and safety of persons and the environment encompasses the period of time when the maximum impact is predicted to occur;

- The predicted impacts on the health and safety of persons and the environment from the management of radioactive waste are no greater than the impacts that are permissible in Canada at the time of the regulatory decision;

- The measures needed to prevent unreasonable risk to present and to future generations from the hazards of radioactive waste are developed, funded and implemented as soon as reasonably practicable; and

- The transborder effects on the health and safety of persons and the environment that could result from the management of radio-active waste in Canada are not greater than the effects experienced in Canada.

CNSC Draft Regulatory Guide G-320, Assessing the Long-term Safety of Radioactive Waste Management

Regulatory guides are documents that indicate acceptable ways of meeting CNSC requirements as expressed in the Act, Regulations, regulatory standards or other legally-enforceable instrument. They provide guidance to licensees and other stakeholders.

The purpose of Draft Regulatory Guide G-320 "Assessing the Long-term Safety of Radioactive Waste Management" is to assist licensees and applicants assess the long-term safety of storage and disposal of radioactive wastes. Long-term safety assessments are used to give reasonable assurance that proposed plans for the long term management of radioactive waste are consistent with CNSC requirements for protecting the health and safety of humans and protecting the environment.

Draft Regulatory Guide G-320 sets out typical ways to assess the impacts that radioactive waste storage and disposal methods have on the environment and on the health and safety of people in the long term. It provides guidance on such matters as:

- Assessment methodologies, structure and approach;
- Level of detail of assessments;
- Confidence to be placed in assessment results;
- Applying radiological and non-radiological criteria;
- Defining critical groups for impact assessments;
- Selecting time frames for impact assessments;
- Setting post-decommissioning objectives;
- Long term care and maintenance considerations, and
- Use of institutional controls.

The approaches described are possible methods of providing reasonable assurance of long-term safety. They are not equally applicable to every assessment; licence applicants are expected to propose and justify their application of the guidance provided.

Compliance Verification

Confirmation of compliance with licences is managed within the CNSC's formal compliance verification program which includes promotion, verification and enforcement.

A compliance promotion program informs the regulated community of the rationale behind the regulatory regime and disseminates information about regulatory requirements and standards.

To verify compliance, the CNSC regularly evaluates the licensee's operations and activities, ensures that administrative controls are in place, reviews, verifies and evaluates information provided and evaluates any remedial action to ensure that incidents are avoided in the future. Routine inspections, evaluations and audits are supplemented by analysis of safety-significant events.

The CNSC uses a graduated approach to enforcement, commensurate with the risk or regulatory significance of the violation.

Canadian Environmental Assessment Act

Canadian laws of general application that are relevant to aspects of the management of used nuclear fuel include the *Canadian Environmental Assessment Act*. An environmental assessment is required prior to the initial issuance of licences by the CNSC that authorize activities involving nuclear substances. Since all of the aspects involved in managing nuclear waste, including interim and long-term storage and disposal and any transportation between, must be authorized through issuance of a CNSC licence, each of these aspects must be considered in the environmental assessment of the project. Certain projects, as defined by the Comprehensive Studies List Regulations, are required to be subject to a comprehensive study. The environmental assessment must be conducted "as soon as practicable in the planning stages and before irrevocable decisions are made."

Nuclear Liability Act

A fundamental component of sound risk management is to anticipate and prepare for potential damages to persons and property associated with major hazards. This is the essence of the precautionary approach. Canada's *Nuclear Liability Act* establishes a compensation and civil liability regime in the event of a nuclear accident with third-party consequences.

The Canadian Nuclear Safety Commission is the federal agency that is responsible for regulating and licensing nuclear activities in Canada. It determines which nuclear installations are covered under the *Nuclear Liability Act*, it sets the basic insurance requirements for designated installations, and it ensures that the operator maintains the appropriate insurance coverage through its licensing process. Nuclear facilities designated to be nuclear installations under the Act include nuclear power generating plants, research reactors, nuclear material processing plants, as well as facilities for managing used nuclear fuel as determined by the Canadian Nuclear Safety Commission.

The fundamental principles of the *Nuclear Liability Act* are as follows:

- Nuclear operators are absolutely and exclusively liable for nuclear damage resulting from the nuclear installation they operate;

- Nuclear operators must maintain mandatory financial security against the third-party nuclear damage that may result from the operation of their installations; and,

- There is a financial limit on the operator's liability as well as a limit on the time period over which a third party may make a nuclear damage claim.

Operators of all nuclear power plants designated under the *Nuclear Liability Act* by the Canadian Nuclear Safety Commission must maintain $75 million in mandatory insurance to cover third-party nuclear damages. The liability limit of smaller nuclear installations covered under the legislation is set to reflect their specific situations and risks.

Under the existing Act, the only acceptable financial cover for the operator's financial responsibility is private insurance through an approved insurer. Only one insurer, the Nuclear Insurance Association of Canada, has been approved by the Government of Canada to provide such insurance. The Nuclear Insurance Association of Canada is a pool of domestic and international insurers that have agreed to come together to provide the necessary insurance coverage for third-party nuclear damage under the Act. The pool provides the basic insurance specified by the Canadian Nuclear Safety Commission. In the event that the basic insurance is less than the full $75 million mandatory coverage under the *Nuclear Liability Act* (i.e. in the case of small facilities), the Government of Canada reinsures the difference between the basic insurance and the $75 million operator limit. The Government of Canada also reinsures certain risks that the insurance pool does not cover. The *Nuclear Liability Act* establishes a regime for handling claims in the event of a nuclear incident with third-party impacts.

The monetary limitation on liability for damages arising from accidents occurring at nuclear installations has been a source of some controversy for many years. Natural Resources Canada is presently leading a comprehensive review of the provisions of the *Nuclear Liability Act*, to identify possible revisions required to modernize the Act and bring it into line with prevailing international practices and standards.

Table A5-1 lists the key federal legislation that provides the overarching legal and administrative framework governing used nuclear fuel in Canada.

International Treaties and Conventions

Canada also participates actively in the conventions and standards development led by the United Nations' International Atomic Energy Agency (IAEA). The IAEA serves as the global focal point for nuclear cooperation, assisting member countries in planning for and using nuclear science and technology for various peaceful purposes.

Among other roles, the IAEA develops nuclear safety standards and, based on these standards, promotes the achievement and maintenance of high levels of safety in applying nuclear energy, as well as in protecting human health and the environment against ionizing radiation.

The IAEA also verifies, through its inspection system, that member countries comply with their commitments under the *Treaty on the Non-Proliferation of Nuclear Weapons* (*NPT*), to use nuclear material and facilities for peaceful purposes only. The verification approaches and measures utilized by the IAEA to verify that nuclear material is not diverted from peaceful uses to nuclear weapons or other nuclear explosive devices are commonly referred to as 'safeguards'.

While the *NPT* is the parent treaty for safeguards, important practical arrangements are contained in a hierarchy of other agreements. The safeguards commitments made by Canada under the *NPT* are detailed in:

- INFCIRC/164, Agreement between the Government of Canada and the International Atomic Energy Agency for the Application of Safeguards in Connection with the *Treaty on the Non-Proliferation of Nuclear Weapons* and

- INFCIRC/164/Add.1, the Protocol Additional to the Agreement between Canada and the IAEA for the Application of Safeguards in Connection with the *Treaty on the Non-Proliferation of Nuclear Weapons*.

In addition, facility specific details are provided in Subsidiary Arrangements and Facility Attachments which are binding between Canada and the IAEA. The Additional Protocol requires Canada to disclose extensive details on all its nuclear activities and allows the IAEA to carry out inspections at any location. The international obligations on Canada are implemented through the regulations associated with the *Nuclear Safety and Control Act* and associated licence conditions. The CNSC is responsible for implementing the Canada/IAEA safeguards agreement and Additional Protocol.

In addition to the *Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste*; and the *Treaty on the Non-Proliferation of Nuclear Weapons*, Canada is involved in a number of international agreements that address nuclear waste management, including:

- The *Convention on the Physical Protection of Nuclear Material*;
- The *Convention on Nuclear Safety*;
- The *Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter*; and
- The *Antarctic Treaty*.

The above treaties, conventions and agreements provide a general framework of considerations within which Canada is committed to operate.

Table A5-1 Key Federal Legislation Governing Nuclear Waste in Canada

LEGISLATION	SIGNIFICANCE
Legislation Related To Nuclear Substances	
Nuclear Energy Act	Legislative framework for development and utilization of nuclear energy.
Nuclear Safety and Control Act	Establishes the CNSC to replace the AECB to regulate the use of nuclear energy and materials to protect health, safety, security and the environment and to respect Canada's international commitments on the peaceful use of nuclear energy.
Nuclear Liability Act	Creates obligation for nuclear operators to prevent injury to health, or damage to property, from nuclear material at the facility (or while it is being transported).
Nuclear Fuel Waste Act	Establishes the NWMO; requires financing mechanism to fund nuclear fuel waste management over the long term.
Canadian Environmental Assessment Act	Requires an environmental assessment of new nuclear waste management facilities.
Transportation of Dangerous Goods Act, 1992	Nuclear substances are classed as "dangerous goods" and fall under this act and its regulations, unless exempted by the *Packaging and Transport of Nuclear Substances Regulations* under the *Nuclear Safety and Control Act*.
Canadian Environmental Protection Act, 1999	Governs environmental aspects of inter-provincial shipments of hazardous wastes and recyclable materials.

Provincial, Territorial & Municipal Requirements

Although Canada's constitutional division of power confers the authority to regulate nuclear energy to the federal government, it does not exclude provincial and territorial authority to regulate related matters within the provincial domain.

There may be some aspects of siting, construction and/or operation of a central used fuel management facility that may be determined to be governed by provincial legislation. The legislative areas listed below may be relevant.

- Transportation: Most provinces and territories include nuclear substances in legislation and regulations addressing the transportation of dangerous goods within that province or territory;

- Emergency preparedness: Provincial governments are responsible for protecting public health and safety, property and the environment within their borders. Provincial emergency preparedness legislation often requires that a plan be formulated to address off-site responses to emergencies at nuclear facilities;

- Environmental assessment and approvals: Provincial legislation requiring the assessment of potential environmental effects of an activity, plan or program may apply to some aspects of our work;

- Other areas of legislation, for example governing endangered species; environmental protection; heritage protection or preservation; water resources protection; occupational health and safety; and/or labour relations may be determined to be relevant.

In addition various permits, licences and approvals will be required and provincial policies and guidelines may come into play at the site-specific stage. Provincial legislative, regulatory, permitting and policy requirements will vary from one province to the next. Municipalities, which derive their authority from provincial legislation, may have requirements that may also be relevant (e.g. permits, codes, standards and/or by-laws). The NWMO will need to ensure that all applicable requirements are met.

Appendix 6 / Nuclear Waste Management in Other Countries

Thirty-two countries in the world use nuclear energy to generate electricity. Together they operate more than 400 nuclear power reactors. Different approaches and programs for the long term management of used nuclear fuel are being considered by the various countries. Some, like Canada, France and the United Kingdom, are undertaking studies of policies and strategies aimed at determining the most appropriate means for the long-term management of used nuclear fuel. A number of countries have determined that they plan to construct a geological repository but are at different stages in the process of site selection. Switzerland and Japan are in the early stages of site selection for deep geological repositories; Finland, the United States and Sweden, are in the latter stages. Still other countries have postponed consideration of the issue, or have extended their planning process for a few decades.

The need for long-term management of used nuclear fuel has been recognized since the beginning of the nuclear programs, yet there are not, at this time, any operating licensed facilities. The task of implementation has proven more challenging than expected. While there has been considerable research undertaken on the science and technology of management options, most programs have faced challenges of delays in implementation and public acceptance. As a consequence the status of the active programs changes regularly. Table A6-1 is a brief overview of the current interim storage practices, and the approach for and status of long term management programs for used nuclear fuel in 12 countries. It is current to the time of production of this report.

Table A6-1 **International Nuclear Waste Management Programs**

COUNTRY	REACTORS	INTERMEDIATE STORAGE	LONG-TERM MANAGEMENT
Canada	22*	Used fuel is stored in wet and dry interim storage facilities at the nuclear generating stations.	NWMO studies approaches for long-term management and its recommendations are submitted to government in November 2005 for review and subsequent decision by the government.
Finland	4	Interim storage of spent fuel is at the nuclear generating stations in either water pool or dry storage facilities (CASTOR-type cask).	In 1983 the government established guidelines for long-term management of nuclear waste in Finland, including interim milestones for progress towards disposal "in an irrevocable manner". In 1987/88 the decision-making process and roles and responsibilities were clarified. In 1994 all imports and exports of nuclear waste were prohibited, and in 1999 the government required that retrievability was to be maintained. Following a site selection process and agreement by the host community, Parliament, through a Decision-in-Principle, approved a site for a spent fuel repository in 2001; construction of an underground rock characterization facility started in mid-2004; and the licence process for the repository is scheduled to start in 2012.
France	59	Spent nuclear fuel is first stored in water at the reactor site, it is then transported to a pool-type, away-from-reactor facility at the La Hague reprocessing plant (operated by Cogema) until it is reprocessed. The plutonium recovered is recycled into mixed-oxide fuel (MOX). High-level waste is vitrified and stored at Cogema's facilities.	In 1991 the French government established a 15-year research program with three main areas of study: • Research on partitioning & transmutation; • Options for retrievable or non-retrievable disposal in deep geologic formations; • Conditioning and long-term surface storage techniques for the waste. Draft reports on underground geological storage, surface storage and separation/transmutation were issued in June 2005. A global evaluation report on the three areas of research will be issued by the end of 2005; the government will submit a report on a proposed strategic direction early in 2006 for consideration by the French Parliament.
Germany	17*	As of December 2003 all nuclear power plants have approval for on-site interim storage of spent fuel. Previously, after storing used fuel in water filled pools to cool, utilities were required to either send the used fuel for reprocessing, or send the fuel (and the vitrified wastes from reprocessing) to a centralized interim storage facility. Germany has four 'centralized' and one 'on-site' interim storage facilities.	Since 1998 the policy of the coalition government in Germany has been for direct geological disposal of spent fuel and no reprocessing after 2005. The new *Atomic Energy Act* came into force in 2002; construction of new nuclear power plants is prohibited and the use of existing plants is limited. A working group developed recommendations on a selection procedure for a final disposal site, which the Federal Government is currently reviewing. The aim is for an operational final storage site, for all radioactive waste, to be available as of 2030.

Table A6-1 (cont'd) International Nuclear Waste Management Programs

COUNTRY	REACTORS	INTERMEDIATE STORAGE	LONG-TERM MANAGEMENT
India	14	Stored in wet pools; then reprocessed.	Repository planned but not sited.
Japan	53	Used fuel stored on site before being sent abroad for reprocessing; domestic reprocessing plant being built.	Siting process underway to seek volunteer community for deep geological repository for disposal of wastes arising from reprocessing. Geo-scientific research is being conducted at two locations: investigations of crystalline rock occur in Mizunami City, Gifu Prefecture; investigations of sedimentary rock occur at Horonobe, Hokkaido.
Republic of Korea (South Korea)	18	Stored at reactor sites; work underway to establish spent fuel dry storage systems at 4 NPP; Korea recently decided to separate the sites for a low and intermediate level radioactive waste disposal facility and the site for a spent fuel interim storage facility; plans for a centralized interim facility by 2016.	In 1997 the Korean Atomic Energy Commission adopted a research and development plan for high level radioactive waste (HLW) disposal. Currently work is ongoing to finalize the Korean repository concept for HLW disposal and to undertake a system performance assessment. The combined research output will be submitted to the government to guide the development of a national policy for HLW disposal.
Russia	27	Used fuel is reprocessed; uranium is recycled; plutonium stored for future use.	Four geological disposal facilities are planned to begin operation in 2025-2030.
Sweden	10*	Used fuel is transported via ship and stored at CLAB, a centralized, interim underground wet storage facility.	Following years of research and feasibility studies the Swedish government endorsed a plan in 2001 for site selection for a deep geological repository. Investigations on two sites began in 2002; an application for a repository is expected in 2008 and construction to start in 2010, with a target for operations around 2017.
Switzerland	5	High level wastes are transported to a centralized dry, interim, storage facility owned by ZWILAG, operating since 2001. Spent nuclear fuel is stored in various wet and dry, centralized and site specific facilities. The *Nuclear Energy Act* (which came into force in February 2005) contains a 10-year moratorium on reprocessing starting July 2006.	Switzerland is considering construction of a national repository for disposal of spent nuclear fuel and high level wastes in a deep geological formation. Nagra (the National Cooperative for the Disposal of Radioactive Waste) conducts research projects in two underground rock laboratories, the Grimsel Test Site (Canton Bern) in granitic rock and the international Mont Terri Rock Laboratory (Canton Jura) in Opalinus Clay.

Table A6-1 (cont'd) International Nuclear Waste Management Programs

COUNTRY	REACTORS	INTERMEDIATE STORAGE	LONG-TERM MANAGEMENT
UK	31	Used fuel is reprocessed; vitrified wastes stored above ground for 50 years.	The government established a new organization (CoRWM) in 2003 to investigate options for a long-term management approach and recommend the best option, or combination of options in 2006. Work to date has produced a short-list of options to be taken forward for detailed assessment (deep geological disposal, phased deep geological disposal, near-surface disposal (for limited volumes) and long-term interim storage).
USA	104	Used fuel stored at reactor sites.	Construction licence application being prepared for deep geological repository at Yucca Mountain, Nevada. The U.S. Department of Energy is planning to submit a licence application perhaps in 2006.

*Note; On August 12, 2005 Ontario Power Generation announced that two units at the Pickering nuclear generating station in Canada would not be returned to service. The Orbrigheim nuclear power plant in Germany was shut down in May 2005; the Barseback-2 nuclear power plant in Sweden was shut down in May 2005. A more complete review of international waste management programs is contained in NWMO Background Paper 7-6, "A Comparative Overview of Approaches to Management of Spent Nuclear Fuel and High Level Wastes in Different Countries" Charles McCombie, Bengt Tveiten **www.nwmo.ca/internationalapproaches**

Appendix 7 / NWMO's Roundtable on Ethics

After ten years of study and public hearings on the concept of deep geological disposal of used nuclear fuel (1989 to 1998), an environmental assessment panel chaired by Blair Seaborn (the "Seaborn Panel") concluded in their 1998 report that the concept had not been demonstrated to have broad public support. It therefore did not have the required level of acceptance to be adopted as Canada's approach for managing nuclear fuel wastes. The Panel identified the absence of an ethical and social framework within which to assess options as an important issue.

From its inception, the NWMO has committed itself to adhering to the highest ethical standards both in its procedures and in its assessment of management options. To guide it in this matter, the NWMO created a Roundtable on Ethics in 2003. The Roundtable members were selected as both trained and practicing ethicists in a variety of disciplines including business, health, law and public policy. Brief biographies of Roundtable members are included in Appendix 1.

As part of its mandate, the Roundtable identified what the relevant ethical standards are, in its judgment, and organized them into an "Ethical and Social Framework" designed to be responsive to suggestions made by the Seaborn Panel. Rather than issue what could appear to be dogmatic statements, the Framework was designed to express the ethical standards concerned as a series of questions for the NWMO to ask itself. The Framework was first published by the NWMO in April, 2004 and was intended to be a living document. A revision to this document was published in March 2005.

Context

Early on in the study process, the Roundtable advised the NWMO to embed ethical and value considerations in all aspects of its study, including the design of the study process as well as the outcome or recommendation itself. In saying this, the NWMO understood the Roundtable to mean that ethical considerations should be discussed openly and in the context of making judgments on the substantive issues of the study, rather than used as an additional and distinct set of criteria to be applied to decision making. The NWMO first reported this direction from the Roundtable in *Asking the Right Questions?* (NWMO 2003).

Ethics treated as an overarching consideration: This recommendation by the Roundtable influenced NWMO's overall approach to the study in a number of ways. For instance, in the NWMO's first discussion document, "Ethical Considerations" were treated as an overarching aspect among the ten questions to be asked and answered in the study. Along with "Institutions and Governance", "Engagement and Participation in Decision making", "Aboriginal Values", "Synthesis and Continuous Learning", Ethical Considerations were identified as among the questions which apply to all aspects of the framework. As the discussion document explained, ethical considerations and the other overarching aspects, "together … ensure that insight is drawn not only from the perspective of specific disciplines, but also from a more holistic, overarching perspective."

Ethical considerations addressed through consideration of the main substantive areas of the study: In the NWMO's second discussion document, the NWMO attempted to incorporate value and ethical considerations in the influence diagrams for each of the eight objectives which had emerged from the ten question framework. A key ethical consideration, 'Fairness', was also included as an objective in its own right.

Focus on common ground but points of divergence also considered: From the inception of the study, and through successive iterations, the NWMO has attempted to be directed in its work by citizen values and concerns. This effort reflects the NWMO's understanding that the most important ethical choices to be made are in fact values-based decisions that, as much as possible, require the involvement of society at large. An ethical process involves engaging a broad cross-section of society in informed dialogue on the core human issues to be addressed. An ethical outcome or recommendation involves being responsive to the values and concerns of society at large. It is for this reason that the NWMO sponsored a National Citizens' Dialogue on values with a random cross-section of citizens to elicit these values. These values were elaborated, and ultimately confirmed through a number of dialogue initiatives, as appropriate for use in selecting a management approach. These initiatives included: discussion sessions conducted across the country with the interested public; public attitude research conducted with a random sample of the public; and national and regional stakeholder dialogues.

From the inception of the study, the NWMO has also attempted to identify and understand not only the common ground which citizens share, but also the issues on which there is active debate and divergence. The attempt was made to document both the common ground and points of divergence clearly in the NWMO's second discussion document, and to refine this discussion through the *Draft Study Report* and *Final Study Report*. With no ethical absolute, and in the face of uncertainty, the NWMO understood that an ethical approach and outcome requires the type of pluralistic and multi-party assessment which formed the foundation for our dialogue and assessment activities.

Consideration of the needs of future generations in decision-making today: The NWMO has understood that given the longevity of the hazard posed by used nuclear fuel, the needs of and potential impacts on future generations must be considered in any decision about long term management made today. The NWMO has, therefore, attempted to explicitly address matters of 'equity' or fairness both within the current generation and across generations including humans and other species. The NWMO first specifically engaged citizens in a dialogue on this issue as part of the National Citizens' Dialogue on values, and then subsequently in the dialogues which followed. Citizen direction on the appropriate balancing of the needs of current generations with those of future generations in used fuel management decision-making became a fundamental component of the study. In addition, the assessment of approaches was explicitly considered within two timeframes (within seven generations and beyond seven generations), selected to bring greater clarity to equity considerations.

Principles

The NWMO has adopted the principles suggested by the Roundtable in its "Ethical and Social Framework":

- As guiding principles for the assessment of the approaches in the study. The principles identified in the Roundtable's document are the basis for the six ethical principles contained in the Assessment Framework described in the NWMO's second discussion document and embedded throughout the consideration of the eight objectives;

- As guiding principles and process considerations for one of the first tasks to be addressed in implementation of any centralized management approach – siting of the facility. These principles, and the associated questions identified in the Roundtable's document, are suggested as the starting point for a siting process which will ultimately need to be developed collaboratively with those potentially affected.

These principles were an explicit subject of dialogue following release of the NWMO's second discussion document, including the discussion sessions conducted across the country with the interested public, the quantitative research conducted with a random sample of the public, and the national and regional dialogues. These principles were confirmed through the dialogue as appropriate for use in selecting a management approach.

Both the process used to formulate the approach, and the substance of the approach itself, were designed to be responsive to the ethical principles, questions and issues raised by the Roundtable and outlined in its "Ethical and Social Framework" document.

"Ethical and Social Framework" Suggested by Roundtable on Ethics

The "Ethical and Social Framework", as drafted by the Roundtable on Ethics, is reproduced in its entirety below. The NWMO suggests that this framework receive further consideration by the NWMO and Canadians for the guidance it may provide concerning the implementation of the management approach selected by the Government of Canada.

"Ethical and Social Framework" Suggested by Roundtable on Ethics

March 4, 2005

Nuclear Waste Management Organization Roundtable on Ethics

The Roundtable on Ethics has developed the following Ethical and Social Framework within which to consider the management of spent nuclear fuel, as was recommended by the Environmental Assessment Panel in its report to the federal cabinet. The Roundtable recommends that the NWMO adopt this framework, publish it in NWMO documents and on the NWMO website, and conduct its activities in the light of it. The Roundtable may refine the framework further as the work of the NWMO progresses.

Andrew Brook
Wesley Cragg
Georges Erasmus
David MacDonald
Arthur Schafer
Margaret Somerville

Ethical and Social Framework

Recognizing that everyone contributing to the NWMO's work seeks to use procedures and make recommendations that are ethically sound, NWMO commits itself to embed ethics in all its activities. The aim is to ensure that its work, its ultimate recommendations, and their implementation reflect the highest ethical standards. To assist NWMO in achieving its ethical goals, the Roundtable on Ethics has constructed a framework of questions designed to guide its deliberations and its ultimate recommendations. These questions aim to identify basic values, principles, and issues.

The ethical principles incorporated in the framework include: respect for life in all its forms, including minimization of harm to human beings and other sentient creatures; respect for future generations of human beings, other species, and the biosphere as a whole; respect for peoples and cultures; justice (across groups, regions, and generations); fairness (to everyone affected and particularly to minorities and marginalized groups); and sensitivity to the differences of values and interpretation that different individuals and groups bring to the dialogue. These principles apply both to the consultative and decision-making procedures used by NWMO and to the recommendations that it will make.

Given the large stockpile of highly radioactive spent fuel that already exists or will be created in the lifespan of existing reactors and that will be hazardous for thousands of years, some solution to managing this material as safely and effectively as possible must be found.

The goal is to find and implement an ethically sound management approach. However, if no ethically sound management approach exists, adopting the ethically least-bad option available to deal with existing and committed spent fuel would be justified.

By contrast, the creation of new spent

fuel (that is, beyond what already exists or will be created in the lifespan of existing reactors) and, thereby, the issue of its disposal, must be judged by the standard of full ethical soundness. If the best current proposal does not meet this standard, then it would not be justified to create new material. To justify creating new spent fuel from an ethical point of view, there must be a management solution that is ethically sound, not just least bad. (The other ethical issues associated with nuclear power generation would have to be resolved, too, problems such as the effects of uranium mining and mine tailings, vulnerability of spent fuel to terrorist attacks, safety of the reactors, danger of diversion for nuclear weapons, and whether increased nuclear power generation can be justified, given the available options.) Moreover, even a least-bad option acceptable for the existing problem might cease to be acceptable if there were changes in the nature of the spent fuel, such as adding spent enriched fuel.

In short, a solution that is ethically acceptable for dealing with existing spent fuel is not necessarily a solution that would be ethically acceptable for dealing with new or changed materials. Thus, a question that urgently needs to be addressed is whether NWMO is dealing simply with existing materials and those that will be created in the lifespan of existing reactors or also with substantial additional spent fuel? And this is no less than the question: What will the future of nuclear power in Canada be?

Ethical Questions Relevant to the NWMO's Procedures

Some of the questions that arise concerning procedures are:

- Who should participate in the decision-making process?
- What principles should guide consultations, deliberations, and the making of decisions?
- When facts are in dispute or unavoidably uncertain, how should NWMO proceed?

These general questions give rise to more specific ones. The list of questions that follow is not meant to be exhaustive. For each question, the principle(s) involved is/are in boldface type.

Q1. Is NWMO conducting its activities in a way appropriate to making public policy in a **free, pluralistic, and democratic society**? In particular, are its activities **open, inclusive, and fair** to all parties, giving everyone with an interest in the matter an opportunity to have their views heard and taken into account by NWMO? Are groups most likely to be affected by each spent fuel management option, including the transportation required by some of the options, being given full opportunity to have their views heard and taken into account by NWMO? Is NWMO giving special attention to aboriginal communities, as is mandated by the governing legislation?

Q2. Are those making decisions and forming recommendations for NWMO **impartial**, their deliberations not influenced by conflict of interest, personal gain, or bias?

Q3. Are groups wishing to make their views known to NWMO being provided with the **forms of assistance** they require to present their case effectively?

Q4. Is NWMO committed to basing its deliberations and decisions on the **best knowledge**, in particular, the best natural science, the best social science, the best aboriginal knowledge, and the best ethics – relevant to the management of nuclear materials, and to doing assessments and formulating recommendations in this light? Equally, have limits to the current state of knowledge, in particular **gaps** and areas of **uncertainty** in current knowledge, been publicly identified and the interpretation of their importance publicly discussed and justified?

Q5. Does NWMO provide a **justification** for its decisions and recommendations? In particular, when a balance is struck among a number of competing considerations, is a justification given for the balance selected?

Q6. Is NWMO conducting itself in accord with the **precautionary approach**, which first seeks to **avoid harm and risk of harm** and then, if harm or risk of harm is unavoidable, places the burden of proving that the harm or risk is ethically justified on those making the decision to impose it?

Q7. In accordance with the doctrine of **informed consent**, are those who could be exposed to harm or risk of harm (or other losses or limitations) being **fully consulted** and are they willing to accept what is proposed for them?

Ethical Questions Relevant to NWMO's Recommendations

As before, key ethical principles are in boldface type.

Q8. Do NWMO's recommendations reflect **respect for life**, whatever form it takes, wherever it occurs, and whenever it exists (now and into the foreseeable future)? In particular, are NWMO's recommended solutions likely to protect human beings, including future generations, other life forms, and the biosphere as a whole into the indefinite future?

Q9. Is a reasonable attempt being made to determine, in so far as it is possible to do so, the **costs, harms, risks, and benefits** of the options under consideration, including not just financial costs but also physical, biological, social, cultural, and ethical costs (harm to our values)?

Special ethical issues arise with respect to risk assessment in the nuclear industry. For example, might some scenarios be so horrendous that even a slight risk of their occurrence would be morally unacceptable or unacceptable by Canadians?

Q10. If implemented, would NWMO's recommendations be **fair**?

This question breaks down into a number of sub-questions:

Are the beneficiaries of nuclear power (past, present and perhaps future) bearing the costs and risks of managing spent fuel and other nuclear materials in need of treatment? Do the recommended provisions avoid imposing burdens on people who did not benefit from the activities that created the spent fuel?

Are costs, risks, and benefits to the various regions affected by the use, possible transport, and disposal of the materials being distributed fairly?

Are the interests of future generations and nonhuman life forms being respected?

Are the rights of individuals and minorities being respected, especially vulnerable individuals and minorities?

Q11. Do the recommended provisions protect the **liberty** of future generations to pursue their lives as they choose, not constrained by unresolved problems caused by our nuclear activities? Do the recommended provisions maximize the range of choice open to future generations?

Important Specific Issues
In connection with Q8 to Q11, at least four specific issues merit special consideration.

1. Monitoring, remediation, and, if needed, reversal. Are sound provisions being made to check on whether management provisions are working as designed? If problems appear, are provisions being made to gain the access needed to fix them? Is the issue of reversal if something goes seriously wrong being taken into account?

2. Risk reduction vs. access. What is the appropriate balance between reducing risk to the greatest extent possible and retaining access to the materials, for remediation, for example, or to recover valuable materials from them?

3. Permanent or interim? Is it ethically acceptable to seek a permanent solution now or would it be preferable to recommend an interim solution in the hope that future technological improvements might significantly lower the risks or diminish the seriousness of the possible harms?

4. Lessons to be learned. What lessons can we learn for the future of the nuclear power generation industry from the problem of management of spent fuel and the NWMO's efforts to resolve it?

In closing, we will repeat a point made earlier. Because we must manage already-existing and already-committed spent fuel in some way, here the least-bad option is an ethically acceptable option. By contrast, new spent fuel – whether generated by new reactors, by replacing existing reactors as they reach the end of their serviceable life, or by importing material from other countries – is ethically another matter altogether. For the creation of new spent fuel to be ethically justified, it would have to be shown that there exists a management option that is ethically sound, not just least bad. (Other ethical issues to do with nuclear power generation such as the ones mentioned above would have to be resolved, too.)

In its final review of the *Draft Study Report*, the Roundtable endorsed the NWMO's recommendation as a way to manage current and currently-planned used nuclear fuel, which was the scenario at the focus of their deliberation.

They strongly emphasized that their acceptance of the recommendation for the treatment of that waste must be distinguished from the treatment of any "new" waste. The ethical standards that should be applied to deal with waste from existing fuel and those that would apply to the generation of waste as a result of a decision to expand nuclear power or to continue production beyond facilities' current lifespans are not the same. Endorsement of this recommendation for current and currently-planned used fuel should, therefore, *not* be taken as endorsement of this approach for a scenario in which new used nuclear fuel is produced. A scenario of new used nuclear fuel was not considered by the Roundtable.

Appendix 8 / Influences for the Assessment of Management Approaches

The NWMO's assessment framework features eight objectives:

- Fairness
- Public health and safety
- Worker health and safety
- Security
- Economic viability
- Community well-being
- Environmental integrity
- Adaptability.

For each objective, the factors that may influence the capacity to perform well against the objective were identified and mapped. The resulting "influence diagrams" created for each of the eight objectives, acted as a road map for assessment. For each objective, except for Fairness, an assessment was conducted in two timeframes: in the near term defined as the next seven generations or approximately 175 years; and, in the longer term defined as beyond 175 years. For a more complete description of this work see **www.nwmo.ca/understanding thechoices**.

Objective 1: Fairness

To ensure fairness (in substance and process) in the distribution of costs, benefits, risks and responsibilities, within this generation and across generations.

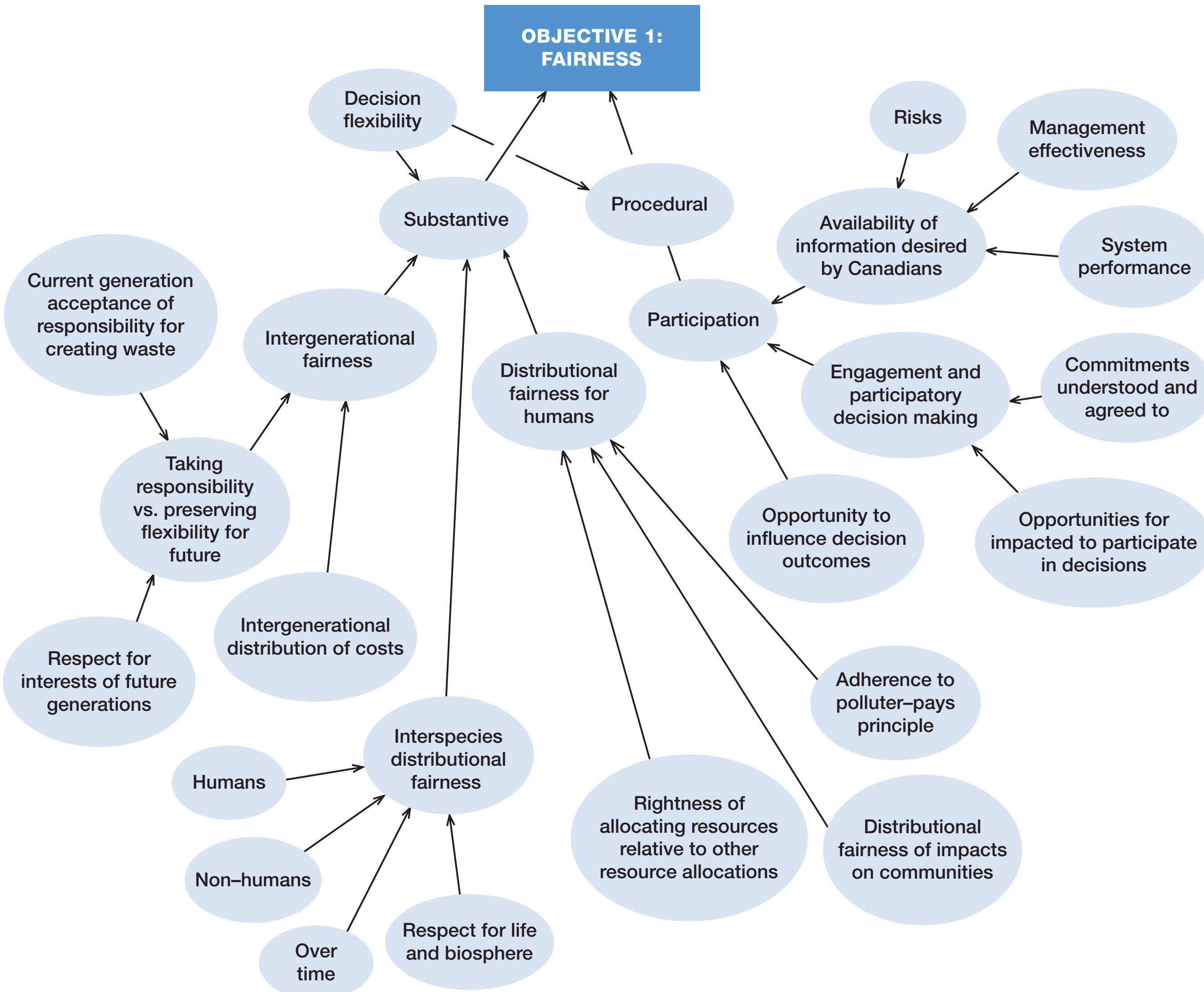
The selected approach should produce a fair sharing of costs, benefits, risks and responsibilities, now and in the future. In addition, fairness means providing for the participation of interested citizens in key decisions through full and deliberate public engagement during different phases of decision-making and implementation.

In our assessment of fairness, the NWMO considered issues of both substantive and procedural fairness.

Substantive fairness focuses on the content or substance of the approach. It includes consideration of how the costs and benefits associated with the approach would be distributed among different people and between humans and other species. It also includes consideration of intergenerational fairness. A key question for intergenerational fairness is the balance struck between the desire that the current generation take responsibility for resolving the problem once-and-for-all versus the desire not to overly constrain future generations by the choices we make today.

Procedural fairness focuses on the processes used and is mainly a function of the degree to which the approach would allow for the participation of concerned citizens in key decisions about how the approach would be implemented. This, in turn, depends in part on the opportunities for decision-making provided by the approach and the availability of information that would be helpful for driving those decisions. The complete list of influences considered is identified in the diagram opposite.

Figure A8-1 **Fairness Influence Diagram**



Objective 2: Public Health and Safety

To ensure public health and safety.

Public health ought not to be threatened due to the risk that people might be exposed to radioactive or other hazardous materials. Similarly, the public should be safe from the threat of injuries or deaths due to accidents during used nuclear fuel transportation or other operations associated with the management of used nuclear fuel.

In assessing the options against public health and safety, the NWMO considered many factors, depicted graphically in the influence diagram below. We believe that any management system employed will result in direct or indirect risks to the health and safety of affected individuals or communities that must be fully acceptable according to current safety standards. The possibilities of unplanned events that could present unexpected risks or stresses must be considered, and appropriate contingency action provided. There should not be foreseeable outcomes of the approach that lead to greater risks to the public from the used nuclear fuel facility at any time in the future than is acceptable today.

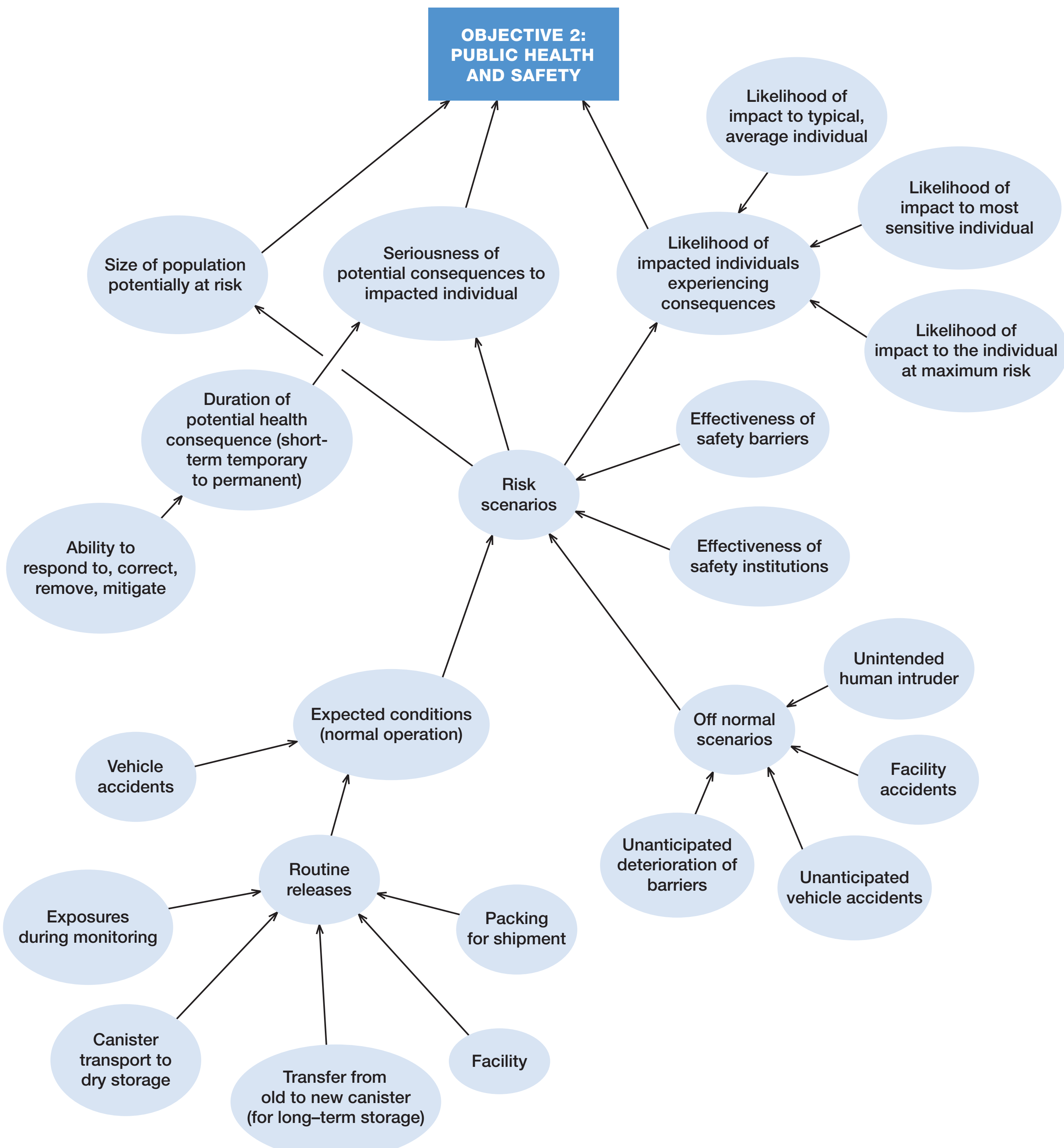
The physical, chemical and radiological characteristics of used nuclear fuel, and their hazards, are well understood. Those hazards need to be managed to prevent unreasonable risk, and licensing requirements and compliance verification by the Canadian Nuclear Safety Commission ensure that the effectiveness of any management approach will be monitored.

The following diagram depicts the scope of influences that were considered. Risks were estimated under normal, expected operating conditions and under "off-normal" scenarios in which members of the public might be inadvertently exposed to hazards associated with the various approaches.

Under normal operating conditions, risks associated with the following operations were considered: packing for shipment, transfer from old to new canisters, vehicle accidents, canister transport to dry storage and exposures during monitoring.

Other risk scenarios considered included unanticipated deterioration of the natural and engineered barriers constructed to isolate the fuel, large-scale transportation accidents (e.g., the wreck of a train carrying used nuclear fuel), facility accidents, and unintended human intrusion.

Figure A8-2 **Public Health and Safety Influence Diagram**



Objective 3: Worker Health and Safety

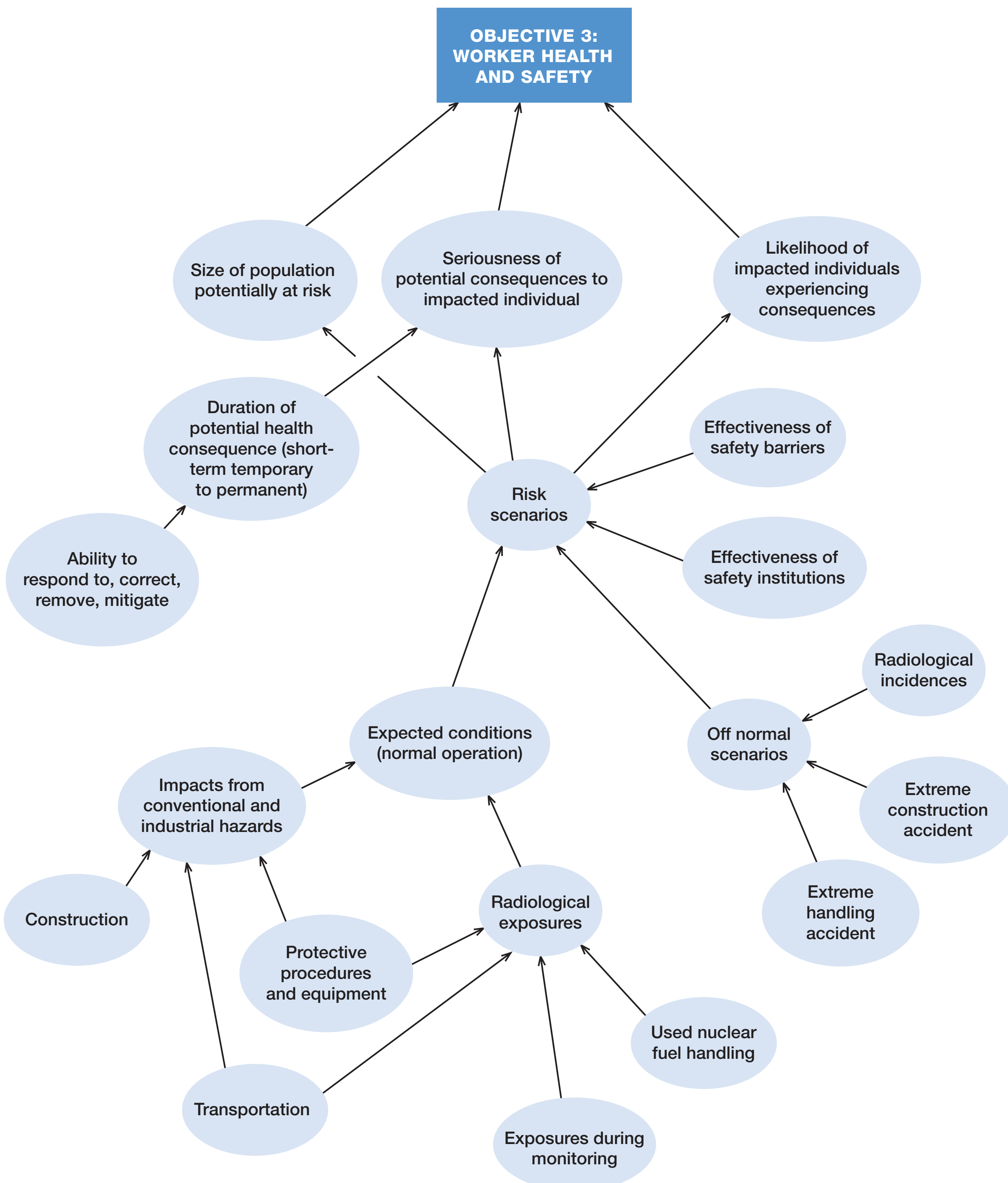
To ensure worker health and safety.

Construction, mining and other tasks associated with managing used nuclear fuel can be hazardous. The selected approach should not create undue or large risks to the workers who will be employed to implement it.

In assessing options for impacts on worker health and safety, the NWMO considered a number of factors. The management system and the technologies used, the design, the construction methods and the operational and monitoring procedures should be such that, in addition to complying with good engineering practices and all industrial safety regulations, workers involved with the used nuclear fuel facility should not be subject to risks of harmful exposures, chronic or accidental, greater than those acceptable to Canadian or international authorities at the time of construction. Workers engaged in future monitoring or maintenance activities should not be subject to risks greater than those acceptable today. The complete list of influences considered is identified in the following diagram.

Risks were separately estimated for two time periods. They were estimated based on normal, expected operating conditions and under "off-normal" scenarios in which workers might be inadvertently exposed to hazards associated with the various approaches. Under normal operating conditions, worker risks associated with the following operations were considered: construction, transportation, fuel handling, and monitoring. The main "off-normal" risk scenarios considered included an extreme construction accident, accidental radiological exposures and extreme fuel handling accidents.

Figure A8-3 Worker Health and Safety Influence Diagram



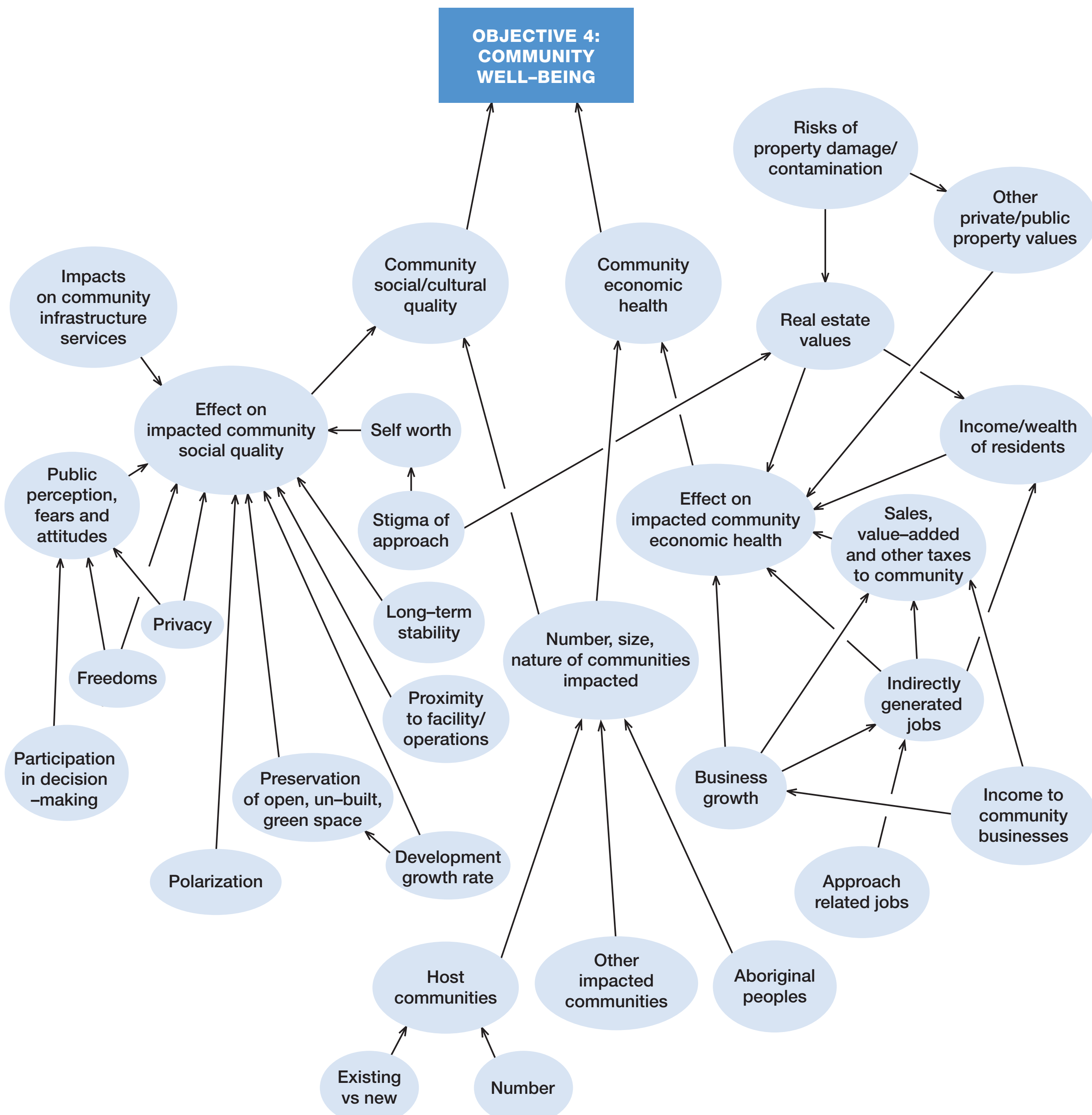
Objective 4: Community Well-Being

To ensure community well-being.

Implications for the well-being of all communities with a shared interest (including host community, communities in the surrounding region and on the transportation corridor, and those outside of the vicinity who feel affected) should be considered in the selection and implementation of the management system and related infrastructure. A broad range of implications must be considered, including those relating to economic activity, environmental disruption and social fabric and culture.

The assessments with respect to community well-being considered both the likely economic impacts of the approach, and the potential effects on social and cultural qualities of affected communities. On the economic side, consideration was given to potential effects on property values, jobs and businesses. Potential social and cultural impacts include raising fears and concerns of citizens and the risk of community polarization (e.g., contrasting beliefs between those who support and those who oppose locating a facility near their community). Some residents may see living near a radioactive waste management facility as placing a stigma on their community. The list of influences considered is depicted in the diagram opposite.

Figure A8-4 **Community Well–Being Influence Diagram**



Objective 5: Security

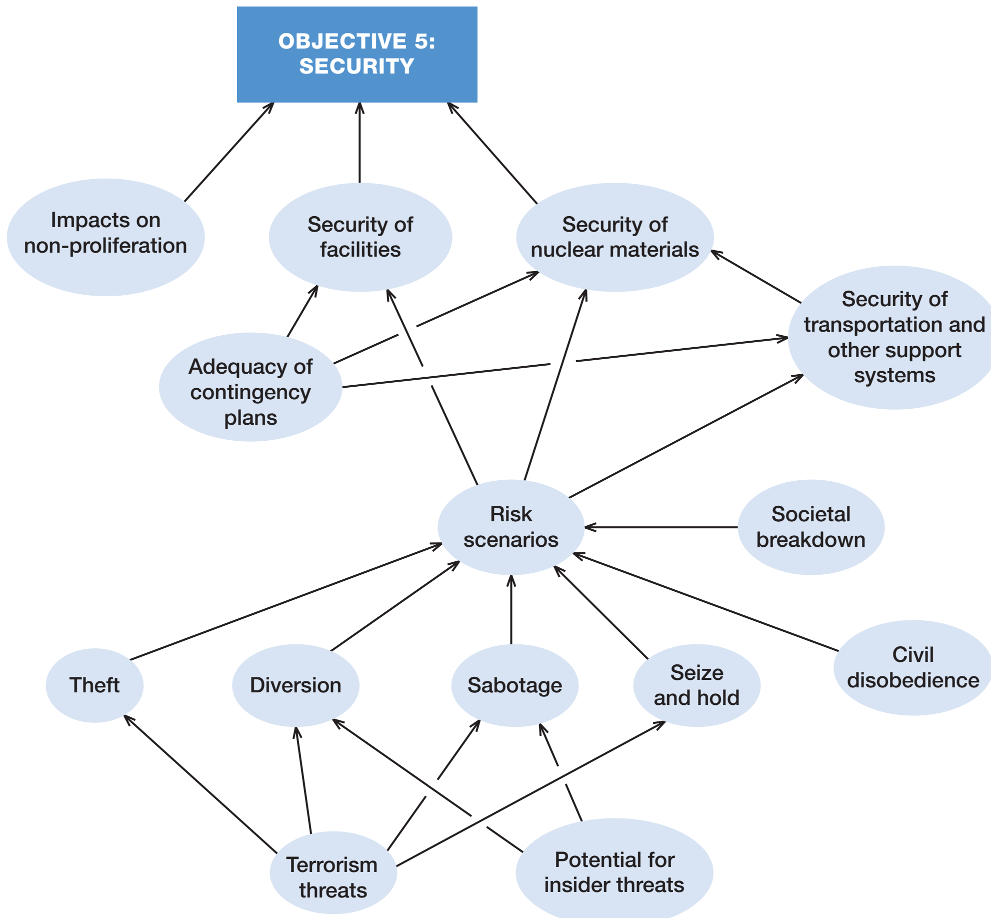
To ensure security of facilities, materials and infrastructure.

The selected management approach needs to maintain the security of the nuclear materials and associated facilities. For example, over a very long time-frame, the hazardous materials involved ought to be secure from the threat of theft, despite possibilities of terrorism or war.

An approach must provide for the security of both nuclear materials and the facilities that store or use them. The loss of nuclear material would likely pose health and safety risks to Canadians and others. The loss of nuclear material could also trigger concerns in relation to international safeguards and non-proliferation obligations. In this context, security and safeguards are fundamental requirements that go beyond protecting the health and safety of Canadians.

To assess security, the vulnerability of each approach to various risk scenarios was considered. The risk scenarios included terrorism and potential "insider" threats focused on theft, diversion, sabotage, and "seize and hold" strategies. The adequacy of contingency plans and the robustness of the approach under scenarios involving societal breakdown and civil disobedience were also considered. The influences considered are outlined in the diagram opposite.

Figure A8-5 **Security Influence Diagram**



Objective 6: Environmental Integrity

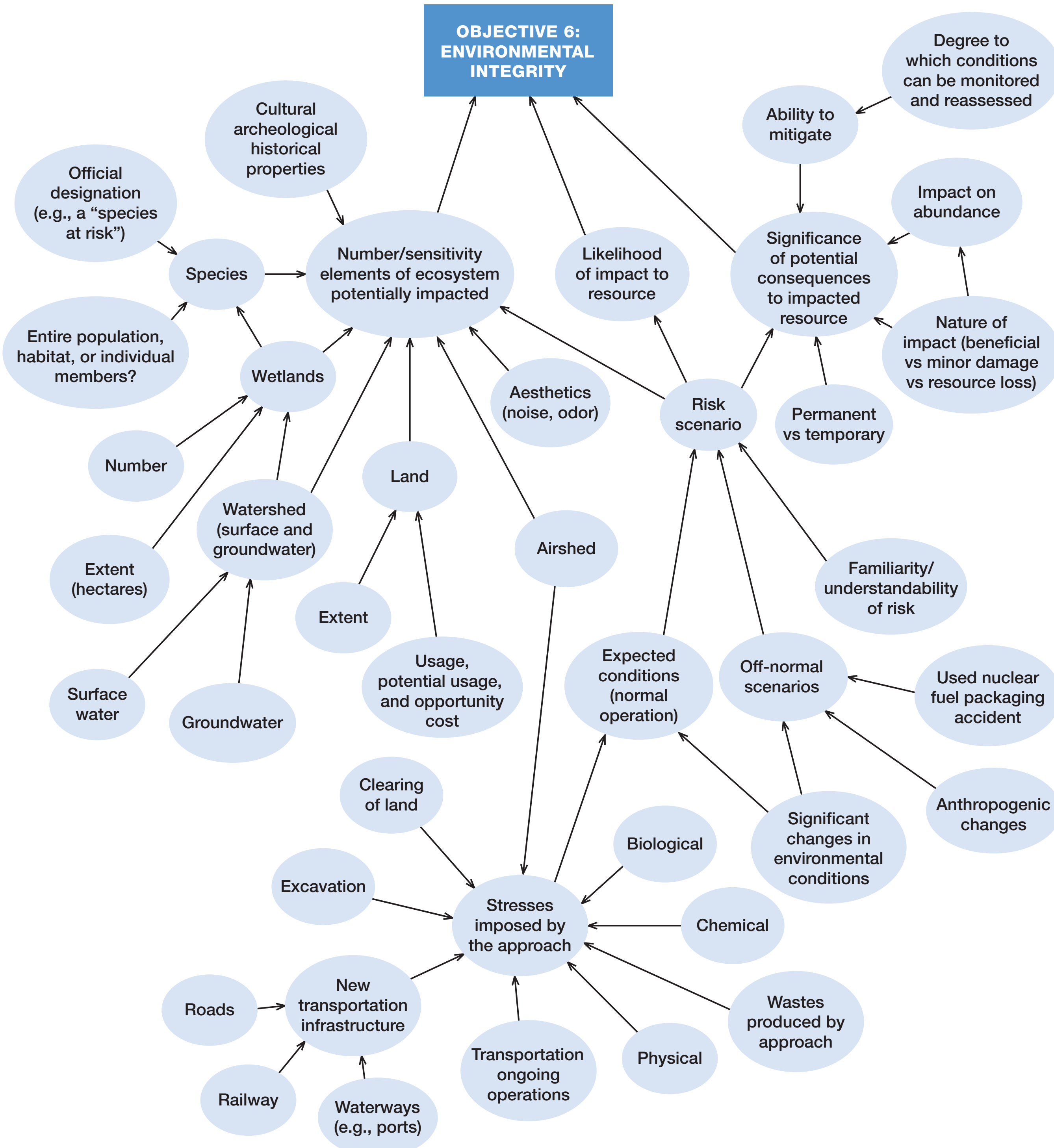
To ensure environmental integrity.

The selected management approach needs to ensure that environmental integrity is maintained over the long term. Concerns include the possibility of localized or widespread damage to the environment or alteration of environmental characteristics resulting from chronic or unexpected release of radioactive or non-radioactive contaminants. Concerns also include stresses and damage associated with new infrastructure (such as roads and facilities) and operations (e.g., transportation).

Assessing the degree of impact each approach would have on the natural environment required consideration of many factors, including the number and sensitivity of ecosystem elements that would potentially be affected, the likelihood of impact to each type of resource, and the significance of the potential consequences to affected resources. Many different types of valued and environmentally sensitive resources could be affected, including plants and animals, land, surface water, groundwater and the air (e.g., through air pollution created during the construction of a new facility). Also included in the assessment were various aesthetic impacts, such as noise, and visual changes to the natural scenery. As in the case of other objectives, it is necessary to consider not only the stresses that each approach would produce assuming that the approach performs as expected, it is also necessary to consider the possibility of "off-normal" risk scenarios. The complete list of influences considered is expressed in the influence diagram opposite.

It is difficult to precisely forecast the environmental impacts of the various approaches. This is especially true in the cases of the geological repository and centralized storage approaches because the impacts of each approach depend greatly on where the new facilities would be located, something that is not yet known. The long time-frames involved complicate forecasts for all approaches.

Figure A8-6 **Environmental Integrity Influence Diagram**



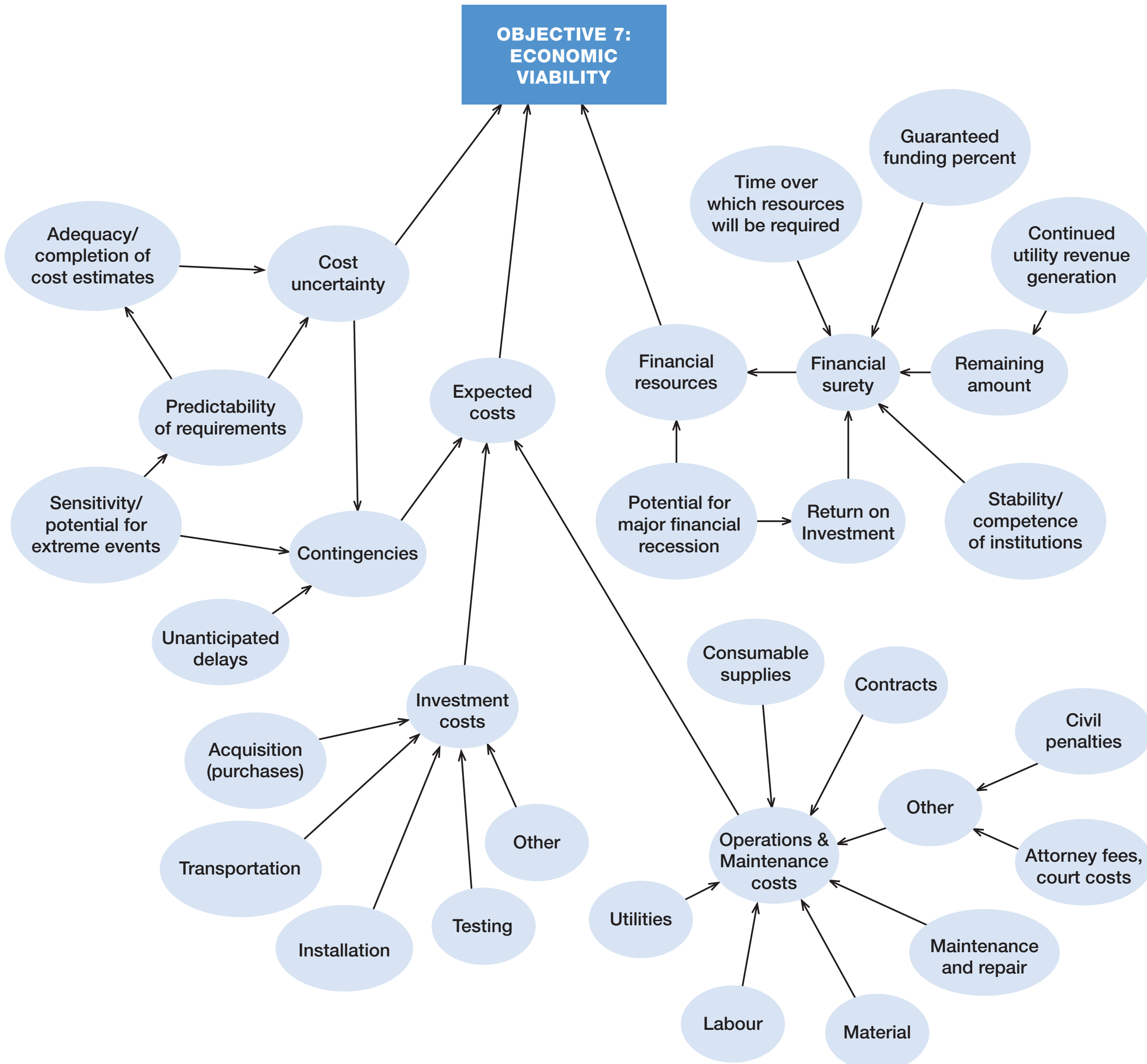
Objective 7: Economic Viability

To design and implement a management approach that ensures economic viability of the waste management system, while simultaneously contributing positively to the local economy.

Economic viability refers to the need to ensure that adequate economic resources are available to pay the costs of the selected approach, now and in the future. The cost must be reasonable. The selected approach ought to provide high confidence that funding shortfalls that would threaten the assured continuity of necessary operations will not occur.

Assessing the economic viability of the approaches required considering the likelihood that financial resources would be available to pay the costs recognizing that these costs are uncertain and, especially in the case of the reactor site and centralized storage approaches, would continue over a very long time. The complete list of influences considered is depicted opposite.

Figure A8-7 Economic Viability Influence Diagram



Objective 8: Adaptability

To ensure a capacity to adapt to changing knowledge and conditions over time.

The selected management approach should be robust in the face of new or unforeseen circumstances. The approach should provide flexibility to future generations to change decisions; not place burdens or obligations on future generations that will constrain them. The approach should be able to function satisfactorily in the case of unforeseen events.

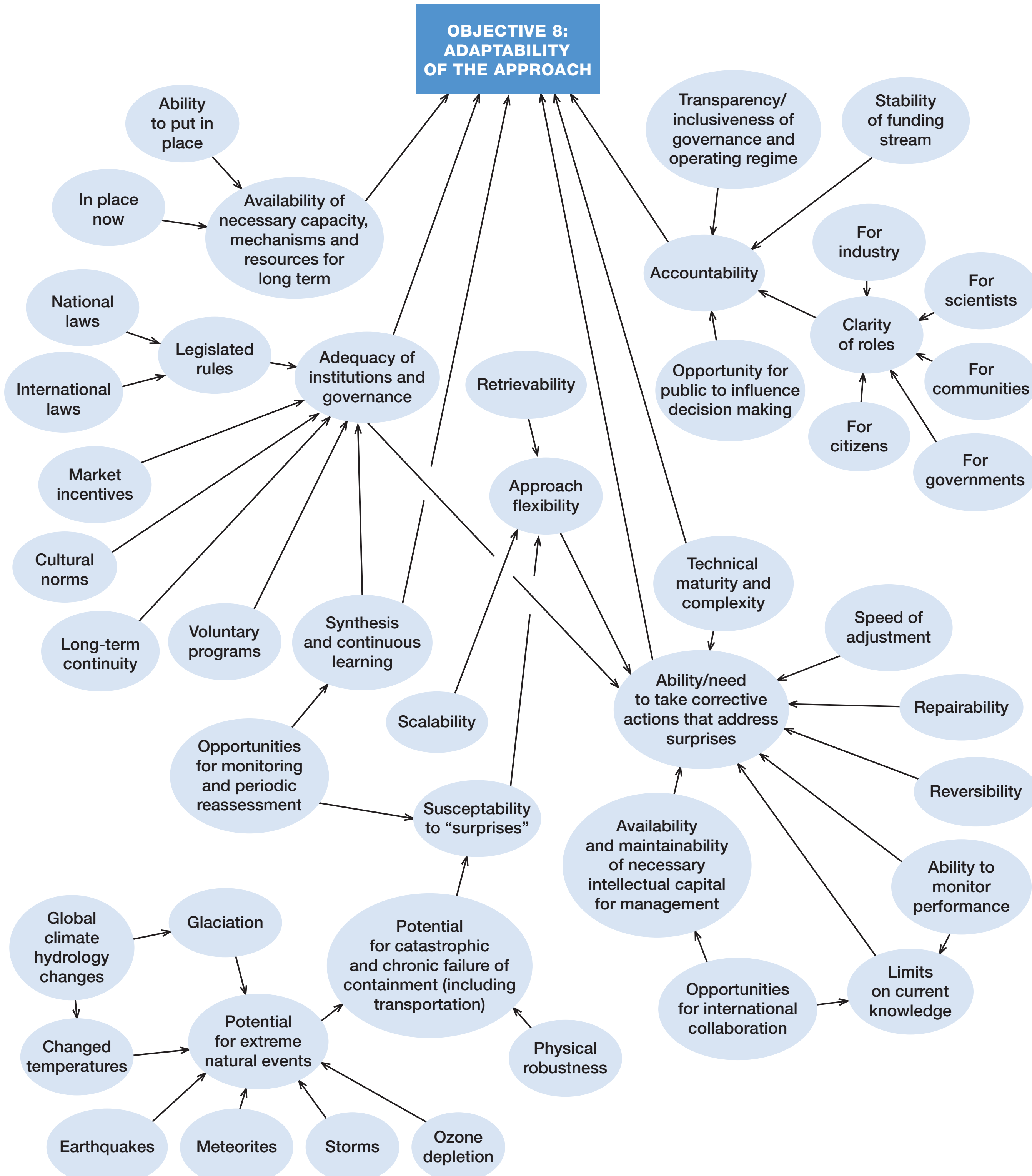
There was much discussion on this objective by citizens during the dialogue following release of the second NWMO discussion document. Although there appeared to be broad agreement on the importance of this objective, some debate was raised concerning how best to characterize or define the objective. Should the adaptability of an approach be defined primarily on the basis of the flexibility in future decision-making that it provides? Should the adaptability of an approach be defined primarily on the basis of the robustness it provides in the face of changing environmental conditions?

The NWMO has proceeded in a way which understands that both of these are potentially important influences on the adaptability of a management approach even though the measures one might put in place to achieve flexibility might directly conflict with the measures one might put in place to achieve physical robustness. What is required to make an approach adaptable in the near term may not be the same as what is required to make an approach adaptable in the very long term. Given the long time-frames for which any management approach will need to effectively contain and isolate used nuclear fuel, the balancing of such tensions is integral to both understanding what adaptability means for this issue and assessing the approaches on it.

The NWMO has approached adaptation as a general strategy of systems for attaining or maintaining a goal in the face of changing environmental circumstances. "Adaptability" is here defined as the set of characteristics of an option that are expected to make a management approach robust with respect to the widest range of possible social and environmental scenarios in the long-term future. To be "adaptable" is to be capable of responding well to changes in environmental and social conditions, over a wide range of such possible changes.

Assessing the adaptability of each approach required consideration of many factors, including whether there are opportunities to adapt to changing knowledge or circumstances during the period when the various stages of the project are being implemented. It also included consideration of the robustness of the operation of the option to contain and isolate the waste, and/or ease of taking corrective action to ensure continued containment and isolation, in response to a wide variety of expected challenges to system integrity over the very long term. These challenges might include extreme natural events, deficiencies in option performance as designed, and unavailability of any institutional controls or systems that may be required. The complete list of influences considered is depicted opposite.

Figure A8-8 **Adaptability Influence Diagram**



Appendix 9 / Other Methods Considered

The *Nuclear Fuel Waste Act* (*NFWA*) requires the NWMO to study approaches based on three methods for the long-term management of used nuclear fuel: deep geological disposal in the Canadian Shield; storage at nuclear reactor sites; and centralized storage, either above or below ground. The *NFWA* allows the NWMO to consider other management approaches in the course of its study.

Methods Receiving International Attention

The first NWMO discussion document, *Asking the Right Questions?*, identified 11 other methods that have been advanced in the past by governments, industry and researchers. The NWMO Assessment Team did not include these additional methods in its preliminary assessment. However, it did suggest keeping a "watching brief" on three methods receiving international attention: reprocessing, partitioning and transmutation; deep borehole placement; and international repository (see Chapter 5).

Reprocessing, Partitioning and Transmutation involve chemical and physical processes to recover and recycle the fissionable isotopes in used nuclear fuel. These processes were considered in our study in light of the ongoing international work to understand their potential for managing used nuclear fuel in the long term. Our research into these areas was further motivated by the high level of interest registered by Canadians in knowing more about the possibility of "recycling" or "reusing" used fuel, practices that we have come to expect in many other areas of our life. Interested in opportunities to "recycle" in the context of used nuclear fuel, and intrigued by international work on transmutation as a potential for reducing the long-term hazard of used nuclear fuel, Canadians expressed a desire for the NWMO to report back on our findings and determinations concerning these options. (See NWMO background papers on reprocessing, partitioning and transmutation by Jackson (2005) available at www.nwmo.ca/partitioningandtransmutation and www.nwmo.ca/implicationsrpt).

Reprocessing is the application of chemical and physical processes to used nuclear fuel for the purpose of recovering and recycling fissionable isotopes.

Partitioning involves a further series of physical and chemical processes to separate various isotopes from used nuclear fuel for further conditioning, treatment or long-term management.

Transmutation refers to the transformation of radioactive isotopes from used nuclear fuel into non-radioactive or stable isotopes by bombarding the target isotopes with neutrons or other particles.

Reprocessing

Most of the existing used fuel in the world was produced in Light Water Reactors (LWR's) which are not operated in Canada. Used fuel from LWR's contains a significant amount of fissile material, twice as much as natural uranium. Thus, it has always been recognized that used fuel has the potential for recycling. Indeed, of the 260,000 tonnes of used power reactor fuel produced in the world to date, about one-third (85,000 tonnes) has already been reprocessed in large commercial facilities to recover the uranium and plutonium for eventual recycling. Most of these reprocessing facilities are located in Europe. They are capable of reprocessing about 40 percent of the used fuel arising from these power reactors. For reasons largely related to weapons proliferation concerns, the United States government has banned domestic commercial reprocessing since 1977, while pursuing research on more proliferation-resistant processes.

Reprocessing technology was first developed 60 years ago to extract weapons-grade plutonium-239 for the nuclear weapons programs of the United States, the United Kingdom and Russia, and later in the military programs of countries such as France, China and India. This initial military-related interest has significantly influenced the choice of fuel cycle-related infrastructure subsequently used by civilian nuclear power programs in these and other countries.

Reprocessing can take place after the used nuclear fuel is removed from the reactor and is allowed to cool for a number of years. The fuel is moved in large lead and steel casks to a reprocessing facility. There, it is dissolved in nitric acid while the volatile radioactive isotopes are mostly contained. Several separation and segregation processes are then used to isolate the different streams of products including uranium, plutonium, highly radioactive liquid waste; and less radioactive solids, liquids and gases. Reprocessing simply rearranges the components of the used nuclear fuel, but does not reduce the overall quantity or toxicity of the radioactive material.

Power reactors in Canada use the CANDU system. At present, these reactors use a once-through fuel cycle, meaning the nuclear fuel is placed in the reactor one time and then discharged for interim storage and future long-term management. Therefore, there has been no need for Canada to reprocess used nuclear fuel for reuse or recycling in a nuclear reactor. Nevertheless, it is recognized that other nuclear fuel cycles aimed at the optimum use of uranium and/or plutonium could at some point be implemented in Canada and some of these fuel cycles could involve reprocessing. While there is no purely technical obstacle to reprocessing, the abundant reserves of natural uranium in Canada suggest that it is unlikely Canada would need to implement reprocessing in the near future. Canada is a leader in uranium mining, and Canadian uranium reserves are far from being depleted. The cost of reprocessing used nuclear fuel is high, and is not about to be exceeded in the near future by the cost of mined natural uranium.

The specific composition of used CANDU fuel offers very little incentive to reprocess used fuel in Canada in the foreseeable future if the sole purpose is to recover uranium. In fact, the uranium recovered from used CANDU fuel would be similar in isotopic composition to the low-level wastes arising from the light water fuel enrichment process (i.e., depleted uranium). Used CANDU fuel contains very little fissile material, much less than natural uranium, and the only economic incentive for recycling would be to recover the small amounts of plutonium it contains (about 0.3 percent).

NWMO cost estimates, based on extrapolation from the LWR reprocessing costs (see the 'Harvard' study by Bunn et al. 2003), suggest that reprocessing used fuel from CANDU reactors could increase the cost of nuclear electricity by as much as 20 percent if no credit is taken for recycling the plutonium. Even with a credit for recycling, the reprocessing option would add five to ten percent to the cost of electricity, as much if not more than the entire cost of long-term waste management and reactor decommissioning. For example, reprocessing costs for CANDU fuel have been estimated to be about $1,500 per kg uranium. The current (July 2005) price of uranium (U_3O_8) is about $80 per kg. The total cost to reprocess 3.7 million used CANDU fuel bundles, which contain about 71,000 tonnes of uranium, would be about $107 billion.

Reprocessing used fuel is potentially economically feasible in the future, but only in the case of a continuing nuclear fission reactor program in Canada. It must be acknowledged that economic conditions could be much different in 50 or 300 years. Waste management approaches that ensure accessibility to the used fuel for a sufficiently long time would provide the adaptability and flexibility to enable future generations to make decisions on the case for reprocessing.

The cost of building the necessary industrial capacity to undertake reprocessing and the need to commit to an expanded and multi-generational nuclear fuel cycle are significant limitations for Canada. With this technology, there would still be radioactive wastes to manage and reprocessing would increase the types of wastes and the risks of spreading technology that could be used for production of nuclear weapons.

While some countries such as the United Kingdom, France, Russia and Japan continue to reprocess used fuel, other countries such as the United States, Germany and Switzerland have issued a ban or moratorium on reprocessing.

For a number of reasons, reprocessing as a management approach for used nuclear fuel is considered to be highly unlikely as a viable scenario for Canada at this time.

The necessary facilities are expensive, and they inevitably produce residual radioactive wastes that could be more difficult to manage than used nuclear fuel in its un-reprocessed form. Reprocessing also requires a commitment to a continuing nuclear fuel cycle, and it potentially separates out material that could be used in the production of nuclear weapons in the course of the process.

Partitioning and Transmutation

Reprocessing and recycling of the plutonium recovered from used CANDU fuel would eliminate the most active component of the wastes (plutonium-239) after 1,000 years, and would thus reduce the long-term toxicity of some of the wastes. Eventually, a process called partitioning and transmutation using nuclear reactions initiated by neutrons, protons, or even photons from lasers may be able to transform some of the other radioactive components (not plutonium or uranium) which have been separated (or partitioned) into non-radioactive isotopes, or into isotopes with shorter half-lives, which would be hazardous for a shorter period of time.

If in the future there were a decision to further process CANDU fuel for the purpose of reducing the volume of high-level radioactive waste and toxicity of the fuel, there would need to be significant advances in the partitioning of certain isotopes and in transmutation. As opposed to reprocessing, which is routinely carried out on a commercial scale, partitioning and transmutation is still in its early developmental stage. Introduction of partitioning and transmutation on a commercial scale would require an additional process step at the back-end of the nuclear fuel cycle and a commitment to the continued use of nuclear energy by current and future generations. Exposure risk would increase appreciably due to the complexity of the fuel cycle and the multiple processing steps involved in partitioning and transmutation. As is the case for reprocessing, there would be further risk of encouraging technology that could be used for production of nuclear weapons. Costs are very difficult to determine, and the time-frame for investments would span many decades, imposing financial limitations with uncertain outcomes.

While partitioning and transmutation might reduce the volume and the toxicity of the used nuclear fuel to be managed, there are practical limitations to the technology and it would not avoid the need for long-term management of the residual high-level radioactive wastes that would be produced.

Transmutation, now in the research phase, has the potential to completely eliminate some short-lived fission products and long-lived minor actinides thereby rendering them harmless. However, some long-lived fission products in used nuclear fuel, such as iodine-129 which has a half-life of 16 million years, are not good candidates for transmutation due to limitations in their inherent nuclear properties. Thus, iodine-129 would remain a component in the residual radioactive waste forms resulting from transmutation. Iodine-129 is the key radionuclide in postclosure safety assessments for deep geological repository concepts because of its long half-life and mobility once it enters the geosphere. It would be unaffected by reprocessing, partitioning and transmutation. Since over 90 percent of the iodine-129 is tightly bound in the uranium matrix of the used fuel and uranium is relatively stable at repository depth (e.g., uranium ore deposits are a natural analogue for the stability of a deep geological repository for used fuel), the long-term benefits of removing and treating this radioisotope are likely very small.

Transmutation research and development programs including experimental accelerator driven transmutation facilities are underway in Europe, Japan, the United States, China, Russia, South Korea and other countries. Partitioning and transmutation continue to be the subject of international study, particularly in France, where substantial funds have been devoted to examining their feasibility as a complementary option for managing used fuel in the future. Based on this research, the scientific and technical foundation is not yet sufficiently advanced for implementation. Long-term management of the residual radioactive

Table A9-1 Methods of Limited Interest

METHOD	CONTRARY TO INTERNATIONAL CONVENTIONS	INSUFFICIENT PROOF-OF-CONCEPT
Dilution & Dispersion	X	X
Disposal at Sea	X	X
Disposal in Ice Sheets	X	X
Disposal in Space		X
Rock Melting		X
Disposal in Subduction Zones		X
Direct Injection		X
Sub-Seabed Disposal		X

materials would still be required. In a recent report from France, the Office parlementaire d'évaluation des choix scientifiques et technologiques, Assemblée nationale, reported that "transmutation at an industrial scale is not foreseeable at best before 2040" (Bataille and Birraux 2005).

The possibility of transmuting various radioactive isotopes has only been demonstrated in the laboratory. **As it is too soon to demonstrate that it would be commercially feasible with the volume of used nuclear fuel that exists in Canada, the NWMO recommends keeping a "watching brief" on the findings concerning partitioning and transmutation.** Systematic monitoring of this technology and other areas of evolving scientific research will continue to be an important function of the NWMO to stay abreast of current developments concerning the long-term management of used nuclear fuel.

Deep Borehole Placement involves placing used fuel packages at depths of several kilometres in boreholes with diameters of typically less than one metre. Packages would be stacked on top of one another in each borehole, separated by layers of bentonite or cement.

Although very deep borehole placement may hold some potential as a method for the disposal of small quantities of radioactive waste, it would be difficult to implement and ensure isolation and containment of larger quantities of used nuclear fuel.

The concept of an **International Repository** (or even a regional repository), which would involve the transboundary movement of used nuclear fuel, does not contravene any international treaty. However, most countries subscribe to the self-sufficiency principle under which they are responsible for any waste they produce. An international repository may become more attractive for some countries in future years, but it is not a decision to be made solely by Canada. It will be important for Canada to continue to monitor developments in this area of radioactive waste management.

Methods of Limited Interest

The following used nuclear fuel management methods have been investigated to varying degrees over the past 40 years and in some cases are still being advocated by a few individuals or organizations. None are being implemented anywhere, nor are they part of any national research and development program. Some are contrary to international conventions. The methods of limited interest and the reasons for screening them out are shown in Table A9-1.

The following discussion of these methods of limited interest is adapted from the NWMO document *Understanding the Choices*, Appendix 4 / Screening Rationale for Methods of Limited Interest.

Dilute and Disperse differs from all other used nuclear fuel management methods in that there would be no containment of the waste or isolation from the environment. One method involves dissolving used nuclear fuel in acid, neutralizing the solution and discharging it slowly down a pipeline into the sea. Another possibility would be to transport the used fuel solution by tanker to the open ocean and release it there. The discharge site and rate would be such that radiation doses to people would never exceed internationally accepted limits.

In principle, dilution and dispersion of radioactive waste is not considered to be sound environmental practice. This method has never seriously been proposed for used nuclear fuel because, similar to disposal at sea, it would be prohibited by international conventions. Dilution and dispersion is not included in any national or international research and development programs.

(Note: Canadian authorities regulate the emission of very small quantities of radioactivity into air and water from operating nuclear facilities).

Disposal at Sea would involve placing packaged used nuclear fuel on the bed of the deep ocean. The packaging would consist of canisters designed to last for a thousand years or more. The used fuel would be in a solid form that would release radionuclides into the ocean very slowly when the canisters fail. The site would be one where the water is a few kilometres deep, so that the used fuel would not be disturbed by human activities and there would be substantial dilution of radionuclides before they reach the surface environment.

Sea disposal was investigated by the Nuclear Energy Agency's Seabed Working Group. It would be an extension of the 'sea dumping' method which was used for disposal of solid low level radioactive waste until the early 1980s and which is now prohibited under international conventions. Sea disposal is prohibited by international conventions and is not included in any national or international research and development programs.

Disposal in Ice Sheets would involve placing containers of heat-generating used nuclear fuel in very thick, stable ice sheets, such as those found in Greenland and Antarctica. Three concepts have been suggested. In the "meltdown" concept, containers would melt the surrounding ice and be drawn deep into the ice sheet, where the ice would refreeze above the used fuel containers creating a thick barrier. In the "anchored emplacement" concept, containers would be attached by surface anchors that would limit their penetration into the ice by melting to around 200-500 metres, enabling possible retrieval for several hundred years before surface ice covers the anchors. Lastly, in the "surface storage" concept, containers would be placed in a storage facility constructed on piers above the ice surface. As the piers sank, the facility would be jacked up to remain above the ice for perhaps a few hundred years. Then the entire facility would be allowed to sink into the ice sheet and be covered over.

There has been very little work on disposal in ice sheets because there has never been enough confidence about predicting the fate of the used nuclear fuel and because of the potential for release of radionuclides into the ocean. Disposal of radioactive waste in Antarctica is prohibited by international treaty and Denmark has indicated that it would not allow such disposal in Greenland. Disposal in ice sheets is not included in any national or international research programs.

Disposal in Space would permanently remove used nuclear fuel from the Earth by ejecting it into outer space. Destinations that have been considered include the sun and ejection beyond the solar system. Because of the high cost estimate for each payload using present day technology, this method has been suggested for disposing of only small amounts of the most toxic waste materials.

Space disposal has never been included in any major research and development program. Considerable further processing of the used nuclear fuel with its associated high costs would be required. Concerns about the risk of an accident and the potential risk to human health and the environment have been reinforced by the U.S. Space Shuttle Challenger and Columbia accidents.

Rock Melting would involve placing used nuclear fuel in liquid or solid form in an excavated cavity or a deep borehole. Heat generated by the used fuel would then accumulate, resulting in temperatures sufficient to melt the surrounding rock and dissolve the radionuclides in a growing sphere of molten material. As the rock cools, it would crystallize and incorporate the radionuclides in the rock matrix, dispersing the used fuel throughout a larger volume of rock.

In a variation of this method, the heat-generating waste would be placed in containers, causing the rock around the containers to melt, sealing the used fuel in place. Research was carried out on this method in the late 1970s and early 1980s, when it was developed to the level of engineering design. The design involved a shaft or borehole that led to an excavated cavity at a depth of two to five kilometres. It was estimated, but not demonstrated, that the used nuclear fuel would be immobilized in a volume of rock one thousand times larger than the original volume of the used fuel. Another early proposal was to use weighted containers of heat-generating used fuel that would continue to melt the underlying rock, allowing them to move downwards to greater depths with the molten rock solidifying above them.

There was renewed interest in rock melting in the 1990s in Russia, particularly for the disposal of limited volumes of specialized material such as plutonium. Russian scientists have also proposed that used nuclear fuel could be placed in a deep shaft and immobilized by a nuclear explosion, which would melt the surrounding rock. There have been no practical demonstrations that rock melting is feasible or economically viable. This method is not being investigated in the national program of any country.

Disposal in Subduction Zones would involve placing used nuclear fuel in a subducting or descending plate of the earth's crust. As subduction zones are invariably offshore, this concept can also be considered as a variant of placement in the sea or beneath the seabed. Either tunneling or deep sub-seabed boreholes could theoretically be used to emplace the used nuclear fuel close to an active subduction zone. Free-fall penetrators could also be used.

Disposal of used nuclear fuel in subduction zones has not received significant attention by the radioactive waste management community in Canada or abroad for several reasons. Potential sites for such a disposal facility are very limited and offshore. In Canada, used fuel transportation distances from the nuclear reactor sites to a subduction zone, such as the Juan de Fuca plate located about 100 kilometres off the coast of Vancouver Island, would be significant. Monitoring and retrieval of used fuel would be more difficult compared with land-based deep geological repositories. And there is concern about whether used nuclear fuel buried in subduction zones might return to the surface environment via volcanic eruptions. It has also been suggested by some that this method could be seen as a form of sea disposal which would be prohibited by international conventions.

Although there remains some interest in Canada concerning the concept of disposing of used nuclear fuel in subduction zones, there is insufficient proof of concept to recommend it as an appropriate approach at this point in time.

Direct Injection would involve the injection of liquid radioactive waste directly into a layer of rock deep underground. Although used for the disposal of liquid hazardous and low-level waste in the U.S. in the past, this technique has only ever been used for liquid high-level waste in the former Soviet Union, at a number of locations usually close to the waste-generating sites.

Direct injection requires detailed knowledge of subsurface geological conditions, as it does not incorporate any man-made barriers. There would be no control of the injected material after disposal and retrieval would be impossible. There are many technical unknowns which would require extensive research to gain the necessary degree of confidence that this method would be appropriate for a specified site. Although the option would not contravene international conventions, it would not be consistent with the spirit of international guidance on the long-term management of used nuclear fuel. Current published assessments indicate no substantive advantages to this method. It is not being pursued in any country as a means of dealing with an entire national inventory of used nuclear fuel.

Sub-Seabed Disposal would involve burial of used nuclear fuel containers in a suitable geological setting beneath the deep ocean floor. The disposal sites would be ones where the sediments are plastic and have a high capacity to absorb radionuclides, and where the water is several kilometres deep. The main sub-seabed disposal concept would use missileshaped canisters called "penetrators" to hold the solid waste. They would be dropped from ships, and bury themselves to a depth of a few metres in the sediments on the ocean floor. The idea behind the concept is that the waste form, inner canister, penetrator and sediments would provide sufficient protection to prevent the release of radionuclides into the ocean for thousands of years or more. When release finally does take place, it would occur very slowly and there would be substantial dilution. Another variation of this option would use deep sea drilling technology to stack used nuclear fuel packages in holes drilled to a depth of 800 metres, with the uppermost container about 300 metres below the seabed. An alternative "sub-seabed" option would be to access a location deep beneath the ocean floor via on-land shafts and drifts. In this instance, the ocean itself would serve as a last line of defense. The theory is that if contaminants were to escape and move to the ocean environment, their volume would be small and the buffering and diluting capacity of the ocean would mitigate the consequences.

Sub-seabed disposal was investigated extensively in the 1980s, primarily under the auspices of the Seabed Working Group set up by the Nuclear Energy Agency (NEA) of the Organization for Economic Co-operation and Development (OECD). Canada participated in this group, as did the United States, the United Kingdom, Japan and several European countries. Research on sub-seabed disposal effectively ceased when it became clear that there would always be intense political opposition. Ocean access to a sub-seabed repository is now prohibited by international conventions.

References

Bataille, M. and C. Birraux. 2005. Projecting into the future: a new law in 2006 to ensure the sustainable management of radioactive waste. A report by Mr. Christian Bataille, MP for the Nord Department and Mr. Claude Birraux, MP for the Haute-Savoie Department, on "The Advances and Prospects Regarding Radioactive Waste Management". Abstract. Office parlementaire d'évaluation des choix scientifiques et technologiques, Assemblée nationale. Paris, France.

Bunn, M., S. Fetter, J.P. Holdren and R. van der Zwaan. 2003. The economics of reprocessing vs. direct disposal of spent nuclear fuel. Belfer Center for Science and International Affairs, John F. Kennedy School of Government, Harvard University. Report DE-FG26-99FT4028. Massachusetts, USA.

Jackson, D.P. 2005. Implications of reprocessing, partitioning and transmutation on long-term management of used nuclear fuel in Canada. Background Paper 6-14 prepared by David P. Jackson, McMaster University for the Nuclear Waste Management Organization, February 2005. (Available at www.nwmo.ca).

Appendix 10 / Used Fuel Scenarios

1. Introduction

In 2003, the NWMO convened a diverse team of individuals largely from across Canada to design a series of scenarios that would span a wide range of alternative plausible futures. The scenarios were prepared to highlight the possible impact of radioactive waste management decisions under a variety of futures with their associated uncertainties over the timeframes of 25 years, 175 years, 500 years and 10,000 years (GBN 2003). In 2004, the NWMO Assessment Team reviewed these scenarios and selected three of them (two pessimistic scenarios and one optimistic scenario) against which to test the preliminary findings of the evaluation of management approaches against a variety of futures (Ben-Eli et al. 2004). The three test scenarios were:

Test Scenario 1 is an optimistic scenario in which institutions remain strong, stable, respected and vigilant in perpetuity. The generation of used nuclear fuel ends with the current fleet of nuclear reactors working to their design life and not beyond. No new technical solution is found for treating the used fuel. Thus, in an overall sense, while care must be taken in perpetuity, society's overall capacity to address the issue of used nuclear fuel is high. This test scenario is split into two sub-scenarios. In Test Scenario 1-A, the "polluter pays" principle is adhered to for all three management approaches (Deep Geological Disposal in the Canadian Shield, Storage at Nuclear Reactor Sites and Centralized Storage). In Test Scenario 1-B, the principle is only truly maintained for the disposal option. For the storage options, resources from future generations are eventually required to cover the cost of repackaging and maintenance thus the "polluter pays" principle is not fully respected.

Test Scenario 2 is more pessimistic than Scenario 1. Here, nuclear energy is abandoned because of a loss of public trust; there is extreme social, political and institutional instability, mass migration of populations, fossil fuel use rises, climate change goes to the extreme, food costs rise, population shrinks by half and many are driven to subsistence lifestyles.

Test Scenario 3 is also pessimistic. While the economy is strong, energy demand is high and nuclear dependency is also high; weapons proliferate and security issues are grave; the gap between rich and poor widens and social instability results; totalitarian rule is imposed, greatly reducing personal freedoms; the threat of nuclear war is real but doesn't occur; society teeters.

The Assessment Team found that on nearly all of the objectives identified as necessary for an acceptable management approach, the deep geological repository concept is likely to perform better in the long term than the other waste management alternatives.

The NWMO has reflected on these scenarios and asked itself how much used fuel and what types of used fuel will need long-term management in Canada, and could the proposed management approaches accommodate the projected volume and types of used fuel?

To answer these questions, it was necessary to examine how much used fuel exists today and estimate how much used fuel would be produced in the future.

To understand the impact of the uncertainty associated with estimates of used fuel on its recommended management approach, the NWMO developed a number of possible future used fuel scenarios.

2. Current Inventory of Used Fuel

As discussed in Appendix 4, at the end of 2004, there were approximately 1.87 million used fuel bundles in Canada. The total number of used fuel bundles that will eventually be produced will depend on a number of factors such as the actual production values at each of the nuclear generating stations, future decisions by the operators of nuclear generating stations on refurbishment or life extension of existing reactors, and whether or not new nuclear reactors are built in Canada. For example:

- In 2004, Bruce Power submitted an application with the Canadian Nuclear Safety Commission (CNSC) for the refurbishment of Bruce A nuclear generating station, including the possibility of using new slightly enriched uranium (~ 1% uranium-235) in the CANDU reactors at Bruce. The proposed refurbishment at Bruce would extend the operational life of the reactors to 2043. Also, if the Bruce reactors operate with slightly enriched uranium, then there is the potential for used nuclear fuel with slightly different characteristics than are currently produced in Canada.

- In July 2005, the Province of New Brunswick announced that it would proceed with the planned refurbishment of the Point Lepreau reactor beginning in 2008. This decision could extend the service life of the Point Lepreau reactor by 25 to 30 years.

- In August 2005, Ontario Power Generation Inc. announced that it would not proceed with the planned refurbishment of Unit 2 and Unit 3 at the Pickering A nuclear generating station. The estimated operating lives for Pickering A Units 1 and 4 have been extended to 2023.

Future decisions on refurbishment or new reactor builds will likely be made by the provincial governments in Ontario, Québec and New Brunswick, possibly in conjunction with the Government of Canada. Thus, there continues to be uncertainty regarding the number of used fuel bundles that will eventually be produced in Canada.

3. Reference Used Fuel Scenario

The conceptual designs and cost estimates for long-term management approaches, prepared for the Joint Waste Owners (JWO) of used fuel and submitted to the NWMO, are based on a projected inventory which assumes that the Pickering, Bruce and Darlington reactors in Ontario will operate an average of 40 years, the Point Lepreau reactor in New Brunswick will operate 25 years, and the Gentilly reactor in Québec will operate 30 years (CTECH 2002; 2003a; 2003b). In this scenario, the existing reactors would be shut down after their respective 25, 30 and 40-year average lifetimes. This reference scenario could be considered a gradual "phase out" for the existing fleet of reactors in Canada at the end of their lives. The projected used fuel inventory was prepared in 2001 and estimated to be 3,557,451 bundles which were rounded up to 3.6 million bundles for conceptual design and cost estimating purposes.

In 2004, the JWO submitted summaries of cost estimates for the various long-term management approaches to the NWMO (JWO 2004a; 2004b; 2004c). These cost estimates were adjusted to reflect a revised estimate of the number of used fuel bundles that would be produced based on a common average nuclear reactor life of 40 years. This revised 2004 estimate is 3,665,094 fuel bundles or a rounded value of 3.7 million fuel bundles. (**www.nwmo.ca/costsummaries**)

In 2005, the installed nuclear generation capacity in Canada consists of 22 reactors for a total of 16,000 MW, although several Ontario units are currently shut down and may not be restarted. Based on previous operating experience, if all of these CANDU reactors were operational, they would generate approximately 100,000 used fuel bundles annually or about 6.25 bundles per MW-year of electrical energy production.

The projected number of bundles was also provided by the JWO for an average station life of 30 years (3.0 million bundles) and an average station life of 50 years (4.4 million bundles), reflecting uncertainty in the projected future estimates.

The change in the reference scenario from about 3.6 million to 3.7 million fuel bundles (< 3%) would not have a significant impact on the conceptual designs for long-term management facilities. The larger value is more conservative from a design and cost perspective, but not materially different than the original estimate since the reference designs were prepared using the projected number of used fuel bundles rounded up to the nearest 100,000 bundles.

A reference used fuel scenario based on 3.6 (or 3.7) million used fuel bundles is considered to be a reasonable projection assuming that the existing fleet of nuclear reactors in Canada have an average operational life of 40 years. Note that 3.7 million used fuel bundles would have a mass of about 71,000 tonnes of uranium for long-term management.

In 1962, the first demonstration of commercial nuclear power in Canada began with the Nuclear Power Demonstration reactor in Rolphton, Ontario. The first unit of the Pickering A Nuclear Generating Station commenced operation in 1971. The last unit of the Darlington reactors in Ontario will potentially reach 40 years of operation in 2033. Therefore, the reference 3.6 million fuel bundle scenario represents about 70 years of CANDU nuclear reactor operation in Canada.

In 2004, the NWMO commissioned a third-party review of the conceptual designs and cost estimates for the various long-term management approaches submitted by the JWO. The report found that all of the conceptual designs have sufficient flexibility to accommodate increased used fuel capacity in the future by constructing either incremental additions or completely new facilities. Further discussions in 2004 between the NWMO and the JWO confirmed that the modular designs of the long-term management approaches are sufficiently robust to accommodate more used fuel bundles or fewer used fuel bundles in the future, relative to the reference assumption of 3.6 million bundles.

4. National Energy Board Scenario

The National Energy Board report on Canada's energy future looked at two plausible energy futures for Canada, both of which assume a growth in electrical generation of 1.8 percent per year until 2025 (NEB 2003):

1. **Supply Push** scenario assumes that energy technology advances gradually and Canadians take limited action to limit the impact on the environment. The main focus is maintaining security of energy supply and a push to develop known resources of energy in Canada. The Supply Push scenario would see a resurgence of coal-fired plants in addition to gas-fired generation, hydraulic and nuclear.

2. **Techno-Vert** scenario assumes that energy technology advances rapidly and Canadians take broad action to limit impact on the environment by using environmentally friendly products and cleaner-burning fuels. The Techno-Vert scenario would see gas-fired generation, hydraulic, and a shift towards cleaner coal-burning technology, wind power and advanced nuclear reactors such as AECL's Advanced CANDU Reactor (ACR), which uses slightly enriched uranium.

The National Energy Board predicts a rise in Canada's electrical generating capacity from about 110,000 MW in 2000 to about 150,000 MW by 2025. For the Supply Push and the Techno-Vert scenarios, electrical generation by nuclear power is assumed to be about 13 to 15 percent, respectively. Under the Techno-Vert scenario, installed nuclear generation capacity in Canada could rise from the current 16,000 MW to about 22,500 MW by 2025. Assuming standard CANDU reactor technology, 22,500 MW of nuclear generation would produce about 140,000 used fuel bundles per year of operation in Canada.

5. Other Future Used Fuel Scenarios

The National Energy Board's report and the NWMO's discussions with Canadians have identified a need for the NWMO to explore other future used fuel scenarios in addition to the reference "3.6 million bundle" scenario provided by the JWO. Four other used fuel scenarios have been developed by the NWMO, which can be used for a high-level evaluation, and comparison with the reference used fuel scenario. They should be considered as "what-if" scenarios to test the robustness of the NWMO analysis of approaches for long-term management of used nuclear fuel. The scenarios have been designed to illustrate a broad range of future scenarios that include an "early" phase out of nuclear power and a continuing nuclear reactor program in Canada with a mixture of nuclear generation types.

These other scenarios have been examined to understand the potential impact of future circumstances on the technical aspects of the management approaches (e.g. facility size, used fuel transportation requirements, duration of activities). They have not been evaluated explicitly to assess the broader range of social and ethical factors which are reflected in the eight objectives of the comprehensive comparative assessment, summarized in Chapter 8.

5.1 Future Scenario 1: Early Nuclear Phase Out

At the end of 2004, there were about 1.87 million used fuel bundles in Canada. With several reactors shut down, the production rate for used fuel is about 85,000 bundles per year. By the end of 2005, there is expected to be about 2 million bundles of used fuel in Canada. For this future scenario, the existing nuclear reactors are assumed to be gradually shut down over a five-year period starting in 2007.

Under an Early Nuclear Phase Out scenario, the total used fuel inventory by 2012 is projected to be 2.5 million used CANDU fuel bundles distributed over the seven reactor sites in Canada. For the central facility long-term management options, both the used fuel transportation period and the used fuel placement period could be reduced to about 20 years.

The potential implications of a future Early Nuclear Phase Out scenario would be similar to the 3 million used fuel bundle scenario which has been costed by the JWO. The long-term management facilities for 2.5 million used fuel bundles (48,000 tonnes of uranium) would be smaller than the current reference designs but still significantly larger than the planned used fuel management facilities in Finland (about 2,600 tonnes uranium) or Sweden (about 9,500 tonnes).

5.2 Future Scenario 2: Existing Reactor Refurbishment and Life Extension

Under the Existing Reactor Refurbishment and Life Extension scenario, the existing fleet of CANDU reactors in Canada is assumed to continue operation until the reactors have reached an average life of 50 years. Most of the material would be standard used CANDU fuel, although there may be some bundles from the Bruce reactors with slightly enriched uranium. The number of bundles produced for this 50 year operating scenario would be about 4.4 million. This total used fuel inventory is assumed to be reached by 2043 when the last reactor unit at Darlington achieves 50 years of operation.

The number of reactor sites in Canada would remain constant at seven. For the central facility long-term management options, both the used fuel transportation period and the used fuel placement period could be increased to about 40 years.

The potential implications of a future Existing Reactor Refurbishment and Life Extension scenario with 4.4 million used fuel bundles have been costed by the JWO. The long-term management facilities for 4.4 million used fuel bundles (84,000 tonnes of uranium) would be slightly larger than the current reference designs. However, it should be noted that this used fuel inventory is less than half of the 10 million bundles assumed by Atomic Energy of Canada Limited and incorporated in their conceptual designs (AECL 1994).

5.3 Future Scenario 3: Continuing CANDU Nuclear Program

The Continuing CANDU Nuclear Program scenario assumes the existing fleet of CANDU reactors continues operation and are refurbished or replaced with additional nuclear generation. While it is recognized that the used fuel could be a mixture of standard CANDU and slightly enriched uranium fuel, the used fuel inventory is conservatively based on standard CANDU bundles. The nuclear generation supply would be based on maintaining nuclear power at 15 percent of the total energy supply in Canada (NEB 2003). Therefore, the current 16,000 MW of nuclear generation would be increased to 22,500 MW by 2025.

Beyond 2025, energy supply and demand in Canada is uncertain. For the Continuing CANDU Nuclear Program scenario, nuclear generation is assumed to remain constant at 22,500 MW for an additional 200 years, or roughly 3 times the current projected life of 70 years for commercial nuclear power production in Canada. Reprocessing of used fuel for reuse in future reactors is not assumed to occur due to the high cost of reprocessing CANDU fuel and the abundance of uranium resources in Canada. The used fuel inventory for the Continuing CANDU Nuclear Program scenario would be approximately 30 million bundles, two million as of 2005 and an additional 28 million by about 2200.

The number of reactor sites in Canada is assumed to increase from the current seven to ten sites. For the central facility long-term management options, both the used fuel transportation period and the used fuel placement period could be increased to 250 years in order to maintain the currently assumed rate of handling 120,000 bundles per year.

The Continuing CANDU Nuclear Program scenario with 30 million used fuel bundles would likely result in a long-term management facility containing three times the 10 million bundle inventory assumed by Atomic Energy of Canada Limited in 1994. The operating period of the management facility would be substantially longer (several hundred years).

5.4 Future Scenario 4: Mixture of Continuing Nuclear Reactor Generation

The Mixture of Continuing Nuclear Reactor Generation scenario maintains nuclear power at 15 percent of the total energy supply in Canada (NEB 2003). The current 16,000 MW of nuclear generation is assumed to increase to 22,500 MW by 2025 and remain constant for the next 200 years. Reprocessing of used CANDU fuel is not assumed for economic reasons.

For the Mixture of Continuing Nuclear Reactor Generation scenario, nuclear generation in Canada is assumed to be a mixture of standard CANDU reactors with natural and slightly enriched uranium, Advanced CANDU Reactors and Pressurized Water Reactors. The amount of used fuel produced over the next 200 years would depend on the exact mix of nuclear reactors and their operating periods, which is uncertain. The amount of used fuel produced can be reduced roughly by the uranium-235 enrichment factor. The fissile uranium-235 content in natural uranium is 0.7 percent; slightly enriched uranium fuel has 0.8 to 1.2 percent; Advanced CANDU Reactor fuel has about two percent and Pressurized Water Reactors fuel has about four percent. As a result, some of these reactors may produce about one quarter to one half the used fuel of a standard CANDU reactor.

For purposes of this future scenario, it is assumed that future nuclear generation in Canada would be dominated by Advanced CANDU Reactors and Pressurized Water Reactor. The number of used fuel bundles (or equivalent bundles in the case of pressurized water reactors) produced in Canada by about the year 2200 is assumed to be 15 million bundles, or half the assumed inventory for the Continuing CANDU Nuclear Program scenario.

The number of reactor sites in Canada is assumed to increase from the current seven to ten sites. For the central facility long-term management options, both the used fuel transportation period and the used fuel placement period could be increased to about 250 years but at a reduced handling rate of about 60,000 bundles (or equivalent) per year. Note that fuel enriched with uranium-235 has a higher burnup and is consequently thermally hotter than used natural uranium fuel. In general, designs for used fuel containers have a thermal limit. Similar used fuel containers may hold less enriched fuel than natural uranium used fuel, depending on their cooling time out of reactor.

The potential implications of a future Mixture of Continuing Nuclear Reactor Generation scenario with 15 million used fuel bundles are that it would likely result in a long-term management facility that is one and a half times the inventory assumed by Atomic Energy of Canada Limited in 1994, although the operating period of the long-term management facility would be substantially longer (several hundred years).

References

AECL. 1994. Environmental impact statement on the concept for disposal of Canada's nuclear fuel waste. Atomic Energy of Canada Limited Report, AECL-10711, COG-93-1. Chalk River, Ontario.

Ben-Eli, M., J. Neate, J. Facella, A. Hodge, T. Issacs, W. Leiss, M. Margolick, K. Moshonas Cole and F. Roots. 2004. Assessing the options future management of used nuclear fuel in Canada. An NWMO Assessment Team Report prepared for the Nuclear Waste Management Organization, June 2004. (Available at www.nwmo.ca/assessmentteamreport)

CTECH. 2002. Conceptual design for a deep geologic repository for used nuclear fuel. CTECH Report 1106/MD18085/REP/01. (Available at www.nwmo.ca/geologicaldisposal)

CTECH. 2003a. Conceptual designs for reactor-site extended storage facility alternatives for used nuclear fuel. CTECH Report 1105/MD18084/REP/12. (Available at www.nwmo.ca/reactorstorage)

CTECH. 2003b. Conceptual designs for four centralized extended storage facility alternatives for used nuclear fuel. CTECH Report 1105/MD18084/REP/08. (Available at www.nwmo.ca/centralstorage)

GBN. 2003. Looking forward to learn: future scenarios for testing different approaches to managing used nuclear fuel in Canada. Background Paper 8-5 prepared by Global Business Network for the Nuclear Waste Management Organization. (Available at www.nwmo.ca/scenarios)

JWO. 2004a. Costs of alternative approaches for the long-term management of Canada's nuclear fuel waste. Reactor-site extended storage approach. A submission to the Nuclear Waste Management Organization by Ontario Power Generation, Hydro-Québec, New Brunswick Power and Atomic Energy of Canada Limited. January 2004, Rev. 00. (Available at www.nwmo.ca/reactorcosts)

JWO. 2004b. Costs of alternative approaches for the long-term management of Canada's nuclear fuel waste. Centralized extended storage facility approach. A submission to the Nuclear Waste Management Organization by Ontario Power Generation, Hydro-Québec, New Brunswick Power and Atomic Energy of Canada Limited. March 2004, Rev. 02. (Available at www.nwmo.ca/centralstoragecosts)

JWO. 2004c. Costs of alternative approaches for the long-term management of Canada's nuclear fuel waste. Deep geologic disposal approach. A submission to the Nuclear Waste Management Organization by Ontario Power Generation, Hydro-Québec, New Brunswick Power and Atomic Energy of Canada Limited. March 2004, Rev. 01. (Available at www.nwmo.ca/disposalcosts)

NEB. 2003. Canada's energy future. Scenarios for supply and demand to 2025. National Energy Board Report Cat. No. NE23-15/2003E, ISBN 0-662-33858-8, Calgary Alberta. (Available at www.neb-one.gc.ca/energy/SupplyDemand/2003/index_e.html)

Appendix 11 / Building the Information Foundation – Engagement and Research

The NWMO has benefited from the knowledge, advice and counsel of many specialists from Canada and abroad, and from citizens across Canada. Reports from these dialogues are available at www.nwmo.ca/dialoguereports.

A) Engagement Activities

As of August 31, 2005, approximately 50,000 people expressed interest in our study by visiting our web site. We conservatively estimate that more than 18,000 citizens have contributed, including more than 500 specialists in scientific (natural and social sciences) and technical disciplines related to the management of used nuclear fuel.

Early in its work the NWMO initiated approximately 250 Conversations About Expectations with individuals and organizations to learn what they expected from the NWMO study and how they wanted to see it conducted.

National Citizens Dialogue on Values

The NWMO partnered with the Canadian Policy Research Networks (CPRN) to bring together 462 citizens for a dialogue about their underlying values and expectations. The goal was to understand how the public at large approaches the complexities involved in the long-term management of used nuclear fuel. The Dialogue took place between January and March 2004, in 12 locations across the country:

Halifax	Moncton	Québec City
Vancouver	Montréal	Toronto
London	Calgary	Thunder Bay
Sudbury	Ottawa	Saskatoon

Participants were randomly selected by a polling firm to be representative of the Canadian population. Using quantitative and qualitative data from the dialogue sessions, CPRN analyzed the results and reported on the core values Canadians would like to see drive decision-making. The full report is available at: www.nwmo.ca/canadianvalues.

13-1. Responsible Action – Citizens' Dialogue on the Long-term Management of Used Nuclear Fuel, Judy Watling, Judith Maxwell, Nandini Saxena, Suzanne Taschereau, Canadian Policy Research Networks. July 2004.

13-2. National Citizens' Dialogue: Video Overview, Canadian Policy Research Networks. July 2004.

Nuclear Host Community Dialogues

The NWMO recognized early that communities which currently store used nuclear fuel have special experience, insights and perspectives which should be drawn upon to inform the NWMO study. Each of these communities was visited.

- Community Dialogue: Report of the Planning Workshop. Glenn Sigurdson CSE Consulting Inc. and Barry Stuart.

In October 2003 a Community Dialogues Planning Workshop was convened in Toronto to develop ways of enabling reactor site communities to participate meaningfully in the process. Twenty-one individuals participated, representing various perspectives including: environment, labour, industry, business, citizen, health and local government. They were drawn from communities in the vicinities of the seven nuclear storage sites in Canada: Point Lepreau in New Brunswick; Gentilly in Québec; Darlington, Pickering, Bruce and Chalk River in Ontario; and Whiteshell in Manitoba.

- Community Dialogue Workshop. Hardy Stevenson and Associates, February 2005.

In February 2005 participants from the 2003 workshop were reconvened for a two-day session in Toronto to review the NWMO's second discussion document *Understanding the Choices* and to seek their input on the preliminary assessment of the management options and the NWMO's implementation strategy. The two-day dialogue included an exercise designed to assist participants in their understanding of the assessment framework presented in the document and was followed by an in-depth discussion of the questions posed in *Understanding the Choices*. Thirteen participants attended these sessions.

Reports of the Community Dialogue Workshops are available on the NWMO website: **www.nwmo.ca/workshopreports**.

8-4. Community Dialogue: Report of the Planning Workshop. Glenn Sigurdson CSE Consulting Inc. and Barry Stuart.

10-8. Community Dialogue Workshop. Hardy Stevenson and Associates, February 2005.

Other Dialogues with Nuclear Host Communities

Throughout its study the NWMO has conducted ongoing dialogue and study updates through meetings with individual Mayors, and through the Canadian Association of Nuclear Host Communities. Citizens from reactor site communities participated in the Information and Discussion sessions held across Canada from October to December 2004.

Also, at their request, information has been presented to citizen groups, advisory committees, local health committees, municipal councils and planning committees in nuclear communities. Among them:

Ajax City Council
Ajax Rotary Club
Citizens for Renewable Energy/ Great Lakes United (Kincardine area)
Darlington Site Planning Committee
Deep River Area Mayors
Deep River CNS
Durham Nuclear Health Committee
Inverhuron District Ratepayers Association (IDRA)
Municipalité Régionale de Comté de Pontiac (MRC Pontiac), Québec
Pickering City Council
Pickering Community Advisory Committee
Pickering Council Management Forum
Point Lepreau Generating Station Community Liaison Committee
Port Elgin Chamber of Commerce
Renfrew Concerned Citizens
South Bruce Impact Advisory Committee

National and Regional Stakeholder Dialogues

- Report on National Stakeholder and Regional Dialogues Regarding NWMO Discussion Document 1 *Asking the Right Questions?* DRPA Canada. 2004.

In March and April 2004, the NWMO held national and regional dialogues in Ottawa, North Bay, Montréal, and Fredericton. These meetings brought together seventy-three people and organizations with a history of involvement in the subject of how Canada should manage its nuclear fuel wastes and others with an interest in similar public policy issues. Participants were asked to critically review the NWMO's first discussion document, *Asking the Right Questions?*

Dialogues consisted of an introductory half-day session, followed by an electronic dialogue, and several weeks later, a full-day facilitated discussion in which participants returned to address a range of topics in depth and to explore their views further.

- Dialogue: National Stakeholders and Regional Dialogue Sessions. Hardy Stevenson and Associates Final Report, February 2005.

The National and Regional Dialogues were re-convened in January and February 2005 to review the NWMO's second discussion document *Understanding the Choices* and to seek input on the preliminary assessment of the management options and the NWMO's implementation strategy. Fifty-nine people participated in these re-convened dialogues held in Toronto, Mississauga, Fredericton and Montréal. The two-day sessions included an exercise designed to assist participants in their understanding of the assessment framework presented in *Understanding the Choices* and was followed by an in-depth discussion of the questions posed in the document.

Project findings for both the initial and follow-up national and regional dialogues are available on the NWMO website at: **www.nwmo.ca/workshopsandroundtables**.

10-2. Report on National Stakeholder and Regional Dialogues Regarding NWMO Discussion Document 1 *Asking the Right Questions?*. DRPA Canada. 2004.
1. National Stakeholders and Regional Dialogue Sessions: Final Report, DPRA.
2. National Stakeholders and Regional Dialogue Sessions: Appendices, DPRA.

10-6. Dialogue: National Stakeholders and Regional Dialogue Sessions. Hardy Stevenson and Associates Final Report, February 2005.

E-Dialogues

Royal Roads University, facilitated by Dr. Ann Dale, conducted four internet-based e-dialogues on behalf of the NWMO:

- On October 26, 2004 risk and uncertainty in the management of nuclear waste was explored by the following panelists: Norm Rubin of Energy Probe, William Leiss of the School of Policy Studies at Queen's University, Andrew Stirling of Science and Technology Policy Research at the University of Sussex, Environmental Studies at Williams College, and David Shoesmith of the Department of Chemistry at the University of Western Ontario.

- On November 29, 2004 approximately 75 young people were engaged in four e-roundtables to consider the assessment framework proposed by the NWMO in its second discussion document and to apply this framework to the three options for managing used nuclear fuel under study. Participants drew from Parliamentary Interns, Action Canada Senior Policy Fellows, Top Forty Under Forty, members of the doctoral science cohort across North America, youth wings of the three major political parties, Royal Roads students, graduates and Trudeau Scholars.

- On February 10, 2005, decision-making under conditions of risk and uncertainty was explored by the following panelists: Christopher Henderson of the Delphi Group, Norm Rubin of Energy Probe, Jim MacNeill formerly of the Brundtland Commission and of the World Bank's Independent Inspection Panel, and Andy Stirling from the University of Sussex. Interested public were invited to view the dialogue and post comments.

From October 2004 to February 2005 the Royal Roads website which accommodated the NWMO e-dialogues recorded 3203 visits.

- From July 1 through to August 14, 2005 Royal Roads University hosted an open E-Forum inviting all interested Canadians to engage in a discussion concerning the appropriateness of NWMO's *Draft Study Report* and recommended approach. The forum was opened with an interview with NWMO President Elizabeth Dowdeswell by Anne Dale. In total, 577 individuals either participated in or viewed the E-Forum dialogue.

Reports on the E-dialogues are available at: www.nwmo.ca/edialogues.

14-1. E-Dialogue on Risk and Uncertainty: October 26, 2006. Royal Roads University.

14-2. E-Dialogue Among Young Canadians: November 29, 2004. Royal Roads University.

14-3. E-Dialogue on Decision-Making under Conditions of Risk and Uncertainty: February 10, 2005. Royal Roads University.

14-4. Final Report: Nuclear Waste Management Organization Public E-Forum: August 2005. Royal Roads University.

Information and Discussion Sessions

- Community Information and Discussion Sessions Discussion Document 2 *Understanding the Choices*, DPRA Canada, Inc. February 2005.

Between September and December 2004, 880 citizens participated in well-advertised public information and discussion sessions convened in every province and territory in Canada. The purpose was to inform Canadians about the NWMO study and to engage them in a dialogue about the preliminary descriptions of long-term nuclear waste management approaches and the framework being proposed to compare them.

One-hundred and twenty meetings occurred in:

Bécancour	Clarington	Charlottetown
Edmonton	Edmundston	Fredericton
Goose Bay	Halifax	Huntsville
Iqaluit	Kenora	Kingston
London	Montréal	Musquash
Ottawa	Owen Sound	Pembroke
Pickering	Pinawa	Québec City
Regina	Rivière-du-Loup	Rouyn-Noranda
Sept-Îles	St. John's	Sudbury
Thunder Bay	Timmins	Toronto
Vancouver	Whitehorse	Winnipeg
Yellowknife		

Summary reports from each of these sessions and a comprehensive report summarizing all of the activities and discussions are available on the NWMO website: www.nwmo.ca/infoanddiscussion.

15-1. Information and Discussion Sessions Regarding NWMO's Discussion Document #2 – *Understanding the Choices*, DPRA Canada. February 2005.

15-2. Bécancour: Information Session: Summary Report: French Version, DPRA Canada. February 2005.

15-3. Bécancour: Information Session: Summary Report: English Version, DPRA Canada. February 2005.

15-4. Bécancour: Discussion Session: Summary Report: French Version, DPRA Canada. February 2005.

15-5. Bécancour: Discussion Session: Summary Report: English Version, DPRA Canada. February 2005.

15-6. Charlottetown: Information Session: Summary Report, DPRA Canada. February 2005.

15-7. Charlottetown: Discussion Session: Summary Report, DPRA Canada. February 2005.

15-8. Clarington: Information Session: Summary Report, DPRA Canada. February 2005.

15-9. Clarington: Discussion Session: Summary Report, DPRA Canada. February 2005.

15-10. Durham Nuclear Health Committee: Discussion Session: Summary Report, DPRA Canada. February 2005.

15-11. Edmonton: Information Session: Summary Report, DPRA Canada. February 2005.

15-12. Edmonton: Discussion Session: Summary Report, DPRA Canada. February 2005.

15-13. Edmunston: Information Session: Summary Report, DPRA Canada. February 2005.

15-14. Fredericton: Information Session: Summary Report, DPRA Canada. February 2005.

15-15. Fredericton: Discussion Session: Summary Report, DPRA Canada. February 2005.

15-16. Goose Bay: Information Session: Summary Report, DPRA Canada. February 2005.

15-17. Halifax: Information Session: Summary Report, DPRA Canada. February 2005.

15-18. Halifax: Discussion Session: Summary Report, DPRA Canada. February 2005.

15-19. Huntsville: Information Session: Summary Report, DPRA Canada. February 2005.

15-20. Huntsville: Discussion Session: Summary Report, DPRA Canada. February 2005.

15-21. Iqaluit: Information Session: Summary Report, DPRA Canada. February 2005.

15-22. Iqaluit: Discussion Session: Summary Report, DPRA Canada. February 2005.

15-23. Kenora: Information Session: Summary Report, DPRA Canada. February 2005.

15-24. Kenora: Discussion Session: Summary Report, DPRA Canada. February 2005.

15-25. Kingston: Information Session: Summary Report, DPRA Canada. February 2005.

15-26. Kingston: Discussion Session: Summary Report, DPRA Canada. February 2005.

15-27. London: Information Session: Summary Report, DPRA Canada. February 2005.

15-28. London: Discussion Session: Summary Report, DPRA Canada. February 2005.

15-29. Montréal: Information Session: Summary Report: French Version, DPRA Canada. February 2005.

15-30. Montréal: Information Session: Summary Report: English Version, DPRA Canada. February 2005.

15-31. Montréal: Discussion Session: Summary Report: French Version, DPRA Canada. February 2005.

15-32. Montréal: Discussion Session: Summary Report: English Version, DPRA Canada. February 2005.

15-33. Musquash: Information Session: Summary Report, DPRA Canada. February 2005.

15-34. Musquash: Discussion Session: Summary Report, DPRA Canada. February 2005.

15-35. Ottawa: Information Session: Summary Report, DPRA Canada. February 2005.

15-36. Ottawa: Discussion Session: Summary Report, DPRA Canada. February 2005.

15-37. Owen Sound: Information Session: Summary Report, DPRA Canada. February 2005.

15-38. Owen Sound: Discussion Session: Summary Report, DPRA Canada. February 2005.

15-39. Pembroke: Information Session: Summary Report, DPRA Canada. February 2005.

15-40. Pembroke: Discussion Session: Summary Report, DPRA Canada. February 2005.

15-41. Pickering: Information Session: Summary Report, DPRA Canada. February 2005.

15-42. Pickering: Discussion Session: Summary Report, DPRA Canada. February 2005.

15-43. Pinawa: Information Session: Summary Report, DPRA Canada. February 2005.

15-44. Pinawa: Discussion Session: Summary Report, DPRA Canada. February 2005.

15-45. Québec: Information Session: Summary Report: French Version, DPRA Canada. February 2005.

15-46. Québec: Information Session: Summary Report: English Version, DPRA Canada. February 2005.

15-47. Québec: Discussion Session: Summary Report: French Version, DPRA Canada. February 2005.

15-48. Québec: Discussion Session: Summary Report: English Version, DPRA Canada. February 2005.

15-49. Regina: Information Session: Summary Report, DPRA Canada. February 2005.

15-50. Regina: Discussion Session: Summary Report, DPRA Canada. February 2005.

15-51. Rivière-du-Loup: Information Session: Summary Report: French Version, DPRA Canada. February 2005.

15-52. Rivière-du-Loup: Information Session: Summary Report: English Version, DPRA Canada. February 2005.

15-53. Rivière-du-Loup: Discussion Session: Summary Report: French Version, DPRA Canada. February 2005.

15-54. Rivière-du-Loup: Discussion Session: Summary Report: English Version, DPRA Canada. February 2005.

15-55. Rouyn: Information Session: Summary Report: French Version, DPRA Canada. February 2005.

15-56. Rouyn: Information Session: Summary Report: English Version, DPRA Canada. February 2005.

15-57. Rouyn: Discussion Session: Summary Report: French Version, DPRA Canada. February 2005.

15-58. Rouyn: Discussion Session: Summary Report: English Version, DPRA Canada. February 2005.

15-59. Sept-Îles: Information Session: Summary Report: French Version, DPRA Canada. February 2005.

15-60. Sept-Îles: Information Session: Summary Report: English Version, DPRA Canada. February 2005.

15-61. Sept-Îles: Discussion Session: Summary Report: French Version, DPRA Canada. February 2005.

15-62. Sept-Îles: Discussion Session: Summary Report: English Version, DPRA Canada. February 2005.

15-63. St. John's: Information Session: Summary Report, DPRA Canada. February 2005.

15-64. Sudbury: Information Session: Summary Report, DPRA Canada. February 2005.

15-65. Sudbury: Discussion Session: Summary Report, DPRA Canada. February 2005.

15-66. Thunder Bay: Information Session: Summary Report, DPRA Canada. February 2005.

15-67. Thunder Bay: Discussion Session: Summary Report, DPRA Canada. February 2005.

15-68. Timmins: Information Session: Summary Report: Revised, DPRA Canada. February 2005.

15-69. Timmins: Discussion Session: Summary Report: Revised, DPRA Canada. February 2005.

15-70. Toronto: Information Session: Summary Report, DPRA Canada. February 2005.

15-71. Toronto: Discussion Session: Summary Report, DPRA Canada. February 2005.

15-72. Vancouver: Information Session: Summary Report, DPRA Canada. February 2005.

15-73. Vancouver: Discussion Session: Summary Report, DPRA Canada. February 2005.

15-74. Whitehorse: Information Session: Summary Report, DPRA Canada. February 2005.

15-75. Winnipeg: Information Session: Summary Report, DPRA Canada. February 2005.

15-76. Winnipeg: Discussion Session: Summary Report, DPRA Canada. February 2005.

15-77. Yellowknife: Information Session: Summary Report, DPRA Canada. February 2005.

15-78. Yellowknife: Discussion Session: Summary Report, DPRA Canada. February 2005.

Dialogue on the *Draft Study Report*

- Dialogue on the *Draft Study Report*, Stratos, Inc. 2005

A series of six dialogue sessions in six cities across five provinces (Manitoba, Saskatchewan, New Brunswick, Québec, and Ontario) was held during the period of June 22 to July 20, 2005. The objectives of the dialogue sessions were to provide opportunities for participants to comment on the draft NWMO recommendation and *Draft Study Report*; provide for an exchange of views; and provide the NWMO with the opportunity to improve the recommendation before it was finalized.

With the exception of Manitoba, each of the provinces chosen have direct involvement in the nuclear fuel cycle. Manitoba was included in response to a request for a dialogue in Pinawa, due to its long-standing involvement with the Atomic Energy of Canada Limited Whiteshell Laboratories and the Underground Research Laboratory located near that community. Participants were invited to the sessions on the basis of their prior involvement with NWMO activities and research and their expressed interest in the NWMO's work. One hundred and sixty-nine people participated in the dialogue.

The Dialogues were held:

- Manitoba: June 22, 2005: Pinawa
- Saskatchewan: June 28 & 29, 2005: Saskatoon
- New Brunswick: July 5 & 6, 2005: Saint John
- Québec: July 8 & 9, 2005: Trois-Rivières
- Ontario: July 15 & 16, 2005: Toronto and July 18 & 19, 2005: North Bay

Reports of the Public Dialogues on the *Draft Study Report* are available on the NWMO website: www.nwmo.ca/dsrdialogue.

10-9. Dialogue on the *Draft Study Report*, Stratos, Inc. 2005
1. NWMO DSR Dialogue Summary Report, Stratos, Inc. 2005.
2. NWMO DSR Dialogue Summary Pinawa, MB, Stratos, Inc. 2005.
3. NWMO DSR Dialogue Summary Saskatoon, SK, Stratos, Inc. 2005.
4. NWMO DSR Dialogue Summary Saint John, NB, Stratos, Inc. 2005.
5. NWMO DSR Dialogue Summary Trois-Rivières, QC, Stratos, Inc. 2005.
6. NWMO DSR Dialogue Summary Toronto, ON, Stratos, Inc. 2005.
7. NWMO DSR Dialogue Summary North Bay, ON, Stratos, Inc. 2005.

Open Houses

A series of Open Houses were held in June and July 2005 in reactor site communities; Ontario: Pickering, Clarington, Kincardine, Pembroke, and Deep River; Québec: Bécancour; and New Brunswick, Saint John. Citizens in these communities were provided the opportunity to learn about the *Draft Study Report* and the recommended approach and to give the NWMO their thoughts on the *Draft Study Report* and recommended approach. Sixty-eight people attended these Open Houses.

Open Houses were held in:

- Saint John – June 23 & 24, 2005
- Bécancour – June 17 & 18, 2005
- Pembroke – July 21, 2005
- Deep River – July 22, 2005

- Pickering – June 13 & 14, 2005
- Clarington – June 23 & 24, 2005
- Kincardine – June 10 & 11, 2005

Roundtable on Ethics

The Roundtable on Ethics was composed of individuals expert in the field of ethics in a variety of disciplines. The Roundtable's role was to assist the NWMO in the development and application of the analytical framework to be used to assess the management approaches. The Roundtable on Ethics was tasked to help the NWMO make explicit, and ensure, the systematic integration of ethical considerations in the development and application of the framework. The Roundtable met several times over the study period in order to provide advice and feedback to the NWMO throughout the study process. Members of the Roundtable were: Andrew Brook, Wesley Cragg, Georges Erasmus, the Hon. David MacDonald, Arthur Schafer, and Margaret Somerville.

Reports from the Roundtable on Ethics are available at www.nwmo.ca/ethicsroundtable.

2-7. Ethical and Social Framework. NWMO Roundtable on Ethics

Workshops and Roundtables

Workshops and meetings have been convened to explore specific topics and key issues. These sessions include:

8-1. Environmental Aspects of Nuclear Fuel Waste Management. Robert W. Slater, Coleman Bright and Associates, and Chris Hanlon, Patterson Associates.

8-2. Technical Aspects of Nuclear Fuel Waste Management. McMaster Institute for Energy Studies, McMaster University.

8-3. Drawing on Aboriginal Wisdom: A Report on the Traditional Knowledge Workshop. Joanne Barnaby, Joanne Barnaby Consulting.

8-5. Looking Forward to Learn: Future Scenarios For Testing Different Approaches to Managing Used Nuclear Fuel in Canada, Global Business Network (GBN).

10-1. Report on Discussion with Senior Environmental and Sustainable Development Executives. Carole Burnham Consulting and Robert J. Readhead Limited.

10-3. Roundtable Dialogue with Youth at the International Youth Nuclear Congress – Summary Report. DRPA Canada. 2004.

10-4. Roundtable Dialogue with Durham Nuclear Health Committee – Summary Report. DRPA Canada. 2004.

10-5. Public Policy Forum: Implementing a Strategy for the Long-term Management of Used Nuclear Fuel. Public Policy Forum, December 2004. Results of a Roundtable with Senior Opinion Leaders conducted by Public Policy Forum in December 2004.

10-7. NWMO Workshop on Nature of the Hazard. Stratos Inc. 2005.
1. A Participant's Statement on Characterizing the Nature of the Hazard of Used Nuclear Fuel.
2. Facilitator's Report on NWMO Workshop on the Nature of the Hazard of Used Nuclear Fuel, Stratos.
3. Background Document, NWMO.
4. Agenda, NWMO.

10-10. Dialogue with the Durham Nuclear Health Committee on Choosing a Way Forward – The NWMO Draft Study Report. Stratos, Inc. 2005

The NWMO initiated and responded to requests for information sessions and presentations. The following illustrates the variety:

Atomic Energy Canada Limited Research and Development Advisory Panel
Canadian Nuclear Association
Canadian Nuclear Society
Canadian Nuclear Workers Council
The Deep River Science Academy
Federation of Northern Ontario Municipalities
GLOBE 2004
Greater Saskatoon Chamber of Commerce
International Youth Nuclear Congress
Lakehead University
Manitoba Institute of Management
NACE (Corrosion Society)
North Saskatoon Business Association
Nuclear Waste Watch
Ontario Bar Association
Timmins Citizen's Group
United Church of Canada
University of Toronto
Various Community Events
York University

Public Attitude Research

An important component of the NWMO outreach has been to track the views of Canadians through public attitude research including discussion groups and telephone surveys.

- In November and December 2002 an independent research company conducted 14 discussion sessions in Pickering, London, Thunder Bay, Saskatoon, Vancouver, St. John and Trois-Rivières to help identify a range of needs and expectations of Canadians regarding the NWMO study.

- The same issues were explored in a national telephone survey of 1,900 scientifically selected people representative of a cross-section of Canadians and 700 individuals living in nuclear site communities.

- A survey on the NWMO website explored similar issues and was accessible to all visitors to the website.

- In December, 2003, six discussion sessions were held with 54 participants in North Bay, Kanata and Mississauga to gauge their reaction to the first NWMO discussion document, *Asking the Right Questions?*

- Similar questions were asked in a national telephone survey of 1900 Canadians from coast-to-coast and 700 citizens from nuclear site communities in spring, 2004.

- A survey on the NWMO website explored similar issues and was accessible to all visitors to the website.

- In late 2004/early 2005, 10 focus groups with 96 participants were convened in Pickering, Sault Ste. Marie, Windsor, St. John and Québec City. These sessions followed the release of NWMO's second discussion document, *Understanding the Choices*, and were designed to provide insight into how people approach trade-offs and balances that will be required in developing a recommendation for the long-term management of used nuclear fuel.

- A survey on the NWMO website explored similar issues and was accessible to all visitors to the website.

- In June and July 2005, 24 discussion sessions were held with 223 participants in Saskatoon, Regina, London, Clarington, Toronto, Kenora, Sudbury, Kingston, Montréal, Trois Rivières, Saint John, and Fredericton to gauge their reaction to NWMO's *Choosing a Way Forward – Draft Study Report*.

- In July 2005 a national telephone survey of 1,900 randomly selected Canadians from coast-to-coast and 700 citizens in nuclear site communities were asked to comment on the key elements of the Adaptive Phased Management Approach.

- A survey on the NWMO website explored similar issues and was accessible to all visitors to the website.

Reports on the Public Attitude Research are available at: **www.nwmo.ca/publicattitude research**.

12-1. Phase 1: Report on Discussion Sessions. Navigator Limited.

12-2. Phase 1: Report on Nation-Wide Survey. Navigator Limited.

12-3. Phase 2: Report on Discussion Findings. Navigator Limited.

12-4. Phase 2: Report on Nation-Wide Survey. Pollara Inc.

12-5. Phase 3: Report on Discussion Group Research Findings. Navigator Limited.

12-6. Phase 4: Report of Findings from Discussion Groups on the Draft Recommendations: Summary Report. Navigator Limited.

12-7. Phase 4: Report on Nation-Wide Survey. Veraxis Research & Communications

Website

The NWMO website was the central site for communicating publicly the many background papers, technical reports, submissions and ongoing NWMO discussion documents. People were invited to review documentation on the NWMO website and submit their comments and thoughts on the long-term management of used nuclear fuel. The NWMO website was visited 264,218 times between February 2003 and August 2005.

In that period, the website was visited by 51,122 unique visitors, 9,925 of which visited the website two or more times, based on Web Trends reporting. In that same period, more than 191 submissions were made to the website.

B) Aboriginal Dialogue

The purpose of the Aboriginal dialogue is to build the foundation for a long-term positive relationship between the NWMO and the Aboriginal peoples of Canada.

- In the early stages of its work, the NWMO initiated a number of activities to explore the nature of the NWMO's engagement and involvement with Aboriginal peoples. Initially letters announcing the creation of the organization were distributed to selected Aboriginal organizations. This was followed by letters of invitation to all those Aboriginal groups and organizations that participated in the Federal Nuclear Fuel Waste Management and Disposal Concept Environmental Assessment Panel hearings. During Phase 1 of the NWMO Study, Conversations about Expectations, the NWMO also contacted and/or met with aboriginal representatives of organizations and communities that resided near existing nuclear power plants or waste storage sites, and other Aboriginal leaders who had a significant role in public policy matters, to introduce the NWMO and invite initial comment on the work before us.

The NWMO met with representatives of various federal government agencies including:

- Natural Resources Canada – which was responsible for and had initiated contribution agreements with the national Aboriginal organizations to consult on long-term nuclear fuel waste management

- Environment Canada, Aboriginal Policy & Intergovernmental Coordination Unit – which had extensive experience in and was developing guidelines for consultation with First Nations

- Canadian Environmental Assessment Agency Staff responsible for the Aboriginal consultations on the five year review of the CEA Act.

Also early in 2003, the NWMO convened an informal discussion with eleven Aboriginal leaders about the approach the NWMO might adopt in developing an Aboriginal engagement program. These were individuals who are engaged in work with Aboriginal political organizations, the private sector, government and universities. Throughout this early phase of discussion, the NWMO was advised to examine ways in which Traditional Knowledge could be incorporated into the NWMO study, to invite Aboriginal participation in all of the NWMO study activities, and to support initiatives where Aboriginal peoples could design and implement discussions amongst themselves to understand and assess the issues and take part in the discussion of options for the long-term management of used nuclear fuel.

As a result, the NWMO has worked in collaboration with and provided support to a total of 15 national, regional, and local Aboriginal organizations across Canada. Each dialogue initiative was unique, reflecting the needs, concerns value systems and/or decision-making process of the organization and people represented. A range of different dialogue processes have resulted involving some 2,500 participants. Together these various initiatives have significantly informed the NWMO study and have provided a rich experience to draw on in the years ahead. Reports from the various Aboriginal dialogues are posted on the NWMO website at www.nwmo.ca/aboriginaldialogues. Following is a brief overview of the key activities in each of the Aboriginal dialogues.

National Associations

The Assembly of First Nations (AFN)

The AFN established a core team that included a project Coordinator plus four regional coordinators (Northern Ontario, Southern Ontario, West/North, and Quebec/East). A National Working Group was established to guide the dialogue process that included the core team as well as various representatives from the regions. In addition, a Regional Chiefs Environmental Council was created and convened to initiate the dialogue. Early in the work of the NWMO, the AFN met with NWMO representatives and attended a number of NWMO study activities including the Scenarios Workshop and the Traditional Knowledge Workshop. In addition to reporting the results of their discussions, the AFN commissioned an environmental scan that provided an overall context for their review of the used nuclear fuel issue. Part way through their process, responsibility for First Nations discussions in the Maritimes (New Brunswick, Nova Scotia, Prince Edward Island, Newfoundland and Labrador) was transferred to the Atlantic Policy Congress of First Nations Chiefs (see below).

In addition to many informal discussions, the AFN has conducted the following meetings:

- Working Group Meeting – Ottawa, July 14 – 15, 2004
- Regional Chiefs Panel on the Environment Meeting – Winnipeg, September 8/9, 2004
- Working Group Meeting – Ottawa, October 27, 2004
- Regional Forum, Ontario South – Toronto, November 18, 2004
- Regional Forum, Ontario North – Wauzhuskh Onigum First Nation, November 23, 2004
- Regional Forum, Canada West, Prince Albert, Saskatchewan – November 30, 2004
- Working Group Meeting (National Update) – Ottawa, May 13, 2005
- Working Group Meeting – Ottawa, June 14, 2005
- Regional Forum, Quebec – Ottawa, July 26, 2005

Lastly, a briefing by the NWMO on the *Draft Study Report* was provided to Ottawa staff on May 13, 2005.

11-AFN-1 Nuclear Fuel Waste Dialogue: Phase II Annual Report, April 26, 2005

11-AFN-2 First Nations Nuclear Fuel Waste Dialogue, Working Group Meeting #1 Report, August 19, 2004

11-AFN-3 First Nations Nuclear Fuel Waste Dialogue, Working Group Meeting #2 Report, November 30, 2004

11-AFN-4 Nuclear Waste Management Regional Forum: Toronto, Ontario (Ontario South), December 17, 2004

11-AFN-5 Nuclear Waste Management Regional Forum: Wauzhushk Onigum First Nation (Ontario North), December 17, 2004

11-AFN-6 Nuclear Waste Management Regional Forum: Prince Albert, Saskatchewan (Canada West), December 17, 2004

11-AFN-7 Nuclear Fuel Waste Dialogue: Phase II Regional Forum – Summary Report, January 31, 2005

11-AFN-8 Nuclear Fuel Waste Dialogue: Phase II Progress Report, January 31, 2005

11-AFN-9 Nuclear Fuel Waste Dialogue: Interim Report # 1, July 5, 2004

11-AFN-10 Background Paper: First Nations Environmental Stewardship, November 2004

11-AFN-11 First Nations Nuclear Fuel Waste Dialogue Working Group Meeting #3 Report, July 2005

Métis National Council (MNC)

The MNC Nuclear Dialogue was overseen by the MNC Environment Committee. The MNC Environment Committee began its exploration of the nature of its dialogue process early in 2004. In December 2004, the Committee held a training session to ensure a common information base and allow Governing Members to discuss information dissemination, collection, and the dialogue process. March 21-22, 2005, the MNC Environment Committee met in Calgary, AB to discuss their progress regarding the Used Nuclear Fuel dialogues.

Used Nuclear Fuel workshops were held across the Métis National Council Territory involving four of the five Governing Members of the MNC.[1] Métis Nation – Saskatchewan was not able to initiate their workplan due to unforeseen circumstances.

Lastly, a briefing by the NWMO on the *Draft Study Report* was provided to Ottawa staff on May 13, 2005. In summary the following workshops and meetings (see Table A11-1) were convened as part of the MNC Nuclear Dialogue.

11-MNC-1 Nuclear Fuel Waste Initiative: Annual Progress Report, for the period 2004 to 2005, May 2005

11-MNC-2 Metis Nation of Ontario Community Dialogue Roundtables, January to February, 2005. Nuclear Waste Management Dialogue Process: Final Activity Report 2004/2005, May 2005

11-MNC-3 Nuclear Fuel Waste Initiative: Final Technical Report, for the period 2003 to 2005, July 2005

11-MNC-4 Response to the Nuclear Waste Management Organization's Report *Choosing a Way Forward: The Future Management of Canada's Used Nuclear Fuel*, August 2005

[1] The five MNC Governing Members are: The Métis Provincial Council of British Columbia, Métis Nation of Alberta, Métis Nation – Saskatchewan, Manitoba Métis Federation and Métis Nation of Ontario.

Table A11-1 Métis National Council – Dialogue Activities

GOVERNING MEMBERS	WORKSHOP LOCATION	PARTICIPANTS	WORKSHOP DATES	NUMBER OF PARTICIPANTS
Métis Provincial Council of British Columbia	Kelowna, B.C.	Captains of Natural Resources	April 2 – 3, 2005	9
	Northeastern B.C.	Elders	March 29 – 31, 2005	15
Métis Nation of Alberta	Edmonton, AB	Regional	March 23 – 24, 2005	60
Manitoba Métis Federation Regional Meetings	Flin Flon, MB	Regional	April 16, 2005	19
	Thompson, MB	Regional	April 17, 2005	15
	Lac Du Bonnet, MB	Regional	April 21, 2005	18
Manitoba Métis Federation Focus Groups	Winnipeg	Elders	April 22, 2005	21
	Winnipeg	Women	April 22, 2005	21
	Winnipeg	Youth	April 22, 2005	21
Métis Nation of Ontario	Midland, ON	Regional	January 14, 2005	77
	Hamilton, ON	Regional	January 22, 2005	43
	Ft. Francis, ON	Regional	January 30, 2005	38
	Timmins, ON	Regional	February 5, 2005	67
	Sudbury, ON	Regional	February 11, 2005	86
	Thunder Bay, ON	30 Community Council President's Meeting	February 18 – 19, 2005	30
Métis National Council	Newspapers and On-line	Citizens at large	January – June, 2005	7
Total Participants				**547**

Congress of Aboriginal Peoples (CAP)

CAP initiated its dialogue program with a meeting of its National Steering Committee on December 7, 2004 to discuss the national and regional programs and the initiation of the regional dialogues.

The following dialogue sessions were subsequently held:

- CAP – Western Office, Calgary, January 14, 2005
- Native Council of Prince Edward Island, Charlottetown, February 5, 2005
- New Brunswick Aboriginal Peoples Council, Fredericton, February 26, 2005
- Labrador Métis Nation Dialogue Session, Goose Bay, February 26, 2005
- Native Council of Nova Scotia Direct Mail/Key Informant Interviews, February/March 2005
- Federation of Newfoundland Indians Dialogue with 9 Band Councils, March 2005
- United Native Nations of British Columbia, Vancouver, March 29, 2005
- National Workshop, June 17, 2005 Ottawa
- Aboriginal Council of Manitoba – CAP questionnaire distributed and analyzed, Spring 2005
- CAP National Youth Council. Special Session, 14 April 2005

11-CAP-1 Summary of Key Observations Regarding NWMO Discussion Document 2, *Understanding the Choices*, January 2005

11-CAP-2 First Interim Report to Nuclear Waste Management Organization – Dialogue Sessions on NWMO's Recommendation for the Long-term Management of Nuclear Fuel Waste, December 14, 2004

11-CAP-3 Preliminary Commentary on: *Choosing a Way Forward – The Future Management of Canada's Used Nuclear Fuel*, July 2005

11-CAP-4 Third Interim Report to the Nuclear Waste Management Organization – July 2005

11-CAP-5 Final Report to the Nuclear Waste Management Organization – September 2005

Inuit Tapiriit Kanatami (ITK)

The ITK shared with the NWMO a preliminary plan for an Inuit specific consultation in the fall of 2003. This evolved in an Inuit Specific Dialogue on the Long-Term Management of Nuclear Fuel Waste which included two-day workshops in each of the four regional land claims regions:

- Iqualiut, Nunavut, November 9-10, 2004
- Inuvik, Inuvialuit Settlement Region, November 17-18, 2004
- Kuujuak, Nunavik, Northern Quebec, January 27-28, 2005
- Makkovik, Nunatsiavut, Labrador, February 9-10, 2005

A special session on nuclear fuel waste management took place during the National Inuit Conference on the Environment in February 2004. The ITK also held a special session with National Inuit Youth at the National Inuit Youth Summit, Nain, Nunatsiavut – March 28-30, 2005, organized by the National Inuit Youth Council. A briefing by the NWMO on the *Draft Study Report* was provided to Ottawa staff on May 19, 2005.

11-ITK-1 2005 Board of Directors Resolution, June 2005

11-ITK-2 Final Report on the National Inuit-Specific Dialogues on the Long-Term Management of Nuclear Fuel Waste in Canada – Determining the National Inuit-Specific Perspective, June 2005

11-ITK-3 Quarterly Report on the National Inuit Specific Dialogues on the Long-Term Management of Nuclear Fuel Waste (January to March 2005), March 31, 2005

11-ITK-4 Year-End Report on the National Inuit Specific Consultation on the Long-Term Management of Nuclear Fuel Waste (March 31, 2003 to March 31, 2004), March 2004

11-ITK-5 Quarterly Report on the National Inuit Specific Consultation on the Long-Term Management of Nuclear Fuel Waste (April 1, 2004 to June 15, 2004), July 2004

11-ITK-6 Quarterly Report on the National Inuit Specific Dialogues on the Long-Term Management of Nuclear Fuel Waste (July 15, 2004 to October 15, 2004), October 2004

11-ITK-7 Quarterly Report on the National Inuit Specific Dialogues on the Long-Term Management of Nuclear Fuel Waste (October 16, 2004 to December 15, 2004)

11-ITK-8 Discussion Document #1: *Asking the Right Questions?* – Comments Prepared by ITK, March 2005

11-ITK-9 Discussion Document #2: *Understanding the Choices* – Comments Prepared by ITK, March 2005

11-ITK-10 ITK Review of the NWMO Discussion Document #3: *Choosing a Way Forward*, August 2005

11-ITK-11 Quarterly Report National Inuit Specific Dialogues on the Long-Term Management of Nuclear Fuel Waste (April to June 2005), June 2005

Pauktuutit Inuit Women's Association

The Pauktuutit Inuit Women's Association brought together women from across the Arctic to a workshop in Ottawa on November 4, 2004.

11-P-1 Pauktuutit Inuit Women's Association Workshop: Managing Canada's Radioactive Waste: November 2004, December 2004

Native Women's Association of Canada (NWAC)

NWAC convened a workshop in Ottawa June 14, 2005 with representatives from across Canada.

11-NWAC-1 National Consultation on Nuclear Fuel Waste Management, Nuclear Fuel Waste Report: June 2005.

Regional/Local Organizations

Ontario Métis Aboriginal Association (OMAA)

The Ontario Métis Aboriginal Association began an exploration of the issues associated with the NWMO work in the early days of the study. Following a workshop and the development of a position paper on the NWMO study process, two Program Coordinators were commissioned to oversee the OMAA nuclear dialogue. An initiating Board workshop was held in Sault Ste. Marie in September 2004 and a final Board workshop was held in Thunder Bay in July 2005. Between these workshops, 65 community meetings were held throughout Ontario reaching some 1,300 people as summarized in Table A11-2.

Table A11-2 **Ontario Métis Aboriginal Association – Community Meetings**

DATE	LOCATION	PARTICIPANTS
December 1, 2004	Elliot Lake	20
December 27, 2004	Spanish	14
December 29, 2004	Iron Bridge	9
January 3, 2005	Echo Bay	3
January 4, 2005	Thessalon	8
January 5, 2005	Orillia	7
January 6, 2005	Port McNicoll	19
January 6, 2005	Midland	26
January 7, 2005	Gravenhurst	6
January 7, 2005	Midland	50
January 8, 2005	Midland	17
January 8, 2005	Owen Sound	2
January 13, 2005	Kenora	7
January 13, 2005	Kenora	60
January 14, 2005	Kenora	100
January 14, 2005	Vermilion Bay	
January 15, 2005	Wabigoon	16
January 16, 2005	Dryden	14
January 18, 2005	Fort Frances	9
January 19, 2005	Rainy River	3
January 20, 2005	Sioux Lookout	9
January 22, 2005	Ignace	7
January 24, 2005	Thunder Bay	14
January 25, 2005	Hurkett	11
January 26, 2005	Terrace Bay	15
January 27, 2005	Nipigon	13
January 30, 2004	Sturgeon Falls	77 (minimum)
January 31, 2005	Chelmsford	75 (minimum)
February 3, 2005	Pembroke	36
February 3, 2005	Pembroke	22
February 4, 2005	Pembroke	11
February 4, 2005	Pembroke	28
February 4, 2005	Arnprior	12

Table A11-2 (cont'd) Ontario Métis Aboriginal Association – Community Meetings

DATE	LOCATION	PARTICIPANTS
February 5, 2005	Renfrew	39
February 6, 2005	Renfrew	37
February 6, 2005	Matawatchan	29
February 7, 2005	Bancroft	92 (minimum)
February 8, 2005	Peterborough	25
February 13, 2005	Iroquois	17
February 13, 2005	Cornwall	9
February 14, 2005	Trenton	11
February 15, 2005	Kingston	6
February 16, 2005	Belleville	32
February 17, 2005	Smiths Falls	25
February 18, 2005	Brockville	17
February 19, 2005	Napanee	16
February 22, 2005	Renfrew	20
February 23, 2005	Haliburton	41
March 2, 2005	Noelville	24
March 3, 2005	Britt	16
March 3, 2005	Spanish	3
March 18, 2005	Ottawa	9
March 19, 2005	Windsor	63
March 20, 2005	Chatham	44
March 20, 2005	Sarnia	4
March 21, 2005	Hamilton	3
March 22, 2005	Welland	6
March 23, 2005	Wawa	9
March 25, 2005	Chapleau	8
March 25, 2005	Iroquois Falls	5
March 26, 2005	Timmins	12
March 27, 2005	Cochrane	17
March 28, 200	Geraldton	n/a
March 29, 2005	Thunder Bay	19

Additional discussions were held in mall-based information sessions. Questionnaires were distributed and analyzed. A web site was created and used to distribute information and compile reaction.

11-OMAA-1 Ontario Métis Aboriginal Association Nuclear Waste Management Initiative, April 2005

11-OMAA-2 Nuclear Waste Management: OMAA Presentation to OMAA Board of Directors, April 2004

11-OMAA-3 OMAA Position Paper on Phase II of the Nuclear Waste Management Process, April 2004

11-OMAA-4 Ontario Métis Aboriginal Association Phase 4, Nuclear Waste Management Initiative Phase 4, September 2005

Northern Saskatchewan Local Dialogues

The Sakitaawak Métis Society, hosted a community retreat at Amyot Lake near Beauval, Saskatchewan on October 21-23, 2004 bringing together representatives from 19 towns and villages, five First Nations, the uranium mining industry and the NWMO. A short video on the long term management of used nuclear fuel was developed including a proposal for development of materials in native languages.

A follow-up dialogue was held in La Ronge, Saskatchewan on May 25-26, 2005.

A Youth Dialogue was held near Ile-a-la-Crosse on August 3, 2005 as part of a Youth Wellness Conference organized by the Youth Program of the Ile-a-la-Crosse Friendship Centre. Some 200 young people participated from First Nations and Metis communities. Written comments from 91 were received.

On August 4th a half-day discussion was held between the NWMO and representatives of the English River First Nation in Patruanak, Saskatchewan.

11-SM-1 Northwest Saskatchewan Site-Specific Dialogue, January 2005

11-NS-1 *Choosing A Way Forward*: Report – La Ronge, Saskatchewan Dialogue, August 25, 2005

11-NS-2 12th Annual Youth Outdoor Wellness Conference, Northwest Saskatchewan – Youth Dialogue Report, August 29, 2005

Eabametoong First Nation, Fort Hope, Ontario

Community elders from the Eabametoong First Nation, Fort Hope, Ontario led a four-part process in 2004 aimed at exploring all of the issues related to the long-term management of used nuclear fuel in Canada, and in particular, implications for Aboriginal peoples. In addition many informal discussions were held involving some 300 people in the community. Meetings throughout this process were held in Ojibwa, Oji-Cree, or Cree. A proposal was written for development of native language capacity and for ongoing dialogue involving their communities and others. Following a pre-DSR-release briefing in the Community on May 19, 2005, residual funds were earmarked for a community review of the *Draft Study Report*.

11-E-1 Eabametoong First Nation Nuclear Waste Dialogue Report – September 2004 to January 2005, February 2005

East Coast First People's Alliance, New Brunswick (ECFPA)
The East Coast First People's Alliance, New Brunswick brought together non-status, off-reserve and unaffiliated Aboriginals in New Brunswick for a workshop in Bathurst on November 6-7, 2004.

11-EC-1 East Coast First Peoples Alliance Position Paper: Report from Workshop in Bathurst, November 2004

11-EC-2 Letter Report Summarizing Survey Results to 262 members; January 2005

Western Indian Treaty Alliance (WITA)
The Western Indian Treaty Alliance, (Congress of Aboriginal Peoples of Saskatchewan Inc., Indian Council of First Nations of Manitoba Inc., and Native Council of Canada – Alberta) representing non-status, off-reserve and unaffiliated Aboriginals in Alberta, Saskatchewan and Manitoba formed a Steering Committee and arranged regional meetings in Edmonton and Regina and The Pas, Manitoba.

11-WITA-1 Initial Commentary on the Nuclear Waste Management Organization Discussion Document *Understanding the Choices*. (WITA First Interim Report: Alberta), December 2004

11-WITA-2 Analysis of NWMO Discussion Document of August 2004 – *Understanding the Choices* (WITA First Interim Report: Manitoba), December 2004

11-WITA-3 Initial Commentary on the Nuclear Waste Management Organization Discussion Document (WITA First Interim Report: Saskatchewan), December 2004

11-WITA-4 Congress of Aboriginal Peoples Saskatchewan, Dialogue: Nuclear Waste Management Final Report, September 2005

Atlantic Policy Conference of First Nation Chiefs (APCFNC)
By mutual agreement with the Assembly of First Nations, in the fall of 2004, the APCFNC assumed responsibility for the First Nations dialogue in Newfoundland and Labrador, Prince Edward Island, Nova Scotia, and New Brunswick. As a result, the APCFNC convened two workshops to review the Discussion Documents:

- Fredericton, New Brunswick, January 20, 2005
- Truro, Nova Scotia, January 31, 2005

In a second phase of activity following publication of the *Draft Study Report*, the APCFNC held an additional three meetings:

- Big Cove, New Brunswick, June 8, 2005 (focus group)
- Fredericton, June 9, 2005 (focus group)
- Halifax (regional workshop – all maritimes), July 11-12, 2005

11-APC-1 Atlantic Policy Congress of First Nations Chiefs Nuclear Waste Management Dialogue: Final Report, March 2005

11-APC-2 Atlantic Policy Congress of First Nations Chiefs Nuclear Waste Management Dialogue: Final Report, July 2005

11-APC-3 Atlantic Policy Congress of First Nations Chiefs Nuclear Waste Management Dialogue: Interim Report, January 2005

Union of New Brunswick Indians (UNBI)

The Union of New Brunswick Indians began exploring the issues associated with nuclear fuel waste management in the early days of the NWMO study.

The UNBI held a series of dialogues on the NWMO *Draft Study Report* in the summer of 2005:

- Fort Folly, FN, July 20, 2005
- Woodstock, FN, July 25, 2005
- St. Mary's, FN, July 26, 2005
- Tobique, FN, August 2, 2005
- Madawaska FN, August 2, 2005
- Oromocto, Woodstock, FN, August 3, 2005
- Kingsclear, FN, August 3, 2005
- Eel Ground, FN, August 4, 2005
- Red Bank, FN, August 4, 2005
- Big Cove, FN, August 5, 2005
- Pabineau, FN, August 9, 2005
- Eel River Bar, FN, August 16, 2005

A Provincial Workshop was held on August 18, 2005 in Red Bank.

11-UNBI-1 Nuclear Waste Management & First Nations in New Brunswick (Final Report), August 29, 2005

Federation of Saskatchewan Indian Nations (FSIN)

The Federation of Saskatchewan First Nations conducted a series of dialogues on the NWMO *Draft Study Report* in the summer of 2005. The following presentations/meetings were convened.

- Thunderchild First Nation – Chief and Council
- Onion Lake First Nation – Chief and Council
- James Smith First Nation – Summer Science Youth Camp
- English River First Nation – Summer Science Youth Camp
- Mistawasis First Nation – Chief and Council
- Agency Chiefs Tribal Council – Senior Management
- Big River First Nation – Chief and Council
- Pelican Lake First Nation – Chief and Council
- Witchekan Lake First Nation – Chief and Council
- Federation of Saskatchewan Indian Nations Youth Assembly in Yorkton, Saskatchewan

At the time of writing, the following are being scheduled or initial meetings have been held to explore the idea of a discussion.

Waterhen Lake First Nation
Pelican Narrows First Nation
Hatchet Lake First Nation
Fond du Lac First Nation
Black Lake First Nation
Buffalo River First Nation
Muskowekwan First Nation
Kawacatoose First Nation
George Gordons First Nation
Beardy's/Okemasis First Nation

11-FSN-1 Nuclear Waste Dialogue Final Report, August 26, 2005

Continuing Local Dialogue, Ontario First Nations

The fall of 2005 has seen a series of initial meetings in six to eight Ontario First Nations communities as part of an ongoing process of dialogue at the local level that will continue after NWMO has filed its report with the Minister of Natural Resources Canada. At time of writing, the following have been approached: Eabametoong First Nation (Fort Hope) (Agreed); Fort Severn (Agreed); Webequie (Agreed); Couchiching (Appointment to be made); Attawapiskat (Appointment to be made); Aroland (Agreed); Long Lake #58 (Agreed); Constance Lake (Agreed); Wahta Mohawks (Appointment to be made); Mohawks of Akwesasne (Appointment to be made).

Elders' Forum, August 25-27, 2005

At the end of August, an Elders' Forum was convened at the Odawa Native Friendship Centre in Ottawa. The Forum brought together 23 elders from across Canada to:

- Review with participants the work of the NWMO since its inception in November 2002 and the draft strategy that has evolved through discussions with Canadians over the past two years;
- Learn what participants' reactions are to the draft strategy; and
- Discuss ongoing involvement of Elders and how we can best engage with Canada's Aboriginal community in the years to come.

Elders' were offered the opportunity to name an accompanying youth support person. Nineteen young people participated in this capacity. In part, the forum was intended as a means to bring holders of Aboriginal Traditional Knowledge to the table in their own right to review the challenge of managing used nuclear fuel over the long term.

The Report of the Forum is available at: www.nwmo.ca/aboriginaldialogues.

11-EF-1 Report of the Elders' Forum, Ottawa, 2005

Building Relationship: The NWMO Aboriginal Dialogue

Canada is home to a million Aboriginal people. Since its inception, the NWMO has sought dialogue with this community regarding how Canada should best manage its used nuclear fuel over the long term.

11-ABO-1 Building Relationship - The NWMO Aboriginal Dialogue 2003 – 2005

This report summarizes the dialogue in terms of overall goal and objectives, the evolving context and role of the Aboriginal community in this country, the 15 national and regional/local organizations that participated, the observations that they offered, and the lessons learned as input for continued dialogue in the future.

C) Submissions

As of August 2005, the NWMO has received 191 submissions on our Study. They are all posted on our website www.nwmo.ca/submissions. The NWMO continues to receive submissions which will be posted on our website once permission is received from the author(s).

The authors of these submissions are listed below:

Armitage, Stephen
Atcheson, Joyce
Baglien, Brandon
Baird, Jim
Barrett, Freda
Beaton, Brian
Beaudoin, Robert
Bradford, Lori
Brady-MacAulay, Lauren
Brain, Steve
Brenciaglia, Giovanni
Burns, Terry
Brydges, Doug
Calabretta, Daniel
Campbell, James
Canadian Association of Nuclear Host Communities
Canadian Nuclear Society
CANTEACH
Catherwood, Lorne
Chandler, Neil
Chisel, Leslie
Citizens for Alternatives to Chemical Contamination
Citizens for Renewable Energy (CFRE)
Citizens Network on Waste Management
Clyde, Tom
Computare
Coxworth, Ann
Cullimore, D. Roy
Cuttler & Associates Inc.
Craik, Neil
Curry, N. Royce
Daley, Andrew
Darnley, Arthur
Davies, David
Devlin, Ian
Doherty, Michael
Don't Waste Michigan

Draak, Marcella
Drummond, Norma
Duncan, Ian
Dykyj, Jerry
Earley, John
Eno, Robert
Farrugia-Uhalde, Ann Marie
Fernandes, Antonio
Franta, Jaro
Freed, Sahaja
Grand Council of the Crees
Griffiths, Franklyn
Gurnham, John
Harti, Jeff
Harley, Mary Lou
Hakli, Don
Hillsburg, Genevieve
Hiner, Richard
InSite & Solutions
Jackson Consulting (UK) Ltd.
Joe, Mendleson
Jones, Deborah
Klein, Ruth
Kuhn, Richard
Lange, Bruce
Lawson, Tom and Pat
Lee, David
Lee, Kai
Lekivetz, Bob
Levesque, Dean
Levesque, Larry
Lockhart, James
Mann, Navdeep
Marczak, Eva
Marczak, John
Martino, Jason
Mather, Allan
Mattmer, Ron
Mcivor, Alastair
Meneley, Daniel
Moss, Kate
Mroueh, Youssef
Murphy, Brenda
National Council of Women of Canada
Norman, Jason
Nuclear Information and Resource Service
Olson, Don
Ottensmeyer, Peter
Paul, Derek
People for Nuclear Responsibility, Thunder Bay
Perreault, Gerald
Polanyi, Michael
Rao, Mohan
Radiological Evaluation and Action Project
Rawlingson, Malcolm Stewart
Rennie, Richard
Riley, George
Robertson, J.A.L.
Sabourin, Gilles
Saint John Citizens Coalition for Clean Air
Schenkel, Walter
Scott, John
Shrives, Ken
Schwimmer, Sorin
Stanley, Anna
Steed, Roger G.
Steeves, Keith W.
Strickert, Graham
Sutherland, John
Temmer, Rebecca
The Regional Municipality of Durham
Thériault, Sophie
Thompson, Paul
Threndyle, Gene
Town of Ajax
Treichel, Judy
Tuer, Bill
Turnbull, Ian
United Church of Canada
Van Vliet, Pieter
Williams, Martin
Wright, James R.
Wright, Jim
Ylonen, George

D) Background Papers

The NWMO has benefited from an extensive series of background research papers. They are all available on-line at www.nwmo.ca/backgroundpapers.

Supporting documents for the NWMO study, that is, those that further elaborate on an element of our study, are marked by an asterisk.

All of our background research, which includes papers, technical reports, engagement activities and submissions to the NWMO, are reference documents that significantly influenced our thinking.

As a standard practice background papers were peer reviewed before they were accepted by the NWMO and posted on the NWMO website. In the case of background papers on "Guiding Concepts" and "Social and Ethical Considerations", independent comment was solicited and posted with each paper in lieu of the peer review process.

Guiding Concepts

1-1. Sustainable Development and Nuclear Waste. David Runnalls, IISD.

1-2. The Precautionary Approach to Risk Appraisal. Andy Stirling, University of Sussex.

1-3. Adaptive Management in the Canadian Nuclear Waste Program. Kai N. Lee, Williams College.

1-4. Nuclear Waste Management in Canada: The Security Dimension. Franklyn Griffiths, University of Toronto.

1-5. Risk and Uncertainty in Nuclear Waste Management. Kristen Shrader-Frechette, University of Notre Dame.

1-6. Thinking about Time. Stewart Brand, The Long Now Foundation.

1-7. Drawing on Aboriginal Wisdom. Joanne Barnaby, Joanne Barnaby Consulting.

1-8. Non Proliferation Aspects of Spent Fuel Storage and Disposition. Thomas Graham Jr. and James A. Glasgow, Morgan Lewis.

1-9. Is Safekeeping of Radioactive Waste Preferable to Disposal? The Importance of Semantics. Colin Allan and Paul Fehrenbach, Atomic Energy of Canada Ltd.

The NWMO asked experts in the field to comment on the Guiding Concepts papers, on the way in which the concepts have been defined, and implications for the long-term management of used nuclear fuel.

1-A Lloyd Axworthy: Comments on "Nuclear Waste Management in Canada: The Security Dimension", Franklyn Griffiths.

1-B William Leiss: Comments on "Risk and Uncertainty in Nuclear Waste Management", Kristen Shrader-Frechette.

1-C Edwin Lyman: Comments on "Nuclear Waste Management in Canada: The Security Dimension", Franklyn Griffiths.

1-D Charles McCombie: Comments on "Adaptive Management in the Canadian Nuclear Waste Program", Kai N. Lee.

1-E Robert Morrison: Comments on "Sustainable Development and Nuclear Waste", David Runnalls.

1-F Ortwin Renn: Comments on "The Precautionary Approach to Risk Appraisal", Andy Stirling.

Social and Ethical Dimensions

2-1. Ethics of High Level Nuclear Fuel Waste Disposal in Canada. Peter Timmerman, York University.

2-2. Social Issues Associated with the Atomic Energy of Canada Limited Nuclear Fuel Waste Management and Disposal Concept. Mark Stevenson, MAS Consulting.

2-3. Key Social Issues Related to Nuclear Waste, or What Do Canadians Want to Do About Nuclear Waste?. Maria Paez-Victor, Victor Research.

2-4. Long-Term Management of Nuclear Fuel Waste – Issues and Concerns Raised at Nuclear Facility Sites 1996 – 2003. Chris Haussmann and Peter Mueller, Haussmann Consulting.

2-5. Overview of European Initiatives: Towards a Framework to Incorporate Citizen Values and Social Considerations in Decision-Making. Kjell Andersson, Karita Research.

2-6. A Review of Waste Facility Siting Case Studies Applicable to Spent Nuclear Fuel Management Facilities and Associated Infrastructure. DPRA Inc.

* 2-7. Ethical and Social Framework. NWMO Roundtable on Ethics.

2-8. NWMO Response to Seaborn.

The NWMO asked selected individuals working in the field to provide additional comment on the issues raised in this series of papers.

2-A Ian J. Duncan: Social and Ethical Considerations "Canada's Used Nuclear Fuel – What to do with it!"

2-B Charles McCombie: Ethical Considerations "Status of Geological Repositories for Used Nuclear Fuel, Appendix B Ethical Issues".

2-C J.A.L. Robertson: "Nuclear Energy – An Ethical Choice".

Health and Safety

3-1. Status of Radiological Protection Technologies and Operational Procedures Related to High-level Radioactive Waste Management (HLRWM). Candesco Research Corporation.

3-2. Human Health Aspects of High-level Radioactive Waste. John Sutherland, Edutech Enterprises.

3-3. Status of Canadian and International Efforts to Reduce the Security Risk of Used Nuclear Fuel. SAIC.

3-4. Considerations in Developing a Safety Case for Spent Nuclear Fuel Management Facilities and Associated Infrastructure in Canada. K. Moshonas Cole, P.R. Reid and R.C.K. Rock, Candesco Research Corporation.

3-5. A Risk-Based Monitoring Framework for Used Fuel Management. Nava C. Garisto, SENES Consultants Ltd.

1. Appendix A: Deep Geological Disposal. Nava C. Garisto, SENES Consultants Limited.
2. Appendix B: Storage at Reactor Sites. Nava C. Garisto, SENES Consultants Limited.
3. Appendix C: Risk From Exposure to Ionizing Radiation. Nava C. Garisto, SENES Consultants Limited.
4. Appendix D: Radiological Benchmarks for Non-Human Biota. Nava C. Garisto, SENES Consultants Limited.

Science and Environment

4-1. Status of Biosphere Research related to High-level Radioactive Waste Management. ECOMatters.

4-2. Characterizing the Geosphere in High-Level Radioactive Waste Management. Jonathan Sykes, University of Waterloo.

4-3. Natural and Anthropogenic Analogues – Insights for Management of Spent Fuel. Paul McKee and Don Lush, Stantec Consulting.

4-4. The Chemical Toxicity Potential of CANDU Spent Fuel. Don Hart and Don Lush, Stantec Consulting.

4-5. Review of the Possible Implications of Climate Change on the Long-Term Management of Spent Nuclear Fuel. Gordon A. McBean Ph.D., FRSC.

4-6. Review of the Implications of Microbiological Factors on the Long-term Management of Used Nuclear Fuel. D. Roy Cullimore, Ph.D. R.M., Droycon Bioconcepts Inc.

Economic Factors

5-1. An Examination of Economic Regions and the *Nuclear Fuel Waste Act* (*NFWA*). Richard Kuhn, University of Guelph and Brenda Murphy, Wilfred Laurier University.

5-2. Status of Financing Systems for High-level Radioactive Waste Management. GF Energy, LLC.

5-3. Considerations for the Economic Assessment of Approaches to the Long-Term Management of High-Level Nuclear Waste. Charles River Associates Canada Limited.

5-4. Economic and Financial Aspects of the Long-Term Management of High-Level Nuclear Waste: Issues and Approaches. Charles River Associates Canada Limited.

Technical Methods

6-1. Status of Reactor Site Storage Systems for Used Nuclear Fuel. SENES Consultants Ltd.

6-2. Status of Centralized Storage Systems for Used Nuclear Fuel. Mohan Rao and Dave Hardy, Hardy Stevenson and Associates.

6-3. Status of Geological Repositories for Used Nuclear Fuel. Charles McCombie, McCombie Consulting.

6-4. Status of Nuclear Fuel Reprocessing, Partitioning and Transmutation. David Jackson, David Jackson and Associates.

6-5. Range of Potential Options for Used Nuclear Fuel. Phil Richardson and Marion Hill, Enviros Consulting Ltd.

6-6. Status of Transportation Systems for High-level Radioactive Waste Management. Wardrop Engineering Inc.

6-7. Status of Storage, Disposal and Transportation Containers for the Management of Used Nuclear Fuel. Kinectrics.

6-8. Review of the Fundamental Issues and Key Considerations Related to the Transportation of Spent Nuclear Fuel. Gavin J. Carter, Butterfield Carter and Associates, LLC.

6-9. Conceptual Designs for Used Nuclear Fuel Management.

1. JWO: Overview of Conceptual Designs for Used Nuclear Fuel Management. Joint Waste Owners.
2. JWO: Summary Presentation of Conceptual Designs for Used Nuclear Fuel Management. Joint Waste Owners.

* 3. Conceptual Designs for Reactor-site Extended Storage Facility Alternatives for Used Nuclear Fuel. CTECH.
   - a. Reactor-site Extended Storage: Facility Alternative Illustrations. Joint Waste Owners.
   - b. Alternatives for the Pickering, Bruce and Darlington Reactor Sites
     - i. Alternatives for the Pickering, Bruce and Darlington Reactor Sites: Main Report. CTECH.
     - ii. Alternatives for the Pickering, Bruce and Darlington Reactor Sites: Supporting Figures. CTECH.
     - iii. Alternatives for the Pickering, Bruce and Darlington Reactor Sites: Supporting Tables. CTECH.
   - c. Alternatives for Atomic Energy of Canada Limited's Chalk River and Whiteshell Laboratory Sites. CTECH.
     - i. Alternatives for Atomic Energy of Canada Limited's Chalk River and Whiteshell Laboratory Sites: Main Report. CTECH.
     - ii. Alternatives for Atomic Energy of Canada Limited's Chalk River and Whiteshell Laboratory Sites: Supporting Figures. CTECH.

   d. Alternatives for Hydro-Québec's Gentilly Reactor Site
      i. Alternatives for Hydro-Québec's Gentilly Reactor Site: Main Report. CTECH.
      ii. Alternatives for Hydro-Québec's Gentilly Reactor Site: Supporting Figures. CTECH.
   e. Alternatives for New Brunswick Power's Point Lepreau Site. CTECH.
      i. Alternatives for New Brunswick Power's Point Lepreau Site: Main Report. CTECH.
      ii. Alternatives for New Brunswick Power's Point Lepreau Site: Supporting Figures. CTECH.

* 4. Conceptual Designs for Four Centralized Extended Storage Facility Alternatives for Used Nuclear Fuel
   a. Centralized Extended Storage: Main Report. CTECH.
   b. Centralized Extended Storage: Supporting Figures 1. CTECH.
   c. Centralized Extended Storage: Supporting Figures 2. CTECH.
   d. Centralized Extended Storage: Supporting Figures 3. CTECH.
   e. Centralized Extended Storage: Supporting Figures 4. CTECH.
   f. Centralized Extended Storage: Supporting Figures 5: General. CTECH.
   g. Centralized Extended Storage: Illustration. CTECH.
   h. Centralized Extended Storage: Appendix A. CTECH.
   i. Centralized Extended Storage: Decontamination Cells. CTECH.
   j. Centralized Extended Storage: Repackaging. CTECH.

* 5. Conceptual Design for a Deep Geologic Repository for Used Nuclear Fuel
   a. Deep Geologic Repository: Main Report. CTECH.
   b. Deep Geologic Repository: Figures. CTECH.
   c. Deep Geologic Repository: Illustration. CTECH.
   d. Deep Geologic Repository: Appendix A. CTECH.
   e. Deep Geologic Repository: Annex 1. CTECH.
   f. Deep Geologic Repository: Annex 2. CTECH.
   g. Deep Geologic Repository: Annex 3. CTECH.
   h. Deep Geologic Repository: Annex 4. CTECH.
   i. Deep Geologic Repository: Annex 5. CTECH.
   j. Deep Geologic Repository: Annex 6. CTECH.
   k. Deep Geologic Repository: Annex 7. CTECH.
   l. Technology Program for Deep Geologic Repository.
      i. Deep Geologic Repository Technology Program – Annual Report 2004. OPG.
      ii. Deep Geologic Repository Technology Program – Annual Report 2003. OPG.
      iii. Deep Geologic Repository Technology Program – Annual Report 2002. OPG.
      iv. Deep Geologic Repository Technology Program – Annual Report 2001. OPG.
      v. Deep Geologic Repository Technology Program – Annual Report 2000. OPG.
      vi. Used Fuel Disposal Program, Annual Technical Report 1999. OPG.

m. Response to Technical Comments raised during Environmental Assessment of AECL Disposal Concept. OPG.
    i. Compilation of Technical Comments Submitted by Participants in the Federal Environmental Assessment Panel Review of the Nuclear Fuel Waste Management and Disposal Concept, with Responses. OPG.

* 6. Conceptual Designs for Transportation of Used Nuclear Fuel to a Centralized Facility. Cogema Logistics.
   a. Conceptual Designs for Transportation of Used Nuclear Fuel to a Centralized Facility: Main Report. Cogema Logistics.
   b. Appendix A: Figures. Cogema Logistics.
   c. Appendix B: Basis and Interfaces. Cogema Logistics.
   d. Appendix C: Road Transport Feasibility of IFTC/BM and DSCTP. Cogema Logistics.
   e. Appendix D: Conceptual design and description for all the UFTS components "All Road". Cogema Logistics.
   f. Appendix E: Conceptual design and description for all the UFTS components "Mostly Rail". Cogema Logistics.
   g. Appendix F: Conceptual design and description for all the UFTS components "Mostly Water". Cogema Logistics.
   h. Appendix G: The COGEMA LOGISTICS Railroad Terminal at Valognes. Cogema Logistics.
   i. Appendix H: The Real Time Tracking System. Cogema Logistics.
   j. Logistics of Transportation of Used Fuel to a Centralized Facility: Report of Study. Cogema Logistics.
   k. Logistics of Transportation of Used Fuel to a Centralized Facility: Appendix A. Cogema Logistics.
   l. Logistics of Transportation of Used Fuel to a Centralized Facility: Sample Shipping Schedule. Cogema Logistics.
   m. Road and Rail Transportation: Illustrations. Cogema Logistics.
   n. Container Illustrations. Cogema Logistics.
   o. Dry and Wet Loading of Transportation Modules. Cogema Logistics.
   p. Intermodal Transfer. Cogema Logistics.

* 7. Cost Summaries
   a. Cost Summary: Reactor-site Extended Storage. Joint Waste Owners.
   b. Cost Summary: Centralized Extended Storage. Joint Waste Owners.
   c. Cost Summary: Deep Geologic Repository. Joint Waste Owners.

* 8. Financing The Management of Nuclear Fuel Waste in Support of the *Nuclear Fuel Waste Act*
   a. JWO: Financing The Management of Nuclear Fuel Waste in Support of the *Nuclear Fuel Waste Act*. Joint Waste Owners, February 2005.
   b. JWO: Financing the Management of Nuclear Fuel Waste in Support of the *Nuclear Fuel Waste Act*. July 2005.

* 6-10. Review of Conceptual Engineering Designs for Used Nuclear Fuel Management in Canada. ADH Technologies Inc.

* 6-11. Validation of Cost Estimating Process for Long-Term Management of Used Nuclear Fuel. ADH Technologies Inc. and Charles River Associates Canada Ltd.

* 6-12. Long-term Used Nuclear Fuel Waste Management – Geoscientific Review of the Sedimentary Sequence in Southern Ontario. Martin Mazurek, Rock-Water Interaction, Institute of Geological Sciences, University of Bern, Switzerland.

* 6-13. Conceptual Designs for Used Nuclear Fuel Management in Sedimentary Rock. RWE NUKEM Ltd.
   1. 6-13A Deep Geologic Repository in Sedimentary Rock, RWE NUKEM Ltd.
   2. 6-13B Centralized Extended Storage (CRC concept) in Sedimentary Rock, RWE NUKEM Ltd.
   3. 6-13C Selection of Sedimentary Rock Formation Type for Review, RWE NUKEM Ltd.

6-14. Implications of Reprocessing, Partitioning and Transmutation on Long-term Management of Used Nuclear Fuel in Canada. David P. Jackson, McMaster University.

6-15 Adaptive Phased Management Draft Technical Description, NWMO.

* 6-16 Adaptive Phased Management Cost Estimate Summary Report. Golder Associates Ltd. and Gartner Lee Limited.

* 6-17 Validation of Cost Estimating Process for Adaptive Phased Management, of the Long Term Management of Used Nuclear Fuel. A.W. Hooker Associates Ltd.

* 6-18 Adaptive Phased Management Technical Description, NWMO.

Institutions and Governance

7-1. Status of the Legal and Administrative Arrangements for Waste Management in Canada. OCETA (Ontario Centre for Environmental Technology Advancement).

7-2. Status of the Legal and Administrative Arrangements for Low-level Radioactive Waste Management (LLRWM) in Canada. Paul Rennick, Rennick and Associates.

7-3. Status of the Legal and Administrative Arrangements for High-level Radioactive Waste Management (HLRWM). Mark Madras and Stacey Ferrara, Gowling Lafleur Henderson LLP.

7-4. Legal and Administrative Provisions for Radioactive Waste Management within the North American Free Trade Agreement (NAFTA). Aaron Cosbey.

7-5. Status of Canadian Expertise and Capabilities related to High-level Radioactive Waste Management. George Bereznai, UOIT (University of Ontario Institute of Technology).

7-6. Comparative Overview of Approaches to Management of Spent Nuclear Fuel and High Level Wastes in Different Countries. Charles McCombie and Bengt Tveiten.

7-7. Relevance of International Experiences in the Sound Management of Chemicals to the Long Term Management of Used Nuclear Fuel In Canada. John Buccini.

7-8. Review of the *Canadian Environmental Assessment Act* (*CEAA*) Process in Relation to Nuclear Waste Management. Robert S. Boulden, Boulden Environmental Consulting.

7-9. Review of the CNSC Licensing Process in Relation to Spent Fuel Management. J.F. Lafortune and F. Lemay, International Safety Research.

7-10. Review of the Legal and Administrative Aspects of the Non-Proliferation Treaty in Relation to Spent Nuclear Fuel Management. Mark Madras and Stacey Ferrara, Gowling Lafleur Henderson LLP.

7-11. Methodologies for Assessing Spent Nuclear Fuel Management Options. ETV Canada Inc., OCETA, Risk Wise Inc. and Science Concepts International.

7-12. Education and Training in Nuclear Waste Management. ITC School of Underground Waste Storage and Disposal.

7-13. The Public Policy Context for Nuclear Liability in Canada. William Leiss & Associates Ltd.

E) Assessments

* 9-1. Assessing the Options. The NWMO Assessment Team Report. Michael Ben-Eli, John Neate, Jo-Ann Facella, Anthony Hodge, Thomas Isaacs, William Leiss, Michael Margolick, Katherine Moshonas Cole, Fred Roots.

Upon release of the Assessment Team Report, the NWMO approached three individuals to learn their perspectives:

9-A Thomas Isaacs
9-B Tim McDaniels
9-C Barry Stuart

* 9-2a. Assessment of Benefits, Risks and Costs of Management Approaches for Used Nuclear Fuel by Illustrative Economic Region, Golder Associates Limited and Gartner Lee Limited.

* 9-2b. Assessment of Benefits, Risks and Costs of a Proposed Adaptive Phased Management Approach By Illustrative Economic Region, Golder Associates Limited and Gartner Lee Limited.

* 9-3. Review of Means for Avoiding or Mitigating Significant Socio-Economic Effects in the Implementation of Managing Used Nuclear Fuel, Golder Associates Limited and Gartner Lee Limited.

Also see 3-5 A Risk-Based Monitoring Framework for Used Fuel Management. Nava C. Garisto, SENES Consultants Ltd.

F) NWMO Discussion Documents

The NWMO Study was built around three milestone documents, each followed by a round of public engagement and dialogue. Each discussion document and accompanying Executive Summary provided an update on the study, keeping people informed of NWMO thinking at every stage and inviting comment from interested citizens.

**** Discussion Document 1: Asking the Right Questions? The Future Management of Canada's Used Nuclear Fuel***

This document began a process of dialogue which sought an approach to the long-term management of used nuclear fuel. It was a first step in defining the issue, communicating potential choices and proposing a way of assessing the alternatives.

This discussion document:

- Described the NWMO legislative mandate, and how we proposed to undertake the study;
- Shared, for discussion, some of the broad issues and concerns that arose in early conversations with Canadians;
- Outlined the initial thinking about building an "analytical framework" for assessing different approaches; and
- Provided information on alternative technical methods for managing used nuclear fuel.

This document is available at **www.nwmo.ca/askingtherightquestions**.

The Executive Summary of this document is available in English and French.

**** Discussion Document 2: Understanding the Choices***

This document:

- Reported what the NWMO had learned from citizens and experts;
- Described what the management options being studied might look like;
- Outlined how the framework to assess them had evolved; and
- Presented a preliminary assessment of the approaches for public discussion.

This document is available at **www.nwmo.ca/understanddingthechoices**.

The Executive Summary of this document is available in English and French.

**** Draft Study Report: Choosing a Way Forward: The Future Management of Canada's Used Nuclear Fuel***

Choosing A Way Forward was the third major report published over the course of the NWMO study. This report reflected the synthesis of ideas from the two years of engagement with citizens and specialists, and proposed a course of action.

This document is available at: **www.nwmo.ca/draftstudyreport**.

The Executive Summary of this document is available in English, French, Ojibway, Cree and Ojicree.

Appendix 12 / Glossary

We offer this glossary to present and explain the terms and phrases that we have used in the course of this study. In some cases definitions are the same as used by others (Webster's dictionary; Canadian Nuclear Safety Commission, etc.) However in other cases they are different. We do this not to agree or disagree with other sources, but to provide clarity around our intent and our meaning.

Adaptive management is a combination of management, research, and monitoring so that credible information is gained and management activities can be modified by experience.

Biosphere is the environment where life exists.

Becquerel is the standard international unit of radioactivity in a material equal to the activity resulting from the decay of one nucleus of radioactive matter in one second.

Borehole is a hole drilled into the earth.

Cask is a mobile durable container for enclosing and handling nuclear fuel waste for storage and transport.

Centralized facility means a facility used for the extended storage or geological placement of used nuclear fuel. The facility would be located at a single, central location and would accept used nuclear fuel from all reactor sites in Canada.

Communities of interest, in the context of the NWMO study, refers to a group of people who share a common interest or purpose. For example, they may live in close proximity to each other, or they may share a common concern or knowledge, and have come together to pursue specific interests.

Container is the vessel into which the waste form is placed for handling, transport, storage and/or eventual placement in a deep geological repository; also the outer barrier protecting the waste from external intrusions. The waste container is a component of the waste package.

Closure refers to administrative and technical actions directed at a repository at the end of its operating lifetime – for example covering the waste (for a near surface repository) or back-filling and/or sealing (for a geological repository and the passages leading to it) and termination or completion of activities in any associated structures.

Contingency (Financial) refers to an additional amount or percentage added to any cash flow item to cover reasonable variability in forecasts. Interest rates, inflation and other variables cannot be forecast with certainty. The size of a contingency is determined by the level of detail within a cash flow forecast and the level of risk mitigation that is required.

Crystalline rock is a generic term for igneous rocks and metamorphic rocks as opposed to sedimentary rocks.

Decommissioning is the closing of a nuclear facility at the end of its life.

Deep geological disposal is the placement of used nuclear fuel deep underground where both natural and engineered barriers shield it from humans and the environment. Deep geological disposal is studied as Option 1 in this report.

Deliberative survey is a public opinion research tool that provides people with background information and multiple perspectives to help inform the views they express.

Design life is the period during which a facility or component is expected to perform according to the technical specifications to which it will be or was engineered.

Dialogue brings people from all walks of life together and encourages them to work through difficult issues, learning from each other as they listen to and understand perspectives that are different from their own. Participants examine their own thinking, and through talking with each other, identify areas on which they can agree, while acknowledging differences.

Disposal is to manage used nuclear fuel in a manner that is conclusive, without the intention of retrieval or further use.

Dry storage is the interim placement of used fuel in specially engineered dry containers after its removal from wet storage pools.

Economic regions are broad-based geographic units based on census divisions and used for analysis of regional economic activity. There are 76 economic regions in Canada.

Escalator is the rate at which future costs are expected to grow on an annual basis. These figures are frequently tied to rates of inflation, but may be composed of a number of variables.

Flexibility refers to a ready capability to adapt to new, different or changing requirements.

Fissile refers to a nuclide that can be induced to fission by an incoming neutron. Only a few nuclides can fission (i.e., the splitting of a nucleus with the release of energy) and there is only one naturally occurring fissile nuclide, U-235. Other fissile nuclides are U-233 and some isotopes of plutonium (Pu-239 and Pu-241), but none of these occurs in nature to any appreciable extent.

Half-life is, for a radionuclide, the time required for the activity to decrease, by a radioactive decay process, by half.

Influence diagram is a tool used in multi-attribute analysis for mapping the principal interacting factors that influence the capacity of an option to perform well on a particular objective.

Isotopes are any two or more forms of an element having identical or very closely related chemical properties and the same atomic number but different atomic weights or mass numbers.

Joint Waste Owners (JWO) refers to corporations that own Canada's used nuclear fuel: Ontario Power Generation Inc., Hydro-Québec, NB Power Nuclear and Atomic Energy of Canada Limited.

Management approach is a strategy for the long-term care of used nuclear fuel which encompasses a particular technical method or sequence of methods, and the conditions necessary for its successful implementation, including societal requirements, related infrastructure, institutional and governance arrangements.

Mitigation refers to actions or measures undertaken with the objective to avoid, or reduce the severity of adverse impacts.

Multi-attribute utility-analysis methodology is a step-by-step decision support methodology that facilities a comprehensive assessment of various options against multiple objectives.

Ordovician sedimentary rock consists of bedrock formations such as shale and limestone bedrock formations that were laid down approximately 450 to 500 million years ago.

Partitioning involves a series of physical and chemical processes to separate various isotopes from used nuclear fuel for further conditioning, treatment or long-term management.

Plutonic rock is intrusive igneous rock formed at considerable depth beneath the surface of the earth by cooling of magma.

Precautionary approach/principle (we use these expressions interchangeably) As defined in the Government of Canada's *A Framework for the Application of Precaution in Science-based Decision Making about Risk*, which outlines guiding principles for the application of precaution to science-based decision making for the protection of health and safety and the environment and the conservation of natural resources: "The application of "precaution", "the precautionary principle" or "the precautionary approach" recognizes that the absence of full scientific certainty shall not be used as a reason for postponing decisions where there is a risk of serious or irreversible harm."

Present value is the amount of money that must be invested today to earn compound interest in order to yield enough future value to cover costs at a known period in time.

Real return is the actual return on an investment after removing the effect of inflation.

Repository is nuclear facility where used fuel is placed deep underground.

Reprocessing is the application of chemical and physical processes to used nuclear fuel for the purpose of recovering and recycling fissionable isotopes.

Retrievability is the ability to remove waste from where it has been placed.

Safeguards are activities by which the IAEA can verify that a State is living up to its international commitments not to use nuclear programs for nuclear-weapons purposes.

Safety is the protection of individuals, society and the environment, from the harmful or dangerous effects of used nuclear fuel, now and in the future.

Passive safety refers to safety systems that do not rely on continuing human activities or intervention to ensure safety.

Active safety refers to safety systems that do rely on continuing human activities or intervention to ensure safety.

Seaborn Panel refers to the Nuclear Fuel Waste Disposal Concept Environmental Assessment Panel, under the Chairmanship of Blair Seaborn, established in 1989 by the Government of Canada under the federal *Environmental Assessment and Review Process Guidelines Order* to review the safety and acceptability of AECL's concept of geological disposal of nuclear fuel wastes in Canada.

Security is a condition in which a referent entity or process is made and kept safe against harmful acts, events and situations (which are not of a social construction). Activities include threat, vulnerability and consequence assessments, and mitigation activities. Includes both physical and policy considerations.

Sedimentary rock is a type of rock resulting from the consolidation of loose material that has accumulated in layers.

Sievert is the standard international unit that indicates the biological damage caused by radiation. The biological damage depends on the type and energy of the radiation.

Storage is a method of maintaining used nuclear fuel in a manner that allows access, under controlled conditions, for retrieval or future activities.

Subduction zone is a descending plate of the earth's crust.

Technical method is the technology, technical process or procedure for handling used nuclear fuel. It is one part of a management approach.

Transmutation refers to the transformation of radioactive isotopes from used nuclear fuel into non-radioactive or stable isotopes by bombarding the target isotopes with neutrons or other particles.

Underground characterization facility is an underground research, rock mass characterization and deep repository technology demonstration facility which is constructed at the site for long-term management of used nuclear fuel. The facility is designed to be located adjacent to, and at the same depth as, the deep geological repository.

Used nuclear fuel means the irradiated fuel bundles removed from a commercial or research nuclear fission reactor.

Waste (Nuclear Fuel) is a fuel bundle from a commercial or research nuclear reactor that has served its intended purpose and has been removed from the reactor.

Wet storage is the interim storage of used nuclear fuel in water-filled pools after its removal from the reactor.

Appendix 13 / Acronyms

ACR	Advanced CANDU Reactor
AECL	Atomic Energy of Canada Limited
ASN	Authorité de Sûreté Nucléaire – Nuclear Safety Commission (France)
BAPE	Bureau d'audiences publiques sur l'environnement – (Public Environmental Hearing Board)
BEIR	Biological Effects of Ionizing Radiation
CANDU	CANada Deuterium Uranium
CANUTEC	Canadian Transport Emergency Centre of the Department of Transport
CEAA	*Canadian Environmental Assessment Act* (administered by the Canadian Environmental Assessment Agency)
CLAB	Centralized Interim Underground Wet Storage Facility (Sweden)
CNS	Canadian Nuclear Society
CNSC	Canadian Nuclear Safety Commission
CoRWM	Committee on Radioactive Waste Management (UK)
CPRN	Canadian Policy Research Networks
CRL	Chalk River Laboratories
DGR	Deep Geological Repository
DOE	Department Of Energy (US)
HLW	High Level Waste
HLRWM	High Level Radioactive Waste Management
HQ	Hydro-Québec
HRL	Hard Rock Laboratory (Sweden)
IAEA	International Atomic Energy Agency
ICRP	International Commission on Radiological Protection
JWO	Joint Waste Owners
LLRWM	Low Level Radioactive Waste Management
LWR	Light Water Reactors
MOX	Mixed-Oxide Fuel
MUA	Multi-attribute Utility Analysis
MW	Megawatt

NAFTA	North American Free Trade Agreement
NAGRA	National Co-operative for the Storage of Nuclear Waste (Switzerland)
NBP	New Brunswick Power
NEA	Nuclear Energy Agency
NEB	National Energy Board
NFWA	*Nuclear Fuel Waste Act*
NPD	Nuclear Power Demonstration
NSCA	*Nuclear Safety and Control Act*
NWMO	Nuclear Waste Management Organization
OECD	Organization for Economic Co-operation and Development
ONFA	Ontario Nuclear Funds Agreement
OPG	Ontario Power Generation Inc.
PV	Present Value
PWR	Pressurized Water Reactor
SLOWPOKE	Safe Low-Power Critical Experiment
SDR	SLOWPOKE Demonstrator Reactor
SKB	Swedish Nuclear Fuel and Waste Management Company
UF	Used Fuel
UCF	Underground Characterization Facility
UNSCEAR	United Nations Scientific Committee on the Effects of Nuclear Radiation
URL	Underground Research Laboratory
ZWILAG	Interim storage facility for radioactive waste (Switzerland)

Advisory Council
to the NWMO

Mr. Kenneth Nash
Chairman of the Board of Directors
Nuclear Waste Management Organization
49 Jackes Avenue
Toronto, Ontario
M4T 1E2

September, 2005

Dear Mr. Nash,

On behalf of the Advisory Council to the Nuclear Waste Management Organization (NWMO), I am pleased to submit our comments on the NWMO study.

Having examined the study, we provide comments on the study process and the management approaches, as required of the Advisory Council under section 8 of the *Nuclear Fuel Waste Act*.

Respectfully submitted on behalf of the members of the Advisory Council,

The Honourable David Crombie
Advisory Council Chair

Copy: NWMO Advisory Council:

Dr. David Cameron	Ms. Helen Cooper	Mr. Gordon Cressy
Dr. Frederick Gilbert	Ms. Eva Ligeti	Dr. Derek Lister
Mr. Donald Obonsawin	Dr. Daniel Rozon	

September 22, 2005

Nuclear Waste Management Organization Advisory Council Final Report

Section 1 → Introduction

This report fulfills our obligations under the *Nuclear Fuel Waste Act* (*NFWA*), as members of the Advisory Council, to comment on the process, report and recommendations of the Nuclear Waste Management Organization (NWMO).

Section 1 provides an overview of the mandate, process and approach taken by the Advisory Council. Section 2 provides our assessment of the process undertaken by NWMO. In Section 3, we provide our evaluation of the approach to nuclear waste management proposed by the NWMO. Finally, in Section 4 we offer some final thoughts and recommendations for future initiatives.

1.1 Background

The *Nuclear Fuel Waste Act* (an Act respecting the long-term management of nuclear fuel waste) aims:

> "to provide a framework to enable the Governor in Council to make, from the proposals of the waste management organization, a decision on the management of nuclear fuel waste that is based on a comprehensive, integrated and economically sound approach for Canada."

The Act required the NWMO, at the end of three years, to submit a study setting out its proposed approaches for the management of nuclear fuel waste and to recommend one of those approaches for adoption. The study was obliged by the *Nuclear Fuel Waste Act* to examine at least the following approaches: deep geological disposal; storage at nuclear reactor sites; and centralized storage, either above or below ground. The examination of other approaches was not precluded by the legislation.

The Act also established an Advisory Council charged with the responsibility of examining the study and commenting on the approaches for the management of nuclear fuel waste contained in the study. The NWMO was required to submit those comments to the Minister along with its study.

The NWMO Advisory Council was established by the NWMO Board of Directors in the fall of 2002. It comprises nine individuals with a range of perspectives, knowledge and experience that includes nuclear engineering, environmental sustainability, public policy, Aboriginal affairs and citizen engagement (see list of members in Appendix 1 of NWMO *Final Study Report*).

1.2 Advisory Council Process

Over the past three years we have worked in a variety of ways to develop our assessment of the work of the NWMO. We have also provided advice on a continual basis in the interest of assisting the Organization to undertake the best possible process within the mandate and time limits established by the legislation. We learned from each other, invited experts in various fields to speak to us, made site visits to explore current nuclear waste management processes in various jurisdictions, observed public engagement activities, and debated numerous issues among ourselves and with others engaged in the NWMO process. These activities allowed us to develop shared knowledge and understanding about a wide range of technical, social, ethical, economic and political dimensions of nuclear waste management. They also allowed us to appreciate the complexity of the discussions that the Canadian public and decision-makers would need to have regarding the choice of an appropriate approach for nuclear waste management.

In January 2005 we issued a statement describing "How the Advisory Council of the Nuclear Waste Management Organization Intends to Fulfill its Mandate" (see Appendix A). The statement included a summary of the requirements of the *Nuclear Fuel Waste Act* pertaining to the Advisory Council and to the study being undertaken by the NWMO. We outlined our relationship with the NWMO (see section 1.2.1 below) and described four criteria that we would use to guide our evaluation of the NWMO process and study (section 1.3). In addition, we highlighted one other issue that has been a source of ongoing concern and deliberation. We noted that:

> "The legislation is silent on the question of the quantity of nuclear fuel waste that is to be managed by the recommended approach. In its examination and selection of management approaches, the NWMO will have to address the matter of capacity, and therefore of quantity. How much nuclear waste is it assumed that any given management approach will be able to handle? This question is tied to the larger policy question of the future of nuclear energy in Canada."

> "The Advisory Council would be critical of an NWMO recommendation of any management approach that makes provision for more nuclear fuel waste than the present generating plants are expected to create, unless it were linked to a clear statement about the need for broad public discussion of Canadian energy policy prior to a decision about future nuclear energy development. The potential role of nuclear energy in addressing Canada's future electricity requirements needs to be placed within a much larger policy framework that examines the costs, benefits and hazards of all available forms of electrical energy supply, and that framework needs to make provision for comprehensive, informed public participation."

We were not alone in raising these points. As the NWMO notes, many participants in the engagement process put forward impassioned arguments about energy policy and the future of nuclear power (Section 1.3 of *Final Study Report*). We note that the NWMO states that the "study process and evaluation of options was intended neither to promote nor penalize Canada's decisions regarding the future of nuclear power". Indeed the *Nuclear Fuel Waste Act* does not provide the NWMO with either the jurisdiction or the mandate to influence the future of nuclear power.

The NWMO also considered the issue of the quantity of used nuclear fuel to be addressed and Appendix 10 describes a number of potential scenarios, ranging from early nuclear phase out to considerable expansion. The reference used fuel scenario employed in NWMO's assessment of the four options is based on the existing and expected spent fuel associated with existing nuclear reactors. This would be approximately 3.6 million used fuel bundles assuming that the existing fleet of nuclear reactors in Canada have an average operational life of 40 years. With plant refurbishments, the average life cycle could increase to 50 years, bringing the total number of used fuel bundles to more than 4.4 million. This range is well within the provisions of the NWMO study.

An increase in the installed capacity of nuclear reactors in Canada beyond the current 16000 MW would lead to a significant increase in the quantity of used nuclear fuel. In addition, a nuclear expansion scenario would likely entail fuel enrichment and new reactor technology, with spent fuel possessing new characteristics. These could affect the performance of the disposal technology and introduce a change in the outlook on reprocessing. Such technical aspects were not considered by NWMO in its study, which focused on existing facilities using natural uranium fuel.

We conclude that it is appropriate to plan for the quantity and type of used nuclear fuel expected for NWMO's reference used fuel scenario as well as refurbishments of the existing fleet of reactors, representing a range of 3.6 to 4.4 million bundles. However we emphasize, as did many other participants in the process, that any significant change in the amount or type of used fuel to be managed (whether due to phase out or expansion of the nuclear program) should trigger a review of the work undertaken by the NWMO to date.

1.2.1 Relationship between the Advisory Council and the NWMO

The legislation required us to provide independent commentary on the NWMO's study and its conclusions once they were completed. However, we felt that it would be most constructive to operate on a "no surprises" basis by providing ongoing advice about the NWMO process as it took place. Accordingly, we undertook to learn as much as possible about the NWMO's work and to meet regularly with NWMO management to provide comments and suggestions. Our Chair made regular reports about our work at Board meetings of the NWMO. The President updated us at each of our meetings on NWMO's activities and invited feedback, advice and suggestions on next steps. A detailed account of the advice provided by the Advisory Council and the actions taken by the NWMO in response is provided in a chart posted on the Organization's website (see "Advisory Council Tracking Matrix" at **www.nwmo.ca/actracking**). We found the NWMO to be very responsive to our advice, resulting in changes and adjustments in its process, communications and recommendations.

The Advisory Council Tracking Matrix provides information about the interactions between the NWMO and the Council in six broad categories:

1. Operations
2. Briefings/Site Visits
3. Workplan
4. Annual Reports
5. Discussion Documents and Study Reports
6. Engagement.

In the area of **Operations**, we created a framework for interactions between the NWMO and the Advisory Council, including in-camera meetings as well as discussions with NWMO staff and Board of Directors. This recognized our dual functions of providing independent comment and also ongoing advice to the NWMO.

Our **Briefings and Site Visits** were designed to allow us to learn as much as possible about the work of the NWMO, perspectives of various stakeholders, and current knowledge and practices in Canada and overseas. Details are provided in sections 1.2.2 and 1.2.3 below.

Our advice on the **Workplan** included a wide range of discussions and comments on the NWMO's statement of vision, mission and values, annual business plans and research designs. For example, we encouraged the NWMO to incorporate more expertise in Ontario geology, to seek the perspectives of young people, to publish its workplan as a "roadmap", to arrange peer reviews of the Joint Waste Owners' work on concepts and costs, and to report on how the NWMO was responding to the findings of the Seaborn Panel.

We provided advice to the NWMO on the content and direction of its **Annual Reports**. In addition, we wrote independent letters to the Minister of Natural Resources on the work undertaken by the NWMO in 2003 and 2004 and tabled them at the same time as the NWMO's annual reports (March 2004 and March 2005 respectively).

We provided comments on the structure and content of NWMO's **Discussion Documents and Study Reports** to assist in ensuring that they provided appropriate information to increase public understanding and stimulate public dialogue. We emphasized the importance of describing how the public helped to shape the questions, process and findings addressed in NWMO's study. We suggested that the NWMO highlight the ways in which two parallel tracks of work with different participants – public engagement and expert analysis – led to convergence on many key findings. Council members also provided wording for specific areas of text, such as parts of Appendix 9 in the *Final Study Report* on reprocessing, partitioning and transmutation. We requested clarification on a number of points contained in *Choosing a Way Forward*, the *Draft Study Report* issued by the NWMO in May 2005. This resulted in adjustments in the *Final Study Report* in such areas as Aboriginal dialogue, ethics, suitability of sedimentary rock, cost estimation, nuclear liability, replicability of the assessment, socially acceptable standards of safety, the option of centralized shallow storage, the underground characterization facility and the definition of a willing host.

With respect to **Engagement**, Council members offered advice on ways to implement effective public engagement and ensure meaningful dialogue with Canadians. For example, we recommended benchmarking to track changes in opinions and views throughout the course of the NWMO's study. This was accomplished by NWMO's public opinion research. We also encouraged the NWMO to use a wide variety of engagement techniques, to develop interactive website capability, to convene dialogues in communities that do not host nuclear facilities, to use multi-media to communicate its work, and to incorporate opportunities for participants to learn about the intricacies of the assessment process.

The Council also established a Sub-Committee on Aboriginal engagement to examine how the contributions of Aboriginal peoples were being addressed in the NWMO's work, to provide advice on Aboriginal engagement, and to encourage the NWMO to incorporate the expertise that resides in traditional Aboriginal knowledge. See Section 2 for further elaboration of our views about the engagement initiatives and Aboriginal dialogue.

1.2.2 Meetings

During the past three years we convened regularly in full and half-day sessions as well as conference calls. Our meetings incorporated briefings and dialogues with NWMO staff, in-camera sessions, and guest presentations and discussions. The guests included people whom we invited, people who were suggested by the NWMO, and others who requested meetings with us. Our chairman, David Crombie, represented the Advisory Council at meetings of the NWMO Board of Directors, and the Council participated in a number of joint sessions with the Board.

Members of the Advisory Council attended, as observers, a number of the NWMO's citizen dialogues, national and regional meetings and public information and discussion sessions in various locations across the country in order to hear first hand the comments of Canadians.

The experts and stakeholders who met us to discuss a range of topics are listed in Table 1. For example, we held an early session in 2003 with Mr. Blair Seaborn, the former Chairman of the Nuclear Fuel Waste Management and Disposal Concept Environmental Assessment Panel. This session allowed us to hear from Mr. Seaborn on the range of public concerns registered with his Panel and some of the key issues that were raised in his Panel's report, including comments on public consultations. We also met the Reverend Lois Wilson to benefit from her perspectives and reflections from the Panel process. We were particularly interested in exploring the ethical issues that arose in that process, including the issue of safety from both technical and social perspectives.

We received a briefing by the Joint Waste Owners on the scope of technical research those companies had undertaken with respect to the conceptual engineering designs, transportation systems and cost estimates for each technical method.

We received a presentation by the Canadian Nuclear Safety Commission regarding its roles and responsibilities and the role it will play in the licensing of any approach for the long-term management of used nuclear fuel.

Officials from the Energy Sector of Natural Resources Canada provided a briefing on the role of nuclear power in the context of Canada's energy supply. We also met officials from the Uranium and Radioactive Waste Division, Natural Resources Canada to provide them with an update on our work.

In March 2003, members of the Advisory Council participated in an NWMO meeting with the Minister of Natural Resources Canada at that time, the Honourable Herb Dhaliwal, sharing with the Minister some of their own perspectives and reflections on the NWMO process to date. In January 2005, a member of the Council accompanied NWMO Chair Ken Nash and President Elizabeth Dowdeswell to a meeting with the Honourable R. John Efford, current Minister of Natural Resources Canada, and reported on the Advisory Council's approach to its mandate and the ways in which the Council was providing ongoing guidance to the NWMO.

Table 1 Participants in Meetings of the Advisory Council

WHO	WHEN
Blair Seaborn, former Chairman of the Nuclear Fuel Waste Management and Disposal Concept Environmental Assessment Panel	January 2003
Ric Cameron, ADM, Energy Sector, Natural Resources Canada	January 2003
Jaime Watt, Chair and Dianne LeBreton, Consultant, Navigator (focus group research)	January 2003
Linda Keen, President and CEO, Cait Maloney, Director General, Directorate of Nuclear Cycle and Facility Regulation and Richard Ferch, Director, Director General's Office, Canadian Nuclear Safety Commission	March 2003
Senator Lois Wilson, former Commissioner on the Seaborn Panel	March 2003
Ken Nash, Chair and Frank King, Director, Nuclear Waste Engineering and Technology, Ontario Power Generation	May 2003
Judith Maxwell, President, Canadian Policy Research Network	January 2004, May 2004
Nuclear Waste Watch members – David Martin, Sierra Club of Canada; Marion Odell, International Institute of Concern for Public Health; Shirley Farlinger, Science for Peace / International Institute of Concern for Public Health / University Women's Organization; Theresa McClenaghan, Canadian Environmental Law Association; Nest Pritchard, Ontario Voice of Women	March 2004
NWMO Assessment Team Members – Michael Ben-Eli, President, Cybertec Consulting Group, and Tom Isaacs, Director, Office of Policy, Planning and Special Studies, Lawrence Livermore National Laboratory,	May 2004
NWMO Roundtable on Ethics Members – Andrew Brook, Professor of Philosophy, Carleton University Arthur Shafer, Director of the Centre for Professional and Applied Ethics, University of Manitoba, and Margaret Somerville, Professor of Law and Medicine, McGill Centre for Medicine, Ethics and Law, McGill University	October 2004
Joanne Barnaby, facilitator, Aboriginal Traditional Knowledge workshop	October 2004
David Hallman, The United Church of Canada and Climate Change Programme Coordinator and Mary Lou Harley, Member, Nuclear Issues Writing Group for Justice, Global and Ecumenical Relations Unit, United Church of Canada	October 2004
Murray Elston, President and CEO, Canadian Nuclear Association and Jeremy Whitlock, President, Canadian Nuclear Society	February 2005
Marvin Stemeroff, Principal, Gartner Lee Ltd. and John Davis, Principal, Golder Associates	February 2005
Peter Brown, Director, Uranium and Radioactive Waste Division and Carmel Létourneau, Senior Policy Advisor, Uranium and Radioactive Waste Division, Natural Resources Canada	March 2005

A member of Council attended the Euradwaste'04 meetings in Luxembourg to learn more about the collaborative research being conducted in Europe on a range of topics related to nuclear waste management, including community and socio-political considerations, stakeholder engagement, and research and development.

In 2004, the Advisory Council met with representatives of Nuclear Waste Watch, a network of 34 organizations concerned about high-level radioactive waste and nuclear power in Canada.

The convener of the 2003 Aboriginal Traditional Knowledge Workshop attended one of our meetings to address the topic of drawing on Aboriginal wisdom to formulate ethical guidelines.

Representatives of the United Church of Canada met us to provide their positions on nuclear issues and their views on some of the societal and ethical considerations.

We received a presentation from the Roundtable on Ethics, in order to understand and discuss the ethical and social framework they were developing.

The Canadian Policy Research Network reported on the findings from the National Citizens' Dialogue, a highlight of the NWMO's research into citizen values in 2004.

In May 2004 the Council received a presentation from members of the Assessment Team and discussed their methodology and findings. In February 2005 we met with representatives of Gartner Lee Ltd. and Golder Associates who briefed us on their comparative assessment of costs, benefits and risks associated with the three management options specified in the *NFWA*.

We met with representatives of the Canadian Nuclear Association and Canadian Nuclear Society to learn about the perspectives of these organizations on the long-term management of used nuclear fuel.

Our work is documented in records of discussion from our meetings as well as the chart we used to assist in tracking our activities and to support the preparation of this report. These documents are posted on NWMO's web site.

1.2.3 Site visits

In order to learn about current practices in Canada as well as relevant activities in the US and Europe, members of the Council participated in a number of site visits for research purposes.

Several Council members visited the Pickering Nuclear Generation Station in Ontario in May 2003 to tour Unit 3 of the plant and receive a briefing and tour of the station's wet and dry interim storage facilities for used nuclear fuel.

In May 2003 Derek Lister and NWMO President Elizabeth Dowdeswell toured the Underground Research Laboratory at Whiteshell, Pinawa, Manitoba operated by Atomic Energy of Canada Ltd. They also met with AECL staff and with the Mayor of Pinawa.

Several members of the Advisory Council visited the Yucca Mountain Disposal Project in Nevada to learn about the US Department of Energy's experiences with preparing a repository for used fuel. Discussions with DOE staff in Las Vegas provided valuable insights into their public engagement processes.

In November 2002, Fred Gilbert had an opportunity while in Helsinki, Finland, to meet with Dr. Juhani Vira, Director of Research at Posiva Oy (the agency implementing the Finnish program for the long-term management of used fuel) to review the site selection process and discuss the nuclear energy situation in Finland.

Eva Ligeti participated in a Canadian delegation (including NWMO representatives) that visited Rauma, Finland in October 2004. The site visit included meetings with officials from Posiva Oy to explore Finland's plans for long-term management of used nuclear fuel, in terms of both the policy underpinnings and the progress in implementation.

1.3 Evaluation Approach

In fulfilling our legislative obligations to provide an independent review of the work of the NWMO, we gave considerable thought to the criteria we would use for evaluation. In developing them, we considered the mandate of the NWMO, the requirements of the legislation, and the experience of the Seaborn Panel. The criteria were published in our January 2005 statement "How the Advisory Council of the Nuclear Waste Management Organization Intends to Fulfill its Mandate" (Appendix A).

The four criteria are:

- **Comprehensiveness.** Did the NWMO study properly consider all of the available reasonable alternative approaches? Did it thoroughly cover the three required options? Does the report adequately address all of the elements stipulated in the legislation with respect to each of the options?

- **Fairness and balance.** Has the analysis supporting the NWMO report given appropriate weight to all relevant evidence, neglecting none of significance? Does the study give adequate consideration to diverse points of view and recognize the interests of minority positions? Is there any evidence of bias or partiality in the analysis and recommendations? Does the recommended policy choice emerge logically out of the careful and considered weighing of the pros and cons of the respective alternatives?

- **Integrity.** Did the NWMO process provide sufficient opportunity for public engagement? Were Aboriginal peoples, concerned stakeholders, and potentially or actually affected communities given real opportunities to make their views known? Were these views responsibly considered and appropriately taken into account? Were available sources of expertise and specialized experience sought out and utilized effectively? Were 'state of the art' processes of public consultation, ethical reflection, socio-economic analysis, technical and scientific study, financial forecasting, and impact assessment employed? Was international comparative experience adequately considered?

- **Transparency.** Did the NWMO make its plans and timetable clear to the interested public? Did it share information with citizens in a timely fashion so that they had the capacity to participate effectively in the process? Did it simplify technical data and complex scientific matters honestly and effectively to assist in the development of public understanding? Did the Organization allow sufficient time for comment, input and reaction from stakeholders and the general public?

Section 2 ➔ The NWMO Process

2.1 Overview of NWMO's Process

The NWMO undertook a complex and iterative process in four phases that involved (1) setting the expectations for the study, (2) exploring the fundamental issues, (3) assessing the options and (4) formulating the recommendation. Throughout these four phases, the NWMO engaged citizens to help develop an understanding of the requirements for an appropriate management approach for Canada, and specialists to help develop an understanding of the practicable options available to address these requirements. The NWMO's work can be described in terms of four linked streams of work: general public engagement, Aboriginal engagement, professional expertise, and the assessment process. All these streams of activity were informed by a set of ethical principles that were treated as over-arching considerations for NWMO's process and outcomes.

Engagement: The NWMO used a wide variety of engagement techniques, including workshops, public information and discussion sessions, open houses, youth workshops, public attitude research (focus groups and telephone survey), a scenarios exercise, an ethics roundtable, meetings with political representatives and international agencies, written submissions, e-dialogue and interactions with the Advisory Council.

Aboriginal engagement: The NWMO's Aboriginal engagement incorporated collaborative agreements with all six national Aboriginal organizations and seven regional/local organizations, an outreach program with First Nations of Ontario, involvement of Aboriginal peoples in all NWMO activities, a workshop on Traditional Knowledge and Aboriginal Wisdom, a program to increase Aboriginal language capacity regarding nuclear waste management, and an Elder's forum.

Professional expertise: More than 60 expert papers were commissioned on a wide range of topics including social and ethical dimensions, health and safety, science and environment, economic factors, technical methods, conceptual engineering designs, cost estimates, risk assessment, and institutions and governance.

Assessment: The NWMO formulated a list of 10 questions that their engagement initiatives suggested that Canadians wanted to have addressed, within the limits of the NWMO mandate. An ethical and social framework was developed based on citizen and Aboriginal values and concerns, ethical principles, future scenarios and societal context. Technical information was introduced from the background papers, engineering design work and cost estimates. Eight objectives were identified to guide the assessment of the four used nuclear fuel management options under consideration.

2.2 Advisory Council Evaluation of NWMO's Process

This section provides the Advisory Council's evaluation of the key elements of the NWMO's process according to the four criteria that we developed to guide our work – comprehensiveness, fairness and balance, integrity, and transparency (see Section 1). We also include some recommendations for future phases of the work of the NWMO, recognizing the opportunity to build on the work undertaken to date.

2.2.1 Engagement

The Advisory Council finds that the NWMO had an extensive and sophisticated engagement program, which was effectively conducted within the limits of the NWMO's mandate and the relatively short time frame allocated to the process by the *Nuclear Fuel Waste Act*. The public engagement program addressed one of the major deficiencies of previous work on nuclear waste management in Canada as identified by the Seaborn Panel, namely that there had been insufficient consultation with Canadians on the proposed management approach. The NWMO employed innovative techniques that were a significant advance in comparison with traditional methods of outreach and provided a great variety of ways for people to participate.

The NWMO process provided opportunities for participation by concerned stakeholders, potentially or actually affected communities and the general public. Despite the usual challenges of attempting to engage large numbers of people in consultations about public policy, we believe that the diverse participation provided a good reflection of the range of different opinions to be found among stakeholders and the general public. The NWMO made an effort to engage citizens across the country, with a heavier emphasis on those communities that host existing nuclear facilities (Ontario, New Brunswick and Quebec) and uranium mines (Saskatchewan). We feel that this was an appropriate balance, recognizing that interest would be higher in the communities with direct experience and that the Provinces that have benefited most from the industry should bear most of the responsibility for dealing with its wastes.

NWMO went to great lengths to record and consider all points of view, and minority opinions are presented throughout the analysis. NWMO endeavoured to reach people other than those who have an expressed interest in nuclear waste management, particularly through the use of the National Citizens Dialogue and the public attitude research.

Although it is typically difficult to secure the participation of young people in engagement initiatives of this nature, the NWMO made an effort in this regard, including a workshop with young people who were participating in an International Youth Nuclear Congress, a youth dialogue convened in Saskatchewan, involvement of young people in the Aboriginal Elders Forum, presentations at universities, and the e-dialogue.

We observed that for the most part, information was generally shared with citizens in a timely fashion so that they could participate effectively in the process. On the whole, technical data and complex scientific matters were simplified and honestly presented to assist in the development of public understanding. However, we also observed that adequate technical and cost information was not always available when needed by participants in the engagement process, particularly in the early phases of the work.

Throughout the process, the NWMO went to great lengths to ensure transparency and open discussions of its work. It provided background documents and drafts of its reports for independent analysis and comment, and clearly demonstrated how it was responding to public and technical input.

2.2.2 Aboriginal Engagement

We found that the NWMO's engagement activities with Aboriginal peoples were slow to get started, but are now going in the right direction. The Advisory Council recognizes that the three year time constraint imposed on the NWMO by the federal legislation was a particular limiting factor in undertaking comprehensive consultations with Aboriginal peoples. Such consultations need adequate time to accommodate the consensual, measured processes that are traditional to Aboriginal peoples, as well as the large geographic distances, language barriers and cultural complexity involved.

The NWMO's work with the Elders, the development of discussion and technical background materials in Aboriginal languages, the traditional knowledge workshops, efforts to involve Aboriginal peoples in general NWMO activities, and the participation of over 3000 Aboriginal peoples over the past three years testify to the NWMO's numerous outreach efforts to Aboriginal peoples. It is noteworthy that the NWMO has been able to sign engagement agreements with six national and seven regional/local organizations. However the Advisory Council wishes that more regional/local agreements had been signed earlier in the process, especially with Aboriginal peoples in the Canadian Shield territories.

The Advisory Council recognizes that the current engagement activities with Aboriginal peoples represent only the beginning of a longer and more involved and inclusive relationship. As Justice Berger recently noted in his July 2005 memorandum to the NWMO, we must remember the statement of the 1987 World Commission on Environment and Development (Brundtland Commission) that tribal people "must be given a decisive voice in the formulation of resource policy in their areas". Justice Berger emphasized that it is the Aboriginal peoples who mainly live on a permanent basis in the more remote parts of the Canadian Shield. The Aboriginal peoples consider their ancient territories as the true dwelling place of generations and consequently will have an important contribution to make to any management processes involving the Canadian Shield. It will be important for the

NWMO to provide the necessary tools and processes required to achieve that goal.

In the next phases of the process, NWMO will have to proceed with more formal consultations with Aboriginal peoples, especially as the siting options become better defined and focused. The NWMO will need to be mindful of the evolving guidelines for consultations with Aboriginal peoples that are emerging from recent and ongoing decisions by the Supreme Court of Canada. For its part, the NWMO will need to better define its own legal and social requirements and expectations of future consultations with Aboriginal peoples.

There is also a need for greater clarification of the fiduciary obligations of the Federal Government in the consultation process with Aboriginal peoples. There should be greater clarity on the scope and purpose of any further consultations by the Federal Government in future phases, including an understanding of how those consultations might complicate, complement or enhance the engagement initiatives of the NWMO.

Engagement and consultation with Aboriginal peoples should become both more complex and more focused as the next phases of NWMO's work proceed. There is a great opportunity for the NWMO to build on its efforts to date and engage in a meaningful and inclusive consultation process with Aboriginal peoples in its future work.

2.2.3 Professional Expertise

The NWMO incorporated extensive professional expertise into its work and covered in depth a wide range of knowledge and experience within the time available. For the most part, all the key areas were covered, providing a satisfactory base for the conclusions of the study. Looking ahead, we believe that it would be advantageous for NWMO to increase the capacity of its own staff to provide more in-house expertise on the complex technical and scientific matters that must be addressed in future phases.

2.2.4 Assessment

The NWMO assessment process was thorough and covered all the key considerations. It identified 14 alternative approaches and provided justification for screening out unacceptable ones. The three required options, as well as the fourth recommended option, were carefully evaluated, and the NWMO addressed all elements stipulated in the legislation. The analysis supporting the NWMO report gave appropriate weight to all relevant evidence, neglecting none of significance.

We found that the recommended policy choice emerges logically out of the careful and considered weighing of the pros and cons of the alternatives. One area of focus for our deliberations was the replicability of the assessment process. The Assessment Team was composed of a diverse group of individuals with a broad range of expertise. This team designed the assessment process so that it was transparent, traceable and comprehensive. Various techniques were used to engage interested citizens in components of the process, including a simulation of the scoring process and detailed discussion of the objectives and findings of the assessment exercise. In addition, the NWMO engaged consultants Golder Associates and Gartner Lee Ltd. to further develop and enhance the work undertaken by the Assessment Team. The public discussions and the work of the Golder/Gartner Lee team provided substantial additional credibility to the assessment. Nonetheless, in future work, we recommend that assessments should be fully replicated to increase confidence in the results.

We also focused considerable discussion on social and ethical matters because of their critical importance in gaining acceptance for any proposed management approach. The NWMO's strategy of integrating social and ethical factors along with technical and economic considerations represents groundbreaking work in the international context of nuclear waste management. Continued public engagement will be required to build on this important element in the next phases of the process.

2.2.5 Conclusion

Overall, we conclude that, within the stipulated statutory limits to which it was subject, the NWMO conducted a process that was comprehensive, transparent, and clearly exhibits fairness, balance and integrity.

Section 3 → Adaptive Phased Management

3.1 Support for Adaptive Phased Management

The NWMO has made a thorough assessment of the three options mandated by the *Nuclear Fuel Waste Act* and developed an improved approach - Adaptive Phased Management (APM). Each of the four options studied by the NWMO has been shown through extensive analysis to possess various combinations of risks and benefits, from both a technical and a social perspective.

Our review of the risks and benefits associated with each option confirms that APM is the best of the options because it provides Canadians with a comprehensive roadmap for dealing responsibly with Canada's existing nuclear wastes. It retains major advantages of the original three options and minimizes risks and disadvantages. Recognizing that we are currently in the middle of the 40/50 year expected life span of existing nuclear reactors, APM provides a mechanism for a portion of their revenue to be allocated to dealing with their wastes, while not foreclosing on choices properly left to the best judgment of succeeding generations. APM also engages the Canadian public at key decision points along the way and provides a process to allow the NWMO to adapt the management system so that it achieves a socially acceptable standard of safety.

3.2 Benefits of Adaptive Phased Management

The most significant benefit of APM is that it is based on a progressive, adaptive process that, if given sufficient time, commitment, resources and leadership, has the potential to provide a socially acceptable solution for existing and expected used nuclear fuel from Canada's current fleet of reactors. We note that the importance of the process is clearly recognized by NWMO in its statement that "the most profound challenge lies not in finding an appropriate technical method, but in the manner in which the management approach is implemented" (Section 8.2 on Streams of Analysis in *Final Study Report*).

APM also addresses one of the major conclusions of the Seaborn Panel – that social issues had not been adequately addressed in developing the concept for deep geological disposal of used nuclear fuel that was presented to the Panel. We believe that APM has the potential to address this limitation and achieve a standard of safety that is both technically sound and socially acceptable.

In the following text, we describe some specific benefits of APM. However, we emphasize that in order for APM to realize these benefits, the process must be implemented with integrity, requiring sufficient time and resources for each step to be undertaken fully.

Ethical Framework – APM is designed to be an ethical management approach that would engage a broad cross-section of society in informed dialogue and explicitly respond to societal values and concerns.

Fairness to Future Generations – APM recognizes that fairness requires that financial responsibility for the management of used fuel from existing nuclear facilities should reside with the generations that are benefiting from the power being generated. It also provides a management approach for both the short and long term, while ensuring that future generations will have opportunities to make genuine choices at appropriate points in the process.

Continuous Learning – the APM management approach is designed to incorporate continuous learning and the application of emerging science and technologies, both specific to the site and from work being undertaken in Canadian institutions and in other countries. In particular, the underground characterization facility will provide valuable opportunities to undertake research to further describe the site, experiment with relevant technologies, and demonstrate the safety and effectiveness of proposed methods for handling and monitoring the used fuel.

Addressing Uncertainty – the NWMO recognizes that some participants in the process questioned whether the current level of technical expertise is enough to make decisions on a solution that will have implications for many future generations. APM is designed to address uncertainties by providing time for continual development of technical expertise and a series of points at which important decisions can be made in an open and transparent manner with public accountability.

Security – the option of interim shallow storage of the used nuclear fuel at the centralized site in the near term provides the opportunity to reduce the risks (e.g. security) associated with above-ground storage at a number of current facilities in several Provinces. It also allows preparations to be made for the orderly decommissioning of existing nuclear facilities once their useful life is over. Over the long term, centralized containment in a deep geological repository will provide the most secure end-point currently identified. In addition, because containment in a deep geological repository relies on a combination of engineered and geological barriers to contain and isolate the used fuel, it has the potential to be effective in the event that social institutions that may be in place hundreds or thousands of years from today can no longer ensure the safety of the site.

3.3 Outstanding Considerations

We recognize the considerable amount of work undertaken by the NWMO to develop the APM approach. However, within the APM framework, there are still a number of outstanding questions that will need to be addressed as the NWMO proceeds to the next phases of its work. Some of the key questions are noted below.

- **Cost Estimates** – the NMWO has undertaken a considerable body of work to identify the costs of each of the four management options. Future work will need to provide more details, for example to specify the incremental costs associated with managing smaller or greater amounts of used fuel, within the range established in the reference used fuel scenario described in Appendix 10.

- **Liability** – the *Nuclear Liability Act* is currently under review to improve victim compensation, clarify key provisions, clarify federal responsibilities and address technical problems. As decisions are made in the future regarding NWMO's liability, it will be necessary to adjust NWMO's cost estimates accordingly.

- **Rock Formations** – the NWMO has concluded that both the crystalline rock of the Canadian Shield and Ordovician sedimentary rock are potentially suitable for a deep geologic repository. However the option to use sedimentary rock was introduced relatively late in NWMO's study process, and limited work has been undertaken in Canada to date on Ordovician sedimentary rock to determine its suitability for this purpose. It is therefore premature to consider Canadian sedimentary and crystalline rock as equivalent options until more research has been undertaken on the former.

Section 4 → Final Thoughts and Recommendations

In this section we draw on the experiences of the past three years to provide some final thoughts and recommendations on the following topics:

- Future governance of the NWMO
- Adaptive Phased Management
- Engagement
- Aboriginal engagement
- Advisory Council
- Energy policy

4.1 Future Governance of the NWMO

We found that the NWMO operated with integrity and transparency to manage a complex study process over the past three years, within the confines of the mandate and the deadlines provided. The characteristics of integrity and transparency will continue to be essential in the future to ensure that the NWMO has credibility and public trust.

In Section 10.7 of the *Final Study Report*, NWMO provides a good assessment of its future governance requirements. We emphasize the importance of expanding the Board of Directors to include a broader range of interests than those of the nuclear waste producers. This should provide diverse and independent viewpoints to assist the Organization as it moves into the operational phases of its work.

In addition, we recommend that, consistent with NWMO's public mandate:

1) The criteria used to define the composition of the Board should be communicated to the public.

2) The Board should adopt a policy of voluntarily adopting the standard of transparency required by the *Access to Information Act*.

4.2 Adaptive Phased Management

We conclude that NWMO's Option 4 – Adaptive Phased Management – is a progressive, adaptive process that, if given sufficient time, commitment, resources and leadership, has the potential to provide a socially acceptable solution for existing and expected used nuclear fuel from the current fleet of reactors. We emphasize that the process should be fully implemented with integrity, as designed by the NWMO. For example, it is possible that a decision will be made that a centralized shallow underground storage facility is not required, but such a decision should emerge from the anticipated process, including meaningful public engagement and full consideration of all social, ethical and technical factors.

Therefore, we recommend that:

1) APM should be implemented with the appropriate leadership, resources and time to undertake the process as described in NWMO's *Final Study Report*.

4.3 Engagement

NWMO's engagement process over the past three years was characterized by a wide range of techniques, openness and depth of discussion, and transparency.

As the NWMO moves into the next phase of work, we recommend that:

1) The NWMO should continue to meet the high standards of engagement established to date, reach out to a broad cross-section of Canadians and seek diverse opinions.

2) Intensive engagement efforts should be undertaken with communities of interest, including potential "willing host" communities.

3) Increased emphasis should be placed on reaching out to young people because the long time frame of nuclear waste management places important responsibilities on future generations.

4) A strong educational program should be provided to deepen public understanding and facilitate informed decision-making.

4.4 Aboriginal Engagement

The NWMO's engagement activities with Aboriginal peoples will continue to be a critical element of the process. Although Aboriginal engagement initiatives got off to a slow start, they are now going in the right direction, and will provide a good foundation for a more involved and inclusive relationship.

We recommend the following measures to build on this foundation:

1) Hire Aboriginal staff and set up an Aboriginal advisory committee with diverse membership to ensure that Aboriginal perspectives are integrated into NWMO initiatives and processes.

2) Continue to engage Aboriginal elders.

3) Improve communications, with communications tools and technical materials appropriate to Aboriginal peoples, in the languages of the Aboriginal peoples involved.

4) Involve traditional knowledge holders in the broader processes of the selected management approach.

5) Go beyond the "traditional knowledge" focus of Aboriginal involvement and better involve Aboriginal peoples in the broader discussions of the selected management approach.

6) Work with the Federal Government to ensure ongoing funding for local capacity building.

7) Continue to focus on appropriate consultation initiatives at the local level.

4.5 Advisory Council

The Advisory Council will continue to play an important role in the next phases of NWMO's work. As this work evolves from a study to implementation, it is appropriate to review the composition of the Advisory Council to ensure that it includes the appropriate range of knowledge, expertise and perspectives, including those of young people. For example, it will be especially important during the site selection process for the Advisory Council to be able to comment with a range of viewpoints on such issues as social acceptability, the public interest and transparency.

Section 10.7 of the *Final Study Report* recognizes the need to review the mandate and composition of the Advisory Council, and we, the current Advisory Council, will be pleased to assist the NWMO with this task.

4.6 Energy Policy

The NWMO Study Report provides a framework for proceeding to address existing and expected used nuclear fuel from the current fleet of reactors. However we emphasize, as did many of the participants in the engagement process, that it does not provide a green light for expansions of nuclear power production beyond the lifespan of the current fleet. As we said in Section 1, any significant change in the amount or type of used fuel to be managed should trigger a review of the work undertaken by the NWMO to date. Such a review should be undertaken in the context of a discussion of federal, provincial and territorial energy policies in Canada, not only for nuclear power, but also for all other forms of energy. Indeed, the need for a broad Canadian perspective was highlighted by the recent proposal of provincial and territorial leaders at their Council of the Federation meeting in Banff to develop a pan-Canadian energy strategy (11 August 2005 Communiqué).

We believe that a public policy discussion about energy in Canada is needed – regardless of any proposals for phase out or expansion of nuclear power. This was a recurring theme in NWMO's engagement activities, with many participants being reluctant to discuss processes to deal with wastes from the generation of nuclear power in the absence of an understanding of the role of nuclear energy in Canada's future.

Recognizing that responsibility for energy in Canada is shared among the federal, provincial and territorial governments, we recommend that:

1) The federal government should work with the provincial and territorial governments to facilitate a national public policy discussion about future energy supplies in Canada.

2) There should be no expansion or reduction of nuclear power generation at the provincial or territorial levels without public policy discussion about future energy supplies within those jurisdictions.

Appendix A → How the Advisory Council of the Nuclear Waste Management Organization Intends to Fulfill its Mandate

January 22, 2005

The Legislation

The *Nuclear Fuel Waste Act* (an Act respecting the long-term management of nuclear fuel waste) aims:

> "to provide a framework to enable the Governor in Council to make, from the proposals of the waste management organization, a decision on the management of nuclear fuel waste that is based on a comprehensive, integrated and economically sound approach for Canada."

The Act requires the waste management organization, at the end of three years, to submit a study setting out its proposed approaches for the management of nuclear fuel waste and to recommend one of those approaches for adoption.

The Act also establishes an Advisory Council charged with the responsibility of examining the study and giving written comments on it to the Nuclear Waste Management Organization (NWMO). The NWMO, for its part, is required to submit those comments to the Minister along with its study. Section 12 of the legislation, which discusses the study, imposes an obligation on the Advisory Council to comment on the approaches for the management of nuclear fuel waste contained in the study. While it does not specifically require the Council to comment on the NWMO's recommendations, that requirement can be reasonably inferred from the obligation to comment on 'the study' and 'the approaches', which will of course contain the recommendations.

The NWMO Study

The NWMO's study is obliged to examine at least the following approaches: deep geological disposal; storage at nuclear reactor sites; and centralized storage, either above or below ground. The examination of other approaches is not precluded by the legislation. For each proposed approach the NWMO must include the following:

- Detailed technical description;
- Specification of an economic region for implementation;
- A comparison of benefits, risks and costs with those of the other approaches;
- The associated ethical, social and economic considerations;
- A description of the waste management services to be offered by the NWMO;
- An implementation plan (description of activities, timetable, means of avoiding or minimizing significant socio-economic effects on a community's way of life or its social, cultural or economic aspirations, and a program of public consultation);
- A summary of comments arising out of consultation with the general public and with aboriginal peoples;
- A financial formula to cover the costs;
- A cost-sharing formula allocating costs to waste producers; and
- The form and amount of any financial guarantees provided by the nuclear energy corporations.

Finally, the study is required to recommend one of the approaches thus described.

This, then, is the nature of the study on which the Advisory Council is obliged to provide written comments.

The Advisory Council's Approach

The legislation creating the Nuclear Waste Management Organization and its Advisory Council is very broad. Within the framework of the legislation, we – as members of the Advisory Council – see our responsibilities in the following way.

As part of our obligation to examine and give written comment on the NWMO's study at the end of the three-year period, we believe it is appropriate for the Council to learn about the ongoing work of the NWMO and for the Council to express its views about that work as it is being done. Accordingly, members of the Advisory Council decided at its establishment in October 2002 to meet regularly with NWMO management and to offer ongoing advice about the conduct of their undertaking. To date we have had 13 formal meetings with NWMO staff as well as four meetings with members of the NWMO Board of Directors. Our work is recorded in the minutes posted on the Organization's web site. At the end of the three-year process, we intend to post the Tracking Matrix we used to assist us in tracking our activities and in supporting the preparation of our written comments on the NWMO study.

In fulfilling its legislative obligations, the Advisory Council will offer written comments and observations on the work and study of the NWMO.

The Council will review and comment on the **comprehensiveness** of the NWMO study. Did it properly consider all of the available reasonable alternative approaches? Did it thoroughly cover the three required options? Does the report adequately address all of the elements stipulated in the legislation with respect to each of the options?

The Council will review and comment on the **fairness and balance** of the study. Has the analysis supporting the report given appropriate weight to all relevant evidence, neglecting none of significance? Does the study give adequate consideration to diverse points of view and recognize the interests of minority positions? Is there any evidence of bias or partiality in the analysis and recommendations? Does the recommended policy choice emerge logically out of the careful and considered weighing of the pros and cons of the respective alternatives?

The Council will review and comment on the **integrity of the NWMO process**. Did the process provide sufficient opportunity for public engagement? Were Aboriginal peoples, concerned stakeholders, and potentially or actually affected communities given real opportunities to make their views known? Were these views responsibly considered and appropriately taken into account? Were available sources of expertise and specialized experience sought out and utilized effectively? Were 'state of the art' processes of public consultation, ethical reflection, socio-economic analysis, technical and scientific study, financial forecasting, and impact assessment employed? Was international comparative experience adequately considered?

The Council will review and comment on the **transparency of the process**. Did the NWMO make its plans and timetable clear to the interested public? Did it share information with citizens in a timely fashion so that they had the capacity to participate effectively in the process? Did it simplify technical data and complex scientific matters honestly and effectively to assist in the development of public understanding? Did the Organization allow sufficient time for comment, input and reaction from stakeholders and the general public?

In conclusion, there is one other issue that requires comment. The legislation is silent on the question of the quantity of nuclear fuel waste that is to be managed by the recommended approach. In its examination and selection of management approaches, the NWMO will have to address the matter of capacity, and therefore of quantity. How much nuclear waste is it assumed that any given management approach will be able to handle? This question is tied to the larger policy question of the future of nuclear energy in Canada.

The Advisory Council would be critical of an NWMO recommendation of any management approach that makes provision for more nuclear fuel waste than the present generating plants are expected to create, unless it were linked to a clear statement about the need for broad public discussion of Canadian energy policy prior to a decision about future nuclear energy development. The potential role of nuclear energy in addressing Canada's future electricity requirements needs to be placed within a much larger policy framework that examines the costs, benefits and hazards of all available forms of electrical energy supply, and that framework needs to make provision for comprehensive, informed public participation.

CONTACT US

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The NWMO invites all interested individuals and organizations to review our public engagement activities, discussion documents, reports and research on our website at **www.nwmo.ca**.

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