NUCLEAR WASTE MANAGEMENT ORGANIZATION
SOCIÉTÉ DE GESTION DES DÉCHETS NUCLÉAIRES

Understanding the Choices

The Future Management of Canada's Used Nuclear Fuel

Our 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.

Understanding the Choices
The Future Management of Canada's Used Nuclear Fuel

Discussion Document 2

Contents

Foreword

For the past months the NWMO has been trying to better understand the choices available to society for the management of used nuclear fuel over the long term. This second discussion document reflects our commitment to sharing our thinking as it evolves.

We are profoundly influenced by the time dimension of this issue. We must look ahead thousands of years. Yet, how can we possibly know the future perfectly? We can't. We also know that inaction is not acceptable. We do believe that the future will not be simply more of the present. And so, we must not constrain our thinking to the limits of our current field of vision. The challenge is to move beyond conventional wisdom while embracing a precautionary approach.

Two assumptions influenced our study plan: the importance of discerning and understanding the values of Canadians and the wisdom of an holistic systems approach to analysis.

Our work must be firmly rooted in the values that Canadians hold dear. If we are to design an approach that generates any degree of confidence about the long term, it must resonate with what matters to people, fundamentally. The exquisite logic of an analytical process alone may not be convincing.

We sought genuine dialogue with citizens through a National Citizens' Dialogue. The pages that follow document a specific approach to deliberative dialogue with Canadians from all walks of life. As the participants struggled with the complexities and inevitable tradeoffs, much common ground emerged. People clearly articulated a basic need to feel safe from harm. They conveyed a sense of responsibility and stewardship and an expectation that systems and institutions should be adaptable, accountable and inclusive. Just as importantly we heard where there were areas of tension and divergence. We were struck by, and are grateful for, the participants' commitment of time, the richness of their contributions, and their eagerness to be involved. These citizens had an appetite for influencing the decision-making process and a broader desire to consider Canada's energy directions. We will continue our efforts to understand what is important to Canadians.

Our search for a way of managing used fuel that is socially acceptable, technically sound, environmentally responsible and economically feasible suggests the need for analytical insight from many disciplines. The complexity, uncertainty and long time horizon characteristic of this important public policy issue further underscore the imperative of a comprehensive, integrative systems view.

Our analytical work was advanced through the contributions of a multidisciplinary Assessment Team. What differentiated this exercise from so many others was that it was grounded in the basic issues identified by Canadians. The development of a framework for analysis started with guidance from the Roundtable on Ethics about the social and ethical issues that needed to be central. Technical information was provided by industry experts but the environmental, economic, social and ethical objectives were drawn directly from the contributions of citizens.

The Team brought rigour and discipline to its consideration of the options. Collectively, from the vantage point of their respective areas of expertise and experience, they too wrestled with the issues and trade-offs. We try to convey some of that vigorous debate in this document. They found that each of the options has specific, and quite different, strengths and limitations. No single management method perfectly addresses all the values and objectives important to Canadians.

What is most important about their work is the elaboration of an assessment framework and their deliberate way of thinking about all of the influences that need to be considered in any decision. Their comparative review of the options tested the methodology and their findings will provide considerable material for public discussion. There is much work yet to be done before we can recommend a preferred approach and comprehensive strategy.

Although ours is still a work in progress our investment in these two very different streams of activity has demonstrated convergence of opinion on several fronts. The voices of the public and the analysis of experts have each found that there is no one right answer. Each expressed strong support for taking a decision now that will result in initial concrete steps being taken, but argued persuasively that any approach should be adaptive, remaining open to new learning and technology.

Consistently we heard that the process by which a method is implemented will be as important as the choice of method itself. Very much a sign of the times, there were calls for strong governance, extensive oversight and clear accountability, along with greater and continued opportunity for citizen engagement. Notably, Canadians reveal an immense respect for technological progress to date, coupled with a sense of optimism for what the future holds. They want to proceed in a way that will allow us to continue to benefit from evolving technical advances and shifting societal expectations over time.

There are moments when this seemingly intractable issue threatens to paralyze us, but they are fleeting moments. We believe that a fair and responsible approach to managing used nuclear fuel can be determined. We are inspired by the wealth of Canadian scientific and technical expertise and a public prepared to share their perspectives and priorities. We invite all interested Canadians to continue to contribute comments, to raise issues of concern, and to participate actively and collaboratively in defining a workable strategy. The way ahead will only be blocked by indifference and passivity.

We approach this task with humility in the face of uncertainty and complexity, but also fortified by the inherent wisdom of citizens.

Elizabeth Dowdeswell, President
August 2004

Executive Summary

Understanding the Choices is the NWMO's second discussion document, an important milestone in a three-year study (2002-2005) designed to recommend to the Government of Canada an approach to managing Canada's used nuclear fuel for the long term.

The report begins with an examination of the values and priorities of Canadians, and how the NWMO has used this understanding to build a framework to assess and compare management approaches.

Used nuclear fuel is primarily a by-product of nuclear electricity production. Small amounts also result from research and the production of medical isotopes. Ontario, which has 20 nuclear reactors at three generating stations, is the largest producer of nuclear electricity in Canada. New Brunswick and Quebec each have one nuclear reactor for electricity generation. The Canadian Nuclear Safety Commission (CNSC) ensures that all of Canada's used nuclear fuel is fully accounted for and safe in interim storage facilities at the reactor sites where it is produced. However, this was always intended to be a temporary measure.

For decades, Canadians have benefited from nuclear power. Responsible stewardship requires that we look beyond today in managing the waste that has been produced. Like many countries, Canada is now carefully considering the appropriate approach for managing used nuclear fuel over the long term.

The Government of Canada passed legislation in 2002 that set a decision-making framework. Under the *Nuclear Fuel Waste Act*, the Government requires the owners of this waste to create an organization that will study the options and recommend a long-term management approach. The Nuclear Waste Management Organization (NWMO), the organization created in response to the *Act*, is required to study approaches based on three methods: deep geological disposal in the Canadian Shield; centralized storage, above or below ground; and storage at nuclear reactor sites. We may also study other methods. We must submit our study to the Minister of Natural Resources Canada by November 15, 2005.

The NWMO has committed to the collaborative development of a preferred management approach. As such, our study seeks the input and advice of the public and experts throughout the process. With each of our milestone study documents, the NWMO describes what it has heard from the public and experts, articulates its thinking to date, and invites comment and further direction from Canadians.

Understanding the Choices continues the dialogue begun with our "conversations with Canadians" and the launch of our first discussion document released in November 2003, *Asking the Right Questions?* In our first discussion document, we asked Canadians if we were capturing the key questions which should be asked and answered in the analysis and study of potential methods for the long-term management of used nuclear fuel.

Over the past year, we have laid the foundation to consider the relative strengths and limitations of alternative management approaches. We have done this through our ongoing dialogue with both experts and the public, and through our continuing efforts to identify and use the scientific and technical expertise available in Canada and abroad.

In Part 1 of *Understanding the Choices*, we report back on the direction we have received from our engagement and research activities to date.

Understanding Canadian Values. From the outset, we recognized the need for the NWMO study to be driven by the values of Canadians. In our first discussion document, we introduced ten key questions that reflected the concerns, priorities, and implicitly the values of Canadians as expressed to us in our early conversations with them. To gain a more in-depth understanding of citizens' values, and to identify these values explicitly, the NWMO initiated three core and parallel activities:

- We launched a National Citizens' Dialogue to better understand citizen values, through a collaborative research project with the Canadian Policy Research Networks (CPRN). This Dialogue brought together 462 unaffiliated Canadians from all walks of life representative of the public at large. Over the course of the day-long sessions, participants articulated six core values which should direct the long-term management of used nuclear fuel.

- Our initial dialogue with aboriginal peoples has identified the principles inherent in Aboriginal Traditional Knowledge. We need to be responsive to their emphasis on planning within very long time horizons.

- Our NWMO Roundtable on Ethics has created an "Ethical and Social Framework" to help direct our activities as well as the assessment of management approaches. The Roundtable provides a constant reminder of the ethical imperative.

Reflecting on the comments of Canadians, it is apparent that although we share certain values and objectives which should inform the NWMO's study, there are also tensions. Throughout the dialogue we have heard an emerging sense that the assessment of management approaches will necessarily involve difficult decisions about priorities, and the conditions under which trade-offs among objectives would be appropriate.

This cumulative insight from Canadians on their values and ethical considerations provides a cornerstone for the study as we proceed with the assessment of management approaches.

Reporting Back on the Initial Framework. In response to *Asking the Right Questions?* we have received important comment and advice. These have come from web-based submissions, public opinion research and face-to-face dialogues and workshops. Overall, people told us that the ten key questions proposed in our first discussion document capture the key issues and considerations that should be addressed in our study.

At the same time, people told us that more study is needed before completing any assessment of management approaches. In particular, they asked us to consider the following issues further:

- A more precise description of the nature of the hazard posed by used nuclear fuel to human health and the environment;

- A more precise account of the nature of the risk posed by transportation of used nuclear fuel;

- Clarification on what "social acceptability" or "public confidence" will entail;

- How the assessment is affected by the volume of used nuclear fuel which ultimately needs to be managed;

- Opportunities to reuse or recycle used nuclear fuel; and

- Opportunities to site a deep disposal repository in geologic media other than that noted in the *Nuclear Fuel Waste Act*.

Reporting Back on the Technical Methods. In *Asking the Right Questions?*, we identified 14 potential methods for managing used nuclear fuel. For the most part, Canadians agreed that our focus should be on the three methods requiring study under the *Nuclear Fuel Waste Act*. That said, several methods were flagged as appropriate for further study or maintaining a "watching brief". In this regard, partitioning and transmutation is of particular interest to Canadians, to explore the possibility of reusing the used nuclear fuel or reducing the hazard it presents.

In Part 2 of *Understanding the Choices* we provide fuller descriptions of the approaches on which we will now focus our study. To further our dialogue with Canadians, we report on how the framework to assess the approaches has evolved since our first discussion document. Finally, we present a practical demonstration of this framework through a preliminary assessment of the management approaches.

Early in 2004, the NWMO assembled a multi-disciplinary group of individuals as an Assessment Team to: 1) translate the ten questions presented in the first discussion document into an assessment framework, taking into account the public and expert comment on those questions; and 2) conduct a preliminary assessment of alternative approaches.

We asked the Team to use a methodology that would allow for a holistic assessment – one that would systematically integrate social and ethical dimensions with technical, economic, financial and environmental considerations. Finally, we requested that the Team produce a report that would set out its thinking clearly as they discussed and debated the options. In so doing, they could share transparently with Canadians the range of considerations – including the challenges - encountered in undertaking the assessment.

The work of the Assessment Team has contributed two very important elements to the study.

First, it has created a preliminary description of the strengths and limitations of the management approaches, for consideration and dialogue among Canadians. In advancing our understanding of some of the distinguishing features of the options, it provides the context for a substantive discussion with Canadians on how to consider the relative risks, costs and benefits of the alternative management approaches.

Secondly, through the broad and integrative approach taken, the work has brought into focus some of the difficult choices and trade-offs which will need to be addressed as part of the assessment of the approaches.

Highlights from the Assessment Team's work are presented in Figure E-1 on the following page:

Figure E-1
Preliminary Findings of the Assessment Team

Strengths and Limitations of Alternative Methods

In summary, the Assessment Team found that each of the options specified in the *Nuclear Fuel Waste Act* has specific, and quite different, strengths and limitations. No method perfectly addresses all of the values and objectives important to Canadians.

In the words of the Assessment Team, we present the strengths and limitations identified through the Team's assessment:

At-Reactor Storage

Advantages: No transportation of used nuclear fuel would be required as the used fuel would remain next to where it is generated. Each of these sites already houses nuclear installations, so there is nuclear expertise on site and in the existing communities. These communities are familiar with the presence of nuclear facilities, including storage of used nuclear fuel. Further, the ability to monitor the performance and the flexibility to adapt to changing conditions should be facilitated. The science and technology required are well in hand.

Limitations: The key disadvantage, shared with centralized storage, is the need for continuing administrative controls and operations, including the necessary funding, for the thousands of years the used nuclear fuel remains hazardous. Unlike centralized storage, at-reactor storage means continued management at a number of sites, each of which has, as its primary focus, the production of power, not the long-term management of used nuclear fuel. These reactor sites were selected for their suitability for reactor operation, not for very long-term storage of used nuclear fuel. The used nuclear fuel will remain hazardous well beyond the almost certain shutdown and ultimate abandonment of the nuclear reactor sites. At-reactor storage would result in very long-term used nuclear fuel management at a number of sites located next to important bodies of water. This raises security, environmental and safety issues and adds significant uncertainty given the potential for changes in institutions and governance and the likelihood of extreme natural and human induced events over such an extended time.

Centralized Storage

Advantages: Centralized storage, either above-ground or shallow below-ground, would allow for the site selection solely on the basis of used nuclear fuel management. If done well, siting can be achieved with community participation. These are both key potential advantages compared to at-reactor storage and apply to the siting of a deep-geological repository as well. Such a site could be either at an already existing nuclear site, if suitable, or at a different site should that prove more advantageous. With the option of shallow below-ground storage, some of the security concerns can likely be abated. As with at-reactor storage, the required science and technology are well in hand.

Limitations: 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. It also would require the identification and development of a site with potentially contentious community involvement. Transportation of the used nuclear fuel to the site would be required with its attendant risks and costs.

Deep Geological Repository

Advantages: The deep geological repository option results in the eventual permanent emplacement 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 emplacement and closure, provision of long-term resources and funding are not required, although further actions are not precluded. The site is chosen with specific features as a requisite and, if done well, can be achieved with community participation. The intrinsic geologic, hydrologic and other features of the site, in combination with engineered features such as long-lived waste packages and material buffers, isolate the used nuclear fuel from the accessible environment for the very long time periods that they remain hazardous. Deep emplacement reduces security concerns, both before and after closure.

Limitations: 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 form the foundation of the assurances of performance provided to regulatory authorities and interested organizations and individuals. Monitoring becomes more difficult as the used nuclear fuel is emplaced deep underground and as the site is backfilled and closed. At this stage adaptability and flexibility are also reduced as retrieval of the used fuel, for example, becomes much more difficult, costly, and hazardous. Siting must pay particular attention to intrinsic geologic features, perhaps limiting options more than for storage alternatives. As with centralized storage, community participation in regard to siting could be contentious and transportation of the used nuclear fuel will be required.

In Part 3 of *Understanding the Choices* we take stock of what we have learned to date and identify a path forward for the next phase of our study.

A Responsive Framework. Acknowledging the advice of the public and experts, and the work of the Assessment Team, we have developed an assessment framework to guide the next phase of the NWMO's work. This framework will be the foundation of the assessment of the approaches and the launching point for the exploration and design of implementation plans. *The framework is summarized in Table E-2.*

The dimensions of a preferred management approach are beginning to emerge through our dialogue with Canadians. Canadians want to see the development of a long-term strategy or plan. But they also want action to be taken now on the first steps of that plan. This will be done in a way that ensures that future generations will be able to make decisions that reflect their own values and priorities. The preferred approach must be adaptable, able to incorporate new knowledge as it becomes available. This might best be accomplished by a phased approach that provides for decisions to be taken in steps over time. Finally, the preferred approach will necessarily entail a robust system of governance and measures to ensure that citizens understand the issues, remain informed and have a voice in decision-making.

Preliminary Requirements of a Preferred Management Approach

- Adaptability
- Phased decision-making
- Robust system of governance
- Opportunities for citizen engagement

NWMO's Work Continues. In the coming months, the NWMO's work will focus on several matters. First, we will continue to elaborate the specific characteristics of each management approach under study. This will include further work on the economic and financial considerations for each approach, and on potential economic regions for implementation of the different approaches. We will consider the questions of types and volumes of waste to be managed and opportunities for recycling. We will be examining in more depth issues related to the hazard associated with used nuclear fuel, transportation implications of the options, and obligations associated with an international nuclear weapons non-proliferation regime.

We will also be examining the different types of geologic media that might provide feasible options for safely and securely hosting a repository or centralized storage option. While we must study the option of deep geological disposal in the Canadian Shield, we recognize that in recent years different types of geologic media have been studied and are under consideration in other countries.

Secondly, we will begin work to develop possible implementation plans for the management approaches. Implementation plans will address, at a minimum, mechanisms for ongoing societal involvement, oversight and monitoring systems, institutional design including human resource capacity, and principles to guide site selection.

Once we have completed this work, and have consulted and received comments regarding *Understanding the Choices*, we will begin to develop our draft recommendations. We plan to share our draft recommendations in early 2005 in a draft study report, after which we will seek further comment and direction from Canadians before we formulate our final recommendations.

Table E-2 What Needs To Be Considered? The Assessment Framework

Value and ethical considerations are by design embedded in the eight objectives which comprise the assessment framework.
The original Ten Questions have been converted into eight objectives and associated guiding principles and influences.
The influences are described in Part 2 of this document.

	A Foundation of Values and Ethics (*)
Citizen Values	**Safety From Harm** An overarching requirement. First and foremost, human health and the environment must be safe as possible from harm, now and for the future. **Responsibility** We need to live up to our responsibilities to ourselves and to future generations, and deal with the problems we create. **Adaptability** We need to build in capacity to respond to new knowledge. **Stewardship** We have a duty to use all resources with care and to conserve, leaving a sound legacy for future generations. **Accountability and Transparency** To rebuild trust. 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 to all. **Knowledge** We need to continue to invest in informing citizens, and in increasing knowledge, to support decision-making now and in the future. **Inclusion** The best decisions reflect broad engagement and many perspectives; we all have a role to play.
Ethical Principles	**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 people and cultures** **Justice** across groups, regions, and generations **Fairness** to everyone affected and particularly to minorities and marginalized groups **Sensitivity** to the differences of values and interpretation that different individuals and groups bring to the dialogue
	(*) Drawn from National Citizens' Dialogue, Roundtable on Ethics and Aboriginal Traditional Knowledge.

	Specific Objectives
	From the ten questions posed by Canadians, and the foundation of values and ethical principles expressed by citizens, eight specific objectives have been developed which will guide our work.
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 through different phases of decision-making and implementation.
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 approach.
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.
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.

	Specific Objectives (continued)
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 timeframe, the hazardous materials involved ought to be secure from the threat of theft despite possibilities of terrorism or war.
Environmental Integrity	**To ensure environmental integrity.** The selected management approach needs to ensure that environmental integrity over the long term is maintained. Concerns include the possibility of localized or widespread damage to the ecosystem 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).
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 will not occur that would threaten the assured continuity of necessary operations.
Adaptability	**To ensure a capacity to adapt to changing knowledge and conditions over time.** The selected management approach should be able to be modified to fit new or unforeseen circumstances. The approach should provide flexibility to future generations to change decisions, and not place burdens or obligations on future generations that will constrain them. The approach should be able to function satisfactorily in the event of unforeseen "surprises".
	A more elaborated discussion of the many influences with an impact on each of the objectives is presented in Part 2 of *Understanding the Choices.*

We invite all interested Canadians to participate in shaping our study and our recommendations.

Engaging Canadians. With this discussion document, we now focus our discussion with Canadians on the many elements of the assessment of management options, as we seek to fully understand the choices.

We continue to seek advice from the public and experts. We will be undertaking activities to directly engage the public, residents of nuclear site communities, aboriginal peoples, and interested organizations and individuals in many regions across Canada. There are many topics we would like to discuss.

Is the assessment framework comprehensive and balanced? Are there gaps, and if so, what do we need to add?

- We want to know if the assessment framework drawn from the original ten questions and the dialogue which followed fully captures the key priorities and perspectives of Canadians.

What are your thoughts on the strengths and weaknesses of each management approach: deep geological disposal; centralized storage; and reactor site storage?

- We would like to discuss the relative strengths and limitations of each of the approaches which are the focus for the study. Does the preliminary assessment accurately describe all of the considerations?

Are there specific elements that you feel must be built into an implementation plan? What are your thoughts on what a phased approach must include?

- Beyond the relative strengths and limitations of the approaches, we welcome input on the elements of an implementation plan for any preferred approach. To date we have heard that irrespective of the management approach which is ultimately selected, it will need to be adaptable and will need to be implemented in a phased manner.

NWMO invites all interested individuals and organizations to get involved.

Make a submission, share your comments with other interested Canadians and make your voice heard at our website, **www.nwmo.ca.**

You can review our public engagement plans, discussion documents, reports and research which are available on our website at **www.nwmo.ca.**

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Part 1 / Foundations of the Assessment

CHAPTER 1 / INTRODUCTION

PURPOSE OF THIS DISCUSSION DOCUMENT

The Nuclear Waste Management Organization (NWMO) presents this second discussion document, *Understanding the Choices*, in order to share with Canadians our recent work and thinking about the long-term management of used nuclear fuel. This discussion document provides information important for a public dialogue about the relative merits of the different waste management approaches.

The NWMO was established to conduct a comprehensive study of approaches for the long-term management of used nuclear fuel. In our first discussion document, *Asking the Right Questions?*, (www.nwmo.ca/askingtherightquestions) released in November of 2003, we:

- Described our legislative mandate, and how we proposed to undertake this study;
- Provided information on alternative methods for managing used nuclear fuel;
- Described some of the issues and concerns that Canadians had raised in our first year of conversations; and
- Outlined a preliminary analytical framework for assessing the different approaches for the long-term management of used nuclear fuel.

We identified ten questions in that document "to be asked and answered in the study", for further consideration and discussion among Canadians. These questions were developed to reflect what Canadians said was important during the early months of the study.

In this, our second discussion document, we move forward to a more considered discussion of the management approaches and their evaluation. We:

- Report on our further exploration of the values and priorities of Canadians concerning the long-term management of used nuclear fuel, and insights from our dialogues convened on our first discussion document, including suggestions we have received to strengthen our work. (Part 1)
- Provide fuller descriptions of the approaches we are required by legislation to study, and our reasons for limiting our focus to these methods. (Part 2)
- Present an assessment framework that builds on the work begun in our first discussion document (the ten questions) for further consideration and discussion among Canadians. This framework also builds upon the advice and comment of a broad spectrum of interested Canadians who sent the NWMO submissions, or who participated in a dialogue on the first discussion document. (Part 2)

The preliminary assessment summarized in Part 2 is a practical demonstration of the framework as it has been developed to this point in the study. The preliminary assessment is designed to highlight the range of issues that must be considered in identifying the strengths and limitations of alternative management approaches and to suggest how these issues might be considered in a holistic and integrated way.

In Part 3, we take stock of lessons learned to date and identify a path forward for the next phase of the study. In so doing, we outline some of the issues that we would like to discuss and think through with Canadians.

THE NWMO STUDY: CONTEXT AND CONCEPT

Used nuclear fuel is a by-product of nuclear electricity production. Small amounts also result from research and the production of medical isotopes. Ontario, which has 20 nuclear reactors at three generating stations, is the largest producer of nuclear electricity in Canada. New Brunswick and Quebec each have one nuclear reactor for electricity generation.

Nuclear fuel that has been used to generate electricity remains highly radioactive. Unless it is properly handled, it can be dangerous to people and the environment for a very long time. Current storage practices for used fuel are described in the NWMO Fact Sheet "How Nuclear Fuel Waste is Managed in Canada." (www.nwmo.ca/nuclearfuelwaste)

Since the beginning of its nuclear program, Canada has produced about 1.8 million used nuclear fuel bundles. The Canadian Nuclear Safety Commission (CNSC) ensures that all of this used fuel is fully accounted for and safe in interim storage facilities at the reactor sites where it is produced. However, this form of storage was never intended to last more than 50 to 100 years. Like many countries, Canada is now carefully considering the best approach for managing used nuclear fuel over the long term – for many thousands of years.

The NWMO was established by Canada's nuclear electricity generators following passage of the *Nuclear Fuel Waste Act* in 2002. 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 develop and recommend an approach to the government by November 15, 2005.

At a minimum, the NWMO must study approaches based on three technical methods: deep geological disposal, centralized storage – above or below ground, and reactor-site storage. In conducting our study we must consult the general public and, in particular, aboriginal peoples.

Consistent with the *Act* the NWMO has the benefit of a broadly-based Advisory Council, which will provide independent comment on the NWMO's study and the management options.

In keeping with the legislation, Canada's owners of nuclear fuel waste – Ontario Power Generation Inc., Hydro-Québec, New Brunswick Power and Atomic Energy of Canada Limited – set up individual trust funds which will be used to finance the long-term management approach that is selected by the government.

Additional information on the NWMO is provided in Appendix 1 and on our website, www.nwmo.ca. A link to the *Nuclear Fuel Waste Act* is also found on our website at www.nwmo.ca/mandate.

We have chosen to base our interpretation of the NWMO's mission on the concept of sustainable development. Our mission is: "to develop collaboratively with Canadians a management approach for the long-term care of used nuclear fuel that is socially acceptable, technically sound, environmentally responsible and economically feasible." (www.nwmo.ca/missionstatement)

The NWMO understands that in order for Canadians to have confidence in any approach for the long-term management of used nuclear fuel, the study must fundamentally reflect and respond to their values. Both the objectives we set for the management options, and the values we weigh in making a decision need to be consistent with our collective sense of how we want to live. The challenge in this study, therefore, is to develop and apply, as much as possible, a societally-directed framework to guide both the development and also the assessment of the management options. Without this, it will be extremely difficult to implement successfully any management option.

Used nuclear fuel management must be founded on robust science and engineering. Equally, it must be responsive to ethical, social, cultural, environmental and economic considerations, as expressed and experienced by Canadians.

To ensure that we understand society's perspectives on these issues, we have initiated dialogues to solicit and bring the insights of a broad range of citizens and interested groups to our study. To ensure that we have taken advantage of the best scientific and technical knowledge and expertise available in Canada and abroad, we have commissioned and received reports from, and conducted workshops with, a wide range of experts describing the state of knowledge which can be brought to bear on the study.

As we have engaged citizens, interested groups and experts through the early stages of our process, we have used their insights and perspectives to shape the study at a fundamental level. Through our discussion documents, we share our work and our thinking to date for review and comment by all interested Canadians.

In Chapter 2, we describe some of the initiatives that the NWMO has undertaken to develop a good understanding of the values held by Canadian society concerning this issue, the feedback we have received to date, and our ongoing work to identify and understand the best scientific and technical knowledge available. We also explain how we are incorporating this advice.

CHAPTER 2 / UNDERSTANDING CANADIAN VALUES

From the outset, we recognized the need for the NWMO study to be driven by the values of Canadians.

In our first discussion document we introduced ten key questions, based on our early conversations, that reflected the concerns, priorities, and implicitly the values of Canadians. To gain a more in-depth understanding of citizens' values, and to identify these values explicitly, the NWMO initiated a number of activities. In this chapter, we highlight some of the findings from these areas of work.

We initiated three core and parallel activities: (1) a national dialogue to elicit citizen values; (2) collaborative work with aboriginal peoples to understand their views, perspectives and insights; and (3) a Roundtable on Ethics, to help articulate the fundamental ethical issues that must be considered in the long-term management of used nuclear fuel.

These activities have deepened our understanding of Canadians' expectations of a management approach which would earn their confidence.

NATIONAL CITIZENS' DIALOGUE

To explore the values which citizens bring to bear in thinking about the long-term management of used nuclear fuel, the NWMO launched a collaborative research project with the Canadian Policy Research Networks (CPRN). A cross-section of citizens from coast to coast participated in the National Citizens' Dialogue on the Long-Term Management of Used Nuclear Fuel.

CPRN is a not-for-profit policy think-tank based in Ottawa. It has been using public dialogue since 1995 as a means to involve citizens more directly in research and public policy discussions on issues such as health care, quality-of-life indicators, Canada's children, aging and the society to which we collectively aspire.

CPRN uses deliberative dialogue which brings together people from all walks of life and encourages them to work through tough issues. As they listen and learn from one another, they come to understand perspectives which are different from their own. Deliberative dialogue can offer profound insight into how people really feel, and what matters most to them. The choices people make arise out of what they hold most dear in their individual and community lives. Deliberative dialogue promotes finding common ground rather than accentuating differences.

In the Citizens' Dialogue on the Long-Term Management of Used Nuclear Fuel, 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.

These groups of approximately 40 people each were randomly selected to be representative of the Canadian population. Canadians came to these dialogue sessions as unaffiliated individuals, not as representatives of stakeholder or special-interest groups. Before arriving, they received background information explaining the dialogue process. On arrival they were given a specially-prepared workbook providing key factual information and different perspectives on scenarios. At each session, two professional facilitators reviewed the factual information with the participants. The participants then worked in smaller, self-managed groups to answer some key questions. When they reconvened in the large group, each smaller group reported on the results of their discussions. As they reported, the similarities and differences of all of the groups were noted. The similarities were tested by the facilitators to ensure that they represented areas of common agreement across a broad majority of the group.

The complete report can be found at www.nwmo.ca/canadianvalues, but here is a summary of its key findings:

"We recognized that a decision had to be taken now, a plan of action put into place…so we wanted to take responsibility, we wanted to say let's get at this now, let's get something started now, but at the same time, we said… it has to be done in such a way that we have options over the next 20 or 30 years to change or divert our plan a little bit, should that become a lot more feasible." **Ottawa**

"…we felt that what we really needed was a flexible plan, a plan that did not make all the decisions for today, but made decisions to work towards what we know today, leaving enough flexibility in it that as time goes on, future generations with their new knowledge can insert into the plan and change it as required. Again, 30 years from now is different than today…So it can't just be something that we make up today and it's going to last forever." **Thunder Bay**

SAFETY FROM HARM - AN OVERARCHING REQUIREMENT

One overriding need underpins the values framework that emerged from the 12 dialogue sessions – that is, the basic human need to feel safe from harm. This need did not arise from a sense of fear, nor from an expectation of a risk-free world, but rather from a sense of responsibility to this generation and future generations to take the necessary precautions.

They talked about safety and security in the context of recent events that posed risks to public health and the environment, and expressed concerns about possible acts of terrorism, both now and in the future.

To manage these risks, they looked to governments to fulfill their responsibilities as regulators and standard setters. And they called for better information, greater transparency and inclusiveness in decision-making to build public confidence about their overall safety.

The values summarized below reflect the choices they made, the conditions they imposed and the reasons they gave for choosing one outcome over another.

Responsibility – we need to live up to our responsibilities and deal with the problems we create

Citizens want to leave a legacy for their children and grandchildren that they can be proud of. They want to take concrete steps to deal with problems. Dialogue participants were surprised and upset that the decision to use nuclear fuel was made 30 or more years ago without a plan in place to manage the used fuel for the long term. As the generation that has consumed the energy and created the used fuel, they felt a sense of responsibility to the extent possible to act now and to pay now.

Adaptability – continuous improvement based on new knowledge

Citizens do not presume that we have the best answers today. They look back over the last century and see how dramatically technology has changed their lives, and they expect this advancement to continue. They wanted to make deliberate investments in research so that future generations will have safer, more efficient ways to deal with the used fuel. They also wanted to invest in measures to ensure that future generations will have the knowledge and capacity to fulfill their own responsibilities with respect to the used fuel.

They therefore wanted to ensure that future generations will have access to the fuel so they can apply new knowledge. And they wanted a flexible, step-by-step management approach that would regularly take stock of new knowledge and adapt accordingly.

Stewardship – we have a duty to use all resources with care, leaving a sound legacy for future generations

The concepts of reduce, reuse and recycle have become deeply embedded principles, and citizens want to use all resources wisely. They want to address issues in an integrated, holistic way, looking at all possible costs and benefits of decisions on used fuel and on broad energy policy.

Dialogue participants saw reducing the volume of waste as a necessary part of the management approach. They acknowledged their own responsibility to reduce the amount of electricity they use, and recognized the challenge in changing behaviour. They called on governments to provide leadership to individuals and industry to reduce consumption by offering incentives and providing more information on the real costs of energy and

"…we're only guests on this planet, and like any good guests, don't leave a mess." **Vancouver**

"Just because it's waste right now... doesn't mean it can't be something else. It's waste right now because we don't have technology. We don't know what to do with it right now so we're just throwing it away. We can probably use it for something else." **London**

"…government must continue to enforce safety regulations, oversee industry standards and site management. It goes without saying, that's what they're there for - to look after us, and they simply must continue to do that." **Calgary**

"I believe we have to trust in government to finally make the decision. That's where the buck stops. But what's impressed me today is that all of us have a responsibility to speak up in one way or another to try and make those decisions the best decisions possible." **Halifax**

the environmental and health impacts. They sought greater use of alternative energy sources like wind and solar. And they wanted more research into how to safely extract more energy from the uranium, as well as to try and reduce the toxicity of the waste.

Accountability and Transparency - to rebuild trust

Citizens hold governments, especially the federal government, as ultimately accountable for the public good, but their level of trust in government and industry is low. Dialogue participants imposed the following conditions on governments:

- There must be real engagement of experts, citizens, communities and other stakeholders before any decision is made;
- People must be told the truth. There must be greater transparency in decision-making and monitoring by both government and industry. They want to know why decisions are made and how they are being implemented. They want to know if standards are being met or not. They want full disclosure of financial and management information;
- They are seeking assurance that decisions will not be made for political expediency or profit; and,
- They hold governments responsible for ensuring safety and security, including enforcing strong regulations and standards.

Participants felt that in order to have trust, they needed an independent, non-partisan oversight body to monitor government and industry, and to provide reliable information to citizens. They wanted this body to be composed of experts from many fields, as well as citizen representatives.

Knowledge – a public good for better decisions now and in the future

Citizens are embracing the idea of knowledge as a public good to help make better choices, both now and in the future.

Their surprise at their own lack of awareness about the used nuclear fuel led to an urgent call for a) better efforts to ensure people are informed so they can engage in an informed way to support better decisions and b) investment in the education of young people to ensure that future generations have technical expertise and social institutions necessary to manage the used fuel.

Participants wanted investments to be made to create new technical knowledge and increased cooperation on research with other countries so that everyone could benefit from the best knowledge available.

Inclusion – the best decisions reflect broad engagement and many perspectives; we all have a role to play

Inclusion is about having a voice that is heard. Dialogue participants believed that better decisions would be made by involving as many perspectives as possible. Consumers, energy producers and related industries, scientists and other experts, affected communities, governments and citizens have a role in making decisions and for contributing in an ongoing way to the management of used fuel over the long term.

"...inform the young people..., think long term... in 20, 25 years, if we have no experts, if we don't have anyone, if we don't have the institutions needed for training the workforce that can handle these problems, we need to think about informing and training the young people. Therefore, education is important."
Quebec City

The National Citizens' Dialogue illustrates that there is much common ground in the values which we as Canadians apply to the long-term management of used nuclear fuel. This common ground provides a solid foundation for the assessment of management approaches.

Although there is much common ground, the dialogue revealed there are aspects of this issue concerning which citizens may well hold a diversity of perspectives. For example, citizens expressed differing views on whether used fuel should be moved to a centralized facility or left at existing locations which may be near population centres; or, whether in transporting used nuclear fuel it is more important to be transparent and fully disclose shipping information or more important to ensure security even if this means concealing information from the public.

As we carry forward this understanding of the values that we as Canadians hold in common, we will also need to be respectful of and responsive to the diversity of our views as we assess the management approaches and develop implementation plans.

ABORIGINAL VIEWS AND PERSPECTIVES

The views and perspectives of aboriginal people are important to our study.

The *Nuclear Fuel Waste Act* requires the NWMO to consult with aboriginal peoples on each of the management approaches, and to report on those consultations. The NWMO is sensitive to the concerns expressed by aboriginal people about their role and participation in planning and decision-making processes around long-term management of used nuclear fuel. In this study, we have adopted the recommendation that participation processes should, to the extent possible, be designed and implemented by aboriginal people so that the processes are appropriate to the value systems and decision-making processes of aboriginal people.

Beyond our desire to meet the requirement of the *Act*, the NWMO believes there is much to learn from the holistic and broadly integrative approach inherent in Traditional Aboriginal Knowledge. This will both broaden and strengthen the assessment of the management approaches, and assist in the development of implementation plans. We continue to seek to learn from aboriginal people how best to bring this knowledge and insight to the study.

In our early dialogue, aboriginal people have told us that it is essential that they be involved in the study of long-term management approaches for a number of reasons, including: as stewards of the land, they feel a strong sense of responsibility to ensure that we provide well for future generations; lands that may host waste management facilities are occupied or used by aboriginal people; and Traditional Ecological Knowledge should be integrated into the development and assessment of management proposals.

One of the issues raised consistently is the need to be aware of Aboriginal treaty and non-treaty rights when considering the long-term management of used nuclear fuel.

Aboriginal people have emphasized the need for our consultations to be designed and conducted in a manner that is culturally appropriate and sensitive to their traditional methods of discussion. The NWMO has entered into collaborative arrangements regarding dialogue on the long-term management of used nuclear fuel and participation in the study with organizations representing the three aboriginal peoples of Canada (Inuit, First Nations and Métis people). In these collaborations, the dialogues are designed and executed by aboriginal people on behalf of their organizations and the NWMO. The status reports and results of the aboriginal dialogues are posted on the NWMO website as they are received. (www.nwmo.ca/aboriginaldialogues)

In addition to entering into these collaborative dialogues with aboriginal organizations, NWMO has also undertaken to solicit aboriginal insight and perspectives in each aspect of our work, and to factor this insight in as much as possible. Aboriginal peoples have contributed their insight to many of the NWMO activities undertaken to date, including: the Scenarios Workshop; the Reactor Site Community Dialogue; the CPRN National Citizens' Dialogue; and the National Stakeholders and Regional Dialogue Sessions.

An early NWMO workshop on the subject of Aboriginal Traditional Knowledge has provided some preliminary insight into the principles inherent in this approach or philosophy, as it has developed through centuries of observation, wisdom and experience. To the extent that the NWMO is able, these principles will be carried forward as part of the values foundation on which the study will proceed:

Honour: the wisdom that can be garnered from speaking to elders in both the aboriginal and non-aboriginal communities;

Respect: the opinions and suggestions of all who take the time to provide insight into this process;

Conservation: particularly as it applies to the consumption of electricity, must be a major part of the solution, not just a footnote in the NWMO process;

Transparency: is essential to the process when NWMO (the producer of the problem) has to suggest the solution;

Accountability: must be part of the fabric of any solution so that those responsible (whether for the concept or the delivery) are held to high account by the public for their actions, given the nature of the problem.

The seven generation teachings, and its inherent consideration of impacts many generations out, has greatly influenced the NWMO study process.

ETHICAL CONSIDERATIONS

The Roundtable on Ethics was established early in the NWMO's mandate to deliberate on the range of ethical considerations which should be factored into the study. It is composed of six individuals experienced in the field of ethics in a variety of disciplines. Biographies of Roundtable members, and meeting notes from their deliberations, are posted on the NWMO website. (www.nwmo.ca/ethicsroundtable)

Our first discussion document highlighted some of the Roundtable's early thinking. Among the advice we received was that rather than treating ethics as a separate and distinct assessment area, it would be preferable to embed ethical and value considerations in all aspects of the NWMO study. With this in mind, ethical considerations were considered as one of the "overarching aspects" in the ten-question framework. Since the release of the first NWMO discussion document, the Roundtable has developed an "Ethical and Social Framework". This framework is composed of a list of principles and questions to help guide the NWMO's activities throughout the study, and is posted on our website. The six principles which form the core of the framework are:

- 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.

The Roundtable has suggested that given the large stockpile of used nuclear fuel that already exists in Canada, some solution to managing these wastes as safely and effectively as possible must be found. The Roundtable noted that a question which needs to be addressed is whether the NWMO is dealing simply with existing wastes and those that will be created in the lifespan of the existing reactors or also with substantial additional wastes. The ethical standard which needs to be met, the Roundtable suggests, is different for each of these scenarios.

As the NWMO study proceeds we will be guided by these six principles as well as those identified in Aboriginal Traditional Knowledge and the values articulated through the Citizens' Dialogue.

CHAPTER 3 / REPORTING BACK

In this chapter, we report on what we have heard about the research and analysis that we have undertaken. We also reflect upon the responses of Canadians to our thinking as presented in the first discussion document.

INSIGHTS FROM OUR ENGAGEMENT & DIALOGUE

In the first phase of the NWMO study, we launched a variety of dialogue and engagement activities to identify issues and concerns of Canadians. In our first discussion document, *Asking the Right Questions?*:

- We described the issue of the long-term management of used nuclear fuel, and asked Canadians if we had described the problem correctly.

- We identified a range of methods for the long-term management of used nuclear fuel, and we asked if we had identified the appropriate range of methods.

- We laid out ten key questions that had emerged from these early "conversations with Canadians", and we asked if these were the right questions that needed to be asked and answered in our study of management approaches.

The range of engagement activities included:

Web-based Activities

To reach a significant portion of the general public the NWMO has created an interactive website. (www.nwmo.ca)

It is key to informing the public through the posting of all NWMO research and documentation. We have commissioned more than 50 papers from individuals expert in a wide variety of knowledge areas, and posted them for review by interested Canadians. (www.nwmo.ca/backgroundpapers) The website features a video overview of the issues, newsletters, the NWMO speeches and more. Since its launch in February 2003, the NWMO's website has received more than 70,000 individual visits from interested Canadians, as well as from international users.

Our website invites comment from Canadians on their own terms through electronic submissions. (www.nwmo.ca/submissions) The website has received more than 60 submissions from individuals, either in response to the discussion document, or in response to one of our commissioned papers. These are posted on our website. In addition, the NWMO has received more than 100 enquiries and requests for information through the website.

Our website also provides opportunities for interested Canadians to participate in our work through deliberative surveys. These surveys are designed to invite input on the same range of issues being explored in the face-to-face dialogue sessions conducted in the various centres across Canada. (www.nwmo.ca/surveys) Just under 200 individuals in all have completed a deliberative survey on the website, although substantially more have completed one of our "poll questions". We encourage more Canadians to complete one or more of these surveys in the weeks and months to come.

Public Opinion Research

Our public opinion research has sought input to the study from a representative sample of Canadians across the country.

In December 2003, an independent research company met with Canadians in six discussion sessions to learn their early reaction to, and comments about, our first discussion document.

In June 2004, we commissioned quantitative research in which we surveyed 1,900 Canadians across the country, and another 700 from nuclear site communities, to understand their views and opinions. This research was designed to examine the elements of the ten key questions presented in our first discussion document.

We invite you to read what Canadians said in this research. (www.nwmo.ca/research)

Dialogues

Since the release of our first discussion document, we have convened a number of structured facilitated dialogues in order to pursue discussions in smaller group settings, and to allow for in-depth exploration of key issues.

We worked with independent consultants to develop and facilitate a series of dialogues that would ensure that many facets of Canadian society were engaged.

Specific dialogues included:

- Residents and representatives of Reactor Site Communities;
- Youth, particularly those engaged in the nuclear industry; (www.nwmo.ca/youth)
- Senior practitioners in sustainable development and environment; (www.nwmo.ca/environment)
- Aboriginal peoples; (www.nwmo.ca/aboriginaldialogues) and
- Stakeholders and those with an interest in public policy at both a national and regional level. (www.nwmo.ca/regionaldialogues)

A more detailed description of the range of engagement and dialogue activities is included in Appendix 2. (www.nwmo.ca/whatcanadiansaresaying)

In the sections that follow, we synthesize what we heard from Canadians over the course of our dialogues, and through public opinion research and website interactions.

For the most part, we heard that the ten key questions presented in our first discussion document do encompass the range of social and ethical considerations that are important to Canadians. At the same time, our dialogues raised additional issues and questions.

Have we described the problem correctly?

The nature of the hazard: Adopt a precautionary approach

Our first discussion document began with a description of the issue, the challenge facing Canada today and the characteristics of Canada's used fuel inventory. Although all agree that radiation from the used fuel can represent a significant hazard or risk to human health and the environment, we heard from the public and interested stakeholders different perspectives on the nature of the hazard or risk, and the time period over which the material is hazardous and needs to be managed.

Several suggested that as time goes by, the nature of the hazard and the associated risks change. Some indicated that the risk from external exposure to radiation is initially great but it is the risk of internal radiation through ingestion that remains a major concern over time. Some suggested that at some point, the hazard and risks will become very low and the requirement for management will diminish. Others remarked that there is no safe level of exposure to radiation, and high management standards will be required until monitoring results clearly indicate otherwise. Some suggested that even low levels of radiation are a concern. Others noted that low levels of radiation might actually have a beneficial effect.

In the face of a diversity of perspective many proposed that the NWMO should therefore be prudent and assume that radiation exposure risk would be significant initially, with no certainty that the risk reduces over time. With this in mind, they suggested that on-going monitoring and oversight of the management approach would be required until there is a clear certainty that the used fuel no longer represents a risk to human health and the natural environment.

Interested Canadians also indicated that radiation exposure needs to be placed in context with other voluntary and involuntary societal risks to inform Canadians as to the true nature of the risk. There would be value in establishing an agreed set of facts on the nature of the hazard, although the process by which we should determine this set of facts was not defined. It may require involvement of a diversity of experts who are trusted by a broad spectrum of stakeholders. Even once there is a consensus on the facts, many recognized that this might not suffice to arrive at a common interpretation of their significance.

With this uncertainty in mind, many believed that a quick and/or final decision on a long-term management approach is not necessary, since there is no immediate danger or risk. Since interim storage at the reactors is both safe and secure, many suggested this provides the NWMO with the time to take a phased or step-wise approach to decision-making, taking advantage of the research studies being undertaken by others and advancements in nuclear waste management technology.

The volume of used nuclear fuel: Consider multiple scenarios

Canadians suggested that the volume of used nuclear fuel is an important element of the nature of the hazard, which needs to be better understood. They suggested that determining the future role of nuclear energy is an important consideration, since the volume of the wastes requiring management may have a direct impact on the selection of the type, cost and requirements of a waste management approach. In the absence of a clear understanding of the future role of nuclear energy, many thought the NWMO should therefore consider the use of different operating scenarios to guide its planning and assessment of management approaches. They suggested three operating scenarios for consideration:

- Phase out/ decrease nuclear energy
- Maintain a steady state (the current situation)
- Expand nuclear energy production.

Waste or Resource: Allow for possible future use

There was suggestion that used nuclear fuel has an energy potential, which should not be ignored in planning for a long-term management approach. While current technology might not be sufficiently advanced to allow for cost-effective re-use of the remaining energy or reducing the toxicity of the used fuel at this time, the potential does exist for the future. For this reason, it was suggested that the NWMO should consider an adaptive approach. This would require anticipating and assessing the possibilities for the future. Whatever management actions are taken today should not preclude Canada's possible future use or treatment of the used nuclear fuel.

Have we identified appropriate ways to deal with the problem?

In the first NWMO discussion document, we identified 14 technical methods for managing used nuclear fuel, and sorted into three categories: methods requiring review as specified in the *Nuclear Fuel Waste Act*; methods receiving international attention; and methods of limited interest. See Table 3-1.

Table 3-1 Potential Technical Methods

Methods Requiring Review	Methods Receiving International Attention	Methods of Limited Interest
Deep Geological Disposal in the Canadian Shield	Reprocessing, Partitioning and Transmutation	Direct Injection
Storage at Reactor Sites	Storage or Disposal at an International Repository	Rock Melting
Centralized Storage Above or Below Ground	Emplacement in Deep Boreholes	Sub-Seabed Disposal
		Disposal at Sea
		Disposal in Ice-Sheets
		Disposal in Subduction Zones
		Disposal in Space
		Dilution & Dispersion

Eight technical methods not to be considered for further study at this time.
We outlined eight technical methods of limited interest. These are methods that have been studied by various waste management organizations and institutions at some point in the past 40 years, but none have been implemented, nor are they a focus of a major research effort. For the most part, interested Canadians agreed that these eight methods ought not to be included in the NWMO study. Their reasons include:

- The fact that almost no country is studying or researching these methods. This suggests that the methods have little merit either because of their feasibility or their potential risk.

- Some methods are clearly unacceptable – dilution and dispersion would be an irresponsible method for Canada to select. The lack of commitment to management and the potential to cause human health and environmental harm are significant reasons for not considering this method.

- Space disposal was described as being too expensive. Not only would considerable re-processing of the wastes be required, the risk and consequence associated with an accident would be too great.

- Several of the methods would contravene international agreements, treaties and conventions. This applies to disposal at sea, sub-seabed disposal and possibly disposal in ice-sheets. Canada, as a signatory to such documents, should not propose actions that would violate the spirit and intent of these agreements.

- Any technical method to be considered must be supported by valid scientific evidence. Since some of these methods have not been sufficiently studied, there is little scientific evidence to warrant further consideration.

- Some participants suggested that any method that closes the door (is conclusive) on the potential to retrieve wastes for possible future treatment or use should not be considered. The future is uncertain and therefore the selected management approach needs to be versatile – many of these methods lack versatility.

- Many of these methods would be too costly to implement.

- Methods should not be studied if there is a loss of control of the material, and/or inability to predict the consequence/fate of the radioactivity.

Methods receiving some attention internationally
The first NWMO discussion document also presented for comment three methods currently being considered in some national programs around the world, and methods that are likely to receive attention in the future. For the most part, Canadians indicated that these methods should not receive detailed study at this point, although it would be appropriate to maintain a "watching-brief" on these methods.

Keep a "watching brief" on partitioning and transmutation

Generally, participants said that Canada should monitor research on the potential for reprocessing, partitioning and transmutation as possible future options for Canada, although they are not deemed practical today. Reasons included:

- The methods are likely not cost-effective given the availability and relative cost advantage of uranium in Canada;
- The methods are challenging from a technological perspective, raising issues of increased risks as a result of transport and handling of the used fuel; and
- Reprocessing poses an additional risk, in that enriched uranium could fall into the wrong hands and could be used for the development of weapons.

Many interested Canadians acknowledged that as a result of future research and technological advancements, reprocessing and/or transmutation may become more attractive over time. Canada should maintain a "watching brief" on research and technological advancements and periodically re-evaluate its management approach as new information becomes available.

Canadians expressed a range of opinions as to whether Canada should consider international repositories for disposal or storage as a technical method. From the perspective of environmental stewardship, many felt that Canada should manage its own wastes. Good stewardship means that wastes should be managed where they are produced, and therefore there should be no import or export.

Few expressed interest in further examination of emplacement in very deep boreholes.

Are we asking the right questions?

The first NWMO discussion document identified ten questions, developed from our early conversations with Canadians proposing that they be asked and answered as the focus of the study. See Table 3-2.

Table 3-2 An Analytical Framework: Ten Key Questions*

Q-1 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?
Q-2 Engagement & Participation in Decision-Making	Does the management approach provide for deliberate and full public engagement through different phases of implementation?
Q-3 Aboriginal Values	Have aboriginal perspectives and insights informed the direction, and influenced the development of the management approach?
Q-4 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?
Q-5 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?
Q-6 Human Health, Safety & 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?
Q-7 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?
Q-8 Environmental Integrity	Does the management approach ensure the long-term integrity of the environment?
Q-9 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?
Q-10 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?

*As proposed in the NWMO's first discussion document *Asking the Right Questions?*

The ten questions are good ones, but more detail is needed.

Interested Canadians generally expressed satisfaction that the ten key questions are both comprehensive and appropriate, and represent the important matters that need to be considered when developing and comparing long-term management approaches for Canada's used nuclear fuel. Many indicated they are anxious to share the NWMO's understanding of some of the key concepts incorporated in the framework, such as equity and acceptable risk, and how it intends to apply the framework. Irrespective of how the framework is applied, interested Canadians indicated that it must include and address the following considerations well:

- A commitment to the principles of openness and accountability;
- Recognition of the need to provide the public with clear, simple and understandable information on nuclear energy and the risks and benefits of the management of nuclear wastes;
- Recognition of the need to describe fully and fairly, and communicate the risks and benefits associated with waste management approaches. Risks need to be presented in a way that is understandable and relevant to the layperson; that provides waste management risks in context and compares them to other societal risks;
- A commitment to conducting research, assessing the findings of research and evaluating the potential for enhancing or modifying Canada's long-term waste management approach. While much is known about the nature of the hazards associated with nuclear wastes and the methods available to manage them, our knowledge and understanding will improve over time. The long time frame needed to develop and implement a management approach holds the potential for technological advancement in the methods for managing the waste;
- Recognition of the need to build confidence that the NWMO's commitments will be fulfilled. People need to have confidence that all work and commitments will meet both the spirit and intent of the framework;
- A commitment to an adaptive management or step-wise decision-making approach for the management of used nuclear fuel. This provides the opportunity to re-direct or adapt the approach to reflect new information as it becomes available and validated;
- A consideration of health and stress effects from all perspectives, including psycho-social health; community mental health; and related social aspects;
- Incorporation of consideration of technical best practices and best proven technology;
- Recognition of the importance of institutional controls, no matter which method is selected;
- Ensure management approaches are reversible. This reflects the concern that any management approach should allow science the flexibility to develop new solutions that could then be applied to old waste; any disposal method that could not benefit from future learning is seen as short-sighted; and

- Ensure management approaches are benchmarked against international standards. The input of international bodies on best practices provides an important measure of confidence in our own practice.

Many have commented on the importance of ethics in developing, assessing and implementing the management approach and expressed an interest in how ethics are to be applied in the framework. Specific suggestions regarding possible ethical principles or considerations which should be factored in to the assessment include the following:

- Those who generate the waste should take responsibility;

- Manage the wastes in a way that provides future generations at least the same level of safety as we have today;

- To the extent possible, our current decisions should not restrict future generations from making different ones;

- We should minimize the burden that we pass on to future generations;

- We have an obligation to select what we believe is the best approach, and to do what we can to develop and demonstrate its efficiency;

- Liabilities should be considered when undertaking new projects;

- We should allow future generations to have access to the used fuel, not close the door to possible future uses;

- We should aim to bequeath a passively safe situation which places no reliance on active institutional controls; and

- We should include transparency of process as an ethical consideration.

Some Canadians also commented on the notion of social acceptability – or, alternatively, public confidence. Some people said that what constitutes "public confidence" is not clear. At a minimum, we were told it would require involving the public in the planning, development and oversight of the management approach. In addition, public confidence will demand transparency in decision-making and assurances around financial surety.

Among the comments we received about the ten questions was a concern about the appropriate standard to use in consideration of "environmental integrity". In our first discussion document, we suggested the management approach be measured against its ability to lead "directly or indirectly, to maintaining (or strengthening) the integrity of biophysical systems, so they continue to support the well-being of people and other life forms". Some told us that it is difficult to imagine how the integrity of biophysical systems can be improved by a management approach; this element of the description should be omitted.

We explored the ten questions through a telephone survey with a representative sample of Canadians. We asked them to rate the importance of some of the elements of the ten questions. See Table 3-3. (www.nwmo.ca/surveys)

A majority of the 1900 Canadians interviewed indicated that the ten questions, as explored at a high level through 18 component statements, do contain the range of elements that should be

Table 3-3 Public Attitude Research on the Ten Questions

Importance of possible traits or characteristics for a management approach	% who said it is very important for Canada's approach to have this trait*
Protects the health and safety of future generations	92
Protects the health and safety of the current generation	92
Ensures the health and safety of workers who build the waste management facilities	91
Protects the environment	90
Ensures the nuclear waste is isolated from human contact forever	85
Fair to both our generation and to future generations	84
Makes certain that communities likely to be most directly affected have an opportunity to participate in decision-making	83
Fair to both humans and to non-human living things	82
Reduces the potential that terrorists would be able to access the materials	81
Guarantees there is enough flexibility to incorporate future improvements in scientific and technical knowledge	81
Provides flexibility to future generations to change or modify the way in which the fuel is managed	77
Makes certain that adequate money is available now and into the distant future when it may be needed	74
Does not negatively affect the cultural or social life of the surrounding communities	70
Ensures any decisions taken about how to manage the waste are reversible	70
Does not negatively affect the economic potential of surrounding communities	68
Ensures the overall cost is reasonable	65
Ensures those who have an interest in the issue, even if they are not directly affected, have an opportunity to participate in decision-making	64
Does not place any obligations on future generations to manage the waste	54

*% who rated the statement an 8, 9 or 10 on a ten-point scale of importance.

explored in the study. A large majority of the Canadians interviewed indicated they feel it is very important that any management approach for Canada's used nuclear fuel have these characteristics.

We note that there were differences among the participants in the research discussion groups which were conducted on the relative importance of the ten questions. For some, the greatest concern is finding and implementing a solution, while for the majority the greatest emphasis was placed on ways to ensure the least risk of harm or damage.

Those looking to minimize risk of harm or damage presented divergent views on the best way to achieve this. The largest number felt that this would be best achieved through focusing on human health, safety and well-being. Others felt that placing the greatest emphasis on environmental integrity would result in the best protection of human health. Still others believed that to achieve all of these objectives demands that the greatest emphasis should be placed on technical adequacy. Those whose greatest concern was finding a solution tended to place most importance on questions like economic viability.

Overall, many recognized that some difficult trade-offs will need to be made no matter which management approach is recommended.

INSIGHTS FROM RESEARCH AND ANALYSIS

Since its inception, the NWMO has been building an extensive body of research related to the management of used nuclear fuel through:

- NWMO-commissioned background papers, roundtables, and workshops;
- Development of conceptual engineering designs and cost estimates for each of the technical methods described in the *Nuclear Fuel Waste Act*; and
- International co-operation.

Background Papers

In commissioning a large number of background papers, we invited a diverse group of experts to provide information conveying current knowledge of systems and approaches for the long-term management of used nuclear fuel, both within Canada and abroad.
(www.nwmo.ca/backgroundpapers)

The background papers are grouped under the following broad headings. A number of new papers have been added to this body of knowledge since the release of our first discussion document:

- **Guiding Concepts –** These papers describe key concepts often used to explore difficult public policy issues and how they might apply to our study.
- **Social and Ethical Dimensions –** These papers suggest a range of social and ethical dimensions of managing used nuclear fuel which should be considered in the study.

- **Health and Safety –** These papers describe the status of relevant research, technologies, standards and procedures to reduce the nuclear radiation and security risks associated with nuclear fuel management.

- **Science and Environment –** These papers review the status of research on ecosystem processes and environmental management issues, including the state of our knowledge and understanding of the biosphere and geosphere.

- **Economic Factors –** These papers suggest some of the economic factors and financial requirements for the long-term management of used nuclear fuel.

- **Technical Methods –** This body of work describes the typical generic technical designs relating to the three methods for the long-term management of used nuclear fuel defined in the *Nuclear Fuel Waste Act*, and the associated cost estimates. This series of papers also address other possible methods and related system requirements.

- **Institutions and Governance –** These papers outline current legal, administrative and institutional provisions that may be needed in the long-term management of used nuclear fuel in Canada. This includes current legislation, regulations, guidelines, protocols, policies and procedures of various jurisdictions.

Beyond these background papers, the NWMO has organized meetings and workshops to explore key issues with experts in various knowledge areas. The outputs and outcomes of these discussions and expert workshops are all available on the NWMO website. (www.nwmo.ca/workshopreports)

Conceptual Engineering Designs and Cost Estimates for Alternative Management Approaches

Since the release of the first discussion document, the NWMO has received and posted to the website a series of technical and engineering reports from the Joint Waste Owners – Ontario Power Generation, Hydro-Québec, New Brunswick Power 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. This information, provided to the Joint Waste Owners by the consulting firms, was developed as typical technical options and not as recommendations.

These materials include:

- Identification and descriptions of a range of potential engineering designs for deep geological disposal, reactor site storage and centralized storage; (www.nwmo.ca/conceptualdesigns)

- A preliminary description of the types of facilities and infrastructure needed to support transportation of used fuel to a centralized facility; (www.nwmo.ca/transportation) and

- Preliminary cost estimates for siting, construction, operation, monitoring, 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. We asked independent consultants 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;
- 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; and
- Although the conceptual designs are conservatively sized and limited to the CANDU fuel inventory from existing reactors, they have the flexibility to provide increased used fuel storage capacity in the future, by building either incremental additions or completely new facilities.

The third-party review of the cost estimates concluded that the cost estimates 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)

International Cooperation

The NWMO recognizes and relies on the work undertaken in other countries that are also addressing the long-term management of used nuclear fuel. We have commissioned reviews of the status of work globally, including the current state of work on long-term storage facility design, deep geological disposal, and on other methods. We participate in gatherings of various international bodies, such as the International Atomic Energy Agency, the Nuclear Energy Agency's Radioactive Waste Management Committee and Forum for Stakeholder Confidence, and the Environmental Disposal of Radioactive Materials discussion forum. By doing so we seek to bring the best knowledge and expertise to our study.

We note from our review that other countries are investigating geomedia other than crystalline rock for the long-term management of used nuclear fuel. This includes France, Switzerland, Germany, Belgium and the United States. The potential of other geologic media will be examined further in the coming months by the NWMO.

Part 2 / A Preliminary Comparative Assessment

Armed with insights from our own engagement with Canadians and the results of our early research and analysis, the NWMO turned its attention to the actual assessment of the options. This is the focus of Part 2 of this discussion document.

CHAPTER 4 / CHOOSING AND DESCRIBING AN ASSESSMENT APPROACH

To help with the task of undertaking a rigorous comparative analysis of alternative management approaches, NWMO brought together a multi-disciplinary group as an Assessment Team. The Team was asked to further develop an assessment framework based on the ten questions posed in our first discussion document, and then, in a preliminary way, apply this framework to the three options outlined in the *Nuclear Fuel Waste Act*.

These individuals were selected by the NWMO based on their diverse experience and complementary skill-sets in addressing complex public policy issues. The Team provided a broad-based systems perspective on the many social, technical, environmental and economic aspects of used nuclear fuel management. Their diverse expertise, both technical and non-technical, ranging from environmental assessment and risk management to economic, financial and policy analysis, was instrumental in achieving a comprehensive comparative assessment.

Consistent with the framework outlined in the NWMO's first discussion document, the Team searched out and selected a methodology that would allow for the systematic integration of social and ethical considerations with technical, economic, financial and environmental considerations.

The Assessment Team operated from three basic assumptions: First, it assumed that Canada needs to make a decision now on an appropriate approach for long-term management of used nuclear fuel. Secondly, it assumed that the volume of used nuclear fuel to be managed would be limited to the levels projected for the life of the current facilities. And lastly, it assumed that a superior management approach would be one that is robust over the long term. While the focus of the assessment was on technical methods, the Team took into account requirements common to any management approach.

It is also important to note that although the *Nuclear Fuel Waste Act* does not require the NWMO to propose specific sites as part of its study, we must identify economic regions appropriate for each of the options. An economic region is a grouping of census divisions for analysis of regional economic activity. Economic regions for the implementation of the methods were not factored into this preliminary assessment by the Team.

The Assessment Team conducted its work over a six-month period, meeting as a group for a full week once each month. Most of this meeting time was used to work through an analysis methodology, which provided the structure for the assessment. Time between meetings was used to examine other factors that could influence the development of an approach for used nuclear fuel management in Canada.

The Team's report is available in its entirety at www.nwmo.ca/assessmentteamreport. In this discussion document we:

- Summarize the rationale used by the Assessment Team for screening the methods to be assessed (Chapter 4)
- Describe the background information available to the Team (Chapter 4)

- Review the development of the methodology (Chapter 4)
- Describe the methodology and its implementation in comparing the three methods. (Chapter 5)

In Chapter 5 we revert to the actual words of the Team as they attempted to convey the intense discussions through which their principal findings emerged.

INITIAL SCREENING OF METHODS

The *Nuclear Fuel Waste Act* requires that the NWMO study include an assessment of three specific technical methods:

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

But the NWMO may also identify additional methods to study. Consequently, one of the important early tasks for the Assessment Team was selecting the range of methods to include in its preliminary assessment and, once determined, to describe these methods for the purpose of the assessment.

For about four decades, various countries have been investigating many possible methods to manage used nuclear fuel and other long-lived highly active radioactive wastes over the long term. In *Asking the Right Questions?*, the NWMO classified potential methods into three different categories: methods required for review under the *Nuclear Fuel Waste Act*; methods receiving international attention; and methods of limited interest.

Methods Receiving International Attention

The NWMO identified the following three methods that are currently receiving some international attention. The Assessment Team reviewed each method, but decided not to include them in the assessment for reasons outlined briefly below. However, the Team suggested keeping a "watching brief" on these methods, particularly in the case of partitioning and transmutation and the international repository concept. Recent interest in the international community suggests that regional repositories may offer a means to improve international security.

A fuller description and discussion of the screening of these options is available in the Assessment Team's report, available on the NWMO website at www.nwmo.ca.

Reprocessing, Partitioning and Transmutation – Reprocessing, partitioning and transmutation involves chemical and physical processes to recover and recycle the fissionable isotopes in used nuclear fuel. For a number of reasons, this option is considered to be highly unlikely for Canada. The necessary facilities are very expensive and inevitably produce residual radioactive wastes that are more difficult to manage than used nuclear fuel in its un-reprocessed form. This option requires a commitment to an expanded and multi-generational nuclear fuel cycle, and it separates out weapons useable material in the course of the process. Eventually, a process called transmutation may make it possible to transform some of the radioactive components which have been separated through reprocessing and partitioning into non-radioactive elements, or into elements with shorter half-lives which therefore would be hazardous for a much shorter period of time. The current scientific and technical foundation for transmutation is still in its infancy, and it is too soon to demonstrate that it would be commercially feasible with the volume of used nuclear fuel that exists in Canada. As well, it would not solve the problem of managing the waste: it would still require a method for the long-term management of the residual materials or radioactive and toxic components that could not be transformed.

Emplacement in Deep Boreholes – Although very deep borehole emplacement may hold some potential as a method for the disposal of small quantities of radioactive waste, the Assessment Team considered that this option would make it difficult to implement and ensure isolation and containment for large quantities of used nuclear fuel.

International Repository Concept - The Assessment Team also reviewed two concept scenarios for an international repository, one located in another country and one with Canada as the host. While no international treaty currently forbids the trans-boundary movement of used fuel, the Assessment Team noted that most countries believe in the self-sufficiency principle under which they are responsible for any waste they produce.

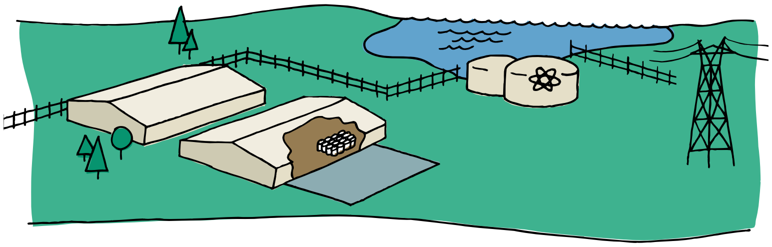
Methods of Limited Interest

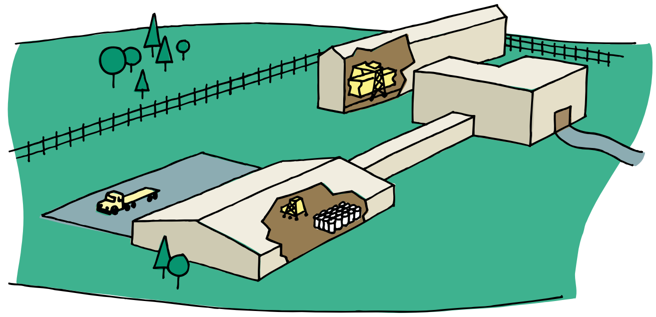
NWMO's first discussion document identified eight methods as being of limited interest. As shown in Table 4-1 below, none of these eight methods was included in the assessment based on the following screening criteria:

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

Table 4-1 Screening Rationale – "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





Storage at Reactor Sites
One concept of reactor site storage is placement of used fuel casks inside surface storage buildings near existing reactors, a continuation of dry storage technology currently used by Ontario Power Generation.

Centralized Storage
Centralized storage could be either above or below ground. One concept is placement of casks and vaults containing used fuel in above-ground storage buildings at a central site.

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

The Assessment Team noted that this judgement is consistent with assessments elsewhere. Although the Assessment Team did not complete a formal assessment for these methods, its opinion was that they would have scored very poorly.

DESCRIPTION OF THE METHODS SELECTED FOR REVIEW

The Joint Waste Owners (*) commissioned considerable work to develop typical conceptual engineering designs and associated transportation requirements for each of the technical methods defined in the *Nuclear Fuel Waste Act*. This formed the basis for the Assessment Team's work. (www.nwmo.ca/conceptualdesigns) The following section describes each of the management approaches. A more detailed discussion is available in the Assessment Team's report.

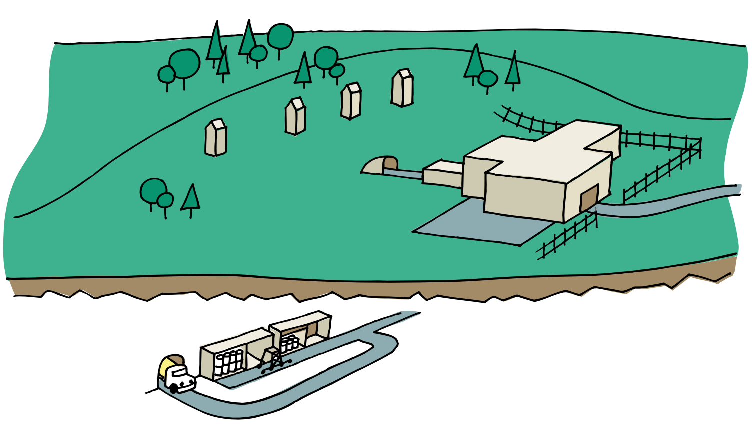
(*) Joint Waste Owners include Atomic Energy of Canada Limited, Hydro-Québec, New Brunswick Power and Ontario Power Generation.

Storage at Reactor Sites

Extended storage is permanent or indefinite storage with the necessary ongoing maintenance and facility refurbishment conducted on an ongoing basis. (www.nwmo.ca/reactorstorage) Canadian industry now has some 40 years of experience with wet storage facilities and more than 25 years of experience with dry storage systems. Today's dry storage containers are designed to last at least 50 years, but their expected life is much longer—100 years or more. With periodic refurbishment, extended storage can be used indefinitely.

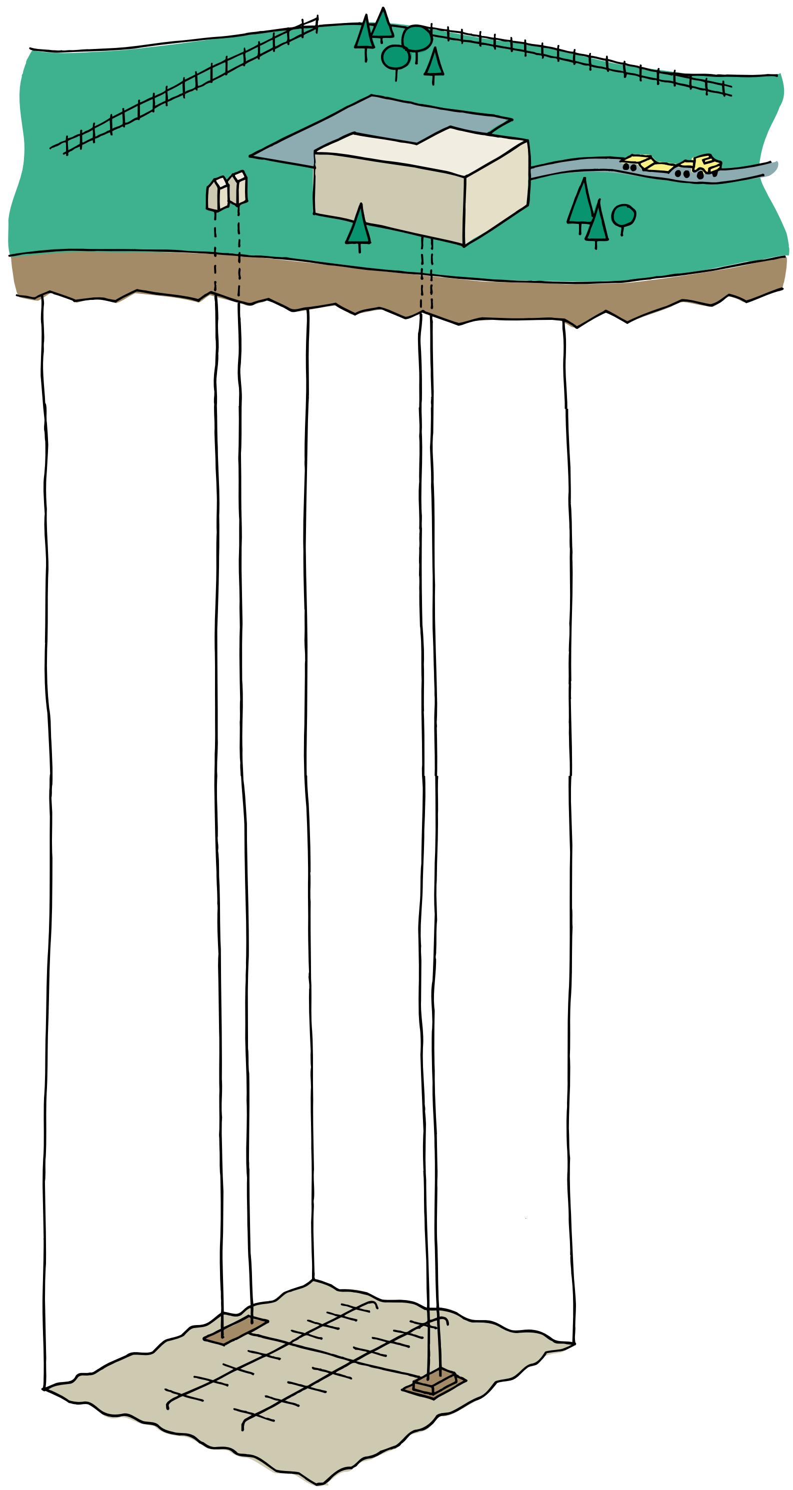
Long-term storage at existing reactor sites would involve the expansion of existing dry storage facilities or the establishment of new, long-term dry storage facilities at each of the seven existing reactor sites in Canada. In the latter case, used fuel would be transferred from the existing interim storage facilities to newly designed storage containers and storage facilities are designed to last between 100 and 300 years. Additional and replacement capacity would be provided by the construction of storage facilities on a rolling program.

There are both surface and below-surface design options for reactor site storage, involving the use of casks, vaults and/or silos. Table 4-2 shows the alternative designs considered in the development of the conceptual designs. The difference in designs considered by geographic location reflects the different methods currently used for interim storage at each location.



Another concept is the arrangement of casks in a series of below-ground caverns at a nominal depth of 50 metres that are accessed from the processing buildings on the surface by ramp.

Deep Geological Disposal
A deep geological repository concept involves the encapsulation of used fuel in long-lived engineered containers which are then placed and sealed within excavated rooms in a naturally occurring geological formation at a design depth of 500 to 1000 metres below ground surface.



Drawings based on conceptual designs prepared for the Joint Waste Owners and described in NWMO Background Paper 6.9, “Conceptual Designs for Used Nuclear Management”

Storage in Casks—A cask is a mobile, durable reinforced concrete and steel container for enclosing and handling nuclear fuel waste for storage or transport. The cask wall shields radiation; heat emitted by the used fuel is transferred by conduction through the wall.

Storage in Vaults—The vault concept would involve the storage of fuel baskets confined in reinforced concrete vaults. The vaults would be constructed in the open on a concrete foundation slab. Natural circulation is used to cool and regulate the used fuel basket temperature inside the vault.

Storage in Silos—Canada and other countries store used fuel inside sealed steel baskets, which are housed within a reinforced concrete silo or canister. The outdoor silos are passively cooled.

The long-term storage facilities need ongoing maintenance, inspections and security systems once the used fuel is transferred. If the storage systems do not perform according to specification, it would be possible to retrieve the used fuel from storage and undertake necessary repairs or transfer it to a new storage facility. The long-term storage facilities would be designed to allow safe retrieval of used nuclear fuel from the storage buildings at any point during the life of the facility.

All reactor site extended storage options include an ongoing, cyclical program of regular replacement and refurbishment activities. Eventually (assumed to be within 300 years) the storage facilities would need to be replaced.

Afterwards, it would be necessary to:

- Build new used fuel storage facilities;
- Establish a used fuel transfer system to remove the fuel from existing storage containers and transfer it to new storage containers, and then to a new storage building;
- Repackage the used fuel storage containers; and
- Refurbish or demolish old storage facilities.

Table 4-2 Concept Alternatives Considered for Storage at Reactor Sites

ONTARIO Pickering, Darlington and Bruce	• Casks in Storage Buildings • Surface Modular Vault • Casks in Shallow Trenches
NEW BRUNSWICK Point Lepreau	• Surface Modular Vault • Vaults in Shallow Trenches
QUEBEC Gentilly	• Surface Modular Vault • Vaults in Shallow Trenches
AECL Chalk River (Ontario) and Whiteshell (Manitoba) Sites	• Silos in a Storage Building • Silos in a Shallow Trench

This approach would require:

- **Siting and Approvals –** This would involve identifying specific locations at each of the reactor sites and obtaining approvals—from the Canadian Nuclear Safety Commission for the construction and operation of the facility, and an environmental assessment under the *Canadian Environmental Assessment Act*. This would take approximately 5 years.

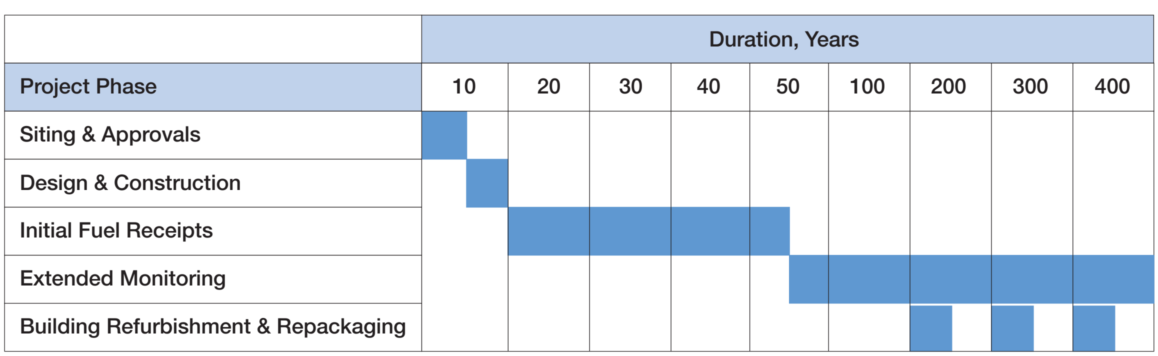
- **Design and Construction –** this would involve preparing the final design considerations, storage container production and storage facility construction. Preliminary estimates say this would take approximately 5 years, including the initial phase of construction.

- **Operations –** this would involve removing the fuel from the existing storage facilities, and placing it in the long-term storage facilities. Preliminary estimates say that the transfer of used fuel from existing interim storage facilities to new long-term storage facilities would occur over a period of approximately 35 to 40 years.

- **Monitoring –** once all the used fuel from the reactor site was placed in the long-term storage facility, it would require on-going monitoring to ensure that facility safety was being maintained as well as ongoing preventive maintenance and repair.

- **Building Refurbishments and Repackaging –** eventually the storage containers would need to be replaced, as would the storage building. 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 10 years and complete refurbishment of all components and repackaging of the fuel storage system is assumed to be repeated every 300 years.

Figure 4-1 Summary of Reactor Site Extended Storage Project Timeline



Note: (1) Extended monitoring and building refurbishment/ repackaging activities continue in perpetuity, based on a 300-year cycle.
(2) Schedule based on implementing a surface modular vault (SMV) at the Pickering site.
(3) Schedules for other RES alternatives at various sites will vary, depending on the type of storage concept and the quantity of fuel being stored.

Figure 4-1 provides a general perspective of the project timeline for reactor site extended storage. A government decision in 2006 to adopt reactor site storage, followed by immediate implementation would lead to the earliest possible availability of long-term storage facilities in 2016 – 2020 (the variation reflects the different design options). The long-term storage facilities would likely require complete refurbishment or replacement by the year 2300. The cost estimates are based on this assumption.

A decision to implement reactor site long-term storage after the existing interim facilities reach the end of their design lives would lead to the earliest possible availability of long-term storage facilities in 2042 (at Point Lepreau) and 2057 (at Darlington).

The cost estimates for long-term reactor storage are based on the following assumptions:

- Long-term reactor site storage would operate indefinitely;

- The facilities and the fuel packaging would be refurbished or replaced on a regular basis and would be carried out indefinitely; and

- The facilities are intended to operate in cycles of approximately 300 years; the cost estimate below addresses the first cycle.

Depending on the specific design, preliminary cost estimates suggest this approach would cost between $17.6 and $25.7 billion (2002 $) for one 300-year cycle. The present value impact of the first repeat cycle is approximately $2.3-$4.4 B (2004 $) based on current long-term economic factors. The calculation of costs beyond this, far in the future, requires the use of long-term economic forecasting, with its inherent uncertainties.
(www.nwmo.ca/reactorcosts)

Centralized Storage

Twelve countries currently operate centralized used fuel storage systems. These systems range from common temporary storage for used fuel from a few reactors, to fully centralized national management systems. Although there are several centralized water pools, dry storage seems to be the preferred option.

Technologies for centralized dry storage of used fuel include metal casks, concrete casks, silos and vaults. The Joint Waste Owners selected four alternatives as representative of a range of possible designs for the Centralized Extended Storage Facility concept. (www.nwmo.ca/centralstorage) The selected alternatives are: Casks and Vaults in Storage Buildings; Surface Modular Vaults; Casks and Vaults in Shallow Trenches; and Casks in Rock Caverns.

Site conditions should not be a major constraint in implementing these alternatives. Two alternatives comprise surface facilities, where storage buildings are built above grade. The remaining two alternatives are below-ground facilities: one near-surface and mounded over, and one at about 50 metres below ground surface in bedrock. The near-surface alternative, Casks and Vaults in Shallow Trenches, would be passively ventilated, with the deeper alternative, Casks in Rock Caverns, ventilated using a forced system. Three of the alternatives would minimize repackaging of fuel upon receipt at the centralized storage facility, which would allow higher fuel throughput and minimize costs, the Surface Modular Vault being the exception.

Centralized storage could be built at a nuclear plant site or at a fully independent site. For assessment purposes, it is assumed that the centralized storage facility would be located on an undeveloped site. The centralized storage facility would not rely on support from other nuclear facilities and would be considered as a stand-alone facility. For all of the alternatives, additional capacity would be provided by the construction of storage facilities on a rolling program.

Long-term centralized storage would involve creating new, long-term dry storage facilities at one site in Canada. Used fuel would be transferred from the existing interim storage facilities at the reactor sites, to newly designed storage containers and facilities. Additional storage facilities would be built as needed, on a rolling program.

Once all of the used fuel is transferred to the long-term storage facilities, ongoing maintenance, inspections and security systems would be required. If the storage systems do not perform according to specification, it would be possible to retrieve the used fuel from storage and undertake necessary repairs or to transfer it to a new storage facility. 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.

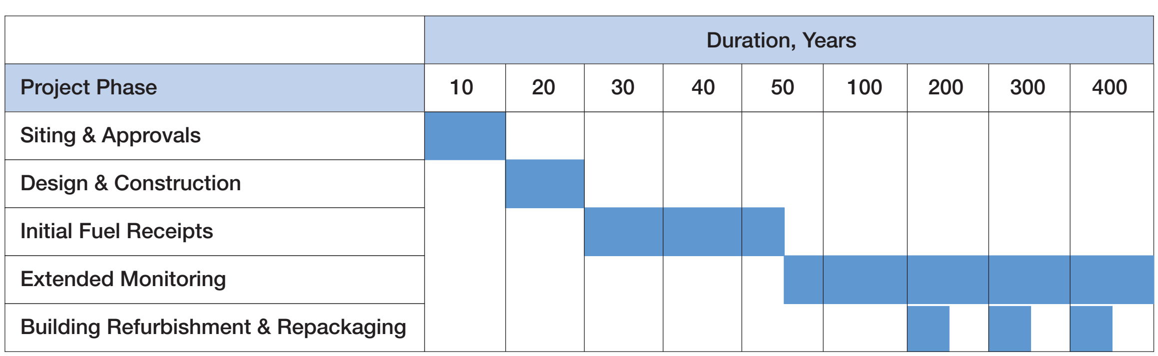
The centralized extended storage option would include an ongoing, cyclical program of regular replacement and refurbishment activities. The storage containers and storage facilities are designed to last between 100 and 300 years. It would be necessary to:

- Build new used fuel storage facilities;
- Establish a used fuel transfer system to remove the fuel from existing storage containers and transfer it to new storage containers, and then to a new storage building;
- Repackage the used fuel storage containers; and
- Refurbish or demolish old storage facilities.

Implementation of this approach would include:

- **Siting and Approvals –** 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 under the *Canadian Environmental Assessment Act*. This would take approximately 10 years.

Figure 4-2 Summary of Centralized Storage Project Timeline



Note: (1) Extended monitoring and building refurbishment/ repackaging activities continue in perpetuity, based on a 300-year cycle.

- **Design and Construction –** this would involve preparing the final design considerations, storage container production and storage facility construction. Preliminary estimates say this would take approximately 10 years, including the initial phase of construction.

- **Transportation and Operations –** the operation of a centralized long-term storage facility would involve removing the fuel from the existing storage facilities, packaging it and transporting it and placing the fuel in the long-term storage facilities. Preliminary estimates say this would occur over approximately 25 to 40 years.

- **Monitoring –** this would require on-going monitoring to ensure that facility safety was being maintained, as well as ongoing preventive maintenance and repair.

- **Building Refurbishments and Repackaging –** eventually the storage containers would need to be replaced, as would the storage building. This would involve construction of new storage buildings, transfer of the used fuel from the long-term storage containers to new storage packages, and transfer of the storage containers to a new storage building. The old buildings and waste storage containers would need to be refurbished or demolished. Complete refurbishment of all components and repackaging of the fuel storage system is assumed to be repeated every 300 years.

Figure 4-2 outlines a general project timeline for centralized storage.

Under a government decision in 2006 to adopt centralized storage, followed by immediate implementation, the new, long-term storage facilities are assumed to be available in approximately 2023 at the earliest. These facilities would require refurbishment or replacement approximately starting by the year 2300.

The cost estimates for long-term centralized storage are based on the following assumptions:

- Long-term centralized storage would operate indefinitely;

- The facilities and the fuel packaging would be refurbished or replaced regularly and would be carried out indefinitely;

- The facility would be located in Ontario (for transportation cost-estimating purposes); and

- The facilities are intended to operate in cycles of approximately 300 years; the cost estimate below addresses the first cycle.

Depending on the specific design, preliminary cost estimates suggest this approach would cost between $15.7 and $20.0 billion (2002 $) for one 300-year cycle, including any transportation costs. The present value impact of the first repeat cycle is approximately $3.1- $3.8 B (2004 $) based on current long-term economic factors. The calculation of costs beyond this, far in the future, requires the use of long-term economic forecasting with its inherent uncertainties.
(www.nwmo.ca/centralstoragecosts)

Deep Geological Disposal

Deep geological disposal would involve construction of an engineered repository within a naturally-occurring geological formation. The design concept used in the assessment has been developed over more than twenty-five years. During the period 1978-1996, Atomic Energy of Canada Limited (AECL) developed a deep geologic 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. The Panel listened to a broad range of stakeholders, including the public. Its final report (1998) recommended changes to address their comments. Since then, the Joint Waste Owners have continued the development of the original AECL repository concept. The conceptual design prepared on behalf of the Joint Waste Owners and used in the assessment was synthesized from all of this work. (www.nwmo.ca/geologicaldisposal)

Under this concept, the repository would be located in the Canadian Shield at a design depth of 500 to 1,000 metres. Construction would be carefully controlled to maximize rock integrity. The repository would be self-contained, except for the supply of materials, used fuel containers and their components. The facility design is based on the receipt, packaging and placement of CANDU used-fuel bundles at a rate of 120,000 per year. The design assumes that these bundles have been discharged from reactors and stored for at least 30 years prior to receipt at the repository. Until the repository is operational, interim measures would be needed to manage the used nuclear fuel effectively and to ensure safety and security.

For assessment purposes, it is assumed that the deep geological repository would be located on a remote undeveloped site on the Canadian Shield. The geological repository would be built so that it could eventually be backfilled and sealed.

Used fuel would be transferred from the existing interim storage facilities at the reactor sites to the deep geological repository. Once all of the used fuel is transferred to the deep geological repository, maintenance, inspection and security-related operations will be required.

Figure 4-3 Summary of the Deep Geological Repository Concept Project Timeline

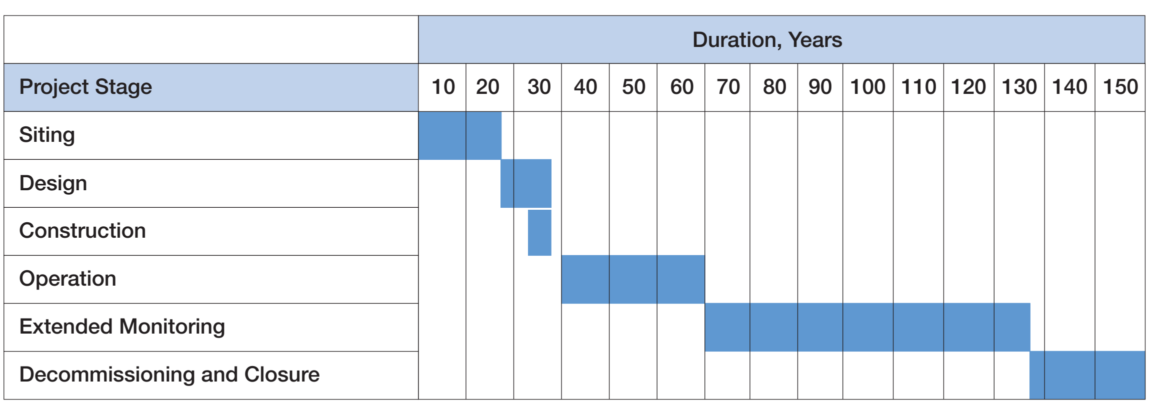


Table 4-3 General Timeline and Institutional Considerations

2005 - 2050

- Power plants are in operation. Used nuclear fuel goes to wet storage and is transferred to on-site short-term dry storage after 10 years.
- Activities in this time frame include R&D, technical design selection, training, construction, commissioning, and operating and maintenance. For the off-site options, activities also include site selection, the development and production of transport containers.
- Construction begins. Emplacement of the used nuclear fuel begins only after completion of construction. For the off-site options, some used nuclear fuel may be transported, limited by the volume that can be accommodated within this timeframe by the off-site facilities.
- Once the short-term facilities at the existing sites are emptied, they are decommissioned (closed) and returned to other use.
- Monitoring of the environment begins prior to the transfer of used nuclear fuel and continues throughout its transfer. Workers are monitored at all locations where used nuclear fuel is handled.

Administrative Aspects	Financial Aspects	Regulatory Aspects
The power plant operator is responsible for the maintenance of wet storage and for the transfer to short-term dry storage containers on site. Responsibilities for the used nuclear fuel in both the short-term and, if appropriate, the long-term dry storage facilities are clearly defined. Organizational roles and responsibilities for the long-term used nuclear fuel management facilities and associated infrastructure are clearly defined. A technical design for the storage facility or geological repository is selected. Responsibilities for safeguards are defined.	Funds are in place to establish a competent organization and its activities for the long-term management of the used nuclear fuel, including R&D, design, licensing, construction, and operation of new facilities, and, if applicable, transportation. Funds are in place for the ongoing maintenance of the short-term facilities. Activities financed by the segregated used nuclear fuel management funds are clearly defined. A mechanism is in place to ensure that funds are available in perpetuity if required for ongoing facility maintenance and replacement (e.g. amounts from endowments, operations or other sources), recognizing that the size of fund could be limiting.	The institutions providing the required surety (financial, human resources) meet CNSC approval. All operations (wet/dry storage, construction, transportation, decommissioning) meet regulatory (CNSC) approval. New facilities and decommissioning of current ones meet CEAA (EA) requirements. Capacity in place to regulate all facilities and associated infrastructure for long-term management of used nuclear fuel.

~2050 and up to the next couple of hundred years

- The last fuel bundles will be moved from the wet storage.
- Based on currently projected reactor life, there will be no more wet storage and no more nuclear production at the sites.
- Once the short-term facilities at the sites are emptied, they will be decommissioned (and eventually returned to other use).
- Construction will be completed. For the off-site options, transportation of used nuclear fuel will be completed during this phase.
- Prior to the transfer of all used nuclear fuel, the storage containers of the short-term dry storage will reach their design lifetime (50-100 years) at different schedules. If emplacement takes too long, there may be a need to refurbish each one as this point is reached.
- Ongoing facility operating and maintenance will continue. Related activities will include security and monitoring of workers, facilities and environment.
- Ongoing R&D will continue on the selected method, lessons from other countries, and the results of monitoring in order to maximize knowledge for the long-term integrity and safety of the facilities, improve on choices where appropriate and possible, and determine options for facility decommissioning (closure).

Administrative Aspects	Financial Aspects	Regulatory Aspects
Organization(s) are in place for maintaining on-site facilities (while the new facilities are being completed) and, if appropriate, for the subsequent decommissioning (closure) of the on-site facilities. Organization(s) are competent to maintain the current facility and to address emerging technologies and possibilities for improvements. Responsibilities for safeguards are maintained.	Funds are in place to complete construction of the new facility and, if applicable, transport the used nuclear fuel from reactor sites. Funds are in place for ongoing operating and maintenance, including monitoring and security. Funds are in place for the decommissioning of the on-site locations if appropriate. The funding mechanisms previously established in Phase I either continue or are changed according to societal/governmental/legal conditions at the time.	Both ongoing and new processes and facilities, as well as facilities not yet decommissioned, meet regulatory approvals, including licensing and EA requirements, if appropriate. The roles of the organizations responsible for providing the required surety (financial, human resources, technical competence) are clearly defined and meet CNSC approval. All operations (wet/dry storage, construction, transportation, decommissioning) meet regulatory (CNSC) approval.

Beyond next couple of hundred years and ongoing

- For the storage options, ongoing maintenance plus storage container overhaul or replacement will be required each 50-100 years for each container. R&D will continue to maximize the long-term integrity and safety of the facilities.
- For the storage options monitoring of the environment and workers will be maintained. For all options, environmental monitoring may be required for a few centuries to establish and test the performance of the system...
- For the storage options, the decision and the technical option selected will be reviewed. For the repository option, if the decision has not been made earlier, the permanent decommissioning (closure) of the facility will be addressed.

Administrative Aspects	Financial Aspects	Regulatory Aspects
A responsible organization is in place to maintain the facilities, address regulatory issues and assess the utilization of new technologies with the possibility for improvement.	Funds are in place for security and environmental monitoring. For the storage options, funds are in place for ongoing facility maintenance, refurbishment, or replacement. Funding mechanisms previously established either continue or are changed as per conditions at the time.	For the storage options, the same regulatory needs as in Phase II would apply. For the repository option, oversight on the status of environmental conditions may be desirable.

Implementation of this approach would include:

- **Siting and Approvals –** a specific location would need to be identified and approval would be required from the CNSC for the construction and operation of the facility. This would also involve an environmental assessment under the *Canadian Environmental Assessment Act*. This would take approximately 10 to 15 years.

- **Design and Construction –** this would involve preparing the final design considerations, container production and facility construction. Preliminary estimates say this would take approximately 10 to 15 years.

- **Transportation and Operations –** the operation of a deep geological repository would involve removing the fuel from the existing storage facilities, packaging and transporting it, and placing the fuel in the long-term storage facilities. Preliminary estimates say this would occur over approximately 25 to 40 years.

- **Monitoring –** extended monitoring of the used fuel containers, sealing systems, rock mass, groundwater and environmental systems would be conducted to confirm the long-term safety of the disposal system. In addition, some preventive maintenance may be required. For costing purposes it was assumed that this would occur over approximately 70 years; however, it could be shorter or longer.

- **Decommissioning –** eventually the deep geological repository could be closed, or "decommissioned", after a period of extended monitoring. Preliminary estimates say this would occur over approximately 25 years.

A 2006 government decision to develop a deep geological repository would result in availability of the new facility in 2035, at the earliest.

Preliminary cost estimates suggest this approach would cost $16.2 billion (2002 $), including any transportation costs. The present value cost is approximately $6.2B (2004 $) based on current long-term economic factors. (www.nwmo.ca/disposalcosts)

In thinking through the evolution of any approach, a broad range of institutional considerations comes into play. Table 4-3 summarizes some of the institutional considerations anticipated by the Assessment Team.

THE METHODOLOGY

The Assessment Team chose to adopt a multi-attribute utility analysis which uses a step-by-step process to help identify a most preferred option. The Team felt that this form of assessment methodology could address the following challenges associated with this issue:

> First, the methodology must accommodate the fact that there exists a diversity of values, concerns and preferences across Canadian society related to this issue.

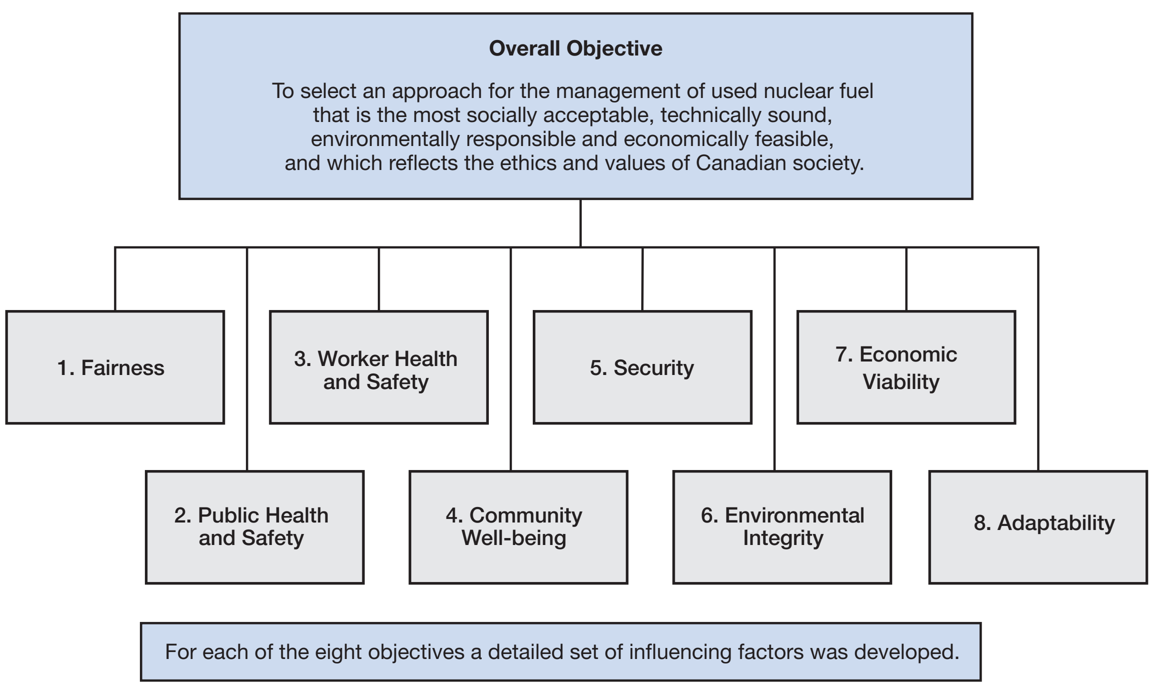
Secondly, it must facilitate consideration of the multiple objectives Canadians want their used nuclear fuel management approach to address;

Thirdly, it must facilitate comparing the different management approaches in terms of the evolving needs of future generations; and

Lastly, it must provide a degree of transparency that will: (1) provide a fair description of the assumptions and judgements made; (2) offer directions to greater underlying detail if the reader should wish to pursue that; and (3) create a report that is effective in communicating the work and results of the assessment.

A fuller discussion of the Assessment Team's choice of methodology is contained in the Assessment Team's report available on the NWMO website.

Figure 4-4 Objectives Hierarchy Showing the Top and Second Levels of the Hierarchy
Below Each of the Eight Objectives Lies a Detailed Set of Influencing Factors.



Defining the Objectives to Drive the Comparative Assessment

At the core of the assessment methodology selected by the Assessment Team is the creation of a hierarchy of objectives. The management approach that best meets these objectives is deemed to be the preferred approach. Thus, definition of these objectives is very important.

In the context of NWMO's study approach, the definition of the objectives was designed to reflect the values and concerns of Canadians, as expressed in the ten questions outlined in NWMO's discussion document, and the dialogue about them that ensued in the months which followed. With this in mind, the Assessment Team designed:

- An overarching objective: "to select an approach for the management of used nuclear fuel that is the most socially acceptable, technically sound, environmentally responsible, and economically feasible, and which reflects the ethics and values of Canadian society".

- Eight objectives that must be met to achieve the overarching objective: Figure 4-4 shows the overarching objective along with the names of the eight second-level objectives.

The Assessment Team set some rules to govern the identification of these eight objectives. For example, any objective selected had to be a "fundamental choice objective" – and not a process objective. In other words, the objectives needed to capture what we as Canadians desire to achieve as an end point (e.g. secure facilities, environmental integrity), rather than the means we use to achieve it (e.g. decision-making process).

Figure 4-5 broadly outlines the relationship between the original ten questions and the objectives used by the Assessment Team.

Current and Future Generations - Setting the Time Horizon of Analysis

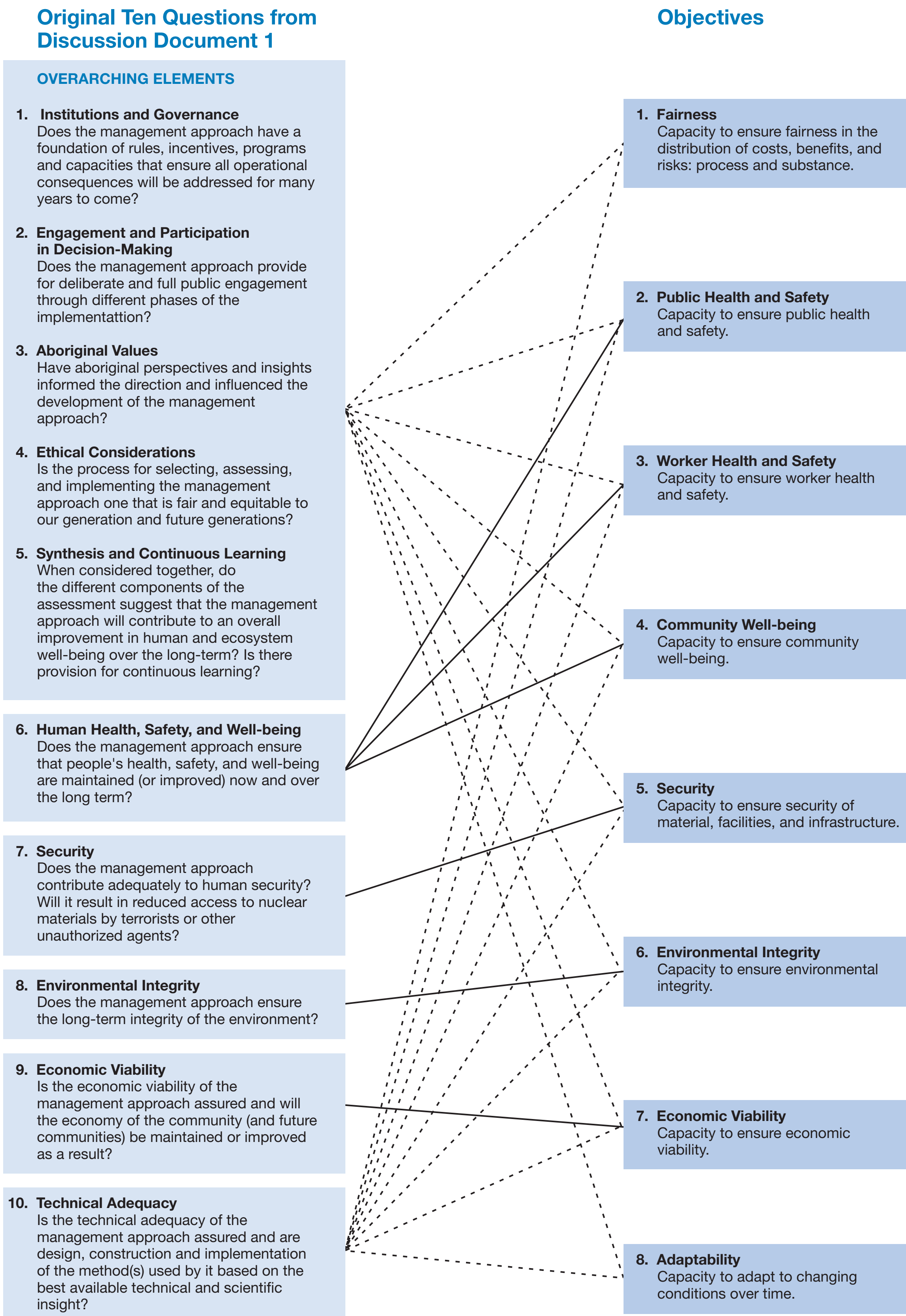
The ten questions in the NWMO's first discussion document clearly conveyed a concern for the needs of both current and future generations in assessing management approaches. The Assessment Team spent considerable effort on the subject of how best to address this issue, reasoning that those now living might justifiably attempt to speak for our own generation, and try to allow for a wide range of values. However, we cannot justifiably presume to know or assume the values, concerns, and thus the objectives that will drive the decisions of future generations over the very long time horizon of the management of used nuclear fuel.

While it is not possible to know those future objectives, the Team formally recognized an obligation of the present generation to: (1) ensure that choices made today do not impose undue risks, obligations, or burdens on future generations; and (2) facilitate choice for future generations rather than foreclose options. Such choices may be related to, for example: the use of materials that might today be considered hazardous waste and tomorrow a valuable resource; ensuring that future generations are free to use their resources for their own priorities, rather than cleaning up waste problems we have left for them; and/or the ability to experience healthy people and a healthy environment uninhibited by stress imposed as a result of today's human activity.

To proceed, the Assessment Team focussed on comparing the various technical methods against each of the objectives, using two time periods of analysis. In taking this approach, the Team attempted to systematically identify and reflect upon the implications to future generations of the decisions we make today.

Figure 4-5 Elements of the Objectives Hierarchy Plotted Against the Original Ten Questions

Note that the numbers assigned to each of the ten questions and eight objectives do not imply a prioritization of concerns. All are equally important.



Period 1 – from the present until 175 years from now. During this period, the selected facility would be built and operated. Filling would be completed. Environmental and ecological aspects would evolve but still maintain reasonable similarity to the present. Within this period, there would be reasonable confidence in engineering predictions and the characteristics of human-made objects as well as the continuity of present institutional and economic structures and activities. It is also the period when the radioactive wastes produced in the period from 1950-2010 will have cooled to near-ambient temperatures and many of the activation products in the fuel will have significantly decayed. This period roughly corresponds to the "seven generations" used by Canadian aboriginal peoples as the timeframe within which each generation should plan. Any succeeding generation would have six generations to learn from, and if necessary adjust, the decisions made by the previous generations.

Period 2 – beyond 175 years. In this time period, aboriginal wisdom and future scenarios work conducted by NWMO suggest that it is not prudent to assume social, institutional, or environmental continuity from the present. Although it is possible to predict the geological characteristics with some confidence, the vagaries of physical environmental conditions and human-induced or natural stresses on the ecosystem make any assessment of the human-ecological interactions extremely speculative. The radioactivity of nuclear fuel wastes will continue to decay, but isotopes of chlorine, caesium, strontium and plutonium will remain radioactive and pose potential, although declining, risks.

CHAPTER 5 / AN ASSESSMENT

DISCUSSION OF OBJECTIVES

The following discussion outlines:

1. Each of the eight objectives, as they were understood by the Assessment Team;

2. For each objective, a principle for guiding the assessment of the objective. The Assessment Team developed the principles as statements of what actions designed to achieve a given objective should strive for, and in that way the principles serve as a guide for the assessment (the principle is not intended as a standard or criteria which must be met); and

3. A preliminary description and comparative assessment of each method by objective.

In the scoring of the management approaches, the Assessment Team recorded both the range of scores assigned by individual Assessment Team members (noted by a bar), as well as an average score for the group (noted by a line). The score is recorded on a scale for which 0 denotes very poor performance (extreme adverse impacts) and 100 denotes excellent performance on objective. A fuller description of the scoring methodology is available in the Assessment Team report.

The text which follows is extracted from discussion contained in the Assessment Team's report. The actual words of the Team are used deliberately to be faithful to the process of assessment through which observations and conclusions were developed. The complete Assessment Team report is available on the NWMO website.
(www.nwmo.ca/assessmentteamreport)

Objective 1

Objective 1: Fairness

Objective: The selected approach, among other things, should produce a fair sharing of costs, benefits, risks and responsibilities that is regarded as being as fair as possible now and in the future.

General principle for guiding the assessment of fairness. The management system and technologies used should ensure that the persons and communities likely to be most directly affected by any activities or consequences of the management of the used fuel have opportunity to participate in decisions in advance of the establishment of the used nuclear fuel management facility; that characteristics of the distribution of short-term and long-term health, environmental, or economic costs and obligations are understood and accepted at the time of decision; and that adequate attention is given, as far as is possible by the current generation, to intra-generational, inter-generational and inter-species aspects of the system selected.

In its assessment of fairness, the Team considered issues of both substantive and procedural fairness. Substantive fairness includes consideration of how the costs and benefits associated with the approach would be distributed across various people and between humans and other species. It also includes consideration of inter-generational fairness. A key question for inter-generational 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 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 notionally identified in Figure 5-1.

The fairness scores assigned by the Team are shown in Figure 5-2. As indicated, on average, the Assessment Team viewed the deep geological repository approach as the most fair, followed by centralized storage and on-site storage. On-site storage was viewed as least fair for several reasons. Perhaps most importantly, the on-site 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 storage and geological repository approaches involve facilities that could be located away from existing communities, thus lessoning the unfairness of involuntarily subjecting many people to additional risks. Indeed, the opportunity for public participation in the locating of a centralized storage or a geological repository facility was seen to be a positive attribute with regard to fairness, assuming that the siting process would be a voluntary one.

Another fairness concern with the on-site storage approach is that it would force future generations to take responsibility for dealing with the fuel consumed by this generation through the requirement to actively manage the waste to ensure safety. If not managed properly, a burden of risk has been shifted to future generations. The centralized storage approach also requires future generations to continue to maintain the facility. However, the costs and other burdens would likely be higher in the case of on-site storage given that multiple facilities would be involved.

Although the geological repository was rated highest for fairness, the range of scores assigned to geological repository was, as shown in Figure 5-2, relatively wide, indicating disagreement among the members of the Assessment Team. Those that scored a geological repository very high felt that a major fairness advantage of a geological repository was the fact that it would remove the burden on future generations to take further actions. Those that scored it less highly were concerned that a geological repository removed too much flexibility from future generations to make their own choices about how the waste should be managed, and provided too little opportunity to monitor the performance of the system and take corrective action. Another disadvantage of a geological repository is that it would provide less opportunity for citizen participation over the long term, since a geological repository, by its nature, pro-

Figure 5-1 Fairness Influence Diagram

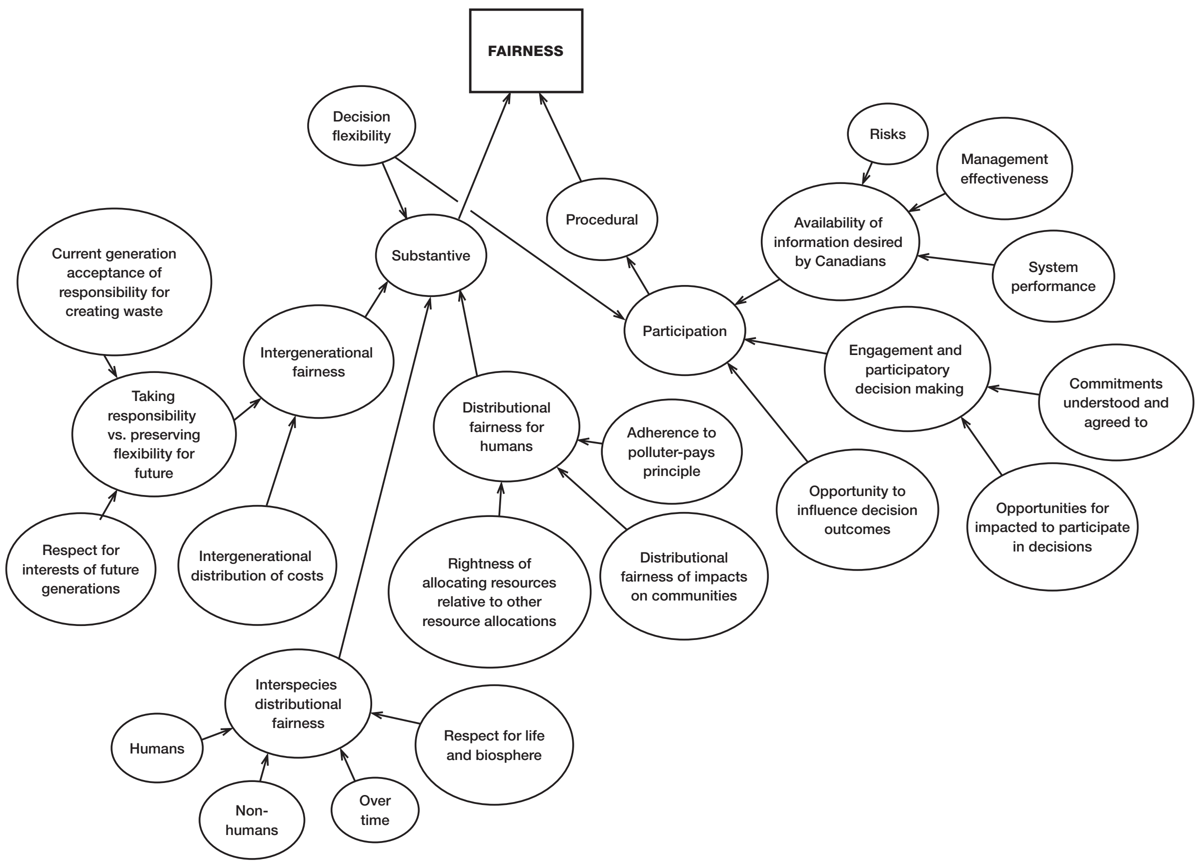
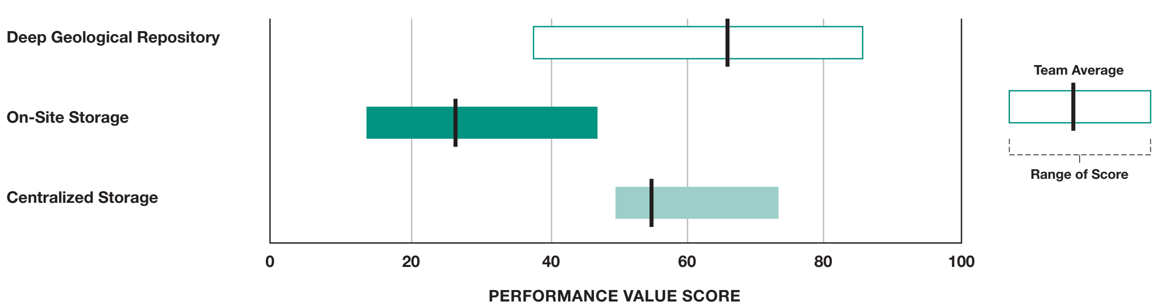


Figure 5-2 Fairness Scores



vides little flexibility for making fundamental changes without considerable additional costs.

Nevertheless, nearly every member scored a geological repository higher than the other two approaches. Other advantages cited for a geological repository included the fact that the current generation would bear most of the costs, which was regarded as fair since our generation also obtained the most immediate and direct benefits from using the fuel. Another fairness advantage of a geological repository is that, because the costs would need to be "paid up-front," there is more assurance that those costs would be paid by the utilities, consistent with the "polluter pays" fairness principle. While it is true that a geological repository makes it more difficult for future generations to have flexibility to shift to another approach, it is also possible that on-site or centralized storage may limit future flexibility. For example, if at some point in the distant future it was decided that used fuel should be buried, it might at that point be impossible to find a site with suitable geology that was not already highly populated with people and/or insufficient monies may remain to fund it.

Objective 2: Public Health and Safety

Objective: 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 the transportation of used nuclear fuel or other operations associated with the approach.

General principle for guiding the assessment of public health and safety. The management system and technologies employed should be such that the direct or indirect risk to the health and safety of individuals or communities in areas that could be affected by the used nuclear fuel management facilities in the near future is fully acceptable according to current safety standards; that the possibilities of unplanned events that could present unexpected risks or stresses have been considered and that appropriate contingency action provided for; and that there is no foreseen possibility of greater risks to the public from the used nuclear fuel facility at any time in the future.

Objective 2

The public health and safety afforded by each approach was assessed under both the short (0-175 year) and long (>175 year) timeframes. 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. The complete list of influences considered is notionally identified in Figure 5-3.

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. None of these risks was estimated to be large with any of the approaches. However, with a geological repository or a centralized approach, large quantities of used fuel would need to be transported away from the reactor sites. Even though the risk of release of radioactive material was judged to be low, the vehicles involved might contribute to collisions and other traffic-related accidents that could cause injuries to the public. The main "off-normal" 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.

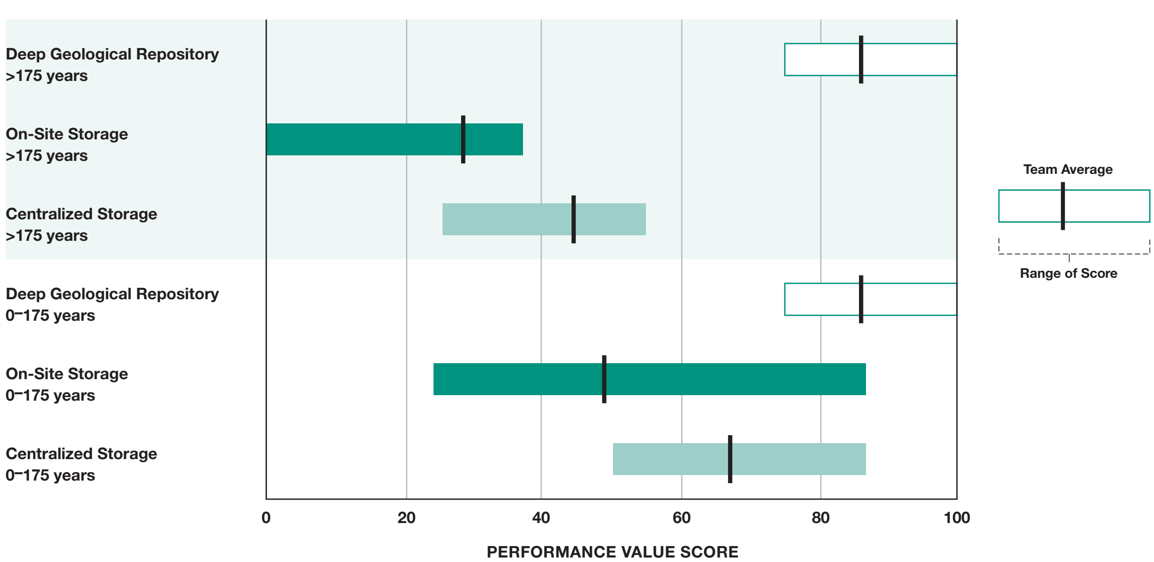
Figure 5-4 shows the range of scores assigned by the Assessment Team. As indicated, on average, on-site storage was estimated to pose the most public health and safety risk, both in the short and long terms. The primary reasons are reflected in the influence diagram of Figure 5-3. With the on-site storage approach, used nuclear fuel continues to be stored at the existing reactor sites. Since these sites are typically in industrial, populated areas, a mishap could potentially expose a larger number of people. Over the long time-period involved, the potential for events that might trigger exposures increases. For example, there is some chance that extreme natural events such as very high winds, rise in sea level, global warming or cooling, and earthquakes could damage the facility, particularly given the location of many of these facilities on large bodies of water. The broad range of scores assigned to on-site storage reflects differences of opinion among the Team over the likelihood and consequences of these and other such events. The centralized storage approach suffers these same concerns, however, since it would require only one facility that would likely be remotely located, the risks are considered not quite so great.

The on-site and centralized storage facilities lack the natural barriers afforded by burying the waste deep underground, and for this reason the security of the facilities depends primarily on 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. As well, although we have a safety conscious society now, the same cannot be guaranteed for the future. Since on-going facility operation will become routine, there is a danger that safety operations may become lax over time. Again, the risks may be lessoned somewhat under the centralized storage approach. Since all of the fuel would be located in a single location and since the facility will be expressly sited and designed to facilitate security, it was judged to be less risky.

As shown, on average the geological repository was estimated to provide the least public health and safety risks. The facility would be located in a remote region selected to minimize the likelihood that any material released would come in contact with people. Unlike the centralized or on-site storage approaches, security does not depend on human institutions. Being located deep underground, the radioactive materials would be very difficult to access. The Assessment Team believed that burying the waste caused the geological repository to have a public health and safety advantage relative to on-site and centralized that would increase over time even though, in the unlikely event of a containment breach, the breach would be relatively more difficult to detect and address. •

Figure 5-3 Public Health and Safety Influence Diagram

Figure 5-4 Public Health and Safety scores



Objective 3: Worker Health and Safety

Objective: Construction, mining, and other tasks associated with managing used nuclear fuel can be hazardous. It is desirable that the selected approach not create undue or large risks to the workers who will be employed to implement it.

General principle for guiding the assessment of worker health and safety. 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 in any way involved with the used nuclear fuel facility will 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; and that workers engaged in future monitoring or maintenance activities will not be subject to risks greater than those acceptable today.

The considerations for assessing worker health and safety were in many ways similar to those used to assess public health and safety. Risks were separately estimated for the same two time periods. They were also 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. The complete list of influences considered is notionally identified in Figure 5-5.

Under normal operating conditions, worker risks associated with the following operations were considered: construction, transportation, fuel handling, and monitoring. None of these risks was estimated to be unusually large compared to the normal risks experienced by workers in construction and other industrial settings. All of the approaches involve some risks associated with handling of the fuel, but the use of robotics minimizes the chance of workers being exposed to radioactivity. Although the geological repository would require the relatively dangerous tasks of mining and earth moving, much of the work would be mechanized and a relatively small number of workers would be directly involved. Both the geological repository and a centralized storage approach would involve transportation of used fuel, with the attendant risks of traffic accidents and other dangers to drivers. The main "off-normal" risk scenarios considered included an extreme construction accident, accidental radiological exposures, and extreme fuel handling accidents.

Figure 5-6 shows the range of scores assigned by the Assessment Team. Overall, on average the risks to workers were judged to be relatively low. 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 safeguards present, they are unlikely to cause serious health consequences. As indicated, on average, centralized storage was estimated by the Team to pose the most worker health and safety risk in the short term. The primary reason for this is that the centralized storage approach produces worker risks during the construction of the facility, during fuel transportation, and then repeatedly as the containers degrade and the fuel must be repackaged. Thus, the risks are greater than with a geological repository because more handling and packaging would be required. Also, workers will encounter a wider range of conditions compared with the geological repository, potentially increasing the chances of mishap. Furthermore, construction risks extend into the long term, due to the fact that the facility will essentially need to be rebuilt roughly every 300 years.

On-site storage was scored best in the short term, largely because it involves minimal construction risks and no transportation risks, but highest in the long term, because it has all of the worker risk problems associated with the centralized storage approach plus would require continuing operations involving more workers at multiple sites with differing conditions. Like the centralized storage approach, institutions must continue to function well to ensure that the safe practices that protect workers (and others) do not decline. If something goes wrong, workers will be called upon to correct the problem. However, so long as institutions remain effective, serious exposure risks to workers are unlikely.

On average, the geological repository was scored almost as low as centralized storage in the short term, and some Team members scored it even lower. The primary reason for this is potential for a large-scale mining accident. Other members did not consider this risk serious, however, arguing that Canada has much experience in mining. Furthermore, the trend toward robotic mining decreases the likelihood of a major disaster. The geological repository was scored highest (at the "ideal" level) on long-term worker risk because there are essentially no workers beyond the 175-year period. Once the geological repository is closed, it does not require additional worker activities.

Figure 5-5 Worker Health and Safety Influence Diagram

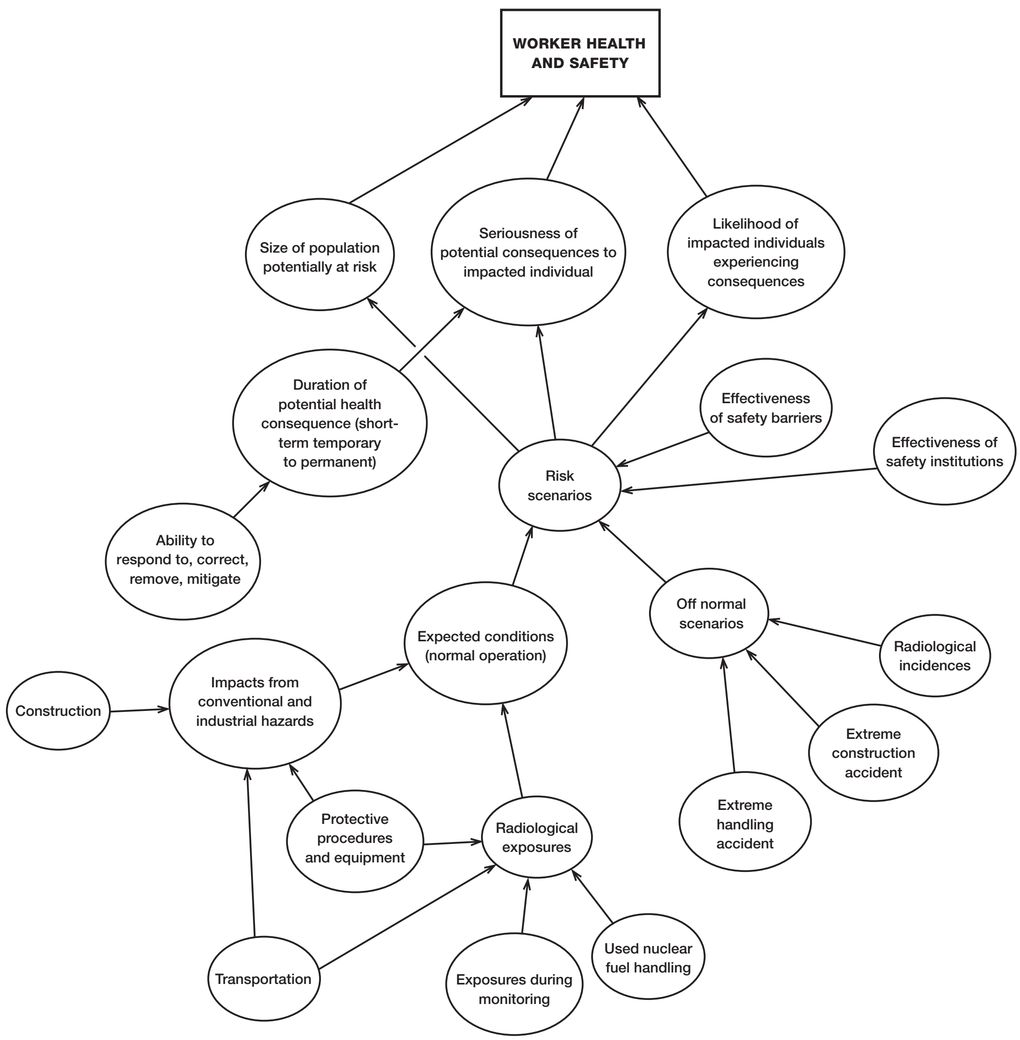
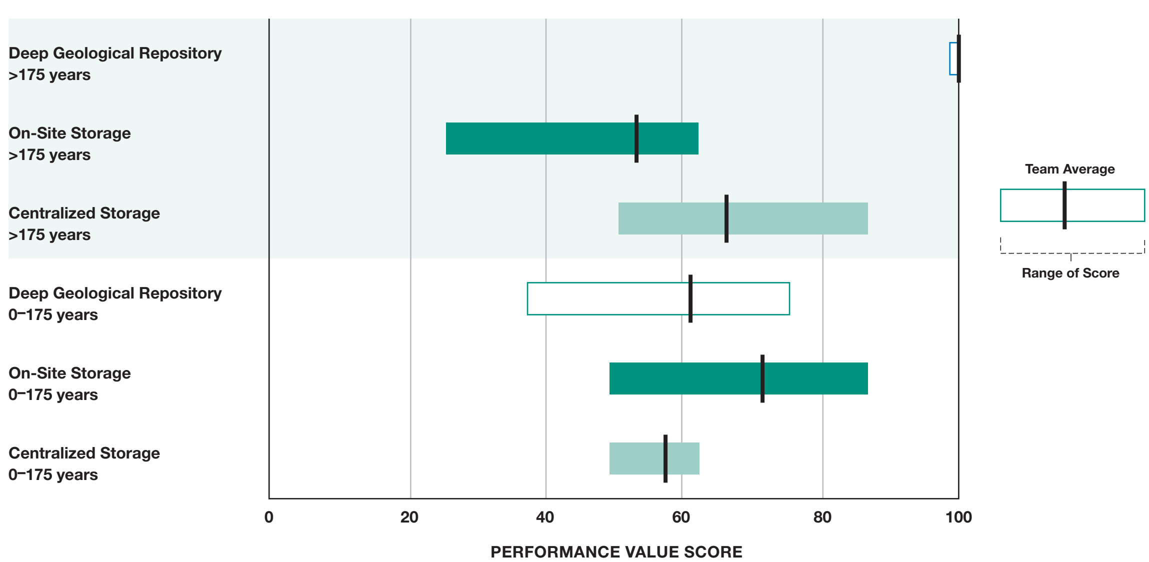


Figure 5-6 Worker Health and Safety scores



Objective 4

Objective 4: Community Well-being

Objective: The approach that is selected and the way it is implemented will determine the specific communities that are impacted and the nature of those impacts. For example, towns near the facilities required by the approach may be affected economically through impacts on jobs and property values. Differing attitudes within a community can lead to polarization that can severely degrade the social fabric. Nearby communities are not the only ones, however, that may be implicated. Many groups may feel that their shared interests are affected regardless of whether they live physically close to used nuclear fuel management facilities. Depending on the sites that eventually are proposed for consideration, Canada's Aboriginal peoples may have a particularly significant stake.

General principle for guiding the assessment of community well-being. The organizational system and the technologies selected for management of used nuclear fuel should be such that the nearby communities and all those in the region that could be involved in, or affected by, the construction, filling, maintenance or monitoring of the used nuclear fuel management facility, or by the transport, manufacture of containers or other related industrial activities, will not be adversely affected through chemical contamination or other environmental disruption, but will benefit as much as possible from the economic activity; and at the same time not be handicapped socially or culturally by virtue of being host to wastes which other parts of the country do not want. Implications for the well-being of all communities with a shared interest are to be considered in the selection and implementation of the management system and related infrastructure.

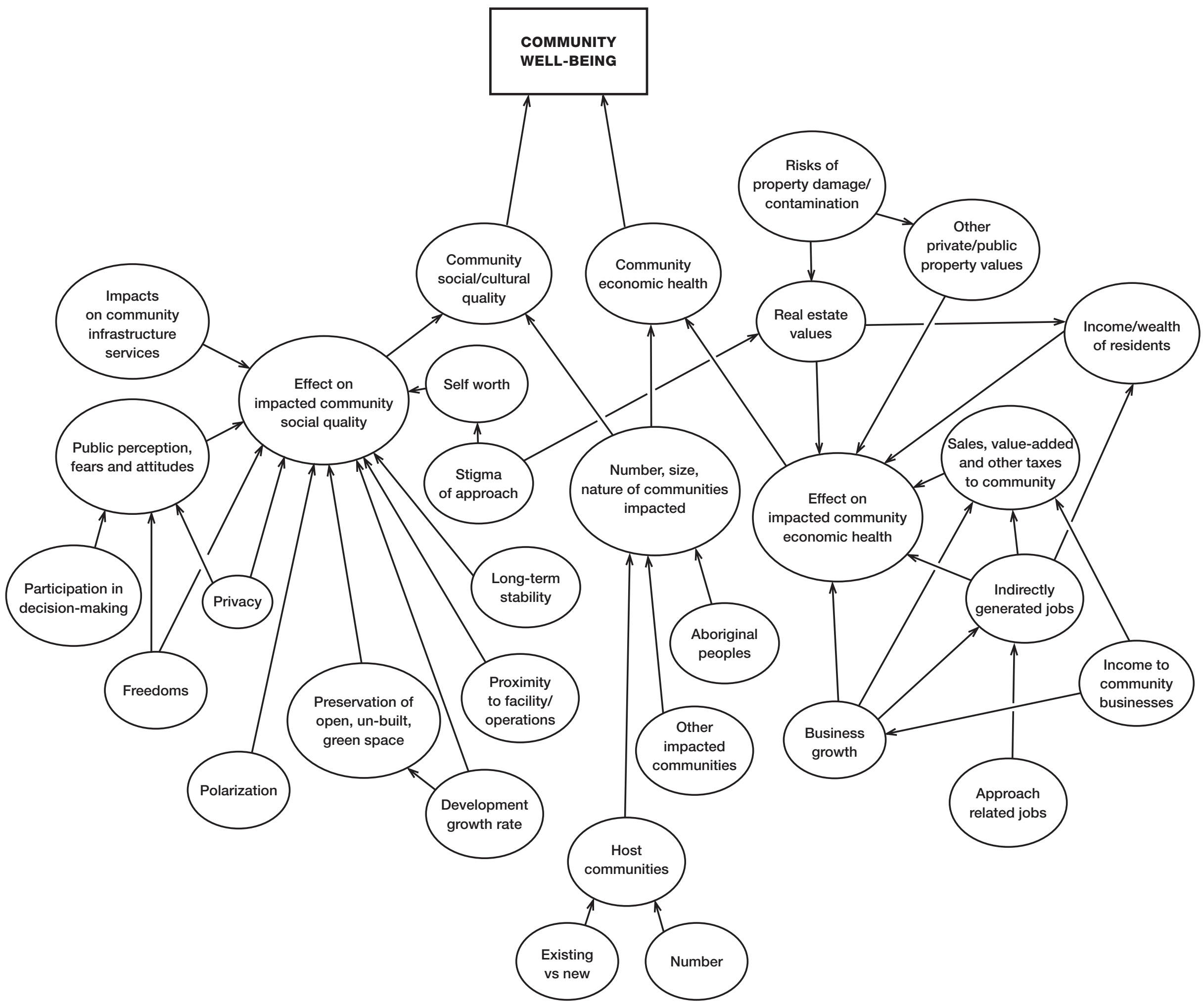
The assessments with respect to community well-being considered both the likely economic impacts of the approach and the potential effects on social and cultural qualities of impacted communities. On the economic side, consideration was given to potential effects on property values, jobs and businesses. Potential social and cultural impacts include raising fears and concerns of citizens and the potential for community polarization (e.g., contrasting beliefs between those who support and those who oppose locating a facility near their community). Some may see living near a radioactive waste management facility as placing a stigma on their community. The complete list of influences considered is notionally identified in Figure 5-7.

The nature of the community impacts will depend, in part, on the nature of communities that are impacted. Smaller, more remote communities may be more vulnerable to impacts. A key determinant of the community impacts in the case of any newly constructed facility will be whether or not the community is a voluntary host. Also important will be how the community manages the opportunities created by having the facility in their midst. Constructing a new facility in a lightly populated area could produce a "boom and bust" cycle with serious adverse effects. On the other hand, the relative permanence of a radioactive storage facility should lead to other development in the local area. It is anticipated that whatever approach is implemented, the local communities would be offered benefits that would at least partially mitigate or compensate for the adverse impacts that would otherwise occur.

As noted previously, to be impacted, a community does not necessarily need to be physically close to a waste management facility. The approaches that require transporting waste away from existing reactors would likely raise the concerns of communities along the transportation routes. Many other communities, including Aboriginal peoples, may be socially or culturally impacted based on their unique values and perspectives, irrespective of where they live.

The community well-being scores assigned by the Team are shown in Figure 5-8. The approaches were rated similarly in the initial time period. The reason for this is that each of the approaches has its own advantages and disadvantages, and these tend to average out so that it is difficult to argue (at least

Figure 5-7 Community Well-being Influence Diagram

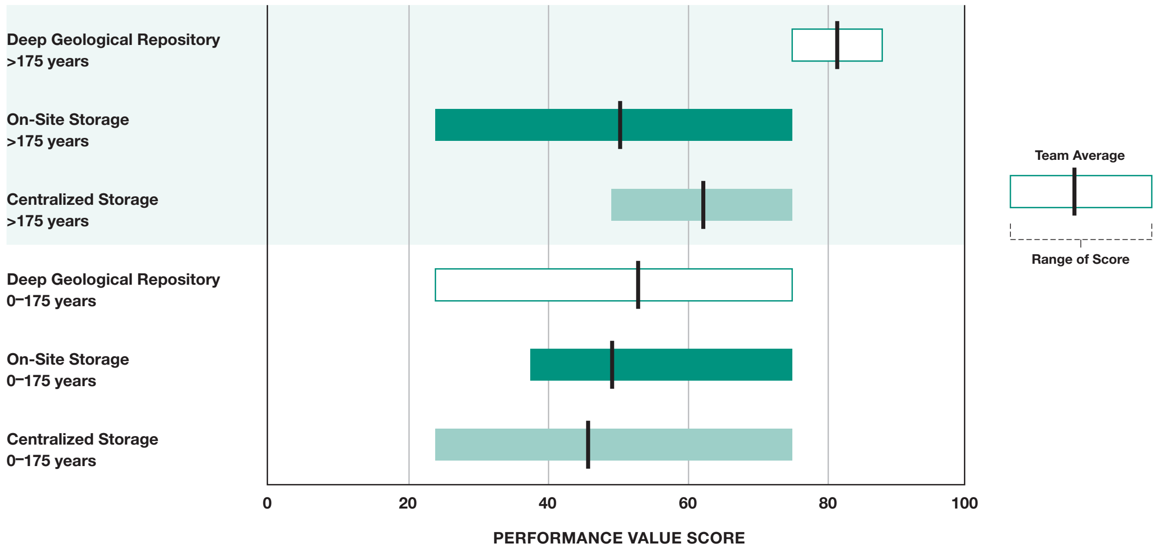


within the near-term time-period) that one approach is significantly better than another with regard to impacts on communities. Furthermore, whatever approach is taken, the fact that a long-term solution is being implemented is expected to have a positive impact on Canadians in general.

The ranges in the initial time period are also similar. All three are quite wide. This is because the community impacts under each approach depend on similar, very significant uncertainties, such as the processes by which choices are implemented, the technical performance of the facilities involved, and the effectiveness of political and social systems that promote community welfare. However, as illustrated, the low end of the ranges for the centralized storage and geological repository approaches are below that for the on-site storage approach. This is because some Team members believe that creating a new facility in a new location will necessarily create more adverse impacts on communities than leaving the waste where it is.

The on-site storage approach provides a good example of the tendency for positive and negative characteristics to balance out. Although on-site storage would involve multiple facilities near existing, relatively highly populated areas, the Team reasoned that local communities have become more accustomed to nuclear materials and, therefore, would experience less social disruption than would be the case for a community dealing with a newly constructed facility. Changing the role of the reactor storage sites from temporary to long term would involve significant facility upgrades. Some might see the project positively, for example, as an improved and more robust facility. On the other hand, 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. Furthermore, the proximity of a facility that is acknowledged to involve risks may be a target for citizen legal action.

Figure 5-8 Community Well-being scores



The centralized storage and geological repository approaches have the advantage of allowing a voluntary process for picking the site of the respective facilities, although there is less flexibility for choosing a site in the case of a geological repository because of its requirements for the host geology. Being more remote, fewer communities and fewer people might be directly impacted. However, the centralized storage facility might well be located closer to people than a geological repository, and might therefore impact more people.

In the case of the centralized storage and geological repository approaches, the economic impacts that do occur would have some positive attributes, for example, the construction of improved roads and other infrastructure as well as generating high-tech jobs. However, most of the effects would be relatively short-lived. Also, the social impacts of such changes could be perceived by many as negative, given that remote communities are often populated by people who have made deliberate choices to live in private, largely un-built, natural environments.

Both the geological repository and centralized storage facilities require waste transportation, which may raise concerns for those who live near or travel on the transportation routes. On the other hand, when the geological repository facility is closed, its physical nature will not create the same visual reminder and associated stigma that a surface facility may.

While the importance of factoring in and addressing the concerns of Aboriginal peoples is recognized in general, and specifically concerning this objective, the Assessment Team did not feel capable of anticipating the perspective of Aboriginal peoples. The perspective of Aboriginal peoples will need to be understood and brought in to the assessment in regard to assessing the methods on community well-being, as well as on each of the other objectives identified in this assessment.

Over the longer time period, the Team agreed that the geological repository would create the least adverse community impacts. No significant long-term operations are required under a geological repository, making it likely that the facility would be largely forgotten in the long term. As indicated in the health and safety scores presented previously, the geological repository, in the long term, is expected to be safer, which brings the additional benefit of reducing the likelihood that adverse performance will be a source of community concern. However, the limited opportunity to demonstrate this performance may be a source of lingering concern among some in the community.

The larger uncertainty regarding the performance of on-site storage over the long term reflects the greater challenge posed by the need to successfully manage multiple facilities. Inadequately managing a facility in one community, for example, would likely raise serious concerns on the part of other communities within which facilities are located.

Figure 5-9 Security Influence Diagram

Objective 5

Objective 5: Security

Objective: The selected management approach needs to maintain the security of the nuclear materials and associated facilities. For example, over a very long timeframe, the hazardous materials involved ought to be secure from the threat of theft despite possibilities of terrorism or war.

General principle for guiding the assessment of security. Without infringing on the freedoms of individual Canadians, the used nuclear fuel management system and the technologies selected should be such that unauthorized access to the used nuclear fuel management facility will be exceedingly difficult, and that attempts at unauthorized access will be detected within a system that ensures appropriate action; it should assure Canadians that their health, safety and the integrity of the environment will not be compromised over time because of the presence of the used nuclear fuel and their potential for being involved in social disruption or institutional changes.

An approach must ensure the security of both nuclear materials and the facilities that manage them. Although a loss of nuclear material would likely pose health and safety risks to Canadians, maintaining security would be an objective even if the lost fuel was sure to be transported out of Canada. Canadians would not want the people of other countries to be at risk from radioactive materials stolen from Canada. Thus, security is a fundamental objective, not merely a means objective for 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 complete list of influences considered is notionally identified in Figure 5-9.

Figure 5-10 Security scores

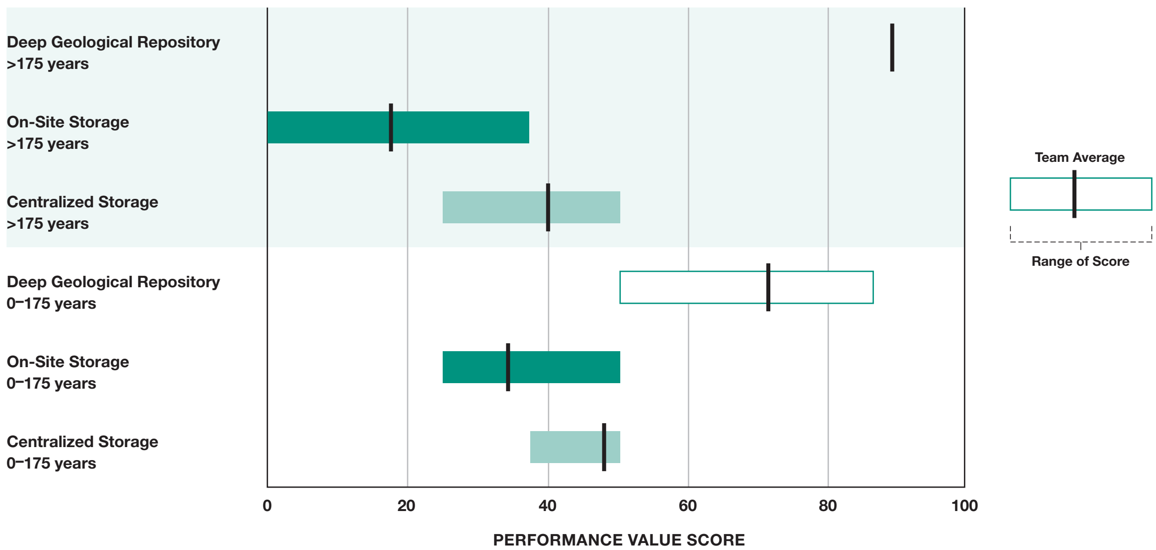
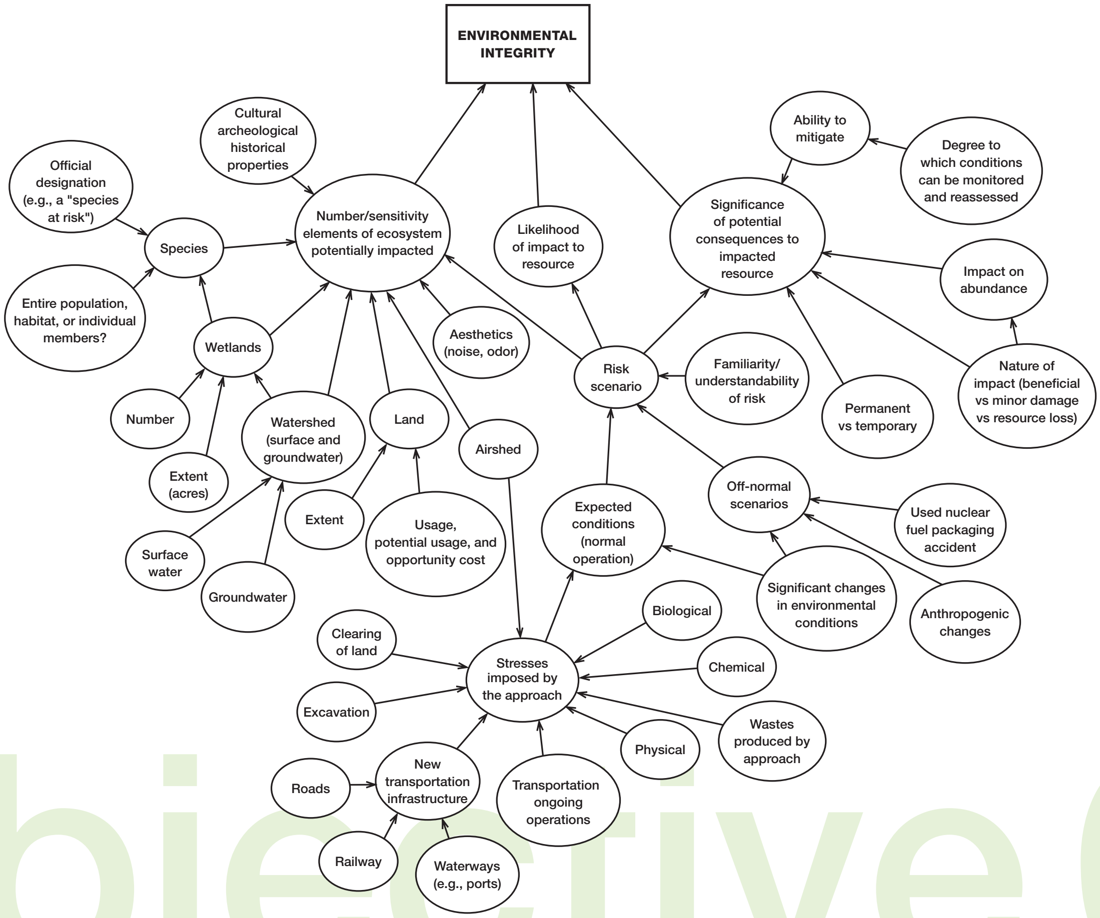


Figure 5-10 provides the security scores assigned by the Team. The nature of spent fuel (e.g., its high radioactivity) makes it difficult to steal during the first several hundred years. Nevertheless, the Assessment Team concluded that security risks do exist and are likely most significant during transportation and repackaging. As indicated by the average scores, in the short- and long-term time periods, the on-site storage approach was estimated to be the least secure. Locating sensitive materials on the surface is inherently less secure than placing them underground. After roughly 300 years, radiation levels will drop to the point that the waste is no longer self-protecting, thus increasing the security risk. Because the on-site storage approach involves multiple facilities in populated areas, it must rely heavily on the integrity of institutions to maintain security over the long term. Although on-site storage does not require transporting the fuel, the need to periodically repackage the wastes at multiple sites was estimated to create a significant challenge for ensuring security.

The centralized storage approach was estimated to do somewhat better, due to the fact that the facility could be sited in a location and setting which would facilitate providing security. However, because the waste would be concentrated in one location, it might be a more attractive target for terrorist activities. Also, there is the near-term threat of a security breach during transportation of the material to the facility.

The geological repository was estimated to provide the greatest security, because, once underground, the waste would be difficult to access. Thus, the geological repository was rated highly with respect to security in the post-175-year time period. Even then, however, security concerns would still exist. Indeed, a closed geological repository would in many respects be similar to a plutonium mine. In the short term, before the waste has been emplaced, security risks for a geological repository would likely be greatest during waste transportation. Security risks could also be increased if the facility became a target for civil disobedience.

Figure 5-11 Environmental Integrity Influence diagram



Objective 6: Environmental Integrity

Objective: The selected management approach needs to ensure that environmental integrity over the long term is maintained. Concerns include the possibility of localized or widespread damage to the ecosystem 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).

General principle for guiding the assessment of environmental integrity. The management system should be designed and technologies selected such that the physical, chemical and biological stresses on the environment imposed by the used nuclear fuel management facility, including cumulative effects, changes over long time periods, 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, thus ensuring the long-term integrity of the environment.

Assessing the degree of impact each approach would have on the natural environment required consideration of many factors, including the number and sensitivity of elements of the ecosystem that would potentially be impacted, the likelihood of impact to each type of resource, and the significance of the potential consequences to impacted resources. Many different types of valued environmentally sensitive resources could be affected, including plants and animals, land, surface water bodies and 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, possible odours, 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 notionally identified in Figure 5-11.

It is, of course, very difficult to be precise regarding 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 on the environment that each approach would produce depend greatly on where the new facilities would be located, something which is not yet known. The long timeframes involved also add to the difficulty of being precise for all three of the approaches.

Figure 5-12 provides the environmental scores assigned by the Team. As indicated, the geological repository approach was estimated on average to perform the best with regard to the environment, particularly in the long time period. Multiple and robust barriers below-ground which do not require institutional controls lead the Assessment Team to score geological repository much higher than the other methods in the long term. In the shorter term, for which there is more overlap in the range of scores assigned the three methods, excavation of the geological repository facility would produce adverse impacts, however these impacts are expected to be localized and relatively short-lived. Unlike a centralized or on-site storage approach, there is no need for periodic repackaging and other operations at the facility that might place the environment at risk. The geological repository, like the centralized storage approach, requires waste transportation, but the environmental effects of this were not regarded to be substantial.

In the near-term period, the range of scores for the on-site storage approach extends to fairly low values. This is due to the greater susceptibility that multiple facilities would have to extreme weather and other natural events, plus the severe consequences that might occur should social instabilities occur that result in a site being abandoned. Even though the current reactor sites are in industrial areas, which are less sensitive from an environmental standpoint, they are located near water bodies (many are on the Great Lakes). Releases from the facilities could result in those water bodies becoming damaged. These concerns multiply in the longer timeframe. These are the primary reasons that the on-site storage approach shows a wider range of scores, both in the short- and long-term time periods. On the plus side, the on-site storage approach provides opportunities for monitoring facility performance, and the proximity to people and accessibility on the surface may mean that any environmental problems that develop might be more quickly noticed and fixed.

The centralized storage approach is expected to have better and more predictable environmental performance than the on-site approach, both in the near- and long-term periods. Not only is there just one facility, which puts less environmental resources at risk, that facility can be purposely located and built to reduce environmental risks. However, the fact that a centralized storage facility would likely be built in a remote location could be a disadvantage in terms of ensuring effective and continuing maintenance of its infrastructure.

Figure 5-12 Environmental Integrity scores

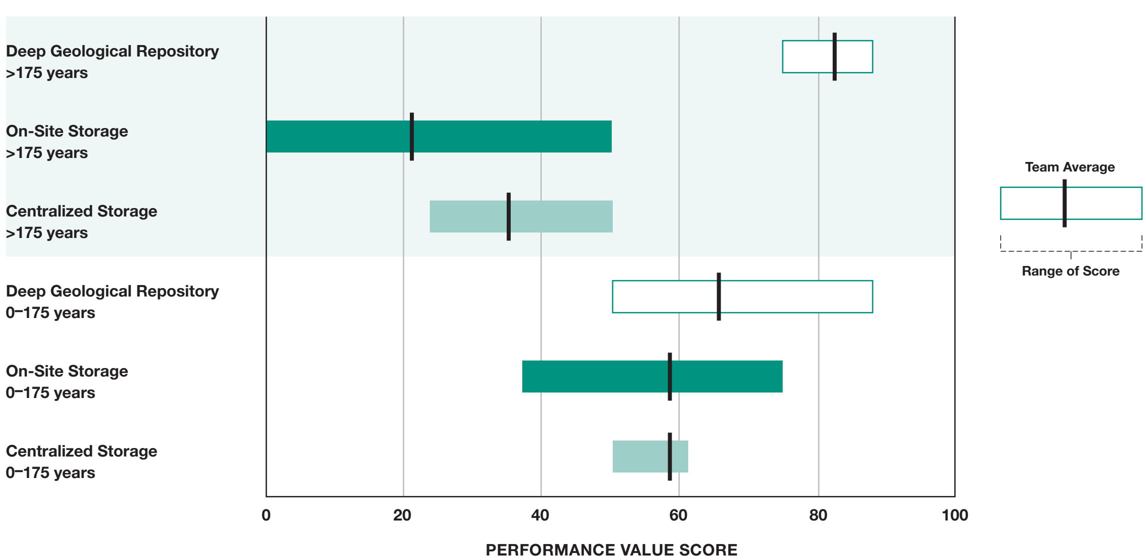
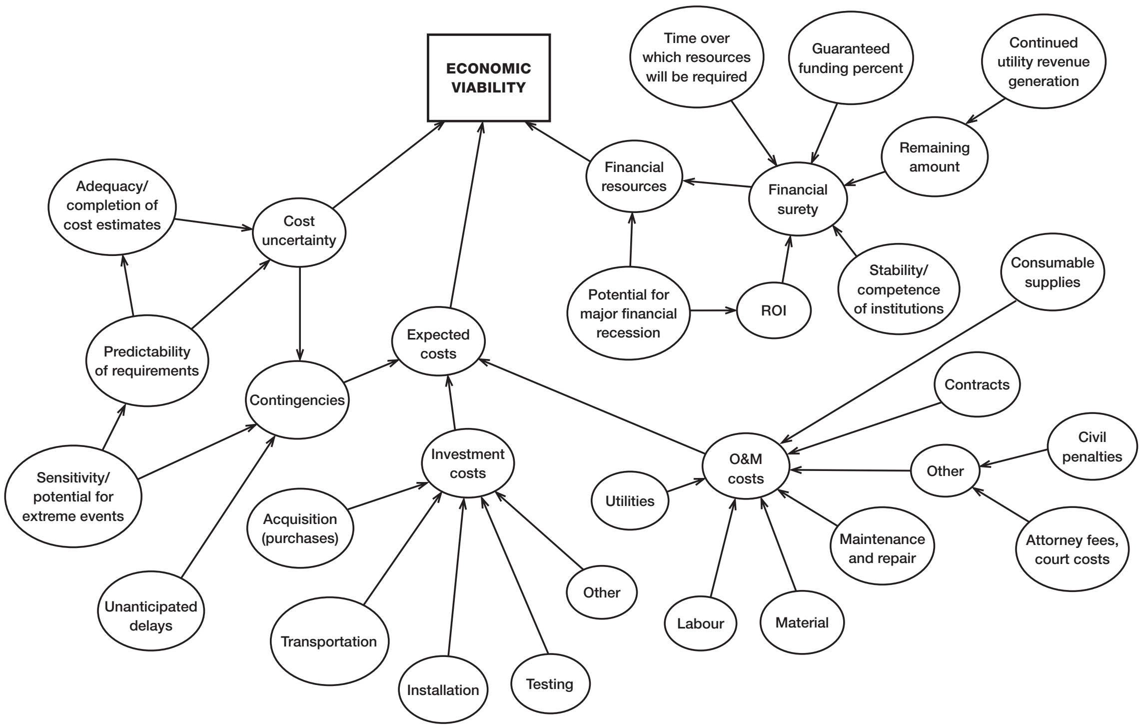


Figure 5-13 Economic Viability Influence diagram



Objective 7

Objective 7: Economic Viability

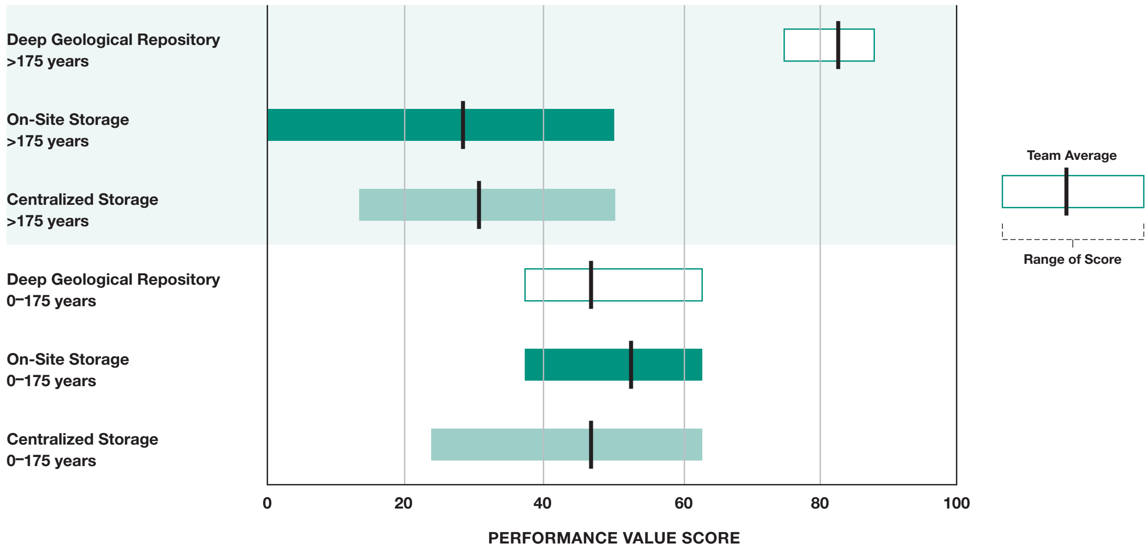
Objective: Economic viability refers to the need to ensure that adequate economic resources are available, now and in the future, to pay the costs of the selected approach. The cost must be reasonable. The selected approach ought to provide high confidence that funding shortfalls will not occur that would threaten the assured continuation of necessary operations.

General principle for guiding the assessment of economic viability. The system for managing used nuclear fuel, including the selection of technologies, must have cost estimates that are thorough and reasonable, include financial surety that covers the full facility life-cycle including construction, filling and long-term maintenance as required. All of this must be undertaken in a way that is fully transparent and accountable.

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 on-site and centralized storage approaches would continue over a very long time period. The complete list of influences considered is notionally identified in Figure 5-13.

The scores assessed by the Team are shown in Figure 5-14. In the initial time period, on average on-site storage was estimated to be most economically viable. It presents the least up-front costs with the least cost-uncertainty, since Canada has much experience with the type of technology required and costs involved through on-going interim storage of used nuclear fuel. Over the initial time period especially, there is reasonable confidence that continued

Figure 5-14 Economic Viability scores



sales of electricity will provide sufficient funds for financing the approach. There was less confidence in the economic viability of the centralized storage and geological repository approaches. Since such facilities have not been previously constructed, there is much more potential for problems and delays, which would raise costs. The technology required for the centralized storage approach is, perhaps, better known than for geological repository, which might make it easier to estimate and control costs. On the other hand, at least the mining costs associated with the geological repository (ignoring the potential for delays) are relatively predictable. Many of the costs would be similar to that of a standard small mine, and Canada has considerable experience estimating such costs.

The geological repository would create the highest upfront costs, and experience in other countries indicates that the selection and characterization of a potential site can be expensive. The possibility also exists that an unforeseen breach of containment would produce future costs, including cleanup costs, but the likelihood was estimated to be substantially less than in the case of the aboveground approaches.

Even though the up-front costs with a geological repository would be very large, the fact that they would be over and done with relatively quickly gave most Team members more confidence in the financial surety of the geological repository approach. Nevertheless, some Team members believed that the very large, required upfront expenditure could not be managed. Experience with other large projects undertaken by the nuclear industry indicates that the costs of such projects can be greatly underestimated. Others, however, viewed the total costs as manageable, since they will likely represent only a small percent of electricity revenue although government guarantees would be necessary.

By comparison, the centralized storage approach might be less costly initially, but there are significant uncertainties. Like the geological repository, there would be substantial costs incurred in finding and characterizing a site. Also, like the geological repository, transport costs may be significant, and could increase if there are major delays. However, unlike a geological repository, there would continue to be significant cost requirements going into the future, as in the case for on-site storage. In fact, the range of scores assigned to on-site storage in the long-term time period extends all the way to zero, indicating that some members of the Assessment Team were very concerned about its long-term financial viability. In part, these low scores were related to concern over the possibility that localized or wide-scale political or economic problems might result in inadequate funding being provided to one or more of the on-site storage facilities.

The very high score for the geological repository in the long-term time period reflects the fact that a geological repository requires very few on-going operations following the closure of the facility. Once it is built and implemented, costs are essentially complete. This is an important advantage, given the difficulty of assuring adequate financial resources in the long term.

Objective 8: Adaptability

Objective: If something is adaptable, it means that it can be modified to fit new or unforeseen circumstances. Although this is an attractive feature for a selected approach, the objective of adaptability as defined here is broader. Adaptability is regarded as a fundamental objective for selecting an approach for the long-term management of nuclear fuel, not just a means to help ensure that the other objectives identified in the hierarchy can be achieved.

The reason that adaptability was identified as a fundamental objective derives from the very long time frame over which the approach must operate. Generations in the distant future may see things differently than we do today. They may have different objectives than those represented in Figure 4-4, or, at least, they may place very different weights on those objectives. It is desirable, therefore, that we facilitate the ability of future generations to pursue and attain their own objectives, whatever those objectives may be. Thus, adaptability reflects our desire for an approach that provides flexibility to future generations to change decisions. It also includes our desire not to place burdens or obligations on future generations that will constrain them. Furthermore, adaptability, as defined here, includes consideration of the degree to which the selected approach is able to function satisfactorily in the event of unforeseen "surprises".

General principle for guiding the assessment of adaptability. The system for management of used nuclear fuel should be adaptable and flexible, and capable of adjusting technologies and procedures if new information is obtained or new equipment or materials become available that will assure or improve the integrity of the management system and, possibly, reduce the costs of establishment, maintenance, and monitoring. Similarly, the system should preserve the ability of future generations to make decisions that they see as being in their best interests.

As indicated previously, the Assessment Team adopted a broad definition of adaptability when scoring the approaches against this objective. Adaptability includes not just the flexibility allowed by the approach for making changes, but also consideration of the need for potential changes. An approach that is more resistant to surprises (e.g., less potential for catastrophic and chronic failure of containment), for example, is less likely to need to be changed. In addition, consideration was given to information that would be available for supporting changes and to the likely availability of mechanisms and resources for making such changes over the long term. Finally, the degree of accountability provided by the approach was also regarded as a factor influencing adaptability. As with some of the other objectives, how the selected approach is implemented would have a significant bearing on its adaptability. Regardless of which technical approach is selected, the management approach needs to be designed to achieve adaptability. The complete list of influences considered is notionally identified in Figure 5-15.

The adaptability scores assessed by the Team are shown in Figure 5-16. As indicated, in the initial time period, the approaches were rated as roughly equal in terms of adaptability. The reason for this is that the different aspects of adaptability considered by the Team tended to balance out. For example, the centralized storage and on-site storage approaches offer easier access to the waste, facilitating the ability to make changes. On the other hand, these approaches were regarded as more vulnerable to various risk scenarios compared to the geological repository approach. One could argue that flexibility is really only important when it is necessary to ensure safety. A geological repository may be less flexible, but flexibility may be less needed given its lower susceptibility to surprises. In the short-term, at least, the relative advantages and disadvantages tended to balance out.

Even though a geological repository ultimately reduces flexibility to move the waste, the Assessment Team felt that making the decision in the short run to move toward a geological repository does not foreclose much flexibility within the first 60 years or so before the repository would be closed. The decision of whether and when to close the facility would be made by a future generation, presumably aided by advances in science and technology, providing some measure of adaptability. By comparison, on-site storage provides no flexibility to select the locations for the facilities, and some constraints would naturally be placed on the designs that could be used. Thus, the geological repository was not scored significantly lower in the near-term period than the other approaches.

Once built, a geological repository facility is likely to be loaded with waste and eventually closed, thus constraining options and reducing flexibility available to future generations. However, as indicated by the scores assigned in Figure 5-16, on average the Assessment Team was more confident in a geological repository. It effectively takes the hazardous material out of the accessible environment. Thus, it is less vulnerable to extreme events than the other approaches. The centralized storage approach, and to an even greater extent the on-site storage approach, create long-term costs and institutional requirements that would burden future generations, and which would compete for resources with other valued objectives of the time. For these reasons, on-site storage, in particular, was rated relatively poorly with regard to long-term adaptability. •

Figure 5-15 Adaptability Influence diagram

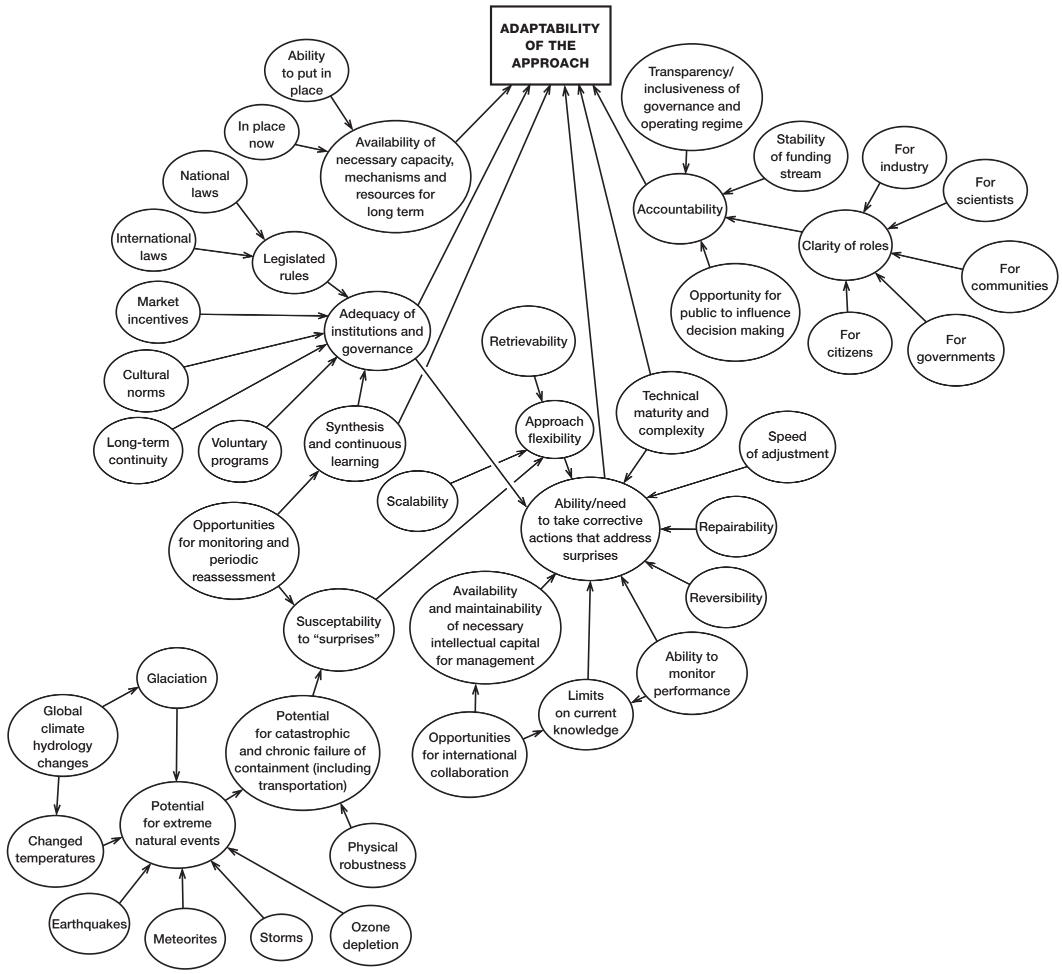
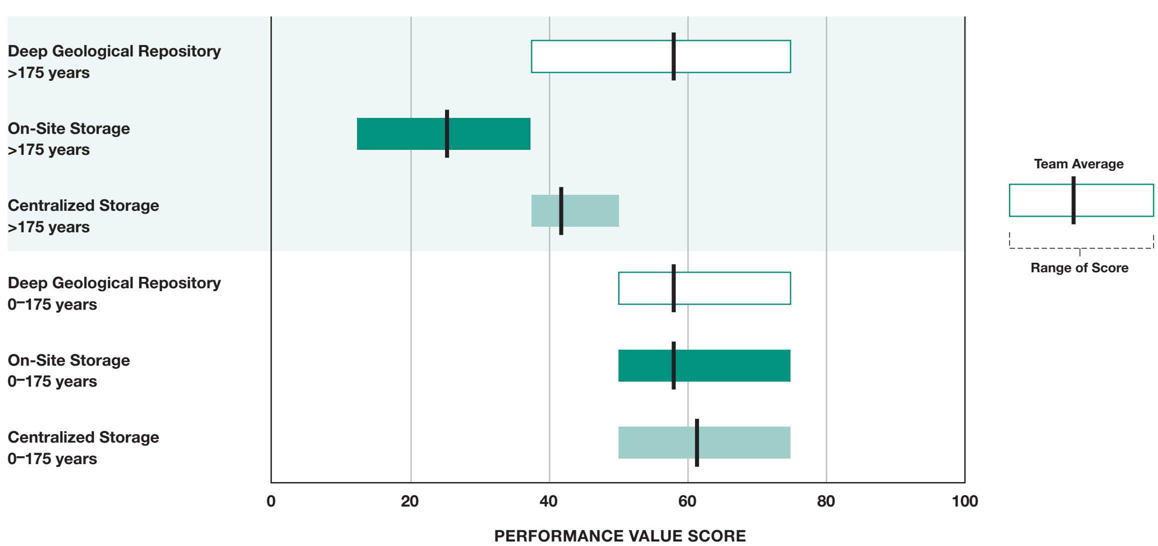


Figure 5-16 Adaptibility scores



STRENGTHS AND LIMITATIONS OF ALTERNATIVE METHODS

In summary, as a result of its deliberations, the Assessment Team found that each of the options has specific, and quite different, strengths and limitations. No method perfectly addresses all of the values and objectives important to Canadians. The strengths and limitations identified through the assessment are summarized opposite, in the words of the Assessment Team:

At-Reactor Storage

Advantages: No transportation of used nuclear fuel would be required, as the used fuel would remain next to where it is generated. Each of these sites already houses nuclear installations, so there is nuclear expertise on site and in the existing communities. These communities are familiar with the presence of nuclear facilities, including storage of used nuclear fuel. Further, the ability to monitor the performance and the flexibility to adapt to changing conditions should be facilitated. The science and technology required are well in hand.

Limitations: The key disadvantage, shared with centralized storage, is the need for continuing administrative controls and operations, including the necessary funding, for the thousands of years the used nuclear fuel remains hazardous. Unlike centralized storage, at-reactor storage means continued management at a number of sites, each of which has, as its primary focus, the production of power, not the long-term management of used nuclear fuel. These reactor sites were selected for their suitability for reactor operation, not for very long-term storage of used nuclear fuel. The used nuclear fuel will remain hazardous well beyond the almost certain shutdown and ultimate abandonment of the nuclear reactor sites. At-reactor storage would result in very long-term used nuclear fuel management at a number of sites located next to important bodies of water. This raises security, environmental and safety issues and adds significant uncertainty given the potential for changes in institutions and governance and the likelihood of extreme natural and human induced events over such an extended time.

Centralized Storage

Advantages: Centralized storage, either above-ground or shallow below-ground, would allow for the site selection solely on the basis of used nuclear fuel management. If done well, siting can be achieved with community participation. These are both key potential advantages compared to at-reactor storage and apply to the siting of a deep-geological repository as well. Such a site could be either at an already existing nuclear site, if suitable, or at a different site should that prove more advantageous. With the option of shallow below-ground storage, some of the security concerns can likely be abated. As with at-reactor storage, the required science and technology are well in hand.

Limitations: 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. It also would require the identification and development of a site with potentially contentious community involvement. Transportation of the used nuclear fuel to the site would be required with its attendant risks and costs.

Deep Geological Repository

Advantages: The deep geological repository option results in the eventual permanent emplacement 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 emplacement and closure, provision of long-term resources and funding are not required, although further actions are not precluded. The site is chosen with specific features as a requisite and, if done well, can be achieved with community participation. The intrinsic geologic, hydrologic and other features of the site, in combination with engineered features such as long-lived waste packages and material buffers, isolate the used nuclear fuel from the accessible environment for the very long time periods that they remain hazardous. Deep emplacement reduces security concerns, both before and after closure.

Limitations: 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 form the foundation of the assurances of performance provided to regulatory authorities and interested organizations and individuals. Monitoring becomes more difficult as the used nuclear fuel is emplaced deep underground and as the site is backfilled and closed. At this stage, adaptability and flexibility are also reduced as retrieval of the used fuel, for example, becomes much more difficult, costly, and hazardous. Siting must pay particular attention to intrinsic geologic features, perhaps limiting options more than for storage alternatives. As with centralized storage, community participation in regard to siting could be contentious and transportation of the used nuclear fuel will be required.

SUMMARY OBSERVATIONS OF THE ASSESSMENT TEAM

The average scores indicate that the deep geologic repository option is expected to perform better than either at-reactor-site or centralized storage on nearly every objective. This is not as clearly the case when the ranges of the scores are considered. The ranges in the scores for the three options are quite wide, in most cases. They almost always overlap at their extremities (low or high ends). The broad range assigned to the scores on many objectives reflect 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. In reflecting on the results of its own work, the Assessment Team was of the view that such wide variation is to be expected and indeed, that similar variations might be obtained by others should they conduct their own exercise.

The Assessment Team noted that irrespective of the method selected, the process of implementation necessarily will stretch out over an extended period of time, at least many decades. For this reason, the Assessment Team thought it both desirable and advantageous to consider the development of any selected approach in a staged, flexible manner. This will provide an opportunity for new learning and new experience to be brought to bear on the difficult issue of choosing an approach to the management of used nuclear fuel that will enjoy a high degree of public acceptability.

The Assessment Team also noted that the process by which any of the methods 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. Whatever technical method is ultimately selected for implementation, the implementation process must invite and achieve the involvement of citizens at key decision points throughout the process. It must also involve the identification and configuration of institutions and systems, likely at multiple levels of government and administration. The assessment suggests it will be necessary to ensure there is a clear and transparent path for decision making and a mechanism in place to provide assurance that commitments made will in fact be met.

To view the report of the Assessment Team in its entirety, please visit the NWMO website. (www.nwmo.ca/assessmentteamreport)

Part 3 / Towards a Management Approach

In Part 3 we review our progress to date and present our current thinking, as it has evolved, about achieving the mandate that NWMO has been given.

CHAPTER 6 / A RESPONSIVE FRAMEWORK

As reported in Parts 1 and 2, the NWMO has gained insight from the contributions arising out of two very important streams of work: our engagement with the public, and with a wide range of experts; and, the work of the Assessment Team to further elaborate on the assessment framework and to perform a preliminary assessment.

This work has advanced the study in a number of important ways:

In our early round of public engagement in 2003, the NWMO invited Canadians to identify issues and concerns that should be addressed in our study of management approaches for used nuclear fuel. Additional issues for our study surfaced through the large number of commissioned research papers, expert workshops and dialogues that we convened. Based on this input, the NWMO proposed a set of ten key questions to form the foundation for the assessment of management approaches. We published these questions in our first discussion document in November 2003, and in so doing, we asked Canadians if we were indeed "asking the right questions". (www.nwmo.ca/askingtherightquestions)

Since release of our discussion document, and through a number of major engagement initiatives with Canadians, we largely heard that, yes, we are asking the right questions. Based on what we heard, described more fully in Part 1 of this document, we have concluded that these questions are a good starting point for the comparative assessment of management approaches and we have proceeded with the study on this basis.

The ten questions are rooted in the values and ethical considerations Canadians bring to bear on long-term nuclear waste management. Since our first discussion document, we have completed further work to clarify these values, and ethical considerations, and to make them explicit. These efforts include the National Citizens' Dialogue, convened with a cross-section of the Canadian public to explore the key values that should be reflected in the assessment. (www.nwmo.ca/canadianvalues) Also included is a workshop convened to explore the values and principles inherent in Aboriginal Traditional Knowledge, the very long perspective it promotes in planning and decision-making, and how these might be brought to bear on the study. (www.nwmo.ca/aboriginaldialogues) As well, the NWMO's Roundtable on Ethics has come forward with an "Ethical and Social Framework" to help guide NWMO activities. (www.nwmo.ca/ethicsroundtable)

The insight from these initiatives has added substantially to our understanding of the factors which are important to Canadians in deciding upon a long-term management approach for used nuclear fuel for Canada.

Since the release of our first discussion document, the NWMO asked a multi-disciplinary group of individuals to give some thought to how the ten question framework might translate into a formal assessment framework. The Assessment Team developed a framework which features eight objectives and a list of specific influencing factors. It is described in Part 2 of this discussion document. In suggesting this framework, the Assessment Team proposed a methodology and approach for considering the breadth of factors which Canadians identified as important, in an integrated and systematic way. If the Team has been effective, the assessment framework which they developed will:

1. Reflect the ten questions Canadians have said are important, and the counsel of experts in a wide variety of knowledge areas, and

2. Respond to the values Canadians have said are important in the selection of a management approach for Canada.

Are we still asking the right questions? And is this framework sufficiently inclusive to form the basis for the assessment? The framework developed by the Assessment Team, modified with the insight from major dialogue activities initiated by the NWMO, is summarized in Table 6-1.

The NWMO will continue to reflect the advice and counsel of Canadians in response to this discussion document as its work on both the framework and the assessment itself evolves.

Table 6-1 What Needs To Be Considered? The Assessment Framework

Value and ethical considerations are by design embedded in the eight objectives which comprise the assessment framework.
The original Ten Questions have been converted into eight objectives and associated guiding principles and influences.
The influences are described in Part 2 of this document.

	A Foundation of Values and Ethics (*)
Citizen Values	**Safety From Harm** An overarching requirement. First and foremost, human health and the environment must be safe as possible from harm, now and for the future. **Responsibility** We need to live up to our responsibilities to ourselves and to future generations, and deal with the problems we create. **Adaptability** We need to build in capacity to respond to new knowledge. **Stewardship** We have a duty to use all resources with care and to conserve, leaving a sound legacy for future generations. **Accountability and Transparency** To rebuild trust. 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 to all. **Knowledge** We need to continue to invest in informing citizens, and in increasing knowledge, to support decision-making now and in the future. **Inclusion** The best decisions reflect broad engagement and many perspectives; we all have a role to play.
Ethical Principles	**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 people and cultures** **Justice** across groups, regions, and generations **Fairness** to everyone affected and particularly to minorities and marginalized groups **Sensitivity** to the differences of values and interpretation that different individuals and groups bring to the dialogue
	(*) Drawn from National Citizens' Dialogue, Roundtable on Ethics and Aboriginal Traditional Knowledge.

Table 6.1 What Needs To Be Considered? The Assessment Framework contd.

	Specific Objectives
	From the ten questions posed by Canadians, and the foundation of values and ethical principles expressed by citizens, eight specific objectives have been developed which will guide our work.
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 through different phases of decision-making and implementation.
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 approach.
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.
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.

	Specific Objectives (continued)
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 timeframe, the hazardous materials involved ought to be secure from the threat of theft despite possibilities of terrorism or war.
Environmental Integrity	**To ensure environmental integrity.** The selected management approach needs to ensure that environmental integrity over the long term is maintained. Concerns include the possibility of localized or widespread damage to the ecosystem 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).
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 will not occur that would threaten the assured continuity of necessary operations.
Adaptability	**To ensure a capacity to adapt to changing knowledge and conditions over time.** The selected management approach should be able to be modified to fit new or unforeseen circumstances. The approach should provide flexibility to future generations to change decisions, and not place burdens or obligations on future generations that will constrain them. The approach should be able to function satisfactorily in the event of unforeseen "surprises".
	A more elaborated discussion of the many influences with an impact on each of the objectives is presented in Part 2 of *Understanding the Choices.*

ACCEPTED WISDOM

While these dialogues and deliberations took very different forms and involved participants with different backgrounds, we were struck by some shared visions, common ground observations and recommendations that emerged from these different sets of activities. We will embrace these ideas as the study proceeds.

Responsible Action Now

We have heard a recognition and desire by the public and experts alike of the need to determine and begin to implement a plan ***now*** for the long-term management of used nuclear fuel.

In citizens' dialogues undertaken across the country, Canadians told us they want to take action now in order to ensure safety and security for people, their health and the environment – now and for the future. For the public at large, action now needs to include taking concrete measures to put in place a long-term management approach, but in such a way as to ensure that future generations would be able to make decisions which reflect their own values and priorities, and incorporate new knowledge as it becomes available.

In support of taking action now, the NWMO has understood from our dialogues that no matter which technical method or management approach is ultimately recommended, we should seek an approach that can begin to be implemented today, while entrenching an openness to new learning as it emerges. A responsive and responsible course of action must entail a measure of adaptability, which includes a process of review and planned opportunities to adjust direction as appropriate.

A Staged Approach

We have heard from our dialogues that taking a staged approach is an important element of building adaptability into any management approach which is selected.

Staging that provides for reviews and adjustments along the way offers the best way of marrying responsible and deliberate action in planning for the long-term management of used nuclear fuel, while ensuring that we take advantage of best practices, new learning and evolving societal expectations at each step in the process. It also creates opportunities for future generations to influence the implementation of the approach.

From both the public and experts alike, we heard the value of continuous learning, as a means to ensure careful, controlled improvements in operations and design that enhance performance, reduce uncertainties and improve economies. In its conclusions, the Assessment Team reflected much of the discussion of the public and experts in the study to date. The Team suggested that whatever approach Canada ultimately selects should be a staged one, to allow Canada to proceed flexibly and most responsively to the values and concerns of Canadians, while incorporating new learning. The Team observed that the extended time frame associated with any of the three management approaches – stretching out over many decades – underlines the need for a flexible step-wise development of the approach.

We accept as a guiding principle that – regardless of the technical method selected – Canada should adopt a staged approach to implementation. As we develop implementation plans for each approach in our study, we will therefore consider how staging might best be designed to provide flexibility and opportunities for adjusting direction.

Monitor Emerging Options

For the most part, Canadians have told us that it would be most appropriate for the NWMO to focus its work on the three methods identified in the *Nuclear Fuel Waste Act*.

However, they would like the NWMO to maintain a "watching brief" on some specific methods.

In many respects the Canadians with whom we spoke are technological optimists. They believe that there will be new advances in science and technology. They emphasize that one should remain open to new learning that may lead to better ways of managing used nuclear fuel. Furthermore, their support for taking action now is linked to a desire to see investments in research and monitoring of technological developments.

The NWMO understands from this that whichever management approach Canada chooses, it must be coupled with a commitment to monitor and participate in research, at home and abroad, to benefit from emerging best practices and new knowledge.

Canadians have said there are methods which are not yet sufficiently mature to warrant consideration now, but may hold some promise in the future. In particular, Canadians are interested in opportunities to use and reuse nuclear fuel more efficiently, and to reduce the hazards associated with it.

Although partitioning and transmutation has not proven to be a practicable alternative at this time, Canadians are interested in monitoring developments in this area, in case there is a technical breakthrough.

Keep Citizens Informed and Involved in Decision-Making

In our national citizen dialogues, we heard that citizens require greater transparency and more information. Citizens want governments and industry to be more transparent about what they are doing, and more inclusive of citizens and other stakeholders, both in how decisions are made and in the ongoing management of the used fuel.

We heard clear messages from both the public and experts alike that whatever approach is selected, implementation must invite and engage Canadians at key decision points throughout the process. At a minimum, as key decisions are taken in the design, siting, environmental assessment and licencing processes and in the ongoing operation of the approach, there will need to be opportunities for real engagement of both citizens and experts. Accountability to citizens and a clear and transparent path for decision-making are requirements of any management approach which is implemented.

Canadians have said we must understand the concerns of the affected regions and communities, and seek to provide their citizens with the capacity to understand the issues, remain informed and engaged on decisions affecting them.

Ensure Strong and Effective Oversight and Institutions

Regardless of the management approach selected, a robust system of governance will be required to respond to public expectations for oversight and monitoring. In our dialogues with Canadians, we heard that the identification and configuration of institutions and systems is crucial. For example, we heard support for roles of many levels of government, independent regulators and oversight bodies, as well as international agencies and watchdogs. Similarly, provisions must be in place for financial surety around the funding of the management process.

Other institutional issues to be addressed relate to the NWMO itself, and how it should be designed to capably assume its future role as an implementing organization. A priority issue to be considered in planning for the future is how to build and maintain the human capital required to sustain capacity for expertly managing the used nuclear fuel into the future as long as active management is required.

Choice of Method Likely to be Difficult

Although there are many common threads concerning the appropriate management approach for Canada, early conversations with the public and experts, and the work of the Assessment Team has highlighted factors which make the task of assessing management approaches a difficult one.

First, there is likely no single technical method which will perfectly address all of the objectives which Canadians have identified as important. In order for a method to address one objective well, for instance 'security', it may need to include practices which would make the method less able to address another of the objectives, for instance 'adaptability'. For this reason, it will likely be necessary to balance and/or trade-off achievement of some of the objectives against other of the objectives in weighing the relative merits of the management approaches.

Secondly, well informed and reasonable people may disagree on how a particular method should be assessed, even against the same set of objectives. This disagreement might reflect different views on the nature of future society and environmental conditions within which the method would need to be able to safely operate. Do we want to plan for the possibility of weak and/or non existent social institutions and extreme climate change effects far into the future, or do we want to count on the existence of strong societies and modest climate change in deciding upon a management approach today? This disagreement might also reflect different perspectives on the best means to address the uncertainty in predictions and calculations associated with the performance of the approaches over the long timeframe for which the used nuclear fuel will need to be managed.

This is the sort of diversity of view we need to anticipate and prepare for as we move forward with the assessment of management approaches.

CHAPTER 7 / NWMO'S WORK CONTINUES

Canadians asked us to "think out loud" as we considered the issues and made early findings. It is in this spirit of transparency that we have shared the results of our public engagement in Part 1 and the preliminary assessment of options in Part 2. We hope that the findings to date will stimulate and provide a backdrop for a very active and interesting dialogue that will continue in the months ahead.

First, as part of this next iteration of our work, we invite Canadians to comment on how well the assessment framework has captured the range of issues that matter to Canadians. We look forward to the views of Canadians concerning needed adjustments to the framework to ensure it captures well society's expectations for a management approach.

Secondly, we have more work to do in responding to the requirements set out under the *Nuclear Fuel Waste Act*. We must develop the financial and management structures associated with each approach, address economic regions, and complete the comparative assessment of approaches. Our work will be guided by the comments of Canadians, responding to discussion documents 1 and 2, as well as by supplementary expert advice to address some of the more complex financial, legal and institutional provisions. Our plans for the elaboration of the management approaches, and development of implementation plans are briefly outlined below.

Thirdly, comments provided by the public and experts since release of our first discussion document have identified a number of information gaps and unresolved issues which NWMO will seek to address in the coming months.

We will be guided by the set of values and objectives that have been identified to this point (Table 6-1). We will continue to mine the record of what the public and experts have told us as we move through successive levels of detail in the assessment. Through our engagement activities, we will expand our dialogue with Canadians.

ELABORATING THE MANAGEMENT APPROACHES

The NWMO will continue its work on elaborating the specific characteristics of each management approach under study. There are two specific areas which will be a particular focus in the coming months.

Economic and Financial Implications—It is important that any approach we recommend for Canada be economically sound, including provisions for financial surety, and a full accounting of all anticipated costs and benefits. Since the release of our first discussion document, the NWMO has received an extensive body of work on cost estimates for each of the three options, prepared earlier by the Joint Waste Owners. (www.nwmo.ca/cost-summaries) We are in the process of reviewing these cost estimates for the appropriateness of assumptions and comprehensiveness.

In addition, we will need to develop the financial formulae and details required by the *Nuclear Fuel Waste Act*. In our draft final report, we will bring forward a fully developed financial formula for each option designed to provide assurance that the management approach chosen by government can be funded in a robust and ongoing way.

Economic Regions—The *Nuclear Fuel Waste Act* requires that the NWMO specify economic regions for the implementation of each management approach.

"Economic Regions", as identified in the *Act*, are those described by Statistics Canada in its Guide to the Labour Force Survey, published on January 31, 2000. Canada has 76 economic regions, broad-based geographic units based on census divisions and used for analysis of regional economic activity. (www.nwmo.ca/economicregions) For the approach involving storage at nuclear reactor sites, identification of economic regions is straightforward, since we know where these reactor sites are now. The focus of the NWMO's efforts in the months to come will be on developing the characteristics that would be appropriate in choosing specific economic regions for deep geological disposal and centralized storage approaches.

DEVELOPING IMPLEMENTATION PLANS

Having listened to the public and experts, and the advice of the Assessment Team, the NWMO is persuaded of the critical importance of mapping out specific plans for implementing any course of action. The manner in which any approach is implemented will affect the effectiveness and the extent to which it is responsive to societal needs and concerns.

We believe that *how* any approach is implemented will be every bit as important as *which* approach is selected. Accordingly, we will be focusing a great deal of our attention in the next six months on carefully considering the elements of an implementation plan.

We will seek to develop implementation plans that will provide Canadians with the assurances they are seeking. The objectives created to reflect the concerns and values of Canadians provide both the basis for choosing the preferred management approach, and some insight for specifying its design and tracking its performance. As well, we have in the course of our public engagement to date received many suggestions and insights for structuring and implementing the management systems in a way that will build public confidence. As we articulate more specifically what each management approach looks like and how it will be implemented, we have an opportunity to be responsive to Canadians in building in the oversight and institutional frameworks that offer the public assurance of the safe, secure operation of each approach. Development of implementation plans will include, at a minimum, consideration of such issues as: oversight and monitoring systems; ongoing societal involvement; institutional design, including human resource capacity; ownership and liability; dispute management; principles to guide site selection and education and information programs.

Further Work on Understanding the Hazard

We have heard from both the public and experts that the assessment of management approaches might be influenced by the volume of used nuclear fuel which we are planning to manage. Over the next several months, the NWMO will be exploring the sensitivity of any assessment of the management approaches to assumptions made about used fuel volumes, as well as types of nuclear fuel.

We have heard a number of perspectives concerning the nature of the hazard over the course of the study, specifically the nature of the potential harm and duration of the hazard. The NWMO will explore these issues further in order to ensure as solid an understanding as possible on which to base the study.

Different Geologic Media

In our next phase of work, we will be examining the different types of geologic media that might provide alternatives for hosting a repository or centralized storage option. The *Nuclear Fuel Waste Act* requires that we include in our study the method of deep geological disposal in the Canadian Shield. We recognize, however, that in recent years different types of geologic media have been studied and are under consideration in different countries. For example, France, Switzerland, Germany, Belgium and the U.S. are all studying the potential of media other than crystalline rock. We need to understand the feasible options available to us in Canada that would safely and securely host a long-term management facility for used nuclear fuel.

Transportation

The different management options have associated with them different requirements for transportation of used nuclear fuel. Transportation is a key distinguishing factor between the different methods, and is a critical factor to be addressed in assessing further risks that might be posed to society or the environment through the movement of fuel between locations. The NWMO has initiated some research on transportation. The Joint Waste Owners considered the transportation implications in their engineering and costing designs. The Assessment Team reflected substantially on this point. The NWMO is undertaking further work to ensure we have a good understanding of the risks associated with the transportation of used nuclear fuel.

Non-Proliferation

Security threats that the world has experienced to date have heightened the interest in rigourously investigating the potential of future threats. We are well advised to test the resilience of our options against possible future concerns. The Assessment Team addressed security explicitly in its review. To supplement this work, we are underataking further work to consider obligations associated with an international nuclear weapons non-proliferation regime given the priority that Canadians assign to this issue.

CHAPTER 8 / ENGAGING CANADIANS

NWMO'S INVITATION TO COMMENT

We have already benefited substantially from the input of interested Canadians and have tried faithfully to incorporate these ideas in the study. We continue to seek the comment of the public and experts at every stage of our work.

This discussion document will form a starting point for our discussions with the public on the comparative strengths and weaknesses of management approaches:

- The preliminary assessment of the management approaches, summarized in Part 2 of this document, provides context for a substantive discussion with Canadians on how we consider the relative risks, benefits and costs of each management approach. Does this assessment framework provide a good foundation on which to assess the options? What adjustment, if any, is required to bring greater focus and refinement to the way in which we assess the relative strengths and limitations of each management approach?

- We are seeking the views of Canadians as we develop detailed implementation plans and management structures which will be included in our draft study report, scheduled for release in early 2005. Comments received will assist us in elaborating on the design of each management approach—from the important institutional and governance mechanisms, to the processes proposed to support future decision-making and implementation, once the Government of Canada makes a decision on Canada's approach for the long-term management of used nuclear fuel.

We'd Like to Know…

Specifically, through our next phase of public outreach, we look forward to exploring the following topics with Canadians:

Is the assessment framework comprehensive and balanced? Are there gaps, and if so, what do we need to add?

- We want to know if the assessment framework, drawn from the original ten questions and the dialogue which followed, fully captures the key priorities and perspectives of Canadians.

What are your thoughts on the strengths and weaknesses of each management approach: deep geological disposal; centralized storage; and reactor site storage?

- We would like to discuss the relative strengths and limitations of each of the approaches which are the focus for the study. Does the preliminary assessment accurately describe all of the considerations?

Are there specific elements that you feel must be built into an implementation plan? What are your thoughts on what a phased approach must include?

- Beyond the relative strengths and limitations of the approaches, we welcome input on the elements of an implemention plan for any preferred approach. To date we have heard that, irrespective of the management approach which is ultimately selected, it will need to be adaptable and therefore will need to be implemented in a phased manner.

GETTING INVOLVED

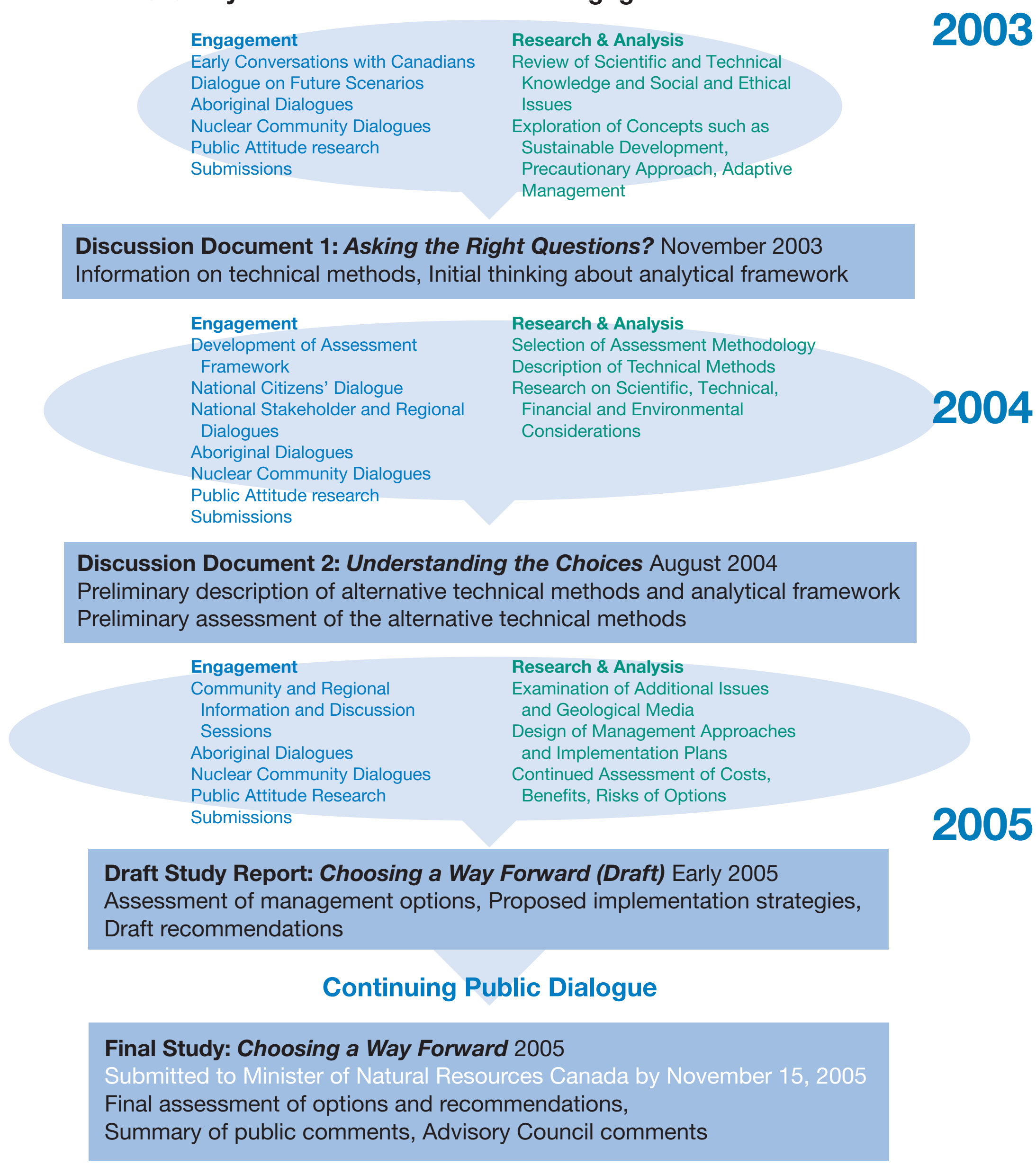
We are initiating a wide range of activities that invite participation and comments from the public at large, while continuing to seek the perspectives of experts and other communities of interest. We will be launching information and dialogue sessions with the public, and continuing our engagement with aboriginal peoples, nuclear site communities and interested organizations and individuals.

Examples of some of these activities are outlined below.

General Public

- Information and discussion sessions will be held in communities and regions across the country from September to November 2004 to help present the work undertaken, and provide an opportunity for people to ask questions directly to the NWMO. The dates and locations are posted at www.nwmo.ca/calendar.

Figure 8-1 **NWMO Study: A Process of Interactive Engagement**



- We continue to invite submissions to our website, on any or all topics of interest raised in this document or on our study generally.
- Deliberative surveys will be posted on the website on a variety of topics related to the study.
- A series of e-dialogues is planned, the first of which is on the topic of Risk and Uncertainty, scheduled for early fall 2004.

Aboriginal Peoples

- The NWMO will continue to support the aboriginal dialogues that have been established with the national organizations, and work to ensure that aboriginal communities at a local and regional level have a voice in the determination of a long-term management approach.

Reactor Site Communities

- A series of dialogue events will be held at reactor site communities to enable residents in these communities to engage in a round table dialogue. The dates, locations and discussion topics will be posted on the NWMO website.

We want to make it as easy as possible for you to contribute. All of our documents can be examined on our website, www.nwmo.ca. Your comments, observations, suggestions and contributions could be posted there. Alternatively, you may contact us by mail or by telephone at the address below.

The NWMO distributes our work widely and makes it available in a range of formats:

- The document is posted in its entirety on our website, and is available via hard copy and/or CD versions upon request; copies have been placed in public libraries, at information centres at nuclear reactor sites, and other publicly accessible community locations;
- A 15-minute DVD is available which summarizes the key work, findings and areas of discussions – it is also available and can be downloaded from the www.nwmo.ca website, and DVDs are available upon request;
- A series of brochures and pamphlets has been developed – each focusing on a key aspect of the work and/or area of discussion.

NWMO invites all interested individuals and organizations to get involved.

Make a submission, share your comments with other interested Canadians and make your voice heard at our website, **www.nwmo.ca.**

You can review our public engagement plans, discussion documents, reports and research which are available on our website at **www.nwmo.ca.**

Or contact us at:
Nuclear Waste Management Organization
49 Jackes Avenue
Toronto, Ontario M4T 1E2 Canada
Telephone: 416.934.9814 or
1.866.249.6966

Figures and Tables

Appendices

APPENDIX 1 / PROFILE OF THE NWMO

The Nuclear Waste Management Organization (NWMO) was established by Canada's nuclear electricity generators following passage of the *Nuclear Fuel Waste Act* in 2002. 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.

At a minimum, three approaches must be studied. They are: deep geological disposal, centralized storage – above or below ground, and continued reactor-site storage. The NWMO may consider other technical methods.

Each approach studied must be fully described including risks, costs and benefits. Implementation plans must also be developed.

The NWMO is committed to developing collaboratively with Canadians a recommendation that is socially acceptable, environmentally responsible, technically sound, and economically feasible. Recognizing that it is not enough to invite people to participate in developing a recommendation, the NWMO has sought to involve citizens in shaping the decision-making process itself. It has developed an iterative study plan which continues to evolve in response to ongoing dialogue. The plan is built on three milestone documents which allow people to learn together with the NWMO and see its thinking at every stage. The intent is that there will be no surprises when the final recommendations are made.

Elizabeth Dowdeswell is President of the NWMO. The NWMO has an independent Advisory Council whose written comments on its study of proposed approaches will be made public. The Council is chaired by the Honourable David Crombie. The NWMO Board of Directors is currently composed of representatives of the major owners of used nuclear fuel.

APPENDIX 2 / ENGAGEMENT ACTIVITIES

The NWMO seeks to engage various communities of interest in developing a strategic direction for Canada's management of used nuclear fuel.

At the same time, research has indicated that while Canadians want public participation in the NWMO work, they may not actively participate themselves. This has raised the need to investigate innovative mechanisms to solicit views and perspectives in ways that are meaningful and relevant. The NWMO has considered this and the engagement plan for 2004 included five major undertakings which are described below:

- Web-based Engagement & Dialogue
- A National Citizen's Dialogue
- National Aboriginal Dialogues
- National Stakeholder and Regional Dialogues
- Reactor Site Community Dialogues

In addition, a brief overview is provided of other roundtable dialogue activities, as well as public opinion research and community presentations, briefings and information sharing sessions.

Canadian Public – NWMO Web-based Engagement & Dialogue

(www.nwmo.ca)

The core of the NWMO dialogue with the general public is via the NWMO website, which is key to:

- informing and educating the public with all of the NWMO research and documentation posted to the website. More than 50 expert comments and reports have been commissioned by the NWMO from individuals expert in a wide variety of knowledge areas and posted on the website for the review of interested Canadians. The website features a video overview of the issue, newsletters, NWMO speeches and more. Since the launch in February 2003, NWMO's website has received more than 70,000 individual visits from interested Canadians, as well as from an international audience.

- soliciting direction and comment from Canadians on their own terms through submissions. More than 60 submissions have been received by the website from individuals either in response to the discussion document, or in response to one of our background papers. In addition, NWMO has received more than 100 enquiries and requests for information through the website.

- soliciting direction and comment from Canadians through user-friendly engagement tools. Four deliberative surveys have been posted on the website, each survey corresponding to one of the four key questions posed for dialogue in the NWMO's first discussion document. A fifth deliberative survey invited interested Canadians to contribute their view on the same set of questions posed in the nation-wide telephone survey.

- The NWMO placed advertisments in major national, regional and selected local newspapers to encourage public review and comment on the first discussion document.

Canadian Public – National Citizen's Dialogue

(www.nwmo.ca/canadianvalues)

The NWMO entered into a collaborative research project with the Canadian Policy Research Networks (CPRN) to hold a National Citizens' Dialogue on the long-term management of used nuclear fuel. The goal of the dialogue was to provide the NWMO with an understanding of how the general public, Canadian citizens unaffiliated with this issue, approach, assess and make tradeoffs around the complex issues related to long-term management of used nuclear fuel. In so doing CPRN undertook to identify the values framework that citizens use when considering this matter.

CPRN is an independent, not-for-profit, public policy research organization which utilizes a dialogue methodology which guides people from initial, uninformed, raw opinion through a journey to more considered public judgment. It requires not only a process of thinking through (deliberation) but also a psychological process of working through deeper values and emotional responses. The methodology draws upon elements of the ChoiceWork Dialogue methods of Yankelovich (Viewpoint Learning) and other deliberative dialogue methods that CPRN has used in the past.

CPRN drew together 462 Canadians, randomly selected by a professional polling firm to be representative of the Canadian population. Groups of approximately 40 participants met in 12 different locations across Canada. CPRN, using a peer reviewed workbook outlined some of the choices to be considered. For example, one set of choices was how much emphasis should be put on using the knowledge we have today to take action, and how much emphasis should be placed on building the capacity for future generations to make their own choices.

Each group met for a full day dialogue session and engaged in a deeper discussion with each other about the key questions outlined in the workbook, the values that underlie their opinions and the consequences of their choices. They collectively worked through the key considerations that they believe governments or decision-makers should incorporate into policy decisions about the long term management of nuclear fuel waste.

Using quantitative and qualitative data from the dialogue sessions, CPRN analysed the dialogue results and prepared a report describing the choices and tradeoffs that Canadians are prepared to make in regard to the long-term management of nuclear fuel waste. The report presents the underlying values framework that citizens bring to this national discussion.

2004 National Citizens' Dialogue Locations and Dates:

- Ottawa (January 24)
- Montreal (January 25)
- Quebec City (February 6)
- Thunder Bay (February 14)
- Moncton (February 23)
- Sudbury (February 28)
- Saskatoon (February 28)
- Calgary (March 6)
- London (March 13)
- Vancouver (March 13)
- Toronto (March 20)
- Halifax (March 28)

National Aboriginal Dialogues

(www.nwmo.ca/aboriginaldialogues)

Early in 1999 Natural Resources Canada, on behalf of the Government of Canada, approached the five national aboriginal organizations and asked them how "they wished to be consulted on next steps of the long-term management of nuclear fuel waste….These consultations will be ongoing throughout the lifetime of the long-term management of nuclear fuel waste ." This initiative culminated in contribution agreements finalized in the summer of 2003, between the Government of Canada and four of the national aboriginal organizations, to build capacity within the national aboriginal organizations to conduct consultations appropriate to their value systems and decision-making processes.

At that time, the NWMO approached the national aboriginal organizations and sought a discussion on how best to proceed with consultations with aboriginal people specific to the NWMO's mandate. The NWMO has since entered into collaborative arrangements with three national aboriginal organizations to conduct dialogue processes with their constituents on the long-term management of used nuclear fuel.

The collaborative dialogues build on and enhance the capacity-building arrangement the national organizations have established with the federal government - and support dialogue on key NWMO study areas.

Inuit Tapirrit Kanatami (ITK)

The ITK is a national organization which represents Inuit people in Canada. In response to the collaborative arrangements made between the ITK, the Federal Department of Natural Resources Canada and the NWMO, the ITK held a special session on nuclear fuel waste management during the National Inuit Conference on the Environment (February 24 & 25, 2004). Staff and personnel with accountabilities for environment from the four Inuit Land Claims organizations as well as the ITK and Nunavut Government gathered in Ottawa. The NWMO worked with ITK to develop the presentations and materials used at the workshop.

Following the presentations and discussions, a smaller group of participants met for a day and a half to set direction and establish a national Inuit working group on nuclear waste. Key issues for the ITK include abandoned sites and northern contaminants from a variety of sources.

Assembly of First Nations (AFN)

The AFN is a national organization which represents First Nation peoples in Canada. The AFN has developed and the NWMO supports, a First Nations Dialogue on Nuclear Waste Management. The First Nations Dialogue includes the establishment of a Nuclear Dialogue Working Group; Regional Nuclear Waste Dialogue Coordinators who will lead regional dialogue forums; the development of background reports; communications and information materials (such as fact sheets and information exhibits) and activities to promote youth involvement.

Métis National Council (MNC)

The MNC is a national organization which represents Métis people in Canada. Its five Governing Members provincially represent the historic Métis Nation from Ontario westward. The NWMO and the MNC have entered into a collaborative agreement to allow the MNC, working with its Governing Members, to conduct and execute a culturally reflective dialogue amongst its constituency, and bring forward issues and concerns to the NWMO in regards to the long-term management of nuclear waste in Canada. Key areas of discussion include the options for the long-term management of nuclear fuel waste, Métis Traditional Knowledge and Métis rights in relation to nuclear fuel waste management. The MNC has developed a framework for engagement which includes among other things, the development and implementation of information materials and community dialogue workshops.

The NWMO has been working with various regional aboriginal organizations, on a case-by-case basis. For example:

The Ontario Métis Aboriginal Association is a non-profit corporation with a long history of articulating the political, social and economic aspirations of Métis and off-reserve and non-status aboriginal people in Ontario. OMAA held a workshop, with the support of the NWMO, and developed a position paper critiquing the NWMO's first discussion document, and provided insight and recommendations on aboriginal participation & involvement; Traditional Knowledge; Traditional decision-making processes; and Traditional Ecological Knowledge.

National Stakeholder & Regional Dialogues

(www.nwmo.ca/regionaldialogues)

A dialogue by definition is not a one point in time discussion. For a dialogue to be meaningful, it must pass through a sequence of interactions that include:

1. providing information that allows a person to determine the nature of interest;
2. reviewing and questioning of information for the purpose of clarification and ensuring understanding;
3. providing an opportunity to express an opinion or idea on the information;
4. reflecting or deliberating on a response to the opinions or ideas presented;
5. providing a forum for an exchange of views and opinions with others; and,
6. a conclusion either in the form of acceptance or advice.

For a dialogue to be successful it should follow this sequence of steps leading to an informed and well-considered exchange of ideas and responses among participants. A key design consideration is to maintain the participation of dialogue members in a series of discussions for the purpose of establishing productive relationships among the participants, a common understanding of the various views and opinions and the underlying reasons why people hold those views.

The National Stakeholder and Regional Dialogues engaged people representing a variety of interests, including persons and organizations with a record of interest in Canada's work on the long-term management of nuclear fuel wastes and those with an interest in public policy matters.

The dialogues were intended to provide opportunities for people and organizations to contribute their views and opinions, and to critically review the NWMO's first discussion document – *Asking the Right Questions?*

The National Stakeholder and Regional dialogues were comprised of three main activities, an initial half-day session where participants were brought together, introduced to each other and to the purpose and structure of the dialogue; an electronic dialogue, where all the participants are invited to explore through a common electronic message board, their initial thoughts and perspectives on the dialogue topics; and finally a full-day facilitated session approximately 3 – 4 weeks after the first session, where the participants return to discuss the dialogue topics in depth and to explore the key values and assumptions underlying their views.

The dialogues were held in March and April 2004:

- Ontario (North Bay - March 3 and March 27)
- Quebec (Montreal – March 9 and April 15)
- New Brunswick (Fredericton – March 10 and April 3)
- National Stakeholder (Ottawa - March 8 and March 25).

The electronic dialogue was initiated March 8 and ran until April 21.

Reactor Site Community Dialogues

Reactor site communities have both a particular interest in and a substantive background in nuclear waste management. The NWMO began working with the reactor site communities in 2003 to establish community-based dialogue mechanisms that would endure throughout the NWMO study – some of these build on existing dialogue forums, others are new. These dialogue mechanisms will be important in facilitating liaison and coordination between the communities and the NWMO throughout the study process.

Reactor Site Communities:

- Pinawa, MB
- Kincardine, ON
- Pickering, ON
- Clarington, ON
- Deep River, ON
- Bécancour, PQ
- Greater Saint John area, NB

Other Roundtable Dialogues:

- **Dialogue with Senior Corporate Environmental and Sustainable Development Executives**

Two meetings were held, January 14, 2004 in Toronto, Ontario and January 15 in Calgary, Alberta with senior corporate environmental and sustainable development executives from a cross-section of Canada's major resource, energy, chemical, waste and recycling industries. We invited these individuals to review and critique the NWMO's first discussion document.

- **Roundtable Dialogue with Durham Nuclear Health Committee – Public Members** (www.nwmo.ca/durhamdialogues)

A facilitated half-day dialogue session was held on Friday, April 2 in Pickering, Ontario with the public members of Durham Nuclear Health Committee, a committee established by the Region of Durham. The Committee provided feedback and critique of the NWMO's first discussion document.

- **Roundtable Dialogue with Youth at the International Young Nuclear Congress** (www.nwmo.ca/youth)

The International Youth Nuclear Congress works to stimulate discussion amongst young professionals from around the world who work in the nuclear industry. The NWMO scheduled a half-day session with youth who were attending the Congress on May 12, in Toronto, Ontario, to invite them to critically review the NWMO's first discussion document and to offer views, from a youth perspective, on matters for Canada to consider in developing a long-term management approach.

Community Presentations, Briefings and Information Sharing Sessions

In the first six months of 2004 NWMO held information - sharing sessions with a number of community groups and organizations. The following illustrate the nature of the NWMO's response to community requests.

- January 16 – Durham Nuclear Health Committee
- February 18 – Canadian Association of Nuclear Host Communities
- March 3 – Nuclear Waste Watch Steering Committee Information Sharing Session
- March 18 – Kincardine Impact Advisory Committee
- April 2 – Métis National Council Environment Technical Committee Meeting
- April 20 – Pickering Community Advisory Council
- May 26 – Timmins Citizens' Group
- May 26 - City of Timmins, Department Heads
- June 1 – Darlington Site Planning Committee

Public Attitude Research with the Canadian Public

Focus Groups

(www.nwmo.ca/discussiongroups)

Soon after the release of the NWMO's first discussion document, an independent research firm was commissioned to conduct six focus groups with a cross-section of Canadians from among the general population to observe and gauge their approach and reactions to the document. The objective of the research was to obtain an early sense of what might be Canadians' reaction to the NWMO's efforts in Phase 2 of the project, with the goal to:

- Primarily – Better understand how citizens engage in a dialogue on the discussion document and its subject matter including their approach to the document, what they deem appropriate and the questions and concerns they raise; and
- Secondarily – Explore the thoughts of participants on how best to engage other Canadians in dialogue on the report.

Focus groups were held in each of the Ontario communities of North Bay (December 10, 2003), Kanata (December 11, 2003) and Mississauga (December 15, 2003). Two focus groups were conducted at each location with 8 to 10 adults per group. Participants were screened into two groups: one group of those who identify themselves as "active" on various community or political measures; and a second group of those who do not identify themselves as particularly active, but regularly watch or read the news. Each focus group session lasted for 2 hours, during which participants were given time to read the report, were asked to answer a short, open-ended questionnaire and engaged in a group discussion about the report and the work of the NWMO.

Nation-wide Telephone Survey

(www.nwmo.ca/telephonesurvey)

The NWMO commissioned an independent research company to solicit the insight of a scientifically selected cross-section of Canadians at this important point in NWMO's work. The results of this study, a telephone survey of 1900 Canadians 18 years-of-age or older from coast to coast, is statistically representative of the perspective of Canadians on these questions (with a margin of error of +/- 2.25%, 19 times out of 20). Additional interviews were conducted with a representative sample of residents living in the vicinity of the 3 nuclear stations in Ontario, one station in New Brunswick and one station in Quebec so that the views of these Canadians with experience living in a community with a nuclear plant could be examined separately. Interviewing was conducted in late June 2004.

The 65 questions asked in the survey explored some issues which were examined in the telephone survey which was conducted one year before. This was to help the NWMO understand whether the broader context in which it is conducting the study has changed. The questionnaire explored:

- Canadians' perception of the issue;
- Canadians' perception of nuclear energy;
- Canadians' perception of the NWMO and the job it has been tasked to do; and
- Canadians' interest and desired involvement in this issue.

As well, and in order to solicit some broad public direction concerning the appropriateness of the ten questions which were presented in NWMO's first discussion document, the questionnaire also explored Canadians' sense of what are the important characteristics which any approach for managing Canada's used nuclear fuel should have, as drawn from the ten questions in the first discussion document. The report summarizing the findings from this survey is available on the NWMO website.

APPENDIX 3 / NWMO BACKGROUND RESEARCH

All NWMO Background Papers are available online at www.nwmo.ca/backgroundpapers.

Papers and reports completed and posted since the release of NWMO's first discussion document are indicated below with an asterisk (*).

1. Guiding Concepts

1-1. Sustainable Development and Nuclear Waste. David Runnalls, IISD.
This paper suggests how the concept of "sustainable development" first emerged, its evolution over time, and what the concept currently entails. The paper discusses how this concept might apply to the issue of the long-term management of used nuclear fuel, and includes discussion of the types of questions raised by the application of this concept. *Comment on this paper provided by Robert Morrison.*

1-2. The Precautionary Approach to Risk Appraisal. Andy Stirling, University of Sussex.
This paper suggests a description of the "precautionary approach" concept, discusses how this concept might apply to the issue of the long-term management of used nuclear fuel, and suggests the types of questions raised by the application of this concept. *Comment on this paper provided by Ortwin Renn.*

1-3. Adaptive Management in the Canadian Nuclear Waste Program. Kai N. Lee, Williams College.
This paper suggests a definition for the concept of "adaptive management", discusses how this concept might apply to the issue of the long-term management of used nuclear fuel, and suggests the types of questions raised by the application of this concept. *Comment on this paper provided by Charles McCombie.*

1-4. Nuclear Waste Management in Canada: The Security Dimension. Franklyn Griffiths, University of Toronto.
This paper suggests a definition for the concept of "security", discusses how this concept might apply to the issue of the long-term management of used nuclear fuel, and suggests the types of questions raised by the application of this concept. *Comment on this paper provided by Edwin Lyman and the Honourable Lloyd Axworthy.*

1-5. Risk and Uncertainty in Nuclear Waste Management. Kristen Shrader-Frechette, University of Notre Dame.
This paper suggests a definition for risk and for uncertainty, discusses how these concepts might apply to the issue of the long-term management of used nuclear fuel, and suggests the types of questions raised by the application of this concept. *Comment on this paper provided by William Leiss.*

1-6. Thinking about Time. Stewart Brand, The Long Now Foundation.
This paper contains thoughts on time and responsibility, particularly thinking about very long time frames. It poses the question: "How do we make long-term thinking automatic and common instead of difficult and rare? How do we make the taking of long-term responsibility inevitable?" This question is explored through the attempt to design a clock that will operate for 10,000 years – a period of time equal to our lives on Earth since the last ice age.

1-7. Drawing on Aboriginal Wisdom. Joanne Barnaby, Joanne Barnaby Consulting.
The paper discusses the importance of Traditional Knowledge, describes what it is and offers a working definition. It then discusses how Traditional Knowledge can help industry and government in environmental management, and suggests the types of questions raised by the application of Traditional Knowledge. This paper was developed in advance of a workshop devoted to examining these and other questions.

1-8. Non-Proliferation Aspects of Spent Fuel Storage and Disposition. Thomas Graham Jr. and James A. Glasgow, Morgan Lewis
This report addresses nuclear non-proliferation aspects of spent fuel storage and disposition at nuclear power plant sites, in central storage facilities and in geologic repositories. The report contains a summary of relevant policy developments over the past several decades as well as commentary concerning international agreements that have significant implications from the perspective of nuclear non-proliferation. Principal provisions of U.S. laws and regulations are also reviewed.

1-9. Additional Concepts: Safe-Keeping. Colin Allan and Paul Fehrenbach
As part of the NWMO's dialogue on concepts, the authors of this paper suggest 'Safe-Keeping' as a potentially helpful concept in the examination and assessment of used fuel management practices.

2. Social and Ethical Dimensions

2-1. Ethics of High Level Nuclear Fuel Waste Disposal in Canada. Peter Timmerman, York University.
This background paper suggests seven ethical questions to be considered in used nuclear fuel management decision-making, and invites the reader to develop their own perspective. The paper draws upon the author's experience in exploring ethical considerations in the context of the earlier Seaborn Panel hearings. *Additional commentary provided by both Charles McCombie and J.A.L. Robertson.*

2-2. Social Issues Associated with the Atomic Energy of Canada Limited Nuclear Fuel Waste Management and Disposal Concept. Mark Stevenson, MAS Consulting.
This background paper provides a listing of social issues related to the concept of deep geological disposal, specifically the Atomic Energy of Canada Limited, Nuclear Fuel Waste Management and Disposal Concept, raised by participants during environmental assessment hearings conducted in 1996 and 1997. Although some of these issues are specific to the AECL proposal for deep geological disposal, many may be relevant to other methods of managing used nuclear fuel.

2-3. Social Issues Associated with High Level Nuclear Waste Disposal. Maria Paez-Victor, Victor Research.
This paper contains an analysis of certain key social issues related to nuclear waste disposal with a focus on the conditions for and barriers to the emergence of social acceptability towards long-term management options for nuclear waste. The paper identifies "four seminal and inter-related social issues that set the contextual parameters for these and all other social issues on nuclear waste". *Additional commentary provided by Ian Duncan.*

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.
This review provides an historical perspective on the issues and concerns raised by the public, affected communities and key stakeholders during seventeen Environmental Assessment (EA) and planning studies at Canada's nuclear research and power reactor sites, mining and radioactive waste and used fuel management facilities dating back to 1996. The review covers 67 available reports.

2-5. Overview of European Initiatives: Towards a Framework to Incorporate Citizen Values and Social Considerations in Decision-Making. Kjell Andersson, Karita Research.
This paper provides an overview of recent European experience in developing long-term solutions to their waste problems, including issues related to the siting of repositories. Examples of lessons learned are provided.

3. Health and Safety

3-1. Status of Radiological Protection Technologies and Operational Procedures related to High-level Radioactive Waste Management (HLRWM). Candesco Research Corporation.
This paper presents the radiation protection principles, technologies and operational procedures related to radioactive waste that are currently in use or are planned for managing radioactive wastes in Canada, with a particular focus on high-level waste. The paper provides an overview of what radiation is and why it is potentially hazardous.

3-2. Human Health Aspects of High-level Radioactive Waste. John Sutherland, Edutech Enterprises.
This paper covers general aspects of all radiation in our living environment including that from nature; from radioactive wastes; and from the many uses and sources of radiation in society, including nuclear power. It examines the radiation exposures and possible related health effects of some of the most highly exposed groups in both the general public and worker populations. There is a critical analysis of the Linear No Threshold (LNT) hypothesis which is used to derive risk estimates of radiation exposures whether they are received chronically or acutely.

3-3. Status of Canadian and International Efforts to Reduce the Security Risk of Used Nuclear Fuel. SAIC.
This paper provides a factual accounting of current Canadian and international efforts for reducing the security risk associated with nuclear fuel waste.

***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.**
This paper provides the historical evolution of the Safety Case concept and lists the key components necessary to build and communicate a convincing argument that a proposal has sound engineering, is environmentally safe, and will meet all regulatory requirements. The paper also describes the type of information that would be included in a Safety Case for the options now being considered for the long-term management of nuclear fuel waste in Canada.

4. Science and Environment

4-1. Status of Biosphere Research related to High-level Radioactive Waste Management. ECOMatters.
This paper describes the current status of biosphere research related to radioactive waste management. It examines biosphere programs in Canada and worldwide, with particular emphasis on the last decade (1993/2003). It includes information relevant to the three possible management approaches for used nuclear fuel as defined in the *Nuclear Fuel Waste Act*, with an emphasis on potential long-term impacts.

4-2. Characterizing the Geosphere in High-Level Radioactive Waste Management. Jonathan Sykes, University of Waterloo.
This paper presents an overview of geospheric research for a high-level radioactive waste management system. The "geosphere" is defined in the paper as the rock underlying a surface storage site or surrounding a subsurface disposal or storage vault, any sediments overlying the rock, and the groundwater in the rock and sediments.

***4-3. Natural and Anthropogenic Analogues - Insights for Management of Spent Fuel. Paul McKee and Don Lush, Stantec Consulting.**
This paper provides a brief description of several analogues relevant to spent fuel management in Canada, including descriptions of the uranium ore bodies that were natural reactors, other natural deposits of uranium found around the world, as well as both natural and archaeological analogues for isolation and containment materials and systems.

***4-4. The Chemical Toxicity Potential of CANDU Spent Fuel. Don Hart and Don Lush, Stantec Consulting.**
This paper identifies elements in CANDU spent fuel that should be included in environmental assessments when demonstrating "safety" with respect to chemical toxicity in long-term storage or disposal of spent fuel.

***4-5. Review of the Possible Implications of Climate Change on the Long-Term Management of Spent Nuclear Fuel. Gordon A. McBean, FRSC.**
This paper reviews the possible implications of climate change on the long-term management of spent nuclear fuel in Canada. As the climate changes and with it, the characteristics of day-to-day weather, the risks of impacts on storage and disposal facilities and transportation systems will change.

5. Economic Factors

5-1. An Examination of Economic Regions and the Nuclear Fuel Waste Management Act. Richard Kuhn, University of Guelph and Brenda Murphy, Wilfred Laurier University.
This paper reviews the concept of economic regions and the implications of the use of this concept for the NWMO. The relationship between the economic regions and siting methods is assessed in relation to different management options including deep geologic disposal, centralized storage and storage at nuclear reactor sites.

5-2. Status of Financing Systems for High-level Radioactive Waste Management. GF Energy, LLC.
This paper examines financial systems related to the management of high-level radioactive waste, focusing on spent nuclear fuel and high-level waste from commercial civilian power generation. Financial systems are an integral component to a country's strategy to determine responsibilities, accountability and timing for waste management.

5-3. Considerations for the Economic Assessment of Approaches to the Long-Term Management of High-Level Nuclear Waste. Charles River Associates Canada Limited.
This paper provides a summary description of some analytical tools that may be useful in conducting an economic assessment of approaches to the long-term management of high-level nuclear waste and outlines some framework considerations for such economic analyses. The paper also discusses some uniquely challenging issues and questions that the NWMO faces as it moves forward in considering the economic and financial implications of various waste management options.

***5-4. Economic and Financial Aspects of the Long-Term Management of High-Level Nuclear Waste: Issues and Approaches. Charles River Associates Canada Limited.**
This paper identifies a range of economic and financial issues that have been raised or addressed as other countries and organizations have approached the long-term management of used nuclear fuel. The paper also considers the Canadian context, by reviewing some of the legislative and regulatory institutions that will form the foundation for Canada's management of used nuclear fuel.

6. Technical Methods

6-1. Status of Reactor Site Storage Systems for Used Nuclear Fuel. SENES Consultants Ltd
This paper provides brief descriptions of used fuel storage systems at commercial reactor power sites in Canada. Comments are also provided on a variety of environmental and regulatory issues relevant to reactor site used fuel management systems.

6-2. Status of Centralized Storage Systems for Used Nuclear Fuel. Mohan Rao and Dave Hardy, Hardy Stevenson and Associates.
This paper reviews the status of centralized storage systems for used nuclear fuel. These are storage facilities built to store used nuclear fuel in an effective manner at a central location. Such facilities are considered by implementing organizations for the management of used fuel in a regional or a national context when there are many reactors producing used fuel.

6-3. Status of Geological Repositories for Used Nuclear Fuel. Charles McCombie, McCombie Consulting.
This paper provides an appraisal of the development of the concept of geological disposal of radioactive wastes and of its current status. It is an overview document which addresses the key issues associated with geological disposal of used nuclear fuel and other high-level radioactive wastes. Some topical issues such as the siting of deep repositories are examined in detail because of their fundamental importance to geological disposal and the significant level of public interest.

6-4. Status of Spent Fuel Reprocessing, Partitioning and Transmutation. David Jackson, David Jackson and Associates.
This paper outlines some of the some of the major issues concerning the feasibility and desirability of reprocessing, partitioning, conditioning and transmutation of nuclear fuel. It addresses a very basic

question about nuclear waste management: What could be done with used nuclear fuel to reduce the quantity and toxicity of the radioactive materials it contains?

6-5. Range of Potential Management Systems for Used Nuclear Fuel. Phil Richardson and Marion Hill, Enviros Consulting Ltd.
This paper provides a summary of recent published assessments of management options for used fuel and, based on these assessments, suggests that they can be placed in three categories of differing levels of interest for further R&D. Sixteen fuel management options are considered in the paper. For each option there is a brief description and a summary of published assessments.

6-6. Status of Transportation Systems for High-level Radioactive Waste Management. Wardrop Engineering Inc.
This background paper provides an overview of the current status of transportation systems for used nuclear fuel.

6-7. Status of Storage, Disposal and Transportation Containers for the Management of Used Nuclear Fuel. Kinectrics.
This paper provides a description of the current status of storage, disposal and transportation containers for the long-term management of used fuel.

***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.**
This paper reviews some of the fundamental issues and key considerations related to the transportation of spent nuclear fuel.

***6-9. Conceptual Designs for Used Nuclear Fuel Management. Joint Waste Owners, CTECH (a joint venture of CANATOM and AEA Technologies) and Cogema Logistics.**
The *Nuclear Fuel Waste Act* requires that the NWMO study include an assessment of three specific technical methods. Anticipating their responsibilities under the *Act* and prior to the establishment of NWMO, the Joint Waste Owners (Ontario Power Generation, Hydro-Québec, New Brunswick Power and Atomic Energy of Canada Limited) commissioned engineering consulting firms to develop preliminary conceptual designs and engineering cost estimates for the alternatives. These documents provide overviews of the typical conceptual designs including basic assumptions and common design features and associated cost estimates.

***6-10. Review of Conceptual Engineering Designs for Used Nuclear Fuel Management in Canada. ADH Technologies Inc.**
This review examines the overall engineering assumptions used in developing the conceptual designs for used nuclear fuel management.

***6-11. Validation of Cost Estimating Process for Long-Term Management of Used Nuclear Fuel. ADH Technologies Inc. and Charles River Associates Canada Ltd.**
This review examines the cost estimation process used in developing the conceptual designs for used nuclear fuel management.

7. Institutions and Governance

7-1. Status of the Legal and Administrative Arrangements for Waste Management in Canada. OCETA (Ontario Centre for Environmental Technology Advancement).
This paper provides general information about hazardous waste - definition, classification, quantity handled in Canada and transport and documentation required for hazardous waste. The key elements of the evolution of waste management are presented. A hierarchy for environmental protection is also described.

7-2. Status of the Legal and Administrative Arrangements for Low-level Radioactive Waste Management (LLRWM) in Canada. Paul Rennick, Rennick and Associates.
This paper describes the current situation with respect to LLRW Management in Canada. The key legal and administrative arrangements are summarized followed by some lessons learned from the application of low-level policies, procedures and facility siting processes that may be helpful for long term management of used nuclear fuel.

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.
This paper reviews the evolution of legal and administrative arrangements for high-level radioactive waste management in Canada. The paper also highlights various provincial and territorial legislation and regulations addressing nuclear substances, as well as a number of international treaties and conventions that Canada has ratified related to the management of radioactive waste and nuclear substances.

7-4. Legal and Administrative Provisions for Radioactive Waste Management within the North American Free Trade Agreement (NAFTA). Aaron Cosbey.
This paper surveys Canada's rights and obligations under the North American Free Trade Agreement (NAFTA) in an effort to better understand what they imply for transboundary movement of radioactive waste and, by implication, to the choices Canada will have to make in selecting or approving a management approach for such waste.

7-5. Status of Canadian Expertise and Capabilities related to High-level Radioactive Waste Management. George Bereznai, UOIT (University of Ontario Institute of Technology).
This paper provides an overview of the current status of Canadian expertise and capabilities related to high-level radioactive waste management. Storage of spent fuel at the reactor site, deep geological disposal in the Canadian Shield, and centralized storage/disposal above or below ground are the three currently recognized alternatives.

***7-6. Comparative Overview of Approaches to Management of Spent Nuclear Fuel and High Level Wastes in Different Countries. Charles McCombie and Bengt Tveiten.**
This paper provides a comparative overview of approaches in the management of spent nuclear fuel and high-level wastes in different countries. The prime objective of this overview is to provide NWMO and the Canadian public with a reference framework against which to assess proposed national options for spent fuel management.

***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.**
This report provides information of interest to NWMO in addressing its current task of developing a proposal for the long-term management of used nuclear fuel in Canada. A description is provided of the environmental behaviour of chemicals and the processes that are used to identify their hazards, assess possible risks and impose risk management actions to reduce or eliminate any unacceptable risks. A brief overview is included of 50 global and regional conventions and protocols and approximately 40 programs and initiatives that have been developed to address chemicals issues.

***7-8. Review of the Canadian Environmental Assessment Act (CEAA) Process in Relation to Nuclear Waste Management. Robert S. Boulden, Boulden Environmental Consulting.**
This paper outlines the federal environmental assessment process under the Canadian Environmental Assessment Act (CEAA) and speculates on some of the more likely scenarios that will arise once the NWMO makes recommendations to the Canadian government. The paper describes the basics of the federal process and discusses the amendments to the CEAA that came into force on October 30, 2003.

***7-9. Review of the CNSC Licensing Process in Relation to Spent Fuel Management. J.F. Lafortune and F. Lemay, International Safety Research.**
This paper examines the CNSC licensing process that may apply to the preparation, construction and operation of facilities for the long-term management of used nuclear fuel. The CNSC is exclusively responsible for the licensing of nuclear facilities. However, the CNSC licensing process takes into account, when applicable, the results of an environmental assessment. Therefore, this paper also examines how the environmental assessment process is incorporated into the CNSC licensing process.

***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.**
This paper provides a review of the legal and administrative aspects of the Treaty for the Non-Proliferation of Nuclear Weapons ("Non-Proliferation Treaty" or "NPT"), particularly in relation to spent nuclear fuel management. The review assesses the implications of the NPT on the various methods that the NWMO might consider for the management of Canada's spent nuclear fuel.

***7-11. Methodologies for Assessing Spent Nuclear Fuel Management Options. ETV Canada Inc., OCETA, Risk Wise Inc. and Science Concepts International.**
This report provides a comprehensive inventory of available methodologies and tools applicable to the assessment of options for the long-term management of used nuclear fuel. The information is organized within a generic assessment framework intended to improve understanding of where and

how individual decision support tools might fit into an overall analytical approach. The assessment framework is derived from broad experience in the use of decision-support methodologies for addressing policy issues of this type, both in Canada and internationally.

8. Workshop Reports

8-1. Environmental Aspects of Nuclear Fuel Waste Management. Robert W. Slater, Coleman Bright and Associates, and Chris Hanlon Patterson Associates.
A workshop was convened in Ottawa in September 2003 to discuss the environmental aspects of nuclear fuel waste management. Eleven experts participated, drawn from business and industry, academia, government, and the non-government sector. Workshop participants were asked to provide advice on the general environmental parameters that govern decision-making and the key environmental questions that need to be answered respecting the management of spent nuclear fuel.

8-2. Technical Aspects of Nuclear Fuel Waste Management. McMaster Institute for Energy Studies, McMaster University.
This workshop was organized by the McMaster Institute for Energy Studies to assist the NWMO in its mandate to stimulate a wide ranging public discussion on nuclear waste management issues. Its primary purpose was to identify the key issues, questions and concerns that need to be addressed from a technical perspective. The meeting was attended by 50 to 60 participants from various universities, nuclear energy organizations, and technical and consulting companies with a wide range of expertise, interests, and commitments.

8-3. Drawing on Aboriginal Wisdom: A Report on the Traditional Knowledge Workshop. Joanne Barnaby, Joanne Barnaby Consulting
A workshop was held at Wanuskewin Heritage Park near Saskatoon, in September 2003 to discuss how Traditional Knowledge and Practices might guide the work of the NWMO. Key objectives were to identify principles and develop recommendations on what should be considered in the study, identify research and information needs, and to develop suggestions for further consideration. Twenty-three people attended, including elders, academics with expertise in Traditional Knowledge and practice, national aboriginal organizations and non-government organizations concerned with nuclear waste management.

8-4. Community Dialogue: Report of the Planning Workshop. Glenn Sigurdson CSE Consulting Inc. and Barry Stuart.
The NWMO has determined from early research and discussions that the communities which currently store nuclear fuel waste have special experience, insights and perspectives which should be drawn upon to help inform the work of the NWMO. Additionally, within these communities there is a wide spectrum of perspectives and concerns that in many ways reflect the diversity of views across the country. Accordingly the NWMO determined that an important focus for engagement is with and within these reactor site communities.

8-5. Looking Forward to Learn: Future Scenarios For Testing Different Approaches to Managing Used Nuclear Fuel in Canada, Global Business Network (GBN)
In the exercise documented by this report, various futures were considered in order to develop a sense of what kind of conditions might be faced in managing used nuclear fuel over the long term. The formal scenarios technique uses the insight of a team of individuals drawn from many interests to design a range of futures, each of which is plausible according to what we know today. In order to undertake the scenarios analysis, the NWMO convened a Scenarios Team consisting of 26 individuals drawn from a range of interests and locations across Canada. This report contains a summary of the future scenarios and criteria developed by this Team.

APPENDIX 4 / SCREENING RATIONALE FOR 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. However, none are being implemented, nor are they part of any national program of research and development. In some cases, they are contrary to international conventions. For most of these methods, the used nuclear fuel would be difficult to retrieve.

Dilute and Disperse would, under one method, involve dissolving the 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.

Reasons for screening out - Dilute and disperse differs from all the other used nuclear fuel management methods in that there would be no containment of the waste and isolation from the environment. It has never seriously been proposed for used nuclear fuel because sea disposal is prohibited by international conventions. Dilute and disperse is not included in any national or international research and development programs.

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 kilometers 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.

Reasons for screening out - 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 meters, thus 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.

Reasons for screening out - 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 the used nuclear fuel from the Earth by ejecting it into outer space. Destinations which have been considered include the sun and ejection beyond the solar system. This method has been suggested for disposing of small amounts of the most toxic waste materials.

Reasons for screening out - This method has never been included in any major research and development program. Considerable further processing of the used nuclear fuel would be required. Concerns about the risk of an accident have been reinforced by the U.S. Space Shuttle Challenger and Columbia accidents.

Rock Melting would involve placing the used nuclear fuel in liquid or solid form in an excavated cavity or a deep borehole. The 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, thus 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 which led to an excavated cavity at a depth of 2-5 kilometers. 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.

Reasons for screening out - There was renewed interest in this method 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 the 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 emplacement 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.

Reasons for screening out - Lack of confidence in predicting the fate of the used nuclear fuel has been the main reason why little attention has been paid to disposal in subduction zones. Concerns have been expressed that the used fuel might return to the surface environment via volcanic eruptions. It has also been suggested that this method would be seen as a form of sea disposal and hence would be prohibited by international conventions. No national or international program is currently examining this option in any way.

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.

Reasons for screening out - 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 that would require extensive research to gain the 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 of this method and 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 a few kilometers deep. The main sub-seabed disposal concept would use missile-shaped canisters called "penetrators" that hold the solid waste, are dropped from ships, and bury themselves to a depth of a few meters or more 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 meters, with the uppermost container about 300 meters 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 consequences.

Reasons for screening out - 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 U.S., the U.K., Japan and several European countries. Research on sub-seabed disposal effectively ceased in the early 1990s 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.

APPENDIX 5 / GLOSSARY

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.

Centralized Facility means a facility used for the extended storage or geologic emplacement 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.

Decommissioning is the closing of a nuclear station at the end of its life.

Deep Geological Disposal is the emplacement of used nuclear fuel deep underground where both natural and engineered barriers shield it from humans and the environment.

Deliberative survey is a public opinion research tool which provides people with background information on which to base the views they express.

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 which 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.

Extended Storage means storage for periods of time significantly greater than 50 years from the time the facility is placed into service. In the context of this study it means permanent or indefinite storage.

Fissile refers to a nuclide which can be induced to fission by an incoming neutron of any energy. 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, 235U. Other fissile nuclides are 233U and some isotopes of plutonium (239Pu and 241Pu), but none of these occurs in nature to any appreciable extent.

Influence diagram is a tool used in multi-attribute analysis for mapping the principle interacting factors which influence the capacity of an option to perform well on a particular objective.

Isotopes are atoms of an element with the same number of protons but different numbers of neutrons. Most are manmade and are radioactive. Radioactive isotopes are called radioisotopes.

Joint Waste Owners refers to corporations that own Canada's used nuclear fuel; Atomic Energy of Canada Limited, Hydro-Québec, New Brunswick Power and Ontario Power Generation.

Management Approach is strategy for the long-term care of used nuclear fuel which encompasses a particular technical method or sequence of methods, and all of the conditions necessary for its successful implementation, including societal requirements, related infrastructure, institutional and governance arrangements.

Multi-attribute utility-analysis methodology is a step by step decision support methodology which permits a comprehensive assessment of various options against multiple objectives.

Partitioning is the separation and segregation of certain radioisotopes from used nuclear fuel.

Reactor Extended Storage Facility is a facility used for the extended storage of used nuclear fuel. The storage facilities would be located at each of the current reactor sites. Each fuel owner would implement a storage solution selected for the specific circumstances of that site.

Repository is a place where used nuclear fuel is disposed of or stored.

Reprocessing is the physical and chemical treatment of used nuclear fuel for the purpose of recovery and recycling of uranium, plutonium and fission products.

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.

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.

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. No national or international program is currently examining this option.

Technical method is the technology, technical process or procedure for handling used nuclear fuel. It is one part of a management approach.

Transmutation is the further processing and transformation of radioisotopes using nuclear reactions initiated by neutrons, protons, or photons from lasers.

Used nuclear fuel means the irradiated fuel bundles removed from a commercial or research nuclear fission reactor.

Values are a set of beliefs, principles or standards which a person considers important and which affect his or her actions.

Waste 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.

NUCLEAR WASTE MANAGEMENT ORGANIZATION

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