Regulatory Document

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Atomic Energy Control Board

Commission de contrôle de l'énergie atomique

REGULATORY DOCUMENT R-71

Regulatory Policy Statement

DEEP GEOLOGICAL DISPOSAL OF NUCLEAR FUEL WASTE: BACKGROUND INFORMATION AND REGULATORY REQUIREMENTS REGARDING THE CONCEPT ASSESSMENT PHASE

Effective date:

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Canada

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5. Copies of Consultative Documents, Regulatory Documents and related index lists are available in both English and French on request from the Office of Public Information. Requests for technical information on and interpretation of documents should be addressed to this office.

6. The Atomic Energy Control Board may be contacted as follows:

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1. BACKGROUND INFORMATION

1.1 Introduction

In their Joint Statement of August 1981, the governments of Canada and Ontario noted that the Nuclear Fuel Waste Management Program had been established to assure the safe and permanent disposal of radioactive waste from nuclear power reactors. The statement addressed the scope and schedule of the Concept Assessment Phase of the Program, and identified the participating organizations and their responsibilities. The scope of this initial phase includes the development and assessment by Ontario Hydro and Atomic Energy of Canada Limited (AECL) of a disposal concept and its subsequent review by the regulatory agencies and government. The Atomic Energy Control Board (AECB), as lead regulatory agency, is issuing this statement to outline its position with respect to evaluation of the concept.

The AECB has formulated its requirements in the context of the background information to follow. The requirements as presented in Chapter 2 relate to both the disposal concept and its assessment.

Although the position presented in this document concerns a specific submission from AECL, the requirements are meant to be of general application, inasmuch as they would be imposed upon any proponent engaged in a similar undertaking.

1.2 Nature of the Problem

Irradiated fuel from nuclear reactor operations is accumulating in storage facilities at the reactor sites. Governments have not yet decided whether the irradiated fuel should be discarded in its present form or reprocessed to recover useful constituents. The irradiated fuel is being stored in water-filled bays at each of the reactor sites, the water being both a radiation shield and a coolant. Evidence exists that irradiated fuel can be stored in this manner safely and reliably for a number of decades. However, regular maintenance and monitoring are required, and reliance cannot be placed on the institutional controls needed for the time period during which the irradiated fuel requires isolation from human beings. Consequently, this storage system can only be considered as an interim measure. A structured program for the development of a disposal method for this nuclear fuel waste has begun.

Disposal is a method of waste management in which a waste is safely discarded without the intention of retrieval. The objectives of disposal are to protect man and the environment and to minimize the burden imposed on future generations for the continued management of the wastes.

A number of disposal methods for nuclear fuel wastes have been suggested internationally, including ejection of the waste into outer space;

transmutation of the radioactive elements; emplacement in a polar ice cap; and burial within various geological formations, both on the continents and beneath the sea floor. There exists an international consensus, which Canada endorses, that efforts to develop a safe method for disposing of nuclear fuel waste can be most profitably directed to concepts which involve some form of geological disposal.

In addition to nuclear fuel waste, it should be recognized that there are other radioactive wastes which might warrant disposal by similar means. It may therefore eventually be appropriate to examine the implications of including these wastes in the proposed inventory for disposal. However, this document is restricted to a consideration of the disposal of nuclear fuel waste.

1.3 Government Initiatives

In June 1978, the governments of Canada and Ontario announced the inception of a program "to dispose of radioactive wastes from nuclear power reactors" safely in a deep, underground repository in intrusive igneous rock. Under the terms of the program established by the two governments, AECL was given responsibility for conducting research on the immobilization and disposal of the wastes, and Ontario Hydro was given responsibility for conducting research on interim storage and transport of the irradiated fuel.

As a result of subsequent developments, the Canada-Ontario Joint Statement on the Nuclear Fuel Waste Management Program was issued in August 1981. This statement announced, among other things, that

- it had been the intention of the governments, from the beginning, to subject the program "to thorough public and regulatory scrutiny";
- "no disposal site selection [would] be undertaken until after the concept [had] been accepted";
- the governments had reached "agreement on the scope of this evaluation process, [on] the roles and responsibilities of their agencies, and on the means by which the public could become involved"; and
- the AECB, in accordance with its basic mandate, would be "the lead agency for regulatory and environmental review of the disposal concept."

The roles and responsibilities of the regulatory agencies and the process of evaluation are further described in sections 1.6 and 1.7 of this chapter.

1.4 The Disposal Concept

The governments of Canada and Ontario have decided to focus their resources on the concept of emplacing nuclear fuel wastes deep in a pluton (a large igneous rock body that crystallized deep beneath the surface of the earth). This disposal concept incorporates both engineered and natural components into an integrated system of multiple barriers, the primary objective of which is isolation and containment of the wastes.

Although the engineered barriers will be designed primarily to isolate the waste from the groundwater, it is recognized that eventually some radioactive material will be leached from the repository and may ultimately be transported to the biosphere. As currently envisaged the engineered barriers can be briefly described as

(a) The Waste Form: The wastes will be incorporated in materials which will immobilize the radionuclides and resist dissolution in groundwater.

(b) The Containers: The waste form will be encapsulated in containers made of a material that is resistant to degradation by groundwater.

(c) The Buffer Material: The containers will be surrounded by a buffer material chosen to inhibit groundwater circulation around the containers and to retard the movement of radionuclides that may become dissolved in the groundwater.

(d) The Repository: The repository will be designed to allow the heat generated by the waste to be dissipated with minimal detriment to the effectiveness of other barriers. Backfilling and sealing of the repository vault and shafts will be designed to enhance the effectiveness of other barriers and retard the ingress of water.

The natural barriers comprise the physical and chemical characteristics of the geological environment of the repository. The major components are the host rock (the pluton), the surrounding rocks (around the pluton) and the groundwater regime. The host rock is a physical barrier to intrusion and radionuclide migration. Once radioactive materials are leached from the waste form and enter the rock-groundwater system, retardation processes will hinder radionuclide migration, allowing longer periods for radioactive decay. The radioactive decay, adsorption, dilution and physical dispersion of the radionuclides throughout the rock mass will contribute to limiting to an acceptable level the quantity and concentration of radionuclides which may eventually reach the biosphere. The following examples may serve to illustrate some of the processes and characteristics referred to above:

(a) Limitations on Groundwater Flow: Low fracture frequency, low permeability, low hydraulic gradient and low groundwater input will slow the rate of groundwater movement. This will contribute to a reduction in the influence of groundwater on the engineered barriers and in the rate of radionuclide transport away from the repository.

(b) Long Flow Path Length: The time required to transport radionuclides from the repository to the biosphere is a function of the depth of the repository and the tortuosity of the flow paths.

(c) Factors Which Promote Radionuclide Retardation: The rate at which radionuclides will migrate is influenced by chemical reactions which result in precipitation; by the capacity of minerals and other compounds in the host rock, surrounding rocks, and along fracture surfaces to promote irreversible sorption reactions and ion exchange reactions; and by diffusion into the host rock.

1.5 The Nature of Concept Assessment and Relevant Considerations

For the purposes of this document, Concept Assessment refers to the program that AECL and Ontario Hydro are carrying out to develop the concept described in section 1.4 and to assess its effectiveness, that is, to predict the performance of such a disposal system. Concept Assessment is a process designed to examine all matters germane to the deep geological disposal of nuclear fuel waste. It begins as an overview which attempts to examine all components of the concept and which considers how these components might evolve and interact with one another throughout the life of the proposed disposal system. This is done in order to identify and anticipate difficulties which might arise.

By an iterative process using data obtained from field and laboratory investigations, the concept will be refined until it can be shown with an acceptable level of confidence that the performance requirements established by the regulatory agencies will likely be met. At the completion of Concept Assessment, there must be little doubt that the concept which is finally accepted can be undertaken successfully in Canada.

It has been agreed by the governments of Canada and Ontario that site selection for a repository will be undertaken only after Concept Assessment has been satisfactorily completed. Therefore, the exercise will be of a generic nature insofar as no reference will be made to a specific disposal site. There are several inferences which arise from this:

(a) The exact nature and magnitude of actual site variables and other information necessary for detailed component design will not be available during Concept Assessment. Therefore, the spectrum of potential site variables and their respective ranges should be sufficiently broad to ensure that variables and their ranges likely to be encountered at any specific site proposed for a repository will have been considered during Concept Assessment.

(b) Although the set of variables to be examined during Concept Assessment should include the set of variables to be examined when a disposal site is being selected, the level of detail will generally be different. During Concept Assessment, it is only necessary to examine variables to the level of detail needed to establish confidence in the acceptability of the proposed concept.

(c) Regulatory evaluation of the expected long-term performance of a repository must be based almost entirely on a consideration of the results of predictive modelling, which incorporates data from extensive laboratory and field studies.

Although there are no comprehensively studied precedents that adequately address certain long-term aspects of deep geological disposal of nuclear fuel waste, there are many aspects of the nuclear fuel waste disposal concept that are well understood. For example, there is a large body of knowledge and experience from which to draw regarding such aspects as

(a) excavation of a vault deep underground;

(b) handling of highly radioactive materials; and

(c) behaviour of certain metal alloys under the chemical, thermal and radiological conditions normally associated with irradiated fuel.

Certain natural processes may also provide valuable information regarding the possible performance of a deep geological waste disposal system. For example, many uranium ore bodies have existed for hundreds of millions of years under conditions similar to those expected at a repository site. In one uranium ore body at Oklo, in Gabon, several natural nuclear chain reactions are known to have occurred about two billion years ago. Some of these continued intermittently for nearly one million years. The radioactive products of these natural reactors were the same as those contained in nuclear fuel wastes, and valuable relevant information may be acquired from studies of their subsequent behaviour during the intervening two billion years.

1.6 Regulatory Roles and Responsibilities

The AECB is responsible for the comprehensive regulation of all undertakings that involve the development, application or use of nuclear energy in Canada. In this capacity, the AECB regularly consults with other federal and provincial regulatory agencies. Since a facility for the disposal of nuclear fuel waste would be a nuclear facility under the terms of the Atomic Energy Control Regulations, it would be subject to licensing by the AECB.

In its regulation of nuclear facilities, the AECB normally reviews the proposed facility concept at the time site approval is sought. However, in the case of the Nuclear Fuel Waste Management Program, the AECB has determined that it will undertake a comprehensive review of the generic concept prior to site selection.

As noted in section 1.3, the Joint Statement of August 1981 by the governments of Canada and Ontario identified the AECB as the lead agency for the regulatory evaluation of the disposal concept. The AECB will be assisted in this task by Environment Canada and the Ontario Ministry of the Environment. Together, these three agencies make up the Interagency Review Committee on Concept Assessment (IRC). Other regulatory agencies will be consulted as necessary.

As noted in an earlier AECB communiqué on the subject (News Release 82-2, March 10, 1982), the terms of reference for the activities of the IRC are as follows:

(a) "to provide recommendations on concept assessment for deep geological disposal in order to assist the AECB in making a decision on the acceptability of the concept;

(b) "to coordinate the reviews of the participating agencies, with each agency committing itself to those parts of the total review most appropriate to its mandate and expertise;

(c) "to make recommendations to the federal government on the public hearing process for concept assessment."

It is the responsibility of the regulatory agencies, in particular the AECB, to review the assessment done by AECL and to evaluate the proposed concept and its assessment in the light of the requirements presented in Chapter 2 of this

document. The evaluation by the regulatory agencies will result from an independent review of the assessment of the proposed concept, but much of the information to be used in this review will have been gathered through the research and development that AECL has undertaken to assess the concept. It is therefore important that the regulatory agencies provide guidance as to what constitutes a comprehensive and thorough assessment and what documentation is required for an adequate regulatory review and evaluation. This document is intended to supply such guidance. In addition, this document presents requirements and criteria which a disposal system based on the proposed concept is expected to meet.

The AECB must be satisfied, within the constraints of a generic study, that deep geological disposal in a pluton can be a safe, adequate and feasible method for long-term management of nuclear fuel wastes. If Concept Assessment does demonstrate the likelihood that deep disposal in a pluton can satisfy the technical requirements for health, safety, security and environmental protection, the AECB will consider this concept to be acceptable.

The concept of disposal in plutonic rock will be judged on its own merits without reference to other options. AECL may nonetheless be questioned on its choice during the review process and should maintain a current awareness of studies on other disposal methods in the event that disposal in plutonic rock should prove to be unsuitable.

1.7 The Review Process

In its role as lead agency for the regulatory evaluation of the disposal concept, the AECB will review the technical issues as they relate to health, safety, security and the environment, in a manner similar to that normally used in the licensing of a nuclear facility. This will be done in consultation with the other two agencies represented on the IRC.

Since the disposal of nuclear fuel waste raises social and economic questions as well as those of a technical nature, the AECB will endeavour to ensure that, concurrently with the technical review, the social and economic issues are also given due consideration. The aid of other agencies will be enlisted, as required, in order to do this. Environment Canada and the Ontario Ministry of the Environment have established review mechanisms and have gained considerable experience with respect to socio-economic matters; therefore, as members of the IRC, these two bodies will be responsible for reviewing submissions on socio-economic impact.

The review process itself has several clearly defined steps. These steps were announced in the Canada-Ontario Joint Statement on the Nuclear Fuel Waste Management Program, August 1981, in the section entitled, "Process for Evaluation of the Concept":

> "1. Public Announcement: Announcement by the governments of Canada and Ontario of the overall process to be implemented in the concept assessment phase of the waste management program."

The Joint Statement of August 1981 constituted this public announcement.

> "2. Issuance of Initial Statement on the Regulatory Review and Assessment of the Disposal Concept: Issuance by the AECB of a statement on the

regulatory review and assessment of the disposal concept for public review and comment. This statement will include requirements on the impact of a sealed repository on the biosphere over long time periods.

"Concurrent issuance by the three IRC agencies of an explanation of the joint consultative nature of the regulatory review."

The present document is the official statement of the AECB referred to above. An explanation of the joint consultative review process is also included in this document as well as in AECB News Release 82-2.

"3. Submission of Interim Concept Assessment Document: Submission by AECL to the members of the IRC, interested groups, public libraries and government offices across Canada of the Interim Concept Assessment Document, which will include a safety and environmental assessment, for review and comment."

The initial draft of the Concept Assessment Document has already been published as AECL-TR-127.

"4. Issuance of Final Statement on the Regulatory Review and Assessment of the Disposal Concept: Issuance by the AECB of the final statement on the regulatory review and assessment of the disposal concept. This document will provide a basis for decisions on the acceptability of the proposed concept."

To satisfy this step of the process, the AECB will augment this present document, as required, with regulatory statements dealing with specific issues.

"5. Issuance of Updated Concept Assessment Documents: Updated Concept Assessment Documents issued by AECL from time to time including new data from the research.

"6. Formal Submission for Acceptance of the Concept Assessment Document: A formal submission of the Concept Assessment Document for the acceptance of the AECB will be made by AECL. This is not expected to occur until several years after the start of the process. This document will also be submitted to the members of IRC, interested groups, public libraries and government offices across Canada.

"7. Review of Concept Assessment Document: Announcement by AECB of the receipt of the submission and of the specific arrangements and schedule for regulatory review including public consultation through a public hearing process under the auspices of the Federal Government. A report from the IRC on the concept assessment document will be made available to the public before the hearing."

At the present time, the type, format, terms of reference and composition of the hearing panel are yet to be identified by the Federal Government.

"8. Report from Public Hearing: Recommendations arising from the Public Hearing Process submitted to AECB by the responsible body and made available to the public."

The Public Hearing Process and the responsible body referred to in this step are yet to be determined by government.

"9. Statement on Acceptability or Non-Acceptability of the Waste Disposal Concept: Issuance of a statement by the AECB on the acceptability, conditional acceptability, or non-acceptability of the concept.

"10. Concept Acceptance: In the case of acceptability, the governments of Canada and Ontario may accept the concept assessment document. Acceptance would be a prerequisite to selection of any site for a waste disposal facility.

"In the case of conditional acceptability, further research work by AECL and resubmission of a final Concept Assessment Document will be required.

"In the case of non-acceptability, the governments of Canada and Ontario must consider alternative proposals."

1.8 Timeliness of Submissions

It is important that, within the overall framework and timetable for Concept Assessment, documentation in support of the concept be submitted to the AECB in a timely fashion. This timeliness will allow a careful, thorough review by regulatory agencies, the scientific community, industry and the public, will permit the necessary and timely feedback to the research and development program, and should serve to increase the confidence in a final decision regarding the disposal concept.

2. REGULATORY REQUIREMENTS

2.1 Introduction

Within the context of Concept Assessment, a distinction may be drawn between those requirements which apply to the concept and those which apply to the assessment and its documentation. This distinction underlies the framework within which the following requirements are presented. The requirements which apply to the disposal concept itself are contained in section 2.2. The requirements which pertain to the assessment and documentation of the concept are dealt with in section 2.3.

2.2 Requirements for the Disposal Concept

2.2.1 Introduction

The life of a deep geological repository may be generally described in terms of

(a) a pre-closure period consisting of the time during which the site is selected, the repository is constructed, and the waste is emplaced, and any subsequent time after emplacement of the wastes that the repository is kept open for surveillance or other reasons; and

(b) a post-closure period which begins after the repository is closed.

Activities associated with closing the facility, such as the backfilling of tunnels, the sealing of shafts and the decommissioning of surface structures are considered pre-closure activities.

The distinction between pre-closure and post-closure is observed in all of the requirements which follow. In addition, the term "disposal system" is introduced and is intended to be a comprehensive term, embracing all structures, materials, processes, procedures or other aspects which, when taken together, constitute the means by which the safe disposal of the waste is achieved.

2.2.2 Requirements Which Apply to Deep Geological Disposal of Nuclear Fuel Waste

In developing the concept for disposal of nuclear fuel waste in a deep geological repository, the following requirements must be taken into account:

1. In the pre-closure period, the disposal system must meet applicable regulations regarding:

(a) radiological health and safety;
(b) conventional health and safety;
(c) environmental protection;
(d) safeguards and security; and
(e) transportation of radioactive material.

2. Following closure, the performance of the waste repository must be such that the probability of radiation doses to members of the public, attributable to the existence of the repository, exceeding a small fraction of doses received from natural background radiation will be small.

Specific criteria on this issue are currently under development.

3. The waste repository must be designed in such a way that no dependence on intervention or maintenance by future generations is necessary to ensure continued safety in the post-closure period.

4. A disposal system must be based upon the use of multiple barriers which incorporate both engineered and natural components.

5. A disposal system must be subject to a quality assurance program at all stages up to and including closure.

6. A disposal system must be able to accommodate natural disturbances likely to occur, such that any increase in risk to members of the public as a result of these disturbances will be insignificant.

The reference to risk, rather than to dose to members of the public, is intended to take into account not only the radiological consequences of natural events, but also the probabilities of their occurrence.

7. The effectiveness of the disposal system must not be compromised by any provision that may be made for

(a) pre-closure measurements.

The performance of the waste repository in the post-closure period will be assessed on the basis of predictive modelling. Therefore measurements will be required during the pre-closure period in order to ensure that input data for the models are sufficiently complete and representative of the repository environment.

(b) post-closure retrieval.

Although there will be no design requirement for including post-closure retrievability of the wastes, should such provisions be made, they must be of a nature that will not compromise the effectiveness of the repository.

(c) post-closure measurements.

The repository will only be allowed to close when sufficient evidence is available to lead to the conclusion, with a sufficient degree of certainty, that the facility could be abandoned without the need for post-closure monitoring. Should post-closure monitoring nevertheless be considered, the methods proposed must be such that the integrity of the repository will not be compromised.

8. For the pre-closure operational period, the concept must, as a contingency measure, incorporate methods for waste retrieval.

2.3 Requirements for the Concept Assessment and its Documentation

2.3.1 Introduction

Section 2.2 outlined requirements pertaining to the development of the concept. This section presents requirements regarding the assessment of the concept and the documentation of that assessment. The requirements which follow have been subdivided into general requirements and those requirements which apply specifically to predictive modelling and analytical considerations relating to the performance of the repository in the post-closure period.

A first step in the assessment of the concept must be to separate the subject into its constituent parts. One of the purposes of the requirements which follow is to ensure that the problem has indeed been adequately defined and delineated. A second purpose is to ensure that the information which is submitted in the Concept Assessment Document is sufficiently detailed that a proper and thorough evaluation of the concept by the regulatory authorities is possible.

The post-closure timeframe encountered in the geological disposal of nuclear fuel waste gives rise to design considerations which are unique in ordinary human terms. This particular aspect of nuclear fuel waste disposal must be adequately addressed, and convincing evidence must be offered, based on relevant research, sound design and realistic predictive modelling that the system will perform over the long term as required. Predictions of component performance will also have associated uncertainties, and the system analysis must reflect this fact.

The Concept Assessment Document must include information which shows that the models effectively represent the processes in question or that further

development to achieve this will take place according to a specified schedule. The document should also demonstrate that the input data for the models can be assembled.

The nature of Concept Assessment is such that not all the information relevant to the final solution will be available before a site is selected. Such limitations in the information available must be clearly identified. The AECB accepts the fact that only a limited data base can be established during the Concept Assessment stage. There must, however, be a reasonable expectation that the necessary data will become available during specified intervals in the licensing process.

2.3.2 General Requirements

1. The Concept Assessment Document must clearly demonstrate that the problem of nuclear fuel waste disposal has been separated into its constituent parts and that all relevant aspects have been adequately considered.

In the normal life cycle of a waste management facility, there are a number of relatively distinct phases:

(a) site selection;
(b) design;
(c) construction;
(d) operation;
(e) closure; and
(f) post-closure.

During the development of a design concept and its subsequent assessment, an attempt is made to preview these phases within the context of the undertaking in question. This preview is characterized by both analysis and preliminary design, and is most easily accomplished if the undertaking has been resolved into its component parts. Deep geological disposal of nuclear fuel waste may be represented by the following components and processes:

(a) regional geological framework (which will include both the host rock body and the surrounding rock bodies);
(b) groundwater system;
(c) transportation of nuclear fuel waste;
(d) receipt and storage of spent fuel;
(e) immobilization and packaging of spent fuel or reprocessing waste;
(f) handling and transfer of waste packages;
(g) repository vault;
(h) waste container, backfill, shaft sealant, other engineered barriers;
(i) storage and disposal of low-level process waste from immobilization, handling and transfer operations; and
(j) the biosphere.

Certain components will be relevant at each phase, and the identification of these correlations between components and phases will define the elements of the problem. It is also important to recognize that there are interrelationships between the elements themselves and that what happens at one phase may profoundly affect what happens at others.

The potentially significant elements and interrelationships between elements must be identified as part of Concept Assessment. The implications and importance of each must be examined within the context of both normal conditions and contingencies, and with respect to the following factors:

(a) radiological health and safety;
(b) conventional health and safety;
(c) technology:
    - present state of the art;
    - areas where development is necessary;
(d) environmental considerations; and
(e) safeguards and security.

2. The chosen concept must be shown to be technically feasible with available technology or with reasonably achievable developments.

The concept will be judged on the basis of whether or not there is a reasonable expectation that the performance requirements established by the regulatory agencies could be met. Because it is possible at the Concept Assessment stage to advance a solution which can be shown to be safe but which is difficult to achieve, the technical feasibility of the proposed concept must be established.

3. Annual effective dose equivalents must be estimated.

Dose calculations must be made for occupational exposures during the pre-closure phase and for members of the public during both the pre-closure and post-closure phases. Dose calculations for members of the public must include the identification of reference critical groups and a thorough consideration of possible release mechanisms and of subsequent transfer of radionuclides through the environment. The timeframe encountered in the geological disposal of nuclear fuel waste must also be considered. Collective dose need not be calculated at the Concept Assessment stage.

4. The significance of inadvertent human intrusion into the repository during the post-closure period must be addressed.

Selection of a repository host rock that does not contain commercial grade minerals and that is generally common to the region will reduce, but not eliminate, the probability of human intrusion. The Concept Assessment Document must address human intrusion, identifying the various scenarios for intrusion, their probabilities of occurrence and their consequences. In this context, the advisability of prominently marking the site of a closed facility with a durable monument (as opposed to taking steps to eliminate all signs of the repository's existence) should be investigated.

5. The environmental impacts resulting from the repository must be assessed.

The Concept Assessment Document must properly address both the short-term and long-term aspects of the environmental impacts resulting from the disposal of nuclear fuel waste, recognizing that the impacts will be different in the pre-closure and post-closure phases and that mitigative action, if necessary, would still be possible in the pre-closure phase. With respect to both radioactive and non-radioactive contaminants, thorough consideration must be

given to release mechanisms and rates, natural mechanisms for retardation or fixation, transport rates in groundwater systems expected to be typical of the actual repository site, the manner in which these contaminants move in the biosphere, their biological effects, their possible geological and geochemical effects, and their combined or synergistic effects. Particular emphasis must be placed on the following:

(a) The nature and extent of chemical interaction between the waste and groundwater, and the effect that this has on release and transfer rates for radionuclides as well as for non-radioactive substances must be determined.

(b) The rates of release and transfer, the concentrations, and the chemical forms of these elements as they arrive at critical boundaries or enter critical pathways and other parts of the biosphere must be determined. The variation in these rates and concentrations with time should also be established.

(c) The various biological pathways by which humans and other forms of life will receive radiation doses as a result of the repository must be assessed.

(d) The possible geological and geochemical effects -- such as changes in the thermal regime or groundwater flow system -- which may result from the repository should be investigated, and their nature and extent described.

6. *Processes which may enhance migration of radionuclides or other hazardous materials must be identified and evaluated.*

The Concept Assessment Document should not focus solely on processes in the geological environment that retard the movement of radionuclides or of other hazardous materials that may be released from the repository. The importance of other processes that may enhance movement must be addressed.

7. *Adequate quality assurance documentation for all aspects of Concept Assessment must be presented.*

The establishment of a quality assurance program prior to a safety-related undertaking is imperative in order that the procedures governing the undertaking may be planned and regularly scrutinized, and their implementation periodically audited. Such a program for Concept Assessment should include provisions for qualified personnel, establishment of procedures, control of documents, and effective organization. Among other things, the program must ensure that the procedures used for gathering data are reliable, that the data are effectively transferred from field and laboratory personnel to the modellers, and that the data are properly incorporated into the model or models. The quality assurance program and its application must be documented in the Concept Assessment Document.

8. *A thorough discussion of the technology needed for deep geological disposal must be included in the Concept Assessment Document.*

In addition to available technology, new technology may be needed for the deep geological disposal program. The Concept Assessment Document should evaluate

both existing and future technology expected to be used in nuclear fuel waste disposal. Solutions which depend on technological development which has not yet been achieved but is expected must be carefully examined to determine whether the expectation is realistic. The steps being taken to address problems of this nature should be described, and an attempt should be made to estimate the scheduling of these necessary developments.

9. *Socio-economic impacts resulting from a deep geological disposal facility for nuclear fuel waste must be addressed.*

Generic issues pertaining to socio-economic impacts will be examined at the Concept Assessment stage through a review and evaluation process which will include the Public Hearing Process referred to in section 1.7. Well in advance of this hearing, the Hearing Panel or responsible body can be expected to issue detailed guidelines regarding the content of submissions. Based upon past experience, these guidelines can be expected to address a broad spectrum of topics which deal with federal, provincial, community and individual matters such as

(a) public perception of the risk associated with radioactive waste disposal;
(b) the availability of natural resources and capital;
(c) transportation;
(d) the availability of persons with the necessary skills required for each step in the life of the facility;
(e) secondary job creation;
(f) additional community services needed; and
(g) effect on property values.

2.3.3 Requirements for the Analysis and Predictive Modelling of Repository Performance

1. *The Concept Assessment Document must describe the set of events and processes to which the proposed repository may be subjected. The Concept Assessment Document must also define the events and processes which the repository is designed to withstand.*

2. *All assumptions used in the assessment of the concept must be identified and justified, and effects of the assumptions on the assessment of the concept must be evaluated, particularly if the assumptions are limiting.*

3. *In assessing the performance of the repository*

(a) limiting values of variables and parameters must be identified, and justification provided for ignoring more extreme values;

(b) if probabilistic methods are to be used, the distribution function for each variable and parameter should be provided and justified;

(c) if distribution functions are sampled to determine scenarios for assessment, the suite of scenarios assessed, their results and overall conclusions must be shown to be representative.

4. *The choice of boundary conditions must be justified (for example, space or time cut-off limits used in calculation of dose).*

5. The Concept Assessment Document must characterize the physical and chemical properties of the wastes, including the variation of these properties with time.

6. Prior to completion of Concept Assessment, the data base required to perform adequate modelling calculations must be shown to be obtainable, and a schedule provided for completion of the data base.

7. The Concept Assessment Document must identify the components of the proposed disposal system and the parameters and variables used to model the components. The models representing the various components and sub-systems must be integrated into a coherent system model. Any significant interrelationships or interactions between components, parameters or variables must be included.

8. Uncertainties in the data or analysis must be clearly identified. Quantified values or reasoned estimates of the magnitude of these uncertainties must be presented.

9. The approach used and the level of detail employed in the models must be shown to be sufficient to represent adequately the associated physical process.

10. The sensitivity of model calculations to input parameter variation must be investigated. Determined values must reflect observations or, where observations are not available or possible, the values must be shown to be reasonable.

11. To the extent possible, the models used and the relationships they represent must be validated by experiments. Where validation is not possible, it must be shown that the models are conservative. The use of natural analogs to demonstrate validity of models and to support estimates of uncertainty is encouraged.

12. A quality assurance program must be used in the development, application and maintenance of computer models. This quality assurance program and its application must be documented in the Concept Assessment Document.