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NWMO BACKGROUND PAPERS
6. TECHNICAL METHODS

6-3 STATUS OF GEOLOGICAL REPOSITORIES FOR USED NUCLEAR FUEL

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NWMO Background Papers

NWMO has commissioned a series of background papers which present concepts and contextual information about the state of our knowledge on important topics related to the management of radioactive waste. The intent of these background papers is to provide input to defining possible approaches for the long-term management of used nuclear fuel and to contribute to an informed dialogue with the public and other stakeholders. The papers currently available are posted on NWMO's web site. Additional papers may be commissioned.

The topics of the background papers can be classified under the following broad headings:

1. **Guiding Concepts –** describe key concepts which can help guide an informed dialogue with the public and other stakeholders on the topic of radioactive waste management. They include perspectives on risk, security, the precautionary approach, adaptive management, traditional knowledge and sustainable development.
2. **Social and Ethical Dimensions** - provide perspectives on the social and ethical dimensions of radioactive waste management. They include background papers prepared for roundtable discussions.
3. **Health and Safety –** provide information on the status of relevant research, technologies, standards and procedures to reduce radiation and security risk associated with radioactive waste management.
4. **Science and Environment –** provide information on the current status of relevant research on ecosystem processes and environmental management issues. They include descriptions of the current efforts, as well as the status of research into our understanding of the biosphere and geosphere.
5. **Economic Factors** - provide insight into the economic factors and financial requirements for the long-term management of used nuclear fuel.
6. **Technical Methods** - provide general descriptions of the three methods for the long-term management of used nuclear fuel as defined in the NFWA, as well as other possible methods and related system requirements.
7. **Institutions and Governance** - outline the current relevant legal, administrative and institutional requirements that may be applicable to the long-term management of spent nuclear fuel in Canada, including legislation, regulations, guidelines, protocols, directives, policies and procedures of various jurisdictions.

Appendix B

Ethical issues

Introduction

In this Appendix, after an introductory overview, relevant ethical principles are identified, their relevance discussed and "messages" derived which should influence the development of safety criteria for deep geological repositories.

B1 Early Ethical Considerations

In the early years of radioactive waste disposal studies, the problem was primarily regarded as a technical and economic challenge without much explicit recognition of political, social and ethical aspects. There was none the less direct recognition of the key importance of ensuring the safety of humans and the environment. The guidelines for the US National Academy Committee on Geological Aspects of Radioactive Waste Disposal already in 1955 included the following principles (quoted in NRC 1966):

1. *Safety is a primary concern, taking precedence over cost.*

2. *Radioactive Waste, if disposed of underground, should be isolated as permanently as possible from contact with living organisms.*

In the eighties, explicit attention was paid to ethical issues during development of objectives and principles for radioactive waste management by the NEA and the IAEA (NEA 1984b, IAEA 1989).

The NEA report concentrates on how to apply operational radiation protection principles to practices that might give doses only in the far future. The ethical basis behind such considerations is reflected in the report's statement (p18) that "*the reasons for adopting the same principles when dealing with hypothetical exposures to the public in the far future from today's waste disposal practices are a desire for equity, in that future generations should be given the same degree of protection that is given to the present generation.*"

The Principles in IAEA 1989 were much broader, reflecting various ethical aspects of waste disposal. They were reformulated after much international discussion to give the wording contained in the high-level Safety Series document of 1995, "The Principles of Radioactive Waste Management" (IAEA 1995a), extracts from which are included in the following section.

B1.1 Ethical principles in IAEA documentation

IAEA 1995a contains the following ethical principles protecting current and future generations:

Principle 3: Protection beyond national borders
Radioactive waste shall be managed in such a way as to assure that possible effects on human health and the environment beyond national borders will also be taken into account.

Principle 4: Protection of future generations
Radioactive waste shall be managed in a way that predicted impacts on the health of future generations will not be greater than relevant levels of impact that are acceptable today.

Principle 5: Burdens on future generations
Radioactive waste shall be managed in a way that will not impose burdens on future generations.

The Safety Principles of the IAEA have formed a basis for the major IAEA Joint Convention on the Safety of Used Fuel Management and on the Safety of Radioactive Waste Management (IAEA 1997a). The above three principles all have relevance for international repositories. Principle 3 was originally intended for application to possible effects of a national repository on its neighbours. It would, however, also oblige a nation sending waste for disposal elsewhere to assume its proper share of the responsibility for the future safety. Principles 4 and 5 are relevant for international disposal for the simple reason that they also apply out to far future generations, i.e. at times when no person can predict if and how national boundaries may have moved. A look at the map of any region of the world illustrates vividly how borders change on the timescales of decades or centuries, without even considering the many millennia being discussed in waste disposal.

The Joint Convention explicitly addresses the issue of transfers of wastes between countries when it states the following:

" (xi) Convinced that radioactive waste should, as far as is compatible with the safety of the management of such material, be disposed of in the State in which it was generated, whilst recognizing that, in certain circumstances, safe and efficient management of spent fuel and radioactive waste might be fostered through agreements among Contracting Parties to use facilities in one of them for the benefit of the other Parties, particularly where waste originates from joint projects; ......".

The first part of the statement emphasises national responsibility for wastes; second half makes it obvious that transfer of wastes can be a justifiable approach. The fact is that risks or hazards are routinely transferred between sovereign states, on the assumption that the benefits and drawbacks are weighed against one another. For example, countries that mine raw materials (including uranium ores) for export implicitly accept the risks from what is often the most hazardous part of the life cycle of commodities. Nevertheless, the argument has sometimes been made that there is a principle of 'self-sufficiency', which dictates that nations should dispose of their own radioactive wastes. One flaw in such a principle is that it is arbitrarily narrow. If a nation wishes to be self-sufficient and also use nuclear power, one might expect it to engage in all aspects of the fuel cycle on its own territory. Very few countries have the possibility of being involved in mining, milling, enrichment, fuel fabrication, nuclear power generation and waste disposal.

B1.2 Ethical discussions within the OECD/NEA

A further, equally important international document is the "Collective Opinion on the Environmental and Ethical Basis of Geological Disposal" produced by the NEA/IAEA/ EEC in 1995 (NEA 1995). This consensus view, drafted following a 2-day, wide-ranging workshop on Environmental Aspects of Long-Lived Radioactive Waste Disposal (NEA 1994b), is that the concept of geological waste disposal rests on a firm ethical basis.

A set of guiding ethical principles is developed in the NEA document; these are broadly similar to the above mentioned principles of the IAEA. Two issues, however, are more strongly emphasised. One is that *"a waste management strategy should not be based on a presumption of a stable societal structure for the indefinite future, nor of technological advance"*. This principle leads to rejection of indefinite storage strategies requiring continuing of resources in favour of geological disposal concepts offering permanent protection. The second issue discussed more extensively in the Collective Opinion is the wish to ensure that one does *"not unduly restrict the freedom of choice of future generations"*. These fundamental principles are very much in line with the Bruntdland definition of sustainable development. It is judged that an incremental process, involving development of deep repositories in a stepwise fashion over decades, meets this requirement - even when disposal facilities have no deliberate provisions for waste retrieval following repository closure.

B1.3 National positions on ethical issues

There have also been, at a national level, numerous meetings and position papers on ethical issues. In Sweden, for example, the advisory council, KASAM, organised a Symposium on the subject in 1987 (KASAM 1988). KASAM was the first organisation to place strong emphasis on the overriding importance of keeping future options open - a topic to which we return below. Other countries have addressed the issue less formally or publicly. In Canada, a workshop was held to give ethical input to the national strategy for disposal of used fuel (AECL 1991). In Switzerland, as a preliminary to revision of the government regulations governing long-term disposal of radioactive wastes, a seminar was held at which ethical issues were presented by experts from outside the nuclear community. The USA has an extensive literature on the general question of achieving equity between successive generations and this discussion has been taken up by those concerned with radioactive waste management.

The following discussion aims at a structured approach linking ethical principles to specific requirements on disposal programmes and thereafter to safety and other criteria established in national programmes. The fundamental principles are **fairness or equity** for current and future generations; these two concepts, as mentioned above, are labelled respectively **intragenerational** and **intergenerational** equity. They are treated separately below.

B2 Intragenerational Equity Aspects

Intragenerational equity means that within current generations it is important to ensure that our finite resources are spent sensibly on solving environmental problems, taking into account the relative scale of the potential impacts and also the distribution of risks and benefits. It implies also that decisions on how to achieve these aims are made in a fair and open manner, involving all sections of society. In the following, we address a series of intragenerational equity issues and try to derive from this the messages which are valuable for waste disposal implementers or regulators.

B2.1 Health risks to current populations

The ICRP has an initial principle of radiation protection which holds that any practice leading to radiation exposures to populations must be justified. For waste disposal, the practice is usually taken to be part of the larger issue of nuclear power production, so that explicit justification of disposal in this sense has not been an issue. The criteria set for allowable exposures to current populations from operational activities is also not a disposal specific issue since the relevant facilities and activities are treated like any other nuclear application.

In radiation protection in general, ethical considerations would argue that intragenerational equity would require the levels of risk criteria to be set relative to other activities that are potentially hazardous to the public. In fact, only few countries have a uniform regulatory framework that should encourage this (e.g. USA with the Environmental Protection Agency and the UK with its Environment Agency). Even in these organisations, there is no real pressure to use uniform risk criteria. The widely recognised "nuclear dread" factor associated with radioactivity tends to lead to especially strict formulation and enforcement of regulations in the nuclear area, including waste management.

B2.2 Social and economic impacts

Despite strict regulation of radiation exposures, there is an additional ICRP requirement to maintain exposures "as low as reasonably achievable, social and economic factors being taken into account". On the one hand, the economic part can justify arguments against exorbitantly expensive measures (e.g. over-design of engineered barriers which do not greatly increase safety). On the other hand, the social argument can justify fully weighting also the subjective arguments of the public – and hence being prepared, for example, to spend more resources per life saved on nuclear than on conventional risk reduction measures.

B2.3 Spatial distribution of burdens and benefits

At a national, the issue of distribution of burdens and benefits is a key issue in the siting of waste repositories. Today, it is a widely accepted practice that a host community should be compensated for its willingness to accept a common facility which is for the good of a wider population. Specific national negotiations on such issues have taken place in numerous countries, including Canada, Finland, France, Sweden, Switzerland, Taiwan and the USA.

At an international level, the IAEA principle 3 on "protection beyond national borders" addresses the geographical distribution of negative impacts. The IAEA also has guidance on international transfers in its Spent Fuel and Waste Convention and on transboundary effects in its Principles. As previously mentioned, the ethical rules proposed do not exclude transfer of wastes between sovereign States. In practice, this has happened often in the past. For example, the reprocessing nations France and the UK originally accepted that they would dispose of the resulting wastes along with their own national waste inventories. Spent radioactive sources were expected to be disposed of by the country which had bought them. The IAEA is currently studying the conditions which should be fulfilled for multinational waste repositories (IAEA 1998, 2003) and the EU has debated equivalence principles for waste substitution. More recently, however, there have been marked movements towards limiting or banning transfer of wastes. For example, countries like France, Sweden, Finland, and Russia have banned waste imports. The reprocessing countries France and the UK now insist on returning wastes to customer countries. The UK has adopted a policy of "self-sufficiency" in this area. In practice there are no ethical reasons for treating radioactive wastes differently from other commodities, including chemotoxic wastes.

There are, of course, strong ethical reasons for not exporting hazardous wastes to any country that does not have the appropriate technological and societal structures to ensure that these wastes are properly handled. The arguments against waste transfers in the case of willing and capable host nations being prepared to accept waste imports are less a matter of principle and more of political expediency. In developing the international repository concept, the issue of equitable distribution of the benefits between host and partner countries is of even greater importance than in the national case. The benefits offered in both cases are regarded as fair compensation and not as bribes or as risk premiums.

B2.4 Public Involvement

Intragenerational equity requires that the public be given open access to information, that their concerns are appropriately weighted and that they can participate in the relevant decision making processes. In virtually all countries today, information on waste management is freely available. This position has been reached despite the initial tendency to secrecy bred in nuclear weapons programmes and taken over into commercial power activities. Increasingly there is also a universal trend towards engaging the public in the debate and ultimately in the decision processes. This is sometimes done informally with public fora or public enquiries. In some cases, e.g. in the rule making of the USA, there is a highly formalised mechanism for gathering public comments on key issues. The ultimate instrument of public participation is perhaps that of a referendum in which every person can record his opinion. A caveat, which is often forgotten here' is that the public cannot be expected to master all of the technical issues involved, so that the implementer and regulator have a direct responsibility to make as clear as possible the scientific issues on which there is a broad consensus.

Finally, it should not be forgotten that, at the highest level, the public in a democratic society has the opportunity for involvement through the political processes. Governments, which have broad responsibilities for society, are elected and can be rejected. There are important issues that must be decided at the political level, rather than scientifically. A wise government will make use, where appropriate, of good scientific input to the decision processes – but may abide also to the adage that "scientists should be on tap and not on top".

B3 Intergenerational Equity Aspects

Intragenerational equity involves ensuring fairness across generations; it is directly related to the topical subject of sustainability. The basic tenets are that we do not pass on burdens unnecessarily; and that we leave future generations with the same freedoms and choices that we have. In the following, we address intergenerational equity issues and try to derive from these the messages which are valuable for waste disposal implementers or regulators.

B3.1 Risks to future generations

The IAEA Principles maintain that future generations should not be exposed to higher risks than current generations. This would lead to dose or risk criteria for future exposures being set equivalent to those for operating facilities. In practice, the argument is made, e.g. in the Swiss Regulation R21 (HSK 1993), that since the current generation is the beneficiary of nuclear power future doses should be less. This has resulted in dose limits like 0.1 mSv/y being set for the future, whilst current radiation protection limits are significantly higher.

B3.2 Burdens and benefits for future generations

The potential burdens on future generations do not involve only radiation risks. The most obvious other risk is financial and this is discussed separately below. In any ethical discussion on future impacts of waste disposal, one should also address the benefits which can result. Most of the benefits are associated with the overall practice of nuclear power – and hence subject to controversial discussions. However, serious debate on ethics must acknowledge also the potential benefits of technology advances and increased energy availability. For nuclear power, additional arguments are conservation of fossil reserves and reduction of greenhouse gases. The aspect of disposal of unwanted materials from disarmament also raises a new and powerful ethical argument. A responsible, secure host nation that accepted the responsibility of the guardianship of fissile materials, which might otherwise cause mass destruction anywhere in the world, would occupy high moral ground. The huge importance of these points for all future generations is often insufficiently stressed in debates on the ethics of nuclear power and radioactive waste disposal.

B3.3 Financial risks to future generations

Implementing repositories will be expensive and postponing this task for long times means that these costs will fall on future generations. For this reason, serious waste management programmes set aside funds to cover these future liabilities. The pioneering example here was Sweden where a fund fully segregated from the utilities and from Government was established early. Many other countries now have funds, although these are sometimes open to (mis)appropriation by Governments for other uses, as in the USA, or are left within the utilities, as was the case in Switzerland until recently. In Canada, the nuclear utilities have established segregated funds for radioactive waste disposal and decommissioning of the facilities.

B3.4 Maximising freedom of choice

As mentioned first in the section above on national positions, the issue of not unnecessarily restricting the choices of future generations was originally highlighted in Sweden. This aim can obviously cause conflict with the principle of minimising potential burdens. In the extreme case**, all** choices can be left open by current generations postponing all decisions on waste management. Wastes should not be conditioned, in case better methods become available; disposal should not be implemented in case alternatives like transmutation provide perfect solutions; repositories should not be sealed in case we wish to retrieve the wastes with ease; etc. This approach, however, passes on also all burdens and is certainly not ethical.

In practice, there is a strong, and increasing, tendency to try to provide a compromise. Implementers are trying to develop repositories that provide future safety but also retain options for change. Retrievability of wastes has become a major topic (see for example IAEA 2000a). In the ethical debate surrounding disposal, achieving the correct balance between maximising freedom to change direction and minimising future burdens is one of the most sensitive of all issues.

B4 Other Ethical Principles

B4.1 Sustainability

The topical issue of sustainability is closely related to intergenerational equity. The most widely accepted definition of "sustainable development" is that of the Brundtland Commission, *"development that meets the needs of the present without compromising the ability of future generations to meet their own needs"* (World Commission on Environment and Development 1987). Most of the relevant points for waste disposal have been touched on above in the discussions on burdens and benefits. Nuclear power with properly implemented, safe disposal is sustainable since it contributes to reducing hazards in the human environment, conserving hydrocarbon resources, etc. Specific repository siting measures can be taken to enhance such attributes; for example locating repositories in areas where intensive human usage is unlikely and where no restrictions are put on the availability of natural resources.

B4.2 Precautionary Principle

This principle calls upon society to take prudent preventative actions to deal with risks with potentially very serious consequences even if there are doubts and scientific controversy surrounding the evidence. Whilst the concept is obviously laudable, its implementation without misuse of society's resources in a manner which conflicts with the principle of intragenerational equity calls for sound judgement. For radioactive waste disposal, it can be argued that any future impacts will be localised and not of a catastrophic nature so that the precautionary principle has limited impact.

B4.3 Polluter Pays Principle

The fact that polluters should not be subsidised is widely accepted and influences environmental legislation is almost all countries. Difficulties can arise in assessing the costs, in particular of pollution which is diluted and dispersed (e.g. CO2 emissions). Nuclear power and geological disposal are more straightforward and, as described above, mechanisms to ensure costs are covered are in place in most countries. The more generalised form in which "users pay full costs" is more difficult because the costs of avoiding pollution are relatively well defined compared to the costs of, for example, using up natural resources.