UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

January 6, 1995

MEMORANDUM TO: Malcolm R. Knapp, Director
Division of Waste Management

FROM: Janet P. Kotra, System Performance Analyst JPK
Performance Assessment and Hydrology Branch

SUBJECT: REVIEW AND COMMENT ON REPORT ON RWMC COLLECTIVE OPINION ON THE ETHICAL BASIS OF GEOLOGIC DISPOSAL (TASK # D-163)

This note responds to your request that I review and comment on the first draft of the proposed Radioactive Waste Management Committee (RWMC) Collective Opinion on the Ethical Basis of Geologic Disposal as provided to Mr. Bernero by Jean-Pierre Olivier. These comments are offered to support Mr. Bernero's meeting with Mssr. Olivier later this month, at which time the draft document will be discussed.

Overall, the draft opinion is consistent with views expressed by Mr. Bernero at the September 1-2, 1994, NEA workshop, and does not conflict with the regulatory approach taken in the development of 10 CFR Part 60. In particular, the draft opinion comports with the often-expressed "Societal Pledge," that the level of protection from radiation hazards afforded future generations should be comparable to that we would expect for ourselves, and that achievement of such protection should not necessitate the imposition of unnecessary burdens on future societies. The opinion concludes that geologic disposal has a sound ethical basis, is more consistent with concepts of intergenerational equity than indefinite storage, and should be implemented with a strategy that is sensitive to intragenerational equity concerns.

Recognizing the overall soundness of the draft opinion, and its consistency with NRC's prior positions, I would note the following concerns which Mr. Bernero may wish to raise with Mssr. Olivier later this month:

1) Most important among these is a concern that the draft opinion appears to cast the argument, exclusively in terms of the imbalance, between benefits enjoyed by present generations, and the liabilities which accrue to future generations. While this is clearly at the core of the issue of intergenerational equity, completeness would necessitate a more thorough consideration of:

   i) the liabilities that continue to accrue to current and future generations that fail to isolate radioactive wastes to the fullest extent that their level of technology would permit; and

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ii) the benefits, albeit indirect, which accrue to future generations as a result of sustained technological advancement made possible by a range of available energy options.

2) The first paragraph of the section, "Ethical Background to the Management of Waste" (p.6) cites "...an ethical imperative to care about future generations and to afford them the possibility of enjoying the same choices and options which we currently enjoy." The draft opinion goes on to assert that one generation's legacy of benefits and burdens to future generations is acceptable so long as an "...appropriate degree of equity or justice is respected and that we do not restrict the freedom of choice of future generations in any major aspect of use of the Earth['s] resources" (p.7 and, later on p.15) [emphasis added]. Using such a test of ethical acceptability, no utilization, let alone depletion, of scarce or non-renewable resources could be found acceptable. It is not reasonable to expect any generation (even if it could) to ensure unlimited freedom of choice to future generations or to ensure that future generations enjoy exactly the same suite of options available today. If the desire on the part of the authors is to express the ethical desirability of preserving options for future societies to act, based on enhanced knowledge or technology, then they should so state. Such an interpretation appears to suggest some obligation to ensure that disposal <u>not</u> be irrevocable. One might argue that the very creation of long-lived hazardous wastes was, in itself, irrevocable and will restrict, to some degree, the freedom of hundreds of generations to come. The need to articulate such a broadly-stated, a priori principle of ethical acceptability in the context of this opinion document should be reexamined. If, on the other hand, the authors are merely speaking to the need to act in such a way so that resources are not inadvertently made unavailable or unusable, this concept should be expressed more directly.

3) The fourth of five principles identified on p.7 as guidelines for making an ethical choice of waste management strategy states that "waste management strategy should not be based on a <u>presumption</u> of a stable societal structure for the indefinite future, nor of technological advance; rather it should bequeath a passively safe situation which places no reliance on action by Man." In general, NRC's regulations, including Part 60, are supportive of this principle and do not permit long-term reliance on active institutional controls. However, in the definition of "unanticipated processes and events," Part 60 expressly contemplates that, in assessing human intrusion scenarios, the NRC would assume that "institutions are able to assess risk and to take remedial action at a level of social organization and technological competence equivalent to, or superior to, that which was applied in initiating the process or events concerned." In other words, NRC would agree that a planned capability to maintain a site, and to take action to assure that isolation is achieved should not be relied on over the long term. However, it is not unreasonable to assume (as NRC does) that, should an unanticipated intrusion occur, technological capability to assess and deal with risk, commensurate with that which occasioned the intrusion,

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The attached copy of the draft opinion has been revised, where possible, to address some of these concerns and includes some minor editorial corrections.

Attachment: As stated

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8th December 1994

DRAFT No. 7

THE MANAGEMENT OF LONG-LIVED RADIOACTIVE WASTE

THE ETHICAL BASIS OF GEOLOGICAL DISPOSAL

An International Collective Opinion

by

the NEA Radioactive Waste Management Committee

FOREWORD

The safe disposal of radioactive waste, and specifically the need to protect humans and the environment in the far future, is given particular attention in all countries engaged in nuclear power generation. It is also a concern in many other countries making use of radioactive materials for medical, industrial, or research purposes.

As for many environmental protection situations linked to industrial development, including the management of hazardous chemical materials, the safe disposal of radioactive waste requires consideration of a broad range of scientific and technical factors, combined with ethical principles drawn from ~~current~~ an evolving environmental consciousness. These ethical principles have in the past been less prominent than technical safety arguments in the proposals put forward for managing the wastes.

The objective of this document is to identify the environmental and ethical issues and to relate them to questions raised by the need for protection of Man and his Environment. In considering the main elements of the strategy for management of radioactive waste, the document addresses the following questions which are central to a balanced appreciation of the subject.

What are the responsibilities of current generations, which are enjoying the direct benefits of nuclear electricity production which is the origin of the waste, but which are also leaving potential risks to future populations? How should the resulting "*intergenerational equity*" issues be approached?

What is the best practical approach for current generations to discharge their responsibilities to future generations? Should they take definitive action now or should they wait until more advanced solutions have been developed? Is there a choice between temporary and final solutions and to what extent should waste disposal actions be reversible?

How should a geological disposal strategy be implemented to incorporate a fair and transparent decision-making process satisfying the safety, technical, ethical and resource deployment requirements for intra generational equity?

This report presents a Collective Opinion of the Radioactive Waste Management Committee (RWMC) of the Nuclear Energy Agency on the strategy for the final disposal of long-lived radioactive waste from an ethical perspective. This Collective Opinion, by professionals having responsibilities at a national level in the field of radioactive waste management, is intended to contribute to an informed and constructive debate on this subject. It is based on recent work reported from NEA countries and on extensive discussions held at an NEA workshop organised in Paris in September 1994 on the Environmental and Ethical Aspects of Long-lived Radioactive Waste Disposal. Of particular importance was the full participation of the OECD Environment Directorate, and of independent experts from academic and environmental policy centres, in those discussions. The full proceedings of this workshop have been published by the OECD.

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EXECUTIVE SUMMARY

The generation of long-lived toxic wastes directly by modern "industrial society" has the potential to impose burdens of cost and risk of detriment to health on generations of people living in the distant future. Although the management of such wastes is arguably not amongst the most challenging of bequeathed liabilities, the current generations, which benefit from the use of nuclear energy, have a moral responsibility to manage their long-lived radioactive waste in a way which is both safe and equitable with respect to themselves and their descendants.

The nuclear industry has, over many years, developed the concept of geological disposal as a secure means of isolating long-lived radioactive waste from the biosphere~~, essentially for all time,~~ and much has been published on this technology and the associated long-term safety assessments. The present "Collective Opinion" is based on an examination of the ethical issues which the industry had to address in the choice of that novel concept. In particular it makes use of the thorough debate of these issues which took place at a special NEA Workshop in Paris on September 1 and 2, 1994, attended by representatives of the OECD Environment Directorate and by relevant experts from Universities, Government Agencies and the Nuclear Industry in OECD countries.

Intergenerational Equity is not a concept amenable to quantitative evaluation, but it can best be achieved if the waste-producing society takes responsibility for total management of the waste in a way which demands no action by future societies and bequeaths only trivial environmental and health risks to them.

Geological disposal within the lifetime of the waste-producing society is the most satisfactory way to satisfy the ethical requirement for intergenerational equity but the process of its implementation should satisfy also the ethical requirements for Intragenerational Equity. These requirements concern the involvement of all sections of society in judgements of the appropriateness of the strategy, of the balance of resource allocation between long-term waste management and other needs of today's society, and of any compensation to be made to affected sections of society.

A satisfactory approach to comply with these ethical principles, whilst meeting the technical requirements for safe waste management, is a stepwise preparation and implementation of geological disposal allowing for modification and reversibility over several decades to accommodate the results of scientific research and public consultation.

The NEA Radioactive Waste Management Committee, with the support of the OECD Environment Directorate:

- *note* that the geological disposal strategy for long-lived radioactive waste is currently favoured by practically all countries and appears both technically feasible and safe, notably in the long-term;

- *note* that this strategy is proposed to be implemented on a basis of intragenerational equity through a step-by-step incremental process over many decades; this will allow scientific progress, consideration of possible alternatives, and consultation of all stakeholders including the public to be taken into account at all stages;

- *acknowledge* that, from an ethical perspective, the geological disposal strategy takes intergenerational equity issues into account by applying the same standards of radiological risk in the far future as it does to the present, and by limiting the liabilities and resource costs bequeathed to future generations;

- *caution* that in pursuing very high standards of risk reduction for radioactive waste repositories, current generations should keep in perspective the resource deployment in other areas where there is potential for long term risk to Man or his environment;

- *consider* that the geological strategy could be regarded as reversible until repository closure and, to a certain extent, even after that since waste will be in fact retrievable at all times, albeit at an increasing cost;

Keeping these considerations in mind, the Committee:

- *confirm* that the geological disposal strategy has a sound ethical basis and that the rights and interests of current generations can be adequately preserved through an open and transparent decision-making process covering the appropriate choice of geological sites, repository designs, and disposal procedures;

- *consider* that from an ethical standpoint, as well as on the basis of long-term safety considerations, the rights of future generations are preserved by a strategy of final disposal rather than reliance only on temporary storage solutions which require surveillance, bequeath long-term responsibilities of care, and may in due course be neglected;

- *conclude* that stepwise implementation of plans for geological disposal leaves open the possibility to adapt them, in the light of scientific progress and social acceptability, over many decades;

- *conclude* that in the unlikely event that better options could be developed in the future these could be applied to waste not already emplaced and, as an extreme measure, to the earlier wastes after retrieval.

- *conclude* that it is justified, both technically and ethically, to continue development of geological repositories for those long-lived radioactive wastes which should be isolated from the biosphere for more than a few hundred years.

ETHICAL BACKGROUND TO THE MANAGEMENT OF WASTE

The development and welfare of modern societies depend to a large extent upon the contribution of technology and industrial processes, such as electricity generation. These processes are, in general, associated with the production of wastes, some of which are hazardous and require careful management systems in order to ensure adequate protection of man and the environment. The timescales over which such protection is required can extend, in the case of wastes containing toxic chemical elements or long-lived radioactive isotopes, well beyond the lifespans of current or forthcoming generations. Hence there is an ethical imperative to care about future generations and to ~~afford them the possibility of enjoying the same choices and options which we currently enjoy~~ ~~safe~~ act in such a way as to preserve their options to enjoy the Earth's resources. Such a concern for the protection of human health and the environment in a developing world has been illustrated by the principally ethical concept of "*sustainable development*" put forward by the World Commission on Environment and Development, "the Brundtland Commission", in 1987. This concept was defined as "*satisfying the needs of the present, without compromising the ability of future generations to meet their own needs*".

The "*sustainable development*" concept was chosen as the main theme of the United Nations Conference on Environment and Development in Rio de Janeiro in 1992, and was therefore extensively discussed. It is appropriate that the principles of this concept be applied, as far as we can, to complex environmental issues such as the ones resulting from the production of potentially harmful wastes. So far, its direct influence on current environmental protection policies has been limited, but these policies are, nevertheless, increasingly concerned with ethical issues, such as those of a global nature related to long-term consequences of ozone depletion and climate changes. In this context, ~~the current~~ an evolving environmental consciousness, coupled with the emergence of strong ethical concerns, indicate the importance attached to "*morally correct human conduct*". This trend should contribute to the adoption of public policies integrating both technical and ethical considerations and limiting the potential adverse effects of industrial development. It is therefore welcome that ethical issues are currently becoming an integral part of the environmental debate.

This debate, however, is affected by the judgmental nature of ethical values which are themselves always influenced by professional, cultural and social backgrounds of the participants. As a result, a balanced and objective understanding of environmental or health impacts is often difficult to obtain, particularly by those who may be directly affected and have an obvious interest as stakeholders. It is, therefore, of some importance that the discussion of ethical and other considerations be approached with an open mind and involve a broad spectrum of public representatives in order to create the conditions for a sound analysis of all the relevant aspects.

In the management of wastes having a long-term potential for harm, there are two classes of ethical concerns.

The first is the achievement of "intergenerational equity" by choosing strategies which minimize the resource and risk burdens passed to future generations by the current generations which produce the waste. It is an unavoidable fact of life that each generation leaves a heritage to posterity, involving a mix

THE BALANCE MUST BE CAREFULLY SCRUTINIZED BETWEEN THE BENEFITS WHICH ARE ENJOYED BY PRESENT AND FUTURE GENERATIONS THROUGH SUSTAINED TECHNOLOGICAL DEVELOPMENT

of benefits and burdens, and that today's decisions may foreclose options or open new horizons for the future. This is acceptable as long as an appropriate degree of equity or justice is respected and that we act to preserve, as much as possible, the options of ~~do not restrict the freedom of choice~~ of future generations ~~in any major aspect of use of~~ to access and enjoy the Earth's resources. In the case of nuclear energy production and the management of radioactive waste, as in other aspects of industrial activity, ~~there could be an imbalance between the benefits, which are enjoyed mainly by present generations,~~ and the liabilities which may be imposed on future generations over a long period. As radioactive waste already exists as a result of past and current activities, the issue has to be faced independently of the future of nuclear energy. The objective is to manage the waste in such a way that potential future impacts are kept at a minimum level which would be acceptable both technically and from an ethical viewpoint.

The second is the achievement of "intragenerational equity" and in particular an ethical approach to the handling, within current generations, of questions of resource allocation and of public involvement in the decision-making process. The form of this process in shaped to some extent by national institutions and political factors, and it was not therefore included in the NEA Workshop discussions, but the need for public involvement in the central decisions on timing of waste disposal actions is clear. Also necessary in this context is the consideration of financial compensation for communities which are judged to suffer an environmental burden during the construction and operation of a centralised national facility such as a geological repository for long-lived waste. Concerning resource allocation, risks from radioactive waste must be held in perspective when allocating resources between competing projects in the area of human health and environmental protection.

Consideration of these concerns leads to a set of principles which should be a guide in making an ethical choice of waste management strategy.

- those who generate the wastes should take responsibility, and provide the resources, for their management;
- wastes should be managed in a way which secures an acceptable level of protection for human health and the environment, and affords to future generations at least the level of safety which is acceptable today;
- wastes should be managed in a way that will not impose undue burdens on future generations;
- development of waste management policy and plans should be openly discussed with representatives of all sections of society concerned.
- waste management strategy should not be based on a presumption of a stable societal structure for the indefinite future, nor of technological advance; rather it should bequeath a passively safe situation which places no reliance on ~~action by Man.~~ active institutional controls.
- having endeavored to create as robust and as passively safe a system as possible, it still must be acknowledged that some future society may inadvertently compromise the safety of such a system by intrusion; it is reasonable to assume, however, that a society sufficiently sophisticated to accomplish such an intrusion will contain within it a technological capability of comparable sophistication to assess the nature of the hazard and take remedial action.

THE RADIOACTIVE WASTE MANAGEMENT RESPONSIBILITY

Long-lived radioactive substances, when they are present in waste at concentrations which could expose Man to radiation at harmful levels, must, like toxic chemical elements, be sufficiently isolated from the biosphere that no unacceptable risk will be presented at any time. Since we cannot consult a public living hundreds or thousands of years in the future, the choice of strategy must be made by current generations. This should be achieved in a way which reconciles the various factors underlying our responsibilities to current and future generations. Broadly these factors are:

- the technical requirements to give confidence in safety at all times;
- the ethical principles of intergenerational and intragenerational equity;
- costs.

It is evident that these responsibilities are taken very seriously in OECD countries in the late 20th century. There is increasing distrust of the 'out of sight - out of mind' philosophy which seemed to underly some early toxic waste management practices. The very long term nature of the risks to Man and the environment from toxic chemical elements and long-lived radioactive materials has focused attention on questions of intergenerational equity and on the balance of benefits and detriments which we pass to posterity. At the same time it is necessary to take account of the intragenerational issues discussed earlier.

In technical and economic terms the exact measures preferred to achieve isolation of the different types of waste depend upon their physical and chemical characteristics. The type of treatment, packaging and transportation required also varies between wastes. It is characteristic of radioactive waste, with the exception of the natural radioactive residues from uranium mining, that its volume is relatively very small. If, as in the case of some wastes from power stations, medical applications and research, the half-life of the radioactive substances in the waste is short enough, effective isolation is achievable by deposition in supervised near-surface vaults, or by other means of storage, whilst decay takes place. The present discussion concerns those longer-lived radioactive wastes which, like waste containing toxic chemical elements, require isolation for times beyond the surveillance capability of current generations.

The toxicity of radioactive substances is well understood. Knowledge of the effects of ionising radiation is comparatively advanced and the biosphere has evolved in the presence of a known natural background radiation level. However, unlike those toxic chemicals which enter waste streams due to inefficiencies in production processes and product use, most of the radioactive inventory of nuclear wastes is the inevitable by-product of power generation by nuclear fission and, except in the sense of packaging into a small volume, is not amenable to actual reduction by recycling or process improvement.

In the management of long-lived radioactive substances, as for toxic chemical elements, we have essentially two options. The first is to dilute and disperse and the second is to dispose by containment and isolation. It could be said that a third option is the actual destruction of the toxic atoms by nuclear transmutation but this is certainly impractical for the foreseeable future.

The dilution and dispersal of wastes in the air and water of the biosphere is now approached with great caution and subject to strict regulatory control. The emergence of CO_2 dispersals as a possible threat to Man via global warming is a good example of the risks which are likely to appear whenever the concentration of a substance in the air or water of the biosphere is artificially changed to a level outside the range within which Man has evolved. In the nuclear industry, and increasingly in the more traditional chemical industries, it is normal practice to purify aqueous and gaseous waste streams to a high degree before dispersal; the product of this action is a solid waste for disposal or re-use.

The disposal of wastes, following the principles above, is essentially a containment and isolation from the biosphere or at least an assurance that the residual quantities eventually dispersed will not disturb natural concentrations or background radiation levels. Geological disposal is the method widely proposed for achieving this.

The differences of opinion today in judging the ethical case for a radioactive waste disposal strategy concern not so much the choice of geological disposal as a preferred means of passively safe isolation, but rather the questions of whether and when to implement that strategy and of its reversibility. The technical performance of waste management systems is to some extent separate from these important subjects of timing, reversibility and the bequest of responsibilities, costs and environmental detriment to future generations. Is the ethical course of action one in which the current generation, which has the use of the nuclear power, disposes of the associated wastes now in a way which is predicted to require no action by succeeding generations? Or should we leave the wastes in supervised, retrievable stores so that future generations of technologists have all options for action open to them?

The indefinite storage strategy has indeed a number of technical and ethical arguments in its favour, particularly if it could be accompanied by suitable efforts to trigger scientific research in the direction of final solutions, and to ensure that financial resources would be available when needed at some point in time in the future. Some interpretation of the sustainability concept would support such an approach consisting of passing on to the next generation a world with "equal opportunity", and so on for the generation coming after, thus preserving options and avoiding the difficulty of predicting the far future. According to this idea of a "rolling present" the current generation would have a responsibility to provide to the next succeeding generation the skills, resources and opportunities to deal with any problem the current generation passes on. Such an approach would require an interactive decision process whereby succeeding generations would reevaluate and adapt policies on the basis of their own perspectives.

A most significant deficiency of the indefinite storage strategy is related to the natural tendency of society to get used to the existence and proximity of storage facilities and ignore progressively the associated risks. Such risks would actually increase with time in the absence of proper surveillance and maintenance, leading at some indefinite future time to possible serious health and environmental damage. There are many well-known examples of bad environmental situations inherited from the past which show that this deficiency of a waiting strategy should not be underestimated.

What is needed is an ethical weighing up of the good and evil aspects of alternative courses of action, given the principles listed earlier. One important factor is the argument that we do not have the right to impose on future generations the very long-term hazards and costs of a supervised store since we do not know whether they will remain able to discharge that responsibility and government institutions retain regulatory control. Perhaps more important is the assertion that we have the benefits of nuclear power generation and applications of radioisotopes in medicine and industry, and we should not leave future generations to bear burdens of responsibility and resource cost if that can be avoided by action during the lifetime of current generations. Action on such a timescale can nevertheless be spread over many decades, particularly if geological disposal is the chosen method of long-term isolation. Public concern, whether ethical or technical, may well require time for resolution by programme modification or by change in social acceptability. We should ask, however, not whether a better or cheaper option might possibly emerge in the future, but whether the proposed course of action is safe enough.

It must be remembered that the health and environment detriment from disposed radioactive waste is planned and regulated to be always at a trivial level, and it should not therefore be seen as one of the larger liabilities which we pass to future generations. There are issues of population control and the dispersal of chemical wastes such as carbon dioxide, sulphur oxides and nitrogen oxides which potentially have much greater consequences.

Social acceptance results from a variety of motivations, some of which may certainly be of an ethical nature. However, public opinion, trends and fashions play a perhaps equal role. Social convictions and ethical justifications should not be automatically equated since this would imply either reducing the question of morality to one of acceptability or avoiding the question of acceptance by asking only what can be justified ethically.

In the opinion of specialists, taking account of the arguments on storage versus disposal, there is little doubt that the preferred course of action is to start implementing now the geological disposal strategy, which offers a high level of safety into the far future with limited reliance on the forthcoming generations, and full use of the passive and stable features of remote geological locations. It has already been pointed out that the resulting risks would remain trivial by all current or conceivable standards, provided certain precautions are taken, and there is still a long time available to confirm this convincingly.

THE GEOLOGICAL DISPOSAL STRATEGY FOR RADIOACTIVE WASTE

Since the inception of the nuclear power industry, the need to protect man and the environment from the potential adverse effects of radioactive waste has been clearly recognised, particularly for long-lived waste such as nuclear spent fuels or waste from spent fuel reprocessing. Consideration of the very long-term and future generations became at an early stage a fundamental concern in the management of radioactive waste, arising from the ethical principle that current generations producing the waste should bear, to the extent possible, the responsibility to manage it. Accordingly, a strategy was developed for the isolation of radioactive waste from humans and the environment for the necessary times, ensuring that no future releases of radioactive substances to the environment would constitute an unacceptable risk. This strategy, which explicitly acknowledges the potential radiological long-term hazard, has the objective of ensuring that future populations are protected at a level at least equal to that acceptable for ourselves and are not committed to expenditure of resources to ensure that this is so.

There is today a broad international consensus on the technical merits of the solution proposed to implement this strategy. It consists of the disposal of long-lived radioactive waste in deep and stable geological formations within a system of multiple containment barriers which would isolate the waste from the biosphere for extremely long periods of time, ensure that residual radioactive substances reaching the biosphere after many thousands of years will be at concentrations insignificant against the natural background of radioactivity, and render the risk from inadvertent human intrusion acceptably small. Such a final disposal solution would be essentially passive and permanent, with no requirement for further intervention or institutional control by Man, although it may be assumed that siting records and routine surveillance would in practice be maintained for many years if society evolves in a stable manner.

Disposal options which were considered, and rejected, during many years of evolution of this strategy, include:

- ambitious, and poorly controllable, disposal concepts such as deposition in polar ice caps or extraterrestrial space;
- disposal under the deep ocean bed, where international agreement would be difficult to obtain.

Geological disposal is not a cheap substitute for something better. It can be shown to provide the required level and duration of isolation. Moreover, it is already the means by which the biosphere is protected from the vastly greater quantities of toxic and radioactive minerals naturally present in the earth.

An essential aspect of the waste isolation strategy is that long-term safety of the geological disposal solution proposed must be convincingly presented, and accepted, prior to implementation. This can be achieved through safety assessments addressing timescales far beyond the normal horizon of social and technical planning, in practice many thousands of years. Scientific and technical assessments provide the principal means to investigate, quantify and explain long-term safety of any selected disposal concept and site to the appropriate authorities and the public. Their feasibility and reliability, including uncertainties unavoidably associated with the assessment of future situations, were addressed and confirmed in a previous international Collective Opinion published by NEA in 1991 (see Annex III for the Executive Summary of this Collective Opinion).

Another important element of the geological disposal strategy is the timing and incremental process leading to a full implementation of most national programmes around the middle of the next century. The main successive phases of this process consist of conceptual and technological development, site-screening, surface and in-situ characterisation studies, selection of a site, construction and operation of an underground facility and, eventually, sealing of all the accesses, dismantling of surface installations and closing of the facility to leave it in a passively safe state. Each phase of this long sequence will last many years, if not decades, and will be subjected to public debate and close scrutiny by the regulatory authorities, who will have to be satisfied with the results obtained before giving the authorization to proceed with the next phase.

During this incremental process, scientific information will be continuously collected from observations at and around the site and will contribute to both a better understanding of the regional and local geology and increasingly refined performance assessments. This process, which must be flexible in order to accommodate inputs from research programmes and from public consultation, would provide ample opportunity for on-going public consultation and review. At any point in the process, if there is an indication that the objectives of safe disposal cannot be met, it would be possible to cease disposal operations and retrieve the waste It is important to note that technical safety is not dependent on any particular rate of progress through the incremental process since supervised storage of the waste, whilst not an acceptable strategy for the very long term, is itself a very safe procedure.

Finally, the decision-making process involves not only representatives of the technical community and competent regulatory authorities at the national level, but also decision-makers at various local and regional levels, and representatives of various public interest groups. An open process is indeed required to ensure that ethical, moral and social considerations are properly taken into account, necessitating, therefore, a broad range of participants in the process. All national geological disposal programmes recognize the need for such procedures, notably to allow the communities affected by the selection of specific sites to be consulted and to participate appropriately in decision-making at all of the stages of implementation.

continues to evolve and will play an increasing role in technological decision making.

What is clear is that ~~the new~~ environmental consciousness ~~of recent years is here to stay~~. In the field of radioactive waste management, experts have published a wealth of information on technical issues (including NEA "Collective Opinions"), but less is known about the attention which has, from the early beginnings of the nuclear industry, been paid to the ethical basis of their plans. X

CONCLUSIONS: THE RWMC VIEW

The extensive international cooperation existing in the field of radioactive waste management contributes to broaden and clarify the debate in this field, and to promote better information and more objective views on the state-of-the-art at the scientific and technical level and on other specific non-technical aspects. This is the case particularly for judgmental issues, such as ethics, on which experts from various disciplines and backgrounds can exchange their views with specialists in the field. Such an exchange happened at the recent NEA Workshop on Environmental and Ethical Aspects of Long-lived Radioactive Waste Disposal, and led to the following Collective Opinion by the RWMC.

On the basis of this Workshop and previous reviews in the area of radioactive waste management, the RWMC:

- ***note*** that the geological disposal strategy for long-lived radioactive waste is currently favoured by practically all countries and appears both technically feasible and safe, notably in the long-term;
- ***note*** that this strategy is proposed to be implemented on a basis of intragenerational equity through a step-by-step incremental process over many decades; this will allow scientific progress, consideration of possible alternatives, and consultation of all stakeholders including the public to be taken into account at all stages;
- ***acknowledge*** that, from an ethical perspective, the geological disposal strategy takes intergenerational equity issues into account by applying the same standards of radiological risk in the far future as it does to the present, and by limiting the liabilities and resource costs bequeathed to future generations;
- ***caution*** that in pursuing very high standards of risk reduction for radioactive waste repositories, current generations should keep in perspective the resource deployment in other areas where there is potential for long term risk to Man or his environment;
- ***consider*** that the geological strategy could be regarded as reversible until repository closure and, to a certain extent, even after that since waste will be in fact retrievable at all times, albeit at an increasing cost;

Keeping these considerations in mind, the Committee:

- ***confirm*** that the geological disposal strategy has a sound ethical basis and that the rights and interests of current generations can be adequately preserved through an open and transparent decision-making process covering the appropriate choice of geological sites, repository designs, and disposal procedures;

- *consider* that from an ethical standpoint, as well as on the basis of long-term safety considerations, the rights of future generations are preserved by a strategy of final disposal rather than reliance only on temporary storage solutions which require surveillance, bequeath long-term responsibilities of care, and may in due course be neglected;

- *conclude* that stepwise implementation of plans for geological disposal leaves open the possibility to adapt them, in the light of scientific progress and social acceptability, over many decades;

- *conclude* that in the unlikely event that better options could be developed in the future these could be applied to waste not already emplaced and, as an extreme measure, to the earlier wastes after retrieval.

- *conclude* that it is justified, both technically and ethically, to continue development of geological repositories for those long-lived radioactive wastes which should be isolated from the biosphere for more than a few hundred years.

See change on p. 7

THE BALANCE MUST BE CAREFULLY SCRUTINIZED BETWEEN THE BENEFITS WHICH ARE ENJOYED BY PRESENT AND FUTURE GENERATIONS SUSTAINED THROUGH TECHNOLOGICAL DEVELOPMENT

ANNEX I

INTERGENERATIONAL EQUITY AND LONG-TERM ISSUES

It is an unavoidable fact of life that each generation leaves a heritage to posterity, involving a mix of benefits and burdens, and that today's decisions may foreclose options or open new horizons for the future. This is acceptable as long as an appropriate degree of equity or justice is respected and that we do not restrict the freedom of choice of future generations in any major aspects of use of the Earth's resources. In the case of nuclear energy production and the management of radioactive waste, as in other areas of industrial activity, ~~there could be an imbalance between the benefits, which are enjoyed mainly by present generations,~~ and the liabilities which may be imposed on future generations over a long period. As radioactive waste already exists as a result of past and current activities, the issue has to be faced independently of the future of nuclear energy. The objective is to manage the waste in such a way that potential future impacts are kept at a minimum level which would be acceptable both technically and from an ethical viewpoint.

There are techniques which are used to take account of the time value of money as an aid to choosing a resource optimised course of action for industrial projects. One of them is Cost-Benefit analysis, which by discounting future costs and benefits gives commensurable valuations to activities spread over a period of time. Discounting of money values expresses both the time preference for current over future consumption, and the opportunity cost of capital.

Cost-Benefit analysis is a valuable tool for project choice and definition when the time span involved is sufficiently short for the costs and benefits to accrue to the same person or society. For example the cost of a project involving expenditures over a period of a decade or two can be discounted back to the present date to obtain an estimate of the present worth of the total project cost. This may be used for comparison with alternative ways of accomplishing the project, and with the present worth of the benefits flowing from the completed construction.

There are however serious deficiencies in the use of this discounting technique to estimate the present day worth of liabilities and benefits from waste management projects extending over many decades, or even centuries.

Not only may the real price of resources, including capital, change over long times, but methods of construction and their associated safety practices and standards are liable to be different from those in place when the analysis was done.

The consequence of this is that we cannot derive a meaningful estimate of the cost to future generations of carrying out work to dispose of wastes, or to perpetuate the storage of wastes, left by the current generation. Moreover, even if a financial provision were to be made by the current generation to meet an assumed eventual cost, there are real ethical concerns about the value of an invested monetary provision to a society faced, many generations later, with the physical liability which it was intended to fund. We may reasonably conclude that Cost-Benefit analysis, with its discounting principle, is not a useful tool for deciding between waste management options which differ greatly with respect to the timing of major expenditures nor for compensating future generations for bequeathed liabilities.

The question of acceptability of health and environmental damage risks when passed by the current generation to populations many generations later deserves comment quite separately from the question of the time value of money. There can be no ethical basis for the discounting of imposed risks of this kind over time; to do so would be to presume advances in medical treatments and environmental restoration technology at no increased cost. For this reason, it is a point of principle that radioactive waste shall be managed so that predicted impacts on the health of future generations will not be greater than the relevant levels of impact that are acceptable today.

Other approaches could be used to assess intergenerational issues and assist in decision-making. For example, attempts have been made to define sets of principles to "balance" the interests of present and future generations, and clarify issues of ethics and fairness in making trade-offs between generations. Such principles are essentially qualitative, indicating preferential choices, such as the "precautionary principle" in environmental protection, calling upon policy makers to take prudent preventive action to deal with potential environmental risk in the absence of compelling scientific evidence to the contrary. Other principles under development emphasize protecting present and near-future generations first, paying attention to long-term risks only when current and short-term risks are properly covered. However, there are strong limitations in all these approaches due mainly to the vast uncertainties about far future societies. The "sustainable development" concept is itself of limited use since it suffers from the same limitations when applied to far future situations.

As far as the long-term is concerned, there is therefore apparently no quantitative assessment methodology which can take account of all the ethical aspects and their relative importance in time. Consequently no specific and unequivocal ethical answer may be given to the question of intergenerational equity in radioactive waste management without considering broader issues in the political decision-making process similar to those of more immediate concern to current societies. It is suggested, however, that this issue is perhaps more theoretical than real if the risks and burdens passed to far future generations remain trivial. It may become then mostly a technical issue regarding the assessment of the risks and burdens and whether or not they would actually be trivial. To keep things in perspective, it should be recalled that plans for geologic repositories aim at a long-term safety level corresponding to only a very small fraction of the risks from natural background radiation (which is one future environmental parameter known with certainty) and at minimization of other bequeathed burdens by early waste isolation in largely inaccessible and valueless areas of the geosphere. It should be the role of the political decision-making process to put all non-technical elements, such as ethics and public acceptability issues, in perspective, in order to arrive at a balanced appreciation of our responsibilities towards posterity.

ANNEX II

A STEPWISE AND REVERSIBLE APPROACH TO GEOLOGICAL DISPOSAL

It should be obvious from the above that the key to the solution of the issues of ethics and strategic planning is a balanced appreciation of all the scientific, technical, environmental and ethical aspects of radioactive waste management leading to decisions at the appropriate levels. While the debate was restricted for some time to the community of specialists, causing serious reservations and a lack of acceptance of the concepts proposed, the situation has considerably evolved during the last decade. National laws and consultation procedures have been adopted in many countries to promote an open and transparent debate between all the "stakeholders", including especially the local populations concerned by the siting of disposal facilities. Complex scientific information such as safety assessments and predictive computer modelling is difficult to understand by non-specialists, but are now widely published, presented and explained to all those interested by radioactive waste management issues. Similarly, basic environmental and ethical considerations are being increasingly and openly discussed, and their importance is fully recognised particularly as they may appear more subjective and therefore less susceptible of a rigorous analysis than are technical matters. A constant, open and transparent dialogue between all actors of the debate, from the specialists to the general public, is therefore a prerequisite for the adoption and acceptance of sound decisions leading to waste disposal.

Another feature already mentioned is the timing and incremental nature of the implementation process. Decisions have to be taken at each step on the basis of a well documented and reviewed case. This is so for the selection of the general strategy and the concept, which are sometimes the subject of a national law. Work at the research level and in the field progresses then relatively slowly. For example, from the first surface investigations at a site until completion of underground reconnaissance work and confirmation of its suitability, a minimum of ten years could be envisaged. Licensing activities followed by repository construction might need another ten years or more. Depending on the extent of nuclear activities and site capacity, the operational period of a repository may last several decades, up to 50 years or more. At each of these steps and during the operational period, the review and decision-making process will be such that the accumulated experience from experimental and real observations, and new scientific development will be taken into account. Improvements and modifications will be integrated in the licences issued at each step. Peer review groups open to scientists and other interest groups, sometimes international, already play an active role in the supervision of these activities, issuing independent advice to national regulatory authorities, or to the agencies in charge of repository development, and operations. Such groups ensure that consultation procedures are broad and transparent, which is in itself an important ethical consideration, particularly for the potentially affected communities.

Throughout all these sequences, and in principle until the end of the operational period of a repository, waste remains accessible and could be retrieved. The disposal concept does not, however, foresee such a possibility later on since it is based on a conscious decision to close the repository and the recognition that its existence may be forgotten in the long-run. Interventions will, in principle, never be needed after repository closure, but they should not necessarily be excluded, whatever the reasons might be. In such a case, waste retrieval might be difficult and costly, but probably not impossible, and somewhat analogous to the extraction of toxic mineral ores.

This is an important ethical consideration since deep geological disposal should not necessarily be looked at as a totally irreversible process, completely foreclosing possible future changes in policy. In this context, it should be noted that sealing of a site and its access will always require a specific decision and that such a decision could probably be delayed until well after the end of waste emplacement operations to continue to allow reversibility and flexibility in the process if considered necessary. Under such circumstances, the incremental process leading to the full implementation of the geological disposal strategy incorporates the advantages of a temporary storage phase, as advocated by some, but without letting this phase be indefinite, since a safe and tangible final disposal solution would be at hand. In this regard, the features of geological disposal would be in line with the need to satisfy long-term ethics.

As a last and related remark, the process of disposing waste into geological repositories will not be carried out entirely and exclusively by this generation, but by a few succeeding generations over the next century or so which will be required to complete all the necessary operations. No doubt our immediate descendants will continue to refine the concept, if not find better solutions, and in doing so, face their ethical duties as "present" generations.