THE ROYAL SOCIETY

**February 1998**

**Ref:**

# Submission to the House of Lords Select Committee on Science and Technology inquiry into The Management of Nuclear Waste

## INTRODUCTION

1. The Royal Society welcomes the opportunity to give its views on the management of nuclear waste. The Society believes that the issues raised are of great importance: it will continue to be active in providing advice to government and others on this subject.

2. In this response, the Society's comments are focused upon the need for a clearly defined and socially acceptable disposal strategy for Intermediate and High Level Waste. In doing so we use the UK definition of HLW as 'waste produced when spent fuel is reprocessed'. We do not class plutonium separated by reprocessing as radioactive waste. The management of this material is discussed in a recent Royal Society publication, *Management of Separated Plutonium* (1998).

3. This response has been endorsed by the Council of the Society. It was prepared by a group led by Professor G.S. Boulton and comprising Sir Francis Graham-Smith, Sir Martin Holdgate, Professor J. D. Mather, Dr R. S. Pease, and Professor R. S. J. Sparks.

## RESPONSES TO GIVEN QUESTIONS

### *1a)What is the best sustainable solution for the long-term management of nuclear waste in the United Kingdom?*

Nuclear waste requires very long-term management because some of the hazardous radioactive isotopes present take hundreds of thousands of years to decay. Management options include geological disposal in deep or shallow repositories, surface storage and disposal below the seabed in deep parts of the ocean.

The last option has scientific merits due to the stable environments of the deep ocean and is worth further investigation, although it is currently unpopular politically and prohibited by the London Convention [1]. Introduction of disposal under the oceans would require international collaboration and agreement.

Surface storage is a short-term option for decades or perhaps centuries. The surface environment is physically and chemically less stable than that at hundreds of metres depth, and a surface repository would require adaptive engineering repackaging of contents from time to time during the waste's lifetime and possible repository relocation. Surface storage does not seem a permanent answer to a problem that will require a solution on geological time scales. Thus all current national strategies by countries with nuclear waste problems have taken the view that geological disposal is the only viable long-term disposal option.

Formidable challenges face the geoscientists and engineers seeking to build robust artificial structures for geological disposal of radioactive wastes. The processes that control what happens to a deep repository operate over thousands or tens of thousands of years and are not fully understood. The science of characterising and understanding deep geological environments is still in its infancy. As a result, scientific programmes to investigate possible sites and designs for deep repositories can be expected to take decades to complete.

The United Kingdom has been exceptional in recent years in developing an accelerated programme. The programme has repeatedly foundered because of its failure to gain public confidence and acceptance. Other countries have programmes that implicitly accept geological disposal but recognise the formidable scientific, engineering and public perception problems that face making this option a reality. We believe that the UK will need to adopt a similar long-term view. If this is accepted it may require a management strategy with both short-term and long-term components. The short-term component is surface storage until sites are identified and engineering solutions established that meet rigorous scientific criteria and gain a sufficient measure of public acceptance and confidence. We suspect that this will take decades rather than years to achieve.

Deep geology offers an inherently more stable environment with a greater fail-safe capacity than the surface. The Nirex programme[2] assumed that a repository solution could be found which made the expensive retrieval option unnecessary. It may however be a necessary option in helping to build public confidence as well as providing an additional management option. We conclude that deep geological disposal is the best available long-term option, but recognise the fact that this is not yet widely accepted.

### *1b) By what process should this be ratified?*

A UK strategy for waste disposal should contain two elements, both of which involve scientific and political/social judgements:

- a rigorous method for evaluating the safety of the disposal/storage option of a specific site; and
- the definition of explicit and agreed criteria for drawing up a shortlist of sites for the disposal/storage option under consideration.

Although we believe that a repository in deep geology is the best generic option, the process of developing a strategy should involve consideration of above ground or near-surface storage in the best practicable engineered facility.

Both site and option selection should include confirmation of the scientific judgement involved by peer-group scrutiny by scientists of high standing not involved directly in the industry and consensus building discussions involving broad public debate. Ratification must have a broad social base.

### *1c) Is there an adequate knowledge base to support such a solution?*

It is axiomatic that, no matter what disposal route is chosen, research on management and technical options for minimising and conditioning waste should be given a high priority.

The greatest challenge, however, is to establish strategies whereby the long-term (on time scales of 100 000 years) safety of disposal/storage options can be evaluated. In relation to deep geological repositories, the capacity of the rocks in specific locations to prevent leakage by groundwater flow to surface can be evaluated by reference to their recent history. Rocks contain evidence of their past, and it is possible, by establishing the history of sub-surface groundwater transport over periods of past time similar in duration to the future toxic lifetimes of radionuclides, to evaluate the long-term behaviour of potential disposal sites under plausible scenarios of climate, glaciation and tectonic processes.

Other important issues for which knowledge needs to be improved include:

- developing better estimates of the risk associated with radiotoxicity. This is far from established;
- techniques for waste storage and conditioning prior to disposal;
- technologies for engineered containment;
- processes of groundwater radionuclide transport in rock masses;
- evaluation of future changes;
- risk analysis including the evaluation of public acceptability of risk.

The immediate task should be the establishment of a robust scientific method for the development of site selection criteria, rather than establishing relatively short-term target dates for the selection and operation of a disposal facility.

### *2. Are you satisfied with the institutional responsibility for nuclear waste in the United Kingdom, and, if not, how might it be improved?*

The 'polluter pays' principle should be applied. Responsibility for the costs of disposal of nuclear waste should lie with the producers. However, Government should provide a coherent policy framework to ensure that a safe, sustainable and publicly acceptable solution is achieved. It must set and regulate the standards that public safety demands and monitor compliance. Where technological advance is essential, forcing standards should be set for industry and progress towards them monitored.

We do not believe that the current system provides an appropriate framework. In particular, the decision-making process conflates issues of national policy, science and technology and local land use. Decisions must be made in the light of pre-determined national energy policy (although the feasibility of safe disposal will contribute to this); of an independent scientific evaluation of safety; of public acceptability of risk; and local concerns about land use. The decision-making process is necessarily a political one: the role of scientific expertise is to identify technical options, specify areas of uncertainty and evaluate the technical component of risk.

For these reasons, we strongly support the proposal, first made by a joint RWMAC/ACSNI[3] study group, to set up an independent body to coordinate advice to government on:

- the needs for research to be undertaken by public agencies;
- the approach to be taken in the selection of disposal sites and the nature of the scientific advice that is required;
- the involvement of the public in consensus building and appropriate approaches to risk assessment;
- the relationship between the regulator and industry and between industry funded and publicly funded research prior to the submission of a proposal for a disposal site.

***3. How should the process of storage and/or repository site selection be conducted to reduce conflict and to ensure that work can be carried out at sites that are agreed to be acceptable? Who should be involved?***

The system of public inquiry should be developed into a sequential process, informed by scientific and public inputs, and explicitly involving a variety of stakeholders. The technical/scientific components of such a process should be:

- definition of standards of safety to be achieved;
- development of an acceptable scientific method for site selection through mainline scientific routes involving the Science Base, peer review and open publication. There has been a tendency for research to be conducted through a closed circle of contractors, with results being presented outside the mainstream of scientific activity;
- a desk study identifying potential sites based on previously agreed criteria;
- site investigation;
- site choice;
- evaluation by the regulator of the industry safety case.

These should interlock with:

- development of national energy policy;
- consensus-building conferences (cf the POST report *Radioactive Waste - Where next?*).

It is vital that the criteria and procedures for site selection are agreed by Government before work begins on possible target sites. The purpose of technical investigations should be to establish **whether** a site is acceptable, not to **demonstrate** that it is.

This technical process should however be embedded in the wider approach described in section 2. It is a waste of time, expertise and money to investigate sites that will be socially unacceptable. A scoping exercise at the start of the above sequential process should list the parameters that will define acceptability, including geology, location in relation to centres of population and to other land uses (there is, for example, little use in investigating sites in national parks) and issues of transport.

***4. It is perhaps unrealistic to assume that the 'perfect' site for a long-term store or repository can be found (or even exists), so what would make a good nuclear waste site ?***

The principal risk to the biosphere from a repository site comes from groundwater transport of radionuclides to the surface. Rather than merely seeking a deep site with rocks that are 'impermeable' (permeability is very difficult to measure), potential sites should be in geological settings in which the potential groundwater transport time to the biosphere is long compared to the toxic lifetime of the waste, irrespective of any conceivable changes in the surface environment (e.g. sea level change, climate etc) or tectonics (e.g. earthquakes). Potential sites in the UK with suitable geological settings can be identified by means of desk studies.

Beyond this stage, detailed site investigations should be concerned to:

- characterise the geology and hydrological regime of the site;
- recover the past history of groundwater evolution as a guide to the long-term behaviour of the groundwater system and dispersal rates from repository depths;
- analyse potential risks through scenarios of future change.

***5. How can a rational assessment of the risks associated with a long-term nuclear waste store or repository site be made and how can one be sure that what is acceptable risk now will remain so in the future? How do the principles of intergenerational equity apply?***

It is clearly difficult to evaluate the risks associated with long-term storage or disposal when the time-scale extends for hundreds of thousands of years into the future. Almost all judgements about future risks are based upon extrapolation of past experience into the future. A rational approach to long-term future risk analysis would be to use geological evidence to reconstruct groundwater changes associated with and driven by events such as glaciation, sea-level change and seismic events on time-scales similar to those relevant to repositories, and thereby evaluate potential risks. Past sequences of climatic and tectonic events which have driven changes in groundwater flow, are well known. There are established means whereby scenarios of future change in these drivers of groundwater flow can be reconstructed from the record of their change in the past. A worst case consistent with geological knowledge can be used to provide a high risk-threshold.

As in all human affairs, however, there could be unanticipated hazards that are not apparent to us. Intergenerational equity could be taken as requiring that all possible steps to minimise risk to currently acceptable standards should be taken according to the knowledge currently available. Alternatively it might be judged that the consequences of leakage from a repository could be so severe, that the possibility of unanticipated effects should preclude use of the technology.

A surface storage facility rather than a repository might be thought to avoid some of these issues, although easier access from the surface and the possibility of a store's location being lost pose other hazards for the storage option.

***6. What is the standard of safety to which a repository or long term store should be designed? Is there a firm public perception that it should be 'as safe as possible regardless of cost' and if so what are the implications?***

A standard of safety set without clear rationale will always cause concern to the public. In order to build consensus about the acceptable levels of safety it is necessary to have a culture of openness and a strategy of risk communication.

There is a growing awareness in society of risk, particularly in relation to technical development. As the hazards of life have diminished in industrialised society, reflected by increasing life-spans, the tolerance of risk, particularly risk associated with technology, has diminished. In addition, there is confusion stemming from public misconceptions about science. Science is popularly supposed to lead to certainty and conclusion, whereas much science in reality attempts to map out the bounds of uncertainty. Science cannot pronounce something to be absolutely safe. At best it is able to estimate the probability of harm.

Political means need to be found for explicit discussion of risk, the acceptability of the uncertainties that remain when the limits of scientific understanding have been precisely and openly set out, and the means of communicating risk strategy. The mechanisms described in section 2 could provide a means of doing this.

***7. Has enough been learned from the experience of natural analogues to determine the optimum design and geological conditions for a nuclear waste facility?***

Natural analogues are able to demonstrate that in particular locations and rock types, radionuclides have been contained, with little dispersal, for many millions of years. Such analogues can be useful as a means of model validation but are not a means for determining the optimum design and geological conditions for a nuclear waste disposal facility. Attempts to do this have proved unsuccessful. The past can provide a key to the future only on a site specific basis.

However, natural analogues can be useful in this more restricted role. Analogues can replicate a process that is being modelled, provided that the process is clearly defined and the physical and chemical analogy is a good one. Examples are the use of volcanic glasses as an analogue of waste glasses or corrosion rates of archaeological finds of iron as an analogue of waste canisters. There is considerable scope for the further use of natural analogues in model validation in this way.

***8. What are the problems and advantages of instituting a waste management programme where intermediate and high level waste are dealt with together i.e. in a co-disposal repository?***

There is an urgent need to develop an acceptable long term strategy for the disposal of the 66,100 $m^3$ of ILW in storage at various sites around the country[4]. Because the time-scales and properties associated with the different types of waste vary, it is not appropriate to dispose of them together. Work towards a solution to the problem of ILW must not be confused by attempting to deal with HLW at the same site.

As the volumes of ILW and HLW are so different, the former will require large volume repositories, the latter could be disposed of in deep boreholes.

This said, after a period in storage, the properties of HLW can come to resemble those of ILW. If it happens that the time lapse between the present storage of HLW and final availability of a repository of ILW is sufficient for this to occur, then there would be substantial economic and logistic advantages in disposing of the HLW in the ILW store. Allowing for the continuation of a nuclear power programme in the UK, the need for a disposal site for newer HLW would remain.

***9. Would an international solution to nuclear waste management be desirable and feasible (e.g. a joint repository accepting waste from many countries) and if so what would this entail?***

No country should embark on a nuclear programme until it has a safe disposal option for its wastes, although this principle has rarely been observed in the past. There are some countries that do not have an appropriate geological setting for the safe underground disposal of waste. Although countries must take responsibility for the disposal of their nuclear waste, in principle there is no reason why this should not be done overseas if:

- this option is clearly safer than that which could be achieved in the originating country; and
- issues such as safe transport and clear statements relating to mutual liability are addressed.

Even though it may be possible to demonstrate the safety of disposal in an overseas repository this option poses obvious political problems.

The UK has several geological settings in which we might expect that the criteria for safe disposal of nuclear waste set out in section 4 might be satisfied. If this proves to be the case, the UK should be expected to dispose of its waste on its own territory.

We should, wherever possible, share expertise and knowledge with scientists in other countries. Shared cost international research programmes are an efficient way of addressing some of the fundamental scientific problems in the field. There is currently much duplication of effort and a largely uncoordinated approach to addressing the problems.

***10. Can we postpone the search for a repository site in the United Kingdom and simply maintain existing arrangements? Might more emphasis on waste partitioning and storage be used both to defer and to reduce the requirement of a repository?***

We should move away from the view that there is an urgent need to establish and use a deep repository site. In the short to medium term, surface storage facilities should continue to be used. **What is urgent** is that the UK should develop a strategy for the disposal or storage of its wastes. Surface storage as currently practised should be regarded as a holding operation in lieu of a long-term strategy.

Both the scientific and the political/administrative approaches for site selection need to be developed further. The choice of a repository must be delayed until this has been done.

We should of course exploit whatever waste partitioning and minimisation methods are available to minimise the dangers of surface storage and to ensure the most effective use of a deep repository.

***11. Does management of UK military nuclear waste present any special problems?***

In comparison to civil nuclear waste, we believe the volume of military waste for the UK to be small. The more pressing problem is to ensure that waste producers do not create waste management problems for which solutions are not currently available.

***12. What measures should UK take to sustain the long-term research base for the management of nuclear waste?***

Research into the management of nuclear waste in UK has been compartmentalised in a variety of agencies. Although we are aware of a great deal of good individual work, this has not been contained within an overarching science-based strategy subject to adequate debate and peer review.

Contracts placed by both NIREX and EA/DETR have been of short duration, which has permitted little of the necessary original research to be done and has encouraged mere re-packaging of existing results.

We recommend that:

- the scientific aspects are dealt with through mainstream scientific processes including peer review;
- steps be taken to ensure longer-term continuity in the production of rigorous, relevant science;
- greater coordination of the research effort between Research Councils, DETR, the Environment Agency and NIREX is promoted, possibly through the coordinating body suggested in section 2;
- relevant international collaboration is promoted, including research on deep sea disposal;
- the information acquired through research commissioned by NIREX, HMIP and EA becomes readily available.

## Footnotes:

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[1] The London Dumping Convention 1996. Agreed at a meeting organised by the International Maritime Organisation, the convention classifies the disposal of nuclear material below the sea bed as 'ocan dumping' which is prohibited under international law. The convention allows the option to be reviewed in 25 years time. The resolution awaits ratification by the signatory nations.

[2] NIREX: Nuclear Industry Radioactive Waste Management Executive.

[3] RWMAC: Radioactive Waste Management Advisory Committee; ACSNI: Advisory Committee on the Safety of Nuclear Installations, renamed as the Nuclear Safety Advisory Committee (NuSAC) in September 1997.

[4] 1994 figures in *Radioactive Waste...Where next?* POST 1997.