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STAGED DECISION MAKING AND PUBLIC PARTICIPATION FOR GEOLOGICAL REPOSITORIES

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ABSTRACT

In recent years there has been a gradual evolution in environmental risk management frameworks towards closer integration of the risk assessment process and wider decision-making processes, with quantitative risk assessments being regarded as decision-making tools rather than providing a precise prediction of actual risk. These frameworks emphasise the need to ensure that there is meaningful participation by stakeholders throughout the process of problem formulation, definition of options and the decision process. These considerations have been applied to the development of a general framework for decision making in the context of radioactive waste management.

INTRODUCTION

Decisions about long-term management issues for radioactive waste are often characterised by tensions between technical experts and the wider public, caused by different perceptions of the meaning of risk and associated differences in social value systems. Technical experts tend to approach the issue as an exercise in risk assessment, seeking to establish scientific comparisons and objective measures such as probabilistic distributions of dose and consequences. The public may, however, adopt a more intuitive approach to deciding between different options, taking account of the perceived characteristics and potential impacts of the hazard, the implications for future generations and the institutional framework for decision-making and for dealing with any impacts that do ultimately arise.

A proposal to develop a long-term management facility is likely to be assessed against a range of sustainable development criteria including environmental responsibility, social equity and economic improvement. The concept of sustainable development implies that development should be undertaken in ways that satisfy the needs of the present without compromising the abilities of future generations to meet their own needs (1). This concept is related to the ethical concept of natural justice, which may be interpreted as a requirement that each generation bears the consequences of its actions (2).

Both the concepts of sustainable development and of natural justice imply that future generations should not inherit a poorer environment than that enjoyed by current generations. This, in turn, suggests that a wide spectrum of stakeholders should be involved in decisions about waste management options and in the implementation of the chosen option. Further, it is a specific requirement of the Espoo Convention (3) and the Aarhus Convention (4) that there should be public participation in decision-making on environmental projects. The Aarhus Convention makes specific mention of installations designed for the disposal or long term storage of spent fuel and radioactive waste.

The time needed to develop consensus on the value issues that underlie the decisions, and the technical complexity of calculations aimed at analysing outcomes that are unlikely to occur for perhaps hundreds of thousands of years, are at the root of the difficulties experienced in many countries in developing management strategies that carry broad public support. In these circumstances a process of prolonged dialogue will be necessary if a proposed strategy is to be in line with societal expectations. Where this objective is not achieved it is unlikely that consent to proceed with the development of a specific facility can be obtained.

A framework for co-operative dialogue with stakeholders is developed in the following sections of the paper. By way of illustration, the issues raised are then discussed in the context of a specific management option, namely the development process of a deep geological repository. It is emphasised that the choice of a preferred management option is itself an issue where the need for dialogue is fundamental and there is therefore the possibility that other options will emerge as carrying a greater level of support.

The paper also discusses the practical aspects of involving the public in the decision-making process, based on the conclusions of a study recently undertaken for the European Commission on environmental impact assessment of waste management facilities (5). The final section of the paper draws a number of conclusions on implications for improving decision-making processes in national waste management programmes.

A FRAMEWORK FOR DECISION-MAKING ON WASTE MANAGEMENT

Introduction

The decision framework shown in Figure 1 has been developed from general environmental risk management and decision making frameworks developed in a number of countries during the last decade (6, 7, 8). It also takes account of procedures for decision making being applied within Nirex in the context of its work relating to developing research and analytical programmes for the management of intermediate level waste in the UK.

The framework is intended to be iterative and comprises the following main elements, each of which involves a process of stakeholder dialogue:

- establish problem context;
- define options;

- analyse options;
- implement decision process; and
- implement and evaluate the chosen option.

Establish problem context

This involves determining not only the specific decision to be made, but its context and purpose. Most decisions do not exist in isolation but are built on decisions that have already been taken and affect the choices that will be available in the future. The timing of a decision may therefore be an important factor as the circumstances surrounding the decision will determine the external constraints, other factors to be taken into account and the people who should be involved.

It will be important that there is clarity about the objectives underlying a specific decision, i.e. what the proponent is seeking to achieve or to avoid, and for policy or legal constraints to be identified. This approach should facilitate the definition of innovative alternatives (9), as discussed below.

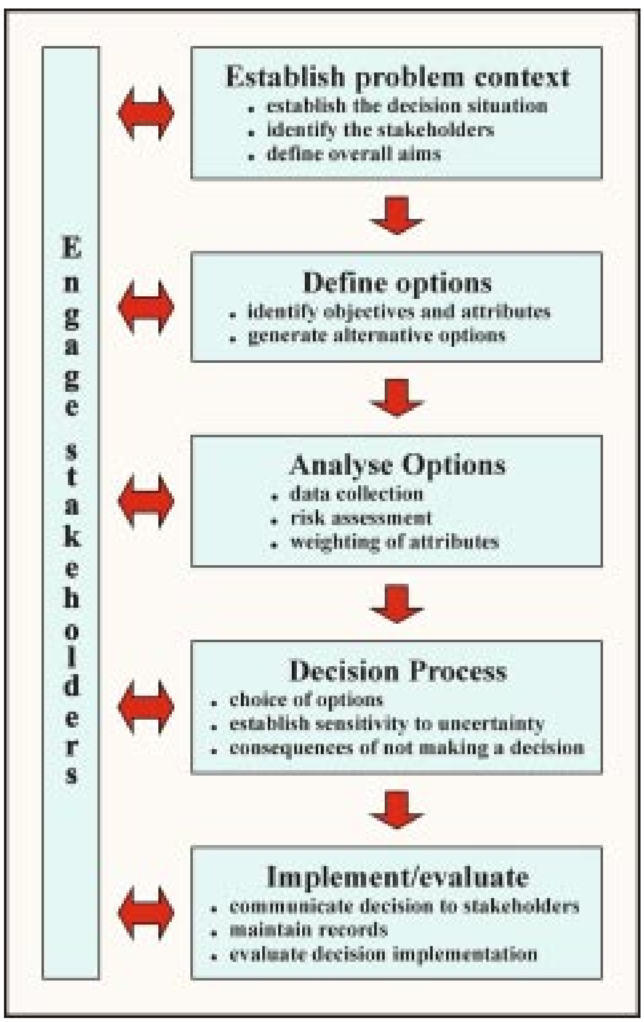

Figure 1 Framework for Decision Making on Waste Management

Having established the decision context it will be necessary to determine the range of stakeholders relevant to the decision, which should be taken to include everyone who may directly or indirectly be affected by the decision. The involvement of stakeholders will depend on the nature of the decision, but there is evidence that including those affected by a decision can greatly reduce the time it takes to find an implementable solution (10). In the context of decisions where social considerations are important, the success of the decision process should not be measured solely by the ability to arrive at a particular solution, but also on the legitimacy of the process itself, e.g.

> *'the measure of a decision is not just whether it is made efficiently and economically but whether the decision making process has sufficient legitimacy, and the decision sufficient acceptability, to permit implementation.'* (11)

Define options

For decisions having a societal as well as technical context it has been postulated that the definition of options should be based on an analysis of the core objectives or values of the relevant stakeholders (12). Having determined key objectives it then becomes necessary to specify those attributes that will indicate the extent to which a core objective is achieved. Some attributes may be objective, such as cost, whereas others may be more subjective, e.g. an attribute aimed at minimising environmental degradation. It is important that the attributes chosen reflect the requirements of the relevant stakeholders.

The process of developing attributes may indicate that some core objectives have been ignored. Once the process of identifying objectives (social as well as technical) and related attributes is complete a range of options likely to meet these objectives should be generated.

The identification of options is undertaken against the background of legal, regulatory and planning requirements as well as national policy considerations. Options that are unlikely to satisfy such requirements should be excluded from further consideration.

Analyse options

The analysis phase is concerned with determining how well each option compares against the chosen attributes. In the context of the technical attributes analytical processes are now well established, though it may be important that an appropriate range of end-points are considered in the analysis, e.g. impacts on the natural environment may need to be considered in addition to the implications for human health. Depending on the core objectives relevant to a specific decision, social and ethical considerations may need to be evaluated in addition to potential impacts on human health and on the environment.

The approach to dealing with uncertainty will be an important aspect of a quantitative assessment. Careful use of expert judgement, e.g. to develop ranges for data that are currently unknown, will help ensure that the assessment is as complete as possible. This will depend also on the identification of a comprehensive range of possible future scenarios. The results of this analysis should be presented in such a way that the underlying assumptions, and the strength of evidence supporting those assumptions, are clear.

The decision process

The process of deciding between alternative options is likely to involve, explicitly or implicitly, some ranking of different objectives, and therefore of different attributes. For example, an option that may result in lower calculated radiation doses to the general public might involve higher doses to the workforce.

Historically, quantitative models for decision analysis, such as Multi-Attribute Decision Analysis, have been used to represent a diverse range of different attributes on a common scale. Such techniques are based on comparing the assumed utility of a given range of possible values of one attribute (e.g. cost) against the range of values of another attribute (e.g. assessed long-term risk). Such a highly structured approach might, for example, be applied to the process of site selection, where there is a particular need to record in detail the basis for the eventual decision (13). Whether such techniques are used or not, the decision process must allow for iteration between different steps so that all important considerations are reflected in the final outcome (14). A key requirement is the use of sensitivity analysis to test the robustness of results to the underlying assumptions.

The process of ranking different overall objectives will involve consultation with stakeholders, possibly involving technical experts as well as representatives of public interest groups, the general public and their representatives. A range of consultative and peer review techniques is likely to be useful. The decision process may lead to a conclusion that more research needs to be undertaken, or that uncertainties need to be resolved before a decision can be made. Such outcomes should be seen as valid outcomes of a decision-making process.

Decision implementation and evaluation

Once a decision is made the result should be communicated to stakeholders by appropriate means, e.g. decisions of interest to the general public will need to be promulgated widely, perhaps using a range of media. It is important also that an adequate long-term record of decisions is maintained, at a level of detail appropriate to the importance of the decision. Such a record should include information on the consultation process, including who was consulted and a summary of the outcome. The record should also incorporate information on how knowledge gained from stakeholder consultations was reflected in the final decision.

Public involvement should not end when the decision is made: mechanisms should be put in place to facilitate continuing input to the implementation process and to any subsequent decisions.

AN INCREMENTAL APPROACH TO IMPLEMENTING OPTIONS FOR WASTE MANAGEMENT

Waste management policy

The process of implementing a specific strategy for the long-term management of radioactive waste necessarily begins with the establishment of national policy by government. In recent years many governments have concluded that the process of establishing policy in this area requires broad consultation with a range of stakeholders, including the scientific community, the nuclear industry, public interest groups, local and national politicians, as well as the wider public (e.g. 15). Such an approach is founded on the belief that only through such extensive consultation can an appropriate level of broad public support for any particular waste management strategy be developed.

The development of national policy on radioactive waste management raises a broad range of issues, including:

- the classification of waste (i.e. material for which no further use is foreseen);
- the extent to which different management strategies should be applied to different categories of waste;
- distributional equity (ensuring fairness between those experiencing benefit and those suffering detriment);
- sustainable development and inter-generational equity;
- standards for health and environmental protection; and
- organisational and regulatory frameworks to facilitate implementation of the chosen management option.

The process used to decide the preferred waste management option will depend on the legal requirements of the country concerned, and may include a strategic environmental assessment of alternative options. A draft Directive on strategic environmental assessment is under consideration by the European Council (16).

The process of implementing a preferred management option will be an incremental one requiring ongoing interaction with stakeholders as further information from relevant research and investigation work becomes available. The general decision framework developed above will apply throughout the steps involved in implementing a specific framework. The next section of this paper outlines, by way of illustration, the main activities involved in the development process for a geological repository, as shown schematically on Figure 2.

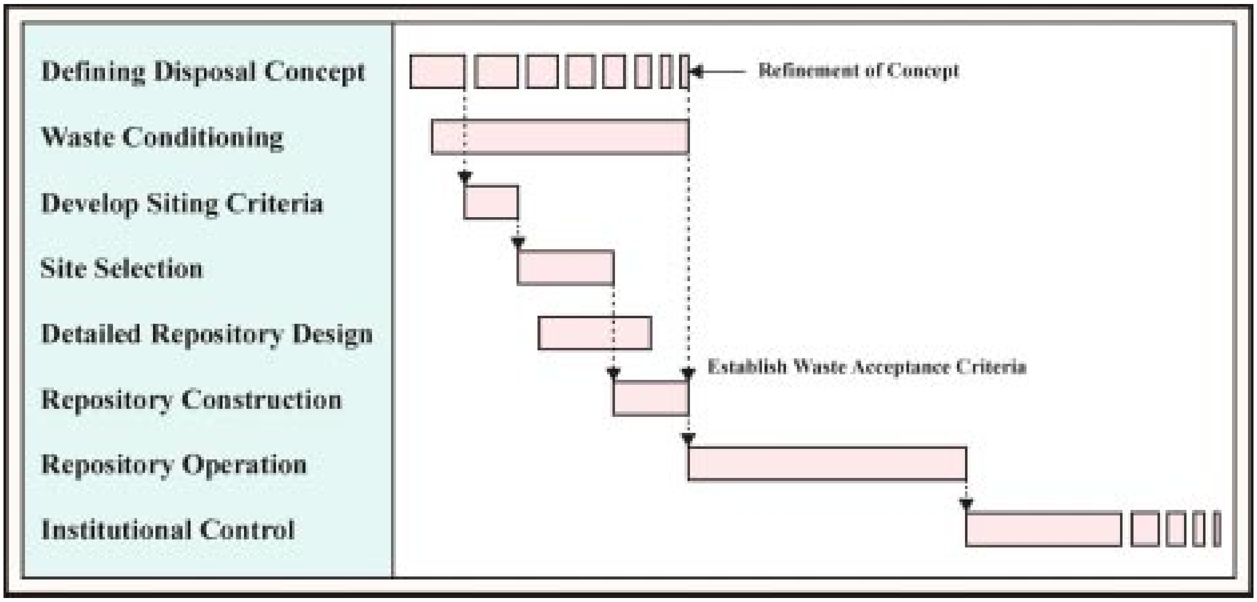

Figure 2 Development and implementation of a geological repository

Defining the disposal concept

The definition of the disposal concept is concerned with decisions about the different elements of the concept and their relative importance. These elements include:

- the extent of reliance on different barriers during different timeframes;
- cost considerations, including costs of materials, exploration and research as well as the costs of transport and the capital and operating costs of the facility;
- the robustness of the concept in relation to the properties of the actual geological environment; and
- considerations of implementation, taking account of social, legal and political requirements and including issues such as retrievability of waste.

The ongoing development and refinement of the disposal concept is an iterative process. The initial formulation of the concept will be constrained by national policy, e.g. as regards the overall standards of radiological and environmental protection. Having made initial assumptions about the nature of engineered and geological barriers a preliminary assessment of performance will be undertaken to determine those features of the design that are important in providing a satisfactory level of protection during the operational phase and over the long term. The initial assessments of performance and of cost will enable attention to be focused on the key design attributes and processes and will assist the formulation of an appropriate research programme.

In due course the limiting requirements and constraints will be refined, as a result of research findings and to take account of the results from the initial assessments, and on the basis of dialogue with regulators and other stakeholders including the public – see Figure 3. These constraints will also be important in developing criteria for siting, as discussed below. As site selection (and, in due course, construction work) proceeds, further refinement of system requirements will occur with greater definition of the geological environment. The development of mechanisms for consultation and public participation, appropriate to the legal and cultural frameworks in the relevant country, is of fundamental importance, as discussed later.

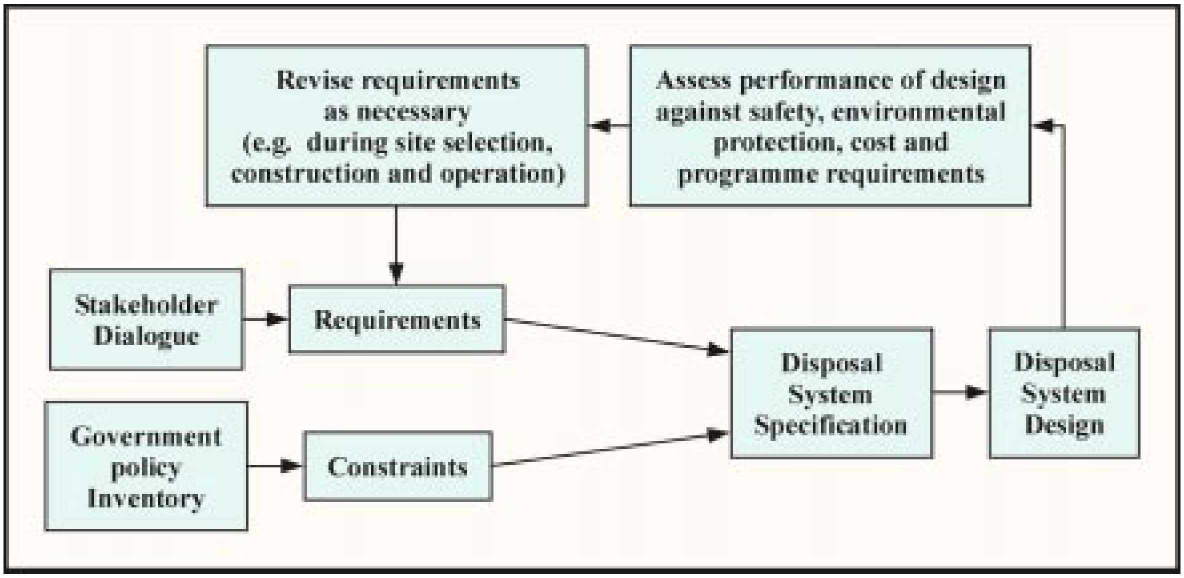

Figure 3 Iterative Process of Design Development

Waste conditioning

In countries with diverse historical waste streams, such as the UK, decisions about the conditioning of wastes may need to be taken in advance of final decisions being taken about the preferred waste management option. As well as those issues relating to interim storage it is appropriate to consider at the outset requirements relating to waste transport and disposal, in order that the likelihood of further reworking is minimised.

Where specific repository design or management measures are necessary to ensure adequate performance, it may be necessary to decide between options for risk management that could be undertaken as part of waste conditioning and those that otherwise would have to be taken as part of repository implementation. Depending on the issues involved such decisions may include societal as well as technical considerations, for example if waste needed to be removed from the site of arising for treatment and further storage.

Develop siting criteria

The development of siting criteria is the stage at which many of the broad principles concerning the selected disposal concept are translated into requirements against which the suitability of potential sites can be assessed, qualitatively and/or quantitatively. Such requirements will include geological, environmental and social factors as well as transport and cost considerations and legal and planning requirements. Depending on the legal and regulatory framework, some high-level criteria may be reflected in statutory or regulatory requirements. Associated with the development of criteria are considerations of the process of selecting a site: this aspect is discussed below.

Experience in many countries with developing disposal programmes shows that radiological or technical optimisation has not been the determining factor in higher level decisions, e.g. on waste management concept or facility siting, although technical analysis can be useful to illuminate factors that have a bearing on the decision (17, 18). Countries such as Sweden and France have adopted approaches based around securing acceptance from local communities as the most critical factor.

The development of siting criteria in an open way, with input from a wide range of stakeholders, will be crucial if the ensuing site selection programme is to be accepted as fair. The process of developing criteria must recognise that different stakeholders will take a range of views on different attributes. An important part of this process will therefore involve gaining an understanding of the requirements and priorities of different stakeholder groups (5). In due course the site selection process must aim to ensure that the chosen site is robust to different views on the appropriate weightings of different attributes – see below.

Site selection

It will be important that there is agreement at the outset on the process of selecting a site, including requirements at key milestones, and failure to gain such agreement will undermine the likelihood of acceptance of the eventual outcome of the selection process. This process of site selection will normally involve the following successive stages (19):

- *concept and planning* – development of an overall plan for the siting process taking account of the criteria discussed above;

- *area survey* – determination of areas on a regional scale that could in principle meet the above criteria;

- *site characterisation* – the collection of sufficient data at a small number of candidate sites to enable a decision to be taken on a preferred site for development; and

- *site confirmation* – extensive underground investigations at the preferred site to enable a safety case to be made to the satisfaction of the appropriate regulatory authorities.

An important aspect will be the extent to which different geological environments can be adequately characterised, i.e. for which uncertainties relating to the site data can be minimised. The process of site selection may therefore involve choices between sites offering higher calculated levels of safety performance but with greater uncertainty, and sites with lesser performance though with greater certainty. The weighting to be applied to robustness should be determined as part of the process of developing the criteria for site selection.

Detailed repository design

Following the selection of a preferred site for a repository it will be possible to refine the generic design of the engineered repository assumed as part of the overall disposal concept. The development of the design should follow the iterative process discussed above (Figure 3), following better definition of the requirements and constraints on the disposal concept as a result of the data obtained through site investigations and, in due course, during construction.

The design of engineered barriers that complement the geological barriers to the greatest practicable extent is a crucial aspect of the overall process of technical optimisation. This process will proceed interactively with site selection, i.e. preliminary performance assessments will begin to take account of site-specific design features and, in turn, the strategy for site investigation can be focused on those features that are most important to the assessed performance of a particular site.

The process of design optimisation should involve the development and analysis of different design options for components of the disposal system. Preferred options should be chosen on the basis of a range of criteria, including:

- assessed performance (taking account of operational and long-term safety and of environmental protection);
- best practice approaches for similar applications;
- use of proven technology;
- cost considerations; and
- the ability to implement design solutions in the relevant host environment.

Many design decisions will be of a largely technical nature and the principal stakeholders will be the disposal company and the regulators. Arrangements should nonetheless be made to ensure that the design considerations are communicated to the public, including non-experts, and that there is ongoing provision for public participation during the detailed design phase, e.g. by inviting lay people onto technical panels. For such decisions a key requirement will be to ensure that records of the basis for the decision, including the range of options considered, are retained and are easily accessible.

Other design decisions will concern a wider range of stakeholders. For example, a decision on the extent to which active design provision should be made for waste retrieval, as opposed to ensuring that the design does not make retrieval unnecessarily difficult, will have wide societal and cost implications. This issue is related to the application of the concepts of sustainable development and ethical justice discussed earlier, because active institutional control will need to be retained for the period during which waste is easily retrievable. In turn, this means there is ongoing reliance on the ability of future society to retain the capability to maintain safety.

Repository construction

An important feature of repository construction is that additional information about the characteristics of the host rock will become available as construction proceeds. In these circumstances it will be appropriate to retain flexibility about methods of construction and about the precise dimensions of disposal vaults until access to the relevant area has been gained. For example, it will be important to ensure that waste is not located near to major faults in the rock, which could provide enhanced pathways for the transport of radioactivity to the surface.

Repository operation

As regards radiological safety and environmental protection during operation, the processes for optimisation are essentially no different from those which apply in other nuclear facilities, with decisions being made on the basis of the assessed impact, best practice considerations, use of proven technology and cost. For decisions with significant potential impacts, a combination of quantitative procedures, e.g. cost benefit analysis, and qualitative analysis, to take account of societal impacts, is likely to be appropriate. An important consideration during this phase will be the level of trust engendered in the institutions managing and regulating the facility, and this will impact on the level of detailed involvement considered necessary by stakeholders.

Institutional control and closure

The institutional control phase is taken here to include a period after completion of waste emplacement during which there will be ongoing monitoring of the waste and of the natural environment. Such a phase will facilitate the development of further confidence in system behaviour through the collection of further data. The overall objective will be to enable a decision to be made in due course on the timing of repository closure, should that be the choice of future generations. During this period active controls over activities in the vicinity of the facility will be retained, requiring ongoing involvement of regulatory agencies as well as the organisation charged with managing the facility.

APPROACHES TO PUBLIC INVOLVEMENT

Public participation is a fundamental component of the process of environmental impact assessment and therefore it is appropriate to develop a public involvement programme as an element of the wider environmental assessment process (5). The nature of public involvement in decision-making relating to the implementation of a waste management strategy will however differ according to the different stages of the implementation process. During this process the focus of public involvement will move from a national to a local level as attention is concentrated on a specific site or sites.

A basic objective for any public participation activity is to achieve a certain level of public awareness. This may be achieved by a combination of methods, including leaflets, science reports, technical reports, the Internet, Open Houses, videos, documentaries, workshops and seminars. Care must be taken to ensure that information is available from a variety of sources, so that people do not feel they are being biased or shielded from differing opinions. Sufficient opportunities must be given for people to obtain clarification about the information, to minimise any misunderstanding.

Any attempt to involve the public in an effective way should adhere to the following principles. Participation should be:

- started early and occur throughout the process (with defined cycles of activity);
- interactive - a two-way process including feedback; and
- inclusive, transparent and honest.

A key requirement will be the development at the outset of a public involvement programme that defines the overall objectives and outlines a series of public activities connected with the various phases of the assessment process. The programme will need to provide for easy access by any interested individuals and must be seen as being fair, i.e. the public must be able to contribute to defining the scope and nature of the programme itself.

A key determinant of a successful public involvement programme is related to the extent to which the mechanisms used enable those participating to identify the core issues important to them. It will usually be appropriate to use several techniques in order to achieve as high a level of involvement as possible. The techniques used may therefore include: questionnaires, the Internet, free telephone lines, free postal addresses, Open Houses, Planning Workshops, Consensus Conferences and detailed elicitation processes.

The above processes should be iterative, and the degree of ongoing involvement by the public will depend on the extent to which it believes that it is able to influence the decision-making process. In this context it will be important that mechanisms are put in place to ensure that queries raised by members of the public are considered by proponents, with visibility of how the query is addressed, e.g. by providing access to correspondence dealing with that issue.

When the management process is concerned with a specific site it will be necessary to increase the involvement of the local community, perhaps by setting up community committees and involving community representatives on scientific panels and as decision makers. It will be important to discuss with the community the level of involvement they wish to have in the implementation process, including the ongoing development of the public participation programme.

SUMMARY AND CONCLUSIONS

Although decision frameworks concerned with protecting human health from radiation resulting from routine discharges from operating nuclear facilities are highly developed, they need to be modified when applied to decisions about long-term waste management. This is because the long-term nature of these facilities introduces issues such as considerations of equity between current and future generations that do not apply to the same extent to conventional nuclear facilities. A framework for making decisions about the management of radioactive waste will therefore have much in common with the general frameworks being applied to environmental risk management.

This paper recognises that much scientific and social scientific innovation is required in establishing detailed mechanisms for engaging with stakeholders through the steps involved in deciding and then implementing solutions for the long-term management of radioactive waste. The overall timescale for these activities is likely to span several decades and will only be successful if there is broad public support for the process itself and trust in the institutions undertaking the work. A further fundamental requirement is that the management option that emerges from the process is in line with societal values, including perspectives on its responsibilities to the natural environment and to future generations.

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