RETRIEVABILITY: AN INTERNATIONAL OVERVIEW

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Abstract

Using available information from the published literature and material obtained from a network of contacts, a short introductory overview of international developments in the field of retrievability of emplaced nuclear waste was produced for the Swedish National Siting Co-ordinator for Nuclear Waste Disposal. This examined the issue in terms of a number of basic questions: Definition, Need, Design Implications, Safeguards for Fissile Material, Public Acceptability and Safety Assessment. The report was submitted in February 1999, and acted as a catalyst for the organisation of an international seminar by KASAM, the Swedish National Council for Nuclear Waste (these proceedings). This paper describes the report contents, and points to the invited papers at the seminar which expand on and update the limited descriptions in the original report.

1. INTRODUCTION

This paper is based on a report produced for the then Swedish National Siting Co-ordinator for Nuclear Waste Disposal, examining the situation as regards the development and possible implementation of retrievability as an integral part of a disposal concept for nuclear waste [1]. Because of the short work period involved, between October 1998 and January 1999, the report was at best only an overview, designed to provide a broad picture of current plans. In the event, the report served as the catalyst for this seminar to be organized.

It had become clear, from monitoring of many national programmes for siting of final repositories for radioactive waste disposal, that the potential or otherwise for retrievability of emplaced wastes is the one issue in particular which is repeatedly raised during public consultation and interaction.

Although even those repositories which may be constructed over the next decades will operate for many decades more and be sealed only after a long term monitoring phase, there is little operational pressure to finalise retrievability concepts [2]. However, as siting processes require detailed conceptual designs to be developed, as do the associated safety assessment exercises, it is becoming increasingly recognised that the potential for retrieval must be examined now. The presentations in this seminar serve to demonstrate how the issue has developed.

For example, as is reported elsewhere [3], a major collaborative investigation, or 'Concerted Action' which began in March 1998, is currently underway under the auspices of the EU (Directorate General XII), involving implementing agencies from the various Member States.

As McCombie and Zuidema have pointed out [2], *'the technical and (much more problematic) the societal processes for decision making concerning methods for remediation,* *up to and including retrieval...have nowhere been completely defined'*. This report was therefore a contribution to that effort, intended to serve as background to these other studies when they appear.

The report included some limited review of the technical aspects of retrievability, with especial regard to the issue of Safeguards, as it relates to the long term monitoring of fissile material, whilst at the same time incorporating information regarding public perceptions of retrievability where possible. Ethical issues concerning responsibilities of present and future generations were also included where appropriate.

As well as describing the developments in a selection of national programmes, the report was structured around a number of basic questions, as briefly outlined below. Other papers at this seminar will provide up to date information on individual programmes.

2. WHAT IS RETRIEVABILITY?

As in many similar cases relating to geological disposal issues, it is helpful to make a comment regarding basic terminology. It is necessary to distinguish between 'retrievability', which is the theoretical ability to recover wastes however difficult that may ultimately prove to be, and 'retrieval', which is the actual act of recovery. Implementing agencies tend to refer to 'retrievability' as an unlikely and probably unnecessary option, whereas the public tends to express concern about how 'retrieval' could actually be carried out.

As pointed out by McCombie and Zuidema [2], deep geological disposal was developed to remove wastes permanently from the human environment, utilising multiple barriers, to ensure that they remain isolated from the human environment and inaccessible to Man for the very long timescales needed to allow for the natural decay of their radioactivity. Indeed, in 1996 the IAEA defined a geological disposal facility as *'one where there is no intention to retrieve the waste'* [4].

This has led to the development of various euphemisms in those countries examining or actively pursuing the issue, as described below. These include *'Very Long term Interim Storage'* and *'Reversible Geological Storage'* in France, and *'Monitored Geologic Repository'* in the USA etc.

As demonstrated by the papers at this seminar, discussion regarding retrievability of nuclear wastes tends to focus on deep geological disposal, as proposed for either high level waste (HLW) or spent nuclear fuel, although several countries propose some form of co-disposal of long lived intermediate level waste (ILW or TRU in the USA).

The French National Assessment Agency (CNE) has suggested there could be little or no justification for development of a retrieval capability in the case of low-level waste (LLW), because of the lack of any re-usable resource value, but did accept the fact that it might ultimately prove necessary because of public concerns [5]. Indeed, proposals have also been made recently in various LLW Compacts in the USA regarding development of so-called 'Assured Isolation Facilities' following the intense public reaction to plans for near-surface disposal of these wastes.

Whilst the nuclear waste industry would claim that retrieval of emplaced wastes is theoretically possible at any time during the operational lifetime of a repository, up to and including final sealing, some present disposal concepts are designed to specifically rule out the possibility, and incorporate immediate backfilling of disposal rooms, tunnels or boreholes, whilst others envisage leaving some or all of these open until a final closure decision is made at some date in the future.

As explained by others, in the **United Kingdom**, for example, Nirex have to date divided the timescale for potential retrievability into 3 [6]:

1. *Following emplacement of (L/ILW) packages, but prior to being surrounded by cementitious backfill.*
2. *Following cementitious backfill placement but prior to access ways being sealed.* Here retrieval would be more demanding but is regarded as relatively straightforward [7].
3. *Following sealing of access ways and after shaft sealing and repository closure.* Clearly, as time moves on, the difficulty of the task would increase due to degradation of the of the waste packages and loss of information [7].

The Netherlands assume that waste disposal takes place as a step-wise process:

- Facility construction;
- Waste emplacement;
- Repository operation as an 'underground waste storage facility', possibly for a period of up to several hundred years;
- Repository closure.

The time period for overall retrievability is currently open to debate in the Netherlands. The 'Commissie Opberging Radioactief Afval' (the CORA Commission), is supporting research into this matter at present. The time basis is referred to as a 'rolling present' scenario [8], in which regular decisions are made as to whether the underground waste storage facility should remain 'open' or be 'closed'. The period between each decision will depend on social and economic developments, the life expectancy of the equipment in the repository and the costs of the maintenance and monitoring activities. In the latest concept a period of 25 years is assumed. CORA envisages a period as long as 200 years before final closure as being a reasonable maximum. Study is underway of scenarios in which the existing surface storage facility at Borssele, operated by the Central Organisation for Radioactive Waste (COVRA), remains operational for up to 300 years before development of the underground waste storage facility.

As mentioned in several presentations, regulations governing some national disposal programmes have always included a period during which the wastes, as emplaced, can be observed, monitored and if necessary retrieved, but the timescales have generally tended to be measurable only in decades, which is long for human activities but negligible in terms of relevant containment periods [2]. For example, the USA Nuclear Regulatory Commission (NRC) stipulates that access must be maintained for up to 50 years following the start of repository operations.

The public, on the other hand, often regards potential retrievability as synonymous with a guaranteed ability for retrieval, and as an 'insurance policy' designed to allow the rectification of problems in the future. It does not often draw the distinction between pre-closure and post-closure periods.

3. WHY SHOULD RETRIEVABILITY BE NECESSARY?

Various reasons may be envisaged for the retrieval of nuclear waste/spent nuclear fuel once it has been placed in a deep geological repository, not all of which are safety-related, such as:

- Removal in the event of an accident or following recognition of poor performance;
- Removal for implementation of transmutation or other new technology;
- Removal for monitoring and disposal concept validation purposes;
- Removal to allow for implementation of an improved emplacement or overall disposal concept;
- Removal as part of work associated with assessment model validation (maybe in an underground rock laboratory or URL).

4. WHICH COUNTRIES ARE ACTIVELY EXAMINING RETRIEVABILITY AS A MANAGEMENT OPTION?

Whilst the papers at this seminar describe in some detail the situation in most of those countries now recognised as examining retrievability, the initial report summarised those programmes where information was obtainable.

Belgium

In 1994 ONDRAF/NIRAS announced a list of 98 potential sites for a near-surface L/ILW facility. By mid-1996 only one community had expressed any interest in even beginning investigations, so the siting process was suspended, and an independent review instituted of the whole effort and criteria employed, and analysis of the comparable costs of near-surface storage, deep disposal or long term storage.

The 'Altsurf Project' report did not recommend whether final disposal or a system of monitored storage is to be preferred. ONDRAF/NIRAS has now developed a new workplan to examine the possibilities.

As de Preter [9] points out, retrievable disposal concepts are also under consideration for deep disposal of HLW and spent fuel in the Boom Clay.

Canada

The disposal concept examined in detail by the CEAA Panel in 1996/7 did not propose any specific enhancement of retrievability. Both methods proposed during the hearings (steel or KBS–3 type canisters) envisaged the immediate backfilling of emplacement tunnels, once full. However, AECB regulations stipulate that retrievability should be feasible during the lifetime of the disposal vault, and therefore the issue did surface as an issue in many presentations to the panel, and was reflected in the Panel's report [10].

France

Until 1998, deep geological disposal was the only concept under consideration, as laid out in the Nuclear Waste Act of 1991. Three research strands were to be followed and reported on in 2006, after which a decision on future actions would be made by government.

These were:

- Partition and Transmutation;
- Waste packaging and effects of long term surface storage;
- Development of at least two underground laboratories, in different geological media. This was to include the study by ANDRA of the feasibility of reversible or irreversible disposal.

In February 1998 it was announced that legislation was to be introduced to also allow research into shallow disposal of HLW to be carried out as well, and in June it was allocated 15% extra funding, to be increased by a further 20% in 1999.

So as to enable this additional research to begin as soon as possible, CEA was instructed to review the concept of shallow disposal by the end of 1998. However, before this CEA began work on the so-called 'Very Long Term Interim Storage' Project (ETLD), which will absorb more than 50% of its total waste management research budget.

CNE also examined the scientific basis and reliability of reversibility for all disposal concepts and in late June 1998 recommended major changes to the French disposal strategy, including separation of non heat-generating plutonium-contaminated wastes from HLW. They would be placed in a deep repository, but with retrievability ensured for around 300 years. The HLW, on the other hand, would go into 'subsurface storage', with continuous monitoring and assured retrievability.

The ETLD Project at CEA is designed to develop potential concepts for these various proposals. In the December statement giving approval for the development of an underground laboratory in the Meuse Department, CEA was instructed to research the feasibility of developing a shallow storage facility in subsurface caverns in marl in the Gard region, probably at Marcoule.

Details of ANDRA's proposals for retrievable concepts are outlined by Hoorelbeke [11].

Netherlands

In 1984 a long term research programme into disposal options was agreed and a research commission set up under the direction of the ILONA Committee, which advises the responsible government department.

Following the ILONA reports, and to comply with the principle of sustainable development, the government said in 1993 that it 'wished' that any wastes disposed must remain retrievable for extended periods, so as to allow for monitoring and recycling if new technologies are developed.

A co-ordinating committee (CORA) was set up in 1995 to examine retrievable disposal possibilities, following the ILONA reports. These included:

- long term above ground storage;
- retrievable storage in rock salt (identified as preferred host rock); and
- retrievable storage in clay.

The CORA programme encompasses now more than 20 projects, amny dealing directly with retrievability. These are scheduled to end by mid 2000.

Three possible scenarios are envisaged, potentially in any combination:

- indefinite above-ground storage;
- 100 years above-ground storage, then transfer to an underground retrievable facility; and
- extended above-ground (up to 300 years), then 200 years in a retrievable underground facility, followed by final closure after around 600 years.

These concepts are described further in this seminar by Selling [12].

Sweden

As explained by several speakers in this seminar, SKB's current plans envisage a two–stage process in which a limited inventory (around 400 canisters) of spent fuel is emplaced in a fully-retrievable form at the final candidate repository site, probably around 2008, with a period of observation and evaluation, as part of a staged decision-making process. Only after this period of so-called 'demonstration disposal' will the full scale repository be developed, following further licensing and evaluation of alternatives. The retrievability of these canisters is seen by SKB (and the regulators) as an explicit design criteria. In this seminar Papp [13] and Jensen [14] describe this from the standpoints of the implementer and regulator respectively.

Switzerland

NAGRA, the implementing agency, had originally envisaged immediate backfilling of emplaced L/ILW waste containers and disposal rooms. However, due to the the negative cantonal vote at Wellenberg in a referendum in 1995, incorporation of some form of retrievability has become one of the major means by which NAGRA and the government have sought to regain public confidence.

HSK (the regulator) envisage no problem as regards 'delaying the closure of the repository for a time period short enough that the passive safety barriers are not compromised'.

United Kingdom

In accordance with the IAEA, UK regulations define disposal as '*emplacement of waste without intent to retrieve it at a later time...* ". However, UK Nirex has developed a concept for the deep geological disposal of L/ILW which incorporates use of a so-called 'soft grout', which can be re-excavated if possible One of the reasons for this was to respond to the perceived public concern over irreversible disposal.

Due to the cancellation of the proposed RCF at Sellafield, plans to carry out in-situ experiments on this grout have been indefinitely postponed, although Nirex has taken out a patent on the formulation of the material. McCall [15] describes the latest Nirex plans in this regard.

United States of America

Following continued problems in developing new near-surface disposal facilities for LLW, a concept known as an 'Assured Isolation Facility' has become increasingly discussed. This facility would be above-ground and fully monitorable and retrievable. This is being examined at the present time by several of the so-called 'Compacts' to see if it is licencable under the Low Level Waste Policy Amendment Act.

As regards HLW/spent fuel, under current regulations, the NRC requires access to the waste in a repository for a minimum of fifty years after emplacement starts, for the purpose of safeguard and safety verification.

When the report was produced, the latest concept for the proposed facility at Yucca Mountain in Nevada incorporated methods for maintaining the easy access required by the NRC. These resulted in the use of the name: 'Monitored Geologic Repository' for the proposal examined in the 'TSPA-VA' that was submitted by DOE to Congress in December 1998. Further changes were announced in mid–1999 and are described by Harrington [16].

5. WHAT ARE THE DESIGN IMPLICATIONS OF RETRIEVABILITY?

The IAEA list a number of factors which can potentially influence the ease with which emplaced wastes (in this case specifically spent fuel) could be recovered [4]. These include:

(a) Host rock

Stable, self-supporting crystalline rocks are less problematic than salt which flows and soft clays which require support. The need to maintain access drifts and galleries for long term maintenance and monitoring, as well as for possible retrieval, means that some degree of convergence will take place. This will be greater for salt and soft clays.

Belgium has yet to finally decide which rocktype to use for shallow disposal; if retrievability is adopted, it may impact on that choice. HLW is to be put into the Boom Clay at Mol, but retrievability has not been proposed there, at least to date, although as mentioned above, de Preter [9] outlines the latest situation.

France has looked at clay and crystalline, but the shallow storage concept is still some way behind the deep one. Clay is the only rock approved for further work to date, and ANDRA has produced several borehole/silo combination design concepts, which are described by Hoorelbeke [11].

The Netherlands is well along the development path, with retrievable designs in salt completed, and one for clay nearing completion. They incorporate staged sealing of short horizontal boreholes, with tunnel access maintained throughout. Selling [12] gives more details.

The situation in Germany as regards potential design options to incorporate retrievability, although not covered in the original report, is described by Brennecke [17] as also being well advanced.

The latest conceptual design for US host rock, tuff, will incorporate the use of support shields to maintain the 50 year access required by NRC, which means that access can actually be maintained for up to 300 years.

(b) Depth of emplacement

This can also affect the rate of closure of tunnels etc. Where this necessitates the provision of a tunnel liner, retrievability potential is considerably enhanced, as in the USA.

It is assumed in the Netherlands that several phases of re-excavation will be necessary to maintain access over the required period. French research in the planned unerground laboratories will dictate the final depth in each rocktype, given the mandate to incorporate retrievability.

(c) Repository design and layout

Certain layouts would inhibit later access, especially those which envisage immediate backfilling. Designs incorporating emergency escape routes may be necessary if retrievability is to be made possible.

Several concepts envisage the need to re-excavate tunnels etc., and to continue long term maintenance programmes. The Canadian designs included details of the equipment which would be needed to actually retrieve waste canisters; the Swedish requirement for demonstration disposal means that it would also be developed, but then may well be discarded once full operations began.

(d) Type of backfill material used

Bentonite blocks are designed to swell and could become difficult to remove, whereas other possible materials exist which could be more easily excavated. The Nirex 'soft grout' is the only example so far of a custom-made material which could actively facilitate retrieval.

The Dutch designs allow for use of salt plugs which could be removed and allow ready access to the rock surrounding an emplaced canister, with a special shutter arrangement to provide radiation shielding.

NAGRA are beginning to develop concepts for allowing retrieval of waste packages from horizontal caverns, leaving access above partially backfilled areas, and maintaining machinery etc., using a range of excavation tools.

(e) Type of container used

The thickness of shielding would affect retrievability options due to proximity constraints for workers, although a long lived robust container with radiation shielding would make it simpler.

Many of the concepts designed to at least allow some form of retrievability incorporate the use of massive containers, so as to guarantee their integrity over the periods proposed (usually around 1–300 years). Some plan to use the massive transport canisters (the Dutch, for example), whilst the USA are currently researching the possible use of drip shields and some form of container covering. Those where borehole emplacement is envisaged must be able to withstand possible remining or drilling.

(f) Temperature in the repository

This is also affected by depth, and at elevated levels could preclude human entry, or even some types of machinery. It can also be affected by the level of passive ventilation that is maintained following completion of disposal activities. Decay heat from emplaced wastes must also be taken into account, due to the potential for 'thermal shock', which has the potential to alter ground conditions with time.

The USA have developed the idea of a 'thermal strategy' in which waste heat actually prevents water entering the tunnel after emplacement. This can have deleterious effects though on the ability to retrieve the waste, as it can damage services etc. As Harrington [16] points out, latest concepts have proposed a 'cooler' repository option.

The Dutch are concerned that temperature will limit access for maintenance and retrievability, and specify a minimum salt plug and pillar between disposal areas.

(g) Special measures to aid recovery or hinder human access

This includes things which range from provision of high resolution near-field monitoring to deliberate destruction of shaft equipment and not retaining archives etc., together with removable borehole seals, emergency escape routes etc.

The degree of retrievability required obviously has an impact on the design. If it is to be 'totally retrievable', then there must be free access to the disposal tunnels etc., with only limited bentonite plugs etc. in the holes themselves. The degree of ventilation is of course another important factor affecting accessibility, so it may be necessary to reduce this and close off the roadway, but not actually remove the ability to restore full ventilation and access. This of course necessitates maintenance and even replacement of all underground environmental systems, in case they are needed. Of course this access may be required at exactly the most unfavourable period, when radiation and tunnel temperatures are at their peak.

Once some form of backfilling starts in the roadways, wastes are then only in a 'semi-retrievable' form. The repository maybe now becomes, in effect, a secure long term storage facility.

Once a facility is closed, it enters into a 'low-retrievability' state, in that access is limited. It could be made even less available by processing of the waste.

Various methods for waste retrieval have been envisaged, albeit in general terms, and some of these are discussed in the report as regards specific national proposals. Suffice it to say here that some form of core drilling, standard mining or over-tunnelling, and some special techniques yet to fully developed, appear to be the most practical means, depending on whether wastes are emplaced in horizontal or vertical boreholes or within disposal rooms. Some form of shielding and remote operation also appears to be a prerequisite.

The report examined the design proposals and implications put forward by those countries identified. The papers in this seminar provide more detail.

6. WHAT IS THE IMPACT ON SAFEGUARDS?

The requirement for maintenance of Safeguards to prevent diversion of fissile material to weapons production should, according to a 1988 IAEA Working group, continue even after it has been sealed in a deep repository.

In general, there has to be a reason for Safeguards to be terminated, or at least relaxed. Under normal circumstances, relaxation is only allowed if it can be shown that the wastes in question have been consumed, diluted in a way to make the contained material no longer available for weapons production or that they have become 'practically irrecoverable'.

A whole session at this seminar is devoted to this issue, in conjunction with other safety-related matters, with major input from the IAEA. The Agency has in the past specified that design information should be supplied to it by waste disposal implementing agencies before any emplacement takes place, so as to allow it to develop a system of 'Design Information Verification' (DIV). Wastes such as vitrified HLW and other conditioned wastes could likely be excluded from Safeguards after their transfer to the final disposal canister in the conditioning or encapsulation plant. Spent fuel, on the other hand, would remain subject to them until final emplacement, and even then, design considerations come into play regarding the question of when, if ever, to relax the regime.

7. WHAT HAS PUBLIC REACTION BEEN LIKE?

Whenever radioactive waste disposal is discussed by the public at large, the potential for making irreversible decisions always comes to the fore, and usually broadens into discussions of ethics and decision making, whilst exploring the unknown wishes of future generations.

The starting position for this debate was originally clear, and was laid down by several international consensus documents, albeit produced by nuclear-oriented organisations, such as the Nuclear Energy Agency (NEA) and the IAEA. These concluded that responsibilities to future generations were better discharged by final disposal, rather than relying on long term storage, as we cannot predict the stability of future generations [18].

That said, they actually also commented that *'retrievability is an important ethical consideration since deep geological disposal should not necessarily be looked at as a totally irreversible process'*, and concluded that stepwise implementation of disposal would leave open the possibility of adaptation in the light of scientific progress and societal acceptability.

Many in the nuclear industry accept that they have had little success in communicating the basic concept and benefits of deep geological disposal to the general public [2] and that many people actually misunderstand the *'laudable, ethical objectives'* of a system which does not require active monitoring and from which retrieval need never be necessary. It is accepted however that this is often interpreted as meaning that monitoring is unlikely actually to be carried out and that retrievability is actually not possible.

In the past, the industry either ignored public criticism or opposition to geological disposal, or regarded it as an 'information problem'. However, following numerous setbacks in terms of siting programmes, which have in some countries even extended to the issue of the development of underground laboratories, it has begun to advocate a more open discussion of the issue, but one which accepts that public concerns must be taken seriously.

In its recent review of waste management issues [19], the EU identifies the initial motivation for introducing retrievability as a political one, *'since it is thought to be a positive influence on the public acceptance of a repository on a particular site'*. This view is echoed in France, where an unnamed utility official commented recently that retrievability was *'the political price to pay'* for obtaining public acceptance for development of an underground laboratory [20]. Similarly, in the UK, Nirex clearly acknowledges that the main reason that it has commissioned work on retrievability is because it may *'have a bearing on public acceptance of deep disposal.knowledge that the process of disposal is reversible should allay unfounded, but nonetheless genuine, fears about "getting it wrong".* [6]. Retrievability is regarded as a 'safety net' [7].

As far as environmentalists are concerned, Greenpeace, for example, advocates an immediate cessation to the production of nuclear wastes. For those which do exist, however, *'there exists no technical solution whereby the net detriment to human health and the environment can be guaranteed to be zero for the long term future...The only possible approach...is therefore to retain them on land and to manage them in failsafe conditions according the maximum in:*

- *safety;*
- *security (from terrorism and theft);*
- *containment;*
- *accessibility (to allow inspection and maintenance);*
- *monitorability (to ensure the early detection of any failure to meet the above criteria); and*
- *retrievability (in the event of the detection of any such failure)* [21].

Meanwhile, the public is caught in the middle of the debate, often unsure of where to turn.

As Riverin [10] describes, retrievability surfaced during the EIS Hearings in Canada in 1996/97 as an issue of major public concern. AECL themselves also gave details of how the issue (together with monitoring) was raised during the public consultation period prior to the preparation of the Environmental Impact Statement. A significant proportion of people felt that retrievability was an important factor, with between 60–70% of those surveyed expressing concern about the waste being inaccessible following repository closure, especially if local or regional monitoring were to highlight some problem with the containment system [22].

The reaction of the public to NAGRA's proposals in Switzerland, albeit for L/ILW, and described by Kowalski [23] demonstrates how difficult it can be for an implementer to move forward with a proposal if the public does not feel happy with the ethical and technical balance.

Since the original report was written, the British House of Lords has published the findings of its wide-ranging Inquiry into nuclear waste management. Retrievability and ethical issues were major topics. The Consensus Conference held in May 1999, and described in this seminar by Hiett [24], again showed just how important these issues are in the minds of the public.

A session at this seminar is devoted to discussion of the ethical framework of the retrievability issue.

8. OTHER ISSUES

The original report did not explicitly deal with the cost implications of incorporating retrievability (to whatever degree) or the specifics of which monitoring techniques could be used to determine the need for it. Three papers, Young [25], McCombie [26] and Söderberg [27] have been invited to encourage discussion on these issues, which are being recognised as major drivers in this debate.

The report also pointed out that retrievability itself had not featured in any major safety assessment work to date, being equated more with some form of deliberate human intrusion. As it becomes more important in the future it is likely to become a scenario in its own right.

REFERENCES

[1] RICHARDSON, P.J., Development of Retrievability Plans, Published by Swedish National Siting Co-ordinator for Nuclear Waste Disposal (M:1996C), March (1999).

[2] McCOMBIE, C., ZUIDEMA, P., (DRAFT 1998), Retrievability; rationale, measures, impacts, (unpublished).

[3] DODD, D., Concerted Action on the Retrievability of Long Lived Radioactive waste in Deep Underground Repositories — Progress to date, this Volume, (1999).

[4] INTERNATIONAL ATOMIC ENERGY AGENCY, Issues in radioactive waste disposal, TECDOC–909, (1996).

[5] CNE, Thoughts on Retrievability; Report (in French) and Summary (in English), July (1998).

[6] BEALE, H., Waste retrieval during and after disposal,. Nuclear Energy, Vol. 37, No. 4, (1998) 273–276.

[7] McKIRDEY, B., (UK Nirex), Pers. Comm., 18 February (1999).

[8] DODD, et al., A repository design for the retrievable disposal of radioactive waste in rock salt, Proceedings of DisTec'98, International Conference on Radioactive Waste Disposal, 9–11 September, 1998, Hamburg, Germany, Publ. by KONTEC, (1998) 235.

[9] DE PRETER, P., Retrievability in the Belgian deep disposal concept in clay, this volume (1999).

[10] RIVERIN, G., Retrievability — a matter of public acceptance? Reflections on the public review of the proposed nuclear fuel waste disposal concept in Canada, this volume (1999).

[11] HOORELBEKE, J.–M., Phased-retrievability under the current French disposal concept, this volume (1999).

[12] SELLING, H., Retrievable disposal — opposing views on ethics, this volume (1999).

[13] PAPP, T., Step wise decision-making and options for retrieval in the KBS3 concept in Sweden, this volume (1999).

[14] JENSEN, M., Retrievability, Ethics and Democracy, this volume (1999).

[15] McCALL, A., Technical feasibility of retrieval options, this volume (1999).

[16] HARRINGTON, P., Retrievability as proposed in the US repository concept, this volume (1999).

[17] BRENNECKE, P., Safety aspects on retrievability — a German study, this volume (1999).

[18] NUCLEAR ENERGY AGENCY (NEA), The Environmental and Ethical Basis of Geological Disposal. A Collective Opinion of the NEA RWMC, (1995).

[19] EUROPEAN COMMISSION, DG XI, 1998, The Present Situation and Prospects for Radioactive Waste Management in the European Union, 4th Report, January (1999).

[20] NUCLEAR FUEL, 14 December (1998).

[21] GREENPEACE INTERNATIONAL, (undated), Nuclear Waste Management Policy Statement.
[22] GREBER, M., et al., The Disposal of Canada's Nuclear Fuel Waste; Public Involvement and Social Aspects, AECL–10712 (1994).
[23] KOWALSKI, E., Has Wellenberg shown the way, or is it merely postponing the inevitable?, this volume (1999).
[24] HIETT, A., Report from the UK Consensus Conference on Radioactive Waste Management, 21–24 May, 1999, this volume (1999).
[25] YOUNG, P., Acoustic Remote Monitoring of Rock and Concrete Structures for Nuclear Waste Repositories, this volume (1999).
[26] McCOMBIE, C., Allocation of responsibilities for monitoring and retrieval activities, this volume (1999).
[27] SÖDERBERG, O., Cost-related implications of retrieval; Who should pay? Who should assess the cost/benefit?, this volume (1999).

QUESTIONS (Q), COMMENTS (C) & ANSWERS (A) AFTER THE PRESENTATION

C: The term "practically irrecoverable" is not used by the IAEA in connection with waste disposal, only in connection with safeguards! The Agency uses the term "disposal" for something which is not intended to be retrieved. That does not preclude that somebody else will later decide to retrieve it. The IAEA Waste Management Glossary of 1993 is recommended.

The IAEA document "Waste Management Safety Fundamentals" also provides some guidance with reference to retrievability. It states that the overall safety should not be compromised and also that no unnecessary burdens should be put on future generations. It is an interesting philosophical question whether retrievability is a burden on future generations or not.

A: I agree. But there seems to be a dichotomy of words used by different sections of the IAEA and also by others. This is true also for different countries and even for different organisations within an individual country.

Chair: It makes a big difference if you look on the possibility to retrieve from the view of the waste managers or from the view of the safeguards regulators. If there is a possibility to retrieve, then one must continue with the safeguards for a very long time.

C: You said that it is more difficult to foresee technical development compared to social development. Coming from a university department where we are doing work, trying to look into the future, I do not agree with you. Technical developments appear to be easier to extrapolate from the present knowledge compared to how people will behave or how they would want to organise their societies. The technology for transmutation, for instance, has been discussed since the seventies.

Chair: The time span from when something is known by the scientists until it transpires in the broader community can be quite long.

C: In your list of reasons for retrieving, I did not find deliberate retrieval to get resources back. Many people think that recovery because of the energy content is maybe the most plausible reason for wanting to get the material back within one hundred years.

A: It was included in a sense. I assumed that if you develop transmutation or a new technology, then you would want to recover it. Some of the plans are actually considering further segregation of the waste material that may not be reusable.

Chair: When Camilla Odhnoff called me about this seminar she made a comment, which I would like to quote and which we should keep in mind: "Waste is what you have when you have no more imagination!"

You mentioned the attitude of the public and environmental organisations. Was there a change in their attitudes between the stage when we were talking about non-retrievable waste disposal and the new stage when we offer an option to retrieve.

A: A lot of the hard line environmental organisations have always said that deep disposal is not the answer and that they would prefer long term monitored surface storage. But there are also others within the same area who would like to see a deep disposal in combination with a monitored surface storage. Many of the opponents are not too impressed by the records of the nuclear industry. I know that the nuclear waste management industry of today has a lot of problems being associated with the nuclear industry and even with the military industry and gets a lot of grief from that. But the public looks at statements made 25, 30 or 40 years ago. "Do not worry, leave it to us, we know what we are doing etc.". Now the children of that generation is saying the same thing again, and people wonder if they can take the words as true or if they should colour them with a bit of past knowledge. My experience with organisations and the public is that people want to know that it is managed safely, but they also have a fear back in their mind that if you walk away from it and something goes wrong, there is nothing anybody can do to put it right. I am not saying this is a valid argument, but that is an argument a lot of people have. It may well be that, if you introduce retrievability as an area of discussion, at the end of the discussion more people will accept that it is not necessary. I do not know, but if the industry just pats the public on the head and says "Do not worry!", then it leaves the area of uncertainty in the public and I think they like to think that a connection to the waste should continue.

Chair: The technical people may be inclined to say that this may be valuable material in the future, that future generations should want to use and we should not deprive them of that opportunity. Some of the sceptics would say they have doubts about our ability to arrange a final repository in a proper manner and therefore would prefer that we do not seal it completely, and maybe also there will be better methods of doing it in the future. So the motivations of different groups may be very different.

C: Very often seminars like this gather people of the same "faith". One should broaden the faith and include different points of views.

Chair: That is true. But there is some legitimacy in having people of reasonably similar thinking to clear out between themselves what they think. Of course, consensus building in society is desirable. But one should also keep in mind the difference between a mediator and a judge. These are two different functions. A mediator will seek a middle ground in order to get acceptance from several sides and no more controversy. A judge will have to judge on the basis of legislation, or of what is considered to be the truth. And the truth is not necessarily in the middle.