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Report on the PAMINA Stakeholder Workshop: Communicating Safety Issues for a Geological Repository DELIVERABLE (D-N°: D2.1.B.1)

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PU	Public	X
RE	Restricted to a group specified by the partners of the [PAMINA] project	
CO	Confidential, only for partners of the [PAMINA] project	

Foreword

The work presented in this report was developed within the Integrated Project PAMINA: **P**erformance **A**ssessment **M**ethodologies **IN A**pplication to Guide the Development of the Safety Case. This project is part of the Sixth Framework Programme of the European Commission. It brings together 25 organisations from ten European countries and one EC Joint Research Centre in order to improve and harmonise methodologies and tools for demonstrating the safety of deep geological disposal of long-lived radioactive waste for different waste types, repository designs and geological environments. The results will be of interest to national waste management organisations, regulators and lay stakeholders.

The work is organised in four Research and Technology Development Components (RTDCs) and one additional component dealing with knowledge management and dissemination of knowledge:

- In RTDC 1 the aim is to evaluate the state of the art of methodologies and approaches needed for assessing the safety of deep geological disposal, on the basis of comprehensive review of international practice. This work includes the identification of any deficiencies in methods and tools.

- In RTDC 2 the aim is to establish a framework and methodology for the treatment of uncertainty during PA and safety case development. Guidance on, and examples of, good practice will be provided on the communication and treatment of different types of uncertainty, spatial variability, the development of probabilistic safety assessment tools, and techniques for sensitivity and uncertainty analysis.

- In RTDC 3 the aim is to develop methodologies and tools for integrated PA for various geological disposal concepts. This work includes the development of PA scenarios, of the PA approach to gas migration processes, of the PA approach to radionuclide source term modelling, and of safety and performance indicators.

- In RTDC 4 the aim is to conduct several benchmark exercises on specific processes, in which quantitative comparisons are made between approaches that rely on simplifying assumptions and models, and those that rely on complex models that take into account a more complete process conceptualization in space and time.

The work presented in this report was performed in the scope of RTDC 2.

All PAMINA reports can be downloaded from http://www.ip-pamina.eu.

Report on the PAMINA Stakeholder Workshop: Communicating Safety Issues for a Geological Repository

Report History

This document has been prepared under the PAMINA Project for the European Commission by Galson Sciences Limited, with support from the Nuclear Decommissioning Authority.

Report on the PAMINA Stakeholder Workshop: Communicating Safety Issues for a Geological Repository				
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Executive Summary

With support from the European Commission, Galson Sciences Limited (GSL) is responsible for the co-ordination and integration of the Research and Technology Development Component "RTDC2" of the PAMINA Project (***P***erformance ***A***ssessment ***M***ethodologies ***in A***pplication to Guide the Development of the Safety Case). RTDC2 is designed to develop a better understanding of the treatment of uncertainty in performance assessment and the safety case. As part of RTDC2, Task 2.1.B is evaluating approaches for communicating about confidence and uncertainties in a safety case.

As part of Task 2.1.B, GSL, in collaboration with the Nuclear Decommissioning Authority (NDA), organised a stakeholder workshop to elicit views on communicating safety issues for a geological repository. The workshop tested particular communication styles and ideas on participants in order to gain some understanding of how public audiences might respond to different approaches. The workshop primarily tested communication styles through the use of presentation, poster and video materials, though these are not all of the components that might be used in an integrated communication campaign.

The stakeholder workshop was held at the Friends Meeting House in Manchester on 17th October 2007. The workshop was attended by fourteen participants drawn from local authorities and stakeholder groups with interests in radioactive waste management issues.

The main messages arising from the stakeholder workshop are set out below. It must be appreciated that these messages are couched within the UK context and the cultures of England and Scotland (there were no stakeholders from Wales and Northern Ireland). Although the key messages could be different if the workshop had been conducted in a different country with different stakeholders, they may still be of interest to other European stakeholders.

- The majority of participants felt that a geological repository concept for the UK should include a commitment to indefinite monitoring and retrievability. This was seen as providing a local community with a sense of reassurance and control over the management of a facility for long-lived radioactive waste. Retrievability was also seen as important in that the radioactive waste might become a future asset as nuclear technology makes advances.

- The posters presented to participants for assessment during the workshop were considered to contain too much text and technical detail to appeal to a lay audience. It was suggested by participants that communication via a poster should focus on one key issue, stating what is known and being clear about the uncertainties.

- While communication of basic technical information (describing radioactive wastes, where it comes from, the nature of radioactivity, and the need for a

geological repository) was considered necessary, participants felt that key safety issues, uncertainties and knowledge gaps that become apparent when having to consider repository performance over hundreds of thousands of years should also be presented.

- Communication methods should be aimed at today's young people, who were considered by participants to be the future managers of our radioactive waste. This should be primarily conducted through the education system.

- A communication approach should be modern and forward-looking, using the latest technology (e.g. interactive CD-ROMs and computer games), and should relate radioactive waste to familiar and beneficial uses of radioactivity in the UK, such as nuclear medicine and the generation of electricity.

- Participants felt that a fresh approach to communicating issues is needed, using lessons from elsewhere, e.g., British Nuclear Fuels Limited used ideas and support from the Science Museum in London in its development of the Sellafield Visitors Centre.

- It was suggested that a "nuclear industry month" campaign could be run, during which people would visit nuclear sites, see interactive displays, talk to staff, and discuss issues. Participants suggested that this could include displays in museums, libraries, and schools.

- Making predictions of how UK climate and society are likely to evolve over the next million years was recognised by participants as being difficult. Participants felt that members of the public would be mainly concerned with the next hundred years or so. However, it was considered important to address a vision of the future in a safety case, and to describe how a geological repository would evolve in the far future. In this respect, participants tended to feel that examples from nature (natural analogues) were potentially useful to illustrate the processes and explain long-term issues.

- Human-induced carbon dioxide emissions and climate change impacts are new factors that need to be considered in communicating issues for a geological repository.

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Report on the PAMINA One-Day Stakeholder Workshop: Communicating Safety Issues for a Geological Repository

1 Introduction

1.1 Background and Aims

Development of a safety case for the management of long-lived radioactive waste involves consideration of the evolution of the waste and engineered barrier systems, and the interactions between these and relatively complex, natural systems, such as climate and geology, which are also evolving. The timescales that must be considered are much longer than the timescales that can be studied in the laboratory or during site characterisation. These, and other factors, give rise to various types of uncertainty e.g., on scenarios, models, and parameters, which need to be taken into account when assessing long-term performance of a geological repository. Owing to the range of different types of uncertainties, it is important to follow a clear strategy for dealing with uncertainties when developing a safety case.

The European Commission's PAMINA Project (***P***erformance ***A***ssessment ***M***ethodologies ***in A***pplication to Guide the Development of the Safety Case), which has 26 partner organisations and is running in the period 2006 to 2009, has the aim of improving and developing a common understanding of integrated performance assessment methodologies for various disposal concepts for spent fuel and long-lived radioactive waste in different geological environments.

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The stakeholder workshop was held at the Friends Meeting House in Manchester on 17th October 2007. The workshop was attended by fourteen participants drawn from local authorities and stakeholder groups with interests in radioactive waste management issues (see Table 1.1 in Section 1.2 for the list of participants). The meeting was organised by Phil Richardson and facilitated by Tamsin Greulich-Smith, both from GSL, with support from Paul Hooker (also from GSL), and Lucy Bailey and John Dalton from the NDA.

1.2 Workshop Participants

The ideal audience for this workshop was always intended to be drawn from members of the general public. In order to focus on suitable candidates GSL/NDA decided that some knowledge of or involvement in the radioactive waste management process in the UK would also be desirable.

In the first instance we contacted the Nuclear Legacy Advice Forum (NuLeAF), a group established to provide support and information to local authorities whose areas include all types of nuclear installations. A workshop announcement was circulated to members of the NuLeAF Steering Group at a Steering Group meeting on 27 June 2007, with the intention of organising the workshop to coincide with the next meeting in October. Cover for costs of any necessary travelling and accommodation was offered in order to encourage members to attend. This elicited responses from a small number of people who expressed an interest in attending, including both local government officers and elected representatives.

Because we felt that there should be at least a dozen or more participants and the NuLeAF approach did not provide us with that many participants, we next approached the NDA's Stakeholder Relations Department. An invitation letter was then circulated to all NDA Local Site Stakeholder Groups, again inviting interested individuals to consider attendance. In addition, we also approached a small number of non-governmental organisations (NGOs) to see if they were interested in taking part. In this way we were able to bring the potential number of participants up to 19, to include other members and officials from local authorities and union representatives from nuclear sites. GSL was approached during the summer by several other interested individuals, but it was decided that they were too closely associated with the regulatory agencies or other expert organisations for the purposes of the workshop.

In the event, due to various reasons including medical and family emergencies, some of which occurred on or around the date of the workshop, a total of 15 individuals took part (although one person also fell sick on the day and was forced to leave early).

The list of participants is presented in Table 1.1 below.

Table 1.1. List of Participants.

Name	Organisation
Tony Bale	Hunterston Site Stakeholder Group and Magnox North
Fred Barker	Nuclear Legacy Advisory Forum
Joseph Clark	West Cumbria Site Stakeholder Group and Prospect Trade Union
Rod Crawford	Dundee City Council
Mike Davidson	Allerdale Borough Council
Terry Fraser	Harwell-Chilton Campus Site Stakeholder Group (Chair) and Vale of the White Horse District Council
Peter Kane	West Cumbria Site Stakeholder Group and the GMB Trade Union
Stewart Kemp	Cumbria County Council
John Lamb	Hunterston Site Stakeholder Group (Chair)
Peter Lanyon	Nuclear Submarine Forum and Shut Down Sizewell Campaign
Kenneth MacDougall	Hunterston Site Stakeholder Group and Ardrossan Community Council
Ivor Roscoe	Hunterston Site Stakeholder Group and West Kilbride Community Council
Jill Sutcliffe	Nuclear Legacy Advisory Forum
Mark Woodger	Essex County Council

1.3 Participant Concerns About Safety

Participant concerns were actively sought by the project team prior to the workshop. Participants were asked to include on their response forms, used for registering an intention to attend the workshop, what they considered to be their three main safety-related concerns regarding the disposal of long-lived radioactive waste and spent nuclear fuel in a geological repository. Appendix A presents the detailed compilation of the concerns raised by the participants. Some of these concerns were addressed in the workshop presentation materials and in the discussions.

1.4 Workshop Agenda

The workshop agenda was structured in part to address participant concerns (Appendix A). The PAMINA workshop agenda, presented in Appendix B, allowed for the following events and features:

- Presentation of a short overview of safety issues, "Discussing Safety", for a geological repository in the UK.
- Presentation of five posters covering different aspects of a safety case for assessment by the stakeholders using a questionnaire format.
- Discussion of the posters in plenary session.
- Presentation of the video 'Traces of the Future', produced by Nagra in 1994, on natural analogues, and to elicit stakeholder views on this video.
- A poster-building break-out group exercise for participants, on the theme of engineered barriers and safety.
- Discussion of the outcomes of the break-out groups' poster-building work in plenary session.
- Comments and ideas from the stakeholders on preferred approaches for communicating safety issues.

An information pack was prepared for each participant containing handouts of the presentations, posters and poster materials. These packs were distributed at the start of the workshop.

1.5 Structure of Report

This report is divided into the following sections:

- Section 1, above, provides some background and context to the workshop, and presents the participants, their concerns, and the workshop agenda.
- Section 2 summarises the main points from the discussions relating to the different sessions of the workshop.
- Section 3 summarises the conclusions, in the form of the key messages that arose from the stakeholder workshop, and the next steps.
- A set of Appendices present participant concerns about safety, the workshop agenda, the presentation "Discussing Safety" with participant feedback on this presentation, and a compilation of anonymous views elicited from the participants on the posters that were presented.

2 Overview of the Workshop

The workshop was opened by John Dalton (NDA). Tamsin Greulich-Smith (GSL) facilitated workshop introductions, and placed the workshop in the context of the PAMINA Project and participant concerns about safety.

2.1 "Discussing Safety" Presentation

Lucy Bailey presented "Discussing Safety", a short overview of safety issues for a geological repository in the UK (see Appendix C). Many points were raised by the participants during a plenary discussion following this presentation, and the detailed, anonymous, comments are given in Appendix C.

Some strong messages emerged from these discussions. A strongly held view of several participants was that the UK concept for a geological repository should include a commitment to indefinite monitoring and consideration of options for retrieval. The Swedish KBS-3 disposal concept was not viewed favourably by some participants because of the way in which monitoring and retrievability are downplayed.

Participants expressed a wish for a managed, monitored facility, rather than a "dump". The reasons given in support of indefinite monitoring and retrievability were:

- The creation of on-going jobs.
- Wastes could possibly become a resource in the future.
- To provide a means of reassurance about safety.
- A closed repository would depopulate the local area.

2.2 Participant Assessments of Five Pre-prepared Posters

Two sets of five posters were displayed in the workshop space in portrait format (size A0), on movable, double-sided presentation boards. A4-sized copies of the five posters are presented below. The posters are numbered and titled as follows:

- Poster 1 – Multiple Barrier Systems for ILW and HLW.
- Poster 2 – Repository Systems in Practice.
- Poster 3 – Transport and Repository Operations.
- Poster 4 – Learning from Nature.
- Poster 5 – Post-closure Safety.

Poster 1: Multiple Barrier Systems for ILW and HLW

Intermediate-Level Waste (ILW)

ILW is more radioactive than LLW, but does not generate sufficient heat during radioactive decay for this to be taken into account in the design of storage or disposal facilities.

ILW arises mainly from the reprocessing of spent nuclear fuel at Sellafield and from general operations, maintenance and decommissioning of radioactive plants, including nuclear power stations and reprocessing facilities. The major component of ILW is metal, largely in the form of nuclear fuel cladding and fuel element debris, as well as plant items and equipment. The photo shows waste debris created when metal fuel rods are dismantled for reprocessing.

Other major contributors are graphite from reactor cores, building materials (cement and rubble), and miscellaneous inorganic materials. There are also smaller quantities of organic materials, soil, glass and ceramics. Some ILW packages are referred to as 'contact-handled' (CH)-ILW, and can be managed by workers directly. Packages with higher emissions of radiation at their surface require shielding and remote handling equipment and are referred to as 'remote-handled' (RH)- ILW.

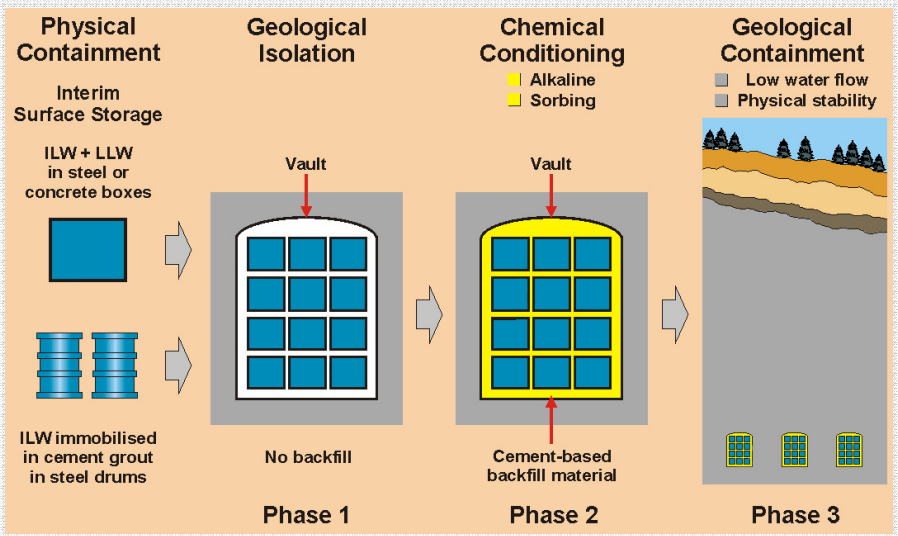
Multi-barrier system for ILW - example concept

1. The waste container. For some time after disposal, the waste container will remain mechanically and structurally intact. All materials will be completely contained; only gaseous releases of radionuclides via container vents are possible.

2. The waste package. The physical containment afforded by the waste package, including the waste form itself, will continue to inhibit the release of radionuclides by groundwater, even after containers lose their integrity through corrosion or other processes.

3. The buffer. Access of groundwater to containers and wastes, and the release of radionuclides from the waste will be further inhibited by material surrounding the waste package. This is likely to be a cementitious material whose main function is to act as a chemical barrier over long timescales.

4. The geological barrier. The geological barrier will perform several functions:-
   - Ensure that groundwater that moves through the repository takes hundreds or thousands of years to return to the human environment;
   - Provide substantial dispersion and dilution of any radionuclides that are released from the repository;
   - Retard the migration of released radionuclides even further by chemical attachment (sorption) onto rock surfaces; and
   - Provide isolation of the repository from the human environment for thousands of years in the future, and even after significant climate, landform, or land use changes at the surface.

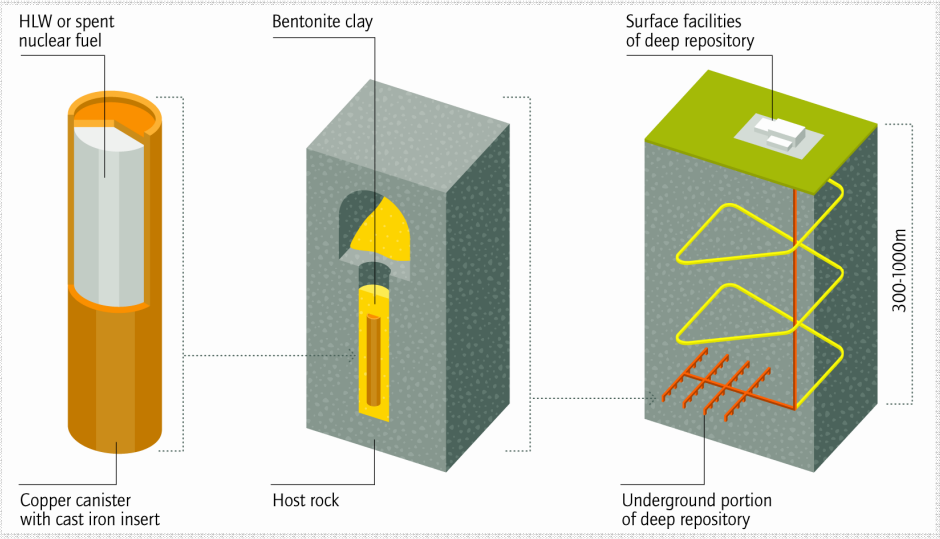


High-Level Waste (HLW)

HLW is generated from reprocessing spent nuclear fuel at Sellafield. This process extracts radionuclides such as uranium, which can be reused, and leaves behind a highly radioactive liquid residue (HLW) and other less highly radioactive wastes.

HLW generates heat as a direct result of its radioactivity.

Liquid HLW is turned into a hard glass by a process known as vitrification and then stored in stainless steel drums, as shown in the cutaway picture on the right.



Multi-barrier system for HLW - example concept

1. The waste container. The canister containing vitrified HLW is encapsulated in an outer container - the overpack - to prevent contact with groundwater during the time when its radioactivity and heat generation are high, and potentially for a long time thereafter, depending on the overpack material used. [The same container may be used for spent nuclear fuel.]

2. The vitrified waste form. Radioactive waste is immobilised in a glass matrix and, after the overpack loses its integrity, radionuclides would only be released as the glass dissolves.

3. The buffer. Access of groundwater to the overpack and waste form, and movement of dissolved radionuclides will be further slowed by surrounding the overpack with an appropriate low-permeability material such as clay.

4. The geological barrier. This performs the same functions as described for ILW. However, for HLW, the stability and geochemical environment of the host rock also play an important role in protecting the engineered barrier system over long timescales.

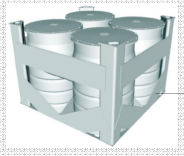
Poster 2: Repository Systems in Practice

Intermediate-level waste

ILW is typically immobilised in a cement-based material within highly engineered stainless steel or concrete containers. The pictures on the right illustrate how waste containers in the UK are combined into packages which will then be emplaced in vaults excavated within the host geology.

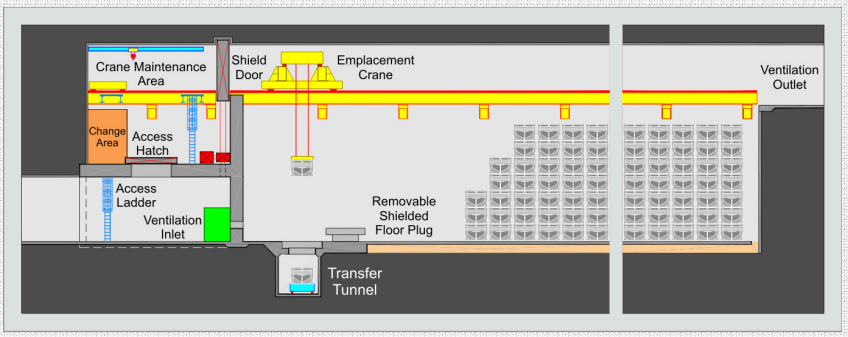
Following emplacement of the wastes, the vaults would be 'backfilled' - for example with a special type of alkaline-based cement formulated to inhibit dissolution of certain, key radionuclides - and then sealed. The schematic diagram below shows a possible design concept for disposal of ILW in the UK.

500 litre steel drum.



Stillage (carrying frame) with four 500 litre drums.

3 cubic metre steel box.

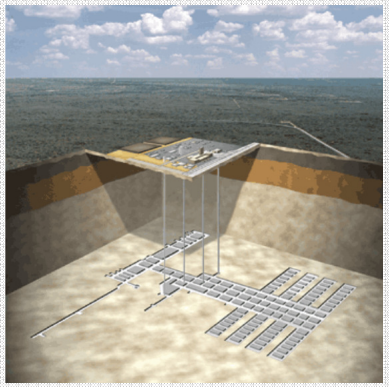


An operational repository in the United States

The Waste Isolation Pilot Plant receives contact-handled and remote-handled ILW from US defence clean-up sites. It is at a depth of 655 metres in a thick salt rock formation near Carlsbad, New Mexico, and has been receiving waste since 1999. It is due to operate for ~35 years.

The left-hand photograph shows contact-handled waste being emplaced in a vault.

The right-hand diagram shows a schematic layout of the repository vaults.

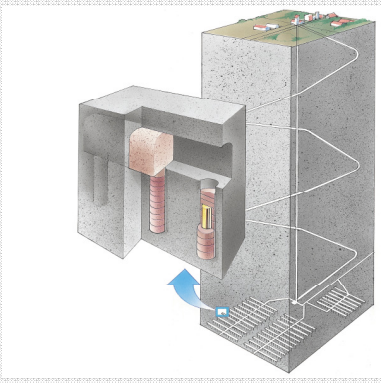


High-level waste

Because they generate heat, HLW and spent fuel (if classified as a waste) require different disposal structures and layouts from ILW, LLW and other non-heat generating radioactive materials.

There are several ways in which HLW and spent fuel could be packaged and contained, and research into the different options will be undertaken in the coming years.

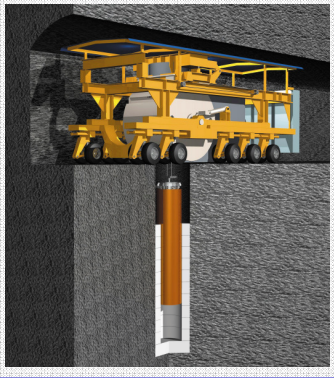
Several different repository concepts for these materials are being investigated in other countries, which could be applicable to the UK. Examples relevant to the UK exist in Belgium, Canada, France, Germany, Sweden, Switzerland and the US. Geological repository concepts in other countries consider a range of different geological environments, and use a range of different engineered barrier systems and repository layouts.



A proposed repository in Sweden

The schematic diagram on the right illustrates the Swedish concept for vertical disposal of spent fuel in crystalline rock. The disposal canister is made of copper and is surrounded by a clay buffer material in the disposal hole. The tunnel in the photograph below is in an Underground Research Laboratory in a similar geological environment to the proposed repository.

The diagram below-left shows how a copper canister could be emplaced in boreholes drilled into the tunnel floor.



Poster 3: Transport and Repository Operations

TRANSPORT

Radioactive waste may be transported as waste packages that are transport packages in their own right, or as waste packages within specially designed reusable transport containers. The most hazardous materials, including ILW, HLW and spent fuel, are transported in massive containers made from high-quality materials with walls up to 30-centimetres thick.

Worldwide, over the last 35 years there have been more than 20,000 shipments of spent fuel and HLW. This amounts to over 50,000 tonnes of material and more than 30 million kilometres.

Radioactive materials have been transported in the UK for 50 years without any significant release of radioactivity to the environment

There has never been an accident in which a container with radioactive material has been breached, or has significantly leaked while being transported through the public domain.

How do we know transporting nuclear waste is safe?

In 1984 the UK Central Electricity Generating Board conducted a public demonstration in which a 140-tonne train travelling at 100 miles per hour was driven into transport container (see photo on the left). Post-crash assessments showed that the containers suffered only superficial damage and would not have released their contents.

Similarly, in the 1970s and 1980s tests were conducted in the United States in which truck trailers carrying transport packages were driven at 60 and 85 miles per hour into three-metre-thick concrete barriers, and a train travelling at 81 miles per hour was crashed into a transport container at a simulated rail crossing.

International Regulations

The International Atomic Energy Agency (IAEA) Regulations for the Safe Transport of Radioactive Material were first published in 1961 and have been revised regularly to keep pace with scientific and technological developments. The IAEA Regulations serve as the basis for regulation of the transport of radioactive materials by the Department for Transport in the UK. The IAEA Regulations are implemented in the UK in the Carriage of Dangerous Goods Regulations.

Containers used for the transport of higher-radioactivity materials, such as HLW, spent fuel and some types of ILW, have to be able to survive tests that are representative of the conditions that could be experienced in normal and severe transport accidents. The tests for accident conditions include:-

Two drop tests – a nine-metre drop onto an unyielding surface, and a one-metre drop onto a steel punch bar, tested at a variety of angles and under worst-case scenarios.

A fire test - the transport container is subjected to a fully engulfing liquid hydrocarbon fire for 30 minutes (see photo at upper right).

An immersion test – the transport container is subjected to immersion in water at a depth of 15 metres for eight hours for ILW, or at 200 metres for one hour for HLW and spent fuel.

REPOSITORY OPERATIONS

Proven technology will be used in the design and operation of the disposal system, so that it is possible to predict how equipment will behave. The hazards associated with emplacement of wastes in the repository include working at height and in enclosed spaces, accidental exposure to direct radiation, and thermal and mechanical damage to waste packages.

ILW packages

We have assessed the potential for damage through modelling studies and in tests where we have dropped waste packages nine metres onto a hard flat surface. Another potential scenario that could result in hazard is a fire occurring underground, for example in the package emplacement machine. We have therefore tested the fire performance of waste packages by fully engulfing them in a 1000ºC flame for one hour (as shown in the far left-hand photograph.

Some waste packages are shielded or only have low radiation emissions near their surface, which means that handling can be done manually with little radiation concern to workers, as shown in the photograph upper right, taken in a former repository developed in salt in Germany.

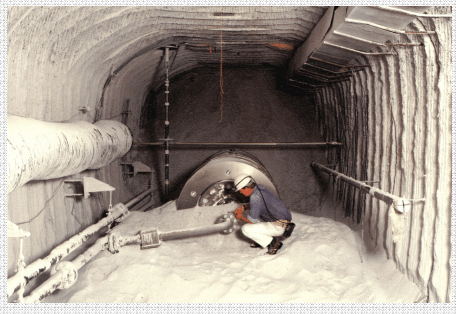
Other packages are unshielded and will have such high radiation emissions at their surface that they must be handled and emplaced using remotely operated equipment. The lower left-hand photograph shows equipment used underground for this purpose in the Waste Isolation Pilot Plant, also in salt, in the US.

HLW packages

There is only limited experience of emplacing HLW or spent fuel in the engineered structures envisaged in a geological repository, and this remains a significant area of research.

We are collaborating with colleagues in other countries to understand the safety of repository systems. Trial emplacement of waste packages, not containing any waste, has been carried out in Underground Research Laboratories in countries such as Germany, Sweden and the US.

The photograph on the right illustrates simulated emplacement of a waste canister in a tunnel excavated in a salt mine in Germany.



Poster 4: Geological Disposal: Learning From Nature

How does Nature help?

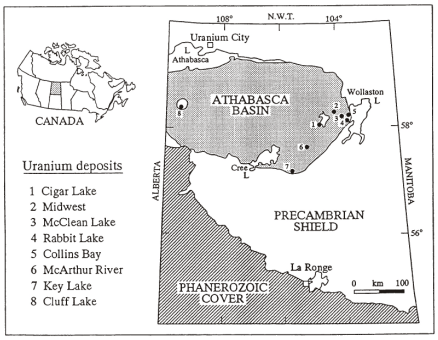
Examples exist in nature and our environment of features, events and processes that can help put meaning into the future potential behaviour of the repository system over the very long time-scales involved. These examples are referred to as natural analogues.

A natural analogue can be a geological, archaeological, historical or industrial system with some definable similarity with one or more components of the repository, its surrounding environment or the processes that control its evolution.

A natural analogue tells us what did happen and thus, by analogy, what might happen in the future - *the past is the key to the future.*

The time-scale of the feature, event or process must be measurable, since this is one of the greatest benefits of a natural analogue over short-term laboratory experiments.

Industrial Historical Archaeological Geological



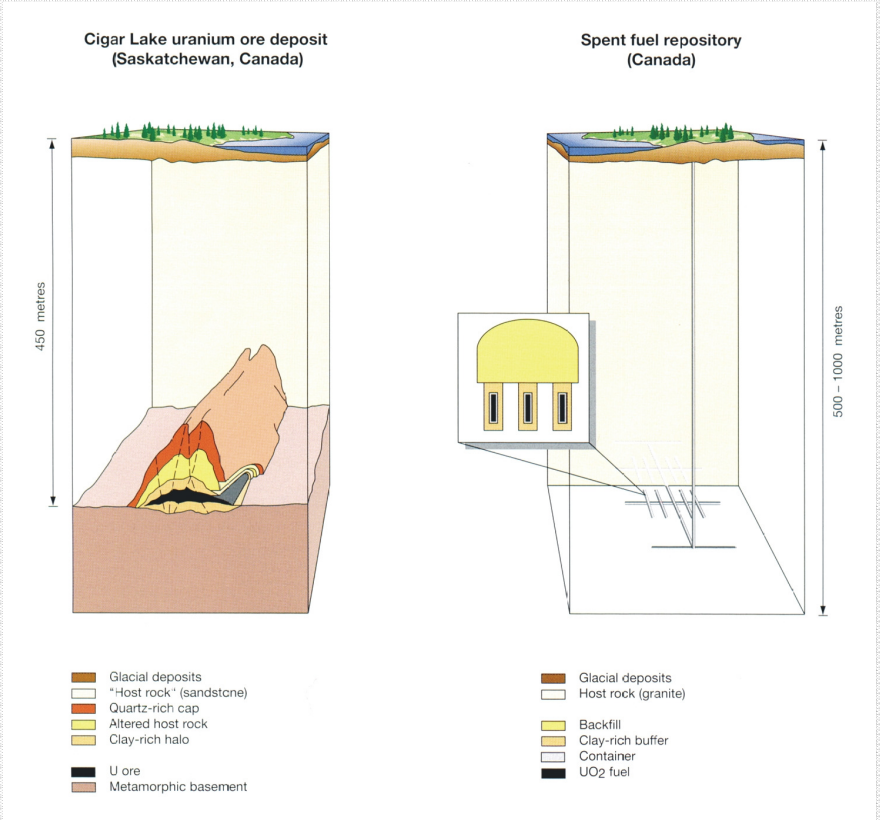
Cigar Lake

One of the best-known natural analogues for a deep geological repository is the **Cigar Lake** uranium deposit in northern Saskatchewan in Canada (see map), which is the second largest and richest uranium-ore body known in the world. The analogue is located entirely below the surface at repository depths.

As shown in the diagram below, the host rock and geometry of the ore body match potential repository designs; the ore is similar to the gross structure and composition of spent fuel, and the clay halo is similar to a compacted bentonite buffer.

What does it tell us?

The clay halo has provided an effective, long-term seal for the Cigar Lake ore body for most of its 1.3 billion year existence, which demonstrates the stability of the clay (illite and kaolinite). In a repository near-field, bentonite, rather than illite, would be used as the buffer material and this can be expected to provide an even more efficient hydraulic barrier than the clay minerals at Cigar Lake. This is because of the greater swelling capacity of bentonite compared to illite.



The natural uraninite composition at Cigar Lake is only an approximation to that of spent fuel UO_2. Therefore the derived data on rates of radiolytic oxidation and dissolution of natural uraninite are of limited, but important, use.

The photograph on the right shows borehole core samples taken across the deposit, from the clay halo on the left to the ore deposit on the right.

The clay contains no visible concentration of uranium minerals.

The main difference between the ore body and a repository is that there is no analogue for a metal canister at Cigar Lake.

Poster 5: Post-closure Safety

Approach to post-closure safety

Our approach to assessing long-term safety aims at understanding and illustrating the possible behaviour of the disposal system, and building confidence in our understanding.

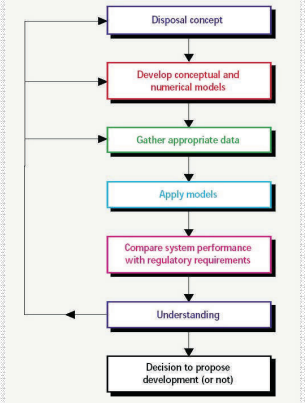
Some of the main ways we do this are:-
1. Modelling the behaviour of the radioactive wastes and the disposal system based on field and laboratory tests and investigations and literature review. A schematic representation of post-closure safety assessment is presented on the right.

2. Using a range of performance indicators to examine the behaviour of the engineered and natural barriers over time.

3. Using reasoned arguments based on comparisons to natural analogues (see the 'Learning from Nature' poster).

4. Using experiments in Underground Research Laboratories to demonstrate our understanding.

An important aim is to understand and manage the uncertainties associated with the behaviour of the wastes and the system of natural and engineered barriers.



Modelling

A key aim of our modelling is to confirm that the maximum impact on humans and the environment from disposing of wastes is below the regulatory safety standards, even though these impacts occur in the far future. Any model by its nature is a simplification of reality. This is particularly pertinent given the long timescales of concern and the heterogeneity of the system we are attempting to model.

We will be able to improve our modelling and reduce uncertainties once specific sites and repository designs have been selected and investigated.

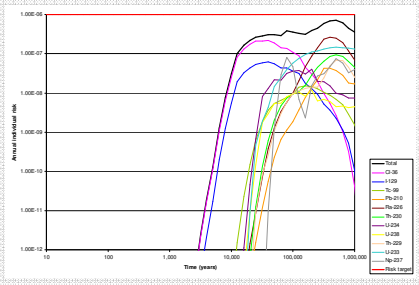
Managing uncertainty

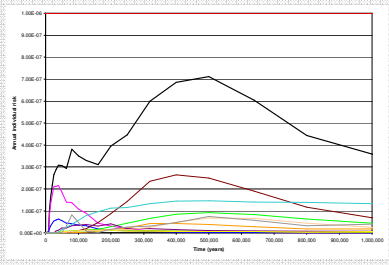
Our calculations of the possible long-term impacts from waste disposal are only indicative. We deal with the inevitable uncertainty by making multiple sets of calculations to evaluate the safety performance of the disposal system under different sets of conditions. Each set of conditions that we model is illustrative of possible system evolution and barrier performance. These different sets of conditions address the range of uncertainties in the modelling process.

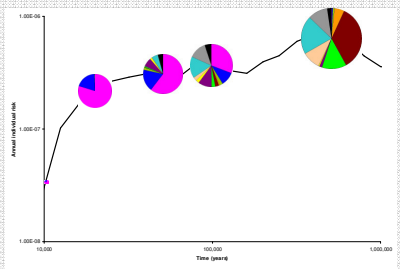
The six diagrams on the right illustrate typical results from a single set of modelling calculations. The top diagram on the left uses logarithmic scales for post-closure time and risk, while the top right one uses linear scales. The regulatory annual risk target for an individual (a representative member of the potentially exposed group at greatest risk) is one serious health effect in a million, and is marked as the horizontal red lines at 10^{-6}.

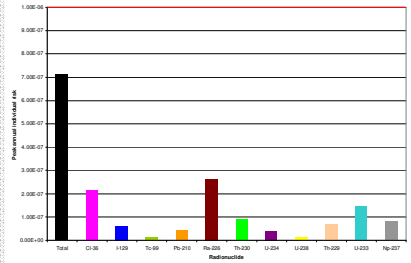
The middle left diagram uses log scales (but note the change in the origin compared to the diagram above it), and indicates the relative contributions made to annual individual risk by different radionuclides after 10,000 years. The middle right diagram shows the total peak or maximum annual individual risk (black column) and the peak risks for different radionuclides, which occur at different times (compare with the chart above it).

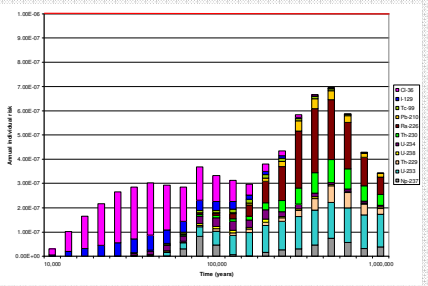
The bottom two plots show annual individual risk plotted on linear axes against logarithmic time. The right-hand plot shows how different radionuclides contribute to risk over time. The left-hand one presents this information in detail starting at 10,000 years after closure.

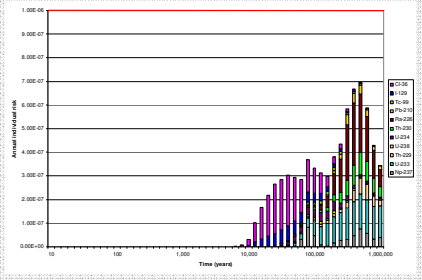


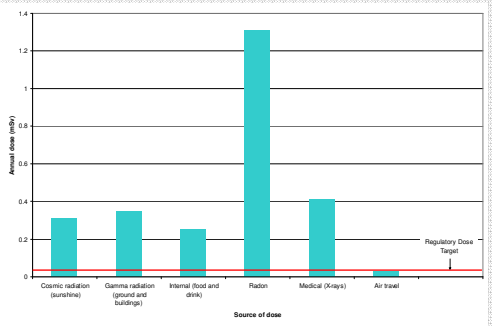












Performance indicators

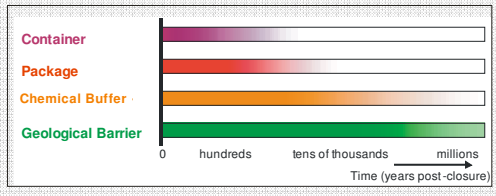
The primary regulatory safety indicator is based on potential radiation exposures to humans in the far future. The expected doses are very low compared to other doses that people are exposed to in their day-to-day lives, as shown in the left-hand diagram. Our illustrative calculations demonstrate that it is possible to site and design disposal facilities that meet stringent criteria.

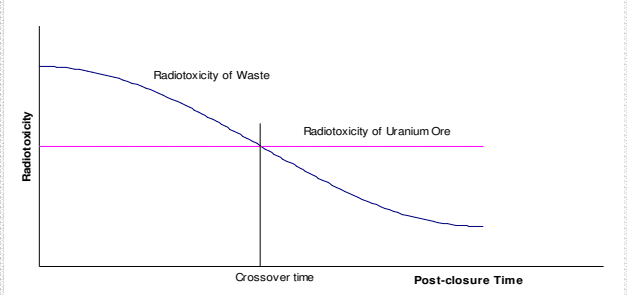
However, we also use a range of other performance indicators to evaluate how well the different barriers are performing. These indicators consider such things as how and in what quantities the waste-derived radionuclides move through the system of multiple barriers with time, and how the amount of radioactivity released from the repository compares to naturally occurring levels in the environment.

The schematic diagram below indicates how the radiotoxicity of the waste in the repository would decrease over time due to radioactive decay. After a certain time it falls below that of naturally occurring uranium ore.

Timescales of barrier performances

The chart below shows the extent to which the safety of ILW disposal relies on the performance of different barriers over different timescales, which will be different for different concepts.





Participants were asked to complete semi-structured feedback forms to assess the set of five posters, each addressing different aspects of the safety of underground disposal of radioactive waste, as well as an overview form considering all five posters together. Completed questionnaire forms on each poster are presented in Appendix D.

The key feedback received during individual assessment of the posters is set out in this section. The style of summarising the feedback has been based on the style of the questionnaire, which contained the following questions:

- Question 1: What is your first impression of the poster?
- Question 2: Does your first impression inspire you to look at the poster in more detail?
- Question 3: Who do you think this poster has been designed for?
- Question 4: What do you think the purpose of this poster is? Does it achieve this?
- Question 5: What do you find most interesting about this poster?
- Question 6: What do you think about the balance between the amount of text and graphics presented?
- Question 7: What do you think about the style of language used in the poster?
- Question 8: Which aspects of this poster make the subject matter most accessible?
- Question 9: Are there any particular features of the poster that provide you with confidence in the subject matter?
- Question 10: Are there any particular features of the poster that you find confusing, difficult to understand, or alarming?
- Question 11: Do you think there are any information gaps?
- Question 12: Do you have any other comments or suggestions about this poster?

Summaries of the completed assessment forms for each poster are presented below. The "Key comments" presented below represent an interpretation by the project team, and includes a comment on whether or not the poster builds confidence about safety.

2.2.1 POSTER 1 Multiple Barrier Systems for ILW and HLW

Key comments:

- Too much text.
- Too busy.
- Did not build confidence.

Question 1: First impressions of the participants:

☒ Too cluttered, too much text, too much information
☒ Too industry based , too technical
☒ Does not introduce the concept of multi-barrier systems
☒ Looks dated
☑ Clean style, well laid out
☑ Good diagrams

Question 2: Most participants were partly inspired to look at the poster in more detail.

Question 3: Participants tended to feel the poster had been designed for the general public, potential volunteer host communities, and young people/schools and colleges. However, one participant commented that it "would have to be a 'nuclear' knowledgeable community to get to grips with it".

Question 4: Participants tended to feel that the purpose of the poster was to inform people about different underground storage systems, and it was generally felt that this objective was partly achieved. Some felt that the poster required more background/introductory information: "assumes knowledge"; "goes too quickly to the detail".

Question 5: The most interesting aspects of the poster, according to some participants, were the diagrams, the cut-away sections, the definitions of the waste types, and the underlying assumptions. Some felt there were no interesting features. The image of the fuel cladding was felt to be ambiguous.

Question 6: No participants felt the poster required more text. Most participants felt there was no need for more photographs. There was a mixed feeling about whether computer-generated images would be helpful, with slightly more participants thinking that this was not required. Participants tended to feel that there was no need for graphs or statistics to support the poster. There was a mixed reaction to the layout of the poster, with slightly more participants feeling that the layout made the poster easy to read. One participant commented that the graphics/photographs should be more clearly identified, particularly the HLW graphics.

Question 7: Regarding the style of the language used in the poster, there was a mixed reaction from participants, with slightly more feeling that the language used was easy

to understand. One participant commented that the language would only be easy to understand if the reader came from a position of knowledge on the issues. Participants had mixed views about whether the language of the poster was interesting, with slightly more feeling that it was not. Most participants felt that the language used was relevant. Slightly more participants felt that the language used was too complex or technical.

Question 8: In ranking the poster's attributes, participants rated the examples used to illustrate the subject matter the feature that made the poster most accessible, while the layout made it least accessible. However, there was not a strong differentiation between attributes. One participant felt that the poster was entirely inaccessible to the public.

Question 9: The majority of participants felt no aspect of the poster gave them confidence in the subject matter. Only one participant felt that the graphics used gave some confidence.

Question 10: In terms of confusing or alarming aspects of the poster, some participants commented that the language was confusing, alarming, or incomplete.

Question 11: Participants commented that the introduction to the poster could be improved upon, particularly explaining the sources of the wastes, and how they would be emplaced and retrieved. Some participants suggested that the poster could be improved with an explanation of buffers, and also of the concept underlying the information.

2.2.2 POSTER 2 Repository Systems in Practice

Key comments:

- Well presented.
- Examples were helpful.
- Provided confidence in ability to emplace wastes safely.

Question 1: First impressions of the participants:

☒ Daunting, "distrust"
☒ Could split information differently to read better
☒ Rename poster "repositories"
☑ Clean style
☑ Well presented
☑ Colourful

Question 2: Most participants were inspired to look at the poster in more detail.

Question 3: Participants tended to feel the poster had been designed for potential volunteer host communities, young people / schools and colleges, and the general public. The poster was felt to be generally accessible owing to the simple text.

Question 4: Participants tended to feel that the purpose of the poster was to inform and educate people to show that a repository is achievable, and it was generally felt that this objective was achieved. However, one participant felt that the aim of the poster was to demonstrate encapsulation, and it was felt that this was not achieved.

Question 5: The most interesting aspects of the poster, according to participants, were the diagrams and photographs, which seemed more contemporary than on Poster One. Several participants felt that the real examples used to demonstrate the issue were most interesting.

Question 6: No participants felt the poster required more text or graphs/statistics. Nearly all participants felt the layout made the poster easy to read. Most participants felt there was no need for computer-generated images, but many felt that additional photographs would enhance the poster.

Question 7: Regarding the style of the language used in the poster, most participants found the poster easy to understand, interesting and relevant. The majority of participants did not consider the poster to be too technical or complex, confusing or alarming. Some participants felt there was information missing in the text. One participant felt that the diagrams were not self explanatory and needed clarification.

Question 8: In ranking the poster's attributes, participants rated the supporting images as the feature that made the poster most accessible, closely followed by the examples used to illustrate the subject matter. The layout and the balance between text and images were equally rated as the features that made the poster least accessible.

Question 9: Participants felt that the actual examples used to illustrate the subject matter gave them most confidence, including the photograph of unprotected people standing adjacent to a waste container.

Question 10: In terms of confusing or alarming aspects of the poster, one participant commented that the introduction to the poster assumes a "done deal". It was suggested that the language be amended to reflect decision-making uncertainty at this stage. Another participant felt that the diagrams needed clarification, and one participant suggested that the location of one of the example repositories was alarming.

Question 11: Some participants suggested that there are information gaps to be addressed in the posters, including an explanation of what a repository is, the alternatives for the UK, the main stages towards closure, and the role of the public in the process.

2.2.3 POSTER 3 Transport and Repository Operations

Key comments:

- Eye-catching.
- Some of the images implied dangers and risks.
- Tried to convince, but did not provide reassurance about safety.

Question 1: First impressions of the participants:

☒ Danger, risk, accident zone
☒ Busy, confused layout
☒ Dated
☑ Good clean style
☑ Eye-catching
☑ Easy to illustrate

Question 2: Most participants were inspired to look at the poster in more detail. Most participants found the poster easy to understand, interesting and relevant.

Question 3: No one felt that the poster had been designed for a technical audience. Participants tended to feel the poster had been designed for the general public, potential volunteer host communities, young people/schools and colleges, and regulators. All but one participant felt that the general public would be the ideal audience for this poster; one participant felt strongly that the poster had not been designed to be viewed by members of the public.

Question 4: Participants tended to feel that the purpose of the poster was to convince and reassure people about safety, and this was not generally felt to have been achieved.

Question 5: The most interesting aspects of the poster, according to participants, were the "dramatic" photographs. The information, particularly in the first panel, was also found to have been interesting.

Question 6: No participants felt the poster required more text or graphs/statistics. Nearly all participants felt there was no need for computer-generated images or additional photos. There was a mixed reaction to the layout of the poster, with slightly more participants feeling that the layout did not make the poster easy to read. One participant suggested that this could be improved by separating the content into two separate posters.

Question 7: The majority of participants did not consider the poster to be too technical or complex.

Question 8: In ranking the poster's attributes, participants rated the supporting images as the feature that made the poster most accessible, followed by the layout. The balance between text and images was rated as the aspect that made the poster least accessible.

Question 9: Generally participants did not feel that any aspect of the poster gave them confidence in the subject matter, although the statements about transport safety were cited by one participant as being helpful.

Question 10: Most participants said that no particular aspect of the poster was confusing or alarming. However, some felt that there were some confusing sections of text that should be clarified. For example, the section on international regulations was felt to be misleading and too complex.

Question 11: Some participants suggested that there are information gaps to be addressed in the posters, including a discussion of worst case scenarios and reference to marine transport.

2.2.4 POSTER 4 Learning from Nature

Key comments

- Confusing.
- Interesting and relevant.
- Informative on long-term safety.
- Did not build confidence in long-term safety.

Question 1: First impressions of the participants:

☒ Complex and confusing
☒ Not engaging
☑ Good layout
☑ Interesting

Question 2: Participants were equally spilt regarding whether or not their first impression of the poster inspired them to look at it in further detail.

Question 3: Most participants felt that the poster had been designed for potential volunteer host communities and young people/schools and colleges.

Question 4: Participants tended to feel that the purpose of the poster was to provide confidence in the long-term safety of a repository. This objective was not felt to have been achieved through the poster. Some participants felt that the poster was designed to inform about the subject matter, and felt that this objective had been achieved.

Question 5: The most interesting aspects of the poster, according to participants, were the information provided, the cut-away diagrams, and the accessible science. Some participants felt there was nothing interesting about the poster.

Question 6: No participants felt the poster required more graphs or statistics. Most felt that there was no need for additional text on the poster. There was a mixed response to the need for extra computer-generated images or additional photos. There was also a mixed reaction to the layout of the poster, with slightly more participants feeling that the layout makes the poster easy to read. One participant suggested that the poster looked disjointed. Some felt that the diagrams and images used in the poster were not helpful.

Question 7: Most participants did not find the poster easy to understand, although the majority did find it interesting and relevant. There was no consensus on whether the language used was too complex or technical. Participants commented that some of the language used was unnecessarily confusing or alarming, and that this could also have been improved with a clearer introduction. One participant suggested that use of the term "spent fuel" could be viewed as propaganda.

Question 8: In ranking the poster's attributes, participants rated the layout as the feature that made the poster most accessible, followed by the supporting images and the examples used. The balance between text and images was rated as the aspect that made the poster least accessible.

Question 9: Most participants did not feel that any aspect of the poster gave them confidence in the subject matter. However, one participant felt that the fact that it "depicts reality" provided confidence.

Question 10: There was a mixed reaction regarding whether the poster was confusing or not. Most participants found some elements of the poster difficult to understand, confusing or alarming. The majority of participants did not consider the poster to be alarming, but most did think it was incomplete. Clarification on the relationship between ore and spent fuel was requested. Some participants felt it was too technical and did not flow.

Question 11: Most participants felt that they did not understand the subject matter sufficiently to be able to determine the information gaps.

2.2.5 POSTER 5 Post-closure Safety

Key comments:

- Too many graphs.
- Too busy.
- Inaccessible.

- Did not provide confidence in post-closure safety.

Question 1: First impressions of the participants:

☒ Busy, confusing, daunting
☒ Nothing guides the eye through it
☒ Too many graphs, too small font
☒ Incomprehensible
☑ Clean design – clear visually

Question 2: The majority of participants were not inspired to look at the poster in more detail.

Question 3: Most participants felt that the poster had been designed for a technical audience, including regulators. It was felt that people viewing the poster would need to have knowledge of the subject matter.

Question 4: Participants tended to feel that the purpose of the poster was to provide confidence in a post-closure safety case. This objective was generally not felt to have been achieved through the poster.

Question 5: Most participants felt that there was nothing interesting about the poster, finding it too difficult to read or understand.

Question 6: No participants felt the poster required more graphs, statistics, or computer-generated images. Most felt that there was no need for additional text on the poster, and also that the layout of the poster did not make it easy to read. There was a mixed response to the need for additional photos. One participant suggested that the poster was difficult to read because of the size and quantity of text and that the graphs were impossible to comprehend.

Question 7: The majority found it too complex or technical and confusing. There was no consensus on whether the poster was relevant.

Question 8: In ranking the poster's attributes, participants rated the balance between text and images as the feature that made the poster most accessible, followed by the examples used to illustrate the subject matter. The supporting images and the layout were felt to be the aspects that made the poster least accessible. One participant suggested that the poor layout affected the ability of all the other poster features to communicate well.

Question 9: Most participants did not feel that any aspect of the poster gave them confidence in the subject matter. However, one participant felt that the graph indicating timescales of barrier performance was helpful in this respect.

Question 10: Most participants found the poster difficult to understand or confusing, with several suggesting that the volume of material presented was overwhelming. Most participants did not find the poster alarming.

Question 11: Most participants felt that there were information gaps in the poster, but did not specify what these were. One participant suggested that an audit trail of uncertainty might be useful. One participant suggested that although there was a lot of data on the poster, it was incomplete in some respects, such as the uncertainty surrounding the validity of dose limits.

2.2.6 Overall Participant Assessment of the Posters

All participants were provided with a form designed to facilitate an overall assessment of the five posters considered together. However, only six of the fourteen participants completed these forms. This low number of returns may not be statistically significant, and bearing in mind that the overall assessment conclusions diverged from those drawn from the summary analysis of the comments on each poster, it was decided only to include feedback information here that was new. The main points concerned communication approaches, and these are summarised below:

- Participants suggested a range of additional communication techniques that might be useful; this included face-to-face discussions, video presentations, CD-ROMs and interactive software, and 3-D models.

- There was a strong recommendation to use moving images for communicating to a wide audience, as they have more impact than static posters; and interactive media was suggested as the modern approach to be used.

- There was a suggestion to use authors trusted by stakeholders to translate technical information into community-accessible language. Comparison was made by one participant with the situation at the Port Hope facility in Canada, where they have a peer review committee to summarise the research and to make it accessible; the lead person, it was claimed, has the confidence of both the research community and the local community.

- Participants felt additional posters could prove helpful by addressing retrievability and monitoring, how wastes arise, and implications and options for host communities.

- It was felt by one participant that having tiers of information, with the most accessible and simple at the top going down to the more technical, would enable people to burrow down for as much information as they want.

2.3 Plenary Discussion of the Five Posters

Following the individual poster assessment exercise, facilitated plenary discussion took place to explore viewpoints. Detailed notes on the participants' comments and remarks are presented in Appendix E. Some key messages were elicited from the plenary discussion of the posters, and these are set out below.

Participants commented that communication should be aimed at young people, as they are the future decision-makers and managers of radioactive wastes, hence communication should begin in schools. Participants felt that the communication approach needs to be modern and forward-looking, using latest technology, e.g. interactive CD-ROMs and computer games. One participant suggested that the approach should relate radioactive waste to familiar things in our lives, such as the use of X-rays, nuclear medicine and the generation of electricity, in order to show that it is a byproduct of beneficial uses of radioactivity. Participants tended to agree that the related issues of decommissioning, new nuclear build, and the resulting wastes from each should not be excluded from the discussion.

If the poster format is used, participants felt that it should treat one key issue at a time. Furthermore, posters should not only present what we do know but should also be open about what we do not know. Participants felt that it is important to be clear about the long-term uncertainties over the performance of the engineered barriers and the ability of host rock to contain the waste safely.

Participants also agreed that thought must be given to ensuring that any communication materials produced are developed to be as accessible as possible, including the use of braille for text boxes, and provision of community language translations.

2.4 Plenary Discussion of the Video 'Traces of the Future'

Participants were invited to watch a screening of the video 'Traces of the Future' produced by Nagra in 1994. This section provides a summary of participant feedback on the video. The following topics were covered by the video:

- Introductions to radioactivity and radioactive waste management, multiple barriers, and natural analogues; followed by a description of the Oklo natural analogue in Gabon, which illustrated the preservation of natural uranium ore bodies that had gone 'critical' about 2 billion years ago (10 minutes).

- Clips on the Cigar Lake natural analogue study in northern Canada (4.5 minutes) and the Loch Lomond sediment study (about 5 minutes) - both demonstrating the potential long-term confining capacities of clay.

- Archaeological analogues for possible durability of canister and container materials – the survival of iron nails at Inchtuthil in the Tay Valley near Perth

(1.75 minutes), and corrosion of the Kronan copper cannon buried in sea sediments off the coast of Sweden (1.25 minutes).

- Archaeological analogues for the durability of cementitious materials - Roman building works around Europe, including Hadrian's Wall (3 minutes).

- Clay pits in Umbria, Italy, particularly those at Dunarobba, illustrating the preservation of tree stumps for more than a million years, thus demonstrating the potential long-term sealing properties of clay (3 minutes).

Thoughts and comments expressed by the participants immediately after the video show included the following:

- Helpful but dated.
- Embedded with extra information.
- Showed how much radiation humans can tolerate.
- Needed to demonstrate science behind this, not just natural analogue stories.
- Analogy may not be convincing or reassuring on its own.
- "If things are natural it's OK" – hinted of propaganda.
- It demonstrated that nothing lasts for ever.
- Needed to address vision of the future – examples from nature may help envisage millions of years ahead.
- Did not cover the role of human intervention.
- Climate change impacts need to be taken into account.
- Many of the analogue examples described do not offer experience over sufficient timescales to be relevant to a repository.

Natural analogues were generally considered by participants to be of more use as a way to help explain issues rather than to provide reassurance for the future evolution and performance of barrier materials. One participant commented that there is a "*need to explain why you have confidence from a bunch of rusty nails and an old Roman wall*".

Following the elicitation of first reactions to the video, Paul Hooker presented a re-cap of the main features of natural analogues, including the chance to gain an insight into the future from the past. He explained the criteria that strengthen and weaken a natural analogue, and outlined the factors that make a natural analogue relevant.

2.5 Group Poster Building

Participants were divided into two workshop groups (Red Group and Blue Group) for a poster-building workshop session. Both groups were given the same instructions: to produce a poster to take into a community meeting, comprising members of the general public. The poster should be designed to explain the concept of engineered barriers in a way that would also provide reassurance to the audience.

The groups were provided with a wide range of materials to enable them to compile a poster about engineered barriers, including several laminated images and sections of text describing natural analogue examples. They were also encouraged to cut out elements from the existing poster displays (which had been assessed earlier in the workshop) or from the presentation materials in their briefing packs, if they felt there were helpful examples within these materials. Blank notes were also provided so that groups could add their own text where desired.

The aim of the poster building exercise was to identify the types of materials that participants felt would be helpful in communicating this kind of subject matter to an uninformed audience. The design of the posters would also help to inform the presentational style that might be considered in producing mass educational materials.

2.5.1 Red Group Poster

The Red Group produced a simple, colourful, abstract-style poster, designed to act as an accessible introduction to the concept of engineered barriers to a lay audience (Figure 2.1).

The Red Group chose coloured paper to create the design of an underground facility, with an emphasis on the fact that the surface environment continues to exist as normal. The Group thought that the layout of the poster would encourage the reader to view the poster sequentially, starting at ground level and following a route underground to the repository.

The Red Group selected some analogue examples to illustrate their subject matter: an image of Roman nails from Inchtuthil was used to demonstrate how materials can be protected from degrading over long periods; while an image of a Saxon iron helmet showing pitting corrosion was used to illustrate how degradation can occur and the 'dangers' associated with deep burial.

The poster began at the top left corner with a description of Inchtuthil in Roman Britain, which explained that a great number of nails had been found in the 1950s dating back to the Roman encampment at Inchtuthil in 87 AD. The introduction explained how the nails have been preserved under broadly similar conditions to the engineered barriers that might be implemented for an underground facility.

A series of questions was used in captions across the top of the poster to help explain the concept of engineered barriers. These questions included:

"What? 500,000 m^3 of radioactive waste from 50 years nuclear, defence, research and health applications. Needs to be disposed of safely."

"Why? Radioactive wastes are harmful. We need to protect people and the environment from its effects."

"How? An underground storage facility which we can keep checking up on."

At the bottom of the poster, there was a caption that set out the key features of barriers:

- Depth.
- Stable geology.
- Little ground water.
- Waste canister which doesn't corrode.
- Clay – to contain possible leakage of radiation.

There was also a caption setting out the 'dangers':

- Corrosion.
- Groundwater.
- Gas.
- Human entry.
- Long timescale.

The depiction of the underground facility was further illustrated with photographs of a tunnel and a waste canister (500 L steel drum for UK ILW, cut open).

Additional captions on the lower left hand side of the poster addressed the questions:

"When? After we have listened to what people want."

"Where? **?**"

"How long? Hundreds of thousands of years."

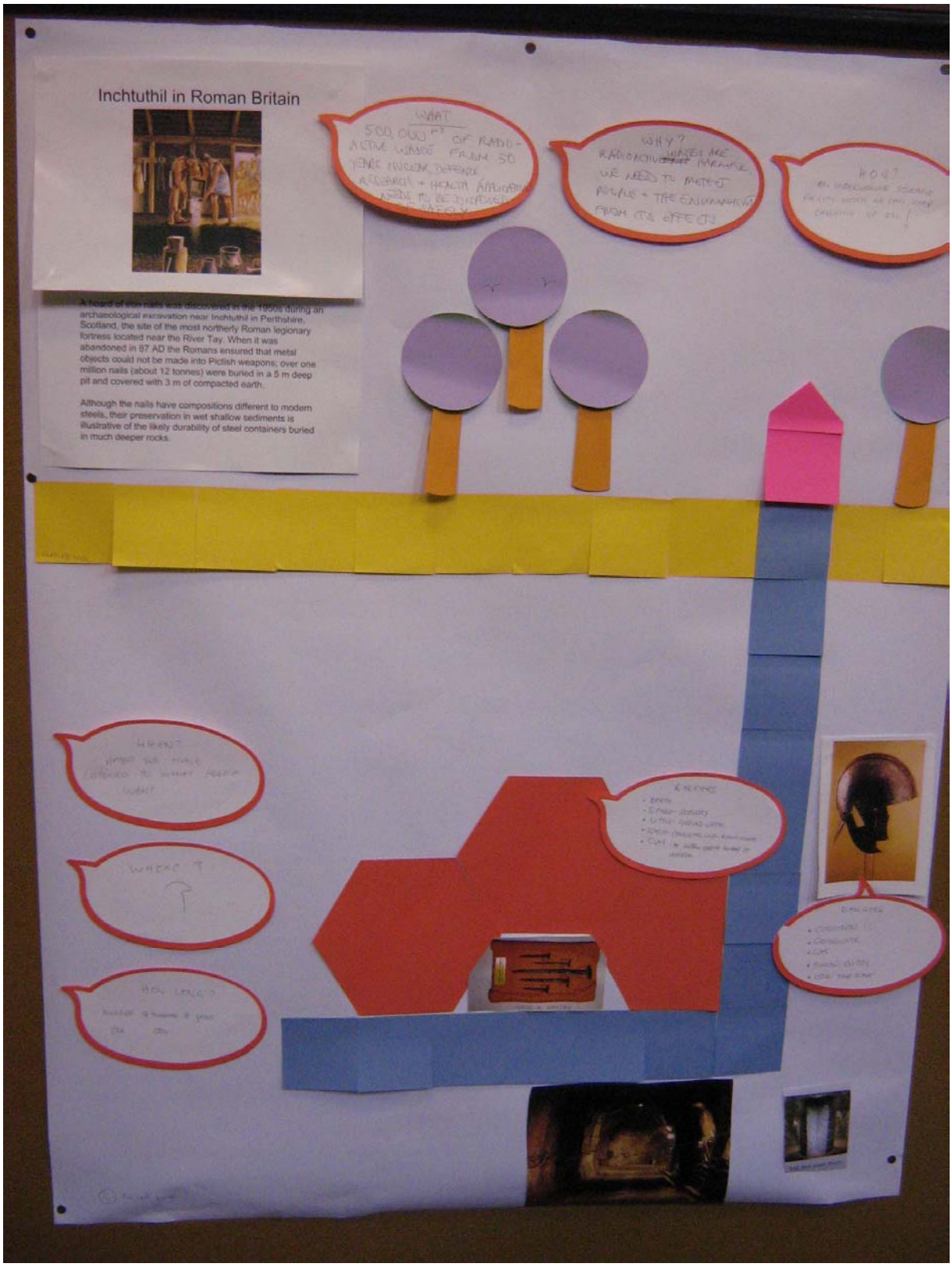


Figure 2.1. Red Group Poster on Engineered Barriers.

2.5.2 Blue Group Poster

The Blue Group produced a more technical and factual-looking poster than the abstract design of the Red Group (Figures 2.2 and 2.3). The poster was entitled 'Safe Deep Storage of Radioactive Waste', and had a clean and logical layout. The Blue Group highlighted, as a sub-title to the poster, the sources of the radioactive wastes under consideration, in large, red font, emphasising the significance that they felt this information should hold before being able to consider the concept of engineered barriers. The sources of radioactive wastes that were listed were power stations, hospitals, research, and military.

Like the Red Group, the Blue Group favoured the use of a large amount of illustration in preference to text.

The Blue Group subdivided their poster into two sections: one addressed "Nature's Examples of Deep Storage", and the other focused on "A Managed Process".

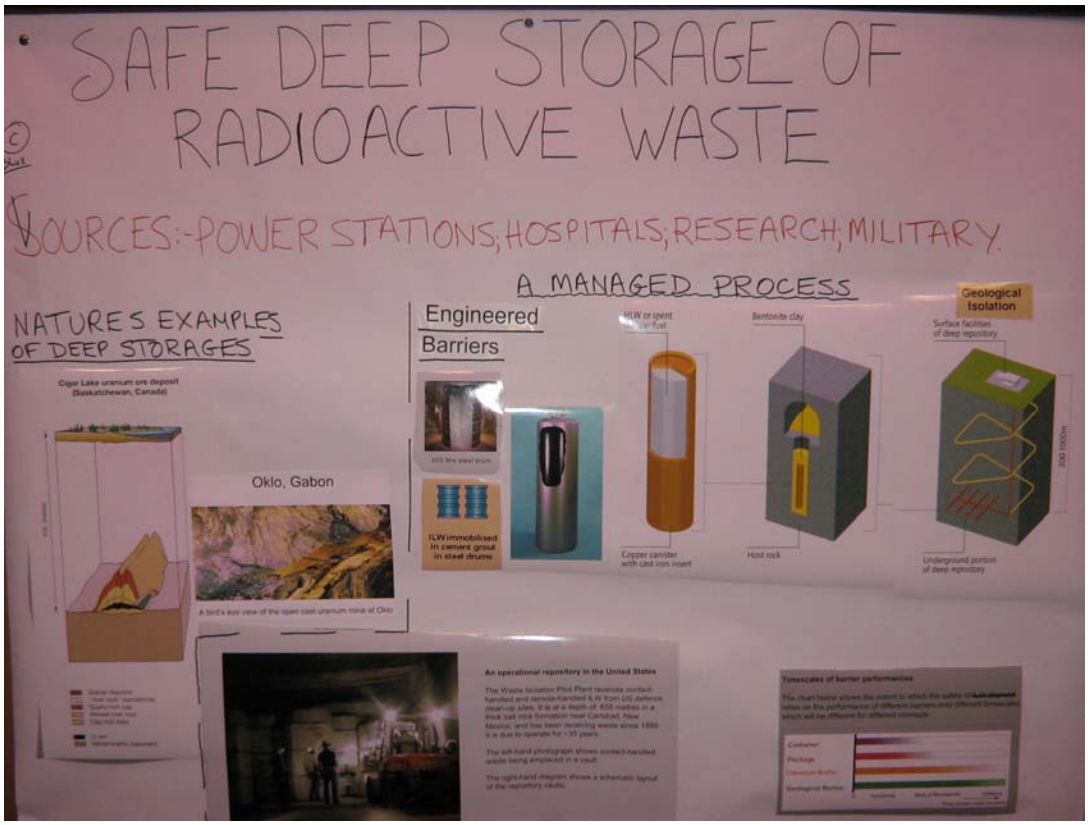


Figure 2.2. Blue Group Poster on Engineered Barriers.

"Nature's Examples of Deep Storage" featured a diagram illustrating the natural uranium ore deposit beneath Cigar Lake in Canada. The Group also used a photograph of the open-cast uranium mine at Oklo in Gabon.

"A Managed Process" featured a series of photographs and diagrams illustrating the various components of "engineered barriers" (Figure 2.3). The section included a diagram titled "Geological Isolation", which provided an indication of how an underground repository might be laid out to provide an additional barrier in the process. Beneath these images the Blue Group included a photograph of an operational repository, with text explaining what the photograph contains. The photograph showed a waste disposal unit being stacked in the Waste Isolation Pilot Plant (WIPP) in the US; WIPP is a geological repository in salt rock at a depth of 655 m.

Adjacent to the photograph, a timeline graph was included to indicate how each barrier could be expected to perform over time. This graph was cut from Poster No. 5.

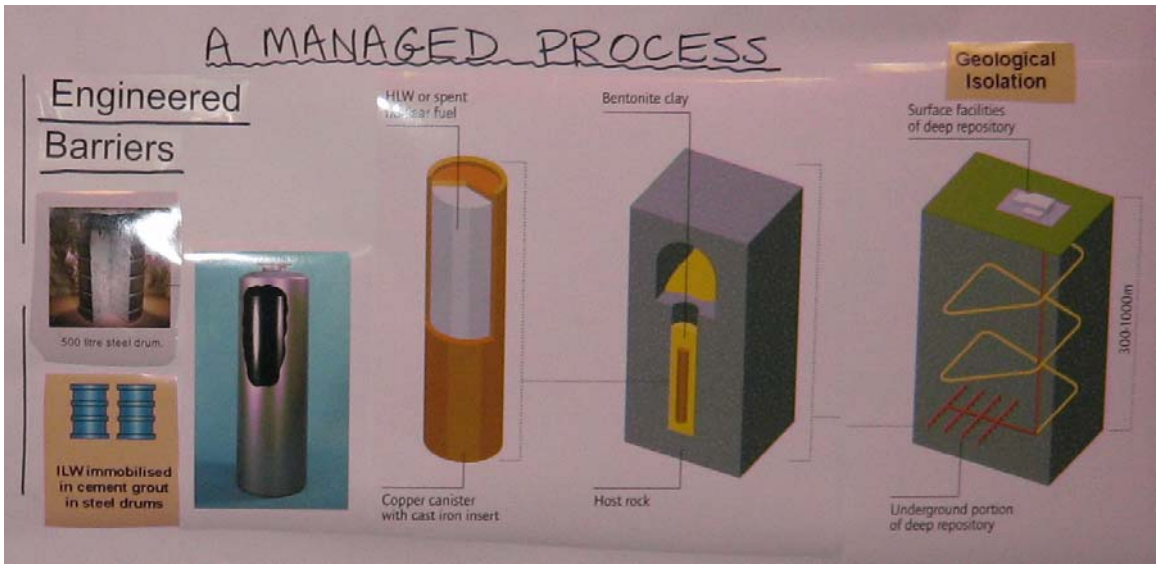


Figure 2.3. Extract from the Blue Group Poster: A Managed Process.

Despite their radical differences in style, both posters provided strong introductory messages for a long-term, managed process of deep radioactive waste *storage*, rather than *disposal*.

2.6 Plenary Discussion of the Newly Built Posters

The Red Group explained that they had tried to create something that would be bright and engaging to the viewer, and simple to understand. In addition, the Group felt that the style of the poster would appear neither threatening nor daunting. The Red Group also felt that the questions and answers helped to set out the data in an accessible manner. They had tried to avoid anything that would be off-putting, such as too much text, lengthy explanations or graphs. They noted, however, that this was merely intended as an introductory poster, and would not in isolation be sufficient to address the subject matter. They did not feel that it was realistic to expect one poster to be

able to stimulate interest in a lay audience, to be engaging, to be reassuring, and to provide sufficient information. The Red Group felt that the natural analogue examples they had selected provided a reasonable metaphor to help communicate the subject matter.

In plenary discussion some participants from the Blue Group felt that the use of the Roman analogue materials dated the poster and made it look "steeped in the past". Overall, there appeared to be agreement among participants that the use of analogues could be helpful, but should only be used as part of an explanation, and could not be used to fully explain and reassure people about geological repositories.

The Blue Group emphasised that, as with the Red Group poster, their poster had been designed only as an introduction to the subject matter. It was intended to depict the basic idea of deep storage. The Blue Group felt that it was inappropriate to also address disposal on the same poster.

The Blue Group added that although the collection of graphs used in the Post-closure Safety poster from the morning workshop session had been seen as unhelpful during the assessment exercise, they considered that individual, carefully selected and simply laid out graphs could have a beneficial role in explaining concepts such as the performance of barriers over time. It was important to ensure that any graphs used were self-explanatory.

In summary, both Groups:

- Agreed that there should be as little text as possible on poster materials and that posters should be made as visually appealing as possible.
- Emphasised the importance of identifying the sources of the radioactive wastes.
- Provided photographic images of a waste canister to illustrate what they meant.
- Supported their explanations with natural analogue examples.

2.7 Communication Approaches

The facilitator asked the participants to consider the different types of communication materials that had been presented during the workshop, and also to think about other techniques that they may be aware of, and to suggest which approaches might best be used to communicate issues around the safety and uncertainties associated with a geological repository for radioactive waste. The plenary discussion on communication approaches elicited the following comments from the participants:

- Posters have a role, but should not be the only format – schools could use posters and other media.

- Posters could be used as a 'backdrop' during other activities, but should not be the main means of communication.
- Look at recent communication techniques, e.g., the schools information campaign on the origins and uses of chocolate run a few years ago by Cadbury.
- 'Hands on' may work best for kids; link into the school curriculum.
- School visits as part of the education process.
- We need 'fresh eyes' to look at communication issues – we can learn lessons from elsewhere, e.g., BNFL used ideas from the Science Museum in London for its development of the Sellafield Visitors Centre. As a rule of thumb communication should:
    - avoid too much gloss
    - show uncertainties
    - acknowledge that intelligent adults understand the pros and cons.
- Consider a "nuclear industry month" campaign on this subject:
    - displays in museums, libraries, schools etc., and drop-in sessions at nuclear sites
    - UK-wide; education for all – transient population
    - nuclear industry is part of global history
    - need to sustain communication momentum.
- One participant commented that information from the International Atomic Energy Agency should be used cautiously, given the IAEA's remit to foster the development of nuclear energy.
- Target audiences should include a wide range of groups such as:
    - men's clubs
    - women's associations
    - sports clubs.
- Everyone will be paying for this, therefore all should be interested.

3 Conclusions and Next Steps

3.1 Conclusions

The principal messages elicited from the participants at the workshop were:

- The majority of participants felt that a geological repository concept for the UK should include a commitment to indefinite monitoring and retrievability. This was seen as providing a local community with a sense of reassurance and control over the management of a facility for long-lived radioactive waste. Retrievability was also seen as important in that the radioactive waste might become a future asset as nuclear technology makes advances.

- The posters presented to participants for assessment during the workshop were considered to contain too much text and technical detail to appeal to a lay audience. It was suggested by participants that communication via a poster should focus on one key issue, stating what is known and being clear about the uncertainties.

- While communication of basic technical information (describing radioactive wastes, where it comes from, the nature of radioactivity, and the need for a geological repository) was considered necessary, participants felt that key safety issues, uncertainties and knowledge gaps that become apparent when having to consider repository performance over hundreds of thousands of years should also be presented.

- Communication methods should be aimed at today's young people, who were considered by participants to be the future managers of our radioactive waste. This should be primarily conducted through the education system.

- A communication approach should be modern and forward-looking, using the latest technology (e.g. interactive CD-ROMs and computer games), and should relate radioactive waste to familiar and beneficial uses of radioactivity in the UK, such as nuclear medicine and the generation of electricity.

- Participants felt that a fresh approach to communicating issues is needed, using lessons from elsewhere, e.g., British Nuclear Fuels Limited used ideas and support from the Science Museum in London in its development of the Sellafield Visitors Centre.

- It was suggested that a "nuclear industry month" campaign could be run, during which people would visit nuclear sites, see interactive displays, talk to staff, and discuss issues. Participants suggested that this could include displays in museums, libraries, and schools.

- Making predictions of how UK climate and society are likely to evolve over the next million years was recognised by participants as being difficult. Participants felt that members of the public would be mainly concerned with the next hundred years or so. However, it was considered important to address a vision of the future in a safety case, and to describe how a geological repository would evolve in the far future. In this respect, participants tended to feel that examples from nature (natural analogues) were potentially useful to illustrate the processes and explain long-term issues.

- Human-induced carbon dioxide emissions and climate change impacts are new factors that need to be considered in communicating issues for a geological repository.

One of many lessons learnt from the workshop is that graphs presented in posters can cause people problems, as they can be difficult to understand, no matter what the axes are, and they should therefore be used with care.

3.2 Next Steps

Lucy Bailey noted that the workshop report would be sent to the participants for comment before being finalised. The report will subsequently be sent to the EC as a PAMINA Project report, and will be available on the publicly accessible PAMINA website (http://www.ip-pamina.eu/). Participants will be notified when the report is placed on the website.

Lucy Bailey commented that there may be a follow-up workshop to develop further the ideas on communicating safety issues for a geological repository.

In his final remarks, John Dalton emphasised the learning gained from BNFL's Sellafield Visitors Centre, which used ideas from the Science Museum in London, and how we can learn from communication approaches used in other industries (*cf.* Cadbury's campaign in schools to explain chocolate).

John Dalton noted that the comments and views expressed during the workshop would provide valuable real-world input for the inaugural meeting of a new DEFRA (Department for Environment, Food, and Rural Affairs) group on communication taking place in the week beginning 22 October 2007. John also drew attention to the government's Foresight programme, based in the Government Office for Science, within the Department for Innovation, Universities and Skills, which focuses on several science subjects, including radioactivity. The projects on radioactivity are supported by the UK Engineering and Physical Sciences Research Council. This shows how the need to engage the interest of young people in the UK has been recognised already.

Finally, although the workshop had a focus on posters, it was emphasised by the facilitator that this is just one media component that would be deployed in a

communication campaign. Different media materials will have to fit together and be suitably appropriate for their actual purpose and audience. It was noted that professional design is an important element to get this right.

Appendix A Participant Concerns About Safety

The following collated concerns about safety have been taken verbatim from the forms used by the participants to register for the workshop.

1. **Siting issues**
   - Where?
   - SUITABILITY (Geographical, geological, strategic).
   - Whose waste will be stored there?
   - What will the effect on the local community?
   - STIGMA (Potential for wellbeing issues).
   - What are the community benefits from waste storage?

2. **Retrievability**
   - There is a need for full accessibility to enable monitoring.
   - Once sealed, it is inaccessible if some unanticipated trouble occurs to it.
   - Ease of recovery if relocation was necessary in the future.
   - The ability to undo what's done.
   - Long term monitoring and retrieval – The local people need to be able to find out what is happening beneath them in the long term and to be able to enter the facility to effect remedial actions.

3. **Accountability**
   - Government accountability regarding long-term liabilities.
   - Maintenance of Accountability and Public Information over the longer term (i.e.: 1000's of years).
   - Transparency and accountability.
   - Generally the willingness now to make an early commitment to, and adequately resource, a programme to tackle the "Difficult technical issues that may require intensive effort and/or an extended research programme to resolve" (EA's NWAT/Nirex/06/005 Report, August 2006, Para: 3.4).

4. **Storage**
   - Why go to the expense when storage can be provided above ground?
   - Deterioration of 'containers' may be greater below ground than above.
   - Above ground storage will provide continued awareness.

5. **Confidence in the host rock**
   - Geological stability.
   - Groundwater.
   - Ability of host rock to inhibit return of radionuclides to bio-sphere.

- Long term geological safety – i.e. post the next ice-age. The material must be protected from the effects of an ice cap overhead.

6. Modelling and Uncertainty

- The inadequacy of the current ICRP model of radiation risk.
- Ability to accurately model behaviour of radionuclides over very long timescales.
- Being able to indicate how much radioactivity is likely to make its way back to the biosphere and over what time period. Putting uncertainties in context and clarifying their potential significance to long-term safety.
- Radionuclides of concern e.g. Tc-99; C-14, I-129, Np-237; Se-79; U-239 and Pa-107 (Beijer report, SKN Report 17, 1986/87).
- Public perception that nuclear waste is dangerous and how you can reassure them that it can be safety contained in the repository.
- Being able to indicate the uncertainty bands either side of the central case above.
- Our descendants and other subsequent life forms may be ignorant of its whereabouts and dangers.
- Long term knowledge – Information on the contents of the facility must be kept in several places and in several different forms to give future generations the maximum possible opportunity to understand what we have done.

7. Transport

- Transportation methods – rail, sea and road risk of accidents and the ability of the emergency services to respond.

8. Climate Change Impacts

- Global Warming - Effects of rising sea levels and/or flash flooding on underground storage facilities.
- With changing weather patterns what are the chances of flooding and discharge of radioactive water into the environment.

9. Miscellaneous

- SECURITY (Location, design, management and operation).
- How?
- At what cost?

Appendix B Workshop Agenda

PAMINA One-Day Stakeholder Workshop:

Communicating Safety Issues for a Geological Repository

AGENDA

17 October 2007

Friends Meeting House, Manchester

9.15am : Introduction and Welcome

9.20am : Background and Review of Participant Priorities

9.45am: "Discussing Safety"

10.05am: Poster Assessment Exercise

TEA/COFFEE (served during poster assessment exercise)

11.15am: Facilitated Plenary Discussion on Posters

LUNCH (12.00 – 12.45pm) Coffee served at start of film presentation

12.45pm: Examples From Nature

1.45pm: Poster Building Group Work

TEA/COFFEE (2.45pm – 3.00pm)

3.00pm: Plenary Poster Presentations

3.40pm: Communication Approaches

4.10pm: Questions from the floor

4.25pm: Conclusions and next steps

Close at 4.30pm

Appendix C "Discussing Safety" Presentation and Participant Feedback

Appendix C provides details of participant comments regarding the presentation by Lucy Bailey entitled "Discussing Safety". The presentation is presented below before the participant comments.

PAMINA

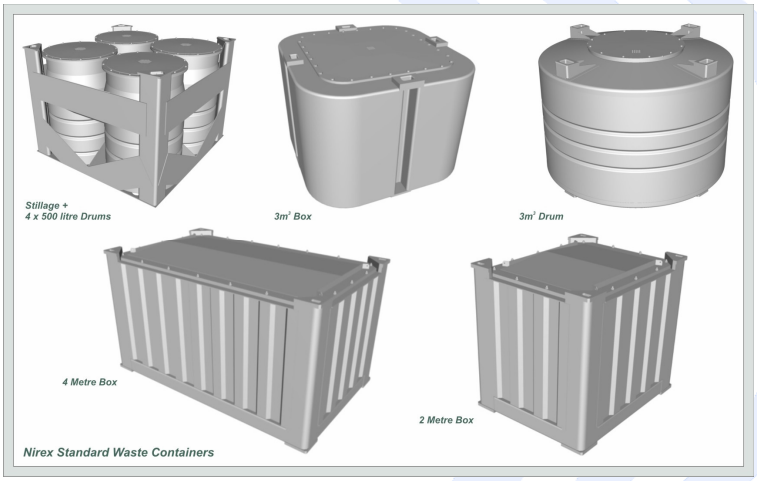
Discussing Safety

Lucy Bailey

Discussing Safety

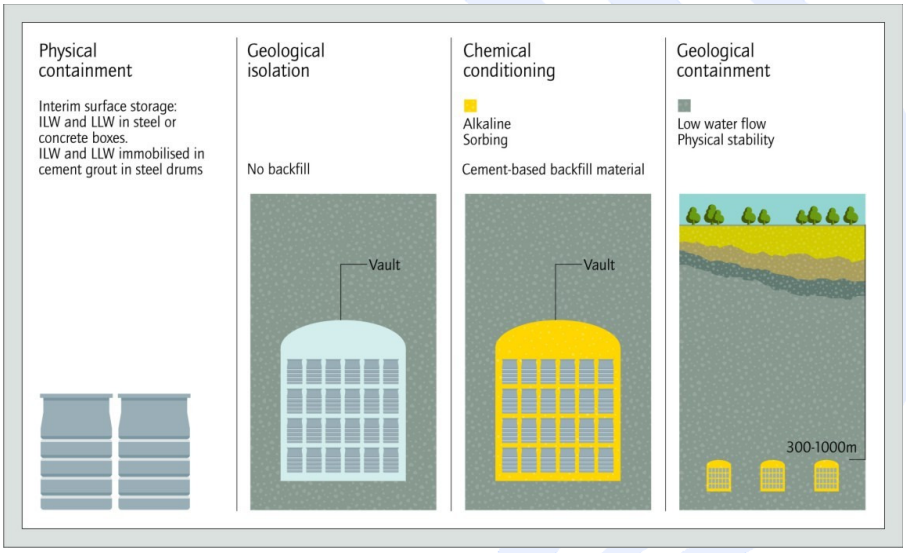
- **Stages in Safety**
  - **Packaging of wastes – different packages for different wastes**
  - **Disposal concepts developed – ILW and HLW**
  - **Transport from store to disposal facility – road, rail, sea**
  - **Emplacement in disposal facility – need for remote-handling for many wastes**
  - **Storage, monitoring and maintenance**
  - **Sealing and closure of facility**
- **Making the safety case**

Intermediate-level waste packages

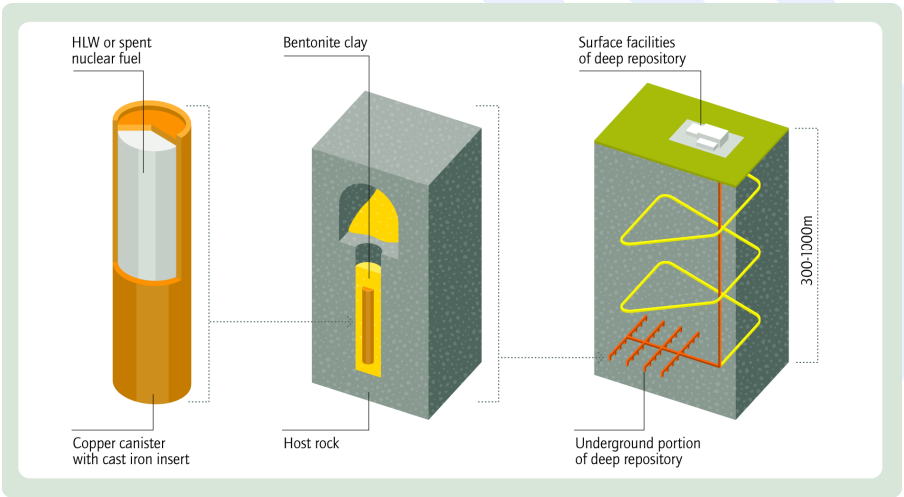


High-level waste package

Intermediate-level waste disposal concept

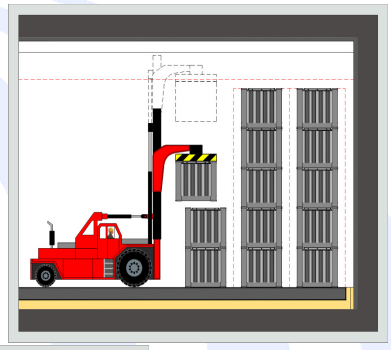


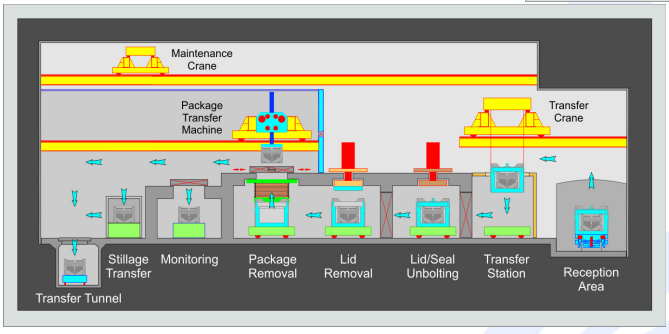
High-level waste disposal concept



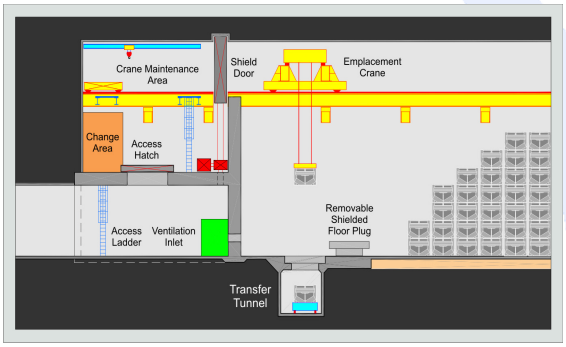
Transport operations

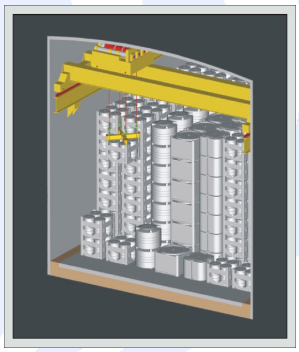
Emplacement in disposal facility





Storage, monitoring and maintenance





Multi-factor safety case

Multi-barrier

Safety functions

- Containment in waste canister
- Wasteform, packaging
- Design & engineering
- Chemical barrier
- Geological barrier

Intrinsic safety

Multiple lines of reasoning

Safety arguments

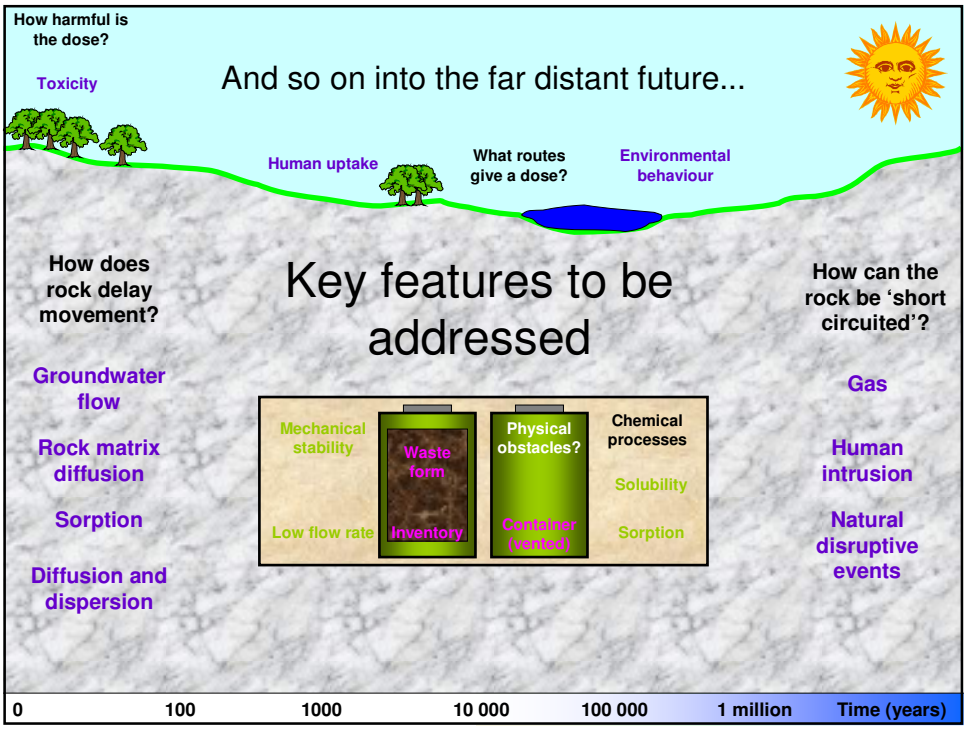
- Natural analogue studies
- Numerical modelling
- Demonstration experiments
- Complementary indicators

Safety assurance

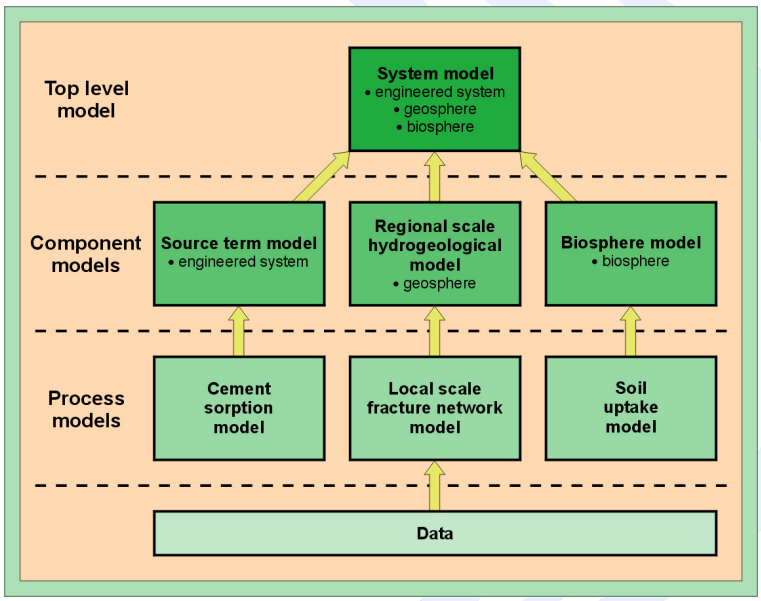
Safety Case

Long-term safety

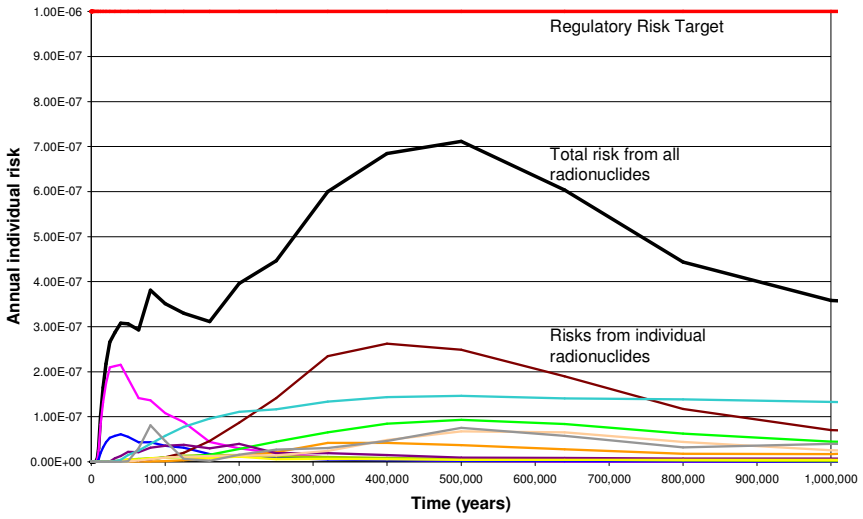
- Need for passive post-closure safety
- Understanding of disposal system and its evolution over very long times (up to 1 million years!)
- Performance assessment models
- Uncertainty must be addressed
  - in data
  - in models
  - different scenarios
  - future human actions



Model hierarchy



Calculating the risk



The presentation sparked a wide range of participant comments and concerns. The plenary discussion comments were captured on a flip-chart by the facilitator, and are set out below.

- How best to plot time - log scale versus linear scale:
    - set in the context of timeframes people can relate to – people only consider short time periods up to 1000 years or less.
- Permanent monitoring rather than post-closure timeframes:
    - monitoring and retrievability are key issues (waste may become a resource/asset in the future); therefore use no backfill in the UK concept
    - making waste retrievable gives us options in the future – don't close the door (industry, waste re-use, etc.)
    - cost cannot matter
    - confidence linked to monitoring and retrievability.
- Sweden's KBS 3 concept – uses backfill, but no monitoring and no retrieval:
    - Swedish concept looks decided already for the UK – a 'done deal'
    - in the UK concept – use no backfill, and plan for monitoring/retrieval.
- Need retrieval and monitoring (for local jobs).
- Do not know how other EU countries communicate with the public – EU context missing:
    - workshop is about testing communication ideas.
- In half a million years no-one will know where the repository is – difficult to grasp/explain that risk will continue to rise.
- How did you (the NDA) reach these estimates of risk versus time?
    - which academics carried out these assessments?
    - who peer-reviewed the data for estimates of risk? – which professors and universities - need reference to peers who have confirmed models
    - need to be able to scrutinise the underlying data, or at least provide transparency on who made the performance/safety assessments.
- This overview of the safety issues for a geological repository in the UK is based on one concept only – need comparison with other concepts.

- It is the subject not the communications approach that matters.
- Cannot walk away and leave (dump and forget).
- Lack of confidence (only becomes an issue as awareness rises) in recent operations, therefore need monitoring.
- Recent disposal pits at Harwell & Dounreay were not monitored in the recent past – not an acceptable practice for the future.
- Set out alternatives, and safety cases, to support informed decision making:
    - make comparisons between surface stores and underground storage
    - compare performance assessment (PA) for backfill & leave option with PA for a repository monitored for the long term (compare PAs for two evolutions).
- UK nuclear skills sector needs development - UK manpower problem in future - we require future experts.
- Local communities need expert support in understanding and dealing with this information.
- Diminishing confidence in moving up the safety modelling hierarchy:
    - if you have multiple models in a hierarchy, each with associated uncertainties, you multiply uncertainties at each level, diminishing overall confidence
    - need to project this uncertainty and lack of confidence
    - bands of uncertainty needed in the risk/time graphs – they currently project a lack of confidence.
- Fear of the unknown – focus on progress, and be positive for future in managing radioactive wastes.

Appendix D Poster Assessment Forms

Appendix D provides details of participant feedback on the five posters presented to them in the morning session. There were places on the forms where it was impossible to read the handwriting, in which case we have tried to best guess the missing text, but have put the uncertain text in *italics*.

Poster 1: Multiple Barrier Systems for ILW and HLW

First Impressions

- Too cluttered.
- Does not introduce the CONCEPT of multi barrier systems.
- Dull 1950s style.
- Needs simple title *cf*. "safety underground".
- Good – clean.
- Industry based – too much info.
- Laid out well.
- Good diagrams, a lot of words.
- Lots of words.
- Dead fish!?
- Too busy too technical.

Does your first impression inspire you to look at the poster in more detail?

3 Yes 1 No 6 Partly

Who do you think this poster has been designed for?

	yes	no	partly
A technical audience	2	3	1
Potential volunteer host communities	6	2	
Young people / schools & colleges	5	2	1
Regulatory bodies	3	4	1
General public	6	3	

Others:

- Would have to be a 'nuclear' knowledgeable community to get to grips with it.
- Mixed – some non-technical, some technical.

What do you think the purpose of this poster is? Does it achieve this?

- Goes too quickly to the detail.
- Browse options for 2 types of disposal.
- Needs to explain purpose of barriers – assumes knowledge.
- To some degree.
- Information.
- To show different systems of storage.
- To show how ILW & HLW will be packaged and stored underground – yes.
- To sell the system.
- General info – overview is achieved.
- To explain the multi barrier concept – yes.

What do you find most interesting about this poster?

- How dated / museum piece it looks.
- Good diagrams.
- Definition of ILW / HLW/ LLW.
- Nothing.
- The assumptions made.
- Cut away sections are good.
- The dead fish (unexplained fuel cladding!).

What do you think about the balance between the amount of text and graphics presented?

	yes	no	partly
Should there be more text?		10	
Should there be more photographs?	2 ?	5 ?	1
Should there be more computer generated pictures?	3 ?	5 ?	
Should there be more graphs and statistics?		7	2

Does the layout make the poster easy to read?	5	3	1

Is there anything else?

- The graphics are a bit obscure. Is there a way of making it more obvious what they are – especially the HLW graphics.
- Needs complete facelift.
- Less, less, less!!!

What do you think about the style of language used in the poster?

	yes	no	partly
Easy to understand	5	4	1
Interesting	3	5	2
Relevant	5	2	1
Too complex or technical	4	3	2
Incomplete	3	2	2
Confusing	3	3	2
Alarming	2	3	

Is there anything else?

- (easy to understand) but from a position of knowledge of the issues.
- unexplained acronym – LLW.
- seems end of discussion.

Which aspects of this poster make the subject matter most accessible?

	Please rank the following from 1 (the aspect that most makes the subject accessible) to 5 (the aspect that least makes the subject accessible)
The layout	3 5 4 1 5 1 2 5
The level at which the information is pitched	3 2 5 2 2 3 3 4
The supporting images	4 5 3 3 4 3 1 1
The balance between text and images	3 2 3 4 3 2 4 3
The examples used to illustrate the subject matter	X 3 3 5 1 3 2 2
Anything else? • Too dense – enough material for 3 -4 posters. • Trying to answer these questions leaves me feeling the poster is inaccessible to general public.	

Are there any particular features of the poster that provide you with confidence in the subject matter?

- No, too simplistic.
- The graphics.
- No.
- None.
- No!
- No.
- No.

Are there any particular features of the poster that you find confusing, difficult to understand, or alarming?

- So dated.
- Intro para – wrong *brief*: what is it, where does it come from – put ILW / HLW in same *pitch*. Explain why they used differ [*sic*] approaches.
- Photograph at the top no title under it to explain.
- Yes – how is ILW / LLW deposited / retrieved.
- Radionuclides?

- Yes – future ILW will NOT be predominantly fuel element debris – decommissioning wastes will predominate.
- No.
- No.

Do you think there are any information gaps?

- What is the context for use of this poster? What other info will the viewer have heard / seen before viewing the poster – difficult to judge it without more understanding of the context.
- Insufficient knowledge of subject to comment.
- Need to explain 'buffers'.
- Yes – access.
- Oh yes!
- What the concept is based upon.

Do you have any other comments or suggestions about this poster?

- Don't use it.
- No method of recovery.
- Comparison with existing repositories would help.

Poster 2: Repository Systems in Practice

First Impressions

- A bit busy.
- Better than the first one.
- Title – "repositories".
- Good – clean.
- Good.
- Colourful.
- The top half of poster 1 and top half of poster 2 should maybe be on same poster (ILW) as should bottom halves of posters 1 and 2.
- Distrust.
- Well presented.
- Daunting!

Does your first impression inspire you to look at the poster in more detail?

6 Yes 4 No Partly

Who do you think this poster has been designed for?

	yes	no	partly
A technical audience	1	5	2
Potential volunteer host communities	7	1	
Young people / schools & colleges	7	1	
Regulatory bodies	3	4	1
General public	6	2	1?

Others:

- Simple generalistic text.

What do you think the purpose of this poster is? Does it achieve this?

- Not sure! What about explaining main stages towards closure and scope for community involvement in decision making?
- Shows how HLW systems work – the past.
- Illustrate repository for ILW and for HLW.
- To inform – yes.
- Yes.
- To show encapsulation – not really.
- To sell a concept.
- Educate and inform – partly achieved.
- To demonstrate a repository is 'doable'.

What do you find most interesting about this poster?

- Diagrams and photographs are better – seems more modern.
- Actual scenarios.
- Nothing.
- The real examples.
- Photographs.
- WIPP info.

What do you think about the balance between the amount of text and graphics presented?

	yes	no	partly
Should there be more text?		8	
Should there be more photographs?	5	3	
Should there be more computer generated pictures?	3	5	
Should there be more graphs and statistics?		8	
Does the layout make the poster easy to read?	5		2

Is there anything else?

What do you think about the style of language used in the poster?

	yes	no	partly
Easy to understand	6	2	1
Interesting	6	1	1
Relevant	5	1	2
Too complex or technical	2	5	2
Incomplete	4	2	2
Confusing	1	6	
Alarming	1	5	1

Is there anything else?

- First paragraph - assumes done deal.

- The emplacement diagram doesn't really tell you anything. Looking again I don't think any of the diagrams help much. They rely on past experience of reader to fill in gaps and make sense of images.

Which aspects of this poster make the subject matter most accessible?

	Please rank the following from 1 (the aspect that most makes the subject accessible) to 5 (the aspect that least makes the subject accessible)
The layout	3 4 x 1 1 3 4 5
The level at which the information is pitched	3 2 x 3 2 1 5 4
The supporting images	3 3 x 2 3 x 2 1
The balance between text and images	3 3 2 4 5 x 1 3
The examples used to illustrate the subject matter	3 3 3 5 4 2 3 2
Anything else?	

Are there any particular features of the poster that provide you with confidence in the subject matter?

- No.
- People standing next to waste tanks without protective gear.
- Yes – actual installations.
- The foreign examples.
- Actual examples of repositories.
- That operation therefore happening in USA.

Are there any particular features of the poster that you find confusing, difficult to understand, or alarming?

- No.
- Yes – where located.
- Yes – the first paragraph.
- No.
- See previous comments. (The emplacement diagram doesn't really tell you anything. Looking again I don't think any of the diagrams help much. They rely on past experience of reader to fill in gaps and make sense of images.)

Do you think there are any information gaps?

- Yes – see response to previous question. (What about explaining main stages towards closure and scope for community involvement in decision making?)
- What's a repository.
- Yes.
- Yes – alternatives for use in UK.
- Unsure.
- Diagrams are not explained.

Do you have any other comments or suggestions about this poster?

- Don't say "will be" when decision is not yet made.

Poster 3: Transport and Repository Operations

First Impressions

- Busy.
- Dated.
- Easy to illustrate.
- Good – clean.
- Risky.
- Danger.
- Confused layout.
- Eye catching.
- Lots of disasters / war zone.

Does your first impression inspire you to look at the poster in more detail?

5 Yes 3 No 1 Partly

Who do you think this poster has been designed for?

	yes	no	partly
A technical audience		5	1
Potential volunteer host communities	5		1

Young people / schools & colleges	6		1
Regulatory bodies	5	2	
General public	7		1

Others:

- NOT for members of the public.

What do you think the purpose of this poster is? Does it achieve this?

- To convince people transport is safe. Not sure whether it achieves it?
- Shows methods of transportation and that they are safe.
- A thing to convince people rather than inform – use of “proven technology”.
- Yes.
- Risk rather than transport / ops.
- Too many crashes and fires – no.
- Reassurance – no!
- Confidence boost re: safety – partly achieved.
- Assurance about transport safety – partly.

What do you find most interesting about this poster?

- Photos.
- Nothing.
- Photos.
- Info.
- The first panel.
- Photographs.
- Dramatic images.

What do you think about the balance between the amount of text and graphics presented?

	yes	no	partly
Should there be more text?		9	

Should there be more photographs?	1	7	1
Should there be more computer generated pictures?	1	7	
Should there be more graphs and statistics?		8	
Does the layout make the poster easy to read?	4	5	

Is there anything else?

- Too many words – repetition of text (e.g. in drop).
- Too many accidents and fires.
- (does the layout make the poster easy to read) poster has two separate issues condensed into one poster.

What do you think about the style of language used in the poster?

	yes	no	partly
Easy to understand	4		2
Interesting	3		2
Relevant	4		3
Too complex or technical	1	6	
Incomplete	1	2	2
Confusing	2	3	1
Alarming	1	5	

Is there anything else?

- Too much text. Its too dense.

Which aspects of this poster make the subject matter most accessible?

	Please rank the following from 1 (the aspect that most makes the subject accessible) to 5 (the aspect that least makes the subject accessible)
The layout	3 4 3 1 1 5 2
The level at which the information is pitched	2 3 3 3 2 4 5
The supporting images	2 4 2 2 4 2 1
The balance between text and images	2 4 4 4 5 3 4
The examples used to illustrate the subject matter	2 3 3 5 3 1 3
Anything else? • Key areas.	

Are there any particular features of the poster that provide you with confidence in the subject matter?

- No.
- No, dated information.
- No.
- Middle panel.
- Safety statements re: transport.
- CEGB test information.

Are there any particular features of the poster that you find confusing, difficult to understand, or alarming?

- No.
- No.
- Needs better information – 1st sentence is confusing.
- Yes – alarming.
- Each topic needs a separate poster.
- No.
- International regulations nothing really about marine transport. Repository operations not relevant to assurances about transport safety.

Do you think there are any information gaps?

- Discussion of 'worst cases' and their likelihood.
- Repetition of text so there must be.
- The block on Internal [*sic*] Regs is too dense – needs to be "popularised".
- Unsure.
- Marine transport.

Do you have any other comments or suggestions about this poster?

- Scrap and update.
- Phrases like "significant area of research will turn off man in street.
- I though this one was pretty poor. Too much info. Too small text. Two issues dealt with one on poster.

Poster 4: Learning from Nature

First Impressions

- Central diagram complex.
- Ah! Perhaps I can get into this one.
- No idea what main sections are trying to show.
- Doesn't draw you in.
- Good – clean.
- Good layout, quite technical.
- Very interesting – but I am a geology student!
- Confusing.
- Confusing.

Does your first impression inspire you to look at the poster in more detail?

3 Yes 3 No 3 Partly

Who do you think this poster has been designed for?

	yes	no	partly
A technical audience	2	4	4
Potential volunteer host communities	6	2	1
Young people / schools & colleges	6		3

Regulatory bodies	3	5	1
General public	4	2	3

Others:

What do you think the purpose of this poster is? Does it achieve this?

- To provide confidence that a repository will be safe in the long-term. No – needs more explanation.
- To convince one that the waste is deep enough and safe enough. Sinisterly it might achieve this.
- No idea. Graphically poor.
- No clear explanation.
- Information – yes.
- Comparison with nature – no.
- As per the title – good poster – yes.
- To sell the concept.
- Natural comparisons to disposal – partly achieved.
- Give confidence in long term repository safety – don't think so.

What do you find most interesting about this poster?

- The grossly incorrect inference that the uranium ore is comparable in danger to "spent" fuel.
- How useless it is.
- Nothing.
- Good, informative.
- Real science at last!
- Cut away sections.
- ?

What do you think about the balance between the amount of text and graphics presented?

	yes	no	partly
Should there be more text?	2	6	1

Should there be more photographs?	4 ?	3	
Should there be more computer generated pictures?	3 ?	5	
Should there be more graphs and statistics?	?	8	
Does the layout make the poster easy to read?	5	3	

Is there anything else?

- Central graphic not explained.
- (layout) should be landscape not portrait.
- It is disjointed. The archaeological images don't help.

What do you think about the style of language used in the poster?

	yes	no	partly
Easy to understand	1	5	3
Interesting	4	1	2
Relevant	5	2	3
Too complex or technical	3	3	1
Incomplete	4	1	2
Confusing	2	3	1
Alarming	1	6	

Is there anything else?

- "derived data on rates of radiolytic oxidation and dissolution"!!
- (alarming) very.
- not a clear introduction to the issue; assumes understanding of the repository concept.
- other natural examples.

Which aspects of this poster make the subject matter most accessible?

	Please rank the following from 1 (the aspect that most makes the subject accessible) to 5 (the aspect that least makes the subject accessible)
The layout	3 1 4 2 1 2 1 3 4 2
The level at which the information is pitched	3 3 3 4 3 3 2 1 5 5
The supporting images	4 3 5 3 2 4 1 2 2 3
The balance between text and images	4 2 5 3 4 5 1 5 3 4
The examples used to illustrate the subject matter	3 5 5 3 5 1 1 4 1 1

Anything else?

- (re: examples used) To compare UO_2 with "spent fuel" is grossly misleading. "Spent" fuel is a propaganda term that you must get rid of.
- Needs better introduction.
- Smaller central image – more explanation.

Are there any particular features of the poster that provide you with confidence in the subject matter?

- No.
- Canada is a confident community – that spins off into the mind of the viewer.
- No.
- Graphics.
- No.
- The layout which is not too crowded and the text.
- It depicts reality.
- No.
- No.

Are there any particular features of the poster that you find confusing, difficult to understand, or alarming?

- Central diagram.

- (alarming) yes mentioned above. (To compare UO2 with “spent fuel” is grossly misleading. “Spent” fuel is a propaganda term that you must get rid of.)
- all of it – especially the sections.
- text and pitch.
- yes – what correlation ore V spent fuel?
- Bottom paragraphs which reduce value of analogue.
- Too technical.
- See above comments. (It is disjointed. The archaeological images don’t help.)

Do you think there are any information gaps?

- The stability, or otherwise, of the geological strata.
- Don’t understand much of it.
- Issue about predicting the future.
- Yes.
- Unsure.
- I’d need to know the subject to know the gaps!

Do you have any other comments or suggestions about this poster?

- I wasn’t happy that I knew what a natural analogue was – I thought I did, but then the pictures muddled me.
- Scrap it.
- Alternative – a repository designed to last a very long time. Are there any current examples which could demonstrate or show us aspects of what we need to know? For example, etc.

Poster 5: Post-closure Safety

First Impressions

- Very busy.
- Oh God graphs! And so much small print.
- Lot to take in – confusing.
- Nothing guides your eye through it.
- Clean – clear visually.
- Confusing.
- Too busy, don’t like this poster.
- Incomprehensible.
- Unreadable – daunting.
- Most daunting!

Does your first impression inspire you to look at the poster in more detail?

2 Yes 7 No Partly

Who do you think this poster has been designed for?

	yes	no	partly
A technical audience	8		1
Potential volunteer host communities		7	1
Young people / schools & colleges	1	6	1
Regulatory bodies	5?	2	
General public		8	

Others:

- Those who are already conditioned to accept the doctrines of ICRP risk and the immutability of radiological science.
- People who already have an understanding of the issue.

What do you think the purpose of this poster is? Does it achieve this?

- To develop confidence in post-closure safety. No – too technical.
- To convince us that all is known and therefore predictable. To a sinister extent it might achieve this, because it plays on the way science is taught in schools.
- Closure safety – no.
- Reassurance and justification.
- To inform – partly.
- Info for technocrats / colleges.
- No idea!!
- Mathematical modelling – unsure if achieved.
- To provide confidence in post-closure safety case.

What do you find most interesting about this poster?

- Most of it is illegible – at the wrong height and so off-putting that no-one will stay with it. YET the sheer weight of its omniscience will tend to leave with those walking away from it “that’s ok then”.

- How difficult it is to read.
- In Cornwall average for exposure is 7.6 mSv and the uk average is 2.6mSv (NRPB/HPA 2005).
- N/A.
- Nothing.
- None – it is totally incomprehensible – and I was a scientist for 30+ years!
- Nothing.
- Its awful.

What do you think about the balance between the amount of text and graphics presented?

	yes	no	partly
Should there be more text?	1	8	
Should there be more photographs?	2	3	?2
Should there be more computer generated pictures?		6	? 1
Should there be more graphs and statistics?		8	
Does the layout make the poster easy to read?	1	6	1

Is there anything else?

- It MUST be landscape, NOT portrait, so that it can be seen. Interrupted flow of concentration. Distracting feedback – in introductory panel at top undermining grasp.
- Horrible!
- This poster is frightening. Far too dense and the graphical data is incomprehensible.

What do you think about the style of language used in the poster?

	yes	no	partly
Easy to understand	1	6	1

Interesting		5	3
Relevant	2	2?	3
Too complex or technical	7	1	
Incomplete	2	??	? 4
Confusing	5	2	1
Alarming	1	5 ?	

Is there anything else?

- Too many different types of graphs and axes to grasp. TOO complete in data, but INCOMPLETE in the uncertainty of validity of "1mSv = ok".
- Needs breaking down into component parts.
- Too rambling.
- Inaccessible.

Which aspects of this poster make the subject matter most accessible?

	Please rank the following from 1 (the aspect that most makes the subject accessible) to 5 (the aspect that least makes the subject accessible)
The layout	3 5 4 2 1 3 5 5 4
The level at which the information is pitched	4 4 3 5 5 1 5 4 5
The supporting images	4 3 5 5 4 2 5 3 3
The balance between text and images	3 2 3 4 2 5 5 2 1
The examples used to illustrate the subject matter	? 3 4 x 3 4 5 1 2

Anything else?

- (the last 4 aspects are) all conditioned by the first. The overall impression wrecks anything else.

- Too much – break it down and use example.

Are there any particular features of the poster that provide you with confidence in the subject matter?

- Different ways of assessing long-term safety. I like the "timescales of barrier performance" bit.
- Only the sinister factor of the "authority" engendered by slick and formal presentation.
- No.
- Should identify all uncertainty and track it e.g. Topic – What do we know? What do we not know? How long will it take us to address the gap? What do we need?
- No.
- NO.
- No.
- No.

Are there any particular features of the poster that you find confusing, difficult to understand, or alarming?

- (difficult to understand) the graphs.
- yes – previous response. (Only the sinister factor of the "authority" engendered by slick and formal presentation.)
- graphics impossible to read.
- trying to cover too much information.
- too many statistics.
- All of it.
- Most of it.
- Far too much information on one poster.

Do you think there are any information gaps?

- Yes – the uncertainty in 1mSv being "ok".
- Yes.
- Yes.
- Yes.
- Can't tell.
- Unsure.
- Uncertainty isn't captured or conveyed.

Do you have any other comments or suggestions about this poster?

- Attempts to cover too much in too short a space.

- Posters MUST be at a comfortable height to read. Landscape not portrait.
- Bin it.
- Too complex – too much to digest.

Appendix E Plenary Discussion of the Five Posters

Appendix E provides details of the participants' comments on the five posters, made during the plenary session and recorded on a flip-chart by the facilitator.

Notes taken from the flip-charts:

Posters 1 and 2:

- Poster format is suitable for 6th form/college; and for local planning committees.
- Two topics (ILW and HLW) presented on the same poster is too much.
- Keep all ILW information together.
- Too much information on all the posters.
- 1950s style:
    - too much text
    - set out - very dated (all have dated style)
    - use other formats e.g. 3-D models
    - like a public library
    - not engaging
    - no wow factor (but do we need a wow factor? – need sober presentations; a serious subject should not be belittled)
    - not eye-catching.
- Some people won't make the effort to read them.
- Not set in the future.
- Make a computer game.
- Image in top left of poster 1 is not clear - dead fish?
- Portrait style cuts off top and bottom of the poster.
- Photos were very poor.
- Could not see connections between text and images.

- Braille and other language inclusions.
- CD-ROM/ interactive materials:
    - why not used today? (reason: lack of resources in the project)
    - can distribute CD-ROM to schools etc more easily.

Poster 3:

- Impressions of danger, risk and disaster.
- Passenger trains used to transport waste.
- Not a positive, comfortable feeling.
- Doesn't show canister surviving.
- Show before and after images.
- What if canister doesn't survive?
    - man-made object fallible
    - show risk management plans
    - demonstrate our safety factors
    - use statistics to reassure.
- Ensure relevant facts are included.
- Risk of leakage of coolant from spent fuel canisters?
- Viaducts are more than 9 m high; and tunnel fires occur:
    - update facts concerning transport and operation risks.

Poster 4:

- Poster 4 is not crowded and projected reality – simpler and direct, BUT used confusing language.
- Uranium dioxide in spent fuel (SF) - analogy with natural uraninite is false; distortion, as uraninite is not spent fuel:
    - misleading
    - use of spent fuel needs addressing

- is it (SF) waste or an asset?

Poster 5:

- Turned off by graphics – could not read them.
- People might think we are trying to hide something if they don't understand or cannot read the graphs or text.

Gaps:

- Links for text and graphics - set side by side but need to clarify links.
- What does half life mean?
- Why does this need burying?
- What's it all about? - big issue.
- Explanation of what is a repository.
- Basic physics.
- Descriptions of LLW/ILW/HLW – public need clearer terms.
- Explain where we are coming from and going to.
- Need to continue public awareness raising.
- Poster explaining how we'll address our gaps in knowledge – honest look.
- Where has it come from? (waste/fuel).
- Bring back to simple level - teach children about issues as they will be the ones to be involved in decision-making phase.
- Demystify.
- Show pros & cons of radioactivity.
- 'Green X Code' approach.
- Public education.
- Take away the 'nasty' image of radioactive waste.

Future:

- Explain why we would need a repository.
- Explain future arisings and their primary sources.
- CoRWM viewpoint on future arisings.
- Lack of professional/government agreement/consistency damages confidence.