

Unclassified

NEA/RWM/RKM(2012)1/FINAL

Organisation de Coopération et de Développement Économiques
Organisation for Economic Co-operation and Development

12-Jun-2012

English - Or. English

NUCLEAR ENERGY AGENCY
RADIOACTIVE WASTE MANAGEMENT COMMITTEE

Cancels & replaces the same document of 08 June 2012

Expert Group on Preservation of Records, Knowledge and Memory across Generations

The Preservation of Records, Knowledge and Memory (RK&M) Across Generations

Workshop Proceedings

11-13 October 2011
NEA Headquarters, Issy-les-Moulineaux (France)

This document cancels and replaces the previous one of 8 June 2012. It contains minor changes which do not affect the content of the document.

Claudio Pescatore (claudio.pescatore@oecd.org)

JT03323564

Complete document available on OLIS in its original format

This document and any map included herein are without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

NEA/RWM/RKM(2012)1/FINAL
Unclassified

English - Or. English

The Preservation of Records, Knowledge and Memory (RK&M) Across Generations

**Workshop Proceedings
Issy-les-Moulineaux, Paris
11-13 October 2011**

FOREWORD

The Preservation of Records, Knowledge and Memory Across Generations Workshop was held 11-13 October 2011 in Issy-Les-Moulineaux, France, as part of the homonymous project under the aegis of the NEA Radioactive Waste Management Committee. There were 33 participants from 9 countries representing national governments, universities, waste management agencies, safety authorities, plus specialists in both the technical and social sciences. Three international organisations were also represented.

The overarching goal of the workshop was to scope the field and gain insights that can guide the further development of the RK&M project. The workshop helped to further contextualize and delineate the field, to learn how different practitioners organise and conduct their work in light of different time scales and what they see as crucial issues throughout their efforts, and to investigate the interaction between RK&M and society.

On the first day the key RK&M project documents and the results of questionnaires were presented and discussed. An overview of situations of records and memory loss was presented and views on regulatory implications on long-term record keeping were given. The contribution to be made by social sciences was presented. On the second day planning record preservation and knowledge management was discussed, including presentations on archaeology, markers, and a panel discussion on the film 'Into Eternity'. On the final day experience and thoughts the connection between memory and physical records were presented and discussed. In total 24 talks were delivered, each followed by time dedicated for Q&A, and 4 plenary discussions took place.

This document provides a synthesis of all the workshop presentations and accounts of discussions that were held. The document also provide a list of lessons learnt for future work within the RK&M project.

Acknowledgments

The RK&M project wishes to thank of external speakers who greatly contributed to the success of the event.

This document was produced by Jantine Schröder (SCK•CEN), Helen Gordon-Smith (OECD NEA) and Claudio Pescatore (OECD NEA).

TABLE OF CONTENTS

FOREWORD	3
TABLE OF CONTENTS.....	4
INTRODUCTION AND ORGANISATION OF THIS DOCUMENT	6
SUMMARY OF THE WORKSHOP.....	8
Key observations and messages for the programme of work of the RK&M project	8
DAY 1.....	11
1. Presentation of updated project documents – A. Claudel & C. Pescatore.....	11
Bibliography	11
Glossary	11
2. Preliminary analysis of the bibliography – J. Schröder.....	12
3. Analysis of project questionnaires - S. Wisbey.....	13
4. Examples of RK&M loss – S. Tunbrant.....	15
5. Contaminated sites: memory loss experience – C. Sieber.....	16
6. European study on waste data & records – W. Hilden.....	17
8. UK Regulators’ View on Long Term Records – Steve Griffiths	18
9. Policy and Regulatory Implications of RK&M – M. Jensen.....	18
10. The Contribution of the Social Sciences to Andra’s RK&M preservation programme – L. Aparicio.....	19
11. Plenary Discussion – Led by E. Van Hove	20
DAY 2.....	21
13. Insights from a comparison of conventional and radioactive waste: Objective and project longevity of programmes in Switzerland – T. Flüeler	21
14. Concerns and issues for what to keep during the operational phase and repositories, and how to keep it – N. Zoltan	21
15. Preparing records as a function of waste life-phases – S. Wisbey	22
16. A Knowledge Management Perspective – J. Day	22
17. Digital Preservation at the Swiss Federal Archives – K. W. Ohnesorge.....	23
18. ANDRA’s long term memory experiences and programme – J-N. Dumont & P. Charton	23
20. Panel Discussion of the Film ‘Into Eternity’ – Led by M. Jensen.....	24
21. One hundred thousand years back and forth: When archaeology meets radioactive waste – C Holtorf and A. Högberg	25
22. The BfE commissioned study on Markers in Geological Disposal – M. Buser.....	26
23. The Need for Proportionate Systems for Markers and Records in the Long Term, and How to Plan for Them – A. Van Luik.....	27
24. Plenary Discussion – Led by E. Van Hove	28
DAY 3.....	29
26. The Connection between the Areas of Safeguards and Physical Protection and Record and Memory Keeping – P. Ormai.....	29
27. RWM Related Work in the Areas of RK&M and the Connection to the ‘Added Value’ Concepts and the ‘Memory’ Aspects of the FSC Programme of Work – C. Pescatore	29

28. Preservation of RK&M for Long Term Storage Facilities: The Results of a French Study – T. Schneider.....	30
29. Embedding the Past in the Present – E. Van Hove.....	31
ABSTRACTS OF THE PRESENTATIONS.....	33
3. Analysis of project questionnaires - S. Wisbey.....	33
Records, Knowledge and Memory Project – Survey of Status and Needs (reported in March 2010)...	33
Records, Knowledge and Memory Project – Supplementary Questionnaire (2011).....	36
4. Examples of Loss of RK&M and Possible Countermeasures as Received by the Members – S. Tunbrant.....	41
5. Contaminated sites: memory loss experience – C. Sieber.....	47
6. EC Study: Radioactive waste and spent fuel data collection, reporting, record keeping and knowledge transfer by EU Member States - W. Hilden.....	50
8. UK Regulators Long-term Management of Higher Activity Radioactive Wastes on Nuclear Sites – S. Griffiths.....	52
9. Preservation of Records, Knowledge and Memory Across Generations: Policy and Regulatory Implications - M. Jensen.....	54
10. The contribution of the social sciences to Andra’s RK&M preservation program - L. Aparicio.....	58
13. Insights from a comparison of conventional toxic and radioactive waste: Objective and project longevity of programmes - Thomas Flüeler.....	59
14. Concerns and issues for what to keep during the operational phase of repositories and how to keep it – Z. Nagy.....	60
15. Preparing records as a function of waste life-phases – S. Wisbey.....	61
16. Management of knowledge across generations: preventing knowledge loss, enabling knowledge readiness – J. Day.....	64
18. ANDRA’S Long-Term Memory-Preservation Program - P. Charton and J. Dumont.....	69
REFERENCES.....	73
21. One hundred thousand years back and forth: When archaeology meets radioactive waste C. Holtorf and A. Högberg.....	74
22. Federal Office of Energy Research program: Survey on Markers, Marcos Buser, INA GmbH, Zürich76	
23. The Need for Proportionate Systems for Markers and Records in the Long Term, and How to Plan for Them – A. Van Luik.....	77
26. The Connection between the Areas of Safeguards and Physical Protection and Record and Memory Keeping – P. Ormai.....	82
27. RWM Related Work in the Areas of RK&M and the Connection to the ‘Added Value’ Concepts and the ‘Memory’ Aspects of the FSC Programme of Work – C. Pescatore & C. Mays.....	85
Introduction.....	85
Overarching Observation.....	86
The Technological Approach: Preserving Information.....	86
A New Central Actor?.....	87
Adding value through functional, cultural and physical design features.....	88
Adding value through the planning and implementation process.....	89
Early reflection is best.....	89
Conclusions.....	90
28. Preservation of RK&M for Long Term Storage Facilities: The Results of a French Study – T. Schneider.....	90
29. Embedding the Past in the Present – Final Remarks - E. Van Hove.....	96
PARTICIPANTS LIST.....	98

INTRODUCTION AND ORGANISATION OF THIS DOCUMENT

Various NEA member countries are currently developing and constructing deep geological disposal projects for high-level and/or long-lived radioactive waste and spent fuel. These take decades to develop and implement, and the facilities are to operate passively and safely for millennia. Although different countries are in various stages of development with regard to their radioactive waste management (RWM) programmes, for all countries with nuclear waste the question arises which relevant records, knowledge and memory should be preserved, why, how, by whom, and for how long?

Consideration of this question has led to the creation of the OECD NEA Project on the Preservation of Records, Knowledge and Memory (RK&M) across Generations. This followed the significant interest in the project shown at a Topical Session, held at the 44th Session of the Radioactive Waste Management Committee, March 2010.

Within the RK&M Project, 2010-11 was designated for scoping the issue and identifying challenges that the project shall consider later. Multi-disciplinary studies have been encouraged from the start. So far, three surveys have been completed,¹ a task on bibliography has been set up and a preliminary analysis conducted, and a glossary of key terms has been started. A Collective Statement and a Vision Document have been agreed and release with RWMC approval.

The key questions, as identified in the Vision Document, for the project in general are:

- Which records need to be maintained?
- For what purpose?
- Over which timescales?
- By whom?
- For whom?
- What can be done now – from a managerial, technical, legal, regulatory viewpoint – to provide maximum continuity of records, message, and accessibility?
- How much effort, and of what kind, is it reasonable to invest, now or later?

The priority at this stage of the project is to complete the scoping work so far by finalizing it into written documents. Furthermore in 2012, the following meetings and activities are under consideration:

- At the WM conference in Phoenix, February 2012, the RK&M project will be presented, including the lessons from the October 2011 workshop;
- The final progress report for 2010-2011 will be prepared and distributed;
- A project meeting will be held in Spring of 2012

¹ 2010 Survey on Status and Needs, 2011 Survey on Responsibilities (cf. item 3 in this document), 2011 Survey on Examples of Memory Loss (cf. item 4 in this document).

- A second, open workshop will be prepared and organised in the autumn of 2012.

As stated in the Vision document, the RK&M project will work towards a *'Menu-driven document that will allow people to identify the elements of a strategic action plan for RK&M preservation'*. This document will contain recommendations to countries on useful practices as well as new suggested follow-on activities in this field. The release of this 'Menu driven document' is foreseen in 2014.

The present workshop was organised to further contextualize and delimit the field, to learn from different practitioners (RWM implementers, archivists, archaeologists, ...) how they organise and conduct their work in light of different time scales and what they see as crucial issues throughout their efforts, and to investigate the mutual interaction between RK&M and society. The overarching goal of the workshop was to gain insights that can guide the further development of the project, keeping in mind the final delivery of the project, which is agreed to be a menu driven document to assist practitioners in realizing the preservation of RK&M.

This document consists of two parts. The first part briefly starts with some key messages and moreover consists of a summary of the various presentations and discussions that took place at the workshop. The second part is a compilation of the extended abstracts supporting each of the presentations.

SUMMARY OF THE WORKSHOP

Key observations and messages for the programme of work of the RK&M project

The workshop delivered a large amount of information, ideas and visions, and a provided a fruitful forum for multidisciplinary reflection and discussion.

Key observations and messages from the workshop are as follows:²

- The importance of having a common glossary is confirmed. This allows the project members to communicate better with one another and with others, and it contributes to the development of a common culture of RK&M preservation. The RK&M project should continue its task of elaborating a common set of terms and providing their definitions. Group members will be responsible for translations into national languages in a form agreed by the group. *Item 1.*
- It is of interest to the project to better understand the contents of the current bibliography on RK&M. Renewed efforts should be made to review each relevant report and to create a more consistent set of abstracts that not only describe the contents of each document but also respond to other questions that are of interest to the RK&M project. *Items 1, 2.*
- Examples of memory loss and records misuse or misplacement exist both inside and outside the nuclear field. The project has performed a first analysis of these examples. Further work is needed in this area: do we have a good taxonomy of events leading to memory loss and records misuse or misplacement? Do we have sufficient number of examples? Emphasis in the project should now be placed on verifying the comprehensiveness and the sufficiency of the information collected to date. A special effort should be made to look for examples that fit more closely the case of deep geological disposal. *Items 4, 5, 16, 22.*
- The relationship between regulation and RK&M preservation for the long-term needs to be better understood. Is RK&M preservation needed for long-term safety or other reasons? Do provisions for preserving RK&M for as long as possible need to be addressed at the time of licensing and in the (geological) disposal safety case? The RK&M collective statement does not address these questions directly. *Items 3, 4, 8, 9, 10, 18, 20, 24, 27.*
- RK&M preservation or loss and recovery scenarios can be constructed based on a wide range of future human-development hypotheses. For the analysis of long-term safety and the case of human

² Please note that the items cited indicate the areas under consideration and are not intended to be exhaustive of the discussion.

intrusion it is agreed that the future human technological capabilities are similar to today's capabilities. *Items 9, 11, 17, 20, 21, 23, 24, 28.*

- The relationship between RK&M preservation and safeguards needs further clarification. It may be that safeguards-related information is part of the multiple approach for RK&M-keeping about repositories at the international level. It must be borne in mind that safeguards agreements are between each single nation and the IAEA and concern fissile materials. Because of its nature, the information collected under safeguards agreements is kept confidential. *Items 2, 3, 9, 26.*
- National archives are a promising venue as one of the multiple approaches for long-term RK&M preservation. The role and functioning of national archives vis-à-vis RK&M preservation in the context of radioactive waste management needs be explored further. *Items 3, 5, 17, 18.*
- Records management alone will not equip future generations to deal with long-term stores. For cross-generation knowledge management, one possible scenario that requires further research efforts is that of 'knowledge mothballing', i.e. the conscious consolidation of knowledge for later resurrection. History has taught us that mothballing and resurrection is possible, through a combining a variety of mechanisms including textbooks, records, archaeological artifacts and the human ability and stamina to reconstruct knowledge. However, for this to be certain, society needs to not only preserve records but also to consciously and purposefully build and maintain a reservoir of tacit knowledge that can provide meaning to records. Further research needs to establish the principles and roles in knowledge mothballing and how the required tacit knowledge can be transferred and then updated according to changes in terminology, technology and environmental issues. *Items 10, 16, 21, 29.*
- It is important to preserve not only technical records, but also records on the history of the programme, including its siting within a community (metadata). *Items 1, 2, 4, 14, 17.*
- The interest in the history of the programme should also be looked at from a *heritage* viewpoint. Adding cultural (historical) value to the facility and creating the conditions for continued value to the community is one of the multiple approaches for contributing to RK&M keeping. *Items 10, 21, 27, 28, 29.*
- Understanding the many ways that clues and records can be left in order that knowledge may be reconstituted by generations beyond those immediately succeeding us is important in this context. Historians and others are specialists in reviving older facts and knowledge. There is relevant expertise in the didactics of history that could be looked at. *Items 10, 21, 27, 28, 29.*
- In the same vein, while we must operate on the assumption that the intra-generational transmission chain continues to preserve RK&M, we have also to reach to farther-out generations directly in case the chain is broken. This is identified in the RK&M project as the "dual track strategy". *Items 1, 3, 28.*
- The aim in reaching out to farther-out generations should be, as far as possible, that of informing them. There should be an attitude of openness towards the future. Monuments or markers that are

intended to scare people are not recommended. We are on stronger ground if we privilege information that allows people to protect themselves. Also, it should be kept in mind that “The more it is hidden, the larger is the temptation to get to it” and that “Prohibition has a short half-life”. *Items 22, 23, 27.*

- The set of data to be kept should be commensurate with the future need for the data and the difficulty of keeping them. Requirement management systems are needed that allow for data not only to be kept, but also to be culled, so as not to “keep everything, remember nothing”. Waste managers should identify which project information needs to be processed and maintained on which time scales; a collection of practices in data keeping and management in organizations with a view to later needs could be started. *Items 8, 14, 15, 17, 18.*
- Standardization of messages may be useful when considering records for the farther future - that is, for the time when national programmes may no longer be extant. One may want to: maximize visual and diagrammatic content; minimize textual presentation; prepare records in host language and major regional languages; and standardize content and the order of material to allow interpretation of fragmentary records. Also, it would be useful to have an international document on markers’ messages. Overall, this area is best addressed through international cooperation, and should be developed further. *Items 16, 23.*
- Operators and regulators would benefit from a clear national or international position on RK&M requirements. From the international point of view:
 - The EC Waste Directive of July 2012 (Art. 12) requires concepts and plans for the post-closure period of a disposal facility, including the period during which appropriate controls are retained and the means to be employed to preserve knowledge of that facility in the longer term;
 - The Aarhus convention needs to be looked at.

Overall there is interest in compiling the international requirements or, more simply, requests, that countries have to fulfil when dealing with post-closure situations. *Items 3, 9, 14, 23, 26.*

DAY 1

1. Presentation of updated project documents – A. Claudel & C. Pescatore

Bibliography

Available from <http://www.oecd-nea.org/rwm/rkm/>

The reference bibliography is a collection of relevant publications on work performed in the field of the preservation of Records, Knowledge and Memory (RK&M) across generations in relation with radioactive waste management, especially deep geological disposal. The references are selected based on the following criteria:

- The document (or at least part of it) addresses the preservation of RK&M in connection with the management of radioactive waste (RWM);
- The document is publicly available or can be made available upon request³;
- One synthesis document (such as a report) is preferable to a list of papers with a similar content;
- Original documents (scientific reports and papers) are preferred to reviews or press coverage.

For each entry an abstract is provided.

The bibliography is not meant to be an all-encompassing list that includes any generic reference that might be useful in the study of the topic under consideration. Therefore it does **not** include:

- general studies outside RWM , e.g. on memory loss, communication, or the history of institutions;
- studies belonging to the field of RWM but only indirectly related to RK&M preservation⁴.

Moreover, it is a living document that will be updated throughout the project.

The RK&M bibliography is supported by a database kept at NAGRA (contact: Anne Claudel) that ensures the continued availability of references that may no longer be available at the original websites.

Relevant references will continue to be added by the project members.

Glossary

Available from <http://www.oecd-nea.org/rwm/rkm/>

The aim of the RK&M project glossary is to define important concepts and terminology for the purposes of the project. It currently contains the following terms:

- data

³ Unless stated otherwise, all documents are available at the Nagra Library, either on paper or in electronic form.

⁴ For instance, the bibliography would not include studies of climatic changes at a specific site. Clearly, they would be relevant for the development of a marking system at that site, but they could be used for many other uses as well.

- information
- record
- knowledge
- memory
- marker (under discussion)
- dual track approach (under discussion)
- time scales (very short, short, medium and long term) (under discussion)

The project acknowledges that the glossary definitions are the result of compromises. Dictionary definitions or mainstream understandings of terms are adapted – albeit to as little extent as possible - to the nature of the project. A note will be added to the glossary to articulate this.

The definition of knowledge will be broadened to also reflect the actual possession of active and passive knowledge.

The dual track approach will be redefined as a strategy.

Furthermore the glossary will be augmented with new terms:

- monument (in connection with marker)
- message
- metadata (contextual data)
- control (passive / active) oversight (direct / indirect)
- complementary approach

The glossary will be revised and augmented with new terms, which will be reviewed by the members and discussed and approved at the next project meeting.

2. Preliminary analysis of the bibliography – J. Schröder

The main aim of the bibliography is to help the participants in the RK&M project to identify the topics of concern in the field of RKM and, eventually, the issues that have not yet been addressed. To support this purpose, this document presents a preliminary analysis of the bibliography, i.e. based on the abstracts as provided throughout the bibliography version of 12th July, 2011.

The bibliography was analysed based on

- The year of publication
- The source of the material
- The structural focus
- The topical focus

Some preliminary findings and recommendations:

- There seems to be a clear focus on markers and deterring inadvertent human intrusion in USA literature on RK&M, whereas the focus of EU references is more diverse and broader (system level). Many of the IAEA references focus on knowledge management and record systems;
- Insights on who is considered to be responsible for the preservation of RK&M were difficult to derive. The role of international organisations and of local communities may deserve more attention;

- It may be useful to elaborate some more on target audiences;
- A point of attention can be said the recognition of the existence of two parts:
 1. the systematic collection of relevant information and
 2. its transmission to future generations.
 One cannot treat these parts in isolation, but nevertheless the first step should not be forgotten;
- The relation between RK&M preservation and safeguards should be discussed;
- A lot of literature is already available. An important added value of the NEA project lies in;
 - o putting the different pieces of available information together
 - o thoroughly reflecting on the topic of RK&M preservation in the contemporary context, and
 - o suggesting guidelines for action – that is, putting the previous two points into practice
 → work towards a “Menu-driven document that will allow people to identify the elements of a strategic action plan for RK&M preservation” (vision document);
- More work is needed to delineate the concrete content the RK&M to be preserved;
- The idea of a ‘dual-track’ strategy (cf. glossary) is also present in literature, and deserves further analysis.

All members agreed both the bibliography in itself as well as the analysis presented to be a valuable part of the RK&M project. It was agreed that the analysis would also be continued, whether in the current format or in a more ambitious manner, once the abstracts will be reviewed and revised to provide more consistent information and data of each study in line with the structure of the analysis. With regard to the latter, the option to perform a proper content analysis (using software) on the (updated / revised) bibliography was discussed. This option was judged rather ambitious with regard to the time such an analysis requires, and also potentially problematic because of the diversity of languages and formats of the references.

The way in which the analysis of the reference bibliography will be continued will be discussed and a proposal prepared towards the next project meeting. Current abstracts will be reviewed and improved, to reflect a more comprehensive perspective in line with the structure of the analysis of the bibliography.

3. Analysis of project questionnaires - S. Wisbey

In 2010, representatives of waste agencies of 12 countries (Belgium, Canada, Finland, France, Hungary, Japan, Korea, Spain, Sweden, Switzerland, United Kingdom and the USA) answered five questions related to long-term preservation of information and memory in the field of geological disposal:

1. *What specific priority areas for long-term memory development have been identified in your agencies/countries? Which are the time scales of largest interest?*
2. *Do these priority proceed from good practice or/and from specific laws, regulations, policies exist in your country that set out requirements for long-term memory in long-term waste management?*
3. *How far advanced are you regarding establishing an action plan for long-term information and memory preservation in the field of geological disposal? Are you addressing the following RWMC questions:*
 - *What information should be preserved?*
 - *Why?*
 - *Where?*
 - *How should it be preserved?*

- *Which target groups?*
 - *Which time horizons?*
4. *What suggestions do you have for possible areas of focus for RWMC? (e.g. an international project that may assist Members?) What are the untapped areas that deserve more attention?*
5. *Would you have studies, research, reports, policies that you might share with RWMC members?*

Common themes throughout the answers were the following:

Long-term records should cover:

- Location and layout of facility
- Waste characteristics
- Safety assessment data
- Generally limited timescales

Key issues to be addressed include:

- National and International archives
- Archival quality media
- Use of 'exclusion zones'
- Markers – anticipated longer lifetimes

In 2011 a supplementary questionnaire was distributed. The following, additional questions were asked:

In your view, when making plans for preserving records, knowledge and memory:

- *Who should have responsibility for what and on which time scales?*
- *Vis-à-vis question 1, are we satisfied with the current guidance? In which direction should it be improved?*
- *What should government (policy makers) know or be told?*

This survey received a less extensive and representative response compared to the first survey. Agencies and individuals from Belgium, Finland, France, Germany, Hungary, Sweden, Switzerland and the UK sent replies.

An important finding was the lack of a common position about the role in time of regulators: does it end with licencing or is it never ending. The regulators's role indeed is not harmonized internationally. It was also noted that there may be several regulators involved, not only the nuclear safety regulator. It was argued that the notion of active institutional control is ultimately unrealistic over the very long term, due to the transient nature of institutions. The notion of transitional responsibility was mentioned as needing elaboration.

The survey seemed to reveal consensus about the key content of RK&M, namely information about the location, design and hazard of a repository and its content. Respondents also agreed upon the importance of international information sharing. It was pointed out that the interface with safeguards needs to be cleared, and that studying parallels with hazardous chemical waste may be useful.

4. Examples of RK&M loss – S. Tunbrant

This presentation gave descriptions and analyses of examples of RK&M loss that were provided by the project members. The purpose was to learn lessons from these examples for the case of final disposal of nuclear waste.

The examples treated were the following:

- Hazardous waste from chalk production, Switzerland
- Riet waste dump landfill, Switzerland
- Sinkhole phenomena along the TGV-line, France
- Hanford Radioactive waste disposal, USA
- Volgermeer waste dump, the Netherlands
- Antrax outbreak, Sweden
- Studsvic interim nuclear storage, Sweden

During the workshop, the example of Love Canal and of Utah mining tailings being used for road works were also mentioned.

The following conclusions and lessons were drawn from these examples:

- Records are not always sufficient, it is not because they exist that they are also remembered or even used. Moreover unexpected events may occur (e.g., flooding) that may have unforeseen impacts on data and records stored in archives.
- To recover or recreate inventory lists of old waste sites may require great efforts and entail great cost.
- Placing the waste far away and unmarked to prevent unintended intrusion, does not work necessarily. Places considered being ‘far away’ at the time, tend to be exploited when communities and industries evolve and grow.
- It is important to establish good communication path between different organizational units. There are examples when data and information are archived/preserved in one part of an organization (authority, company, municipality, etc.) and not available to another part of the same organization that needs the data/information.
- In the beginning it is better to preserve too much than too little.

Discussions during the workshop showed the importance of dedicated attention to the reasons for RK&M preservation (cf. why question in the collective statement), especially in relation to the fact that final disposal is about passive safety. Societal and ethical reasons should not be forgotten.

Moreover the issue of misuse, of purposeful misuse or neglect of information for profit was noted. The latter was added to a table that SKB derived after a workshop about incidents and risks related to record keeping and information transmission in 2008.

Incident	Consequence	Measure
War/sabotage. (Political)	Files or markers are destroyed or degraded.	Geographic redundancy of archives.
Society continuity breaks. (Political)	Loss of authority facts.	Geographic redundancy of archives. Markers.
Information preservation poorly performed. (Social)	Information is lost, entirely or partly.	Long-term mandate with clear responsibilities.
Change of language and importance of markers. (Social)	Misinterpretation can lead to wrong behaviour.	Regular update and revision of archives and markers.
Environmental changes. (Environment)	File or markers damaged or lost.	Geographic redundancy of archives.
Degradation of the medium. (Technical)	Misinterpretations.	Update medium. Several mediums, markers and archives.
Information has deliberately been withheld. (Political)	Information is lost, entirely or partly.	Established routines and transparency.

Table 1. Incidents, consequences and measures associated with record keeping and transmission of information to the near and more distant future.

5. Contaminated sites: memory loss experience – C. Sieber

Over a period of 50 years, the district of Zurich has financed four projects to catalogue contaminated sites. One lesson is that as soon as there is a new register, the older one fades, so any data that did not get transferred is lost.

Several concrete case studies were also presented:

- The Glattbrug case, where heavy contamination was discovered to be caused by a carbolineum plant that had been registered at the wrong place and was completely forgotten only 40 years after its closure.
- A case where contaminated municipal waste slag was used as compost by winegrowers, and where it was impossible afterwards to find any reliable data concerning the amount or location of compost deliveries.
- The Tössegg remediation case, where a number of steel barrels filled with acidic tar were buried above an important aquifer and below grassland. It took the combination of the local level delivering knowledge and the higher political level delivering power to come to action.
- The Harwald case, which shows a gap between risk assessment on the one hand and the implementation of results of such risk assessments on the other hand.

All of these cases reveal power game between state officials, representatives of the industry, technical experts, politics and the common man. Information may be out there, but not in the right place or not with the right people. It was thus pointed out that RK&M preservation is not only a scientific or a technical problem, but at least as much a social, political, economic, issue. *Differences in institutional interests, rivalry, politics and power imbalances play a major role.*

An important lesson was thus that one may improve the process of archiving, but one also needs to improve the distribution of information and its correct use. The principle of subsidiarity, which delegates power to the lowest competent authority, was judged to be helpful in potentially solving some of these problems, since the international and national level may be too distant and disinterested. The action is located at the local, district level.

It was also argued that the development of archiving solutions is only possible relying on the cooperation between the archives and specialists from other fields. It was underscored that archives have a regulatory role, and are, in a sense, societal regulators.

6. European study on waste data & records – W. Hilden

Preservation of RK&M starts in the pre-closure phase. A comprehensive waste inventory is required which needs to be maintained over significantly long time spans before RWM has reached the step of disposal. Since long term management solutions are often not clearly defined, disposal acceptance criteria are and cannot be known beforehand, at least not in early stages of disposal programmes. Thus a Preservation of RK&M should therefore be approached within the rationale of life cycle analysis.

There is a wide variety of approaches with regard to waste inventories at EU level, and retrieving data is often lengthy and difficult. The Commission dedicated a study to identify good practices and formulate recommendations.

There are two main issues; firstly waste data collection, recording and reporting, and secondly record keeping and knowledge transfer. One concerns the present time, while the other is concerned with long periods of time.

With regard to the analysis of data requirements, it was found that they depend on the context of their use, be it safe treatment, storage and disposal, policy making and capacity planning or funding. The study identifies for each use relevant data sets. Thus, the question of the purpose of RK&M preservation heavily influences the question of which records need to be maintained (cf. the RK&M Vision Document). This is also true with regard to the potential need to cope with changes of the regulatory system or overall RWM policy, which requires to preserve raw data in continuously accessible form. On the other hand the contextualization of data is needed, for which the safety case may be a useful tool.

With regard to legacy waste, re-assessment or re-conditioning campaigns should aim at maximum information gain. Agreements on how to coherently account for the total volume of the waste need to be made. A balance needs to be found between completeness and overload (watch out for “Keep everything, find nothing”). Data security is also an issue.

Responsibilities have to be defined as to waste data generation and recording, updating, preservation and reporting.

As good practice with regard to the question of how to preserve RK&M (cf. Vision Document), the study recommends establishing one comprehensive national database, keeping the data of all waste packages, from all waste producers and all locations. It is recommended for data collection and storage to use methods building on formalisation, preferably using a standardized software tool. Databases should be

used with on-line or even automated input. Searchability, accessibility, flexibility and preservation are aspects to be considered when designing the system. Data should be evaluated at regular intervals as function of time and technical developments.

For the long-term preservation of data, database backup techniques should be used. This should include backup servers, regular integrity check of backup copies, long-lasting backup media, separate sets of paper copies, regular transfer of waste data into national archives as well as geographical redundancy and use of dedicated electronic archives. The feasibility of a single, comprehensive national database was questioned, given the dynamism of the software industry.

With regard to reporting, lessons can be learned from the IEAE guidelines. On the other hand, substantial differences were found between reports to the EU and to the IAEA.

RK&M forms an important part of the new Council Directive on the management of SF and RW, (which asks member states to set up a national framework – to set up national programmes (a project planning, including post closure) – and to make an inventory). The Commission therefore intends to turn the study Commission Recommendation by the end of 2013.

8. UK Regulators' View on Long Term Records – Steve Griffiths

There are long time frames from the production of waste to packaging, transport, storage and final disposal in a repository. This entails changing custodians, as the responsible individuals and organisations change. This presentation once again pointed out the importance of a life cycle approach towards RK&M preservation and RWM in general. The traditional focus for the safety case has been examining individual facilities and short term goals (put bluntly, on 'getting the permit'). This approach does not lend itself to forward planning, or a holistic vision of the process.

The 'Radioactive waste management case' is an effort to integrate the different individual safety cases, and focus on waste streams rather than facilities, so that the trail of decisions is documented. The concept of 'waste streams' was explained as having been developed in the context of decommissioning, in order to make concrete the idea of 'cradle to grave' life cycle analysis.

The importance of creating an 'information management culture' at the level of organisations was underscored.

With regard to needing to find a balance between completeness and overload, it was once again pointed out that one needs to wary to avoid a situation of "Keep everything, find nothing".

9. Policy and Regulatory Implications of RK&M – M. Jensen

There are a number of valid, safety-related, reasons for initiatives to address the need of record keeping to retain memory of a repository after closure. Such initiatives are valuable through all stages of repository development, but are indispensable in the last stages of license dialogue. Regulatory guidance for such initiatives thus is needed to allow for a measured, optimized and graded; that is, it is a proportional approach. In the absence of guidance, the operator's or implementer's work is susceptible to uncertainties regarding direction, the proper use of research resources, and so on. Inspiration may be found in national regulatory frameworks such as the ones of Finland, Japan and Germany.

Nevertheless, the safety regulator alone may not possess all the necessary mandates needed for the transfer of records to a post closure archive. It is therefore advisable to formulate, at a government level, a project to establish the ultimate goal for RK&M, and the general steps that are needed. An additional issue requiring governmental action is the assessment of the RK&M initiatives' relation to international conventions, such as the Joint Convention, the Aarhus Convention and the Non-Proliferation Treaty (regarding safeguards). This presentation agreed with the fact that the local level indeed has a role to play, but highlighted that national, high level awareness is indispensable.

During discussions, it was acknowledged that RK&M preservation includes a large number of elusive matters that tend to blow up debates. Even so, the need for a more or less detailed reference that delineates boundaries is needed. Presuming that the present society is a model for the future society may be the most robust way to go about it, as this avoids the temptation to indulge in science fiction. This is also relevant when thinking about reconstruction measures to account for the fact the chain of information may be broken at some stage. The relevance of the international level and the importance of finding a balance between raw data and meta data was underlined.

It was pointed out that the issue of how the dimension of openness relates to safeguards deserves further attention.

10. The Contribution of the Social Sciences to Andra's RK&M preservation programme – L. Aparicio

Andra's research in the field of social sciences and humanities (SSH) takes currently place in the context of a Groupement de laboratoires devoted to the general theme "Transgenerational transfer and long-time scales". The research focus of the Groupement has been put on practices and specific devices related to the Cigéo project (geological disposal) with a view to the transmission of means and resources to next generations. The aim is thus to continue the transdisciplinary work they started on reversibility, but by expanding it towards the idea of next generations 'agency'. Within the axe of "Knowledge and Memory", a framework is currently being derived, consisting of a review of academic literature and a benchmarking study on very long term memory.

This work has identified some research fronts for the social sciences and humanities. For instance, in the field of economics, art and landscape, cultural studies, institutions, archives, etc. Nevertheless, a prominent result of the study is that although a lot of work has been conducted by RWM agencies, academic interest in the topic so far remains limited.

RK&M management is usually approached according to the logic of demonstration inspired by safety analysis, and makes a distinction between active and passive safety. Various dilemmas concerning the purpose, as well as the content and the supports, intended for RK&M preservation result from this demonstration approach. For example;

- What is the main objective, to facilitate or to avoid access (to remember or to forget, *in fine*, the existence of the repository)?
- What should be preserved, information or contextualized knowledge?
- Which are the most reliable devices, those intended for the long term or those for the short term, the technical (passive) or the social (active) devices?

An alternative 'demonstration' would consist of approaching the memory issue in term of dilemmas. And dilemmas, by definition, cannot be solved.

Taking dilemmas seriously and assuming that we have to deal with an uncertain world, means to examine the whole range of possibilities, with their respective pros and cons, in depth and in a creative manner.

11. Plenary Discussion – Led by E. Van Hove

In his summary of the first day, Professor Van Hove underlined that we can construct a rational model of data collection, division of responsibilities, and so on, but we can make it stronger when we accept a meta level; when we let social aspects enter into the rational schemes. History shows that all our rational super structures are ephemeral – what stays are the human, existentialistic parts. Therefore, with regard to the preservation of RK&M across generations the importance of making a repository locally valued was highlighted.⁵

On the other hand, waste may very well be something one may be more eager to (actively) forget than to remember. It was debated whether we should not differentiate between functional monuments and religious or spiritual monuments, i.e. between things people do and do not want to remember. It was agreed that we need to better understand the mechanisms of oblivion.

Moreover, when memory is preserved, we should not make the mistake to think that future generations will believe or listen to what we tell them. In fact we do not have any control over the fact whether future generations will follow our advice or not. If they think they are smarter than us, they will interfere with the repository. Should we therefore remove any potential advantages from the deep underground at the spot of the repository? Taken into consideration the growing interest in the deep underground, e.g. with regard to geothermal energy, very deep oil drilling etc., is this realistic?

Overall, Prof. Van Hove defends a social constructivist understanding of the issue. That is, values are also constructions, and context delivers the final meaning of everything. In this regard the topic of compensation was raised, deployed as a means to make a sustainable link between financial means (for example, via a robust fund structure) and the repository (cf. Belgian partnership approach for LILW disposal, where a local fund will be created and a broadly conceived communication centre constructed).

⁵ Cf. also FSC leaflet “Towards waste management facilities that become a durable and attractive part of the fabric of local community – relevant design features” (September 2008).

DAY 2

13. Insights from a comparison of conventional and radioactive waste: Objective and project longevity of programmes in Switzerland – T. Flüeler

Questions concerning ‘how safe is safe enough?’, and which levels of risk are acceptable, are societal questions. Geological disposal is a sociotechnical issue, not solely a technical one. Neither context, social nor technical, can dominate the other. The role of the regulator with regard to this integration needs to be stressed. There needs to be the combination of technical barriers and passive geology together with archives and symbols. There is a clear need for independent, multidisciplinary regulatory body / bodies, including safety authorities and pluralistic oversight committees, which must be able to implement of the principle of causality, provide competent oversight and ensure public involvement. In this context, the RISCOM model was referred to (cf. www.karita.se/our_approach/riscom_model.php).

When the geological disposal facility is sealed, the knowledge management needs to be taken over by an institution with a chance of surviving longer historical periods – presumably, the nation state, so that the reasoning behind the safety case is traceable.

In summary, the preservation of records, knowledge and memory across generations is potentially achievable via a trans-disciplinary, trans-political, trans-generational and socio-technical defence-in-depth process ensuring/aiming at a societal ownership of the problem over time.

14. Concerns and issues for what to keep during the operational phase and repositories, and how to keep it – N. Zoltan

This presentation provided a detailed overview of pre-operational and operational data collection. Waste generation and pre-disposal waste management may precede the start of a planned, organized RWM programme. Records Management System (RMS) should be developed as early as practicable. The importance of the early establishment of a coordinated, integrated and well managed information set was thus underlined. Information should be driven by the ‘back end’ of the waste management process, so that records required by the later stages are maintained throughout the earlier stages. RMSs should be systematic, given a high priority in the organisation and the ownership and responsibility of the RMS should be unambiguously clear. Each WM organisation should have a RMS group that oversees all phases of the RWL life cycle.

A distinction was made between generation, pre-disposal, pre-operational and operational records. Highly relevant suggestions were given with regard to the content of the pre-operational and the operational phase, by specifying the following components:

- *The pre-operational phase of a repository*
- Planning records

- Siting records
- Design records
- Licensing for construction records
- Licensing for operation records

• *The operational phase of a repository*

- Waste specific records
- Facility and site specific records
- General operational records
- Closure related records

It was pointed out that we should consider both the long term retrievability and the long term usefulness of records. Reproducibility, transparency and traceability thus are important requirements. This underlines the importance of meta-data (e.g. not only measurement result but also with which measurement tool, who did the measurement and other information concerning the origin of the data). The term ‘contextual data’ was suggested as an alternative. Both terms require attention to the fact that creativity is needed to think about what a person with a completely different reference frame would require to understand certain records was. Metadata was thus held to be part of quality assurance, but the ease with which this sort of data could be interpreted was questioned.

15. Preparing records as a function of waste life-phases – S. Wisbey

This presentation looked at ideas and suggestions for practical developments, which could be used to shape plans for records preparation to support the various phases of waste management, and to develop a common records format for the long-term.

Nuclear power generation is highly regulated, technologically advanced, socially controversial. It may turn out to be a transient industry, and has inter-generational effects. Records of radioactive waste management, leading up to and including ultimate disposal, will thus be required to satisfy a wide range of requirements. It has been proposed that to maximise the potential for surviving records to be correctly interpreted, a common format should be developed and applied internationally.

It is generally accepted that the nature of the required records will vary with time, generally needing less detail as time evolves and the hazard declines. This leads to the concept of ‘time-expired’ records, meaning that records that are ‘time-expired’ should be discarded, and the potential for developing records targeted at different future audiences. The use of information will most likely undergo a transition from direct to indirect oversight, and means should be adapted accordingly.

16. A Knowledge Management Perspective – J. Day

J. Day argued that the preservation of records is a necessary, but not a sufficient condition to enable intelligent future decision making and management of nuclear waste. He distinguishes knowledge management from information management. Information without the potential to act on it is information for its own sake. He believes that knowledge will be a key factor for the generations that follow us. Records need knowledge, and knowledge needs records.

A single representation of knowledge can be dangerous. Knowledge is multifaceted and complex, which necessitates a holistic approach.

Throughout the presentation the concepts of ‘knowledge readiness’ and ‘knowledge mothballing’ (the process of knowing, forgetting and relearning) were proposed. Based on experiences at Sellafield the actions of knowledge audit mapping (including technical, societal and historical knowledge), knowledge loss risk assessing (although we would like to we cannot hold on to everything, and should thus take a risk approach, asking ourselves what is at stake if we delete certain parts of information), and knowledge retention for the long term management of a nuclear facility were presented.

During the discussion, the link between knowledge and behaviour was raised. It was argued that the better informed people are, the less likely they are to make mistakes.

17. Digital Preservation at the Swiss Federal Archives – K. W. Ohnesorge

The Swiss Federal Archives (SFA) archives Swiss government data when it is no longer in use. The SFA is responsible for advising, inspecting and issuing directives in records management and archiving services in offices, agencies and institutions subjected to the Federal Act on Archiving; as well as archiving and disseminating records and data of archival value. With regard to RWM, it thus in fact is an additional regulator.

The conceptual basis for digital archiving at the SFA is based on the ISO OAIS Open Archival Information System Reference Model (ISO 14721:2003). The SFA use a process-orientated approach. The SFA and the Federal Office decide jointly which documents and data are to be archived. Archive-worthy documents and data are selected on the basis of a systematic appraisal. Wherever possible this should be carried out proactively - before the documents are actually created - based on an indexing or classification system. If there is clarity, people will know what data – and metadata – to keep for the submission. The submission is split into several stages, from appraisal to the conclusion of the submission. Information is never changed once it is archived, except that it carries out conservation measures. New information is a new submission. The sustainable information management is a core expertise of national archives. The SFA preserves digital records and data and is responsible for their secure and appropriate safe-keeping, description and dissemination.

For the archiving of relational databases (e.g. Microsoft Access, Oracle and SQL Server), the SFA have developed a format known as SIARD (Software Independent Archiving of Relational Databases). SIARD is an open standard and is supported by the SIARD Suite application, which can be used to convert relational databases into SIARD format. The SIARD Suite is now in use worldwide (over 170 downloads). The SFA distribute the SIARD Suite free of charge in conformity with the licence agreement. Currently, the SFA are working on Project Ellipse, the goal of which is to provide a solution for archiving the geodata for the entire federal administration.

It was pointed out that the development of archiving solutions is only possible with to the cooperation between the archives and specialists from other fields. In the next 20 years, if possible, international standards for file formats, metadata, interfaces, etc. will be established.

It was concluded during the workshop that national archives are powerful partners for preserving RK&M over long time scales. Their potential deserves further attention throughout the project.

18. ANDRA’s long term memory experiences and programme – J-N. Dumont & P. Charton

Maintaining the memory of repositories over the long term is required not only to ensure safety and reversibility (legal requirements), but also in response to social expectations. Since 2010, ANDRA has been implementing a long-term memory preservation programme to reinforce and diversify its current

arrangements in that field, as well as explore opportunities to extend memory keeping over thousands of years. As a reference solution, ANDRA uses the arrangement and practices in place at its surface disposal facilities.

Although at ANDRA they are well aware of the fact that the operational time of a LILW disposal corresponds more or less with the implementation time of a geological disposal, useful insights can nevertheless be gained from the experience with short-lived LILW. The reference solution implemented at the Centre de la Manche and de l'Aube includes five memorization devices, differentiating between passive and active memory keeping. There are three passive memories, consisting of copies with various degrees of information on permanent paper, and two active memories, consisting of oral transmissions under the form of events and meetings with various (local) stakeholders.

For HLW, ANDRA calculates a timescale of 200 years for the total implementation of a geological disposal, and a minimum of memory of 500 years afterwards, which necessitates conservation of RK&M for 700 years in total. Permanent paper lasts 600-1000 years. ANDRA also developed a sapphire disk which can contain large amounts of records and endure 1 million years. In fact this device created more questions; the purpose is exactly to question 'solutions' that are solely based on engineering. It for instance evokes questions such as "Which languages should we use, which graphical material should we add, how can we avoid vandalism, what meaning will future generations give to the traces we leave?"

All these issues and more are being investigated under ANDRA's long term memory preservation programme, in which the social sciences are heavily involved. In 2013 a large public debate will be organized about the project, and in 2015 the description of the memory preservation mechanisms will be included in the licencing application for a deep geological disposal.

During the discussion, it was clarified that the 'sapphire disk' could not be updated, but the plan would be to update the data every ten years and a new disk made. Also with regard to data carriers, it was questioned why for instance the Swiss Federal Archives go for 'all digital', while France would stick to paper. There are indeed pros and cons for both.

A concrete example of collaboration with the national archive was given: in 1994, the safety authority asked questions related to the centre the la Manche for which ANDRA did not have the answers. This encouraged them to work together with the national archive of France. In this context, the question arose whether ANDRA had conducted any work on also connecting with international archives, such as the IAEA and the UN.

20. Panel Discussion of the Film 'Into Eternity' – Led by M. Jensen

The film 'Into Eternity', directed by Michael Madsen, was released in 2010 (<http://www.intoeternitythemovie.com/synopsis/>). It documents the construction of the Onkalo Waste Repository nearby the Olkiluoto Nuclear Power Plant, Finland. The tone of the film is reflective, and focuses largely on how the enormous timeframes of geological disposal are being and should be addressed. It poses fundamental questions related to whether to remember or forget RWM repositories ("To remember forever to forget" is a quote from the movie). With regard to memory preservation, the documentary focusses on markers. It is mentioned by one of the experts interviewed in the film, that fact archives have the same troubles as surface storage facilities, which is exactly geological disposal is opted for.

It was pointed out by the discussants at the workshop that the fact that such a movie is made, proves the public interest and relevance of the topic of long term RK&M preservation. Discussions furthermore

centred on the use of markers, the expectations for future generations and the response to the film from the general public.

The film reflects about whether in fact it would be less likely that people would hit the repository by accident than that they would intrude due to the existence of markers. Nevertheless, one cannot force oblivion. People are curious in nature. Moreover, during discussions, the point was made that we cannot expect that the limits of our civilization have been reached. It was discussed whether we have moral obligations towards future generations, not only with regard to man, but also to the environment.

It was pointed out that, unlike archives, markers may cause a feeling rather than give a detailed message; they transfer a type of emotional information.

With regard to the timespans mentioned in regulatory documents, in line with current Swedish guidance documents, the documentary mentions 10 000 years. This was discussed by the workshop participants. Time frames for geological disposal are currently also under discussion at the ICRP; it is unlikely that timescales are mentioned.

It was noted that the film reflects that neither scientists nor scientific solutions are infallible. Overall, everybody agreed that the documentary gives an honest evaluation of the situation. The fact that the experts interviewed did not receive the questions beforehand, probably added to this authentic image.

Participants reported similar reactions of the public in various countries. Apart from those who are against deep geological disposal, who may find further arguments to back up their opposition in the dilemmas discussed in the film, all project members believed the movie not to have caused additional opposition. This was for instance the case for the UK, where the film was viewed by the local partnerships.

In France, ANDRA followed the French diffusion of the film and participated in some debates. An issue that came up was the need to preserve memory, given that the facility was designed to be permanently, passively safe. This made participants discuss the source of the question to preserve RK&M; is it, as it is often presented, indeed a societal desire?

SKB pointed out that the movie was shown on television Friday evening and in cinema's, but received rather limited reactions. It was pointed out that in general there is surprisingly little debate on nuclear issues in Sweden, and that RW is also a local issue.

Also in Switzerland, discussions following the movie were very calm and practical. Only one part was a bit difficult, namely the images with water running from the walls in the underground, as migration through water is a debated topic related to geological disposal in Switzerland.

21. One hundred thousand years back and forth: When archaeology meets radioactive waste – C Holtorf and A. Högberg

This presentation discussed the final repository of radioactive waste as an issue at the interface of the sciences and the humanities.

Archaeologists have learned that a hundred thousand years ago abstract thought and symbolism by humans began. Since then many communities of human beings have succeeded each other. They often intended to leave a mark for eternity, but they established in fact the truism that nothing ages faster than the future.

Archaeologists and historians are promoting remembering, learning and understanding of history for contemporary and future generations. Disposal sites of nuclear waste constitute a special case of heritage.

We are creating a very distinctive kind of heritage that in the future may be remembered or forgotten, just like any other heritage we create.

The presentation addressed what the realms of heritage and radioactive waste disposal can learn from each other regarding making provisions for the future. Rubbish reflects the conditions from which it originates. The final deposition of radioactive waste is by nature a question of historical consciousness and future uses of the past, of memory and forgetting, and of future didactics of history. Heritage studies as well as history and archaeology are thus inherently relevant. Similarities between archeology & RWM were thus pointed out, for instance the long time frames, specific sites, dealing with the meaning of rubbish, the fact that we both like to think we are doing something good for future generations, ... But there also are differences, notably that archaeology works with precious objects one wishes to keep. How will the future use our present, which is their past, for their own future? The *meaning* people give to information is important, and meaning is a continuous process of reinterpreting.

22. The BfE commissioned study on Markers in Geological Disposal – M. Buser

Marcos Buser presented the state of the art on markers by means of a literature survey; the study has synthesized the knowledge on markers, identified gaps and contradictions in the marker programmes and addressed research areas that have been covered in the past. The boundary conditions for the study were that it would take a very broad inter- and trans- disciplinary approach that incorporates results and evidences. Questions related to knowledge transfer and long-term societal issues show important gaps of knowledge, particularly regarding message transmission. The transmission process is strongly dependent on contextual understanding, and better understanding of such contextual changes is necessary for better encoding.

The general findings of the survey are:

- Need of synthesis has been confirmed
- Contradictions in the goals of marker strategies must be identified
- Entirety: although questions of technical nature or relating to the natural sciences are easier than societal questions, all processes must be analyzed from a inter- and trans-disciplinary point of view, and not from specific perspectives
- The importance of social sciences is greatly underestimated

The specific findings are:

- Research on intrusion motivation is crucial for the design of marker programs (as well as for the configuration of a repository)
- System development has to be understood, not just the development of single elements
- Findings in semiotic sciences, message transmission and misinterpretation and misuse are decisive

In the discussion, the question was raised whether the repository itself may acts as a marker, for instance because of the fact that all advanced drills apparently have a radiation detector, or, additionally, by adding symbols on the walls of the shafts.

Buser underlined that knowledge transfer and long-term societal issues raises a series of questions related to stability of societies, stability of social structures, evolution of laws and regulations, transfer problems and loss of memory, misuse and manipulation. In this context, the comment was made that the distinction social and technical gaps in knowledge were less clear-cut than had been suggested by the presentation.

There was some disagreement on this point; while the presenter held that the previously mentioned issues are of social nature, others defended that all issues are socio-technical.

It was argued that there needs to be a more imaginative approach when considering possible motivations for intrusions. Currently, there is a reliance on liberal, capitalist reasoning on this issue.

23. The Need for Proportionate Systems for Markers and Records in the Long Term, and How to Plan for Them – A. Van Luik

Passive Institutional Controls (PICs) are markers and archives designed to warn and inform future generations about the location, purpose and to some extent the content of a repository. These warnings are addressed to potential intruders into deep geologic repositories, advertent and inadvertent.

Current thought is that rather than attempt to manipulate the emotions of future generations through ominous symbolic warnings, the structures and messages ought to *inform* those generations that the content of the repository is dangerous and useless. The presenter raised the issue that although careful efforts were made to show that there is no valuable resources in Yucca Mountain, it is undeniable that a repository project involves a massive amount of valuable materials.

It was asked why markers were labelled ‘passive’ controls. It was explained that under EPA definitions, ‘active’ controls cover the use of fences, gates, and guards; essentially, those structures and systems which imply continued human presence. Markers are ‘Passive Institutional Controls’ because they are intended to fulfil their purpose without the need for anyone to remain on site.

In discussing this specific understanding of ‘passive’ and ‘active’ controls, the comment was made that there had been no mention of the fact there are going to be regulators and institutions for a long time; neither had the presentation discussed the role local communities could play with regards to monitoring and record keeping. It was suggested that the focus remained too strongly on passive controls. It was suggested that it would be better to see the marker system as the redundancy in the event that all continuity – of institutions or of community – was broken. It was suggested furthermore that there should be some agreed terminology which expressed this scenario.

In response to the comment on using the local communities, Van Luik explained there was a reluctance to rely on the community in question, because as it is highly dependened on the presense of the oil and gas industry and WIPP. The difference between the USA and Europe, with regards to climate and the density of the population, was raised. It was argued that in the different circumstances, the notion of guardianship was unworkable. Another context related matter was pointed out: Yucca Mountain uses the WIPP design with regard to PIC’s, but adapted to a mountain environment: there is collaboration on design and messages, but materials have to be adapted to localities.

The ethical dimension was also touched upon throughout the presentation and subsequent discussion. It was stated that markers, monuments and archives are the ethical thing to do by this generation, as long as they are not unreasonable for this current society in terms of cost and effort. Clarification was requested on the relative cost of preventing a potential death in 10 000 years and saving someone today (cf. Appendix D Nordic Studies).

The possibility of future generations misusing markers was also raised – for example, if they became collectables. It was argued that one’s moral responsibility had been fulfilled once you have put a warning in place. This position was contested, as there are plenty of examples of warnings failing – for example, those at the entrance to pyramids did not deter grave robbers. The response was that it was important to learn from such examples and try and create more resilient warnings. For example, current thinking on the

subject favours trying to inform future generations, rather than trying to scare people away. If our best efforts fail, we have still met our moral responsibility. The example of the failure of the tsunami markers in Japan was given in this context: although they failed, older generations did their duty, their ethical obligation to future generations.

Some more factual issues were also clarified: WIPP called a ‘pilot plant’, because in the beginning it was, and now the name is kept because of its illustrative function. WIPP is now half full.

EPA requires WIPP to have 10 000 year lasting markers, whereas Yucca Mountain legislation said ‘as long as possible’. In response to the comment on using the local communities, Van Luik explained there was a reluctance to rely on the community in question, because as it is highly dependent on the presence of the oil and gas industry and WIPP, *activities that cannot be relied on to support a community thousands of years into the future.*

24. Plenary Discussion – Led by E. Van Hove

Prof. Van Hove pointed out the mixture of both reassurances and discouragements throughout the presentations of the day. Although there seems to exist confidence with regard to the endurance of technical devices and materials, how to transfer and maintain less concrete things to and on them, such as meaning, tacit knowledge, and meta data, clearly needs further elaboration. This finding got confirmed by representatives the USA, where the materials to make the markers are agreed upon, but uncertainty persists with regard to the messages and symbols accompanying these markers. The characterization of the long term preservation as a socio-technical challenge thereby was confirmed.

In dealing with such challenges, we need to acknowledge that some of our implicit assumptions may be false. For instance, we should not presume that future generations will be docile and simply obey our instructions. It seems more realistic that intrusion will happen, also in light of developing technologies. Therefore, social controls to safeguard the integrity of a repository should be mustered, for instance through the creation of local funds and multiple use surface facilities.

A second assumption that we should not take for granted, is the survival of modern scientific understanding. We should not presuppose the future possession of scientific language, but should also include the most simple messages. Thirdly, we can not predict the future. The speaker therefore proposes to see the long term as an extension of the responsibility we feel for the next generations.

Throughout the discussion, the ‘why’ question was underlined as needing clarification, especially with regard to the connection between RK&M and safety. Is the preservation of RK&M solely a reassurance for the inherently passive safety of geological disposal, or has it a more substantial role to play? Should we merely focus on inadvertent intrusion, or should we also try to foresee future ‘advertent intrusion’? To answer such questions related to the why of RK&M, it was suggested that clarifications with regard to the origin of the desire to preserve RK&M may be useful. We easily assume that it mainly is a public, ethical demand, but politics and regulators also seem to favour it. It was pointed out that the same debate is taking place with regard to the notions of R&R, which are clearly connected to RK&M.

DAY 3**26. The Connection between the Areas of Safeguards and Physical Protection and Record and Memory Keeping – P. Ormai**

Safeguards are concerned with nuclear — especially fissile — materials and associated technology. In general, nuclear safeguards exist on different levels, each with different motivations (the facility operator, national authority, international authority). Safeguards basically comes down to accountancy on fissile material (mainly U and Pu), which seeks to verify the “material balance” .

For international nuclear safeguards, accountancy assures that nuclear materials are present and used as intended. International safeguards are called for by treaties and other agreements between parties. Euratom and IAEA are the main actors. Implementing safeguards for geological disposal is considered a big challenge as it is a new area.

Although the complementarity between safeguards and general RK&M preservation was pointed out, there are also substantial differences. With regard to complementarity, it was mentioned that the challenges for preserving of IAEA safeguards relevant information and documentation are the same as that of other long term archiving. An effective application of safeguards shall assure continuity-of-knowledge about the nuclear material in the repository. A variety of technical tools enables safeguards to provide accountancy and continuity of knowledge of nuclear materials..

On the other hand it was mentioned that safeguards are only interested in fissile materials, so e.g. not really in intermediate level waste. Moreover, safeguards records keeping is a State, not a waste agency responsibility. Some more fundamental, challenging differences were also pointed out. For instance, although the record-keeping requirements for retrievability and safeguards might be considered to be complementary, their aims are in fact opposite. Safeguards can only be abandoned in case of practical irretrievability. Whether this is possible remains a question mark. In any case spent fuel will never be regarded as ‘waste’ by the safeguards community. Another issue is the potential contradiction between the spirit of openness of RK&M preservation, in line with for instance the Aarhus and the Joint Convention, whereas safeguards information is deliberately not publicly available. This poses a challenge, especially in connection to nuclear weapon states.

27. RWMC Related Work in the Areas of RK&M and the Connection to the ‘Added Value’ Concepts and the ‘Memory’ Aspects of the FSC Programme of Work – C. Pescatore

For geological disposal sites, the time scales over which the hazard exists are enormous. It must be accepted that the current generation’s capacity to assure continued integrity cannot be projected indefinitely into the future, but rather diminishes with time. At the same time there is a common understanding that we should neither ‘walk away’ from these facilities nor to hide them, even when we think they will be safe. In fact, the sense of safety will be coming from continuing, over time, some element of familiarity and control. Hence the need to conceptualise a ‘rolling future’ in which each

generation takes responsibility to provide continuity and safety for the succeeding several generations, including a need for flexibility and adaptability to circumstances as they change.

The idea of archives and markers that last as long as possible (the technological approach) continues to be central. However, we are beginning to understand today that physical markers and archives may need to be complemented by – or integrated within – a cultural tradition that could be sustained over time starting with the planning of a repository and continuing through its implementation and beyond its closure. The mandated need to install ‘permanent’ records and markers can only be fulfilled if one aims to make them become part of the local, subsequent cultures, and ideally be renewed as their materials are degraded, or as their significance evolves.

Because a radioactive waste repository and site will be a permanent presence in a host community for a very long time, a fruitful, positive relationship must be established with those residing there, now and in the future. Simply put, designers have to make the facility and site to suit people's present needs, ambitions and likings, and provide for evolutions to match, at reasonable cost, the needs and desires of future generations. The challenge is to design and implement a facility (with its surroundings) that is not only accepted, but in fact becomes a part of the fabric of local life and even something of which the community can be proud. Parts of the facility and its surroundings may thus become themselves cherished markers of the existence of an underground waste repository.

With regard to the suggestion to turn a surface facility connected to a geological disposal into a marker during the discussion the point was made that it would still be a long way from the waste itself, and only cover a very small part of the total surface of the underground disposal. On the other hand, the importance of this was questioned, since the danger presented by the waste a few square kilometres underground is also rather diffuse, and not restricted to the dimension of the underground facility.

It was mentioned that in the USA a visitor's centre and museum were being examined, but financial constraints restrict this approach.

The use of the word ‘oversight’ was questioned, as it has two possible contrary meanings. It was suggested that another word was found which would convey the meaning less ambiguously. There was some clarification of the difference between the terms ‘control’ and ‘oversight’. A ‘control’ can function without a person to operate it, whilst ‘oversight’ requires human presence.

It was pointed out that whilst most would like believe that future generations will be more intelligent and sophisticated, this is not guaranteed.

It was argued that in order to develop a supportive local community, there needs to be acceptance of the whole process within that community from the beginning. The process of engaging with the community so they feel a level of responsibility for the preservation of the memory of the facility must begin with the siting process, and include the technical decision making.

28. Preservation of RK&M for Long Term Storage Facilities: The Results of a French Study – T. Schneider

Due to the specific long lasting radioactivity of high level waste types, new issues may arise for radiation protection. In this perspective, technical, societal and organizational aspects have to be considered. For the two latter aspects, it is interesting to analyse the efficiency of protection systems available in other fields than nuclear waste management, in order either to protect society from specific risk or to preserve world heritage. Few years ago, CEPN together with MUTADIS have performed a specific study, commissioned by CEA (Commissariat à l'Energie Atomique). The presentation briefly presented the case studies

performed on long term protection, as well as the key lessons related to the continuity and sustainability of the surveillance and control of radioactive waste facilities, and the effectiveness of financing schemes for the long term management of radioactive waste. This study has identified a set of performance criteria to deal with long term protection. These results were notably discussed within the framework of the European project COWAM 2 in a working group involving experts, authorities, waste managers, locally elected representatives and NGOs.

One part of the study was to analyse the characteristics of protection systems used to manage risks associated with the presence of past underground cavities and mines. A case study presented was the following: After the closing of last mines, maintenance also ended, which, years later, caused ground collapses which led to discussions on responsibility. The connection between the safety problems and the loss of economic activities was underlined. In this context, the IGC (Inspection Générale des Carrières) was set up. An important part of its functioning is the interaction with the building owners of Paris. The arrangement is that the current owners pay for assuring safety, even though the cause of the safety issue goes back long before owners bought the premises. It was pointed out that market value clearly has a role to play in the functioning of this system: outside Paris such a system perhaps would not work.

Another part of the study investigated the mechanisms designed and implemented by UNESCO for the preservation of world heritage sites. ‘Heritage’ is a word that expresses solidarity between local, regional, national and international level. It could thus be an inspirational theme for the RK&M project, also in with regard to the organisational level (e.g. monitoring, connection to sustainable development, ...)

The possibility of making surface facilities or markers part of UNESCO world heritage was further discussed after the presentation. This would have the advantage of really being ‘dual track’ memory conservation. It was observed that there had been a debate at UNESCO about the possibility of using a similar method at Chernobyl. The conclusion had been that given that the area was contaminated, it would be a good idea to put some value into protecting it – but that this would be very difficult to implement.

It was concluded that it was important to have both records and community awareness, as the one strengthened the efficacy of the other. However, in relation to the connection between RWM and heritage, it was pointed out that it is very difficult to know what the next generation will find valuable. Moreover, also connected to the previous presentation, the comment was made that the spirit of the community is perhaps not as amenable to control as it is implied by the presentations.

29. Embedding the Past in the Present – E. Van Hove

Archives get lost, monuments are often destroyed or their meaning forgotten. A third way to retain the past is to make it part of present daily life.

Prof. Van Hove talked about an organisation that takes care of handicapped children, which originated out of an old boarding school run by nuns. He was involved in a project about how to constitute an archive and give such an institution its memory back. The background of this project is the fact that such organisations are today less backed by the caring spirit, the cultural, idealistic context of before, and ever more becoming part of an average business environment. The project thus wanted to make past and present meet.

In trying to do so, oral tradition was a major source of information. Such traditions developed for instance through practices such as younger nuns looking after sick, elder nuns, during which a lot of talking was done. Moreover there existed written sources of information, such as personal diaries, letters, ... By putting these different pieces together, the past was reconstructed. The speaker pointed out that every record is

almost a story of itself, under the condition that the interpreter has some historical background. This memory circulation and transition is enabled by community feeling; connectedness.

Prof. Van Hove thus highlighted the notion of a ‘human memory’. He referred in this regard to the relationship between local communities and RWM implementers. This is not about handing out written information documents, but about “inseminating information into the community”.

Living information, for example about incidents and strange things that happened one day, can be added to promote a ‘human memory’ among local communities. Archives take information outside society, and hide it somewhere far away from daily life. If we want to make the past useful for the present and future, we need to take into consideration the living memory.

There are various types of means to insert people with information. Referring once more to the illustration of the care taking centre, the meeting rooms at the centre are filled with living information, mixing pieces of past and present. They also organised a meeting between the nuns (the story tellers) and the young people working there now (the listeners and future story tellers). The same can be done at nuclear facilities, where elder and retired employees have a valuable role to play by interaction with younger generations of employees. At WIPP, the tour guides for instance are retired employees.

In summary, in order to preserve RK&M, one needs to make it into a human story. A ‘living memory’ is a very important complement to record keeping systems.

It was suggested that three parts of our project should be acknowledged: archives, markers or monuments, and ‘heritage’.

ABSTRACTS OF THE PRESENTATIONS

3. Analysis of project questionnaires - S. Wisbey

Records, Knowledge and Memory Project – Survey of Status and Needs (reported in March 2010)

The RWMC commissioned a survey of approaches to the preservation of long-term records, and received a report on the results at the 43rd meeting, held in March 2010. Those results have formed an input to the initial stages of the Records, Knowledge and Memory (RK&M) Project. This note consists of an analysis of the March 2010 survey to: summarise responses, identify common themes, and make proposals for further work items. The questionnaire consisted of five detailed questions, reproduced in Annex 1 to this note.

Analysis of the Survey Results

Twelve formal replies were received from national agencies, together with a partial response (focusing on published literature) from the IAEA. Agencies from the following countries responded: Canada, Finland, France, Hungary, Sweden, Switzerland, UK, USA. Additional responses were received from agencies in: Belgium, Japan, Korea and Spain. Eight of those agencies now form part of the NEA Working Group. There was no response from a number of significant players in the field, including: Germany, Russia, Netherlands, China, Czech Republic.

Most of the responses were discursive, and some had significant reference lists. In order to present a summary output that is easily assimilated, all the responses are summarised against the following questions:

What should be preserved?
 How should it be kept?
 How long to keep it for?

The summarised results are given in Annex 2 to this note.

Analysis of Common Themes

Analysis of these responses led to the identification of some common themes. These are set out in the following list:

Location and layout: there is a strong consensus that the location of the disposal facility, and aspects of its layout (including ‘as built’ design) are key aspects of information required for long-term preservation.

Waste characteristics: the nature of the waste, its origin, inventory, and material properties were also highly valued by respondents.

Safety assessment data: many responses identified safety assessment data as important, mainly because it gives context to time dependent risk, but also because it relates to site evaluation information.

National and International archives: the use of specialist archives, staffed by professionals, forms part of the plans of many national agencies

Archival quality media: in order to preserve information into the distant future, it is widely recognised that the quality of the media is vital.

Generally limited timescales: there is a general consensus that the active management of records must be targeted on timescales for which there is some historical precedent – none of the respondents suggested that records are designed to reach beyond about 1,000 years

‘Exclusion zones’: several responses describe plans or legal requirements for physical exclusion zones around the facility – again the timescale for which this applies does not appear to extend beyond several hundreds of years.

Site markers: many respondents mention the use of site markers, which are anticipated or legally ‘required’ to be functional over much longer lifetimes.

Although some progress has been made in addressing most of these themes, with the exception of archival media, none were considered to be technically ‘mature’. Many of these themes will therefore need to be further developed as part of the work of the RK&M project.

Less Developed or Novel Concepts

The questionnaire also raised a number of issues, some new, others partially developed or explored in other programmes, which seem to have the potential for application to the RK&M project. These are described below:

Review the history of loss and retention of records: much can be learned through studies of the manner in which organisations retain and dispose of information (either actively or by passive neglect).

Distinguish between active and passive systems: by investing in both active maintenance of records (inspection and renewal) and passive retention (dedicated archive services) it might be argued that the chance of retaining memory in the long-term is maximised.

Develop mechanisms for records using a ‘dual track’ approach, developed and applied in parallel:

Support to decision making – this recognises the importance of retaining information during the project lifetime to enable key decisions

Long-term warnings – the development of systems to provide ‘new information’ in the long-term future, on the assumption that all memory of a disposal facility has been lost.

Commission proposals for a common format for records: if the international community can agree on a common records format, then even fragmentary information from one programme may be recognised and interpreted due to surviving records from another programme.

Develop marker systems on various spatial and temporal scales:

Develop large surface structures to act as long-term markers – small marker systems are vulnerable to collection and erosion, whereas large ones, visible from aerial surveys or even from space, are known to have survived for thousands of years

Consider use of ‘time capsules’ – building a sense of expectation about the recovery and examination of information concealed in such capsules may help with its onward transfer

Place records ‘out of harm’s way’ – notwithstanding the technical challenges, the use of satellites, perhaps in highly elliptical orbits (cf. comets) could provide a method of storing and periodically transmitting information to future users.

It is considered that over long time periods (more than 100 years), there is significant vulnerability to organisational change. Even with planned transfer of knowledge and responsibility, the chain of information transfer will inevitably become a lower priority issue, particularly as one curator is replaced by another with ‘fresh ideas’. This is considered to be inevitable on the basis of historical precedent, and will result in the general down-grading of historical information. Ultimately this path leads to partial or total loss of information.

A Possible Way Forward

Any active method of preserving information is vulnerable to economic and social change. Potential changes can occur suddenly and in unexpected ways. The future will always remain uncertain and even our best efforts may soon be forgotten, as technology advances or as more pressing problems appear in society. Ultimately we may have to simply accept that we can only offer a diverse set of records, and trust that some long-term memory will survive.

As an example, consider the UK public library service, which may have been expected to play a role in providing access to records. It is currently under severe threat, with the management of local libraries being offered to local communities. Even if they remain open, the community-based managers may not understand, or be able to afford, the need for preservation of technical data. Similarly, the research library of the NDA in the UK was closed in 2010. This was done on the grounds of cost and the availability of data via the internet. At a stroke, this avenue for information retention may be closed.

It may be suggested that an advanced society will maintain the ability to detect radioactive material and will re-discover a ‘lost’ repository before they intrude. Given its importance to the natural behaviour of ‘planet Earth’, we can be reasonably confident that knowledge of radioactivity and its harmful effects will be retained. We also know that a geological repository is likely to provide a substantial magnetic and/or gravitational anomaly to any pre-drilling survey. Therefore members of such an advanced society will not be likely to suffer serious harm, even if all records are lost.

In contrast, a degraded society will have much more serious problems, relating to personal subsistence and health. This is likely to result in significantly reduced life expectancy, to the extent that the potential harm from a ‘lost’ repository may not be realised. Therefore members of such a society would not benefit from the protection we are planning. Whether this is a sustainable ethical position remains to be demonstrated.

Summary and Conclusion

In conclusion, the outcome of the ‘Status and Needs Survey’ provides very useful direction for the on-going plans of the RK&M project. The key questions are not really technical, but are now emerging in social sciences.

On this basis, it appears that there is a need to consult specialists in key fields, including Ethics (our responsibility to the future), Archiving (for detailed guidance on what, how and where to preserve

information), and Cultural Studies (to explore the power of story and tradition). These issues are being developed within the scope of work planned for the RK&M project, and are picked up in the Vision document.

Records, Knowledge and Memory Project – Supplementary Questionnaire (2011)

During 2011 the NEA RK&M project commissioned a supplementary survey of approaches to the preservation of long-term records, requesting more details of national planning for preserving records, knowledge and memory. This note consists of an analysis of the 2011 survey to: summarise responses, identify common themes, and make proposals for further work items. The questionnaire consisted of three detailed questions, reproduced in Annex 1 to this note.

The additional questions focus on:

Who should have responsibility, for what, for how long
Current satisfaction with guidance, and how it could be improved
Provision of information to government / policy makers

Responses were received from agencies and individuals from the following countries: Belgium, Finland, France, Germany, Hungary, Sweden, Switzerland and United Kingdom. All of those nations are now represented on the NEA Working Group. There has been no response from a number of significant players in the field, including: Canada, United States, Netherlands, Japan, Korea, Czech Republic.

Analysis of the Survey Results

The responses to the 2011 survey were generally quite short, and were not supported by reference lists. This is in marked contrast to the previous questionnaire, for which responses were generally discursive, with some significant reference material identified.

There was a notable diversity of responses. In particular, three of the responses focused on existing national arrangements, whereas the other five made a more general response. There was also diversity over the role of regulators.

The summarised results are given in Annex 2 to this note.

Analysis of Common Themes

Analysis of these responses led to the identification of some common themes. These are set out in the following list:

Question 1

Role of the developer: all respondents identified the facility developer as having a key role, noting that some nations have captured this in law

Key information: there was broad agreement that the key information covers facility location, design and nature of the hazard

Timescales: several of the respondents stated a requirement for 'permanent' retention, often reflecting legal or regulatory provisions

International dimension: there appears to be general support for sharing of information between nations, although plans are not substantially developed

Question 2

Satisfied: three of the nations, with well-developed legal and regulatory frameworks (Finland, Germany and Switzerland) appear to be satisfied with the current guidance

Unsatisfied: the remaining five respondents recognise the need for further guidance and harmonisation of records management arrangements

Question 3

Key responsibility: there is general agreement that governments and policy makers (usually equivalent to funding bodies) must know enough to make properly informed decisions, with awareness of the potential consequences of information loss

Other Responses

Interface with safeguards arrangements: there was recognition by several respondents that disposal facilities designed for nuclear materials will need to consider arrangements for safeguards, with attendant information retention needs

Parallel with hazardous chemical waste: there was recognition by several respondents that there are significant parallels between the management of radioactive and chemically toxic wastes, and that lessons could be learned from experience in other fields

There appears to be a measure of consensus on the types of key information, the importance of the international dimension, and reference to useful parallels (including safeguards arrangements and the treatment of chemical hazards).

Although some progress has been made in addressing most of these themes, none were considered to be technically 'mature'. Many of these themes will therefore need to be further developed as part of the work of the RK&M project.

Summary and Conclusion

The incomplete response to the 'Supplementary Questionnaire' could be summarised as 'inconclusive'. The diversity of responses seems to reflect the different regulatory regimes, and the current analysis provides limited clear direction for the on-going plans of the RK&M project. The areas in which developments might usefully be made by the project appear to include the following:

- Development of international consensus for sharing and retaining information
- Development of guidance on records management for the long term
- Investigation of the implication of safeguarding wastes for records
- Investigation of lessons from management practice for other toxic wastes

Further responses may add clarity, and these should be encouraged from all 'signed-up' members of the RK&M project. As noted in the analysis of the original 'Status and Needs' survey, the key questions are not really technical, but are now emerging in social sciences.

*Annex 1***NEA RK&M Supplementary Questionnaire (2011)**

When making plans for preserving RK&M:

Question 1 Who should have responsibility for what, and on which time scales?

Question 2 With respect to the previous question, are you satisfied with the current guidance? In what direction should it be improved?

Question 3 What should government / policy makers know, or be told?

Question 4 What suggestions do you have for possible areas of focus for RWMC? (e.g. an international project that may assist members?) What are the untapped areas that deserve more attention?

Question 5 Would you have studies, research, reports, policies that you might share with RWMC members?

Annex 2

Summary of Responses to the NEA RK&M Supplementary Questionnaire (2011)

National Response	Who should have responsibility, and for what, for how long?	Are you satisfied with current guidance – if not, how to improve?	What should government / policy makers know / be told?
Belgian	Focus on who and what. Records: facility developer and regulators. Knowledge: state level, be aware of gradual loss. Memory: international level	Further guidance / harmonisation required	This is a key responsibility, so there is a need to know
Finnish	Safety authorities, information on the facility and the waste, permanent retention	Current position adequate, more detail needed, including discussion on markers	Time schedules and requirements, encourage international cooperation
French	Facility developer and regulators, passive system of records, information to be reviewed periodically	Only the start of the process, develop multiple parallel methods of retention	Government responsible for archives, use international bodies, comparison with hazardous chemical waste
German	Developer provides information, regulator sets timescales, authorities preserve and provide access	Relatively content, safety requirements document exists	Need to set framework, start collecting information, make comparison with hazardous wastes
Hungarian	Facility developer, then authorities during institutional control	Improvements needed to deal with complexity – make guidance user-friendly	Government responsible for legal framework – should not be too prescriptive
Swedish	Developer during phases to final closure, then transfer to society; basic	Need more clarity on long-term preservation of information, parallel with	Need to be aware of potential and consequences of loss, desire for

National Response	Who should have responsibility, and for what, for how long?	Are you satisfied with current guidance – if not, how to improve?	What should government / policy makers know / be told?
	information on location and hazard, archives to allow for redundancy	toxic waste	international cooperation, safeguards link noted
Swiss	Requirements captured in law: developer to compile document and mark the site, government to maintain records and transfer to international agencies	Content with current guidance	Seeking a joint international approach
British	Information to be held by those who would take action; gradual transfer from developer to government, safeguards body; consider skill-base	Not satisfied, need a toolbox of good practice, practical lessons learned	Funding body needs to be able to judge risks and opportunities

4. Examples of Loss of RK&M and Possible Countermeasures as Received by the Members – S. Tunbrant

This paper gives my conclusions from the examples of memory loss that I received before the workshop with the OECD/NEA RK&M project in October 2011. It also includes full versions of the examples.

The purpose is to learn lessons from these examples that can be applied in terms of final disposal of nuclear waste.

Conclusions

There are many examples on loss of records, knowledge and memory (RK&M) – and the consequences of these losses in the field of industrial history, for example from disposal of common or industrial waste in landfills. Reasons for loss of RK&M may be that records never were established, the data stored were not sufficient or that one organizational unit in a company does not know what the other is doing. Lessons learned from the examples are:

- To recover or recreate inventory lists of old waste sites often requires great efforts and are done at great cost.
- Placing the waste far away, and not marked, to prevent unintended intrusion does not work. Places considered being “far away” at the time, tend to be exploited when communities and industries evolve and grow.
- It is important to establish good communication path between different organizational units. There are examples when data and information are archived/preserved in one part of an organization (authority, company, municipality, etc.) and not available for another part of the same organization, that needs the data/information.
- In the beginning it is better to preserve too much than too little.
- Records are not always sufficient. Unexpected things (for example heavy rains that undermine the ground) might happen even though data and information are available in archives.

A central issue is to better understand the reasons/driving forces for long-term memory keeping. Why shall we preserve information and knowledge? Societal/ethical reasons, long-term safety and requirements linked to international requirements for safeguards are three possible reasons. The long-term safety reason is not obvious, since a deep underground final repository for high-level waste should be safe without monitoring or surveillance.

In the short term it is clear that we should manage today's knowledge and information so that the long term goals can be reached. The long term goals are to avoid damage by unintended human intrusion and to make decisions based on sufficient knowledge (use of the site, withdrawal of waste packages, etc.). Another goal is to make it possible for future generations to understand the decisions made by our generation and the sociological context in which they were taken.

Potential incidents leading to loss of RK&M

In May 2008 SKB organized a workshop with various Swedish stakeholders. The aim was to – with an open mind – highlight incidents and risks and propose alternatives for taking action associated with record keeping and transmission of information to the near and more distant future. The goal was to identify and

analyze incidents (= factors that may affect the transmission of information) and their consequences. The incidents were divided into different categories (political, social, economic, technological, environmental and other). Furthermore, possible measures to reduce the risk or mitigate the consequences were identified.

During the workshop many aspects of the issue of preservation of information far into the future were discussed and examined. Among other things, it was emphasized that the loss of information may take place both in the near future and in a distant future. However the time horizons to be considered may not be as not as important as questions related to the evolution of society, considering both political development and environmental changes, e.g. natural disaster (continuity versus discontinuity).

Table 1 presents the incidents, consequences and measures that were identified at the workshop and valued as relevant with respect to probability and consequences. The incident “Information has deliberately been withheld” was added after the discussion at the RK&M workshop in October 2011.

Table 1. Incidents, consequences and measures associated with record keeping and transmission of information to the near and more distant future.

Incident	Consequence	Measure
War/sabotage. (Political)	Files or markers are destroyed or degraded.	Geographic redundancy of archives.
Society continuity breaks. (Political)	Loss of authority facts.	Geographic redundancy of archives. Markers.
Information preservation poorly performed. (Social)	Information is lost, entirely or partly.	Long-term mandate with clear responsibilities.
Change of language and importance of markers. (Social)	Misinterpretation can lead to wrong behaviour.	Regular update and revision of archives and markers.
Environmental changes. (Environment)	File or markers damaged or lost.	Geographic redundancy of archives.
Degradation of the medium. (Technical)	Misinterpretations.	Update medium. Several mediums, markers and archives.
Information has deliberately been withheld. (Political)	Information is lost, entirely or partly.	Established routines and transparency.

Some examples of memory loss

The examples are based on inputs from Marcos Buser, (Switzerland), Patrick Charton, (France), Nagy Zoltan (Hungary), Abe Van Luik, (USA), Claudio Pescatore (IAEA, example from Netherlands) and from Sweden.

Conventional waste disposal, Switzerland

In Switzerland there are many examples of how information about landfills and industrial sites was lost within a single generation. This is also demonstrated by the attempts of the government to acquire information about the deposited waste in hindsight.

Fabrique de Chaux SA, St-Ursanne, Jura, 1995–1997 and Céramiques industrielles SA (CISA), Bonfol, Jura, 1995–1997

Source of the problem: Loss of archives/records regarding hazardous wastes. In both cases, there was an erroneous destruction of the technical archives of the companies. As a result, valuable knowledge about the facilities was lost.

Between 1907 and 1993 the Fabrique de Chaux St-Ursanne SA produced fired chalk from reef limestone with very high carbonate content, the reef limestone was extracted from an underground mine in the Jurassic mountains. The mine is located directly above a local aquifer and below two rivers that accommodate various pools with fish farms. Hydro geological studies showed that colorants injected in the mine reached the rivers within a few hours.

The Fabrique de Chaux backfilled several major galleries in the western part of the old mine with their industrial waste. Among the different sorts of wastes were also barrels containing heavy oil from the operation of the lime kiln. The great hazard posed to rivers and groundwater by the oil residues led to the complete clean up of the filled galleries.

Due to a lack of economic prospects Fabrique de Chaux St.Ursanne SA stopped operation in 1993 and sold the facilities to a waste management company. This company went bankrupt in March 1997. In turn, the bankruptcy office in charge vacated the archives. The cantonal environment agency was brought in to assess the documents; it rated the technical documents of the factory not as sufficiently valuable to warrant further archiving. All technical reports were thus destroyed. In consequence, valuable knowledge about the infrastructure of the factory was lost, and needed to be restored with great expenditure.

A similar situation appeared in the case of Céramiques Industrielles de Bonfol SA (CISA), which operated a large clay pit for more than two decades. In the early sixties of the last century, in order to comply with the requirements and obligations of the clean-up of the pit, CISA sold the rights of the pit to a company of the Basel Chemical Industry. This company then converted the mine via several stages into a hazardous waste landfill. In 1975, the hazardous waste landfill was closed. Starting in 2000, the Basel Chemical Industry committed itself to clean up their old hazardous waste site completely. In 2000, CISA went bankruptcy as well. As in the case of the Fabrique de Chaux St.Ursanne SA, the technical and geological reports, including plans of the old pit, have been destroyed completely due to carelessness. As a result, valuable knowledge was lost, which would have been of great value for the clean-up of the waste site.

Major errors: Although clean up was already planned or in progress at both contaminated sites, the communication between the relevant administrative bodies failed. In both cases, the importance of the technical and geological records for the clean-up was not recognized.

Lessons learned: Fabrique de Chaux St-Ursanne SA is a typical example for the disposal of hazardous waste in the industrialized nations of Europe of the 20th century. Since then, cadastres of old waste sites had to be created with great effort and great cost and clean ups of particularly hazardous locations are being initiated.

Interdisciplinary contacts have to be ensured when dealing with complex problems. It is not enough when government agencies carry out their statutory duties. It is also necessary, that the legitimate call for a massive selection of documents that will be passed on doesn't come down to chance but considers the long-term significance.

Waste landfill site of Riet

Source of the problem: Agricultural drainage systems below a waste dump.

Problem that surged: The landfill Riet is the big disposal site for domestic and industrial waste of the city of Winterthur. It is operated since the beginning of the 20th century and was, as far as the old parts of the landfill are concerned, built on an ancient system of drainage ditches and drains which were part of a large agricultural melioration. The landfill was operated until the seventies without any further protective measures. One of these ditches was used as a central waste water drainage of the landfill. This way, the landfill leakage found its way directly into a stream, respectively, the ground water.

After groundwater contamination had occurred, the responsible authorities decided to clean up the waste site. The exploration work and the redevelopment plan also included historical studies. In the course of this work the old agricultural melioration plans were rediscovered, and the importance of the old drains for the drainage of the landfill was realized.

Major errors: From today's perspective, one was not aware of the danger of waste materials with regards to the ground water. At the time, the city council had chosen a very remote area. The environmental pollution by the landfill was only recognized once there was a shift in the perception of ecological values.

Lessons learned: First of all, it shows, that concepts for final disposal and security considerations change in the course of time; in consequence, fundamentally new questions about long-term safety validation arise. Second, it is seen from this example how important interdisciplinary contacts are. For decades, it did not cross the minds of the investigating geologist to consult with the drainage plans of the cantonal melioration office.

Measurements of boreholes and markers

As part of the Swiss' "deep geological repositories" sectoral plan, the available historical geological information has been re-evaluated. It was found that the data of drilling (coordinates, altitude, length, etc.) was very often entered incorrectly. In hindsight, these errors are no longer correctable or correction requires great effort.

Underground quarries and chalk mines, France

The tragedy/catastrophe of Clamart

On the 1st of June 1961, there was a great underground roar/rumbling in between the municipalities of Clamart and Issy les Moulineaux (in the suburbs of Paris). A moment later six hectares of chalk quarry collapse to a height of two to four meters at the edge of the town. Six streets disappeared, almost three hundred buildings were severely damaged, 21 persons died and 45 were injured

The causes of the disaster have never been proven with certainty. Some speak of a collapse of the poor condition of the quarry. However, the quarries were known and under surveillance (visit of an engineer two month earlier). The collapse of the mines/quarries was (partly) attributed to the intense rain events that occurred earlier in the week.

The sinkhole phenomena along the TGV-Nord line in France

Sinkholes phenomena have been causing technical and security problems for the high speed railway line (TGV) in northern France. The occurrence of cavities in the ground and the sinkholes phenomena (the collapse of the cavities) can be explained in different ways:

The cavities have been attributed three different origins:
Underground works from World War I

Abandoned quarries and chalk mines Natural cavities and dissolution features in chalk

The underground works from WW I are relatively well known and the archives (including maps and aerial photos) are of great quality. Information on underground quarries and chalk mines in that region is relatively poor. The mines/quarries were often small-scale exploitations, in some cases illegal and were poorly registered.

After detailed geotechnical studies, about half of the sinkholes were attributed to natural reasons (dissolution of features in the local geology).

The fact that the sinkholes occurred at specific periods of time is strongly correlated to heavy rain events (as for example in 1993 and again in 2001).

The national inspectorate of quarries (founded in 1777)

The inspectorate was created after a catastrophe occurring in 1774 when several hundred meters of the Rue d'Enfer in Paris collapsed. The accident was attributed to the collapse of old/forgotten chalk mines/quarries. Chalk and limestone was exploited since Middle Age outside of Paris but with the growth of the city the areas that were used for chalk exploitation soon became part of the city and built on, without considering/knowing about the old underground cavities and quarries.

Additional investigation program, Hungary

Within Hungary, radioactive waste is finally disposed only in Radioactive Waste Processing and Storage Facility (hereinafter RWPS) operating in Püspökszilágy. The efforts made by PURAM during the last three years in 90's in relation to the RWPS were oriented on prolongation of the operational license of the facility by the authorities. With this aim in mind the reconstruction of the facilities of the RWPS and the preparation of the safety assessment corresponding to the state-of-art level were started. To satisfy the geological environment related information demand of safety assessment, a site characterization program was carried out by a PURAM's subcontractor. The results of these geological investigations were not accepted by the competent geological authority because the authority could not form an opinion on the basis of the available information about the favourable classification of the decisive geological properties from the perspective of the facility's safety requirements. For this reason additional geological investigations and the uniform approach of the "old" and new information were ordered by the geological authority. The additional investigational program was carried out by a new subcontractor between 2003–2006 years.

Very soon it became apparent during the data processing, that some information originating from earlier investigation programs are not fit for use, because of the lack of metadata, which would allow to judge the reliability and the quality of these information and which would allow their "reprocessing". There was unable to verify some previous reasoning because the reports in which these reasoning were outlined did not contain information about the data processing. There was unable to determine the original dataset and which data from the original dataset were involved in the data processing. For this reason some former sampling plan, some former measurement program and some data processing were renewed, were did over again.

On the basis of these experiences PURAM realized among others the importance of metadata describing the circumstances of the data-origin, and the importance of strictly documentation of all data processing. The first version both of the data processing and the data uploading guidelines were set up by PURAM on the basis of these experiences.

A new practice was installed by PURAM at this time that an investigation report (a work) may be accepted and paid in that case only, when the information related to the report (to the work) together with their metadata are uploaded by the “authors” (subcontractors) into the PURAM’s Safety Case Supporting Information System, which includes among others databases and a knowledgebase too.

Radioactive waste disposal, USA

Based on Haass et. al., 2007. Case study of anomalies encountered during remediation of mixed low-level waste burial grounds in the 100 and 300 areas of Hanford site.

The Hanford site was established in 1943 as part of the Manhattan Project on the Columbia River, Washington. During 1945–1975 radioactive waste was buried away from the facilities. The waste was disposed at a place that, at the time, was considered to be “far away”, to prevent unintended intrusion. It was not marked, not to attract attention and so it would be safe. The waste was run into when excavating for another purposes.

The records were not totally lost, but inadequate. The paper stresses the effort that has to be made to remediate past, inadequate documented, waste disposal facilities.

Lessons learned: Places considered to be “far away” tending to be exploited when communities and industries evolve and grow.

Waste dump, Netherlands

Volgermeerpolder waste dump is situated in Waterland on the northern border of Amsterdam. (Is is not a polder. The name is a mistake made by a mapmaker in 1853.) From 1927 it was used as a dump for Amsterdam. In the 1960s there were chemical industrial waste added, including residues from manufacture of pesticides.

In 1980 were the first toxic vessels discovered accidentally and in 1998 a decision was taken to use a new technique and cover the former landfill with foil. The method was tested successfully in 2001 and full scale work started in 2006. Now the area has been successfully transformed into a recreational area, opened for the public. The restoration work was expensive and laborious, and would have been much easier if information about the site had been preserved.

Interim nuclear waste storage and Antrax outbreak, Sweden, Studsvik

Studsvik offers the treatment of low and intermediate-level waste in Sweden, USA, and UK. The primary purpose is to achieve volume-reduction and stabilization of the waste before disposal.

The documentation in Sweden of interim stored waste from 1970’s was properly done due to the requirements at the time, but does not fulfil the requirements of today. Prior to final disposal, all wastes are classified again to assess whether it shall be deposited in the repository for long-lived radioactive waste, or in the final repository for short-lived waste. It is a time-consuming work.

Lesson learned: Now Studsvik plan to save “everything” until the waste is disposed in a final repository.

Anthrax

Anthrax is a bacterial infection that can be passed from animals to humans through close contact with dead or dying animals that carry the disease. People who became infected often show a skin infection that can be treated with antibiotics, but bacteria can, in rare cases cause a severe respiratory infection. During the 1900s, anthrax was a not uncommon cause of sudden death, mainly among cattle but also among pigs, horses, sheep and goats. When the bacteria get in contact with air, it forms a highly resistant spore. It was therefore a tradition that dead animals would absolutely not be opened or removed to reduce the risk of spreading the very resistant bacteria. They were immediately buried often in close proximity to where they died. The old archives have unfortunately no list of where these burial sites are located.

The bacteria can survive very long in the earth and excavation work can uncover infected soil and spread the infection. There was one outbreak in southwest of Sweden in 2008. The place was cleaned up and no human was infected. In August 2011 – another outbreak of anthrax was confirmed on a farm in the county of Örebro, central part of Sweden. Anthrax spores may have spread from the source of infection via a stream that runs through the pasture.

At the outbreak of anthrax in 2008 the National Veterinary Institute searched historical background to the cause of the outbreak. During 1956–1957, there had been a major outbreak of anthrax among cattle in the county, caused by an imported consignment bone meal that was contaminated with anthrax spores. However, there was no indication of where the animals had been buried, but the scientific summary that was made after the outbreak, contained an overview of the number of anthrax cases in Sweden from 1901 to 1957. It turned out that outbreaks had occurred sometime in all counties. Most cases were in the southern and central parts of the country but also in the northern counties.

In 2010 the National Veterinary Institute initiated a project to search existing archives and try to locate the farms that had been affected and, if possible, where the animals were buried. The goal is to make a geographical survey of the affected areas, that can be used for both investigations both in the infectious area and when the land shall be processed or the land use changed, for example excavation or construction work.

5. Contaminated sites: memory loss experience – C. Sieber

Marc Twain put it succinctly: The only earthly certainty is oblivion. In waste management, we are well aware of the problem. The present contribution presents a few common, real-life cases. Our experience shows that after an astonishingly short time, aftercare-monitoring or the required remediation of conventional waste disposal sites is usually neglected. You may improve the process of archiving. But you also need to improve the distribution of information and its correct use. The organizing principle of subsidiarity, which delegates power to the lowest competent authority, may help solve some of these problems.

High Efforts on Registration

In 1960, a register of contaminated sites was established in the district of Zurich. It is not clear whether there had been any earlier projects because nobody is taking the time to investigate that question. Accordingly, data from 1960 or earlier may be forever lost or inaccessible. In 1973, another register of contaminated sites, named „Waste Deposit Concept“, was evaluated. During the following 10 years, a great deal of remediation work was done on many of the registered sites. As a result, we have got meters of important documents, including hundreds of colour slides.

In 1990 we started the „Remediation Project: Register, Evaluate, Remediate“. Its incorporation of industrial and accident sites was a novelty. 10 years later, the remediation project had to be redone according to new national standards. By the end of September 2011, the directorate celebrated the end of the „Registration of Contaminated Sites“. Over a period of fifty years, the district of Zurich financed four projects to register contaminated sites. These combined efforts prevented the oblivion of contaminated sites in Zurich. That's the good message. But the story also illustrates what kind of effort is needed to preserve the memory of contaminated sites. And despite our archives, the older records are fading.

The Glattbrugg Case

In 2002, a new office complex was constructed in the community of Glattbrugg near Zurich. The register of contaminated sites indicated an abandoned petrol station and an oil spill on the project site. During the excavation work an oily, water insoluble, flammable, dark brown coal tar mixture was found. The actual contamination had nothing to do with a petrol station or an oil accident. Investigations led to a carbolineum plant that had been abandoned in 1963 and registered in the wrong place. Carbolineum (also known as creosote) is a highly carcinogenic residue from the coal gasification process. It's not just the probable registration error that is bewildering. It is rather disturbing that 40 years after the closure of a widely known plant, neither landowners nor local authorities nor planners found any such information while gathering data in preparation for the excavation work. Sometimes there are more reasons to blur the facts than to register them.

The Case of Municipal Waste Compost

In 1893, the City of Zurich started operating its first waste incineration plant. In 1993, a hundred years later, the district of Zurich had sufficient incineration capacity to burn all its municipal waste in waste incineration plants. In 1968, the Zurich Cantonal Winegrowers Commission proposed using the so-called „compost“ from municipal waste in order to reduce the amount of municipal waste slag. In the following years, the highly contaminated „compost“ was extensively used by winegrowers and hobby gardeners for soil improvement. According to the Commission, it would loosen the soil, store fertilizers and retain soil heat. In 1995, one generation later, there was a remediation case involving municipal waste compost. It was impossible to find any reliable data in our archives concerning the amount or location of compost deliveries. That doesn't mean that the knowledge about these things has completely disappeared. The state organization does probably have accurate information. But it will be hard to gain access to the information or to get the approval to publish it.

The Tössegg Remediation

In 1968, geologists, industrial chemists and state officials decided to bury a number of steel barrels filled with acidic tar, a slump product from the remediation of used oil. They created a dump site in the calm and quiet grasslands called „Tössegg“, above an important, highly productive aquifer. In 1973 the disposal site was full. In 1988 aftercare was abandoned because the sewage appeared to be clean. The grassland was again calm, and the acid tar disposal fell successively into oblivion.

However, when you approached the vegetation you would find small black acidic tar drops penetrating the overburden and the soil so beloved by the cattle, posing dangers to cattle and children. Two expert panels came to the conclusion that remediation measures were needed because PCB hindered the biodegradation of the organic compounds. The dump posed a considerable potential risk to the underlying aquifer. The experts' opinion was in contradiction to that of the authorities. So the acid tar site again fell into oblivion.

Eventually, help came from politics. The mayor of Wildberg, a farmer, ended his political career. Before he left, he asked for a clear statement concerning „this Tössegg thing“ from his political colleagues in the

government. That was the chance we had been waiting for, because the request now came from politics to the administration or from top to bottom. The administration knew the answer. And now it had the necessary political push. The authority was now able to develop the project towards complete remediation. The question from outside had been essential; in this case it had come from a retiring mayor. Another essential point had been the link with local politics. Furthermore, a certain top-bottom-top – process had been helpful: top here stands for power and bottom for knowledge.

Aftercare: The Hardwald Case

According to Swiss legislation from 1990, a minimum of 15 years of aftercare is required for “bioactive” landfills. The announced “revision 2013” of the respective Technical Ordinance on Waste will probably increase this period to 25 or even 50 years. The district of Zurich assumes an aftercare period of 50 years when calculating aftercare costs. Other districts assume an aftercare of 100 years. These figures are usually in contrast to the reality.

The Hardwald in the communities of Weiningen and Unterengstringen was originally a forest, then a gravel pit and, between 1946 and 1974, the main waste disposal site of the City of Zurich. To give you an example: much more acidic tar was deposited in the Hardwald area than in the already mentioned Tössegg waste disposal site. In 1978, when a new highway was built through the site, it became necessary to construct a methane degassing system in order to control the risk of explosions. Over time, the authorities remarked the absence of any aftercare. So in 1986, a monitoring system was installed. Four years later, the aftercare budget was spent and monitoring was reduced to degasification. Around eight years later, the site of an industrial complex bordering on the Hardwald was found to be contaminated, the contamination originating most probably from leachate from the Hardwald site. For two years, another groundwater monitoring system was installed. We have not at all forgotten the Hardwald disposal site. It is even treated as a potential high risk. So in 2010 we started another investigation campaign. The only thing is there is an astonishing gap between risk assessment on the one side and the implementation of the results of the assessment on the other. And the way we ignore the facts instead of taking action caricatures our aftercare standards. We do have plenty of information and knowledge. But on the political level, the time for remediation is not ripe yet.

Sometimes children don't pass on their fathers' knowledge of environmental sins. In late September 2011, a license was issued that permits reusing the „Moosbrunnen Springs“ in the community of Lufingen. Within the catchment area near the springs, there is a bioactive landfill. Operation of the landfill ceased in 1991. The community as applicant is well aware of the site and the date of closure. But 20 years after closure, it denies any potential risk. And we as the granting authority approve.

Daily Power Politics Governs

There are many investigations on truly disastrous contaminated sites. For the district of Basel, Martin Forter described one century of environmental exploitation by the Basel chemical industry. His very readable book is titled “Farbenspiel”. It is not only a play of colours or a play with colours. It is a power play or a power game between state officials, representatives of the industry, technical experts, politics and the common man. The facts and figures were usually good enough to base a decision upon. But information or knowledge were allocated in an extremely biased way. Moreover, facts were denied by one party or another. Scientists from the Swiss Aquatic Research Institute EAWAG or technical advisers such as hydrogeologists normally had the correct answers or questions but very little influence.

So sometimes the feeling prevails that a major problem is the way information is distributed between the different players and the way it will be used by the players. It's one task to improve the distribution of information and knowledge. It's another task to improve the correct use of existing information. Here, the organising principle of subsidiarity may help. It proposes that matters ought to be handled by the smallest,

lowest or least centralized competent authority so decisions may also grow from bottom to top. Decision making is influenced by and often start with trivial daily politics. The principle of subsidiarity reflects this fact.

6. EC Study: Radioactive waste and spent fuel data collection, reporting, record keeping and knowledge transfer by EU Member States - W. Hilden

Introduction

Knowledge preservation in the context of disposal includes waste data and is of key importance also in the pre-disposal phase. The availability of a comprehensive and sufficiently detailed waste inventory is essential for the definition of management solutions for each relevant type of waste and their subsequent implementation. However, long-term management solutions are often not clearly defined. This leads to uncertainties as regards future waste acceptance criteria and the required waste data. It also requires preserving data over significantly long time spans before waste management has reached its ultimate step, i.e. disposal. It is therefore of utmost importance that all potentially required waste data are identified, recorded in real time, near real-time or periodically, as appropriate, and to the extent necessary and preserved for long time spans. Experiences made in the EU and also world-wide indicate, however, that there is a wide variety in the approaches implemented by the various actors at national level. It appears therefore useful to identify good practices and recommendations to address these challenges. To this end, the Commission ordered a study to analyse the situation in EU Member States, to identify shortcomings and good practices and finally provide conclusions and suggestions. Two main issues had to be addressed: waste data collection, recording and reporting as well as record keeping and knowledge transfer. The work was carried out by Brenk Systemplanung, Aachen, Germany. Results were published in 2008 and are available on the WEB site of the European Commission⁶.

Study findings

The following outline summarises the most important findings of the study, together with follow-up initiatives planned by the European Commission in the context of the recently adopted Directive on the management of spent fuel and radioactive waste⁷.

Analysis of data requirements

Requirements as to the contents and precision of waste data depend on the context of their use, be it safe treatment, storage and disposal, policy making and capacity planning or funding. The study identifies for each use relevant data sets.

For planning purposes, data like volume, mass, activity, heat generation, fission products/nuclides relevant for criticality, place of origin, physical and chemical properties as well as biological and pathogenic properties (waste from medical applications) are required. For treatment, conditioning and disposal, additional data are needed depending on the process involved, such as compressibility, waste content, corrosiveness, residual fissile material, etc. As to safety, the location of a package (tracking), radiation (dose rate, radiation type), toxicity (radiological, biological, chemical), fire (e.g. flammability, explosiveness), leaching (e.g. gas generation, corrosiveness, reactivity) as well as the potential for criminal use has to be considered.

In addition, responsibilities have to be defined as to waste data generation and recording, updating, preservation and reporting.

⁶ [http://ec.europa.eu/energy/nuclear/waste_management/doc/0707-03_finalreport_090916_\(2\).pdf](http://ec.europa.eu/energy/nuclear/waste_management/doc/0707-03_finalreport_090916_(2).pdf)

⁷ Council Directive 2011/70/Euratom of 19 July 2011 establishing a Community framework for the responsible and safe management of spent fuel and radioactive waste, OJ L 199, 2.8.2011, p. 48–56

Whenever possible, it is recommended for data collection and storage to use methods building on formalisation, such as a form or a software tool. Databases should be used with on-line or even automated input. Searchability, accessibility, flexibility and preservation are aspects to be considered when designing the system.

Reporting normally is an inherent part of supervision and can be useful as back-up as already recommended for decommissioning by IAEA Guide WS-G-2.1. In this context, issues like reporting intervals, scope, format, responsibilities, consequences of missing or wrong data and control mechanisms have to be defined.

As to data preservation in the pre-disposal phase, it is essential that data are available for the demonstration of safety whenever needed and as input to the next management step. When considering the potential need to cope with changes of the regulatory system or the overall waste management policy (e.g. classification, inventory keeping), there is a need to preserve raw data in continuously accessible form and to foresee continual migration of electronic databases as well as back-ups. In the post-closure phase data do not need to be updated anymore, therefore paper archives can be a valid option for data preservation in addition to electronic means.

Good practices

As a first good practice, the study recommends to establish one comprehensive national database, keeping the data of all waste packages, from all waste producers and all locations. This provides easy and rapid update of national inventories and a broad overview for national institutions (e.g. to determine interim storage capacities and disposal needs). Further advantages are reduced transmission errors, less delays and more flexibility.

As to data entry into the national database, it is recommended to do it on-line. Depending on the size of the nuclear programme, this could be direct data entry or by use of distributed database networks. Data could also be transferred by electronic means. Important is that transmission routes are kept short and double data entry is avoided. As a result, the process is fast, does not suffer from transcription errors and leads to up-to-date inventories.

It is furthermore found to be a good practice to have the data records as comprehensive as possible and to keep them permanently, also after emplacement (at least quantity, package characteristics, total + specific activity, physical/chemical state, safety relevant non-radioactive substances).

Legacy waste often poses a problem here as databases are found to be faulty or incomplete. Here the study recommends achieving maximum information gain during re-assessment or re-conditioning campaigns and to apply measurements or analyses, possibly making use of key-nuclides. Reliance on waste history and calculations should be minimised or avoided while respecting ALARA principles.

Data should be evaluated at regular intervals as function of time and technical developments. Trending can help to identify the need for technical re-orientations or adaptations, e.g. as to decommissioning waste.

To avoid costly maintenance and updating and to ensure maintenance and update over decades, the study recommends using only a few or no customised programs and preferably standard software of large companies.

For the long-term preservation of data, database backup techniques should be used. This should include backup servers, regular integrity check of backup copies, long-lasting backup media, separate sets of paper copies, regular transfer of waste data into national archives as well as geographical redundancy and use of dedicated electronic archives

Follow-up by the European Commission

The new Council Directive on the management of spent fuel and radioactive waste requires Member States to establish and maintain a national legislative, regulatory and organisational framework and to ensure the development and implementation of comprehensive national programmes for all spent fuel and radioactive waste from civilian activities and from generation to disposal.

Beyond others, national programmes shall comprise a spent fuel and radioactive waste inventory as well as estimated future quantities. To that end, good data management practices play a key role.

The Commission therefore intends to develop until end 2013 a non-binding Commission Recommendation in consultation with relevant stakeholders. The study results will provide an important but not sole input here. Experiences made by stakeholders when improving their data management will be equally important to arrive at meaningful recommendations.

Conclusions

Acquiring correct and meaningful data and to preserve them over sometimes very long time spans is of key importance also in the pre-disposal phase. Normally, it takes decades until a repository is developed and uncertainties about the data requirements at the time of waste acceptance represent an additional challenge. Thus, it is strongly recommended to optimise data management methodologies and systems and it is hoped that the Commission study and the planned recommendation will help authorities, organisations and companies to achieve this goal.

8. UK Regulators Long-term Management of Higher Activity Radioactive Wastes on Nuclear Sites – S. Griffiths

UK Government covers the disposal of ‘higher activity’ waste in England and Wales. It is based on three assumptions:

- The construction of a geological disposal facility
- Safe and secure interim storage of waste on nuclear sites
- A strong and independent regulator

There are regulatory requirements for safety and environmental care, transport and disposal.

The long timescales for this process imply changing “custodians”, both individuals and organisations, who will need access to the information.

Safety cases are used to demonstrate an adequate plan has been developed for the waste, though to disposal. The focus is on waste streams, rather than facilities, and the continuity of oversight. The pertinent records and information ‘travel’ with the waste as the management phase changes.

Regulators can facilitate this process by minimising the changes and additions to legislative requirements, avoiding the repetition of earlier safety case information and requiring that information is accessible and decisions are auditable. It is also important for regulators to bear in mind the unusually long timescales under consideration.

The Radioactive Waste Management Case (RWMC) has been designed as a single summary document to aid this process. In addition, organisations need to promote a culture of information management, so the value of records is understood, and relevant information is treated appropriately.

This might include (or refer to);

- options study

- justification of chosen disposal route
- advice from NDA RWMD (potential disposal operators)
- stakeholder dialogue
- QA documents, R&D, design, operational aspects
- package inventory records
- storage arrangements for packaged wastes

Many of the required activities were already being carried out and were fully understood by site staff. However,

- is the information available specific, complete, coherent and “frozen” (could regulators make a decision against version controlled documents)?
- is it in one place?
- is the information visible to all stakeholders (“line of sight”, especially regulators)?
- will the (relevant) information be available in the future?
- will future stakeholders understand the full picture (project staff, contractors, regulators, new management (companies), repository operators)?
- is information about failed/changed initiatives included?

Organisations need to recognise the value of the information, risks associated with losing key information and the life time costs of managing information. It is important to create a culture where everyone, at all levels of an organisation, is committed and understands the needs and processes associated with managing information. The big challenge is making it happen.

Organisations need to collect and actively manage appropriate, consistent, accurate and adequate information over the lifecycle:

- to meet national and international reporting obligations
- to meet statutory requirements
- to equip future waste management organisations with information they need to safely manage wastes

Records form basis for information transfer. Therefore, we need to keep and manage records for the next waste custodian, whether that is the waste producer (new incoming company), waste conditioner/packager, waste disposal organisation, or the National Nuclear Archive.

Information management systems and procedures can be broken down to three parts:

- Creation
- Storage
- Preservation

The key is managing the information – if you keep everything, you will find nothing. In other words, you won't be able to see the woods for the trees.

When organizing records storage and transfer, there are standards and guidance for records storage facilities. It is permissible to transfer records to an off-site archive operated by a third party. However they still maintain responsibility for records relating to waste that is currently under their jurisdiction. One can transfer responsibility for records relating to waste that is transferred to a new custodian

The key is to manage the information, so that it remains relevant, visible and useful.

The Joint Guidance is available to view at;

<http://www.hse.gov.uk/nuclear/wastemanage.htm>

Part 1 - The Regulatory Process

Part 2 - Radioactive Waste Management Case

Part 3a - Waste minimisation, characterisation and segregation

Part 3b - Conditioning and disposability

Part 3c - Storage of radioactive waste

Part 3d - Managing information and records

9. Preservation of Records, Knowledge and Memory Across Generations: Policy and Regulatory Implications - M. Jensen

Background

Successful nuclear waste programs most often include extensive societal dialogue. The licensing dialogue is in itself an example of a highly regulated discourse, but through various formal requirements in areas such as the environmental impact assessment process also questions more general in nature are included. More generally, there is a natural requisite to produce answers, and the long time scale itself generates a series of new questions.

Within the safety assessment, so-called what-if questions can be used to demonstrate understanding of e.g. a particular barrier, but questions could also stem from a wish to grasp the longevity of society's records keeping and memory (RK&M) of a radioactive waste repository:

Regarding preservation of records and memory

- How long will records and memory be available (and thus prevent any inadvertent disturbance of the repository)?

The parallel to the safety analysis is

- What happens to the repository's radioactive content (if undisturbed) after 10, 100 million, or a billion years?

RK&M can be seen as a question related to both ethics and confidence in the technology. In particular, RK&M is related to

- hypothetical remedial action,
- inadvertent intrusion, and
- other formal requirements assumed for the post closure period, such as
 - environmental post closure supervision and
 - safeguards.

Stages of RK&M

One centrifugal principle that must be overcome in international cooperation is that countries in different stages of repository development will have different views on the issue. What is expected to be available in different stages of repository development is obviously very different:

In a very early stage it may be worthwhile to mention the issue, i.e. the issue has low priority but is not forgotten. Later stages might warrant some research, literature studies, and following ongoing research. In a license dialogue it is natural that the issue is addressed more explicitly, by assuming a measured, optimized or proportionate position, preferentially following an international consensus position.

What kind of repositories would benefit from RK&M?

The NEA collective statement document on RK&M (NEA_RWM, March 2011) suggests that proportionate measures are taken, i.e. a graded approach, taking into account both wastes radioactive content - regarding the activity concentration, radiotoxicity and longevity - and the repository design.

In Sweden a national plan has been established to describe all waste streams and to denote areas where future work or national decisions are needed. One such case is Chapter 4 of the national waste plan:

- **Title**
“Conservation of Information for long-term control of landfills and disposal”, with the
- **stated goal**
“The State shall maintain a register that allows long-term preservation of information the location, design and content of the near-surface disposal sites and geological repository for radioactive waste”, and
- **Suggestion**
A State registry is established. The government appoints a government agency with the task of establishing a register to enable long-term preservation of information on landfills and disposal of long-lived radioactive waste.

The Swedish waste plan considers not only geological repositories, but also municipal waste disposal sites. These may accept radioactive components through several radioactive waste streams, originating from

- Waste with naturally occurring radioactive waste material, so called NORM waste,
- Waste subject to exemption. i.e. waste from radioactive material which has never been in regulated, and
- Waste subject to clearance and to conditional clearance

The third point is of special importance. A regulator may accept that material is disposed of in a municipal site, in excess of the clearance levels, if the population exposure following the disposal is limited to a low annual dose, around 10 $\mu\text{Sv/a}$, in the EU and IAEA as stated in their respective versions of the Basic Safety Standards, BSS. However, the calculation of dose to individuals involves assumption that the radioactive waste is limited in exposure scenarios. Such assumptions may rely on the disposal site being undisturbed, i.e. not only remembered but also subject to present land use restrictions, i.e. all the prerequisite of RK&M.

Therefore, there are no reasons in principle to exclude any waste stream from the activities, or benefits of RK&M.

National governments' management of eternity

The elusive nature of references to societies the distant future merits some special attention. There is already today a built-in ambiguousness in present societal practices. State (i.e. national government) archiving institutions are expected to keep archives for all eternity. The Swedish church books explain decisions in connection with a graveyard, formulated in the following form “The grave is granted for eternity”. (The decisions stem from the time when Sweden had a state church, and thus represent a formal

national government decision.) The concept of eternity is meant to convey a meaning of sincerity and absoluteness. The contradiction involved in its formal or informal use is not seen as problematic in itself.

In 1898, the British and Chinese governments signed the Second Convention of Peking, which included a ninety-nine year lease agreement for the islands surrounding Hong Kong. The example of the British agreement with China on Hong Kong is probably the longest time period that can be expected in societal planning. However, in the Anglo-Saxon common law⁸, some provisions exist in the form of “the Rule Against Perpetuities”. The ninety-nine years in the lease of Hong Kong probably stems from this concept, judging from the peculiar choice of the number ninety-nine. This legal concept is designed to prevent property from being tied up and controlled for too long from the grave, through testaments. It is not a general precaution against paradoxes, philosophical or mathematical, involving eternity.

Regulatory initiatives for RK&M

Safety is seen as a key issue for the state to guarantee, through regulatory activities, but RK&M is not always included in this. However, there are good reasons for regulators to be active.

RK&M is strongly safety related and therefore deserves regulatory attention. The collective statement above gives the following relations to safety for RK&M, stating that RK&M activities should be taken in order to:

- maintain confidence in the safety and security of the system by allowing for accurate and reliable review ...
- address concerns and answer requests from the public, especially local communities
- ensure that future generations can base their decisions on relevant and pertinent data
- promote awareness of past activities

A proportionate, graded approach requires regulatory input

The operators are already active such as is evident by the NEA RK&M initiative, but the operator’s activities in this field need a clear national / international position) to be effective, i.e. to address the right issues, and to be cost-effective, i.e. proportionate regarding both the need for safety and regarding longevity. A regulatory initiative late in the process may disturb RK&M project, and divert the operator’s resources (and possibly even infringe on the operator’s legal rights).

The fact that RK&M is not addressed in, or removed from, the license dialogue in some countries does not imply that the issue goes away. The responsibility then – by default – ultimately rests with the national government anyway. This is also evident from the so called joint convention⁹ (The Joint Convention on the Safety of Spent Fuel Management and on The Safety of Radioactive Waste Management).

Cooperation with other institutions such as the national archives

Transition of records from an operational records management system to a post-close archive sooner or later requires input from governmental institutions. Such a process may require cooperation between different governmental bodies. For this reason, it may be necessary that the government carries out a project to define the basic provision in such a transfer.

A “Finnish”, “Japanese”, or “German” solution?

⁸ In England, first found in “the Statute of Uses” (1536) and “the Statute of Wills” (1540)

⁹ If there is no such licence holder or other responsible party, the responsibility rests with the contracting party which has jurisdiction over the spent fuel or over the radioactive waste. The Joint Convention, Article 21. responsibility of the licence holder, section 2.

The Finnish example is a possible reference option. It simply amounts to a legal requirement of a post-closure record/archive to be established and submitted to the authority.

Although it is a seemingly modest requirement, it lends credibility to a project like RWMC's RK&M, since it raises the follow up questions in a natural and legitimate way.

Similar positions are mentioned in the Japanese response to question about the NEA questionnaire on the evolution of the regulatory role. The German requirements are more detailed (BMU document on safety requirements as of 30 Sep. 2010)

If not regulated at all, there is an obvious risk for actions in excess of an optimized response. Well-intentioned projects from the operator will be in danger of lacking *raison d'être* and momentum.

An international consensus may function both as reference in its own right, and as a motivation for concerted initiatives from national governments

The content of a waste archive

Describing the expected transformation of an existing Records Management System (RMS), to a post-closure waste archive require regulatory input to define

- Expected formal role of the archive
 - Part of the national archives?
 - Relation to conventions:
 - The Joint Convention
 - the Aarhus Convention on availability of environment-relevant information
 - Openness (relations with Safeguards?)

Also, condense versions may be submitted to international body (-ies) within a number of possible agreements.

Post-closure archive management after closure

A number of questions may be addressed early on regarding the continued management of a post closure archive. It is valuable if guidance can be available on e.g.

- The expected period of post-closure active archive management
 - 100 y?
- Expected culling practices during that time for e.g.
 - Worker's doses (if included)
 - Environment measurement reports?
 - Safety reports?

Summary observations

There are a number of valid, safety-related, reasons for initiatives to address the need for post closure record keeping to retain memory of a repository after closure.

Such initiatives are valuable though all stages of repository development but are indispensable in the last stages of license dialogue.

Regulatory guidance for such initiatives is needed to allow for a measured, optimized and graded, or proportional, approach. In the absence of guidance, the operator's/implementer's work is susceptible uncertainties regarding direction, proper use of research resources, etc.

The safety regulator alone may not possess all the necessary mandates needed for the transfer of records to a post closure archive. It may therefore be advisable to formulate, at a government level, a project to establish the ultimate goal for RK&M, and the general steps that are needed.

An additional issue requiring governmental action is the assessment of the RK&M initiative's relation to international convention, such as the Joint Convention, the Aarhus Convention and the Non-proliferation Convention (regarding safeguards).

10. The contribution of the social sciences to Andra's RK&M preservation program - L. Aparicio

Introduction

The terms "knowledge" and "memory" are a bit tricky; they refer both to outcomes (things we know, memories we have) and to processes (knowing, memorizing). This ambivalence is meaningful, as stressed in the precedent discussion, because of the very dynamics of RK&M preservation, which has to do not only with data but also with their production context. The ensemble of RK&M to be preserved in a particular stage can be stable and be fixed in a way, but evolution and progress should also be taken into account.

Andra's research in the field of social sciences and humanities (SSH) takes currently place in the context of a Groupement de laboratoires devoted to the general theme "Transgenerational transfer and long-time scales". This particular organization financed by Andra assembles various research teams working together under the aegis of a steering committee. Composed by 13 representatives of the institutions involved and two members of Andra, this committee defines the scientific program, and assumes assessment in the long run (4 years renewable). Transdisciplinary research is therefore made in the basis of common interests and independency of the participants.

The research focus of the Groupement has been put on practices and specific devices related to the Cigéo project (geological disposal) with a view to the transmission of means and resources to next generations (beyond reversibility). The scientific program is being defined around three axes: governance; knowledge and memory; socio-economic evaluation. One of the works realized in the context of the second axe "knowledge and memory" has been a review of academic literature and a benchmarking exercise on very long-term memory associated to RWM. This framing work has contributed to Andra's memory-preservation program, though the Groupement de laboratoires has no specific research program on memory-preservation so far.

Long-term memory associated to RWM in the academic literature

A review of academic literature and benchmarking on very long-term memory associated to RWM has been recently realized by M. Lehtonen (SPRU, University of Sussex) under Andra's auspices. A preliminary analysis of the results is briefly presented in the following paragraphs.

The main discussion terms on the topic of RK&M preservation have been established in the pioneer works steered by RWM organizations (WIPP, KAN) in the 1980s-1990s. RK&M management is usually approached according to the logic of demonstration inspired by safety analysis. The remaining problem is how to demonstrate the preservation of data in the long run with a view to avoid human intrusion "by accident" (safety scenarios). The demonstrations make use of a distinction between active and passive memory that resonates very much with that of active and passive safety. They also share a similar social denial, namely that we cannot count on social institutions in the long run. Therefore, the demonstrations tend to rely only on "pure technical" devices.

Various dilemmas concerning the purpose, as well as the content and the supports intended for RK&M preservation, result from this demonstration approach: what is the main objective, to facilitate or to avoid

access (to remember or to forget, in fine, the existence of the repository)? What should be preserved information or contextualized knowledge? Which are the most reliable devices, those intended for the long time or those for the short time, the technical or the social devices? ...

The distinction between active and passive memory is supposed to correspond to two different perspectives of RK&M management. One perspective, developed mainly in the EU, would focus on the short term and the creation of a mediated link to the next generations through social devices (continuity of institutions). The second, developed mainly in the USA, would focus on the long term and the creation of a direct link to future generations through technical devices (markers). In fact, both perspectives are pretty much mixed in reality and know a permanent process of hybridation. A plurality of demonstration means are usually mobilized in any case.

An alternative “demonstration” would consist of approaching the memory issue in term of dilemmas. And dilemmas, by definition, cannot be solved. Take the dilemmas seriously, and therefore to assume that we have to deal with an uncertain world, means to examine the whole range of possibilities, with their respective pros and cons. Why not consider markers designed for the present time and enhance institutions with a view to the distant future? The exploration of all socio-technical scenarios, combining social and technical devices whether with long-term or short-term purposes, can be also a way of putting ethics into practice. Indeed, this approach allows discussing on values and principles, and the sharing of responsibilities among the interested parties.

The review of academic literature and benchmarking study has also identified some research fronts for the social sciences and humanities. Interesting research on the topic of RK&M preservation in radioactive waste management could be done, for instance, in the field of economics (cost/benefit analysis, long run financing), art and landscape (audiences, bizarre landscapes), cultural studies (values, myths and religion, monumentality), institutions (distributed governance, NGOs, networks), archives (knowledge management, information systems), etc. Nevertheless, the most prominent result of the study is the relatively few academic interest in the topic so far.

13. Insights from a comparison of conventional toxic and radioactive waste: Objective and project longevity of programmes - Thomas Flüeler

In considering the preservation of records, knowledge and memory for this project we are looking at a timescale of around 300 generations. In Switzerland, the timescale for getting from the disposal demonstration to an operational high level waste facility spans ten terms of office for the Swiss government.

The problem of ensuring safety and an acceptable level of risk is a societal one, so we need technological and sociotechnical solutions. Neither context, social or technical, can dominate the other, but there needs to be a balance of technically assured safety and social intervention. To rely on archives to ensure that this is managed is insufficient.

In Switzerland, the requirements, goals and boundary conditions are to ensure protection, to provide a domestic solution, to ensure the validation of the safety analyses, and to provide a safe and permanent disposal for radioactive waste. The Swiss project to provide this is EKRA, a long-term monitored geological disposal facility.

In order to achieve this, there needs to be a separation of functions, so that there is an independent regulatory body. They must be able to the implementation of the principle of causality, provide competent oversight and ensure public involvement.

The institutional consequence of this is the need for integration by the regulatory body to face the special challenges the project brings, including potential conflicts with implementers, long term responsibilities, and the advisory bodies.

In order to do this, it needs to have a strong, independent monitoring process. It needs to establish platform for inclusive knowledge generation and ensure consistency, accountability and an iterative process. Its role is to set the safety requirements and ensure that they are met. When the geological disposal facility is sealed, the knowledge management needs to be taken over by an institution with a chance of surviving longer historical periods – presumably, the nation state, so that the reasoning behind the safety case is traceable.

The primary goal of the programme is the long term safety of human beings and the environment. The secondary goal is flexibility, defined as intervention potential (controllability, retrievability). The regulatory body/bodies ensuring continuity have to take the lead over the entire programme, whilst respecting the causality principle. The role of a leader, thus, presupposes adequate resources, extensive reviewing, appropriate anticipatory research in diverse technical, non-technical and institutional fields as well as a continuous international and intergenerational knowledge transfer.

The preservation of records, knowledge and memory across generations is potentially achievable via a trans-disciplinary, trans-political, trans-generational and socio-technical defence-in-depth process ensuring/aiming at a societal ownership of the problem over time.

14. Concerns and issues for what to keep during the operational phase of repositories and how to keep it – Z. Nagy

The presentation provides an overview of the various records that could be generated up to the repository closure, what information needs to be gathered and how it should be managed and preserved during the operational phase of repository and beyond the closure. It presents the importance of the early establishment of a coordinated, integrated and well managed information set and it explores the challenges relating to the effective use of information resources during the operational phase of repositories.

The main sources of waste related information are the waste generators, operators of waste processing or storage facilities, waste management organisations and competent authorities. The nature of information that is transferred is typically specified by the receiver, who bears sole responsibility for the preservation of these records as long as the waste is in their possession.

For a repository, there will be the following types of records:

- The pre-operational phase of a repository
 - Planning records
 - Siting records
 - Design records
 - Licensing for construction records
 - Licensing for operation records
- The operational phase of a repository
 - Waste specific records
 - Facility and site specific records
 - General operational records
 - Closure related records

Elements of all of these types of records will need to be kept for future use. Records can easily lose their usefulness to subsequent generations, so the expectation should be to establish the irretrievability and usefulness of records.

In order to reduce the possibility of losing records, a number of steps can be taken. For example, metadata should be recorded alongside data, the requirements for data acquisition should be planned as early as possible, and there should be clear requirements for the data's reproducibility, transparency and traceability. There is a more exhaustive list in the full presentation.

The Records Management System (RMS) should be developed as early as practicable. It should be systematic, given a high priority in the organisation and the ownership and responsibility of the RMS should be unambiguously clear.

Information should be driven by the 'back end' of the waste management process so that records required by the later stages are maintained by the earlier stages.

The RMS should address:

- The identification of records to be included in the RMS
- Inventory and indexing
- Classification, retention and destruction
- Storage format (media)
- Periodic renewal or transfer of record format(s)

15. Preparing records as a function of waste life-phases – S. Wisbey

Introduction

There are a number of high profile factors that together make nuclear power generation unique. Not only is it technologically advanced, socially controversial and highly regulated, but the wastes are much more toxic than the inputs and have inter-generational effects that could extend for thousands of years. Unlike many other industries it has no long-term history, and emerged over about 10 years as a by-product of intense efforts to develop weapons. Although nuclear power is currently widespread, it may turn out to be a transient industry, with technological know-how consigned rapidly to the history books.

Radioactive waste requires active long-term management in order to protect workers, the public and the environment from harm. That management includes containment, shielding, isolation and ultimately disposal in a manner that meets internationally agreed standards. Confidence in the efficacy of these management arrangements will be greatly enhanced by the preparation of good quality records.

Therefore there is a clear responsibility to prepare long-lasting records for all relevant waste management activities. These records are needed to demonstrate compliance with regulatory requirements, to help protect workers and public, and to meet our obligations to future generations.

Identifying Key Users

The records need to communicate to all potential users, both now and in the future. The records are likely to be used by waste producers, regulators / safety authorities, governments (local or national), Safeguards inspectors, local residents, pressure groups and historians. The uses include remediation, monitoring, land re-development, and even possible retrieval.

Future users of records will seek answers to some key questions. At the highest level, it is likely that they will ask:

What did we do? They will want to know what technology was used, how was the waste generated, how was it treated, conditioned and stored?

What is the hazard? Information about the radiological hazard associated with the waste will need to be supplemented with a description of toxic and non-radiological hazards.

Where is it? In addition to the geographical location and geological setting of a facility, some will want to know the layout (design) and emplacement (stacking) plan.

How much is there? Future decisions will need to be informed by the disposal inventory, both radioactive and non-radioactive components, including its evolution due to radioactive decay and in-growth.

Planning for long-term records requires some assumptions to be made. The primary assumption relates to continuity of 'civilisation'. To build confidence that the records will even be recognised, it may be necessary to assume that nation-states and 'sophisticated' society (i.e. specialist – consumer lifestyles) endure. For the message to be interpreted correctly it may also be necessary to assume that dominant languages to evolve gradually. None of these assumptions may be sustainable or fully viable.

It will be helpful to define a number of broad timescales, defined by key phases of waste management. Although this could be as simple as the active management and passive management phases, further subdivisions are suggested, as follows:

Project Phase	Timescale	Potential Users	Example Uses
Production and accumulation of wastes	> 50 years	scientists / engineers / radiometric technicians / health physicists	monitor performance update/review safety cases
Conditioning and surface storage	ca. 100 years	scientists / engineers / logistics and warehousing staff	confirm on-going suitability
Implementation – excavation, emplacement and pre-closure storage	ca. 50 years	mining engineers, radiometric technicians / health physicists	contingency plans
Active institutional management – post-closure	ca. 300 years	national and local government, regulators, museum curators	
Passive management – land returned to general use	> 500 years	governments, regulators historians and story tellers	warning to protect people avoid disturbing barrier systems

It is important to note that the boundaries between these phases are not sharp, and will not extend over the full timescale for every development. The transition to passive uses will be gradual and at uncertain future date, so it is necessary to prepare now.

Preparing Records to match Time-frames

Given the various users and the range of time-frames involved, the relevant records will vary. Some key examples are given for the various phases in the following table.

Production phase	Conditioning and implementation	Active management	Passive management
Research data	Package history and inspection	Local monitoring results	Location
Technological background	Stock-take / audit	Information for land control	Hazard
Detailed manufacturing records	Evidence of evolution	Nature of safety case	Generic monitoring
Quality Management System	Quality Management System	Maintenance of marker system	
Evidence for SQEP staff	Materials conformance		
	Evidence for SQEP staff		

It is suggested that retaining every record without a time limit is an unreasonable burden, particularly for future generations. Therefore, the implication is that some information can be discarded. A key question is then how to choose. As one phase ends and another begins, some information becomes irrelevant, and it is proposed that this 'time expired' data can be deleted. There is value in defining a principle for this decision:

'Where there is no conceivable use for information (e.g. it provides no context, or prompts no action) it can be actively deleted.'

An example may be useful. The training records for staff involved in waste conditioning will be of no value once all waste has been emplaced for long-term storage. It is suggested that this principle does not apply to radionuclide data at any time, as this remains potentially useful to reconstruct the original inventory.

Initial Proposals for a Common Records Set

Preliminary consideration has been given to defining a minimum set of enduring records, to be retained for the long term. This set should clearly include the location of the facility (geographical location and geological setting), the origin of the waste (including a summary of the processes led to its existence), the design of the waste management system (containers, barriers, facility design), the hazard presented by the waste (radionuclides, gases, toxic species), and the main elements of the safety case (including the case for establishing the facility).

Such a minimum set of enduring data would primarily be aimed only at the passive management phase. The nature and format of this long-term record is vitally important. It should maximise the visual and diagrammatic content, while minimising textual presentation, and records should be prepared in both the host language and major regional languages. Of primary importance is the preparation of such enduring records to an agreed standard content, with a consistent layout of material. This approach would greatly assist with interpretation of fragmentary records, should they be retrieved in the future. The advantage could be realised through surviving records from one facility providing a template from which to interpret

and read fragmentary records from another. To gain maximum advantage from this approach, international agreement for its implementation would be particularly helpful.

Summary and Conclusion

Long-term records need to be designed to inform future decision-makers and other potential users of information. Waste management consists of overlapping phases of activity, and each phase has different needs for records. Some records will become redundant, and to avoid storing such data, it would be sensible to plan to discard records that are ‘time-expired’. The explicit preparation of records for the passive management phase should include a minimum set, developed to a common format. Some suggestions for content and format have been made. To achieve maximum advantage from the use of common formats will require ongoing international collaboration.

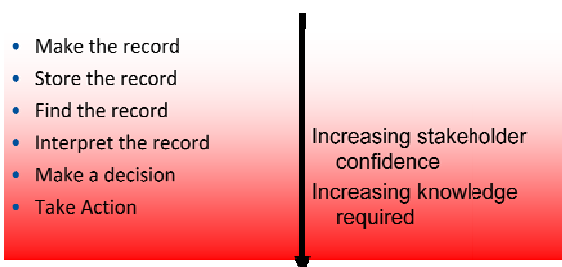
16. Management of knowledge across generations: preventing knowledge loss, enabling knowledge readiness – J.Day

Introduction

This paper presents some thoughts on the long-term management of knowledge necessary for managing the disposal of long-lived radioactive waste in engineered facilities, with a view to contributing to the safety of future human generations in general and the RK&M project in particular. We will argue that the preservation of records is a necessary, but not a sufficient condition to enable intelligent future decision making and management of nuclear waste. We believe that knowledge will be a key factor for the generations that follow us. We will describe various facets of knowledge and explain that, if not managed well, knowledge can become lost or difficult to mobilise. We will propose the concepts of ‘knowledge readiness’ and ‘knowledge mothballing’ and offer experiences from operations at Sellafield nuclear complex with respect to the mapping, assessing and retention of critical knowledge for the long term management of a nuclear facility. We will introduce a model that integrates records, knowledge and memory with continuous learning and close with a number of conclusions and recommendations.

Knowledge is needed to create meaning from records

Although the creation and maintenance of records of nuclear waste is fundamental for public acceptance, it is of even more importance that a society maintains the capability and knowledge to transform information represented in records into either new information or meaningful action (see Figure 1), as without knowledge, records are in principle meaningless.



Preserving the ability to take informed action is necessary to build stakeholder confidence – Information without the capacity to act is information for its own sake

vessels, travel into space, etc.).

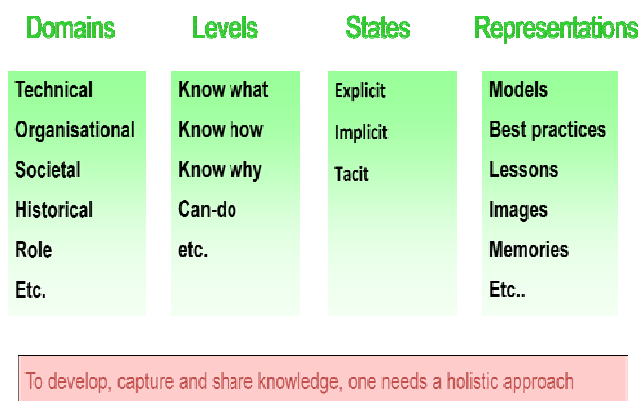
As knowledge has many dimensions (see Figure 2), its preservation requires a holistic approach that addresses all of the functionally different aspects of knowledge. It should not be assumed that knowledge will be preserved by default. History has shown that knowledge can get lost or may not be readily available (*‘knowledge readiness’*) anymore to civilisation at large or to individual societies or nations (e.g. the knowledge of how to build pyramids, manufacture glass, build seagoing

in of knowledge

Knowledge readiness defines a situation where knowledge is available at the point of action: ensuring not only that knowledge is preserved but also that knowledge is ready through the lifetime of the facility is a critical question for the RK&M project.

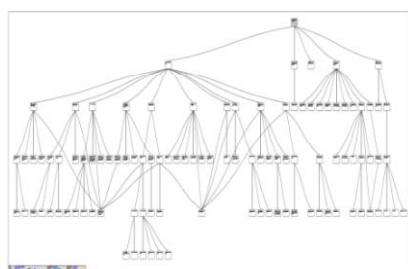
It should be noted that the lifecycle of a nuclear waste repository presents many opportunities to lose knowledge, particularly during planned and unpredictable discontinuities in both operations and the wider environment.

Degradation in knowledge readiness usually precedes knowledge loss. Scenarios of abrupt knowledge loss are also plausible and can be triggered by technologies becoming obsolete or by discontinuities such as socio-economic change, natural disasters or resource depletion.



The challenge then is to maintain a minimum level of knowledge readiness, across a long timeline with both planned and unpredictable discontinuities. We believe that knowledge management provides some of the processes and tools to address this challenge. Experience demonstrates that knowledge can indeed be retained in a complete and ready state if organised and systematic processes are employed. If we are then able to extend or repeat these processes endlessly, then in theory at least we have a solution that is robust across generations.

Knowledge management approaches to prevent knowledge loss and enable knowledge readiness



At Sellafield experience has been developed with a three-pronged approach to knowledge retention. The first element is to identify and map the critical knowledge we need to operate safely and reliably and when we need this knowledge. This process is supported by a systematic methodology and knowledge structure mapping software.

The second element is an assessment of the importance and risk posed by each of the knowledge domains, using a KM “health check” instrument. This instrument identifies risks associated with insufficient levels of proficiency, codification and diffusion in each

knowledge domain. These risks can lead to decreasing knowledge completeness, readiness and eventual knowledge loss in key areas of nuclear operations if they remain unmitigated.

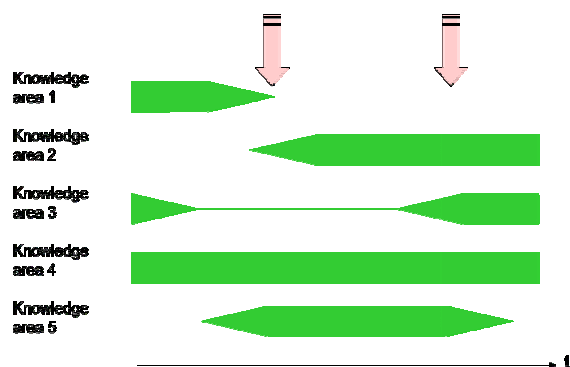
The third element uses the risk assessment to focus the knowledge retention and transfer (KRT) actions in each of the knowledge domains. KRT employs a comprehensive range of incisive tools for the capture of explicit and implicit knowledge and the transfer of tacit expertise, by e.g. mapping expert’s career histories, construction of concept maps, elicitation of lessons learned and the capture of design rationale.

The Sellafield approach applied to cross-generation retention?

If we were to apply the approach above to the management of knowledge associated with nuclear waste facilities, one could argue that, assuming the records remain intact, accessible and associated with the physical items (i.e. it is clear which record relates to what waste), future generations and societies would then need to know (and thus maintain) three types of knowledge:

- Knowledge required to give meaning to the records;
- Knowledge to make informed decisions based on the records' meaning;
- Knowledge necessary (but additional to that included in the records) to take informed decisions and appropriate actions.

It is clear that this knowledge base would not just include technical knowledge. As a minimum the ‘knowledge map’ for nuclear waste facilities would show those knowledge areas that enable future generations to appreciate and respond to emerging risks and events associated with the store, i.e. knowing what to do and knowing why this is the right thing to do and when to do it. Ideally, that knowledge map would also identify knowledge that enables future generations to manage the facility and its contents, purposefully and safely, to either reduce the risk and/or utilise its contents to add value i.e. knowing how to take action and having the capacity and capability to do so.



A knowledge retention programme defines how to action each knowledge area on this timeline and be robust against discontinuities.

ledge over time

With such a knowledge map, it is possible to undertake a risk assessment and create a prioritised knowledge retention programme which identifies which knowledge areas need to be available at what points in the store’s lifecycle. Traditionally, Knowledge Managers concentrate on just two scenarios: i.e. the just-in-time development of knowledge (‘learning’) and the continuous maintenance of knowledge (‘knowledge maintenance’). An additional third scenario is the de-investment in knowledge, (‘forgetting’) frequently associated with the introduction of new technologies that make knowledge of earlier technologies redundant and wasteful to maintain. (see figure 5)

The ‘learning’ scenario is supported by activities such as research, simulation, experimentation and practice and reflection, that work best in an environment that allows for mistakes, where there are mechanisms for feedback and improvement, where there is access to existing knowledge resources (people and artefacts) and if there is the possibility to interact with fellow learners and experts.

The ‘maintenance’ scenario is typically supported by the:

Undertaking of regular knowledge health checks to actively manage knowledge risk and opportunity;

Upkeep of proficiency by succession planning, training, coaching and mentoring, R&D, targeted recruitment and supply chain engagement;

Codification of knowledge by creating accessible libraries of documents, images, videos, drawings, graphs, or other information artefacts;

Diffusion of knowledge through international communities of practice;

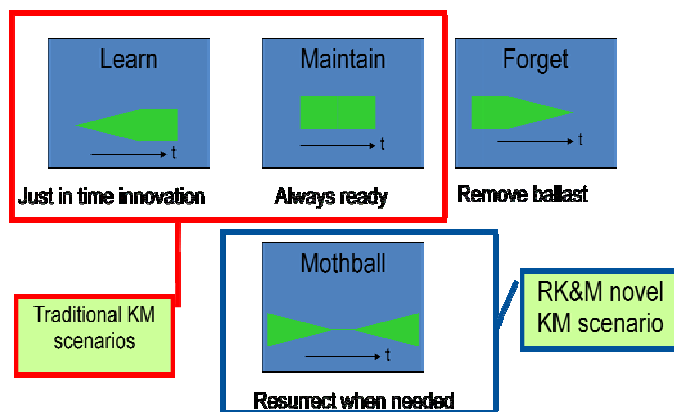
Systematic capture, retention, resolving and sharing of lessons learned.

In order to maintain knowledge across generations we believe that as a minimum the following three aspects need careful attention:

People (communities, masters, apprentices and facilitators),

Processes (knowledge capture, validation, consolidation, sharing and finding processes) and

Technologies to support storage, sharing, finding of explicit knowledge and people.



Knowledge can only be maintained if there is:

- Someone to carry the baton,
- A knowledge infrastructure that enables persistence of knowledge: this may be hard infrastructure (records, archives, books, etc.) or soft (oral history), and finally
- Commercial, intellectual, moral or regulatory impetus to maintain the knowledge base at sectoral, national or international level.

management scenario

For cross-generation knowledge management, there is a fourth, novel scenario that needs to be the focus of further research efforts. We propose to call that scenario ‘*knowledge mothballing*’, i.e. the conscious consolidation of knowledge for later resurrection. History has taught us that mothballing is possible, through a variety of mechanisms including the combination of textbooks, records, archaeological artefacts and the human ability and stamina to reconstruct knowledge. But for this resurrection of knowledge to be effective society needs to consciously and purposefully maintain a tacit knowledge reservoir.

The making and keeping of records is a key part of this scenario, but as knowledge has many dimensions, effort should also be directed to the capture of implicit knowledge and expertise. As this is a resource-intensive task, it is essential that this is preceded and guided by a comprehensive mapping identifying what critical knowledge is required when.

Conclusions

The cross-generational management of knowledge for nuclear waste facilities is a *conditio sine qua non* for public confidence. History has shown that knowledge can suffer from reduced readiness and even become lost: we believe that records alone will not equip future generations to deal with lost knowledge.

As knowledge is multi-faceted and complex, it requires a multi-faceted approach to ensure its preservation across the lifetime of any facility. Such an approach needs to take into account the knowledge needs of future generations and address the risks associated with insufficient levels of proficiency,

codification and diffusion at any point in the store's existence. Proven methods and tools need to be deployed that help map, assess and retain knowledge readiness across the store's lifespan.

Although commonly used Knowledge management processes are fit for building up new knowledge and the maintenance of existent knowledge, further work needs to be undertaken to support a novel knowledge management scenario that consciously consolidates knowledge for re-use at a very much later time. (*knowledge mothballing*). To further develop this scenario, the RK&M project would benefit from addressing the following research questions:

1. What is the minimum knowledge that needs to be mothballed and be resurrectable, and what is the risk appetite with respect to losing knowledge?
2. What would a complete knowledge retention plan look like for a typical nuclear waste facility?
3. What are the various roles for nations and international bodies in the knowledge retention plan?

17. Digital Preservation at the Swiss Federal Archives – K. Ohnesorge

The Swiss Federal Archive is responsible for advising, inspecting, and issuing directives in records management and archiving services in offices, agencies and institutions subjected to the Federal Act on Archiving; as well as archiving and disseminating records and data of archival value.

The presentation summarises the OAIS reference model in use at the SFA, and the content of the information packages accepted by the SFA.

The SFA use a process-orientated approach. There is;

- A Reduction of the number of file formats to a few file formats that are suitable for archiving purposes
- A Separation of the data from specific IT environments (applications, databases and operating systems, hardware) and original data carriers
- Migration procedure
- Open, standardised environments that are as generic as possible
- Homogeneous storage infrastructure

Design classification schemes are important to clarify, so that they are considered early in the process – that is, before the information falls out of use. If there is clarity, people will know what data – and metadata – to keep for the submission.

The submission is split into several stages, from appraisal to the conclusion of the submission. This approach has six stages.

1. Appraisal
2. Identification of data and documents for delivery to the archives
3. Creation of the submission
4. Transfer of the submission to the SFA
5. Conclusion of the submission

The SFA uses SIARD software, which means Software Independent Archiving of Relational Databases. Data is stored on a set of tables which are related to each other. This was developed for the SFA and is now in use worldwide. The SFA have also created Package Handler. Originally, this was a tool for SFA

archivists, but has been developed to become a tool for customers, government units, and the public as well as the archivists.

Currently, the SFA are working on Project Ellipse, the goal of which is to provide a solution for archiving the geodata for the entire federal administration. The preliminary study was carried out 2009-2010. The current stage of Conception considers:

- Long-term availability / Archiving
- Scenarios
- Data catalogue
- Requirements of the users
- Pilot und Proof of Concept
- Basic principles
- Consolidation
- Planning of the implementation

The project will be implemented 2013-2014.

In conclusion, we have to archive now with today's technology. However, in the next 20-50 years, if possible, we will use open and established international standards for file formats, metadata, interfaces, etc. If not, then we will develop new concepts and solutions. These new developments will be carefully revived in national and international projects.

The development of archiving solutions is only possible due to the cooperation between the archives and specialists from other fields.

18. ANDRA'S Long-Term Memory-Preservation Program - P. Charton and J. Dumont

Introduction

Maintaining the memory of repositories over the long term is required not only to ensure safety and reversibility, but also in response to social expectations. Hence, since 2010, Andra has been implementing a long-term memory preservation program to reinforce and diversify its current arrangements in that field, as well as explore opportunities to extend memory keeping over thousands of years.

The program includes opportunity studies of dedicated facilities. Theoretical studies are also conducted on various subjects, most of them related to social sciences. Fruitful discussions of such issues are also expected to take place at the international level within the RK&M project launched by NEA. In parallel, Andra intends to launch discussion groups around its research and industrial sites to involve the local public in the preservation of the repository's memory.

For these studies, a starting point for Andra is the reference solution developed and implemented for surface disposal facilities.

1. Presentation of the reference solution

a) Background information on Andra's memory policy

The memory issue appeared as early as the early 1980s during the first monitoring phase of the Centre de la Manche Disposal Facility, when the solutions under study favoured the development of computer tools.

As early as 1990, long-term archiving was prescribed for all information deemed necessary for monitoring a repository over three centuries, as follows:

- (i) 120,000 pages of technical documents and 1,000 Andra plans;
- (ii) 600,000 pages of data generated by waste producers on their waste packages, and
- (iii) 120 megabytes of data on waste-package management.

At that time, the project on memory preservation is oriented towards an electronic filing solution associated with setting up a centralized document-management system as the reference basis for electronic document management (EDM).

In late 1995, after more than a decade of research and three unsuccessful calls for tenders, the project to develop an electronic filing system was dropped and the decision was made instead to duplicate all relevant documents on permanent paper.

In 1996, the Governmental Assessment Commission for the Environmental Status of the Centre de la Manche Disposal Facility (also known as the Turpin Commission) supported the modalities selected by Andra to develop a long-term filing system on permanent paper. As a complement to long-term archiving, it advocated new improvements that Andra reintegrated in the memory mechanism intended for disposal facilities for low -and intermediate-level waste.

That ensemble constitutes the reference solution and includes three “passive-memory” devices:

- (i) a detailed memory (former long-term memory) encompassing all technical documents for monitoring, understanding and modifying a disposal facility;
- (ii) a single-volume synthesis memory intended for decision-makers and various publics,
- (iii) a list of registered public easements in the cadastre.

It also includes two “active-memory” devices with a view to:

- (i) improve communications with the various publics and
- (iv) enhance the role of local information committees (commission locale d’information – CLI) or local information and oversight committees (commission locale d’information et de suivi – CLIS).

b) Description of the reference solution

The constitution of the detailed memory relies on selecting and ranking information according to 13 identified risk scenarios that are consistent with the long-term safety approach. A series of research instruments (e.g., inventories, glossary, indices and abstracts) ensures its legibility and understanding. The long-term endurance of the documents is guaranteed by a suitable selection of the ink and permanent paper and the maintenance of two documents on two different sites – the disposal site itself and the French National Archives. Lastly, the validity and updating of the detailed memory are handled by regular inputs every five years until the end of the monitoring phase.

The synthesis memory is a single document based on a synthetic approach to technical and historical information. Regular updates are scheduled after each revision of the safety reports. The informative strength of the final version will rest on its broad distribution among relevant city halls, notaries, general councils, prefectures, ministries, and national and international institutions. The “temporary” synthesis memory of the Centre de la Manche, for instance, includes 169 pages and is already available through social networks.

The registration of public-utility easements in the cadastre ensures the actual presence on site of appropriate administrative means to warn against the risks involved in conducting any work on the site. The actual registration itself, notably for the Centre de la Manche, is scheduled in the early decades of the monitoring phase of the site.

Within the section on “active memory”, the communication policy covers all publics, thanks to the organization of “open-door” days, conferences, exhibits or interviews; the distribution of specific communication tools on memory, booklets, as well as the availability of a website. As a complement, the

memory issue forms an integral part of the topics addressed at CLI and CLIS meetings and should ensure their local survival.

2. The need to go beyond the reference solution

Although the above-mentioned reference solution fulfils French prescriptions, it includes some weak points over the long term, as described below.

- First, it is too oriented on preserving the printed documents or data, and does not take sufficiently into account other supports, such as photographs, testimonies, soundtracks, and images that may be of interest to future generations
- Second, it does not fulfil the needs of future generations because the relevant information is mostly selected according to the current state of mind and risks.
- Third, in the case of the deep geological repository, the different reversibility phases to be specified in the future act of 2016 may prescribe some long-term memory requirements that need to be anticipated.
- Finally, and still in the case of the deep geological repository, several stakeholders, including nearby residents, expect memory preservation to be applied for a short period of only a few centuries after the closure of the repository (according to the reference solution).

For these reasons, Andra felt it would be useful to launch a memory-preservation program with a dual purpose: enhance the robustness and the defense-in-depth of the current reference solution for existing facilities, and develop various points-of-view and studies on memory preservation over several millennia.

That dual purpose is reflected in various actions pertaining to the two main components of memory: active memory and “passive” memory. In the case of “active” memory, which recognizes the risk of letting nuclear institutions assume responsibility for it, the goal is to transfer it to the cultural and archiving collections of the nearby and national populations. In the case of “passive” memory, the goal is to expand those memory supports to such topics as architectural elements, items, and symbols.

3. Andra’s memory-preservation program

Andra’s Memory-Preservation Program was launched in the fall of 2010 and currently involves approximately 20 part-time employees working on several related topics as summarized hereunder:

a) *Work on strengthening of the reference solution*

- Decennial revision of the *Centre de la Manche* Disposal Facility to make it consistent with the last version of the safety report of that facility from a technical standpoint and take into account the opinions formulated by various stakeholders on societal issues;
- Decennial analysis of the relevancy of the detailed memory in relation to the needs of future generations by gathering an international group of French-speaking stakeholders (since all documents are written in French) in order to reflect on its adequacy for decades;
- Validation of the studies done between 2007 and 2009 by two French laboratories on the durability of the ink/permanent paper solution over 600 to 1,000 years;
- Preparation for the future five-years inputs of 2015 and onwards on the detailed memories of the disposal facilities located in the Aube and Manche Districts, with due account of the experience feedback from previous inputs.

b) *Preliminary work for preparing the memory preservation of a future deep geological repository*

- The constitution of the detailed memory of the Meuse/Haute-Marne Underground Laboratory and other supporting documents before the creation of the Cigéo;
- The studies and the implementation of memory- support demonstrators over two million years (e.g., sapphire disks).

c) *Theoretical studies*

- The perception of large timescales (e.g., multi- millennia and beyond) among the public, in the framework of a laboratory group specializing in human and social sciences;
- The long-term durability of writing and engraving supports, other than paper, and especially studies on surface markers to be installed on the cover of disposal facilities, in relation with existing international studies produced by Andra's counterparts;
- The long-term durability of languages and symbols to determine a reasonable time estimate during which currently spoken languages around the world might be known by the populations at first, and then only by specialists, and ultimately, the communication solutions that might be adopted when those languages become obsolete;
- The institutional preservation of written documents, sound-tracks, images, and items by French and international specialized organizations to analyze the preventive measures to limit degradation over time and favour appropriation by future generations;
- The archaeology of landscapes, notably those associated with the evolution of the Earth that may differ from anthropic ones generated by human beings, as well as memory-preservation possibilities within the human creations themselves;
- Potential societal evolutions, not only in the technical and scientific fields, but also in the behaviour of our societies, divided into three broad orientations (regression, stagnation, progression), notably in relation to Japanese studies on that topic;
- Potential contributions to the archaeology of the future by combining futurology scenarios (with what, with whom and how might the future occur) together with interpretations of the traces of radioactive waste disposal facilities within those scenarios;
- The integration of memory preservation of radioactive waste disposal facilities in training programs on nuclear energy, in general, and on radioactive waste, in particular, with Andra's partner universities and colleges;
- The interactions between long-term memory and safety in order to determine the benefits of memory preservation for long-term safety and the consequences on that long-term safety, if the memory of disposal facilities for radioactive waste disappeared;
- Art as a potential vector for memory preservation over the very long term, by hiring numerous French and international artists in different artistic fields in order to express their vision of the issue through their art;
- The potential contributions of electronic filing over long timescales, notably by organizing a watch over that field, which is starting to structure itself and, within a few decades, should open up to new horizons over the long term;
- The intergenerational transmission of the memory through available social networks on Internet, because where it is possible to organize modern revolutions (such as the "Arab Spring"), it might also be feasible to disseminate sustainable information worldwide on disposal facilities for radioactive waste;
- The interactions between the memory preservation and the reversibility of a disposal facility in order to determine the needs relating to memory preservation throughout the different reversibility phases and what consequences there might be on that reversibility if the memory of disposal facilities for radioactive waste disappeared;
- The memory of various "historical" disposal facilities spread across France and French territories, but not managed by Andra (old uranium mines, former testing sites for nuclear weapons, etc.), and of course
- International work on memory preservation within the NEA/RWMC Working Group on Record, Knowledge and Memory Preservation (RK&M) as the benchmark for best practices in participating countries, common definitions and bibliography, and drafting of recommendations).

d) *Three reflection groups with local populations* around Andra sites and concerned with memory preservation over the long term (*Centre de la Manche* Disposal Facility, *Centre de l'Aube* Disposal

Facility for low-level and intermediate-level waste and the Cigéo facility straddling the Meuse and Haute-Marne Districts) with a view not only to attracting the interest of those populations in that issue, but also to collecting their views on the best approach for them to appropriate it locally;

e) Opportunity studies to create dedicated buildings for memory preservation:

- a centre for historical archives (in connection with the French *Public Archive Act* and Heritage Code) not only to ensure memory preservation, but also to promote it among the various publics;
- a residence for artists, comparable to what is achieved in contemporary art, in order for artists to isolate themselves in a suitable location and to develop new memory-preservation leads through their art;
- a disposal-facility museum, which would display various concept of disposal facilities along with technologies that were used over decades (France started waste disposal on land in 1969 and is expected to continue likewise until at least 2150, thus justifying the need to display the large number of evolutions to the public);
- a nuclear museum, similar to the above presented one, that would not be limited to the sole issue of radioactive- waste disposal, but extended rather to nuclear energy as a whole, and
- the use of already dedicated sites for public purposes, such as the Technological Centre in the Meuse and Haute-Marne Districts, and the Visitors' Centre at the *Centre de l'Aube* in order to make available a public space dedicated to memory preservation and public reactions.

4 Planning

The Memory Preservation Program includes two milestones associated with the deadlines of the French Program: (i) a public debate to be held in the first half of 2013 and during which Andra will be called upon to justify the relevant elements of its project within a broad debate involving the stakeholders; (ii) a license application for the creation of a deep geological repository to be submitted in 2015, together with a description of the mechanisms set in place by Andra to manage the memory preservation of the facility, the layout modalities and the prospects for subsequent complements, in particular for the future closure of the site.

References

a) In English

Andra / Charton P. and Ouzounian G. (2008): A Challenge for Radioactive Waste Management: Memory Preservation. –*WM'08 Annual Waste Management Symposium*:

Proceedings, February 24 -28, 2008, Phoenix, AZ. <http://www.wmsym.org/archives/2008/pdfs/8014.pdf>

Andra (2006): *Disposal facilities: Preserving a collective memory for future generations* (brochure explaining ANDRA's activities regarding memory preservation). <http://www.andra.fr/download/andra-international-en/document/editions/299.pdf>

Andra / Charton P. (2005): From knowledge management (KM) to memory preservation over several centuries. Experience feedback from long-term archiving at the "Centre de la Manche" (CSM) disposal facility. Reference: SUR.TR.ADSQ.05.0029/A

Andra / Haas J. (2002): French experience in long term memory preservation, for Nirex seminar on March 5th 2002. DQ/AQ/JH QUA.TR.ADQ.02.001/A

Andra / Boursier F.O. (2000): Record and Archival System for the Monitoring Period of a Surface Disposal Facility. - American Nuclear Society: *WM '00: HLW, LLW, mixed wastes and environmental restoration - Working towards a cleaner environment*. Proceedings of Waste Management '00, February 27-March 2, 2000, Tucson, Arizona. American Nuclear Society, La Grange Park. Session 66, Paper 4. <http://www.wmsym.org/archives/2000/pdf/66/66-4.pdf>

Andra / Raimbault P. and Valentin-Ranc C. (1993): How to mark repositories in geological formation. – *SAFEWASTE 93: International Conference on Safe Management and Disposal of Nuclear Waste*, Avignon, 13-18 June 1993, vol. 3, p. 212-221.

b) In French

Andra (2009): Centre de stockage de la Manche : Rapport définitif de sûreté - Année 2009. Phase de surveillance. SUR.RP.ACSM.08.0017.A. ANDRA, Chatenay-Malabry.

Andra (2008): *Centre de stockage de déchets radioactifs de la Manche (50), situé sur la commune de Digueville. Mémoire de synthèse pour les générations futures (destinée à maintenir une connaissance minimale aux générations prochaines et à toutes celles qui se succéderont jusqu'en 2500 au moins)*. CSM Mémoire DD.NSY.ADSQ.07.0017.A. ANDRA, Chatenay-Malabry.

Andra (2007): *La mémoire industrielle au service des générations futures*. Colloque 11 décembre 2007. Référence : DD.TR.ADSQ.07.0032/A

Andra (2003): Archivage à long terme du centre de stockage de la Manche: *Présentation générale de l'archivage à long terme du centre de stockage de la Manche*. DOC.NSY.ADSQ.03.240/A

Andra (1995): *Critères de sélection des données nécessaires à l'archivage à long terme des centres de surface (phase de construction, d'exploitation et de surveillance)*. N.RP.AGDA.95.007/A

21. One hundred thousand years back and forth: When archaeology meets radioactive waste C. Holtorf and A. Högberg

In this presentation we discuss the final repository of radioactive waste as an issue at the interface of the sciences and the humanities. Engineers are investigating safe ways to handle and store radioactive waste from nuclear power plants for at least 100,000 years to come. Archaeologists can contribute to this planning process with a long-term perspective on human evolution, technological innovation and cultural change.

As archaeologists we are used to dealing with time, material cultural and cultural heritage. Our temporal perspective extends over hundreds of thousands of years into the past, we are promoting historical consciousness, and we are analysing and interpreting material culture, i.e. how societies created ways of living through their things and their technologies. We also interpret the cultural heritage, from the distant past until today and manage contemporary change in our surroundings.

Both archaeology and nuclear waste management are dealing with long time periods. We both engage with material culture and specific sites, give meaning to rubbish from another culture, and are seeking to preserve (some) heritage and associated knowledge. We are working today for the sake of future generations and are creating confidence that past and future are manageable.

Relevant Questions to be Addressed

Archaeologists have learned that a hundred thousand years ago abstract thought and symbolism began in humans. 100,000 years in the past, homo sapiens sapiens in the African savannas displayed for the first time modern social and cognitive behaviour, represented, for example, in the use of engraved artefacts as symbols of personal ownership. Since then many communities of human beings have succeeded each other. They often intended to leave a mark for eternity but they established in fact the truism that nothing ages faster than the future.

We can therefore pose certain questions:

1. How can archaeological understanding of human evolution contribute to understanding communication a hundred thousand years in the future?
2. Are there any real continuities across time?
3. Which human species are likely to emerge in the long-term future?

Archaeologists contemplate whether in 100,000 years yet another human species will roam planet Earth, or the same species displaying very different kind of behaviour. Archaeologists know that these humans will live under other circumstances than we do and most likely with different understandings of both past and future. We can only speculate what they will make of our repositories but quite likely not the same we make of them. This issue is related to practices in the heritage sector where selected sites are indefinitely preserved by legislation and/or regulations in the planning process for the benefit of future generations. Even though likely future uses of preserved heritage (and sometimes even its long-term survival) are little known and never much addressed in the heritage sector, few people have been questioning its basic rational to preserve and most are confident that it will succeed.

Archaeologists and historians are promoting remembering, learning and understanding of history for contemporary and future generations. With regards to how this applies to RK&M, we can ask;

1. To what extent is knowledge about nuclear waste disposal sites a question of historical consciousness?
2. What can we learn from existing debates about the didactics and pedagogy of history for communication with generations in the long-term future?
3. To what extent are our views of the past and the future projections of conditions in our own time?

Disposal sites of nuclear waste constitute a special case of heritage. We are creating a very distinctive kind of heritage that in the future may be remembered or forgotten, just like any other heritage we create. Those concerned with the RK&M should therefore ask;

1. What does the heritage sector know (or assume) about the future?
2. Why is nobody much concerned about the lack of interest in the future regarding heritage (which costs resources and constraints people's choices in the present and may cause wars in the future)?

In our view, final deposition of radioactive waste is by nature a question of historical consciousness and future uses of the past, of memory and forgetting, and of future didactics of history. Heritage studies as well as history and archaeology are thus inherently relevant. We are asking in this presentation what the realms of heritage and radioactive waste disposal can learn from each other regarding making provisions for the future.

Some envisaged project activities

Session at the European Science Open Forum (Dublin, 12-16 July 2012)

Session on future issues at an international conference in archaeology or heritage studies (2012/13)

Publication of a theme issue of an international peer-reviews journal 2013/14 – for example,

- *International Journal of Heritage*
- *Heritage & Society*

22. Federal Office of Energy Research program: Survey on Markers - Marcos Buser, INA GmbH, Zürich

EKRA, the Swiss Commission on disposal concepts on radioactive waste, recommended marker programmes in the year 2000. The Federal Office of Energy began an R&D programme on markers, the first stage of which has been a literature survey and synthesis.

The survey was conceived as a foundation for further discussion on the marker concept, both in Switzerland and internationally. The general approach was an appraisal of published literature, a synthesis of knowledge on markers, key questions about marker strategies, identification of gaps and contradictions in the marker programmes and of research areas that have to be covered in the future.

The boundary conditions for the study were that it would take a very broad inter- and trans- disciplinary approach that incorporates results and evidences. It would take evidence from physics, geology, chemistry, history, archaeology, sociology, epistemology, and others.

The survey used twenty eight key questions to analyse marker strategies. The procedure was an analysis of the problem, a search of the published literature, and evaluation. Over 200 reports, books, and articles have been evaluated.

Many questions of knowledge and memory preservation are technical questions or questions related to natural sciences, such as techniques of information preservation. The preliminary findings on marker techniques were that there is a great variability of techniques and devices for protection purposes available, many technical protection measures are under discussion and that technical questions are generally easier to deal with than societal questions.

Questions related to knowledge transfer and long-term societal issues show important gaps of knowledge, particularly regarding message transmission. The transmission process is strongly dependent on contextual understanding, and better understanding of such contextual changes is necessary for better encoding.

The general findings of the survey are:

- Need of synthesis has been confirmed
- Contradictions in the goals of marker strategies must be identified
- Entirety: all processes must be analyzed from a inter- and trans-disciplinary point of view, and not from specific perspectives
- The importance of social sciences is greatly underestimated

The specific findings were:

- Research of intrusion motivation is crucial for the design of marker programs (as well as for the configuration of a repository)
- System development has to be understood, not just the development of single elements
- Findings in semiotic sciences, message transmission and misinterpretation and misuse are decisive

23. The Need for Proportionate Systems for Markers and Records in the Long Term, and How to Plan for Them – A. Van Luik

Passive Institutional Controls (PICs) are markers and archives designed to warn and inform future generations about the location, purpose and to some extent the content of a repository.

In the US, the Waste Isolation Pilot Plant (WIPP) is required by its regulator, the U.S. Environmental Protection Agency, to use markers and other controls to indicate there is danger below.

Who are these warnings addressing? Potential intruders into deep geologic repositories. Potential intruders come in two types: advertent and inadvertent.

- The inadvertent intruder is drilling for a purpose other than to see what is in the repository. He or she is drilling through it, to get to a suspected resource or other item of interest. Such an intruder needs to be warned that there is something below ground here that poses sufficient health and financial (cleanup) risk to merit not drilling here.
- The advertent intruder is one who knows there is a repository, who hopefully understands the health and fiscal risks, but wants to drill into it, or through it, anyway.

The present cannot control the future. However, the obligation of the present is to inform the future to eliminate the inadvertent intruder to the extent practicable, and to fully inform the advertent intruder of the risks he or she is choosing to face.

Substantial thought has gone into how to warn a future generation. When WIPP was conceived, in the 1980s, advice was sought from experts who were divided into a Futures Panel and a Markers Panel. Their recommendation was a dire warning in a number of languages, and symbolic warning objects. The symbols were ominous in aspect, as suggested in this conceptual drawing of a Garden of Thorns (Figure 1).



Figure 1: Artist's depiction of an ominous marker system for a repository: a Garden of Thorns

Good thought went into this concept, but it is not very practical. Since the goal from the regulatory authority is to have markers that last 10,000 years, materials must be very long-lasting and shapes must be stable and not have needless stresses built into them by branches, non-vertical structures, and sharp points.

The panels were also insistent on these markers and messages conveying a negative tone, to cause fear or foreboding. But more current thought is that rather than attempt to manipulate the emotions of future

generations, the structures and messages ought to simply inform those generations. The idea is to assure that future generations understand the risk posed by the buried materials, plus the lack of usefulness of these materials. The bottom line of the messages is that it is not worth the risk or the effort to unearth this material: it is trash, with a radioactive component.

The most recent version of the repository marker system proposed for the Waste Isolation Pilot Plant is given in Figure 2:

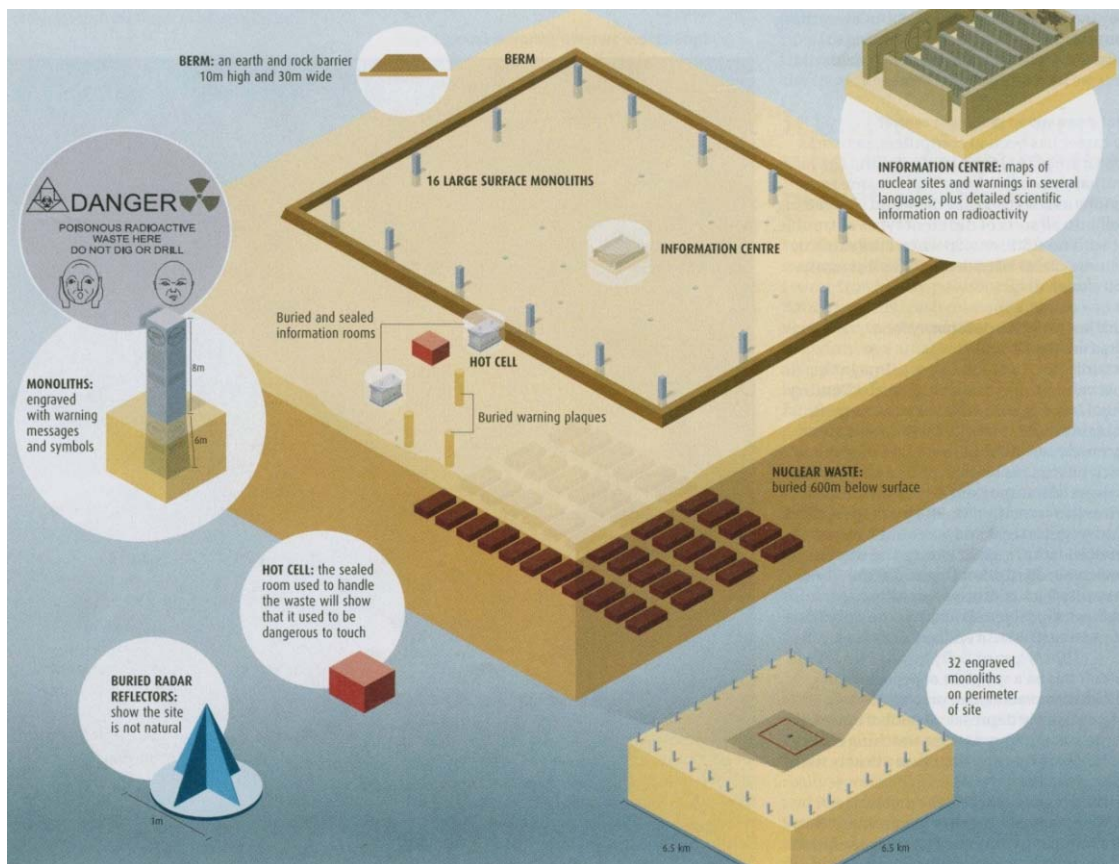


Figure 2: Current proposed design for the Waste Isolation Plant repository marker system

The design provides layers of information and warnings. Redundant messages will be carved into the perimeter monuments, and will be contained in the information centre and the two information storage rooms. But the site is not the only place where this memory is to be retained.

The DOE will also develop a WIPP summary document to be sent to several archival organizations that will make it available to the public, but especially to potential natural resource investigators, historians, and archaeologists. The summary will be available in the six recognized United Nations languages, plus Navajo, on archival-quality paper. Each volume of the summary will be clearly labelled with warnings that they must be maintained (which means occasionally duplicated) for the 10,000-year regulatory period.

The question as to what is to be contained in these archives is a very important one. A salient point to consider is this (submitted to the authors by Roger Nelson, Chief Scientist for the Waste Isolation Pilot Plant at the Department of Energy's Carlsbad Field Office:

The warned intruder (no longer inadvertent) can still be dissuaded if the warning is believed. How do you make someone believe you? You cannot force belief. Belief is an internal emotion. The only way to encourage intruders to believe and not intrude is to tell the whole story, and let them (readers) judge for themselves. Thus warning messages must be complete and detailed, not cryptic (pun intended).

Finding the right balance between the amount of information to make available in the archives so that a potential intruder is fully informed, and hopefully dissuaded, is an issue that deserves close attention. This is an area where an international consensus, international guidance, could be particularly useful.

In the nearer term there will be an active program of assuring that WIPP is located on maps, discussed in textbooks and described in online encyclopaedic information archives. These are also PICs, also passive controls, but they need to be actively maintained so there can be no assurance of them being effective in the future.

A roughly similar design was being developed for the proposed Yucca Mountain repository, as shown in Figure 3:



Figure 3: Conceptual design for a proposed Yucca Mountain repository marker system

It is similar in having standing markers around central message-containing structures. This complex would be repeated several times around the site, just as the vaults containing materials conveying information about the WIPP repository would be repeated three times over the site (see Figure 2, the information centre and the two buried storage rooms would have the same content). As is proposed for use at the WIPP repository, burial of small tokens, coins, with warning messages engraved onto them was also proposed for use on a Yucca Mountain repository.

How effective will PICs be? At latest count there were 18,000 casualties from the March 11, 2011, tsunami in Japan. That is a grim reminder of the ineffectiveness of stone markers. Previous generations

erected stone warning signs to warn future generations not to live below these signs. One of these markers, several hundred years old, is shown in Figures 3a and b.



(a)



(b)

Figure 3: Stone marker, several centuries old, warning of tsunami danger below village of Aneyoshi, Japan (a)

Associated Press photo taken from <http://www.cbsnews.com/stories/2011/04/06/501364/main20051370.shtml>

(b) Huffington Post photo taken from http://www.huffingtonpost.com/2011/04/06/japan-tsunami-warnings-fr_n_845818.html

This marker stands below the village of Aneyoshi. It says "High dwellings are the peace and harmony of our descendants," and "Remember the calamity of the great tsunamis. Do not build any homes below this point."

Modern generations decided these markers, coming from a more primitive time were no longer needed: technology would protect them. Sea walls were constructed, and power plants and villages were built behind them. On March 11, 2011, tsunami waters reached to near where the Aneyoshi marker stands.

This is the problem with ancient markers. Tsunami signs were ignored because new generations felt themselves more capable of protecting themselves. Similarly, warnings to keep out of the Egyptian tombs or suffer dire consequences and curses were taken as invitations to plunder.

So what about repository markers? Repositories are a type of tomb, and may attract the new breed of treasure hunters: resource hunters. The best way to stop this type of intrusion is to describe what is in the repository, and why it is both useless and dangerous. Once a would-be intruder has been informed, he or

she is no longer an “inadvertent” intruder. If a future society decided to unearth the waste, for any reason they choose, and knows what is there before intruding, it is not this generation’s concern or problem.

The duty of this generation is to make a best-effort to warn future generations. Best effort, however, does not mean bankrupting this generation to warn future generations of a danger that is small compared to what prematurely takes human life, daily, today and as likely in the future: human-caused and natural disasters, wars, traffic, dirty water and poor nutrition. Eminent health physicists have observed that vast resources are currently being spent to prevent potential, very small, distant future radiation exposures, to a hypothetical public dose receptor. This is being done, they have observed, at the expense of taking immediate measures that would save many real lives today, measures such as providing clean water and more nutritious food to many areas of the world, where starvation and its attendant health problems are still part of our human condition. This, they suggest, is unethical because it discounts current lives and raises the importance of hypothetical future lives. They have a very good point.

However, markers, monuments and archives are the ethical thing to do by this generation as long as they are not unreasonable for this current society in terms of cost and effort. This generation should not be deprived of a comfortable, even enjoyable, life to warn a future generation of a potential threat if they ‘dig here.’

There is an ethical balance that needs to be struck, but in the meantime regulators, including the one that regulates the long-term safety implications of a WIPP repository, require markers and archives, and require that they last a very long time. To do this in a cost-effective manner, most programs will consider using native stone materials that stand up well over time in the environment of the repository. As an example, for the WIPP repository it has included looking at stone messages left to their future offspring from earlier Native American tribes. This is looking at both a natural analogue (the stone) and an anthropogenic analogue (the physical material used for the message), and the message itself). Examples of messages studied include those shown in Figures 4a and b.



(a) Petroglyph in good condition in sandstone at Frying Pan Canyon.



Petroglyphs gradually being lost to exfoliation (lighter area).
(b) Cornudas Mountain Site

Figure 4, two examples of old rock-scraped messages being studied to inform the WIPP marker program taken from http://www.wipp.energy.gov/picsprog/pics_images.htm

Work is addressing suitable natural materials, the best way to engrave messages onto or into them, and the content of the messages.

Although materials need to be matched with current and expected future environmental conditions at a site, to assure longevity, a basic design and message scheme ought to be readily transferable from repository location to repository location.

If national implementing programs and regulatory agencies could agree in advance on a standard design to be used for all repositories, and set an international repository warning marker standard that takes into account the ethical balance needed to both warn future generations and not damage the well-being of the present generation, it would be very helpful.

It is the Waste Isolation Pilot Plant's intent to help create such a consensus product as an outcome of the larger Records, Knowledge and Memory (RK&M) Project program of work. WIPP stands ready to lend its experience and expertise to this effort.

26. The Connection between the Areas of Safeguards and Physical Protection and Record and Memory Keeping – P. Ormai

Safeguards are concerned with nuclear — especially fissile — materials and associated technology. In general, nuclear safeguards exist on different levels, each with different motivations (the facility operator, national authority, international authority). Safeguards are based on accountancy, which seeks to verify the “material balance”. For international nuclear safeguards, accountancy assures that nuclear materials are present and used as intended. International safeguards are called for by treaties and other agreements between parties.

For purposes of safeguards the amount of fissile material, especially the concentration of uranium and plutonium, and fuel characteristics like burnout, cooling time and decay heat may be of interest.

Geological repository safeguards represent a new challenge. As yet, no country has taken a deep repository in use; therefore, there are no routines for how the safeguarding of the nuclear material will be implemented. National safeguards regime must be extended to include these facilities.

Spent fuel – even if finally disposed of – will never be regarded as waste by the safeguards community. Therefore records must be kept. Both IAEA and Euratom and will have to keep the info in their archives.

1988: IAEA advisory group meeting initiated the development of the IAEA safeguards approach for the final disposal of SNF. The international safeguards community adopted the issue of final disposal of spent fuel – when the IAEA advisory group recommended – as long as the world community kept IAEA safeguards in force anywhere, not to terminate safeguards on SNF.

1994: IAEA started the Program for Development of Safeguards for the Final Disposal of Spent Fuel in Geologic Repositories, SAGOR

1997: IAEA Policy on Safeguards for Geological Repositories

1999: IAEA established the Geological Repository Safeguards Expert Group (ASTOR). Its objectives were to discuss more practical issues like establishment of baseline knowledge.

1999: Coordination meetings between Finland, Euratom, and IAEA

- Of what information the IAEA assess and what activities IAEA should perform to apply effective safeguards the geological repository.

2003: ASTOR report - proposed safeguards measures for GD

2004: In Finland excavation of underground tunnel system for bedrock characterisation at repository site began.

2004: Implementation of the necessary safeguards measures by Finnish safeguards authority was initiated based on IAEA initiatives.

A geological repository safeguards present unique challenges and will pose novel requirements:

- Long period of time that the facility will contain nuclear material;
- The disposed nuclear material will be very difficult to access;
- The space, into which the repository will be constructed and the underground areas of the repository cannot be directly observed.
- Once emplaced, the IAEA will no longer be able to re-verify the inventory of nuclear material contained in the repository because of the backfilling of the emplacement drifts.

The continuity of knowledge of the nuclear material content of the repository may be lost, and that knowledge cannot be restored.

The initial knowledge base is created in pre-operation. Upon declaration of a new facility, the state is to provide sufficient design information (DI). In Euratom terminology the basic technical characteristics are to be provided regarding the as-built structures of the facility as well as the operational processes. Based on this information the IAEA develops a facility-specific safeguards approach.

Finland's proposed Olkiluoto geological repository presents the first site-specific case at which the safeguards approach is applied. Substantial baseline data regarding the integrity of the host bedrock provide a basis for the creation of the initial knowledge base. As the ability to independently verify the baseline information will be lost when the excavation operations begin, activities must be initiated early on.

The IAEA safeguards policy statement relevant to geological repositories recommends that design information verification activities begin during early phase of the repository programme.

IAEA concerned only with safeguards relevant information.

With regards to operational information, prior to closure active safeguards measures equivalent to those in place at other nuclear facilities will be required. Independent inspections periodically verify the declaration by:

- examining operator records & reports
- identifying & counting items
- assaying nuclear materials

Containment and surveillance measures ensure “Continuity of Knowledge”: i.e., that no changes occur between inspections (tags & seals, video cameras). The requirements for material and design accounting to support safeguards may also support retrievability, and in this sense the record-keeping requirements for retrievability and safeguards might be considered to be complementary.

Post-operation, the continued requirement on nations to be able to assure non-proliferation may result in the need for monitoring for institutional control and possible retrieval of the waste. Again these record-keeping requirements may be complementary to monitoring and institutional control measures that would support continued retrievability, even if retrieval is not intended. Nevertheless, the ultimate goal of safeguards after closure is, like the ultimate goal of disposal, not to retrieve the materials, but rather to continue to isolate them from access and contact with persons and the environment (which is, of course, in opposition to the concept of retrievability).

To design for waste/SF retrieval, the implication is that a repository that stays open to facilitate retrieval will prolong a need of the facility and nuclear material physical protection and the safeguards inspection period. As long as the repository remains open, there may be greater potential for diversion of nuclear material if physical protection and institutional controls are not maintained. Hence, from the safeguards and physical protection point of view, the extended time for retrieval may be less effective than if closure occurs immediately after completion of the waste emplacement.

Providing a retrievability period after emplacement operations will require that safeguards measures be maintained continuously for the surface and the underground facilities during that period. Typically, the required safeguards provisions will depend on the ease of access to the nuclear material and the ease of retrieval. The level of safeguards required will likely be comparable to an interim storage facility at or near the surface. An effective application of safeguards shall assure continuity-of-knowledge that the nuclear material in the repository will not be diverted for an unknown purpose.

The post-closure phase will begin when the repository access ways have been backfilled, permanently closed and sealed. After closure, the safeguards measures will be reduced to those measures that give assurance that no intrusion to the repository occurs. After the repository has been backfilled and sealed the geological repository is subject to, environmental monitoring and societal controls as will be deemed necessary at that time. Monitoring of a closed repository is necessary to fulfil the safeguards criteria to maintain safeguards on the nuclear material in the repository.

Safeguards should maintain unbroken continuity of knowledge of material content based on operator data verified by IAEA.

How long may IAEA safeguards last? Spent fuel disposed in geological repository remains subject to safeguards as long as the safeguards agreement remains in force. The agreements on non-proliferation between the signatory States and the IAEA specify that nuclear safeguards can only be abandoned if the nuclear material is practicably irretrievable.

A safeguards objective is to preserve safeguards relevant information and documentation for as long as the nuclear material in the repository is under safeguards. This could imply that the information about the storage or disposal should be accessible for a very long time, which cannot be defined, e.g. in the extreme,

100 000 years. There is no technique proven to preserve data for such a long time span, so some updating of the documentation will be necessary.

In summary;

- IAEA safeguards on a geological repository are not conceptually different than those at fuel cycle facilities.
- An effective application of safeguards shall assure continuity-of-knowledge about the nuclear material in the repository.
- A variety of technical tools enables safeguards to provide accountancy and continuity of knowledge of nuclear materials.
- The record-keeping requirements for retrievability and safeguards might be considered to be complementary.
- Challenges for preserving of IAEA safeguards relevant information and documentation are the same as that of other long term archiving.

27. RWMC Related Work in the Areas of RK&M and the Connection to the ‘Added Value’ Concepts and the ‘Memory’ Aspects of the FSC Programme of Work – C. Pescatore & C. Mays

Introduction

An issue that has long been on the radioactive waste management agenda is the means of marking a waste repository site, such that future generations will be able to comprehend its purpose and risks even if written records have been lost.

For years the main reason cited for needing such comprehension was to preclude unintentional future human intrusion into the repository and the ensuing exposure of the intruder to radiation. Such a future intruder could also cause damage to the repository system and endanger his own and subsequent generations¹⁰. More recently, other reasons have included the wish to maintain a certain degree of flexibility for future generations, in case the latter decide to retrieve the waste for motives that may go beyond safety, e.g., the economic exploitation of the energy potential that may remain in the waste.

The conceptualisation and design of markers of records by technologists has typically focused on durability and has assumed that the repository is – and will be – something totally separated from its cultural environment. A new vision is emerging, however, that it may be worthwhile to consider the repository as part of a societal fabric. The task of maintaining memory would thus be facilitated by measures that would foster community involvement and would go as far as foreseeing that these communities will in time build their own new markers to replace old ones that have become obsolete or are fading away.

It must be understood that the time scales over which the hazard exists are much longer than just a few thousands of years, and it must be accepted that the current generation’s capacity to assure continued integrity cannot be projected indefinitely into the future, but rather diminishes with time. Hence, there is perhaps the need to conceptualise a “rolling future” in which each generation takes responsibility to ensure continuity and safety for the succeeding several generations, including a need for flexibility and adaptability to circumstances as they change. The issue of archives and markers that last as long as possible (the technological approach) continues to be a topical one¹¹. However, we are beginning to

¹⁰ This would be the case also for a large class of chemically hazardous wastes, but the issue does not seem to be a prominent one in that field as witnessed also by the programme of the present workshop.

¹¹ See proceedings of Workshop on “Record Management and Long-Term Preservation and Retrieval of Information regarding Radioactive Waste” held in Rome 27-28 January, 2003 (available from SKB, Sweden and NEA)

understand today that physical markers and archives may be complemented by – or integrated within – a cultural tradition that could be sustained over time starting with the planning of a repository and continuing through its implementation and beyond its closure.

Overarching Observation

Traditional approaches to markers and institutional controls for geological disposal were based on the premise that safety was best assured by keeping the facility apart and isolated from people and the surrounding community. Active controls, for example, could be envisioned to include fences and guards that would restrict access to the site even after closure. It was acknowledged that we cannot rely unquestioningly on future generations to maintain, monitor and interact with the installation; eventually, the institutional structures supporting such controls could disintegrate. To address this contingency, geological disposal concepts are founded on the concept of “passive safety”, which can function even without further intervention or maintenance. Furthermore, markers and records would be put in place with the goal to pass on knowledge of the site and its hazards. The tacit assumption, nevertheless, was nearly always that such an understanding was meant to help keep people away from the site, thereby best providing “safety.”

Yet in everyday life, the concept of safety implies an element of control and familiarity. Even if continued active controls may fade away, familiarity and elements of indirect control continue to be important to safety. Because safety is related to our ability to function freely (unimpeded by fear), safety is also related to quality of life. Hence there has been an evolution in the very concept of disposal. In addition to the traditional actions for oversight and monitoring, preservation of information in archives, and passive markers, it now typically also includes the elements of reversibility/retrievability as well as active participation by local communities in decision making.

The extension of this trend for greater participation by local communities in making decisions implies that disposal facilities can be made part of the fabric of the community rather than operated in isolation from it--and there is a growing awareness that such integration can contribute to, rather than undermine, safety. Our understanding from stakeholder dialogue is that not only should we not hide the facility, but recognise that it will be a central part of a host community and its identity. Today’s overarching message is very simply, *“Do not hide these facilities; do not keep them apart, but make them A PART of the community.”*

The Technological Approach: Preserving Information

Past work on markers and records for geological disposal have focused on the durability and preservation of information as a prerequisite for preserving knowledge and understanding. Certainly, in order to be useable, information must first exist and must already be reasonably accessible.

Records that have to last thousands of years will need renewal from time to time. Paper lasts about 1000 years. We have the record of ancient books because these were re-copied over time scales that are compatible with the shelf life of paper. Records such as microfilm, magnetic and optical tapes are not as durable in that recording and play-back technology constantly require new supports. Who is using floppy disks these days? Hence another message: when dealing with large time scales, the recording technology should be as basic as possible. Stone, like in “The Rosetta Stone” is another, non-paper example of “basic” technology.

Besides the challenges associated with the physical limitations of the technological media and of the readability of the information, we need to face the challenge of weathering institutional and political changes. The best strategy here is to intentionally maintain duplicate records in several sites, including internationally. The Rosetta Stone is probably an example of duplicate records. National legislations typically require archiving of repository information in multiple venues.

To fully achieve the goal of knowledge transfer to future generations, however, we must ensure not only that information is available, but also that it is understandable. This is a significant challenge. In all cases the issue will exist of the interpretation of the information that is being provided. For instance, it takes specialists to interpret medieval inscriptions, and it took Champollion to decrypt the Egyptian hieroglyphs starting with those on the Rosetta stone. Once again, this re-interpretation would take place quite naturally if records were renewed intermittently, like it happened for the writings in the ancient books

As a minimum, there ought to be a strategy to maintain awareness. Partial duplicate records will be derived from other institutional sources, such as land use control records, mining archives, and regulatory archives. These will offer the opportunity to triangulate knowledge.

One simple way for ensuring that awareness of the repository is widely preserved is to have it included on maps. Maps are constantly renewed and updated and daily use is made of them. Another way is to foresee passive markers with minimum amount of information but constructed in such a way as to be evocative and make people to want to look for more information. For each repository, one may need more than just one marker as the principle of duplicate record still applies. Markers can be placed both on the surface – where people may constantly interact with them –, and under the surface, to inform and/or warn off intruders in the case of excavation¹².

Above and beyond such tangible actions as placing duplicate records in order to maintain awareness, there is a growing recognition that more cultural mechanisms---more informal but potentially self-propagating and highly persistent---could contribute substantially.

A New Central Actor?

We have talked about institutions, implementers, regulators: but where does the greatest interest lie in keeping memory alive? Who is most likely to be willing to attend to and to renew and re-interpret the records? It must be the local communities for whom the facility is a constant presence. Ideally, the facilities should be seen by these communities not as a long-standing threat but as something that belongs to the local, social fabric and requires respect, as well as a source of added value: cultural, amenity, economic.

The FSC report *Fostering a Durable Relationship*^{13,14} explores the means by which a facility can respond to the requirement of providing added value and, with it, a basis, for a continued relationship – which could extend over the centuries and millennia - with the facility and its site. Could we, for instance, memorialise the facility? If a monument could be made of it – or of its (symbolic) image – that had the same distinctiveness and aesthetic quality as the Tour Eiffel, say, would this not be one reason for communities to proudly own the site and maintain it? The ultimate question is, thus, whether the surface facility and its surroundings not become the ultimate marker of the existence of the underground repository

In the 1st century BC, classical Roman architect Vitruvius outlined what good architecture should achieve. He stated that a structure must exhibit the three qualities of *firmitas*, *utilitas*, and *venustas*: it must be strong or durable, useful, and beautiful. These are qualities that can be sought for the radioactive waste

¹² See for example: T.L. Tolan, “The Use of Protective Barriers to ...”, Sand91-7097, Sandial National Labs, June 1993

¹³ NEA (2007) *Fostering a Durable Relationship Between a Waste Management Facility and its Host Community; Adding Value through Design and Process*. Paris: OECD. <http://www.nea.fr/html/rwm/docs/2007/rwm-fsc2007-1.pdf>; AEN (2007) *Créer un lien durable entre une installation de gestion de déchets et sa collectivité d'accueil: Valeur ajoutée à travers la conception et les processus*. Paris: OCDE. <http://www.nea.fr/html/rwm/reports/2007/nea-6177-lien.pdf>

¹⁴ See also article with pictures: http://www.nea.fr/html/pub/newsletter/2007/NEA_News-25-1-fostering.pdf

management installation, for both the physical building structures, and for what the installation can bring to the community.

The FSC looked into designing and implementing facilities in ways that provide added cultural and amenity value to the local community and beyond. By cultural and amenity value we mean: agreeable additions to quality of life, through such features as distinctiveness, aesthetic quality, convenience and meaningfulness; through providing opportunities for residents and visitors to meet, learn, relax, enjoy; through fostering community improvements in areas like educational level, image definition, or problem-solving capacity.

A number of basic design elements to foster a durable relationship between the facility and its host community were identified, based on the analysis of input from 32 stakeholder contexts (interviews, questionnaires) and FSC experience. Such design elements include functional, cultural, and physical features. These features tend to maximise the potential of a facility to be “adopted” by the members of the host community, by fitting-in, adapting-to and, moreover, contributing directly to their preferred way of life. The report includes tables to summarise design features and characteristics, the value that each may add to the community, and possible strategies to achieve each feature.

Adding value through functional, cultural and physical design features

Function concerns the uses to which an installation may be put. The radioactive waste management facility must serve the primary purpose of assuring safe and secure long-term management of radioactive waste. Careful multi-functional design then can add value by allowing appropriate parallel uses that are of direct interest to residents and visitors (see the Port Hope example and photo). In the same vein, while in operation, parallel uses of radioactive waste management installations may add scientific value. Zero-gravity experiments are carried out at Japan’s Tono Mine underground laboratory. Laboratory facilities at Spain’s El Cabril and WIPP in the US are available for regional environmental analysis or monitoring. Additionally, when creating a new facility, it is necessary to foresee the end of its useful life. If future needs are not anticipated, there is a risk that the facility will become a liability for the community. An adaptable, flexible facility can provide enjoyment during its operation and also make possible at reasonable cost the transition to a full community facility when its industrial use is no longer needed. Along with careful planning for radiological safety on-site, adaptability and flexibility will leave development pathways open.

The UNESCO Universal Declaration on Cultural Diversity defines culture as “the set of distinctive spiritual, material, intellectual and emotional features of society or a social group, encompassing, in addition to art and literature, lifestyles, ways of living together, value systems, traditions and beliefs”. In this way, culture may be assimilated to shared meaning and practices. Cultural value is found in arrangements that reflect and strengthen a given society’s knowledge, tastes, aspirations, ethical views, or beliefs. It lies in all that is meant to help to transmit an honoured legacy, to communicate symbolic meaning, or to advance ideals. Amongst the cultural design features, distinctiveness may be mentioned, indicating that the facility or site is attractive and like no other, and has the potential of becoming an icon, lending a positive reputation and drawing visitors. Other cultural features include aesthetic quality and understandability, whereby the installation can be tied in with existing knowledge and related to everyday life. Memorialisation is another cultural feature, meaning that both physical and cultural markers identify the site and tell its story, so that people will grasp and remember what is there.

Technical features will provide the agreed level of protection (the primary condition set by stakeholders consulted for the FSC study). Physical design elements will help create the feeling of security (another part of what community and regional stakeholders expect). Physical design features can be combined to create harmonious integration of the installation into its geographic setting, and increase overall amenity: enhancing attractiveness and overall satisfaction. Accessibility means that the site and facility are not barricaded, but are open and welcoming. Communities like Port Hope have pointed out that if a site that is

licensed to operate can be freely visited, walked through, or enjoyed for other uses, it clearly must be safe. It no longer seems to impose restraints on the user, nor shuts people out in an alarming way. It accomplishes its goal of protection without emphasising danger.

Certainly, especially during operation, each and every area of a radioactive waste management facility cannot be made open to the public. Areas restricted for the necessities of safety and security need not benefit from the same degree of functional, cultural, and physical design input. Still, the radioactive waste management facility and site should be considered in a holistic manner, in order to maximise the added value that it is possible to achieve with reasonable effort.

Adding value through the planning and implementation process

Local stakeholders who take an active role in site investigations, or who participate with implementers in formal partnerships, report that the very process of working out the desired features of a radioactive waste management facility and site can bring added value to the community. Social capital—networks, norms and trust—is built up, equipping the community to face other decisions and issues. Local stakeholders may also focus their work on community identity, image and profile. Even when not favourable to hosting a radioactive waste management facility, communities can use the opportunity to develop quality-of-life indicators and reflect on the direction they want to take in coming years. Other benefits that may be accrued are an enhanced educational level in the host community related to the influx of highly skilled workers. Not least important, when host communities demand training and participate in monitoring site development and operations, they are building their capacity to act as guardians and therefore ensure another layer of defence-in-depth¹⁵

Early reflection is best

It takes time to work out new ideas, new possibilities, and where the communities' own interests lie. Integrative reflection on technical and socio-economic aspects, and on cultural and amenity value that could be added by a radioactive waste management facility, is best started from the very first planning stages even before final siting agreement is reached. The information, concepts and ideas gained from this reflection will form a part of the basis on which a local community may agree to become a candidate and then actively engage in the final siting stages.

Institutions generally cannot commit to the final form of a radioactive waste management facility before a specific site is agreed, nor to the ultimate fate of the facility and site. As well, the relationship between a community and a facility or site will depend in part upon external events (for instance, safety performance in the nuclear or radioactive waste management realm; attitudes and statements by political actors, etc.). Still, feasibility studies and social science investigations early in the decision-making process can provide meaningful preparation. Such an approach is coherent with the UNECE Aarhus Convention, which has given many European citizens formal rights to participate in decision-making about their environment.

A presentation by Janet Kotra (US-NRC) at the 8th meeting of the FSC (June 2007) indicated that the mandated need to install “permanent” markers can only be fulfilled if one acknowledges that the markers themselves will evolve over time. Namely, they will become part of the local, subsequent cultures, and they will (or ideally should) be renewed as their materials are degraded, or as their significance evolves. This emphasises again the importance of integrating the disposal system into the community: renewal (as compared to “durability”) depends on future people to take action. The awareness of future people of such markers and their understanding of the meaning of the markers is more likely to persist if it is part of the daily community life than if it is something kept apart, isolated and forgotten.

¹⁵ See article on the 2006 FSC workshop in Hungary: http://www.nea.fr/html/pub/newsletter/2007/NEA_News-25-1-regional-development.pdf

Conclusions

The time scales over which the hazard exists are much longer than just a few thousands of years, and it must be accepted that the current generation's capacity to assure continued integrity cannot be projected indefinitely into the future, but rather diminishes with time. At the same time there is a common understanding that we should not "walk away" from these facilities nor to hide them, even when we think they will be safe. In fact, the sense of safety will be coming from continuing, over time, some element of familiarity and control. Hence the need to conceptualise a "rolling future" in which each generation takes responsibility to ensure continuity and safety for the succeeding several generations, including a need for flexibility and adaptability to circumstances as they change

The issue of archives and markers that last as long as possible (the technological approach) continues to be a topical one. However, we are beginning to understand today that physical markers and archives may be complemented by – or integrated within – a cultural tradition that could be sustained over time starting with the planning of a repository and continuing through its implementation and beyond its closure. The mandated need to install "permanent" records and markers can only be fulfilled if one acknowledges that these will evolve over time. Namely, they will become part of the local, subsequent cultures, and they will (or ideally should) be renewed as their materials are degraded, or as their significance evolves.

Because a radioactive waste management repository and site will be a permanent presence in a host community for a very long time, a fruitful, positive relationship must be established with those residing there, now and in the future. Simply put, designers have to make the radioactive waste management facility and site to suit people's present needs, ambitions, and likings, and provide for evolutions to match at reasonable cost the needs and desires of future generations. The challenge is to design and implement a facility (with its surroundings) that is not only accepted, but in fact becomes a part of the fabric of local life and even something of which the community can be proud. Parts of the facility and its surroundings may thus become themselves cherished markers of the existence of a waste repository underground.

28. Preservation of RK&M for Long Term Storage Facilities: The Results of a French Study – T. Schneider

Due to the specific long lasting radioactivity of high level waste types, new issues may arise for radiation protection. In this perspective, technical, societal and organizational aspects have to be considered. For the two latter aspects, it is interesting to analyse the efficiency of protection systems available in other fields than nuclear waste management, in order either to protect society from specific risk or to preserve world heritage. Few years ago, CEPN together with MUTADIS have performed a specific study, commissioned by CEA (Commissariat à l'Energie Atomique), in order to analyse the characteristics of protection systems used to manage risks associated with the presence of past underground cavities and mines, as well as the mechanisms designed and implemented by UNESCO for the preservation of world heritage sites. This study has identified a set of performance criteria to deal with long-term protection. These results were notably discussed within the framework of the European project COWAM 2 in a working group involving experts, authorities, waste managers, locally elected representatives and NGOs.

This paper presents briefly the case studies performed on long-term protection as well as the key lessons related to the continuity and sustainability of the surveillance and control of radioactive waste facilities.

1. Introduction

The long-term persistence of the radioactivity of the waste gives a new dimension to protection and raises the question as to which technical means and organizational and societal aspects could contribute to an efficient protection throughout long periods of time. In this perspective, CEPN was involved in different

research activities since more than 15 years in order to contribute to the debate among the radiation protection community concerning the way to establish a protection system to cope with the long-term dimensions. Notably, it is interesting to mention the reflections developed within the framework of the French research law, adopted in 1991, on radioactive waste and the National Public debate on this issues organised by the National Commission of Public Debate (CNDP) at the end of 2005. In this context, the French Atomic Energy Commission (CEA) asked to CEPN and Mutadis to perform a study to analyse the effectiveness of long-term protection systems implemented in other fields. The main result of this study was to identify performance criteria originating from arrangements existing in the risk management developed for abandoned quarries and mines, as well as arrangements used by UNESCO for the world heritage sites [1, 2]. It has also clearly shown that the question of preservation of memory and long-term considerations are not only a matter of centuries or several thousand years but could be of concern only a few years after the closure of the activities at the origin of the risk. In addition, within the framework of the Euratom Research Programme, CEPN led the reflections on long-term radioactive waste management with European stakeholders as part of the activities of the COWAM research project [3, 4].

This paper summarises the key findings from these researches pointing out the key features for the conservation of records and memory as well as the governance issues associated with the long-term management of radioactive waste.

2. Characteristics of some long-term protection systems

2.1. Management of ancient cavities under the City of Paris

There are many cavities under the City of Paris, some of which are many centuries old, and their presence raises a risk of subsidence (see Figure 1). In fact, more than 70 km² are concerned for the City of Paris and its suburb area.

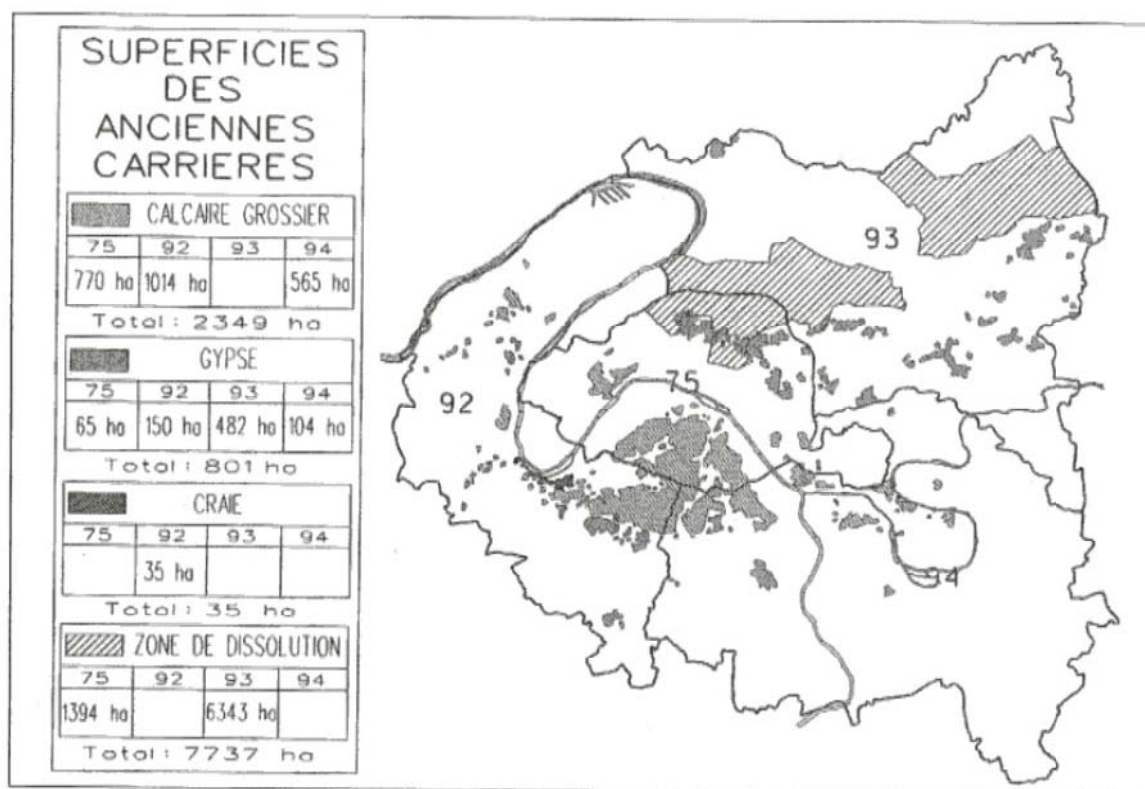


Figure 1. Old quarries in the City of Paris and its suburb.

After an accident that occurred in the 18th century, a risk management system was set in place, and is still operating today. It is characterised by a judicious division of responsibilities between the quarry inspection service (Inspection Générale des Carrières - IGC), the land owners and the City of Paris:

- The IGC is in charge of acquiring, securing and maintaining relevant information. It also makes sure that problems associated with the existence of these cavities are kept on the agenda. It has built up a considerable expertise in the techniques of risk management and in making the land safe.
- The owners of buildings in high-risk areas, and the City of Paris as far as public property is concerned, address the risks as identified by the IGC, since they must finance the work to be carried out to ensure safety.

This arrangement has made it possible, despite the persistence of the risks, to ensure sustainable development of the city and long-term management of the risk by maintaining a dynamic action system. The durability of the system is essentially based on:

- Clear division of the responsibilities between private owners, the IGC and the municipal authorities;
- The market value of the land and buildings, which is continually increasing over time. The cost of remedial work is thus generally marginal compared to the current value of real estate, which is a powerful incentive for the owners to carry out the necessary work;
- A system which stimulates periodically risk awareness, when real estate transactions are being made and the surveillance of any of the ancient cavities results in the IGC issuing an alert, or should a ground collapse occur.

2.2. *Management of the legacy of mining in the Lorraine Basin*

Iron mines were operated in Lorraine during the 19th and 20th centuries. The last mines were closed in the early nineties, resulting in the transfer of the surveillance of the mined areas from mine operators to the French State. The ending of the regular maintenance resulted in subsidence of the land in a number of areas, which made it necessary to set in place a system for management of the long-term risks. This included the creation of:

- A centre of expertise on the risks of ground collapse, to support the government authorities (GEODERIS);
- A centre for scientific research into systems of detection and prevention of collapse (GISOS);
- A regional committee for evaluating the terms and conditions of the cessation of mining work and surveillance of the installations, combining civil servants, local politicians and non-governmental organizations.

The emergence of problems associated with subsidence in iron ore-mining areas is clearly linked with the cessation of mining throughout the region. The ending of this economic activity in the region has resulted in the absence of individuals or organizations with an incentive to conduct long-term surveillance. Unlike the case of the ancient cavities under the city of Paris, in the Lorraine Basin low land prices have resulted in difficulties concerning funding of protection and have necessitated the direct governmental intervention. With a view to long-term management of the situation, local politicians and populations have requested that consideration be given to the possible economic future of the region.

Regarding the reinforcement of surveillance of the mines after closure, a system of expert appraisals has been set in place, on the one hand to mobilise local and regional skills (expert appraisal organizations

present in the region, creation of collaboration with the university), and, on the other hand, to make use of such special knowledge in other regions.

2.3. Protection of UNESCO world heritage sites

The UNESCO Convention Concerning the Protection of the World Cultural and Natural Heritage, signed in Paris in 1972, set in place a system which established, for more than 900 specific locations, considered specifically significant for humanity, the terms and conditions of management combining concerted action by the international community, the government involved and the local population. Currently, 188 countries are involved in this Convention.

The effectiveness of this system of protection is primarily based on the recognition of the existence of one heritage that is common to local, national and international players, and the division of responsibilities between them over time. Everyday management of such a site is handled by a local organization in contact with local inhabitants. The national level sets up a regulatory framework, provides legal guarantees and makes technical and financial contributions to protection-related actions. At the international level, the UNESCO monitors the permanence and durability of the local and national protection actions and initiates procedures in the event of any shortcomings, mobilising technical and financial resources as necessary. Effectiveness also depends on the procedures for listing and monitoring the sites to be protected, encouraging the governments involved to 'identify, protect, conserve, enhance and transmit to future generations their natural and cultural heritage'.

Apart from recognition that responsibility for heritage sites is more the affair of the government involved than UNESCO, among the projects that have arisen in the context of the 1972 convention, all recognise the need to link site conservation to the sustainable development of the concerned area to encourage the local population to play a positive role in taking care of the site. This integration is fostered by the creation of centres of activity handling both safeguard issues and those relating to development (tourism, and the fostering of intellectual and technical skills for instance).

It is finally to be noted that the 1972 convention provides for the keeping of long-term records concerning the protected sites, featuring the compilation of archives and inventories, and the circulation of copies to museums and libraries throughout the world.

3. Addressing the issue of continuity and sustainability of surveillance and monitoring with stakeholders involved in radioactive waste management

These lessons have been further investigated within the COWAM-2 European Commission Research Project with a group of European stakeholders, in order to derive, when possible, performance criteria regarding long term management processes. It was recognised that the continuity and sustainability of surveillance and monitoring over long-term periods cannot be guaranteed nor decreed. Nor is it possible for people living today to define how society should be run in the future to ensure waste management. Therefore, in a long-term governance process, it is necessary to search how to create the conditions that will promote the preservation of vigilance (at local, national and international levels) and its transmission from generation to generation.

Based on these different studies presented above, the stakeholder group of COWAM-2 identified several areas of action that could be studied when designing surveillance systems around radioactive waste management facilities to promote the sustainability of these systems over long-term periods. The main points to consider within these areas of action are presented below.

Organising surveillance and vigilance

- The transfer of the surveillance system from one generation to the next should be studied in order to promote an active conservation of the memory of the facility. For this purpose, it is necessary to allow the waste management and facility surveillance systems to evolve over time.
- Local stakeholders should be involved in the site's surveillance system as they are key actors in the vigilance and the transfer between generations.
- The surveillance and monitoring programme has to be clearly organised (distribution of responsibilities, monitoring procedures, etc.). The sustainability of such a programme would be strengthened by the creation of regular meeting points between state regulatory authorities, the body in charge of surveillance and local stakeholders, to assess its efficiency and identify the needs for evolution.
- A dedicated and sustainable funding system should also be associated with the surveillance programme. If necessary, the possibility of mobilizing international resources should also be studied.

Developing a centre of competence

- A centre of competence could be created for the operation, maintenance and surveillance of the radioactive waste management facility over the long-term.
- This centre of competence should focus on developing, using and transferring to future generations the expertise and know-how required to ensure efficient surveillance and monitoring of the facility over time.
- The centre of competence should be able to benefit from local, national and international expertise. The possibility of using this centre's expertise in different places and in fields other than radioactive waste management should be promoted.
- Involving stakeholders in the definition and follow-up of activities at the centre of competence is also an important way of ensuring sustainability and vigilance over the long-term.

Integrating the radioactive waste management facility and its surveillance into local/regional socio-economic development

- It should be made possible to integrate the surveillance function into a global project for sustainable socio-economic territorial development. Such a project should be designed with a view to "maintaining life" around the radioactive waste management facility because the stability of the local and regional population is a key factor in ensuring sustainable surveillance.
- For example, economic activities linked to the surveillance and monitoring of the environment could be developed in interaction with scientific and technological competence at local/regional level.
- It is also essential to set up systems that guarantee that the presence of the radioactive waste management facility is compatible with long-term territorial development.

Sharing out responsibilities fairly between territories and between generations

- To ensure an efficient protection system, the distribution of responsibilities between local, national and international stakeholders has to be clearly defined.
- The notion of "safety heritage" should be developed in order to create a "safety link" between local, national and international players and between generations.
- Finally, the advantages of setting up an international convention on the protection of radioactive waste management facilities could be studied.

4. Lessons that can be learnt for the management of radioactive waste

To summarise the reflections, the following properties of a system enabling management of risks in the long-term could be mentioned:

- The sharing of roles and responsibilities between the different parties involved;
- The existence of durable and available expert knowledge;
- The presence of multiple centres of expertise;
- The recognition of a common goal by the different parties involved;
- The promotion of a sustainable local development;
- The legal, institutional and financial structures;
- The existence of a sequential decision-making process;
- The redundancy of the records.

References

- [1] Hériard Dubreuil G., Gadbois S., Schieber C., Schneider T., Réflexion sur les critères de performance d'un entreposage de longue durée (ELD) vis-à-vis des situations de délaissement temporaire, Rapport CEA - DEN/DDIN/DPRGD/2003/3, 2003.
- [2] Marvy A. et al., A look at new key performance criteria that could affect the most the safety of a long term storage for nuclear waste - A case study commissioned by CEA, International Conference on Issues and Trends in Radioactive Waste Management, IAEA, Vienna, Austria, 9-13 december 2002.
- [3] Schneider T., Schieber C., Lavelle S., Long-term governance for radioactive waste management - Final report of COWAM 2. CEPN-R-301 / Report COWAM2 - D4-12.
- [4] Schneider T., Schieber C., Gadbois S., Hériard Dubreuil G., Considering the modalities of intergenerational transfer associated with radioactive waste management. In: Proceedings of the 12th International Congress of the International Radiation Protection Association-IRPA 12, Buenos Aires, Argentina, 19-24 October 2008.

29. Embedding the Past in the Present – Final Remarks - E. Van Hove

The need for context

Several papers presented at the workshop on Preservation of RK&M Across Generations in Paris on 11 to 13 October 2011 demonstrated that it is technically possible to preserve information for sufficiently long to cover the most dangerous period of the existence of a repository. It also seems quite feasible to agree on what information should be kept and in what form. All of that is worthwhile work that should be pursued in cooperation with other relevant international bodies.

For such an information system to be meaningful, however, some implicit assumptions should be addressed. Most of the very worthwhile discussions held at the workshop were devoted to the context of such an information system.

Assumption 1: Man is a rational being, inherently good natured, honest and willing to obey sensible rules.

There is nothing wrong with this piece of wishful thinking. Most people, except perhaps evangelical preachers caught in the act, try to behave this way: no emotional outbursts should cloud our thinking. ‘Trying’ is the key word in the previous sentence, this image of man is very much aspirational and must be helped with an ample dose of social control in order to prevail. Go by the rules, certainly when police is around, don’t lie too blatantly, pay your taxes and avoid fines.

How should we take this into account?

1. Accept the fact that no matter how extreme the warnings are about accessing a repository, this will happen anyway. Man is adventurous, warnings given now will be treated as jokes a couple of generations from now. Future technology will make it trivial to access deep repositories. In the construction of repositories this fact should be acknowledged. In the choice of materials less valuable ones should be preferred, contrasts in filling materials should be provided, in situ warnings should be left.
2. Muster social controls to safeguard the integrity of a repository. A local social fund builds a long term link to the repository, multiple uses of surface facilities increases familiarity and interesting architecture generates appreciation.

Assumption 2: The paradigmatic superstructure of scientific information is stable and will endure.

No matter how extensive it is, a scientific information system concerning a repository will still be only snippets taken out of a broader discourse cast in the language of science. This broader canvas that we acquire in education and professional training, is needed to make the message understandable. Somehow we have the strong conviction that modern science is final and permanent and can only be added to. Modern science will not be superseded like pseudo-science of the old days. It is very difficult to imagine a radical change of paradigm. It will happen someday anyway.

What we can more easily imagine is a new age of obscurantism descending over the earth. The loss of precious knowledge when future generations are engaged in a Malthusian struggle for survival.

In both scenarios a scientific information system cast in the language of present day science won’t be of much use.

How should we take this into account?

1. The information system left for future generations should not only contain scientific information that presupposes scientific language. If we consider messages from the earliest days of written language, the Babylonian tablets in cuneiform script, those about the simple facts of life, a father admonishing his son, the sadness of a lost child, are things we understand immediately. Their bookkeeping and astrological observations are another matter. No matter how distasteful to the professional mind, information systems about a repository should also have simple messages written by the local schoolchildren to their future successors or warnings given by mothers to future parents.
2. The possession of language and written script is something we can assume, not the use of a specific language. However, if our experience of the past can be relied upon, decoding unfamiliar language and script is not that difficult to the dedicated geek. Getting at the meaning of a specific message is the difficult part. If this is true, the effort to develop language free symbol systems is a waste of time.

Assumption 3: We can plan for thousands of years

Repositories are guaranteed for a hundred thousand years. What this means is that all major barrier systems provided have withstood laboratory tests that can be extrapolated to such time spans. It doesn't say anything about what will happen in the future. In fact such time spans are beyond what we can grasp and therefore have no concrete meaning. Rather than provide a sense of security such guarantees are frightening.

We have no qualms about acting with permanent consequences. We are surrounded by things which are supposed to last forever: roads, some buildings and monuments, firms and institutions. We trust that people in the future will provide the maintenance and efforts to give these things further vitality. We have no ambition at all to say now what should happen to that road in a hundred years' time. We litter the landscape with things that are forever but we do not plan forever.

How should we take this into account?

1. The message on a deep repository is that the infrastructure is forever and that the maintenance costs for the foreseeable future are covered and later on are reduced to nothing.
2. We should not cripple future generations in their ability to act on a repository according their needs by extreme secrecy, and hiding information. The notion that we know best and should dictate what people in hundreds of years' time should do is ludicrous.

PARTICIPANTS LIST

Belgium

Jean-Paul BOYAZIS - ONDRAF/NIRAS
Jantine SCHRÖDER – SCK•CEN
Erik VAN HOVE - University of Antwerp

Finland

Kai HAMALAINEN - STUK

France

Luis APARICIO - ANDRA
Patrick CHARTON - ANDRA
Amélie DE HOYOS - IRSN
Jean-Noël DUMONT - ANDRA
Basak Sarac LESAVRE - Ecole des Mines de Paris
M. Thierry SCHNEIDER - CEPN

Germany

Stephan HOTZEL - GRS

Hungary

Zoltán NAGY - Hungarian Competition Authority

Sweden

Mikael GONTIER - SKB
Anders HÖGBERG – Linnaeus University
Cornelius HOLTORF - Linnaeus University
Mikael JENSEN - SSI
Georg LINDGREN - SSM
Erik SETZMAN - SKB
Sofie TUNBRANT - SKB

Switzerland

Christian SIEBER – Cantonal Directorate of Public Works, Zürich
Simone BRANDER - (BfE) SFOE
Marcos BUSER - Institut für nachhaltige Abfallwirtschaft
Anne CLAUDEL - Nagra
Thomas FLÜELER - ETH Zürich
Krystyna OHNESORGE - The Swiss Federal Archives (SFA)

United Kingdom

John A. DAY - Sellafield
Helen GORDON-SMITH - NDA
Stephen GRIFFITHS - HSE
Simon WISBEY - NDA

United States

Abraham VAN LUIK - US DoE

European Commission

Wolfgang HILDEN - DG Transport and Energy

IAEA

Peter ORMAI - Division of Nuclear Fuel Cycle and Waste Technology

OECD NEA

Claudio PESCATORE - Radioactive Waste Management and Decommissioning