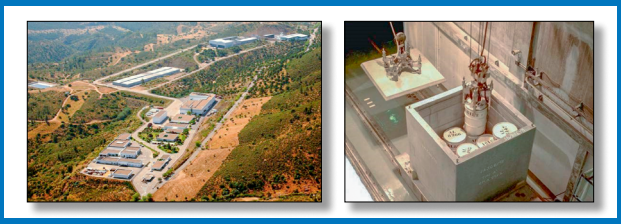
Radioactive Waste Management and Decommissioning
2019

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

Compiling a Set of Essential Records for a Radioactive Waste Repository



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Radioactive Waste Management and Decommissioning

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

Compiling a Set of Essential Records for a Radioactive Waste Repository

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Cover photo: Aerial view of the El Cabril repository (Enresa); low- and intermediate-level waste disposal unit (Enresa).

Foreword

Many member countries of the Nuclear Energy Agency (NEA) are engaged in the development of projects for the final disposal of radioactive waste and spent fuel. Disposal facilities will be built, implemented and operated over many decades and are meant to remain functional for up to hundreds of thousands of years.

For high-level, long-lived radioactive waste and spent fuel, geological disposal is the reference management strategy. Such repositories are designed to be intrinsically safe and final: their safety should not rely on human maintenance or intervention. Nevertheless, there is no intention to abandon these repositories or to lose oversight of them.

Records, knowledge and memory (RK&M) of each repository and the waste it contains should be preserved as long as possible. Consequently, RK&M preservation, aimed at avoiding inadvertent human intrusion and supporting informed decision making in the future, has been identified as an integral part of responsible radioactive waste management in line with a prudent approach to safety and a conscious attitude to ethics. Such preservation constitutes a dedicated management task that is best addressed while waste management plans are being designed and implemented, and while funding is available.

In 2011, against the background of increasing demands by waste management specialists and other involved parties for international reflection and progress towards viable and shared strategies in this field, the NEA Radioactive Waste Management Committee (RWMC) launched an initiative on the Preservation of Records, Knowledge and Memory (RK&M) across Generations. The objective of the initiative was twofold. Firstly, the initiative sought to develop a theoretically founded, broad-based understanding – technical, managerial, institutional, societal and cultural – of the issues at stake. Secondly, it set out to develop a practice-oriented "toolbox" of concrete RK&M preservation methods, a "menu" that will allow future generations to identify various approaches and mechanisms to develop a strategic action plan for RK&M preservation across generations.

One mechanism of this strategy is the Set of Essential Records (SER). The SER can be understood as a collection of the most important records for waste disposal. These would be selected, during the lifetime of the repository, for permanent preservation. The SER would provide sufficient information for current and future generations to ensure an adequate understanding of the repository system and its performance. One working group within the RK&M initiative was dedicated to devising an example procedure for how to develop a repository-specific SER. The essential steps are to select, manage and preserve, from the vast amount of records produced before and during the lifetime of a geological repository, a relevant set of

records. The result is described, and illustrated by example, in this report. It is important to note that this is an example procedure, supported by appropriate tools. Alternative approaches would be valid, but need to respect the overarching goals of being clear, traceable and transparent, too.

Acknowledgements

The NEA would like to thank the many individuals who contributed to the RK&M initiative (2011-2018), by direct participation as a member, by participating in particular project meetings, workshops or conferences, by responding to project questionnaires or by contributing to project documentation. This report on the Set of Essential Records (SER) concept was drafted by a subgroup, with members including: Gwenaëlle Clerc (Andra); Martin Eliáš (SÚRAO/RAWRA); Joaquín Farias-Seifert (Enresa); József Fekete (PURAM/RHK); Miroslav Kučerka (SÚRAO/RAWRA); and Ulrich Noseck (GRS), who co-ordinated the subgroup.

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List of abbreviations and acronyms

Andra	Agence nationale pour la gestion des déchets radioactifs (France)
CSN	Consejo de Seguridad Nuclear (Spain)
EBS	Engineered barrier system
EIA	Environmental impact assessment
Enresa	Empresa Nacional de Residuos Radiactivos (Spain)
FEP	Features, events and processes
GRS	Gesellschaft für Anlagen- und Reaktorsicherheit – Global Research for Safety (Germany)
IAEA	International Atomic Energy Agency
ICRP	International Commission on Radiological Protection
KIF	Key Information File
L&ILW	Low- and intermediate-level waste
NEA	Nuclear Energy Agency
OECD	Organisation for Economic Co-operation and Development
PURAM/RHK	Public Limited Company for Radioactive Waste Management (Hungary)
PVRA	Environmental Radiological Surveillance Programme (CSN, Spain)
QA/QC	Quality assurance/quality control
R&D	Research and development
RK&M	Records, Knowledge and Memory
RMS	Record management system
RWMC	Radioactive Waste Management Committee (NEA)
SER	Set of Essential Records
SÚRAO/RAWRA	Radioactive Waste Repository Authority (Czech Republic)
TOR	Terms of reference
URL	Underground research laboratory
VLLW	Very low-level waste

Chapter 1. Introduction

The Nuclear Energy Agency (NEA) Radioactive Waste Management Committee (RWMC) has managed an international initiative to address the Preservation of Records, Knowledge and Memory (RK&M) across Generations. This multi-affiliation forum provides an important vehicle for exploring and developing guidance on regulatory, policy, managerial and technical aspects of the long-term preservation of RK&M to support waste disposal programmes. Several radioactive waste disposal programmes are now active or are approaching implementation, and have recognised the need to actively manage RK&M from the start. Member organisations are committed to working together on an international framework supporting national programmes to move forward in this area.

Five guiding principles were established in the first phase of the initiative.

1. Maintaining RK&M for a radioactive waste repository after its closure will allow future members of society to make informed decisions regarding the repository and its contents, and will help to prevent inadvertent human intrusion.
2. Enabling future members of society to make these informed decisions is part of a responsible, ethically sound and sustainable radioactive waste management strategy.
3. Preparing for RK&M preservation is best addressed while waste management plans are being designed and implemented.
4. Systems for preserving RK&M will need to be flexible and adaptable over time.
5. A "systemic strategy" should be applied, whereby various approaches implemented through specific mechanisms complement each other, provide for redundancy of message communication and maximise the survivability of a recognisable message.

National programmes on repository development typically extend over many decades across a range of facilities and nuclear applications. Operators may be required to generate and retain large numbers of records[1] on the basis of legal and regulatory instruments. As a result, the large numbers of records are produced

1. The RK&M initiative defines a record as "a usually unique and original object or a selected piece of data/information that has been committed to a medium (analogue or digital) and that is kept, together with the appropriate context and structure, for later use."

against a background of increasing knowledge from site characterisation and research and development (R&D), evolving management systems, and revisions to laws and regulations.

The basic goal of preserving information on the repository is to enable future generations to understand the repository system and its performance and, if necessary, to assist them in making informed decisions. Therefore, the information stored must be sufficient to allow reliable understanding of the repository location and system, and to assess potential hazards. It must be ensured that this information remains available and comprehensible over a long period of time.

As the large numbers of records are challenging, there are evident advantages to a reduction in their scale, using appropriate criteria. The reduction in scale would increase transparency and traceability, and would open the potential for producing more copies and using more durable materials, which should improve their accessibility and longevity. Nevertheless, the main messages must still be preserved so as to be fully understood.

In order to address concerns about the volume of records generated for a national radioactive waste facility, the RK&M initiative has identified "dedicated record sets and summary files" as an important approach in an RK&M preservation strategy. This approach consists of a Set of Essential Records (SER) and a very condensed Key Information File (KIF), both of which are for long-term retention.

The KIF is a single document of approximately 40 pages that is anticipated to provide comprehensive basic information on the location and the repository system for a broad spectrum of stakeholders. It should be distributed widely (e.g. in schools, libraries) and kept in use by local administration. The SER should serve as a source of detailed data and information on the repository system. It is primarily aimed for radioactive waste management specialists, decision makers, regulators and other authorities to help them make informed decisions.

The goal is not to speculate on what type of societies can be anticipated in the distant future. Rather, the SER is being developed in light of current specialists' data and information requirements.

The main objective of this SER concept report is to provide a form of guidance to the actors involved with the management of repository records while focusing on the specific needs of the post-closure period. The guidance set forward in this document and its appendices comprises recommendations for criteria on the selection of records to form part of the SER and, where necessary, an explanation as to why these criteria have been selected. The recommended criteria should be tested against the radioactive waste management organisation's (RWMO) individual requirements for adequacy and completeness. It is recognised that the content of individual SERs may vary according to legislative requirements and the specific issues associated with each repository.

This report will also highlight the need for creating a process to establish and maintain an SER within an RWMO. This concept report is organised as follows:

- The idea and concept of the SER, and its correlation with other repository documents and other RK&M preservation approaches developed in the RK&M initiative, are shown in Chapter 2.

- Recommendations for records classification and selection are given to all interested stakeholders who are working towards realising a detailed SER concept in Chapter 3.
- Recommendations for management of the SER are outlined, and aspects of long-term preservation of the SER are discussed, in Chapter 4.
- There are two annexes. Annex A covers the detailed selection of records, while Annex B uses the safety studies of the El Cabril repository in Spain to illustrate the scale of records produced for a real repository and important issues that need to be considered before creating the SER.

Chapter 2. **The SER concept**

2.1. **Definition of the SER**

The Set of Essential Records (SER) should be understood as a collection of the most important records for waste disposal selected for permanent preservation during the lifetime of the repository. It provides sufficient information for current and future generations to ensure an adequate understanding of the repository system and its performance. This will enable responsible parties to review and verify the repository performance and the safety case, and to make informed decisions.

The SER (particularly taking into account its volume, technical language and accessibility) should serve as a source of detailed data and information on the repository system primarily for specialists and researchers, as well as for decision makers, regulators and other authorities. This is in contrast to the Key Information File (KIF), which is primarily intended to be used by non-specialists.

2.2. **SER in relation to other records**

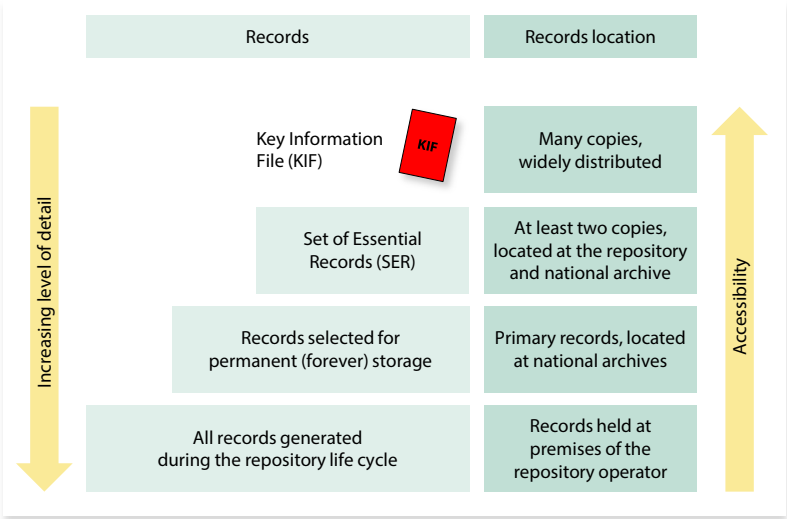
The total amount of records and levels of information generated during a repository's life cycle will be vast and therefore requires careful records management. Appropriate policies and processes will be needed for records categorisation and the selection of records, as well as information for temporary preservation, permanent preservation or for discarding. Reducing the vast scale of records to a manageable SER opens the potential for better preservation, comprehension, longevity and accessibility.

The basic hierarchical division of records into levels proposed within the RK&M initiative is illustrated in Figure 2.1. The highest level is occupied by the KIF, a single document of about 40 pages. The KIF would have the lowest level of detail, but the highest probability of survival and would be intended for wide accessibility by all interested stakeholders.

In contrast to the KIF, the lowest level of the figure represents the complete collection of all records generated during the repository lifetime. This is where the records with the highest level of detail are found. Although held in institutional archives or databases, many of these records are transient and a significant percentage of records are expected to be discarded during and after the operational period of the repository.

Two intervening levels fall between the highest and lowest levels of the figure. A subset of the total records, shown in the second-lowest level, will be selected for permanent storage in the archives. This includes records selected in response to legislative requirements and those identified to belong to the SER. Therefore, the SER contains a selection of the most important records foreseen for permanent storage – but only a fraction of all records will be part of the SER. However, even records not considered based on regulatory requirements may be identified as relevant to the SER and selected for permanent storage in archives (see Figure 3.2).

Figure 2.1. **Sets of repository records with relevance for RK&M preservation**



2.3. Relationship to other RK&M preservation approaches

The objective of the RK&M initiative is to develop and publish a "menu" of approaches and mechanisms to preserve RK&M about radioactive waste disposal facilities (NEA, 2019). National disposal programmes can then select components from this menu to create a system that maximises the likelihood of information survivability while meeting the legal requirements in force. This is referred to as a "systemic strategy" wherein a variety of avenues are established in order to maximise the likelihood that information survives and can be understood over relevant timescales. All mechanisms in a particular application should be chosen on the basis that they provide robustness through reinforcement, cross-referencing and redundancy.

The menu comprises a set of "approaches" including: memory institutions; time capsules; markers; culture, education and art; oversight provisions; international mechanisms; regulatory framework; knowledge management; and dedicated record

sets and summary files. Each approach is composed from "mechanisms", for which unique descriptions have been developed, based on a standard template (NEA, 2019). The list of approaches and identified mechanisms are included in Table 2.1.

Table 2.1. **Approaches and their corresponding mechanisms**

Approaches	Mechanisms
Memory institutions	Archives; libraries; and museums.
Time capsules	Large visible time capsules; large invisible time capsules; and small time capsules.
Markers	Subsurface markers; surface markers; deep geological markers; surface traces; and monuments.
Culture, education and art	Surface infrastructure as industrial heritage in itself; alternative reuse of the site and/or its infrastructure; heritage inventories and catalogues; local history; intangible cultural heritage; nuclear and related topics in (academic) education, research and training; information dissemination activities; and nuclear and related topics in art.
Oversight provisions	Monitoring; land use control; and clear and planned responsibilities.
International mechanisms	International treaties, conventions and directives; international standards and guidelines; international inventories and catalogues; international co-operation; and international education and training programmes.
Regulatory framework	National regulatory framework; and safeguards.
Knowledge management	Knowledge retention tools; knowledge risk analysis; and knowledge sharing philosophy.
Dedicated record sets and summary files	SER; and KIF.

There is a strong relationship between the SER and the approach "memory institutions", which comprise archives, museums and libraries. Especially important are the archives, which are defined through their long-term mission to permanently preserve collections of records for future generations. Therefore, archives are a key institutional approach of the RK&M preservation process and particularly relevant for the transfer of the SER to future generations.

Furthermore, it is important to note the relationship between the SER and the KIF. The KIF is designed as a summary document that captures, at a level that is accessible by people with no specific knowledge of radioactive waste management, basic information on the repository and the wastes it contains. The SER captures, in a more technical language, detailed information about the disposal facility, its contents and the associated safety cases. While the SER *may* include the KIF as one of its documents, the KIF *should* identify the intended location and distribution of more detailed records, including the SER.

Chapter 3. Procedure for record selection for the SER

The records produced during a repository programme are diverse in nature (e.g. paper documents, engineering drawings, maps, photographs, physical objects, and electronic records and databases). Their content is also – to some extent – dependent on the regulations in each country, the type of repository (deep geological or near-surface) and the type of waste. This variety of records also has an impact on the selection of records for the Set of Essential Records (SER).

Therefore, the aim of this work is neither to evaluate concrete guidelines for the SER selection process, nor is it to present a complete table with records to be included in the SER. Rather, it is to present an example procedure to select records for the SER, illustrated by an example application, that may be modified or adapted to the specific conditions of each country or organisation dealing with this topic.

The general requirement of this procedure is that the record selection process for the SER should be transparent, traceable and justified. As discussed before, the SER should serve as a source of detailed data and information on the repository system, primarily for specialists and researchers as well as for decision makers, regulators and other authorities. Thus, the procedure presented here is oriented on legislative, specialist and technical know-how.

Before the SER selection procedure is developed, the following sections discuss the potential needs of future generations, the records produced during the repository lifetime and the time periods of the repository programme factors – which all influence the SER.

3.1. Future generations and their potential needs

The habits and skills of future generations can change rapidly; thus, what future generations want or need to know with respect to a repository is speculative. Consequently, the potential needs of these generations are not predictable, but can be assumed based on potential needs of current generations. Thus, the SER procedure is based on the skills, abilities and needs of the current generation.

A wide range of potential needs relating to direct repository actions is assumed: e.g. to perform monitoring at the site; to retrieve material from the repository; to perform remedial actions in the environment; or to prepare repository modifications for any correction of an unexpected and unacceptable evolution of the repository. A second group of potential needs relate to possible actions in the vicinity of the repository that may impact repository functions: e.g. construction of tunnels; mining activities; construction of geothermal or large-scale electrical installations; land use provisions/regulations; or other relevant activities.

However, the aim of this chapter is not to formulate a comprehensive list of such potential needs, but to develop a SER selection procedure. For this aim, three potential needs have been chosen on the basis that they cover a wide range of requirements. The example needs used as a basis for the SER selection procedure are that future generations may want to:

i. Perform their own long-term safety assessment.

ii. Trace back decisions from the implementation process.

iii. Retrieve material from the repository.

The first need (Item I) is directly connected with the intent of a future generation to identify potential hazards connected with the facility. A future generation might follow the information from a safety case produced during the pre-operational and operational phases of the repository, but it is plausible that they will prefer applying their own methods and tools. This need is very technical; thus, it is expected that involved stakeholders would be specialist modellers and scientists. Regulators may be involved with defining the boundary conditions to fulfil the need.

The second need (Item II), which may be desired by technical and social stakeholders, comprises questions such as:

- Why is radioactive waste disposed of in deep geological formations?
- Why is it deposited at this site in particular?
- What was the reason for choosing one type of backfill as opposed to another?
- What were the reasons for granting a licence to a certain step in construction?

The third need (Item III) is already a requirement in the regulations of some countries: namely, that retrieval of waste containers from a repository should be possible for a given time after repository closure. Such a future need might not be restricted to the waste, but also applied to other material from the repository (e.g. copper) to be used for other purposes.

As a basis for the SER selection process, it is necessary to identify the essential records that will allow a future generation to reasonably fulfil these needs. The needs formulated here are examples used by the RK&M project to illustrate a potential selection procedure to compile the SER.

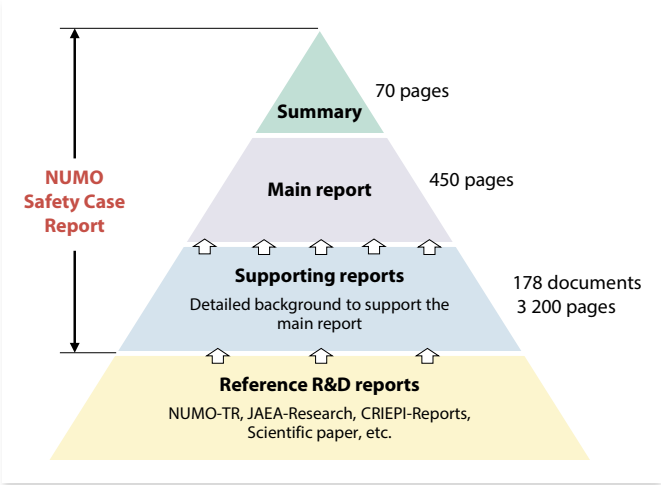
3.2. Records related to radioactive waste repositories

This section considers all records which are related to the repository and have been created during the repository lifetime. Many of them are related to the safety cases.

During a repository implementation and operation process, safety cases are key components. They are usually created and presented by the implementer for each relevant decision in the stepwise process of the repository programme. Ultimately, they are used to demonstrate the safety of the repository to all involved stakeholders, particularly the regulator, the concerned municipality and other authorities.

An illustrative example of a safety case report is given in Figure 3.1 for the newest safety case of the Nuclear Waste Management Organization (NUMO), Japan. Usually, for experts, a summary and a more detailed safety case main report are produced. In addition, the safety case report contains a large number of supporting documents. These supporting documents are based on an even larger number of reference R&D reports, which are not part of the safety case report.

Figure 3.1. **Structure of NUMO Safety Case Report 2017**



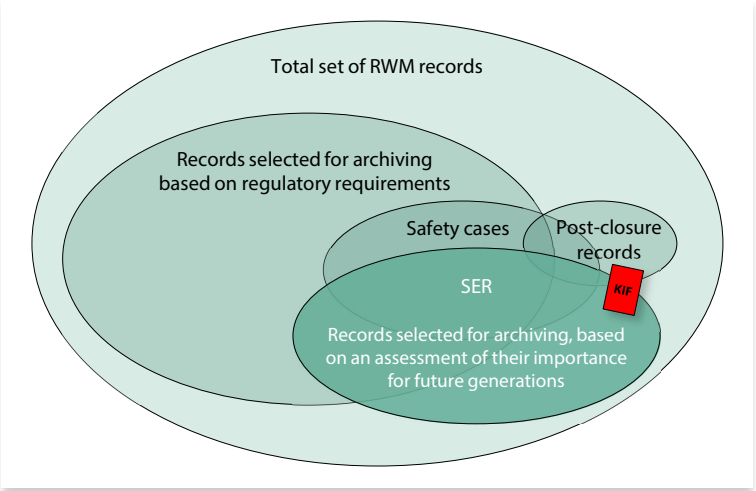
Note: The number of pages and documents are tentative.

Source: Adapted from a presentation by T. Fujiyama, Nuclear Waste Management Organization of Japan (NUMO) at 19th IGSC meeting, Paris, October 2017.

Further, as schematically illustrated in Figure 3.2, many relevant records that are not part of the safety case will be produced. These will include: financial records; contracts and corresponding records; records on socio-political decision-making procedures and outcomes; logistic records (such as transportation-related topics); and records produced in the frame of repository siting, licensing, construction and operation that do not explicitly belong to the safety case. These records will be produced during all periods of the repository implementation and operation process (described in more detail in Section 3.3).

Figure 3.2 also illustrates that not all records considered to be part of the SER are currently prescribed by legislation for preservation by the relevant archives (see also Section 4.2). These records may include reference R&D reports that support the safety case (but are not part of it) and other records deemed to be essential, but which may possibly be rejected by the archive due to reasons such as a lack of storage space. Still, not all records sent to the archive for preservation can be considered essential for future generations to base their decisions on. For example, construction-related contractual records are important during the operational phase, but may lose their relevance after closure of the repository.

Figure 3.2. **Interrelations among sets of repository records**



As noted above, the concept of a KIF is a separate output from the RK&M initiative. As one mechanism of the systemic approach, the KIF is intended to be widely distributed as a single document. Since it gives a concise overview of the repository, the KIF is viewed as one of the records of the SER.

For an illustration of the various types of contents and records, the organisations involved in creating them, and the storage policy, the reader should refer to Annex B which contains a description of the near-surface disposal facility El Cabril. Annex B provides background information and explains some details relevant for the SER that may not be obvious to future users.

3.3. Stages of repository programmes and time frames for SER

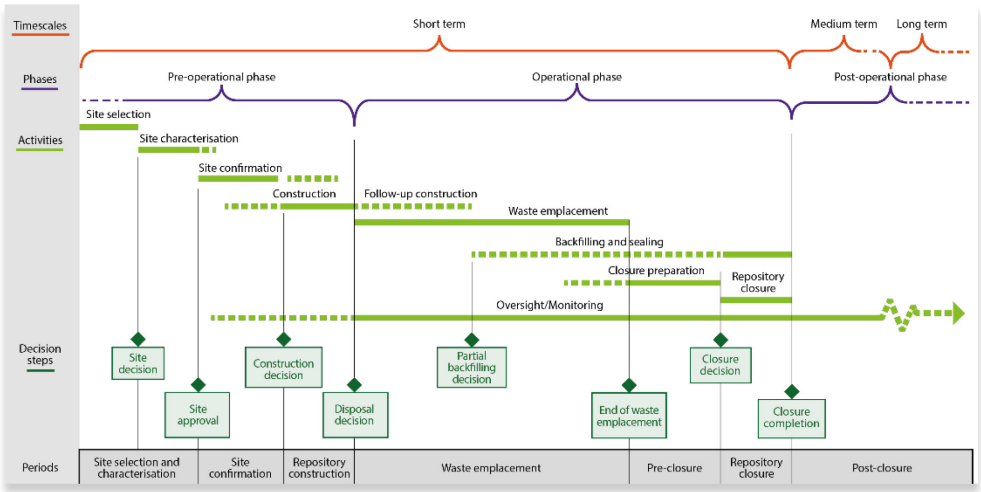
The whole repository process will last several decades until closure and might even take more than 100 years. The RK&M initiative has defined reference timescales to be consistent with the concept of oversight or "watchful care", developed in the publication ICRP-122 by the International Commission on Radiological Protection (ICRP, 2013). The three main life phases of the repository are the pre-operational, operational and post-operational phases, as illustrated in Figure 3.3. The three main RK&M reference timescales are the "short term", "medium term" and "long term", which are defined as follows:

– Short term refers to the time frame that ends with repository closure. This phase includes both the pre-operational and the operational phases of the repository. Timescales are in the order of 100 years.

– Medium term refers to the time frame of indirect oversight activities that would follow repository closure. Timescales are in the order of a few hundred years, though it is not possible to foresee the point at which oversight might terminate.

– Long term refers to the time frame with no repository oversight. It extends over the time of concern in the safety regulations and typically lasts over hundreds of thousands of years in the case of high-level waste.

Figure 3.3. **Reference time frames and examples for important activities, periods and decisions during the implementation process of deep geological radioactive waste repositories**



Source: Based on ICRP, 2013.

Figure 3.3 also shows that the implementation and operation of a repository comprises several activities, illustrating the stepwise decision approach in the repository life cycle. The number, purpose and scale of decision steps might vary according to national regulations or the repository implementation strategy in each country. To demonstrate the type and variability of records generated during the repository life cycle, the figure also defines periods. These periods have been used in the example record compilation in the tables in Annex A to address the time dependence of the constitution and the reviewing of the SER. Six periods are described as follows:

i. Site selection and site characterisation: from several potential localities, one (or more) site is selected as a candidate site for the repository construction. A further site survey and evaluation follows to ensure that the site meets – with sufficient probability – the requirements of the repository construction.

ii. Site confirmation connected with the construction and operation of an underground research laboratory (URL): in situ detailed host rock properties testing and evaluation, engineered barriers (EBS) technology, properties testing, and confirmation that the site and host rock comply with the repository construction requirements.

iii. Repository construction: additional host rock properties evaluation, EBS testing, equipment testing, repository test operation, etc.

iv. Waste emplacement period.

v. Pre-closure period: monitoring of the repository structures and disposed waste behaviour, and preparatory activities for the repository closure.

vi. Repository closure.

There might be some temporal overlap among the activities. For example, a widely used strategy is that an operation with emplacement in some parts of the repository is accompanied by construction (namely the excavation of new tunnels, drifts or boreholes) in other parts of the repository. Partial backfilling of the repository structures during the waste emplacement period might be adopted for the purpose of backfill material testing or for decreasing the radiation background.

Usually, before the transition from one period into the next, a safety case is created by the implementer and sent to the authority, requesting approval for the next step in the repository programme. Thus, for each decision in the repository programme, a new version of the safety case is produced, namely a comprehensive set of records substantiating the claim that the repository will be safe (NEA, 2013).

Accordingly, the amount of records produced for the safety case will increase with the evolution of the repository programme. This could be caused by the identification and development of new topics and a more detailed level of available information (e.g. geological characterisation during repository construction providing a precise picture of host rock properties surrounding of the repository, or concrete information from the repository operation with details about disposed waste and engineered barriers).

While the SER will play a role in the short, medium and long term, the most relevant target time frame is likely to be the medium term (i.e. the time phase of indirect oversight activities after repository closure). At the end of repository operation, the archive of the radioactive waste management organisation might be closed. At that time, it is important for the present generation to have access to a permanently stored SER. In this phase, the SER will most likely have reached its final state and the mediated transmission[1] of the SER might pass over to non-mediated transmission,[3] in which reliance is no longer placed on intermediaries.

1. In the case of mediated transmission, the record is passed on from one generation to another. In non-mediated transmission, the record is delivered directly (e.g. in its original format) from the present time provider to the future receiver, with no reliance on the presence of intermediaries.

Nevertheless, the SER is also seen to have high value for the short-term phase as relevant records can be lost in a time frame as short as a few years or decades. Key factors for the loss of records, primarily in the field of hazardous waste management, have been evaluated by the NEA (2014). Establishing the right structure and suitable processes for creating and updating the SER would be a good basis for retaining the relevant information and knowledge about all repository-related aspects. Although it is not created for this purpose, the SER can also play a role with respect to knowledge transfer in the short term, as the SER can provide a basis for the exchange and sharing of information between staff, organisations and stakeholders that may be separated across generations due to the long operational phase.

3.4. Identification of essential records

The proposed procedure to identify essential records, taking into account the issues presented in Sections 3.2 and 3.3, is driven by a balance between the requirements to keep the SER as small as possible for clarity and traceability, and providing as much information as possibly necessary for future generation to fulfil their needs. The procedure is based on the assumption that the anticipated needs are representative for future generations. The example selection process proposed here is based on a classification and rating scheme. The procedure then comprises the application of this scheme to an extensive list of records produced during the repository programme as delineated in Section 3.2 and illustrated in Annex A.

Classification and rating scheme

The proposed classification and rating scheme comprises two aspects:

i. The relevance of the respective record for the formulated need of the future generation.

ii. An estimation of the effort it would take for a future generation to recreate the information contained in the record (i.e. if record transfer from the past would have failed).

With respect to the first aspect, relevance, the following four categories are distinguished:

0 = Not relevant: information contained in this record does not address the need in any way.

1 = Nice to have: information contained in this record contributes to meeting the need, but it is possible to do without it.

2 = Should have: information contained in this record would normally be required to meet the need.

3 = Must have: it is not possible to meet the need without the information contained in this record.

Concerning the second aspect, effort, two categories are distinguished:

a. Without this record, the information can be obtained by future generations with some effort.

b. Without this record, the information can only be obtained by future generations with extreme difficulty or cannot be directly obtained at all.

For example, detailed information about the waste container might be a 3 (must have) for performing a long-term safety assessment, but a 1 (nice to have) for tracing back decisions of the repository implementation process. If no records were available, it would be nearly impossible to re-construct this information. In this case, the container would need to be retrieved and analysed in order to derive the relevant information. This would require an extremely high level of effort. Another example could be that existing regulations at the time of repository implementation are categorised as 2 (should have) for tracing back decisions during the implementation process, but as 0 (not relevant) for a future generation to perform its own safety assessment or retrieve material from the repository. Further, some information compiled during the repository lifetime might become outdated over time. For example, near-surface features, like soil properties or hydraulic conditions, may change on the timescale of a few centuries. On the basis of a kind of "relevance-averaging" over time, the relevance of such a record is classified as 1 (nice to have) instead of the 2 (should have) that might correspond to the relevance at time of record creation.

The authors of the present report emphasise that the evaluation of the categories is somewhat subjective and might be done differently by other experts.

For the final selection of the respective records to be placed into the SER, it is proposed to include all records classified in two categories: must have (3a and 3b), irrespective of the effort needed by the future generation to produce the information on its own; and should have (2b), which is relevant information that can only be obtained with high levels of effort. For the final selection, the highest rating for any example need is applied (see also Section 3.4) as illustrated in Table 3.1.

Table 3.1. **Classification and rating scheme proposed for selection of records for the SER**

Relevance/effort		**a) Some effort**	**b) Extremely high effort**
Not relevant	**0**		
Nice to have	**1**		
Should have	**2**		SER
Must have	**3**	SER	SER

Note. For final selection, the highest rating of each of the three needs is used.

Procedure

The proposed procedure is based on a list of records produced during the different periods of a repository programme. An example of such a list is shown in the table in Annex A. Different record categories are distinguished by respective headlines in the table. The second and third columns contain two topical levels of records of the respective category. The first level describes record groups while the second level denotes the records examples. The list of records and record topics is not meant to be complete. Further, the level of detail is deliberately suppressed to make the description of the procedure more transparent. One line in the table typically represents more than one record.

In order to compile the list of records, input was taken from another NEA initiative, namely Radioactive Waste Repository Metadata Management, known as RepMet (NEA, 2018). The RepMet initiative was dedicated to the management of metadata and developed a number of relevant data models to systematically cover as many topics as possible related to repository planning, construction, operation and closure. Although developed for data (and not records), the structured list of RepMet was helpful to identify several types of records and to make sure no important topic was left out from the record list.

The first column of the table lists the time period (see Section 3.3) in which the respective records were created. To distinguish between the individual time periods, each period is marked by a specific colour. Usually, the same time period is always marked with the same colour. However, in order to keep the table in a manageable size, in some cases two or three different time periods are merged. This chronological information is an important aspect of the procedure because the SER will change over time, at least until repository closure (see Sections 3.3 and 4.2). At an early stage of the repository programme (e.g. at the end of the site selection period), the table will contain only the blocks marked in yellow, for the site selection period and the corresponding records. At the stage after repository closure, the table will contain different coloured blocks with all time periods, as depicted in the table in Annex A. For each time period, new blocks are added in the table. This means that the content of the table will increase with each additional time period until repository closure. The result of the proposed selection procedure is shown in Table 3.2, which contains only the records selected from the table in Annex A.

One exception to the time period allocation is the subject “societal and general information”. For these records, no time period is given since most of these records are not related to the time periods of the repository programme.

For each of the three needs and each type of records, the rating as described in Section 3.4 is given in Annex A. For transparency and traceability, each decision for rating can be explained by a remark. From the three ratings given for each record, the highest value is listed in the column “highest rating”. The highest rating – namely the highest rating value with respect, firstly, to relevance (as a priority) and, secondly, to effort – is used to decide whether or not the record should be included in the SER.

The evaluation result (rating) is, to some extent, dependent on the time of evaluation. For example, many of the records of the SER connected to a safety case will likely be replaced when a new version of the safety case is created. The records from the new safety case are most relevant for the SER at this point in time, whereas the records from the previous safety case are not as relevant and probably classified as "nice to have". As discussed above, the table will be updated with each review of the SER and is likely connected to important steps in the repository programme. The record list and rating in the table in Annex A are given for a point in time after repository closure, i.e. the records from the last safety case [safety assessment] are rated as "should have and extremely difficult to recreate" (Classification 2b) while the records from all previous safety cases are rated with "nice to have but extremely difficult to recreate" (Classification 1b).

Although the objective was to give a comprehensive list of topics, it is likely that not all possible record topics connected with the repository implementation are covered. It is also expected that some topics might be different depending on the regulations in the country, the type of host rock formation or the type of repository.

3.5. Examples of records recommended for SER

A selection of records proposed for the SER can be derived by applying the classification and rating scheme described above. All selected records (record topics) are marked in orange in the Excel table shown in Annex A in the column "highest rating", with the topics extracted and compiled in Table 3.2.

As discussed, the records or record topics compiled in Table 3.2 were derived by the procedure presented here, using three example needs of future generations assumed as being representative and equally important. The aims were to present a systematic, traceable and transparent procedure and to give an illustrative example. It is clear that such a procedure has to be adapted by each country under the different boundary conditions and specific characteristics of the repository.

The identified record topics are generally in line with the examples of records for radioactive waste disposal proposed in IAEA (1999) for maintenance and transfer of high-level information. This IAEA study focuses on a "mediated transmission" through the use of a record management system that would operate throughout the active oversight phase (in our terms, the medium-term phase), but does not explain or identify the needs of future generations. It deals with the transfer of so-called high-level information in light of regulatory needs and as part of a record structure to be maintained over time.

Table 3.2. **Example of a set of records to be included in the SER, derived from the proposed procedure**

Period[1]	Records group examples	Records/documents examples	Purpose/need[2]
	Record category: Site and host rock survey and characterisation records		
Site selection and site characterisation	Site acceptance criteria and requirements	Criteria proposal and definition, external reviews and updates	**II**
		Criteria approval and criteria evaluation methodology	**II**
	Surface survey	Initial surface and subsurface monitoring of the environment (e.g. radiological properties, air/water pollution)	**I,II,III**
		Surface survey summary report	**I,II,III**
	Geological survey	Geological model	**I,III**
	Hydrogeological survey	Survey measurement records	**I,III**
		Hydrogeological model	**I,III**
		Hydro (geo)logical survey evaluation summary report	**I,III**
	Site properties evaluation	Acceptance criteria, compliance evaluation report	**II**
Repository construction	Site acceptance criteria and requirements	Site acceptance criteria review, update, external examination and approval	**II**
	Site and repository properties verification	Site and repository properties verification protocols and reports	**I,III**
		In situ survey evaluation and site verification summary report	**I,III**
Waste emplacement	Above-ground and underground survey and monitoring	Survey and monitoring sensors performance records	**I,III**
		Survey and monitoring measurements records	**I,III**
		Survey and monitoring results summary and compliance checking reports	**I,II,III**
Pre-closure	Above-ground and underground pre-closure survey and monitoring	Survey and monitoring measurement records and laboratory protocols	**I,III**
		Survey and monitoring summary reports and evaluation reports	**I,III**
		Input data for closure safety assessments, environmental impact assessment (EIA) and licensing process	**I**
		Input data for repository decommissioning, closure plan and design	**I**

See notes on page 31.

Table 3.2. **Example of a set of records to be included in the SER, derived from the proposed procedure** (cont'd)

Period[1]	Records group examples	Records/documents examples	Purpose/ need[2]
	Record category: Repository design and realisation		
Site confirmation	Repository realisation preparation	Engineered barrier system (EBS) design, external examination and approval	**II**
		Repository construction design external examination and approval	**II**
Repository construction	Repository construction	Construction material, EBS and equipment testing/measurement report	**I,III**
		Repository construction, EBS modification proposals and approval	**I,II,III**
		Repository complex performance testing and evaluation	**I,II,III**
		Repository "as built" design documentation, repository equipment operational and maintenance manuals	**I,II,III**
Waste emplacement	Repository operation	Repository structures, EBS, equipment modifications proposal, external examination, approval, implementation, "as built" repository design and documentation updating	**I,II,III**
		Partial boreholes and disposal chambers backfilling realisation	**I,III**
Pre-closure	Monitoring	Repository structures, EBS and equipment monitoring, testing – inputs for decommissioning, and closure plan development	**I,II,III**
	Decommissioning realisation preparation	Decommissioning and closure plan external examination and approval	**II**
Repository closure	Repository closure realisation	Repository dismantling and closure diary, co-ordination meetings protocols, quality control (QC) protocols, external inspection protocols, material compliance protocols, etc.	**I,III**
		Closure realisation quality evaluation and external peer review report	**I,II,III**
		Final decommissioning and closure "as built" documentation, technical description, drawings, requirements compliance declarations and QC evaluation report	**I,III**
		Inputs and data for EIA and closure safety assessments and for licensing process	**I,III**
		Construction material, EBS testing/measurement protocols, laboratory protocols, material proof samples and photo/video documentation	**I**

See notes on page 31.

Table 3.2. **Example of a set of records to be included in the SER, derived from the proposed procedure** (cont'd)

Period[1]	Records group examples	Records/documents examples	Purpose/ need[2]
	Record category: Waste and waste packages		
Site selection, characterisation and confirmation as well as repository construction	Waste inventory	Waste characterisation and categorisation report (waste form, radionuclide content, toxic properties, etc.)	**I,II,III**
		Waste inventory register	**I,II,III**
	Nuclear material inventory	Nuclear material register	**I,II,III**
	Waste package design and development	Waste packages design, drawings, calculations, technical solution report and quality assurance (QA)/QC plan	**I,II**
		Waste package manufacturing, preconditioning and conditioning reports	**I,II,III**
	Waste taking over preparation	Waste acceptance criteria specification, external examination and approval	**II**
Waste emplacement	Waste taking over	Waste package delivery protocols, waste package information files, other relevant information and compliance declarations	**I,III**
		Waste package compliance checking protocols and non-conformity protocols	**I,III**
		Waste package positioning files	**I,III**
		Waste interim storage records	**I,III**
	Waste inventory	Waste packages monitoring and checking	**I,III**
		Waste packages register and nuclear material register	**I,III**
		Disposal chamber and gallery inventory records	**I,III**
		Repository summary inventory reports	**I,II,III**
		Nuclear material inventory changes reports, inventory reports, inventory taking protocols and nuclear material balance reports	**I,II,III**
	Record category: Repository operation records		
Waste emplacement	Repository internal regulations	Repository safeguards, nuclear safety, radiation protection instructions, guidelines and safety culture implementation plan	**I**
		Record management system, records classification, selection archiving and discarding rules	**I,II,III**
	Monitoring records	Surface (site/vicinity) monitoring (e.g. radiological, other pollutions, seismicity and precipitation monitoring)	**I**
		Underground monitoring (e.g. radiological, geological and EBS performance monitoring)	**I**
		Post-closure monitoring concept	**I,II**
	Nuclear material accountancy	Nuclear material register	**I,III**
		Inventory change reports, physical inventory taking and book inventory	**I,III**
	Safety, safeguards and security	Operating diary, emergency training, emergency events records, adopted measure records and emergency event evaluation report	**I, III**

See notes on page 31.

Table 3.2. **Example of a set of records to be included in the SER, derived from the proposed procedure** (cont'd)

Period[1]	Records group examples	Records/documents examples	Purpose/ need[2]
	Record category: Safety and environmental impact assessments and licensing documentation		
Site selection, characterisation and confirmation	Safety case and EIA evaluation and licensing	Public hearings and compiled objections from the public, etc.	**II**
		Site selection, approval, governmental decision document, etc.	**II**
		Preliminary construction approval and governmental decision document	**II**
		Repository construction approval and governmental decision document	**II**
Repository construction	Safety case and EIA evaluation and licensing	Public hearings and compiled objections from the public	**II**
		Repository operation approval and governmental decision document	**II**
Waste emplacement and pre-closure	Periodical or ad hoc safety assessments/ safety cases	Authorities decisions and approvals	**II**
	Safety assessment/ safety case and EIA for repository closure	Repository decommissioning and closure approval, and governmental decision document	**II**
Repository closure	Safety assessment/ safety case for repository site release	Safety case strategy, plan and time schedule	**I,II**
		Process reports (including underlying R&D) on geology, rock mechanics, hydrology, chemistry, microbiology, etc.	**I,III**
		Models and tools	**I**
		Geoscientific long-term evolution	**I,II,III**
		Site-specific features, events and processes (FEP) catalogue	**I,III**
		Scenario development (reference, alternative and what-if cases)	**I,II,III**
		Input data specification; safety assessment model calculations; assessment results including safety functions, performance and integrity of (sub)systems; indicators; compliance with regulations evaluation; and discussion of uncertainties	**I,III**
		Multiple lines of evidence (additional geological arguments, analogues, other indicators, etc.)	**I,II**
		Additional analysis (e.g. criticality, future human action, optimisation and qualitative analyses)	**I,II,III**
		External examination and peer review	**I,II**
	EIA development and evaluation for site release	EIA methodology, input data collection and calculations	**I**
		EIA summary report, drawings, maps and calculations	**I,II**
	Safety case and EIA evaluation and licensing for site release	Safety case report external examination and peer review	**I,II**
		EIA external examination and peer review	**I,II**
		Public hearings and compiled objections from the public	**I,II**
		Repository operation approval and governmental decision document	**I,II**

See notes on page 31.

Table 3.2. **Example of a set of records to be included in the SER, derived from the proposed procedure** (cont'd)

Period[1]	Records group examples	Records/documents examples	Purpose/ need[2]
	Record category: Societal and general information		
	Legislation, regulations	Nuclear law and regulations (nuclear law, radiation protection regulations, waste management regulations, nuclear installations construction and operation, safeguards, emergency planning, etc.)	**II**
	Communication with externals	Correspondence with licensing and supervising authorities	**II**
		Correspondence with other authorities	**II**
		Communication with politicians and political parties	**II**
		Communication with designated communities and relationship with stakeholders	**II**
	Policy and conceptual materials	National waste management policy and practice, including public hearings and discussion on proposed options	**II**
		EIA on waste management and repository implementation concept	**II**
	Memory tools	KIF	**I,II,III**
		Markers and tracers	**II**

1 To distinguish between the individual time periods, each period is marked by a specific colour. Usually the same time period is always marked with the same colour. However, in order to keep the table in a manageable size, in some cases two or three different time periods are merged.

2 Denotation for purpose/need: I = perform own safety assessment; II = trace back decisions of the repository process; and III = retrieve material from repository.

The aim of the study presented was to develop a scheme for non-mediated transmission relevant for the medium- and long-term phases by identifying typical information needs of future generations. The proposed procedure is based on clear criteria for selecting essential records and provides an example for a traceable and transparent process in this regard. It is emphasised that the SER selection is discussed as a dynamic process, which includes modifying and updating the SER during the different periods of the whole repository programme.

Chapter 4. **Managing the SER**

4.1. **Key stakeholders and organisations**

Many of the records that will form part of the SER are developed and compiled for the safety cases presented at different stages in the repository programme. Thus, it is clear that most of these records are directly developed by, or on behalf of, the operator/implementer responsible for the repository in the pre-operational and operational phase. This suggests that the operator should be involved in the creation process of the SER. However, it should be noted that not all records needed in the SER will be owned by the operator, although most of them will most likely be available in this archive.

It would therefore be a reasonable expectation that the responsible organisation creates and organises a team to be in charge of the selection and organisation of the records. It is recommended that this team be multidisciplinary and composed of personnel with very different profiles such as safety specialists, technical experts on wastes, waste packagers, repository construction engineers, communication specialists and social scientists. In this way, all selected experts can contribute their skills to ensure a relevant selection of records and overall comprehensiveness of the SER. To help answer the topic of suitable media and all technical details of records preservation, archiving specialists should also be part of the team. Moreover, this team could be assisted, at least temporarily, by other parties (e.g. regulators, former employees, residents close to the repository or international experts).

However, the ultimate responsibility for the SER lies with the state, which is expected to have ultimate responsibility for the repository after its closure. The government will provide, often by delegation to regulators, appropriate legislation to define the structure, content and terms of storage of records for the geological repository. The definition and scope of the information to be contained, how to maintain the information, the distribution of responsibilities concerning the future of the SER and other aspects connected to the SER, should also be established by regulation.

4.2. **Creating and maintaining the SER**

As described in Chapter 3, the SER is expected to be a comprehensive set of records. The content of the SER will change with time according to a long-term process of ongoing record selection and review. This section addresses questions related to the selection and review process of the SER, namely:

i. When does this selection process begin and when does the SER start to exist?

ii. How is the selection process put in place?

iii. What is the physical form of the SER?

iv. Who is responsible for the SER (i.e. who organises the creation and maintenance of the SER, and who grants or denies access to the SER)?

v. How can it be assured that the SER is implemented in the correct way?

vi. How many full copies of the SER should be created?

There are some issues related to copyrights, ownership and confidentiality, which may be raised during the selection and management of the SER, that were not considered in detail in this report.

The constitution of the SER is a long-term process dependent on the lifetime of the repository. The records can only be selected after production. Therefore, it is strongly recommended to start the creation of the SER as early as possible in the repository programme, i.e. once the repository site is selected. The first version of the SER may even already exist as early as during the site characterisation period. In this way, the organisation in charge of the constitution of the SER could ask for help on technical questions from specialists still working on the repository (this would not be possible if creation of the SER were done at the time of repository closure). Moreover, the start of the creation of the SER could be locally impacted by national regulation, as is the case in France. The detailed memory file for La Manche repository, for example, has to be provided to the authorities before closure of the repository. This means that the SER has to be constituted a long time in advance. Although it is expected that the SER be as complete as possible at the time of repository closure, it is likely that additions will be made after this period (e.g. to include post-closure monitoring or maintenance records about specific facilities, such as the cover on surface repositories).

The SER development process is an ongoing one that may span several decades. A lot of information relevant for the SER (e.g. the waste itself, the emplacement of the waste, the building of plugs and seals, the facilities for the closure of the repository, and much more) will only be produced during the operation of the repository. Using the selection process presented in Chapter 3, it is recommended to gradually enlarge the SER as the life of the repository progresses by adding a new record each time it is necessary while keeping the total number of records as low as possible. During the long life of the repository process, specialists will update investigation results and produce new reports as their knowledge of the repository and its environment evolves (see Section 3.3). As a consequence, the responsible body may replace an old version of a record with a new one. For example, the safety case of El Cabril (Spain) has been updated 14 times since the beginning of the repository implementation process (see Table 4.1 and Annex B). However, it is not meaningful to store the complete records of all these safety case versions in the SER.

It should be noted that the replacement of older versions of records with updated versions must be considered on a case-by-case basis. For example, conserving in the SER two versions of a record produced at different time periods of the repository lifetime can help to understand the evolution and choices made at different times of the repository's life. Therefore, it is strongly recommended to establish a specific

review process that is approved by the authorities. Each case can then be analysed by a specific working group, tracing back every choice and decision made. Tables, as exemplarily developed here (Annex A), can be used to support such a process.

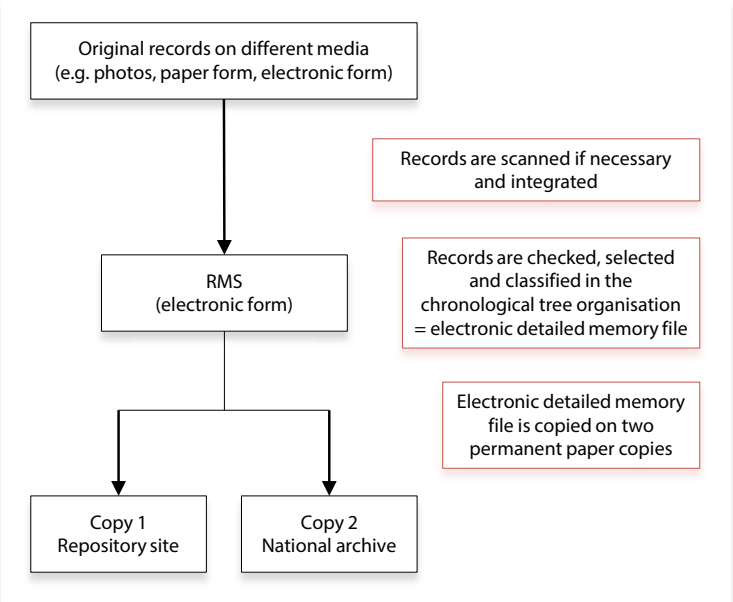
Table 4.1. **History of revisions of the Spanish Safety Study for the near-surface repository El Cabril**

Revision	Date	Remarks
0	Jun 1991	Prepared for the application to authorise the construction of the L&ILW disposal facility.
1	Apr 1993	The four-year interim licence for operation included some conditions, among them was the issuance of revision 1 (October 1992).
2	Nov 1995	The revision was prepared for the application for the renewal of the interim licence.
3	Feb 1997	It was required in an annex to order the extension of the interim licence for an additional five years as of 6 October 1996.
4	Apr 2003	Actualisation of contents.
5	Oct 2003	Actualisation of contents.
6	Feb 2004	To include new waste forms acceptance criteria approved by the ministry.
7	Apr 2005	To meet the resolutions of the ministry related to design modifications for the conditioning of solid waste from iron melting incidents and the auxiliary conditioning building. Also, to comply with ministerial order authorising operation of the facility.
8	Oct 2006	To comply with regulatory body requirements linked to the operation licence as well as to include design modifications.
9	Jul 2008	To comply with the authorisation of design modification related to the VLLW disposal facility.
10	Sep 2008	The Nuclear Safety Council required a new revision of the safety report for the inclusion of additional information about Cell 29 from the new VLLW disposal facility.
11	Jan 2012	Related to requirements of the ministry and the regulatory body to explain the presence of water under the L&ILW disposal vaults.
12	Jul 2012	Actualisation of contents.
13	May 2014	Related to the modification of the design for the storage of radioactive isotopes with a half-life between the ones of Co-60 and Cs-137, as well as to include other design modifications.
14	Jul 2016	Related to the operation of Cell 30 from the VLLW disposal facility.

The selection of the records for the SER would be facilitated if the documents and information produced during the repository lifetime were identified and marked within a records management system (RMS) from an early stage (see Figure 4.1). This ensures the ease of maintenance, selection and transfer of relevant records into and out of the SER. In case a radioactive waste management organisation does not have a complete and adequate SER requirement and classification of records at the time

of their creation, use of an RMS could limit the risk of information loss. This is important since it is unlikely that the loss of information can be repaired at a later stage (e.g. at repository closure).

Figure 4.1. **Example of the creation system of the detailed memory file of the La Manche repository (France)**



With respect to the physical form of the SER, a kind of catalogue needs to be created. For example, an RMS that contains all necessary information about each selected record and its location can be used to guarantee the accessibility of all records of the SER. Whether all records of the SER will, in addition, be stored from the beginning at a selected location needs to be decided by the responsible organisation. This decision is also dependent on the legislation in each country, particularly on archiving rules (see Section 4.3).

To identify the records selected among all the documents produced during the repository lifetime, one option is to physically mark them with a label like “SER”. This concept of document marking has already been discussed internally by Andra, France in the context of differentiating between copies of the detailed memory file of the La Manche repository (France) destined for long-term preservation and copies made for communication actions. It quickly became clear that marking all records was a very cumbersome and time-consuming activity, and that it was not possible to adapt to old documents in which the layout does not allow a stamp to be affixed.

Before the repository closure, the SER should be under active maintenance. To monitor and control the evolution of the SER over such a long period, it is recommended to set up a review process in which the frequency of reviews is to be determined by the authorities. For example, that frequency could be:

- regularly every five to ten years, a time frame easily manageable on a human scale;
- connected to regular updates of the safety case, which are usually undertaken at relevant stages or decisions relating to the repository programme;
- connected to other activities required by regulations, namely revisions of the safety of installations and specific events (such as sealing of filled emplacement areas or changes in the applied technology) that are likely to happen over several decades of repository operation.

As described in Section 4.1, it is proposed to have one organisation (likely the implementer) to be in charge of the SER process. This includes the responsibility for selecting records, updating the list of records, and having the records accessible and available (whether or not archives are involved). For each review process, the responsible organisation should establish a multidisciplinary team that could be assisted by external experts.

To allow an easy and efficient discovery of records in the SER organisation, the aforementioned multidisciplinary team should create search tools. These tools could be based on international archival description standards and should, for example:

- describe all the records selected and their organisation;
- present the history of the repository;
- facilitate the understanding of records, for example with concordance tables or explanatory sheets on specific topics.

Finally, as the SER consists of a large number of records, it is recommended to create only one final version of the SER to facilitate the management of the set and avoid the risk of confusion that could be produced by the existence of two or more parallel versions. This single final version should exist in at least two copies to promote long-term preservation (see Section 4.3). This is the case for the detailed memory file of the La Manche repository (France), which is available in two copies: both copies are totally separated from the original records and are identical, but are managed independently (see Figure 4.1).

4.3. **Preserving the SER**

Besides the creation and maintenance of the SER, important questions are related to its preservation: e.g. on what type of media and where the SER should be kept? This is particularly a challenge for the period after the repository closure.

With respect to the preservation of the SER during the repository's lifetime, electronic media have the advantages of providing high data storage, simple search functions and multiple copies. The experience from the detailed memory file of the La Manche repository (France) supports the view that electronic form is preferable for everyday use since it is easier to manipulate than a corresponding paper form and can be used by more than one person at a time, even in different geographic locations.

However, such media are not recommended for long-term preservation due to their relatively low durability and the need for permanent maintenance, updates or upgrades of hardware and software tools. At the time of writing of this report, permanent paper seems to be the best medium for long-term preservation. Permanent paper has been chosen since the middle of the 1990s by France for the print of copies of its detailed memory file relating to La Manche. This choice has been validated by authorities. Archiving specialists have to be consulted to help answer the topic of suitable media and all technical details of records preservation.

As described in Section 4.2, it is strongly recommended to make at least two copies of the SER. Both copies must be kept in suitable premises for long-term preservation. Many options can be considered. For example, France decided to keep one copy of the detailed memory file on the repository site and sent the other one to the national archives (see Figure 4.1).

The prevailing opinion of the RK&M initiative is that the national archives are the best solution for preserving the SER in the long term. A unique example of a nuclear archive has been established in Wick (Scotland). In the dedicated nuclear archive, "Nucleus", relevant UK nuclear records are being archived to prevent them from being lost in a sea of other material.

The final decision on the preservation of the SER is also dependent on the policy and laws in force in each country. The system of archiving is different across countries according to national legislation, as observed by the members of the RK&M initiative. In some cases, the records intended for long-term preservation, including their subset SER, are sent to the national archives after the repository closure for further preservation and maintenance. In other cases, one copy of the selected records is sent to the national archives periodically during the whole repository lifetime while one copy remains in the local repository archive for everyday use.

Chapter 5. **Summary**

The NEA RK&M initiative has developed a "systemic strategy" to maintain records, knowledge and memory for a radioactive waste repository after its closure, for future generations. One mechanism of this strategy is the Set of Essential Records (SER). The SER can be understood as a collection of the most important records for waste disposal, selected for permanent preservation during the repository lifetime. It provides sufficient information for current and future generations to ensure an adequate understanding of the repository system and its performance. This will enable them to review and verify the repository performance and the safety case, and to make informed decisions.

During repository implementation, construction, operation and closure a large number of records that are diverse in nature (e.g. paper documents, engineering drawings, maps, photographs, physical objects or electronic records) will be produced. In order to keep the information preserved for future generations clear, transparent and traceable, the RK&M initiative developed an example procedure to identify a reduced set of records. The proposed procedure is based on the representative needs of future generations related to the repository and on a classification and rating scheme applied to all records produced during the lifetime of the repository. The proposed classification and rating scheme comprises two aspects. The relevance of the respective record for the formulated need of the future generation and an estimation of the effort it would take for a future generation to recreate the information contained in the record (i.e. if record transfer from the past had failed).

The pre-operational and operational phases of the repository will last many decades. It is strongly recommended to start the SER selection process as early as possible in the repository programme to avoid the risk of loss of important information that might not be available at a later stage. Although it is likely that regulations will require one organisation (possibly the implementer) to be responsible for the selection and compilation of the SER, the large variety of records suggests that multidisciplinary teams should be involved.

It is clear that the development of the SER will be an ongoing process that should be under continuous maintenance and be regularly reviewed before repository closure. These reviews might be connected with regular updates of the safety case or other activities required by regulations.

Since the SER in its final state will contain numerous records, only one version should be created, but existing in at least two copies. To allow future generations to easily and efficiently discover the information, search tools based on international archival description standards should be part of the SER. Meta information can be added to each record for better understandability.

With respect to preservation of the SER during the repository lifetime, electronic media have the advantages of providing high data storage, easy searching and multiple copies. However, such media are not recommended for the long-term preservation due to their relatively low durability and the need for permanent maintenance, updates or upgrades of hardware and software tools. At the time of the study presented here, permanent paper appeared to be the best option. However, this decision should be taken by archiving specialists at the time that the SER is finalised.

The proposed procedure for SER selection has been illustrated by examples of records compiled using information regarding record creation and preservation from the near-surface repositories El Cabril in Spain and La Manche in France. As a next step, the procedure should be applied in order to evaluate its feasibility and identify any shortcomings. A second recommendation is made by the authors to further evaluate the review process of the SER. The proposed classification and rating scheme can be part of the review process, but other instruments might be identified and applied.

References

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NEA (2018), *Metadata for Radioactive Waste Management*, OECD Publishing, Paris.

NEA (2014), "Loss of information, records, knowledge and memory in the area of conventional waste disposal", NEA/RWM/R(2014)3.

NEA (2013), *The Nature and Purpose of the Post-closure Safety Cases for Geological Repositories*, OECD Publishing, Paris.

Annex A. Illustration of the proposed procedure

Rating

Relevance

- **3** Must have
- **2** Should have
- **1** Nice to have
- **0** Not relevant

Effort

- **b** Without this record, the information can only be obtained by future generations with extreme difficulty or cannot be directly obtained at all.
- **a** Without this record, the information can be obtained by future generations with some effort.

Records selected for the SER, i.e. rated 2.b and 3.a or 3.b, are marked by an orange colour in the field, "Highest rating".

Colours

To distinguish between the individual time periods, they are marked by colours. Usually the same time period is always marked with the same colour.

However, in order to keep the table in a manageable size, sometimes two or three different time periods are merged.

Abbreviations used in the table

EBS	Engineered barrier systems
EIA	Environmental impact assessment
FEP	Features, events and processes
KIF	Key Information File
QA/QC	Quality assessment/quality control
R&D	Research and development
SER	Set of Essential Records
TOR	Terms of reference
URL	Underground research laboratory

Record creation period	Records examples			Option			Remarks
				Perform own long-term safety assessment	Trace back decisions from implementation process	Retrieve material from the repository	
				Involved: specialists, scientists, regulators, etc.	Involved: policy makers, historians, etc.	Involved: technicians, policy makers, etc.	
	Records group examples	Records (documents) examples	Highest rating	Rating	Rating	Rating	
	Record category: Site and host rock survey and characterisation records						
Site selection period and site characterisation period	Site selection and site characterisation	Site selection concept, site selection plan and methodology, potential sites definition, etc.	1b	1b	1b	0	
		Site primary characterisation plan (technical solution, maps, drawings, site characterisation methodology, etc.)	1b	1b	1b	0	
		Site detailed characterisation plan (technical solution, maps, drawings, site detailed characterisation methodology, etc.)	1b	1b	1b	0	
		QA/QC plans, etc.	1b	1b	1b	0	
	Site acceptance criteria and requirements	Criteria proposal and definition, criteria external examination, criteria reviews and updates, etc.	2b	1b	2b	0	
		Criteria approval and criteria evaluation methodology	2b	1b	2b	0	
	Supportive R&D	R&D plans (TORs, reviews, external examinations, etc.)	1b	1b	0	0	
		R&D results reports	2a	2a	0	2a	
		Input data for site survey and characterisation, safety assessments, etc.	1b	1b	0	0	
	Surface survey	Surface survey plan (design, QA/QC plan, etc.)	1a	1a	1a	1a	
		Site description and general characterisation	1a	1a	1a	1a	
		Geographical maps of the site, broader region geomorphological maps, etc.	1a	1a	0	1a	
		Meteorology information and data	1a	1a	0	0	
		Demographical study of site vicinity, societal aspects, etc.	1b	0	1b	0	
		Infrastructure analysis report (technical description, maps, plans, pictures, etc.)	1b	0	1b	0	
		Flora, biota, protected areas characterisation (reports, maps, pictures, etc.)	1b	0	1b	0	
		Initial surface and subsurface monitoring of the environment: radiological, air/water pollution, etc.	2b	2b	2b	2b	
		Surface survey summary report	2b	2b	2b	2b	
	Geological survey	Geological survey plan (design, QA/QC plan, etc.)	1b	1b	1b	1b	
		Rock characterisation processes and methodology (geology, rock mechanics, hydrology, chemistry, microbiology, etc.)	1b	1b	0	1b	
		Geological survey plan, external examination and approval	2a	2a	1a	2a	
		Geological survey documents (borehole drilling records, drilling journal, drilling protocols, photo documentation, etc.)	2a	2a	2a	2a	This categorisation belongs only to the selected site; information from other sites is not relevant
		R&D results reports	2a	2a	0	2a	
		Core sample physical object and core sample accompanying records	1a	1a	0	1a	Physical objects will be altered after long storage time; for hard rock, may be less problematic
		Core sample characterisation and evaluation records (laboratory protocols, etc.)	2a	2a	1a	1a	
		Geological survey summary report	2a	2a	0	2a	
		Geological model	2b	2b	0	2b	

Record creation period	Records examples			Option			Remarks
				Perform own long-term safety assessment	Trace back decisions from implementation process	Retrieve material from the repository	
				Involved: specialists, scientists, regulators, etc.	Involved: policy makers, historians, etc.	Involved: technicians, policy makers, etc.	
	Records group examples	Records (documents) examples	Highest rating	Rating	Rating	Rating	
Site selection period and site characterisation	Geophysical survey	Geophysical survey project (design, methodology, QA/QC plan, etc.)	2a	2a	1a	2a	
		Geophysical survey journal	2a	2a	1a	2a	
		Primary measurements and monitoring record (protocols, etc.)	2a	2a	1a	2a	
		Geophysical survey summary report	2a	2a	1a	2a	
	Hydro-geological survey	Hydrogeological survey plan (design, methodology, QA/QC, etc.)	1b	1b	0	1b	
		Survey measurement records	2b	2b	0	2b	
		Survey measurement protocols, laboratory protocols, etc.	1b	1b	0	1b	
		Hydrogeological model	2b	2b	0	2b	
		Hydrogeological survey evaluation summary report	2b	2b	1b	2b	
	Site properties evaluation	Acceptance criteria compliance evaluation report	2b	1b	2b	1b	
		Input data for siting safety assessments and site approval	1b	1b	1b	1b	Not as relevant as information related to the latest safety assessment
		Input data for site safety, environmental assessments and the pilot repository (URL) construction approval	1b	1b	0	0	
Site confirmation and repository construction period	Site and host rock detailed (in situ) characterisation plan	Site and host rock in situ characterisation plan (design, technical description, drawings, maps, QA/QC plan, etc.)	1b	1b	0	1b	
		Site and the repository structures characterisation methodology, instructions, etc.	1b	1b	1b	1b	
	Site acceptance criteria and requirements	Site acceptance criteria review, update, external examination and approval	2b	1b	2b	0	
		Site and repository properties verification methodology	1b	1b	1b	0	
	Site and host rock in situ survey	Above-ground (near-surface) survey	2a	2a	0	2a	
		Host rock properties (and behaviour), detailed characterisation, geotechnical, hydrogeological, geochemical survey, etc.	2a	2a	0	2a	
		Repository construction and engineered barriers testing, properties (and behaviour) characterisation, etc.	1b	1b	0	1b	
		Survey results (measurement records and protocols, laboratory protocols, etc.)	2a	2a	0	2a	
	Site and repository properties verification	Site and repository properties verification protocols, reports, etc.	3b	3b	1b	3b	
		In situ survey evaluation (site verification summary report, etc.)	3b	3b	1b	3b	
		Input data for safety assessments and repository construction approval	1b	1b	0	0	Not as relevant as information related to the latest safety assessment
		Input data for safety assessments and repository operation approval	1b	1b	0	0	

Record creation period	Records examples			Option			Remarks
				Perform own long-term safety assessment	Trace back decisions from implementation process	Retrieve material from the repository	
				Involved: specialists, scientists, regulators, etc.	Involved: policy makers, historians, etc.	Involved: technicians, policy makers, etc.	
	Records group examples	Records (documents) examples	Highest rating	Rating	Rating	Rating	
Waste emplacement period	Above-ground and underground survey and monitoring	Above-ground and underground follow-up survey and monitoring plans (methodology, QA/QC plans, etc.)	1b	1b	0	1b	
		Survey and monitoring performance records (diaries, QC protocols, etc.)	3b	3b	1b	3b	
		Survey and monitoring measurements records (laboratory protocols, etc.)	3b	3b	0	3b	
		Survey and monitoring results summary reports (compliance checking report, etc.)	3b	3b	2b	3b	
		Input data for periodical safety assessments and licensing process	1b	1b	0	0	Not as relevant, as the information related to the latest safety assessment
		Input data for repository decommissioning and closure plan	1b	1b	0	0	
Pre-closure period	Above-ground and underground pre-closure survey and monitoring	Above-ground and underground pre-closure survey and monitoring plan (time schedule, survey methodology, manuals/instructions, QA/QC plan, etc.)	1b	1b	1b	1b	
		Survey and monitoring measurement records (laboratory protocols, etc.)	3b	3b	1b	3b	
		Survey and monitoring summary reports (QC protocols, evaluation reports, external examination protocols, etc.)	3b	3b	0	3b	
		Input data for closure safety assessments (EIA and licensing process, etc.)	2b	2b	0	0	
		Input data for repository decommissioning, closure plan and design	2b	2b	0	0	
	Record category: Repository design and realisation						
Site selection period and site characterisation period	Repository conceptual solution	Technical concept (description, radiation protection, safeguards, drawings and calculations, etc.)	1b	1b	1b	0	
		External review (comments, concept approval, etc.)	1b	1b	1b	0	
		Specification of requirements on repository preliminary design development (TORs, contractor selection, etc.)	1b	1b	1b	0	
		Repository preliminary design (technical solution description, drawings, calculations, budget, equipment specification, etc.)	1b	1b	1b	0	
		Specification of requirements on R&D on special equipment (engineered barriers TORs, etc.)	1b	1b	1b	0	
		Preliminary feasibility study (report, drawings, time schedule, budget, etc.)	1b	1b	1b	0	
		Preliminary design evaluation (external examination, approval, etc.)	1b	0	1b	0	
	Engineered barriers system (EBS) development and testing	EBS development plan (time schedules, budget, etc.)	1b	1b	1b	0	
		EBS design (technical description, drawings, calculations, realisation plan, QA/QC plan, etc.)	1b	1b	1b	0	
		EBS design (external examination, approval, etc.)	1b	0	1b	0	
		EBS contract specification (procurement notice, contractor selection, etc.)	0	0	1b	0	
		EBS model (prototype) realisation (realisation records, requirements, compliance protocols, etc.)	1b	1b	1b	0	
		EBS model testing (measurements, properties verification protocols, etc.)	1b	1b	1b	0	
		EBS model summary evaluation and verification report	1b	1b	1b	0	
		Input data and recommendation for follow up EBS development and realisation	1b	1b	1b	0	

Record creation period	Records examples			Option			Remarks
				Perform own long-term safety assessment	Trace back decisions from implementation process	Retrieve material from the repository	
				Involved: specialists, scientists, regulators, etc.	Involved: policy makers, historians, etc.	Involved: technicians, policy makers, etc.	
	Records group examples	Records (documents) examples	Highest rating	Rating	Rating	Rating	
Site selection period and site characterisation period	Special equipment development	Special equipment specification (requirements, TORs, R&D plan, etc.)	1b	1b	1b	1b	
		Special equipment design (technical description, calculations, drawings, etc.)	1b	1b	1b	1b	
		TORs on equipment manufacturing (procurement notice, contractor selection, etc.)	0	0	0	0	
		Special equipment prototype manufacturing (QC protocols, requirements compliance declarations, etc.)	1b	1b	1b	0	
		Special equipment (prototypes testing and measurements protocols, diaries, photography, etc.)	1b	1b	1b	0	
		Input data and recommendation for follow up equipment development, realisation design and manufacturing	1b	1b	1b	0	
	Pilot repository (URL) construction planning (preparation)	Specification of requirements on pilot repository (URL) (design, TORs, contractor selection, etc.)	1b	1b	1b	1b	
		Pilot repository (URL) (design, technical description, drawings, calculations, budget, material and equipment specifications, etc.)	1b	1b	1b	1b	
		Design external examination (approval, etc.)	1b	1b	1b	0	
		Inputs for safety case and environmental impact assessments, pilot repository (URL) construction approval, etc.	1b	1b	1b	1b	
		Specification of requirements on special equipment and EBS (in situ testing, R&D, etc.)	1b	1b	1b	0	
		Pilot repository (URL) construction and performance plan (time schedule, budget, programme specification, etc.)	1b	1b	1b	0	
		Pilot repository (URL) construction contractor selection (selection of contractors on in situ R&D, testing, etc.)	1b	0	1b	0	
Site confirmation period	Pilot repository (URL) realisation (construction)	Construction diary (co-ordination meetings protocols, QC protocols, external inspection protocols, material compliance protocols, material proof samples, etc.)	1b	1b	1b	0	
		Repository construction (EBS or equipment modifications proposals, technical description, drawings, reviews and approvals, etc.)	1b	1b	1b	0	
		Inputs for repository structures and equipment testing	1b	1b	1b	0	
	Engineered barriers system (EBS) in situ testing	Repository structures and equipment testing plan (time schedule, testing procedures/manuals, QA/QC programme, etc.)	1b	1b	1b	0	
		EBS material testing records (co-ordination meetings protocols, laboratory protocols, construction material proof samples, etc.)	1b	1b	1b	0	
		EBS testing evaluation (summary report, external examination, etc.)	1b	1b	1b	0	
		Input data and recommendation for EBS realisation (design, etc.)	1b	1b	1b	0	
		Input data for safety assessments (EIA, etc.)	1b	1b	1b	0	
	Repository equipment in situ testing	Repository equipment testing plan (time schedule, testing procedures/manuals, QA/QC programme, etc.)	1b	1b	1b	0	
		Repository equipment in situ testing records (co-ordination meetings protocols, laboratory protocols, construction material proof samples, etc.)	1b	1b	1b	0	

Record creation period	Records examples			Option			Remarks
				Perform own long-term safety assessment	Trace back decisions from implementation process	Retrieve material from the repository	
				Involved: specialists, scientists, regulators, etc.	Involved: policy makers, historians, etc.	Involved: technicians, policy makers, etc.	
	Records group examples	Records (documents) examples	Highest rating	Rating	Rating	Rating	
Site confirmation period	Repository equipment in situ testing	Repository equipment testing evaluation (summary report, external examination, etc.)	1b	1b	1b	0	
		Input data and recommendation for follow up equipment development, realisation design and manufacturing, etc.	1b	1b	1b	0	
	Repository realisation preparation	EBS realisation project (design, technical description, drawings, calculations, material specification, budget, QA/QC plan, etc.)	1b	1b	1b	1b	
		EBS design external examination (approval, etc.)	2b	1b	2b	1b	
		Repository equipment (design, technical description, drawings, material specification and requirements, QA/QC plan, etc.)	1b	1b	1b	1b	
		Repository equipment (design external examination, approval, etc.)	1b	1b	1b	1b	
		Repository summary construction (design, technical description, drawings, calculations, time schedule, budget, QA/QC plan, etc.)	1b	1b	1b	1b	
		Repository summary construction (design external examination, approval, etc.)	2b	1b	2b	1b	
		Input data for preconstruction safety assessment (EIA, construction approval process, etc.)	1b	1b	0	0	
		Specification of the repository construction supplies (contracting conditions, delivery requirements, suppliers qualification requirements, etc.)	1b	0	1b	0	
		Procurement notice (suppliers selection process, contracting, etc.)	1b	0	1b	0	
Repository construction period	Repository construction	Repository construction diary (co-ordination meetings protocols, QC protocols, external inspection protocols, material compliance protocols, etc.)	1b	1b	1b	0	
		Repository equipment manufacturing and delivery, assembly and installation (equipment documentation, etc.)	1b	1b	1b	0	
		Construction material, EBS, equipment testing/measurement report	2b	2b	1b	2b	
		Construction material, EBS, equipment testing/measurement protocols (laboratory protocols, material proof samples, photo/video documentation, etc.)	1b	1b	1b	1b	
		Repository construction, EBS or equipment modification proposals (approval, etc.)	3b	3b	2b	3b	
		Repository complex performance testing (evaluation, etc.)	2b	2b	2b	2b	
		Repository 'as built' design documentation (repository equipment operational and maintenance manuals, etc.)	3b	3b	2b	3b	
		Inputs and data for performance and safety assessments (licensing process, etc.)	1b	1b	0	0	
Waste emplacement period	Repository operation	Repository structures, EBS, equipment modifications proposal (external examination, approval, implementation, 'as built' repository design and documentation updating, etc.)	3b	3b	2b	3b	
		R&D of dismantling processes and closure technology (reports, reviews, inputs for repository dismantling and closure design, etc.)	1b	1b	0	1b	
		Preliminary decommissioning (closure plan and design, technical description, drawings, etc.)	1b	1b	1b	1b	
		Partial boreholes and disposal chambers backfilling design (external examination, design and realisation approval, etc.)	1b	1b	1b	1b	
		Partial boreholes and disposal chambers backfilling realisation, etc.	3b	3b	1b	3b	
	Repository follow up construction	Records identical with above mentioned 'repository construction' records	2b	2b	0	0	

Record creation period	Records examples			Option			Remarks
				Perform own long-term safety assessment	Trace back decisions from implementation process	Retrieve material from the repository	
				Involved: specialists, scientists, regulators, etc.	Involved: policy makers, historians, etc.	Involved: technicians, policy makers, etc.	
	Records group examples	Records (documents) examples	Highest rating	Rating	Rating	Rating	
Pre-closure period	Monitoring	Repository structures (EBS and equipment monitoring, testing, etc. and inputs for decommissioning, closure plan development, etc.)	3b	3b	2b	3b	
	Decommissioning realisation preparation	Detailed decommissioning and closure plan (design development, technical description, drawings, methodology, budget, time schedule, QA/QC plan, etc.)	1b	1b	1b	1b	
		Decommissioning and closure plan external examination (approval, etc.)	2b	1b	2b	1b	
		Inputs and data for EIA (closure safety assessments inputs, closure approval procedure, etc.)	1b	1b	1b	1b	
		Specification of the repository dismantling and closure supplies (contracting conditions, delivery requirements, suppliers qualification requirements, etc.)	0	0	0	0	
		Procurement notice (suppliers selection process, contracting, etc.)	1b	1b	0	0	
Repository closure period	Repository closure realisation	Repository dismantling and closure diary (co-ordination meetings protocols, QC protocols, external inspection protocols, material compliance protocols, etc.)	3b	3b	1b	3b	
		Construction material, EBS testing/measurement protocols (laboratory protocols, material proof samples, photo/video documentation, etc.)	2b	2b	1b	1b	EBS testing can be valuable for future use
		Closure realisation quality evaluation report (external peer review report, etc.)	2b	2b	2b	2b	
		Final decommissioning and closure 'as built' documentation (technical description, drawings, requirements compliance declarations, QC evaluation report, etc.)	3b	3b	1b	3b	
		Inputs and data for EIA (closure safety assessments, licensing process, etc.)	3b	3b	1b	3b	
	Record category: Waste and waste packages						
Site selection, characterisation, confirmation and repository construction period	Waste inventory	Waste producers register (contracts/agreements, etc.)	1b	1b	1b	1b	
		Waste characterisation (categorisation methodology, QA/QC, etc.)	1b	1b	1b	1b	
		Waste characterisation, categorisation report (waste form, radionuclide content, toxic properties, etc.)	3b	3b	2b	3b	
		Waste inventory register	3b	3b	2b	3b	
		Waste generation prediction (time schedule, etc.)	1b	1b	1b	1b	
	Nuclear material inventory	Nuclear material register	3b	3b	2b	3b	
		Nuclear material generation prediction, time schedule, etc.	1b	1b	1b	1b	
	Waste packages (transport, storage, disposal, etc.) design and development	Requirements on waste package construction (material, size, etc.)	1b	1b	1b	1b	
		Waste packages design (drawings, calculations, technical solution report, QA/QC plan, etc.)	3b	3b	2b	1b	
		Waste treatment (preconditioning, conditioning requirements, etc.)	1b	1b	1b	1b	
		Waste preconditioning (conditioning material and technology development and testing, etc.)	1b	1b	1b	1b	
		Waste packages prototypes (manufacturing, testing, testing evaluation records, protocols of compliance, approvals, etc.)	1b	1b	1b	1b	
		Waste package manufacturing (preconditioning and conditioning reports)	3b	3b	2b	3b	
		Input data for repository safety assessment	1b	1b	1b	1b	
		Input data for repository and special equipment design and development	1b	1b	0	0	

Record creation period	Records examples			Option			Remarks
				Perform own long-term safety assessment	Trace back decisions from implementation process	Retrieve material from the repository	
				Involved: specialists, scientists, regulators, etc.	Involved: policy makers, historians, etc.	Involved: technicians, policy makers, etc.	
	Records group examples	Records (documents) examples	Highest rating	Rating	Rating	Rating	
	Waste taking over preparation	Waste package information file specification (accompanying document), external review, approval, etc.)	1b	1b	0	1b	
		Waste acceptance criteria specification (external examination, approval, etc.)	2b	1b	2b	1b	
		Waste taking over procedures (manuals, waste packages checking methodology, instructions, etc.)	1b	1b	1b	1b	
Waste emplacement period	Waste taking over	Waste package delivery protocols (waste package information files, other relevant information, compliance declarations, etc.)	3b	3b	1b	3b	
		Waste package compliance (checking protocols, non-conformity protocols, etc.)	3b	3b	1b	3b	
		Waste package positioning files	3b	3b	1b	3b	
		Waste interim storage records	3b	3b	1b	3b	
	Waste inventory	Waste packages monitoring, checking, etc.	3b	3b	1b	3b	
		Waste packages register, nuclear material register, etc.	3b	3b	1b	3b	
		Disposal chamber inventory records, disposal gallery inventory records	3b	3b	1b	3b	
		Repository summary inventory reports	3b	3b	2b	3b	
		Nuclear material inventory changes reports (inventory reports, inventory taking protocols, nuclear material balance reports, etc.)	3b	3b	2b	3b	
		QC, external inspections records, etc.	1b	1b	1b	1b	
	Record category: Repository operation records						
Waste emplacement period	Repository internal regulations	Repository working instructions (manuals, guidelines, etc.)	1b	0	1b	1b	
		Repository safeguards (nuclear safety, radiation protection instructions, guidelines, safety culture implementation plan, etc.)	2b	2b	0	1b	
		Record management system (records classification, selection archiving and discarding rules, manuals, etc.)	2b	2b	2b	2b	
		Repository operation (QA/QC plan, internal inspection manuals, etc.)	1b	1b	0	1b	
	Staff records	Personnel register	0	0	0	0	
		Personnel attendance records	0	0	0	0	
		Education, training, exams, etc.	0	0	0	0	
	Activities records	Activities plans (annual, monthly, daily)	0	0	0	0	
		Operating diary (activities reports, etc.)	0	0	0	0	
		Monthly operating reports	0	0	0	0	
		External providers reports	0	0	0	0	
	Equipment records	Above-ground equipment performance records (transportation, encapsulation, repacking, wiring, periodical testing, maintenance, etc.)	0	0	0	0	
		Underground equipment performance records (transportation, waste packages loading, wiring, equipment periodical testing, maintenance, etc.)	0	0	0	0	
		Safeguard and security systems performance records (periodical testing, maintenance, etc.)	0	0	0	0	
	Structures records	Above-ground structures (buildings, roads, rails, etc.) inspection and maintenance records, etc.	0	0	0	0	
		Underground structures (communications, EBS, drainage system, etc.) inspection and maintenance records, etc.	0	0	0	0	
	Internal QC records	QC plans	0	0	0	0	
		QC protocols, findings, adopted measures, etc.	0	0	0	0	
	External audits and inspections	Mining authorities, nuclear regulators, other authorities inspection protocols, etc.	1b	0	1b	0	
		Inspection findings, adopted measures, etc.	1b	0	1b	0	

Record creation period	Records examples			Option			Remarks
				Perform own long-term safety assessment	Trace back decisions from implementation process	Retrieve material from the repository	
				Involved: specialists, scientists, regulators, etc.	Involved: policy makers, historians, etc.	Involved: technicians, policy makers, etc.	
	Records group examples	Records (documents) examples	Highest rating	Rating	Rating	Rating	
Waste emplacement period	Personal dosimetry records	Daily, monthly and annual doses register and records	0	0	0	0	
		Health examinations records	0	0	0	0	
	Monitoring records	Surface (site, vicinity) monitoring (radiological, other pollutions, seismicity, precipitation, etc.)	2b	2b	1b	1b	
		Underground monitoring (radiological, geological, EBS performance, etc.)	2b	2b	1b	1b	
		Post-closure monitoring concept	2b	2b	2b	1b	
	Nuclear material accountancy	Nuclear material register	2b	2b	1b	2b	
		Inventory change reports (physical inventory taking, book inventory, etc.)	2b	2b	1b	2b	
	Safety, safeguards and security	Operating diary (emergency training, emergency events records, adopted measure records, emergency event evaluation report, etc.)	2b	2b	0	2b	Emergency event records, along with the adopted measures and evaluation, can be valuable for future use
		Checking, testing protocols, findings, adopted measures, etc.	0	0	0	0	
	Record category: Safety, environmental impact assessments, licensing documentation						
Site selection, characterisation and confirmation period	Safety assessment / safety case	Safety case strategy	1b	1b	1b	0	
		Process reports (including underlying R&D) on geology, rock mechanics, hydrology, chemistry, microbiology, etc.	1b	1b	1b	0	
		Models and tools development (adaptation, modifications, etc.)	1b	1b	1b	0	
		Geoscientific long-term site evolution	1b	1b	1b	0	
		Generic FEP catalogue (identification and selection of FEPs relevant to the repository, etc.)	1b	1b	1b	0	
		Scenario development (reference, alternative and what-if cases)	1b	1b	1b	0	
		Input data specification (safety assessment model calculations, assessment results, including safety functions, performance and integrity of (sub)systems, indicators, compliance with regulations evaluation, discussion of uncertainties, etc.)	1b	1b	1b	0	
		Multiple lines of evidence (additional geological arguments, analogues, other indicators, etc.)	1b	1b	1b	0	
		Additional analysis (e.g. criticality, future human action, optimisation and qualitative analyses)	1b	1b	1b	0	
		Safety case summary report (drawings, maps, calculations, etc.)	1b	1b	1b	0	
	Environmental impact assessment (EIA)	EIA methodology (input data collection, calculations, etc.)	1b	1b	1b	0	
		EIA summary report (drawings, maps, calculations, etc.)	1)b	1b	1b	0	
	Safety case and EIA evaluation and licensing	Safety case report (external examination, peer review, etc.)	1b	1b	1b	0	
		EIA external examination (peer review, etc.)	1b	1b	1b	0	
		Public hearings and compiled objections from the public, etc.	2b	1b	2b	0	
		Site selection (approval, governmental decision document, etc.)	2b	1b	2b	1b	
		Preliminary construction approval (governmental decision document, etc.)	2b	1b	2b	0	
		Repository construction approval (governmental decision document, etc.)	2b	1b	2b	0	

Record creation period	Records examples			Option			Remarks
				Perform own long-term safety assessment	Trace back decisions from implementation process	Retrieve material from the repository	
				Involved: specialists, scientists, regulators, etc.	Involved: policy makers, historians, etc.	Involved: technicians, policy makers, etc.	
	Records group examples	Records (documents) examples	Highest rating	Rating	Rating	Rating	
Repository construction period	Safety assessment / safety case for operation	Safety case strategy, plan and time schedule	1b	1b	1b	0	
		Process reports (including underlying R&D) on geology, rock mechanics, hydrology, chemistry, microbiology, etc.	1b	1b	1b	0	
		Models and tools	1b	1b	1b	0	
		Geoscientific long-term evolution	1b	1b	1b	0	
		Generic FEP catalogue (identification and selection of FEPs relevant to the repository, etc.)	1b	1b	1b	0	
		Generic FEP catalogue	1b	1b	1b	0	
		Scenario development (reference, alternative and what-if cases)	1b	1b	1b	0	
		Input data specification (safety assessment model calculations, assessment results, including safety functions, performance and integrity of (sub)systems, indicators, compliance with regulations evaluation, discussion of uncertainties, etc.)	1b	1b	1b	0	
		Multiple lines of evidence (additional geological arguments, analogues, other indicators, etc.)	1b	1b	1b	0	
		Additional analysis (e.g. criticality, future human action, optimisation, qualitative analyses)	1b	1b	1b	0	
		External examination (peer review, etc.)	1b	1b	1b	0	
	EIA for operation	EIA methodology (input data collection, calculations, etc.)	1b	1b	1b	0	
		EIA summary report (drawings, maps, calculations, etc.)	1b	1b	1b	0	
	Safety case and EIA evaluation and licensing	Safety case report (external examination, peer review, etc.)	1b	1b	1b	0	
		EIA external examination (peer review, etc.)	1b	1b	1b	0	
		Public hearings and compiled objections from the public, etc.	2b	1b	2b	0	
		Repository operation approval (governmental decision document, etc.)	2b	1b	2b	0	
Waste emplacement and pre-closure period	Periodical or ad hoc safety assessments/ safety cases	All safety assessment, safety case and EIA records (as mentioned for repository construction period)	1b	1b	1b	1b	
		Authorities decision (approvals, etc.)	2b	1b	2b	0	
	Safety assessment/ safety case and EIA development and evaluation for repository follow up construction	All safety assessment, safety case and EIA records (as mentioned for repository construction period)	1b	1b	1b	1b	
		Repository follow up construction approval (governmental decision document, etc.)	2b	1b	2b	0	
	Safety assessment/ safety case and EIA development and evaluation for repository partial backfilling	All safety assessment, safety case and EIA records (as mentioned for repository construction period)	1b	1b	1b	1b	
		Repository boreholes/chambers partial backfilling approval (governmental decision document, etc.)	2b	1b	2b	0	
	Safety assessment/ safety case and EIA development and evaluation for repository closure	All safety assessment, safety case and EIA records (as mentioned for repository construction period)	1b	1b	1b	1b	
		Repository decommissioning and closure approval (governmental decision document, etc.)	2b	1b	2b	0	

Record creation period	Records examples			Option			Remarks
				Perform own long-term safety assessment	Trace back decisions from implementation process	Retrieve material from the repository	
				Involved: specialists, scientists, regulators, etc.	Involved: policy makers, historians, etc.	Involved: technicians, policy makers, etc.	
	Records group examples	Records (documents) examples	Highest rating	Rating	Rating	Rating	
Repository closure period	Safety assessment/ safety case for repository site release	Safety case strategy, plan, time schedule	2b	2b	2b	1b	
		Process reports (including underlying R&D) on geology, rock mechanics, hydrology, chemistry, microbiology, etc.	2b	2b	1b	2b	
		Models and tools	2b	2b	1b	1b	
		Geoscientific long-term evolution	2b	2b	2b	2b	
		Site-specific FEP catalogue (identification and selection of FEPs relevant to the repository, etc.)	2b	2b	1b	2b	
		Scenario development (reference, alternative and what-if cases)	2b	2b	2b	2b	
		Input data specification (safety assessment model calculations, assessment results, including safety functions, performance and integrity of (sub)systems, indicators, compliance with regulations evaluation, discussion of uncertainties, etc.)	2b	2b	2b	2b	
		Multiple lines of evidence (additional geological arguments, analogues, other indicators, etc.)	2b	2b	2b	1b	
		Additional analysis (e.g. criticality, future human action, optimisation, qualitative analyses)	2b	2b	2b	2b	
		External examination (peer review, etc.)	2b	2b	2b	1b	
	EIA development and evaluation for repository site release	EIA methodology (input data collection, calculations, etc.)	2b	2b	1b	1b	
		EIA summary report (drawings, maps, calculations, etc.)	2b	2b	2b	1b	
	Safety case and EIA evaluation and licensing for repository site release	Safety case report (external examination, peer review, etc.)	2b	2b	2b	1b	
		EIA external examination (peer review, etc.)	2b	2b	2b	1b	
		Public hearings, compiled objections from the public, etc.	2b	2b	2b	1b	
		Repository operation approval and governmental decision document	2b	2b	2b	1b	
	Record category: Societal and general information						
	Legislation and regulations	Nuclear law and regulations (nuclear law, radiation protection regulations, waste management regulations, nuclear installations construction and operation, safeguards, emergency planning, etc.)	3a	1a	3a	0	
		Mining law, mining safety regulations (mining construction operation regulations, archiving law and regulations, building law, geological survey regulations, etc.)	2a	1a	2a	0	
		Internal regulations (operational and maintenance instructions, manuals, methodologies, QA/QC rules, safety, safeguards, security, emergency planning rules, etc.)	2a	1a	2a	1a	
	Communication with externals	Correspondence with licensing and supervising authorities	2b	1b	2b	0	
		Correspondence with other authorities	2b	1b	2b	0	
		Communication with politicians, political parties, etc.	2b	0	2b	0	
		Communication with designated communities, relationship with stakeholders, etc.	2b	1b	2b	0	
		Information material/publications for dissemination on repository and waste management issues (operation, R&D, safety issues, environmental monitoring results, etc.)	1b	1b	1b	0	
	Policy and conceptual materials	National waste management policy and practice, including public hearings and discussion on proposed options	2b	1b	2b	0	
		National energy policy, nuclear installations development, etc.	2a	1a	2a	0	
		EIA on waste management and repository implementation concept	2b	1b	2b	0	
	Memory tools	KIF	3b	3b	2b	2b	
		Markers, tracers, etc.	2b	1b	2b	0	

Annex B. Overview of the Safety Study of El Cabril L&ILW and VLLW disposal facility

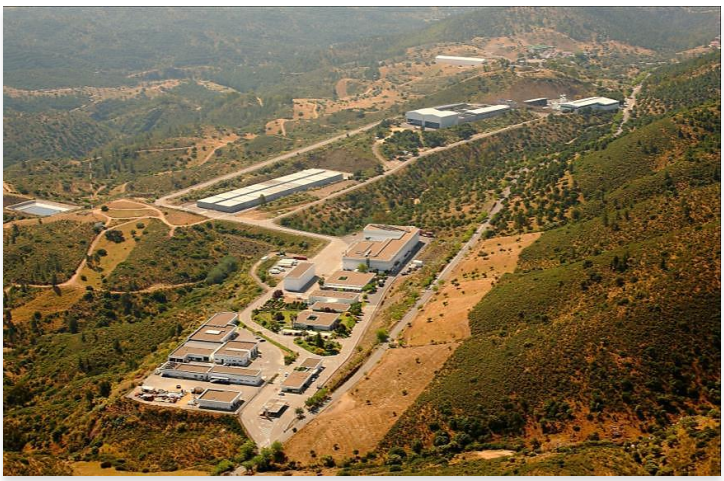
By Joaquín Farias-Seifert, Enresa, Spain

Introduction

This report was prepared to aid in the development and understanding of the Set of Essential Records (SER) Concept Report within the NEA Records, Knowledge and Memory (RK&M) initiative. Its objective is to present a real case study of a repository for low- and intermediate-level waste (L&ILW) and very low-level waste (VLLW) that will provide an overview of the main types and topics as well as an estimate of the number of records that can be proposed for an SER. It should be noted that it is not intended to be exhaustive.

The facility Safety Study has been the main document used for this purpose. It thoroughly describes the facility and is considered to be an essential document to prove its safety. A characteristic of the document is that the implementer has to update it regularly according to the developments of the repository, taking into account new regulations, updated technologies, etc.

Figure B.1. **Aerial view of El Cabril L&ILW and VLLW repository**



Source: Enresa.

The studied facility, called "*Centro de Almacenamiento de residuos radiactivos sólidos de Sierra Albarrana*", more commonly referred to as "C.A. *El Cabril*" or "*El Cabril*", is the Spanish repository for L&ILW and VLLW and is located in the province of Córdoba in the Southern part of Spain. Its main objective is the definitive disposal of these types of wastes in solid form. The El Cabril L&ILW disposal site belongs to the near-surface type of disposal facilities with engineered barriers. It is based on concrete barriers and concrete disposal units.

El Cabril also has various technological capabilities, such as treatment and conditioning facilities for the processing of waste from radioactive facilities and waste removed from non-regulated installations. Treatment equipment at the facility includes a super-compactor and an incinerator for organic waste. The facility carries out final conditioning whereby conditioned packages of L&ILW are placed in reinforced concrete containers or disposal units, which are subsequently put in the disposal vaults. El Cabril also has waste characterisation and verification laboratories for compliance testing of different types of wastes and verifying their characteristics. There are also workshops, laboratories and other auxiliary systems necessary for its operation.

In October 2008, the operation of a new complementary disposal facility for VLLW started at the site which is based on clay and High-Density Polyethylene (HDPE) barriers and different types of disposal units.

El Cabril has a total surface area of 35 ha. Buildings and the L&ILW disposal area occupy 20 ha, while the remainder is occupied by the VLLW disposal area. The facility has an internal capacity for L&ILW of 100 000 m^3 (corresponding to 35 000-50 000 m^3 of primary waste packages as delivered by the producers, depending on the waste types) and, for VLLW of 130 000 m^3. As an average, there is an annual reception of 1 700 m^3.

Milestones of the facility

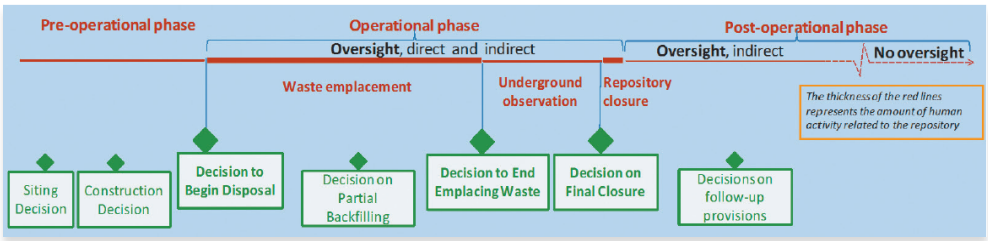
- 1935: Uranium mineralisation was discovered.
- 1935: The Uranium Mine at El Cabril started operation (discontinuously).
- 1951: The Nuclear Energy Research Commission (Junta de Energía Nuclear [JEN], now Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas [CIEMAT]), took possession of the mine and continued the exploitation of Uranium until 1959.
- 1961-85: Radioactive wastes were sent to "Beta" mine galleries of El Cabril. A pilot plant for treatment of liquid and solid radioactive wastes was constructed with a safety storage capacity of up to 900 drums.
- 1985: A new storage facility consisting of four units with a capacity of 5 000 drums each was constructed and started operation in February 1985. On 13 December, by a Ministerial Order, the transfer of the ownership of the installation to Enresa took place.

- 1986: On 1 January, Enresa took over the facilities of El Cabril. On 8 April, the Ministry of Industry and Energy authorised Enresa to take over the operation of the facilities.
- 1988: Enresa applied for a construction licence for the extension of El Cabril disposal facility. An Environmental Impact Statement was required and the project was subjected to public information.
- 1989: The construction licence was granted after Enresa received favourable mandatory reports from the Nuclear Safety Council (CSN) and the Environmental Impact Declaration.
- 1990: The L&ILW disposal vaults were constructed.
- 1991: Enresa applied for the operation licence.
- 1992: On 9 October, the first provisional operation permit was given for four years.
- 1993: On 23 April, the first container was stored in one of the storage cells of the North platform.
- 1996: The second provisional operation permit was given for five years.
- 2001: The indefinite operation authorisation was granted. The authorisation was valid until the available disposal capacity was completed. The authorisation imposes a set of technical and administrative "conditions". These conditions were modified when the VLLW disposal facility was authorised in July 2008.
- 2002: The first "periodical safety revision" was sent for evaluation.
- 2003: Enresa applied for the construction of the VLLW disposal facility as a design modification. Additional documentation was presented for the preliminary safety assessment and the general project. An Environmental Impact Statement was required and the project was subjected to public information.
- 2006: The VLLW disposal facility design modification was approved.
- 2007: Completion of the first storage structure for VLLW, Cell 29.
- 2008: The Ministry of Industry, Tourism and Trade granted authorisation to operate the complementary installation to Enresa, following a favourable report from the CSN. In October 2008, radioactive waste began to be stored in Cell 29.
- 2012: The second "periodical safety revision (2002-2011)" was prepared.
- 2013: Enresa started the process for the construction of the second storage structure for VLLW, Cell 30.
- 2016: Construction of Cell 30 was completed. The CSN reported favourably on the start-up of the operation phase of Cell 30.

Phases of the facility

The RK&M initiative uses the phase classifications from the ICRP-122 document (ICRP 2013). The phases are pre-operational, operational and post-operational with each phase having major decision points called milestones. These phases and milestones can be recognised in the evolution of the El Cabril facility and are identified in the following paragraphs.

Figure B.2. **Disposal facility phases and relevant oversight periods**



Source: ICRP, 2013.

Pre-operational phase

The pre-operational phase consists of the disposal site selection, characterisation, confirmation and construction of the facility. Its end point is defined by the decision to begin disposal activities.

The first milestone of the pre-operational phase, siting decision, can be considered as the date of transfer of the property from the public research institution (CIEMAT) to the radioactive waste agency (Enresa) which occurred on 1 January 1986.

The second milestone, the construction decision, was reached in 1989 when the competent authorities granted the construction licence.

The phase ended on 9 October 1992 when Enresa received the first provisional operation permit from the ministry.

Operational phase

The operational phase is the present phase of the El Cabril repository. The major decision points such as the decision on partial backfilling, decision to end emplacing waste and decision on final closure, are still far in the future.

Several design modifications have been made during the operational phase. This includes the construction of the complementary facility for the VLLW. The construction of the complementary facility implies the completion of applications for its siting, construction and start of operation, which, again is the pre-operational phase for this facility.

Post-operational phase

When the competent authorities grant a Declaration of Closure, the post-operational phase of the repository will start. The duration of this phase is estimated to be 300 years for L&ILW (North and South platforms) and 60 years for VLLW (East platform).

The main concerns for this phase include maintaining the integrity of the engineered barriers and avoiding uncontrolled human intrusion. The activities planned will be focused on the monitoring programme of the disposal areas (L&ILW and VLLW), the facility and the barriers, maintenance and performing a radiological control of the surrounding area.

It is foreseen that El Cabril will remain as a property of Enresa during this phase.

History of the El Cabril facility Safety Study Report

The facility Safety Study is considered to be an essential document to prove its safety and is characteristically updated regularly according to the developments of the facility. An analysis of the information included in the Safety Study of the L&ILW and VLLW facility of El Cabril has been proposed in the present study to help in the identification of records that might be included in the SER. Additionally, information on the number of records might be derived from the analysis.

Up to October 2017, 14 revisions of the document as listed in Table B.1 have been made to demonstrate the safety of the facility at different stages. Some of the different reasons for the revisions include:

- the actualisation of contents (i.e. inclusion of a number of modifications made in the facility);
- attachments to an application of construction or operation;
- a requirement of the authorities linked to a granted permit;
- to include modifications of the design of the installation;
- a requirement of the authorities to take into account new events or new methodologies to improve the safety assessment.

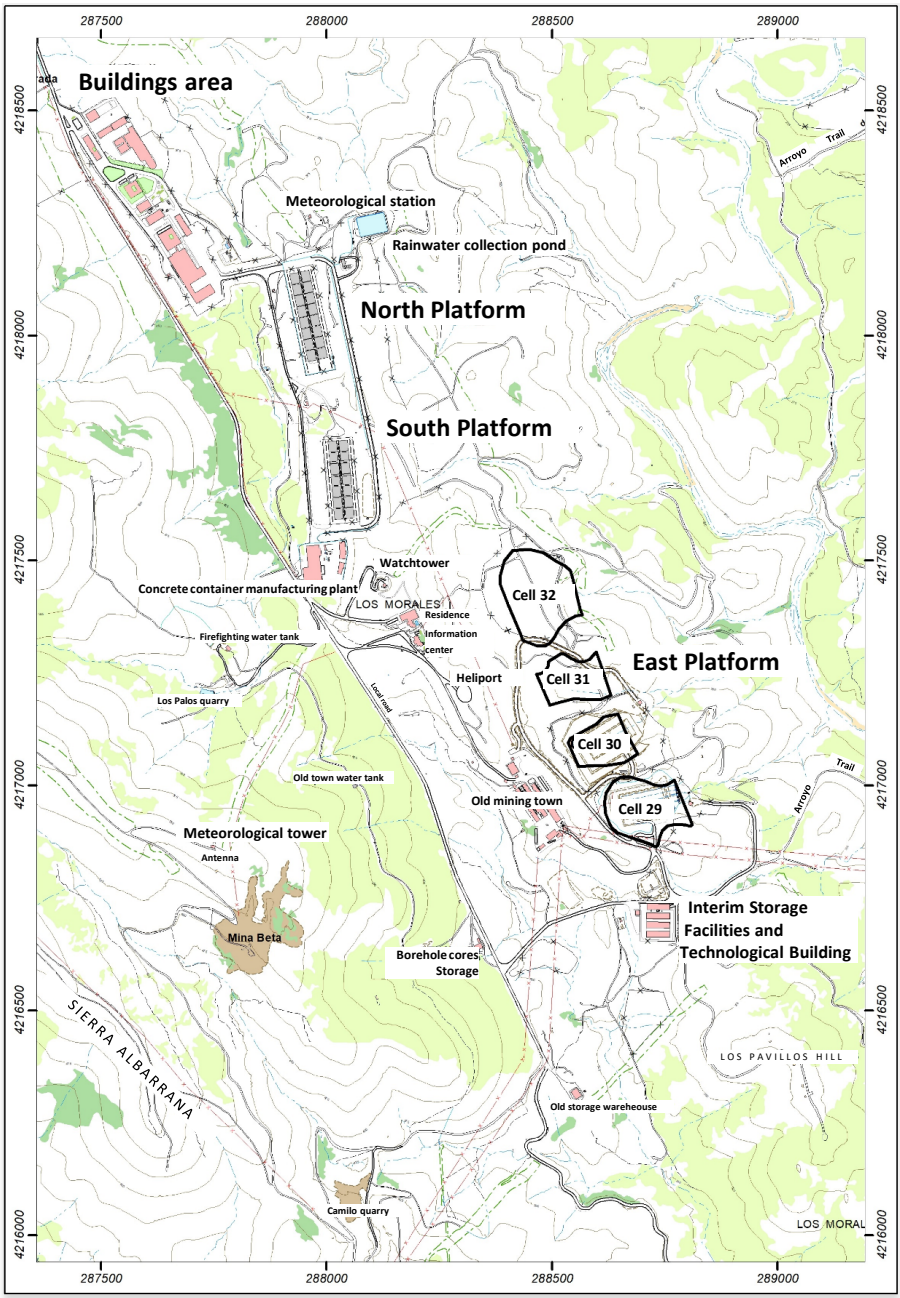
Table B.1. **History of revisions of the El Cabril Safety Study**

Revision	Date	Remarks
0	June 1991	Prepared for the application to authorise the construction of the L&ILW disposal facility.
1	Apr. 1993	The four-year interim licence for operation included some conditions, among them was the issuance of revision 1.
2	Nov. 1995	The revision was prepared for the application for the renewal of the interim licence.
3	Feb. 1997	It was required in an annex to order the extension of the interim licence for an additional five years as of 6 October 1996.
4	Apr. 2003	Actualisation of contents.
5	Oct. 2003	Actualisation of contents.
6	Feb. 2004	To include new waste forms acceptance criteria approved by the ministry.
7	Apr. 2005	To meet the resolutions of the ministry related to design modifications for the conditioning of solid waste from iron melting incidents and the auxiliary conditioning building. Also, to comply with ministerial order authorising operation of the facility.
8	Oct. 2006	To comply with the regulatory body requirements linked to the operation licence as well as to include design modifications.
9	July 2008	To comply with the authorisation of the design modification related to the VLLW disposal facility.
10	Sep. 2008	The Nuclear Safety Council required a new revision of the Safety Study report for the inclusion of additional information about Cell 29 from the new VLLW disposal facility.
11	Jan. 2012	Related to requirements of the ministry and the regulatory body for explaining the presence of water under the L&ILW disposal vaults.
12	July 2012	Actualisation of contents.
13	May 2014	Related to the modification of the design for the storage of radioactive isotopes with a half-life between the ones of Co-60 and Cs-137 as well as to include other design modifications.
14	July 2016	Related to the operation of Cell 30 from the VLLW disposal facility.

Safety Study: Part 2, site and facility description

The Safety Study is a document that, among other objectives, describes the facility exhaustively. It has remarkably increased in information from the initial *Preliminary Safety Study* up to the most recent version, after revision 14. As an indicator, the scanned version of the latest Safety Study consists of 3 905 pages, while version 3 consisted of 2 948 pages.

Figure B.3. **Layout of the facility "Instalación de Almacenamiento de Residuos Radiactivos Sólidos de Sierra Albarrana, El Cabril"**



Source: Enresa.

The structure and contents have been set according to the requirements of the CSN, the Spanish regulatory body. Initially, up to revision 6, the study was organised in three parts:

- Part I defining the facility as a basic element for the management of L&ILW in Spain, showing their essential characteristics and safety principles, including quality assurance applied.
- Part II providing a detailed description of the site, facility and environment.
- Part III describing the hypothesis and methods used for the radiological impact assessment of the facility as well as its results.

Starting from revision 7, part III was separated into part III and part IV:

- Part III setting out the initial hypotheses, data and methodologies for calculating and analysing the results of the safety assessment during the operational phase.
- Part IV determining the long-term hypotheses, data and methodologies for calculating and analysing the results of the safety assessment during the safety analysis.

The preparation of the study needs a multidisciplinary team, including the collaboration of external organisations.

An overview of part II is included in the following pages. It is organised following the structure of the Safety Study.

Physical characteristics of the site

This section provides information on the meteorological, geological, hydrological and seismic characteristics of the site. It also includes its radiological situation of reference, natural resources and arguments about the adequacy of the site and facility. A brief description of the storage systems has also been included.

Geography and topography of the property

The site is located on the foothills of Sierra Albarrana, which is part of Sierra Morena. It is in the northern part of the municipality of Hornachuelos within the province of Córdoba. The centre of the area under the control of Enresa is located at 38° 4'24"N, 5° 24'55"W.

The area that occupies the centre of El Cabril is located on a hill that from the Cerro de Los Morales extends in direction south-north and half slope between this hill and the stream of the Montesina, at an altitude of approximately 450 m above sea level. It is located in the central part of the northern half of the 1 126 ha of the Sierra Albarrana site.

The relief of the study area is moderately steep, which was caused by the erosive action of tributary streams on the right bank of the Guadalquivir River.

The disposal area of the North and South platforms (for L&ILW disposal) is located on the Los Morales hill. The structure is elongated in the NE-SO direction, which has a maximum height of 453.5 metres. This alignment is crossed by small streams of scarce entity.

The disposal area of the East platform (for VLLW disposal) is located halfway between the top of Cerro de los Morales and the stream of Montesina.

The basic information used for this chapter comes from the National Geographic Survey (IGN), and topographic surveys contracted by Enresa.

Meteorology

The climatic description of the site has been made using the climatological classification of Spain that uses criteria defining the types of climates according to thermal and water regimes. For the area of El Cabril, the assigned climatic type is Mediterranean Subtropical (SU-ME).

The precipitation and thermometric studies have been conducted based on data interpreted from an area of 6 600 km^2 around the facility with up to 44 meteorological stations considered. It has been possible to obtain a series of 35 years of precipitation with monthly values (1951-1985).

The study area is located in a zone characterised by the existence of mountains in a NW-SE formation, which forces the wind to move in this direction. The detailed analysis of the meteorological data available from June 1985-1988 shows the existence of local effects and hillside winds with local stagnation in different meteorological situations. To analyse these effects in more detail, an R&D project has been developed on the characterisation of atmospheric processes in complex topographies that has used the El Cabril site as an experimental field.

During the operational phase, the following climatic parameters are being surveyed and analysed: rainfalls, temperatures, average frost days per year, annual hours of sun and cloudy days, winds and adverse weathering phenomena.

Surface hydrology

The purpose of the studies carried out is to determine the hydrological parameters of the site and to assess the risk of flooding. Surface hydrology is treated both at the regional level and at the site level.

The hydrological parameters such as annual rainfall, evapotranspiration, useful rainfall, water contributions and flash floods were studied. This data was the basis for both the determination of hydrological parameters of the site, and for the consideration of flood risk.

As a basis for the local hydrological study, a summary of the regional hydrological study was carried out using the meteorological data already mentioned. At the beginning, preliminary data was extracted from the yearbooks of the Ministry of Public Works, edited for the years 1963-1976.

The study on site hydrology used hydrographic parameters that were derived from the regional study. It included some identified nuances, particularising the total rainfall in 24 hours and indicating the absence of flood risk.

A second study on the probable maximum rainfall has also been carried out using the deterministic method.

Geology

The geological description of El Cabril and its surroundings was made using geological works ordered by Enresa in the area of El Cabril. The initial description has been enriched by successive projects aimed mainly at gaining insight of the L&ILW disposal area (North and South platforms), and the characterisation of the VLLW disposal area (East platform). The works carried out started in 1987, with a regional geology covering a radius of 300 km around the site at a scale of 1:500 000. The last one considered in this report is from 2015 and consists of the geological monitoring during the excavation of Cell 30 (for VLLW disposal). A total of 13 projects have been performed so far.

As a result of the works done so far, a geological model of the property has been made (Figure B.4). The model of the areas of the L&ILW and VLLW platforms are more detailed.

Hydrogeology

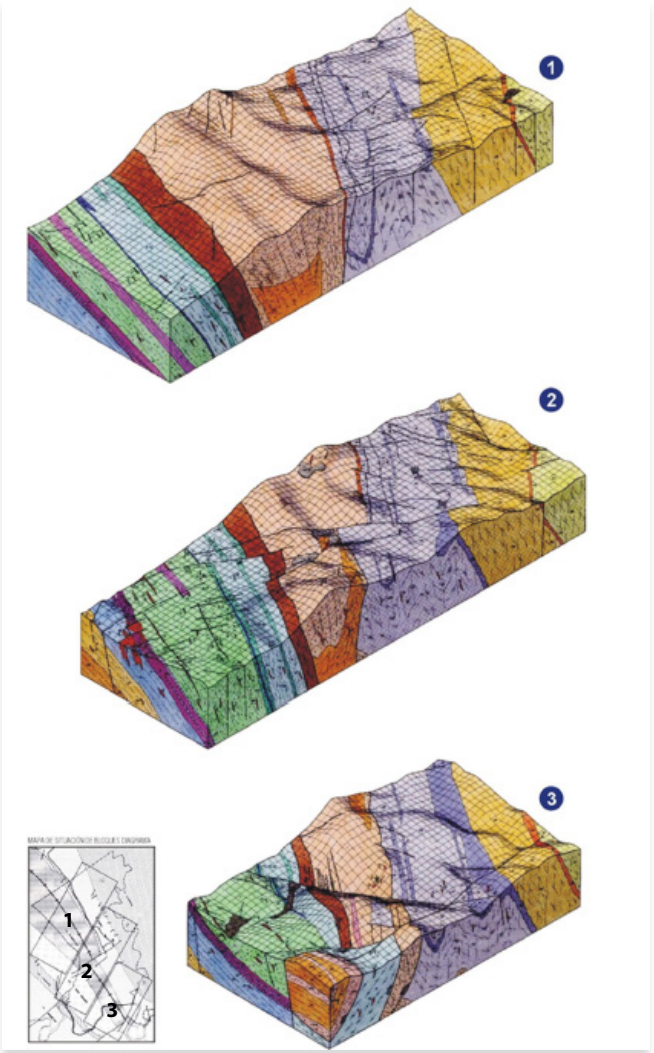
Hydrogeological characterisation of the site is a continuous activity being performed since 1984. The objective during the initial years was devoted to obtaining information for the construction of the L&ILW (North and South platforms) and VLLW (East platform), and for assessing the safety. At the disposal platforms, it is aimed at knowing: i) depth and evolution of the water table; ii) location of groundwater discharge zones; and iii) groundwater flow and trajectories from storage areas to discharge points.

To this end, it has been necessary to study the hydrogeological performance of El Cabril in depth through boreholes and to develop a mathematical model of flow and transport. The hydrogeological investigations of the El Cabril site have been carried out in four phases:

- Phase I (1987-1991): The characterisation of the site for the construction of the North and South platforms. The research includes two scales of work: a semi-regional scale encompassing part of El Cabril and a local scale centred on the North and South platforms (Cerro de los Morales). The modelling was done with two different numerical codes in 2D.
- Phase II (1992-2002): The modelling was performed to introduce modifications for incorporating changes caused by new buildings and data from the new surveys.

- Phase III (2003-2006): Studies were aimed at explaining several observed phenomena around the North and South platforms, and at selecting a site for a new disposal facility for VLLW within the property. A 3D mathematical model for flow and transport was developed.
- Phase IV (2007-2014): During this phase, in addition to understanding the behaviour of the site, it was necessary to make a detailed characterisation of Cell 29 and Cell 30. A migration to a commercial numerical code was made.

Figure B.4. **Structural – geological model of El Cabril**



Source: Enresa.

An unconventional methodology for the study of the hydrogeological characterisation has been developed due to the geological complexity of the area. It included the following items:

- *Climatic and meteorological information* based on the compilation and analysis of data provided by the Spanish Meteorological Service and the meteorological stations in El Cabril.
- *Hydrological behaviour* investigated with the support of the data registered in gauging stations of the Guadalquivir Hydrographic Confederation and in the gauging stations and landfills installed by Enresa in the vicinity of the site.
- *Geological knowledge* based on detailed morphological, lithological and structural studies from outcrops, trenches and clearings supported by the research of remote sensors, mechanical wells, and surface and borehole geophysics.
- The *hydrogeological characterisation* based on the study of the water points, piezometric control, geophysical and isotopic analyses of water, hydrodynamics trials of several typologies, analysis of the directions of drainage, etc.
- The analysis of the *piezometric evolution* after the construction of the facility by means of analysing all available information, not only of the aquifer environment itself, but also including the chronology and characteristics of the buildings.
- *Geophysical methods*. The information obtained was based on seismic refraction, crosshole and downhole tests, very low frequency methodology and electrical methods.
- *Borehole cores*. During Phase I (1987-91) a total of 4 438 m of borehole cores were studied from 70 wells drilled with varying depths of 30 to 300 m.
- Information on the *groundwater flow* obtained from a geochemical study carried out on certain borehole cores.
- Measurements *of faults cinematic signs*.

The *piezometric* studies performed so far can be grouped into two periods. The first period describes the studies carried out up to 1992 during the pre-operational phase of the facility, which were a basic element for the conceptualisation of the flow system at El Cabril. The second period that started in 1992 describes the evolution of the groundwater after the construction of the first disposal platforms up to 2014.

Most of the *boreholes* were drilled for piezometry measurements. From 1983-2016, 19 series of boreholes have been drilled to create a total of 234 individual boreholes. The total length drilled is 10 988 m.

The *hydrodynamic characteristics* of the L&ILW and VLLW disposal areas were determined separately, according to their construction schedules. The following tests have been performed: lugeon tests, slug and pulse tests, pumping tests, injection tests and tracer tests.

Hydrogeochemical characterisation work has been carried out at two geographical scopes. A general one of the El Cabril site and a more detailed one considering only the areas of the L&ILW and VLLW facilities. Five different campaigns were performed so far: two preliminary studies, a detail study, a study of the observed changes in chemistry and a detailed study of the VLLW area.

Seismo-tectonics

The seismotectonic study on Sierra Albarrana has been developed according to accepted methods in the usual and common practices. The final objective of this study is the definition of the design earthquake in terms of the peak ground acceleration and a response spectrum at the site.

A study of historical and instrumental seismicity has been carried out in a region of 300 km around the site, extended to the west to incorporate the Lisbon and Azores-Gibraltar areas.

A definition of the seismotectonic provinces has been done from the study of general geology (radius of 300 km), local geology (radius of 25 km) and the tectonic activity (seismicity).

The seismic risk at the site has been evaluated based on a deterministic analysis, with which the design earthquake has been defined. The return periods and probabilities of occurrence associated with the design earthquake and other intensity earthquakes have also been obtained through a probabilistic analysis.

A study of surface faulting in an area of 25 km around El Cabril has also been carried out in order to relate these occurrences to the recorded earthquakes in the study area.

To complete the range of tools that can be used in this type of study, the monitoring of microseismic activity has also been carried out in a circular area of 40-50 km around the facility. The microseismic surveillance network operated in two phases, the first from June 1987 to July 1989, and the second from June 1990 to December 1992. The results have been described and evaluated in several reports. Special attention has been given to the locations of microseismic activity after reviewing the paper records.

At present, the monitoring of the seismic activity of El Cabril continues through the study of the data provided by a field accelerometer installed on the site (1991) and the information provided by the seismic surveillance networks of the National Geographic Institute (IGN) and the Andalusian Institute of Geophysics (IAG). In addition, the national network of the IGN has its own equipment installed and operational on the site (seismic station and accelerometer).

Geotechnical studies

The geotechnical studies carried out at El Cabril have been developed as studies associated to, and prior to the construction of, the L&ILW disposal cells (1987-91), disposal Cell 29 for VLLW (2003) and disposal Cell 30, also for VLLW (2012-15).

Research carried out in the L&ILW disposal area was aimed at defining the stability conditions of the slopes and the foundation conditions of the disposal structures (North and South platforms), buildings (storage) and the Active Characterisation Laboratory. Studies have included:

- *Geotechnical cartography*: natural outcrops and trenches were observed.
- *Test wells drilled with a rotary hammer*: 24 boreholes, of which 19 are vertical and 5 inclined, were made having a total of 754.95 linear metres.
- *Piezometry*: perforated PVC pipes were placed in 16 of the boreholes.
- *Pressure tests*: a total of 91 tests were carried out, of which 81 are static and 10 cyclical.
- *Geophysical tests* using techniques such as crosshole and downhole.
- *Trenches* (complementing those made for the hydrogeological study).
- *Laboratory tests*.

Geochemical characterisation

The target of geochemical characterisation is the description of the rock mass features, which define its behaviour as a geological barrier in relation to radionuclide migration. For that purpose it is necessary to know the retention parameters (*distribution coefficient* and *cation exchange capacities*), as well as any other parameters that directly affect either the retention properties of the formation or their modelling. Petrologic and mineralogical characteristics of the materials include porosity, specific weight, permeability, density and pore size (which is a characteristic of the fracture network).

The study of the migration parameters of this formation and its hydrogeochemical characterisation constitute the two major areas of work within the geochemical characterisation.

The methodology used for the characterisation of the rock mass consists of:

- A detailed study of the borehole cores: lithology, fracture density, selection of sampling points and degree of alteration and fills.
- Mineralogical and petrographic characterisation: study by thin films and X-ray diffraction of the selected samples of both the rock matrix and the fissures.
- Lithogeochemical characterisation: exhaustive chemical analysis of the selected materials and an interpretation of their spatial and lithological distribution.
- Characterisation of the properties of the fracture network: porosimetric analysis, specific surface, specific weight and diffusion in fractures, and permeability.
- Physical-chemical characterisation: cationic exchange capacity, calculation of batch and column distribution coefficients for caesium and cobalt, and calculation of delay factors.

- Modelling of El Cabril formation as a geological barrier: conditioning factors of the migration process.

The samples used the analyses taken from 16 boreholes distributed in two profiles. The result of the research was a report released in April 1989.

The hydrogeochemical characterisation of the rock formation was already mentioned in Section "Hydrogeology".

Reference radiological status

The reference environmental radiological situation prior to the operation of the facility (site radiological background) has been determined with the Pre-operational Environmental Radiological Surveillance Programme (PVRA). The possible deviations of the radiological characteristics during operation of the facility can also be determined.

Prior to the start-up of the L&ILW facility of El Cabril, a 12-month operational radiological survey programme of the four disposal buildings existing before the transference of El Cabril to Enresa was conducted. The data obtained from this program are representative of those obtained in the PVRA specific to the new pre-operational installation. The following measures have been taken:

- direct radiation through thermoluminescence dosimeters (TLD);
- analysis of groundwater and surface water: alpha and total beta, rest beta, uranium, Ra-226, Sr-90 and gamma spectrometry.

Fifty sampling points were defined for the following potential exposure pathways: soil, groundwater, air, surface water, sediment, vegetation, fishing, hunting (rabbit, deer and partridge), direct radiation and food (honey and sheep meat).

Natural resources

Mineral resources and water uses are the resources that could affect the El Cabril site.

The activities of the existing uranium mine are already finished. Nevertheless, there is a definitive mining reserve within the area of Enresa for all substances, the so-called "Sierra Albarrana – JEN".

The water uses considered in the study only involve surface water; the amount of underground water is so small that it may be considered negligible. There are two reservoirs near the facility, named Bembézar and Hornachuelos. The amount of water annually stored is 307 Hm^3 and 100 Hm^3 respectively.

Human environmental description

This chapter describes the elements and main parameters of the biosphere that are essential for a complete description of the potential ways to transfer radionuclides to the human being.

Demography

For study purposes, the influence area of the facility has been divided into five concentric areas with an increasing radius of 10 km starting from the centre of the installation and ending 50 km away.

The initial data was taken from the National Institute of Statistics and are the censuses of 1950, 1960, 1970, 1981 and 1986. The last version of the Safety Study (version 14) also includes data from 1990, 1995, 2000, 2005 and 2012.

Industry and communication network

The analyses have been made in two geographical areas. The first sector is the closest area within a radius of 10 km from the facility and the second sector is the area from 10-50 km.

Within the first sector there is zero industrial activity, as described by *demographic studies* of the periods 1950-1986 and 1986-2005. The second sector is characterised by low industrialisation indices. Only coal mining has stood out in the region from the period of 1950-1986. However, during the period 1986-2005 mining activity has declined to a large extent with more than half of the mines having ceased operation. There are only some family-run carpentry and mechanical workshops.

The agri-food industry has increased their productivity progressively. The main activities are grain dryers for the transformation of crops to compound feed for livestock, local poultry farming, slaughterhouses, sausage factories and the scattered olive oil industry.

Concerning the commercial sector, the evolution of services by population is also described. Existing commercial licences are shown, as well as the evolution of the number of family houses, industrial activities and equipment.

The study describes the access network to El Cabril existing in 1986, as well as in 2016.

Agriculture, livestock production

The agricultural and livestock production in the area covering up to a distance of 50 km from El Cabril is described using data from: i) Ministry of Agriculture, Fisheries and Food, ii) Andalusian Council of Agriculture and iii) direct survey.

Likewise, the hunting and fishing reserves existing in this area are presented according to the data supplied by the provincial *delegation of ICONA* (Nature Preservation Institute) of Seville and *IARA* (Andalusian Institute of Agrarian Reform) of Córdoba. The surface and hunting type is collected for each reserve.

The abruptness of the first sector (0-10 km) and its small population make the agricultural activity very small. It is practically reduced to family plots destined for self-consumption. The tendency is to diminish them and become progressive by turning them into hunting reserves or forestry exploitations.

In farther areas from El Cabril (10-50 km) there are two clearly differentiated sub-areas. The first and larger one corresponds to the central area of Sierra Morena and extends around El Cabril. It consists of practically uncultivated land. Nevertheless the existing agriculture is based on a combination of cereal, olive grove and grasslands. Irrigation has very little implantation and is located in a dispersed manner. Towards the west, the cultivated areas and pastures are reduced and the forests of oak and cork trees are increased.

The second sub-area, located in the south of the study area, is characterised by smooth topography, broad ridges and flat valleys. Unlike the previous sub-area, a continuous and homogeneous population is located throughout the course of the Guadalquivir River. The abundance of generous soils has led to the cultivation of nearly the entire depression.

An outline of the production in 1986 and the current production is also shown.

Ecology

The weather conditions of Sierra Albarrana are marked by the seasonality typical of Mediterranean climates. It consists of rainy winters and dry summers, all during periods of generally rainier and drier years.

More specifically, it belongs to the Mesomediterranean subregion. The average annual rainfall is about 700 millimetres and the wettest month is February, followed by November. The warmest month is July with an average maximum of over 41°C.

Flora and fauna are described as well as some activities devoted to the preservation of the environment, including R&D projects with local universities.

Pathways to transfer radionuclide and identification of the critical individual

Infiltration waters that might have been in contact with the radioactive waste can only flow into the watercourses delimiting the disposal area, the streams of Palos and La Montesina.

The average flow of Montesina is 0.45 m^3/s. It flows into Bembézar River which has a downstream flow of 6.07 m^3/s. Four main ways of transference to humans are consumption of water, consumption of vegetables, consumption of fish and crabs of the area, and consumption of animals.

- The analysis of transference through water shows that this method may be disregarded.
- The transference through consumption of freshwater products, such as crab and fish, is also disregarded since the food uses of the population only considers sea fish.
- The transference through vegetable ingestion is then analysed. As it was described before, there is scarce self-consumption of agricultural production near the facility (downstream). The production 50 km away using water from the river is important. Only when water is taken from Bembézar River might the transference be considered.

- The analysis of consumption of animal products considers three groups. Cattle, farm animals and game. The methods of bioaccumulation of radionuclides to the animals are also analysed, followed by an analysis of the most probable points of contamination for each group:
  - the Bembézar River after the union with La Montesina for cattle;
  - the Bembézar reservoir for farm animals;
  - La Montesina stream for game.

Other possible routes of transfer analysed are external irradiation by exposure to the reservoirs and inhalation of suspended particles in the air from the deposits on banks and floors.

Surveys have been carried out in the municipalities within the radius of 50 km for a qualitative knowledge of the regular diet of the population. As a general characteristic, the low degree of self-sufficiency in the population due to low production in family-type orchards is noteworthy. In addition, in most of the municipalities the commerce is well developed, making the itinerary trades practically null. The studies have identified the staple diets of the population, as well as the main consumption, commercialisation and distribution products that have their origin in the area of study.

The most unfavourable situation, from the point of view of receiving a higher dose, is defined as a critical individual such as a *hypothetical farmer* with livestock living in the area near the head of the Bembézar reservoir with a high level of self-sufficiency.

Radioactive wastes

According to the operation permit, the El Cabril facility can dispose of low and medium activity radioactive waste (*L&ILW*). The Exploitation Authorisation defines those radioactive wastes as those whose activity is mainly due to the presence of beta or gamma emitting radionuclides of short or medium half-life (less than 30 years) and whose content in long-lived radionuclides are very low and limited by the levels of residues established in such authorisation.

The disposal-unit-type L&ILW (L&ILW-DU) is a package authorised for being emplaced in the cells of the North and South platforms. It is defined as a set consisting of three subsets: the concrete container, the conditioned medium and the low activity radioactive waste including the filling/sealing material that complies with the limitations of mass activity, requirements and technical conditions established. Up to 8 960 L&ILW-DU are foreseen to be disposed of considering the actual licence.

Additionally, within L&ILW it can be distinguished as a subset called very low activity radioactive waste (VLLW). It consists of solid or solidified material that is non-viable given its declassification. If its radioactive content does not exceed a defined limit value in the waste acceptance criteria it will be disposed of in the disposal units on the East platform of the facility.

The disposal-unit-type VLLW (VLLW-DU) is a set consisting of the container, very low activity radioactive waste and a stabilisation or filling material. Several configurations are used given that the most usual metallic containers are about 2 m^3, 220 litre drums or 1 m^3 big-bags.

The treatment and conditioning of waste is performed at El Cabril in a dedicated building. The flow of the radioactive wastes depends on their origin and may be summarised as follows.

L&ILW packages (220-litre drums) from nuclear installations (NPP) are either:

- Placed in concrete containers (called CE-2a, with a capacity of 18 drums) after the removal of the transport overpack.
- If the packages (drums) are compactable, compressed by applying 1 200 t pressure to obtain "pellets" that are placed in the concrete container (CE-2a) and immobilised with mortar.
- In the case of incinerable waste (oils and solvents) from the nuclear installations, they are sent to the waste treatment system for incineration. Ashes are collected and immobilised.

Table B.2. **Potential amount of L&ILW and VLLW to be managed at El Cabril, classified by their origin**

Origin	Comments	Amount
L&ILW		
Production of fuel elements.	Mostly solid and heterogeneous, pre-conditioned by producer.	50 waste forms, 11 m^3 per year.
Operation of nuclear power plants.	The packages are classified for their inventory and acceptance considering the conditions of their generation and the nature of the waste including conditioning made, bulk volume and characterisation level. A reclassification of the packages at the facility attending to characterisation level (activity), conditioning line followed and volume of waste form.	2 000-3 000 waste packages (440-660 m^3) per year.
Activities related to R&D and application of radioisotopes.	Enresa removes the wastes from the producer and conditions them at El Cabril.	About 100 m^3 per year.
Decommissioning of Nuclear Power Plants.	As a waste producer.	Estimated 135 000 m^3 in total.
Decommissioning of other nuclear and radioactive facilities.	Other installations than nuclear power plants.	About 1 000 m^3 in total
Generated in C.A. El Cabril.	Waste generated in the facility as consequence of the treatment and conditioning of the waste disposed.	50-100 packages per year (11-22 m^3 per year).
Incidents in non-regulated installations.	Inadvertently melted sources.	n/a
VLLW		
Decommissioning of nuclear and radioactive facilities. Operation and maintenance of nuclear and radioactive facilities. Incidents occurring in Spanish facilities.	Grouped according to their potential interaction to environment: 1) Only radioactivity (otherwise inert or non-hazard industrial waste) 2) Additionally to radioactivity some hazards to the environment (mixed wastes).	Estimated volume (2006) slightly higher than 100 000 m^3 in total.

The treatment and conditioning carried out on L&ILW from radioactive installations and solid and liquid wastes generated in the facility are incineration, immobilisation, manufacturing of mortar with radioactive effluents, compaction and filling of gaps in non-compactable packages.

If necessary, VLLW are treated, conditioned or disposed of directly at East platform.

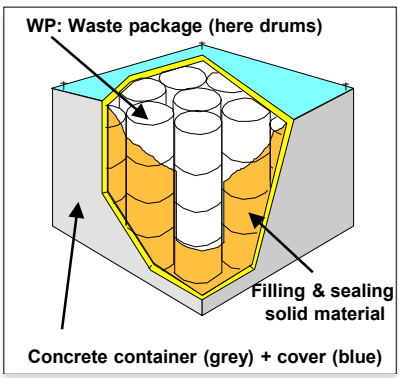
Table B.3. **Reference inventory; authorised inventory to be disposed of in the facility**

Nuclide	TBq
H-3	2.00E+02
C-14	2.00E+01
Ni-59	2.00E+02
Ni-63	2.00E+03
Co-60	2.00E+04
Sr-90	2.00E+03
Nb-94	1.00E+00
Tc-99	3.20E+00
I-129	1.50E-01
Cs-137	3.70E+03
Pu-241	1.15E+02
Alpha Total (300 years)	2.70E+01

Disposal unit

Figure B.5. **L&ILW disposal unit**

Scheme of the elements of a disposal unit



During fill up of a disposal unit



Source: Enresa.

The L&ILW-type disposal unit (L&ILW-DU) is defined as an assembly made up of three elements. An authorised container, conditioned low and medium activity radioactive waste, and filling/sealing material. L&ILW-DUs are classified according to their mass activity in levels 1 and 2 and must comply with technical requirements and conditions for the final acceptance and storage at El Cabril.

The activity of classifying level 1 or 2 must be determined following an approved methodology and must correspond to the sum of the activities of each individual waste package plus the mortar made with contaminated effluents.

Regardless of its level, any type of VLLW-DU must comply with generic criteria related to the following aspects:

- activity limit;
- distribution of activity;
- container;
- waste forms or wastes incorporated;
- non-radioactive waste content;
- structural resistance;
- retrievability and transportability;
- identification and functionalities.

Additionally there are specific conditions for L&ILW-DU of Level 1 and Level 2.

The L&ILW-DU is accepted only if each of its components (concrete container, waste package and the filling mortar) is individually accepted.

Figure B.6. **Examples of different VLLW disposal units**



Source: Enresa.

Characterisation and acceptance of wastes

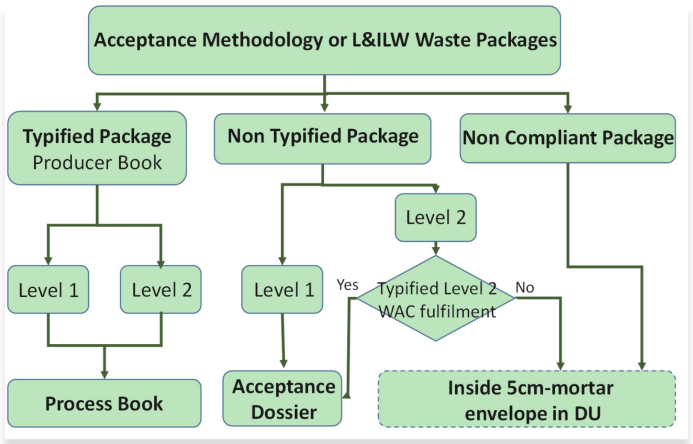
The L&ILW waste package (WP) unit, usually a 220-litre drum, consists of the L&ILW, immobilising agents, outer packaging and possibly overpacks or other temporary transport elements. During the management at El Cabril, the possible overpack is no longer a part of it.

The conditioned wastes forming the WP are considered in the Safety Study, according to their generation conditions, as typified or not-typified ones. The *typified WP* are those that have been created following a package specification, Descriptive Document of the WP (DDB), which has been previously approved. Their acceptance is made according to the methodology of the "Process Book". This is the case of regular L&ILW generated in nuclear power plants.

The *non-typified WP* are those that do not have a previous DDB and their acceptance has generally been done through a Dossier of Acceptance for historical waste. Its production is either prior to the implementation of the Process Book Methodology or derived from unplanned or unusual operational situations.

The classification "*non-compliant WP*" may be accepted by adding an extra inside mortar envelope of 5 cm in the concrete container resulting in a loss of volume capacity, but ensuring the fulfilment of the waste acceptance criteria of the disposal unit.

Figure B.7. **L&ILW waste acceptance criteria implementation**



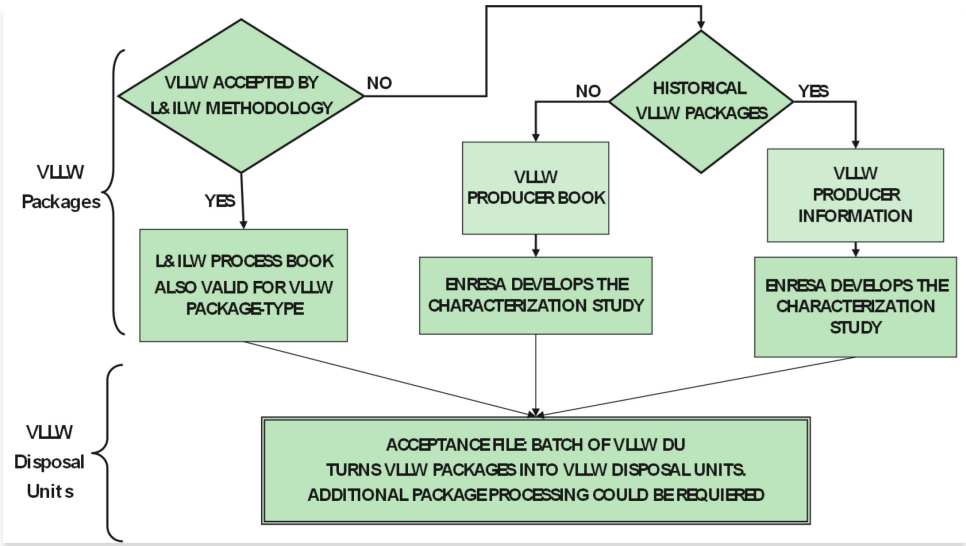
Source: Enresa.

There are technical specifications of acceptance criteria for primary packages, waste and sealed sources that apply to waste generated by nuclear or radioactive facilities in Spain, to those for the treatment of Spanish waste abroad, to those for interventions in Spain outside the scope of the Regulations for Nuclear and Radioactive Installations (RINR in Spanish) and to any other that is authorised by the competent authorities.

The maximum authorised activity per package is related to the different configurations of the DU and the activity distribution criteria.

The VLLW packages will be grouped by taking into account their origin and their radiological and physicochemical characteristics to allow an adequate control and monitoring of the processes of the acceptance of waste.

Figure B.8. **VLLW waste acceptance criteria implementation**



Concrete containers for L&ILW

The containers are the basic elements that are disposed and stacked in the storage cells of the North and South platforms, containing the solid or solidified radioactive waste, usually 220-litre drums or compacted drums ("cookies"). These containers are the first confining barrier of the repository during both the operational phase and the following surveillance phase. Their main function is avoiding the dispersion of radionuclides both directly and by leaching.

The concrete container has been approved for use by the regulatory authorities (CSN). There is a technical study that contains the following aspects:

- description of the container (dimensions, other physical characteristics, etc.);
- design criteria (safety criteria, civil works, etc.);
- controls and tests to be performed during fabrication (weight, visual and dimensional control, sealing, tests of structural and functional integrity, etc.).

The technical study has also demonstrated compliance with the requirements contained in the current ADR (formally, the European Agreement concerning the International Carriage of Dangerous Goods by Road [ADR]), as well as the structural and functional integrity tests necessary for its recoverability.

Each concrete container has a manufacturing dossier according to the established specifications.

Description of the facility

At El Cabril two types of clearly differentiated facilities can be observed. The structures or disposal cells, in which the disposal units are introduced being buried under a cover layer at the end of the exploitation phase, and the auxiliary facilities. These are the facilities for waste conditioning, laboratory of verification of the quality of the waste, building of interim reception, technological building and other auxiliary services, whose functions are limited to the operational phase. Most of the auxiliary facilities are foreseen to be dismantled at the end of the operational phase, except those needed for the post-operational phase, during which functions of disposal control, environmental monitoring and possibly, maintenance of the coverage layer and the control network will be carried out.

The installations cover an area of approximately 35 ha. It is fenced around its entire perimeter. A single point located in the industrial safety building allows access to the general facilities and those related to the conditioning and disposal of L&ILW.

The centre also has three storage modules for the temporary storage of waste that allows for regulating and optimising the flow of waste. Next to these modules is the technological building for the conditioning and temporary storage of VLLW.

The disposal area is divided into three platforms, the North and South for L&ILW, and the East for VLLW.

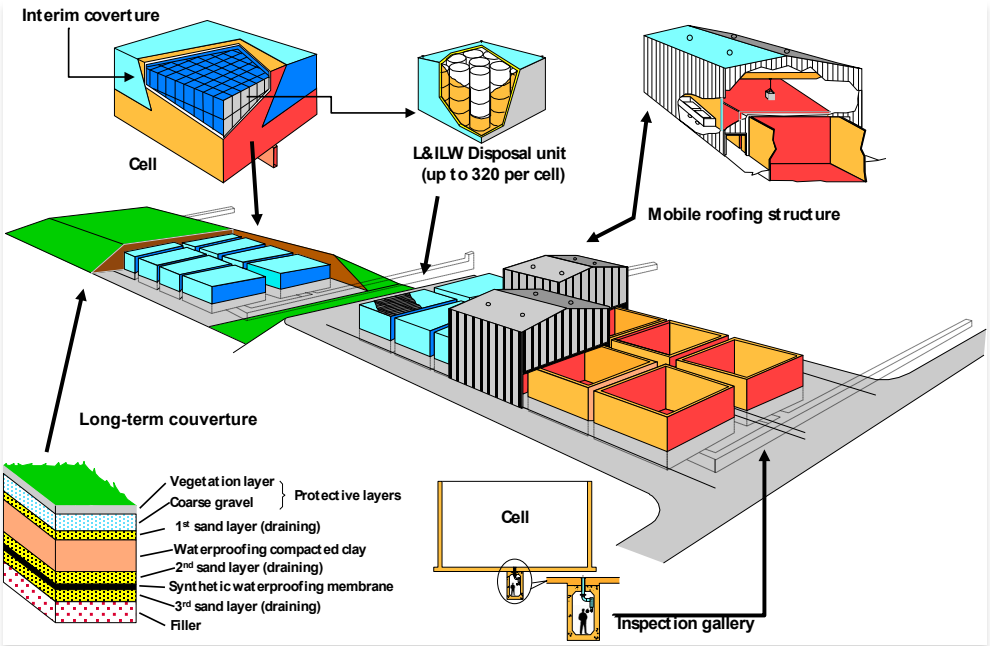
Disposal cells of the North and South platforms (L&ILW)

The disposal cells are concrete parallelepiped structures with external dimensions of approximately 23 x 20 x 10 m.

This type of cell has a lower support slab made of very low permeability reinforced concrete which incorporates a synthetic membrane and four vertical walls. An infiltration control network is installed in a lower inspection gallery. The lower slab is located 3 m below the level of the ground. The side walls act as a shield during the operation phase of the cell and after being filled, a closing slab is constructed. Inside the cells, disposal units formed by reinforced concrete containers containing conditioned waste will be placed. At the end of the operation of each cell, a slab of closure will be built and waterproofed.

The cells are arranged on two platforms, the North with 16 cells, and the South with 12. Each platform has two rows of cells.

Figure B.9. **Concept of L&ILW disposal facility at El Cabril**



Source: Enresa.

Disposal cells of the East platform (VLLW)

The VLLW will be disposed of in four cells called 29, 30, 31 and 32. Each cell is excavated in a trough and closed by a rock armour covered by impermeable materials (clay based). Once the bottom and the walls are conditioned, the waste is disposed of and organised according to its morphology in order to achieve a stable stacking with minimum volume occupation. Once the cell is filled, the protective layers and waterproofing membranes will be deposited over the waste for their total isolation from the environment.

Given the depth and extension of the cells, the disposal may be performed in several 4 to 6 m thick layers, which will constitute independent sections in each cell.

A leachate collection system is installed in each cell to collect the water that may have been in contact with the wastes. Cells 29 and 30 have been built and both are in operation. Cells 31 and 32 will be built as needed.

Infiltration control network (L&ILW)

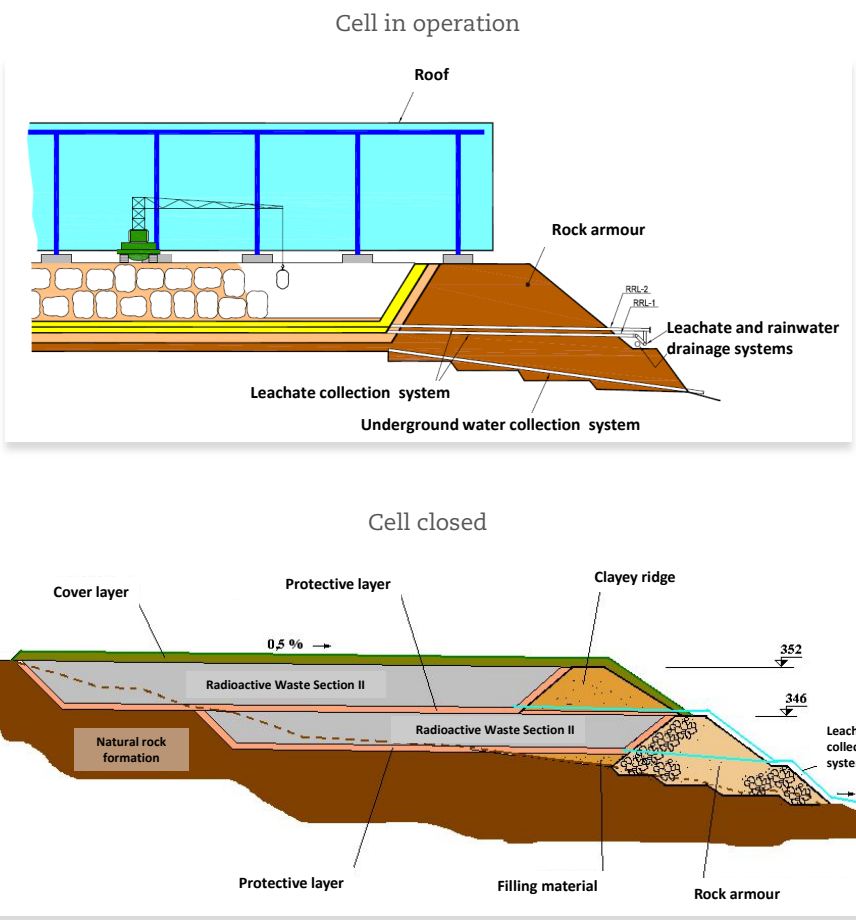
The purpose of the *infiltration control network* is to monitor the performance of the disposal platforms and to collect water that may infiltrate inside the closed cells and that may have been in contact with the waste. Any water recovered by the

infiltration control network will be controlled (control of radioactivity, chemical analysis and radiochemistry). The infiltration control network is passive, operating by gravity, and is independent of the stormwater collecting network.

This network will remain in operation during the surveillance and control period and is designed in such a way so that it can easily identify any anomaly and locate the disposal cell where the anomaly came from.

Each disposal cell is individually connected to the network through a retention vessel, which in case of water collection or a presence of activity detected in the RCI control tank, allows for the identification of the structure in which it was detected.

Figure B.10. **Longitudinal section of a disposal cell for VLLW**



Source: Enresa.

Leachate collection network (VLLW)

The leachate collection network has the mission of collecting and monitoring the water that may have been in contact with the waste disposed in the East platform (VLLW). There is a differentiated system for each cell that ends in a control deposit. Leachates are then conducted from each control deposit to a 100 m^3 centralised tank.

This network will remain operational during the surveillance period and has been designed to easily identify a possible anomaly and locate the disposal cell in which it was produced.

Interim storage facilities and technological building

The *interim storage facilities* consist of three identical modules with a rectangular floor plan of about 12 m x 50 m located in a regulated area and intended for the storage of waste packages. These buildings were constructed before the transference of El Cabril to Enresa and their initial function was to be an interim storage facility for radioactive wastes. They offer an interim storage capacity and allow to regulate and optimise the waste flow.

The *technological building*, located in a regulated domain in the area of the storage modules, is an auxiliary installation whose purpose is to treat the VLLW waste that requires it, as well as to accommodate their temporary storage.

Auxiliary facilities

The interim reception building, located in the regulated area, offers a storage capacity and also allows regulating and optimising the flow of waste to the conditioning building. In addition, it allows for the eventual decontamination of vehicles.

The conditioning building, also located in the regulated area, is the installation where the unloading, identification, treatment, conditioning and currently, the insertion of the waste in containers is made before being sent to the disposal cells.

The waste quality verification laboratory is the facility where the experimental determinations are made both on packages and radioactive samples, and on simulated packages and inactive samples. This includes a view of the characterisation of the different types of packages and the technical verification of the packages generated. It comprises two buildings that are physically separated.

1) *Active Laboratory*, in which the characterisation and verification tests on samples and radioactive waste packages are carried out.

2) *Inactive Laboratory*, in which the tests on inert samples are carried out.

The general services building is located on the border between the unregulated and regulated areas (supervised and controlled). It includes the following facilities: laboratories, where the necessary analyses for the operation of the facility are carried out; premises of the radiological protection services; laundry, for non-contaminated clothing; radiological control of access to regulated areas; medical service; changing rooms; and the calibration laboratory for radiological protection equipment.

There are also a number of ancillary buildings and facilities, among them are the following:

- *Industrial security building*, in which the physical surveillance and access control services and the fire protection of the facility are centralised.
- *Administration building*.
- *Technical services building*, which includes the general service systems such as the water treatment plant, the transformation centre and the distribution of electrical energy for conditioning, compressed air, conventional ventilation, etc.
- *Auxiliary facilities*, which include the maintenance workshop, archive building and social services, spare parts store, etc.
- *Concrete production plant*.
- *Concrete container manufacturing plant*.
- *Concrete laboratory*.

All of them are located in the unregulated area while the *rainwater collection pond* is located in the regulated area.

Exploitation of the disposal facility

This section deals with the description of the organisation of the facility, the emergency plan, the control of documentation, record keeping and filing, the strategy for the competence and training of the staff, and the operation of the facility during the operational phase and closure.

The exploitation in normal operation follows a mandatory document, the "operating regulations". The document describes the organisation, operating rules and control methods governing the El Cabril facility for low and medium, and very low activity radioactive waste disposal in order to ensure the correct fulfilment of the assigned missions at all times.

There is also an "internal emergency plan" for the operation of the facility in situations that require action outside normal activities. The emergency situations are classified from lower to higher severity:

- category I events – pre-announcement;
- category II events – emergency alert;
- category III events – emergency on-site.

Any emergency situation in which radioactive material is released in such a quantity that it is necessary to adopt protective measures outside El Cabril is not foreseen. Therefore, an emergency level of severity greater than that of emergency on site is not defined.

Control of documentation, record keeping and filing

There is a system implemented to *control the documents* related to the facility operations to ensure that only applicable documents are used and that they are used by authorised personnel. Likewise, the system also established *record keeping* and filing controls.

The requirements established for the "control" of documents are applicable to the main documents regulating the organisation, responsibilities, functions and conduct to be followed by the personnel who carry out their activities in the facility and who carry out activities related to safety and radiation protection. They are:

- *Official documentation* such as Safety Study, Technical Specifications of Operation, Operating Regulations, Internal Emergency Plan, Radiological Protection Manual, Quality Assurance Program, Physical Protection Plan and Disposal Units acceptance criteria.
- *Supplementary documentation* such as the Manual for Calculating External Doses for Gaseous Emissions, Environmental Radiological Surveillance Program, Hydrological Surveillance Program, Environmental Surveillance Program, ALARA Installation Manual, Fire Fighting Manual, Manual of Occupational Risks Prevention, Environmental Management Manual of El Cabril, Manual of Integrated Management of C.A. El Cabril and Procedures.
- *The activities associated with the processes of* the construction of the closing slab of disposal cells; manufacturing of containers; reception, treatment, conditioning and disposal of waste; monitoring of activity; radiological protection; operation of the Verification Laboratory; monitoring and maintenance requirements; actions in emergency situations; physical surveillance; and contingencies are collected in procedures, operating instructions and maintenance ranges.

As for the activities of "record keeping and filing", they will be applicable to the following documents:

- documentation indicated above in "control";
- records generated from the application of operating procedures and the Quality Assurance Program for exploitation;
- reports and documentation generated in the Installation;
- external correspondence: letters, documents and external reports.

The preservation period of the documents in the archives is established in the Exploitation Quality Assurance Programme and there are different possibilities. The following is the rule with exceptions made for specific documents:

- Duplicated files are located in two different places. The following will be permanently kept throughout the operational phase:
  - Information regarding the waste disposed of, especially its origin, nature, mass, total activity, specific isotope activity, reference to the treatment and conditioning method (with indication of the characteristics of the

matrix where appropriate), basic data on the manufacture and authorisation of use of disposal containers, reference and location in disposal cells.

  - Information on each disposal cell, which will include the descriptive information of the cell such as characteristics of its design and construction, closing slab, calculation notes of the structures, start and end dates of the work, eventual incidents or anomalies, and information regarding the waste disposed of.
  - The results of the monitoring of the site and the environment with the information useful for its interpretation.
  - Reports relating to accidents, incidents, failures and anomalies that have had or could have consequences on the security of the storage facility.
- Other records related to quality assurance. The provisions of the Quality Assurance Programme for exploitation will be followed and must be duplicated in two different places.

The Management Archive of the installation is under the responsibility of the area of quality control. The duplicate is located in Madrid and a subsidiary of the Services Directorate.

In addition, each service or area may have its work file that will not be subject to the conditions of the Installation Management File.

Radiological protection and radiological survey

The design, the operation procedures and the internal organisation of the El Cabril facility are aimed to ensure that individual and collective exposures to radiation, both by professionally exposed people and the general population, are below the limits specified in the Spanish Regulation on Health Protection against Ionising Radiation. They should also always be at levels as low as reasonably achievable (ALARA).

The radiological surveillance of the facility is in charge of the radiological protection and environment service (*PRYMA, Servicio de Protección Radiológica y Medio Ambiente*). PRYMA ensures the management of radiological protection equipment and materials, the management of radiological control of people and site, the collection of samples and their analysis, and the performance of the periodic reports of the facility's radiological status.

To this end, Enresa has carried out pre-operational radiological surveillance plans. There are annual plans corresponding to the operational phase since 1993. The documents referred to as PVRA (from Spanish *Plan de Vigilancia Radiológica Ambiental*) produced so far are the following:

- operational PVRA of the interim storage facilities (1987-92);
- pre-operational PVRA of C.A. Cabril with a duration of 21 months (1991-92);
- operational PVRA (1993-present).

Each PVRA consists of a programme previously approved by the regulatory authority on an annual basis, sets of sampling points, procedures, laboratory records and an annual report that Enresa forwards to the regulatory authority. The radiological control points have been selected considering the exposure ways of radionuclides to humans and the environment. Those considered in the PVRA are the following:

- air;
- surface, underground and runoff water;
- soils and sediments;
- vegetation, food, hunting and fishing;
- environment gamma dosimetry.

Table B.4. **Total samples of the El Cabril 2016 radiological surveillance plan**

Exposure related way	Sample		# control points	# samples /year (*)
	Code	Definition		
Direct radiation	DT	Direct radiation (dosimetry)	29+10+16	220
Air	PP	Atmospheric dust particles	7	364
	H3	Tritium in water stream	7	128
	CB	C-14 in Air		
Surface, underground and runoff water	SB	Underground water	19	78
	SP	Surface water	6	24
	AE	Runoff water	2	8
Soils and sediments	S	Soil	14	14
	SDF	Bottom sediments	6	6
Vegetation, food, hunting and fishing	PT	Vegetation	9	9
	OV, VE, PE	Meat sheepSheep, deer and partridge meat	3	3
		Honey	2	2
	P	Fish	1	1
Total				**853**

(*) Additional samples for QC cross-checking not included.

The controlled radionuclides have been restricted to those that are included in the source term of the facility and, since 2008, also include those of the isotope chain for all samples required by the gamma spectrometry analysis.

Final remarks and conclusions

The overview of the Safety Study of the El Cabril L&ILW and VLLW repository points out easily relevant topics, as well as the main records that can be candidates to be included in an SER. The purpose was to analyse and learn from a radioactive waste repository facility that has been operating in a safe way for 25 years. The study of a L&ILW and VLLW repository is useful even for the RK&M initiative that is focused on a Deep Geological Repository for high-level waste and spent fuel as it has some commonalities including the handling of radioactive wastes, the need to perform safety analyses and a number of human generations are involved (at least 15).

An attempt has been made to obtain the number of records associated with the list of relevant topics needed to describe the facility, the activities performed and the radioactive wastes disposed of that is shown in Table B.5. To this end it was necessary to interact with the El Cabril archive and consult internal management reports.

The figures obtained so far are incomplete and should only be considered qualitatively due to the following reasons:

- The number of documents assigned to the El Cabril archive by the end of 2016, starting in 1984, is around 350 000. Around 315 000 of them are permanent. These figures do not include other El Cabril-related documents which are included in other project archives, such as the R&D projects.
- The archive of the El Cabril facility is a “management archive” that increases by about 7 000 new documents every year if there are no relevant design modifications. Its organisation follows national and international standards and is focused on operational needs.
- The documents are produced in paper form. For several years, the new incorporations are made simultaneously in paper and electronic form. That means that today not all of the documents were available in electronic format for consultation during the preparation of this report. There are plans to incorporate all of the records in digital format.
- The database platform for records management used has been changed and not all of the documents in electronic form have been transferred. Additionally, the new management system does not have a counter. This means that it is not possible to automatically obtain accurate figures of the records ordered by topic.

A more precise table than Table B.5 will need time and resources that are beyond the scope of the RK&M initiative. Nevertheless, the table shows the order of magnitude of the number of records and the potential size of the final archive of a repository similar to that of El Cabril.

Table B.5. **Overview of topics, reports and records and their quantity by the end of 2016**

Chapter of the Safety Study	Topics/activities	No. reports	No. supporting records/reports	Remarks/sources
1. Physical characteristics of the site	Geography and topography (reports, topographical campaigns, aerial photography, maps, etc.) Meteorology (specific reports, R&D project reports and climate survey reports) Surface hydrology (specific reports, annual rainfall survey report and R&D reports) Geology (specific reports and maps) Hydrogeology (specific reports, R&D reports, more than 200 borehole reports and annual survey reports) Seismo-tectonics (specific reports and seismic survey programme reports) Geotechnical studies (specific reports, Cell 29 reports and Cell 30 reports) Geochemical characterisation (specific report and survey reports) Reference radiological status Natural resources	≈ 500	Several tens	Mostly recorded in a GIS 44 external rainfall stations Own work Ministry of Public Works Andalusian Institute of Geophysics National Geographic Institute
2. Human environmental description	Demography (Census): pre-operational and operational Industry and communication network (demographic studies) Agriculture and livestock production (reports) Ecology (reports, R&D projects report) Dietary customs of the population (surveys)	≈ 50	n/a	National Institute of Statistics Ministry of Agriculture, Fisheries and Food Andalusian Council of Agriculture Provincial Delegation of ICONA (Nature Preservation Institute) Seville Andalusian Institute of Agrarian Reform (IARA), Córdoba

Table B.5. **Overview of topics, reports and records and their quantity by the end of 2016** (cont'd)

Chapter of the Safety Study	Topics/activities	No. reports	No. supporting records/reports	Remarks/sources
3. Radioactive wastes	L&ILW disposal units (several types)	9 501	13 to 31	
	L&IL waste packages (≈131.000), acceptance documentation (process books, acceptance dossier and process dossier)	≈ 450	5 to 15	Generally grouped by waste streams and origin Each waste package has its own records All radioactive related information is included in a specific database (called SGR)
	VLLW disposal units (≈13.150), acceptance documentation (characterisation studies and characterisation dossier)	≈ 50		
	Reports on completed L&ILW disposal cells	21		
	VLLW disposal cells completed	0		
	Acceptance criteria, acceptance methodology, acceptance activity, and in situ producers audits and procedures	8		
4. Description of the facility	Project documentation associated to applications for: 1) Construction licence (1988) 2) Operation licence (1991) 3) Operation licence (1996) 4) Indefinite operation licence (2001) 5) Construction of VLLW cells (2003)	>500 (estimated)		
	Design modifications dossier	>250	Variable from tenths to hundreds	More than 250 design modifications
5. Exploitation of the facility	El Cabril Safety Study	17		Including three pre-operational
	Operation documents: technical specifications, procedures, plans, internal regulations, manuals, survey plans, management reports, etc. Other supplementary documentation	>2 000		
	Closing slab of storage cells dossier	21	20	2 000 pages each dossier
	Concrete containers manufacturing dossier (only accepted)	6 422	10-20	
	Other			

Table B.5. **Overview of topics, reports and records and their quantity by the end of 2016** (cont'd)

Chapter of the Safety Study	Topics/activities	No. reports	No. supporting records/reports	Remarks/sources
6. Radiological surveillance (PVRA)	Operational PVRA of the storage modules (1987-1992) report	6	Several hundreds	
	Pre-operational PVRA (1991-1992) report	1	≈ 1 100	Activity finished
	Yearly operational PVRA report from 1993 onwards	24	≈ 850	Own and external laboratories
	Sampling Procedures	30		Several revisions each

Table B.5 contains the six areas of information, physical description of the site, human and environment description, radioactive wastes, description of the facility, exploitation of the facility, and radiological survey. Other topics related to stakeholders, regulatory matters or the selection of the site have not been included as they are not specifically considered in the section of the Safety Study overviewed in this document.

Finally, the following conclusions are reached:

1. Most of the records are classified as permanent (> 90%).
2. At the end of the operational phase, there will be a huge amount of records in the system, even if only the permanent ones are considered. The selection procedure for having a manageable SER should be designed carefully and as soon as possible.
3. For quick and easy access to a required record or subset of them, a record management system based on electronic files of the original records is recommended. This means that there is a need to regularly update the technology of the management system and possibly the format of each record. This will involve the need for the disposing of significant financial and human resources to maintain or update the system.

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Preservation of Records, Knowledge and Memory (RK&M) Across Generations: Compiling a Set of Essential Records for a Radioactive Waste Repository

Radioactive waste repositories are designed to be intrinsically safe in that they are not dependent on the presence or intervention of humans. In response to this challenge, the Nuclear Energy Agency initiated the Preservation of Records, Knowledge and Memory (RK&M) Across Generations Initiative, calling on the international community to help create specific means to preserve RK&M.

This report proposes and describes the concept of a Set of Essential Records (SER) as an important component of a RK&M preservation strategy. The SER is designed to be a compilation of actual records, selected because they would be required for future generations to understand the repository system and its performance, and to assist them in making informed decisions.

The guidance set forward in this document is complemented by appendices, illustrating an example procedure for the selection of records to form part of the SER.

Nuclear Energy Agency (NEA)
46, quai Alphonse Le Gallo
92100 Boulogne-Billancourt, France
Tel.: +33 (0)1 73 21 28 19
nea@oecd-nea.org www.oecd-nea.org

NEA No. 7423