

The French Programme
A development plan for a geological repository for high level and long-lived waste

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ABSTRACT

On completion of the research required under the Waste Act of 30 December 1991, the "Dossier 2005 Argile" submitted by Andra concluded that high-level and intermediate-level long-lived waste (HLW) geological disposal in the Callovo-Oxfordian clay formation is basically feasible. During 2005 this report received several assessments the conclusions of which were reported during January and February 2006: (i) the global scientific and technical report of the National Review Board (CNE), (ii) the opinion of the Nuclear Safety Authority (ASN), (iii) the report of the International Review Team conducted in the framework of an International Peer Review under the aegis of the Nuclear Energy Agency of the OECD at the request of Andra's supervisory ministries (Industry and Research).

On the basis of all these elements, the results of other ways of research set up in 1991, and the reports of the public debate on management of radioactive waste, a Planning Act on sustainable waste management was publicised on 28 June 2006 (Act no. 2006-739). This Act stipulates that "after surface storage, the ultimate radioactive waste that, for reasons of nuclear safety and radiological protection, cannot be disposed of above ground or at limited depth, shall be disposed of in a deep geological repository". It also confers on Andra the task of "conducting or contracting research and studies on storage and deep geological disposal and co-ordinating this research".

With regard to the reversible deep geological disposal, the Act states that "appropriate studies and research shall be conducted for siting and designing a waste disposal facility so that on obtaining the study results, the licence application provided for can be examined in 2015, and if this licence is granted, the facility can be commissioned in 2025.

The purpose of the development plan which main tasks are introduced in this paper is to present Andra's research and study strategy for meeting the objectives of the Planning Act concerning disposal of HLW.

INTRODUCTION

On completion of the research required under the Waste Act of 30 December 1991, the "Dossier 2005 Argile" submitted by Andra concluded that high-level long-lived waste geological disposal in the Callovo-Oxfordian clay formation studied using the Meuse/Haute-Marne Underground Research Laboratory (MHM URL) is basically feasible. During 2005 this report received several assessments the conclusions of which were reported during January and February 2006: (i) the global report of the National Review Board (CNE), (ii) the opinion of the Nuclear Safety Authority (ASN), (iii) the report of the International Review Team (IRT) conducted under the aegis of the Nuclear Energy Agency of the OECD at the request of Andra's supervisory ministries (Industry and Research). In addition to this external assessment of the dossier 2005, Andra's Scientific Council also gave its opinion.

On the basis of all these elements and the reports of the public debate on management of radioactive waste, a Planning Act on sustainable waste management was publicised on 28 June 2006 (Act no. 2006-739). This Act stipulates that "after surface storage, the ultimate radioactive waste that, for reasons of nuclear safety and radiological protection, cannot be kept in surface or shallow underground storage, shall be disposed of in a deep geological repository" and confers on Andra the task of "conducting or contracting research and studies on storage and deep geological disposal and co-ordinating this research".

With regard to the reversible deep geological disposal, the Act states that "appropriate studies and research shall be conducted for siting and designing a waste disposal facility so that on obtaining the study results, the licence application provided for can be examined in 2015, and if this licence is granted, the facility can be commissioned in 2025. Filing of the construction licence application for the facility is preceded by a public debate on the basis of a dossier produced by Andra, the French Radioactive Waste Management Agency. "After review of the licence application file by the relevant experts, especially CNE and ASN, the Government will present a "bill setting the reversibility conditions". After promulgation of this "Reversibility" Act, the construction licence of the facility can be granted. During review of the licence application, the safety of the facility is assessed for the various stages of its management, including its final closure".

The development plan (PDD) presents Andra's research and study strategy for meeting the objectives of the Planning Act concerning disposal of high level and intermediate level long lived waste. This research and study form the "HAVL Project" (HAVL is the French acronym for High-Level Long-Lived).

Taking the main input data, the PDD identifies the project milestones, gives a forecast description of the deliverables and describes operating logic, focusing especially the period from January 2007 to the end of 2014. It proposes a schedule of meetings with the reviewers, enabling them to monitor project progress effectively. Finally, it identifies and schedules activities undertaken to control the performance and cost of the disposal facility project.

The PDD allows for co-ordination with the National Plan for Management of Radioactive Materials and Waste (PNGMDR). The PNGMDR was drawn up in 2006 and will be revised every three years.

After 2015, the PDD provides a preliminary schedule for construction of the disposal facility, to prepare for the start of operation in 2025.

RESEARCH AND STUDY RESOURCES

The project relies on the implementation of various types of resources, studies and work contributing to the objectives. The main resources relate to the scientific knowledge and technological know-how acquired (especially at the MHM URL), demonstration experiments and tests (underground and surface-based), engineering studies, simulations, information campaigns and local consultation actions.

Given the innovative nature of the project, the time scales concerned, the importance attached to the population's acceptance involved in the project, wherever possible these resources are based on international co-operation and exchange, allowing them to be pooled and compared. Similarly, they assume strong involvement by the scientific and technological community.

Acquired scientific and technological knowledge, demonstration operations

Although a large body of knowledge was acquired for the Dossier 2005, the prospect of a repository licence application requires additional acquisition together with scientific and technological demonstrations.

At the MHM URL, continuation of existing measurements over the long term together with new experiments and demonstration tests will allow:

- development of technical construction and closure processes (excavation and ground support of drifts and possibly ILW disposal cells, excavation and lining of HLW disposal cells, elements of cell and drift closure processes);
- acquisition of additional scientific data for repository design and safety assessment (mechanical and thermal behaviour of argillites, transfer properties, effects of argillite variability, etc.);
- integrated *in situ* tests for demonstration purposes.

Involvement in international programmes conducted in other underground laboratories (Mont Terri in Switzerland, Aspö in Sweden), will result in the acquisition of knowledge on subjects of common interest complementing acquisition at the MHM URL.

Data can also be acquired at Meuse/Haute-Marne site through new surface-based explorations. This includes geophysical resources for modelling the geometry and physical properties of the underground environment (2D and 3D seismic profiles), bore-holes to collect fluid and solid samples and *in situ* measurements (logs, hydrogeological and/or geomechanical tests, etc.) and geological field surveys. The aim is to supplement knowledge acquired during pre-2005 surveys in order to provide information supporting the siting of the facility, its design and long-term safety assessment.

Some knowledge is acquired from other sources or only partially from field work. This includes the formulation and development of engineered materials used to construct a repository, the behaviour of waste packages and radionuclides, the basic mechanisms of radionuclide transport and retention in the geological medium, modelling of the biosphere, behaviour of repository structures (coupled processes, etc.), development of digital tools and methods to represent coupling and interfaces, geoprospective studies and geostatic processing of data acquired at Meuse/Haute-Marne site.

Similarly, surface-based technological tests will supplement underground demonstration tests. These surface tests will concern especially waste package manufacturing processes, procedures for transferring packages and placing them in cells and ventilation procedures.

Research and development concerning repository observation and monitoring aim at providing resources to measure and analyse signals assisting future management of the repository. The objective is to obtain concrete technological development by the time that the repository is constructed, preceded by testing through the Underground Laboratory demonstration test programme.

It is also planned to promote the creation of a permanent surface environment observatory (OPE) at the Meuse/Haute-Marne site. This will involve using the existing set-up for monitoring environmental quality and the dynamics of elements within the area studied by the Laboratory, and supplementing them as necessary for the purposes of repository siting. The objective is to characterise, over a sufficiently long period, the atmosphere, hydrosphere, biosphere, geosphere-biosphere interface and human environment (socio-economic aspects, behaviour, etc.). The knowledge gained will assist assessment of the repository's impact on the environment and region.

Other activities will concern the inventory, specification and monitoring of waste packages.

The various different means of acquisition and demonstration implemented will converge towards the final conclusions. Each means on its own is not sufficient for the demonstration, but can contribute to it in association with the others. The time scales involved and the innovative nature of the project make this approach necessary for building a shared conviction.

In this context, the scientific programme is Andra's roadmap in scientific matters. It also assists communication with the scientific community, enabling it to integrate the project objectives more effectively into the framework of joint research. In addition, the scientific programme includes Andra's new responsibilities concerning the long-term behaviour of the waste packages.

The subjects of the scientific programme, based on field work as well as more fundamental research, are:

- greater understanding of the basic phenomena, primarily those that govern release and transfer of radionuclides and toxic chemicals;
- coupling between phenomena and at interfaces between components of the repository and its environment;
- changes of scale and more specifically the spatial and temporal variabilities of the geological medium.

Aspects of basic research will be applied to qualify and quantify the processes involved as accurately as possible, to supplement the thermodynamic and kinetic bases required to produce simulations, to detail the major processes and to prioritise the issues involved. The progress required, especially to respond to the evaluators' recommendations, often involves the most recent scientific knowledge available.

The scientific programme is based on the following tools:

- optimal use of knowledge acquired at the Meuse/Haute-Marne site up to 2005-2006;
- underground surveys, experiments and demonstration tests at the Meuse/Haute-Marne site after 2006;
- European R&D projects (6th and 7th European framework programmes);
- renewal or creation of scientific partnerships linking Andra to the major French and foreign research organisations;
- setting up laboratory groups around targeted objectives, structured in a similar way to the groups set up for corrosion or for thermodynamic data.

The programme aims to reduce remaining uncertainties and refine the hypotheses, add to the existing data bases, develop technological and simulation tools, and combines the progress made with repository engineering and phenomenology in a single approach. The scientific investigations will support the dimensioning and monitoring of experiments conducted in the URL. The results will be used as a basis for characterising the reversibility phase, extracting the relevant parameters for observing and monitoring the repository, improving the representation of repository evolution over time, reducing the parametric uncertainties and increasing the robustness of models for long-term safety assessment.

Engineering studies

Engineering studies are the basic tool for designing the repository. They allow technical solutions to be chosen and developed in response to the needs. These solutions are an input to safety assessment.

The engineering studies cover the following fields:

- definition studies for disposal containers;
- study and optimisation of processes: receipt of primary packages, manufacture of disposal packages, transfer, emplacement and withdrawal of packages, structure closing (sealing and backfill structures, in conjunction with related experiments at the URL), muck rock extraction, ventilation, management of excavation and package emplacement co-activity, control processes. This also includes adapting excavation procedures developed in the Underground Laboratory to the repository architecture and integrating the procedures and means of observation and monitoring into the architecture;
- identification and definition of logistics support and maintenance studies;
- definition studies for installations and operating equipment: surface nuclear workshops, railway terminal, infrastructure modifications, storage modules, disposal modules, surface-underground connecting structures, connection drifts, underground support facilities, surface support facilities and spoil tips,
- technological demonstrators.

Preparation of the Dossier 2005 showed the importance of computer graphics resources, to assist repository design and inform the stakeholders, evaluators and general public.

Simulations

Digital modelling and simulations represent the phenomenological evolution of the repository and its surrounding environment over time periods covering operation, reversibility and post-closure phases up to one million years.

They are an essential means of assessing repository safety, allowing repository performance to be appraised with respect to its safety functions.

They also constitute a means of reversibility assessment.

In addition, they play a role in dimensioning the architecture of the repository and its components when, given the time scales involved or data and models to be used, the needs are outside the scope of standard engineering tools. This concerns especially the cells and disposal packages.

Ultimately, simulation resources will assist repository management.

To make these various types of simulation possible, improvements must be made to the computing tools available and the methods used, in line with the recommendations of the evaluators of the Dossier 2005.

Informing and consulting

At the Meuse/Haute-Marne site, informing and consulting at local level are essential for the success of the project.

Prior to a constructive debate, the project must be clearly understood through relevant information. As a corollary, listening to the public and the stakeholders ensures that their expectations receive the best attention.

Consultation will concern primarily aspects relating to the choice of a site. The dialogue can also take in the choice of compensatory measures for the project's environmental impact and some aspects of repository design that may need to comply with public expectations, such as observation, monitoring and reversibility.

In response to these requirements, a technological demonstration centre will be built close to the URL.

Information and consultation actions will be conducted for the preparation of the public debate required by law and as well in its follow-up.

Breakdown of research and study resources and consolidation of the project objectives

The PDD provides a breakdown of the various research and study resources described in the previous section. The aim is firstly to have the results required for producing the deliverables at the major milestones and secondly to identify the requirements for interim data from one type of research or study that are needed for others.

Data acquisition, tests, engineering studies and simulations, information and consultation are structured as thematic programmes which break down the PDD objectives at operational level:

- Experimentation and demonstration test programme at the MHM URL,
- Surface-based exploration programme,
- Scientific programme,
- Simulation programme,
- Engineering studies and technology testing programme (surface-based),
- Information and consultation programme
- Environment and repository observation and monitoring programme,
- Package management, monitoring and transport programme,
- Surface storage programme

In addition there are transversal tasks addressing:

- Safety
- Reversibility
- Cost
- Occupational health and safety
- Impact assessment

These transversal tasks consolidate the data obtained by the thematic programmes at the various stages; they allow global control of the project performance levels and costs. Their conclusions establish the framework adopted for the continuation of research and studies.

Regular progress monitoring, based on programme descriptions and detailed scheduling, is conducted to ensure that technical objectives and lead-times are met and the budget correctly controlled. On-going project control ensures that risks likely to affect the running of the project are monitored, corrective actions set up in the event of problems and a response made to external requests.

At major project milestones, all the results obtained are recorded in summary files.

PROJECT PLANNING

The Planning Act provides for:

- filing of a repository licence application (so-called DAC), for examination in 2015;
- commissioning of the facility in 2025 (if a licence is granted).

Prior to the licence application, the Planning Act requires an interim milestone: "Filing of the repository licence application for the facility is preceded by a public debate on the basis of a report produced by the Agency (...)."

Project planning must also take into account the 2006 National Plan for Management of Radioactive Materials and Waste and its revisions (2009 and 2012).

Repository licence application for the disposal facility

It is planned to file the repository licence application in December 2014, given that the Planning Act provides for its examination in 2015. Depending on the progress of the licence application process, this should allow (i) the promulgation of a new act specifying the reversibility conditions around mid-2016 and (ii) a decree authorising the repository towards the end of 2016.

Filing of the repository licence application as soon as December 2014:

- allows the best lead-time for technical and scientific examination during 2015;
- allows the earliest possible licence decree, optimising the time then available for constructing the facility with a view to commissioning within the period set by the Planning Act.

A building licence application must be produced as well for the various nuclear and non-nuclear surface installations and for underground installations. The regulations require the application to be made at the same time as the repository licence application, despite the differences in construction phasing between the various facilities.

As the applications are submitted at the same time, a single public enquiry concerning both the repository licence and the above ground facilities licence is possible.

Allowance for development of the facilities over time should be covered by specific administrative procedures defined by the future act on reversibility. These procedures could be applied as soon as construction of the facility begins.

Construction and commissioning of the disposal facility

Commissioning of the disposal facility, at the latest by the end of 2025, provided a licence is granted, will be immediately followed by receipt of the first waste packages, preparation of the disposal packages and their transfer to the first disposal cells built underground. It will allow a full-scale, "active mode" demonstration with real waste packages. Active mode tests are conducted at commissioning to check all the facility functions under real conditions, including the possibility of retrieving disposal packages in the context of reversibility.

Given that the repository licence for the facility can be reasonably expected by the end of 2016, the time assigned to construction and non-active tests prior to commissioning is nine years.

Public debate

The Planning Act requires a public debate to be held before filing the repository licence application.

The public debate will be taken into account for later decisions, especially the bill relating to reversibility conditions to be established by the government after technical assessment of the repository licence application file.

Before setting date for holding the debate, the following two requirements should be taken into account:

- the project documents available for the public debate must be as complete as possible; in addition to the possibilities of reversibility, this concerns a justified proposal for the repository site, surface storage options, an initial outline of impacts and replies to scientific questions that may have emerged during previous meetings. This is only possible if a sufficiently complete geological survey has been carried out and there has been consultation at local level to prepare the location proposal;
- there must be sufficient time between the publication date of the debate report and the filing, in December 2014, of the repository licence application, to allow the fullest possible incorporation of the recommendations made.

The following timetable has therefore been proposed:

- Andra submits the public debate file to the National Public Debate Commission (CNDP) in June 2012;
- The debate is prepared during the second half of 2012;
- The debate is held during the first quarter of 2013;
- The report is made available mid-2013.

The French Environment Code allows for public participation in the preparation of infrastructure projects of national interest throughout the project preparation phase, from the preliminary studies through to closure of the public enquiry. In principle, the public debate is held during the period preceding formal application, during which the search for a location is accompanied by consultation at local level. The overall methods and planning of the debate will therefore be defined with the National Public Debate Commission.

2009 and 2012 milestones

In addition to being the limit date proposed for preparation of the public debate, 2012 is also the date planned for a revision of the National Plan for Management of Radioactive Materials and Waste. An interim dossier known as the "Dossier 2012", providing an update of research and studies at this date, will be delivered along with the public debate file.

This milestone finalises the preliminary design study which will act as a reference for the repository licence application.

Prior to this, the first revision of the National Plan for Management of Radioactive Materials and Waste is planned for the end of 2009.

This milestone corresponds to (i) the designation, within the transposition zone, of a smaller zone of interest on which investigations for repository siting will focus, (ii) the identification of the HLLL waste and conditioning processes that will be taken into account, (iii) the proposal of reversibility options to be provided in the design, and (iv) the proposal of storage options complementary to disposal.

Andra will submit, approximately by September 2009, the necessary scientific and technical documents to the government so that they can be used by the public authorities for the revision of the National Plan for Management of Radioactive Materials and Waste.

Likewise, in mid-2009 Andra will submit to the Nuclear Safety Authority (ASN):

- its basic options concerning safety, providing a basis for the repository description to be delivered in 2012;
- the impact assessment and safety assessment methods to be provided in the repository licence application file.

The 2009 and 2012 milestones will lead to extensive updating of this PDD and the programmes, to take into account the results obtained, since these results provide input data for the next phase of the project. At each milestone the content and schedule of the programmes for the next stage will be detailed.

SCHEDULE FOR THE PERIOD 2007-2014

The schedule is established by analysing especially the needs relating to site selection, preparation of the public debate, the construction licence application followed by design and construction of the disposal facility. It takes into account the inputs, especially the recommendations of the Dossier 2005 evaluators, the operational constraints of the work and experiment schedule of the MHM URL and surface-based exploratory work.

The overall schedule for the 2007 to 2014 project is summarised in the simplified schedule and diagram of figure 1.

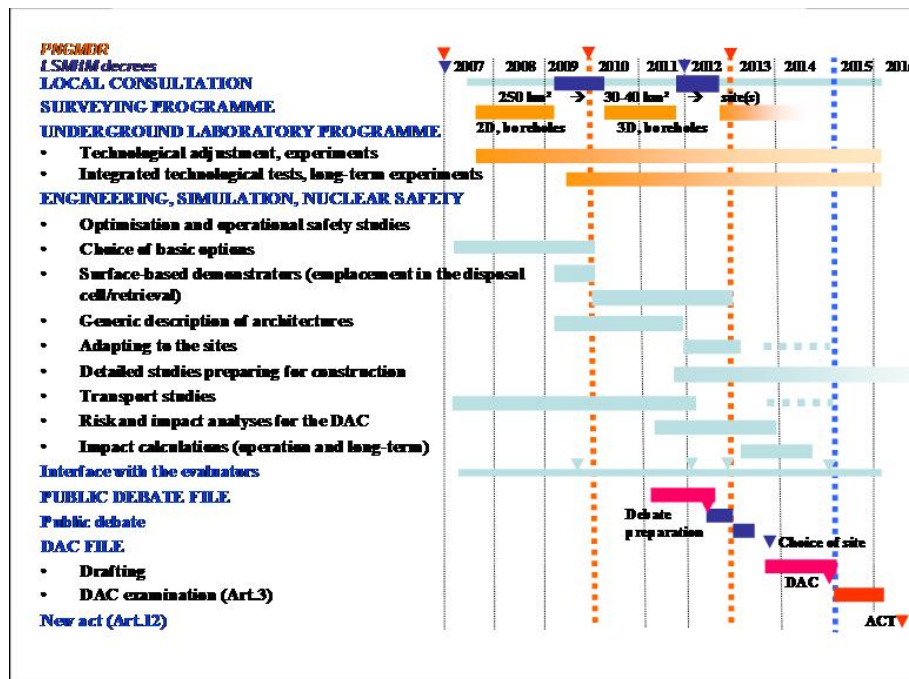


Fig. 1. Simplified schedule for the 2007-2014 project

Location of the disposal facility

The choice of site is an input to preparation of the repository licence application file, particularly for:

- the description of the planned facility (position within the land to be acquired, insertion in the surface and underground environment, connection to public networks), of its situation and of the perimeter requested for the INB;
- the impact assessment;
- the safety analyses: the long-term safety analysis presented in the preliminary safety report is based on the description of the geological site and the repository situation with regard to hydrogeological flows, taking geodynamic evolution into account. Therefore, all the site elements used to determine installation dimensioning will be described in detail in the preliminary safety report.

The choice of site is also a prerequisite for finalising studies associated to the DAC. It is also important for preparing the construction of the repository prior to commissioning, if a licence is granted.

A gradual approach, based on consultation with local players, will be adopted. The social, economic and environmental impact of the project must be integrated at an early stage. The public debate will allow wider consultation of the public and then the decision of the repository site can be proposed to the public authorities.

The siting approach includes scientific and technical elements informing the parties concerned of the technical implications of this choice and responding to recommendations from the evaluators, who should be presented with the results obtained at each major stage of the process.

To examine these points, at the scientific and technical level the repository location is based on:

- data acquisition by surface surveys with additional acquisition at the MHM URL;
- analysis of environmental constraints (fauna, flora, heritage, human activities);
- preliminary studies on the layout possibilities for surface installations, including accessibility (various types of transportation including waste packages), the relief, environmental constraints, etc.

In principle, the initial approach to siting takes into account the entire transposition zone (250 km²) defined in the vicinity of the URL as illustrated on the map of figure 2.

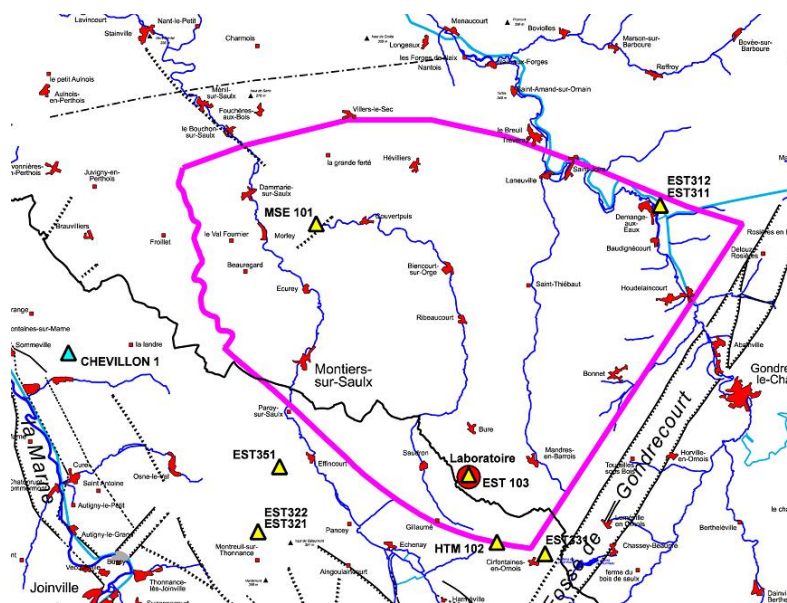


Fig.2. Map of the transposition zone (250km²)

At the scientific level, the surveying work is divided into a series of campaigns. The first, concerning the entire zone, will provide additional data allowing detailed and uniform knowledge of the geological context of the Calvo-Oxfordian over the entire transposition zone (depth and thickness variations, vertical and horizontal lithological variability, fracturing). Another objective will be to extrapolate to the transposition zone the mechanical behaviour model of underground excavations based on observations at the MHM URL. Finally the knowledge base of hydrogeological and argillite transport parameters in the Calvo-Oxfordian will be completed in order to conduct the simulation programme for these topics.

Beyond this, a more detailed exploration will be conducted (2010-2011) on a smaller zone with an area of roughly 30 square kilometres.

The switch from the transposition zone to the smaller one (2009) will take place after consultation at local level. The definition of the zone of interest should be confirmed by the public authority during the 2009 revision of the National Plan for Management of Radioactive Materials and Waste.

The second surveying campaign will aim at establishing:

- a detailed geometric model of the Calvo-Oxfordian, accurate to within roughly one metre, corresponding to the scale of study used for the underground structures;
- the existence of any tectonic structures (secondary faults and minor faults) that could affect the repository architecture;

- a geomechanical model of the Callovo-Oxfordian at scale of structures (taking into account coupled behaviour, swelling properties and interactions between structures).

The consultation will continue in parallel to the second surveying campaign (2010-2011). The aim will be to specify the possible location of the installations within or close to the zone of interest. Characterisation of the environment (in its initial condition) will become more detailed over this zone, but global work on a larger scale will continue.

By the time of the public debate (mid-2012) this will have resulted in:

- one or more proposals for the location of installations and identification of the significant impacts of the project on the environment and region;
- updating of geological knowledge demonstrating the geological suitability of the proposed installation zone for a repository.

At the end of the public debate, the location proposal(s), possibly amended, will be submitted to the public authorities, in possession of the debate report, for selection of a site. The choice of the site will assist in specifying the content of additional investigations that could be conducted during 2013-2014 to complete the detailed characterisation of the site for the purposes of the repository licence application file (initial condition of the site) and also to prepare for construction work under the hypothesis that the licence is granted.

Preparation of the public debate for 2012 includes the presentation of basic options of the repository design, a revision of the waste inventory model already produced in Dossier 2005, integration of advances in knowledge (scientific acquisitions, URL), updating of the phenomenological analysis of repository situations (PARS). The options for operational safety also need to be defined precisely. A critical analysis of options concerning reversibility must be carried out, taking into account especially the operational safety options. The options to be defined may concern the stages to be considered in the study, the level of package retrievability required for each stage, possible time limitations (radiological conditions during package retrieval, probability of accidents given the condition of the packages, etc.), and the role of repository observation in managing the process.

One of the recommendations of the Dossier 2005 evaluators was to confirm the effectiveness of measures used to retrieve packages. To assist in confirming that the reversibility options presented in the file are realistic, package emplacement and retrieval tests will be conducted and demonstrations will be available to the public by the time of the debate.

Repository simulations, additional data acquisitions

In 2012, in addition to the revision of the site reference document, it is planned to update the phenomenological analysis of the repository (PARS) and to conduct conceptual modelling of repository evolution.

The priority is to provide scientific evidence supporting the reversibility options presented in the public debate file. This concerns especially qualitative and quantitative modelling of the evolution of the packages, structures and argillite over one to a few centuries. For each stage of closure, the required results concern especially the following areas: chemical alteration of the packages and structure linings (degradation of materials, radioactive dissemination outside the package); mechanical evolution of structures (convergence, rupture), packages and rock; production and accumulation of gas in relation to the safety of repository operation and package retrieval (hydrogen and oxygen concentrations, pressure rise). These simulations concern the design options selected between now and 2009. They rely on observations and additional data relating to the short- and long-term hydro-mechanical and thermo-hydro-mechanical behaviour of the Callovo-Oxfordian gradually acquired and validated in the MHM URL (from 2007 to 2010).

At a more general level, greater knowledge must be available in response to issues likely to arise during and around the debate.

Impact assessment

Prior to producing the initial state report the type of data, measuring frequency and sampling sites must be specified. Andra will rely on the permanent environment observatory project (OPE) to define the most suitable acquisition methods for characterisation of the environments concerned. The dimensioning of this observatory will depend particularly on its designation as a "workshop zone" and the level of long-term participation and involvement of the research organisations.

The impact assessment methods must be defined at the latest when the zone of interest is designated, so that all additional data needing to be collected can be fully identified. These procedures will be presented to the future evaluators of the impact study to obtain their opinion at a sufficiently early stage.

Finally, a data base will be created containing the data already acquired since 1996 on the MHM URL environment and gradually expanded with new data.

The initial state report concerns especially the natural heritage and agricultural, woodland and leisure areas, property and cultural heritage likely to be affected by the project; it contains a radiological report of the environment at the site and in proximity to it. The proposed perimeter of the initial state report, centred on the zone of interest, will have been defined after local consultation in preparation for the public debate. The area of study will be confirmed or narrowed down after the public debate. Data concerning this area will then be acquired to complete the description of the reference condition. In particular, the pedological map of the sector will be updated.

The initial state report of the surface environment will be supplemented by an initial hydrological state report.

To analyse the effects of the disposal facility on the environment, the potential impacts for each environment sector described in the initial state report are assessed. The analysis is based on the description of the facility presented in the public debate file, to be supplemented in 2012. Some impacts are determined using specific mathematical simulations (for example, physical environments formed by surface water, groundwater, the air, the soil, etc.). Other impacts are assessed by expert judgement (the biological environment for example). Each impact will be compared against the regulations in force and the reference state.

General measures for environmental monitoring will be defined and presented in the preliminary safety report. This will involve determining the means of data acquisition and the locations where they are set up. The effects on human health will be assessed (identification of dangers and exposure levels, assessment of chemical risks, reference values). Therefore, a reference report (initial state in terms of human health) is to be compiled in order to establish the health impact assessment.

The radiological risk assessment will draw on the safety assessments.

Andra will rely on the permanent environment observatory (OPE) whose objectives include developing new methods for assessing environmental quality (quantification of biodiversity, identification of new indicators, etc.).

For Post-closure safety assessment, extending the methods developed for the Dossier 2005, post-closure safety assessment will include:

- modelling, with update of the phenomenological analysis of repository situations (PARS), conceptual modelling of processes and phenomenological simulations based, like the reversibility appraisal, on design options selected by 2009;
- update of the qualitative safety analysis, based on the functional analysis of the repository, its phenomenological modelling (PARS and conceptual notes) and identification of uncertainties. The qualitative safety analysis will be started in parallel with the PARS; in particular, it must confirm the completeness of the scenarios and sensitivity studies to be conducted;
- updating and/or confirmation of the scenarios (2010);

- preparation (preliminary calculations to define the representations of repository behaviour, conceptual modelling of scenarios, preparation of the calculation cases, 2012) followed by safety calculations (2013-2014).

Finer characterisation of the hydraulic transient will be undertaken in line with the design and operation options chosen, in order to measure the consequences on alteration of repository components, radionuclide transport and, in wider terms, the evolution of the near field. These data must allow the influence of the transient to be processed in simulations and calculations conducted to prepare the safety analyses, and also to be represented as recommended by the evaluators. Certain very conservative hypotheses concerning gas production, chemical degradation of the materials and the release of radionuclides could also be ruled out.

These activities are based on the body of knowledge already acquired and the additional needs for knowledge raised by the evaluators of the Dossier 2005.

CONCLUSION

The development plan for a geological repository in the Callovo-Oxfordian argillite in East of France is the detailed roadmap to submit the licence application which is due end of 2014. Many tasks all linked to each other are described; only a sample could be given in such a short paper. Additional information can be downloaded from the Website www.andra.fr.