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Executive Summary of the activities during the second annual period

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The Integrated Project PAMINA is part of the 6th framework programme of the European Commission. It runs from October 1, 2006 until September 30, 2009 and brings together 26 organisations from ten European countries and one EC Joint Research Centre in order to improve and harmonise methodologies and tools for demonstrating the safety of deep geological disposal of long-lived radioactive waste and spent nuclear fuel in different geological environments. The results may be exploited by different stakeholders such as national waste management organisations, regulators and the public at large.

The participating organisations represent all major radioactive waste producing countries within the European Union. The consortium includes national waste management organisations, a regulator, several technical safety organisations (TSO) that closely support the regulator, universities and research organisations and two SMEs. From their different roles within their national radioactive waste programme, the participants bring in complementary viewpoints and experiences into the project which allows exploitation of the project results by both national waste management organisations and regulators alike.

A number of organisations in various countries in Europe but also overseas have been invited to become an associated group to IP PAMINA. Several institutions have signed a respective agreement.

The main objective of IP PAMINA is to improve and harmonise integrated performance assessment (PA) methodologies and tools for various disposal concepts of long-lived radioactive waste and spent nuclear fuel in different deep geological environments. The IP PAMINA aims at providing a sound methodological and scientific basis for demonstrating the safety of deep geological disposal of such wastes, that will be of value to all national radioactive waste management programmes, regardless of waste type, repository design, and stage, that has been reached in PA and safety case development.

The work is organised in four RTD (Research and Technology Development) components and one additional component dealing with knowledge management and dissemination of knowledge.

- In RTD component 1, the state of the art of methodologies and approaches needed for assessing the safety of deep geological disposal is evaluated on the basis of a comprehensive review of the international practices, which includes the identification of any deficiencies in both methods and tools, and in the quality of data required.

- In RTDC 2 a framework and methodology for the treatment and management of uncertainty during PA and safety case development will be established. In the context of the development of the post-closure safety case, guidance on, and examples of, good practise will be provided on how to treat different types of uncertainty, spatial variability, the development of probabilistic safety assessment tools, and the techniques for sensitivity and uncertainty analysis.

- In RTDC 3 methodologies and tools for integrated PA for various geological disposal concepts will be further developed. This includes the development of scenarios, the PA

approach to gas migration processes, and the PA approach to radionuclide source term modelling. In some of the areas, PA representations are known to be less advanced. With respect to the planned work concerning safety and performance indicators several test cases will be defined and calculated for host rocks such as clay and rock salt, for which the use of safety and performance indicators has hardly been investigated in detail yet.

- In RTDC 4 several benchmark exercises on specific processes will be carried out, in which quantitative comparisons are made of approaches that, on the one hand, rely on simplifying assumptions and models, and on the other hand, on complex models that take into account a more complete process conceptualization in space and time.

Work has progressed in all project areas according to schedule with small delays in some instances. Apart from some minor deviations the use of work resources and the use of financial resources are in balance and deviate slightly from the original planning. The total work effort used in the second year was about 9 % lower than originally planned for the second project year. However, in none of the work packages there are indications for a serious underperformance. Due to reorganisation one contractor no staff was available for performing the work in one work package. This situation has now been resolved, i.e. another contractor will perform the respective work.

Six deliverables are now publicly available via the PAMINA Internet Web site. Also, some important milestone reports will be made publicly available via the PAMINA internet site. The established links between PAMINA and the IGSC of OECD/NEA have been tightened and the members of the IGSC project on “Review of Safety Assessment Methods” have been granted access to the PAMINA intranet to allow the direct use of the PAMINA results in the IGSC MeSa project.

A training course will be held within PAMINA which will be organised by GRS. The main objective of the training course is to familiarise the participants with performance assessment methodologies and the foundations of safety case development. The PAMINA Final Workshop will directly follow the course. Attendance of the course will help participants to understand the results presented at the workshop. The target audience includes professionals and scientists entering the field of performance assessment and safety case development.

The work that has been carried out in the various components within the second year is shortly summarised in the following:

RTDC1:

The main objective of RTDC 1 is to assess the state of the art of the methodologies and approaches needed for the safety assessment of geological repositories, and to distil the lessons learned from the rich experience accumulated in their development and application. The scope of WP1.1 is comprehensive of the relevant topics that need to be addressed in safety assessment in the frame of safety cases. Initially 12 topics were identified for consideration during the PAMINA project, covering four topics each project year. However,

later two topics were merged for the review since they are strongly linked to each other. The review of the state of the art in these 11 topics is carried out by bringing together the views from all participating countries and integrating the work from countries outside PAMINA where possible.

In the second project year, the first set of topics has been finished. The contributions to the first 4 topics were discussed at the 1st WP1.1 workshop that was held in Paris in October 29-31, 2007, hosted by ANDRA. The following organisations were represented in the workshop: NDA, IRSN, NIRAS-ONDRAF, SCK-CEN, GRS-K, GRS-B, BGR, ANDRA, NRI, POSIVA (and Saanio Riekkola Oy), AVN, NRG and ENRESA. On the basis of the outcomes of the workshop some conclusions were drawn and the preparation of the task reports by the respective topic coordinators was initiated. In addition, the second set of topics was started.

During the past 12 months of the project most of the work done within WP1.1 has been focused on the second set of topics, which comprise the following topics:

- assessment strategy - safety approach
- evolution of the repository system
- modelling strategy
- sensitivity analysis

The coordinators for these topics are ONDRAF-NIRAS, ANDRA, ENRESA and GRS-B respectively. A technical meeting was convened in the offices of SCK-CEN in Brussels in April 2-3, 2008 in order to review the draft contributions to the second set of topics and take decisions on the final phase of the work on them. The 2nd WP1.1workshop was held in Helsinki in September 10-12, 2008, hosted by POSIVA. The following organisations were represented in the workshop: NDA, IRSN, NIRAS-ONDRAF, SCK-CEN, GRS-K, GRS-B, ANDRA, NRI, POSIVA, Bel V, BGR and ENRESA. The participants had produced their final contributions on time before the 2nd WP1.1 workshop (see table below). During the 2nd WP1.1 workshop, the final contributions to the second set of topics were discussed on the basis of summaries prepared by the topic leaders and conclusions were drawn. These conclusions, together with the final contributions will be used by the topic coordinators to generate the corresponding task reports.

During the second project year some preliminary work has been done for the third set of topics:

- Biosphere
- Human intrusion
- Criteria for input and data selection

The topic coordinators prepared the launching of these topics in the 2nd WP1.1 workshop. The topic coordinators are IRSN, GRS-K and ENRESA. The target definition was presented

by the topic leaders and discussed with all participants. The contents and structure of the expected contributions were also discussed during the workshop and it was agreed to maintain the common structures used in previous topics.

RTDC2:

RTDC2 is the largest of the technical components of the project PAMINA with respect to supply of manpower and funds. It consists of three work packages of which the last one is to pull together the large amount of work in one final report. The two technical work packages deal with

- Key Drivers and Methodologies for the Treatment of Uncertainty and
- Development and Testing of Concepts for the Treatment of Uncertainty

Each of the two work packages is subdivided in individual tasks to structure the work. Progress in RTDC-2 is generally on course, and closely matches expectations. During the second project year four deliverables were completed and 21 milestones were achieved.

In WP2.1 there are altogether four tasks from which the first one about *Regulatory Compliance* specifically deals with issues relating to how uncertainty impacts the choice, use and interpretation of performance measures in regulations developed for geological disposal facilities. SKI and GSL organised a workshop for regulators and other organisations with experience of the issues relating to the management of uncertainties in a regulatory framework. The workshop was held in Stockholm, 10-11 June 2008, and was focused on the following topic areas: uncertainties in the safety case; regulatory guidance on the treatment of uncertainties; and regulatory review of uncertainty treatment. Sixteen participants, from Belgium, Finland, France, Germany, Japan, Sweden, Switzerland, the UK, and the NEA, provided discussion on the relevant issues under these topics. The workshop report was submitted and accepted as a final PAMINA deliverable (D2.1.A.1). All of the work under Task 2.1A has been completed.

A task on *Communication of Uncertainty* aims to understand the effectiveness of different methods for communicating the results and methodologies of PA applied to the geological disposal of radioactive waste. A one-day stakeholder workshop was held on 17 October 2007 in Manchester, UK. A group of 14 interested stakeholders, mainly from nuclear communities in England and Scotland, participated by evaluating a set of prepared posters on the safety of geological disposal systems. As part of the workshop, participants built their own posters using various materials supplied by GSL/NDA. The participants' posters expressed their concerns over safety. In addition, the video 'Traces of the Future', produced in 1994 by NAGRA, was shown to elicit stakeholder views on the strengths and weaknesses of natural analogues in the treatment of uncertainties in a safety case. The stakeholder views and messages from the workshop are described in the workshop report prepared by GSL as deliverable D2.1.B.1. As a follow-up activity to the stakeholder workshop, a set of brochures was created for communication to a lay audience about how uncertainty in the safety case of

a geological disposal facility is treated. This set of brochures will be tested on target audiences for their efficacy in communicating messages about uncertainty.

A third task in WP2.1 on *Approaches to System PA* is exploring the relative advantages and disadvantages of different approaches to the quantification of uncertainties in system-wide PA calculations. It comprises four high-level topics (posed as questions below) that need to be addressed in determining the type of PA to be conducted, and how the results will be presented:

- Under what circumstances is it appropriate to use probability to treat uncertainty, and under what circumstances are deterministic approaches more appropriate?

- At what stage of repository development should assessments aim to be more conservative or more realistic?

- Do hybrid approaches such as “fuzzy mathematics” offer any advantages over standard probabilistic approaches?

- What alternatives are there to presenting the results of PA and associated uncertainties?

The topics will covered by performing detailed reviews and conducting research by means of case studies taken from the programmes of the organisations taking part.

Under Topic 1, a draft milestone report was completed on the treatment of uncertainty using probability. The issues that need to be considered in deciding which parts of the disposal system uncertainty should be treated using a total probabilistic simulation approach, a pure deterministic approach, and intermediate approaches have been reviewed weighing considerations such as regulation, system design, spatial variability, implementation of the PA, and the nature of the uncertainties. An analysis of the Strengths, Weaknesses, Opportunities and Threats (SWOT) of the different approaches has been performed. In another contribution a case study was considered involving the post-glacial faulting scenario for the Finnish disposal concept. VTT is evaluating issues associated with assessment based on deterministic treatment of epistemic uncertainty, and the use of a single probability of occurrence for treatment of aleatory uncertainty. Also, a comparison is being carried out of deterministic and probabilistic system approaches for the biosphere component of a PA. In particular, the radiological impact of long-term radioactive releases to a landscape that evolves due to land rise, such as is likely to occur at repository sites in Scandinavia, is being evaluated.

Under Topic 2, a draft of the milestone report on the levels of conservatism and realism in PA has been prepared. The use of safety functions in terms of its role as a conservative approach has been evaluated. The work was based on interviews conducted with key staff from waste management organisations in Belgium, Sweden, Switzerland, the UK, and the US. Work in progress concentrates on assessments to illustrate the use of a graded approach for dealing with uncertainties in complex systems, involving many processes and uncertain parameters, in a landscape model. Also, guidance will be developed on when conservative and realistic assessment approaches should be used from a regulatory

perspective, based on information from the International Atomic Energy Agency (IAEA) project on Application of Safety Assessment Methods for near-surface disposal of radioactive wastes (ASAM) and other sources.

The work on the last two topics has been completed and respective milestone reports have been finalised. A review of hybrid stochastic-subjective treatments of uncertainty, in which the relative merits of hybrid stochastic-subjective approaches to treating uncertainty were evaluated, has been performed. Under Topic 4, CEA completed a review of alternative approaches for presenting PA results, and offers alternative ways of carrying out uncertainty analysis using partial safety factors.

The last task in WP2.1 on *Techniques for Sensitivity Analysis* involves parallel studies performed by 7 organisations to compare the relative advantages and disadvantages of different methods of sensitivity analysis in PA calculations. A draft topic report on sensitivity methods is being prepared providing a review of the methodologies for performing sensitivity analysis, sensitivity analysis methods, and experience of sensitivity analysis. This includes screening methods and global methods. Among global methods, much attention was paid to variance-based methods (Sobol indices and FAST); Monte Carlo based methods (correlation and regression based techniques, Monte Carlo filtering techniques) and graphical methods (scatter-plots, cobweb plots and contribution to the sample mean plots).

The use of different sensitivity analysis techniques is being studied using PA results from specific national test cases. A “realistic” generic HLW/SF repository model for a German repository in a rock salt dome has been defined and a disturbed evolution scenario has been chosen for investigation. Several Monte-Carlo-based and variance-based sensitivity analysis methods were applied to the system, running the model a large number of times. Specific problems with the different methods have been identified. NRG, in cooperation with JRC, has performed a probabilistic uncertainty analysis for the abandonment scenario for disposal facilities in rock salt and in clay. The basic description of the scenario and the input from the Dutch national programme has been used as a starting point for the analyses. The definition of the calculation case for a repository in granite was prepared, which contains a description of the models and parameter distributions that will be used to test the sensitivity analysis techniques.

For the intended test of sensitivity analysis techniques PA benchmark cases have been selected and post-processing sensitivity analysis algorithms have been developed. The computation of benchmarks studying a range of sensitivity analysis techniques and convergence issues have been carried out by the organisations involved in the benchmark study..

Work package WP2.2 consists of five tasks dealing with parameter uncertainty, model uncertainty, scenario uncertainty, spatial variability and fully probabilistic assessment for geological repositories.

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The first task on *Parameter Uncertainty* is exploring the advantages and disadvantages of different approaches for treating uncertainties associated with parameters used in PA of geological disposal facilities for radioactive waste. Different methodological approaches for deriving Probability Density Functions (PDFs) for the representation of parameters in probabilistic PA have been developed. Based on considerations about managing uncertain knowledge and quantifying parameter uncertainties a general protocol was developed that allows determination of PDFs following a well-defined procedure. Secondly, a tool to derive PDF has been developed using MATLAB®, and it will be tested and evaluated for improvements. An implementation of fuzzy set methodology to treat parameter uncertainty has been started. Also guidance on methods for determining PDF types (shapes) was developed. The general framework for parameter uncertainty management has been identified from a regulatory perspective. Specifically, progress was made on the definition of a simplified representative model of a repository based on the SAFIR 2 report of ONDRAF/NIRAS, the selection of safety indicators to assess repository performance., the identification of possible relevant parameters of the model, their uncertainty ranges and their possible PDFs, and the identification of sensitivity analysis (SA) methods. The implementation and testing of Bayesian methods that can be applied for the updating biosphere PDFs: methods for updating a PDF, derived from the literature using site-specific data; and methods for updating PDFs using regression and hierarchical models was continued. An expert judgement elicitation exercise to assess PDFs of the solubility of radionuclides in the near field of a repository in a granitic host-rock was defined and implemented. This included a literature review about expert judgement and the design of an expert judgement protocol. The actual implementation of this protocol was started with the selected experts.

The second task on *Model Uncertainty* is evaluating methods for treating uncertainties in PA calculations arising from the representation of physical processes by models, at both conceptual and practical levels. The work in this task is complete and the results are described in three delieverables. Results from a probabilistic implementation of a simple ‘Insight’ model for estimating peak risks from the groundwater pathway as a static simulation using GoldSim were compared with the results of a full dynamic simulation of radionuclide transport, also using GoldSim. The work suggested that when carrying out probabilistic calculations to represent parameter uncertainties which are large, the model uncertainty introduced by using a very coarse model such as the insight model, may in fact be rather insignificant. The model uncertainty associated with models assessing the consequences of gas generation and migration was studied in some detail. Uncertainty in gas generation and gas migration are scoped in a reference case and variant scenarios. It is noted that the treatment of uncertainty in groundwater pathway assessment studies is generally at a more mature position than the treatment of uncertainty in the assessment of the consequences of repository-derived gas. This study is therefore seen as part of a staged approach to develop further understanding of the treatment of uncertainty for gas issues in the safety case, and to identify key aspects affecting the consequences of repository-derived gas. Finally, modelling uranium transport in a moving redox front in a tunnel backfilled with bentonite demonstrated significant differences between a retardation approach using sorption distribution coefficient (Kd) values and one based on thermodynamic reactions. The calculated uranium transit times through the backfill were different for the two models used.

The third task on *Scenario Uncertainty* is evaluating various methods for the treatment of uncertainties associated with scenarios. Methods for scenario development and a study on analytical hierarchy processes suitable for quantification of scenario probability using expert judgement have been reviewed and reported. Also, work is underway on reviewing methods for assigning probabilities to scenarios in selected national PA programmes. A trial of formal use of expert judgement for scenario conceptualisation for the abandonment scenario was set up. An “Elicitation Document” has been compiled, comprising an inventory of relevant topics that could play a role in scenario uncertainty, and a questionnaire was developed for the trial.

Another topic on *Spatial Variability* aims to evaluate approaches to treating uncertainties in PA calculations that arise from the spatial variability of facies, materials, and material properties inherent in the geosphere, and to develop guidance on the treatment of this source of uncertainty in PA. A review of the treatment of spatial variability in PA was conducted and reported upscaling methods has been performed and a report on sensitivity analysis methods that take spatial variability into account has been finalised.

The final task of WP 2.2 on *Probabilistic Safety Assessment for Geological Repositories* aims at developing and evaluating a fully probabilistic safety assessment approach incorporating scenario, model and parameter uncertainty. The Integrated Flow Code (IFC) has been developed incorporating all flow-related FEPs described in the FEP screening report. The IFC is currently being merged with the Transport Code into the Integrated Radionuclide Release Code (IRRC), which will be run in a probabilistic environment using the GOLDSIM probabilistic driver. First test runs of the IFC have been completed successfully, and further tests are under way. A review of options for developing the IRRC came to the conclusion that an approach based on the TOUGH family of codes would be most promising, and that the actual implementation would best be done at LBNL (USA). This was followed up, with full funding by NAGRA.

RTDC3:

The main objective of this component is to develop methodologies and tools for integrated performance assessment for various geological disposal concepts. These topics include

- scenario development,
- PA approach to gas migration,
- PA approach to radionuclide modelling and
- safety indicators and performance indicators.

Each of these four topics is represented within RTDC3 as an independent work package.

The objectives of the work package on *Scenario Development* are the identification of normal and altered evolution scenarios based on safety functions and the development of stylized

scenarios. Practical cases using different approaches are presently being developed for salt, clay and granite as host rocks.

The use of safety functions in identifying altered evolution scenarios has been tested with respect to a repository in a clay formation. The proposed methodology consists of breaking down the safety functions in a number of sub claims which should be substantiated with evidence from the assessment basis. The uncertainties in these substantiations are then identified. Those uncertainties that can affect the safety functions of the safety concept are taken into consideration for the identification of altered evolution scenarios. An advantage of the proposed methodology is that it combines scenario-initiating FEPs and non-negligible uncertainties for the identification of altered evolution scenarios. Another approach investigated in combination with the 'classical' FEP approach to scenario identification, involves a systems engineering methodology called FRAT (Function, Requirement, Architecture, Test) which has been applied for decomposition of spent fuel/carbon steel canister/bentonite/granite concept of disposal system. Insight conceptual and mathematical models have been created to highlight the relation of repository components and their safety functions to the main aim of a disposal system after closure. A specific safety function covering the containment provided by the host rock salt is applied it in combination with a FEP analysis to the normal evolution scenario

The work on stylisation of scenarios focuses mainly on future human actions and particularly on human intrusion into a deep geological repository in salt. On the basis of selected references the main aspects concerning human intrusion were identified as well as essential topics that should be addressed when dealing with stylized human intrusion scenarios. The main potential human intrusion activities into a repository in salt were determined. These activities comprise exploration and exploitation drillings, mining activities and construction of a cavern.

The second work package on the *PA Approach to Gas Migration* aims at improving the understanding of gas transport processes on the process level and the representation of such processes in PA models in order to allow the determination and quantification of the impact of gas on the engineered and natural barriers. This work is being conducted for disposal facilities in clay, salt, and granite, respectively. Several benchmark cases were defined which required some code development, e.g. to enable axisymmetric calculations for a repository in clay, or to account for a pressure-driven dilation of gas-pathways in rock salt. The different benchmark calculations are now being performed. Results of model calculations on gas production and transport based on SCK·CEN's "Supercontainer concept" were reported, which include an estimation of the resaturation time of the EBS materials from which the onset of the anaerobic corrosion process can be estimated, an overview of the potential gas production mechanisms and an estimation of gas generation rates, an assessment of the diffusive gas dissipation capacity through the host rock for various gas generation rates and hydrogen diffusion coefficients (in the liquid phase), and a detailed multiphase flow analysis in which seven cases have been calculated in order to assess the sensitivity to different gas source term formulations, different material properties for the Supercontainer buffer and different conditions (isothermal case and a fully coupled case taking into account the radiogenic heat production).

The objective of the work package on *PA Approach to Radionuclide Modelling* is to develop more realistic PA approaches to radionuclide source term modelling by a more detailed modelling of the chemical environment. Full 3D simulations were performed with the MELODIE code for the source term homogenization benchmark in order to compare the results with those obtained using the scale-up method. "Scaled up" global models were built corresponding to the different values and parameters of all the defined test cases. These test cases and the stylized models are to be used in both in WP 3.3 and WP 4.2. Results of radionuclide transport calculations using the "Scaled up" global model were compared on the domain faces to the fluxes obtained from preliminary simulations using the MELODIE code, and the Castem3m code, respectively, on the detailed disposal cell representation. Calculations concerning the interaction of waste, canister and geological environment with the code TRANSAL were performed. Thermodynamic equilibrium reactions including sorption and diffusive exchange were considered. Model calculations employing GoldSim were performed in order to evaluate water availability for corrosion process and for evaluation of oxygen availability in bentonite surrounding canister.

The final work package of RTDC3 dealing with *Safety Indicators and Performance Indicators* aims to achieve a common understanding of the role of safety and performance indicators, to establish indicators for all types of host rocks and to test different performance indicators / function indicators with formations other than granite. In the second project year two WP meetings were held in which the findings of the participants were discussed and conclusions were drawn. The general concepts of assessing repository safety by means of safety and performance indicators, as understood by the WP3.4 group, have been analysed and compiled in a deliverable. With respect to the disposal in the Boom clay formation data on naturally occurring radionuclides have been collected, that can be used to derive reference values for safety indicators.

The safety and performance indicators defined in the first phase have been calculated for a number of test cases. In case of rock salt a revision of the preliminary list of indicators was not necessary. Suitable reference values for the safety indicators have been derived and justified. Risk indicators have not been considered in detail so far. For the case of disposal of spent fuel in the Boom Clay formation new performance indicators quantifying the contribution of the main safety functions have been proposed. The set of safety and performance indicators as agreed at the WP3.4 meeting in February 2008, which consists of the most successful indicators tested in the SPIN project complemented with the new performance indicators related to safety functions, have been calculated for fission and activation products and the results were presented at the WP3.4 meeting. Under the assumption of the abandonment scenario for a repository in rock salt, PA calculations were carried out. The emphasis for the simulation itself was on the compaction behaviour of the salt host rock and compacted salt sealing plug. Special attention has been paid on the functionality of the "SPIN" output parameters.

RTDC4:

In this component it will be evaluated whether using more complex and more realistic modelling approaches provide added value and whether they are required to include in PA. It deals with three types of complexity which are dealt with in individual work packages:

- PA Approaches based on Different Complexity of Process Modelling,
- PA Approaches based on Different Geometric Complexity of Modelling and
- Uncertainty Analysis Codes

The first two work packages deal with a variety of host rock types, while the third one deals with clay host rocks.

The work package on *PA Approaches based on Different Complexity of Process Modelling* focuses on specific processes as salt convergence, brine intrusion and radionuclide transport by density driven exchange for salt as host rock and as reactive transport for granite and clay as host rock.

Modelling of the convergence of backfilled cavities in repositories in rock salt with two different PA codes shows satisfactory agreement with the detailed modelling calculations performed with the FLAC code. It was concluded that no further enhancement of the PA code is currently needed. The results were documented and presented at the second annual workshop. Also, the GoldSim/CORE benchmark calculations for non-reactive transport showed a good agreement between both codes for several types of anionic, cationic and conservative stable and radioactive solutes. The Benchmark specification for the test case in granite has been completed and it contains a complete description of the planned transport calculations considering the elements Uranium, Caesium and Nickel. The verification of geochemical subroutines for thermodynamic sorption models of CORE2D were completed and detailed reactive transport calculations for Ni and Cs have been performed.

Benchmark calculations related to a clay site were performed with Hytec with respect to the migration of radionuclides using constant Kd and solubility limit model, the Cs migration taking into account Langmuir isotherm curve for sorption, and the Cs-migration with full chemical transport coupled calculations.

Other work focused on the implementation of Cs transfer in a 1D and 2D radial geometry in the geochemical code PHREEQC. Additionally, verification calculations for the Kd approach have been performed using (non-reactive) conventional flow and transport codes, such as PORFLOW and COMSOL Multiphysics. Also, the Cs transfer through the bentonite plug was modelled using Kd/SL and thermodynamic models.

The main focus of the work package on *PA Approaches based on Different Geometric Complexity of Modelling* is on the investigation of the usefulness of codes dealing with geometric complex representation of geosphere in comparison to coarse or simplified 1D representations used in PA. For all types of host rocks test cases have been modelled and first results on some simple test cases are available.

The transport calculations with the codes d3f/r3t and CHET for the far-field for the simplified test case have been finished. The results from both codes were compared on the basis of the time-dependent radionuclide concentration profiles. The results were presented on the 2nd annual workshop. Additionally, a more realistic test case was defined and similar transport calculations were started for this case. It has been found out in early stage that this

more realistic test case was not suitable to study the respective questions. Therefore, another alternative test case was created for the second set of calculations.

For a repository in clay several benchmark calculations were defined and carried out. 1D and 2D Finite Elements (COMSOL multiphysics) and Finite Volumes (PORFLOW) calculations were performed with a rectangular gallery approximation for the key radionuclides I-129, Cs-135, Se-79 and the actinide chain 4N+1. The calculations were performed stepwise with increasing complexity in the conceptual model (dimension and transport processes). Special attention was given to an adequate representation of the radionuclide release from the waste form. A 3D model has been developed representing a repository in clay formation in order to test various complexity levels of numerical modelling. Calculations have been performed to check the validity of the model. In addition some calculations have been performed for the 3D complex geometry (square and cylindrical geometry) on the basis of the M4.2.3 benchmark and preliminary computations on 1D geometry were started.

The objective of the work package on *Uncertainty Analysis Codes* is to evaluate the effects of uncertainties of parameters describing geological components of a repository in clay on nuclide migration through the host rock and through the disposal structures, in a PA context. The uncertainty and sensitivity analysis on the first benchmark (2D radial ILW disposal cell), was performed with a comparison of results obtained with the Alliances and Goldsim codes, respectively. The relevant input data were identified whose uncertainty has a major influence on the uncertainty of the result at different surfaces and times. The computed data are now being analysed by JRC by sensitivity and uncertainty analysis methods developed in RTDC2. The definition of a second benchmark was carried out, including more complexity: geometry (3D), physics, statistics, and new methods/tools to be compared such as surface response.

Component 5:

The results generated within the IP PAMINA are of direct relevance to waste management programmes and can be exploited on a national level by both waste management organisations and regulators alike. Accordingly, knowledge management and the dissemination of results are key elements of the IP PAMINA. The dissemination of information takes place on two different levels: first on the integrated project level between the different participating organisations and second to the external community.

The main pillar of knowledge management within PAMINA is the project Intranet site which is accessible for all project partners via Internet. This platform is operated since its initial start in December 2006 without encountering any problems. By downloading and uploading documents (only via RTDC leader or coordination team), this platform is actively used by all partners for convenient information exchange. On a weekly basis, all project partners are automatically informed about new documents that have been added to the system. The platform is structured according to the individual RTD Components and work packages, and, thus, allows easy retrieval of documents. Associated Groups also have access to this internal platform.

All deliverables are made publicly available for download from the PAMINA internet site. The Consortium decided that also important Milestone Reports will be made publicly available via the PAMINA internet site. Upon request these Milestone Reports will be accepted by the Steering Committee in the same way as all deliverables. At the end of the second project year, six deliverables are available.

The 2nd Annual PAMINA Workshop was held in September 2008 in Hyéres, France. At this Annual Workshop 23 contractors were represented. The major part of the workshop was devoted to the presentation and discussion of intermediate results in the various RTD components. In addition, two invited presentations dealt with aspects of the safety and performance assessment for the Yucca Mountain project in the USA. In total 52 persons attended the 2nd Annual Workshop.

The established links between PAMINA and the IGSC of OECD/NEA have been tightened and the members of the IGSC project on “Review of Safety Assessment Methods” have been granted access to the PAMINA intranet to allow the direct use of the PAMINA results in the IGSC project.