Mr. Thomas H. Isaacs
Associate Director for External Relations and Policy
Office of Civilian Radioactive Waste Management
U.S. Department of Energy
Washington, D.C. 20585

Dear Mr. Isaacs:

I am providing the comments of the U.S. Nuclear Regulatory Commission (NRC) staff on the draft document "Collective Opinion on Safety Assessment" by the Radioactive Waste Management Committee (RWMC) of the Organization for Economic Cooperation and Development/Nuclear Energy Agency. This document was discussed during the January 23-24 meeting of the RWMC held in Paris, France. It is the NRC staff's understanding that the RWMC agreed in that meeting that the draft Collective Opinion should be redrafted and that there is a need for two documents on performance assessment, a technical state-of-the-art report and a summary report.

The NRC staff has two basic disagreements with the draft Collective Opinion in the areas of modelling and model validation. First, the document states that models are available for treating the key processes affecting performance (p.10). We believe that the document should recognize that some of these models may be so conservative as to be impractical for use in performance assessments of some actual sites. Thus, further model development is needed in some key areas. For example, we are not aware of models capable of adequately treating processes such as engineered barrier performance or unsaturated groundwater flow in a fractured medium. Second, the document states that "sufficient validity of many models used in safety assessments has been established" (pp.13-14). We believe this overstates the current state-of-the-art of model validation. The document should discuss more fully the basic reality of long-term performance assessment model validation which is that it will likely not be possible to empirically test the ability of models to predict long-term repository performance.

In view of our disagreements, the NRC staff cannot fully support the conclusions presented on page 15 of the report. Specifically, the NRC staff questions whether reliable safety assessment methodologies exist today to predict, with the accuracy implied, the maximum impacts which a repository would have on human health and the environment, especially in the very far future. It is important to bear in mind that there are great uncertainties inherent in projecting far into the future and in modelling complex heterogeneous natural systems. Also, the use of safety assessment methodologies in making decisions on repository safety will depend on the ability to acquire and evaluate data on specific sites. However, the NRC staff does believe that existing safety assessment methodologies can be used to provide a basis for society to decide if proposed radioactive waste disposal systems are acceptable, and that they can provide a sufficient level of safety for present and future generations, so long as the uncertainties noted above are considered in these decisions.

The NRC staff believes that the draft Collective Opinion requires substantial revision, both in the overall tone of the text and in its content. We would also recommend that the document include a discussion of the probabilistic nature of predicting repository performance thousands of years into the future, and of the safety standards to be used to evaluate predicted performance. Finally, we are enclosing a mark-up of the draft Collective Opinion with a few additional detailed comments for the use of the RWMC in preparing a draft summary document on performance assessment.

If you or the RWMC have any questions on these comments or on the Enclosure, please contact Mr. Seth Coplan, Section Leader, Performance Assessment Section, NRC, and Chairman of the Performance Assessment Advisory Group, RWMC.

Sincerely,

(Signed) Robert M. Bernero

Robert M. Bernero, Director
Office of Nuclear Material Safety
and Safeguards

Enclosure: As stated

DISTRIBUTION

Central File	B.J. Youngblood	R.E. Browning	J. Bunting
LSS	J. Linehan	R. Ballard	On-Site Reps
CNWRA	NMSS R/F	HLPD R/F	J. Corrado
J. Holonich	J. Linehan	S. Coplan	G. Arlotto
R. Bernero	H. Faulkner	LPDR	ACNW
PDR			

* SEE PREVIOUS CONCURRENCE

OFC	:HLPD	:HLPD	:HLPD	:HLGP	:HLGP	:HLWM	:HLWM
NAME	:JCorrado*	:JHolonich*	:JLinehan*	:SCoplan*	:RBallard*	:BYoungblood*	:RBrowning*
DATE	:02/ /90	:02/ /90	:02/ /90	:02/ /90	:02/ /90	:02/ /90	:02/ /90

OFC	:NMSS	:NMSS	:	:	:	:	
NAME	:GArlotto	:RBernero	:	:	:		
DATE	:02/14/90	:02/20/90	:02/ /90	:	:	:	

OFFICIAL RECORD COPY

The NRC staff believes that the draft Collective Opinion requires substantial revision, both in the overall tone of the text and in its content. We would also recommend that the document include a discussion of the probabilistic nature of predicting repository performance thousands of years into the future, and of the safety standards to be used to evaluate predicted performance. Finally, we are enclosing a mark-up of the draft Collective Opinion with a few additional detailed comments for the use of the RWMC in preparing a draft summary document on performance assessment.

If you or the RWMC have any questions on these comments or on the Enclosure, please contact Mr. Seth Coplan, Section Leader, Performance Assessment Section, NRC, and Chairman of the Performance Assessment Advisory Group, RWMC.

Sincerely,

Robert M. Bernero, Director
Office of Nuclear Material Safety
and Safeguards

Enclosure: As stated

DISTRIBUTION

Central File	B.J. Youngblood	R.E. Browning	J. Bunting
LSS	J. Linehan	R. Ballard	On-Site Reps
CNWRA	NMSS R/F	HLPD R/F	J. Corrado
J. Holonich	J. Linehan	S. Coplan	G. Arlotto
R. Bernero	H. Faulkner	LPDR	ACNW
PDR			

OFC	:HLPD	:HLPD	:HLPD	:HLGP	:HLGP	:HLWM	:HLWM
NAME:	JCorrado	:JHolonich	:JLinehan	:SCoplan	:RBallard	:BYoungblood	:RBrowning
DATE:	02/13/90	:02/13/90	:02/16/90	:02/14/90	:02/14/90	:02/ /90	:02/20/90

OFC	:NMSS	:NMSS	:	:	:	:	:
NAME:	GArlotto	:RBernero	:	:	:		
DATE:	02/ /90	:02/ /90	:02/ /90	:	:	:	:

OFFICIAL RECORD COPY

ORGANISATION FOR ECONOMIC
CO-OPERATION AND DEVELOPMENT

NUCLEAR ENERGY AGENCY

RWM/DOC(89)1

RESTRICTED

Paris, drafted: 18th Dec. 1989

distr.: 21st Dec. 1989

Engl. Text Only

COMMITTEE ON RADIOACTIVE WASTE MANAGEMENT

RWMC Collective Opinion on Safety Assessment

(Note from the Secretariat)

1. The preparation of a RWMC Collective Opinion on Safety Assessment Methodologies for the disposal of radioactive waste has been mentioned or discussed several times within the RWMC itself and its Bureau, and the Performance Assessment Advisory Group (PAAG), notably on the occasion of last PAAG meeting in October 1989 [SEN/RWM(89)7]. It is recalled that the objective of such a Collective Opinion is to present the degree of consensus achieved on technical matters for the benefit of a large non-specialised audience, including decision-makers, political authorities and the media. Such a Collective Opinion has therefore to be based on a technical appraisal of the state-of-the-art. In this particular instance, the state-of-the-art on safety assessment methodologies for the disposal of radioactive waste has been extensively revieved during the CEC/IAEA/NEA Symposium in October 1989 and during the subsequent meeting of PAAG. These meetings provided the basis for the preparation of the first draft of a Collective Opinion in this field. This first draft is attached as Annex 1.

2. The draft document has been prepared by the Secretariat with the assistance of three consultants (Messrs. Coplan, McCombie and Papp) with a view to its discussion at the 21st session of the RWMC in January 1990. It is largely based on a preliminary report of the state-of-the-art prepared by the Secretariat in an attempt to summarise the information revieved at the October 1989 Symposium. The preliminary state-of-the-art report, which is a technically oriented report of about 50 pages, will be tabled at the meeting of the RWMC as an informal document supporting the Collective Opinion. In this respect, the preliminary state-of-the-art report represents an intermediate step between the type of information presented in the proceedings of the Symposium (to be published in the first part of 1990) and the draft Collective Opinion, and it might therefore be appropriate to consider the publication of such a state-of-the-art report after proper discussion and editing by PAAG.

ENCLOSURE

3. As the Commission of European Communities (CEC) and the International Atomic Energy Agency (IAEA) have jointly sponsored the recent Symposium on safety assessment with the NEA, it would seem desirable to associate them to the publication of a Collective Opinion in this field. In this respect, it is recalled that collective opinion documents should be seen as the expression of a consensus among the scientific community, and do not represent necessarily the views of official national authorities. The responsibility of such opinions should therefore remain with the technical committees of experts behind them. Consequently, it is suggested that, if agreeable to the RWMC, CEC and IAEA Expert Committees should be invited to sponsor the proposed Collective Opinion on Safety Assessment. Ultimately, the NEA Steering Committee would be invited to support the publication of the Collective Opinion by the OECD as a joint CEC/IAEA/NEA report.

4. On the basis of the above considerations, a proposed timetable and procedure has been established which concerns the finalisation and approval of both the Collective Opinion by the RWMC, CEC and IAEA Expert Committees, and the state-of-the-art report by PAAG and the RWMC. The proposed timetables and procedures are attached as Annex 2.

5. On this basis the Committee is invited:

i)

- to discuss the draft Collective Opinion prepared by the Secretariat, with the help of consultants, and reproduced in Annex 1;

- to note that it should be regarded as a technical appraisal of the state-of-the-art under the responsibility of the RWMC;

- to agree with the timetable and procedure proposed in Annex 2 to finalise the text, and to associate the Commission of European Communities (CEC) and the International Atomic Energy Agency (IAEA) to this work;

- to note that the final text will be submitted to the Steering Committee which will be invited to support its publication.

ii) To approve in principle the preparation by PAAG of a separate state-of-the-art report on performance assessment methodologies, according to the timetable and procedure given in Annex 2.

RWM/DOC(89)1

DRAFT 20.12.1989

ANNEX 1

DISPOSAL OF RADIOACTIVE WASTES:
TECHNICAL APPRAISAL OF SAFETY ASSESSMENT METHODOLOGIES

A Collective Opinion of the

Radioactive Waste Management Committee
OECD Nuclear Energy Agency

[CEC]

[IAEA]

NUCLEAR ENERGY AGENCY
ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

Paris, 1990

DISPOSAL OF RADIOACTIVE WASTES:

TECHNICAL APPRAISAL OF SAFETY ASSESSMENT METHODOLOGIES

Why is there a Need for a "Collective Opinion" on Safety Assessment?

In the planning and implementation of projects for final disposal of radioactive wastes, some basic premises upon which the work is based are novel. In particular, two unique decisions, never before explicitly taken in scientific and technical work, guide the extensive work on disposal being performed in nations with nuclear power programmes.

Firstly, a new, pioneering approach was taken to be the problem of dealing with wastes, some of which are toxic for extremely long periods of time. The long-term hazard was explicitly acknowledged and specifically quantified - and the technical community openly accepted the responsibility of ensuring that these wastes should never - even in the very far future - present any unacceptable hazard to man or his environment. It is not the long, but finite hazardous lifetime which is unique - some chemical wastes can be permanently toxic; it is the firm commitment to directly face the resulting challenge of implementing safe disposal.

The second key point was the recognition that the long-term safety of the resulting solutions which technologists offer for the disposal problem must be convincingly demonstrated in quantified terms. This means that one must be able:

- to understand the behaviour of the disposal system;
- to translate this understanding into numerical estimates of performance - or ultimately of achievable safety;
- to convince specialists on the implementing and regulatory side that these estimates are representative of what might actually happen; and
- to illustrate transparently for a wider public how the predicted impacts of a repository are arrived at and compare to regulated acceptability levels or to other societal risks. The need for developing these abilities has led over the past 10 or more years to the growth of the discipline of performance assessment.

How successful has one been in meeting the two unique challenges accepted by the radioactive waste management community? It is valuable at intervals to step back from the complexity of all detailed project work underway and to formulate the current consensus on the major issues determining the course of the work on waste disposal.

Accordingly, the first key question on the basic feasibility of developing adequately safe disposal systems was already addressed in 1985 in the NEA RWMC first Collective Opinion, in the form of a "Technical Appraisal of the Current Situation in the Field of Radioactive Waste Management" [Ref.]. In this document, it was noted that the generally accepted technical solution

for disposal of radioactive vastes, and, in particular, those containing long-lived radionuclides vas based on geologic disposal with a system of overlapping partly redundant safety barriers ensuring the adequate isolation of the vastes; the consensus was recorded that such systems were capable of providing adequate levels of safety. Subsequently, the RWMC supported publication in 1988 of a further report on "In Situ Research and Investigations in OECD Countries ...", which contains a preface collectively reaffirming the basic confidence in the feasibility and safety of geologic disposal.

But what of the second question, that of demonstrating safety in quantitative terms? There are many technologies which should be submitted to an analysis of the risks they present, not just during the relatively short, operational phase, but also for the entire hazardous lifetime of any vastes produced. Only in radioactive vaste management, however, has one openly claimed that meaningful analyses are possible over thousands or tens of thousands of years - i.e., over timescales far beyond the normal horizons of man's social and technical planning. It is not surprising that debate has arisen on the feasibility of such analyses and that scepticism is often encountered on the part of many individuals, groups and organisations which are not directly involved in performance assessment or safety analyses.

On the other hand, within vaste disposal programmes, performance assessments have become a commonplace vorking tool. Large investments in supporting research and in data collection programmes in the laboratory or the field are being justified based on such assessments. Key decisions on site suitability or on facility design are being based on performance assessments. Major decisions on energy policies have been based on the results of technical safety assessments in formal demonstration projects [Refs.] or in licensing procedures.

Are the available performance assessment methods sufficiently high quality tools for such applications? Do they treat all relevant aspects of system behaviour with adequate accuracy? Is the discipline of safety assessment mature enough to provide all information needed for decisions on repository acceptability and transparent enough to be accepted as valid even by non-experts in the field? To provide a basis for ansvering such crucial questions, a joint CEC/IAEA/NEA Symposium vas organised in October 1989. In addition to the extensive proceedings of the Symposium a summary of the state-of-the-art will be published under the auspices of the NEA Performance Assessment Advisory Group (PAAG).

A further valuable step, hovever, is made with the publication of the present collective opinion on the status of performance assessment. The objective of the present document is to distill into a concise form the consensus vhich has emerged on the role and the capabilities of the nev discipline of safety assessment for radioactive vaste disposal. The intention is that senior-level representatives responsible for national radioactive vaste management policies, regulations, programmes or implementation - avare of the depth of supporting technical material - should summarise their common opinion in a form accessible also to further decision-makers or opinion leaders vho can carry the message further.

What is Safety Assessment About?

Safety assessment can be defined as an analysis of the future "performance" of the overall vaste disposal system, followed by comparison of the results with appropriate safety standards or criteria. Whilst the detailed formulation of specific safety criteria may differ from one country to the next, and from one vaste disposal concept to the next, increasing consensus has been reached on the roles of and framework for safety assessment. Three aspects in particular of this consensus form an important basis for development of this report.

First, it is commonly recognised that safety assessments require effective use of predictive modelling methods and a wide range of information that describes the disposal system and its possible evolution. Such information will have (in addition to making use of available knowledge in physics, chemistry, geology, etc.) to be obtained from intensive field investigations at the potential repository site - both at the surface and, in the case of deep geological repositories, deep underground - from complementary laboratory investigations, from possible analogues in nature to parts of the disposal system, and from design requirements for the engineered barriers selected.

Second, it is realised that it will not be necessary to predict the future behaviour of the disposal system in every detail. What is needed is to understand enough to be assured that no harmful releases will occur. Safety assessments provide the discipline to assure such understanding and the vehicle to convey it to the responsible authorities, decision-makers and the interested public.

Third, it is necessary that performance or safety assessments should form an integral part of repository development programmes at an early stage, and throughout the course of siting, evaluation, design, construction, operation and decommissioning and final sealing of radioactive vaste disposal systems. Prior to licensing of a particular repository and site, safety assessments are needed periodically to determine if further information is required to provide a sufficient data base for licensing purposes and, if so, what types of information and data should be collected. Thus, safety assessments form a crucial part of the licensing documentation for disposal systems.

What Can and Cannot Be Expected from Safety Assessments?

"Deep geological disposal" is the answer offered by the scientific community to the problem of disposal of long-lived hazardous vastes. Such disposal is intended to ensure long-term isolation of the vastes from man's environment, without the need of passing on any burden to future generations to manage or maintain control over the disposal site. Safety assessment is the tool for determining whether a repository and site can safely isolate the vaste into the far future almost regardless of how living conditions evolve on the Earth. But to what extent can the scientific community really assess the safety of such disposal systems into the far future?

Safety assessments are expected to answer this question. They can illustrate that one has a good understanding of the disposal system and they should be able to estimate the behaviour (or range of possible future

behaviours) with sufficient accuracy to allow comparison with safety criteria, and they should be convincing to all involved persons and organisations.

The search for a way to show that the objective of safe disposal of the waste is satisfied, can lead to a demand for the strongest level of assurance, that is, not only a convincing demonstration of adequate isolation, but an absolute proof that this will be achieved. Proof, in the strict sense of the word, is not attainable for waste isolation performance assessment (or, for that matter, for the assessment of the future performance of any other technical systems), and it should not be expected. One should expect and should seek an analytical and regulatory process that rigorously considers all of the elements of adequate isolation, and in that way provides the basis for society to decide if the proposed waste disposal system is reasonable and sufficient and can be considered to be safe enough.

What Type of Information is Provided by Safety Assessments and How Should it be Interpreted?

When one speaks about the results of a safety assessment, it is normally the estimation of radiological consequences in terms of radiation doses or risks to human beings that one has in mind. For long-lived radioactive waste the practical objective of disposal, however, is passive isolation of the wastes from man's environment for up to many tens of thousands of years or more. Thus, caution is required in interpretation of the estimated radiological consequences of radioactive waste disposal activities. For example, while calculations of doses to human beings resulting from a release at an operating nuclear plant represent an estimation of doses that will actually be received by an existing population, dose calculations for potential waste repository releases are "stylised" calculations of doses to hypothetical individuals assumed to be living at the site under postulated conditions at a time far in the future. Accordingly, two important observations should be made:

This statement is incorrect. Most repositories will release some radioactivity without severe disruption.

i) Calculated consequences (doses) from waste repositories are normally estimated to occur only under unlikely circumstances involving a severe disruption to the series of containment barriers that comprise the waste disposal system. They must therefore always be seen in the light of how likely they are to occur.

ii) A dose estimated to occur from a release of radioactivity from the disposal system several thousands of years or more from now should rather be viewed as an illustration of what the doses would be if the release occurred today than as a prediction of the dose to far-future human beings, because we cannot estimate in any detail the characteristics of man's immediate environment and man's living habits so far into the future.

It is therefore commonly understood that assessments of the long-term radiological consequences of disposal systems are meant to be used as indicators of safety that can be compared to the regulatory criteria established by the competent national and international authorities. Limitations on the dose or risk are the most commonly used criteria but the use of other indicators, e.g., limitation of activity releases to the biosphere, is also being discussed as a suitable indicator for times far into the future. The choice of indicators does not strongly influence safety assessment methodologies.

- The natural processes and events that could potentially disrupt the repository

What is the Present Status of Safety Assessment Methodologies?

A necessary basis for a reliable analysis of disposal system safety is a good scientific understanding of all parts of the system. This encompasses for instance:

- The physical and chemical properties of the waste materials and the canisters in which they are encapsulated;
- The chemical and physical interactions and radionuclide transport phenomena within the parts of the repository engineered by man;
- The chemical interactions and radionuclide transport phenomena in the geological formation in which the wastes are emplaced; and
- The effects on man of possible releases of radionuclides to the surface environment.

In all these areas, research is being performed through experiments and observations in laboratories and in the field. Mathematical models are being developed to describe important processes which can occur after closure of the repository. The large amount of data obtained from experiments and field tests are collected in a systematic way and stored in data bases.

Although the type of models being used and the type and amounts of data collected will depend upon particular conditions for each disposal concept and site, there is almost unanimous consensus regarding the general approach for safety assessments, as well as the procedures for developing and using models, obtaining data, and performing and revieving safety assessments.

Note: some in U.K. disagree with scenario approach.

To be able to quantify the environmental impact, the long-term performance of the barrier system of the repository has to be predicted. The general approach in safety assessments is:

- To define the repository site and barrier system;
- To identify the interactive processes between the waste, the barrier materials and the natural geological medium ~~for all~~ external circumstances that can occur; The range of

overstated!

- To represent the interaction processes as mathematical models; and
- To evaluate the effect of the interactive processes on the isolation capacity of the repository in terms of probability and environmental consequences.

The verdict of acceptability of a waste disposal system has to be made only after due consideration of the uncertainties associated with performance assessment results.

International co-operation - through information exchange and co-operative projects - has played and is playing a substantial role in the development of coherent and well-structured safety assessment methodologies.

Scenario development

Scenario development, the starting point for safety assessments, is concerned with defining the broad range of futures to be considered in the subsequent modelling and consequence calculations. Human imagination and judgement coupled with existing knowledge of natural systems and man-made barriers is at the source of scenario development. Over the last few years, scenario develoment methodologies have been substantially improved by the use of approaches that are systematic and transparent. Extensive lists of phenomena (e.g., faulting, erosion, etc.) that have to be initially considered in safety assessments have now been developed within many safety studies and they seem to have reached a state of maturity, that is, they remain basically the same and few new phenomena are being identified. Further development can be expected regarding the methods to construct scenarios, or an overall system model, from the list of selected important phenomena.

Note: U.K may want some recognition of simulation approach

Modelling

From scenario development, one has to move to the definition of models that can quantitatively describe the potential behaviour of the disposal system. Modelling is used extensively in safety assessments in many different ways. At different levels of detail and complexity, models are used to describe and understand individual processes (for instance the interaction of radioactive elements with groundwater), subsystem performance (for instance the overall movement of radionuclides through geological media) or performance of the total disposal system (for instance by integrating several subsystem performance models).

The necessity of using models in safety assessments is well recognised and the general procedures for development of models are well accepted. Key modelling areas were identified a long time ago, and predictive models have been developed in these areas. Substantial improvements toward more realism and detail have been made over the years. There are models available for treating the key processes determining the performance of radioactive waste disposal system. By using these models one can produce estimates of the upper limits of the future impacts of proposed disposal practices. Further development is still justified in some key areas because better modelling in these areas could i) clarify or reduce uncertainties associated with assessment results, and ii) contribute to further improvements in disposal system design. Special attention has been given during the last few years to the interdependence between model development and corresponding data gathering efforts. A main area of on-going development is the coupling of process models into larger integrated models and the simplifications needed to make them practical tools for safety assessments.

Data Requirements

Data acquisition is a particularly extensive and expensive activity within repository development programmes. A well-planned and well-managed site-investigation programme, and appropriate and effective control over data for performance assessment, are crucial to the success of repository development programmes.

base During the last decade there has been a major development of the data ~~basis~~ underlying safety assessments of radioactive vaste disposal systems. Data quality has increased owing to an improved ability to design experiments as our understanding of basic processes progresses, as vell as to the continuous development of measurement techniques and instruments. There is a need to further strengthen the link between performance assessment and data collection so that such assessments provide direct guidance on the need to collect further data or to develop nev data collection techniques.

An substantial part of the data used in safety assessments has to be collected at proposed disposal sites if these assessments are to provide the relevant information for decisions in vaste disposal programmes. Thus, another general trend is that more data are being collected today at specific sites. In fact, future major developments in the application of performance assessment methodologies will be dependent upon the availability of site-specific data.

Consequence Calculations

Once scenarios have been established, related models have been developed, and necessary data have been obtained, it is possible to perform meaningful quantitative consequence calculations. Estimations of radiological consequences for man involve calculations of release of radionuclides from the vaste, and the transport of these radionuclides through a series of man-made barriers and the surrounding geological formations, to man's living environment and uptake by man himself.

Meaningful in what way? As bounding estimates? -- Issue of whether existing models are any good Was lodged in the section on modelling

Several different techniques, deterministic as vell as probabilistic, have been developed and are being used for consequence calculations. They should be vieved, not as competing alternatives for consequence calculations but as a suite of tools to be used in concert to gain understanding of the behaviour of the disposal system.

Although it may often be convenient to use a set of different submodels instead of one global model, it must be realised that there will be interactions between various submodels, and modelling requirements will depend upon the situation. There will also be overlaps between submodels: for example, the use of deep groundvater as a source of fresh drinking vater will result in several pathvays for radionuclides to reach man. Consistent assumptions must apply through all models and for all data used.

The capability to make relatively detailed consequence calculations has increased rapidly with the advance in models, and with the groving capacities of computers and data base systems. These provide tools for advanced and complex methods, and it is important that the effort to maintain a global overviev and transparency keep pace with the development of technical methods.

Uncertainty Analysis

Uncertainties will always be associated with assessment results. Uncertainties can partly be reduced by further model development and by collecting more and better data, but they can never be completely eliminated

< a section on probability estimation is needed

or reduced because they reflect a genuine variability in natural systems and, in some instances, what may be a limited understanding of controlling processes. However, by evaluating the uncertainties, using both quantitative methods and expert judgement, a sufficient basis for decisions can be provided.

The question of how much uncertainty is acceptable is central for decisions regarding implementation of disposal systems. Integrated performance assessments can provide clear guidance on the areas in which one should try to reduce uncertainties. This guidance must by its nature be specific with regard to disposal site and concept, and can be used to direct resources for research and development to areas where they are most needed.

The issue of uncertainties has been and still is a matter of some confusion in the discussion of the safety of radioactive waste disposal. It is difficult for experts in different fields to put uncertainties in their specific fields in perspective, and those performing integrated performance assessments have an important role in this context. For instance, large uncertainties in the modelling of a particular process may have little influence on the overall assessment results because other processes and barrier functions will dominate the assessment results. A process or phenomena might be completely unimportant in the "expected" evolution scenario, and still be crucial to the results for an assessment of some very unlikely scenario. Discussions of uncertainties should therefore not be done in isolation. Thus by identifying and quantifying the uncertainties and by understanding how they affect the results of consequence calculations, it will be possible to make more reliable evaluations of the safety of a disposal system. Therefore, the intensified discussion of uncertainties associated with assessment results is a sign of the maturity of assessment methodologies and not a sign of growing uncertainty about the conclusions that can be drawn. The information on uncertainties should also be provided to those responsible for repository design since it may enable them to improve the design and, if needed, the siting of the repository.

Integrated Assessments

The ultimate goal of scenario development, modelling and consequence calculations is an integrated assessment describing the characteristics of the disposal system and quantifying the performance of the overall system in terms of radiological safety. Such integrated assessments are indispensable for licensing of a repository; yet experience has shown that they are of considerable value and should be carried out in an iterative way throughout the whole repository development process.

Many integrated assessments of repositories in various host-rocks have been made over the years. They give evidence that it is possible to build repositories that can be considered safe for man and his environment. [Ref. of examples].

There seems to exist two quite different approaches for integrated assessment: one aiming at licensing and characterised by an intention to have as robust as possible bounding analyses of the system; another aiming at the research and development guidance where the models are selected to be as

process-oriented as possible and where the use of safety margins is, if possible, avoided. For the robust bounding analyses, the net uncertainties that predicted consequences lie below specific values are reduced by proceeding in a pessimistic way, using conservatively chosen models, parameters and input data. Thereby the assessments are simplified and unnecessary discussions around uncertainties, not important for the acceptance criteria, will be avoided.

The presentation, in a clear and understandable way, of the information obtained in an integrated assessment is an important and challenging task where much work remains to be done.

What is being done to build confidence in safety assessments?

One major objective of safety assessments is to provide a basis for well-founded decisions about radioactive waste disposal. To this end it is necessary that scientists, safety assessors, regulators, and those involved in or concerned with the decision-making process have confidence in the information, insight and results provided by safety assessments. This raises the question of the relevance and the quality of safety assessment methods as such, as well as the procedures for performing and reviewing assessments.

The necessity of building confidence in safety assessments was recognised at an early stage by the radioactive waste management community. Concrete procedures have been adopted and are now applied to ensure that each element of safety assessment, as well as overall assessments, addresses relevant issues and provides results of such quality that they can be used as a firm basis for decisions. Existing techniques for quality assurance and quality control, adapted to the needs of safety assessments of waste disposal systems, are being introduced within every element of assessments and in the data collection activities. Model validation - that is, assuring that the models used adequately represent the real system behaviour - is an area where efforts, often in international co-operation, have been intensified during the last years. Model validation is comprised of systematic evaluation of modelling results against data from experiments in laboratories or in the field, as well as against data from studies of natural analogues. The sufficient validity of many models used in safety assessments has been established. This is true in particular for models used in bounding assessments that are built to consistently overestimate the potential impact of a repository. It is recognised, however, that further efforts are needed, in particular for coupled models and models representing complex processes. As models ~~rarely can be validated in an absolute sense~~, one needs to decide where to put the priorities and how far to go in efforts to validate different models. These validation needs will also depend upon concept and site-specific conditions. From a practical point of view, it must be remembered that safety is provided by the barriers placed between the waste and the environment, and that there are many ways by which to achieve a safe repository. It is essential that there exist close co-operation between those designing the repository and selecting the relevant barriers, and those studying the possibility of validating the models to be used in assessing the performance of the system.

conclusion on probability estimates?

What are the Main Conclusions

The long-term safety of radioactive vaste repositories must be assessed using predictive models that describe the behaviour, or "performance", of the disposal system over time. Safety assessments do therefore represent a major component of any vaste disposal programme. They are the primary vehicle for describing to national authorities and the public the level of confidence held in the long-term safety of proposed disposal systems.

There is vide consensus regarding the general approach to safety assessments as vell as the general procedures for developing scenarios and models, obtaining data and performing and revieving integrated assessments. However, different specific techniques must be used depending upon the purpose of an assessment and the type of safety criteria to be met. International co-operation is playing a substantial role in the development of coherent and vell-structured safety assessment methodologies.

Methods for identification and selection of scenarios, important for the long-term safety of disposal systems, have been substantially improved by the use of systematic and transparent approaches. Therefore, there is a high confidence that all important phenomena will be addressed in safety assessments.

There are models available for simulating the key processes determining the performance of radioactive vaste disposal system. By using these models one can produce estimates of the upper limits of the future impacts of proposed disposal practices. Further model development is still justified in some areas because better modelling could clarify or reduce uncertainties associated with assessment results and contribute to further improvements in disposal system design.

reviewers present situation

The sufficient validity of many models used in safety assessments has been established. This is true in particular for models used in bounding assessments that are built to consistently overestimate the potential impact of a repository. It is recognised, however, that further efforts are needed in particular for coupled models and complex process models. As models rarely can be validated in an absolute sense, one needs to decide where to put the priorities and hov far to go in efforts to validate different models. These validation needs will also depend upon concept and site-specific conditions.

Sufficient data of adequate quality form an indispensable basis for any calculations of system performance and, in the case of performance assessments used to support license applications for disposal systems, a substantial amount of these data must have been collected at the proposed repository site. In fact, future major developments in the application of performance assessment methodologies will be dependent upon the availability of site-specific data.

Uncertainties associated with safety assessment results, can often be reduced, if needed, by further model development, by collection of more and better data, or by changes in the disposal system design or location, but they can never be completely eliminated. However, by evaluating the uncertainties, using both quantitative methods and expert judgement, a sufficient basis for decisions can be provided. Uncertainties can therefore be accepted after careful analysis of their relative importance.

The aim of safety assessments is to demonstrate an adequate understanding of disposal system behaviour and to provide indicators of system safety that can be compared to regulatory criteria. Whatever the detailed criteria might be, however, the assessment work that has to be done remains, to a large extent, the same. Doses calculated to occur in the far future must be interpreted as "stylised" calculations, or illustrations, of possible doses to hypothetical individuals and not as predictions of actual doses to future human beings.

As assessment methods and models become more complex, there is a need to further develop the methods to present the procedures used and the results obtained in a well-structured and transparent way.

* *
*

After having carefully considered the current scientific basis for safety assessments and the experience now available from using safety assessment methodologies in many countries for several different disposal concepts and geological formations - as described briefly in this summary document and more fully in supporting technical doduments - the RWMC [INWAG and CEC] are of the opinion that reliable safety assessment methodologies exist today to predict with sufficient accuracy the maximum impacts which a repository would have on human health and the environment, even in the very far future. Accordingly such methodologies can be used to provide a basis for society to decide if proposed radioactive vaste disposal systems are acceptable and can confidently be considered to provide a sufficient level of safety for both present and future generations.

quantified

ANNEX 2

Proposed procedures and timetables for the finalisation of a Collective Opinion and of a state-of-the-art report on safety assessment methodologies for radioactive vaste disposal

Collective Opinion	State-of-the-Art-Report (SOAR)
1. 23-24 January 1990: Discussion of first draft at RWMC meeting, and agreement on approval procedures (incl. PAAG comments).	1. 23-24 January 1990: First SOAR draft tabled at RWMC meeting and distributed to PAAG for comments.
2. 15 February 1990: Distribution of 2nd draft to RWMC and PAAG (and CEC and IAEA) for comments.	2. 31 March 1990: Deadline for written comments from PAAG and RWMC
3. 30 April 1990: Deadline for comments on 2nd draft.	3. i) 30 April 1990: Distribution of 2nd draft to PAAG.
4. 31 May 1990: Distribution of 3rd draft to PAAG and RWMC (and CEC and IAEA).	ii) 11-13 June 1990: Special PAAG meeting to finalise SOAR for submission to RWMC on 3-4 Sept 1990 and clearance for publication, OR
5. 3-4 September 1990: RWMC meeting for final approval.	3.bis i) 31 May 1990: Distribution of 2nd Draft to PAAG, with the possibility for written comments before 15th July.
6. 3-4 October 1990: Steering Committee's approval of publication.	ii) Mid September 1990: Normal PAAG meeting, including finalisation of the SOAR, for clearance for publication in October 1990 by RWMC or RWMC Bureau through a written procedure.
7. November 1990: Publication.	4. November 1990: Publication.
	Note: Option 3 puts pressure on Secretariat and PAAG members, and Option 3 bis seems therefore more appropriate.