SKI Report 99:30

The Swedish Nuclear Power Inspectorate's Evaluation of SKB's RD&D Program 98

Summary and Conclusions

April 1999

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1 Introduction

1.1 General

According to the Act (1984:3) on Nuclear Activities, the full responsibility for the safe management and final disposal of spent nuclear fuel and nuclear waste rests with the owners of the Swedish nuclear power reactors. In accordance with the Act (1992:1537) on the Financing of Future Expenses for Spent Nuclear Fuel etc., the owners are also responsible for ensuring that funds are set aside to cover the future expenses of the management and final disposal of spent nuclear fuel and nuclear waste. Furthermore, nuclear reactor owners must conduct, and every three years, submit a research and development programme for the management of the spent nuclear fuel and nuclear waste. The programme must also cover the measures which are necessary for the decommissioning and dismantling of the nuclear installations. The Ordinance on Nuclear Activities stipulates that the programme must be submitted to SKI for evaluation no later than on the last day of September, once every three years. SKI must submit the programme documents to the Government, along with its own statement. The owners of the nuclear power reactors have formed a joint company, the Swedish Nuclear Fuel and Waste Management Co (SKB) which, on behalf of the owners, fulfils the owners' statutory obligations with respect to the management and final disposal of spent nuclear fuel and nuclear waste and conducts related research and development.

Previous RD&D Programmes

The programme now submitted by SKB is the latest in the series which started with R&D Programme 86. However, as early as 1984, SKB's programme had been evaluated in connection with the presentation, for the first time, of the KBS-3 method as a basis for an application to start up the Forsmark 3 and Oskarshamn 3 reactors. The current programme was submitted in September 1998 and is called RD&D Programme 98 (programme for Research, Development and Demonstration).

In the Government's decision of December 19, 1996 concerning SKB's RD&D Programme 95, the Government stated that SKB must "carry out a system analysis of the entire final disposal system (encapsulation plant, transportation system and a repository). This system analysis shall allow for an overall, integrated safety assessment of the entire final disposal system, including how principles for safety and radiation protection are to be applied, in practice, in the safety assessment work. Furthermore, the system analysis shall include an account of the alternative solutions to the KBS-3 method described by SKB in previous research programmes or which have been described in international studies. Different variations on the KBS-3 method should also be described. In addition, the consequences which would arise if the planned repository is not constructed (zero alternative) as well as ongoing international work on transmutation shall be presented".

In its decision on RD&D Programme 95, the Government stated that, before the site selection process can progress to the stage of site investigations at a minimum of two sites, "SKB's overall report on general siting studies,

feasibility studies and any other background and comparative information which, after consultation with the government-appointed National Co-ordinator for Nuclear Waste Disposal, SKB may wish to present, must be made available to the municipalities concerned." Furthermore, as regards the planned final disposal method, SKB should be able to specify criteria for the evaluation of candidate sites and specify which factors will determine whether a site will be excluded from further investigation". The Government also stated that, prior to the start of site investigations, SKB should consult with SKI and SSI concerning the conditions which should apply to the investigation work.

With respect to feasibility studies, the Government takes it for granted that "SKB, in consultation with the municipalities concerned, will be given the opportunity to carry out site-specific feasibility studies in such a way that an adequate basis for decision-making is available prior to SKB's consultation with SKI and SSI regarding the site investigations. SKB should make every effort to ensure that the municipalities concerned are given as adequate information as possible before different decisions are made in the siting work."

SKB's Requests

In RD&D Programme 98, SKB has stated that it particularly welcomes viewpoints concerning:

- whether deep disposal[1] according to the KBS-3 method will continue to be the preferred method.
- the body of material that SKB is compiling in preparation for the selection of sites for site investigation.
- what is to be included in future environmental impact statements.

Compared to previous programmes, RD&D Programme 98 is focused to a greater extent on method and site selection and on issues relating to the decision-making process. This is natural, since the programme is now approaching the stage where vital decisions will have to be made.

1.2 SKI's Work on the Matter

The RD&D Programme 98 report is supplemented by a background report "Detailed Programme for Research and Development 1999-2004" as well as a number of main references "System Reporting", "Alternative methods", "Criteria for Site Evaluation" and the "North-South/Coast-Interior" report. In addition, a number of references are available in the form of county-specific general siting studies, feasibility studies etc.

Several of the reports were submitted to SKI at a fairly late stage ("North-South/Coast-Interior" was only submitted in January 1999), which made the evaluation work somewhat difficult for SKI and many of the reviewing bodies.

SKI has distributed RD&D Programme 98 to sixty-three reviewing bodies for comment. Forty-five responses were received. The reviewing bodies include universities and institutes of technology, local safety committees, municipalities hosting nuclear facilities and municipalities participating in feasibility studies as well as many authorities such as county administrative boards, the Swedish Environmental Protection Agency, the National Housing Board and SSI.

During October 1998, SKI arranged a meeting for the reviewing bodies, where SKB was given

[1] In order to emphasise that the final disposal system is not irrevocable, SKB now uses the term deep disposal. . However, the term used in the legislation is final disposal. In acknowledgement of the legislation, SKI uses the term final disposal (except for referenced text). Regardless of which term is used, different degrees of retrievability can be discussed.

the opportunity of presenting the programme and where SKI presented the evaluation and review process, including time-schedules.

The comments of the reviewing bodies mainly focused on the decision-making process, including issues relating to method selection and site selection and, in particular, on the selection of sites for site investigation. Several reviewing bodies, particularly universities and institutes of technology, have also submitted comments of a more technical-scientific nature.

SKI's Evaluation

SKI's evaluation has focused on determining whether SKB's programme can be considered to fulfil the requirements stipulated in the Act on Nuclear Activities that such a programme should be able to result in the implementation of solutions for the final disposal of the spent nuclear fuel from the Swedish nuclear power programme . Furthermore, SKI's evaluation has also focused on the conditions that SKI considers should apply to SKB's future work.

In accordance with SKI's directive, SKI's statement to the Government must be dealt with by SKI's Board. SKI's statement to the Government includes the "Summary and Conclusions" of the Review Report. In the Review Report, SKI reviews SKB's RD&D Programme 98 and also deals with comments provided by the reviewing bodies. Furthermore, SKI has commissioned a separate report called "Comments of the Reviewing Bodies" (in Swedish). In addition, SKI and SSI have jointly prepared a report entitled "SKI's and SSI's Evaluation of SKB's System Report in RD&D Programme 98" (in Swedish).

2 SKI's Evaluation and Proposal for a Decision-Making Process

2.1 Introduction

SKB's programme is approaching the time when vital decisions, from the standpoint of SKB and the municipalities concerned, will have to be made concerning how SKB should proceed with the selection of site for a repository. This is reflected in the structure of RD&D Programme 98, where issues concerning the decision-making process have been given a considerably more prominent role than in previous RD&D programmes, which have been more focused on technical issues. This is also evident in the three issues that SKB considers should be addressed: site selection, basis for the selection of sites for site investigation as well as the content of an Environmental Impact Statement (EIS). Moreover, it is evident that the reviewing bodies have focused on the decision-making process in their review.

SKB states its intention of conducting site investigations at a minimum of two sites, providing that the municipalities concerned give their consent. Before this stage, SKB would like the regulatory authorities and the Government to state clearly whether a geological deep repository of the KBS-3 type is the most suitable solution for Sweden. The municipalities involved in feasibility studies also emphasise that it is important that SKI, SSI and the Government should clearly state their opinion of the method. This is considered to be necessary in order for the municipal decision-making process to proceed.

However, several of the environmental organisations are highly critical of SKB's work and are of the opinion that the site selection process should not continue until a method has been selected in a separate process.

2.2 SKI's Evaluation

2.2.1 Method Selection and System Analysis

Method Selection

SKI concludes, as does SSI, that some form of final disposal in deep geological formations appears to be the most suitable method for the final disposal of the spent nuclear fuel and long-lived waste from the Swedish nuclear power programme, taking into account established ethical principles and technical feasibility within the foreseeable future.

Storage above ground, for an extensive period of time, would entail a transfer of responsibility to future generations and this line of action cannot be defended from the ethical standpoint. Methods involving reprocessing and transmutation are still associated with significant technical and economic uncertainties which probably require decades of technical development to overcome. This method would also involve transferring responsibility to future generations. The facilities would also probably be so large and complex that Sweden would not be able to develop, construct and operate them on its own: a combination of a large accelerator, several reactors and a reprocessing plant would be required. It should also be emphasised that some form of final disposal would still be necessary, since all long-lived radioactivity cannot be eliminated.

System Analysis

SKI concludes, as does SSI, that an adequate system analysis is necessary in order to justify the selection of a method. In a memorandum (SKI dnr: 5.8 – 971083, SSI dnr: 6220/1994/97 from March 5, 1998), SKI and SSI have specified what should be included in a system analysis submitted by SKB. In summary, SKI and SSI consider that the system analysis which has been submitted has deficiencies, especially with respect to the justification of the method selected. SKB has not fully taken into account the instructions of the authorities. It is therefore necessary for SKB to conduct additional work on the system analysis.

Licensing in Stages

SKI reiterates that the direction of the RD&D Programme, the method and site selection as well as the licensing of nuclear facilities in the final disposal system are all part of a process comprising many stages of decision-making which extend over a period of almost a century, if one takes, as the starting point, the date when the foundation was first laid for the Swedish strategy for the management and final disposal of spent nuclear fuel and nuclear waste through the AKA Committee and, as the finishing point, the time when a decision on the closure of the completed repository can be made. Figure 2.1 shows how far we have come in this process and some of the forthcoming

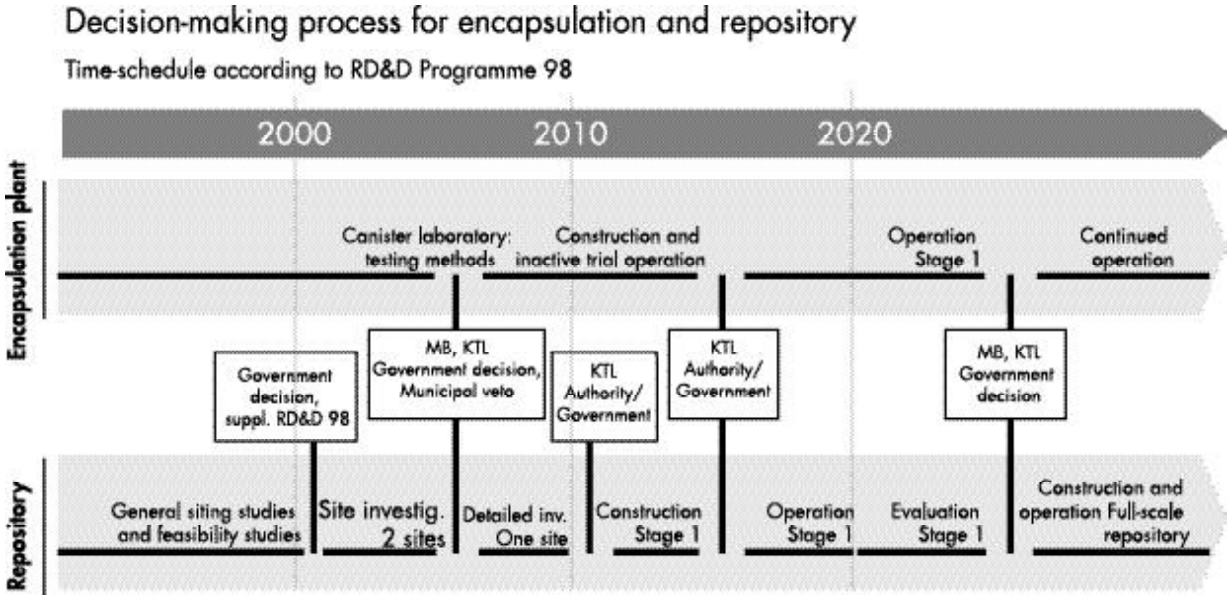

Figure 2.1.
Overview of the decision-making process for the different stages of siting and construction of an encapsulation plant and repository. The laws under which licensing is to be conducted are specified for each stage where a decision is to be made (KTL stands for the Act on Nuclear Activities and MB, for the Environmental Code). The major stages, e.g. when SKB submits applications for permission to conduct detailed investigations, to construct the encapsulation plant and to expand the repository from demonstration-scale disposal to full-scale disposal, will require decisions by the Government. At certain stages, licensing by a regulatory authority may be sufficient. In this review statement, SKI has proposed that SKB, as a condition for starting site investigations, should have to submit additional material to supplement RD&D Programme 98 (see Table 4.1) and that this material should be approved by the Government.

stages where decisions will have to be made, as SKI described them in its Review Report on RD&D Programme 95.

With a general focus on final disposal in deep geological formations, it is obvious that the detailed design of the method must be evaluated at different stages. The focus of SKB's research and development work on the KBS-3 concept has been evaluated in previous RD&D review reports. As mentioned above, SKB, the municipalities involved in feasibility studies and SKI consider that it is necessary to once again evaluate the KBS-3 method prior to the next stage in the site selection process, namely the start of site investigations. The method must then be evaluated again in connection with the licensing of the relevant facilities (encapsulation plant and repository) under the Environmental Code and the Act on Nuclear Activities. Additional evaluations will be made before spent nuclear fuel is transported to a facility which represents the first stage of the repository and before this facility is expanded to a full-scale repository.

Before the facilities are licensed and constructed, the formal and economic commitments to a particular method are limited. Future changes in the choice of method would naturally entail a considerable delay in reaching the final goal – a completed repository. However, any additional cost can, to a significant extent, be compensated for by the interest on the capital in the Nuclear Waste Fund, which would be accrued over the extended period of time.

2.2.2 Focus of the RD&D Programme and the Feasibility of the KBS-3 Method

RD&D Programme 98 Complies with the Legal Requirements

In SKI's opinion, the Swedish Nuclear Fuel and Waste Management Co (SKB) has presented a research and development programme which complies with the basic requirements stipulated in § 12 of the Act on Nuclear Activities. The owners of the nuclear power reactors have, thereby, through SKB and for the period of time in question, fulfilled their obligations under §§ 11 – 12 of the Act on Nuclear Activities.

On the whole, the programme is appropriate with regard to the development and evaluation of a method for the final disposal of spent nuclear fuel and nuclear waste in the Swedish bedrock. The quality of the supporting research programme is good. In comparison with other methods and on the basis of the body of material available, SKI considers the focus of the programme on the KBS-3 method to be suitable. In its own review of RD&D Programme 98, SSI also supports SKB's choice of method.

Feasibility

As described in Chapters 5 and 7, in SKI's opinion, considerable technical development and testing still remain to be carried out, both with respect to the canister (fabrication, sealing, control) and with respect to the bentonite and the final disposal technology in general. However, in SKI's opinion, the scope of knowledge is such that it should be possible to implement the KBS-3 method as a project, from the purely technical point of view. Similarly, it is essential that the method be subjected to critical evaluation, in stages, with the support of system analyses and safety assessments etc.

SKB's research for support for the development of the KBS-3 method is generally of adequate quality and has, to a large extent, focused on issues that have been identified as essential in connection with previous safety assessments. SKI finds that, also in the long term, there will be a need for further research, in order to gradually

improve the body of material for future safety assessments. SKI assumes that a repository, during its operating lifetime and up to the time of possible closure, will be subjected to periodic safety reviews in the same way as the existing nuclear power reactors. Consequently, it is essential for SKB to develop and maintain its competence over a sufficiently long time. In SKI's opinion, SKB should strive to, as far as possible, ensure that its research results gain the acceptance of the rest of the research community, e.g. by publishing particularly important results in scientific journals.

2.2.3 Safety Assessments

The assessment of the safety of all parts of the final disposal system (encapsulation plant, transportation, repository) and of the safety of the system as a whole must maintain a high level of quality. The methodology for this work must be developed, although it already exists to a large extent. It is particularly important to be able to assess the long-term properties of a repository and for this to be done in a way that inspires confidence in the safety assessment. System analyses and safety assessments should specifically examine issues relating to retrievability over different time ranges and how this can affect the safety of the system as a whole.

During an operational phase, there is the possibility of experience feedback and of immediately implementing corrective measures, if necessary. For example, this applies to the operation of the encapsulation facility, to the transportation system as well as to the operation of the repository (as long as the repository is kept open). In SKI's opinion, SKB has the necessary knowledge and experience to carry out safety assessments and safety management during the operational phase, from the operation of CLAB and SFR etc. as well as from the transport of nuclear fuel.

Regulations

During 1998, SSI promulgated regulations concerning the protection of human health and the environment in connection with the final management of spent nuclear fuel or nuclear waste (SSI FS 1998:1). The regulations include requirements concerning the limitation of the annual risk exposure of an individual in the critical group. SKI is currently preparing regulations including criteria for how the long-term safety of a repository can be achieved through a combination of engineered and natural barriers as well as for how safety assessments should be structured in order to show how these criteria are met. SKI-PM 97-17, which is currently being reviewed by external bodies, contains a general description of the criteria in these forthcoming SKI regulations. SKI's forthcoming regulations are harmonised with the above-mentioned SSI regulations with respect to risk limitation.

SR 97

For SKI to be able to evaluate the KBS-3 method, before the work proceeds to the stage of the selection of sites for site investigation, SKB must show, through an up-to-date safety assessment, that the necessary conditions exist to identify a site in the Swedish bedrock which meets regulatory criteria with respect to long-term safety and radiation protection (see also Section 6.2.2). SKB is currently developing methods for the assessment of the safety of the long-term properties of the repository (SR 97). According to SKB, the report will be presented in summer 1999 (August). SKI will arrange for an international review of the SR 97 report to be conducted toward the end of 1999. SKI will also conduct its own evaluation of SR 97.

In its review statement on RD&D Programme 98, SSI has emphasised that SKB must conduct more detailed studies of the biosphere as a basis for modelling and calculations in the safety assessment.

Additional views on SKB's safety assessment work are presented in Chapter 6.

New Safety Assessments to Be Presented at Various Stages

As is mentioned above, safety assessments will have to be presented as a basis for decision-making at different stages in the development of the final disposal system (Figure 2.1). The stages which can already be anticipated at this stage are:

1. Decision(long-term safety) of the method prior to the selection of sites for site investigation.

2. Safety assessments in connection with licensing, under the Environmental Code and Act on Nuclear Activities, of the encapsulation plant, transportation etc.

3. Decision in connection with an application, under the Environmental Code and Act on Nuclear Activities, for permission to conduct detailed investigations (excavation of shafts down to repository depth etc.) as the first stage in the construction of a repository.

4. Safety assessment in connection with the evaluation of an application for a license, under the Environmental Code and Act on Nuclear Activities, to operate the first stage of the repository (demonstration-scale repository).

5. New safety assessment in connection with the licensing, under the Environmental Code and Act on Nuclear Activities, of the second stage of the repository (full-scale repository).

6. New safety assessment prior to a decision on repository closure.

2.2.4 Siting

According to SKB's plans, the siting of the repository will be conducted in stages. The basis for the selection of sites for site investigation includes general siting studies of Swedish geology, regional geological studies, a study of the advantages and disadvantages of siting in the north/south and coast/interior as well as the feasibility studies which SKB has conducted and is currently conducting in a number of municipalities as well as feasibility studies of other municipalities identified by SKB in the future. In addition, there are the earlier geological investigations which SKB previously conducted at a number of sites in Sweden.

In SKI's opinion, the scope of the reports which SKB plans to submit prior to the transition to site investigations appears to be reasonable and taking into account the findings of this review statement, can be expected to provide an adequate basis for review statements concerning the final disposal method and the selection of sites for site investigations.

Like Oskarshamn Municipality and the Local Safety Committee at Oskarshamn Nuclear Power Plant, SKI emphasises that it is important for SKB to account for how it balances the various siting factors (safety, technology, land, environment and society) in the selection of sites for site investigations. On the basis of an up-to-date safety assessment (SR 97), SKB must also reconcile and clearly account for the minimum criteria and discriminating factors which determine whether a site can be judged to be suitable for a repository.

In summary, it is important that the additional material submitted by SKB before a decision is made regarding site investigations should include:

- a clear account of measurement programmes for the site investigations, based on insights from the safety assessment and other studies,

- an integrated evaluation of implemented feasibility studies and other site selection material together with an evaluation of the suitability of the sites investigated in the feasibility studies which are included in the body of material for the selection of sites for site investigations,

- SKB's plans for consultation at the different stages of siting.

2.3 Decison-making Process

2.3.1 Premises

SKB, like many other reviewing bodies, including the municipalities involved in the feasibility studies, considers that a clearer position on the KBS-3 method must be adopted, on a national level, before proceeding with site investigations. SKI shares this view. The start of site investigations marks an important stage of decision-making in the successive process which is to result in the implementation of a repository.

In that respect, adopting a positive position with regard to the KBS-3 method must not be viewed as a definite approval of the method, but as a stage in the gradual development of a process of evaluation, where the next stage would be the licensing of the various facilities in the system. As far as geological disposal is concerned, the next stage means the evaluation of an application for permission to conduct detailed investigations (excavation of shafts down to repository depth).

Based on the comments of the reviewing bodies and SKI's findings, three main options can be distinguished in the future licensing and decision-making process:

- The presentation of additional material for decision-making prior to the selection of sites for site investigation.

- The initiation of a separate process, in parallel to SKB's RD&D programme, to conduct a Strategic Environmental Assessment (SEA) for the selection of a method.

- The discontinuation of SKB's site selection process and the transfer of the responsibility for developing a method for final disposal to a new organisation which will carry out work in an impartial manner.

As is mentioned above, SKI considers that the evaluation of SKB's RD&D programme shows that SKB and, thereby, the owners of the nuclear power reactors, has fulfilled its obligations under §§ 11 – 12 of the Act on Nuclear Activities. Therefore, SKI sees no reason for selecting the third option.

Several reviewing bodies, including the National Housing Board and the Swedish Environmental Protection Agency, consider that a decision with respect to the selection of a method should be based on some form of Strategic Environmental Assessment (SEA), as outlined in the second option above. However, neither the concept of SEA nor the process is defined in Swedish legislation. Since the concept of SEA is not yet defined in Swedish legislation, SKI concludes that, for example, if the Government were to charge an agency or special commission with the task of conducting such a process, this would render unclear the responsibilities towards SKB, and SKB's obligations, under §§ 11 – 12 of the Act on Nuclear Activities. A comprehensive and complex SEA, extending over a period of many years would also delay and, according to the municipalities involved in feasibility studies, render the site selection process which has already begun more difficult.

SKI emphasises, in this context, that the periodic, public evaluation and review process - stipulated in § 12 of the Act on Nuclear Activities and its precursor – which has been in progress for two decades, contains many of the elements that, according to ongoing

discussions, are assumed to be included in a SEA, including public consultation. After all, the aim is to ensure that the basis for decision-making is sufficiently comprehensive and substantiated.

On the basis of the above discussion, SKI recommends that proposals to introduce new processes without the support of the existing Swedish legislation or EC legal acts should be rejected. In SKI's opinion, § 12 of the Act on Nuclear Activities gives the Government adequate opportunity to ensure, by requesting additional material, that a sufficiently comprehensive and substantiated basis for decision-making exists prior to decisions regarding method selection and the start of site investigations. SKI proposes that such a process should be structured as follows:

2.3.2 SKI's Conclusions concerning Future Action

The Possibility of Stipulating Conditions, under § 12 of the Act on Nuclear Activities, Provides the Legal Foundation

The legal foundation for SKI's proposal for future action is § 12 of the Act on Nuclear Activities. According to this Act, the Government, in connection with evaluations and decisions on the RD&D programme, may stipulate the necessary conditions for future research and development activities.

In SKI's opinion, a reasonable interpretation of the application of the law is that the Government can use the possibility of stipulating conditions to ensure that the municipalities involved in feasibility studies obtain a comprehensive and well-substantiated basis for their decision-making in the site selection process. After all, the consent of the municipalities is necessary for the siting process to continue and, according to SKB, the siting process is an important aspect of future work in the RD&D programme. Furthermore, there is a link between the Act on Nuclear Activities and the Financing Act. In SKI's opinion, it is therefore also reasonable for the Government to stipulate conditions concerning the body of material which must be available, in an evaluated and approved form, before the programme continues, in view of the fact that the programme is financed by funds which are administered by the state.

Additional Material for the Basis of Decision-making Prepared through a Review and Consultation Process

In SKI's opinion, the additional material that is necessary, as described above, for the Government and central authorities to make decisions and for the municipalities involved in feasibility studies to proceed to the site investigation stage, should be prepared through a review and consultation process. This process should reflect, to a reasonable extent, the provisions concerning extended consultation and environmental impact assessment, in Chapter 6 of §§ 4 –6 of the Environmental Code. In this context, it can be reiterated that according to Article 2.7 of the Espoo Convention, which was ratified by Sweden, "to the extent appropriate, the Parties shall endeavour to apply the principles of environmentl impact assessment to policies, plans and programmes." On the basis of the proposed process, it could be maintained, with good reason, that the requirements of the Espoo Convention are met to a reasonable extent, especially if all of the previous public evaluations and reviews of the RD&D programme are considered in the light of § 12 of the Act on Nuclear Activities.

2.3.3 SKI's Proposal for the Position to Be Adopted by the Government on Method Selection

SKI proposes that a government decision on RD&D 98 should be made in early autumn 1999 and should contain the following

elements in order to satisfy different views on the future process which have emerged during the review of the programme.

1. SKI proposes that the Government should state that SKB, and thereby the reactor owners, have so far fulfilled their obligations under § 12 of the Act on Nuclear Activities.

2. As a condition for starting site investigations, SKI proposes that the Government stipulate that the additional material which, in this statement, SKI considers should be presented, should have obtained government approval prior to the start of site investigations (Figure 2.2), namely:

   - A supplement to the analysis of alternative system solutions, including the "zero alternative". The aim is to verify, more clearly, that there is no method which is essentially more suitable than the KBS-3 concept, from the Swedish standpoint.

   - An in-depth safety assessment of the KBS-3 method. The aim is to show, in a credible manner, that the KBS-3 method has the necessary conditions to comply with the safety and radiation protection criteria that SKI and SSI have stipulated in recent years. The safety assessment must be subjected to international peer review.

   - A clear account of measurement programmes for the site investigations, based on insights from the safety assessment and other studies,

   - Other material which, according to SKB, will comprise the basis for the selection of sites for site investigation and SKB's plans for achieving consultation in the different stages of siting.

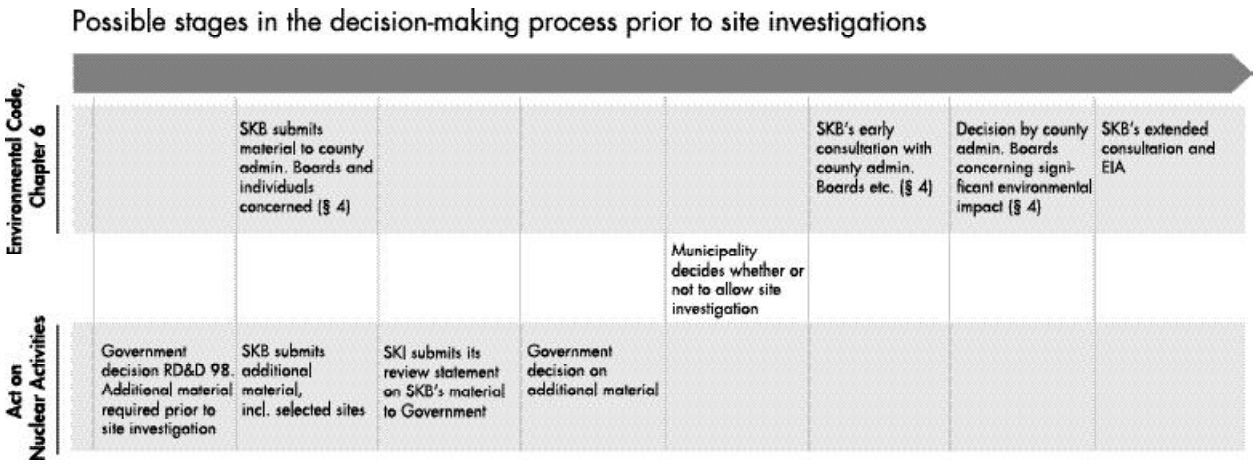

Figure 2.2
SKI's proposal for the decision-making process prior to the start of site investigations. The figure shows how various activities and decisions could be co-ordinated to comply with the requirements of the Act on Nuclear Activities and the Environmental Code as well as satisfy the desire for a transparent decision-making process. SKI is of the opinion that SKB's early consultation with county administrative boards could be conducted in connection with municipalities concerned deciding whether or not to participate in site investigations. This will provide a clear, formal starting point in the EIA for the repository since, according to the Environmental Code, this early consultation must be followed by the county administrative board's decision concerning extended consultation and environmental impact assessment.

- An integrated evaluation of implemented feasibility studies and other site selection material together with a judgement of the suitability of the sites investigated in the feasibility studies which are included in the body of material for the selection of sites for site investigation.

The Government's approval of this additional material would entail approval, as a matter of principle, of the KBS-3 method as a basis for future technical development and site selection work. However, at the same time, it should be emphasised that such approval does not, in any way, anticipate or restrict the full evaluation and licensing of future facilities, under the Act on Nuclear Activities and the Environmental Code.

3. SKI proposes, as an additional condition, and in accordance with the intentions concerning extended consultation and environmental impact assessment provided in Chapter 6, §§ 4-5 of the Environmental Code, that the Government should stipulate that SKB must consult with the municipalities concerned (i.e. the municipalities involved in feasibility studies), county administrative boards, authorities and other bodies with respect to the additional material that SKB must provide. The EIA forums established in the counties and municipalities concerned should be used as far as possible. An account of this process of consultation and what has emerged from it should be included in the additional material that SKB is to provide.

4. SKI proposes that the Government charge SKI with the task of evaluating the additional material presented. This will include an evaluation of how viewpoints emerging from the consultation process have been taken into account. SKI's evaluation should include comments from reviewing bodies. SKI should – as in the case of the licensing of the construction of Stage 2 of CLAB (Central Interim Storage Facility for Spent Nuclear Fuel) – arrange public meetings in the municipalities concerned in order to further ensure that all relevant viewpoints and issues are taken into account in SKB's material as well as in the review statements of SKI and other authorities.

The Government does not necessarily have to set a time limit for the additional material which is to be submitted by SKB. As shown above, it is in the interest of SKB and the municipalities concerned that the process does not take too long. On the other hand, one reason for setting a time limit is that this would be a way for the Government to clearly demonstrate to the municipalities that it feels responsible for ensuring that the process makes progress. In such a case, the aim should be to announce a government decision by no later than June 30, 2001 (Figure 2.3).

In SKI's view, the Government should particularly emphasise, in its decision, that previous RD&D programme reviews have entailed more opportunities for consultation than those touched upon in points 3 and 4 above, and that this process is not a new one, but rather an opportunity for ultimate reconciliation and for adding material prior to an important stage in the decision-making on site selection and the future RD&D programme.

2.3.4 SKI's Proposal for the Clarification of Certain Issues Relating to Future Work in the Decision-Making Process, Including the EIA

The Environmental Code entered into force as of January 1, 1999. The Environmental Code requires SKB to submit an Environmental Impact Statement (EIS) as a basis for decisions

concerning planned nuclear facilities (repository and encapsulation plant). The Environmental Code regulates the content of the document (EIS) and the process of preparing the document (EIA) which, in the case of nuclear facilities, must be achieved through an extended consultation, in accordance with Chapter 6 § 5 of the Code.

In their review comments, municipalities concerned state that they would like to have greater clarity with respect to when a formal EIA actually starts. For several years, a process, which is similar to an EIA, has been in progress in Oskarshamn Municipality, under the leadership of the County Administrative Board of Kalmar County (cf. government decision of May 18, 1995). This process has been conducted on a voluntary basis and without any legislative requirement. Through this process, it has been possible for representatives from SKB, the municipality, the county administrative board, SKI and SSI to constructively discuss issues relating to the content of future EIS. Similar groups have also been established in connection with SKB's other feasibility studies. This has made it possible to lay an

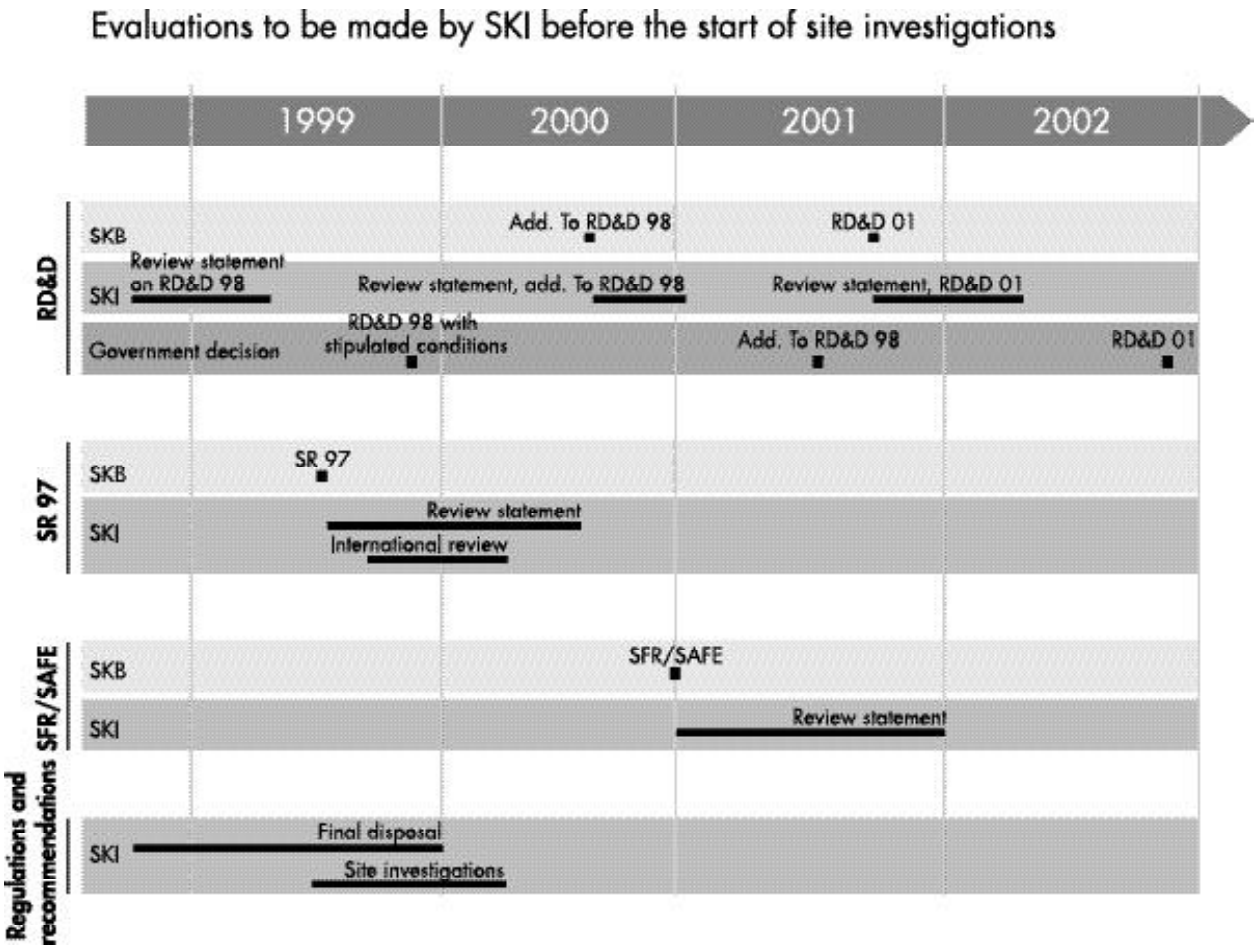

Figure 2.3
Overview of major evaluations of SKB's work which SKI will have to conduct over the next four years. The figure is based on the assumption that SKB, in accordance with the proposal in this review statement, will be required by the Government to submit additional material to supplement RD&D Programme 98, prior to the start of site investigations. In addition to SKB's RD&D Programme reports and the new safety assessment study for the repository (SR 97), during the period, SKI must also evaluate SKB's new safety report (SAFE) for the repository for radioactive operational waste at Forsmark (SFR).

adequate foundation for conducting extended consultation in accordance with the Environmental Code.

Extended Consultation

According Chapter 6, §§ 4-5 of the Environmental Code and the Ordinance on Environmental Impact Assessment (1998:905), a formal process involving extended consultation and environmental impact assessment is to be initiated through a decision made by the county administrative board concerned with when SKB announces its intention to make preparations to submit an application for permission to site a facility for the management or final disposal of spent nuclear fuel in a municipality in the county. In SKI's view, this should be interpreted to mean that extended consultation should be initiated when SKB starts site investigations, since the aim of these investigations is to prepare an application for siting permission in one of the municipalities (see Figure 2.2). Through the extended consultation, municipalities concerned, SKI, SSI and other competent authorities have the opportunity to influence the content of the EIS which is to be appended to a licence application under the Environmental Code and Act on Nuclear Activities.

Contents of an EIS

SKB's proposed table of contents for an EIS comprises the compulsory issues stipulated in the Environmental Code which have been adequately adapted to the final disposal issue. In SKI's opinion, SKB's proposed table of contents can comprise a basis for further discussion with actors concerned within the framework of the extended consultation, in accordance with the Environmental Code.

Co-ordinated Licensing

One issue which is unclear at present is how to co-ordinate the licensing of allowability, in accordance with the Environmental Code, with the licensing, in accordance with the Act on Nuclear Activities, of future facilities in a final disposal system. It is important that the Environmental Court, municipalities involved and the Government should have access to the complete review statements of the competent authorities – SKI and SSI – on the Act on Nuclear Activities when these bodies make decisions on allowability, in accordance with the Environmental Code. This is particularly important for municipalities which can then exercise their veto right. One possibility is for the Government to make a decision on allowability, under the Environmental Code, at the same time as it makes a decision on whether to grant permission for final disposal facilities under the Act on Nuclear Activities. Like many of the reviewing bodies, SKI would like to have clarification from the Government with respect to how this co-ordination will take place. In SKI's opinion, clarification is necessary in order to direct the co-ordination of licensing, which has been desired by the Government in previous decisions, even at a lower level, since the question of allowability is now to be prepared by the Environmental Court and not by authorities and ministries. Several municipalities have also expressed a desire for greater clarity with respect to how the Government's right to override a municipal veto can be applied.

SKI's Proposal

In order to clarify the regulations regarding future work in the decision-making process – as requested by several of the reviewing bodies – SKI proposes that the Government, in addition to the position that it has adopted in previous government decisions should:

- Propose to the Swedish parliament to amend the Act on Nuclear Activities by including a

provision whereby the Government's licensing, under the Act on Nuclear Activities, of the construction of nuclear facilities is to be co-ordinated with the licensing of allowability, in accordance with the Environmental Code.

- Furthermore, clarify the criteria on the basis of which the Government's right to override a municipal veto is to apply.

- Stipulate that the start of site investigations is to be viewed as the first stage in SKB's preparation of an application for permission to construct a repository under the Act on Nuclear Activities and the Environmental Code. Thus, extended consultation and environmental impact assessment prior to licensing under Chapter 6, §§ 4-5 of the Environmental Code, is to be initiated at that time.

3 Method Selection and System Analysis

3.1 Introduction

SKI's evaluation of SKB's selection of a method for the final disposal of spent nuclear fuel and long-lived waste is presented in this chapter. In SKI's opinion, which is also shared by SSI (see below), such an evaluation should be based on the government decision concerning RD&D Programme 95 (December 19, 1996). The Government stipulated that SKB, in its future work, should conduct a system analysis of the entire final disposal system, and that the system analysis should include a description of alternative methods. The idea that an account of the method selection should be included in SKB's system analysis report has subsequently been developed and clarified in a memorandum which was jointly written by SKI and SSI (SKI dnr: 5.8-971083, SSI dnr: 6220/1994/97 from March 5, 1998). The evaluation of the method selection and the system analysis should, therefore, be conducted within the same context.

With reference to the above-mentioned memorandum, SKI would like to emphasise that the system analysis should be viewed as a tool for:

- justifying the selection of a strategy and method for the disposal of spent nuclear fuel and nuclear waste

- showing how safety and radiation protection criteria are satisfied by the selected method.

The fact that the method selection is viewed in this way, as a part of the system analysis, should improve the clarity of reporting. However, SKB has not been able to make full use of these possibilities in its RD&D Programme 98. Already in early 1998, it became clear that it would not be possible for SKB to present a complete system analysis in RD&D Programme 98, i.e. the essential safety

"***system analysis***, analysis of complex systems as a basis for decisions, often using mathematical tools. Such systems include industrial manufacturing systems, transport systems etc as well as ecological systems. The aim of a system analysis is to determine how the resources at one's disposal should be used to achieve the specified goals in the best possible way".

(Swedish National Encyclopaedia)

SKI and SSI propose the following definitions for the concepts occurring in this context:

System analysis: the implementation of an analysis of an overall system for the disposal of spent nuclear fuel and nuclear waste The analysis should comprise a study of how the objectives of safety and radiation protection are fulfilled on different time scales and for different facilities. The term can also refer to a comparative study between different system alternatives. In principle, the system analysis can be said to consist of two parts: system description and system evaluation.

System description: A description of one (or several alternative) system(s) as a basis for the system evaluation.

System evaluation: The part of the system analysis where (in this case) an overall assessment of safety and radiation protection is made with respect to the various stages of the final disposal system and which covers different time periods.

System analysis reporting: One or several reports/background reports comprising the presentation of a system analysis.

assessment study of the final disposal system for spent nuclear fuel, SR 97, has not yet been completed.

SKI's and SSI's view of the content of a system analysis report has, in spite of this, been used as a basis for the evaluation. One important reason for this is that SKB's system analysis will have to be presented several times during the decision-making process, for example, it will also be needed as a basis for an application to construct planned facilities. Therefore, it is essential that the opinions of the authorities should be taken into account, already at this stage, by SKB, in its future work. An additional reason is the requirements regarding adopting a position on method selection which have emerged in recent years and which are evident from the comments of the reviewing bodies. SKI is of the opinion that the system analysis and system analysis reporting, as defined in the authorities' joint memorandum, should be used as a tool to clarify and justify the selection of a method.

In their previous statements concerning SKB's programme, SKI and the Government have seemed to adopt a "wait-and-see" approach to the method selection and the studies of alternative methods. This is partly due to two reasons:

- the stipulations of the Act concerning the comprehensiveness of the research programme, also stated in the Ordinance, which contains explicit requirements on the evaluation of alternative methods.

- SKI also wished to avoid adopting a position with respect to a method, which it would subsequently have to evaluate in connection with license applications.

This cautious approach may have been misinterpreted to mean that it has been unclear whether the KBS-3 method has all along been considered to be the most suitable alternative for further development work.

3.2 SKI's and SSI's Joint Evaluation

In SKI's and SSI's opinion, as expressed in the memorandum of March 1998, method selection and system analysis should be seen as two interrelated activities. The reporting of the method selection should be viewed as a part of the reporting of the system analysis. This opinion has been the basis of the joint evaluation carried out by the authorities.

In SKI's and SSI's view, SKB has made a good start on the work on a complete system analysis. In early 1998, it became clear that the system analysis report would not be complete in connection with RD&D Programme 98.

SKB has clearly described method selection in the main report of RD&D Programme 98 and in the "Alternative Methods" report. SKI and SSI have no essential objections to make to SKB's selected strategy. On the other hand, the description of the justification of the selection of different strategies and the account of the selection of strategies must be improved from a logical and pedagogical standpoint.

Alternative Methods

On the basis of the material presented by SKB, it is difficult to determine how the alternative methods have been selected. It would be desirable to have a more systematic comparison, based on a somewhat more detailed assessment of the advantages and disadvantages of the alternatives.

Apart from the main alternative (KBS-3), the system descriptions for the alternatives which must be compared in the system analysis are inadequate. Furthermore, the actual comparative analysis, based on the assessment of consequences in terms of safety and radiation protection is lacking. However, as in all previous presentations of SKB's programme, SKI and SSI consider that the

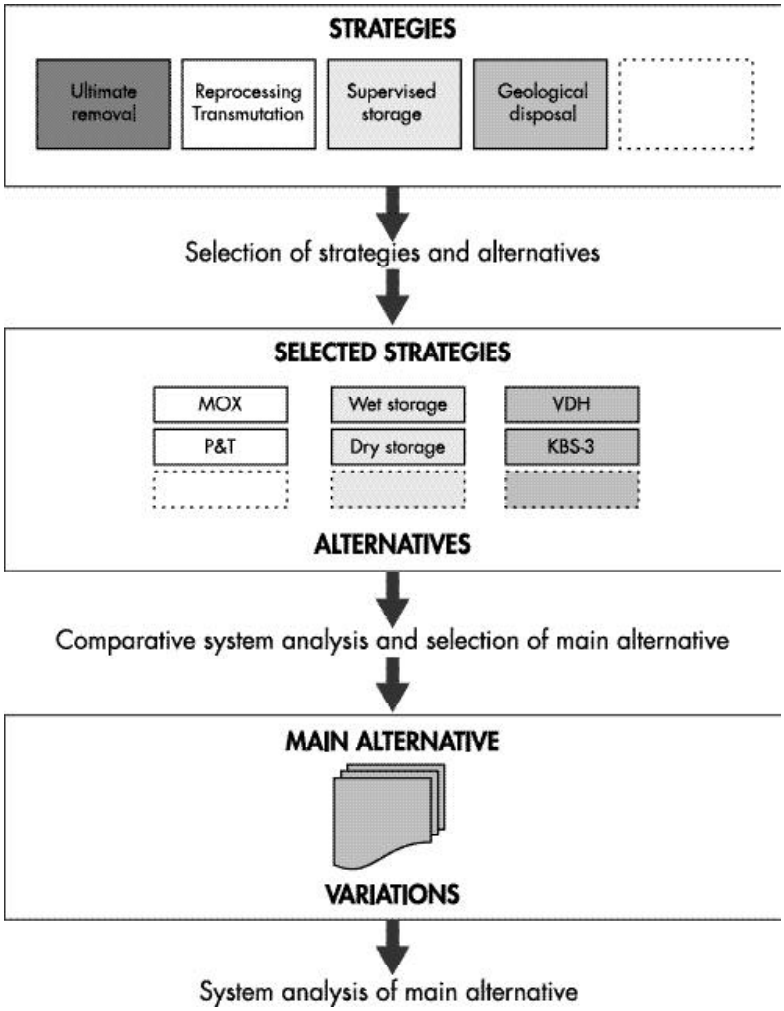

Figure 3.1
SKI and SSI's proposed model for interrelationships between system analysis and method selection.

In the first stage (box at the top: STRATEGIES) a number of strategies are defined. Although these strategies are described in general terms, the description is so complete that an initial, well-founded selection of strategy/strategies and alternatives can be made.

This stage is then followed by "Selection of Strategies and Alternatives", which, in fact, comprises two sub-stages: First the selection of a strategy/strategies and then the selection of alternatives within one, or several, strategies so that work can proceed to the next stage. Several strategies can exist at this stage due to the fact that different types of criteria are used: Technical, economic, ethical, legal and societal criteria. In the case in question, the strategy of "Ultimate Removal" is excluded on the basis of being unrealistic.

In the third stage (middle box: SELECTED STRATEGIES AND ALTERNATIVES), the selected alternatives are defined and described as completely and in such detail that a comparative system analysis is possible.

In the fourth stage ("Comparative System Analysis and Selection of Main Alternatives"), the consequences of the different alternatives are assessed so that a comparison on the basis of various criteria, including safety and radiation protection, can be made.

In the next stage (box at the bottom: MAIN ALTERNATIVES WITH VARIATIONS) the main alternative is defined and described, largely along the lines of SKB's system analysis report for KBS-3, including safety reports for the various facilities within the system.

In the final stage, the system analysis focuses on the main alternative. The analysis must show that the safety and radiation protection criteria for all of the parts of the system are fulfilled and that safety and radiation protection is reasonably distributed among the different facilities and over different time periods. This system analysis must also provide the justification for selecting or prioritising variations (e.g. horizontal or vertical tunnels in the case of the KBS-3 method) within the main alternative.

selection of geological disposal as a main strategy is correct. Furthermore, the authorities also consider that, in view of the material available, SKB's selected main alternative, the KBS-3 method, is a reasonable choice. However, the authorities will have the important task of evaluating SKB's forthcoming system analysis and of deciding whether or not this opinion can be confirmed.

KBS-3

The reporting of the system analysis of the main alternative is largely complete and well-structured. However, SR 97, the essential safety report for SFL 2 and the separate safety report for SFL 3-5, are still not available. A detailed discussion of how balance, in terms of safety and radiation protection, is achieved in the system is also necessary. The structure and content of the safety reports presented in connection with RD&D Programme 98 are generally adequate. However, it is not possible – and it is not the intention – at this stage to state an opinion on the extent to which these reports show how existing safety and radiation protection criteria can be fulfilled.

In their summary, SKI and SSI also present their opinion on how SKB should conduct future work (see below).

3.3 SKI's Overall Evaluation

Final Disposal

The selection of a method comprises several stages. In the first stage, a strategy is selected, i.e. the main principle for the disposal of the spent nuclear fuel and long-lived low and intermediate level waste (see Figure 3.1). With respect to this stage, SKI, like SSI, is of the opinion that SKB's choice of geological disposal is correct. In SKI's opinion, the selection of the KBS-3 main alternative as the main strategy for research and technical development appears to be the most suitable in relation to other alternatives. This conclusion is primarily based on the application of basic ethical principles concerning what is known about the technical feasibility of the different alternatives as well as the possibility for the retrieval of deposited spent nuclear fuel.

Transmutation

SKI shares SSI's view that the strategy of transmutation can, for the time being, be excluded from SKB's programme, as a realistic alternative to final disposal. Transmutation as a method is associated with significant technical and economic uncertainties which probably require decades of technical development to overcome. This method would also involve transferring responsibility to future generations. The facilities would also probably be so large and complex that Sweden would not be able to develop, construct and operate them on its own: a large accelerator would be required, several reactors and a reprocessing plant. It should be emphasised that some form of final disposal will still be necessary, since all long-lived radioactivity cannot be eliminated. However, in connection with the system analysis report, SKB must improve its description of the implications of transmutation, so that it can be understood by a broader audience than the regulatory authorities, and explain why this strategy is not suitable for Swedish conditions.

System Analysis

SKB's system analysis is not yet complete. However, the material presented in RD&D Programme 98 can be viewed as a good start. Even if SKB's presentation of the system analysis and method selection is incomplete within the framework of RD&D Programme 98, this does not mean that the justification for the selected method has been lacking in the material presented by SKB ever since SKB started reporting on its programme in 1984. It is important that all of this material should now be compiled and reported within the same

context, in a way that makes it easily accessible to a broader audience than that of the competent authorities. It is also important that SKB presents its method selection on the basis of system analyses. In SKI's opinion, the system analysis and the system analysis reporting should incorporate the stages described in SKI's and SSI's joint memorandum of March 5, 1998.

SKB must supplement its reporting no later than in connection with the selection of sites for site investigation and the authorities must evaluate the new material that SKB has presented. What might be called "final approval" can only be given after review of applications for permission to construct an application plant and a repository (see Chapter 2). However, periodic judgements of the compliance of the repository and system will be required as long as they are in operation, including prior to the planned full-scale operation and prior to the closure of the repository.

SKI, like SSI, is of the opinion that it is important that SKB, during the coming period and in dialogue with the authorities, should examine and define its view of the safety analysis. SKB should clarify how it intends to report its justification of the method selection and the selection of variations on the main alternative. SKB should also state how detailed it intends its account of the consequences of choices to be and how the scope for freedom of choice which is provided within different subsystems will affect these systems and the system as a whole as well as how this will change with time.

A detailed and broad history of the method selection and its evaluation by the authorities should be published in a separate report which provides a pedagogical explanation of the process for the benefit of a broader audience. International developments should be presented in a similar way, in a separate report.

In connection with the selection of sites for site investigation, SKB should:

- Present a complete system analysis, including an overall assessment of the radiation protection and safety aspects of the various strategies for the management of spent nuclear fuel (reprocessing/transmutation, supervised storage, geological disposal) as well as of selected alternative methods within these strategies. The report should clearly specify the basis used for the selection of the different alternatives.

- Present a complete system analysis of the main alternative.

4 Siting

4.1 Introduction

Considerable attention has been devoted to issues concerning the siting of the remaining facilities necessary for the final disposal of spent nuclear fuel and nuclear waste by both SKB and the reviewing bodies. At present, the major issues concern the body of material which will provide a basis for SKB to select two sites for site investigation as well as how this site selection process should be carried out.

The municipalities involved in feasibility studies, SKB and others have stated that site investigation is such a major step that the authorities and the Government should clearly state their opinion on the method and site selection. SKI shares this view, and consequently, SKI's evaluation in this chapter largely concerns the body of material which should be available before the start of site investigations.

Previous RD&D Programmes

Considerable attention has also been devoted to various aspects of siting in previous research programmes, reviews by external bodies and government decisions. For example, in its decision on RD&D Programme 95, the Government required that SKB should, no later than in connection with RD&D Programme 98, account in greater detail for the factors which should determine the selection of a suitable site for a repository. Such an account e.g. the comparative study of siting in north or the south of Sweden and of siting along the coast of Sweden or in the interior, has been submitted and is evaluated in greater detail below. The Government has also particularly emphasised the importance of the municipalities concerned having access to SKB's entire body of material on this issue before they make a decision on whether or not to allow SKB to conduct site investigations within their municipalities. SSI's views on the body of material which should be available in connection with the selection of sites for site investigations are presented in Section 4.2.3.

Environmental Impact Assessment (EIA)

The Government has also stated its opinion on EIA and the site selection process. The Government's decision of May 18, 1995 on RD&D Programme Supplement 92, was an important starting point for the consultation processes relating to the content of Environmental Impact Statements (EIS), conducted on a regional level. The decision emphasises the task of the county administrative boards in co-ordinating liaison between municipalities, authorities etc. in connection with SKB's feasibility studies, site investigations and detailed investigations. In SKI's opinion, the importance of these various "Environmental Impact Assessments" (EIAs) must be viewed in the light of the Government's unambiguous statement of opinion.

4.2 SKI's Overall Evaluation

4.2.1 Environmental Impact Statements (EIS)

The Environmental Code, which entered into force on January 1, 1999, has an impact on the final disposal programme in several ways. Licence applications submitted by SKB in the future are to be evaluated in accordance with the Environmental Code. Consequently, it must

be established how co-ordination with licensing under the Act on Nuclear Activities should be achieved. Furthermore, the Environmental Code contains new regulations for the content and structure of Environmental Impact Statements (EIS). SKI concludes, as do several reviewing bodies, that it is important for the Government, in its decision on RD&D Programme 98, to state its opinion on the application of the Environmental Code in connection with SKB's ongoing site selection process and prior to future licensing actions.

Consultation Required by the Environmental Code

One question which was raised by several of the reviewing bodies is that of determining when the EIA actually starts. It is important to identify suitable points within the siting process for initiating and conducting the early and extended consultation processes required by Chapter 6 of the Environmental Code.

According to the Environmental Code, SKB must conduct consultations at an early stage with the county administrative board and individuals who are assumed to be particularly affected by the issue (Chapter 6, § 4). Prior to this early consultation, SKB is to submit information concerning the siting, scope and design of the activity and the anticipated environmental impact. Following early consultation, the county administrative board must make a decision concerning extended consultation and Environmental Impact Assessment (EIA), (Chapter 6, § 5). Such extended consultation is compulsory when preparing a licence application for facilities for the management and final disposal of spent nuclear fuel and nuclear waste (EIA Ordinance (1998:905)). SKI is of the opinion that SKB's early consultation with the county administrative boards concerned should be initiated once the municipalities concerned have decided to participate in site investigations. Since early consultation is to be followed by a decision by the county administrative board, this will ensure that there is a clear and formal start to the extended consultation and EIA stipulated in the Environmental Code (Figure 2.2). In SKI's opinion, it is advantageous that such a decision should be made in conjunction with the vital stage of site investigation within SKI's programme. A process for SKB's planned encapsulation plant can be conducted in a similar manner.

Content of an EIS

SKB's proposed table of contents for an EIS comprises the compulsory issues stipulated in the Environmental Code which have been adequately adapted to the final disposal issue. In SKI's opinion, SKB's proposed table of contents can provide a basis for further discussion with actors involved in an extended consultation process, in accordance with the Environmental Code.

Additional Reporting

SKI supports SSI's proposal that SKB should be required to submit material which will comprise the basis for SKB's selection of sites for site investigation along with its plans for achieving consultation in the different stages of siting. SKI therefore proposes that the Government should stipulate such a condition for SKB's future work.

Strategic Environmental Assessment (SEA)

Several reviewing bodies have proposed that a process of strategic environmental assessment (SEA) of SKB's final disposal programme should be introduced. All of these bodies share the view that the selection of a method for final disposal can be based on such an assessment. SKI shares the view that the nuclear waste issue covers many strategic issues, primarily the selection of a method which is often discussed in the various processes of consultation in

connection with SKB's feasibility studies. Such issues have also been the focus of attention in previous RD&D programmes, programme reviews and particularly in government decisions. For example, SKI considers that, in accordance with the Government's requirements, a system analysis of the entire final disposal system, including an account of alternative solutions to the KBS-3 method, is an important basis for adopting a position on SKB's selection of a method.

A couple of reviewing bodies refer to the work which has been in progress for several years within the European Commission on preparing a directive on strategic environmental assessment. A revised directive proposal was presented by the Commission in 1999. However, it will be a long process before such a directive is adopted and can be implemented in Swedish legislation. In SKI's opinion, it is not reasonable, at present, to develop a Swedish process for the nuclear waste disposal issue on the basis of the directive proposal. However, SKI considers that the proposal may be a source of assistance and inspiration to SKB, authorities, municipalities and other parties involved in the work of developing the Environmental Impact Assessment process.

EIA Commission

The proposals for establishing a separate body for supervision of and/or responsibility for EIA, put forward by some reviewing bodies, is closely related to the issue of SEA. SKI does not support this proposal. In SKI's view, the most important factor is that the various actors in the nuclear waste disposal issue should have transparent and unambiguous roles and responsibilities. At present, these roles are sufficiently unambiguous in both the Act on Nuclear Activities and the Environmental Code. It is clear that SKB is responsible for preparing the EIS and any other basis for decision-making before submitting a licence application. In SKI's opinion, the authorities which are responsible for supervision and review, under various legislation, of the planned activity are also responsible for supervising the EIA to ensure that it is adequate. SKI therefore concludes that an EIA Commission for nuclear waste disposal is not necessary. On the contrary, such an organisation would lead to a lack of clarity in relation to the statutory and established allocation of responsibilities.

Support to Municipalities and Organisations

When SKB started conducting feasibility studies, the municipalities' need for resources to provide information to the general public came to the fore. This resulted in amendments to the Financing Act and Ordinance so that, since 1995, SKI can grant municipalities where feasibility studies are being or have been conducted, compensation for information-related costs. In SKI's opinion, ample provision has been made for compensation to the municipalities involved in feasibility studies, even if the level of compensation may have to be adjusted in the future.

On the basis of the current wording of the Financing Act and Financing Ordinance, environmental organisations cannot obtain funds directly from the Nuclear Waste Fund. However, the new Environmental Code attaches considerably greater importance to environmental organisations than the previous legislation. In its review statement, SSI proposes that the Government addresses the problem of how resources can be placed at the disposal of environmental organisations. In the light of the recent legislative changes, SKI agrees with SSI's proposal that the Government should investigate the possibility of providing support to environmental organisations which are particularly involved in the nuclear waste disposal issue.

4.2.2 General Siting Studies and Feasibility Studies

North-South/Coast-Interior

In SKI's opinion, SKB's comparative study of siting in north or the south of Sweden and of siting along the coast or in the interior of Sweden is a good start in identifying and discussing important siting factors.

SKI concludes that, with the approach adopted by SKB, involving qualitative reasoning, it is difficult for SKB to draw any unambiguous conclusions about the advantages and disadvantages of siting a repository in different parts of Sweden. In SKI's view, one problem in this context is that SKB has avoided establishing quantitative goals which should be answered in the analysis and guidance in future siting.

SKI considers for example, that regional modelling of the groundwater flow with respect to the importance of recharge and discharge areas, combined with SKB's approach in the North-South/Coast-Interior study, should result in less ambiguous conclusions and, thereby, provide a more useful basis for decision-making prior to the selection of sites for site investigation.

SKI therefore proposes that SKB should increase the level of detail of this study by a degree and use the data from the completed and ongoing county-specific general siting studies.

County-specific General Siting Studies

SKI considers SKB's intention of conducting county-specific general siting studies in 20 counties (of which 10 have been published) to be laudable. In SKI's view, these studies should provide adequate possibilities for identifying additional municipalities that are suitable for feasibility studies. The level of ambition for the implementation of the general siting studies has been appropriate. SKI considers the county-specific studies so far reported to be of good quality. SKI also considers that the reports fulfil the function of demonstrating, to a wider audience, SKB's evaluation of potential with respect to geoscientific factors.

The Geological Survey of Sweden has presented new data in the general siting studies which show plastic deformation zones (old deformations). Although this is satisfactory, SKI would like to see a similar level of ambition with respect to brittle deformation zones (younger deformations) on a regional scale. A presentation of coherent brittle-tectonic maps on a suitable scale could probably show structural patterns which have previously not been analysed with respect to their importance to the siting of a repository.

Furthermore, in SKI's opinion, SKB should have more clearly accounted for the selection of data in the county-specific general siting studies by more clearly describing the limitations in the data as well as the general siting studies.

Feasibility Studies

With respect to feasibility studies, SKI has not found any reason to change, in its evaluation of RD&D Programme 98, the overall evaluation that it made in connection with RD&D Programme 95. At that time, the evaluation was that:

- SKI shares the view that municipalities are suitable administrative units for feasibility studies
- several important geoscientific conditions must be investigated on a regional scale (this work has been started in connection with SKB's county-specific general siting studies)
- SKI supports SKB's intention to identify actual potential sites for a repository in the municipalities concerned

- SKB must conduct field surveys in the areas identified (and possible additional geophysical measurements) of important existing geoscientific data in order to reduce the risk of an early decision based on deficient data making a significant impact on the site selection process.

In its evaluations (ranking of potential repository sites in a municipality) SKB also takes into consideration other siting factors besides geoscientific factors. In SKI's view, it is important that SKB, as far as possible, should account for the emphasis placed on different factors when ranking sites in the different feasibility studies and account for how it has treated different available data for the different sites.

4.2.3 Selection of Sites for Site Investigation

Basis for Site Selection

In SKI's opinion, the material which SKB plans to submit prior to the transition to site investigations appears to be reasonable and, providing that the findings of this review statement are taken into account, can be expected to provide an adequate basis for a review statement concerning the final disposal method and the selection of sites for site investigation.

Evaluation and Decision

SKI concludes, like the municipalities involved in feasibility studies and SSI, that the authorities should conduct an evaluation of the entire

Activity: \ Reporting:	RD&D Programme 98	When selecting 2 sites for site investigations	Prior to the start of site investigations
System analysis [2, 3]	Preliminary report	Full report	Updates taking into account work on canister development etc.*
Safety assessment [3]	Not included as a separate report (SR 97). Report planned for August 99.	Report submitted and subjected to international review and evaluation by authorities	Evaluation by SKB and presentation of additional material taking into account the findings of regulatory evaluations*
Site selection [3]	Reports from general siting studies and feasibility studies as well as structure of siting factors	Complete body of material for selection of at least 2 sites for site investigation	Updates taking into account possible supplements to feasibility studies*
Site investigations[3]	Preliminary plans	General programme	Site-specific programmes
EIA	Proposal for content of the EIS	Plans for implementation based on the requirements of the Environmental Code	Site-specific programmes for extended consultation on EIA in accordance with Environmental Code*

Table 4.1
Summary of SKB's published and planned reports prior to the start of site investigations. Additional material proposed by SKI is marked with "*".

[2] Previous requirements on reporting were established in the government decision of May 18, 1995, concerning the RD&D Programme 92 Supplement.

[3] Requirements on reporting were established in the government decision of December 19, 1996, concerning RD&D Programme 95.

body of material that SKB intends to present for the selection of sites for site investigation. SKI also shares the opinion that such an evaluation should be followed by a government decision. Therefore, in addition to general siting studies, study sites, feasibility studies etc., the overall evaluation of the authorities and the government decision should also include SKB's SR 97 safety assessment, a complete system analysis and SKB's proposal for the site investigation programme. In SKI's opinion, it is reasonable for SKB to also include proposed sites for site investigation along with a justification of the selection of these sites in the basis for decision-making. However, the ultimate selection of sites for site investigation should not be made by SKB before the authorities have evaluated and the Government has made a decision on the additional material submitted by SKB (see Figure 2.3).

Proposal for Additional Material

SKI therefore proposes that the Government stipulate conditions for SKB's future work which will include submitting additional material (see Table 4.1) prior to the selection of sites for site investigation and the review by the authorities and external bodies, followed by a government decision, as in the case of the RD&D programmes. This will give authorities, municipalities involved in feasibility studies and other parties concerned the possibility of evaluating the practical application of siting factors and criteria.

Selection Procedure and Criteria

In SKI's opinion, in RD&D Programme 98, SKB has presented an adequate structure for defining siting factors and general safety functions prior to the selection of sites for site investigation and site evaluation.

SKI shares SKB's opinion that the suitability of a site for a repository must ultimately be judged on the basis of an integrated safety and design analysis which takes into account uncertainties and the interaction between different factors. The criteria fulfil an important function in clarifying what characterises a suitable site for a repository. However, on their own, the criteria do not provide an adequate basis for judging whether the site complies with the basic safety criteria.

Balancing of Factors

Like Oskarshamn Municipality, SKI emphasises that it is important for SKB to account for how it balances the various siting factors (safety, technology, land, environment and society) in the selection of sites for site investigations. On the basis of an up-to-date safety assessment (SR 97), SKB must also reconcile and clearly account for the minimum criteria and discriminating factors which determine whether a site can be judged to be suitable for a repository.

The Biosphere

SKI concludes, like the municipalities involved in feasibility studies, SSI and the Geological Survey of Sweden, that the authorities should improve the investigation and account of the importance of biosphere conditions, recharge and discharge areas as siting criteria.

Functions of the Bedrock

SKI concludes that SKB's work on defining requirements and preferences relating to basic safety functions which can be made with respect to the function of the bedrock is closely connected to the development of a description of the repository process system. The aim of the description in the safety assessment is to identify and describe all of the processes and conditions which can affect the performance and safety of the repository. In SKI's opinion, SKB should improve the explanation of how these activities have been co-ordinated.

4.2.4 Site Investigations and Site Evaluation

Geoscientific Site Investigation Programme

In SKI's opinion, it is positive that SKB is planning to conduct the site investigations in stages with periodic performance and safety assessments, since this will give SKB an opportunity to interrupt the investigation at a site if the site is not considered to be suitable for further study.

SKI agrees with SKB that the Äspö Hard Rock Laboratory has given SKB access to established measurement methods and expertise for conducting site investigations. SKI also views SKB's programme for the further development of certain measurement methods and instruments as a positive step and concludes that SKB has taken SKI's previous recommendations fully into account.

Measurement Methods

At the same time, SKI now concludes, as in previous RD&D statements, that considerable work remains to be done to develop individual measurement methods and, particularly, to determine how different measurements should be combined into a suitable site investigation programme prior to the safety assessment. In SKI's opinion, SKB must show that it has relevant measurement methods in order to determine, on a site-specific basis, some of the more critical parameters in the safety assessment. This applies, for example, to the measurement methods which are necessary to analyse the retention and retardation capabilities of the bedrock, rock stability and the capability of the bedrock to buffer any changes in the groundwater chemistry. SKI therefore urges SKB to review, and if necessary, develop the measurement methods which can be used to determine these parameters, already at the site investigation stage.

Regional Conditions

In SKI's opinion, it is important that SKB, at an early stage of a site investigation, should prepare the necessary data for determining the large-scale flow pattern and regional trends in geochemical conditions, e.g. deep to saline groundwater around the repository site. SKI would therefore like to see an account of the measurement work, e.g. deep boreholes, which is being planned on a regional scale in connection with a site investigation.

Quality Assurance

SKI also emphasises that SKB, prior to the start of site investigations, should present an overall programme for quality assurance of all of the components of a site investigation (measurement instructions and procedures, a description and verification of measurement instruments, the management of data, including databases, evaluation methods, documentation etc.).

Site Evaluation

In SKI's opinion, SKB's general premises for site evaluation are good. However, a safety assessment (SR 97) is required for an in-depth evaluation and this assessment has not yet been completed. Consequently, SKI intends to wait and present its views on SKB's site evaluation programme once SKB has presented SR 97 and when SKB has presented the entire body of material for site investigation and site evaluation.

SKI is of the opinion that SKB, prior to the planned site investigations, should clarify its strategy for the identification, evaluation and comparison of alternative conceptual models for, e.g. hydrogeology and radionuclide transport. SKI also emphasises that SKB should take into account alternative interpretations and models within other areas such as structural geology and geochemistry etc.

Like Chalmers Institute of Technology, SKI recommends that SKB should review and account for how it intends to manage and document the comprehensive body of data and information which will have to be handled during the site investigations.

5 Technical Development

5.1 General Comments

In Chapter 7 of RD&D Programme 98, SKB describes the status of the development of technology and its programme for future development work within different areas. For natural reasons, there is no sharp distinction between research and development. However, in SKI's opinion, where different activities are reported is not so important. The important factor is that the reporting should be complete and that nothing essential should be omitted.

Performance Requirements

SKB's programme for technical development should focus on meeting the performance requirements which can be made with respect to the different barriers on the basis of safety assessments for each facility. SKB must be able to show that the performance requirements can be fulfilled no later than when it submits a licence application.

In the introduction to Chapter 7 of RD&D Programme 98, SKB reviews and defines "fundamental technical requirements" which, in qualitative terms, correspond to the performance requirements above. SKI is of the opinion that SKB should review the structure of its account of these requirements and of how the requirements can be developed, in stages, into increasingly detailed technical requirements and goals for the development work, as the decision-making process and construction of facilities progress. This applies to engineered and natural barriers as well as barrier functions.

Range of Variation

Another issue of importance to a technical development programme is the range of variation in the design of barriers which SKB will have to specify in its applications for permission to construct facilities. In SKI's opinion, it is not only quite acceptable but also necessary to include a certain range of variation, or freedom of choice, in the licence for a facility. In future reporting, SKB should also address these issues more clearly than it has in RD&D Programme 98, even if the account of freedom of choice in the system analysis report (SKB, 1998) is a good start.

5.2 SKI's Overall Evaluation

5.2.1 Canister

SKI concludes that the development of the canister is seriously underway within several areas such as manufacturing technology for the copper canister and the cast iron insert as well as sealing and control. SKI views this progress as positive. Furthermore, it is particularly valuable that SKB has now established a canister laboratory, where sealing and testing can be developed on a full scale.

In SKI's opinion, the design basis for the canister has been adequately derived from the fundamental canister requirements. However, the justification of these requirements on the basis of the safety assessment of the repository must be improved.

As far as the selection of canister material is concerned, SKI is of the opinion that the mechanism whereby phosphorus affects the creep properties of the canister must be

further investigated. Furthermore, SKI considers that SKB must improve its justification of the requirement on the grain size of the copper.

SKI emphasises that the central issues when deriving the requirements on the wall thickness of the canister are the assumptions and analyses on which the corrosion rates for determining the copper thickness are based and not the use of safety factors. In SKI's opinion, SKB should conduct a new overview of canister corrosion. However, the wall thickness which is selected is determined by several factors, primarily the potential for achieving satisfactory results during fabrication, sealing and control. An important task for SKB will be to balance these factors against each other.

SKI questions SKB's claim that roll-forming and longitudinal welding is a functioning manufacturing method for copper tubes. However, SKI agrees that extrusion and pierce and draw processing are interesting alternatives which should be further investigated (Figure 5.1).

SKI concludes that electron beam welding has not been fully developed on the scale required for canister sealing and that a comprehensive development programme may be required to understand and solve the remaining problems. In SKI's opinion, if the testing of the method in the Canister Laboratory does not show satisfactory results within a reasonable period of time, intensified efforts to develop alternative methods may be necessary.

SKI agrees with SKB that nodular iron is a better choice of material for the insert than cast steel. SKI recalls that the properties of nodular iron are highly dependent on the shape and size of the object that is cast. Consequently, SKB should investigate the

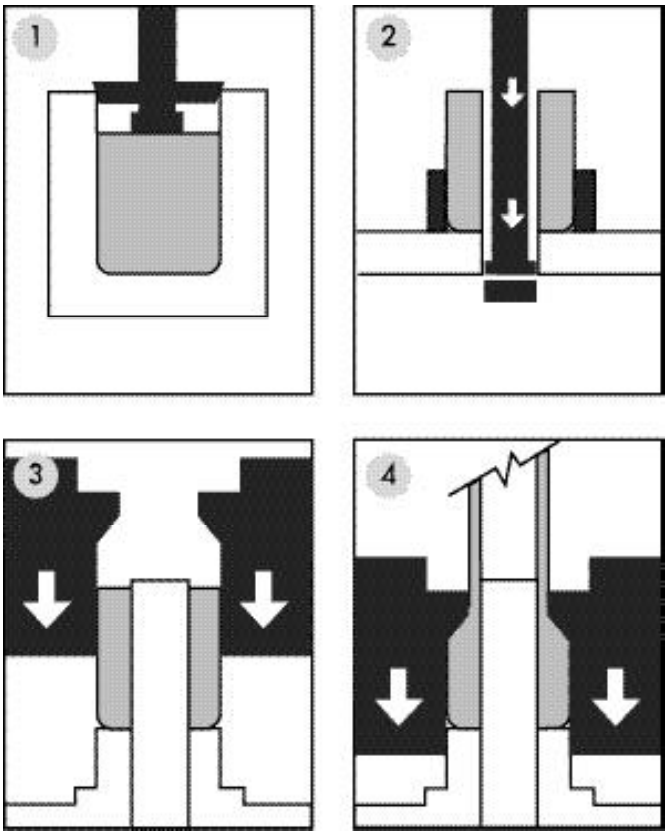

Figure 5.1
Extrusion of the copper canister: comprises a pre-forming stage and the actual extrusion stage. The entire process is conducted using heated material.

1. The copper ingot is forged into the shape of a solid cylinder.
2. The bottom is trimmed out of the cylinder, making it hollow.
3. The hollow blocker is placed in a press (30,000 tonnes).
4. The copper tube is extruded: a tube is made by drawing the heated material upwards from the blocker, a cylindrical mandrel provides the inner diameter and a ring-formed tool provides the outer diameter.

After extrusion, the tube is machined (inner and outer surface) to the right size.

actual mechanical properties of the cast insert, and identify and determine any defects.

In SKI's opinion, SKB has not yet shown through control, how it can comply with the criterion of a maximum of 0.1% defect canisters. SKB must improve the way in which it derives the acceptance criteria for permissible defects in the weld. SKI also emphasises the importance of continuing the development programme for ultrasonic testing and the importance of presenting an account of a similar programme for the development of X-ray testing.

SKI concludes, like Oskarshamn Municipality and the Local Safety Committee at Oskarshamn Nuclear Power Plant, that a critical issue for the technical feasibility of the KBS-3 method is that SKB can show that sealing and control methods actually exist and are suitable for series manufacturing. This means that, no later than at the stage when SKB submits an application for permission to conduct detailed investigations, a number of full-scale canisters must be manufactured, sealed and quality-controlled. Moreover, the canisters must show that they comply with the criteria specified in the assessment of long-term safety.

5.2.2 Encapsulation

In SKI's opinion, the work completed on the design of the canister fabrication and encapsulation plants appears to be reasonable. However, SKI would like to emphasise that the detailed design will be determined by the canister manufacturing and sealing methods which are ultimately selected.

SKI agrees that co-siting the encapsulation plant with CLAB has many advantages. However, in SKI's opinion, a systematic analysis of the advantages and disadvantages

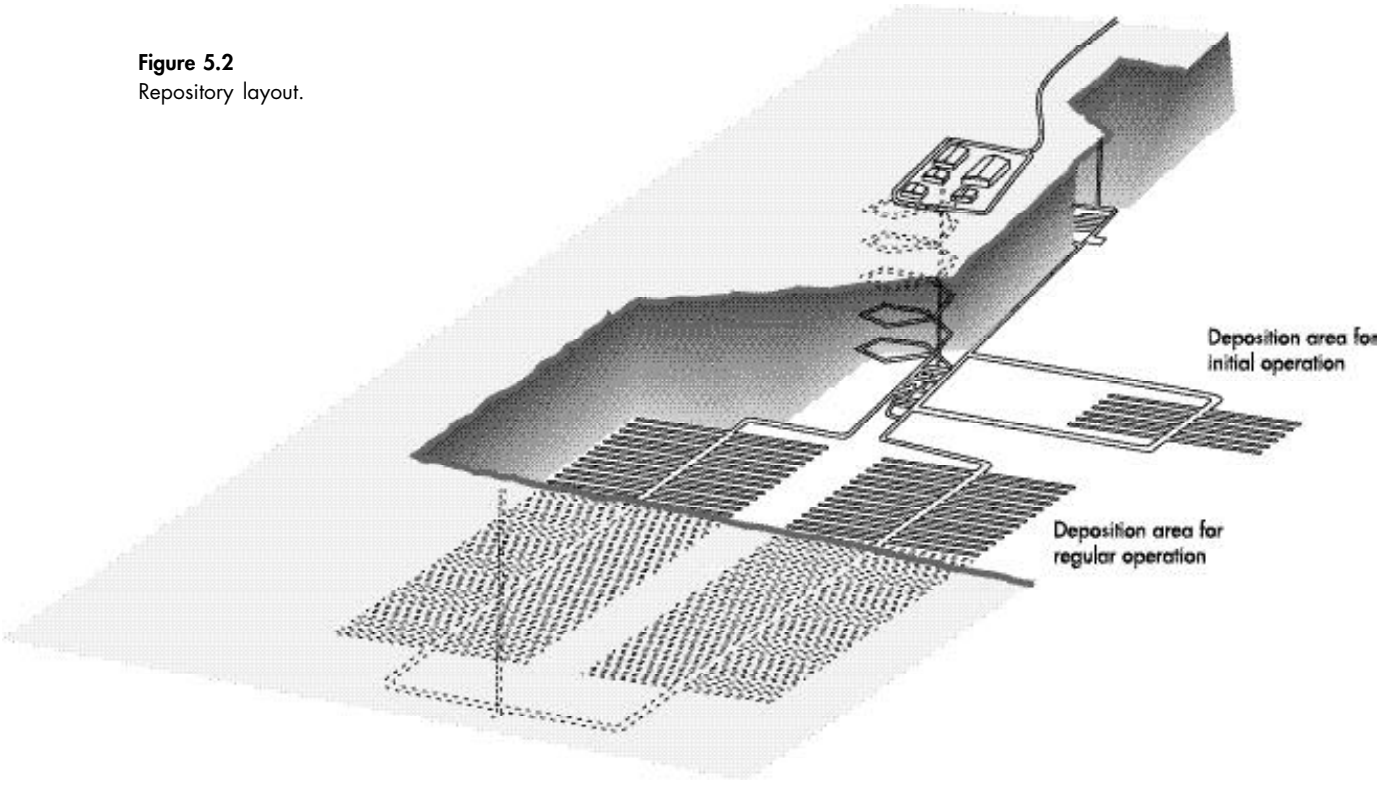

Figure 5.2
Repository layout.

of different siting alternatives should be conducted.

5.2.3 Transport

SKI concludes that the transportation system presented is based on the assumption that the encapsulation plant will be located next to CLAB. However, no account is given of alternatives which do not involve co-siting. Furthermore, no account is given of how canisters damaged during handling are to be returned from the repository to the encapsulation plant.

The transportation of canisters between the encapsulation plant and repository is largely based on SKB's current transportation system for spent fuel and nuclear waste, from which the operating experience has been good. Safety during transportation is mainly based on the use of internationally certified packaging which is designed to withstand considerable stresses.

In SKI's opinion, long-distance transportation by road of canisters containing spent fuel is a less realistic alternative. SKI concludes, like the National Housing Board, that SKB should investigate and consider the alternative of building a new railway, in the event of a siting of the repository in the interior of Sweden, in a region without a railway.

5.2.4 Final Disposal Technology

Many technical issues must be taken into account for the construction of a repository at a depth of 500 m in crystalline bedrock (Figure 5.2). However, since Sweden has considerable experience of rock engineering, SKI sees no major and decisive obstacle to the implementation of the KBS-3 concept from the standpoint of rock engineering. However, issues remain which must continue to be given considerable attention, e.g. blasting and drilling techniques, methods of depositing canisters,

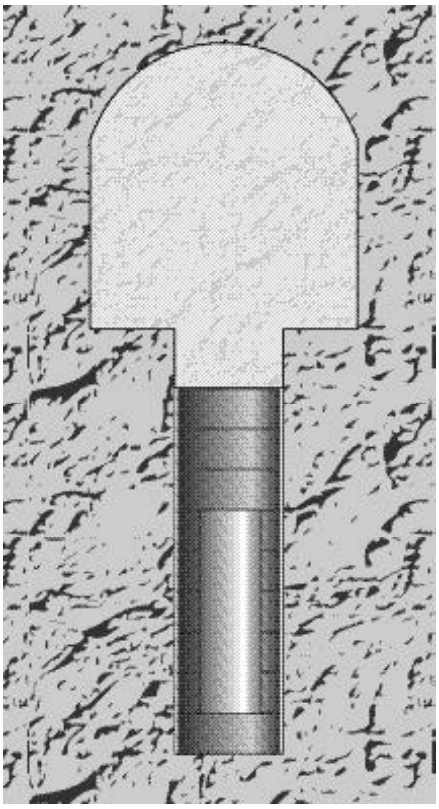

Figure 5.3
KBS-3 concept with canister, bentonite and backfill.

methods of backfilling tunnels and shafts etc. (Figure 5.3).

In SKI's opinion, it is important to develop and use reliable methods to describe the extent of damage zones in tunnels and deposition holes in a repository. An in-depth discussion concerning the interpretation of SKB's results from the disturbed-zone experiment (ZEDEX) in the Äspö Hard Rock Laboratory is presented in Section 7.12 of the Review Report.

As far as the acceptance or rejection of deposition holes is concerned, SKI concludes that SKB has not yet discussed which criteria should apply for the acceptance of a deposition hole. In SKI's opinion, an important issue is how an even resaturation of the bentonite can be achieved and which requirements for water flow to the deposition holes should therefore be made. A decisive factor in this context is whether cement grouting around the deposition holes should be permitted in order to limit the water flow. In SKI's view, SKB should avoid introducing cement/concrete into the respository environment as far as possible.

Further investigation and analysis is required to determine whether an uneven resaturation of the buffer can result in uneven stress distribution on the canister and also disturbance of the barrier properties of the buffer.

SKI's overall evaluation, on the basis of the viewpoints presented above, is that SKB has considerable development work left with respect to final disposal technology (canister deposition, backfilling etc.).

5.2.5 Retrieval and Monitoring

In Sweden, the retrievability of deposited spent nuclear fuel is not yet formally required. However, SKI intends to stipulate such requirements in its future regulations on final disposal. SKI agrees with SKB that retrieval can be achieved in a number of stages; from CLAB, during encapsulation, during deposition, after backfilling and sealing of deposition tunnels as well as after repository closure.

Even if there can be no question of planning for retrieval when it ultimately comes to the final disposal stage, i.e. of viewing the repository as an interim storage facility, SKI is of the opinion that SKB must develop methods for retrieval. In SKI's opinion, methods for retrieval should be developed and full-scale demonstration conducted no later than when a decision is made to start a detailed investigation. Therefore, it is positive that SKB has started to study retrieval technology and SKI is looking forward, with interest, to the results of the planned retrieval experiment at the Äspö Hard Rock Laboratory.

In SKI's opinion, the repository must be designed to ensure that monitoring is not necessary after sealing. If, however, monitoring is carried out, for political or other reasons, this must be done in such a way that repository barriers are not damaged.

5.2.6 Safeguards and Physical Protection

An efficient international safeguards system exists for the transport and handling of radioactive substances. However, SKI would like to emphasise the need for new technology for safeguards from the time that the spent nuclear fuel is encapsulated.

Based on studies carried out within the IAEA, SKI considers that safeguards with respect to a closed repository can be achieved with relatively simple methods such as inspections, seismic measurements and satellite monitoring. This type of control will be conducted as long as treaties on the non-proliferation of nuclear weapons exist (such as the existing Non-proliferation Treaty).

Sweden has an adequate system for the physical protection of nuclear facilities and shipments. A closed repository will not need any physical protection.

6 Safety Assessment

6.1 Introduction

Safety assessment is the method used to systematically analyse and assess the performance and safety of a repository. Consequently, safety assessment reports are an important part of the basis for decision-making that SKB must present, and SKI evaluate, in connection with future licence applications for a repository and encapsulation plant. The safety case is also an important basis for the Environmental Impact Statement (EIS) that is submitted along with a licence application.

In connection with the evaluation of RD&D Programme 95, SKI's evaluation was that SKB had prepared an adequate framework for future safety cases. SKI also stated that SKB should apply and evaluate the methodology by conducting a complete safety assessment, based on site specific data prior to planned site investigations and licence applications for a repository and encapsulation plant. This requirement was subsequently established in a government decision on RD&D programme 95 (December 19, 1996).

SKB's work on the new safety assessment (SR 97) is not yet complete. Consequently this evaluation is limited to reporting and plans presented in RD&D Programme 98 as well as to the detailed description of methods and models for safety assessment provided in the background report to RD&D Programme 98 (Chapter 2 and 3 of the "Detailed Programme for Research and Development 1999-2004").

SKI will conduct a separate evaluation once SR 97 has been published. According to SKB, SR 97 will be published in 1999.

6.2 SKI's Overall Evaluation

6.2.1 Safety Assessment Methodology

System Description and Scenarios

For some time, SKB has had access to influence diagrams and interaction matrices for the description of a coupled model of the system comprising all of the processes and characteristics of the repository as well as the various barriers (the process system) which must be taken into account in the safety assessment. SKB has stated that it is now developing, within SR 97, a new method to describe the process system which is based on a classification into thermal, hydrological, mechanical and chemical (THMC) processes. In SKI's opinion, SKB's programme for the documentation of the basic assumptions used in safety assessment is ambitious. However, SKI considers that the presentation of the new methodology is unclear with many unresolved questions concerning the practical application of the safety assessment and the possibility of making comprehensible presentations.

In SKI's view, SKB's proposal for the classification of scenarios is a sound basis for the safety assessment calculations. However, SKI would like to emphasise that the assessment of repository performance and safety must be based on a scenario which includes reasonable assumptions concerning defects in the engineered barriers *as well as* probable external impacts such as climate changes.

SSI's regulations concerning the final management of spent nuclear fuel and nuclear waste (SSI FS 1998:1) mean that SKB, to a

greater extent than before, must take into account and quantify scenario and calculated consequence probabilities. In SKI's opinion, several complementary approaches and models (deterministic and probabilistic, qualitative and quantitative) should be used to provide as comprehensive a view as possible of the risks associated with the repository.

Safety Assessment Models

In SKI's view, it is positive that SKB is now developing more detailed/realistic models for fuel dissolution and damaged canister processes. The detailed models fulfil a vital function in improving the understanding of different transport processes and their interaction in the near field. However, SKI would like to emphasise that there is considerable work left to be done to show that these models are sufficiently reliable to be directly applicable to consequence calculations in the safety assessment.

SKB intends to develop alternative models for calculations of radionuclide transport in the geosphere. SKI considers that this development work is necessary and that, in combination with the migration experiments which are being conducted at Äspö, it should provide SKB with an adequate basis to develop suitable calculation tools for future detailed investigations and safety assessments. SKI also views as positive the fact that SKB is conducting extensive updates of the models necessary for the calculation of radionuclide dispersion in the biosphere.

Treatment of Uncertainties

In RD&D Programme 98, SKB presents a strategy for the treatment of uncertainties which is based on the newly developed THMC method for the description of the process system. SKI considers, like Stockholm University, that the description is deficient and that it does not present an adequate view of how SKB intends to treat uncertainties in the safety assessment. However, SKI is aware that the methodology is currently being developed within SR 97. Consequently, SKI intends to once again raise these issues in connection with its evaluation of the SR 97 safety report.

SKI also reiterates the recommendation from its evaluation of RD&D Programme 95; that SKB should develop a strategy for describing validation issues in the safety assessment, e.g. the assessment of model validity and relevance on the basis of laboratory and field experiments, natural analogues, paleohydrological data and other knowledge.

SKI is positive to the fact that SKB, in this context, is discussing the possibility of using safety assessments to prioritise future work in the R&D programme. However, SKI emphasises that the prioritisation of work must be clearly justified and documented. The priorities proposed in RD&D Programme 98 have not been clearly justified and documented. SKI is prepared to continue to participate in a dialogue with SKB on this important issue.

Quality Assurance

It is positive that SKB is pursuing its work on the quality assurance of data, models and the traceability of calculations in the safety assessment. However, an overall description of SKB's work on the quality assurance of safety assessments is still lacking. In SKI's opinion, during the coming three-year period, SKB should present an overall description of the quality systems and control instruments which are necessary to attain a high level of quality and fitness-of-purpose in the future safety assessment work.

6.2.2 Safety Report Programme

In RD&D Programme 98, SKB presents a description of planned safety reporting in the

form of a list of times when comprehensive safety reports will be required for decision-making. SKI considers that SKB, in the coming three-year period, should prepare more detailed descriptions with respect to the purpose and scope of the planned safety reports. It is important for SKB to clarify the role of the safety assessments in the subsequent stages of the nuclear waste programme.

SKI concludes, as do the municipalities where SKB is conducting feasibility studies, that SR 97, SKB's forthcoming safety report, is an important document in view of the imminent transition to site investigations and the commitments to the KBS-3 method and geological disposal which this will entail. Consequently, SKI would like to remind SKB that SR 97, in addition to demonstrating safety assessment methodology, should also provide a basis for:

- demonstrating the possibility of identifying a site in the Swedish bedrock which fulfils the long-term safety and radiation protection criteria stipulated in SSI and SKI's regulations.
- specifying the factors on which the selection of sites for site investigation will be based.
- deriving the parameters which must be determined and the other criteria which should be made with respect to a site investigation.
- deriving preliminary performance criteria with respect to the canister and the other engineered barriers.

SKI intends to evaluate SR 97 in the light of the above when SR 97 is presented by SKB in 1999.

SKI also reminds SKB that future safety reports must include the repository for other long-lived waste (SFL 3-5). SFL 3-5 is a part of the final disposal method on which the Government, authorities and municipalities concerned must make a decision. Furthermore, SKB must describe the way in which the performance of different parts of the repository is interrelated. Finally, SKB must ensure that the planned site investigations provide adequate data so that all repository parts can be analysed.

7 Research

7.1 SKI's Overall Evaluation

In SKI's opinion, in general SKB has a research programme which is good in terms of quality and suitability. This opinion is not only based on RD&D Programme 98, since, in SKI's view, the account in this report does not do full justice to SKB's research.

In SKI's opinion, in most cases, SKB has presented, in RD&D Programme 98, a moderately detailed account of results achieved. However, certain chapters are very general and brief in terms of the description of planned work. In SKI's opinion, it may be difficult, even for someone with the necessary background, to understand which problems are the most critical in each area of research and how much progress SKB has made within each area. SKI would have liked SKB to present more detailed information in order to be able to make a better evaluation of SKB's allocation of priorities for the period of 1999-2004. SKB also needs to present more specific time-schedules in order to actually show what it intends to achieve during this period.

SKB's Presentation

SKB has put considerable effort into preparing an RD&D programme report which is easy to understand. The report covers the areas of research, safety assessment, method selection, safety, siting, technology and decommissioning.

Since research-related aspects of the programme are only briefly dealt with in the main report, SKB has also compiled a background report with a more detailed account of its research and development work. In SKI's opinion, this structure may be warranted and has probably made the information more accessible to a layman, compared with previous RD&D progamme reports. In SKI's opinion, this structure, which emphasises issues other than research, should not be allowed to lead to a loss of status of SKB's research programme. SKB should, therefore, make every effort to ensure that the quality of the actual reporting of its research is maintained.

Scientific Basis

In SKI's opinion, the following-up of the reporting on research would have been considerably simplified if SKB had chosen a more consistent method for the handling of references. There are a number of references to unpublished manuscripts in RD&D Programme 98. There may be reasons for refraining from publishing these results. In other cases, significant conclusions have been presented which are not substantiated or referenced which can lead to difficulties in the evaluation work.

SKI emphasised, at the time of its evaluation of RD&D Programme 95, that references cited in SKB's material do not reflect the full range of knowledge of the scientific community.

SKI is still of the opinon that it is important for SKB to make every effort, at an early stage, to gain the support of the rest of the research community for the research results that it has obtained within various areas. In this way, discussions at a late stage (licensing) of issues which should have been resolved at an earlier stage, can be avoided as far as possible.

Link to the Safety Assessment

With respect to certain parts of RD&D Programme 98, it would have been desirable to have clearer descriptions of how various results can contribute to the overall description and to the safety assessment. SKI has previously emphasised the importance of continuous integration between the results from different areas and the needs of the safety assessment. It is also important to use the results from completed safety assessments as a basis for decisions concerning future research work. More specific goals with links to the safety assessment would make it easier to judge whether the knowledge base is sufficient to justify making a decision. SKI assumes that this will be dealt with in the SR 97 report on safety assessment. SKI intends to follow up and comment on this in connection with its separate evaluation of SR 97.

As SKI has emphasised in previous evaluations of SKB's RD&D programme, it is important that the specific goals and focus of the research as well as the allocation of resources between different areas of research should reflect the needs which have emerged in connection with preliminary safety assessment. Once SKB has published SR 97, there may be reason for SKB to review the focus of its research programme. On the basis of the information presented in RD&D Programme 98 (and the budget presented to SKI), SKI has no objection to the direction of SKB's research and the allocation of funds among different areas of research. Within all of the areas, there are areas where it is important to continue research. However, this does not necessarily mean that, in all areas, there are issues which it is absolutely necessary to resolve. It all depends on which parts of the system (fuel, canister, buffer, geosphere) are considered to be more or less important in the safety assessment. The requirements which can be made on demonstrating a certain redundancy between the parts of the system should also be considered.

Long-term Competence

SKI emphasises that it is important that SKB should evaluate the more basic research-related issues from a perspective that is adequately long-range in nature. As the details of the selected final disposal concept are worked out, greater demands will be made on the quality and scope of the data used in the safety assessments which must be prepared and this requires long-term planning. It is essential that SKB should take into account the need to develop and maintain competence when allocating research funds.

7.2 SKI's Evaluation of Specific R&D Areas

7.2.1 Spent Fuel

In SKI's view, SKB's experimental work is adequately focused on issues which it is important to resolve. In SKI's opinion, with the present level of knowledge, it is difficult to develop models for the corrosion of spent fuel which can claim to be realistic. Examples of issues which must be clarified include the relative importance of various release mechanisms, the effect of radiolysis and secondary solid phase formation. In spite of these deficiencies, present-day knowledge may very well prove to be sufficient to assess the reliability of a fuel model which is exclusively based on simplified and conservative assumptions. The resources which SKB must invest in this area will depend on the extent to which the barrier function of the fuel will be used in future safety assessments.

7.2.2 Canister

In SKI's opinion, SKB should compile a new report on how the knowledge of various types of corrosion processes is used in the assumptions and analysis on which corrosion

rates in the safety assessment are based. SKB should obtain and interpret results from ongoing corrosion studies before it decides whether it should conclude its studies of corrosion in reducing environments. Research on corrosion in the initial oxidising state is probably of less importance and can be pursued alongside the other corrosion research. SKB deals with the following issues which are of particular importance: the corrosion process in the gap between the iron insert and the copper canister, microbial activity and corrosion studies in a realistic environment. In SKI's opinion, these are vital studies. SKI emphasises the importance of conducting studies of the properties of the copper on samples taken from actual, fabricated canisters, as soon as this is possible.

7.2.3 Buffer and Backfill

In SKI's opinion, it is essential that SKB, to a greater extent than before, should present an integrated account of its requirement specification for the selected materials and co-ordinate this work so that all aspects are covered at the same time. In SKI's opinion, SKB must be able to show, more clearly than before, that the buffer fulfils the performance requirements on maintaining favourable chemical and physical properties in a long-term perspective. Further work on developing a knowledge base will be required to identify possible chemical and structural changes in the bentonite which can occur in the long and short term in order to be able to predict the effects of the changes. In SKI's opinion, SKB must also improve its understanding of bentonite resaturation.

7.2.4 Structural Geology and Mechanical Properties of the Bedrock

In SKI's opinion, in the account of this subject presented in RD&D Programme 98*, a clear discussion* is lacking of the areas where knowledge, according to SKB, is adequate and of the areas where SKB considers that further work must be done. SKB intends to study plastic shear zones and the importance of these zones to a deep repository. It is important to do this, especially if SKB actually intends to locate a repository in or near to a regional plastic shear zone (tectonic lens). SKI also emphasises the importance of completing the work that has been described and started. Furthermore, SKB should take advantage of knowledge gained in the future work on site characterisation. SKI intends specifically follow SKB's work within the area of structural geology and rock mechanics in order to provide viewpoints on the areas where additional work must be done in the coming years.

7.2.5 Water Flow in Rock

On the basis of the overall account presented by SKB in RD&D Programme 98, SKI is of the opinion that SKB's research programme on water flow and transport in the bedrock is appropriate. However, SKI considers that SKB should review the co-ordination of research on these important issues within the different projects for site characterisation, safety assessment and supporting R&D at Äspö and elsewhere.

SKB is conducting an extensive research programme to improve the understanding of the groundwater flow and radionuclide transport in the Äspö Hard Rock Laboratory. However, SKI would like to repeat the recommendation from its evaluation of RD&D Programme 95 that SKB should describe how it plans to determine the bedrock transport properties in connection with surface-based site investigtion.

SKI considers that SKB, prior to the selection of sites for site investigation, should explain the role of the regional groundwater flow as a siting factor. SKB's own account contains contradictory conclusions concerning

the factors which determine groundwater flow at repository depth.

A site evaluation and estimate of parameters for consequence calculations in the safety assessment will require several stages of model simplification and the scaling up of measurement data and model parameters. SKI is therefore positive to the fact that SKB is now planning to conduct field experiments and modelling to study the problem of the scaling up of hydraulic parameters and transport parameters.

7.2.6 Groundwater Chemistry

Within the groundwater chemistry programme, SKB has made considerable progress in developing sampling, interpretation and analysis methods. This work must continue, focusing on the further improvement of interpretation models, analysis methods and, particularly, collecting samples that are as undisturbed as possible. Furthermore, SKB will have to put more work into optimising the analysis classes on the basis of data needs and the interpretation models. Furthermore, SKB should set aside research funds for the long-term, basic research on chemical processes in deep groundwater. Many gaps still exist in the knowledge of the interaction between the groundwater, minerals and geogas as well as the mechanisms for these processes, which can be controlled by microbial catalysis, kinetics for slow mineral reactions etc. This knowledge is necessary to assess how the chemical conditions can be affected by different types of events (climatic changes, changes in the groundwater flow, repository-related effects etc.).

7.2.7 Chemistry

In SKI's view, it is essential that SKB should provide a reasonable level of long-term support for the more basic research on radionuclides, sorption and matrix diffusion. The development of the basic understanding of the processes which have so far mainly been covered by empirical data (such as sorption data) will provide the basis for gradually developing and improving the data for the safety assessment. Alongside this work, databases used for safety assessment must be maintained and updated. SKI reminds SKB that it needs to determine the importance of colloidal transport and complexing to more extreme conditions and to take into account the presence of certain materials, such as cement and organic substances, in the repository. Furthermore, unresolved questions remain regarding how microbes can affect the chemical properties in the near field as well as the radionuclide transport. A clearer integration with geochemistry, safety assessment and site investigation is recommended in the future.

7.2.8 Biosphere

SSI is the competent authority on the subject of the biosphere and the conclusions presented below are largely based on SSI's Review Statement (dnr 6240/2745/98).

SKI shares SSI's view that the fact that SKB, in recent years, has expanded the scope of its biosphere research – largely by applying a system-ecological approach - as a positive step. At the same time, SKI and SSI consider that considerable work remains to be done before SKB reaches its overall goal of conducting credible consequence calculations in the safety assessments. Furthermore, taking into account the long time ranges involved, it is the opinion of the authorities that it is essential to complete plans to study other safety indicators besides dose and risk, e.g. concentration changes in the biosphere.

SKI concludes, as does SSI, that SKB has now established a satisfactory level of ambition for its biosphere studies. However, considerable work remains to be done, in quantitative terms, before material is available for an application for permission to construct a repository.

7.2.9 Other Waste

SKI emphasises the importance of continuous knowledge improvement with respect to issues relating to the barrier function of the cement and the transfer of knowledge between SFR and SFL 3-5 in terms of biodegradable products from cellulose and other organic substances which can form complexes together with radionuclides. SKI is expecting a detailed description of long-term barrier properties of the cement in connection with future safety assessments. Furthermore, SKI is of the opinion that SKB should more clearly justify the changes in the layout of SFL 3-5, proposed in RD&D Programme 98.

7.2.10 Alternative Methods

SKI concludes that two alternative methods, partitioning and transmutation as well as deposition in Very Deep Holes (VDH) are dealt with in SKB's detailed programme. SKI has no objection to this choice of alternatives for future, more detailed study.

In SKI's opinion, SKB's work on partitioning and transmutation has been successful so far. SKI agrees with SKB's view that the work in this area should be kept to approximately the same level as before. However, at the same time, SKI emphasises the importance of including system studies and studies of the quantity and composition of the waste.

SKB's plans for the VDH method are more general in nature. In SKI's opinion, the focus of the plans on safety assessment and system analysis is suitable. However, SKI reiterates that, in this context, the safety assessment should be considered to be a part of the system analysis.

SKB may have to review its plans for both methods – partitioning and transmutation as well as Very Deep Holes – to take into account the reporting requirements which may be made prior to the selection of sites for site investigation.

7.2.11 Äspö Hard Rock Laboratory

In SKI's view, the extensive experimental and demonstration programme which is now being planned for the Äspö Hard Rock Laboratory can be expected to provide adequate opportunity to improve the understanding of important parameters and processes in crystalline bedrock and to further develop methodology for site and detailed investigations. However, SKI is of the opinion that considerable work remains to be done on combining different methods into an integrated site investigation programme. SKI also emphasises that the need to develop individual methods, e.g. detection of horizontal fracture zones and a programme for groundwater chemistry sampling.

According to SKI, it is very important to identify any flowpaths and hydraulic relationships for radionuclide transport in affected and disturbed rock in deposition holes and deposition tunnels as well as further investigate whether it is possible to block transport paths through strategically placed plugs. SKI is of the opinion that SKB must establish, more clearly, which safety-related factors can be determined in connection with a surface-based site investigation as well as a detailed investigation from tunnels and shafts.

SKI emphasises that SKB should determine the impact of different processes on the consumption of oxygen remaining in the repository after closure. Furthermore, in SKI's opinion, knowledge of changes in hydraulic properties in connection with a pressure drop around tunnels and the degassing of groundwater (two-phase flow) must be improved. SKI fully supports SKB's ongoing and planned work on studying the barrier function of the rock and, in its view, the application of different models in parallel is very valuable.

SKI also supports SKB's plans to use the Äspö Hard Rock Laboratory to develop technology for and to demonstrate the

function and interaction between the different components of the deep disposal system. In SKI's opinion, SKB's plans to conduct full-scale testing are very important, since these tests may confirm whether the final disposal technology is suitable from an engineering perspective before it is applied on the actual repository. With respect to the experiment on the demonstration of disposal technology and retrievability, SKI considers that there are good grounds for SKB to demonstrate the different stages of disposal and retrieval of canisters in the Äspö Hard Rock Laboratory for the public and specialists. At the time of the evaluation of RD&D Programme 95, SKI emphasised the importance of SKB improving its knowledge of the durability and long-term properties of the grout in the repository. The possible impact of the grout on the chemistry of the repository must also be further investigated.

7.2.12 Natural Analogues

In SKI's opinion, SKB should ensure that knowledge is continuously improved within the area of natural analogues and should, therefore, ensure that work is continued in this area once the current projects are completed. SKI recommends SKB to:

- use existing information from natural analogues, by allocating resources for additional interpretations of field data as well as modelling
- attempt to assess the usefulness of new or additional measurement series at existing sites
- at least ensure that it is prepared to conduct analogue studies at completely different sites in cases where the possibility of obtaining new knowledge is considered to be reasonable.

7.2.13 Paleohydrological Programme

SKI concludes that the development of time-dependent modelling of glaciations has now advanced to such a stage that SKB can claim that the modelling will be useful as a tool in future performance and safety assessments. In SKI's opinion, all of the issues dealt with by SKB in the paleohydrological programme are relevant and should be included in SKB's work in the future. However, SKI would like to see a coherent presentation (including time-schedules) of how SKB intends to deal with the issues, especially with respect to meeting the needs of the safety assessment. SKI assumes that SKB's planned SR 97 report will be an important document, among many, prior to decision-making regarding which activities it will prioritise.

During the current RD&D period, SKB must clearly show how it intends to integrate the issues in this area. SKI also emphasises the importance of SKB discussing, for example, input data, the applicability of theories used as well as uncertainties. This knowledge must be placed in the appropriate context when assessing the usefulness of models and when evaluating the results obtained.

7.2.14 Deep Drilling in Laxemar

SKI concludes that the drilling previously conducted by SKB shows the importance of conducting drilling in future (at possible repository sites) to a greater depth than has been the case so far (500 – 700 m). Drilling at Laxemar has been conducted down to a depth of about 1,700 m.

In SKI's opinion, it is important for SKB to plan for and develop practical methods to obtain the necessary data in connection with site and detailed investigations down to a depth of 1,500 m. SKI concludes that the existing knowledge of the bedrock at depth exceeding 500 m is still deficient in spite of the investigations which SKB has carried out at

different sites (e.g. the study sites and Äspö). This is a deficiency, even if the repository were to be located at a depth of about 500 m. Therefore, SKI is of the opinion that SKB should compile data relating to the full range of depths, 500 – 1,500 m.

7.2.15 Scientific Information

In SKI's opinion, it is important to make the results of SKB's programme available to the public, in varying degrees of detail. Simple, general descriptions should refer to more detailed studies in order to make it easier for the public to conduct further reading on the subject and to satisfy the need for ensuring traceability. SKI's view is that publications which are referred to in published reports should be accessible. This particularly applies to the reports referred to in the RD&D programme and the background reports to the programme.

In general, SKI considers that SKB has maintained a good level of quality in its research and has, on the whole, satisfied the need for accessibility to information and openness. SKI considers that it is important for SKB to continue to strive, as far as possible, to publish its work in scientific journals and, in this way, ensure that peer review is continuously achieved. This is very important for gaining the support of the rest of the research community.

8 Decommissioning and Dismantling of Nuclear Facilities

8.1 Introduction

SKB states that a certain practical experience of the decommissioning and dismantling of nuclear facilities exists. This experience was acquired when research reactors and other facilities in Sweden were shut down. Major maintenance projects, such as the replacement of steam generators, reactor internals etc. and the necessary decontamination work have also provided an adequate knowledge base for the future decommissioning of power-producing reactors.

Furthermore, SKB concludes that the power companies are responsible for planning and implementing the decommissioning work as well as for determining exactly when this will be done. The power companies are responsible for waste treatment while SKB is responsible for the final disposal of the radioactive decommissioning waste. SKB and the power companies consult with each other.

On the topic of the decommissioning of facilities, SKB mainly refers to its study from 1994, which it also referred to in RD&D Programme 95. SKB is participating in and following international development work within the area, particularly within the OECD/NEA, and within the EU and the IAEA. According to SKB, its goal is to ensure that knowledge, technology and a final solution to the nuclear waste disposal problem is available before nuclear power plants are dismantled.

In its review statement, SSI emphasises that SKB should give a clearer account of the different waste streams which are generated by the decommissioning of nuclear power plants and of the level of flexibility of its plans, including the waste facilities which will be necessary.

8.2 SKI's Overall Evaluation

The decommissioning of nuclear power plants in the world is accelerating as the technical and/or economic lifetimes of the plants expire. The dismantling of the radioactive components of a nuclear power plant is very similar to the major maintenance projects which are periodically conducted at the nuclear power plants.

In the case of the handling of very large components, such as reactor pressure vessels, international experience also exists of how safe handling can be achieved. The conclusion is that the actual decommissioning and dismantling of nuclear facilities is based on established, conventional technology. However, finding a solution to the problem of nuclear waste disposal is an important step in the decommissioning and dismantling work, as described above. For this to be achieved, repositories for short and long-lived decommissioning waste must be constructed and licensed, SFR must be expanded or relicensed and SFL 3-5 constructed.

In SKI's opinion, SKB is following international developments within the area of decommissioning and dismantling as well as the work on finding a solution to Sweden's nuclear waste disposal problems in a satisfactory manner. However, in view of a possible early shut down of Swedish nuclear power plants, SKB must give greater priority to the issue of the disposal of the decommissioning waste.