SKI Report 01:32

The Swedish Nuclear Power Inspectorate's Review Statement on the Swedish Nuclear Fuel and Waste Management Co's RD&D Programme 98 Supplement

September 2001

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To the Government
Ministry of the Environment
103 33 Stockholm

Review Statement on the Swedish nuclear fuel and waste management Co's RD&D Programme 98 supplement – "Integrated account of method, site selection and programme prior to the site investigation phase"

On January 24, 2000 the Government decided (M1999/2152/Mk, M1999/3040/Mk), with respect to the Programme for Research, Development and Demonstration 98 (RD&D 98), that the Swedish Nuclear Fuel and Waste Management Co (SKB) prepared in accordance with § 12 of the Act (1984:3) on Nuclear Activities, that RD&D 98 should be supplemented by SKB in ways specified in the Government's decision. On December 13, 2000, SKB submitted the requested supplement to the Swedish Nuclear Power Inspectorate (SKI).

In SKI's opinion, SKB has submitted the accounts and conducted the consultations that were requested in the Government's decision of January 24, 2000.

1. SKI's Proposal for a Position to be Adopted by the Government

In the light of SKI's own review and the statements of opinion submitted by the reviewing bodies presented in the attached reports (SKI Report 01:32, SKI Rapport 01:21), SKI proposes that the Government adopt the following position on SKB's RD&D Programme 98 Supplement:

- That the Government should establish that SKB, and thereby the reactor licensees, have fulfilled their obligations under § 12 of the Act on Nuclear Activities.

Method Selection

SKI proposes that the Government should establish that:

- SKB has accounted for its selection of a method in a manner that is considerably improved compared with the account provided in RD&D Programme 98. This also applies to the zero alternative in the form of continued storage at CLAB. The account provided of method selection is an adequate basis to start site investigations. However, it must be updated prior to future decision-making.

- SKB has presented a good account of the possible designs and the difficulties of deep boreholes. However, deep boreholes are not a realistic alternative.

- SKB should continue to follow developments with respect to other alternative methods.

- At present, the KBS-3 method is considered to be the most suitable and the only realistic basis for planning the site investigations.

SKB's safety assessment (SR 97) is acceptable as a basis for starting the site investigations. SR 97 has not identified any conditions which would indicate that geological final disposal, in accordance with SKB's method, has decisive deficiencies in relation to the requirements on safety and radiation protection established by the authorities.

Site Selection

SKI proposes that the Government should establish that:

- SKB has presented an adequate basis for selecting sites for hosting a repository.

- SKB has shown that the proposed sites of *Simpevarp, Forsmark* and *northern Tierp,* as far as can be determined by the feasibility studies conducted, meet the pre-conditions to comply with the safety and radiation protection criteria established by the authorities. This means that site investigations can be initiated at these sites. However, there are deficiencies in SKB's justification for the selection of *northern Tierp*.

- SKB should not exclude *Hultsfred* from the site selection before issues relating to recharge/discharge and depth to saline groundwater are investigated.

Site Investigation Programme

SKI proposes that the Government should establish that:

- SKB's accounts fulfill the Government's requirements on a clear site investigation programme.

One necessary condition and a strength is that SKI and SSI can follow up remaining issues in the process of consultation that SKB is to conduct with the authorities before the start of the site investigations, in accordance with the Government's decision of December 19, 1996.

Stipulations after Initial Site Investigations

SKI proposes that the Government should state that:

- A new safety assessment and system analysis for the KBS-3 method should be submitted by SKB after the initial phase of the site investigations has been conducted.

Support to Municipalities and County Administrative Boards

One question that has been raised by all of the feasibility study municipalities is whether municipalities and county administrative boards can obtain (increased) funding for participation in the forthcoming site investigation phase. In SKI's opinion, there is good reason for the Government to consider whether the level of compensation, in accordance with the Ordinance (1981:671) on the financing of the future expenses for spent nuclear fuel etc., can be raised from the current level of SEK 2 million per year. In SKI's view, the Government should also decide whether resources should be allocated to the county administrative boards in connection with the site investigation phase.

Support to Environmental Organizations

Several of the environmental organizations and opinion groups request resources to conduct their own activities in connection with the site selection process. In its review statement to the Government regarding RD&D Programme 98, SKI recommended that this issue should be dealt with. In its decision of January 24, 2000, the Government stated that "the Government is considering the issue of whether special support should be given to voluntary organizations." SKI holds the same view today as it did at the time of the review of RD&D Programme 98 and considers it important for the Government to decide whether support should be provided to environmental organizations.

2. Handling of the Matter

SKI conducted its review of SKB's RD&D Programme 98 Supplement in the same way that it normally reviews the RD&D programmes. SKI distributed the programme to sixty reviewing bodies (authorities, universities and environmental organizations etc.). Statements of opinion were received from forty-five of these. The statements of opinion mainly focused on issues relating to method choice and site selection, particularly the selection of sites for investigation.

A new activity was also conducted to improve the possibility of the feasibility study municipalities gaining insight into SKB's programme and of obtaining answers to the issues raised by the programme. SKI and SSI arranged joint public hearings of SKB in the feasibility study municipalities. Questions were raised by the public and answered by SKB and by the regulatory authorities, SKI and SSI. Hearings were conducted in Northern Uppland, in Oskarshamn/Hultsfred and in Nyköping in February 2001.

3. Main Points of SKI's Evaluation and Conclusions

Through SKB, the reactor licensees have met their obligations in accordance with §§ 11-12 of the Act on Nuclear Activities

In SKI's opinion, the Swedish Nuclear Fuel and Waste Management Co (SKB) has presented a supplementary programme that meets the basic requirements stipulated in § 12 of the Act on Nuclear Activities.

Geological Final Disposal Most Suitable for Sweden

SKI, and SSI still consider that disposal in accordance with the KBS-3 method in deep geological formations is the most suitable method for the final disposal of spent nuclear fuel from the Swedish nuclear power programme.

However, in SKI's view, SKB should continue to follow technological developments with respect to different alternatives for the disposal of nuclear waste within the framework of future RD&D programmes, at least until the license to construct a geological repository has been granted.

Adopt an Unambiguous Position regarding Method before Starting Site Investigations

SKB shares the opinion of many of the reviewing bodies that an unambiguous position must be adopted on a national level, regarding the KBS-3 method, before site investigations begin. SKI shares this opinion and points out that the start of site investigations marks an important decision in the stage-by-stage process that will result in a repository.

A positive approach to the KBS-3 method as a basis for planning site investigations should thereby not be viewed as a final approval of the method but as a stage in an

ongoing evaluation process. The next stage should be the licensing of the encapsulation plant and repository. In the case of the geological repository, this means, in particular, the granting of a license to start detailed characterizations (excavation of shafts at repository depth).

Necessary Basis for Starting Site Investigations

SKB's changing of the siting factors, from the previous four to three factors, has been pointed out by several reviewing bodies which consider that this may mean that SKB is giving the long-term safety of the repository a low priority. However, SKI considers that the content of the three new factors correspond to the content of the four that were previously used. SKI is also of the opinion that SKB's new factors are less ambiguous and intuitively simpler to understand than the previous four factors and that the new factors do not indicate that a lower priority has been given to safety.

In SKI's opinion, SKB's descriptions of method, site selection and site selection programmes, prior to the start of site investigations, are reasonable in scope and provide an adequate basis for SKB, after the Government has made a decision, to be able to initiate discussions with the municipalities proposed for site investigations.

However, SKI considers that there are weaknesses in the justifications concerning the selection of *northern Tierp*. This opinion is supported by the views of several reviewing bodies. SKB states, as its main reason for selecting *northern Tierp*, that this alternative provides a greater geological breadth to the basis for decision-making. In SKI's opinion, SKB should better justify the way in which Tierp differs from the other alternatives in this respect.

SKI is also of the opinion that there are other factors besides bedrock geology that can provide geoscientific breadth. Experience from safety assessments shows, for example, that the hydrogeological and geochemical conditions are of considerable importance for long-term safety. Consequently, SKI recommends SKB not to eliminate *Hultsfred* until issues concerning recharge/discharge and salinity are further investigated.

The safety assessment for long-lived low and intermediate-level waste, SFL 3-5, is not yet adequately developed so as to comprise a basis for the siting of these repositories. In order to make a decision regarding co-siting, this assessment should be prepared before the final phase of the site investigations.

In order for site investigations to be initiated in accordance with SKB's time-schedule, it is desirable for the Government to make a decision during autumn 2001.

4. Other Viewpoints Directed to SKB

In this Review Statement and the accompanying Review Report, SKI submits a number of other viewpoints for SKB to take into consideration. These are based on SKI's own evaluation and the statements of opinion submitted by the reviewing bodies.

A decision on this matter was made by SKI's Board. Apart from the undersigned Chairperson, the following board members participated in the decision: Andersson Öhrn, Axelsson, Ericson, Holm, Karlsson, Persson, Sjöström and Veiderpass as well as SKI employees, Norrby and Toverud, the latter in the capacity of rapporteur.

SWEDISH NUCLEAR POWER INSPECTORATE

Judith Melin

Öivind Toverud

Appendices:

Swedish Nuclear Fuel and Waste Management Co:

1. RD&D Programme 98 Supplement. Integrated Account of Method, Site Selection and Programme Prior to the Site Investigation Phase. December 2000.
2. What Requirements Does the Deep Repository Place on the Rock? Geoscientific Suitability Indicators and Criteria for Siting and Site Evaluation. SKB R-00-15. April 2000 (*in Swedish*).
3. The Deep Borehole Alternative. Content and Scope of RD&D Programmes Necessary to Enable a Comparison with the KBS-3 Method. SKB R-00-28. April 2000 (*in Swedish*).
4. System Analysis – Final Disposal of Spent Nuclear Fuel in accordance with the KBS-3 Method. SKB R-00-29. October 2000 (*in Swedish*).
5. Geoscientific Programme for the Investigation and Evaluation of Sites for a Deep Repository. SKB R-00-30. August 2000. (*in Swedish*).
6. What Happens if a Repository Is not Built? The Zero Alternative – Extended Interim Storage in CLAB. SKB R-00-31. September 2000 (*in Swedish*).
7. System Analysis – Selection of Strategy and System for the Disposal of Spent Nuclear Fuel. SKB R-00-32. October 2000 (*in Swedish*).
8. What Do Other Countries Do with their Spent Nuclear Fuel? SKB R-00-36. October 2000 (*in Swedish*).

9. Deep Repository for Spent Nuclear Fuel. SR 97 – Post-closure Safety – Main Report (Two Volumes). November 1999.

Swedish Nuclear Power Inspectorate:

10. The Swedish Nuclear Power Inspectorate's Review Statement on the Swedish Nuclear Fuel and Waste Management Co's RD&D Programme 98 Supplement. SKI Report 01:32. September 2001.
11. The Swedish Nuclear Power Inspectorate's Review of SKB's RD&D Programme 98 Supplement. Summary of Statements of Opinion by Reviewing Bodies. SKI Rapport 01:21. June 2001 (*in Swedish*).
12. SKI and SSI's Joint Review of SKB's Safety Assessment Report, SR 97. SKI Report 01:4/SSI-report 2001:3. May 2001.
13. SKI and SSI's Joint Review of SKB's Preliminary Safety Assessment for a Repository for Long-lived Low and Intermediate-level Waste. SKI Report 01:34/SSI-report 2001:19. September 2001.

Reviewing Bodies:

14. Original statements of opinion received from 45 of the reviewing bodies on the distribution list.

Distribution List:

Reviewing Bodies

County Administrative Board, Kalmar
County Administrative Board, Södermanland
County Administrative Board, Uppsala
County Administrative Board, Västerbotten
Geological Survey of Sweden
Local Safety Committee for the Nuclear Installations at Studsvik
Local Safety Committee, Forsmark Nuclear Power Plant
Lund Institute of Technology/University of Lund
Mehedeby-Orrskogs Group
Municipality of Hultsfred
Municipality of Nyköping
Municipality of Oskarshamn and the Local Safety Committee, Oskarshamn Nuclear Power Plant (*joint statement*)
Municipality of Tierp
Municipality of Älvkarleby
Municipality of Östhammar
National Archives
National Board of Psychological Defence
National Chemicals Inspectorate
National Heritage Board

National Housing Board
People's Campaign against Nuclear Power-Nuclear Weapons - Oskarshamn
Royal Institute of Technology, Stockholm
Society for the Conservation of Nature, Uppsala County
SOS-Tierp
SOS-Älvkarleby
Special Advisor on Nuclear Waste Disposal
Stockholm University (*two statements*)
Swedac
Swedish Association of Municipalities with Nuclear Reactors
Swedish Defence Research Agency
Swedish Environmental Protection Agency
Swedish Geotechnical Institute
Swedish National Energy Administration
Swedish Radiation Protection Institute (SSI)
Swedish Rescue Services Agency
Swedish Research Council
Swedish Society for the Conservation of Nature
The Green Party, Tierp
The Swedish Agency for Civil Emergency Planning
The Waste Network
The Waste Network Association
Umeå University
Uppsala University

Statements have also been submitted by Ulf Blomquist (Tierp) and Sören Linde (Tystberga)

Others

Finnish Centre for Radiation and Nuclear Safety (STUK)
Forsmarks Kraftgrupp AB
National Board of Civil Emergency Preparedness, Denmark
National Council for Nuclear Waste (KASAM)
Norwegian Radiation Protection Authority
OKG AB
Prime Minister's Office
Research Service of the Swedish Parliament
Swedish IAEA Delegation
Swedish Nuclear Fuel and Waste Management Co (SKB)
Swedish OECD Delegation
Sydkraft AB
Vattenfall AB

The Swedish Nuclear Power Inspectorate's Review Statement on the Swedish Nuclear Fuel and Waste Management Co's RD&D Programme 98 Supplement

CONTENTS

Overall Evaluation

In SKI's opinion, SKB, and thereby the reactor licensees, have fulfilled their obligations in accordance with §12 of the Act on Nuclear Activities.

Method Selection

Conclusions – System Analysis

The description of the method selection has been considerably improved compared with RD&D Programme 98. This also applies to the zero alternative, which entails continued storage in CLAB. In SKI's opinion now, and in its opinion at the time of the review of RD&D Programme 98, SKB has shown that KBS-3 is, on the whole, the most suitable method for final disposal of the spent nuclear fuel.

The description of costs and time required for an RD&D programme for the deep borehole alternative underestimates rather than overestimates the difficulties of this alternative. The description provided reinforces SKI's opinion that deep boreholes is not a realistic alternative, primarily with respect to the major uncertainties which seem to exist with respect to the deposition technology and the possibility of conducting a meaningful safety assessment.

With respect to following and investing in alternatives besides the KBS-3 method, SKI is of the opinion that SKB should proceed to more or less the same extent as at present.

The deficiencies that can be noted in the system analysis for the KBS-3 method are acceptable and do not have to be remedied until prior to the preparation of the next system analysis and safety assessment report.

Conclusions – Safety Assessment

SKB's safety assessment of the repository for spent nuclear fuel is acceptable taking into account the requirements that can be made prior to the start of site investigations. However, in good time before the application for permission to construct the encapsulation facility or repository is submitted, a new safety assessment should be prepared. This is also necessary taking into account the feedback of experience into the site investigation programme to determine more definitive performance requirements for the barriers. A suitable time for this would be after the end of the initial phase of the site investigations.

Criteria for Site Investigation

In SKI's opinion, SKB's summary of siting factors has been pedagogically developed and comprises a valuable starting point for the site investigation programme and the subsequent selection of sites for detailed characterization. In connection with this report, SKB has also defined a site investigation terminology. The appropriate use of requirements and criteria makes it possible to continuously achieve reconciliation during different phases of site investigations and site selection and makes it possible to, at an early stage, reject a completely unsuitable area.

Since the use of requirements and criteria alone do not provide an adequate basis for an evaluation of long-term safety, in SKI's opinion, it is important for SKB to conduct a complete safety assessment, based on the results of the initial site investigations. In SKI's opinion, requirements and criteria cannot and should not be used to evaluate issues such as the ranking of sites from the standpoint of safety.

One of the most important absolute requirements that SKB presents is that no ore potential should occur in the deposition area of the repository site. In SKI's opinion, SKB must formulate this requirement more clearly.

SKI notes that SKB has chosen not to place any significant emphasis on the importance of regional recharge and discharge conditions. In SKI's opinion, SKB should develop a better basis for its evaluation that recharge and discharge areas are not an important siting factor.

Site Selection

The Siting Process

Issues concerning strategic environmental assessment, an independent EIA body etc., were discussed in connection with the review of RD&D Programme 98. In SKI's view, nothing new has emerged since that time and, therefore, SKI sees no reason to re-evaluate its previous decisions on these issues.

In SKI's opinion, the recurrent, public review process that is stipulated in §12 of the Act on Nuclear Activities and preceding acts and which has been in progress for two decades contains many of the elements which are assumed to be included in a strategic environmental assessment and public consultation process. The purpose is to ensure that an adequate, complete and well-supported basis for decision-making exists.

Bearing in mind this, SKI rejects the proposal of introducing new processes without the support of current legislation.

SKB's change in the siting factors, from the previous four to three factors has been pointed out by several reviewing bodies. These bodies consider that this may mean that SKB is giving the long-term safety of the repository a low priority. However, SKI considers that the content of the three new factors correspond to the content of the four

that were previously used. SKI is also of the opinion that SKB's new factors are less ambiguous and intuitively simpler to understand than the previous four factors and that they do not mean that a lower priority has been given to safety.

Basis for Site Selection

SKI's overall evaluation is that SKB has, systematically and consistently, conducted the feasibility studies in accordance with a pre-determined methodology where the choice has been conducted in a three-step process. The geological factors are reported in a relatively uniform way for each feasibility study. However, SKB has not clearly described the (geological) considerations that have been taken into account in each municipality regarding the selection of sites for field investigations and the considerations that have determined the scope of the field surveys.

Decision-making for site selection was based on the following factors: *the bedrock, industrial establishment* and *societal aspects*. Requirements and preferences with respect to industrial establishment were accorded considerable importance, since SKB considers that the selected areas within each municipality are similar from the geological standpoint. In SKI's opinion, SKB should, in any case, have attempted to achieve a more systematic compilation and evaluation of more or less favourable conditions for the selected areas, on the basis of the available geological information.

Selection of Site Alternatives for Site Investigations

SKI finds that SKB has conducted feasibility studies in six municipalities (a total of eight, including Storuman and Malå), which together provide a broad coverage of geological and other geoscientific properties that can be expected in Swedish bedrock. Therefore, in SKI's opinion, SKB has presented an adequate basis for selecting sites for a repository and for initiating site investigations.

In SKI's opinion, SKB has shown, as far as is possible on the basis of the feasibility studies, that the siting alternatives (western) *Simpevarp* in Oskarshamn Municipality, *Forsmark* in Östhammar Municipality and *northern Tierp* in Tierp Municipality have the prerequisites to comply with the authorities' safety and radiation protection requirements. In SKI's opinion, it is also reasonable to take into consideration the advantages that Simpevarp and Forsmark offer with respect to industrial establishment and societal aspects in the way that SKB has done in its selection. SKI therefore supports SKB's wish to start site investigations at these two sites.

In SKI's view, which is supported by the view of several reviewing bodies, there are weaknesses in the reasons for choosing northern Tierp, a site which does not have any direct connection to a nuclear facility. The main reason provided by SKB for the selection of northern Tierp is that this alternative provides a greater geological breadth to the investigation. However, SKI considers that SKB should better justify the way in which Tierp is different from other alternatives in this respect. SKB's clarification of its reasons for the selection of northern Tierp should be conducted through the consultation

process that the Government decided upon on December 19, 1996. Nevertheless, SKI has no objection to make to SKB also conducting site investigations in Tierp.

SKI also emphasizes that there are other factors besides bedrock geology that can provide geoscientific breadth. Experience from safety assessments shows, for example, that the hydrogeological and geochemical conditions are of considerable importance for long-term safety. Consequently, SKI recommends SKB not to exclude Hultsfred until issues concerning recharge/discharge and salinity are further investigated.

Programme for Site Investigations

Programme for Measurements

In SKI's opinion, the general programme for site investigations provides a good framework for the preparation of the more detailed site-specific investigations.

An important issue which was left unresolved in SKI and SSI's review of SR 97 is whether SKB has taken adequate account of the experience from SR 97 in the design of the site investigation programme. Therefore, in SKI's view, on the basis of an integrated evaluation of SR 97 and previous site investigations, SKB should describe, in a clearer manner, before the start of site investigations, how the site investigation programme has been designed in order to respond to the needs of the safety assessment.

In SKI's opinion, SKB should clarify the minimum level of measurements required to obtain an adequate basis for comparing the suitability of the different sites, namely, specify the parts of the measurements that are common to all sites and the supplementary measurements that can be required to determine site-specific conditions.

In SKI's opinion, prior to the start of site investigations, SKB must clarify the specific requirements that should be made with respect to the site investigation programme taking into account the repository for long-lived low and intermediate-level nuclear waste (SFL 3-5). In order to be able to identify a suitable rock volume for SFL 3-5 during a site investigation, a well-investigated database is necessary to justify these issues. SKB's preliminary safety assessment showed that the local flow conditions and the local geochemical conditions have a considerable impact on long-term safety. This indicates that a high level of ambition will be required to characterize a suitable rock volume for SFL 3-5.

Site Evaluation

SKI's preliminary evaluation, based on the general site investigation programme, is that SKB's planned site investigation programme meets the prerequisites to provide the data required for the safety assessment and repository planning. However, a final evaluation cannot be made until SKI has examined the subject and site-specific programme descriptions in detail.

In SKI's opinion, there is good reason for SKB to conduct a complete safety assessment based on the results from the initial site investigation. One of the most important arguments is that a new safety assessment would give SKB an opportunity to show the way in which it has corrected the deficiencies in the safety assessment methods that were pointed out by the authorities' and the International Review Team's reviews of SR 97.

Overall Evaluation of the Site Investigation Programme

In SKI's opinion, SKB's description in the RD&D Programme 98 Supplement meets the Government's requirements regarding an unambiguous site investigation programme. The justification for this opinion is as follows:

In SKI's view, SKB has adequate scientific and technical knowledge to conduct site investigations.

In SKI's opinion, the general site investigation programme that SKB has presented in the RD&D Programme 98 Supplement meets the prerequisites to provide the necessary data for an application for the siting of a spent nuclear fuel repository.

SKI and SSI will be given the opportunity to review and state their opinion of the more detailed programme descriptions that will be submitted prior to the start of site investigations, in the framework of the consultation process that will take place between SKB and the authorities before the start of site investigations. Therefore, the authorities will have the opportunity to follow up the issues presented in this review.

Financial Compensation

Financial Compensation to Municipalities

SKI shares the municipalities' opinion that the site investigation phase will require significant municipal involvement and that there is good reason for the Government to consider whether the level of compensation in accordance with the Ordinance (1981:671) on the financing of future expenses of spent nuclear fuel etc. can be raised from the current level of SEK 2 million per year. SKI is not adopting a position on whether or not the proposed level of SEK 5 million per year is suitable since this, in SKI's opinion is ultimately a political issue. SKI shares the municipalities' view that SKI, in the same way as at present, should be given the authority to decide on compensation to the municipalities since this would seem to be an efficient approach to handling this issue.

Financial Compensation to County Administrative Boards

SKI shares the municipalities' opinion that the work of the county administrative boards is of considerable importance and that the scope of the work is likely to increase during the site investigation phase. SKI has previously rejected an application from the county administrative boards concerning resources for work in connection with SKB's

feasibility studies. However, SKI emphasized the fact that this decision only applied to the conclusion of SKB's feasibility studies. Therefore, SKI's opinion is that the Government should once again adopt a position on whether resources should be allocated to the county administrative boards in connection with the site investigation phase.

Financial Compensation to Environmental Organizations

As was the case during the review process for RD&D Programme 98, several environmental organizations and opinion groups have also expressed a desire for resources to conduct their own activities in connection with the site selection process. In its Review Statement to the Government, SKI stated that this issue should be dealt with. The Government stated in its decision of January 24, 2000 that "the Government is considering the issue of whether or not special support should be given to voluntary organizations." SKI has the same view on this matter as at the time of its review of RD&D Programme 98 and therefore considers it important for the Government to decide whether support should be given to environmental organizations.

1 Introduction

1.1 General

Under the Act on Nuclear Activities, the owner of a nuclear reactor must undertake all of the necessary measures for the handling and final disposal of spent nuclear fuel and nuclear waste. The Act stipulates requirements for a research programme, which is to be submitted to the competent authority once every three years. The Swedish Nuclear Power Inspectorate (SKI) is the competent authority in this area and it evaluates and reviews the programme. SKI submits the programme to a wide range of external bodies for review. These include authorities, universities and institutes of technology as well as environmental organizations. Research programmes will also be reported once every three years in the future.

The Swedish programme for the final disposal of spent nuclear fuel was started many years ago and will continue for many more years before all of the measures to manage the spent nuclear fuel have been adopted. According to the Swedish Nuclear Fuel and Waste Management Co (SKB), the planned repository will not be closed until sometime in the year 2050. It is obvious that a series of decisions must be made before this goal is reached. The decision-making process can therefore be characterized as a multi-stage process.

In the Government's decision of January 2000, the Government stated that the research, development and demonstration for the handling and final disposal of nuclear waste (RD&D Programme 98) fulfilled the requirements of the law but that certain supplementary reporting should be made by SKB, no later than by when the next programme under § 12 of the Act on Nuclear Activities was prepared.

The supplementary report requested by the Government, which SKB submitted to SKI in December 2000, deals with issues concerning system analysis (including the zero alternative and deep boreholes) and the reporting of feasibility study material and site selection as well as the site investigation programmes. The Government also pointed out that if SKI finds SKB's reporting complete, SKI could submit a Review Statement to the Government before the preparation of the next programme, RD&D Programme 01.

1.2 SKI's Handling of the Matter

The report submitted by SKB, Integrated Account of Method, Site Selection and Programme prior to the Site Investigation Phase (TR-01-03) is supplemented by eight background reports and final reports from six feasibility study municipalities. The final reports from three feasibility study municipalities were only submitted to SKI in February – March 2001.

SKI's review considers the issue of whether the material that has been submitted is "complete". As described above, SKB's research programme is very comprehensive, spanning more than fifty years and involving recurrent reporting and reviews as well as related decision-making by the Government which also has the possibility of making stipulations. This review is one of the many review occasions and SKI's task is to evaluate whether the material submitted by SKB is adequate (complete) for the next stage. The next stage is, primarily, the selection of sites for investigation and a decision regarding whether or not site investigations can start. One condition for the site selection is that the final disposal method (KBS-3) is sufficiently well investigated to provide a basis for site selection and site investigations. It is obvious that extensive research and development work must be conducted during the many years remaining before the programme is completed in the middle of this century. It is also obvious that many decisions remain to be made in the stage-by-stage decision-making process. During these stages, safety will be evaluated and there will be the possibility of taking further time for development work or selecting improved solutions. SKI's task is to ensure compliance with the safety requirements during all of these stages.

SKI has reviewed SKB's RD&D Programme 98 Supplement in the same way as it normally reviews the RD&D programmes. SKI distributed the programme to sixty reviewing bodies (authorities, universities and institutes of technology as well as environmental organizations etc.). Statements of opinion were submitted by forty-five of these. The opinions largely focus on method selection and site selection issues, especially the selection of sites for investigation.

A new activity was also conducted to improve the possibility of the feasibility study municipalities gaining insight into SKB's programme and of obtaining answers to the issues raised by the programme. SKI and SSI arranged joint public hearings of SKB in the feasibility study municipalities. At the hearings, questions were raised by the public and answered by SKB and by the regulatory authorities, SKI and SSI. Hearings were held in Northern Uppland, in Oskarshamn/Hultsfred and in Nyköping in February 2001.

SKI's Review Report and Review Statement to the Government were handled by SKI's Board in May and June. The Statement to the Government includes SKI's Statement on SKB's RD&D Programme 98 Supplement and a Summary of Comments by Reviewing Bodies (*in Swedish*) as well as the complete statements of opinion.

2 SKI's Premises for the Evaluation of Method Selection, Site Selection and the Site Investigation Programme

SKI's premises for the evaluation of the RD&D programmes and supplements to these programmes are based first and foremost, on the Act (1984:3) on Nuclear Activities. The Radiation Protection Act (1988:220) and the Environmental Code (1988:808) must, in some respects, also be complied with. In addition, the accompanying ordinances and applicable regulations should be added to these legal acts.

SKI's evaluation of method selection, site selection and the site investigation programme is also based on the regulatory authorities' statements of opinion and government decisions on RD&D Programmes 92, 95, 98 and the Supplement to RD&D Programme 92.

2.1 Method Selection

The premises for method selection are based on the requirements made by the authorities and the Government in various contexts, particularly in connection with the reviews of RD&D Programme 95 and 98. In its decision on RD&D Programme 95, the Government stipulates that SKB, in its continued research and development programmes, should conduct a system analysis of the entire final disposal system which will allow an overall judgement of compliance to be made of the entire final disposal system.

SKI and SSI realized the need for a suitable interpretation and clarification of these requirements and, therefore prepared a joint report (System-PM 98) presenting the view of the regulatory authorities on the content of a report on method selection and system analysis (System-PM 98, SKI dnr 5.8-971083, SSI dnr 6220/1994/97, PM March 5, 1998, *in Swedish*).

In its evaluation of SKB's report within the framework of RD&D Programme 98, the conclusion of the authorities with respect to method selection was that the KBS-3 method was the most suitable, but that logical and pedagogical aspects of the presentation of the method selection should be improved.

The Government's decision on RD&D Programme 98 agrees in part with the most important views of the authorities. According to the decision, SKB must supplement its analysis of alternative system designs. In the first instance, the meaning of the zero alternative (a scenario where the planned measure is not implemented) should be clarified. Furthermore, the deep borehole alternative (final disposal in boreholes at depths of several kilometres) should be described with a focus on the scope and content of the research and development programme that is necessary in order for this method to be compared with the KBS-3 method on similar grounds.

Following the Government's decision, SKB further developed its description of method selection and system analysis in consultation with the authorities, which has also been described in RD&D Programme 98 Supplement (RD&D-S).

To facilitate an understanding of the premises for the evaluation of these issues, the description is structured in a similar way as in RD&D-S.

2.1.1 Strategy Selection and Overall Structure

An evaluation of the following therefore applies to strategy selection:

- Whether the logical structure and pedagogical presentation of SKB's report is adequate so that it can be understood by the broad public (including the evaluation of the system description for possible alternatives).
- Whether the specified requirements regarding strategies and systems for nuclear waste disposal applied by SKB are correct and comprehensive (ethics, conventions, laws etc.),
- Whether the stated reasons for selecting the strategy are well founded (including the reporting of the zero alternative).
- Whether any strategy is lacking or whether any new information has emerged since the last review, which contradicts SKB's justifications (including an evaluation of SKB's reporting on the international situation).

In its review of RD&D Programme 98, SKI's criticism primarily concerned the first point, the structure and pedagogical presentation of the report.

2.1.2 System Selection within the Geological Final Disposal Strategy

- The comprehensiveness of the system description of different alternatives for geological final disposal (including the reporting of the deep borehole method requested by the Government).
- Whether the specified requirements for a system for geological final disposal are correct and comprehensive.
- Whether the stated reasons for selecting the system are well founded (including the discussion of the deep borehole alternative).
- Whether any alternative is lacking or whether any new information has emerged since the last review which contradicts SKB's justifications.

Also in this case, SKI's criticism in its review of RD&D Programme 98 was more focused on the presentation than on the handling of the issue.

2.1.3 KBS-3 System Analysis

In its review of RD&D Programme 98, SKI stated that the system analysis for the main alternative presented by SKB was largely comprehensive and well structured. The deficiencies that were noted were related to the fact that no safety report for SFL2 (SR 97) nor for the repository for long-lived waste etc. (SFL 3-5) existed at the time. The

safety reports available for other system parts (canister, encapsulation plant and final repository operation) were generally considered to be of good quality with respect to the stage of the programme at that time. One reason why SKI nevertheless recommended a new system report prior to the site investigations was so that the results from SR 97 could be taken into account and, therefore, more clearly justify the connections between the different parts of the system.

In conclusion, the following factors are the basis for the review of the KBS-3 system analysis:

- The comprehensiveness of the description of the different parts of the system.
- Whether there is anything to indicate that safety would not be upheld.
- Whether there is a balance between different components, from the standpoint of radiation protection and safety.
- Whether the links between different parts have been taken into account.
- Whether the descriptions of variations in system design and freedom of action are of adequate breadth and depth.

When evaluating these points, the following factors must be taken into account: previous reporting for RD&D Programme 98 and the fact that the reporting is also being developed in stages, as was stated by SKI in its review of RD&D Programme 98 (p. 32, SKI Report 99:31).

2.1.4 Safety Assessment

The premises for evaluation are linked to the authorities' regulations and to the purposes of SR 97 which were specified by the authorities and the Government in connection with RD&D Programme 95.

In accordance with the Government's view, an assessment of the long-term safety of the repository should be conducted before an application to construct the planned encapsulation plant is submitted to the authorities and before investigations are initiated at two or more sites.

The review of the safety assessment carried out in connection with RD&D-S has focused on long-term safety, particularly the safety of the repository for spent nuclear fuel (SFL 2), and also that of the repository for other long-lived waste (SFL 3-5). A review of the safety assessment for the operation of these and other facilities has not been conducted in this context. Instead, the reader is referred to the regulatory review of RD&D Programme 98.

The introduction to the regulatory review of SR 97 summarizes the purposes of SR 97, as described in previous reviews and government decisions concerning SKB's programme:

- to show that KBS-3 would have good prospects of meeting long-term safety and radiation protection requirements and to demonstrate the feasibility of finding a site in Sweden that meets the requirements

- to demonstrate safety assessment methodology
- to provide data for measurement programmes for geoscientific site investigations and to evaluate the measurement results
- to provide data for the specification of requirements with respect to the canister and other barrier functions
- to contribute to specifying the factors that serve as a basis for the selection of sites for site investigations.

In the review of SR 97, the requirements concerning the first two points were presented under the heading "Overall Requirements on Safety and Radiation Protection", while the three other requirements were dealt with under the heading "Specific Purposes of SR 97". This structure is applied in the summary of requirements provided below.

Overall Requirements on Safety and Radiation Protection

As was stated in the Review Report for SR 97 (Section 2.1.1), all of the overall requirements on safety and radiation protection do not have to be met at this time, namely, about a decade before construction, if permitted, can start and many years before the final licensing. However, it is reasonable to demand of the analysis and the independent review that there should not be any unresolved issue that seriously indicates that the requirements should be fulfilled when an application is submitted. On the contrary, SKB's report should show that the requirements could be met. This is in agreement with SKI's statement to the Government on RD&D Programme 98, where it is stated about SR 97 that "the purpose is to show that KBS-3 would probably meet the safety and radiation protection requirements that SKI and SSI have stipulated in recent years, see above.

An evaluation of whether these overall requirements have been satisfied can be broken down into three questions:

- Is the methodology used for safety assessment sufficiently developed to allow an assessment based on a complete background material?
- Are there any deficiencies in the knowledge base presented and in the technical basis, or has any knowledge emerged during the independent peer review that indicates that the KBS-3 method would not be able to meet the overall requirements?
- Is the consequence analysis adequate, bearing in mind the current stage of the programme?

The importance of the first two points can be seen by the fact that it is not only the calculated and reported consequences (mainly in the form of radiation dose) or risks that are of decisive importance. What is at least equally important is *how* (methodology) and *which* basis (background knowledge of processes and materials properties etc.) has been used to develop these measures of consequences.

Specific Purposes of SR 97

To demonstrate the feasibility of finding a site in Sweden that meets the requirements

The feasibility of finding an acceptable site was already established in SKI's review of KBS-3 1983-84 (SKI dnr. 7.3.1-633/83, page 9; February 23, 1984, *Statement to the Ministry of Industry*). The purpose of SR 97 should be interpreted so that it should be clear whether this conclusion is still valid based on present-day knowledge. At the same time, it is evident that complete knowledge can only be achieved through actual site investigations.

To provide a basis for site investigations
The purpose is that, on the basis of SR 97, it should be possible to determine which kinds of investigations are necessary and the level of quality to be maintained in the measurement programmes. It is well known which investigations can be performed and this does not have to be specified further. On the other hand, the importance of different types of information has not been determined. In order to do this, it is necessary to conduct comprehensive analyses which can provide guidance as to which investigations should be given priority. However, in order to reach more definite conclusions, a broader basis of information is required than can reasonably be demanded of a single safety assessment.

To provide data for the specification of function requirements on the barriers
In the same way that the safety assessment can be used to formulate requirements on the rock and site investigations, it can be used to formulate design basis requirements in the form of function requirements, technical requirements and testing and control programmes for the engineered barriers. This was also one of the aims of SR 97. Once again, it is the completeness of the assessment that determines the extent to which such a purpose can be fulfilled. A complete set of requirements must be prepared no later than before the repository is taken into operation. However, it is important that the more basic function requirements should be identified during the current stage of the programme, particularly so that they can be used to guide work in the RD&D programme.

To contribute to the specification of site selection factors
The geological site selection factors intended here can be specified through SR 97 only on the basis of differences in the properties of the rock at the sites included in the study. It should be determined whether the site evaluations are adequate in this respect.

2.2 Site Selection

2.2.1 Siting Factors – Requirements and Criteria

Siting Factors concerning Feasibility Studies
SKB has based all of its feasibility studies on the following siting factors: safety, technology, land and environment as well as society. SKI has accepted this as a reasonable point of departure. At the same time, SKI has pointed out that sites in a municipality cannot be evaluated or ranked from the standpoint of long-term safety since the available data do not allow this. However, it is reasonable to make some kind of prognosis for a site, on the basis of the scope of the available data.

General Requirements and Criteria
SKB defines requirements as an absolute condition that must be fulfilled while criteria are defined as characterizing values for suitability indicators (parameters) which can be used to evaluate whether a site meets the requirements and preferences.

SKI stated in its evaluation of RD&D Programme 98 that the suitability of a site for a repository must ultimately be evaluated on the basis of an integrated safety and construction analysis which takes into account uncertainties and the interaction between different factors. The criteria fulfil an important function in clarifying what characterizes a suitable site for a repository. However, it does not provide an adequate basis to evaluate whether a site fulfils the basic safety requirements.

Criteria for Siting and Site Evaluation
Within the framework of its review of RD&D-S, SKI evaluated the importance of the geoscientific suitability indicators and criteria for siting and site evaluation that SKB presented in the "criteria report", SKB R-00-15. In its evaluation of SKB's report, SKI has particularly taken into account the following points:

- Is the structure that SKB has used to group the suitability indicators and criteria logical and usable for site evaluation?
- Does SKB's report represent a reasonable level of ambition and is the compilation complete?
- Are the priorities and conditions upon which SKB's report is based consistent with SR 97?

The role that the use of requirements and criteria can be expected to have in relation to the complete safety assessments that will be prepared at later stages is a decisive factor in SKI's evaluation.

2.2.2 Basis for Site Selection

Geoscientific Data
In its review of SKB's RD&D Programme 92, SKI considered it to be important for SKB to map the Swedish bedrock and, on the basis of this, eliminate sites that were unsuitable from the standpoint of final disposal. In connection with RD&D Programme 95, SKB presented such an overview which SKI, however, considered to contain a number of deficiencies and to not be particularly useful in the elimination process.

On the recommendation of SKI and the Government's decision of 1996, SKB reported the North-South/Coast-Interior study in RD&D Programme 98 without drawing any far-reaching conclusions with respect to repository siting in Sweden. SKI also found that this study contained a number of deficiencies and that it was not particularly useful in the elimination process.

As a follow-up to General Siting Study 95, SKB conducted individual studies in a total of 20 counties after the mountain ranges, parts of Skåne, Öland and Gotland were eliminated. In SKI's opinion, the studies are of good quality and show those there

prospects for siting a repository in the identified areas within, in principle, all of the investigated counties.

SKI's Premises for Evaluation
SKI's premises for its evaluation is that it is important for SKB, as far as possible, to report the weighting accorded to different factors to prioritize the areas in the different feasibility study municipalities and for SKB to describe how it has handled the varying factual data for the different sites.

In its review of RD&D Programme 98 (two feasibility studies had been completed and three initiated at that time), SKI stated that SKB had not clearly shown which siting factors had led to the recommendation of certain sites in municipalities, in comparison to other sites identified in the same municipalities.

2.2.3 Selection of Siting Alternatives for Site Investigations

The selection of sites for investigation and the implementation of the investigations are not regulated by Swedish legislation. In its review of RD&D Programme 98, SKI stated that it considered it reasonable for SKB, in its overall basis of selection, to also include *proposals* for selecting sites for investigation and to justify the selection of these sites. SKI stated that the *ultimate selection* of sites for investigation should not be made by SKB until the authorities and the Government had adopted a position regarding SKB's supplementary reporting.

SKI has evaluated whether SKB has correctly applied the siting factors reported in the feasibility studies and in the main report. Furthermore, SKI has evaluated whether the reporting is systematic, comprehensible and transparent.

Above all, SKI has evaluated how SKB has applied geoscientific and safety-related factors and how these have been weighted against industry establishment, infrastructure and societal factors.

2.3 Site Investigation Programme

2.3.1 Geoscientific Site Investigations

In this area, SKI has evaluated whether SKB's overall reporting is adequate to meet the Government's requirements on a transparent site investigation programme (government decision of January 24, 2000 on RD&D Programme 98). The overall issue is whether SKB's programme for site investigations can be expected to provide relevant data for repository construction planning and for evaluating long-term safety. In its evaluation, SKI has particularly taken into account the following issues:

- Has SKB taken into account insights gained from the safety assessment, particularly SR 97, in its design of the site investigation programme?
- Has SKB taken measures to deal with the most important viewpoints expressed by SKI and SSI in the most recent RD&D Programme reviews?

- Is there a plan for successive evaluation of data and regular feedback from performance and safety assessments to the investigations?
- Has SKB presented an appropriate programme for quality assurance of implementation, measurements, data handling and evaluation?
- Is there a programme for the continuous development and improvement of measurement methods and evaluation models?

One condition for SKI to consider SKB's reports as adequate for starting site investigations is that the above questions should be satisfactorily reported in the RD&D Programme 98 Supplement or that there should be a concrete plan for how they will be dealt with in continued work.

3 Method Selection

The part of SKB's report that is reviewed and commented upon in this Chapter is, primarily, Part II – Method – of SKB's RD&D Programme 98 Supplement (henceforth referred to as RD&D-S) in Integrated Account of Method, Site Selection and Programme prior to the Site Investigation Phase (TR-01-03). The following main references are included in the review:

- (Comparative) System Analysis – Selection of Strategy and System for the Final Disposal of Spent Nuclear Fuel. SKB R-00-32 (*in Swedish*).
- System Analysis – Final Disposal of Spent Nuclear Fuel in accordance with the KBS-3 Method. SKB R-00-29 (*in Swedish*).
- What Happens if No Repository Is Built? The Zero Alternative – Extended Interim Storage in CLAB. SKB R-00-31 (*in Swedish*).
- The Deep Borehole Final Disposal Alternative. Content and Scope of the RD&D Programme Necessary for Comparison with the KBS-3 Method. SKB R-00-28 (*in Swedish*).
- What Do Other Countries Do with their Nuclear Waste? SKB R-00-36 (*in Swedish*).
- The Swedish Nuclear Waste Management Programme. SKB, December 2000 (*in Swedish*).

A separate evaluation of SKB's safety assessment, SR 97, is provided in Section 3.2 on the basis of the premises that, in SKI's view, should apply before site investigations start.

3.1 System Analysis – including the Zero Alternative and Deep Boreholes

3.1.1 SKB's Report

In each chapter, Part II of RD&D-S deals with strategy selection (Chapter 4, Strategies), system selection within the strategy of geological final disposal (Chapter 5, Methods for Geological Disposal), the system analysis for the KBS-3 method (Chapter 6 Deep Disposal Based on KBS-3). SKB's most important conclusions are provided below for each of these parts.

Strategy Selection
SKB's conclusions are summarized in Table 4-1 of RD&D-S as follows:

- Ocean dumping, sub-seabed disposal and disposal beneath the continental ice sheet are considered to be in violation of international agreements.
- Supervised storage (which in principle also includes the zero alternative) would entail shifting responsibility to future generations; furthermore, the long-term safety and radiation protection requirements are not satisfied.
- Launching into space is considered to be too resource-intensive and costly.

- A strategy involving reprocessing and transmutation requires a complicated nuclear system, including new reactors. Furthermore, extensive research is needed. The long-lived waste will also still have to be dealt with. Furthermore, such a strategy is not considered to be viable or politically relevant for Sweden.
- SKB considers that geological disposal fulfils all requirements, is viable and allows future generations to retrieve the waste.

Selection of System for Geological Final Disposal
SKB's overall evaluation concerning the selection of methods within the strategy of geological final disposal is presented in Section 5.3.7 of RD&D-S. In short, SKB's evaluation entails the following:

- For the WP-Cave and deep borehole alternatives, considerable work is necessary within technology development and knowledge development to be able to evaluate safety; in the overall evaluation, these alternatives are considered to be less attractive due to the significant uncertainties associated with if and when such repositories are constructed. In a separate study, SKB estimates the cost of developing the deep borehole alternative to be at the same level as KBS-3, about SEK 4 billion. The development work is estimated to take 30 years.
- Very long tunnels are considered to correspond to KBS-3 but are not considered to provide the same level of safety during operation.
- SKB considers the KBS-3 method to be well developed and sufficiently mature to be implemented. According to SKB, radiation protection, safety and long-term safety during operation are the factors that make KBS-3 preferable to other alternatives.

System Analysis for KBS-3
SKB's conclusions are presented in Section 6.7 of RD&D-S.

According to SKB, the system analysis shows that the possibility of meeting all of the requirements on the system is good. SKB states that there are degrees of freedom before the layout of the repository must be finalized. SKB states that this is due to the stage-by-stage implementation of the programme that SKB is planning, which allows decisions to be made successively, based on the new knowledge that emerges from SKB's programme and from international work.

3.1.2 Comments by the Reviewing Bodies

In the opinion of Umeå University, a deep rock repository with several protective barriers is widely accepted and is obviously the best method. The University considers other methods for geological final disposal to be less feasible alternatives, for example, that the deep borehole method has not yet been developed and, furthermore, it does not appear that it will be for practical, operational and control-related reasons.

Lund Institute of Technology's opinion is that the KBS-3 method is convincingly the most suitable technical alternative for Sweden, in the light of current knowledge. At the same time, the Institute emphasizes that the KBS-3 method cannot function satisfactorily at every site. Therefore, a specific site must be assigned for the method

and the population must have the security of knowing that a correct decision has been made, on behalf of many generations, if the project is to maintain its credibility and function optimally.

Fysikum, Stockholm University, considers that the alternatives to KBS-3 that are available at present or in a future perspective of 50-100 years are not realistic. In particular, the University specifies transmutation, deep boreholes, the DRD method and the zero alternative.

The Paleogeophysics and Geodynamics Unit of Stockholm University expresses the criticism that the DRD method (Dry Rock Disposal), launched by Mörner, has not been investigated. In Mörner's opinion, a time-limited deep storage in accordance with this method would provide the opportunity to develop other methods in time and, in this way, avoid the risks that are associated with bedrock movements in connection with a future ice age.

The Medeby-Orrskog Group's views can be summarized as follows:

- That the KBS-3 method has such serious weaknesses that alternative methods are required, especially with respect to the evaluation of the environmental impact statement where at least two methods must be compared with each other.

- That a programme to systematically develop and test one or several alternatives such as deep boreholes or supervised storage in dry or wet rock caverns for long periods of time should be procured through an official procurement process.

The Municipality of Oskarshamn and the Local Safety Committee at Oskarshamn Nuclear Power Plant, in a joint statement, state that clarity is now required with respect to the method issue. Particularly, on the topic of whether the KBS-3 method provides an adequate basis of planning as required by the Government prior to site selection. The Municipality assumes that the regulatory authorities, SKI and SSI, on the basis of their expertise, will clearly state their opinion of SKB's description of the KBS-3 method in comparison to other methods that may exist. However, in the Municipality's view, a site investigation for KBS-3 must not lead to an absolute focus on this method. Parallel research, at a reasonable level, must continue to be conducted on other methods. For the municipality, it is therefore important that SKI and the Government should evaluate SKB's level of ambition in order to be able to maintain the necessary competence to follow and learn from progress made internationally. Another issue raised by the Municipality is the time-schedule for the application to construct an encapsulation plant and detailed characterizations.

In its review statement, the Waste Network put forward a number of demands which, in brief, are based on the assumption that an independent body should take over the responsibility for a national Environmental Impact Assessment (EIA) in order to select the best available technique and site and that SKB should be relieved of all overall responsibility for resolving the nuclear waste issue. The Waste Network also attaches a detailed history concerning the treatment of the waste issue in the Swedish nuclear power programme.

The Municipality of Östhammar raises issues concerning the determination of final disposal depth with respect to future glaciations and considers that rock seismics must be investigated.

The Municipality of Älvkarleby does not find any reason to question the KBS-3 method. However, it also states that final disposal depth is the remaining issue. In the Municipality's view, other methods should be further investigated, such as deep boreholes.

SOS-Älvkarleby expresses the concern that the process is progressing too rapidly: Why the hurry? Examples of issues that should be dealt with before progressing to the next stage are provided, especially the issue of long-term chemical problems in deep groundwater and microbial influences on copper corrosion.

Uppsala University dwells on method selection, especially in connection with transmutation and emphasizes the importance of maintaining flexibility in method selection. Taking into account the long time horizon for the programme, the University considers that SKB's rejection of transmutation for political and economic reasons is questionable since these phenomena can change considerably, even in the short term. The University also underlines the importance of transmutation research as a means of maintaining and ensuring the qualified training of students and researchers in the industry. On the whole, the University's opinion is that, based on the present-day waste management situation and state of knowledge, the KBS-3 method is optimal for its purpose. However, the deep borehole method could be attractive in the future in combination with transmutation, which generates a lower volume of waste.

In its statement, the Swedish Society for the Conservation of Nature expresses a number of points, largely with the following content:

- that the method selection has not been adequately investigated and that, therefore, site investigations cannot be based on KBS-3,
- that SKI's DIALOG project should be resumed in order to create a national and democratic forum for dealing with the nuclear waste issue,
- That a Strategic Environmental Assessment (SEA) should be conducted to determine a suitable method and that an independent body should assume responsibility for this assessment.

In SOS-Tierp's opinion, SKB's account of alternative methods in RD&D-S is deficient and its only purpose is to confirm KBS-3 as the only possible method: "By consistently undervaluing other alternatives and by making deluding references to "retrievability" as an explicit requirement, SKB AB has managed to reject other alternatives as "unrealistic"." SOS-Tierp puts forward a number of demands, which can be more or less summed up as follows:

- that the siting process should be discontinued and that the Government should assume responsibility for method selection and site selection
- that financial resources must be allocated to independent actors

- that the Government must appoint an independent review body with the responsibility of conducting an EIA on the programme level (Strategic Environmental Assessment).

The Swedish Geotechnical Institute shares SKB's view that KBS-3 is still the best alternative, that the zero alternative is not compatible with the specified requirements and that essential uncertainties must be identified in order for the deep borehole alternative to be compared to KBS-3 on similar grounds.

In the opinion of the Geological Survey of Sweden, in the light of the reported information, SKB can retain the KBS-3 method as the final disposal alternative that is most suitable for Sweden at present.

In its statement, the Royal Institute of Technology (KTH) does not take into account SKB's method selection but considers that the transmutation alternative has been unfairly treated in RD&D-S and that it important for SKB, also in the future, to substantially support this alternative.

The People's Campaign against Nuclear Power-Nuclear Weapons (Oskarshamn) considers that method selection must precede site selection and that SKB is attempting to accelerate a decision on final disposal and is therefore reducing the value of the possibilities that would exist with extended storage in CLAB, such as allowing further research to be conducted.

The County Administrative Board, Kalmar considers that the issue of the status of the KBS-3 method is often viewed as unclear and that, therefore, it is of the greatest importance that SKI and SSI should be very clear, in the future, with respect to the position that they adopt on KBS-3 method and the scope of research conducted on other methods.

The County Administrative Board, Uppsala considers that, of the different methods for geological disposal that SKB has reported, none of the alternatives to the KBS-3 method is obviously better than KBS-3 with respect to environmental and health hazards.

The Municipality of Tierp considers that the method selection, with the emphasis on alternatives to KBS-3, e.g. deep boreholes, must be further investigated and that both advantages and disadvantages should be clearly specified for the methods described.

The Local Safety Committee in the Municipality of Östhammar's opinion on SKB's evaluation in RD&D-S is that the KBS-3 method should be given preference over the deep borehole method.

The National Housing Board agrees with the view that it should be possible to use the KBS-3 method for the safe long-term disposal of nuclear waste at the same time that the method gives other generations the freedom to re-evaluate the decision.

To summarize, the Swedish Radiation Protection Institute considers that SKB's reporting of alternative system designs, including the research programme that is required to attain a good level of knowledge of the deep borehole alternative, as well as the investigation of the zero alternative are in agreement with what the Government has requested and are acceptable. SSI considers SKB's selection of geological final disposal as a strategy to be well founded. With the exception of deep boreholes, SSI does not find any advantages, in principle, with the alternatives to KBS-3 that SKB describes. According to SSI, deep boreholes could be an "implementation alternative, in accordance with the requirements of the Environmental Code". Therefore, this alternative may have to be supplemented by a safety assessment, no later than in connection with SKB's application for permission to construct a repository. Furthermore, SSI comes to the same conclusion as it did in connection with the review of RD&D Programme 98, namely, that transmutation is not a feasible solution for Swedish conditions. SSI also shares SKB's view that extended interim storage in CLAB should be considered to be a zero alternative and that this is not an implementation alternative.

SSI would like to see a better link between the system analysis and the assessment of long-term safety with respect to the operation of various facilities in the final disposal system. For this purpose, SKB should present a plan of action (strategy document) for the work that remains to be done during the time until the application is submitted, which also specifies when main goals and stage goals need to be attained. However, SSI does not consider the deficiencies that have been observed in SKB's system to be an essential drawback (at this stage of the programme).

3.1.3 SKI's Evaluation

Strategy Selection
The views on the strategy selection that SKI and SSI put forward in connection with the review of RD&D Programme 98 concerned SKB's way of presenting the material which, in that case, was considered to be unstructured and difficult to follow, especially for a broader public. SKB has made considerable improvements in these respects in RD&D-S. The information is straightforward and presented in a clear and pedagogical manner and the reasoning is easy to follow. SKI does not see any essential reason to change the opinion presented in the review of RD&D 98 that geological final disposal is a correct choice.

The need for an improved and coherent presentation of the zero alternative was also pointed out by SKI in its review of RD&D Programme 98 as well as in the Government's decision of January 24, 2000 on RD&D Programme 98. In this case, the presentation in RD&D-S was considerably improved in comparison with previous presentations, for example, the consequence description. SKB has clearly stated that continued storage in CLAB is the zero alternative in accordance with the requirements of the Environmental Code. At the same time, in SKI's view, it is clear that such an alternative is not realistic, from the standpoint of possible consequences or bearing in mind the fact that such a procedure is in conflict with the principle of not shifting responsibility to future generations. On the other hand, it is quite clear that extended storage in CLAB is the most reasonable short-term alternative if a repository is not

built. It is not possible to specify the additional measures and decisions that may be needed in such a situation and, in SKI's opinion, they do not have to be planned at this stage of the process. In its statement, SSI raises the issue of whether continued storage in CLAB can actually be considered to be a zero alternative in the sense of the Environmental Code, even if it is not in agreement with the Act on Nuclear Activities nor realistic from the technical standpoint. SKI shares SSI's and SKB's opinion that this alternative, in spite of everything, must be considered to be a zero alternative.

For the same essential reasons as for the zero alternative, SKI's opinion is that other alternatives involving supervised storage that should be considered to be time-limited must also be excluded. This includes dry or wet storage of fuel in other facilities besides CLAB as well as storage in the bedrock (the DRD method).

The separate descriptions of international work and the retrospective on the handling of the nuclear waste issue that SKI requested in its review of RD&D Programme 98 have not been subjected to a detailed evaluation in this context. However, it is satisfactory that SKB has followed these recommendations. The aim of the recommendations was to facilitate the communication between those concerned by placing the current stage of the process in a wider context.

Selection of a System for Geological Final Disposal

SKB's reporting has also developed in a positive direction, even in the case of the selection of a system within the framework of the geological final disposal strategy. Furthermore, SKI does not see any reason to change its view of the KBS-3 method as the most suitable choice.

The Government's decision on RD&D Programme 98 required that the description of the deep borehole alternative should "focus on the scope and content of the research and development programme that is necessary for this method to be compared, on an equal basis, with the KBS-3 method". Such a description has now been presented by SKB in connection with RD&D-S.

In SKI's opinion, SKB's description in the background report presents a relatively neutral and concise view of the work that would be necessary to – if possible – develop deep boreholes to the same level as KBS-3. However, the conclusions of this description are only presented in the main report, namely, that in SKB's opinion "there is nothing to indicate that final disposal in deep boreholes, if this can be shown to comply with all requirements, would improve the level of safety or reduce the costs of spent nuclear fuel final disposal".

SKB's description of an RD&D programme for deep boreholes clearly indicates possible designs of such a method as well as the difficulties that would result from an investment in this alternative. Examples of difficulties that are evident are:

- The choice of system design are far from obvious. This applies, for example, to the canister design, including the choice of material and the choice of drilling fluid and buffer material. In SKI's opinion, this would entail significant difficulties in

conducting a complete safety assessment that includes engineered barrier performance.

- The conditions at repository depth are considerably different from KBS-3 and decidedly more inconvenient in terms of temperatures, rock mechanics and groundwater chemistry. SKI believes that, especially with respect to the chemistry, there may be a need for a substantial basic research.

- The necessary feedback between barrier development, drilling and disposal techniques and the safety assessment will be of more critical importance than in the case of alternatives based on available technology. However, this issue has not been emphasized by SKB.

- There are no guarantees that such a programme would receive the international support received by alternatives based on the KBS-3 method.

In the light of these issues, in particular, SKI is very dubious to the value of requesting that SKB conduct complete safety assessments of deep boreholes. In actual fact, it is not possible, as a matter of principle, to conduct a safety assessment of deep boreholes that is on the same level as that of KBS-3 before a complete RD&D programme and a number of geological surveys have been conducted. Performance assessments of parts of the system could be conducted, primarily with respect to the role of the rock as a barrier against radionuclide migration. However, it is doubtful as to what the findings of such analyses could be compared with.

In SKI's view, there is also considerable uncertainty linked to the possibility of depositing canisters in a controlled manner at the significant depths that this method entails. To a greater extent, this also applies to any canister retrieval that is necessary due to incorrect emplacement or other reasons. In turn, these uncertainty places a limitation on the possibility that future generations would have of re-evaluating decisions made by the present generation.

On the whole, SKI's opinion is that there are such major uncertainties associated with deep boreholes, relating to implementation and the possibility of conducting a sufficiently well founded safety assessment that this method should not be included as a realistic alternative to KBS-3 in future discussions. This view is supported by SKB's review of the costs and time required to carry out an RD&D programme for this alternative. SKI considers SKB's estimated cost of SEK 4 billion to be an underestimate. SKI also shares SKB's opinion that the cost of developing a drilling method is probably highly underestimated. The estimated time to implement the programme, 30 years, is more difficult to estimate but would appear to be reasonable, bearing in mind the fact that the method is in many respects ground-breaking, that new technology and science must be developed and that there must be adequate time for the above-mentioned feedback between technological development and performance assessments. The estimated cost and time reinforce SKI's opinion that a programme for deep boreholes is a considerably less optimal alternative than continuing with the KBS-3 method.

As can be seen from the line of reasoning above, it is very dubious whether the deep borehole alternative can be a meaningful alternative to KBS-3 in connection with licensing under the Environmental Code. Furthermore, it is not obvious that such an alternative must be reported on the same level as the main alternative. In any case, SKI's view is that the issue of which alternative should be described in connection with licensing under the Environmental Code does not have to be resolved at this stage, before the site investigations.

With respect to following and investing in other alternatives besides KBS-3, SKI believes that this should continue to more or less the same extent as at present. It is in SKB's own interest to continue with these parts of its programme, in order to benefit from new findings and to continue to justify its selection of the main alternative. However, the implementation of such a programme should not be perceived as evidence that there is any doubt, at present, that KBS-3 is the only realistic alternative and the method upon which the planning of site investigations is to be based.

System Analysis of KBS-3

SSI shares SKI's opinion that SKB's KBS-3 system analysis has certain deficiencies but that the analysis is acceptable, bearing in mind the current stage of the programme. The description of operations-related issues is not complete, for example, the handling of damaged canisters. However, in SKI's opinion, these issues are not of a critical nature for the implementation of the method and there is adequate time to resolve them later on in the programme.

Future system reports need to more clearly describe the link between the different parts of the system so that the interaction of the system, as a whole, in meeting the requirements on safety and radiation protection during operation and during the time after repository closure is clear. This particularly applies to the canister and the bentonite where the design and performance of these engineered barriers have so far comprised the conditions for the safety assessment and not observed data. This raises the issue of the performance requirements on the different parts of the system and how these have been derived. In SKI's opinion, SKB should consider preparing a document (a safety strategy) that defines the performance requirements, technical requirements and that also specifies a time-schedule for this work in relation to the programme as a whole. Plans for long-term experiments, for example on the buffer, can also be included in such a plan. The idea of such a document has been put forward by the NEA's International Review Team for SR 97 (NEA, 2000) and by SSI in its Review Statement on RD&D-S. Such a document would need to be prepared in consultation with the authorities and reported no later than in connection with the next system analysis and safety assessment (see below).

Conclusions

The presentation of the choice of method is considerably improved, compared with RD&D Programme 98. This also applies to the zero alternative in the form of continued storage in CLAB. In SKI's opinion, as with the review of RD&D Programme 98, SKB has shown that the KBS-3 method, on the whole, is the most suitable method for the final disposal of spent nuclear fuel.

The account of the cost and time required for the development of a RD&D programme for the deep borehole alternative underestimates rather than overestimates the difficulties of this alternative. SKB's account reinforces SKI's opinion that deep boreholes are not a realistic alternative, primarily with respect to the major uncertainties associated with deposition methods and the possibility of conducting a meaningful safety assessment.

With respect to following and investing in other alternatives besides KBS-3, SKI believes that this should continue to more or less the same extent as at present.

The deficiencies observed in the system analysis for the KBS-3 method are acceptable and do not have to be remedied until prior to the next system analysis and safety assessment.

3.2 Safety Assessment

3.2.1 SKB's Report

The conclusions of SR 97 and the review of the International Review Team as well as that of SKI and SSI are dealt with by SKB in Chapter 7 of RD&D-S – Long-term Safety.

According to SKB, SR 97 confirms that a KBS-3 repository in rock that does not differ significantly from normal Swedish bedrock has good prospects of meeting the requirements on long-term safety with good margin. Therefore, SR 97 shows that the prospects of constructing a safe repository for spent nuclear fuel are good. The results of the analysis show that the maximum radiation levels are less than one-tenth of the regulatory requirements.

In SR 97, new methods were tested, for example, a new method for the systematic reporting of knowledge about different processes and how they affect the repository barrier performance. According to SKB, the methodology was found to perform well and is considered to provide a good basis for further development for future analyses.

According to SKB, the experience from SR 97 is also a basis for according priorities in future RD&D programmes, for example, with respect to biosphere and seismic modelling and backfill performance. According to SKB, the experience has also been used in the work on formulating programmes for site investigation and evaluation as well as for reviewing the design of repository barriers.

In summary, SKB's opinion is that the scope of the safety assessment and the confidence in the results obtained adequately meet the requirements that should be made prior to the site investigation phase.

3.2.2 Comments by the Reviewing Bodies

A small number of reviewing bodies have made specific comments on the safety assessment of the repository, as was reported in SR 97. A couple of examples of such comments are presented below.

The Mehedeby-Orrskog Group refers to the criticism that was directed towards the regulatory review of SR 97, for example, with respect to scenario selection, corrosion attack on the canister and the bentonite's capability to perform as intended in the repository.

The Municipality of Oskarshamn emphasizes the importance of following up the review of SR 97, especially in relation to the site investigations. Scenario selection, post-glacial displacement and microbial influence on the repository are specified as issues upon which the Municipality would like SKI's evaluation.

SSI maintains the same opinion expressed by the authorities in connection with the review of SR 97, namely that no findings have emerged to indicate that KBS-3 would not be able to meet the necessary safety and radiation protection requirements. Therefore, in SSI's view, it should be possible for the KBS-3 method to be a basis for planning the selection of a site for a repository and for the design of the site investigation programme.

For the reviewing bodies comments on SR 97 in connection with the review, see the authorities' review report (SKI, 2001a).

3.2.3 SKI's Evaluation

SR 97 has already been jointly reviewed by SKI and SSI (SKI, 2001a). A summary of the authorities' conclusions from that review, emphasizing certain issues that are of particular importance for RD&D-S is provided below. In addition, it should be emphasized that formal requirements on SKB, with respect to SR 97, are only presented here in connection with the review of RD&D-S.

The methodology developed by SKB and applied for the SR 97 safety assessment is considered to be a clear advancement, which can be further developed. This positive conclusion applies primarily to the analysis of the process system for the repository. Certain deficiencies exist with respect to the systematicness of scenario selection and development, the evaluation of uncertainties (including the use of the risk concept) as well as the use of alternative indicators for safety and radiation protection. However, in all of these respects, it is considered to be possible to develop the methodology prior to future analyses.

In their evaluation of the knowledge base and the technical conditions, SKI and SSI concluded that, even if the use of models was generally adequately based on scientific approaches, the documentation and justification of the use of models must be improved in future analyses.

In their review of SR 97, SKI and SSI came to the conclusion that there were no obstacles to prevent a repository in accordance with the KBS-3 method from meeting the necessary safety and radiation requirements. However, a more detailed evaluation is only possible after the properties of the barriers have been investigated through the manufacturing of the engineered barriers and through the collection and evaluation of data from site investigations with respect to the rock's properties as a barrier.

The purpose of SR 97 was also to provide a basis for site investigations and performance requirements on barriers and where SKI and SSI noted that SKB referred to separate projects (see Chapter 6).

SKB in RD&D-S, has reproduced the conclusions of the International Review Team and of the authorities' review and that both are entirely based on methodology, the knowledge base and the evaluation of the importance of the uncertainties for the final consequence analysis. However, in its own conclusions in RD&D-S, SKB highlights the estimated consequences in a way that is misleading, with respect to the fact that it is the quality in the basis for the calculations that must be evaluated in the first instance, not whether or not the results meet the requirements.

To summarize, SKB's safety assessment is considered to be sufficiently well developed prior to the site investigation phase. The methods, including the selection and evaluation of scenarios need to be further developed in good time before the application to construct the repository is submitted. The safety assessment should therefore preferably be reported when adequate information is available from the site investigations. The results of such an analysis would also be of importance for setting the direction of the concluding investigations.

SFL 3-5

SKI and SSI have conducted a joint review of SKB's preliminary safety assessment for the SFL 3-5 repository (SKI, 2001b). An International Review Team was also commissioned to conduct a review (SKI, 2000).

In summary, the conclusions from this review are that SKB's assessment is not yet adequate for the siting of this repository. An action plan must be prepared to improve the safety assessment, especially so that it can be used, within a reasonable period, as a starting point for performance requirements for the waste products which already exists or will exist before the SFL 3 and 5 repositories are completed. In order to adopt a position at a later stage on a co-siting of SFL 2 and SFL 3-5, a new assessment must be conducted before the start of the final phase of the site investigations.

Conclusions

SKB's safety assessment for a repository for spent nuclear fuel is on an acceptable level with respect to the requirements that can be made prior to the start of site investigations. However, in good time before the application to construct the encapsulation facility or repository, a new safety assessment report must be submitted. This is also necessary taking into account the feedback to the site investigation programme and to establish more definitive barrier performance requirements. A suitable time for this is after the end of the initial stage of the site investigations.

4 Criteria for Siting and Site Evaluation

The part of SKB's report that is reviewed and commented upon in this Chapter is primarily the "Criteria Report" SKB R-00-15 and Part III – Site, Chapter 10, Siting Factors, of RD&D-S in Integrated Account of Method, Site Selection and Programme prior to the Site Investigation Phase.

4.1 SKB's Report

Prior to the planned site investigations, SKB presented its view on how geoscientific factors will be taken into account in the evaluation of candidate sites (SKB, 2000). The choice of requirements and criteria has partly been based on results from SKB's most recent safety assessment, SR 97. The report investigates how geological, mechanical, thermal, hydrogeological, chemical and transport properties affect repository performance. The suitability indicators and criteria identified relate to measurable individual properties and parameters where possible. The report also describes the phases during which different types of information will be available for evaluation. SKB has chosen to characterize several siting factors as preferences with respect to specific conditions in the rock and only in a few cases are absolute requirements specified.

4.2 Comments by the Reviewing Bodies

SSI states that SKB does not specify any biosphere parameters as determining factors for requirements or as a basis for formulating preferences with respect to long-term safety. Furthermore, SKI has determined that the biosphere conditions are therefore not considered by SKB to be site-specific with respect to long-term protection. In this context, SSI states that different conditions in the biosphere, such as dilution, groundwater salinity and accumulation processes can have a considerable impact on radiation doses to man and the environment. SSI has previously requested that SKB should describe the ecosystems in the areas included in the basis for selection and state how compliance with SSI's regulations can be determined for the selected sites. However, SSI states that this description is missing from RD&D-S. Furthermore, in SSI's view, it is unclear how SKB has applied its *preference* to avoid pronounced discharge areas and its preference that the total salinity should be less than 50 g/l, in the selection of sites for investigation.

In the opinion of the Municipality of Oskarshamn, SKB's report on requirements and criteria (SKB, 2000) contributes to raising the credibility of the site selection process, even if the report was submitted at a late stage, considering the fact that the feasibility studies had almost been completed. The Municipality states that it is now vital that SKI should evaluate SKB's requirements and preferences regarding the rock and determine whether they should be applied during any site investigations that are carried out. The Municipality would also like to be informed about how SKI intends to follow up the results from the site investigations in the light of these criteria.

The Municipality of Hultsfred considers that more detailed investigations of the Hultsfred area as a siting alternative are warranted bearing in mind the many advantages offered by the area from the standpoint of safety. The Municipality also emphasizes the fact that Hultsfred is the only municipality that is largely above the highest shoreline and underlines the advantages this would lead to in terms of recharge areas and groundwater chemistry.

The Municipality of Älvkarleby, the Municipality of Tierp and the Green Party, Tierp consider that SKB's report on requirements and criteria (SKB, 2000) must be subjected to peer review and evaluated now, before the sites are selected. These reviewing bodies consider that all factors that are of importance for long-term safety, such as radionuclide transport, must be given the status of requirements and not simply preferences. The question of whether the properties of the rock should not also be evaluated in a long-term geological perspective, for example, with respect to the expected climate changes, is also raised. These reviewing bodies would also like to have the authorities' answer to the question of whether SKB should select and propose the site that has the highest safety margins or whether it is sufficient for the level to be "adequate". The reviewing bodies also maintain that SKB's application of requirements and preferences has been arbitrary in some respects and that certain selected sites have been justified by criteria which are not included in the list of requirements. The bodies also believe that a more comparable database from the feasibility study municipalities is needed to provide a basis for site investigation.

SOS-Tiep's opinion is that SKB's requirements and preferences do not provide an answer to the question of the best rock type for geological final disposal. Therefore, in its view, it is not possible to achieve a systematic elimination of the feasibility study municipalities from a safety perspective. The reviewing bodies also consider that the value of the geological factors has been played down in the site selection process and, as an example of this, they cite the fact that SKB wishes to continue its work on the Simpevarp peninsula in spite of the fact that it is not prioritized from the geological standpoint. Furthermore, SOS-Tierp maintains the fact that SKB can hardly expect to "lose out" at the trial drilling stage, bearing in mind the fact that the requirements on the rock are limited (a few requirements with considerable margins).

The Mehedeby-Orrskog Group's view is that SKB's account of requirements and preferences is easy to grasp. However, the Group objects to the fact that certain requirements have been selected in such a way that they are not site distinguishing in practice. The Group states as an example that it should be possible to meet the requirement on a highest salinity of 100 grams per liter at repository level in large parts of the Swedish bedrock. The fact that SKB has only formulated preferences for the hydraulic conductivity of the rock and certain chemical properties is also questioned.

Uppsala University points out that the rock's properties must be such that they not only meet present-day requirements but also withstand the stresses that will occur with time, for example land elevation and glaciations. The University also considers that the database for the Tierp area is inadequate, due to the low outcropping. Therefore, the

University considers that, for the time being, the Tierp area should be given lower priority than other geological more accessible sites.

In the opinion of the Geological Survey of Sweden (SGU), it is a positive step that SKB has formulated requirements and preferences for the bedrock and that these have been converted into measurable parameters and criteria. However, SGU believes that it is unacceptable that it is only SKB, which is formulating the requirements and preferences and proposes that the regulatory authorities, SKI and SSI, should formulate several specific requirements and preferences before SKB's siting work is reviewed in future.

The County Administrative Board, Västerbotten, presents in an appendix, an extensive review of geological siting conditions, focusing on the conditions in Västerbotten for the siting of a repository. This reviewing body considers that there are a number of advantages of including Västerbotten as an alternative for site investigations, taking into account geological, hydrogeological and geochemical siting factors, the geological breadth and other factors. The County Administrative Board also discusses siting factors of importance from a long-term perspective, including the effects of future land elevation and sea level changes.

Per-Arne Lindqvist and Karel Miskovsky (expert advisors to the Board) consider that SKB's method of defining systematic requirements and preferences for the rock has allowed the work on identifying a site to host a repository to make progress. The authors present a review of the geoscientific conditions for the siting of a repository within the municipalities of Storuman and Malå, and reach the conclusion that there are advantages that would justify SKB selecting an area in these municipalities as a further siting alternative. Furthermore, in the authors' opinion, SKB should also apply more stringent requirements on bedrock stability, bearing in mind the links between the operational phase and long-term safety as well as other factors.

4.3 SKI's Evaluation

In SKI's opinion, SKB's compilation of siting factors is presented in a pedagogical manner and is a valuable basis for the site investigation programme and the subsequent election of sites for detailed characterization. In connection with this report, SKB has also defined a useful site evaluation terminology. The use of requirements and criteria are a suitable means of enabling continuous reconciliation during different phases of site investigation and site selection and the possibility of, at an early stage, rejecting a completely unsuitable area. SKI intends to follow up SKB's requirements and criteria during the planned site selection phase, through a permanent group of national and international experts (see also Section 6.1).

In SKI's view, SKB's choice to limit the number of absolute requirements is well-founded, bearing in mind the probability that an integrated evaluation of long-term safety can only be conducted within the framework of a complete safety assessment. There are many aspects of the suitability of the site that cannot be unambiguously evaluated on an individual basis. How different processes and properties are inherently related to each other is decisive for long-term safety. Even if SKB were to restrict itself

to geoscientific siting factors, a more stringent formulation of absolute requirements could also lead to the exclusion of potentially favourable sites on the basis of deficient information. Since the use of requirements and criteria does not, on its own, provide an adequate basis for the evaluation of long-term safety, SKI considers it to be important for SKB to conduct a complete safety assessment based on the results from the initial site investigations (see also 6.1). In SKI's opinion, requirements and criteria cannot and should not be used to evaluate issues such as the ranking of sites, from the standpoint of safety.

One of the most important absolute requirements that SKB presents is that no ore potential should be present in the deposition area of the repository. In SKI's opinion, SKB must formulate this requirement more clearly. For example, it is inadequate that only the repository deposition area should be included. It would be reasonable for the requirement to also include a well-defined area around the selected deposition area. The purpose of this requirement is naturally to minimize the risk of future drilling in connection with prospecting from damaging the repository. In SKI's opinion, SKB should also describe which measures will be conducted to detect the presence of mineral deposits within the area covered by SKB's requirements.

SKI notes that SKB has chosen not to place any significant emphasis on the importance of regional recharge or discharge conditions. Therefore, SKI has conducted its own analyses which indicate that siting in regional recharge areas could result in significant advantages with long transport routes to the biosphere as well as greater depths to the saline groundwater (Voss and Provost, 2001). SKI shares the opinion of SGU, SSI and the Municipality of Hultsfred that SKB should develop a better basis for its evaluation that recharge and discharge areas are not an important siting factor.

SKB's requirements and preferences with respect to specific conditions in the rock are mainly based on factors that could breach the integrity of the engineered barriers. SKI is of the opinion that this may be a reasonable standpoint, bearing in mind the conditions upon which the SR 97 safety assessment was based. However, SKB's requirements and criteria are only discussed for the existing requirements in the rock. The major safety-related importance of the engineered barriers assumes that it must be possible to evaluate the corresponding conditions during periods with, for example colder climate conditions in a credible manner. Therefore, in SKI's opinion, SKB, at least in its reporting prior to the start of site investigations, has not paid adequate attention to the requirement on a geoscientific understanding of the history of the candidate site. Requirements and preferences regarding specific conditions must also apply during periods when climate conditions are different since the engineered barriers are also assumed to work during these periods (see also SR 97). Therefore, in SKI's view, SKB should pay more attention to the importance of indirect observations on, for example, the development of geochemical conditions. These can then provide a basis for assessing the climate evolution in future safety assessments. In SKB's general site investigation programme, it is stated that an extensive database, relevant to the history of the candidate sites will be developed. However, there is no report on how this information will be handled and on the importance that will be given to the evaluation of different candidate sites.

The Municipality of Oskarshamn would like to see SKB take a clearer position regarding the risk of paleoseismic movements in the bedrock. In SKI's view, this issue should have been discussed in the "Criteria Report" (SKB, 2000). A basis for evaluating possible risks associated with young rock movements needs to be developed in connection with the site investigations.

In SKI's opinion, the importance of favourable conditions for radionuclide retardation existing at a candidate site is greater than described by SKB. In its report (SKB, 2000), SKB states that it does not have to make any specific requirements on radionuclide retardation and justifies this by stating that SSI's requirements can be met by the engineered barrier functions, solubility limitations etc. However, in SKI's view, in spite of this, radionuclide retardation is very important in demonstrating repository performance in accordance with the multi-barrier principle. The application of this principle is included as part of SKI's proposal for regulations for the final disposal of nuclear fuel and nuclear waste. This should prompt SKB to develop an adequate basis for evaluating retardation before the final evaluation of candidate sites. However, vital information will not be available at this time, since SKB states, for example that the main work within the tracer experiments will be conducted during the detailed characterization phase. SKI recommends that SKB compile the information on retardation conditions in the rock so that it can be made available before the final evaluation of candidate sites.

Other important aspects of long-term safety which are partially dealt with in the report concern the necessary conditions in order for the engineered barriers to perform as intended. An important example is the water saturation phase in the bentonite. For example, SKB describes the consequences of an uneven wetting process and states that the extra load on the canister will be marginal. Another potentially unfavourable process is when resaturation of the bentonite continues for long periods. There is a risk that the properties of the bentonite will become locally degraded by high temperatures at the canister surface. SKI's view is that SKB should more clearly show that this can be avoided, especially in the case of deposition holes with extremely low water influx. The most reliable results are expected from full-scale experiments that could confirm that water saturation can be reached rapidly enough. SKB mentions the possibility of artificially resaturating the buffer if necessary. However, in SKI's opinion, SKB must show how this can be done before this possibility is taken for granted, for example, through full-scale experiments.

SKI intends to raise the above-mentioned points as well as a number of more detailed viewpoints in connection with consultations between SKB and the authorities prior to the start of site investigations (government decision of December 19, 1996 on RD&D Programme 95).

5 Site Selection

The part of SKB's report that is reviewed and commented upon in this Chapter is primarily Part III – Site, of SKB's RD&D-S in Integrated Account of Method, Site Selection and Programme prior to the Site Investigation Phase as well as final reports and certain related background reports on the feasibility study municipalities.

5.1 Siting Process

5.1.1 Background

SKB's programme comprises the siting of an encapsulation plant and a repository for spent nuclear fuel, both of which are nuclear facilities. Furthermore, a plant for the fabrication of copper canister must also be sited. This plant is an important component in the final disposal system, although it is not a nuclear facility. At a later stage, a repository for long-lived low and intermediate-level waste will also be sited and taken into operation. According to SKB's current plans, this repository is scheduled to be taken into operation in 2030 at the earliest.

The current process for the siting of a repository for spent nuclear fuel was presented in RD&D Programme 92 and in the supplement to that programme. In simple terms, the process comprises feasibility studies in 5-10 municipalities, site investigations at no less than two sites and detailed characterizations at one site. Both SKI and the Government have approved this structure, and this is stated in reviews and decisions made on SKB's RD&D programmes.

Information, dialogue and consultations between SKB and parties concerned, such as municipalities, county administrative boards and other authorities have been essential in the siting process so far. The Government has also, in several decisions, emphasized the importance of consultations (such as the decision of May 18, 1995 concerning SKB's RD&D Programme 92 Supplement, the decision of December 19, 1996 concerning RD&D Programme 95 and January 24, 2000 concerning RD&D Programme 98).

5.1.2 Comments by the Reviewing Bodies

With the exception of environmental organizations and opinion groups, few of the reviewing bodies have commented on the siting process that has been conducted so far. With respect to the siting process, the reviewing bodies focus on the information presented by SKB and on the method by which SKB has proposed sites for investigation. Above all, several municipalities question why SKB, in RD&D-S, uses three factors (bedrock, industrial establishment and societal aspects) instead of the four factors used in the feasibility studies (safety, technology, land and environment and society). The Municipality of Oskarshamn is particularly critical. The Municipality considers that SKB's changeover to new factors should have been dealt with in the EIA Forum in Kalmar County. The basic reason for the criticism seems to be concern that SKB is giving lower priority to the long-term safety of a repository in relation to other

siting factors. SSI also considers that SKB's arguments for the changed classification of siting factors are unclear and that they have been put forward at too late a stage in the feasibility study work.

In SSI's opinion, the importance of the biosphere to long-term safety has been given lower priority in connection with site selection and this does not agree with the information that SKB distributed prior to the feasibility studies. However, in SSI's opinion, the biosphere part of the site investigation programme is based on extensive investigation work, even if the programme has certain deficiencies.

Uppsala University's opinion is that siting near to an existing nuclear power plant is positive, on condition that safety can be ensured, taking into account public opinion, and that transport can be minimized. The National Housing Board also finds a co-siting of facilities preferable, if possible.

Some of the reviewing bodies (The People's Campaign against Nuclear Power-Nuclear Weapons in Oskarshamn, the County Administrative Board, Kalmar and feasibility study municipalities) in various ways raise the question of the siting of a repository near to a nuclear power plant, taking into account the consequences of a possible accident. This issue was also raised on several occasions during the hearings that SKI and SSI arranged in February 2001.

In its statement, SSI states that with the current safety level of nuclear power plants, there is nothing to indicate that the siting of a repository near to a nuclear power plant would be unfavourable. In SSI's view, not even a severe reactor accident would jeopardize the operation of the repository and the deposition of spent nuclear fuel in any decisive manner.

The County Administrative Board, Södermanland, states that SKB's proposal to conduct site investigations in Tierp, Oskarshamn and Östhammar should mark the discontinuation of further investigations of Fjällveden in the Municipality of Nyköping. Only if the site investigations show that these areas are not suitable for a repository should investigations of Fjällveden be considered once again.

The County Administrative Board, Västerbotten argues for conducting site investigations in the county. The Board's opinion is that the county's knowledge and the siting process have both developed in a way that make it possible and suitable for Storuman and Malå to once again participate. The Board also considers that investigations in Västerbotten will provide a broader geological base, which will mean an improvement in the quality of the entire process. In its statement, the Board also refers to the fact that the municipal councilors in both Storuman and Malå have voted, with a large majority, to renew their contact with SKB.

The environmental organizations and opinion groups that have submitted statements of opinion to SKI concerning RD&D-S are all highly critical of the site selection process and recommend that the process be interrupted. The most salient arguments are that SKB's proposed final disposal method is uncertain and associated with considerable deficiencies and that the site selection process is unsystematic and unscientific. Several

of these organizations propose that a new site selection process should be designed on the basis of the conclusions of SKI's Dialog Project (SKI, 1993a-c), which was conducted at the beginning of the nineties. Furthermore, a few organizations suggest that a Strategic Environmental Assessment (SEA) should be conducted for the management of spent nuclear fuel before an active site selection process starts. In several cases, it is proposed that the responsibility for the SEA and the site selection process should be transferred to a new and independent body.

In SSI's opinion, the scope of SKB's consultations with municipalities, county administrative boards and authorities in the preparation of RD&D-S has been adequate.

5.1.3 SKI's Evaluation

In the nineties, SKI has supported SKB's siting process and at the same time required supplementary studies and further investigations in a number of areas. SKI's criticism has above all concerned the extent to which the siting process has been systematic, focusing on issues of importance for the long-term safety of the repository. SKB's county studies, now completed, are for example largely a result of SKI's criticism against the national general siting study that SKB presented in connection with RD&D Programme 95. SKI agrees with the Geological Survey of Sweden's view that the siting process would probably have gained more credibility if the siting studies had been conducted before or at least early in the feasibility study work. However, the most essential is that the siting studies have now been completed and can, thereby, be used as a basis for evaluating SKB's site selection.

As described above, the information, dialogue and consultations between different parties concerned were important at the feasibility study stage. Various forms for the consultation process have been developed in the different regions and municipalities. In SKI's opinion, good work routines have gradually emerged, even if they are different from region to region. In SKI's opinion, the most important consultations are direct contact between SKB and the feasibility study municipalities and the contacts conducted on county level under the chairmanship of the county administrative board concerned. The fact that these consultations are valuable is also supported by all of the municipalities which emphasize the importance of allocating sufficient resources to the county administrative boards to participate in the consultation process and the forthcoming EIA (more detailed comments are provided in Section 6.2).

In Chapter 8 in RD&D-S, SKB provides an overview of the siting process so far carried out and the consultations that have been conducted are compiled in an appendix. Reports on the consultation meetings etc. are also included in the final reports from the feasibility studies. SKI has participated in practically all of the consultation meetings that have been conducted on a national level and on a county level. SKI shares SSI's opinion that SKB's reporting of the consultations is satisfactory. Neither municipalities nor county administrative boards have expressed any criticism against RD&D-S with respect to this. In accordance with government decisions (December 19, 1996 and January 24, 2000), SKB has also had several direct contacts with SKI and SSI. In the light of this, SKI considers that SKB has fulfilled the Government's request in the decision on RD&D Programme 98 that the company should consult with municipalities

concerned, county administrative boards and authorities as well as compile a report of the consultations.

SKI shares the view of the environmental organizations that the Dialog Project was valuable and gave insight into problems and possibilities relating to the site selection and decision-making processes. The Project was a research/development project that must be viewed in the light of the conditions existing in the early nineties. Environmental Impact Assessment (EIA) was, at that time, still a new instrument in Sweden and the legislation was vague with respect to the ways of conducting an EIA. Sweden's membership of the EU and the establishment of the Environmental Code have resulted in a clarification of the EIA rules. According to these rules, the proponent, in this case SKB, is responsible for the EIA. SKI considers the rules that apply at present to be suitable and adequate for the continued siting process.

The issue of SEA, an independent EIA body etc. were discussed in connection with the review of RD&D Programme 98 (SKI 1999a-b). In SKI's opinion, no new conditions have arisen since then and, therefore, it does not see any reason to revise its previous views on these issues. Since the concept of SEA is not defined in Swedish legislation, SKI considers, for example, that a government mandate to an authority or special committee to conduct such a process would lead to unclear responsibilities vis à vis SKB and its obligations in accordance with §§ 11-12 of the Act on Nuclear Activities. An extensive and complex SEA, extending over many years, would further delay and render the ongoing site selection process difficult.

Furthermore, In SKI's opinion, the recurring, official evaluation and review process, stipulated in § 12 of the Act on Nuclear Activities and its precursors, and which has been in progress for two decades, contains many of the elements that are assumed to be included in a SEA along with related public consultations. The aim, after all, is to ensure that a comprehensive and well-founded basis of decision-making exists.

In view of the reasoning presented above, SKI rejects the proposal to introduce new processes that are not supported by the current legislation. In SKI's opinion, § 12 of the Nuclear Activities Act provides the Government with adequate possibilities of ensuring that a comprehensive and well-founded basis of decision-making exists prior to the decision on method selection and the start of site investigations.

Several municipalities raise the issue of SKB's siting factors. They primarily question why SKB in RD&D-S uses three factors instead of the four factors used in the feasibility studies. SKB's reason is that the "new" factors correspond better to SKB's own assessments and that they facilitate evaluations by other parties. To a certain extent, SKI shares the view that SKB could have explained and justified the change in a better way. SKI realizes that SKB's new factors have led to a certain concern that SKB has given lower priority to the long-term safety of the repository in relation to other siting factors. However, the content of the three new factors corresponds to the content of the four that were previously used. In SKI's opinion, SKB's new factors are clearer and intuitively easier to understand than the four factors previously used. Furthermore, SKI does not consider that the change would have any significant bearing on such issues as SKB's choice of sites for investigation.

The basic requirements on safety and radiation protection, that are expressed in SSI's and SKI's regulations (SSI FS 1998:1, SKI FS 1998:1 and proposals for regulations on long-term safety, SKI dnr. 5.1-990760) apply, regardless of which factors SKB applies in its work. Therefore, SKI does not consider that the changeover to three siting factors means that there is a risk that long-term safety will be given lower priority than other more short-term factors.

SKI shares SSI's opinion that, with the current safety level of the Swedish reactors, there is no essential obstacle, from the standpoint of safety, to how near a repository or any other nuclear facility can be located to a nuclear power plant. However, bearing in mind that the issue is of public interest, SKI considers that any consequences of a nuclear accident to a repository should be investigated and reported by SKB. SKI proposes that this should be done within the framework of the consultations and investigations that SKB will conduct to prepare the EIS that will be included in an application to construct a repository.

5.2 Basis for Site Selection

5.2.1 Geoscientific Data

Since the mid-seventies, SKB has built up a general knowledge base on the bedrock and on its importance for long-term safety. In RD&D-S (Chapter 9), SKB provides a short summary of investigations and major projects that are included in the knowledge base that has been built up prior to the selection of sites for investigation. According to SKB, the knowledge base has been used to formulate requirements and preferences with respect to the rock, to compare between different areas and to draw conclusions regarding conditions for a repository in different geological environments (described in Chapters 10, 11 and 12 of RD&D-S). The knowledge base has also been the basis for the development of a programme for site investigations (Chapter 13, RD&D-S).

In RD&D-S, SKB refers to a summary of the geoscientific data up to the present day. This is presented in a separate report. A preliminary version of the report was submitted to SKI (Documentation of Geoscientific Background Data, SKB R-01-01, *in Swedish*). The report comprises about 750 references listed under a number of subject areas/themes. Each subject area/theme starts with a brief text that describes important issues within the selected subject area, the character of the documentation, the links between different documents. According to SKB, all of the KBS, SKBF/KBS and SKB Technical Reports as well as other relevant SKB reports are listed. A selection of references have been included, relating to Stripa and Äspö, HRL as well as SKI, SSI and KASAM's reports. A selection of references to the work included in the Finnish and Canadian programme are reported as well as a selection of references to the work published in the open, scientific literature and to a number of doctoral dissertations in relevant subjects.

In SKI's opinion, the report provides a good insight into the background references for SKB's geoscientific knowledge base. The report allows the interested researcher to penetrate parts of the knowledge base and allows for independent reviews of SKB's

cited source references to be conducted on a scientific level. In SKI's opinion, the report is an important part of improving the traceability of the material that SKB, as a whole, considers has resulted in the knowledge base that is making it possible for the step to be taken toward site investigations.

Since certain parts of the report only provide a selection of references, SKB cannot claim that it is complete. However, in SKI's view, the selection of references is a good starting point that makes it possible to penetrate the specific subjects. The listed references can, in this way, provide a platform for further research so that answers may be found to questions that are of interest for various reasons.

The report is limited to geoscientific data exclusively. In SKI's opinion, it would be valuable if similar compilations were also made for other areas that are of importance for repository safety, such as the engineered barriers.

Over the years, SKB has continuously presented parts of the investigations, studies and safety assessments that form part of the knowledge base, in connection with R&D and RD&D reports. On these occasions, SKI has evaluated, commented on or expressed an opinion on the information presented. In this way, SKI has continuously followed and evaluated parts of SKB's knowledge base and, thereby, has also gained an insight into SKB's total knowledge base.

Through its own research work in a number of areas and through the its preparation of its own "safety assessment", SITE 94, SKI has developed its own knowledge base which facilitates an evaluation of the present-day knowledge base. SKI's opinion is that the geoscientific data to which SKB currently has access through SKB's own studies and those of others are extensive and, on the whole, should make it possible for the transition to be made to site investigations. If they are conducted in the correct manner, the site investigations and subsequent detailed characterizations will make it possible to obtain the necessary site-specific information (geoscientific data) for various assessments of long-term repository safety.

SKI emphasizes that SKB's R&D activities in different areas will also continue to fulfil an important role. The knowledge base is dynamic and must be updated and supplemented with new findings that are relevant to the issue which are obtained both externally, in the scientific community, and internally through SKB's own further research.

5.2.2 Feasibility Studies

Background

SKB has conducted feasibility studies in eight municipalities during the period from 1993 to 2000. Local referendums in two municipalities in Norrland (the northern region of Sweden), namely Storuman and Malå, have resulted in SKB's withdrawal from these municipalities. In the Municipalities of Östhammar, Nyköping, Oskarshamn, Hultsfred, Tierp and Älvkarleby, all of the feasibility studies have now been completed and final reports published (SKB, 2000a-f). At the time of SKB's submission of the RD&D-S rapport, final versions of the reports from the feasibility studies in Tierp, Älvkarleby

and Hultsfred were not available. However, no new and essential geological information has been provided in the final reports that has affected SKI's (earlier) evaluation of this issue.

On the basis of the four siting factors: safety, technology, land and environment and society, a number of suitable areas within each municipality has been identified by SKB. Overall evaluations, based on the specified siting factors of technological and environmental conditions for establishment and transport have then been used as a basis for a limited choice of areas where geological field surveys and other supplementary studies should be conducted.

The unequal map database complicates the geological evaluation of the areas within each municipality where certain municipalities lack modern (5-25 years) geological maps of a suitable scale.

SKB has summarized its methodology for selecting areas in the following three steps:

1. Exclusion of areas with potential negative geological conditions
2. Choice of areas of interest for field surveys and supplementary studies
3. Evaluation of siting alternatives

In Step 1, the following negative siting properties (factors) have been taken into account:

- rock types that are of interest for mineral prospecting/mining or other utilization
- highly heterogeneous or difficult-to-interpret bedrock,
- known deformation zones or neotectonic (post-glacial) faults,
- pronounced groundwater discharge areas,
- indications of groundwater chemistry that is abnormal for Swedish bedrock.

Within the framework of Step 2, field surveys are conducted after eliminating areas with the properties described in Point 1.

After field surveys and other investigations, SKB conducts an overall evaluation (Step 3) of the alternatives that have particularly good prospects of meeting SKB's requirements and preferences. The following conditions are considered to be desirable:

- a common rock type that is of no interest for any other utilization of natural resources,
- a large area with few fracture zones,
- a high proportion of exposed rock and/or thin soil cover, simple and homogeneous bedrock conditions and a regular fracture/fracture zone system,
- access to the necessary infrastructure and good transport options in the form of harbours, railways or roads,
- few competing land use and environmental interests,
- positive local interest.

SKB's report on feasibility studies conducted (final reports) is evaluated below. In Section 5.3, a discussion is provided of the selection of sites for investigation based on the main report in RD&D-S and the feasibility study reports as well as certain background reports to these.

Östhammar Feasibility Study

After the first geological review, nine sub-areas with a potential for further study remained. In the next step, five areas were eliminated on the basis of conflicting interests, such some form of restriction from the standpoint of land use. Of the four remaining areas, Gimo, eastern Österbybruk, Hargshamn and Forsmark, the first two were rejected, partially on the basis of the same reason as that previously mentioned, namely special interests regarding land use. The field studies have therefore focused on Forsmark and Hargshamn. In Hargshamn work was relatively limited and comprised the mapping of two geological profiles with about 25 rock observations, while efforts were concentrated in the Forsmark area (about 70 rock observations).

In SKI's opinion, the selection of Forsmark over Hargshamn is not based on any obvious geological advantages (both areas are located in tectonic lenses, which SKB considers to be advantageous). The main focus is rather on the existing infrastructure and on the occurrence of existing industrial harbours (further comments are provided in Section 5.3). SKI shares SSI's opinion that infrastructure, in the form of industrial establishment and transport, should carry less weight in comparison with (good) geological conditions which are the basis for demonstrating that long-term safety can be achieved.

The Geological Survey of Sweden (SGU) states that regional fracture zones do not only follow the older plastic shear zones, but also intersect the tectonic lenses.

The Municipalities of Tierp and Älvkarleby state that SKB's site selection is not justified by pre-defined criteria (tectonic lenses).

On the basis of the preferences specified by SKB (the first three points under Point 3, evaluation of siting alternatives), the geological basis on which the Forsmark location is ranked higher than Hargshamn is not clear to SKI. In SKI's opinion, in order to achieve a more equitable comparison between the areas, the same mapping work should have been conducted in both areas.

SGU mentions that it is obvious from the Östhammar final report that the field survey work was less extensive in Hargshamn than in Forsmark. Furthermore, in SGU's opinion, it is regrettable that SKB's report lacks a clear account of the consideration that has been given in each municipality with respect to the selection of sites for field investigations as well as the extent of the work conducted during the field surveys.

SKI's consultants consider that in its selection of areas for field surveys, SKB has consistently used requirements and preferences regarding industrial establishment as the decisive factors (Andersson and Tirén, 2001).

Nyköping Feasibility Study
SKB considered seven areas in this municipality to be so favourable from a geological standpoint that field surveys were conducted within all of the areas with outcropping rock. This work is considerably different than that conducted in Östhammar, where SKB considered that only two areas had to be surveyed. After the field surveys, only the 2.5 square kilometre Svankäng area was eliminated.

Four of six remaining areas were eliminated on the basis of their value in terms of environmental protection, culture-nature conservation, outdoor activities and water supply. After this, the combination of Skavsta/Fjällveden and Studsvik, north and south remained. SKB states that, these areas are also of interest from the nature conservation standpoint and that this must be taken into account in connection with siting. SKB's preliminary overall evaluation is that the geological environment in the Fjällveden area has good prospects for long-term safety as well as the construction and operation of a repository, but that supplementary investigations are required before this can be determined. SKB bases its assumptions on the previously conducted KBS-3 safety assessment and on SR 97, where the Gideå area, with the corresponding geological environment has been investigated and found to fulfil the safety requirements with a good margin.

SKI has no serious objection against the feasibility study in the Municipality of Nyköping. SKI states that it has followed the three-stage process described above. However, SKI is dubious to the proposal of constructing a 15 kilometre-long tunnel, that probably intersects several regional and probably water-bearing fracture zones from Skavsta to Fjällveden. Furthermore, from the standpoint of cost, it is not justifiable to construct such a long tunnel if other, less expensive alternatives exist. Furthermore, SKI questions the benefit of conducting a new safety assessment of the Fjällveden area, which is proposed by SKB, solely on the basis of old data (further comments are provided in Section 5.3).

In its statement of opinion to SKI, the Municipality of Nyköping's preliminary evaluation of the Fjällveden alternative, which involves train transport through two municipality centres, is that this will not be considered to be acceptable.

Oskarshamn Feasibility Study
Most of the municipality has been evaluated by SKB as potentially suitable for the repository. In SKB's opinion, it is not possible, on the basis of the feasibility study data, to prioritize these areas using geological factors. The premises used in selecting certain areas for field surveys were, therefore, (in addition to the requirement on a potentially suitable bedrock) the technical and environmental conditions of establishment.

Following the overall evaluation, field surveys were therefore conducted in the form of bedrock mapping on the *Simpevarp peninsula* and in the area west of the peninsula, the *Simpevarp area*, as well as within the southern Oskarshamn area. Dominant rock types within the Simpevarp area consist of various varieties of Småland granite with elements of other rock types, especially fine-grained granites (aplite) which, at Äspö, was found to have a high hydraulic conductivity in places. The area south of Oskarshamn is considerably more homogeneous than the Simpevarp area and almost completely lacks

hypabyssal rock/dykes. However, a northeast-southwestern plastic deformation zone divides the area into two dominant granite types (Bergman et al, 2000a).

The field surveys did not change previous evaluations. Consequently, SKB prioritized the Simpevarp area due to the advantages of the existing infrastructure and opportunities for co-ordination.

SKI has no major objection to make to the feasibility study in the Municipality of Oskarshamn. SKI's evaluation is that SKB has conducted the three-step procedure that it has developed. Siting on the *Simpevarp peninsula* could involve risk-taking with obviously limited rock volumes. This is due to the complex bedrock with major water-bearing fracture zones and an abundant occurrence of fine-grained granite. The entire area west of the peninsula features large rock volumes. However, there is also a relatively abundant occurrence of granitic dykes which could be important in terms of hydraulic conductivity. In SKI's opinion, particular attention should be paid to this problem. SKB is also aware of this.

Hultsfred Feasibility Study

After conducting the study, SKB's preliminary evaluation was that six areas of varying size were potentially favourable from the standpoint of the bedrock conditions. On the basis of the size of the surface characterization alone, two large areas were then chosen for field surveys, west (60-170 km^2) and southeast (85 km^2) of Hultsfred, dominated by Småland granite of the Växjö and Filipstad types respectively (Wahlgren et al, 2000).

SKI also finds, as does SKB, that modern bedrock maps are not available for the area of southeastern Hultsfred/eastern Målilla and that the pattern of interpreted fracture zones appears to be somewhat denser and less regular than the area west of Hultsfred (preliminary final report). After the field surveys, the preliminary evaluation that both areas are potentially favourable remains.

The regional group in the Municipality of Hultsfred considers that the western area has obvious advantages compared to the eastern area. Furthermore, those living in the Municipality are surprised that SKB has chosen the eastern area and they also consider that SKB's choice is in breach of the consultation that was held with the Municipality in connection with the selection of the eastern area.

SKI can also note that the areas are located in the interior of Småland and largely above the highest shoreline which entails possible advantages with respect to groundwater chemistry and flow patterns in comparison with a coastal siting (Voss and Provost, 2001).

SKI has also found that SKB has systematically applied criteria/preferences. However, SKI questions why the area of eastern Hultsfred is considered to be most suitable for further investigations since the geological map data and other geological information (see above) would point to the western area. Therefore, SKI does not agree with SKB that the feasibility study does not provide a basis for ranking both alternatives from a geological standpoint. However, SKI agrees with SKB with respect to the overall

evaluation (possibilities for establishment, nature conservation areas etc.) where the choice is that of the eastern area.

Tierp Feasibility Study
With respect to large parts of the Municipality, the map material is limited to SGU's combined bedrock and rock type maps from the late 1800's. Modern, detailed maps (on a scale of 1:50,000) are only available for the southeastern part of the Municipality. The Finnsjön study site that was investigated in detail and which is located in a major tectonic lens is situated in the eastern part of the Municipality near to the border of the Municipality of Östhammar.

After the study, SKB preliminarily selected nine areas of varying size that could be of interest from the geological standpoint for further investigation. Based on SKB's overall evaluation, the granite massif at Mehedby-Söderfors and Karlshomsbruk were selected for field surveys. The granite massif between Tobo and Månkarbo was eliminated by SKB due to the risk of high radon concentrations. In SKI's opinion, this should not be a decisive argument since any radon problems during the construction phase can be resolved through ventilation arrangements.

SKI finds that SKB has eliminated other areas due to limited surface extension (some areas of the size of the Forsmark lens) with the motivation that a small area means less flexibility and, thereby, increases the risk that the area must be abandoned in connection with a site investigation.

In SKB's view, the positive evaluation made of the Finnsjö area in the SKB-91 safety assessments and SR 97 could also be an argument for the Forsmark area. In spite of the fact that these safety assessments have shown that the bedrock at Finnsjön can be suitable from the standpoint of safety, SKB has eliminated this area. SKB's reasons for doing so are the negligible size of the area (about 10 km^2), the proximity to ore potential rock types and heavy water flows in the rock mass as well as the fracture zones (cf. the ore potential of the Forsmark area and surface extension). SKI understands why Finnsjön has been eliminated for these reasons. However, at the same time, SKI has found deficiencies in terms of the agreement with the findings of the safety assessment. Therefore, SKI considers that the safety assessments for Finnsjön can not be used to support SKB's choice of Forsmark.

After the field surveys, SKB considered parts of the Mehedeby-Söderfors area to have better prospects for continued investigations than the area near to Lövstabukten/Karlholmsbruk. The field surveys in the large granite massif, which comprises granite of the Hedesunda type, were conducted within two separate areas, west and east of the Uppsala esker. In these areas, the outcropping is very low, especially in the central part of the eastern area and also in the northern and south-eastern part of the western area.

The Paleogeophysics and Geodynamics Unit of Stockholm University has noted paleoseismic indications in rock and sediment in the Mehedeby area and is therefore surprised at SKB's interest in the area. The Mehedeby-Orrskog Group also points out that there are indications of postglacial movements (boulder accumulation in Hålgrytet).

SKI cannot easily understand how SKB has reached the conclusion that the bedrock in the 60 km^2 area, with unevenly distributed and low outcropping rock east of the Uppsala esker, can be described as very homogeneous since fine-grained, decimetre-wide granite dykes (locally with a higher fracture frequency) have been observed in almost a half of a total of 40 mapped outcropping rock areas. SKI would like to remind SKB that this type of granite dyke (aplite), which also occurs on the Simpevarp peninsula and on Äspö, has in places been found to have a high hydraulic conductivity which may also be the case in this area.

However, in connection with an excursion to the area in April, SKI was informed that SKB considers the area to be homogeneous and that SKB's conclusions are mainly based on indirect (geophysical) indications (Bergman et al, 200b). During the excursion, an area of an outcropping rock was also visited in the area's north-western part, about 3 km south-east of Mehedeby where the rock type was found to be relatively homogeneous.

SKB's argument that the low extent of outcropping in the western area means that an evaluation of the area is associated with some uncertainty and that this would render further investigations difficult is understandable. In SKI's view, this argument should also apply to the eastern area since both areas appear to have an equally low degree of outcropping (< 1 outcrop/km^2), as a matter of principle, and about the same type of inclusions. Therefore, SKI considers that SKB must clarify its selection of the eastern area.

Älvkarleby Feasibility Study

SKB's initial preliminary evaluation after the study was completed was that an area of about 50 km^2 between the population centre of Älvkarleby and the coast could have favourable properties for a repository. Consequently, field surveys were conducted here. However, the surveys showed that the bedrock is more heterogeneous than was previously known and consequently SKB's conclusion is that there is no area that, from a geological standpoint, can be recommended for site investigations.

With respect to the site selection process, the Municipality of Älvkarleby points out that the selection of certain sites has been justified on the basis of criteria that have not been listed among the requirements (tectonic lens) and that the results of the field surveys have been evaluated differently.

SKI has no objection to make against the quality of the feasibility study and against the conclusions that SKB draws with respect to the suitability of the site for site investigations. Furthermore, SKI understands that Skutskärs harbour would be of interest to SKB if extensive site investigations were to be carried out in the area in Tierp.

5.3 Selection of Siting Alternatives for Site Investigations

5.3.1 Comments by the Reviewing bodies on SKB's Site Selection

The County Governor in Västerbotten has taken an initiative to start a county-specific project on behalf of the municipalities of Storuman and Malå to re-instate Västerbotten in the siting process. The view is that the conditions of the societal factor have now been fulfilled in the County at the same time that participation of the municipalities in the process again would broaden the geological base, resulting in a tangible improvement in quality as a whole.

In SSI's opinion, based on public opinion and the existing infrastructure, it is reasonable that SKB has included the siting alternatives of Simpevarp and Forsmark in the site selection process. Furthermore, SSI states that if several sites at a time are found to be suitable, the site that best can be expected to meet the siting requirements should be included in the selected sites, even if it is deemed to be less favourable in other aspects (industrial establishment, society etc.). At the same time, in SSI's opinion, there is a broad consensus that the issue of safety and radiation protection for future generations is the main purpose of the activity and that this purpose must carry the greatest weight.

SSI states that different conditions in the biosphere, such as dilution, groundwater salinity and accumulation processes may have a considerable impact on radiation doses to man and the environment. SSI previously requested that SKB should describe the ecosystems in the areas included in the basis for site selection and state how the selected sites can comply with SSI's regulations. However, in SSI's view, this account has not been presented in RD&D Supplement. Furthermore, in SSI's opinion, it is a considerable advantage if a site can be shown to have significant advantages for the period up to the next ice age.

In a statement to SKI, Ulf Blomquist, Tobo specifies 15 aspects that make Hargshamn a better choice for drilling and repository siting, if the rock is of a better quality than Forsmark.

The Swedish Society for the Conservation of Nature also considers that the area in Forsmark is of considerable value from the conservation standpoint and would be very negatively affected by the reduced groundwater level that would result from the repository. The Society also notes that SKB, at this late stage, has reached the conclusion that a tectonic lens (Forsmark) can be advantageous from the hydrological and mechanical standpoint. The Society considers that this is in no way supported by scientific studies and originates from a very brief comment made by Uppsala University in connection with its review of the Östhammar feasibility study. The Society has misgivings about this small rock block in Forsmark, which is surrounded by 2 major fracture zones.

SGU and Uppsala University emphasize the difficulty of determining the suitability of the Tierp area on the basis of inadequate data (low level of outcropping rock) and specifies other sites that are geologically more accessible. In the University's opinion, considerations in the form of proximity to industrial facilities, local opinion and short

overland transportation must not be given a higher priority than the geological requirements, since these are decisive for final disposal safety in the time horizons considered.

The Mehedeby-Orrskog Group considers that SKB, in its selection of suitable areas in the Municipality of Tierp has considered size alone as the deciding factor.

The Green Party, Tierp considers that in relation to the proposed siting in Tierp, SKB has not described the hydrological, environmental and societal consequences that siting will result in.

The Municipality of Älvkarleby's opinion is that it is not credible to initially specify all of the advantages of a municipality and to then eliminate the same municipality without even investigating what is said to be the most important safety barrier – the rock.

In SGU's opinion, an important argument that has not been taken into account in the selection of siting alternatives is the unique position of the eastern part of Hultsfred, since the area is above the highest shoreline and this has positive consequences for groundwater salinity. This may entail certain safety-related advantages, for example, that the depth to groundwater salinity here is greater than in the case of a coastal siting. Consequently, SGU's conclusion is that the eastern part of Hultsfred has obvious advantages over the northern part of Tierp.

The evaluation of the Municipality of Hultsfred is also that a detailed investigation of the rock located over the highest shoreline is warranted in order to more closely determine groundwater chemistry (fresh water) as well as discharge and recharge areas. In summary, Hultsfred's regional group considers that the municipality has been excluded from further work on identifying a suitable site for a spent nuclear fuel repository on unjust grounds. Furthermore, the group considers that it is important for the Municipality of Hultsfred to be included in site selection.

SSI also considers that SKB, to a greater extent, should have discussed the possible advantages that interior siting may have on the groundwater flow.

Umeå University considers that the bedrock under Simpevarp appears to be more uniform and to be more promising than that at Forsmark.

The Municipality of Oskarshamn states that even SKB is dubious to the *Simpevarp peninsula* as a repository site.

5.3.2 SKI's Evaluation of SKB's Basis for Site Evaluation

In its review of RD&D Programme 98, SKI agreed with SKB that the possibility of assessing *long-term safety* on the basis of feasibility studies is limited. Furthermore, direct comparisons between different areas are complicated by the fact that the geoscientific data in different municipalities and within a municipality may vary considerably.

Prior to selecting sites within a feasibility study municipality, SKB has opted to use a new classification of siting factors: the bedrock, industrial establishment and societal aspects. Requirements and preferences regarding long-term safety are now classified under the new siting factor "bedrock". SKI has no objection to make to the new classification since there is no essential difference in the requirements on long-term safety.

Bedrock
SKB introduces the concept of geological breadth, different geological conditions/environments for investigated regions. SKI has not made any requirements concerning geological breadth but understands if SKB wishes to keep its options open for alternative siting in different geological environments if the prioritized areas do not meet expectations.

The Municipality of Oskarshamn is surprised that this concept has been introduced at such a late stage in the process and would like an explanation of the way in which the geological breadth contributes to increased safety.

On the basis of all of the completed feasibility studies, SKB has selected eight siting alternatives. The following municipalities and areas have been selected: Forsmark and Hargshamn in the Municipality of Östhammar, where Forsmark has been prioritized, northern Tierp/Skutskär in Tierp and the Municipality of Älvkarleby, Skavsta/Fjällveden and Studsvik/Björksund in the Municipality of Nyköping where Skavsta/Fjällveden has been prioritized, Simpevarp and southern Oskarshamn in the Municipality of Oskarshamn where Simpevarp has been prioritized and eastern Hultsfred in the Municipality of Hultsfred. SKI agrees with SKB that, together, these siting alternatives provide an adequate basis for the further selection of final disposal sites.

In SKB's view, comparisons with previous safety assessments show that there is a good potential for all of the selected siting alternatives. This particularly applies to the geological environments analyzed in SR 97, namely Äspö, Finnsjön and Gideå which SKB ranks equally with the bedrock environment in Simpevarp, Forsmark and Fjällveden.

SKI emphasizes that each site has specific properties and, therefore, this type of argument should be used with some caution. As SKB itself states, the database from the feasibility studies is too limited for a reliable evaluation of long-term safety to be made. Comparisons with SR 97 will provide some guidance. However, SKI does not share SKB's view that SR 97 has shown that there are large safety margins for all of the sites studied in SR 97. The inescapable fact is that the selection of sites for investigation is associated with uncertainty and, consequently, there is a risk that a site may have to be abandoned at a subsequent stage.

SKB's selection of siting alternatives is based on the following siting factors: the bedrock, industrial establishment and societal aspects. In order to achieve a clear comparison, SKB has provided tables with overviews of the eight different areas with respect to the bedrock conditions and industrial establishment. SKB does not evaluate

specific advantages and disadvantages with respect to properties, data and important issues and uncertainties concerning the bedrock. However, SKB makes such an evaluation for industrial establishment. In SKI's opinion, it would have made it easier for the reader if SKB had also shown the advantages and disadvantages for the bedrock in tabular form.

SKB's overall conclusion is that all of the areas have a good potential for meeting the requirements (and preferences). However, issues and uncertainties exist for all of the areas. Therefore, in SKB's opinion, none of the areas can be excluded solely on geological grounds. SKI agrees with SKB that no area appears to have such negative properties that it must be excluded. On the other hand, SKI and SKB both find, based on the tables provided by SKB, that there are a number of uncertainties and questions in certain areas whereas this is not as obvious for other areas. In SKI's opinion, on the basis of available geological data, SKB should have attempted a more systematic compilation and evaluation of more or less favourable conditions at the selected areas.

Industrial Establishment
With respect to the industrial establishment, SKB considers that the least extent of intrusion into and impact on the environment is achieved if existing industrial land, especially land where nuclear activities are conducted, can be used and if overland transportation can be avoided. SKI agrees with this view, providing that geological and safety requirements are not given lower priority.

In SKB's view, the establishment and operation of the repository can be conducted in an environmentally acceptable manner for all of the alternatives. However, in SKB's view, there are two alternatives that present obvious advantages. These are Forsmark and Simpevarp, which both have a harbour, access to industrial land and nuclear activities. In the case of the other alternatives, SKB considers the conditions for the establishment of the repository to be comparable, besides Fjällveden and Björksund where the uncertainties are considered to be greater than for the other alternatives. Furthermore, in Furthermore, in SKB's view, the siting alternatives can be ranked with respect to societal conditions, insofar as Simpevarp and Forsmark have better conditions than other areas.

SKI has no objection to make to the views and arguments presented by SKB with respect to industrial establishment.

5.3.3 SKI's Opinion of SKB's Site Selection

SKB's Site Selection
Based on the evaluation factors of bedrock, industrial establishment and societal aspects, SKB has prioritized sites for investigation in Forsmark, Simpevarp and northern Tierp, while SKB intends to conduct a new safety assessment of the Fjällveden area in the Municipality of Nyköping. In SKB's opinion, in the case of all of the siting alternatives, there is bedrock with good prospects of meeting the safety requirements. However, in most cases, knowledge of conditions at repository depth is lacking. According to SKB, this means that, at present, there is no basis for ranking alternatives. In SKB's view, the possibility of establishing the industrial activities for final disposal

and transportation is important, although this is less important than the properties of the rock.

SKI's Opinion

SKI finds it difficult to understand what the advantages of a new safety assessment of old data would entail for the Fjällveden area, since SKB's own conclusions are that extensive, supplementary re-interpretation and fieldwork (such as excavation) is needed, including new boreholes in order to obtain a more reliable/improved model (Ahlbom et al, 1991).

On May 8, 2001, the municipal councillors in Nyköping decided to inform SKB and the competent authorities that the feasibility studies in the Municipality of Nyköping should be immediately discontinued. One consequence of this is the loss of the geological breadth proposed by SKB.

SKI finds that SKB, in its selection of areas, has attempted to spread the risks of possible site deficiencies (which would lead to the abandonment of a site) to different geological environments in different regions. The areas which host nuclear power plants, Forsmark and Simpevarp, are prioritized, taking into account the fact that there are deep geological data from nearby areas that indicate that there is a possibility of finding suitable bedrock in these locations. However, there are some uncertainties surrounding the geological conditions for these siting alternatives. The third alternative, northern Tierp, has been selected on the basis of the size of the area and the possible homogeneity of the bedrock. The fact that the area is largely covered with a deep layer of overburden means that there is some uncertainty in evaluating the suitability of this site.

SKB has emphasized the importance of geological breadth. Both SKI and SGU consider that the choice of northern Tierp does not essentially contribute to the geological breadth since the granites in Tierp (the Hedesunda massif) and Småland (Oskarshamn/Hultsfred) both comprise large, coherent massifs of younger granite, of approximately the same age and composition.

In the opinion of SKI's consultants, Andersson and Tirén (2001), soil types should also be included as an important parameter when evaluating an area (Tierp). SKI's consultants also consider that soil layers can easily camouflage complex and irregular bedrock conditions, and they refer to the conditions at Fjällveden in the Municipality of Nyköping (saline clay).

SKI does not see any geological advantage in SKB's choice of Forsmark over Hargshamn, since the Forsmark lens is only half as large as the Hargshamn lens (10 and 20 km^2, respectively). The lens in Hargshamn thereby offers greater freedom of action if any of the negative properties mentioned by SKB above (horizontal fracture zones, high rock stresses, ore potential) should be found. SKB considers that a siting in the Forsmark lens would give adequate freedom of action, even if certain parts of the rock must be abandoned.

In general, SKI's opinion is that it should have been possible to more clearly describe geoscientific advantages and disadvantages, for example, with respect to the importance of the recharge and discharge areas and groundwater chemistry such as the depth to saline groundwater. SKI has conducted its own analyses (Voss and Provost, 2001) which support SGU's conclusions that there may be potential advantages of inland siting above the highest shoreline. In SKI's opinion, SKB should investigate this more thoroughly before Hultsfred is eliminated.

In SKI's opinion, certain questions are unresolved for the *Simpevarp area* in the Municipality of Oskarshamn, particularly due to the abundant occurrence of possible water-bearing fine-grained granite dykes on both the *Simpevarp peninsula*, which has a limited rock volume, and west of this area. Furthermore, tunnel excavation on the peninsula could entail both construction-related and safety-related problems since the plan is to let the tunnel pass three zones of high hydraulic conductivity (SKB, 2000c). If the tunnel is located further to the west, these problems and risks will naturally decrease.

From the safety standpoint, SKI sees no reason for SKB, at this stage in the siting process, to once again incorporate the Municipalities of Storuman and Malå, in spite of the changed attitude and improved insight of these municipalities with respect to the safe management of spent nuclear fuel. In SKI's opinion, SKB with its RD&D-S report, has fulfilled the requirement on the number of feasibility studies to be conducted (5-10) and considers that it is up to SKB to decide whether additional municipalities, for some reason, have to be involved in the siting process.

SKB's selection of sites for investigation is a gradual process, achieved in stages, where the final choice will only be made after consultations have been held with the municipalities concerned. This is in agreement with the opinion expressed by SKI in its review of RD&D Programme 98 that the final choice of sites for investigation should not take place until after a decision on the matter had been made by the Government and the municipalities involved.

5.3.4 SKI's Overall Evaluation

SKB has conducted feasibility studies in six municipalities (a total of eight, including Storuman and Malå) which together provide a broad coverage of geological and other geoscientific properties that can be expected in Swedish bedrock. On the basis of this work, SKI's opinion is that SKB has presented an adequate basis for selecting sites for the siting of a repository and for starting site investigations.

In SKI's opinion, SKB has shown, as far as is possible on the basis of the feasibility studies, that the siting alternatives of (western) Simpevarp in the Municipality of Oskarshamn, Forsmark in the Municipality of Östhammar and northern Tierp in the Municipality of Tierp have the necessary conditions to fulfil the authorities' safety and radiation protection requirements. Furthermore, in SKI's opinion, it is reasonable to take into account the advantages that Simpevarp and Forsmark offer with respect to industrial establishment and societal aspects in the way that SKB has done in its

selection. Therefore, SKI supports SKB's intention to start site investigations in these two areas.

SKI's opinion on the selection of northern Tierp, which does not have any direct link to a nuclear facility, is that there are deficiencies in SKB's reasoning. This view is supported by several of the reviewing bodies. SKB's main reason for selecting northern Tierp is that this alternative will add greater geological breadth to the data. However, in SKI's opinion, SKB needs to better justify the way in which Tierp is different from other alternatives in this respect. SKB's clarification of the reasons for the selection of northern Tierp should be made through the consultation process decided upon by the Government on December 19, 1996. However, SKI has no objection to make to SKB also conducting site investigations in Tierp.

In SKI's opinion, there are other factors besides bedrock geology that can add geoscientific breadth. Experience from safety assessments show, for example that the hydrogeological and geochemical conditions are of considerable importance to long-term safety. Consequently, SKI recommends SKB not to eliminate Hultsfred from the programme until issues relating to recharge/discharge and salinity have been further investigated.

In addition, SSI has pointed out deficiencies in the description of SKB's site selection with respect to biospheric issues such as dilution and accumulation effects in ecosystems and their importance for long-term radiation protection and safety.

6 Programme for Site Investigations

6.1 Geoscientific Site Investigations

6.1.1 Background

In its RD&D Programme 98 (SKB, 1998) SKB stated that if the selection of sites for investigation can be conducted in 2001, site investigations can start in 2002. In the decision of January 24, 2000 on RD&D Programme 98, the Government requested that SKB should present a clear programme for site investigations, no later than in connection with RD&D Programme 2001. The Government has previously, in its decision of December 19, 1996 on RD&D Programme 95, also stated that SKB should consult with SKI and SSI on the conditions that should apply to the investigation work, before site investigations start.

6.1.2 SKB's Report

In RD&D-S, SKB presents a *general programme for geoscientific site investigations*. The programme is described in a background report (SKB, 2000a) and summarized in Chapter 13 of the main report on RD&D-S. In March 2001, the general programme was supplemented by *subject-specific investigation programmes* which describe, in greater detail, the investigation methods that will be used at different stages of the site investigations (SKB, 2001). SKB further states that, in 2001, it will prepare *site-specific investigation programmes* for the areas where SKB proposes to conduct site investigations.

SKB states that the overall goals of the site investigations are to:

- Show how the selected site fulfils safety and technical requirements.
- Serve as a basis for adapting the repository to the characteristics of the site.
- Permit comparisons with other investigated sites.

The site investigations are divided into three main activities: investigations, repository construction planning and safety assessment. These activities will provide important data for the material that is required before an application is submitted for permission to site a repository, namely a site description, a facility description and a safety report. The site investigations are conducted, as was previously described in RD&D Programme 95, in two main stages: initial investigations and complete site investigations, with an intermediate evaluation.

During the *initial site investigations*, general geological and geophysical investigations are to be conducted with the aim of selecting a site (about 5-10 km^2) for further investigation within the candidate area. Furthermore, a limited borehole and measurement programme (2-3 deep cored boreholes) will be drilled to determine the suitability of the prioritized site for further investigations.

The initial site investigation will be reported in the form of preliminary reports for the site investigation, facility descriptions and long-term safety. Investigations at a site will be interrupted if SKB's requirements on the rock cannot be fulfilled, for example, if the dissolved oxygen is present or if the groundwater salinity is too high. The evaluation of the initial site investigation will also provide a basis for deciding what should be measured at the next stage in the site investigation.

If, following the initial site investigation, a site is evaluated as having good prospects for the siting of a repository, a *complete site investigation* will be conducted. The complete site investigation entails further mapping and measurements from the ground surface as well as a more extensive borehole programme with about 10 – 20 percussion boreholes and as many deep cored boreholes. Drilling will be conducted in campaigns of about 3-4 holes with subsequent measurements and evaluations so as to determine the geological, geochemical, hydrogeological and mechanical properties of the repository site. The site investigations will be discontinued when the reliability of the site characterization is such that the basis for safety assessment and repository construction planning is satisfactory or if the data show that the rock does not meet the requirements.

6.1.3 Comments by the Reviewing Bodies

In SSI's opinion, SKB is at an advanced level in its data inventory and method development for ecosystem characterization. At the same time, SSI states that further development work is necessary for SKB to show that the requirements in SSI's regulations can be met. This applies to issues relating to the use of site investigation data and the modelling of the biosphere in the safety assessment. In particular, SSI points out that SKB should describe how it plans to take into account the viewpoints expressed by SSI in the review of SR 97 and proposes that this can be done in RD&D Programme 2001.

In SSI's opinion, SKB needs to clarify how it will take into account a possible future co-siting of the spent fuel repository and the repository for long-lived low and intermediate-level nuclear waste (SFL 3-5) in its design of the site-specific site investigation programmes. SSI points out that SKB's own criteria for the siting of this repository entails considerable limitations on how it can be located in relation to the spent fuel repository.

To summarize, in SSI's opinion, the site investigation programme presented meets the Government's requirements on a transparent site investigation programme which can be applied in the initial stages of the investigations. However, the programme must be more specific with respect to the implementation of the complete site investigations. SSI emphasizes that consultation within the EIA is important for the further adaptation of the site and the detailed specification of the site investigation programme. Furthermore, the baseline measurements should be initiated as soon as possible and no later than in connection with the second part of the site investigation.

Fysikum, Stockholm University, considers that SKB should be supported in its ambition to initiate site investigations at this time, since it is necessary to obtain site-specific data in order to continue to work on the siting issue.

The Paleogeophysics and Geodynamics Unit of Stockholm University considers that, at each area that is selected for site investigation, SKB must allow a separate and independent study of the paleoseismic conditions and associated problems to be conducted in order to evaluate long-term stability.

Uppsala University states that it is unsuitable for site investigations to be primarily envisaged as a drilling project. The University therefore emphasizes the importance of conducting the investigation process so as to achieve a continuous interaction between different methods and results. The University also comments on certain investigation methods, including the importance of ensuring that a dense seismological network is established before penetration of the rock.

The Geological Survey of Sweden (SGU) considers that SKB can start investigations and consultations at the selected sites. The extended consultation planned during the site investigation phase is considered to be very important. SGU has no direct objection to make to SKB's plans for the geoscientific site investigations. In SGU's opinion, the gradual "focus" approach to be adopted during the initial investigation stage – from a candidate site, via a sub-area to the final site where a complete site investigation will be conducted – is completely suitable. Furthermore, SGU points out that it is important that the results are constantly objectively weighed against the requirements and preferences described by SKB.

On the other hand, SGU does not believe that the establishment of a seismic observation network is sufficient to improve knowledge of future seismic risks. Greater knowledge of the tectonic conditions in connection with glaciations is necessary in order to assess future risks. SGU states that the expert knowledge existing in Sweden with respect to groundwater conditions at great depths has largely been developed within the framework of SKB's activities. Therefore, SGU believes that the results from and evaluations of such investigations should be subjected to independent international peer review.

In the opinion of the Municipality of Oskarshamn, the link between the safety assessment and site investigations must be clarified. The Municipality wonders whether SKB's work on site selection factors, safety assessment and site investigations are separate projects without any linkage between them. The Municipality considers that it is important that the transition from general to site-specific programmes should be conducted in consultation with the municipalities concerned. For the municipality, it is important that SKI and SSI state their position on the content of the site investigation programme, especially with respect to linkages to the safety assessment and the need for data that exists in order to be able to evaluate the long-term safety of a site. The Municipality also considers that site investigations must identify all of the consequences to the municipality, for example, the impact on the infrastructure, tourism, demands on municipal service.

The Waste Network does not see any reason to provide detailed comments on SKB's proposal for site investigations since this is the result of an unacceptable process, both in terms of method selection and site selection.

The Waste Network does not believe that it is possible to comment on the site investigation programme before there is a generally accepted and credible method for the safe final disposal of nuclear waste and, in the opinion of the Waste Network, this is not the case at present.

The Municipality of Älvkarleby emphasizes the importance of SKB developing its knowledge of the ongoing and expected seismic movements in the selected investigation areas.

The County Administrative Board, Kalmar states that it is important to assess, as early as possible, issues relating to the need for transportation and the handling of crushed rock residue in the area.

6.1.4 SKI's Review and Evaluation

Goal, Stage Goals and Results
In connection with the reviews of RD&D Programme 95 (SKI, 1996a) and 98 (SKI, 1999), SKI has previously stated that SKB's overall strategy for a stage-by-stage implementation of site investigations is suitable. The accounts presented by SKB in RD&D-S and the accounts that SKB intends to present prior to the start of site investigations aim at a more detailed description of how this strategy is to be applied at the selected sites.

SKB's grouping of the site investigations into three main activities is good since it clarifies the need for information exchange and feedback between the investigations and those commissioning the results, namely, construction planning and safety assessment. SKI agrees with SKB that efficient co-ordination is necessary between the three main activities throughout the site investigation phase in order to attain the goals. SKI assumes, as does Uppsala University and the Municipality of Oskarshamn, that the combined reporting prior to the start of site investigations will show, in detail, how this vital co-ordination is to be organized in practice. SKI considers it to be particularly important for SKB to use future performance and safety assessments as a tool to focus the rest of the measurement programme.

In SKI's opinion, the scope of the planned account of results for the various main activities is reasonable. However, in SKI's opinion, SKB should conduct a more comprehensive safety assessment after the initial site investigation phase. Further detailed comments are provided below.

Investigations – Measurement Methods
In SKI's opinion, SKB largely has access to the technical competence and the measurement methods that are necessary to be able to conduct a suitable site investigation. Over the past decades, SKB has developed an extensive set of tools in the form of drilling and measurement methods for geoscientific characterization of the rock. The different methods have been developed and evaluated in connection with earlier site investigations at the study sites, Finnsjön and, more recently, Äspö. Some of the development work has also been conducted in the form of joint international projects.

At the same time, SKI recommends that SKB continue to develop and improve its measurement methods. SKB needs to take into account international progress in site investigation methods. Furthermore, SKB needs to regularly re-evaluate the adequacy of existing methods, bearing in mind the need for data that emerges in the evaluations of the recurrent performance and safety assessments. The development of measurement methods for parameters that are difficult to measure and that are vital for safety should be particularly emphasized. Such parameters include the retention properties of the rock and their spatial variation, the mechanical properties of the fracture zones and the rock's ability to buffer oxygenated groundwater. It may also be necessary to further develop or adapt certain measurement methods, depending on the local geological conditions at the sites selected for investigation.

Investigations – Measurement Programme
In SKI's opinion, the general site investigation programme (SKB, 2000a) provides a good framework for the development of the more detailed site-specific investigation programmes. Implementation in stages makes it possible to conduct the necessary evaluations and to provide feedback to the safety assessment and the planning of repository construction. Based on a preliminary evaluation, SKI's opinion is that the subject-specific programme descriptions (SKB, 2001) provide a good overview of the planned measurements and analyses in different geoscientific areas. However, SKI considers that certain parts must be described in greater detail, including the measurement campaigns and the characterization of quaternary geological deposits, neotectonic movements and conditions in the interface between the rock and sediment/soil types. The subject-specific programme descriptions do not provide any detailed information on the planned scope of different types of measurements. However, SKI assumes that this will be described in the site-specific programmes.

One important issue that was left unresolved in SKI and SSI's review of SR 97 (SKI, 2001a), is whether SKB, to an adequate extent, has exploited the experience from SR 97 in its design of the site investigation programme. SKB's previous reports provide a good review of the parameters that are necessary for different parts of the safety assessment (Andersson et al, 1998 and SKB, 2000b). In the general site investigation programme (SKB, 2000a, page 85), SKB states that a review of all of the experience from the preparation and review of SR 97 would be conducted during 2000. However, such a review has not yet been presented.

Consequently, SKI shares the opinion of SSI that, on the basis of an overall evaluation of SR 97 and previous site investigations, SKB should more clearly describe, in connection with the formulation of site-specific programmes, how the site selection programme has been devised in order to meet the needs of the safety assessment, especially with regard to the following:

- the prioritization of various measurement and sampling programmes taking into account their importance to the safety and construction analyses, such as the level of ambition for determining the retention properties of the rock and mechanical stability,
- assessments of the precision with which various parameters must be determined in order to provide an adequate basis for the needs of the safety assessment,

- a strategy for positioning boreholes, taking into account the need for data for various assessments and conceptual models (different borehole configurations may, for example, be optimal for different types of models, which entails a balancing of factors),
- the needs to further develop certain measurement methods to be able to restrict the uncertainties in the most critical parameters for the safety assessment.

SKB states that the level of ambition for drilling and measurement programmes at the investigated sites will partly be determined by the site-specific conditions. In SKI's opinion, SKB should clarify the minimum level of measurements needed to obtain an adequate basis for the comparison of the suitability of the different sites. This means that SKB should specify which parts of the measurements are common to all of the sites and which supplementary measurements may have to be conducted in order to determine site-specific conditions.

The experience from previous safety assessments, such as SKI SITE-94 (SKI, 1996b), has shown that the positioning of boreholes can have a major impact on the possibility of conducting a meaningful evaluation of a site's geoscientific conductions. Consequently, SKI's opinion is that it is important for SKB, in the site-specific investigation programmes, to clearly justify its strategy for positioning boreholes on the basis of the need for data for different analyses. One important issue that must be investigated is the way in which the drilling programme has been adjusted to investigate interpreted anomalies, such as fracture zones in relation to the need for an adequate (statistical) description of the rock properties over larger rock volumes. Bearing in mind the heterogeneous properties of the rock, there is a risk that important information will be missing if the measurements are too greatly determined by preliminary and uncertain interpretations of, for example, structural geology.

SKI recommends that SKB, on the basis of regional models of groundwater flow and geological conditions, should consider drilling a deep cored borehole on a regional scale, already during the initial site investigation. In SKI's view, knowledge of the large-scale flow pattern and regional trends in the geochemical conditions are of considerable importance for the planning of the detailed measurement work at the prioritized site.

In SKI's opinion, before starting site investigations, SKB must perform a systematic analysis of how borehole drilling and various measurements can affect the long-term properties of the site. In SKI's view, the general site investigation programme does not adequately examine the considerations that must be made between the benefits of boreholes and the possible negative impact that they can have on the long-term safety of the repository site. Furthermore, these issues are not dealt with in SR 97 (SKB, 1999a). SKB should also clarify what "respect distance between boreholes and deposition areas" means in practice, since it is not possible to know, in advance where the deposition area will be located.

In SKI's opinion, SKB should specify the scope of the measurements that are being planned to determine the radionuclide transport properties of the rock (including tracer tests and fracture and backfill characterization) with respect to the experience gained

from SR 97. The rock's capability to retard radionuclide migration to the biosphere is an important part of the multi-barrier principle and is, thereby, an important basis for evaluating the suitability of a site for a repository prior to submitting an application for detailed characterizations. SKB itself finds that the sensitivity analyses in SR 97 show that "retardation [is] one of the most important parameters." (SKB memorandum, dated March 27, 2001, SKI Dnr. 5.8 001293). In its RD&D-S, SKB describes ongoing work on the development of new methods for tracer tests and states that most of the tracer tests will probably be conducted during the detailed characterization.

SKI shares SSI's opinion that, prior to starting site investigations, SKB must specify the special requirements that should be made on the site investigation programme, taking into account the repository for long-lived low and intermediate-level waste (SFL 3-5). In order to be able to evaluate the possibility of co-siting, SKB must also focus on issues that are of particular relevance to SFL 3-5. In SKI and SSI's review of the safety assessment for SFL 3-5, the authorities pointed out that additional work was necessary to determine a suitable repository depth for SFL 3-5 and the requisite distance between SFL 2 and SFL 3-5 (SKI, 2001b). To identify a suitable rock volume for SFL 3-5 during a site investigation, a thorough basis of support is required. SKB's preliminary safety assessment (SKB, 1999b) showed that the local hydraulic conditions and the local geochemical conditions have a major impact on long-term safety. This means that a high level of ambition is required for the characterization of a suitable rock volume to host SFL 3-5.

Site Evaluation

In SKI's opinion, SKB itself, or through consultants, has access to relevant models for the evaluation of the site-specific information that is to be obtained from a site investigation. SKI's preliminary evaluation, on the basis of the general programme for site investigations, is that SKB's planned programme for site evaluation meets requirements for providing the necessary data for the safety assessment and repository construction planning. However, a final judgement cannot be made until SKI has evaluated in detail the subject and site-specific programme descriptions.

SKB states that at least two major safety reports will be delivered during the site investigation phase: a preliminary safety report after the initial site investigation and a complete safety assessment prior to the licence application. The purpose of the former is to provide a basis for judging if it is reasonable to continue with a complete site investigation. SKB states that this judgement will be based on:

- a comparison with the geoscientific requirements and criteria,
- comparisons between the conditions at the sites analyzed in SR 97,
- simple analytic transportation calculations.

In SKI's opinion, there are strong reasons for SKB to conduct a comprehensive safety assessment based on the initial site investigation. One of the most important arguments is that a new safety assessment would give SKB an opportunity to show the way in which it has dealt with the deficiencies in the methods for safety assessment pointed out in the authorities' and the International Review Team's reviews of SR 97 (for example, with respect to scenario analysis, handling of uncertainties and risk calculations). In

SKI's opinion, it is of considerable importance for SKB to carry out the necessary method development to ensure that there is the appropriate feedback from the safety assessment to the planning of further measurements in the complete site investigation.

A new safety assessment will also give SKB the opportunity to evaluate the updated knowledge that has emerged from the development work on the canister, buffer and final disposal technology. This is an important issue since the assumptions on the initial and long-term properties of the engineered barriers may have a considerable impact on the site's (and the rock's) importance to safety and, thereby, the evaluation of the accuracy with which different parameters must be determined in the site investigation. Finally, an updated system analysis and safety assessment will still have to be conducted before SKB submits an application for permission to construct an encapsulation plant which, according to SKB's time-schedule, should be done in 2005.

SKB's accounts provide a good view of planned evaluations within the individual geoscientific disciplines (geology, rock mechanics, hydrogeology, hydrogeochemistry, transport properties in the rock etc.). However, SKI considers that SKB, in its further work on the development of the site investigation programme, should describe in greater detail the concrete work that is being planned in order to develop a geoscientific understanding of the site, both with respect to planned integrated data analyses and models and interactions between different analysis groups. An important issue that must be investigated is whether the different site models (for different disciplines and spatial scales) provides a consistent view of the existing properties at the repository site and of its historical evolution.

It is also important for SKB to clarify how models within the various subject-specific areas are related to each other and how the consistency between the different geoscientific models is to be maintained when new model versions are gradually developed. SKI considers it to be a positive step that SKB is planning to develop alternative conceptual models to be able to quantify conceptual uncertainties. However, SKI recommends SKB to formulate a strategy for how these models will be used as a basis for the safety assessments.

Confidence in the models and their results is vital to the safety assessment. In the final stage of the site investigations, SKB plans to evaluate the accuracy of these models by performing prognoses of the rock properties and of the reaction of the groundwater to a hydraulic test, before a new borehole is drilled. In SKI's view, this is a good initiative. However, SKI considers that it should be possible, already at this stage, to plan for more systematic validation tests at fixed times during the site investigations. This would create added confidence in the modelling work and in the results from this work and would actively contribute to the continued development of the modelling tools.

Quality Assurance

In previous reviews of SKB's RD&D programmes, SKI has stated that SKB should develop an integrated programme for the quality assurance of site investigations. Such a programme is now presented in the geoscientific programme for site investigations (SKB, 2000a). The programme comprises a system for management and quality control

and includes a hierarchical structure of control documents for implementation. The system is based on the ISO 9001 and ISO 14001 quality standards.

SKB has a high level of ambition for quality assurance. However, SKB still has to develop parts of the control instruments and an organization for the quality system. SKI emphasizes that this work must be unambiguous and must be accessible to SKI and SSI for consultation before site investigations can start. In connection with this, SKB should prepare a plan for recurrent evaluations of the actual performance of the quality assurance system since the system is largely new and untried.

The site investigations will generate vast quantities of data and will involve a large number of consultants and contractors. This will place considerable demands on unambiguous instructions and manuals for individual measurements and for the handling of measurement data. Experience from the expansion of CLAB has also indicated the importance of a good control programme in SKB's co-operation with contractors and consultants.

It is a positive step that SKB's quality strategy is clearly based on the overall programme descriptions for site investigations. However, in SKI's opinion, SKB must also clarify, in its quality strategy, the control and quality assurance of the ongoing information exchange and other types of feedback between the investigations and the safety assessment as well as repository construction planning. This particularly applies to how modelling and data analysis will be used in the design of the site-specific drilling and measurement programmes.

In their review of SR 97, SKI and SSI recommended that, before licence applications are submitted, SKB should evaluate the quality of the most important data prior to presenting a safety assessment. For example, this could be achieved through independent peer review. In SKI's opinion a similar requirement should be imposed on SKB's site investigation programme. In spring 2001, SKB arranged an international workshop on its site investigation programme. A similar workshop on site investigation methods was conducted in 1998. SKI assumes that SKB will describe how it has dealt with the viewpoints presented in these meetings in its integrated account of the site investigation programme which will be submitted prior to the start of the site investigations.

In order for SKI and SSI to be able to adequately follow up and evaluate SKB's site investigations, the issue of the site investigation data must be resolved before SKB starts site investigations. In SKI's opinion, SKB in consultation with the authorities, should formulate the procedures and routines necessary to provide the authorities and their consultants with access to the data in the SICADA database and other relevant information.

Organization, Resources and Time

SKB presents an overview of the organization required for the necessary co-ordination and information exchange between the investigations, safety assessment and repository construction planning (SKB, 2000a). A local organization for the practical implementation of each individual site investigation is planned. Furthermore, shared

functions for quality assurance, safety assessment, construction planning and databases etc. are planned. In addition, a reference group will be appointed and connected to the shared functions. SKI has no objection to raise to this structure. However, SKI emphasizes that, prior to the start of site investigations, SKB must specify what responsibilities different parts of the organization will have and the way in which these parts will interact.

SKB estimates the time to implement initial and complete site investigations at about 2 and 4 years, respectively. The investigations will be conducted with a time delay of 4-6 months between the sites. However, SKI emphasizes that adequate time must be set aside for evaluations of data and for necessary feedback to the safety assessment and repository construction planning. Plans must be inherently flexible and an allowance must be made for different types of delays.

SKI and SSI's Continued Follow-up of SKB's Site Investigations

This evaluation of SKB's programme for site investigations has comprised the accounts that are provided in RD&D-S. However, SKB's integrated report, prior to the start of site investigations contains further details that have become available during this review (SKB, 2001) and will be published at the end of the year (site-specific investigation programme). SKI will review and provide viewpoints on these accounts within the framework of its review of RD&D Programme 01 and the consultation that SKB, according to the Government's decision of December 19, 1996 on RD&D Programme 95, must conduct with SKI and SSI prior to starting site investigations.

SKI is currently formulating a strategy for the follow-up and evaluation of SKB's implementation of site investigations. This includes conducting independent evaluations of parts of the data that SKB will obtain for the different sites. As a support in this work, SKI will appoint a permanent group of national and international experts, several of whom have been previously used in SKI's research work. The aim is for SKI to be very familiar with the data and evaluations that are produced during the site investigations. SKI intends to provide viewpoints on SKB's site investigations, on an ongoing basis, within the framework of the recurrent reviews of SKB's RD&D programmes and the ongoing contacts between the authority and SKB.

6.1.5 SKI's Overall Evaluation

In SKI's opinion, SKB's account in the RD&D Programme 98 Supplement fulfils the Government's requirements on a clear site investigation programme. The reasons for this are:

- SKI considers that, at present, SKB has adequate scientific and technical competence to conduct site investigations.

- In SKI's opinion, the general site investigation programme that SKB reported in the RD&D Programme 98 Supplement meets the pre-conditions for providing the necessary database for an application for a licence to site a repository for spent nuclear fuel.

- SKI and SSI will be given the opportunity to review and present viewpoints on the more detailed programme descriptions which will be presented prior to the start of site investigations. This includes accounts presented in the consultation process to be conducted between SKB and the authorities prior to the start of site investigations (government decision of December 19, 1996 on RD&D Programme 95). The authorities can thereby follow up those questions that have been raised in connection with this review.

Furthermore, SKI proposes that SKB conduct a complete safety assessment based on the results of the initial site investigations and new knowledge from the development work on the engineered barriers.

6.2 Environmental Impact Assessment and Consultations

6.2.1 Background

Licences to construct, own and operate a repository and an encapsulation plant are required under the Act on Nuclear Activities and the Environmental Code. An important basis for decision-making is the EIS that is required by both laws. SKB intends to start the consultations that are required to develop the EIS in connection with the start of site investigations. In Chapter 13 and 14 of SKB's RD&D-S, SKB describes the main features of the consultations that will take place. However, no detailed plans are described since these will be formulated in consultation with municipalities, county administrative boards, authorities, local communities etc.

After RD&D-S was submitted in December 2000, SKB developed and presented detailed plans for the structure of the EIA. These plans have been reported to the municipalities concerned, county administrative boards and authorities during spring 2001. SKI's opinion, which is set forth below, takes into account the development that has occurred since December 2000, since SKB's work has resulted in an essential specification of the more general plans presented in RD&D-S.

6.2.2 Comments by the Reviewing Bodies

The Municipality of Oskarshamn and the County Administrative Board, Kalmar's opinion is that SKB in RD&D-S describes an approach to the link between the encapsulation plant and the repository which does not agree with the reasoning presented so far. The Municipality of Oskarshamn repeats its opinion from previous RD&D reviews that an application from SKB for permission to start detailed characterizations must be handled by the authorities and the Government before the municipality in question can make a decision on the siting and construction of the encapsulation plant.

Several authorities (National Heritage Board, Swedish Environmental Protection Agency, National Housing Board and the county administrative boards) emphasize the importance of environmental impact statements, both with respect to their content and how they are prepared. Infrastructure, land history, cultural remnants, transportation,

handling of crushed rock and other issues must be dealt with in parallel to the bedrock investigations in the site investigation phase.

One issue which is raised by some of the reviewing bodies (Municipality of Oskarshamn, Municipality of Nyköping and the Swedish Environmental Protection Agency) is when the consultation process under the Environmental Code should start. In RD&D-S, SKB states that this will be done in connection with the start of site investigations. The Municipality of Oskarshamn's opinion is that consultations should start at an earlier stage and the Swedish Environmental Protection Agency supports this view to some extent. Furthermore, Oskarshamn states that it considers that consultations and other EIA-related work can be conducted with different levels of ambition in different municipalities and counties. In the opinion of the Municipality of Nyköping, consultation should be co-ordinated and its conclusion is that "SKB should notify the county administrative boards in Kalmar and Uppsala at the same time". The Municipality of Östhammar also raises this issue and, in its opinion, co-ordination should not result in "time-related or geographical limitations or in any way impair dialogue and insight".

The County Administrative Board, Uppsala, has no objection to make to SKB's account of the planned consultation process. This evaluation is based on a memorandum, dated November 7, 2000 concerning "Issues relating to consultation prior to the licensing of a repository for spent nuclear fuel etc.", that the county administrative boards in Kalmar, Södermanland and Uppsala jointly composed. The County Administrative Board, Uppsala also states that SKB has started a special process of consultation with the county administrative boards concerned regarding the co-ordination and a suitable time for the start of early consultations.

In SSI's opinion, SKB should, as soon as possible, initiate early consultations with county administrative boards and individuals who are expected to be particularly affected in those municipalities concerned. If the different municipalities have different preferences for the starting of the consultation, SSI believes that SKB should comply with these preferences, as far as possible. Furthermore, SSI proposes that SKB should submit a programme explanation for the different stages of the EIA work.

The Municipality of Oskarshamn proposes that a complete and municipality-specific site investigation programme should be prepared in consultation with SKB, the Municipality and the authorities *after* the municipality has made a decision to participate in a site investigation.

In the opinion of the National Housing Board, it is important from the societal standpoint that the land areas that will be under consideration for site investigations should be marked as areas of national interest for the final disposal of spent nuclear fuel. To implement this, the Board proposes that SKI, in accordance with its authority under the Ordinance (1998:896) on land and water area conservation etc. should, after the Government's decision, conduct the necessary consultations and designate the areas of national interest.

All of the feasibility study municipalities state that the current level of compensation, namely SEK 2 million per year, is too low to meet the demands of the work that is expected during the site investigation phase. Some of the municipalities (Oskarshamn, Hultsfred, Tierp and Älvkarleby) have already, during the feasibility study phase, received extra resources based on a special decision by the Government. This procedure is considered to entail too lengthy decision-making routes and is, therefore, not suitable for the site investigation phase. Following joint consultations, the municipalities propose that the Government should authorize SKI to make a decision regarding compensation for up to SEK 5 million per year to the municipalities concerned.

As was the case with the review of RD&D Programme 98, several of the environmental organizations and opinion groups expressed a need for resources to conduct their own activities in connection with SKB's siting process. Furthermore, certain organizations believe that independent researchers should be able to receive funding from the Nuclear Waste Fund. Furthermore, some believe that SKB has an unreasonable advantage with respect to information, and that SKB's information shows significant deficiencies in terms of its comprehensiveness. Some of the organizations consider that SKB, on the whole, lacks credibility as an information provider and should be relieved of this task.

6.2.3 SKI's Evaluation

SKI shares the view of the Municipality of Oskarshamn and the County Administrative Board of Kalmar that SKB's planning of licence applications for an encapsulation plant and repository are not entirely in line with the reasoning put forward since the issue was raised in connection with RD&D Programme 95. SKI has not found any reason to change its opinion and considers that a requirement for a licence to construct an encapsulation plant should be that there is a complete safety assessment for the repository, based on data from an actual site. Furthermore, in SKI's opinion, the authorities should approve a repository before SKB starts to seal canisters containing spent nuclear fuel (SKI, 1996a and 1999). In SKI's view, SKB should initiate negotiations concerning the co-ordination between applications for the two facilities at a very early stage in the consultations that lead to the preparation of environmental impact statements for the repository and the encapsulation plant. In this context, SKI reiterates Chapter 16 Section 7 of the Environmental Code which stipulates that "licensing under this Code should take into account other activities or special facilities that are expected to be necessary for the activity to be suitably conducted". Therefore, formal obligations exist to take into account the link between the encapsulation facility and repository as well as other facilities. Bill 1997/98:45 on the Environmental Code also states that it is the proponent, which usually describes consequential undertakings and their consequences.

The description of the planned EIA, provided by SKB in RD&D-S, agrees with the opinion that SKI presented in its review of RD&D Programme 98 and which was later elaborated on in a joint document from SKI and SSI (December 20, 1999, SSI dr. 6240/3626/99, SKI dnr. 15.2-991427). SKI shares Oskarshamn's and Hultsfred's opinion that the EIA should be conducted with a considerably high level of ambition that that required by the Environmental Code. In SKI's opinion, this is also SKB's intention. It is desirable for SKB to further describe its view on when, how and to what

extent consultations will be conducted. Such a specification should be made available for discussion between the parties concerned in connection with the start of early consultations in accordance with the Environmental Code.

In its review of RD&D Programme 98, SKI recommended that it might be suitable to start early consultations after the proposed municipalities have adopted a position on whether or not to participate in site investigations. This is in line with SKB's proposal in RD&D-S. In the light of the fact that work in accordance with the intentions of the EIA has been in progress in the Municipality of Oskarshamn since 1994, SKI understands the Municipality's view that early consultations can be initiated at an earlier stage. From SKI's standpoint, the exact time is not a deciding factor, since the extent of SKI's involvement will probably not be affected by the name used to describe the consultations. At the same time, SKI recognizes the advantages of a co-ordinated process between the different municipalities and counties. However, in SKI's opinion, co-ordination does not mean that all of the work and all of the consultations will be initiated at the same time and conducted in parallel. In the light of this, SKI and SSI share the opinion that the issue of the start of early consultations must be resolved by a mutual agreement between municipalities, county administrative boards, authorities and SKB. To make a mutual agreement possible, flexibility should be maintained with respect to the possibility of starting consultations at different times in different municipalities and counties.

The recommendation made by the National Housing Board to SKI whereby areas of national interest for the final disposal of spent nuclear fuel should be designated is in agreement with SKI's own plans. SKI has already contacted the County Administrative Boards of Uppsala and Kalmar concerning suitable ways of designating areas of national interest. After the Government has made a decision on RD&D-S and after the municipalities have decided on whether or not to participate in site investigations, SKI will continue to pursue this issue as well as consult with the National Housing Board and SSI on this matter.

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