SKB

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Feasibility study for siting of a deep repository within the Malå municipality

Swedish Nuclear Fuel and Waste Management Co

March 1996

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FEASIBILITY STUDY FOR SITING OF A DEEP REPOSITORY WITHIN THE MALÅ MUNICIPALITY

March 1996

Key words: Deep repository, site selection, feasibility study, Malå

FOREWORD

This report presents the results of the feasibility study in Malå, summarizing a broad investigative effort undertaken to shed light on the prospects for siting a deep repository in the municipality of Malå, and what consequences this would have for the individual, the community and the environment.

SKB's overall evaluation is that the municipality of Malå could provide good prospects for a deep repository. We would like to mention two factors in particular as arguments in support of this conclusion; the bedrock and the local mining tradition.

The bedrock is decisive in determining the feasibility of achieving safe disposal, and there are large areas in Malå Municipality where we judge the bedrock conditions to be good. We cannot determine, however, whether a particular site is definitely suitable from the feasibility study – that will require direct investigations on the site.

The mining industry, with all its peripheral activities, has through the years made Malå a centre of knowledge on geoscience and underground rock excavation. We are familiar with the value of this knowledge because specialists from Malå – geologists, geophysicists, diamond drillers and others – have participated in SKB's development activities since the start in the 1970s. When the deep repository is to be built and put into operation, much of the work will be related to the rock. Examples range from scientific investigations to tunnelling work and transportation. It is obvious that the expertise that exists in Malå within these areas would be of great advantage.

Will the deep repository be sited in Malå? We cannot answer that today, either for Malå or any other place in Sweden. What we do know is that we have nuclear fuel that has to be permanently disposed of, and that this must be done at a suitable site in Sweden. The process leading up to a final decision is a long one. In Malå's case, the results of this preliminary study must first be compared with data from feasibility studies at other locations. Then, a coordinated evaluation will be made of all candidate sites and areas with respect to the siting factors and criteria which SKB has outlined to the regulatory authorities and the Government. The intention is to find at least two areas in the country where siting studies for the deep repository can proceed with so-called site-specific investigations, entailing detailed characterization of the bedrock on a particular site. Only when the results of these investigations have been evaluated will we have the data needed to propose a site for the deep repository.

Good safety-related and technical conditions are basic requirements for considering a site for more detailed siting studies. But other factors are also important. The deep repository will affect the local community and the region in different ways. The issue is controversial and opinions differ as to whether a deep repository would be of benefit to the community or not. SKB's ambition is that the deep repository project should contribute to positive socioeconomic development, but the support of both the regional community and society as a whole is needed.

An important principle in our planning of the deep repository is that it should be constructed in a step-by-step fashion. The intention is to construct the repository first for a small volume of spent fuel, proceeding only after a thorough evaluation. This will enable new findings to be taken into consideration, for example new technology or options for reuse. Thanks to the fact that we have built an interim storage facility, those who will then have responsibility for making the decisions will even be able to retrieve the fuel and return it to interim storage, if this should be deemed desirable for any reason. Our main alternative is, however, that the deep repository will be constructed to its full extent, since we are convinced that deep disposal will be found to be the right option in the future as well, and that the method satisfies the stringent requirements that must be made.

Malå Municipality has initiated an independent review of the feasibility study. It is our hope that this process will also provide an opportunity to shed light on questions that could not be dealt with in this report. Viewed from a local perspective, the deep repository issue can involve numerous additional aspects beyond the technical and environmental criteria that form the basis of both our judgements and those of the regulatory authorities. SKB will continue to maintain a presence in Malå. We are naturally prepared to assist with further information, additional data or clarifications.

Many people have participated in the feasibility study and contributed to its results – from SKB, the municipality, universities and consulting firms, government authorities, the county administrative board, and various interest groups. To all of those who have been involved in different capacities and from different vantage points, we would like to express our sincere gratitude.

Stockholm, March 1996

SWEDISH NUCLEAR FUEL AND WASTE MANAGEMENT CO

Sten Bjurström
President

ABBREVIATIONS

Svensk Kärnbränslehantering AB (The Swedish Nuclear Fuel and Waste Management Company), **SKB**, is responsible for the management and disposal of Sweden's radioactive waste. The primary category is waste from the nuclear power plants, but some waste also comes from hospitals, industry and research institutions. The power utilities that produce nuclear power have jointly formed SKB.

Every three years SKB reports to the authorities regarding the state of knowledge in the nuclear waste programme, ongoing work and planning. The accounts submitted in 1986 and 1989 are referred to as the **R&D-Programme 86** and **R&D-Programme 89** (R&D = Research & Development), respectively. The equivalent reports from 1992 and 1995 are referred to as the **RD&D-Programme 92** and **RD&D-Programme 95** (RD&D = Research, Development & Demonstration). The programmes are reviewed by the regulatory authorities and undergo extensive circulation for review and commentary. This work serves as a basis for decisions and guidelines issued by the Government for the waste programme.

The Swedish Nuclear Power Inspectorate, **SKI**, and the Swedish Radiation Protection Institute, **SSI**, are the state regulatory authorities who scrutinize activities and oversee safety for both nuclear power plant operation and waste management. SKI is also the authority who administers the surcharges on the production of nuclear-generated electricity which are set aside in reserve funds to pay for the disposal of the nuclear waste. The Swedish National Council for Nuclear Waste, **KASAM**, is an advisory scientific body tied to the Ministry of Environment which has to present its independent assessment of the state of knowledge in the nuclear waste field every three years.

CLAB (Central Interim Storage Facility for Spent Nuclear Fuel) is an underground rock facility situated at the Oskarshamn Nuclear Power Station. Spent nuclear fuel from the nuclear power plants is taken to CLAB for interim storage for 30–40 years. During this time the radioactivity and heat output of the fuel declines by 90%, which simplifies subsequent handling in encapsulation, transport and deposition. Storage and handling at CLAB takes place under water.

SFR (Final Repository for Radioactive Operational Waste) is located under the sea off the coast of the Forsmark Nuclear Power Station. All the low- and intermediate-level short-lived waste from nuclear power plant operation is disposed of in SFR. Like CLAB, SFR began operation during the 1980s.

The Äspö Hard Rock Laboratory or HRL is an underground laboratory situated in the vicinity of the Oskarshamn Nuclear Power Station and extends down to a depth of about 450 metres. Different methods for bedrock investigation, as well as technology for deposition and disposal, are tested at the Äspö HRL.

SUMMARY

It is SKB's task to gather the data that is needed to site – i.e. to select the general locality and specific location of – a deep repository for Sweden's spent nuclear fuel and other long-lived radioactive waste. The feasibility study in Malå is one of the many components in this work.

A deep repository differs from other industrial and underground facilities in one essential respect; the deep repository is intended for the handling and storage of material with a high concentration of radioactive substances. This is the main reason why a facility and its siting is so controversial. It also gives rise to special requirements on how the siting work is to be carried out and on the site that is selected. A number of factors must be considered. The most important criterion is that the safety requirements can be satisfied on the site where the deep repository is built. Other siting factors depend on technical conditions, land and the environment, plus a broad spectrum of societal aspects.

Background material concerning siting factors is compiled in **general siting studies** of all or parts of the country. **Feasibility studies** examine the siting prospects in potentially suitable and interested municipalities. SKB plans to carry out feasibility studies in five to ten municipalities in different parts of the country. Besides in Malå, feasibility studies are currently being conducted in the municipalities of Östhammar and Nyköping. Previously a feasibility study has been conducted in Storuman.

General siting studies and feasibility studies are broadly conceived investigations that are primarily based on existing material. One purpose is to be able to identify land areas that could be suitable for further studies. Among these areas, a selection will be made for the site investigations that are the next step in the siting process. Site investigations will be conducted at at least two places in the country.

The feasibility study in Malå was begun in 1994. Before that a decision had been taken in the municipal council to request a feasibility study, and an agreement had been drawn up between SKB and Malå Municipality. SKB has been in charge of the execution of the feasibility study. The municipality has had insight into and been able to influence the feasibility study through a project organization. A steering group composed of two members from SKB and two from the municipality has led the feasibility study. A reference group with 22 members, appointed by the political parties and a number of local interest organizations, has had the task of following the work and contributing viewpoints and ideas.

Experts from universities, the Swedish Geological Survey (SGU), consulting firms and industrial companies have been engaged to carry out the fact compilations, investigations and analyses. As the results of the investigations have become available, they have been published in working reports. The persons who have conducted the investigations have themselves taken responsibility for the factual contents and conclusions presented in the reports. SKB has been responsible for a status report, published in May 1995, and this final report.

The purpose of the investigations has been to describe, as far as available data permit, the prospects for siting a deep repository in the municipality of Malå, and to shed light on the consequences – both positive and negative – of such a siting.

Do prospects exist for siting a deep repository in Malå Municipality?

The feasibility study shows that areas exist within Malå Municipality which may offer good prospects for the siting of a deep repository. However, a more detailed assessment of long-term safety requires comprehensive geoscientific investigations and a safety assessment.

The bedrock which may be of interest for a deep repository is situated within those parts of the municipality that are covered by large areas of granitic bedrock, which is of no economic interest for prospecting. There are also areas within the municipality that must be judged as unfavourable for a deep repository due to the fact that they are or may become of interest for mineral extraction or prospecting.

Any further investigations should be concentrated primarily on two large granite areas. One is located in the far west of the municipality and is about 100 km^2 in size. The other is situated in the northern part of the municipality and covers an area of about 55 km^2. Available data indicate that there are within these two areas large volumes of granite that are homogeneous and fracture-poor with relatively few fracture zones. These properties are favourable for a deep repository. The size of the areas should provide ample opportunities to take into account both bedrock conditions and the interests of various groups – such as landowners, nearby residents and reindeer herders – when deciding on a precise location of the facility and transport connections. Important geoscientific questions that need to be further explored in continued investigations are the depth of the granites, the presence of major fracture zones, and geohydrochemical and rock-mechanical conditions.

Shipments to a deep repository in Malå Municipality could go by sea to a suitable coastal harbour. Further overland transport from the harbour to the site of the deep repository is deemed possible from a safety-related and technical viewpoint to carry out by rail or road. In both cases, however, investments in transport guideways (i.e. roadway or railway) would be required. There is no railway in the municipality, so transport by rail would require a new connection from the Main Line to the municipality. In the case of road transport, certain road sections and bridges would have to be upgraded so that the heavy vehicles used for the shipments will not cause undue traffic disturbances or undue damage to the roads. Regardless of which mode of transport is chosen, the improvements in the infrastructure that are required are measures that would concern many local and regional interests, and therefore need to be analyzed in a broader perspective than has been possible in the feasibility study.

What are the positive and negative consequences of a deep repository?

Consequences for external environment, working environment and safety

Like any major industrial facility, the deep repository would entail some environmental impact on the site where it is built. In comparison with other industries, however, this impact is deemed to be little. One important reason is that the activities at the repository do not involve any real industrial process. Another is the limited amount of area covered by the surface facilities, about 0.3 km^2 in all. This includes rock waste dumps, which may be needed if the rock waste cannot be used for backfill or for other uses. Local traffic links, and in particular the aforementioned railway or road extensions, may result in greater problems from the disturbance viewpoint than the facility itself. The laying of train track in particular may be associated with disturbances of nearby residents, reindeer herding, outdoor recreation activities, nature protection areas, etc.

The activities at a deep repository entail work both above and below ground. In terms of working environment, the excavation work bears great similarities to the work in a mine. Experience underground shows that rock engineering work, as well as materials handling and transportation, poses particularly great risks of occupational injuries. Facilities, equipment and work routines must therefore be designed to minimize these risks.

The radiological working environment at the deep repository will conform to the standards and requirements that apply to nuclear facilities. Based on experience gained from CLAB, SFR and M/S Sigyn, shipments and handling at the deep repository can be designed so that personnel doses are kept well below existing safety limits. In general, the operating environment underground will resemble that at SFR or a hydropower plant.

Transport safety will be ensured through a system of transport planning, transport casks and containers, physical protection and emergency planning. The radioactive waste is in solid form and completely enclosed in canisters, which are in turn contained in transport casks/containers with steel walls, approximately two decimetres thick. The technology has been tried and proven in connection with the shipments of radioactive waste that have long been carried out in Sweden and abroad. Despite this good track record of transport safety, however, many people feel uncomfortable and anxious about shipments of radioactive materials. A good understanding of transport safety is therefore an important factor in the event of a siting of the deep repository in Malå Municipality.

The design of the deep repository and all measures in conjunction with deposition are aimed at containing and isolating all radioactive material. A central part of an environmental impact assessment for the deep repository is the assessment of long-term radiological safety. The feasibility study does not include such a safety assessment for a possible deep repository in Malå, since this requires, among other things, borehole investigations, which will be done in connection with a site investigation.

The question of the long-term safety of a deep repository has been investigated by both SKB and the regulatory authorities with the aid of detailed and comprehensive safety assessments for different alternatives with regard to repository design and rock conditions. Similar assessments have been conducted in other countries. The results show that if the bedrock and the repository's engineered safety barriers fulfil certain requirements, disposal can accomplished in a safe manner.

Consequences for the community

The deep repository project is controversial, and the question of what constitutes positive and negative consequences for the community is largely a question of viewpoints and values. In simplified terms, there can be said to be two essentially different ways of looking at the question:

- In one perspective, the deep repository is a safe environmental facility of importance to everyone, where the nuclear waste is isolated so that people in the future will be protected. It is based on long-range planning and stringent quality standards, provides good jobs with advanced technology, attracts positive attention both in Sweden and internationally, and contributes in many ways to the positive development of the municipality and the region.

- In another perspective, the deep repository is an atomic refuse dump and a threat to the environment and the future. This arouses anxiety and fear among the population. The world's attitude towards the municipality and the region is negative, visitors stay away, and the region's economic development is adversely affected.

In other words, there are scarcely any objective ways to evaluate the consequences of the deep repository for the community. The differences in attitude become clearly evident when it comes to judging the possible effects of a deep repository on tourism in the region, where opinion is strongly divided. Many of the tourist industry's own representatives believe that a deep repository would have negative repercussions on tourism, while experience from other controversial establishments show no such effects. As far as Malå Municipality is concerned, it is judged that the total customer base for the travel industry would increase due to the extensive work-related journeys and study visits a deep repository would generate.

The aim of the community-related investigative work in the feasibility study has been to gather background material on the municipality and on the immediate consequences of a deep repository. The procedure followed has been to:

- Compile facts on Malå's socioeconomic development to date, the current situation and the development tendencies;
- Outline the possible future development of Malå, without the establishment of a deep repository;
- Describe the investments, personnel needs etc. that would accompany the deep repository project in different phases of planning, construction and operation;
- Estimate what effects the establishment of a deep repository in Malå would have on the development of the municipality, and to some extent the region, as far as population, employment and business are concerned. The judgements are based on the assumption that initial trial operation and regular operation of the deep repository are carried out in accordance with current plans.
- Compile relevant experience from other industrial establishments.

The cost of the deep repository, including peripheral activities, is estimated at about SEK 8 billion for the first phase, including construction and initial trial operation. The total cost for expansion to full size and operation is estimated at about SEK 15 billion. In the event of a siting at Malå, it is estimated that one quarter of this can be absorbed locally in the municipality. This would give an estimated employment effect of about 200 direct jobs during the first 50 years of the next century. An additional 100 or so indirect jobs will be generated within public and private services. These estimates pertain to the municipality. About 70 additional jobs will be created within the rest of the region. The population increment in the municipality during the same period would be about 400 persons. Seen in relation to the present-day situation, these increments are substantial. At present about 4,000 people live in the municipality. Unemployment has been rising sharply in recent years, mainly due to the decline in the forestry and mining industries. Today there are about 1,500 jobs in the municipality.

According to the plans, the activities at the deep repository cover a time period of about fifty years. This means that the site organization will be based on personnel who are permanent residents in the community. A high proportion of local recruitment of the work force is desirable. The region's strong tradition within fields such as geoscience, rock construction, mining and heavy transport can entail considerable advantages here, since skills in these areas are needed for the construction and operation of the deep repository. Within other fields, early planning may be necessary in order to ensure good recruitment opportunities, for example through training activities.

Will the siting studies in Malå continue?

SKB's overall evaluation at this stage is that Malå Municipality will provide good prospects for a deep repository establishment. Before the interest in further investigations – following the feasibility study – can be determined, however, the results of the feasibility study must be evaluated against the background of results of other feasibility studies and general siting studies on a national and regional scale.

The next step in the siting programme for the deep repository is site-specific investigations, which are planned to be conducted on at least two sites in the country. A coordinated evaluation of all potential localities and areas is planned prior to selecting these sites. The evaluation will be based on the factors and criteria which SKB has described and which the Government, after approval by the regulatory authorities, has stipulated shall provide guidelines for the siting work. The basic requirements that must be fulfilled in order for an area to be of interest for site investigations are that the safety-related and technical prospects are preliminarily judged to be good. This is deemed to be the case for the areas within Malå Municipality that have been identified as being of interest for possible further studies, but it is the coordinated evaluation that will determine whether site investigations in the municipality are of interest to SKB.

Furthermore, a decision to site the deep repository in the municipality requires acceptance and interest on the part of the community. Attitudes and positions in the matter which are expressed in the municipality and the region are therefore of crucial importance in determining whether further siting studies will be conducted in Malå.

In the present phase of the siting programme for the deep repository, the studies in Malå are more or less concluded for SKB's part. Supplementary or other measures may, however, be necessary in conjunction with the independent review of the feasibility study initiated by Malå Municipality. Further, SKB will actively follow the public debate in the matter, and is prepared to contribute to illuminating various aspects of a possible deep repository establishment in Malå as comprehensively and fully as possible.

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1 INTRODUCTION

This report comprises SKB's overall account of the feasibility study in Malå. It summarizes the results and also offers SKB's evaluation of the resultant data.

The feasibility study is one of many components in the programme that is carried out to site – i.e. to select the general locality and specific location of – a deep repository. The deep repository in turn comprises a part of a system for the disposal of radioactive waste, mainly from the nuclear energy programme but also from other sources in the country. An overview of the waste types and quantities managed in this system is given in Appendix 1 to this report.

This chapter deals with the current situation in the implementation of the nuclear waste programme and the main features of the planning for the remaining parts. The emphasis has been placed on describing SKB's work to gather data for the siting of the deep repository.

The remainder of the report, chapters 2 through 9, concerns the feasibility study. Chapters 2, 3 and 4 describe the background and premises of the work. The results are reported in Chapters 5 through 8. Chapter 9 provides a summary and evaluation of the results of the feasibility study.

1.1 Background

1.1.1 The waste system

Figure 1-1 provides an overview of the different parts of the Swedish waste management system. Radioactive waste from the nuclear power programme has varying form and activity content, from virtually inactive waste to spent fuel, which is highly radioactive. Altogether, it is estimated that the Swedish nuclear power programme will produce 8,000 tonnes of spent nuclear fuel and 25,000 m^3 of other, long-lived waste up until the year 2010. The quantity of operational and decommissioning waste will be considerably greater – a total of about 190,000 m^3.

Different waste types require different kinds of handling, and the design of the system is based on the following fundamental principles:

- Short-lived waste is disposed of as soon as possible after arising.
- Spent nuclear fuel is stored for 30–40 years before being emplaced in a deep repository.
- Other long-lived waste is disposed of in connection with the deep repository for spent nuclear fuel.

The waste management system in its present-day form, Figure 1-1, is the result of progressive development during a 20-year period. The process has included a number of crucial decisions regarding handling and disposal methods. The division of roles has been (and is) that the power industry – through SKB – is responsible for and executes the work, the regulatory authorities review and oversee, while the state lays down framework decisions and guidelines. This division of roles was established by Parliament in the Act on Nuclear Activities.

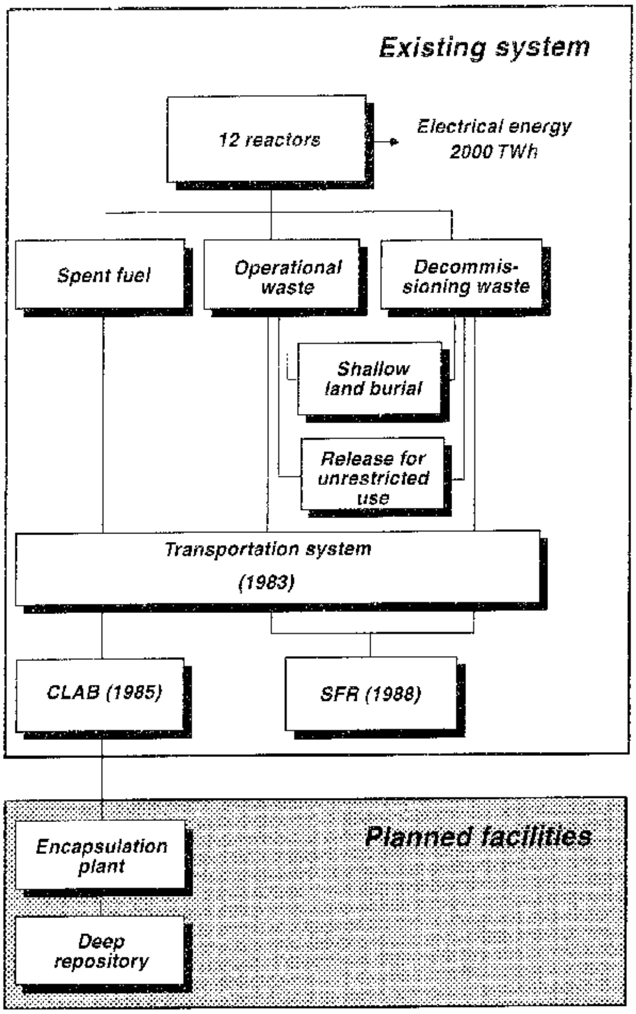


Figure 1-1. The Swedish waste management system.

Two waste facilities have been taken into service. One is SFR in Forsmark, where low- and intermediate-level waste is disposed of (this category includes operational waste; disposal of decommissioning waste is also planned). The other is CLAB outside of Oskarshamn, to which the spent fuel from the nuclear power plants is taken and stored temporarily. During this interim storage in water pools, about 90% of the radioactive content of the waste decays. Both SFR and CLAB are underground facilities. Besides these facilities, a transportation system has also been built and taken into service for the purpose of transporting the different waste types from the nuclear power stations to the waste facilities.

What remains to be built to make the system complete are:

- an encapsulation plant for spent nuclear fuel,
- a deep repository for encapsulated, spent fuel and other long-lived waste.

Other work remaining to be done is modification of the transportation system for shipments to the deep repository and certain additions to existing facilities.

The encapsulation plant is planned to be built in direct connection with CLAB. At present the design and development work is under way, including testing of methods for canister fabrication. Development and design work has long been under way for the deep repository. The siting process is in a relatively early phase.

1.1.2 Step-by-step execution

Decisions on siting, construction and operation of the remaining facilities will be taken in steps following licensing reviews based on a progressively more detailed body of data, with the opportunity to integrate new knowledge and experience into consideration at each step. The main outline of the planning is illustrated in Figure 1-2.

The siting work for the deep repository (the upper half of the figure) is currently under way. When SKB has gathered all the data needed to be able to propose a site, a thorough review will be undertaken by the regulatory authorities before a permit can be issued to begin the construction process. After construction, in an initial phase for a limited quantity of waste, a new regulatory review will be held concerning an operating permit for initial trial operation. SKB's objective is that operation can commence in the year 2008. Approximately one-tenth of the encapsulated waste will be disposed of during initial trial operation. A similar process is planned for the encapsulation plant (lower half of Figure 1-2) up to initial operation.

After initial trial operation, a thorough evaluation will be made of the entire system. This will provide an opportunity to take into account operating experience and the general development of technology that has occurred during the course of the process. The deposited canisters can be retrieved at this point if deemed desirable for any reason. If the evaluation shows that continued deposition is suitable, the deep repository will be further expanded and activities will continue until all waste has been deposited, which is estimated to occur around 2040.

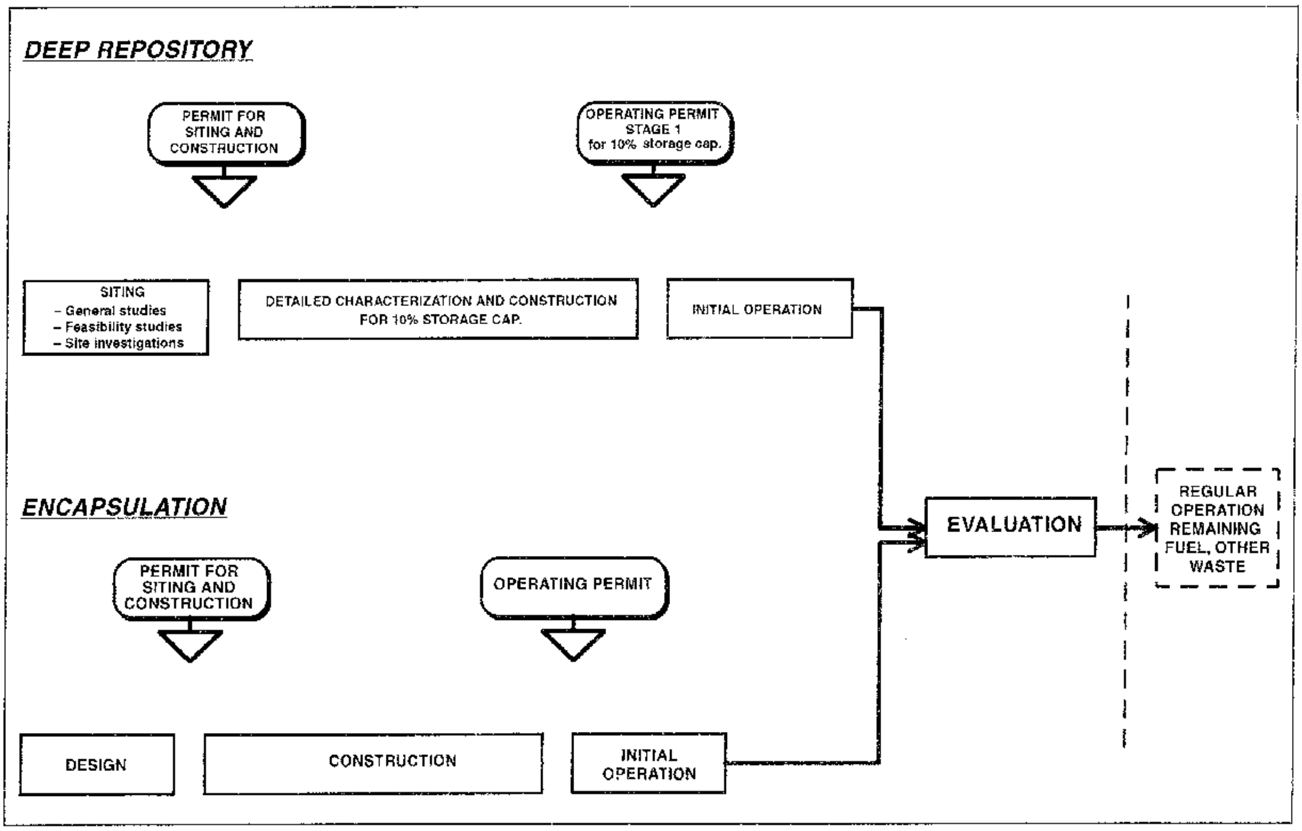


Figure 1-2. Plan for remaining parts of the Swedish nuclear waste management system. The figure shows main activities and important permits for the deep repository (upper half) and the encapsulation plant (lower half). In an initial stage, the facilities will be built for introductory trial operation. A thorough evaluation will be made before a decision is made regarding regular operation.

1.1.3 The deep repository

Figure 1-3 shows the main features of the planned design of the deep repository, while Figure 1-4 shows the principles for achieving safe disposal. The deep repository is an industry with facilities both above and below ground. The underground portions are situated at a depth of about 500 metres, and consist for the most part of tunnel systems. Most of the tunnel systems form deposition areas – a small one for initial trial operation (about 400 canisters), larger areas for regular operation (about 4,000 canisters) and an area for other long-lived waste.

The purpose of deep disposal is to isolate the waste so that it cannot harm man or the environment, now or in the future. Evaluations of possible disposal methods have resulted in a main alternative involving deep disposal in accordance with the KBS-3 concept or a closely related optimized design. Safe long-term disposal is achieved by means of a number of engineered barriers which prevent the escape of hazardous radioactive material. The spent fuel in itself is very stable and poorly soluble at repository dephts; it is enclosed in canisters designed for a service life well in excess of what is needed; the canisters are emplaced in deposition holes drilled from the tunnel floors, and embedded in compact clay. Finally, the crystalline basement rock provides a stable environment for these barriers and in itself comprises an extra protective barrier.

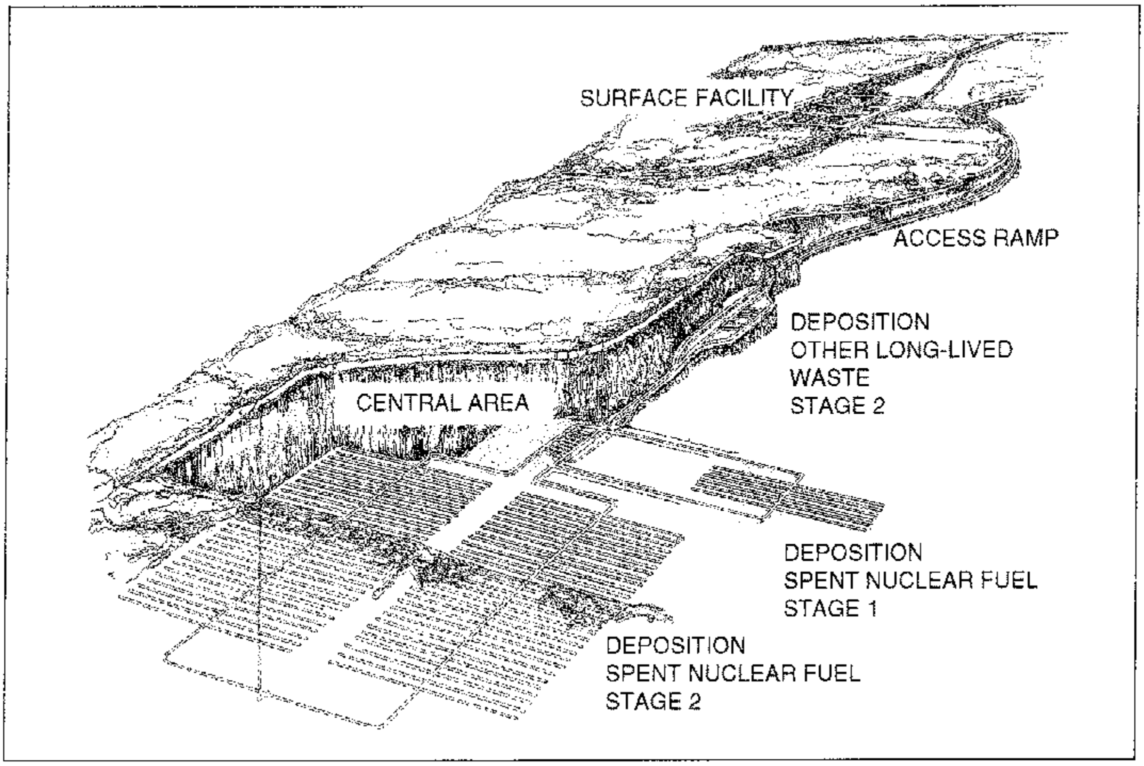


Figure 1-3. *Schematic drawing of the deep repository.*

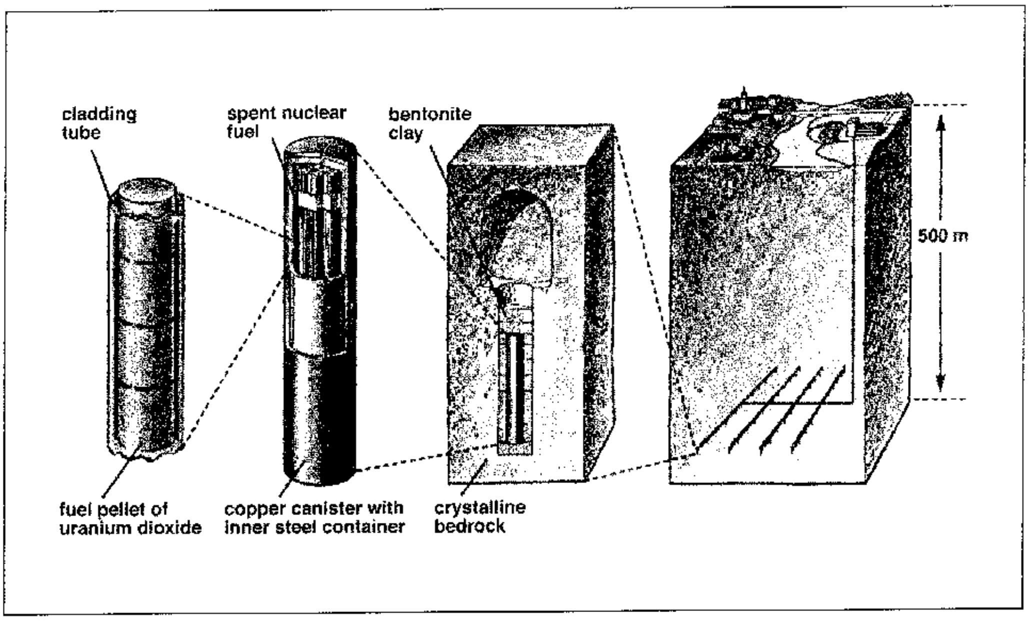


Figure 1-4. Protective barriers in the deep repository.

1.2 The siting work for the deep repository

1.2.1 Premises

The purpose of the siting work is to gather all the background data that is needed to select a site for the deep repository and to obtain permission to begin detailed characterization on this site, Figure 1-2.

The siting of the deep repository is a key question for the Swedish nuclear waste programme. It is also a controversial and multifaceted activity. Technology and, above all, safety are issues of central importance, but other significant aspects are community planning, politics and public opinion. Experience from other establishment projects – such as the nuclear power stations, CLAB and SFR – is a valuable asset in the siting work, but no previous project is comparable in all respects to the deep repository.

The siting of the deep repository is influenced by a number of safety-related, technical, environmental and societal factors. The criteria that guide the work are discussed in greater detail in chapter 4. Most important is to choose a site where the safety-related conditions are very good.

The programme for siting of the deep repository worked out by SKB is presented in detail in the supplement to RD&D-Programme 92 /1-1/. The programme was based on, among other things, long-lasting and comprehensive scientific studies and investigations aimed at building up a general body of knowledge concerning the Swedish crystalline basement and the conditions that could influence the performance of a deep repository. These studies started in the late 1970s and have continued without interruption since then. General experience of e.g. siting, construction and operation of rock facilities has been utilized, but much of the background work has consisted of SKB's own investigations of rock conditions at depth in Swedish crystalline rock.

The investigations have included a thorough survey of the crystalline basement at a number of sites in the country, research in the Stripa Mine and the work done in conjunction with the establishment of the Äspö Hard Rock Laboratory. SKB and other organizations have conducted safety assessments for a deep repository in the environment represented by Swedish crystalline basement rock.

Important general results from these studies are:

- There are good opportunities for locating areas in Swedish crystalline rock with conditions suitable for a deep repository.
- The suitability of the bedrock is not clearly associated with any particular region or geological province within the crystalline rock area. Most important are instead the local conditions.

It is against this background that SKB found it "reasonable and realistic to first consider municipalities that actively wish to participate or otherwise show an interest and that are situated in those parts of Sweden that may possess favourable conditions and examine the prospects for the siting of a deep repository there". The existing Swedish system with interim storage in CLAB also makes it practically possible to take the time to thoroughly examine the feasibility of carrying out siting and later deep disposal in collaboration.

1.2.2 General siting studies, feasibility studies and site investigations

Figure 1-5 shows a schematic illustration of the structure of the siting work and indicates the current situation with regard to execution. The background material needed to select a site and apply for permission to carry out detailed characterization is gathered by means of **general (siting) studies, feasibility studies** and **site investigations.**

General siting studies

General siting studies (or simply general studies) is the collective designation used to refer to the comprehensive background work described above, which defines the general premises and principles for the siting work. Databases on a national scale of factors that can be of interest from a siting point of view are also compiled in the general siting studies. The results of the general siting studies have been published for the most part in technical reports. A collective and up-to-date report – General Siting Study 95 /1-2/ – was presented in conjunction with RD&D-Programme 95 /1-3/.

Feasibility studies

A feasibility study examines the prospects for siting a deep repository within a municipality. The studies are based principally on existing material. The following questions are dealt with:

- What are the general prospects for siting of a deep repository in the municipality?
- Within which parts of the municipality might geoscientific conditions exist that are favourable with respect to the long-term safety of a deep repository?
- What are the technical prospects for constructing a deep repository in the municipality, and how can transportation be arranged?
- What are the important environmental and safety issues?
- What are the possible consequences (positive and negative) for the population, the environment and socioeconomic development in the municipality and the region?

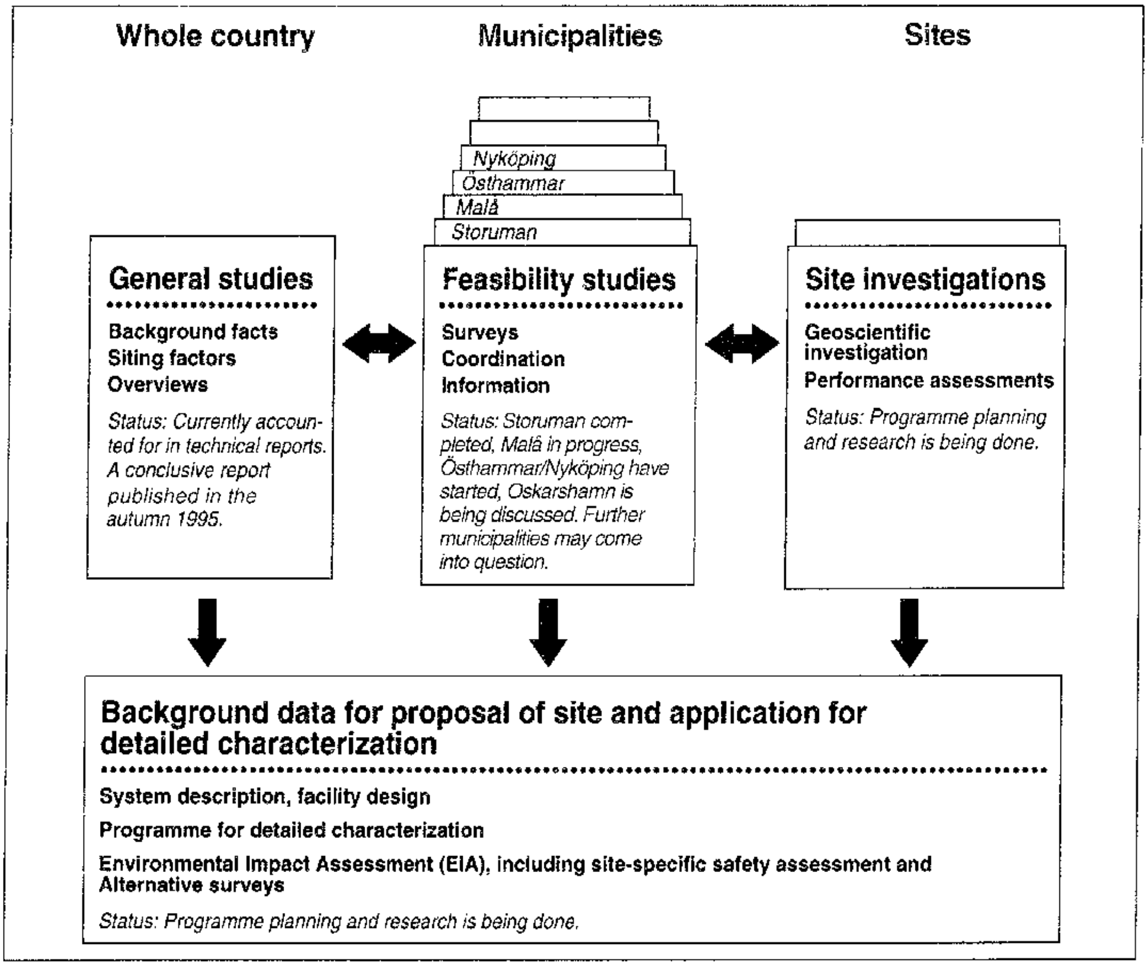


Figure 1-5. *Main components in the siting work.*

SKB does not need any formal permits to conduct a feasibility study. In practice, however, it is necessary that SKB is able to come to an agreement with the municipality in question on a programme and forms for execution of the study.

A feasibility study should provide a broad body of factual information for decisions by both the municipality and SKB. Both parties can then decide for themselves whether they are interested in starting a site investigation. The same facts are made available to all concerned parties, who thereby have an opportunity to state their views long before any decisions need to be taken on the siting of the deep repository.

The purpose of the feasibility study is thus to investigate whether prospects exist for siting a deep repository in a particular municipality, and to gather data as a basis for a decision on whether to proceed with continued investigations. Questions regarding the principles for final disposal, the advantages and disadvantages of the chosen concept, and the methods for evaluating long-term safety are dealt with in other contexts and are not investigated in the feasibility study. These questions are, however, naturally taken up in the dialogue which is conducted with all concerned parties in connection with a feasibility study. It is also important to note that the results of a feasibility study do not permit any far-reaching conclusions to be drawn concerning long-term safety. This is because data on the bedrock conditions at depth on a specific site are not available at this early stage. Such data are necessary in order to make overall assessments of safety.

SKB's siting programme is based on the execution of 5–10 feasibility studies. This scope has been judged to be reasonable to ensure a broad body of data for later phases of the siting programme.

The current situation with regard to the execution of feasibility studies is indicated in Figure 1-6. A feasibility study has been conducted in Storuman Municipality and a final report has been published on the results /1-4/. They showed that good prospects may exist for a deep repository in the municipality. On 17 September 1995, the municipality held a referendum on the question "Should SKB be allowed to continue searching for a final repository site in Storuman Municipality?" The result was 28.4% yes, 70.6% no and 1.0% blank votes, which means that Storuman Municipality is no longer a candidate for continued siting studies as far as SKB is concerned. The data compiled in Storuman will nevertheless be valuable for purposes of comparison in the continued siting work.

At present, feasibility studies are under way in three municipalities: Malå, Östhammar and Nyköping. Östhammar and Nyköping are two of the five municipalities in Sweden with nuclear facilities where general studies have been made of the siting prospects for a deep repository /1-5/. The others are Oskarshamn, Varberg and Kävlinge. These general studies have led to decisions to go ahead and commence feasibility studies in Östhammar and Nyköping, while SKB is holding discussions on a feasibility study with Oskarshamn Municipality. In Kävlinge Municipality, however, SKB has decided that a feasibility study is not of interest, since the available data show that a siting in the municipality would be complicated from both a geological and a technical point of view.

Several other municipalities in the country have at different points considered feasibility studies. SKB discussed a feasibility study with the municipalities of Tranemo and Varberg during the spring of 1995, and similar discussions have previously been held with the municipalities of Överkalix and Arjeplog. These municipalities have not decided to pursue the matter any further, however.

Site investigations

On the basis of general studies and feasibility studies, SKB plans to select at least two sites for site investigations. The site investigations are supposed to furnish all the background data needed to propose a site for the deep repository and to support an application for a permit to commence detailed characterization on this site, Figure 1-2. The final decision on the application will be made by the Government in consideration of both the Act Concerning the Management of Natural Resources and the Act on Nuclear Activities. The review process which serves as a basis for the Government's decision in the matter takes place with SKI as the responsible authority. If the application is approved, the siting process is complete.

The site investigation phase will take 3–4 years and is expected to be commenced during 1997. The investigations entail making a thorough survey of the rock conditions on selected sites. Among other things, extensive investigations are performed in boreholes down to repository depth. The site-specific data that are collected serve as a basis for a proposal for site-adapted layout of the deep repository and comprehensive assessments of safety and performance. The land-use, environmental and societal aspects of a repository on the investigated site are examined at the same time.

The site investigation phase also includes an Environmental Impact Assessment (EIA) procedure. The design of the EIA process can be influenced to a great extent by the concerned parties. The resultant EIA should shed light on the consequences of the deep repository for man and the environment and present different alternatives for design and siting.

***Figure 1-6.** Current situation with regard to feasibility studies in different municipalities.*

1.2.3 Government decision concerning the siting process

In May 1995, a Government decision was announced concerning the supplementary report to RD&D-Programme 92. The decision contains a number of clarifications that are of great importance for the continued siting work. The most important points can be summarized as follows:

- The factors and criteria which SKB says will serve as guidelines for the siting process *"should, in the view of the Government, be a point of departure for the continued siting work"*. The guidelines for the siting process have thereby been adopted.
- Applications to commence detailed characterization are reviewed under both the Act Concerning the Management of Natural Resources and the Act on Nuclear Activities. In previous programmes, it was foreseen that review would be based on the Act Concerning the Management of Natural Resources, to be supplemented with review under the Act on Nuclear Activities after the detailed characterization had been completed. The decision thus gives added weight to the review phase following site investigations.
- The EIA process is said to be *"an important instrument in contacts with authorities, concerned municipalities and the public"*. It is further stated that *"The Government presumes that the County Administrative Board in the counties where feasibility studies, site investigations or detailed characterization are carried out will assume coordinating responsibility for the contacts with municipalities and national authorities that are required in order for SKB to gather background data for an EIA"*.
- *"Those municipalities that are concerned by the site selection process should be given an opportunity to follow SKB's site selection studies at first hand"*. Municipalities in which SKB conducts feasibility studies can therefore obtain on request up to SEK 2 million per year for *"costs that enable the municipality to follow and assess and to furnish information in questions that pertain to final disposal of spent nuclear fuel and nuclear waste"*. SKI is instructed to administer this, the money to be taken from the funds that have been accumulated for financing of the nuclear waste programme. It is further stated that the County Administrative Board should assume coordinating responsibility in this context as well.

2 THE FEASIBILITY STUDY IN MALÅ

This chapter relates the events and decisions that led up to the feasibility study in Malå. It also explains how the work was organized, executed and documented. Finally, it describes the information activities and public debate that have taken place in connection with the feasibility study.

2.1 Decisions regarding a feasibility study in Malå

The first contacts between Malå Municipality and SKB were taken during the spring of 1993, and on 11 May 1993 the municipal executive board decided to request information on the Swedish nuclear waste programme.

The process was initiated by a letter which SKB had sent to all municipalities in Sweden in October 1992. The letter was occasioned by the attention which SKB's RD&D-Programme 92 received in the media, which led to questions from many municipal officials and citizens about the siting plans for the deep repository. The letter therefore contained general information on SKB's programme and the planned siting work. This led to various requests from several municipalities for further information from SKB. Among the municipalities who wanted to discuss the possibility of a feasibility study, SKB made an internal assessment of whether a feasibility study would be of interest from SKB's point of view.

In the case of Malå Municipality, it was concluded that the municipality is situated in its entirety within the crystalline basement rock area that covers most of Sweden and is generally judged to offer good prospects for finding sites with conditions suitable for a deep repository. At the same time, the evaluation showed that considerable portions of Malå Municipality are covered by bedrock which may contain mineral deposits and which therefore must be avoided when siting a deep repository. A large body of scientific material was also found to be available on the region.

The possibilities of avoiding competing land-use interests were judged to be good. Furthermore, it was noted that Malå has good road connections to suitable harbours on the coast, but that railway connections are lacking. The region has a strong industrial tradition and competence within fields such as geoscience, rock construction and heavy transport.

Based on these and other observations, SKB concluded that a feasibility study in Malå would be of interest for SKB's part.

The decision-making process in the municipality took place during the autumn of 1993, resulting in a decision by the municipal council on 22 November 1993 to request a feasibility study from SKB. The decision was passed by the narrowest possible majority (14 ayes, 14 nays, 3 abstentions, with the chairman casting the deciding vote). In connection with the decision, the municipal council stressed the fact that the feasibility study concerns the nation's nuclear waste, that the decision does not entail saying yes to nuclear waste management in the municipality, and that the municipality will follow the feasibility study with a referendum.

After the decision of the municipal council, an agreement was drawn up between SKB and Malå Municipality. The agreement entered into effect on 1 February 1994 and has regulated responsibilities, the conditions for the execution of the feasibility study and matters of compensation. It stipulated, for example, that the feasibility study should be paid for by SKB, including costs which the municipality has incurred in conjunction with its execution. The agreement also defined the goals of the feasibility study, the outline and scope of the investigation work, and the organizational arrangements.

A motion was submitted to the municipal council in April 1994 that the decision regarding a feasibility study in Malå should be reconsidered. The motion was voted on by the council on 13 June 1994, whereby it was defeated by a margin of 24 to 6.

2.2 Organization

Responsibility for the feasibility study rests with SKB. The municipality has been kept informed on the execution of the study through the project organization, enabling it to influence the work during the course of the project.

Figure 2-1 shows an organization chart for the feasibility study. The members of the project organization are presented in Appendix 2. The project has been under the direction of a steering group with four members – two from the municipality and two from SKB. The steering group held its first meeting on 11 March 1994 and has met ten times during the course of the feasibility study.

A reference group, organized by the municipality, has been attached to the steering group. Its 22 members were appointed by the political parties and a number of interest organizations. The purpose of the reference group has been to follow the work, disseminate information and contribute viewpoints and ideas.

The day-to-day work has been overseen by a project manager appointed by SKB, who has reported to the steering group. A municipal coordinator has been responsible for the activities of the municipality in connection with the feasibility study and for coordination with SKB. The site office opened by SKB in Malå at the start of the feasibility study has also served as a unit tied to the project organization.

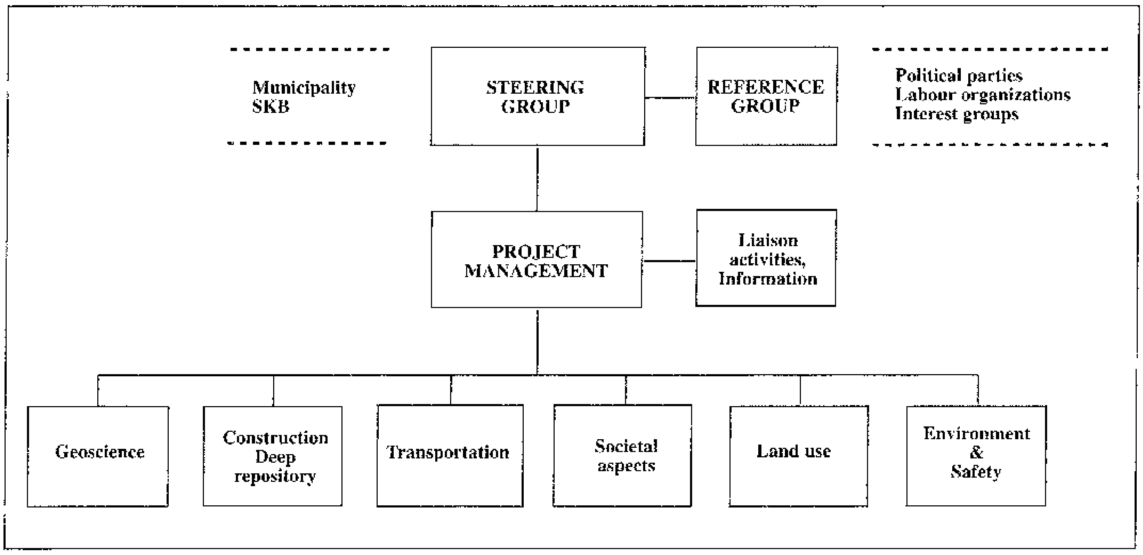


Figure 2-1. Organization chart for the Malå Feasibility Study.

The actual investigation work was divided up into a number of subject areas as shown in Figure 2-1. A principal investigator has been responsible for activities within each subject area. The project manager, the principal investigators, those responsible for administration and the site office, and the municipal coordinator have comprised a standing project group. This group has engaged experts from universities and consulting firms to compile facts and conduct studies and analyses.

2.3 Execution

2.3.1 General

With the agreement between SKB and Malå Municipality as a basis, the feasibility study started with the drafting by the project leader, together with the principal investigators, of a work programme that described in greater detail which subjects were to be studied and how the work was to be executed and organized. The draft plan was circulated for comment to the reference group and subsequently adopted by the steering group.

Figure 2-2 shows the main phases in the execution of the feasibility study. The first phase was dominated by studies within a number of subject areas. The results were presented as they were obtained in work reports and at seminars, and were summarized in a comprehensive status report. This was followed by circulation of all study material for scrutiny to solicit viewpoints and suggestions from the reference group and any other interested parties. After the material had been augmented and adjusted in response to the viewpoints received from the reviewing bodies, the present final report was compiled.

The feasibility study has taken nearly two years to execute. The study work started gradually during the spring of 1994, as study needs were clarified and suitable experts could be engaged. The results of the first sub-studies were published in December 1994, and the remainder during the spring of 1995. The study phase was concluded and summarized at the end of May 1995. Circulation for review and comment and supplementary adjustments were carried out during the summer and autumn of 1995, after which all material was compiled and evaluated and the final report was written.

2.3.2 Studies

With the work programme serving as a guide, the studies were planned in detail and suitable experts were engaged where needed to carry out the different sub-studies. The experience gained from the feasibility study performed in Storuman Municipality was utilized in this work.

Regarding the geoscientific sub-studies, the extensive information gained from ore prospecting in the region has been of great importance as background material. In order to get the most out of this material, consultants with long experience of prospecting activities were contracted. The Swedish Geological Survey (SGU) was engaged at an early stage and has played an important role in several of the studies.

The Department of Geography at Umeå University was contacted for the socioeconomic part of the study programme. This department has a strong position within the relevant branches of the social sciences. Consultants with expertise on the tourist industry were also engaged, along with persons with experience from mining activities in the region. The intention was to ascertain the current situation in Malå as regards

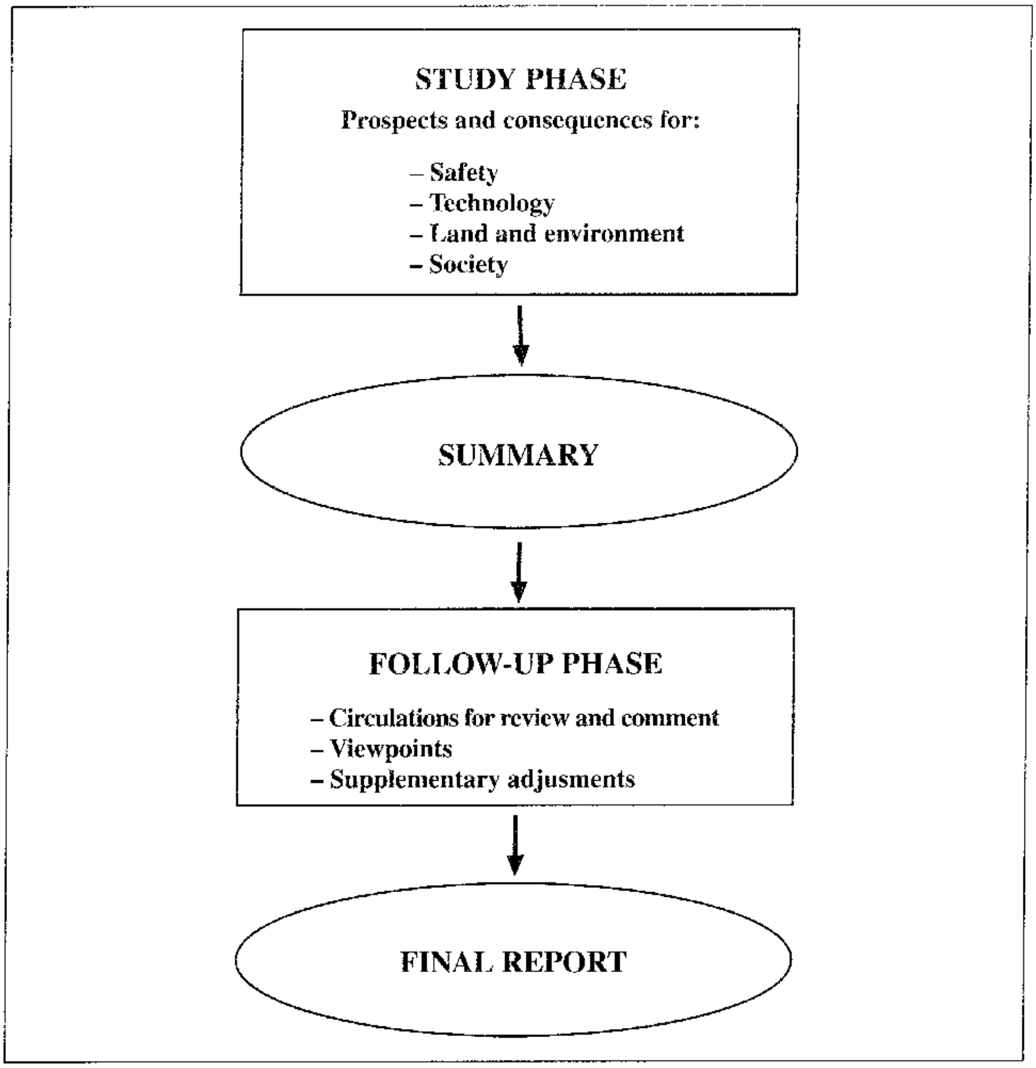


Figure 2-2. *Main phases of the feasibility study.*

history, population, business activities, employment, etc. and to try to project the future socioeconomic development of the municipality and the consequences a deep repository would have for this development.

Land-use plans, environmental protection considerations and community planning issues have been examined in close contact with the municipality and the county administrative board, from whom most of the background material was obtained. To further broaden the basis of the work, discussions were also been held with local interest groups.

The system-related material includes data on the design, construction and operation of the deep repository, plus surveys of transport options. As far as data on the deep repository as such are concerned, the information was obtained from the general development and design work that has long been under way at SKB. The spent nuclear fuel is being stored in the central interim storage facility for spent nuclear fuel, CLAB, north of Oskarshamn, from which it will be transported to the future deep repository. The prospects for sea transport of both spent fuel and backfill material to possible suitable harbours in Norrland have been examined, as have the possibilities for overland transport from a harbour to Malå Municipality.

2.3.3 Work of municipality and reference group

In parallel with the project organization (see Figure 2-1), a working group appointed by the municipal executive board has been responsible for handling municipal matters in connection with the feasibility study. The working group has consisted of the municipality's two representatives in the feasibility study's steering group, the chairman of the reference group and the municipal coordinator.

The project's reference group, which was organized by the municipality, has played a vital role as a forum for contacts with the local community. The reference group was constituted at the end of March 1994 and has met on eight occasions. The members of the group and the interest organizations which they have represented are reported in Appendix 2.

Figure 2-3 is a schematic illustration of the reference group's activities and interaction with SKB's project group, which has been in charge of conducting the studies. Knowledge-building activities were arranged in the initial phase for the benefit of the reference group, including study trips and seminars. As the study results became available, the reference group took on the function of a reviewing body, where the organizations represented in the group were given an opportunity to go through the material and offer their viewpoints. Their questions, comments and suggestions are cited in Appendix 3. Their statements of comment served as a basis for supplementary work and corrections of the study material. Among other things, a supplementary study was conducted of the travel industry and the possible consequences for this industry of a deep repository establishment. The review and commentary process has been documented in a special report.

Malå Municipality arranged a series of seminars for the reference group. The seminars were coordinated with evening lectures and question-and-answer periods for the public. The following subjects were dealt with at the seminars:

- Legislation in the field of nuclear waste management (August 1994).
- Radiation and radiation protection (October 1994).
- Research for the deep repository (November 1994).
- The bedrock in the municipality of Malå (January 1995).
- Malå and the future (February 1995).
- Nuclear waste and the environment (May 1995).
- SKB's feasibility study in Malå – status report (May 1995).

The three first seminars dealt with questions of importance for the Swedish nuclear waste programme in a general perspective. Experts from the Swedish Nuclear Power Inspectorate (SKI), the Swedish Radiation Protection Institute (SSI), various universities and SKB participated. The remaining seminars dealt with results obtained from the feasibility study, with the participation of the principal investigators for the substudies whose results were being presented.

Finally, the municipality arranged study trips to nuclear facilities. Seven groups of 15–20 persons each made such trips. The destinations were the facilities in Simpevarp (the O3 nuclear power plant, CLAB and the Äspö HRL) and Forsmark (SFR). The participants were for the most part members of the reference group, the municipal council and the municipal executive board, plus municipal officials and representatives of interest organizations.

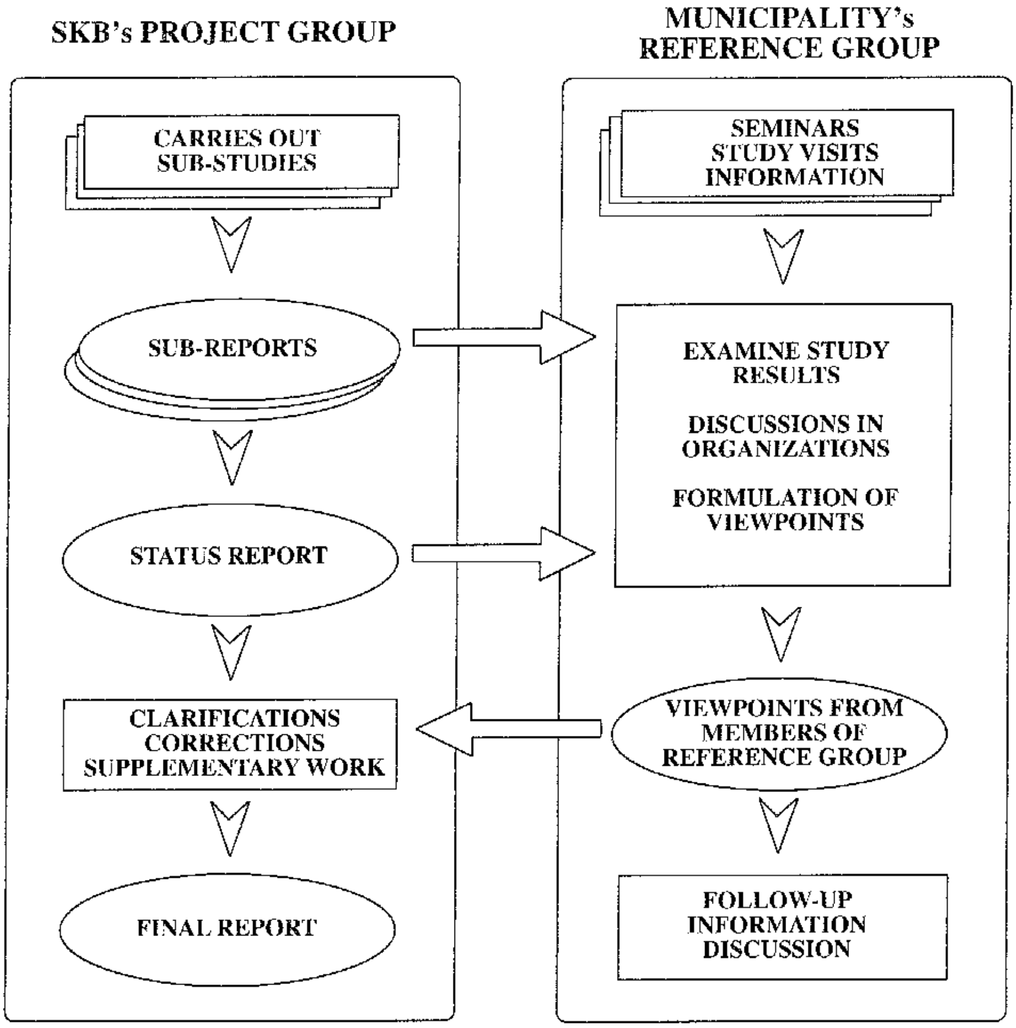


Figure 2-3. *Activities during the course of the feasibility study in SKB's project group and the municipal reference group.*

2.3.4 Documentation

Besides in this final report, the results of the feasibility study and its various sub-studies have been published in a number of reports and other documents:

- Sub-reports: All studies have been published separately in a series of 14 sub-reports. The studies have been conducted by independent experts who take responsibility for their own reports.
- Summary status report: This is SKB's summary of all results from the feasibility study's study phase.
- Documentation of the work of the reference group: The results of the circulation of the study material for review and commentary have been published in a special report, compiled through the offices of the municipality.
- Other documentation, including minutes from all meetings in the project's steering and reference groups.

Table 2-1 is an overview of the reports that have been published.

Table 2-1. Published reports from the feasibility study.

Presented	Title
SUB-REPORTS	
Geoscientific conditions	
Dec. '94	Feasibility study Malå. Description accompanying bedrock map of Malå Municipality. H Lindroos, Mirab AB (SKB PR 44-94-027).
Dec. '94	Feasibility study Malå. Ores and minerals in Malå Municipality. H Lindroos, Mirab AB (SKB PR 44-94-028).
Dec. '94	Feasibility study Malå. Geophysical documentation and interpretation. H Isaksson, GeoVista AB, R Johansson, SGU and C-A Triumf, Triumf Geophysics AB (SKB PR 44-94-029).
Dec. '94	Feasibility study Malå. Hydrochemical conditions. R Jönsson and V Nõmtak. VBB/VIAK (SKB PR 44-94-029).
Jan. '95	Feasibility study Malå. Soils in the Malå area. G Ransed, L Rodhe and M Sundh, SGU (SKB PR 44-94-030).
April '95	Feasibility study Malå. Hydrogeological description. C-L Axelsson and A Ekstav, Golder Associates AB (SKB PR D-95-003).
Societal aspects	
Dec. '94	Feasibility study Malå. Mega-environmental analysis – Malå in the heart of the true Norrland. C Fredriksson, EuroFutures AB (SKB PR 44-94-034).
Jan. '95	Feasibility study Malå. Socioeconomic consequences of siting a deep repository for spent nuclear fuel. E Holm and U Lindgren, Umeå University (SKB PR D-95-001).
Jan. '95	Feasibility study Malå. Development of tourism in Malå with or without a deep repository. M Johnsdotter and G Lindgren, Turismutveckling AB (SKB PR 44-94-041).
Dec. '95	Feasibility study Malå. The consequences of a deep repository for tourism and the travel industry – Compilation of available data. E Setzman, Vattenfall Energisystem AB (SKB PR D-95-012).
Land and environment	
April '95	Feasibility study Malå. Community planning and land use. E Setzman, Vattenfall Energisystem AB (SKB PR D-95-005).
April '95	Feasibility study Malå. Environmental aspects of siting of a deep repository for spent nuclear fuel and other long-lived waste in Malå Municipality. N Kjellbert, SKB (SKB PR D-95-006).
Technology	
April '95	Feasibility study Malå. Means of transport to a deep repository in Malå Municipality. P Lindemalm, Saltech AB (SKB PR D-95-004).
March '96	Feasibility study Malå. Rock construction data and experience. Bengt Leijon, SKB (SKB PR D-95-011).
STATUS REPORT	
May '95	Feasibility study Malå – Status report (SKB PR D-95-007).
WORK OF REFERENCE GROUP	
Sept. '95	Records of the work of the reference group, Malå Municipality (SKB PR D-95-009).

2.4 Information and debate

SKB's general policy is that the siting work should take place in an atmosphere of open discussion with the participation of SKB and concerned authorities, interest organizations and the public. The feasibility study has therefore been accompanied by activities aimed at furnishing local information on, and discussing, both the feasibility study and the Swedish nuclear waste programme as a whole.

In June 1994, SKB opened an information office in Malå. The office has served as a place of work for two local employees and for persons who have temporarily worked with various studies. Records on the feasibility study's sub-studies are also available there, along with a reference library and an exhibition that depicts the system for disposal of Sweden's radioactive wastes. The office has been open to the public all through the feasibility study, and has also been used for information meetings of various kinds.

Besides activities at the office, representatives from SKB have participated in numerous information meetings at workplaces as well as at meetings organized by different local organizations and citizens' groups. Most villages in the municipality have been visited by a van equipped for information purposes. A number of newsletters with current information from the feasibility study have been distributed to the households in the municipality. When SKB's transport ship M/S Sigyn visited Skelleftehamn in August 1995, the inhabitants of the municipality were given an opportunity to visit the ship. A collective account of the various information activities in which SKB has participated is given in Appendix 4.

In parallel with SKB's information activities, Malå Municipality has arranged exhibitions in the municipal centre and in the municipal library, with information from different sources. Furthermore, the municipality arranged the aforementioned seminars and evening lectures, as well as trips to nuclear facilities. A study trip was also arranged to Umeå University. Representatives of Malå Municipality have arranged information meetings with neighbouring municipalities and the county administrative board.

Extensive local debate and opinion formation activities took place when the proposal to carry out a feasibility study of Malå Municipality was put forward, and during the municipal decision-making process up to the final vote by the municipal council. The debate was reflected in numerous items in the local media. After this initial period of publicity, mass-media interest in the feasibility study seems to have waned, and it cannot be said to have been a major issue of public debate in the community. Seminars and other arrangements have, however, regularly been covered by the local media, and there have been some debates. Swedish and foreign broadcast media have on several occasions done reports featuring the feasibility study in Malå.

An opinion group (Opinion Group Against Nuclear Waste in Malå) was formed when the question was being dealt with in the municipal decision-making process. During the same period, statements were made opposing a feasibility study, and petitions were circulated supporting these statements. During the course of the feasibility study, the opinion group has also arranged other events, including a seminar and a training day for members of the municipal council and other interested persons. In July '95, the Waste Chain arranged a summer camp in Malå.

The debate has also been conducted on the regional plane, and some of the municipalities in Västerbotten have come out against a final repository in the region. Municipalities that could be affected by waste shipments in the event of the establishment of a deep repository in Malå, among them Skellefteå and Norsjö, have decided to oppose any such shipments.

Finally, mention should be made of certain events which occurred during the feasibility study and which – even if they have not directly affected the actual execution of the feasibility study – have been of importance for the development of the deep repository programme in its entirety. The following can in particular be noted:

- August '94: The supplement to RD&D-programme 92 is published. It gives an account of the principles and factors on which SKB's siting programme – and thereby the feasibility study in Malå – is based.
- February '95: The final report on the feasibility study in Storuman is published.
- Spring '95: The question of a feasibility study in Tranemo is considered, but the municipality decides not to pursue the matter further.
- Spring '95: Feasibility studies are considered in the municipalities of Östhammar, Nyköping, Oskarshamn and Varberg, after a general study of the siting prospects in municipalities with established nuclear activities.
- May '95: Government decision in response to RD&D-Programme 92. The decision confirms the principles and premises of the siting programme and clarifies the rights of concerned municipalities to obtain financing of their own activities.
- September '95: Feasibility studies are initiated in the municipalities of Östhammar and Nyköping.
- September '95: Referendum in Storuman, with the result that the municipality is no longer being considered for siting.
- September '95: SKB presents RD&D-Programme 95 and later also General Siting Study 95.

These events have received attention both nationally and, to some extent, regionally. In some cases, possible implications for Malå have been discussed in the media.

2.5 Independent review of the feasibility study

A necessary prerequisite for a continuation of the siting studies in Malå is that both SKB and the municipality are interested in going further. The evaluation of the feasibility study in this respect, which SKB can do at this point in time, is presented in Chapter 9.

Malå Municipality has decided to conduct an independent review of the feasibility study. The primary purpose is to obtain a more comprehensive illumination of the matter and thereby broaden the basis for its decision. The decision to commission the independent review was taken by the municipal council in June '95. At the same time the main features of the internal organization that has since been set up to deal with the matter were established. The practical review tasks have been divided among a number of committees appointed within the working group. Outside experts are being co-opted to the process. At present (February '95) preparations are being made for the actual review work. In accordance with the guidelines laid down by the Government in its decision in May '95, the municipality has applied to SKI for, and received, funds to finance the review.

3 MALÅ MUNICIPALITY

This chapter provides an introduction to Malå Municipality. Figure 3-1 shows the geographic location of the municipality on a map of Sweden. Figure 3-2 presents a general map of the municipality, which shows most of the geographic locations mentioned in the report.

3.1 General description

Malå is in many ways a typical sparsely populated inland municipality in Norrland, the vast northern part of Sweden. The municipality was first created in 1861. During the period 1973–82, Malå was a part of Norsjö Municipality, but later became a municipality of its own. Situated in the forested northern interior of Västerbotten County, the municipality is located approximately midway between the coast and the mountains. Geographically, it belongs to the "Pine-forested and hilly plains of northern Norrland". The total surface area of the municipality is about 1,700 square kilometres, which is relatively small compared with many other Norrlandian municipalities, but considerably larger than the average Swedish municipality.

Malå Municipality borders on the Västerbotten municipalities of Sorsele, Lycksele and Norsjö, as well as the municipality of Arvidsjaur in Norrbotten County. The boundary with Arvidsjaur in the north follows the Skellefte River.

The population of the municipality is currently about 4,000 people. The population density is about 2.5 inhabitants per square kilometre. The number of inhabitants has fluctuated rather widely with the advent of forestry, mining and hydropower, and their ups and downs. The population peak, about 5,300 people, was reached at the end of the 1950s. There are two conurbations: The central locality of Malå, with just under 2,500 inhabitants, and Adak with just over 200. Major villages are Rentjärn, Rökå and Malåvännäs.

Forestry is the dominant use of land in the municipality in terms of area. Reindeer herding, which is practised in virtually the entire municipality by Malå forest Sami (Lapp) village, is another area-demanding enterprise of special character and great importance. Only a very marginal portion of the municipality's surface area is developed with housing, industry, infrastructure etc. Otherwise the municipality's surface area consists of very sparsely settled countryside /3-1/.

The municipality, with the community of Malå at its centre, is located off to the side of the most heavily trafficked roads between the coast, the mountains and Norway. Through route 370, Malå nevertheless has good road connections in the east-west direction and above all with Skellefteå on the coast. The road connections in the north-south direction are poorer. There is no railway in the municipality. There are several airports within a distance of 100–150 km (Arvidsjaur, Gunnarn/Storuman, Lycksele and Skellefteå) with scheduled flights to Stockholm/Arlanda.

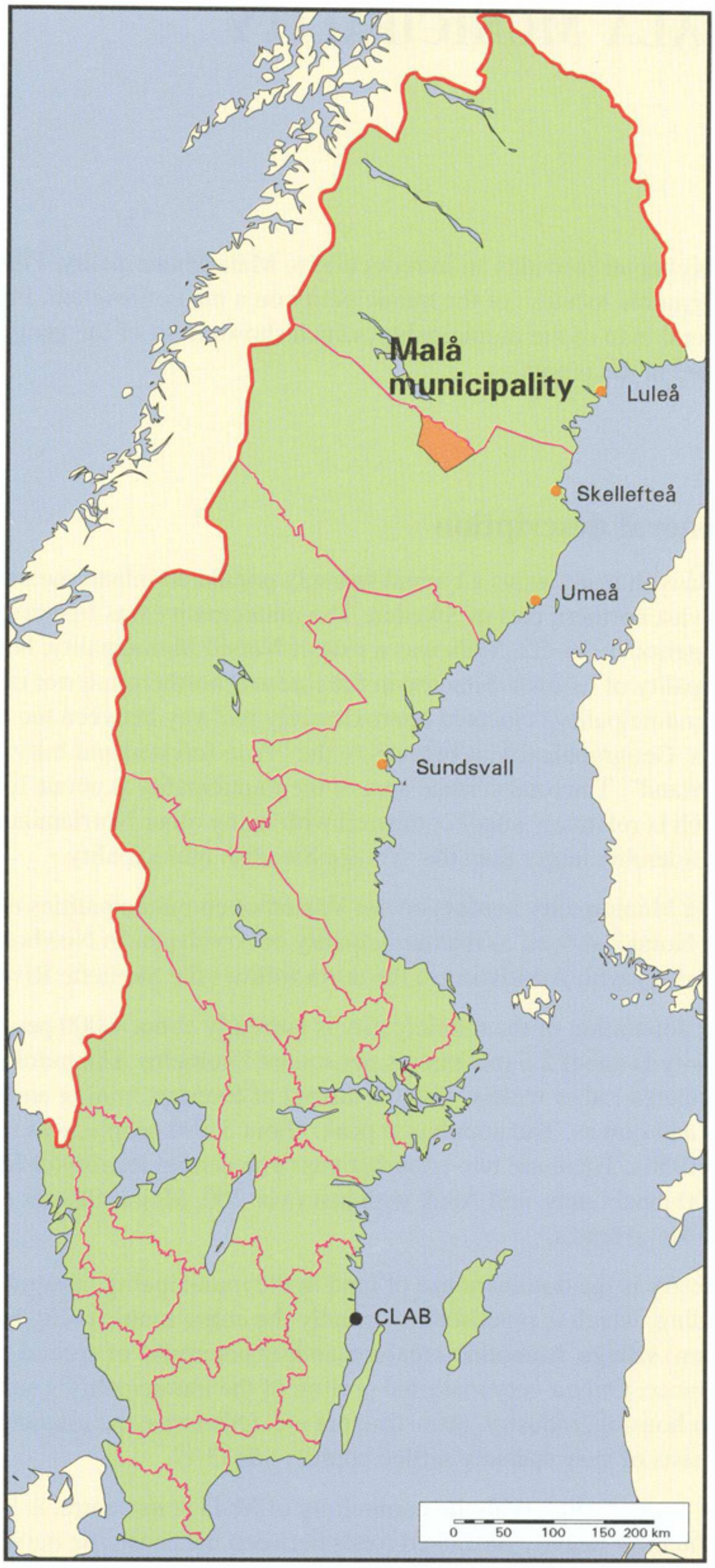


Figure 3-1. *Malå Municipality on the map of Sweden.*

3.2 History

The forests of northern Norrland and the districts around Malå have been inhabited for a fairly long time. The core area of the Swedish Sami (Lapp) culture is located in the region, which is reflected in the place-names which are often of Sami origin. The district begins to figure in written records in the middle of the 16th century, when the coastal farmers found their way to Malå to hunt and fish. The map from 1671 of Ume Lapland shows Malå, which actually belonged to Pite Lapland, for the first time. The Lapland Boundary, above which no new land was allowed to be cultivated, was determined in the 18th century. Today this is still the boundary of the province of Lappland, to which Malå belongs. The first permanent non-Sami development came in the latter part of the 18th century when isolated settlements were built, among them four so-called free mountain homesteads. Except for the Sami and their reindeer herding, agriculture (including hunting and fishing) was long the main source of livelihood /3-2, 3-3/.

Two industries, forestry and mining, dominate the development of Malå during the 20th century up to the present. These two industries, plus hydropower and its installations, led to a decline in the importance of agriculture, and the old way of living gave way to a more modern lifestyle.

Ore deposits were found in Malå Municipality back in the early part of the century. They began to be exploited during the 1920s, and proper mining operations began during the 1930s. In Malå, first the mines in the Adak area and later the Näsliden Mine were opened. The Kristineberg Mine and the mines in the Rävliden Field, situated just across the municipal border in Lycksele Municipality, have also been of great importance in the Malå area. The entire process from prospecting to ore extraction, concentration and transport has dominated the development of Malå Municipality /3-4/. Mining in the region has been dominated by the Boliden company, but state prospecting activities have also been concentrated to Malå.

Since the mine closures of the 1970s and 1980s, however, there is no mine in operation in the municipality today, and operations at the Kristineberg Mine have been considerably curtailed. State prospecting, through SGU and later SGAB, has been discontinued. Some small hived-off remnants of these enterprises remain in the municipality, however. In recent years, SGU has once again started operating through the mineral office opened in Malå.

The now-defunct aerial ropeway – "the longest in the world" – which was used for concentrate transport between the Kristineberg Mine and Boliden during the period 1943–87 also runs through the municipality. Today only a short part in Norsjö Municipality is used for tourists.

Traditionally, the forestry industry with associated woodworking and engineering enterprises also means a great deal for the municipality. This sector has succeeded better than the mining industry in retaining or strengthening its positions, so that it is the largest economic sector in Malå Municipality today (aside from public-sector activities). The sawmill and Malå Trä, founded in the 1940s and now owned by AssiDomän, plus Hultdins Verkstads AB, which manufactures equipment for forestry machines, are examples of companies that contribute to the region's economy.

Hydropower installations in Malå include the Bastusel facility on the Skellefte River. But hydropower does not have the same importance here as in many other Norrland municipalities. The Malå River is not harnessed along those sections that run through the municipality.

Figure 3-2. General map of Malå Municipality on a scale of 1:500,000. 1 cm on the map corresponds to 5 km in reality. Source: The National Land Survey's Västerbotten map (published with the Survey's consent dnr 420-242-82).

The overall trends in trade and industry, the labour market, employment and population have been downward since the 1960s. The population in the municipality as a whole and in rural areas has declined, while that in the central locality of Malå has continued to increase slightly.

A possible scenario for the future socioeconomic development of Malå Municipality, based on its history and the present-day situation, is presented in Chapter 8. The consequences a deep repository establishment could have for the development of the community are also dealt with there.

4 FACTORS AND CRITERIA FOR SITING

This chapter deals with factors that are important in the siting process for the deep repository, and how these factors can be taken into account in a feasibility study. A overview of the siting process in its entirety is given in Chapter 1.

4.1 General

The fundamental requirements on a site for a deep repository are described in RD&D-Programme 92, Supplement /4-1/ and are further treated in RD&D-Programme 95 /4-2/. A summary is given here, with an emphasis on what is applicable in a feasibility study.

The fundamental requirements that must be met by a deep repository primarily have to do with long-term safety and other environmental consequences. These requirements are defined by laws and regulations issued by the government authorities. The question of whether or not the requirements are met for a deep repository on a specific site will be determined by the authorities when they review the safety assessments and environmental impact assessments to be presented by SKB during the siting process, see Figure 1-2. It is the results of such broad and deep evaluations which will decide whether the deep repository may be built and commissioned on a proposed site.

4.2 Siting factors

The so-called siting factors which determine whether an area is suitable for siting of a deep repository can be arranged in the following main groups:

Safety	Siting factors of importance for the long-term safety of the deep repository.
Technology	Siting factors of importance for the construction, performance and safe operation of the deep repository and the transportation system to the deep repository.
Land and environment	Siting factors of importance for land use and general environmental impact.
Societal aspects	Siting factors connected to societal considerations and community impact.

Figure 4-1 shows schematically that these four main groups contain a host of criteria which determine the suitability of a site.

Some siting factors have the character of absolute criteria which a site must fulfil. These are primarily properties of the bedrock which are connected to the safety of the repository. Examples of such criteria are that the groundwater at repository level must be free of dissolved oxygen, and that there may not be any mineral deposits on the

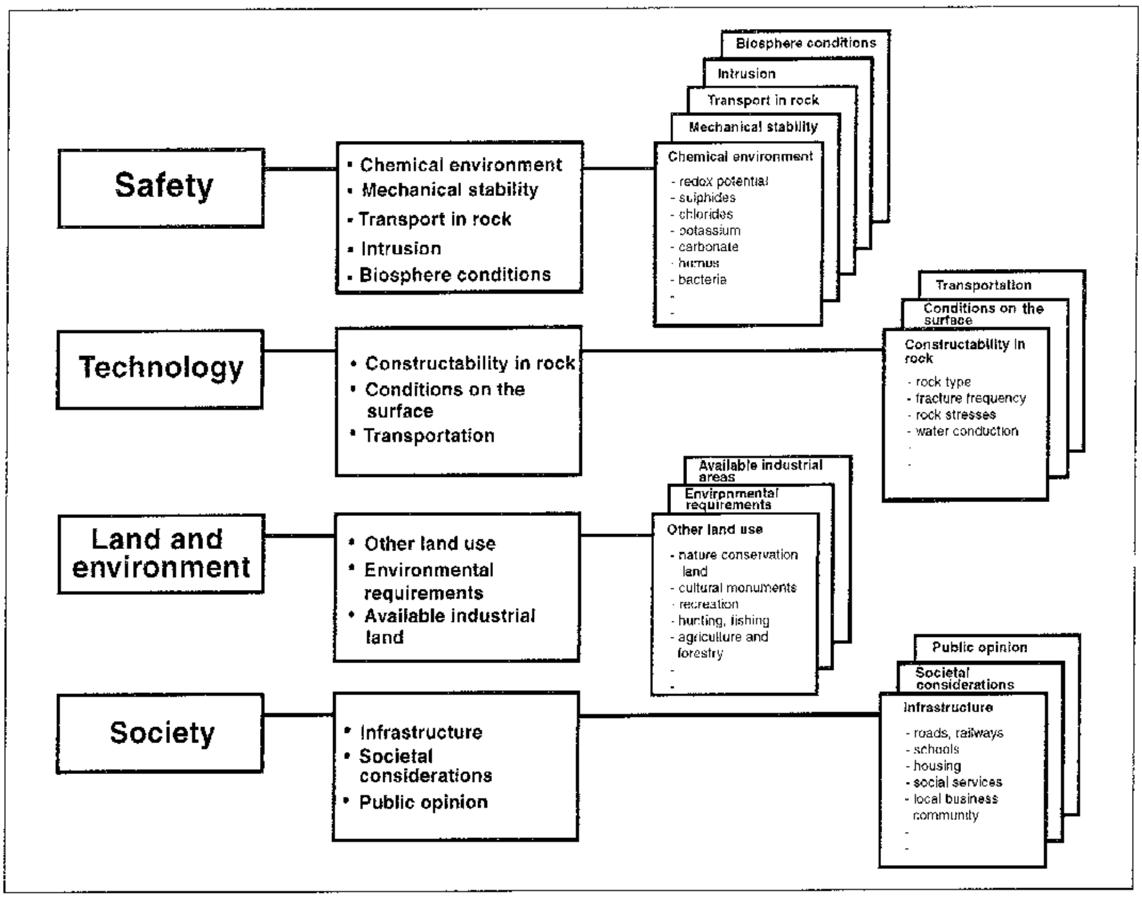


Figure 4-1. Main groups and sub-groups of siting factors.

site. These types of fundamental requirements can be regarded as points of departure in the siting work.

It is, on the other hand, not possible to stipulate in advance, and in quantitative terms, specific requirements or optimal values for all the parameters that can in any way influence the safety-related performance of the repository. This is because safety is governed by complex relationships, where many parameters – associated with both the properties of the bedrock on the site and the design of the repository – enter in. For this reason, quantitative values for many individual parameters only become meaningful when they can be placed in their site-specific context.

A holistic assessment of long-term safety thus requires access to site-specific data on bedrock conditions. Such data can only be obtained via thorough investigations on sites, which must be selected on the basis of incomplete data. This greatly influences the siting work and the way of working with siting criteria in different phases. An important consequence is that the process must proceed in a step-by-step fashion. In order to obtain the necessary breadth in the background data, general investigations are conducted at an early stage over large areas. The focusing on smaller areas then proceeds progressively, at the same time as the degree of detail in the investigations increases. It is important that the evaluations and assessments that are made in each step are in harmony with the degree of detail in the available data.

This dependence on knowledge of the rock conditions on a particular site generally distinguishes the siting of underground facilities from conventional industrial sitings on the surface, where as a rule information on all important factors is rather easily accessible, even at early stages. This situation is thus not unique for the deep repository, but may be particularly pronounced depending on the scope and complexity of the siting work.

A large portion of the siting factors are of the type favourable or unfavourable. Such factors are important in an overall assessment of a site, but do not solely determine the suitability of the site. This is true of many of the technology- and environment-related parameters, for example distance to existing transport guideways (road or railway), competing land-use interests and risks of disturbances in the natural environment. The importance of such factors is in many cases linked to the opportunities that exist to fine-adjust the layout of the deep repository to the conditions on the site.

The requirements associated with the four main groups of siting factors in Figure 4-1 are dealt with briefly in the following.

4.2.1 Safety

The fundamental safety principle for the deep disposal system planned by SKB is to completely contain and isolate the radioactive waste for such a long time that the radionuclides decay and no longer pose a risk to man or the environment. It is the requirement of isolation from the biosphere over a very long period of time that leads to the choice of the bedrock as a disposal medium.

In order to put the siting factors that can affect long-term safety in their proper context, it is necessary to briefly review some basic principles for the design of the deep repository. For a more exhaustive account, see RD&D-Programme 95 /4-2/.

Figure 4-2 shows a schematic drawing of the most important parts of the deep repository. The waste is encapsulated in tightly sealed canisters, which are deposited at a depth of 500 metres. The canisters prevent the waste from coming into contact with groundwater and have an estimated life which exceeds by a good margin the time for which the waste must be isolated. The canister design incorporates an inner container of steel and an outer container of copper. The steel provides mechanical strength and the copper shell protects against corrosion.

The basic design of the repository is based on the multibarrier principle, which means that if a canister should, in spite of everything, be damaged, other protective barriers will prevent radionuclides from reaching the biosphere. The waste in itself has extremely low solubility in water. The canister is surrounded by compacted bentonite clay, which fills out the disposal chamber. The bentonite absorbs water, swells and forms a highly impermeable buffer. This buffer counteracts groundwater movements while protecting the canister against mechanical damage. Finally, the rock on the selected site should have a good capacity to retain or retard radionuclides, so that they cannot reach the biosphere if the chain of internal protective barriers fails to perform in the intended fashion.

The canister and the bentonite comprise the near-field engineered barriers, whose main function is to isolate the waste from its surroundings. The performance of these barriers is dependent on site-specific chemical and mechanical conditions. This means that the rock, besides constituting a protective barrier in itself, has another important safety-related function, namely to provide a suitable environment for the engineered barriers over long spans of time.

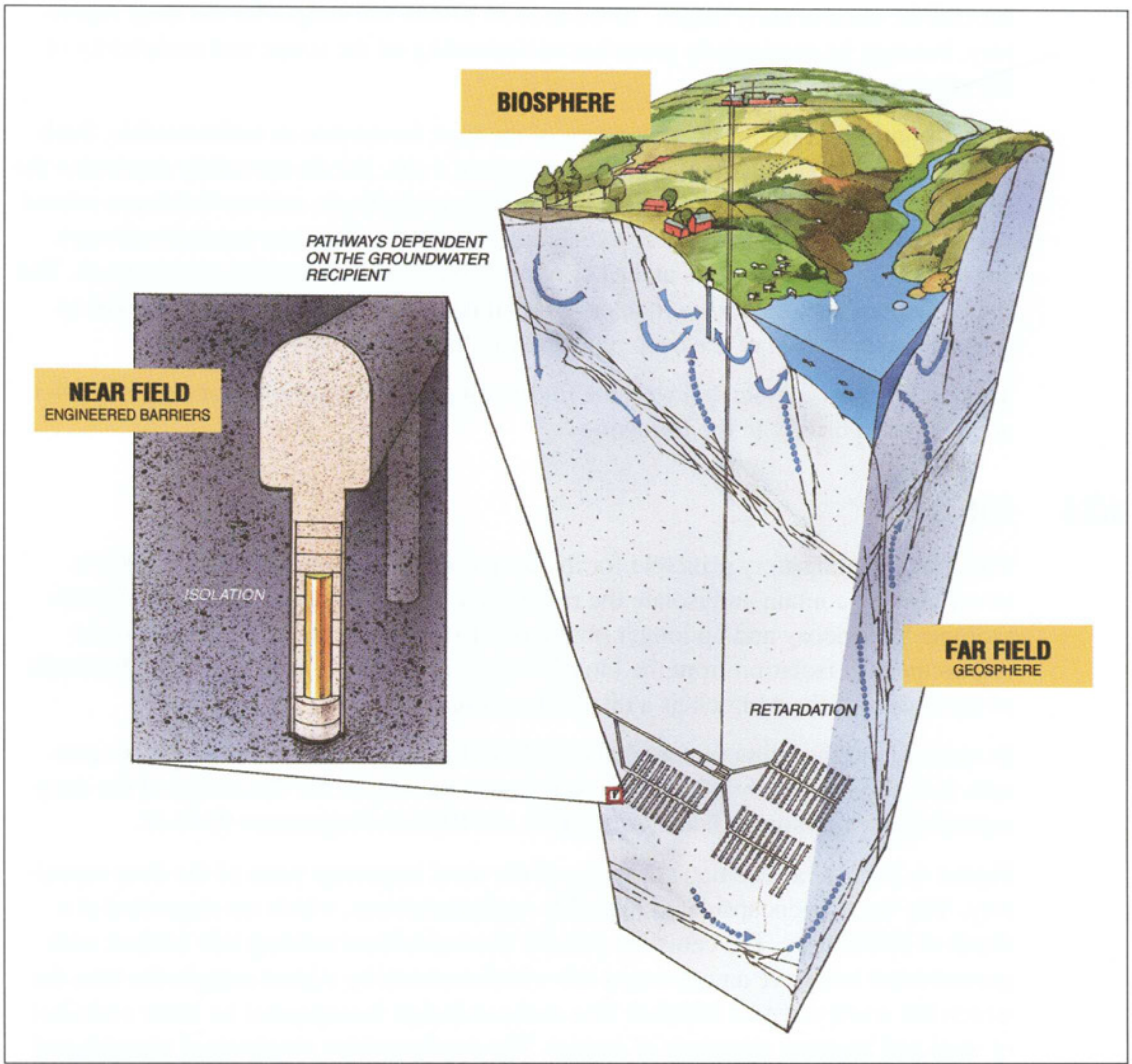


Figure 4-2. The most important safety functions of the deep disposal system.

In summary, the rock has the double function of:

- ensuring a long-range stable chemical and mechanical environment which is suitable for the engineered barriers, and
- comprising in itself an extra protective barrier.

These main principles for achieving long-term safety and the fundamental requirements on the rock which follow from them mean that the following factors must be taken into consideration in the selection of the site:

- chemical environment for canister, bentonite clay and fuel,
- mechanical stability of the rock,
- conditions for transport of corrodants and radionuclides in the rock,
- the risk of future intrusion, i.e. mainly conceivable utilization of natural resources in the bedrock.

4.2.2 Technology

When it comes to the requirements on the selected site with regard to construction and operation of the deep repository, one can distinguish factors that apply to the repository's surface installations, the underground facilities, and the transportation system. Site-specific information on "surface factors" can be gathered early, while information on "underground factors" proceeds from the step-by-step investigations.

The deep repository's surface facilities

All receiving of goods, as well as buffer storage and transloading, takes place on the surface. The facilities should be designed and equipped so that the requirements on public safety, occupational safety, radiation protection and other environmental protection are met. It is an advantage if the facilities are located near infrastructure in the form of public transport, social services, etc. The requirements made on the bearing capacity of the ground do not differ from what is required for other construction activities.

The deep repository's underground facilities

The underground facilities include shafts, access tunnels, personnel quarters, storage rooms, transport tunnels, deposition areas, etc. The construction of these facilities can to a great extent be compared with other rock excavation work, such as development excavations in mines. The operating environment will bear great similarities to the facilities in SFR and CLAB.

The rock where the facilities are built must have such properties that the work can be done with adequate safety and using known technology. By international comparison, Swedish crystalline basement rock provides good conditions for rock construction. There is also considerable and well-established experience in Sweden of siting and construction of rock facilities for various purposes. Experience does not suggest the existence of any crucial regional differences or that any region should be particularly unsuitable for rock construction. Suitability is more tied to local conditions.

The construction feasibility of a site can be determined with greater accuracy when investigation data from repository depth becomes available. Important factors include the homogeneity of the bedrock, locations and character of fracture zones and rock stresses. Abnormally heterogeneous rock conditions or high rock stresses are examples of conditions that can be unfavourable.

Transportation

The requirement that transportation shall be accomplished safely can be met with the aid of the appropriate technology and the necessary investments. The required technology is well known from the shipments of radioactive materials that have long been carried out in Sweden and abroad. It is an advantage if existing infrastructure can mainly be utilized for sea and overland transport. It is a disadvantage if extensive new investments are required, or if new harbours, roads or railways come into conflict with other important environmental or land-use interests.

4.2.3 Land and environment

Site selection and design of the facilities should be done so that conflicts with competing interests are minimized. Consideration should be given in a broad sense to the natural and cultural environment. Factors to be taken into consideration are nature conservation, recreation, hunting, fishing and other outdoor activities, cultural monuments, important natural resources, agriculture and forestry, and current and planned land use. Facilities and lines of transport and communication should blend in smoothly with the terrain.

To comply with the requirements of Swedish environmental legislation on a comprehensive environmental impact assessment of civil engineering projects, the facility's environmental impact must be evaluated on the basis of local conditions early in the siting process.

In summary, the site for the deep repository should have:

- few competing land-use interests,
- good prospects for being able to build and operate the facilities in compliance with all environmental protection requirements.

4.2.4 Societal aspects

Socioeconomic considerations are important for both site selection and design of the facilities on the selected site. The establishment and operation of a deep repository will have different impacts on the locality and the region. Perhaps the most concrete effects are impact on population, employment, the local business community and local services. Politically and in terms of public opinion, siting is a sensitive issue. Experience in both Sweden and other countries shows that strong feelings and opinions can be aroused.

Siting of a deep repository should be carried out so that:

- different stages of investigation, construction, commissioning and operation of the facility are supported by a thoroughly democratic decision-making process,
- social and socioeconomic consequences are taken into account.

4.3 Application of siting criteria in a feasibility study

The siting factors that have been discussed must all be taken into account in an overall assessment of a chosen site. But as noted above, the opportunities to obtain the data needed to make such an assessment vary for different siting factors. Many of the geoscientific factors that influence the long-term safety of the repository and the conditions for rock construction can only be clarified by means of extensive underground investigations on a specific site.

The feasibility study contains no such investigations, but is aimed at compiling and analyzing existing data on a general scale (the whole municipality). The knowledge that can be obtained about the geoscientific conditions at repository depth is therefore incomplete.

The work in the first stage of the feasibility study is aimed at identifying and analyzing geoscientific conditions that may be unsuitable or unfavourable on the basis of generally available information. Conditions that should be avoided are:

- rock types of interest for mineral extraction or other exploitation,
- highly heterogeneous or difficult-to-interpret bedrock,
- known deformation zones or neotectonic (geologically recent) faults,

- pronounced discharge areas for groundwater,
- abnormal (for Swedish bedrock) groundwater chemistry.

A review with respect to these factors can lead to the dismissal of large or small areas from further studies. Important questions for the remaining areas are:

- which areas may have particularly good chances of meeting the requirements relating to safety, technology, land and environment and societal aspects?
- which of these areas offer good opportunities for later carrying out a reliable characterization of, above all, the important environmental and safety factors?

Conditions which are primarily favourable with respect to these questions are:

- a common rock type of no interest for other exploitation of natural resources. This provides good prospects for obtaining a good understanding of the bedrock conditions that are important for safety, and it reduces the risk that the area will be considered for other use in the future;
- a large area with few major fracture zones. This provides extra flexibility in connection with coming investigations and improves the chances of being able to construct a repository with room for the necessary number of canister positions in good rock with a high level of safety;
- a high degree of rock exposure, simple and homogeneous bedrock conditions and a regular system of fractures and fracture zones. This ensures good prospects for obtaining at an early stage a thorough understanding of bedrock conditions of importance for safety and rock construction.

These factors are all connected with the bedrock. From the environmental and societal viewpoints, the following conditions are also favourable:

- access to the necessary infrastructure and good transport options in the form of harbours, railways or roads. Limited need for new investments in roads or railways;
- few competing land-use and environmental interests, which means good opportunities for adapting the facilities so that the environmental requirements are met.
- local positive interest.

Based on these criteria, an evaluation is made in the second stage of the feasibility study for the purpose of identifying and making a rough evaluation of possible areas that are deemed to be of special interest for possible further investigations.

The sub-studies that have been carried out have all been aimed at furnishing background material for the evaluation process outlined above. The following chapters summarize the results obtained from the studies with respect to the siting factors safety, technology, land and environment, and society.

5 PROSPECTS FOR LONG-TERM SAFETY

The prospects for achieving a safe repository are associated with the properties of the bedrock. This chapter provides an overview of the geoscientific data that has been compiled in the feasibility study and presents the assessments that have been made on the basis of these data.

5.1 Introduction

In an overall evaluation of safety (safety assessment) both the properties of the bedrock on the site and the design of the deep repository must be taken into consideration, since the results are determined by a combination of these factors. Safety assessments for different assumed alternatives with regard to repository design and rock conditions have been carried out in connection with the development activities which SKB has pursued and in support of different permit applications. Similar studies have been conducted by Swedish government authorities as well as by organizations and government authorities in a number of other countries. These assessments are based on data on the bedrock obtained from various investigations. Taken together, these data give an idea of both typical conditions and how the properties of the bedrock vary. RD&D-Programme 95 /5-1/ provides an overview of methods and data requirements for safety assessments, as well as the current state of knowledge.

An important conclusion is that it is possible, with a combination of design measures and careful site selection, to meet the requirements on long-term radiological safety with good margin. Furthermore, the conclusion is drawn, based on the investigations that have been made of the bedrock in Sweden, that sites with the conditions required for safe disposal can be found at many places in the country.

In order for a safety assessment concerning a specific site to be meaningful, thorough investigations must be conducted on that particular site, first from the surface and then in boreholes. Such investigations are undertaken in that phase of the siting process called site investigations according to Figure 1-5. In later phases, when data from detailed investigations in shafts and tunnels become available, the safety assessment can be further refined, at the same time as the configuration of the repository can be adapted in detail to prevailing rock conditions.

In the feasibility study, the geoscientific work has been limited to compiling and analyzing generally available data. The rough material that has been gathered does not permit any safety assessments. It is therefore not possible, on the basis of feasibility studies, to conclude that a particular site in the municipality possesses the safety-related prerequisites for a deep repository. A forecast can, however, be made concerning the safety-related prospects by taking into account the siting factors discussed in section 4.2, as well as by utilizing the general knowledge concerning what different bedrock conditions mean for conditions at repository depth.

In accordance with the methodology for application of siting criteria in the feasibility study that is described in section 4.3, the work has been organized in a step-by-step progression with the following objectives:

- Firstly, identify and analyze unsuitable or unfavourable conditions. This can lead to the dismissal of large or small areas from further studies.
- Secondly, try to identify any areas where the bedrock is judged to have particularly good prospects for meeting the safety-related requirements.

5.2 Compiled data from the feasibility study

The geoscientific study material has been compiled in the following sub-reports (cf. Table 2-1):

- Description accompanying bedrock map of Malå Municipality /5-2/.
- Ores and minerals in Malå Municipality /5-3/.
- Geophysical documentation and interpretation /5-4/.
- Hydrochemical conditions /5-5/.
- Hydrogeological description /5-6/.
- Soils in the Malå area /5-7/.
- Rock construction data and experience /5-8/.

Figure 5-1 indicates contributions made by the different sub-studies to the aggregate body of background material. Most of the material has previously been presented in the status report published in May 1995 /5-9/.

Few municipalities in the country can be compared with Malå when it comes to availability of geoscientific information. This is a consequence of the ore prospecting and mining activities that have gone on for a long time within the municipality's boundaries. Prospecting for metals associated with sulphide mineralizations in particular has through the years produced a large quantity of records in the form of maps and reports. For example, there are more than 1,400 documented boreholes in the municipality.

In other words, the background material for the geological and mineralogical studies is good compared to many other municipalities, but the value of the material in the present context should nevertheless not be overestimated. Most of the investigations that have been done are concentrated to small areas within known ore belts. There are large areas within the municipality where the information from surface investigations is sporadic and where boreholes are lacking. Thus, the material does not provide a comprehensive picture, particularly with regard to conditions at depth.

The geological material that has been utilized derives for the most part from work done under state auspices, through the State Mining Property Commission (NSG), the Swedish Geological Survey (SGU) and later Swedish Geological Company (SGAB), and from Boliden's prospecting activities. Within the framework of SGU's mapping activities, both bedrock geology and soils within the region are being systematically surveyed. Material from this ongoing work has been utilized in the feasibility study. Further, Malå Municipality is relatively well covered by general geophysical surveys, a large portion of which have been conducted aerially. Most of the geophysical information also derives from the prospecting work.

The geological observations that are available often provide detailed information at individual points, but since only a small portion of the bedrock is exposed, the observations are largely of a random nature. Different types of geophysical measurements have a better chance of extrapolating continuous information over large surface areas and can to a varying degree indicate the properties of the rock at greater depths. On the other hand, the geophysical information is indirect, and can therefore be difficult to interpret. It is important that geological and geophysical base information be combined in order to get the best possible picture of the bedrock structure. The data gathering work within the feasibility study has therefore taken place in close cooperation between geologists and geophysicists.

Occasional field studies were made at an early stage in support of the compilation of the geological and geophysical general maps. Several additional field studies were conducted in the final phase of the feasibility study, in the summer of '95, of areas with granitic bedrock that were of particular interest for the feasibility study. The purpose was to verify and clarify the data for these areas.

As far as the groundwater and its chemistry are concerned, information is available from wells in the municipality. Results of geochemical analyses of well water have been taken from SGU's archive and from the municipality. The depth of the wells is normally a few tens of metres, in exceptional cases up to about 100 metres. It is not always possible to apply well data to repository depth, since the chemistry of groundwater changes with depth in several important respects.

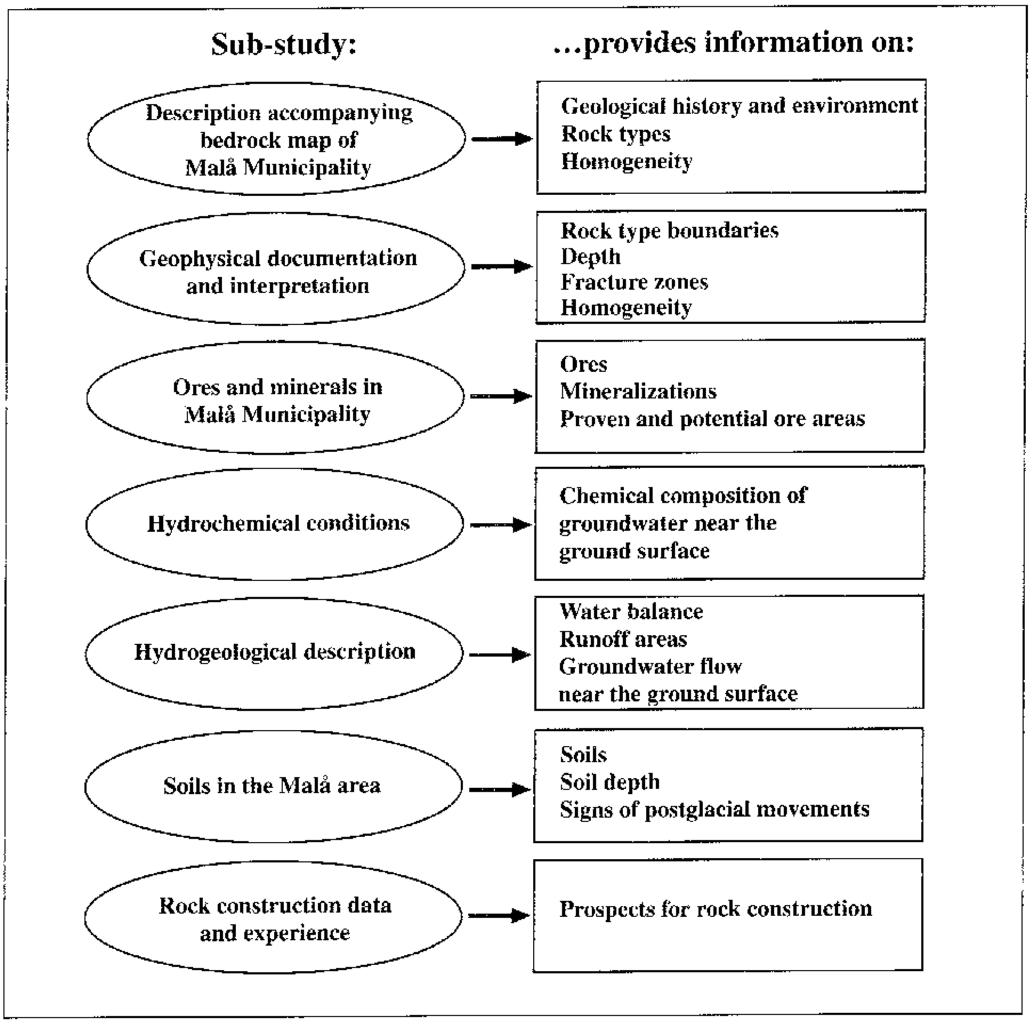


Figure 5-1. *Background material from geoscientific sub-studies.*

General information on water balance, groundwater recharge etc. within the municipality has been obtained from meteorological databases. To study the water-conducting properties of the bedrock, in a general sense and in near-surface formations, data from wells have once again been used. Well capacity (water discharge) is measured regularly when new wells are drilled, and the results are filed in databases at SGU. Data of the type required for calculations of groundwater flow at repository depth are not available for Malå.

Rock engineering data and experience have been obtained from the mines in the region, a few boreholes and the hydropower plant in Bastusel. This information concerns the technical suitability of the rock for excavation more than the safety-related conditions and is dealt with more thoroughly in Chapter 6.

5.3 Geological overview

Malå Municipality is situated in its entirety within the crystalline basement rock area that constitutes most of Sweden. The bedrock in the region was formed during a period that lasted about 150 million years and ended about 1,750 million years ago. The distance from Malå to the considerably younger bedrock comprising the Scandinavian mountain range (the Caledonides) is about 100 km.

Viewed on a regional scale, Malå is located in a transitional area between different geological provinces. Parts of the bedrock in the municipality are included in the Skellefte Field, which reaches into the municipality from the east. The Skellefte Field is dominated by so-called supracrustal rocks of various kinds. The area is an important sulphide ore province with numerous known mineralizations and several mines. Areas with plutonic rocks extend west and south of the Skellefte Field. The municipality's bedrock can therefore be roughly divided into two main rock categories: supracrustal and plutonic. The map in Figure 5-2 gives a rough idea of the extent of these two main types, each of which covers about half of the municipality's surface area.

Figure 5-3 shows a bedrock geology map of the municipality with environs, which provides a more complete picture of the extent of different rock types. Granites of the Revsund type dominate the plutonic rocks.

The granites tend to form more or less rounded areas, which reflects their mode of formation. The Revsund granites are younger than the other rock types, having been intruded from below, deforming the older bedrock formations and forming mushroom-like bodies.

5.4 Ore potential

Rock types or areas with potential for future ore extraction or prospecting should be avoided in view of the risk of future intrusion. Future generations must be able to exploit the natural resources in the bedrock without incurring special risks due to proximity to the repository. In view of the location of Malå Municipality on the edge of the Skellefte Field with its ores and mineralizations, it is obvious that this factor must be taken carefully into consideration. An important task for the feasibility study has therefore been to describe known ore deposits and mineralizations in the municipality and to estimate the extent of areas where mineral extraction might conceivably be of interest in the future.

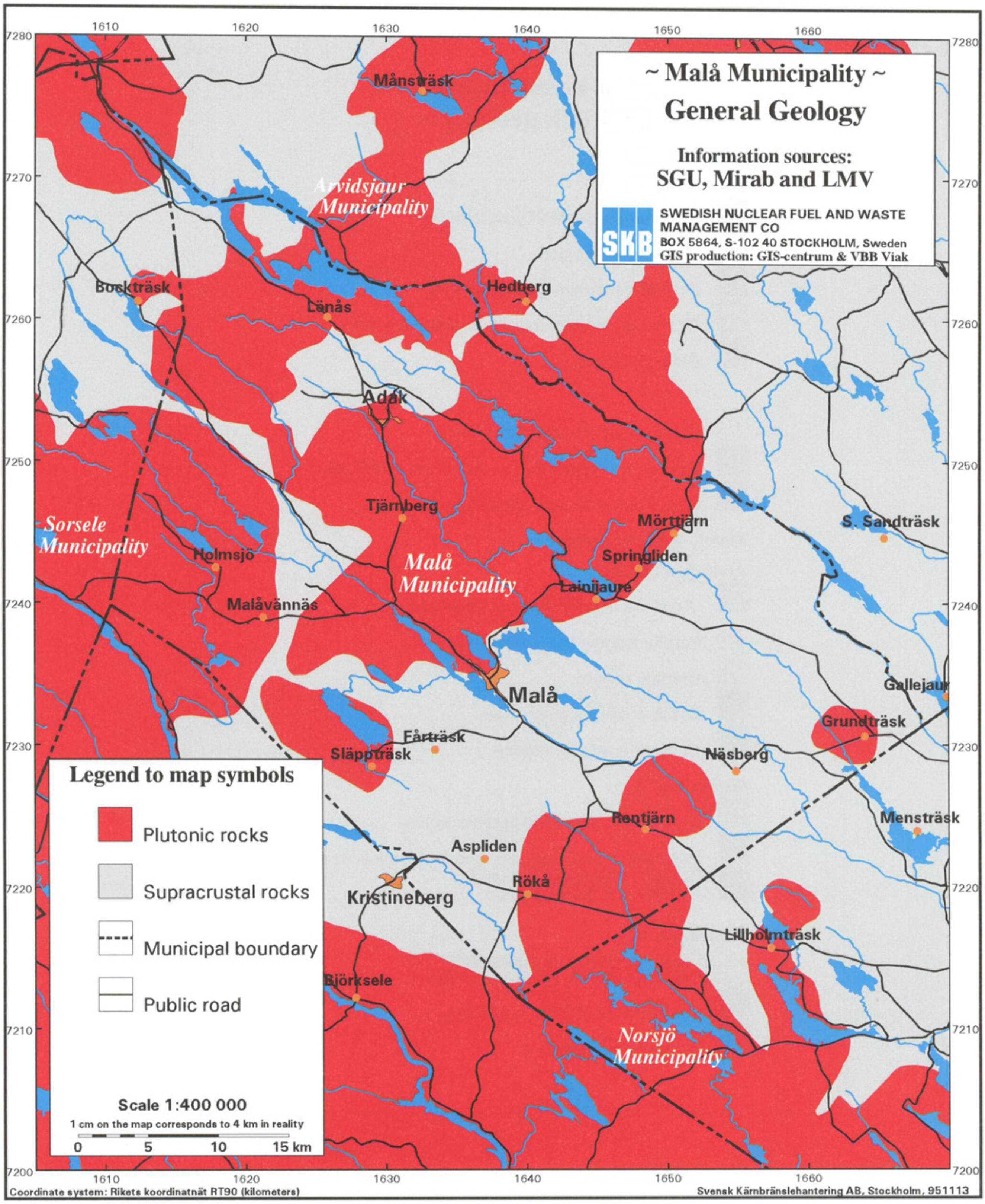


Figure 5-2. *Areas with plutonic and supracrustal rock types in Malå Municipality with environs.*

Legend to map symbols
~ Bedrock geology ~

Plutonic rocks

Revsund series

- P Pegmatite, aplite and granite dykes
- Monzonite, syenite
- Fine- and medium-grained granite
- Coarse-grained to coarse-porphyritic granite
- Gabbro, diorite

- ~ Gneissification, migmatization
- Xenoliths of sediment or vulcanite in granitoids
- Major fault or zone of weakness

Mainly supracrustal rocks

Arvidsjaur group

- Vulcanite, sandstone or conglomerate
- Porphyrs and volcanic breccias
- Granite, gabbro
- Basalt-andesitic greenstone
- Conglomerate, sandstone

Malå group

- Greywacke, shale and graphite shale
- Intercalations of limestone and basic vulcanites
- Dykes of ultramafic rock and intrusions of diorite-gabbro

Skellefte group

- Layered-massive and porphyritic fragment-bearing acidic vulcanites
- Intercalatons of basic vulcanites
- Gneissified granitoid

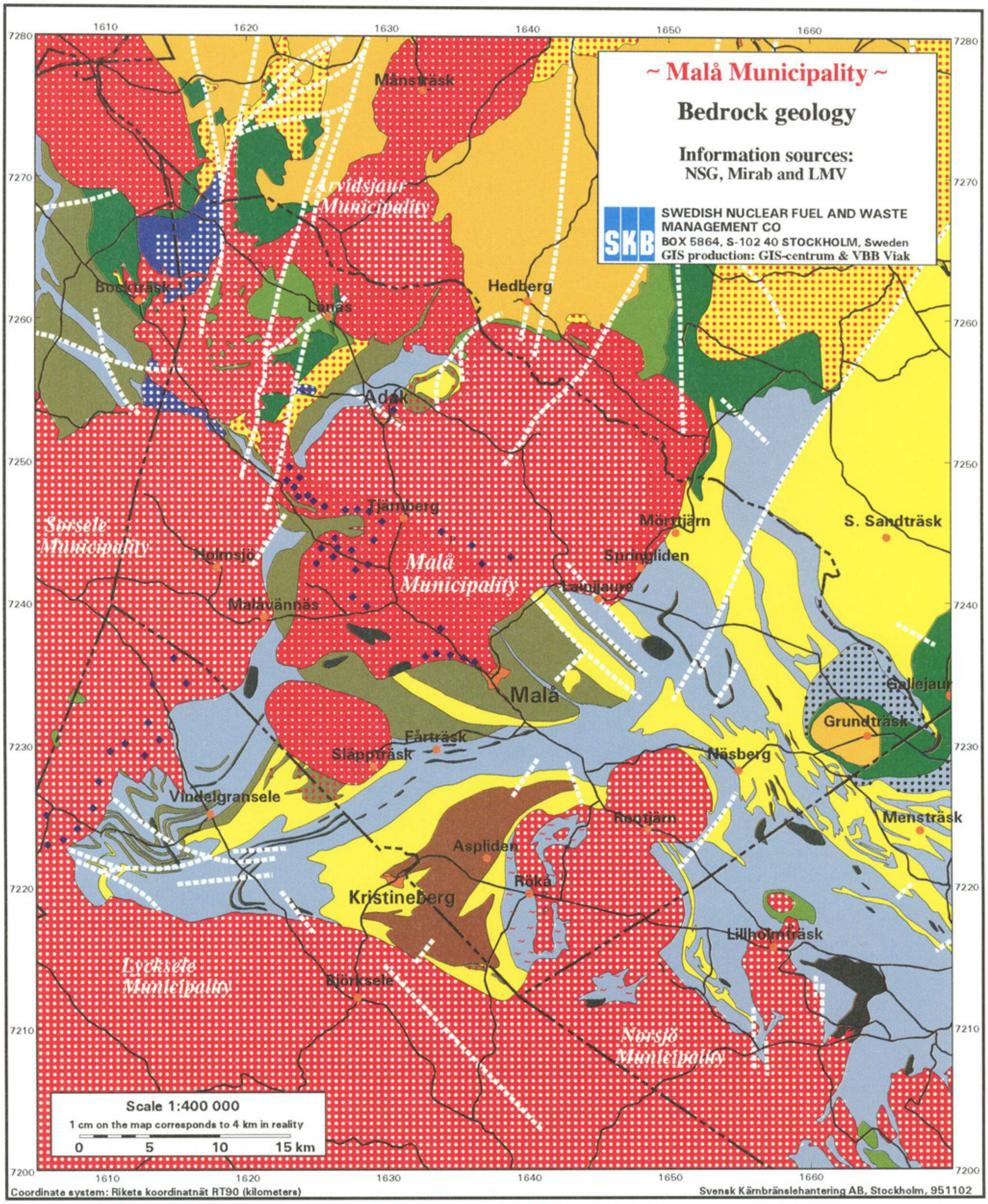


Figure 5-3. *Bedrock geological map of Malå Municipality with environs.*

The claims that are registered with the Swedish Bureau of Mines serve as a measure of the interest in prospecting in the area. Figure 5-4 shows active (currently applicable) claims in the municipality with environs. In the same way, Figure 5-5 shows claims that were registered during the past 15 years or so but were subsequently struck from the register because the investigations did not yield positive results. The majority of claims concern base metals such as copper and zinc. In recent years, interest in gold prospecting over large areas has also increased. There has been little prospecting for industrial minerals and natural stone. It should be added that the maps show the situation in June 1994. Since then a major claim has been added in the northern part of the municipality, just east of the claims marked in Figure 5-4 in the area east of Adak. Otherwise, changes in the claims picture in the municipality are judged to be small.

The size of the claims seldom reflects the potential of the areas, being influenced instead by a number of other factors, including investigation phase and method. A clearer picture of known ore zones and areas of interest for prospecting is obtained from the ore geology map prepared within the feasibility study and presented in Figure 5-6. Areas marked with red and yellow on the map are defined as follows:

- Proven ore areas (red): Areas with known ore-bearing zones.
- Potential ore areas (yellow): Areas that are, or may become, of interest for prospecting.

Since the proven ore areas are included in the potential ore areas, only the latter term is used in the following. The potential ore areas cover about 50% of the municipality's surface area. They cover most of the southeastern part of the municipality, a large area around Adak, and a narrow belt east of Adak and southward to the municipal boundary. A comparison with the maps of the extent of the rock types, Figure 5-2 and Figure 5-3, shows that the ore potential is essentially associated with the supracrustal rocks.

The potential ore areas circled in Figure 5-6 are judged to be unfavourable for a deep repository owing to the risk of future intrusion or conflicts of interest. These areas are thereby of less interest for further investigations. It should be added that the boundaries shown in Figure 5-6 should be regarded as approximate, due to the regional scale of the map. More detailed studies may occasion adjustments. Furthermore, the map reflects the situation near the ground surface. In a more thorough evaluation on a more local scale, the in-depth extent of the potential ore structures may have to be investigated. For example, the granite intrusions, which do not have ore potential, may be of limited depth and may in certain cases be underlain by rock types with ore potential.

5.5 Fracture zones

Lineament interpretations are often used to estimate the frequency of fracture zones. Topographical features - such as valleys, strings of mires, long straight cliffs or lake contours - usually reveal fracture lines in the bedrock which are the visible evidence of fracture zones and faults. Similar information on the locations of fracture zones can also be obtained from geophysical measurements of magnetic and electrical properties of the bedrock. Maps of the extent of different rock types, such as the one in Figure 5-3, can provide further information, since fault movements may have displaced originally continuous rock units.

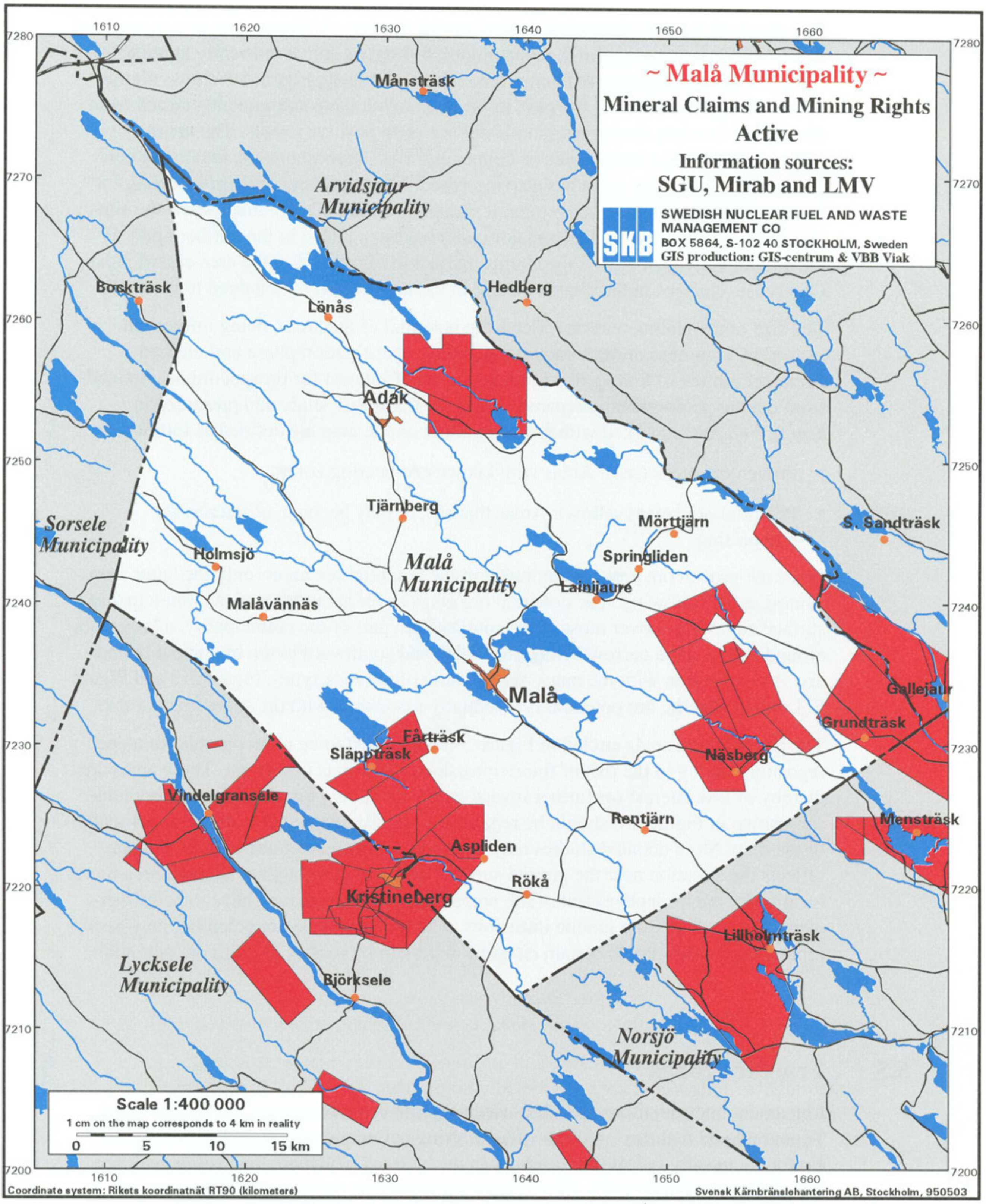


Figure 5-4. *Active claims, June 1994.*

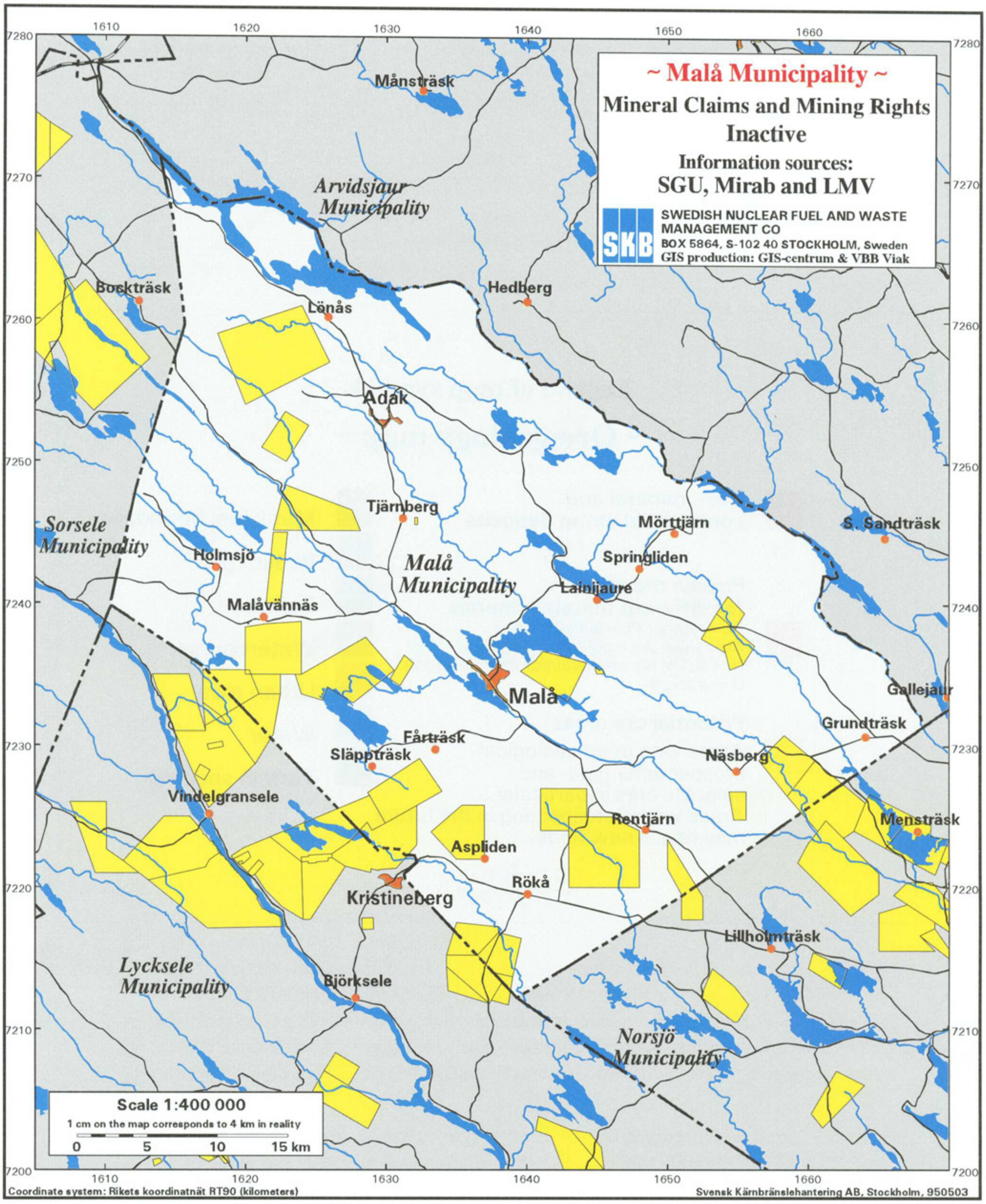


Figure 5-5. *Inactive claims. Compilation for period January 1980 to June 1994.*

Legend of map symbols

~ Ore geology map ~

Ore-, mineral and commercial stone deposits

Proven ore areas for different metals/minerals
Cu = copper Pb = lead Zn = zinc
Ag = silver Au = gold Pt = platinum
Ni = nickel Mi = mineral/commercial stone
U = uranium

Potential ore areas
Areas with good geological prospects for gold- and sulphide ores in particular.
Areas where prospecting in the future may reveal new finds.

Municipal boundary

Public road

Railway

Watercourse

Urban area

Water

Terrain shading

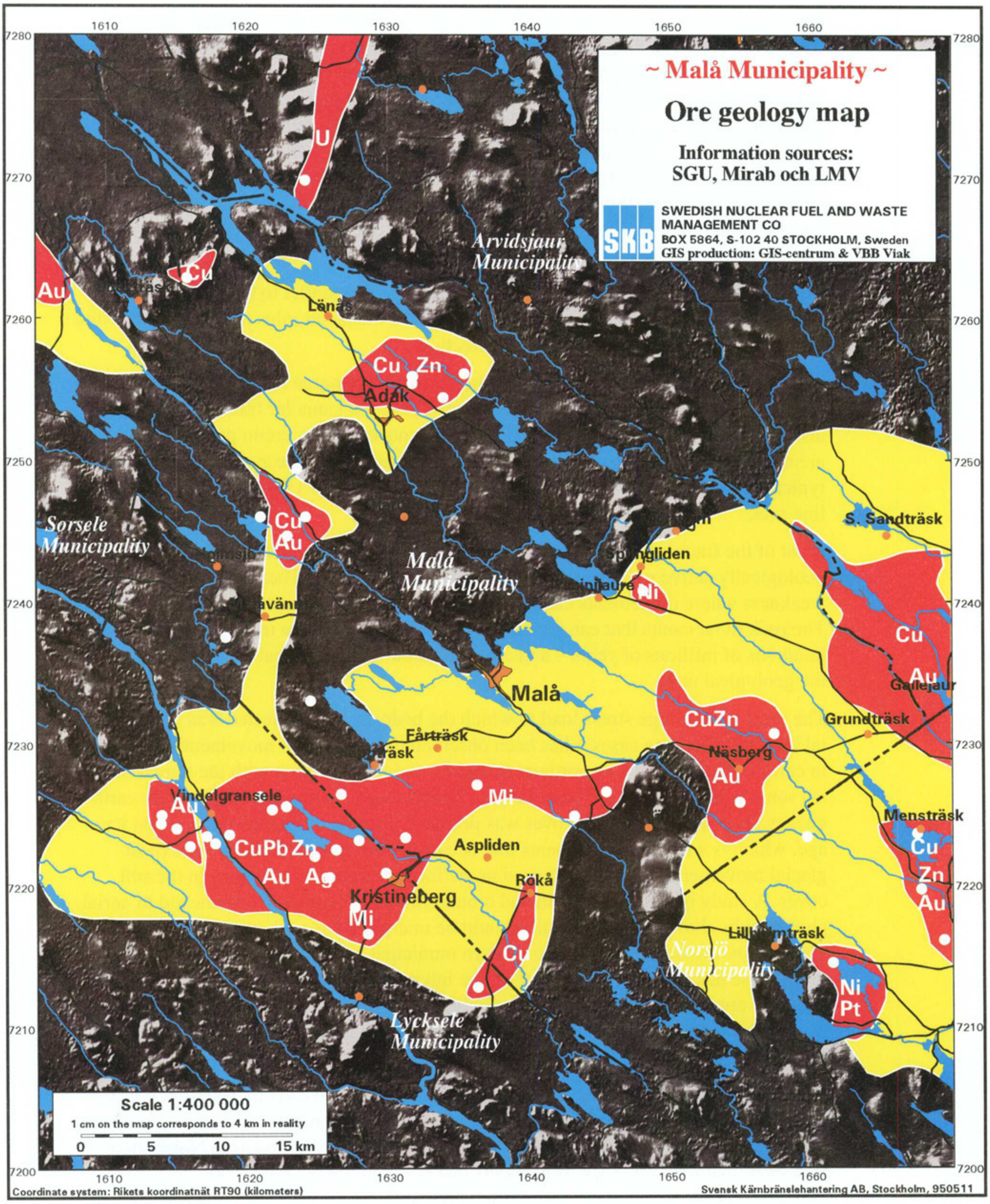


Figure 5-6. Ore geology map with proven ore areas and potential ore areas.

Figure 5-7 shows fracture zones which are interpreted from these different types of data /5-4/. The most distinct lineaments follow the valleys of the Skellefte, Vindel (outside the municipality) and Malå rivers. This pattern, comprising a system of interconnected fracture zones that form regional bands running in a NW-SE direction along the river valleys, is typical for large parts of Norrland. The bands can extend from the Caledonides all the way down to the east coast. Experience from hydropower plant construction shows that the rock in these fracture zones can be heavily deformed and altered, which affects the geotechnical properties of the rocks. An example is the considerable rock engineering problems which accompanied the construction of the Bastusel plant, see section 6.4.2.

The fracture zone map further indicates zones running parallel to the river valleys, oriented in the same direction but of a subordinate character, plus a number of fracture zones oriented primarily in a NE-SW direction.

The map shows the distribution of fracture zones that emerge from a lineament interpretation on a regional scale. Experience has shown that smaller fracture zones are also present. Data from geophysical measurements exist for certain parts of the granite areas in the municipality. These data show that smaller fracture zones occur spaced at typical distances of 1–2 km, which agrees well with overall values for Swedish crystalline rock.

Most of the fracture zones in the Swedish crystalline basement were formed during geologically active periods more than one billion years ago. They constitute planes of weakness where movements can occur if the bedrock is subjected to large stresses. The rock movements that can be traced in fracture zones are in most cases very old – hundreds of millions of years – and are associated with tectonically active periods in the geological past.

The most recent large stress load to which the bedrock was subjected was the continental ice sheet. In some cases it has been observed that large rock movements took place in certain fracture zones in northern Scandinavia in conjunction with the retreat of the ice some 9,000 years ago. These rock movements were accompanied by severe earthquakes. The present-day soil cover was primarily formed during the most recent ice age, which is why rock movements that occurred during or after the ice age (postglacial movements) may be indicated in the form of local perturbations in the soil cover. A study of terrain forms in and around Malå Municipality with the aid of aerial photographs shows some forms that could be interpreted as such perturbations /5-7/. The terrain forms are found at the western municipal boundary and just west of it, and in one case near Kristineberg. They can be interpreted as evidence of rock movements, but there are alternative explanations. Field investigations and excavation work on the sites in question are required in order to clarify the origin and possible importance of the terrain forms for the bedrock in the region.

Rock movements can damage a repository if the movement directly transects a canister and is sufficiently large. Roughly speaking, large movements are matched by fracture zones of large extent. Studies of, for example the Lansjärv Fault in Norrbotten, also show that the large rock movements that occurred there about 9,000 years ago took place along an existing, very old fracture zone. Such zones are relatively easy to detect in surveys and can be avoided when siting a deep repository.

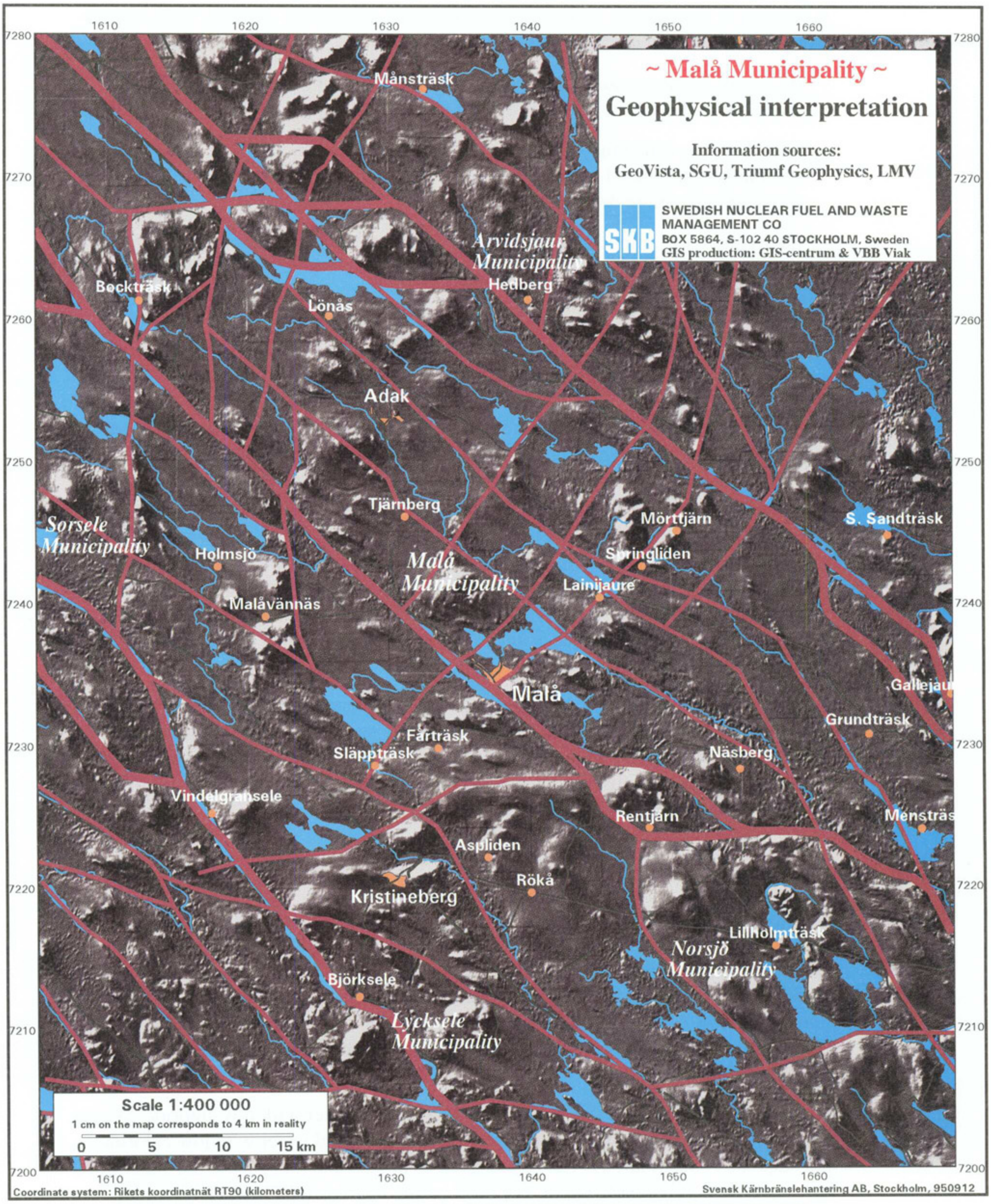


Figure 5-7. *Interpreted fracture zones.*

With respect to the factors and criteria for siting of a deep repository that are discussed in Chapter 4, the existing body of background data on fracture zones in Malå Municipality thus occasions the following conclusions:

– the regional fracture zones that run along the valleys of the Skellefte and Malå rivers make these areas unsuitable for a deep repository;

– terrain forms, which may be indications of recent (postglacial) rock movements, should be investigated more closely if the areas where they are observed are being considered for more detailed studies;

– the frequency of minor fracture zones is normal for Swedish crystalline basement rocks.

5.6 Homogeneity and interpretability

In general, the repository should not be sited in highly heterogeneous or difficult-to-interpret bedrock. A complex geological setting with many different rock types makes interpretation difficult. As a rule, the areas in Malå Municipality that are covered by supracrustal rock types, Figure 5-2, are characterized by a higher degree of geological complexity than the granite areas. The original stratified structure of the supracrustal rocks, which has subsequently been deformed and raised up to steeply dipping rock units, is often reflected in many rock type alternations within restricted areas. The term "supracrustal rocks" also includes many rock types with widely differing structures and mechanical properties, something which is clearly seen in the mines of the Skellefte Field.

Consequently, aside from the ore potential that is associated with the supracrustal rocks, their suitability for hosting a deep repository can also be questioned with reference to the concepts of homogeneity and interpretability. Plutonic rocks, especially the younger granite intrusions, are much more homogeneous as regards rock type distribution and less affected by deformation processes.

5.7 Groundwater

The chemical composition of the groundwater has been evaluated from previously performed water analyses from 48 drilled rock wells and 83 dug wells within the municipality /5-5/. The sampling points have a relatively good geographical spread within the municipality and are judged to provide a good picture of geohydrochemical conditions near the surface.

The samples from the dug wells consist mainly of soft water with low chloride concentrations. The drilled rock wells exhibit soft to medium-hard water with low chloride and sulphate concentrations. The concentrations of iron and manganese are generally low, regardless of borehole depth. For other studied parameters, such as alkalinity, electrical conductivity, calcium, magnesium, pH, sulphate, chloride and sodium, the data do not permit any conclusions regarding possible correlations between concentration and depth. The same applies to possible connections between rock type and groundwater composition.

A geohydrological compilation /5-6/ shows that Malå Municipality lies within the drainage basins of the Skellefte, Malå and Vindel rivers. On a more local scale, the municipality can be divided into some 40-odd drainage basins with a typical length of 3–15 km. A large portion of the groundwater circulates within systems of comparable geographic size. The water discharge in different main categories of rock types has been investigated with the aid of statistical analyses of capacity data from drilled wells /5-6/. Since data are available for only some 60-odd wells within the municipality, the analysis was extended to include wells in similar rock types all over Västerbotten County. The results show that any differences in hydraulic conductivity between different rock types are marginal in comparison with the variations that can be observed within each rock type. The results also illustrate the great importance which local conditions, especially the presence of water-bearing fracture zones, have for the flow of water in the bedrock.

To summarize, nothing has emerged during the feasibility study to indicate that the groundwater situation in Malå Municipality might be unsuitable or unfavourable for a deep repository. The results as far as both the chemical composition of the groundwater and groundwater flow are concerned do not deviate from what can be regarded as normal for Swedish crystalline basement. An important reservation is that the results pertain to conditions near the surface. The wells reach down to about 140 m at the most, but the majority are much shallower. Data from these depths can be used for rough assessments, but borehole measurements are required to determine the actual conditions at repository depth.

5.8 Studied areas

The above presentation has primarily concerned geoscientific factors that are of interest with respect to possible unsuitable or unfavourable conditions for a deep repository. Important conclusions are that the parts of the municipality that are covered by supracrustal rock types, plus the valleys of the Skellefte and Malå rivers, are not suitable for hosting a deep repository.

In accordance with the methodology for the feasibility study presented above, the main question in a second evaluation step is whether it is possible within the remaining areas to identify sub-areas where good prospects are deemed to exist for finding sites with conditions that are favourable for a deep repository.

It is evident from the geological and geophysical data that within those parts of the municipality that are covered by plutonic rocks, it is primarily areas with Revsund granites and other younger granites that may be of interest. The main reasons are the following:

- the large extent of these granites within the municipality,
- their lack of ore potential,
- the relatively good homogeneity with regard to rock type distribution and structural composition which experience has shown is typical of these granites.

In the status report /5-9/, three sub-areas were presented which were preliminarily deemed to be of interest for further studies. The evaluation of existing material pertaining to these areas has since been completed, and geological field studies have been done. These supplementary studies have improved the clarity of the background material. The revised evaluation of the sub-areas that follows is based on the total body of available material. It should once again be stressed that the basis for the evaluation is limited to existing material, which essentially describes the situation at the ground surface. Considerable uncertainties therefore remain with regard to conditions at depth.

The three sub-areas are named the Southern, Northern and Western sub-areas. Their location and extent in relation to the extent of the plutonic and supracrustal rocks are shown by the map in Figure 5-8. The sub-areas are all situated within granite intrusions of considerably greater extent than the areas in themselves, and in areas with, as far as can be determined, few major fracture zones.

Since the status report /5-9/ was presented, a change has been made as regards the estimated extent of the areas, Figure 5-8. It concerns the Northern sub-area, which has been given a tighter limit towards the south and west than before. The reason is that the supplementary studies showed that the parts that have now been excluded were intersected by a band of more heterogeneous bedrock. As a general rule, the limits of the sub-areas should be regarded as approximate, since the evaluations are based on rough data.

The sub-areas have been identified on the basis of geophysical as well as geological evaluations. The geophysical interpretation has mainly focused on identifying areas that can be judged to comprise coherent tectonic units /5-4/. Based on this principle, sub-areas are obtained which contain, and are much larger than, those shown in Figure 5-8. The geological interpretation /5-2/ and the field studies that have been made since then have taken into account other factors, among them location in relation to potential ore areas, the final result of which is the limits shown in the figure.

Southern sub-area

The Southern sub-area is about 40 km^2 in size and is situated in the centre of a major granite intrusion between Rentjärn and Rökå near the municipality's southeastern border, Figure 5-8. The granite borders on areas with supracrustal rocks in the east and west. Towards the north there is a smaller granite body, Figure 5-3. The western limit of the granite is not distinct, but consists of a diffuse transition zone towards supracrustal rocks.

The opportunities for judging the area's bedrock are limited by the fact that the degree of exposure is very low, both within the sub-area and in the granite area as a whole. Some of the few rock exposures which can be observed exhibit coarse porphyritic granite of the Revsund type. In a few cases there are rock types of a granitic composition, but these normally appear in dykes or indicate tectonically perturbed bedrock. Boulders which are probably of local origin also exhibit some variation as regards rock types. These observations indicate a more heterogeneous bedrock, at least within parts of the area, than has previously been known.

Geophysical data indicate a persistent conductor in a roughly north-south direction through the area, which can be interpreted as a substantial fracture zone, Figure 5-7. Measurements which can indicate the frequency of minor fracture zones cover only a small portion of the area, and indicate a low frequency there /5-4/.

It can be concluded from geophysical calculations made on the basis of existing measurements of the gravitational field that the granite is of very great depth, probably over 3 km /5-4/. The calculations are based on the fact that the granite has a slightly lower density than surrounding supracrustal rocks, which gives rise to local aberrations in the gravitational field. The calculations also show that the horizontal extent of the granite body is at least as great at depth as at the surface. This judgement is supported by geological observations.

The bedrock within the sub-area lacks ore potential or prospecting interest /5-3/. The location of the granite formation in the western part of the Skellefte Field means, however, that there is bedrock with ore potential in its surroundings. Less than 10 km to

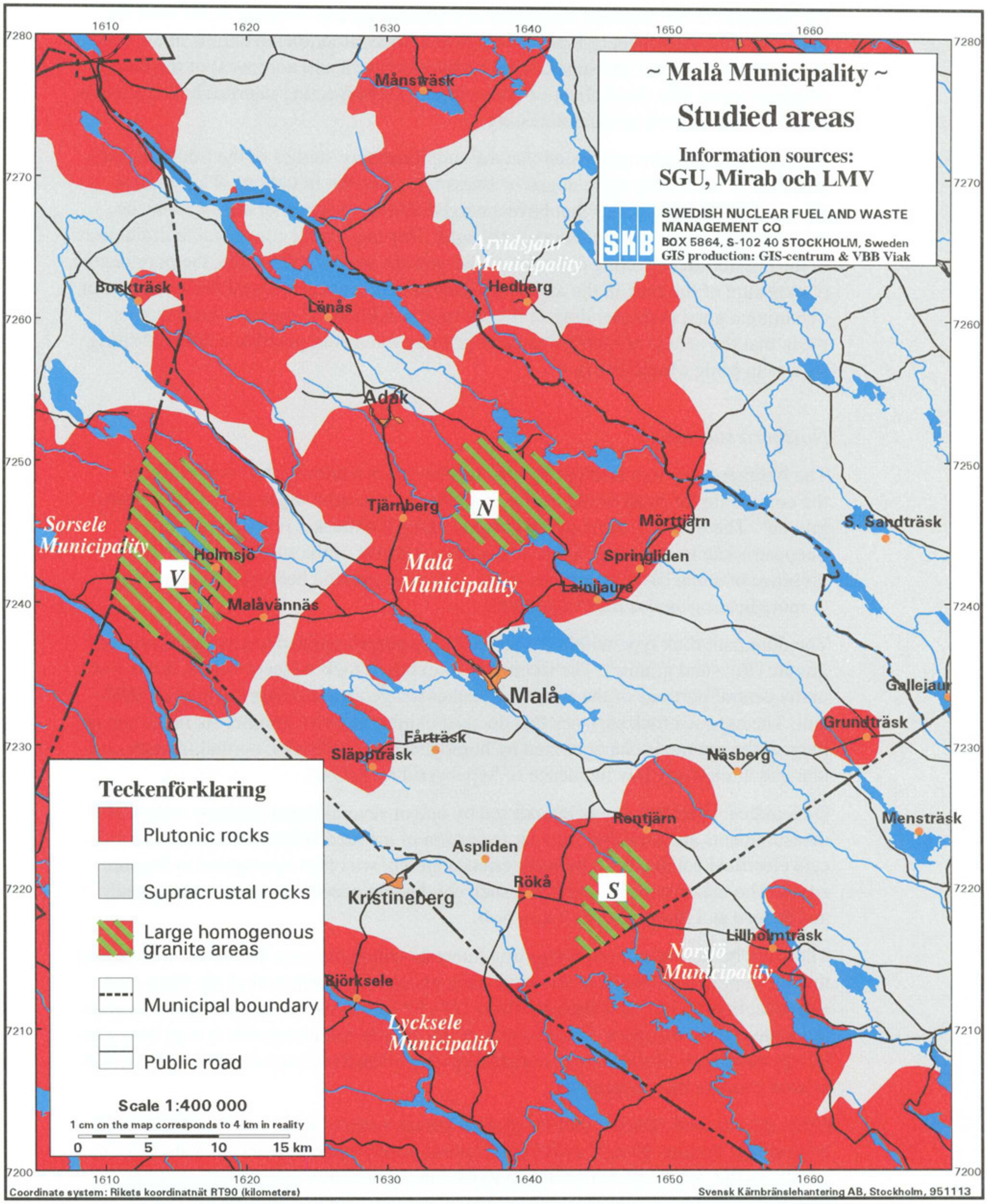


Figure 5-8. Studied sub-areas. The larger areas with plutonic rocks within which the sub-areas are located consist primarily of granites.

the northeast is the Näsliden Field, and at a slightly greater distance to the west are the ores of the Kristineberg Field. Furthermore, there are mineralizations in the border areas between granite and supracrustal rocks, southwest and northwest of the designated sub-area. The mineralizations have attracted prospecting interest, but have been found to be economically uninteresting.

In summary, it can be concluded that the supplementary studies of the Southern sub-area lead to a partially more negative assessment than the initial one. This applies above all to the indications that have emerged that the bedrock in the area may be more heterogeneous than previously thought. This may entail considerable limitations in the possibilities of siting a deep repository in the area. Furthermore, the poor degree of exposure of the rock in the area is a disadvantage, since it worsens the prospects of obtaining a good understanding of the bedrock conditions. Together, these factors mean that the area is not judged to be of primary interest in possible continued siting studies in Malå Municipality.

Northern sub-area

The Northern sub-area is about 55 km^2 in size and is situated 10–15 km north of the community of Malå in the centre of a large granite area, often called "the Adak granite". The limits of the area run roughly along Kokträsket in the north and Skeppsträskån in the south. There is a band southwest of the sub-area where the presence of some basic rock types in the otherwise granitic bedrock has given rise to more heterogeneous rock conditions.

The dominant rock type within the sub-area is a coarse-grained to coarse-porphyritic granite (Revsund granite). The frequency of exposed rock surfaces varies, but is low in the central portions of the area. This makes the geological assessment more difficult. The exposed rock surfaces that do exist exhibit massive granite. As far as can be judged, the granite is characterized by homogeneous conditions, normal fracture content and a relatively low incidence of hypabyssal rocks/5-2/.

Data indicate that the area is intersected by one or several major fracture zones. VLF measurements are available for a large portion of the area. These measurements indicate electrical conductors which experience has shown often correspond to fracture zones. The measurements show that such conductors occur with uniform frequency and spaced at a distance of 1–2 km /5-4/.

There are no known ore or prospecting interests within the area. However, it is known that the supracrustal rocks in the Adak area, about 5 km northwest of the limit of the sub-area, Figure 5-3, dip relatively flatly (25–30°) towards the east, in under the granite dome. This indicates a limited depth of the granite and means that it may be underlain by rock units of unknown ore potential /5-3/. Observations east of the granite formation confirm this judgement.

Other data as well indicate that the granite has the form of a flat bowl, probably with an irregular bottom. Rough model calculations based on gravimetry indicate that the granite in the central parts that are contained in the sub-area has a depth of about 1.3 km /5-4/. There is, however, considerable uncertainty in the calculations.

In summary, nothing has emerged to indicate unsuitable or unfavourable conditions within the Northern sub-area. Large geographic extent in combination with homogeneous conditions and few major fracture zones are factors that can allow great freedom and flexibility in siting. However, questions with regard to the depth of the granite and underlying rock units should be emphasized. The area is judged to be of primary interest for possible further studies, but with clear reservation for this uncertainty.

Western sub-area

The Western sub-area is about 100 km^2 in size and is situated in the western corner of the municipality, 20–25 km west of the community of Malå. Its limits on the west and south coincide with the municipal boundary. The eastern limit of the area is approximate and has been drawn in the district of Holmsjö.

The sub-area comprises a part of a large and well-defined granite dome, which also covers areas in the municipalities of Sorsele and Lycksele. The dominant rock type is coarse-grained to coarse-porphyritic granite (Revsund granite) /5-2/. Towards the north and east, the granite dome borders on supracrustal rocks. The contact with the supracrustal rocks is judged to dip relatively steeply, indicating that the granite reaches down to considerable depth. Model calculations based on gravimetry indicate a depth on the order of 1.8–2.0 km /5-4/.

Parts of the area are well exposed. This is particularly true of a large area in the north, and a smaller one in the far south. There are large, contiguous areas of exposed rock on a number of mountain ridges. The high frequency of exposed rock surfaces enables judgements to be made with greater reliability than would otherwise be the case.

Data from observations of exposed rock surfaces show very homogeneous granite with few fractures. The geophysical information reinforces the picture of homogeneous conditions and low occurrence of hypabyssal rocks. The aeromagnetic map exhibits several weak anomalies that can be interpreted as residual supracrustal rocks within the granite dome, but may also be caused by variations in the mineral composition of the granite /5-4/. The field studies that have been made suggest the latter. The fracture zones that have been interpreted within the granite dome mainly run in a NW-SE direction. The granite in the area has no known ore indications and is of no interest for prospecting. One area near the southeastern corner of the sub-area has been studied for possible commercial rock interest, but no known plans exist to continue these studies /5-3/.

In summary, there are no signs of unsuitable or unfavourable conditions within the Western sub-area. Existing data indicate homogeneous conditions. The area is big, about 100 km^2, which can, as noted, be of considerable advantage in detailed siting. The relatively high degree of rock exposure and homogeneity in the area provide good opportunities in a site investigation for making a good assessment of the bedrock with respect to properties of importance for long-term safety and rock construction. All in all, the Western sub-area is deemed to be an area of primary geoscientific interest for possible further siting studies in Malå Municipality.

The signs of possible postglacial rock movements observed in the vicinity of the area constitute a potential problem. If further investigations are undertaken, this question should be given particular attention.

6 TECHNICAL PREMISES

The technical design of the deep repository and the transportation system are described in this chapter. Furthermore, data and evaluations are presented regarding the rock construction premises and the transport options to Malå Municipality. Finally, the safety principles that are applied to shipments of radioactive waste are discussed.

6.1 Introduction

The principles for construction, operation and closure of the deep repository have been set forth in KBS 3 /6-1/ and RD&D-Programme 92 /6-2/. SKB conducts continuous planning work aimed at progressive detailing and concretization of the technical design of the facilities, calculating labour and material requirements, costs, etc. An account of the current situation and programme is provided in RD&D-Programme 95 /6-3/. Annual status reports are also issued /6-4/. A more detailed technical description of system solutions that have been developed and examples of how details in the facilities can be designed is provided in /6-5/.

The planning work proceeds in defined steps, where each step corresponds to a higher degree of detail. It is largely a question of using components of existing technology, and integrating these components into a system. This includes, for example, construction and operation of the rock facilities, where well-established technology and experience is available. Greater development efforts are required in other areas. An example is equipment for transport and deposition of canisters underground, where substantial development work remains to be done.

The planning work must be closely coordinated with performance and safety assessments, as well as with the research activities. The Äspö HRL fills an important function as a testing ground for technical solutions. On-going research, such as that associated with the Äspö HRL, should also provide further material in support of the detailed design of the repository.

The planning work must also proceed hand in hand with the siting and investigation activities. So far the work has been of a general nature, i.e. not tied to any specific site. Later, when site investigations have been commenced on some potentially suitable sites in Sweden, more detailed plans will be drawn up, where the facilities are adapted to conditions on the investigated sites. This includes both the surface facilities and, to an even greater extent, the actual repository underground.

The spent fuel is being kept in temporary storage in CLAB at Simpevarp near Oskarshamn. Encapsulation is also planned to take place at CLAB in a special plant. Methods are currently being developed for fabrication and sealing (welding) of canisters. SKB plans to build a pilot plant in Oskarshamn within the next few years for testing of sealing and handling methods on an industrial scale. In a later phase, serial fabrication of "empty" canisters will also be necessary for subsequent filling and sealing at the encapsulation plant. The place and other arrangements for this fabrication have not yet been determined.

From CLAB, the encapsulated waste, along with other long-lived radioactive material, will be transported to the deep repository. The planned transportation system bears great similarities to the system that is in use today for transportation of spent fuel from the nuclear power plants to interim storage in CLAB, and for low- and intermediate-level waste to the final repository SFR in Forsmark, /6-4, 6-6/.

Transportation must also be arranged to the deep repository of bentonite clay, which will be used to backfill around canisters. Sand may also be used for backfilling of tunnels, which in that case entails further transport needs.

6.2 Compiled data from the feasibility study

Construction and operation

The bedrock where the deep repository's underground facilities are built must possess such properties that the work can be carried out with adequate safety and utilizing established technology. This means, among other things, that stable shafts and tunnels etc. must be able to be constructed and that this excavation work must be able to be carried out with adequate control of stability and water inflow. Important factors include rock type, strength properties and structural composition of the rock material, locations and character of fracture zones, loads (rock stresses) and the water-bearing properties of the rock.

Building conditions on a site can be determined with greater accuracy when investigation data from repository depth become available. The background material for assessing the conditions for rock construction that are available at the feasibility study phase consist partly of general experience from rock construction in rock types comparable to those that occur within the municipality, and partly of data from existing rock facilities within the municipality. The rock facilities can serve as random checks in support of estimates of hydraulic conductivity and rock quality for different rock types.

The feasibility study has compiled and evaluated data from mines in the municipality and its vicinity, a few existing boreholes in granite areas, and from the hydropower plant in Bastusel /6-7/. The material for the compilations has mainly been obtained from Boliden Mineral AB, Vattenfall AB and from the bedrock geology sub-study /6-8/.

Transportation

A siting of the deep repository in Malå Municipality would necessitate transporting waste and backfill material by sea to a harbour in the Bay of Bothnia (the northern part of the Gulf of Bothnia) and further transport overland by road or rail to the deep repository. In the sub-study within the feasibility study that deals with transportation /6-9/, possible harbours for the types of goods in question have been studied with respect to suitability, existing resources and need for expansion. Possible transport routes for overland shipments from the harbour to the municipality have been studied with road and rail transport as alternatives. The purpose has been to identify, describe and evaluate some possible harbours and transport routes, but not to designate all or decide which alternative is the most favourable. From the alternatives examined, calculation examples have been taken for assessments of expansion requirements and cost estimates.

Besides specifically dealing with the transport options to Malå Municipality, the study provides an overview of the general structure of the transportation system, plus safety precautions and regulations for shipments of radioactive material.

6.3 Deep repository

6.3.1 Construction and operation

In the division of the deep repository programme into stages, Figure 1-2, the first stage involves construction of the surface facilities, common facilities underground and the first areas with underground deposition tunnels. At the same time, equipment for deposition and peripheral activities will be completed. The ensuing initial trial operation is intended to include 400 of the total of 4,500 canisters of spent nuclear fuel. The results will then be evaluated by SKB and the regulatory authorities. This initial stage can be completed in about 20 years at the earliest. The evaluation provides opportunities to take advantage of experience gained and to take into account other advances and technology development that have been made during this twenty-year period. If desired, the already deposited waste can also be retrieved for other treatment.

If the outcome of the evaluation is good, operation will continue until all waste has been deposited, which is planned to occur around the year 2040. New deposition areas will be excavated as they are needed. The total quantity of spent fuel which will then have been deposited is estimated to be about 8,000 tonnes, which is the quantity produced by the Swedish nuclear power programme up to the year 2010.

During regular operation, other waste will also be deposited in a special part of the deep repository. This waste resembles that which is deposited today in the Final Repository for Radioactive Operational Waste, SFR, in Forsmark, but some of it is more long-lived. The total quantity of other waste is estimated at 25,000 m^3.

6.3.2 Activities

The central activities at the deep repository are receiving canisters with spent nuclear fuel and depositing (emplacing) them in selected positions approximately 500 m down in the rock. These activities involves the following main sub-activities:

- preparations in the form of geoscientific investigations, shaft sinking, tunnelling, excavation of rock caverns, drilling of deposition holes, etc.;
- transport down underground and emplacement of canisters and surrounding bentonite buffer in deposition holes;
- transport down underground and emplacement of other radioactive waste in rock caverns;
- post-emplacement tasks such as of instrumentation, backfilling of deposition tunnels and rock caverns, inspection, etc.

The personnel requirement and the organization required for these activities plus additional staff and service functions are given in Chapter 8.

6.3.3 Schematic design

Underground portion

Figure 6-1 shows a schematic drawing depicting the possible design of the deep repository and its main components. The underground facilities are situated at a depth of about 500 metres and consist of:

- a central area with transloading hall for transport casks/containers, workshops, personnel quarters, etc.;
- connection tunnels for transportation and other communication,
- deposition areas for canisters and a special, smaller area for deposition of other waste.

The deposition areas consist of tunnel galleries with parallel tunnels. The waste is emplaced in holes drilled in the floors of the tunnels. The holes are about 7.5 m deep and have a diameter of about 1.6 m. The canister is planned to have a length of about 5 m, a diameter of about 0.9 m and weigh about 15 tonnes. The canister is surrounded by bentonite, which fills out the space against the sides of the bored hole. The bentonite comprises a buffer which acts as a mechanical protection for the canister and counteracts water movements in the repository. The deposition tunnels will be backfilled, and different alternatives are being considered with regard to the backfill material. One alternative is quartz sand mixed with bentonite. Another may be crushed rock, which could permit the use of much of the rock waste material that is excavated during construction.

Surface portion

Externally, the surface facilities do not differ noticeably from a medium-sized industrial plant of conventional type. Figure 6-2 shows an example of the schematic layout of the facilities, where it has been assumed that the facilities are built on a flat industrial site. There are ample opportunities to adapt the facility layout to the local topography and other conditions on the actual site. The space requirement for the surface facilities is estimated at about 0.3 km^2.

The surface portion consists in principle of four main zones:

- rail yard, or terminal zone for long-haul vehicles
- production zone
- service zone
- rock waste dump zone.

If the backfill material and transport casks/containers with radioactive waste are transported by rail, the trains will be received in a rail yard where there are special facilities for off-loading of transport casks/containers, bentonite and possibly sand. Owing to its length and the necessity of its being flat, the rail yard will determine the location of the surface facilities. In the case of road transport, similar equipment is required for cargo handling, but the space requirement is smaller and flexibility is greater with regard to location.

The production zone contains a transloading building for transport casks/containers with waste, storage and production buildings for backfill material and buildings for ventilation, water supply and sewage. The access shaft or ramp to the repository is located within this zone.

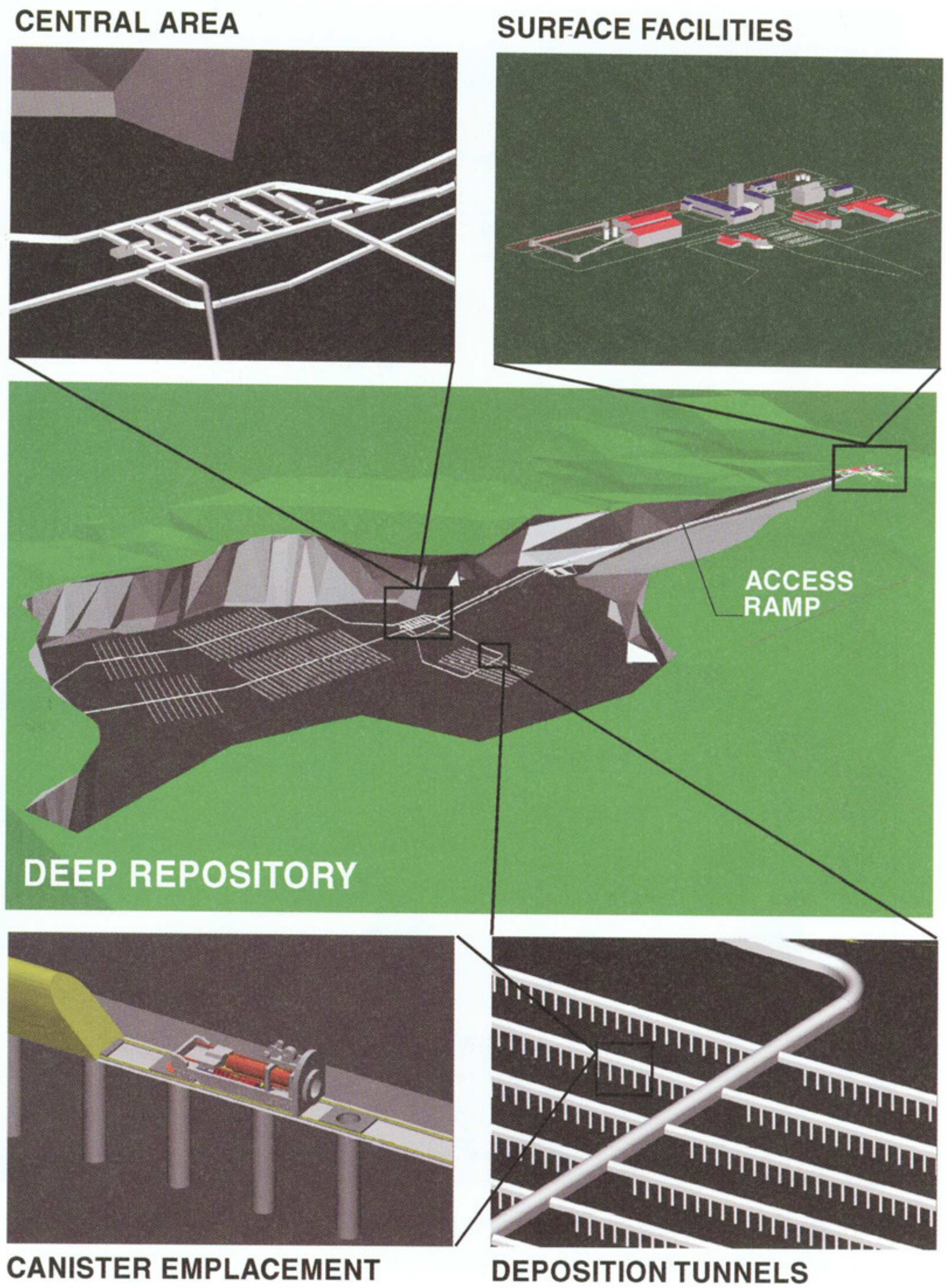


Figure 6-1. *A schematic diagram of the deep repository and its main components.*

Figure 6-2. *A possible layout of the deep repository's surface facilities. The example assumes flat ground and a railway connection to the facility.*

1 Operations building – transport casks/containers

2 Operations building and stores – backfill material

3 Personnel quarters, stores

4 Offices

5 Entrance, information, restaurant

6 Ventilation building

The service zone contains premises for large numbers of people, such as entrance and information building, offices, workshops for service and maintenance, canteen and personnel quarters. The zone faces the access road and comprises a transition zone between the industrial area and the surrounding landscape.

Whatever rock waste cannot be utilized for backfilling of the deep repository or elsewhere will be dumped near the facility. The rock waste can be covered with soil and the dump site can be subsequently replanted. The form of the rock waste dump as well as the site remediation measures will be determined by local conditions.

Connection between surface and underground facilities

Transportation and provision of utilities (ventilation, water, sewage, electricity, etc.) between the surface portion and the repository level can be designed in accordance with three different alternatives:

1. All transportation takes place via a long, sloping ramp. Shafts are used solely for ventilation. This permits a lateral offset of up to several kilometres between the surface and underground portions.
2. All transportation of heavy and bulky goods takes place via a spiral ramp. Besides a ventilation shaft, a shaft will also be built for personnel transport.
3. All transportation and ventilation between the surface and the repository level takes place via shafts.

In all alternatives, the repository is positioned optimally in relation to the geological conditions on the site. But there may be good reasons to offset the surface facilities laterally in relation to the repository. Such an offset may, for example, be warranted by such considerations as nature conservation, reindeer herding, municipal land-use plans, topography or possibilities of linking up with existing infrastructure.

6.4 Civil engineering conditions in Malå Municipality

6.4.1 Construction and operation of surface facilities

From a construction point of view, Malå Municipality does not exhibit any special conditions that could generally render the municipality unsuitable for the erection or operation of the surface portions of the deep repository. The different types of glacial till that dominate the soil cover /5-7/ normally provide ground with good bearing capacity. However, bearing capacity problems can be expected in low-lying areas and on boggy ground. Of greater importance for the options for siting the deep repository in the municipality are possible conflicts regarding land use and environmental considerations. These aspects are dealt with in Chapter 7.

6.4.2 Construction and operation of underground facilities

The geological study material shows that the bedrock in the municipality can be divided into two types of rock: supracrustal and plutonic, each of which covers approximately half of the municipality, Figure 5-2. Supracrustal rocks have been found by experience to exhibit a wide range of properties of importance for rock construction. The different rock types occur in more or less distinct stratum sequences, which can lead to large variations in rock properties within limited volumes. It is nevertheless possible to find sites within the supracrustal rocks with good and above all of low hydraulic conductivity – something which experience from the mines in the region offers good examples of. The structural heterogeneity which characterizes the supracrustal rocks could nevertheless entail considerable limitations in siting a deep repository as far as the rock construction aspects are concerned.

Those parts of Malå Municipality which are judged to have the best safety-related potential for a deep repository (Figure 5-8) lie within areas with granites, mainly coarse-grained Revsund granites. Experience from rock construction in this type of granite shows generally good conditions, with good rock quality and often low fracture frequency.

In some cases, rock stresses (loads) have been noted in granite formations which are elevated in relation to the normal range of variation in crystalline basement rock. In fracture-poor rock, elevated rock stresses affect stability around tunnels and shafts, which can in turn adversely affect construction. Measurements in boreholes are necessary to determine the rock stresses in situ. Therefore, the question of whether abnormal rock stresses occur within the granite areas in Malå cannot be answered within the feasibility study.

Occupational safety problems in the form of high radon concentrations have been encountered in rock facilities in granites. The radon concentrations depend on the natural uranium content of the bedrock, and the problems are associated with those parts of the country where elevated uranium concentrations occur. This is the case in, for example, alum shales and certain granites. The granites in the Malå area do not exhibit any elevated concentrations, however, so no special risks of radon problems in conjunction with construction and operation of a repository are judged to exist.

The Bastusel plant

The Bastusel plant on the Skellefte River was built in the late 1960s and commissioned a few years later. The construction works included blasting of approximately 1.8 million m^3 of rock (a figure which can be compared with the 1–1.5 million m^3 of rock expected to be extracted from a deep repository).

The main features of the plant are a short headrace, a powerhouse situated near the dam at Bastusel, and an approximately 13 km long tailrace tunnel which runs more or less parallel to the river. The depth of the plant varies down to about 75 m below the surface. The bedrock along the tunnels is dominated by different types of granites, but basic rock types also occur.

The tunnelling of the tailrace in Bastusel was associated with considerable rock engineering problems due to fractured and weathered rock. Extensive rock reinforcement measures and special excavation methods had to be resorted to over long stretches in order to ensure stability. Modification of both the tunnel cross-section and the tunnel route was required in certain sections. The most distinguishing characteristic seems to have been that the problems persisted over unusually long distances /6-7/.

The poor rock quality along large portions of the tunnel route is believed to be a consequence of the fact that the tunnel is situated in the large regional fracture zone which follows the valley of the Skellefte River, Figure 5-7. Extensive rock movements have occurred during geological history within this zone, resulting in disturbed rock conditions with irregular and locally heavy fracturing. Near the surface, extensive weathering contributes to greatly deteriorated rock quality.

The weathering phenomenon is surface-related and rarely reaches deeper than a few centimetres in undisturbed granite. In the zones of movement, however, weathered rock occurs down to a depth of several tens of metres, which in the case of Bastusel has affected conditions at tunnel depth. In rock outcroppings near the route of the tunnel, disturbances can be observed in the form of both abnormal fracturing and highly weathered granite. In the extensive granite areas on both sides of the Skellefte River, however, available data and observations on the surface and in existing boreholes indicate normal conditions and undisturbed bedrock /6-8/.

Those parts of the Bastusel plant that are accessible today, mainly the powerhouse, exhibit good rock conditions. The need for maintenance of the rock caverns since the plant was commissioned appears to have been slight /6-7/.

In summary, it can be concluded that the Bastusel plant provides an approximately 20 km long cross-section through mainly granitic rocks, but also that its location near the surface in a regional fracture zone entails that the cross-section cannot be regarded as being representative of granite areas in Malå Municipality.

The mines

The mines within the municipality that are of interest are the mines in the Adak Field (Adak, Lindsköld, Karlsson, Brännmyran, Rudtjebäcken), Näsliden and Lainejaur. None of these mines are still in operation. Information on construction-related conditions has been obtained from the Adak Field and the Näsliden mine, as well as from the Kristineberg Field (the Kristineberg Mine and the Rävliden mines) situated just outside the municipal boundary /6-7/. The Lainejaur Mine was only mined for a few years during the 1940s, and the data available on it are meagre.

The Adak Field

The mines of the Adak Field are connected to the Adak Dome, an ore-bearing structure consisting of vulcanites and sediments (both supracrustal rocks). Mining took place from the mid-1940s until 1977, reaching a maximum depth of over 350 m. The mines of the Adak Field were characterized by good rock conditions, which permitted large open working chambers. Rock quality was locally significantly reduced in conjunction with faults (fracture zones) which occur within the mine field. Water inflows seem in general to have been slight, with local exceptions. No rock stress measurements have been made, but experience from mining indicates moderate loads.

The Näsliden Mine

The Näsliden mine, situated just south of the village of Näsberg, was in operation during the period 1969–1988. Mining reached a depth of nearly 600 metres. The deposit is situated in the transition between volcanic and sedimentary rocks (both supracrustal rocks). Rock conditions can be described as medium-good to good, but the differences in rock quality and mining conditions between the different rock units encountered in the mine were considerable. Rock stress measurements indicate values that can be regarded as normal for Swedish crystalline basement rock /6-7/.

The Kristineberg Field

The Kristineberg Mine has been in production since 1941. At present, mining is conducted to a depth of 1,020 metres. The geology in the Kristineberg area is dominated by different volcanic rocks (supracrustal rocks). The quality of the rock types occuring varies within very wide limits. Certain types have low strength and poor rock construction properties. As a consequence, mining conditions are unusually difficult by Swedish standards and extensive rock reinforcement is needed. Other rock types exhibit good construction properties. The inflow of water to the mine is moderate, and declines with depth. Water inflow in excavations below a depth of 500 metres is judged to be slight. Rock stress measurements have been made down to a depth of about 800 metres. The results indicate comparatively high values, which nevertheless fall within the normal range of variation for Swedish bedrock. Conditions in the mines in the Rävliden Field, situated adjacent to the Kristineberg Mine, are similar to those in the Kristineberg Mine.

The mines as random samples

The studied mines all lie in areas with supracrustal rocks. They also represent areas with inhomogeneous and disturbed geological conditions. This is a consequence of the fact that the ores that have been the object of the mining interest were formed in contact zones between different geological units. Typical conditions include sequences of stratified supracrustal rocks with radically differing rock-engineering characteristics. From a rock construction point of view, these conditions cannot be regarded as directly comparable to those which experience has shown characterizes granites of the type that may be of interest.

Thus, geographic proximity alone doesn't mean that data from the mines are directly useful as a basis for judging the rock construction-related conditions in areas of interest. An exception may be the rock stresses, which are affected less by local conditions than the rock properties. The rock stress measurements that have been made in the mines, and which amply cover the depths being considered for a deep repository, may thus more or less reflect regional conditions. This would mean that normal Swedish bedrock conditions can be expected in the bedrock within the municipality. However, no definite conclusions regarding the stress conditions on specific sites can be drawn, since local conditions have a great influence.

It should be emphasized that the limited applicability of data from the mines in the area has to do with rock conditions. From a general viewpoint, it is clear that mining industry has contributed much of the existing knowledge in the field of rock engineering, which is a prerequisite for constructing a deep repository, regardless of the site selected. Good examples of important contributions in recent years are the development efforts on rock stability and reinforcement that has been pursued with the mines in Näsliden and Kristineberg as a base /6-7/. Another consequence of mining in the Skellefte Field, important from the siting viewpoint, is the tradition and expertise within the field of rock engineering which has been amassed within the region.

Assessment

The assessment which can be made at the present stage regarding the conditions for construction and operation of the underground facilities of the repository can be summarized in the following points:

- Experience has shown that granites of the type that are of interest in Malå offer good conditions for rock construction. Special attention must, however, be given to the possibility of elevated rock stresses at repository depth in the fracture-poor varieties.

- Extensive rock engineering experience is available from the Bastusel plant on the Skellefte River and from the mines in the region. However, the location of these facilities – the first in a regional fracture zone, the second in ore-bearing supracrustal rocks – means that documented rock conditions are not directly comparable to those that can be expected in the granite areas that may be of interest for a deep repository.
- There is nothing to indicate that the rock engineering conditions in the areas judged to be of interest in Chapter 5 as far as geoscientific conditions are concerned deviate from what is normal in Swedish crystalline basement rock.

6.5 Transportation system

6.5.1 Goods types and quantities

The transportation system to the deep repository will handle two main types of goods during the operating period, namely heavy units containing encapsulated fuel and other long-lived waste, and bulk goods in the form of bentonite clay and possibly sand.

The heavy units are specially designed transport casks for encapsulated fuel and similar containers for moulds containing other waste. The transport casks/containers will be shipped back empty from the deep repository for refilling and will thus circulate in the transportation system. Table 6-1 shows approximate quantities, total and annually, provided that all reactors are operated until 2010. Only canisters with spent nuclear fuel will be deposited during the initial operating period. During regular operation, other long-lived waste will also be deposited.

Table 6-1. Estimated number of shipments of casks/containers with encapsulated spent nuclear fuel and other long-lived waste to the deep repository.

Waste product	Total quantity	Per year
Spent fuel		
– copper canisters (initial operation)	400	100
– copper canisters (regular operation)	4,000	210
Other long-lived waste (regular operation)	2,000	100

The bulk materials consist of a maximum of 45,000 tonnes of quartz sand and 15,000 tonnes of bentonite clay per year. The bentonite will be shipped dry in granular form and be used after compacting at the deep repository as buffer material around the canisters. The transport requirement of sand may be reduced or eliminated if it can be replaced with crushed rock.

Besides transportation of casks/containers and backfill materials, which is specific to the nature of the operation, local and regional transportation of the kind that is customary for industrial enterprises will also be necessary. This includes transportation of building materials, personnel and visitors, goods and services.

6.5.2 Transportation of radioactive materials

The safety requirements that apply to the transportation of radioactive material are codified in a number of laws and regulations, which are in turn based on generally accepted safety principles. These regulations and their application are discussed in section 6.7. The technical design of the system that is planned for the shipments to the deep repository is described below.

Encapsulated spent nuclear fuel

Figure 6-3 illustrates the different steps in the transport chain for the radioactive materials that are to be deposited in the deep repository.

Spent nuclear fuel is a solid ceramic material that is enclosed in metal tubes ("cans") of a zirconium alloy. The fuel-can elements are called fuel rods. A batch of fuel rods held together in a bundle is called a fuel assembly. In the encapsulation plant that is planned to be built in connection with CLAB, the fuel assemblies will be encapsulated in highly durable canisters. Figure 6-4 shows a cutaway view of what a canister may look like. The outer part of the canister wall consists of 5 cm of copper and the inner part of 5 cm of steel. A filled canister of the type shown in the figure weighs about 15 tonnes, is about 5 m long and has a diameter of about 0.9 cm.

The canisters are hermetically sealed and the risk that radioactive substances will leak out during handling or transport is virtually non-existent. However, some radiation does penetrate the canister walls, which is why the fuel canisters must be transported in radiation-shielded casks.

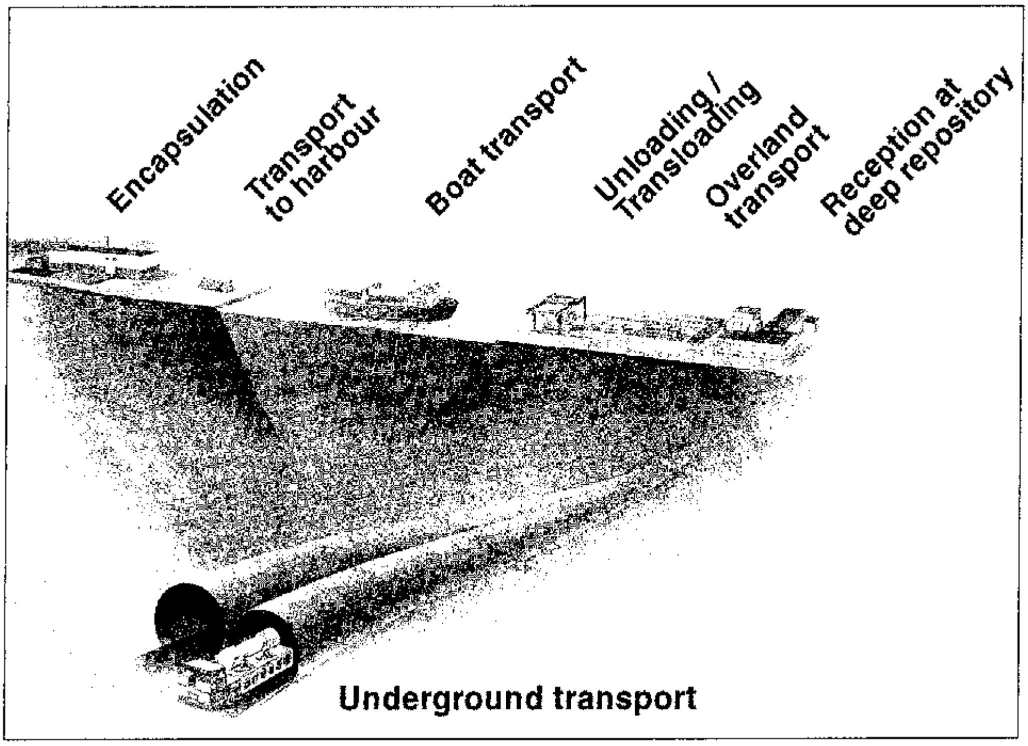


Figure 6-3. *The transport chain from the encapsulation plant to the deep repository.*

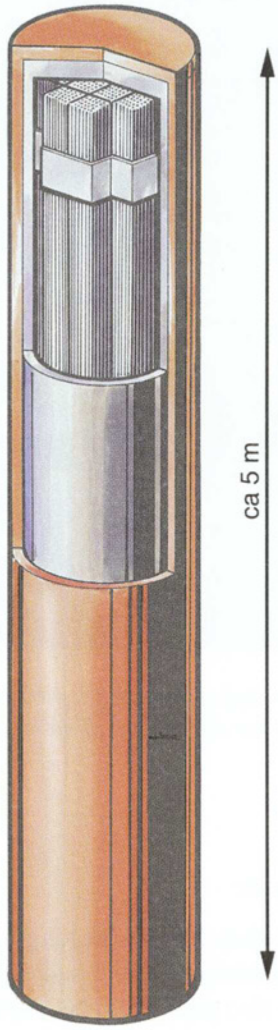


Figure 6-4. *Cutaway of copper canister with inner steel container.*

The transport casks that are used today for shipments between the nuclear power plants and CLAB (Figure 6-5) are designed for spent fuel that has been stored for a number of months after discharge from the reactor. The shipments to the deep repository will consist of 30–40-year-old fuel whose radioactivity is about 10% of what it was when it arrived at CLAB. Moreover, it will be enclosed in a canister of the type described above during transport to the deep repository. All in all, this means a lower radiation level and lower heat generation compared to today's shipments, permitting the design of the casks to be modified accordingly. It is estimated that a transport cask with canister will weigh about 55 tonnes, of which the canister will account for about 15 tonnes.

The main purpose of the transport casks is to shield off the radiation to such a low level that they can be handled without any special protection. The sturdy construction of the casks enables them to withstand severe mechanical stresses. This means that the rest of the transportation system does not have to be designed to provide mechanical protection for the goods. Nevertheless, the goods are classified as dangerous goods in accordance with international regulations and must be marked, segregated and monitored in accordance with the regulations that apply to radioactive goods.

Figure 6-5. *Transport cask during transport on terminal vehicle. The cask is of the type that is used today for shipments of spent nuclear fuel from the nuclear power plants to CLAB.*

Other radioactive waste

Core components and other waste with long-lived radioactivity resulting from the operation and decommissioning of the nuclear power plants, CLAB, the encapsulation plant and Studsvik are also planned to be emplaced in the deep repository. Most of this waste will be embedded in concrete moulds. This waste type also requires some radiation shielding and is therefore transported in steel containers, of which the type used today weighs 65 tonnes, including waste. The total quantity of other waste to be disposed of in the deep repository is estimated to be about 25,000 m^3.

Sea transport

The system planned for handling of the transport casks/containers at the encapsulation plant and sea transport from there to the deep repository's harbour does not differ essentially from the one used today for transportation of radioactive material from the nuclear power plants. The present-day system has been in use since 1983. Since 1985, 80–100 casks with spent fuel have been shipped annually to CLAB, and since 1988 roughly equally many transport containers for radioactive operational waste have been shipped from the nuclear power plants to the Final Repository for Radioactive Operational Waste, SFR, in Forsmark. Experience from these shipments is good. No disturbances or accidents of safety-related importance have occurred /6-10/. The ship used is M/S Sigyn, Figure 6-6, which is specially designed for the purpose. The design of the ship with double hull, double bottom and a large number of watertight sections makes her very seaworthy. Safety is still based on the transport cask/container, however, which is supposed to work and be able to be salvaged even after an accident at sea.

Figure 6-6. M/S Sigyn.

Prior to sea transport to the deep repository's harbour, the transport casks/containers are placed on carrier frames at the encapsulation plant and transported by terminal vehicle aboard the ship. The carrier frames remain with the casks/containers on board and are lashed in special positions on the ship. M/S Sigyn can be used for sea transport to the deep repository, but it is likely that the Sigyn will be replaced by another ship of similar design due to age. The annual quantity of 310 transport casks/containers means 31 round trips, provided the ship (like M/S Sigyn) has 10 positions for casks/containers.

Handling in local harbour

The harbour is either a designated terminal in an existing harbour or a local harbour built for the shipments to the deep repository. It is equipped with driving ramps, railway tracks, lifting equipment for casks/containers, handling and storage equipment for the bulk cargoes, parking places for vehicles and carrier frames and the necessary inspection and safety arrangements.

When the ship has docked, the casks and containers are driven ashore on their carrier frames and parked alongside railway tracks or vehicle places. The casks/containers are lifted by special lifting tackle and secured on the railway car or road vehicle. Empty casks/containers are loaded aboard and secured for the return trip.

Further transport to the deep repository

The transport of the casks/containers from the harbour to the deep repository can take place by rail or by road. Suitable trailers and tractor vehicles are available for road transport, as are railway cars for the rail alternative.

From the safety point of view, the choice of rail or road cannot be assessed at the present stage of investigation. An important reason for this is that the safety of the system in both cases is based on the transport cask/container, which is designed to withstand very high loads without losing any of its radiation-shielding capability. The safety of the system is therefore insensitive to the choice of transport mode.

Few overland shipments of spent nuclear fuel and other high-level materials have been made in Sweden. Such shipments are common in other countries, however, such as the UK, France, Germany and the USA. Approximately 180,000 container-kilometres of such shipments have been carried out by road and rail in the UK. In the USA, such shipments take place exclusively by land and have amounted to approximately 300 casks/containers per year for the past 20 years or so. No accidents of safety-related significance have occurred /6-10/.

A fundamental technical difference between road and rail transport is that railways are built for higher axle loads and that the load can be distributed over a larger ground area. This can be of importance for the choice of transport mode, since the transport casks/containers are heavy. The existing railway network is normally capable of handling the weights in question without special measures, while road transport may require improvements in the bearing capacity of roads and bridges, even along major roads.

6.5.3 Transportation of backfill materials

Bentonite clay is exported from many countries, including the USA and the Mediterranean region. At sea, bentonite can be transported in bulk form in special containers or in other types of packages. The same applies to transportation by road and rail. The amount of bentonite needed is about 18 freight containers per week for an average of 40 weeks per year. The material is sensitive to moisture and must be kept dry and protected against contamination during transport and storage. Handling and storage in the harbour and at the deep repository can be done with conventional equipment.

If quartz sand is used as a backfill material in tunnels, a suitable grade can be obtained from the southern Baltic region, among other places. Ordinary bulk freighters or systems for barge transport can be used to ship the sand to the local harbour. The total annual amount needed is about 45,000 tonnes, which, shipped in consignments of 4,500 tonnes each, amounts to about 10 shiploads per year. Conventional equipment and vehicles can be used for handling in the harbour and overland transport.

6.6 Prospects for transportation to Malå Municipality

6.6.1 Existing transport guideways

Figure 6-7 shows the location of Malå Municipality on a map of Sweden which includes railways and major roads. A siting of the deep repository in the municipality would require that all goods be transported by ship to a suitable harbour along the northern Baltic coast. The transport distance at sea from the encapsulation plant at CLAB is 750–950 km, depending on the choice of harbour.

The distance from the coast to the municipality is 150–200 km. For such long distances, rail is normally a competitive alternative for heavy shipments, especially if they occur regularly over a long period of time. Malå has no rail link, however. Existing railways run on all sides of the municipality, but at a considerable distance. Railway transport would therefore require construction of a railway link from the existing network to the site of the deep repository.

***Figure 6-7.** Malå Municipality in relation to the railway network and main road network in northern Sweden.*

For this and other reasons, the prospects for road transport should also be studied. The road network in the region is relatively well-developed, and a number of roads of good standard lead from the coastal towns to Malå. An important factor in this context is, as mentioned previously, the bearing capacity of the roads.

6.6.2 Harbours

Only two harbours have been studied: Skelleftehamn (the harbour in Skellefteå) and Umeå outer harbour (Holmsund). There are other harbours with a suitable location along the section of coast east of Malå, of which Piteå (Haraholmen) is preliminarily assumed to offer conditions similar to those at Skelleftehamn and Umeå.

Skelleftehamn and Umeå outer harbour (Holmsund) have been examined with respect to prospects for handling the transport needs of the deep repository. Both are active industrial harbours with considerable traffic as well as capacity to handle the additional traffic which waste transportation to the deep repository would entail.

Both Skelleftehamn and Umeå outer harbour have suitable entrance channels, sufficient depth and land areas that would be appropriate for the purpose. However, there are no available quays or storage areas within these harbours. They would have to be built in both cases. Further, facilities and vehicles are needed for unloading of transport casks/containers as well as unloading and storage of bulk materials and equipment for transloading to rail or road vehicles. Roads and railways exist to the harbour areas. There are rail and road links from both Skelleftehamn and Umeå outer harbour to the respective trunk network.

Both harbours offer good potential for winter navigation. In general, however, ship design requirements for navigation under difficult ice conditions are gradually being tightened, which may have to be taken into consideration when M/S Sigyn is eventually replaced.

6.6.3 Rail transport from harbour to deep repository

Railway cars and the other equipment needed to transport goods destined for the deep repository by rail are available on the market.

Figure 6-7 shows the railway network in the region. The main rail line with connections to the coastal towns runs east of Malå Municipality. To the west lies the Inland Railway (*Inlandsbanan*) between Storuman and Sorsele. The Inland Railway then bears off eastward and passes north of Malå Municipality, towards Arvidsjaur. South of the municipality, the Cross Railway (*Tvärbanan*) runs from Vännäs to Storuman.

Northeast of the municipality and closer to the boundary lies the now-abandoned line between Jörn on the main line and Arvidsjaur.

On the main line, which is the most heavily trafficked rail line in the region, 30–40 trains per day run today, which corresponds to roughly half its capacity. The transport requirement of the deep repository would be equivalent to about 1.5 trains per day. The increase in traffic intensity would thus be marginal and not cause any capacity problems.

A possible rail link to Malå Municipality should branch off from the main line, east of the municipality /6-9/. It may also be possible to use a section of the abandoned railway from Jörn to Arvidsjaur. In that case, the section in question will have to be restored. The topography and ground conditions in Malå Municipality and in the region to the east, leading up to the main line, can generally be said to provide good conditions for railway construction.

Figure 6-8 shows the existing infrastructure in the region, as well as possible corridors where new rail lines could be run from other points along the main line to Malå Municipality. Some of the branching possibilities for running a rail line from these main corridors to different parts of the municipality are also indicated in the figure.

The corridors have been sketched roughly working from available material. The guiding factors have been terrain conditions, particularly topography and ground conditions, which are important parameters in terms of where a rail line might be run. An attempt has been made to find continuous corridors with reasonable gradients and curves and a minimum of passages over watercourses and wetlands.

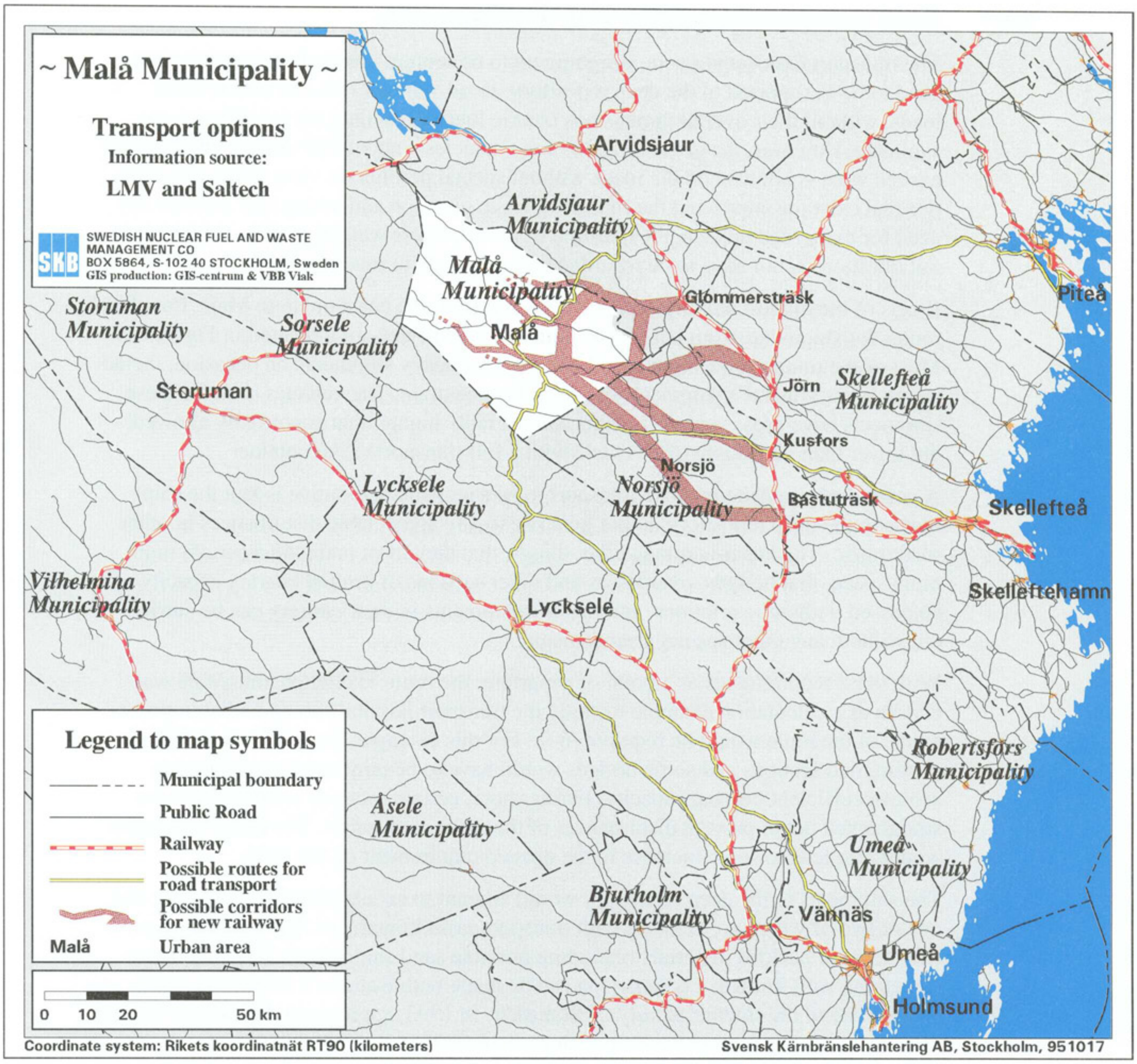


Figure 6-8. Regional map with existing roads and railways, plus possible corridors for a new railway to Malå Municipality.

The study of the prospects for a railway link to Malå Municipality show that good technical options exist for laying a new railway from the main line to a deep repository in the municipality. The distance would be roughly 30–80 km and depends, as does the choice of route, on the site selected for the repository.

It should be emphasized that the purpose has been to indicate some possible alternatives, not to make a complete evaluation of them or determine which route would be most favourable. In the event of a further investigation it is important to examine not only the technical premises but also the socioeconomic aspects as well as possible conflicts of interest with regard to land use, reindeer herding, nature and culture conservation, etc.

6.6.4 Road transport from harbour to deep repository

The transport casks/containers, weighing up to 65 tonnes, are the heaviest units that need to be transported to the deep repository. Road vehicles that can handle these loads, without their overall dimensions or axle loads exceeding the legal limits, are available. However, the gross weights of the vehicles – about 100 tonnes – will greatly exceed what is allowed on the roads without special permits. In view of the possibilities that exist for improving the road sections in question and taking into account any need for extra road upkeep, the question of gross vehicle weights and the related permit question do not have to be regarded as an obstacle to road transport.

Roads of the highest bearing capacity class run from the coast on up to Malå. Possible routes for shipments from Umeå, Skelleftehamn and Piteå are indicated in Figure 6-8. Most of the routes in question have been used for heavy shipments on occasion, including Boliden Mineral's shipments of ore and concentrate. The vehicles used for these shipments have gross vehicle weights considerably higher than is normally allowed, but lower than the weight of a vehicle with a full transport cask/container.

A general prerequisite for road transport to be a realistic alternative is that the shipments to the deep repository do not give rise to any appreciable disturbances in other road traffic. This means, among other things, that they must maintain a certain minimum speed, that bridges, overpasses and other sections of limited bearing capacity can be passed without restrictions, and that the shipments in their entirety can be carried out without any other special arrangements.

With these requirements as a point of departure, the route Skelleftehamn–Malå was chosen as a calculation example to study the transport possibilities and what improvements of the route would be required /6-9/. For this example, the study showed that certain road sections and some bridges would have to be reinforced or replaced to achieve sufficient bearing capacity. Furthermore, certain sections would have to be straightened out to prevent disturbances of the other road traffic. The heavy shipments would also lead to some increase in the upkeep requirement on the route.

The shipments to the deep repository would amount to an estimated 5–13 rigs per day, one or two of which are vehicles with transport casks/containers. The remainder are shipments of backfill materials (including possible sand shipments). To relate this to something well-known, a comparison can be made with Boliden's shipments of ore concentrate to the smelter facility of Rönnskär. In 1993, approximately 800,000 tonnes of concentrate was transported, equivalent to 16,000 loads, or about 50 loads per day. The example shows that the volume of shipments to the deep repository would be small in relation to other shipments in the region, and would therefore not result in any capacity problems on the roads.

All factors considered, road transport is judged to be a feasible alternative. With relatively limited improvements of the roads, road transport is judged to be able to be carried out without causing any appreciable disturbances to other traffic. As in the case of the railway alternative, the improvements in transport guideways that are required are questions that need to be explored from a broader perspective than has been possible in the feasibility study.

6.6.5 Costs for transport between harbour and deep repository

Cost calculations for the different activities associated with the deep repository are done as a part of the general development work for the deep repository /6-4/ and are not included in the feasibility study. However, since the feasibility study has included a parallel evaluation of both the rail and road alternatives for overland transport from the harbour to Malå, a rough cost estimate has been made for these alternatives. The examples of possible transport routes, by rail or road, described above have comprised the basis for the calculations.

The costs can be divided into the costs of the actual transport guideway, i.e. construction or improvement of the roadway or railway, plus the costs of executing the actual shipments. The costs of the shipments include upkeep of transport guideways, procurement and maintenance of equipment, and the actual transport activities during the entire operating life of the deep repository. For the railway alternative, investments in the transport guideway are estimated at about SEK 500–600 million, and the cost of executing the shipments at about SEK 120 million. The equivalent costs for the road alternative are about SEK 130 million for investments in the transport guideway and about SEK 165 million for execution of the shipments (all costs in present value).

Altogether, the cost of the railway alternative is thus more than twice that of the road alternative. The difference is mainly due to the large investment entailed by construction of a railway. It should be added that the estimates are based on single calculation examples, and that it is assumed that the investments in their entirety would be borne by the deep repository project. A more complete analysis would require taking account of socioeconomic aspects as well.

6.7 Transport safety

General

As has been mentioned, considerable experience exists today of transportation of radioactive materials. In Sweden there is a system for sea transport in operation, and in many other countries large quantities of radioactive materials are transported over land. No accidents of any safety-related significance have been reported in connection with these transport activities.

The following safety principles will be applied to the shipments between the encapsulation plant and the deep repository:

- The risk of accidents and incidents during transport shall be minimized.
- If an accident should nonetheless occur, it shall not cause release of radioactive material to the environment.
- The radiation levels on the outside of the transport casks/containers shall not exceed the relevant limit values, so that the casks/containers can be handled without risk to the personnel.

Abiding by these principles will ensure that the shipments do not pose any threat to the environment, either in the vicinity of the repository or along the transport routes that are used. Similar shipments today are characterized by very high safety in these respects.

Three laws govern shipments of radioactive material in Sweden today: the Act on Transport of Dangerous Goods, the Act on Nuclear Activities and the Radiation Protection Act. A large number of regulations have been issued under these laws stipulating what permits are needed and what safety requirements must be met. These regulations are largely based on rules arrived at and agreed on internationally.

The Act on Nuclear Activities sets forth what information must be reported to and permits obtained from the responsible authorities before the activities get under way. The Act on Transport of Dangerous Goods contains provisions governing transport by sea, land and rail. Transportation to the deep repository shall be arranged and executed in compliance with applicable laws and regulations.

Shipments to the deep repository

In shipments to the deep repository the solid radioactive material will be contained, first in canisters or moulds and then in a very sturdy transport cask. This will provide additional protection compared with today's shipments of spent fuel, which are not encapsulated. There is no known mechanism that could release the radioactive material, even if an accident should occur with the casks/containers during transport.

The transport casks are designed in accordance with the requirements set up by the UN's International Atomic Energy Agency, IAEA. They are supposed to protect the enclosed canister against damage while simultaneously shielding off the radiation emitted from it so that the cask can be handled safely during loading and unloading. The strength of the cask is such that it can resist forces in excess of those that could occur in connection with conceivable accidents, such as collisions and falls, without breaking apart. What is important in an accident situation is that the radiation-shielding capacity of the cask is largely retained, in other words that the 40-50-tonne steel body remains intact around the enclosed waste.

No measures shall or need to be adopted with the transport casks/containers along the transport route, beyond lashing on loading, unloading and transloading. Since the casks/containers are designed so that the radiation levels on the outside are within legal limits, and so that the time required for handling is fairly short, the total radiation dose to the handling personnel can be kept at a low level. Experience from today's transportation system for spent fuel to CLAB shows that this goal can be achieved.

Planning and organization

The system for planning and execution of the shipments that is used today has proved to work well, and it can therefore be assumed that the shipments to the deep repository will be organized in a similar fashion. It is thereby of minor importance that the deep repository shipments may involve a longer overland transport distance than today's shipments, since the important safety-related factors, in terms of both organization of the shipments and their technical execution, are the same regardless of transport mode and distance. Even though radioactive goods are not transported by road or rail to any appreciable extent in Sweden today, other dangerous goods are transported, so a successful protocol already exists for rail and road traffic.

Transport planning consists firstly of long-range planning for a year or so ahead to ascertain the need for transport resources, and secondly of detailed planning for each shipment. The plans are notified in good time to concerned personnel, as well as to responsible authorities and local bodies.

Communication and physical protection

Physical protection is aimed at preventing theft or sabotage of the casks/containers and constitutes one component in the safety system. Physical protection consists of a combination of engineered and administrative measures which protect the cargo and provide for detection and alarm if anything abnormal occurs. The measures include guarding, communication with a transport command centre and the like. Certain information on this system is confidential to reduce the risk of sabotage. There is, however, no need for secrecy regarding how transportation is carried out.

For today's sea shipments there is a transport centre that tracks SKB's shipments with M/S Sigyn. In the event of an accident or an incident at sea, the transport centre is informed. If there is danger to human life, the commander of the vessel notifies the nearest coastal radio station, which sends an alarm to the Swedish Lifeboat Service. The transport centre contacts those agencies that may need to provide assistance, if there is a risk of damage to or loss of a transport cask/container.

The function of the transport centre in conjunction with rail and road shipments can be expected to be roughly the same as for sea shipments. In the event of an accident or incident, the transport leader on duty contacts the transport centre, which contacts the agencies whose assistance may be needed, such as the local police and rescue service. The radiation protection inspector on duty at SSI is also contacted. Written instructions accompany the shipment as to what measures should be adopted in different situations. There will also be a plan for how transport casks/containers can be salvaged along different sections of the route if the ship is unable to continue by its own engines.

Emergency plan

The purpose of the emergency preparedness organization, which includes the local police and rescue service and the concerned county administrative board, is to enable these agencies to proceed as efficiently as possible if something abnormal occurs. All available information on the transportation system should be given to these agencies before the shipments to the deep repository begin. SKB (which is in charge of the execution of the shipments) is responsible for ensuring that this information is correct and available, while public agencies are responsible for their own planning.

The emergency plan should contain information on what should be done in the event of an accident along the transport route and what contacts should be made with authorities or other experts who might assist in making sure that the correct measures are taken. It is important in an accident situation that correct information can be furnished, since overreaction may cause more harm than the event in itself.

7 EFFECTS ON LAND USE AND THE ENVIRONMENT

This chapter first provides an overview of the present-day situation as regards land use and the environment in Malå Municipality. This is followed by a description of possible environmental effects of the construction, operation and closure of the deep repository. Working environment and radiological safety matters are treated in general terms.

7.1 Introduction

Site selection for the deep repository and design of the facilities should be carried out so that conflicts with competing land-use interests are minimized. Consideration should thereby be given to the natural and cultural environment, recreation, hunting, fishing and other outdoor activities, important natural resources, agriculture and forestry, reindeer herding and other current and planned land use.

The selected site should provide good opportunities to build and operate the facilities in compliance with all environmental protection requirements. Facilities and lines of transport communication should blend in smoothly with the terrain.

The requirements in Swedish environmental legislation on a comprehensive environmental impact assessment (EIA) of civil engineering projects entail that the environmental impact of the facility should be evaluated against the background of local conditions already during the siting work. The design of the EIA process and its role in the deep repository programme are discussed in greater detail in RD&D-Programme 95 /7-1/. A detailed environmental impact assessment will be presented when SKB applies for a permit to begin a detailed characterization on a site. This will include an assessment of the repository's long-term safety on the site in question. The EIA will be carried out with the participation of concerned municipalities, authorities etc. (EIA process). Before and during the work of site selection, permit application, facility design and final construction, consultation will also take place with local concerned interest groups.

The feasibility study is not conducted within any formally defined EIA process, but nevertheless includes much of what is included in the EIA process. From the start the work is conducted openly and with complete insight from and participation of local stakeholders. The questions that are taken up and examined are broad, and the direction of the work can be influenced at an early stage by different parties.

7.2 Compiled data from the feasibility study

Situation in the municipality

The feasibility study has compiled available information on current and planned land use within Malå Municipality /7-2/. The municipal comprehensive plan /7-3/ has been an important source of information. Compilations have also been made of areas and sites that have special protection or preservation value with respect to nature and culture conservation, reindeer herding, outdoor recreation, hunting and fishing etc. Information on areas that are or may be classified as being of national interest for one of these reasons has been obtained from the county administrative board. Background material has also been obtained from other inventories and via contacts with local interest groups /7-2/.

Environmental effects of the deep repository

A deep repository can be regarded in many respects as a medium-sized industrial facility. Establishment and operation of the facility will affect the environment in different ways, even if the effects are judged to be relatively small in relation to other industrial enterprises. In the feasibility study, possible environmental consequences have been inventoried based on existing plans for the design of the deep repository and the activities in conjunction with establishment and operation /7-4/.

The compilation of the situation in the municipality and the assessments of the environmental effects of the deep repository together provide a basis for an initial assessment of the siting prospects with regard to land use and environment.

Working environment

The feasibility study includes a general description of the working environment associated with various activities at the deep repository /7-4, 7-5/. The underground environment and the radiological protection aspects are of particular interest. The description is based on the conceptual design of the deep repository and on relevant experience from other industrial enterprises, including nuclear installations and mines. As far as the radiological aspects are concerned, attention is focused on handling of the canisters with spent nuclear fuel. Handling of other waste (concrete moulds with embedded core components etc.) is dealt with in passing, since it is simpler from the occupational safety point of view.

Radiological safety in the short and long run

The deep repository will contain large quantities of radioactive material. All features of the deep disposal system are aimed at keeping the radioactive substances isolated for very long periods of time. A crucial question is how safe this isolation can be made. This is analyzed thoroughly in safety assessments, where the long-term performance and safety of the repository are assessed on a broad scientific basis.

Safety assessments specific for a given site cannot be carried out until data are available from repository depth on this site. Such data emerge from site investigations, which include drilling of deep boreholes and measurements from the surface and in boreholes. Conclusions from safety assessments conducted in other contexts are referred to in section 5.1.

One question that worries many people is what short-term risks to man and the environment are posed by the radioactive waste in conjunction with the shipments to the deep repository. The fundamental principles for achieving safe transport, the design of the transportation system, as well as available experience of transportation of radioactive material, are presented in section 6.7.

7.3 Situation in the municipality

7.3.1 Comprehensive plan

Figure 7-1 shows an overview of present-day land use in Malå Municipality. The municipality is almost completely covered by sparsely populated forests and wetlands. There is little competition for land and water, and little development pressure. There are, however, a number of protected sites and sites worth protecting with regard to different conservation interests which must be taken into consideration.

For the large portions of the municipality where no change in present-day land use is expected, the municipal comprehensive plan /7-3/ is fairly sketchy. Planning activities have mainly been concentrated to the central locality of Malå, where the need for trade-offs between competing demands from different land-use and conservation interests has been greatest.

The proportion of the total surface area of the municipality that has been developed for housing, industry, infrastructure etc. is very marginal. There is scarcely any industrial land or land set aside for industrial purposes that could be suitable for a deep repository. Land where mining activities have been conducted is not likely to be of interest, since it is normally located in areas where the possibility of mineral extraction or prospecting in the future cannot be excluded.

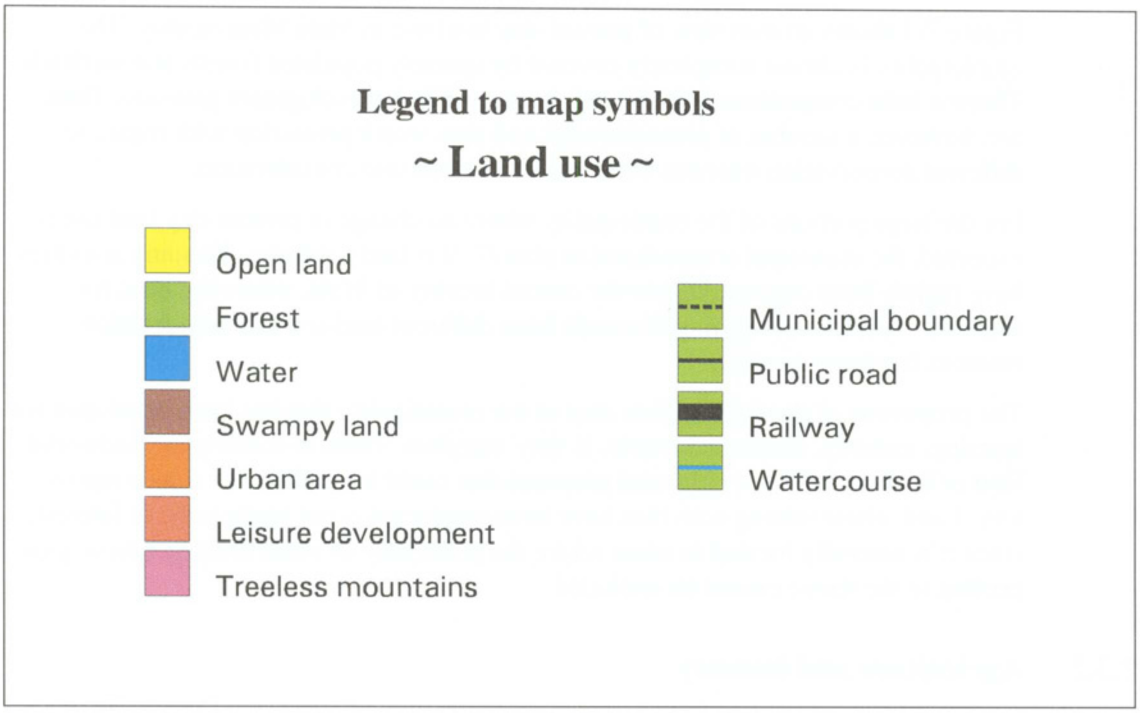
7.3.2 Agriculture and forestry

Forestry is the predominant form of land use and is practised on most of the surface area of the municipality. The fraction of agricultural land is very small and the importance of agriculture continues to decline.

The comprehensive plan /7-3/ says the following about agriculture and forestry: "Great consideration shall be given to the interests of agriculture and forestry. An active agricultural sector is important to enable the character of the villages and a living countryside to be preserved. Arable land with long-term farming value should therefore not be used for other purposes. Other arable land that is being farmed should also be left undeveloped if reasonable alternative sitings exist. When arable land is nonetheless developed, the intrusion shall be minimized". It is further stipulated that contiguous forest areas should not be used for development or other change in land use.

7.3.3 Reindeer herding

Reindeer herding may be pursued on both public and private land. The rights of the Sami people (Laps) are referred to collectively as reindeer husbandry rights and include the right to use land and water to sustain themselves and their reindeer.


Legend to map symbols
~ Land use ~
Open land
Forest
Water
Swampy land
Urban area
Leisure development
Treeless mountains
Municipal boundary
Public road
Railway
Watercourse

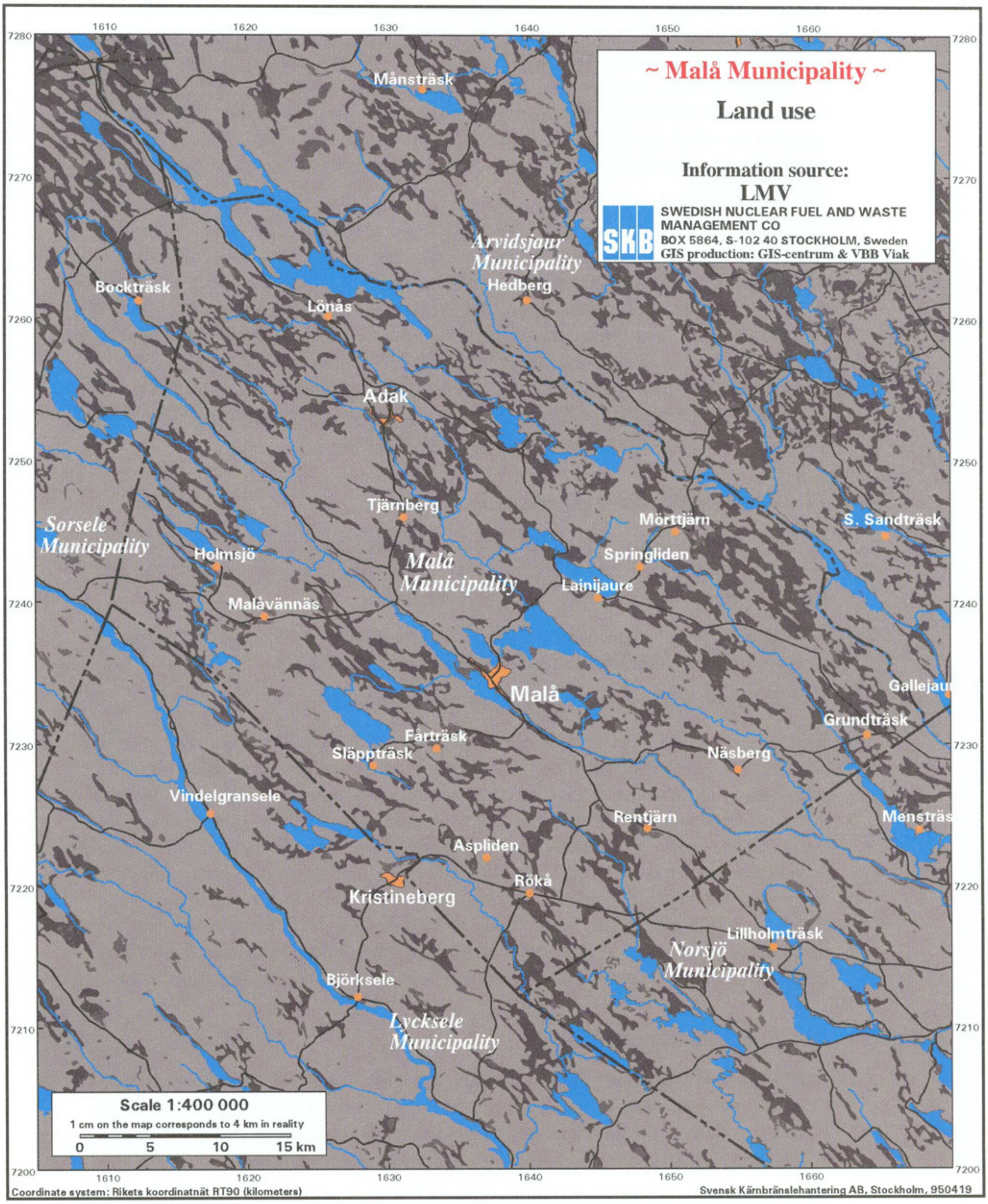


Figure 7-1. *Land use in Malå Municipality.*

Reindeer herding is generally an activity which requires vast areas of land and is conducted within different regions during different seasons. In Malå Municipality, reindeer herding is pursued by Malå Sami village, which consists of some twenty or so reindeer-owning families. The activity is conducted during most of the year and involves large portions of the municipality to a varying extent. In the wintertime, the reindeer are often moved down to winter pastures nearer the coast. Besides Malå Sami village, other Sami villages have certain rights to move their reindeer within the municipality.

The County Administrative Board has proposed that considerable areas within Malå Municipality be classified as being of national interest for reindeer herding, Figure 7-2. It is mainly a question of migration routes, night camps, gathering places, difficult passages, special grazing areas and calving areas. The proposal will probably be adopted in the near future. According to the Act Concerning the Management of Natural Resources, areas of national interest shall be protected wherever possible against measures that may substantially impede the conduct of reindeer herding. Consultation with the concerned Sami village should precede any measures that lead to a change in land use and that may affect reindeer herding.

7.3.4 Protected land with high natural values

Figure 7-3 shows areas within Malå Municipality which are of interest in different ways for nature conservation. There are two areas of national interest under the Act Concerning the Management of Natural Resources:

- Water areas and adjacent land areas around the Malån and Skäppträskån rivers, including the Verbobäcken tributary and Stora Skäppträsket.
- The virgin forest area of Björnhultet/Fågelmyrkölen.

Besides areas of national interest, there is a nature reserve at Storforsen and several smaller reserves set aside by the forest industry companies AssiDomän and MoDo which enjoy a certain protection. In addition, there are a number of areas of regional and local interest for environmental protection and nature conservation, including wetlands of high nature protection value. These areas have been designated as interesting or valuable in various nature inventories by the municipality or the county administrative board. There are also other areas with old-growth forest worth protecting, rare lichens and habitats with endangered or rare animal species. In many cases, thorough inventories of the areas' protection values are lacking. Future inventories, yielding further knowledge, may therefore entail new requirements on particular protection.

7.3.5 Active outdoor recreation

Active outdoor recreation, along with being outdoors in general, is traditionally one of the most popular categories of leisure-time activities in the municipality. Outdoor recreation includes a variety of activities. Hunting, fishing, skiing, snowmobiling, hiking, berry-picking, boating and canoeing are important examples.

The municipality offers good opportunities for hunting and fishing. Hunting is pursued on more or less all land. Moose are the most important game, but small game hunting is also very popular. According to an estimate, as many as two-thirds of the adult male population in the municipality hunt. Fishing includes both sport fishing (angling) and professional fishing by the Sami. To promote sport fishing and tourism, several fishing conservation areas have been created and certain waters have been stocked.

Snowmobile excursions have become a widespread and popular phenomenon. Most snowmobiling is of a recreational nature and there are several snowmobile clubs in the municipality. Snowmobiling may be done in areas where there are no restrictions and is concentrated to marked trails.

Malå Municipality has no area that is classified as being of national interest for active outdoor recreation. Areas classified as being of national interest for nature conservation or of interest for the natural environment, Figure 7-3, are however of great value for active outdoor recreation as well.

Mount Tjamstan with ski slopes, lifts, exercise trails and biathlon course are also of great importance for active outdoor recreational purposes. The central locality's swimming and athletic facilities, as well as hotel and camping facilities, are located adjacent to the Mount Tjamstan area.

7.3.6 Preservation of cultural monuments

Within the municipality of Malå there are both extensive cultural environments and individual sites, for example buildings and ancient remains, which various inventories have deemed worth preserving. The designated cultural monuments are of local or regional interest. There are no cultural monuments of national interest in the municipality. Malå Municipality intends to develop a cultural monument preservation programme as a basis for future revisions of the comprehensive plan /7-3/.

7.3.7 Conditions in geologically interesting areas

Three areas judged to be of preliminary interest from a geoscientific point of view and therefore subjected to special study are described in Chapter 5. Their location and extent are shown in Figure 5-8. The areas have been identified solely on geoscientific grounds. A general review of the prospects of these areas with respect to land-use and environmental conditions is given below.

The Southern sub-area (approx. 40 km^2) borders on Norsjö Municipality and appears to be the least developed, despite its situation between the villages of Rentjärn and Rökå. The area is intersected by a migration route for reindeer which has been proposed to be designated as being of national interest and which can be utilized for grazing and calving. Otherwise it does not have any specially designated areas of interest, aside from a wetland area in the northern part of the area.

The Northern sub-area (approx. 55 km^2) seems, with the exception of a couple of virgin Crown forest reserves in the inner parts of the area and the border in the south with the Skäppträskån area of national interest, to be free of protection interests for nature conservation. The area is intersected by a migration route for reindeer and has a gather-place for reindeer in the south. Both belong to proposed national interests for reindeer herding. Parts of the area may be utilized as calving land.

The Western sub-area (approx. 100 km^2) in the western corner of the municipality borders on the municipalities of both Sorsele and Lycksele. Its northern half touches upon areas of national interest for both nature conservation and reindeer herding, as well as considerable water and wetland areas of high preservation value. Even if these facts do not necessarily comprise insurmountable obstacles, the southern half of the area appears to be slightly more advantageous than the northern half in a brief initial judgement.

Legend to map symbols

~ Reindeer herding interests ~

- Reindeer herding (National interest)
- Reindeer migration route (National interest)
- Difficult passage (National interest)
- Working corral
- Reindeer wardens cabin

- Municipal boundary
- Public road
- Railway
- Watercourse
- Urban area
- Water

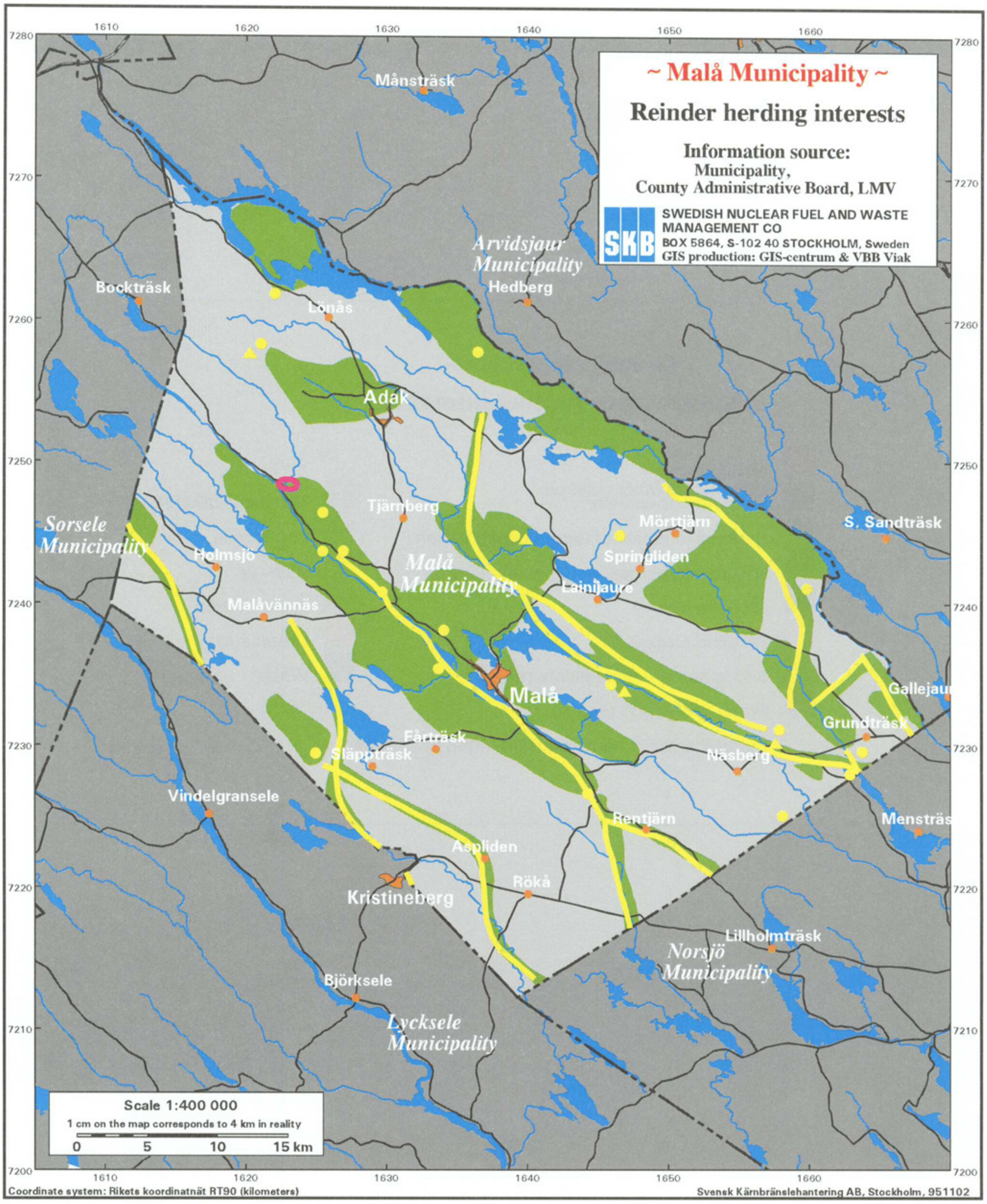


Figure 7-2. *Areas proposed by the County Administrative Board as being of national interest for reindeer herding in Malå Municipality.*

Legend to map symbols

~ Nature conservation interests ~

- Nature reserve
- Crown- and MoDo reserve plus virgin forest site
- National interest for nature conservation
- Nature site of local or regional interest
- Wetland class 1
- Wetland class 2
- Bird sanctuary and wildlife refuge
- Water protection area
- Cultural environments and cultivated landscape
- Municipal boundary
- Public road
- Railway
- Watercourse
- Urban area
- Water

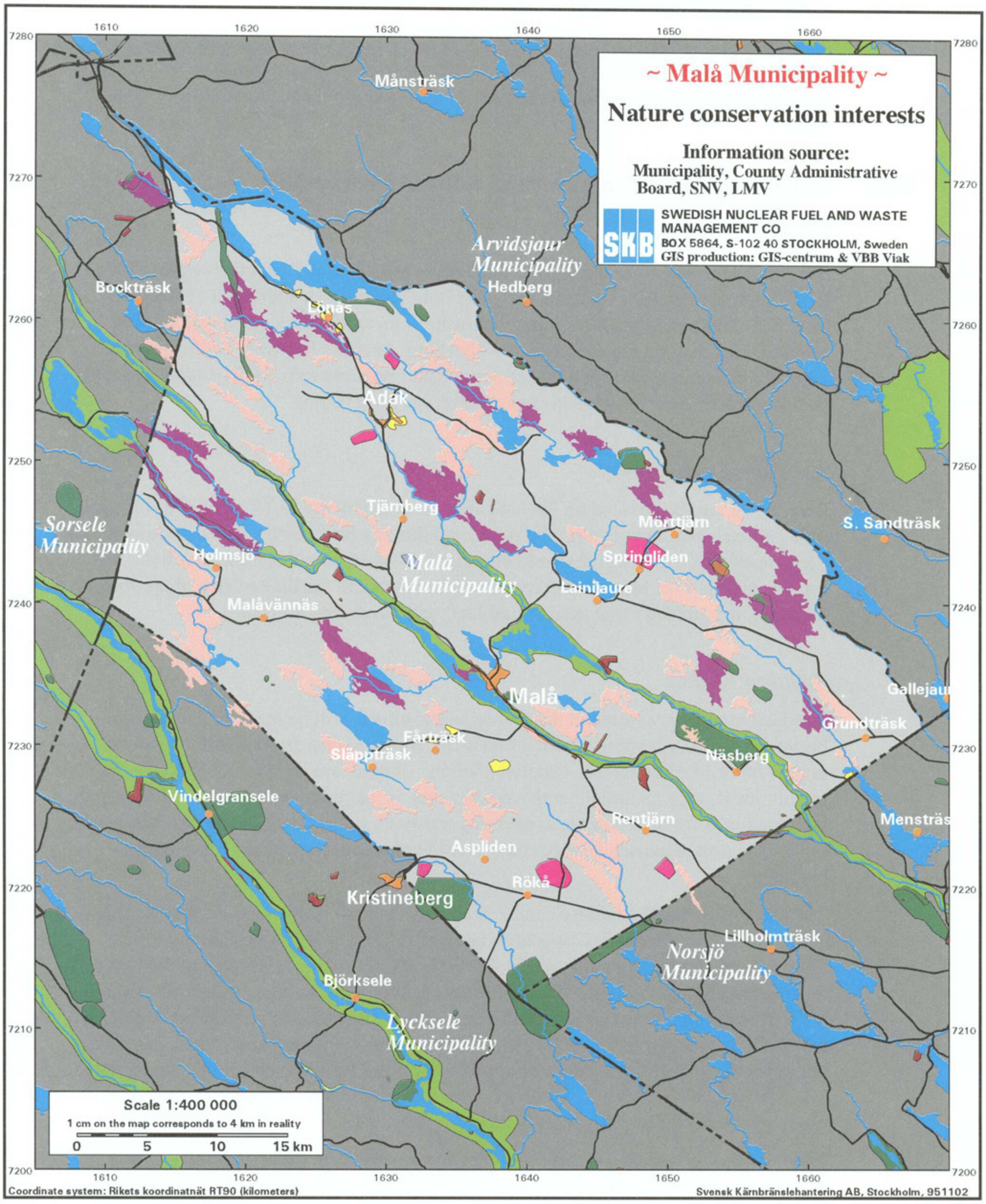


Figure 7-3. Areas of national interest and other protected areas or areas worth protecting in Malå Municipality.

7.4 Environmental effects of the deep repository

The description of the environmental effects of the deep repository mainly applies to Malå Municipality. In a complete environmental impact assessment, aspects having to do with the transportation system from the encapsulation plant should also be dealt with.

7.4.1 Impact on land use, natural and cultural environment

Area requirements

The area requirement for the surface facilities is estimated at 18 hectares (600 x 300 m). Rock waste dumps for excavated rock spoils may require an additional 15 hectares (500 x 300 m) unless the rock waste can be used for other purposes. The total area requirements may thereby amount to 33 hectares, or about 0.3 km^2. To this must be added land requirements for connecting road and possibly railway. The land area will be taken over when the detailed characterization work begins.

Agriculture and forestry

Forestry cannot be pursued on the land area occupied by the surface facilities or traffic links. No negative impact on forestry beyond this can be foreseen. The activities at the deep repository will not give rise to emissions of substances that could harm the forest. Considering the location of the agricultural land and the limited size of the surface facilities, it is unlikely that agricultural land will have to be utilized.

Reindeer herding

If a deep repository is sited in the municipality, efforts will be made to avoid disturbances of reindeer herding wherever possible. Similar consideration will be shown in the choice of route for and detailed planning of road and railway connections. The facility itself, with its limited area requirements, is judged to be less of a problem from an intrusion point of view than connecting transport guideways. The laying of a new rail connection in particular may entail considerable inconveniences for reindeer herding.

The possibility that the facility can be sited outside areas of national interest for reindeer herding, see Figure 7-2, appear to be relatively good. This does not mean that there will be no impact on this sector, but it should be able to be limited to the loss of grazing land and possibly disturbances in connection with reindeer migration. Even if areas of national interest are affected, it may be possible to site the surface facilities so that the impact is not unacceptably great. During the operating phase, the facilities are not expected to disturb the reindeer appreciably other than in their immediate vicinity. The risk of disturbances in conjunction with the construction and civil engineering phase may have to be given special attention, however.

The impact of connecting transport guideways is very difficult to determine at this point, since neither transport mode (road or rail) nor candidate sites can be specified. The length and route of the transport guideways is naturally of crucial importance for the degree of intrusion. What is clear, however, is that a railway connection to a deep repository in the municipality is likely to be a greater problem than road transport on largely existing roads.

In the event of a continuation of the siting studies in Malå Municipality, it is important that thorough consequence studies be conducted to shed light on the impact on reindeer herding of the siting of a deep repository in a specific area. The studies will require recurrent consultation and contacts with the Sami, the county administrative board and the municipality.

Natural environment, flora and fauna

Siting within an area with protected nature or an area of interest for nature conservation, Figure 7-3, entails a risk of conflicts with the values or interests to be protected. In those cases where the value of the areas lies in the fact that they are relatively large and unaffected by human activities, a surface facility entails a conflict of interest that should be avoided.

How a surface facility affects the landscape will be highly dependent on the local conditions and on how the facility is adapted to the landscape. There is considerable flexibility to adapt the configuration of the facility parts to local requirements. The activities at the deep repository are of such a nature that local animal and plant life will not be affected except within the land that is directly occupied within the immediate environment. The animals that can be expected to be the most sensitive are large predators and birds of prey.

Facilities and transport guideways can cause barrier effects, limiting the mobility of animals in certain directions. It is not likely that the deep repository will cause any appreciable barrier effects for animals. One reason is the limited area occupied by the surface facility. The low frequency of traffic on connecting road/railway will also limit any effects.

Active outdoor recreation

Some impact on hunting interests would appear to be unavoidable in the event of a siting of the deep repository in Malå. One or more hunting teams will be affected by the surface portion of the deep repository and the road or railway leading to it. The degree of disturbance of hunting will depend a great deal on the size and type of the hunting areas concerned. For a normal-sized hunting area, the loss of hunting land will be little. For a small hunting area, the loss may at worst be significant.

As far as fishing is concerned, the impact is judged to be small, provided that the most attractive fishing waters are avoided in detailed siting, and that appropriate consideration is given to watercourses of special importance for the fish stocks. Conflicts with recreation in the form of hiking, skiing, snowmobiling, canoeing etc. stemming from the surface facilities should be able to be avoided for the most part.

As is the case for the local animal life, transport guideways can cause barrier effects for active outdoor recreation. There are not likely to be any direct difficulties in crossing a road or railway built to the deep repository, since the traffic intensity will be low and fencing will not be necessary. A newly built road or railway through a previously uninterrupted area can nevertheless be experienced as a considerable barrier. If a rail line is run to Malå Municipality, a section running outside the municipality to an existing railway would also be affected by such effects.

Cultural environment

The cultural environments worth protecting in the municipality are not located in any of the areas subjected to special geoscientific studies. Moreover, they are often situated so close to human settlements that they will scarcely be affected by the deep repository. Ancient remains and cultural monuments are so geographically delimited that it should be possible to avoid them when siting the facilities of the deep repository.

7.4.2 Impact on air and water

Air pollution

The activities at the deep repository and transport to and from the facility irrevocably lead to some environmental impact due to exhaust emissions from vehicles and blasting emissions. The scope of these emissions is greater during the construction phase than during the operating phase. Calculations show that the emissions both around the deep repository and along the transport routes are small compared to the present-day pollution load /7-4/.

Water pollution

The facility is characterized by the absence of any real industrial process, which means there are no process effluents. The water pumped out of the facility must nevertheless be monitored for impurities such as oil, rock dust and nitrate from explosives. If impurities are present, the water must be treated before being discharged. During those phases when large quantities of water are pumped up, the water will pass through sedimentation ponds and oil separators before being discharged to a recipient (receiving body of water) or an infiltration field.

The deep repository does not give rise to wastewater that is any more difficult to handle than, for example, an engineering works. It is assumed that the wastewater will be purified in a sewage treatment plant before being discharged to a recipient.

Lowering of groundwater table

The groundwater table will be lowered locally when tunnels are driven during repository development and operation. The amount of lowering will depend on the occurrence of water-bearing fractures and fracture zones, and the extent of sealing measures undertaken. Experience from mines and from the Äspö HRL shows that the quantity of groundwater that needs to be pumped up from the full-sized facility may amount to a cubic metre or so per minute. The lowering of the groundwater table may affect wells within one or a few kilometres of the deep repository. A smaller and temporary lowering may also occur during test pumping of boreholes in connection with the site investigations.

Water supply

The supply of water to the facility will be arranged locally. The total requirement can be estimated to be about 100 m^3 per day. Since the underground work will probably cause a rather large groundwater lowering and there are probably not any suitable eskers in the vicinity, water will probably be taken from some not-too-distant lake or watercourse.

Leaching of rock waste dumps

The rock waste that is hauled up may be dumped near the surface facility. It will consist primarily of granite without any appreciable concentrations of metals or other polluting substances. If such substances should nonetheless occur in significant concentrations, leaching to the groundwater must be limited, for example by a suitable thickness or composition of the soil layer used to cover the waste. Radon emissions from the rock waste will probably not pose any great problem, since the rock types present in the Malå area do not have enough uranium to give rise to radon problems.

7.4.3 Other effects

Accidents, fire etc.

The activities at the surface facility must be regarded as uncomplicated in comparison with industrial activities in general. It is difficult to think of any possible accidents with environmental consequences. Explosions caused by blasting explosives or LPG, or a fire in a tanker truck or fuel depot, are probably the worst conceivable accidents in this respect. The environmental consequences of such accidents are limited to smoke emissions and spillage of oil, fuel or other chemicals.

Noise and light

Like any other traffic, the traffic to and from the deep repository will give rise to some noise and light. During the construction period, noise will be caused by blasting, construction equipment and other building activities.

7.4.4 Management of natural resources

The deep repository does not require utilization of any natural resources of which there is a regional or global scarcity. Siting of a deep repository in the municipality of Malå could, on the other hand, affect the management of the natural resources that exist within the municipality (natural environment, mineral resources, timber, groundwater and peat) by blocking access to them. As mentioned previously, consideration will be given to these natural resources in conjunction with siting, so no appreciable impact on their management is expected.

7.4.5 Site restoration

After the repository has been closed and sealed, the groundwater table will eventually resume its former, natural level. This may take several decades. During this period the site will be restored to a condition that is as close to the original condition as possible.

The buildings at the deep repository can be regarded as conventional industrial buildings. When and if they are demolished, the demolition waste will not differ significantly from other industrial building waste. Early planning in accordance with the ecocycle principle (reuse, recycling and recovery) will facilitate the reuse of building materials.

As mentioned previously, the hauled-up rock waste will be covered with soil, unless it has been used for backfilling or other purposes. Since the rock waste consists of granite or other harmless "gangue", it does not present the same problems as mining wastes, although it does have to be disposed of in a manner that blends in with the landscape. Nevertheless, the areas used for dumping of the waste must be regarded as being permanently altered, which means that it will not possible to get back the same habitat after site restoration as existed there before.

No restrictions need be imposed on land use on the restored site, with the exception of a ban on deep drilling. The site should be permanently marked in some fashion. Records of the existence and contents of the repository will be preserved in such a manner that they are not destroyed. Principles for record-keeping in conjunction with disposal of nuclear waste are currently being discussed in the International Atomic Energy Agency, IAEA. The work can be expected to lead to the adoption of international guidelines within a few years.

7.4.6 Damage prevention

The impact of the deep repository can be minimized by means of damage prevention measures both during siting and during the later phases. Such damage prevention measures may include:

- inventory of flora and fauna with a focus on sensitive habitats and areas that may be of importance for biological diversity. Attention should be given to possible conflicts with nature interests, even on a small scale, such as populations of plants worth protecting, breeding sites for birds of prey, etc.;
- mapping of surface water and groundwater conditions, regional flow paths, sensitive wetlands and habitats;
- inventory of sectors where impact on the landscape should be minimized;
- inventory of present-day and possible future outdoor recreation activities in the area;
- inventory of natural resources whose access may be blocked by the facility;
- detailed layout of the surface facility with a view towards blending in with the terrain;
- learning from experience gained from environmentally sound construction, e.g. with regard to choice of materials, recyclability, energy and water supply;
- use of environmentally-friendly fuels;
- early planning of chemicals handling, alternatives to environmentally harmful methods and products;
- monitoring programme for e.g. discharges, emissions and noise, and environmental monitoring;
- special measures and consideration during the construction phase and operating phase.

7.5 Working environment and radiation protection

7.5.1 Working environment under ground

Underground activities always involve a working environment which differs in many ways from other industrial environments. In the case of the deep repository, the initial construction phase will be dominated by rock excavation work which is comparable in nature to the development phase in a mine. Even when the deposition of canisters has got under way, rock excavation will continue as the underground portion of the facility is gradually expanded. Areas under construction will be well separated from parts where deposition is in progress or is being prepared, and these different activities will not affect each other. The working environment in the parts of the facility where rock excavation work is not under way can be compared to the environment characterising hydroelectric power stations or at SFR.

Experience has shown that the working environment associated with underground civil engineering work poses greater risks of occupational injury than many industrial environments. A great deal can be done – and has been done in recent years – to mitigate these risks. Improvements in technology, strict safety routines and good experience feedback are examples of important components in the safety work. The deep repository's facilities will be designed so that the risk of occupational injury is minimized. The same applies to the execution of the civil engineering work.

7.5.2 Radiological working environment

Monitoring of the radiological working environment during transportation and handling at the deep repository will conform to the customary standard for nuclear activities. The fundamental principle in all work with radioactive materials is that the total radiation (dose load) to which the personnel are exposed shall be the minimum necessary for execution of the work. A more detailed description of radiation and the radiological aspects of work in the deep repository is provided in /7-5/.

Transport from encapsulation to deep repository

The canisters with spent fuel are contained during transport in transport casks with steel walls a couple of decimetres thick (see section 6.5). The primary purpose of the transport casks is to shield off the radiation from the canisters so that the casks can be handled without danger to the transport personnel. The casks also provide mechanical protection that prevents the canisters from being damaged during transport.

The casks must comply with international rules regarding, among other things, strength and maximum radiation level. During transport the radiation level from the casks will always lie below relevant limit values, which means that the only protective measures taken for the personnel are to limit the time spent next to the containers to what is needed to carry out loading and unloading. This is in keeping with the principle that all unnecessary radiation should be avoided. Experience from today's sea shipments of casks containing spent (but not encapsulated) fuel assemblies to CLAB shows that the system can be designed in such a way that the actual radiation dose to the personnel is well below relevant limit values. As an example it can be mentioned that the crew of the ship M/S Sigyn has received lower radiation doses than the average Swede receives due to natural background radiation. This is because radiation levels are generally lower at sea than on land and the radiation from the casks does not make up for the low background level.

Reception at the deep repository

From the time a transport cask arrives at the deep repository to the time it is transported down to repository level to be emptied of its contents, the only handling to which it will be subjected is unloading and possibly temporary storage. This handling, which takes place within the deep repository site, is thus comparable to that performed by the transport personnel.

Transport down into the repository and deposition

Handling in the deep repository can also be designed so that personnel doses are kept well below relevant limit values. Different parts of the facility will be divided into zones according to radiation level. Dosimetry will be used to monitor radioactivity. No airborne activity (except radon from the rock) or surface contamination will be present, which means that no special clothing is needed.

The casks will be transported down into the repository either by vehicles in the tunnel or by a shaft hoist down to the deposition level. In the meantime, the canisters will be contained inside their transport casks. The same applies if other waste is handled.

At the mouth of the deposition tunnel, a deposition machine will open the transport cask and take out the canister for further conveyance to its deposition hole. Only a few persons will be occupied with this work. Of those who work at the deep repository, this is the only personnel category that can be expected to receive measurable dose contributions from the waste being deposited. Extensive steps will be taken to minimize the radiation doses to the personnel. The equipment will be remote-controlled and equipped with radiation shields, preventing the personnel from coming into direct contact with the canisters.

The dose contribution must naturally lie below the limit values set by SSI for persons who work with ionizing radiation. In practice it can be assumed that the doses will be much lower than the maximum values calculated in the design phase. For example, experience from SFR shows that the radiation doses are ten times lower than those calculated when the repository was commissioned /7-5/.

An objective in work with ionizing radiation is to keep all radiation doses as low as is practically possible, even when they are already well below relevant limit values. When designing the facility and the equipment and machines that will work there, this goal will be accorded great importance. To give the personnel the knowledge and skills they need to contribute towards this goal, training is needed in both radiological safety and the handling of canisters and use of handling equipment. Experience from e.g. SFR or CLAB can be valuable here. Personnel categories that do not work directly with deposition should also be given basic training, since a general understanding of the requirements and principles that are applied regarding safety and radiation protection contributes both to increasing job satisfaction and to reducing the risk that any measure will be taken which is in any way counterproductive to these purposes.

A contributing factor to keeping the radiation doses down is the fact that the equipment is designed for high reliability. Furthermore, detailed instructions on how the work is to be done will be provided and followed. In this way, unscheduled interruptions and time-consuming repairs can be avoided.

In the event of a breakdown of the handling and deposition equipment, either the equipment or the canister will be moved out of the way so that repairs can be made without exposing the personnel to radiation. Should this be impossible or impractical for any reason, temporary radiation shields will instead be erected so that repairs can be made without risk to the personnel.

Radon

Radon problems in underground facilities have nothing to do with handling of radioactive materials. The source of the radon gas is rather decay of uranium present naturally in the bedrock. The gas enters excavations via groundwater leaking in or direct emission from exposed surfaces. Limit values have been established for the concentration of radon gas and its daughter products.

As mentioned previously, the bedrock in Malå Municipality is not judged to have uranium contents high enough to give rise to radon problems in a deep repository. It is nonetheless advisable to monitor radon levels during both the construction and operating phases. Should problems arise contrary to expectation, measures in the form of ventilation and the like will be adopted.

7.5.3 Working environment in other service areas

The deep repository will also contain traditional working environments for offices, workshops and construction above and below ground. Examples of work duties are geological investigation and analysis work, administrative work and routine handling of large vehicles and heavy goods, including maintenance and repairs.

Great care will be devoted to designing the surface buildings so that they blend in as unobtrusively as possible with the environment and so that pleasant workplaces are created. The goal in the office and the workshops on the surface is to create an internal environment that balances function and technical requirements with uniform design solutions and good accessibility for service and maintenance.

8 SOCIETAL ASPECTS

Malå Municipality and the prospects for the siting and establishment of a deep repository there are described from a socioeconomic, "non-technical" perspective. History, present-day situation and possible future development with respect to population, trade and industry, labour market, tourism, services and municipal finances are dealt with. With this as a basis, the development prospects in the municipality with and without a deep repository are discussed.

8.1 Introduction

The investigation activities involved in the siting of a deep repository should be carried out in stages, rooted in a democratic decision-making process. The social and socioeconomic consequences should be explored by conducting studies of e.g. population development, socioeconomics, repercussions for the local business community, and labour market aspects.

The societal aspects to be taken into account span a wide field and pertain to different levels of society. An important component on the local plane is what concrete effects the establishment of a deep repository would have on employment, the local economy and the overall development of the community. But more hard-to-grasp psychosocial effects must also be considered, not least the feeling of anxiety and insecurity to which the handling of radioactive materials can give rise.

It is inevitable that a discussion of the societal aspects of the deep repository must be based in part on value judgements, not least because an important part involves assessments and predictions of the future socioeconomic development of the municipality. Even if the following account is based wherever possible on factual material, it therefore also reflects subjective judgements from the sub-studies that have been performed.

8.2 Compiled data from the feasibility study

General

The socioeconomic research conducted in the feasibility study has primarily concentrated on Malå Municipality. Secondary consideration has also been given to regional aspects.

The feasibility study has involved forecasts of the future socioeconomic development of Malå Municipality – both with and without a deep repository in the municipality.

The forecasts can be said to be based on three components:

- Description of current situation and historic retrospect.
- An assessment of the effects of the deep repository on the socioeconomic development of the municipality.
- A reference scenario, in the form of a description of the future socioeconomic development of the municipality if a deep repository is not built.

It is important to bear in mind that these components can be judged with different degrees of reliability – something which is of great importance for the forecast results.

A description of the current situation in the community and of the underlying socio-economic trends – in the surrounding society and locally in the municipality – is, naturally enough, possible to do with good precision.

The second component, the effects of the deep repository on for example population, employment, trade and industry etc. can also be assessed fairly accurately, since the extensive experience available from other projects can be drawn on. A prerequisite is naturally that the deep repository is constructed and operated in accordance with existing plans.

The greatest uncertainty lies in the third component – the reference scenario which describes the general evolution of society. The time span that has been studied extends over nearly a century, from the present till the end of the next century. The long forecast period is warranted by the direct and indirect effects that could be discerned before, during and after the approximately 50-year period during which the deep repository facility is being planned, built, operated and eventually closed and sealed. Naturally, such long-range forecasts of the future development of society are associated with great uncertainties. The future that has been sketched in the feasibility study is firmly anchored in present-day socioeconomic trends, but is still just one of many possible alternatives.

Experience from similar sitings can contribute knowledge on how the establishment and operation of a deep repository would affect the community. General experience has therefore been compiled from establishments of nuclear facilities, as well as other establishments which have been controversial due to the nature of the activities. These data can shed light on effects which are otherwise difficult to judge, including influence on the travel industry. The possibility of drawing parallels with Malå is, however, limited by differences in fundamental premises between different municipalities and regions as well as differences between a deep repository and the other kinds of facilities that have been established.

Mining is a useful reference activity for comparison in certain respects, and is of particular interest in Malå. There are clear similarities in type of facility, personnel requirement etc. between the planned deep repository and a large mine. There are also obviously crucial differences, such as in the goals of the activities and the planning horizon. In view of the extensive experience that exists in Malå from mine projects, the feasibility study has attempted to shed light on some similarities and differences.

Studies

The plans and strategies for the various studies were originally discussed with the municipality and with local representatives of political parties, companies, civic organizations and other interest groups. The discussions were carried on via the project's steering and reference groups. Under the guidance of these contacts, a study programme was devised which has included the following sub-studies:

– Mega-environmental analysis: "Malå in the heart of the real Norrland" /8-1/, which deals with Malå's current situation, prospects and development options, with an emphasis on trade and industry, municipal enterprise and economy. The study was conducted by EuroFutures AB.

– "Socioeconomic consequences of siting of a deep repository for spent nuclear fuel" /8-2/, which was conducted by Umeå University (Department of Geography) and deals above all with the development of population and employment both with and without a deep repository.

– "Development of tourism in Malå with or without a deep repository" /8-3/, which was conducted by Turismutveckling AB. The study deals with the tourist industry in Malå Municipality, and reflects the viewpoints of tourist industry leaders on a deep repository establishment.

Furthermore, in the final phase of the feasibility study a supplementary study was conducted concerning the travel industry and possible consequences of a deep repository establishment for this sector:

– "Consequences of a deep repository for tourism and travel – Compilation of available reference material" /8-4/, conducted by Vattenfall Energisystem AB.

The experience of the mining industry from sitings in the region, and how this experience can be utilized to assess the effects of a deep repository, has been treated in a special study conducted by Boliden Contech AB /8-5/. In addition, material has been taken from a number of surveys and articles published in other contexts /8-6, 8-7, 8-8, 8-9, 8-10, 8-11/.

8.3 Current situation in Malå

8.3.1 Population

Figure 8-1 compares the development of the population in Malå Municipality with support area 1 (municipalities given top priority in regional development planning, includes large parts of the interior of Norrland), the county and the nation. The population trend is negative for all the sparsely populated municipalities in the interior of Norrland. In Malå Municipality, the population has declined during the last 30–40 years by more than one-fifth or over 1,000 persons, from a peak of 5,300 persons in the late 1950s to about 4,000 persons at the end of 1994. If the population in Malå had developed at the same pace as that in Västerbotten County and the nation as a whole, the municipality would have had just over 1,000 more inhabitants today.

The main reason for the population decline is emigration, largely due to a lack of jobs and educational opportunities. It is mainly people aged 25–64 years, in other words the occupationally active age groups, who move. At the same time as the working-age population has declined, the number of old-age pensioners in the municipality has increased. This has lead to imbalances in the age structure of the population, with a sharp decline in the number of inhabitants of productive age, Figure 8-2. The negative trend is reinforced by the fact that the net birth rate, i.e. the number of births in relation to the number of deaths per annum, shows a declining tendency.

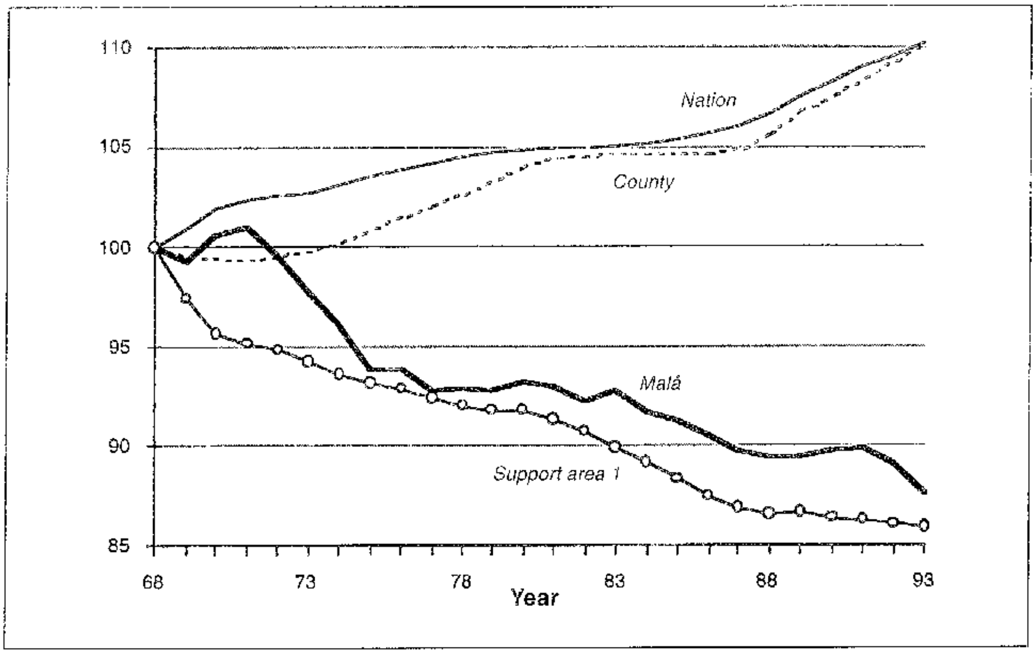


Figure 8-1. *Population curves 1968–1993 for Malå, support area 1, the county and the nation (index 1968 = 100).*

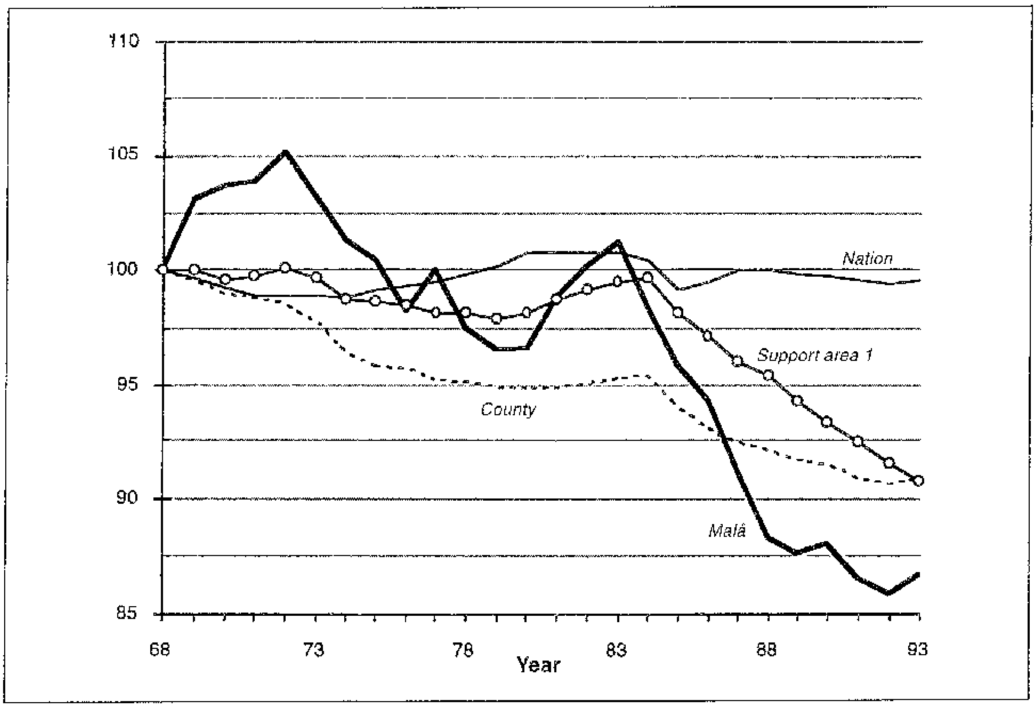


Figure 8-2. *Relationship between inhabitants of productive age (16–64 years) and other inhabitants, 1968–1993 (index 1968 = 100).*

During the past ten years, the population decline has been particularly evident in the villages, while the central locality of Malå shows an unchanged or slightly rising population. The only exception among the villages is Rentjärn, situated on the road to Norsjö and Skellefteå, which has exhibited a marked population increase.

8.3.2 Industry and employment

The most important industrial sectors in Malå are forestry and wood-processing. The surface area of the municipality is 2/3 forestland. AssiDomän owns nearly half of this, while the other half is divided among a large number of private landowners, including MoDo, SCA and the church.

As a result of mechanization and other rationalization, the importance of forestry for employment in the municipality has declined sharply in recent years, and today the forest accounts for only 5% of the total number of jobs in Malå Municipality. If the wood-processing industry is added, the figure is 20–25%. Independent contractors, haulage firms and parts of the engineering industry are also heavily dependent on the forest and wood-processing industry. An example is the largest engineering company, Huldin System AB, which manufactures equipment for forestry machines and other components for the forest industry. Agriculture is also closely associated with forestry. Farms in this part of the interior of Norrland can seldom operate without some income from timber, which provides the long-term base.

AssiDomän has a very dominant role within the timber and wood-processing sector in the municipality and the region. In a regional perspective, Malå Municipality is also strategically well situated in view of the company's substantial forest holdings in the interior of northern Norrland. AssiDomän owns the sawmill in Malå and Malå Trä. They are now investing SEK 150 million to modernize and increase the capacity of their operations in Malå. Malå Trä and its planned expansion are judged to be of great importance for the municipality's industrial strategy /8-1/.

The mining industry in the region expanded for several decades and still has a strong position in the region. In recent years, however, the importance of the mining industry for employment has declined sharply. Today no mining takes place within the boundaries of the municipality. Of the job commuting that takes place from Malå, about 2/3 goes to the neighbouring municipalities of Lycksele and Norsjö, and a large portion goes to mines in these municipalities. State prospecting, which was conducted through SGU and later SGAB, has been abandoned. Just a few years ago, SGAB employed more than 200 persons in the municipality. The instrument company Malå Geoscience and consulting companies such as Malå Mineral have arisen in the wake of the prospecting activities. These companies together employ 40–50 persons. SGU has once again started some activities in Malå through the establishment of a mineral office, which administers national prospecting archives and handles SGU's contacts with commercial prospecting interests.

The industrial sector in Malå is relatively bigger than average for both the county and the interior of Norrland. Big companies are represented, but no single company dominates in terms of jobs. The biggest is Malå Trä, which has about 150 employees. Small-sized enterprises are of great importance for employment.

Like other municipalities in the country, Malå has for some time now had most of its jobs, nearly 70%, in the service sector. Nearly 2/3 of the service sector lies within the public sector, which is fairly typical for the inland municipalities of Norrland.

The private portion of the service sector includes trade, transportation, some consulting and service activities, and the travel or tourist industry. Activities within the tourist business are limited. Malå lies outside the major tourist belts and does not really have any unique or better attractions for tourism than other Norrland municipalities. The number of guest-nights in the municipality has been estimated at about 85,000 per annum, of which 15,000–20,000 are commercial (hotels, rented cabins, camping grounds etc.). The rest are nights spent in own cabins, with friends and relatives, etc. Depending on how tourism and the travel industry is defined, it brings in SEK 10–40 million in revenues per year and provides 10–40 full-time jobs. The number of individuals employed is greater, however, since many work part-time /8-3, 8-4/.

The marketing campaign launched by Malå Turism – under the motto "Malå with everything so near" – has been successful. The emphasis is on regional family tourism, with the centrally located skiing and sports facilities in connection with the hotel at Mount Tjamstan and the bathing and camping grounds at Nölviken as a base. With supplementary contributions from successful individual activity organizers and entrepreneurs, this is very valuable for creating a positive image of the municipality at the same time as it provides additional employment and rich leisure-time opportunities for the inhabitants of the municipality.

Table 8-1 shows how employment in the municipality in 1992, with a total of about 1,500 jobs, is distributed among different economic sectors. The number of persons employed has declined by nearly 25% since 1985. Only the sector "Public services" has increased, but even there the trend now seems to have been broken. There has been a shift from the base industries to the public sector. Table 8-2 shows Malå Municipality's six largest employers.

Table 8-1. Number of persons employed in different sectors in Malå Municipality /8-2/.

Economic sector	1985	1992	Absolute change	Annual change (%)
Agriculture and forestry	194	64	– 130	–14.7
Manufacturing	337	296	– 41	– 1.8
Construction	102	78	– 24	– 2.8
Commerce	124	128	4	0.5
Transport and communications	127	132	5	0.6
Private services	343	198	– 145	– 7.5
Public services	553	584	31	0.8
Not classified	42	18	24	– 9.5
Total	**1,822**	**1,498**	**– 324**	**– 2.8**

Source: NUTEK/UMDAC 94-09-23

Table 8-2. Six largest employers in Malå 1994 /8-2/.

Employer	Number of employees
Malå Municipality	400
AssiDomän Malå Trä	120 (150 according to recent information)
Västerbotten County Council	70
Hultdin System AB	50
Samhall Safac AB	40
Malå GeoScience AB	20
Total	**700 (730)**

Source: NUTEK/UMDAC 94-09-23

The percentage of gainfully employed persons in Malå is insignificantly below the average for the interior of Norrland, which is in turn a few percentage points below the national average. Like the rest of the country, Malå has been suffering from sharply increased unemployment for the past few years.

8.3.3 Infrastructure

The main road, Highway 370, passes in a east-west direction through Malå Municipality and the central locality of Malå. The roads in the municipality are rather narrow and winding and do not conform to the best national road standard. From Lillholmträsk, about 30 km southeast of Malå in Norsjö Municipality, and eastward, however, Highway 370 is utilized for the heavy shipments from the Kristineberg Mine and is of a higher standard there. Therefore, Malå has relatively good connections eastward towards Skellefteå and the coast, despite the fact that it is located off to the side of the busiest roads in the region. Road connections in the north-south direction and the rest of the road network in the municipality are of a poorer quality, however (Figure 3-2).

There are no railways or commercial airports located in the municipality, but some are located within a reasonable distance. The Inland Railway passes through the municipalities of Sorsele to the west and Arvidsjaur to the north. The railway between Jörn and Arvidsjaur (no longer in service) passes to the northeast and links up with the main rail line further to the east. The nearest stop on the main line is Bastuträsk, which is about 90 km away. The Hällnäs-Storuman Cross Railway passes through Lycksele in the south. There are four airports within a distance of 100–150 km (Arvidsjaur, Gunnarn/Storuman, Lycksele and Skellefteå) with scheduled flights to Stockholm/Arlanda.

When it comes to job commuting and population relocation, Malå conforms to a general pattern in the region whereby the movements are mainly from the northwest towards the southeast, i.e. from the mountains and inland towards the coast. Approximately 350 Malåites work outside the municipality, while only about 125 persons residing outside the municipality work in Malå. Most outward commuting is to the neighbouring municipalities of Lycksele (including the Kristineberg Mine) and Norsjö, and to Skellefteå Municipality. Inward commuting comes mainly from Sorsele and Arvidsjaur.

8.3.4 Education

The employment problem is also connected to the educational level of the population. New enterprises on the labour market require increasingly qualified labour and continuous in-service training. In the future it will probably become increasingly difficult to balance the large number of job-seekers with the declining need for labour. Work experience and education will then increasingly become key factors.

Table 8-3 shows the educational structure in Malå Municipality in relation to that in the nation. Generally speaking, the inhabitants of Malå have less education than the national average. A large portion have only a nine-year compulsory-school education. Those who have a higher education are primarily employed within industry, crafts and education.

The need for upper-secondary education has been solved through collaboration with the neighbouring municipalities, whereby parts of the upper-secondary programme are given in Malå and the remainder is offered elsewhere. There are no other local opportunities for higher education.

Table 8-3. Level of education in Malå versus the nation as a whole /8-2/.

Level of education	Malå, %	Nation, %
9-year compulsory school	46.9	37.7
2-year upper-secondary school	34.0	26.7
3- and 4-year upper secondary school	7.2	11.9
2-year post-secondary education	6.0	9.9
3-year post-secondary education or higher	4.4	8.8
Other	1.5	5.0

8.3.5 Municipal enterprise and finances

Malå has a fairly typical economic situation for the rural municipalities in the interior of Norrland with a relatively poor tax base and extensive resource contributions in the form of state transfer payments. At the same time costs are inevitably high, something which has to do with the population density, long distances and the harsh climate. Table 8-4 shows some of the major municipal cost items in relation to equivalent costs for comparable municipalities, the county and the nation.

In 1993, the municipality's gross running costs were nearly SEK 33,000 per inhabitant. This is clearly higher than the average for the nation, and slightly higher than the average for the county. However, if we instead compare with municipalities of similar size and industrial-geographic situation, Malå is in fairly good shape. The municipality's net costs (gross costs minus revenues) are about SEK 24,000 per year and inhabitant. This is clearly lower than the average for comparable municipalities and also lower than the average for the county. Municipally-owned companies also influence the cost picture. In the case of Malå, municipally-owned enterprise has total costs which are on a par with the municipality's net costs for day-to-day operations.

Table 8-4. Major cost items in the municipal budget (SEK/inhabitant) /8-1/.

	Labour market	Education			Social care	
	Employment-promoting measures	Nine-year Compulsory school	Upper secondary school	Other education	Children	Elderly
Malå	1,595	7,516	3,158	1,134	3,828	10,583
Municipalities with 5,000 inhabitants	793	6,400	2,172	749	3,108	10,072
Rural municipality	706	6,420	2,314	657	3,617	10,231
AC counties	639	6,442	2,363	662	3,758	9,010
Nation	496	5,258	1,927	632	4,203	6,323

Malå Municipality spends considerably more than average for comparable municipalities on employment-promoting measures, school and care of the elderly. Compulsory schools in Malå have 20% higher costs per pupil than the national average. This value is close to the average for municipalities with fewer than 5,000 inhabitants and is probably largely a function of the size of the municipality. Malå has considerably higher costs per pupil than the national average for upper-secondary education as well. However, the differences are insignificant compared to the county as a whole and directly comparable municipalities.

Child care has slightly lower costs per child than the national average, but higher than for other small municipalities, see Table 8-4. Malå has considerably higher costs for care of the elderly than comparable groups of municipalities. However, direct social benefits are much lower. The same is also true of housing allowances for families with children.

In view of the acute employment situation and the dramatic structural transformation which the municipality has experienced, Malå can be said to have managed its municipal finances fairly well, compared with other municipalities with similar situations /8-1/. Of the county's inland municipalities, Malå had the next-strongest tax-paying ability after Lycksele.

8.4 Future development of Malå

8.4.1 Threats and possibilities

The investigators' review of the situation of Malå Municipality with regard to population, employment, education etc. /8-1, 8-2/ reveals a severely burdened municipality whose situation could become critical if the downward socioeconomic trend continues.

In view of the municipality's geographic location and already low number of inhabitants, a continued population decline would seriously affect its ability to maintain municipal and private services. The business sector also has to contend with disadvantages in the form of for example long distances to important markets, a harsh climate and difficulties recruiting an educated workforce.

In addition to the decline within sectors of importance for the municipality, there is also uncertainty about overall resource distribution within society. One of the studies conducted within the feasibility study /8-1/ concludes that in view of Sweden's strained finances and high dependence on international markets, it is no longer politically feasible to sustain the present-day scope of resource distribution in the form of state transfer payments. A concentration of jobs within traditional sectors plus a long-standing high level of unemployment makes the municipality vulnerable to cutbacks in the systems of state subsidies and transfer payments. Cutbacks would above all affect municipal finances.

The many unfavourable external factors lead the investigators in one of the feasibility study's sub-studies /8-1/ to draw a comparison between Malå and a bumblebee, which manages to fly even though it lacks the natural capabilities to do so. However, the same study also finds that Malå possesses important inherent advantages: a considerable measure of entrepreneurship, a strong timber products industry and municipal finances in reasonable balance are important plus factors that are mentioned.

According to the same study /8-1/, one possibility for long-term survival could be to once again consider joining with one or more other inland municipalities to form a new mega-municipality. It would then be possible to further cut costs in a kind of defensive emergency economy.

The second alternative is the offensive approach, which means that the municipality must increase its population so as to be able to offer a reasonable level of public service. This requires recruitment of an educated workforce to permit an expansion of trade and industry. Expansions among existing companies and new local business ventures are necessary, but far from sufficient. It is judged unlikely that an expansion of the existing business sector could create more than 100 new jobs during the next 5–10 years /8-1/.

In addition to efforts to promote growth of companies with development potential, it would thus require a massive initiative to find and establish new enterprises. The investigators find it urgent that Malå Municipality re-examine its strategic situation and concentrate its efforts on areas and business sectors where they have or can create potential advantages over other municipalities.

Special mention is made of some favourable characteristics which, if properly managed, could yield advantages and contribute to "commercial opportunities":

- The entrepreneurship and business savvy that exists in a number of companies.
- The municipality's position as a wood-products centre in AssiDomän's northern province.
- The know-how in mineral prospecting and the information base that still exists.
- Municipal leaders who have managed to keep the municipal finances in reasonable balance.

A long-term stable base in one of Europe's largest timber products companies, a tradition of enterprise and a potential jackpot in the mineral prospecting sweepstakes combined with the possibility of new mining operations could at best provide opportunities to reverse the situation in Malå.

However, there are scarcely any "hard facts" to suggest that the negative trend could be reversed. Such a trend reversal would require a combination of positive outside events and hard work on the part of the municipality. This requires political consensus and the broad, united support of business leaders and citizens. According to the investigators, the small size and peripheral location of the municipality mean that current efforts must be redoubled many times over to yield results /8-1/.

Other drives and campaigns, such as in the tourism and travel sector, are judged to hold out less promise. The actors involved in this sector within the municipality should work to develop their present-day markets and products. There is probably also room for one or two new entrepreneurs – the crucial factor is whether there are people with the ideas, the ambition and the capability to develop new businesses. If so, new jobs can be created within this sector as well /8-3/.

8.4.2 A reference scenario

In order to assess how the development of population and employment in Malå may be affected if a deep repository is established in the municipality, a forecast or projection is first needed of how the socioeconomic situation will develop without a deep repository – a reference scenario.

As has been previously noted, many alternative assumptions can be posited as a basis for forecasts of future trends in society. Naturally, the longer the time periods considered, the greater the uncertainty. The point of departure for the reference scenario chosen in the feasibility study is the currently known set of structural preconditions. The predictive model used is based on systematic studies of historical industrial and infrastructural investments, with an emphasis on ventures in the counties of Norrland /8-2/.

In relation to the current development trend, the chosen predictive model can be said to paint a slightly optimistic picture of the course of events. It should also be noted that any long-term projection of economic development based on currently observed industrial trends has a tendency to be conservative on the whole. This is due to the fact that the truly new and important developments which the future always brings are underrated, since by definition they can never seen in the present.

The studied reference scenario (without deep repository) is based on the following assumptions:

- For the three industrial sectors agriculture/forestry, manufacturing and tourism, it is assumed that most of the demand lies outside the municipality. Production and employment are therefore not affected on the demand side by changes in the local population base. Employment in these sectors is assumed to change as follows:
  - agriculture/forestry declines by 10% per annum up to 2000, thereafter by 1% per annum;
  - manufacturing declines by over 2% per annum up to 2000, thereafter by 0.5% per annum.
- For all other economic sectors it is assumed that the demand mainly exists within the municipality. Production and employment therefore follow changes in the population base and are projected to be as follows:
  - construction declines by 10% per annum up to 2000, thereafter by 0.25% per annum;
  - commerce declines by 4% per annum up to 2000, thereafter unchanged;
  - transport and communications declines by 2.5% per annum up to 2000, after which the number of jobs increases by 0.25% per annum,
  - private services increases by 10% per annum up to 2000, after which it increases by 0.25% per annum;
  - public services declines by 2.5% per annum up to 2000, after which the relative share remains unchanged.

Figure 8-3 shows how the number of jobs in the municipality according to this model would change up to 2080, in different economic sectors and overall. From a maximum of 1,800 in 1985, the number of jobs declines according to the projection by about 500 during the period, i.e. to less than one-third of the original level. This decline may appear drastic, but the time period is long. Between 1985 and 1992, the number of jobs declined from 1,822 to just under 1,500, i.e. by nearly 3% per annum. During the projected period 1990 to 2080, the total number of jobs declines by an average of 1.35% per annum. Thus, with the assumptions made concerning the trends within the different economic sectors, the rate of decline during the forecast period is less than half of the current rate.

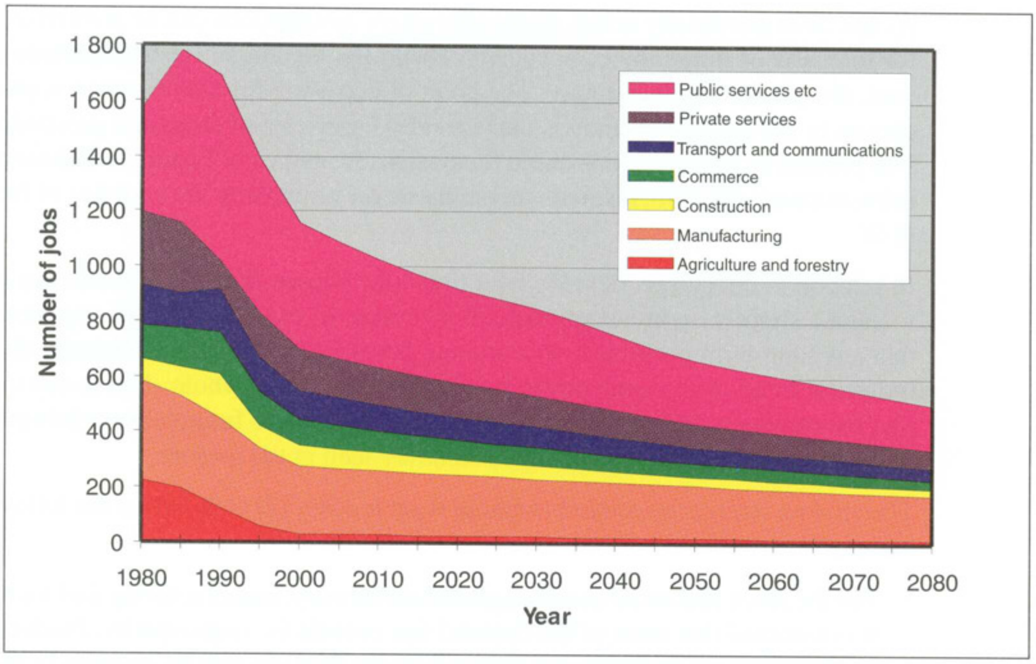


Figure 8-3. Forecast: Total number of jobs broken down by economic sector – without a deep repository.

The population decline in the municipality is assumed to lead to a reduction in the number of inhabitants by more than half by the middle of the next century. This has to do with the interplay between population and labour market. The municipality had 4,300 inhabitants in 1980. The number of inhabitants is projected to have fallen to below 1,400 a century later /8-2/.

8.5 Local and regional effects of a deep repository establishment

8.5.1 Activities, personnel requirement and recruitment

Activities

The deep repository's facilities and the planned activities are presented in Chapter 6. In brief, construction of the deep repository according to plan entails that regulatory review, detailed characterization and primary construction be carried out starting around the turn of the century, with the aim of starting initial operation no earlier than 2008. During this period, the necessary expansions of the transportation system (harbour, roads, possibly railway) will also take place. The subsequent operating phase will involve about one-tenth of the total quantity of waste, and will be concluded with a thorough evaluation. If the outcome of this evaluation is good, deposition will be completed in a second operating phase, which will last until the early 2040s. Operation will proceed in parallel with continuous construction underground, proceeding at the pace at which new deposition areas are needed. After concluded deposition, a period will follow with a gradual winding-down of the activities, closure of shafts and ramps, demolition of the surface facilities, site restoration, etc.

Expansions and improvements of transport guideways, from the harbour to the site of the deep repository, are conventional engineering works. The construction of the deep repository's surface portion, the "industrial area", will largely consist of ordinary industrial building and installations. Transportation of equipment and materials will comprise a considerable portion of the construction and civil engineering activities. The emphasis in the underground construction work will be on conventional rock excavation and installation tasks and continuous geological investigations.

Operations at the deep repository will bear resemblances to the activities at a processing industry, and even more to operations at the existing waste facilities CLAB and SFR. The activities are characterized by relatively high labour intensity (labour as a proportion of total costs). The facility will contain a lot of high-tech equipment, but the high-tech share of the total work that needs to be done is lower than is often believed.

Personnel requirement

SKB's planning work includes calculations of the deep repository project's labour needs. On average, when viewed over the 50-year period the project is expected to span, it is estimated that the deep repository with peripheral activities will employ about 250 persons. The number of employees and their occupational categories will, however, vary during the different phases of the project.

Site investigation

The tasks involved with a site investigation consist primarily of drilling, investigations and measurements, plus minor road construction. A site investigation is estimated to take 3–4 years and occupy 10–20 persons. The site investigations are a part of the siting process and are thus carried out before a decision is taken regarding the location of the site.

Detailed characterization and construction

Detailed characterization will be done when a site for the deep repository has been selected and a permit for construction has been obtained. The characterization includes excavation of a ramp or shaft down to a depth of about 500 metres, so a large part of the workforce will be engaged in rock excavation works. Some civil engineering work will also take place above ground for construction of access roads etc. Furthermore, the characterization work will engage technicians and personnel with a geoscientific background.

The initially limited scope of the work during the detailed characterization phase will gradually expand into full construction activities. As the construction phase's civil engineering works get under way the personnel requirement will increase rapidly and may at most amount to 500–600 persons. Of these, roughly half will work with construction of the deep repository above and below ground, and half with construction/improvement of the harbour and transport guideways. The labour requirement for the transport guideways will naturally be determined by the choice of transport mode (rail or road) and by the geographic location of the deep repository in relation to existing transport guideways.

Operation

Viewed over the entire operating period, including initial trial operation and subsequent regular operation, the personnel requirement is estimated at about 200 persons. The requirement is slightly smaller during initial trial operation, since deposition activities then take place on a limited scale, while the requirement during regular operation is estimated to be slightly more than the average of 200 persons.

Table 8-5 provides an idea of what duties will be incumbent upon the deep repository's site organization during the 30-year period during which regular operation is estimated to take place. The operational tasks include the activities involved with transportation, deposition and backfilling, as well as the continuous expansion of the deep repository which will proceed at the pace at which new deposition areas are needed for disposal. Besides operating personnel, there will be a need for personnel for units for technical support functions and maintenance, geoscientific investigations and documentation, plus general staff functions.

Decommissioning and monitoring

The personnel requirement gradually diminishes during the decommissioning phase. The scope of any monitoring after completed deposition, closure and finally decommissioning and restoration of the deep repository site is determined by every new generation. It is therefore difficult to estimate today personnel requirements or time horizons for these activities.

Qualification requirements and recruitment

When it comes to qualification requirements and recruitment for the deep repository project, clear differences can be seen, as for other industrial establishments, between the facility's construction phase and the operating phase. The construction phase is relatively short-lived. The procurement form has not been determined, but it can be assumed that much of the work will be contracted out. Regardless of procurement form, the activities will be characterized by a high proportion of temporary undertakings with delimitations in time and scope. This is reflected in the organizational arrangements and the forms for recruitment of personnel.

The operating period has a much longer time horizon, requiring a more permanent site organization and continuous access to qualified personnel. The site organization for operation must be built up in good time so that personnel with the right training and skills for the tasks at hand can be found. As within other branches of industry, in-house training will be required both before and during the operating period.

In view of the long period of time and the need for continuous access to qualified personnel, it is essential that the site organization be based as much as possible on personnel who live and have roots in the local community. A high proportion of local recruitment is therefore desirable from the viewpoint of the project. Experience from similar projects also shows that operation is usually characterized by a high proportion of local recruitment and low personnel turnover. Experience also shows that people who are initially engaged temporarily during the construction phase often put down roots and find permanent employment during the operating phase.

Table 8-5. Examples of duties at the deep repository during regular operation (total about 220 full-time jobs).

Function	Activities
Operations	
Operations management	Work planning, preparation, coordination, management, waste records, access control, radiation protection, dosimetry, control room function
Rock engineering works	Rock excavation, reinforcement, rock haulage, boring of deposition holes, drilling of test holes/coring
Deposition	Deposition tunnels: preparations, quality control of deposition holes, deposition, backfilling
Harbour	Operation and administration, unloading/loading/maintenance
Road/railway	Shipments, surveillance
Transportation at deep repository	Unloading and buffer storage of transport casks/containers, bentonite, sand Waste canisters from buffer store on surface to deposition tunnels Other waste from buffer store on surface to repository for such waste Bentonite blocks from factory to deposition tunnels Bentonite-sand mixture from preparation plant to deposition tunnels Building materials, machine parts, consumable supplies etc.
Preparation of backfill material	Fabrication of bentonite blocks for deposition holes and backfill material for deposition tunnels Stores-keeping – sand, bentonite and ready-made bentonite blocks
Service	Preventive maintenance, repairs – installation and machines
Rock dumping	Dumping of rock waste, possible crushing, landscaping
Technology/Maintenance	
Plant records	Buildings, systems, machines, components
Systems engineering	Design: mechanical, electrical, hydraulics, pneumatics, electronics for systems, equipment and machines
Workshops	Qualified machining work for steel structures, welding and forging, electrical and electronic equipment
Stores	Forwarding, receiving inspection, internal distribution, stores-keeping
Assembly	In-house assembly, assembly inspection, trial operation of contracted works
Maintenance	Elevators, hoists, overhead cranes, etc.
Rock investigations	
Documentation	Geo-data, CAD documentation
Geology	Mapping, evaluation
Rock mechanics	Documentation, strength measurements, calculations, evaluation
Hydrology	Measurements of flows, chemical composition, sampling
Chemistry	Sampling, chemical analyses, evaluation
Geophysics	Measurement, evaluation
Surveying	Surveying, position measurement of boreholes, map-keeping
Drill cores	Drill core storage, specimen preparation
Geoinstruments	Instrument service, storage
Administration	
Personnel	Wages and salaries, training, fitness, health care
Accounting	Budget, follow-up, book-keeping, invoicing, cash
Purchasing	Goods, services
Office services	Custodian, telephone and computer service, files, library, office materials, furniture
Security	Access control, perimeter protection, rescue service, fire protection
Building services	Cleaning, road upkeep, snow clearance, in-facility transport, refuse disposal, building maintenance
Food service	For own personnel, contractors, visitors

The potential for local recruitment in the event of a deep repository being established in Malå Municipality is determined not only by the deep repository's personnel requirement, but naturally also by the availability of labour in the municipality and the region. The feasibility study has not included any thorough analysis of this. One factor which would obviously contribute to good local recruitment potential is the knowledge and tradition which exists within different areas such as geoscience, rock construction and operation of underground facilities, as well as heavy goods transport.

Access to qualified personnel within these fields is of crucial importance for the deep repository project during both the construction and operating phases. Another category that may be of interest is persons who are sometimes called "latent homecomers", in other words persons who have roots in the municipality, are living somewhere else and might consider returning if they are offered jobs. Whether or not this category might be important for recruitment purposes is difficult to tell.

It is also obvious that the distance of Malå from large population centres entails some limitations in local recruitment possibilities, particularly to certain specialist positions. This type of recruitment problem is generally a well-known problem in the interior of Norrland. From the viewpoint of the deep repository project it is therefore important that an establishment in Malå be preceded by careful and early planning – on the part of both SKB and the community – to create good recruitment conditions.

8.5.2 Investments, employment and population

Projections of the effects of establishing a deep repository on the employment situation in Malå are presented in this section, based on how the costs of the project are distributed among different activities, chronologically and geographically.

Cost estimates for the deep repository project have been obtained from SKB's plan work. Besides the customary cost items, these cost estimates also include a general contingency allowance of 20%. The reason for this allowance is that the estimates are used as a basis for calculating the size of the allocations that are made to the reserve funds which finance the nuclear waste programme. The purpose is to ensure with ample margin that safety is not compromised due to insufficient financing or optimistic cost estimates.

The total cost for the deep repository is estimated at about SEK 15 billion. About half of this is labour costs. The rest is divided among different kinds of materials and equipment. Machines, sand, bentonite clay and electrical installations are examples of large cost items.

Of the total investment, some will be absorbed locally in the municipality, some will be used for the benefit of the region, and a third portion will be spent elsewhere in the country or abroad. Experience from other industrial investments shows that the local share of the total value added in the investment activities varies a great deal from case to case. Studied cases show a span between 11 and 60% local procurement /8-2/.

In the case of the deep repository, the biggest costs in the beginning will be for construction of the surface facilities and investments in the harbour and transport guideways. Resource consumption will then progressively shift towards the underground portion. In the calculations that have been made of the distribution of resource consumption over time, it has been assumed that the largest costs (nearly SEK 4 billion) will be incurred during the period 2005 to 2009, when for example the traffic connections are built. Operation is then assumed to continue until the beginning of the 2040s, after which activities will be gradually wound down.

Jobs will be generated directly at the deep repository, but also upstream in the value-adding chain, at the companies that deliver goods and services in connection with construction and operation. The customer base for the local service businesses will also be strengthened, which creates indirect employment.

To calculate the direct, local employment effect, i.e. the effect generated solely by the deep repository, an assessment must be made of the components of the investment. Based on relatively detailed data from SKB's plan activities, the different cost items have been analyzed for the purpose of estimating the portion that will be a local cost – a local value added. The local portion varies greatly between different cost items. For example, it can be assumed that payroll costs for the construction on the site will be fully absorbed locally. On the other hand, the payroll costs for design and manufacture of equipment will probably have small local effects, since these activities are carried out elsewhere. In general, items characterized by purchases of materials have smaller local effects than items that include wages.

After the local, regional and external shares of the components of the investment were assessed, they were added together. The results are shown in Figure 8-5. The total local value added is estimated to be about SEK 4 billion, which is roughly 27% of the whole cost of the deep repository. In terms of employment, this corresponds to about 200 jobs per year during the first 50 years of the next century.

Another portion of the value added is absorbed regionally, i.e. outside the municipality, but within the counties of Norrbotten and Västerbotten. This portion is estimated to be SEK 1.5 billion, or 10% of the total cost. This would correspond to about 70 jobs per year in the region.

The local and regional employment effects calculated in this manner – 200 plus 70 jobs – can be compared with the figure given in section 8.5.1 – 250 jobs – which was based directly on estimates of the deep repository's personnel requirement. In other words, the two calculations yield comparable results.

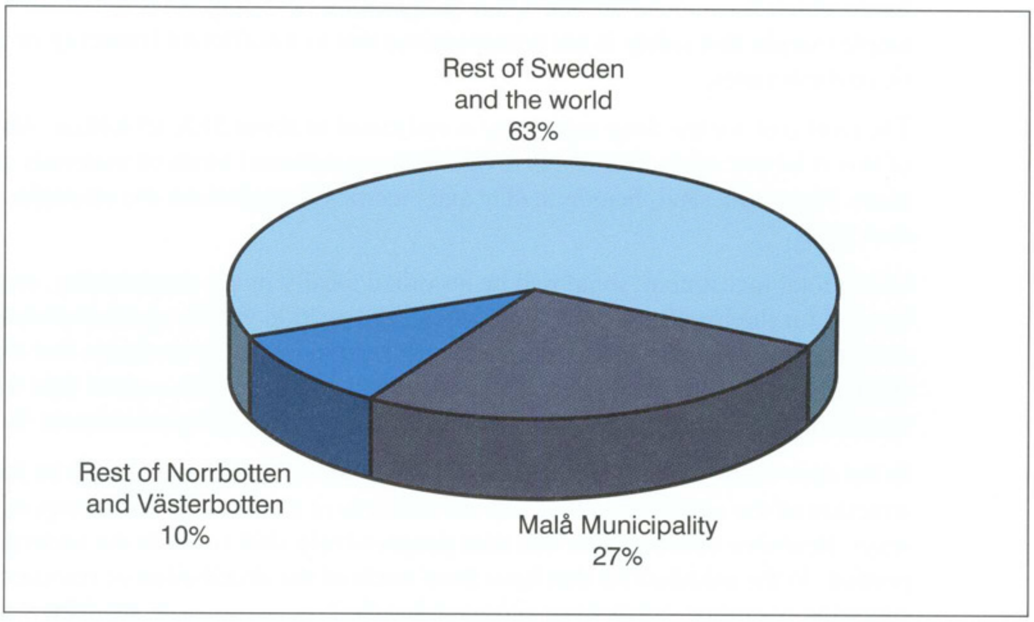


Figure 8-5. *Where will the money go if a deep repository is established in Malå? The total cost is estimated to be SEK 15 billion.*

In addition to the direct, local employment effect in Malå, about 100 jobs will be created in private and public services. This indirect effect is a consequence of the population increase generated by a deep repository establishment. The aggregate employment effect in Malå would thereby be about 300 jobs per year for a period of 50 years.

Based on the subdivision of the investment into different components and its geographic distribution, a breakdown among different economic sectors can also be estimated. Figure 8-6 shows such an estimate, regarding the local employment effects in Malå (direct and indirect).

Not unexpectedly, the biggest job bonus goes to the construction industry, which accounts for over one-third of the whole employment effect. Rock construction, which takes place throughout the operating period, comprises an important part of this. Public and private services together account for nearly another third of the total. The final third is distributed, in order of size, among transport and communications, manufacturing, commerce and other.

If the effects outside the municipality – in the region, the country and internationally – are considered instead, the picture is another one. There the contribution to the construction industry is small. Instead the picture is dominated by commerce and manufacturing. This also means that it is within these economic sectors that possibilities exist to redistribute the geographic distribution of the investment, as shown in Figure 8-5. Proximity to subcontractors is generally an advantage, which, in view of the strong industrial tradition in the region, means that it may be warranted to evaluate the possibilities of increasing the local and regional shares of manufacturing, fabrication, product agencies etc.

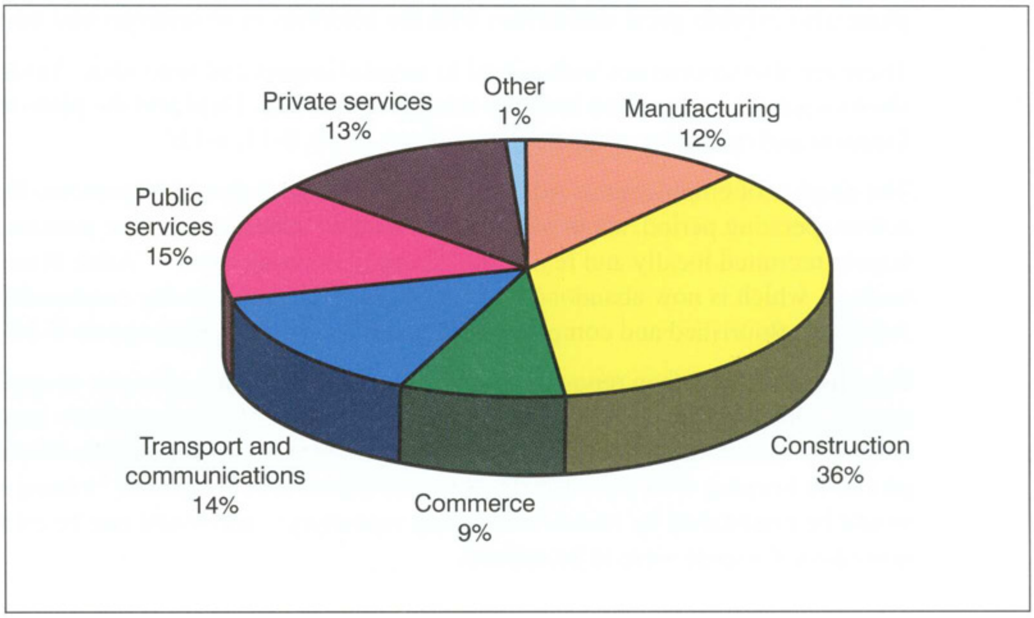


Figure 8-6. *Forecast: Local employment effect (direct and indirect, total about 300 jobs) of a deep repository establishment in Malå. Average for the period 2000–2050, broken down among economic sectors.*

The stipulated employment effects are average values over a fifty year period. Figure 8-7 shows an estimate of how these effects may be distributed over time. According to the calculations, a large need for labour will arise during a period of a few years after 2005 in conjunction with the construction of the facilities and the transportation system.

In order to enable the estimated employment effects to be evaluated from a socioeconomic point of view, they must be converted to equivalent population effects and considered in relation to the projected socioeconomic trend without a deep repository. This is where the reference scenario outlined in section 8.4.2 enters the picture again.

Figure 8-8 shows a forecast of employment and population in Malå Municipality, with and without a deep repository. The higher level of activity with 300 new jobs would mean that, on average, an additional 430 persons would be living in the municipality during the first half of the next century. This population effect will be relatively evenly distributed throughout the period and give the municipality a larger population and more jobs even long after the activities at the deep repository have ceased.

In conclusion, it can be said that the effects of a deep repository on employment and population would be considerable. But the effect is still not sufficient to compensate for the downward trend in the population and employment curves /8-2/.

8.5.3 Experience from comparable facilities

Similarities and dissimilarities with mines

A deep repository resembles a mine in many respects. The most obvious similarities are purely physical, with the facility's tunnels and shafts and excavation at roughly the same depth. In terms of working environment, the deep repository's construction phase also exhibits great similarities with the activities in an underground mine.

There are also similarities with regard to societal impact and time scale. Table 8-6 shows a simple comparison between mining in the Adak Field and the plans for establishment and operation of the deep repository /8-10, 8-11, 8-12/.

The number of employees in Adak varied, but averaged about 160 persons. During the active operating period, about half of them worked underground. The personnel was largely recruited locally and regionally. A special mining town – "Adak Mine" – was built up, which is now abandoned, like the mines. The present-day community of Adak also flourished and competed with Malå during the mining epoch /8-10/.

Establishment of a deep repository would, as reported earlier, give rise to approximately 200 direct and 100 indirect jobs, a large portion of which could be recruited locally. The duties at the deep repository would require personnel with an educational profile in keeping with the estimate shown in Figure 8-4. No special "mining town" would be established by reason of the deep repository – nor would one be established nowadays if a mine were to be opened.

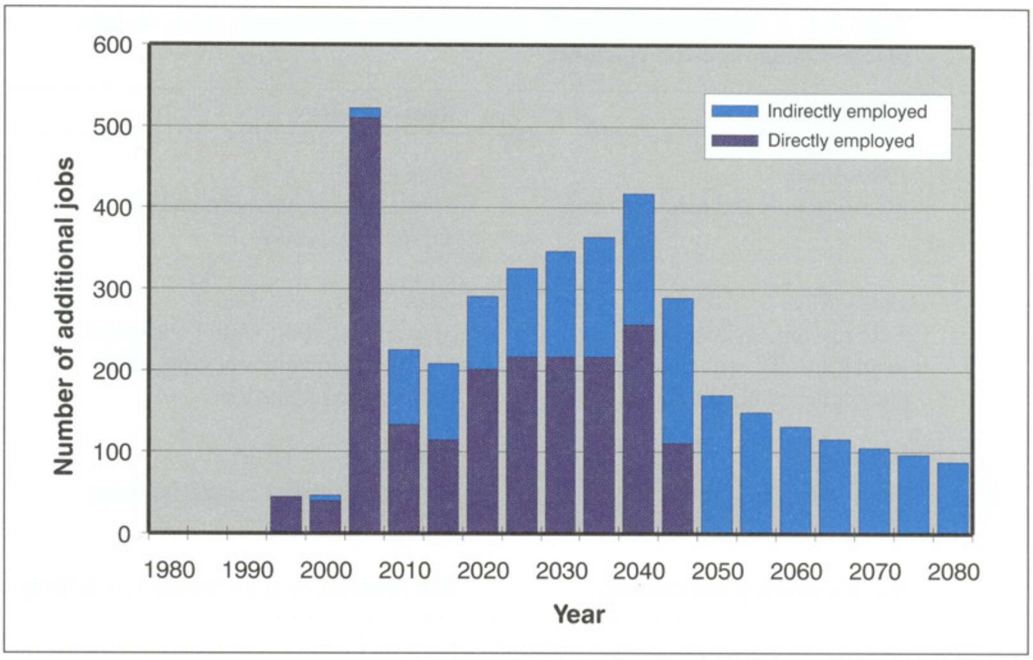


Figure 8-7. *Forecast: Direct and indirect employment effects of a deep repository in Malå Municipality.*

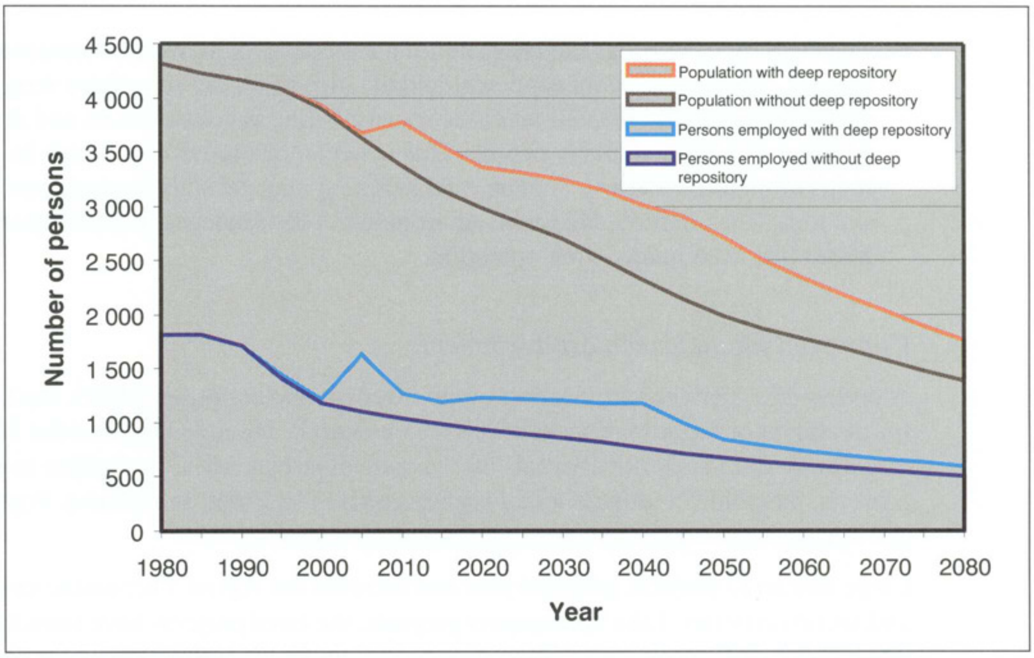


Figure 8-8. *Forecast: Population and employment in Malå with and without a deep repository.*

Table 8-6. A comparison between former mining activities in Adak and the planned deep repository project.

Adak mine field	Deep repository
1920–1940 Investigations and measurements	1994–2010 Studies – investigations and civil engineering works
1940–1977 Trial mining, and expansion to regular mining with concentration plant, plus continued investigations	2010–2040 Start of operation, initial operation, evaluation, regular operation and progressive expansion
1977–1980 Final mining and shutdown	2040–2050 Final deposition, decommissioning and closure
Site remediation and cleanup	Site restored, only prohibition on drilling etc.

There is also reason to point out some important fundamental differences, from the viewpoint of society, between a deep repository establishment and mining operations:

- The deep repository is not dependent on revenues or economic cycles. The resources for construction, operation and decommissioning have been set aside in advance. This makes long-range planning of the activities possible in a way that is not possible in an industry whose existence is based on generated revenues. This is of great importance for the integration of the project in general community planning.
- The deep repository has the character of a national project which contains unique aspects. Nuclear waste management and the idea of a deep repository arouse political interest and debate at all levels of society. Siting is controversial and arouses feelings of anxiety in many people. This is in contrast to mining, which is not in the focus of national interest. A mine establishment may possibly be more controversial today than before, due to the environmental disturbances (not unknown in Malå) that accompany mine operation.

Controversial industrial establishments

A review of experience from siting of the Swedish nuclear power plants, the facility for treatment of hazardous waste (SAKAB) in Kumla Municipality, and the Scanraff oil refinery in Lysekil /8-8/ reveals that in spite of strong initial opposition to these projects, the public's attitude today is characterized by broad acceptance. Population and employment levels have exhibited favourable development.

Large industrial projects generate jobs and increase the region's economic strength and social activities. Like hydropower projects, the cited projects have initially had a labour-intensive construction phase. For a municipality it is the subsequent operating and maintenance phase that provide long-term employment, stability and development potential. The facilities studied, with the exception of the smaller SAKAB plant, account for 10–20% of the employment in the municipality in question and are therefore regarded as very valuable by the municipalities.

The personnel recruited have largely been well-educated and have often brought young families with them. This population increment is judged to have contributed to positive developments in many ways, for example through an expansion of activities within the cultural, athletic and social spheres. The establishments have often had a positive effect on the educational system and infrastructure in the municipalities, in some cases on health care as well. No direct negative effects have been mentioned by municipal officials /8-8/.

An establishment leads to increased tax revenues for the municipality thanks to the immigration of labour and the often relatively high wage level in the enterprises. Many municipalities have also been able to increase their economic gain from the establishments by signing land development and cooperation agreements with the developer. This enables the municipality to cover special costs occasioned by the establishment, but can also simply be means of generating revenue.

8.5.4 Tourism and the travel industry

The effects of a deep repository establishment on tourism and the travel industry include both direct effects in the form of business travellers and visitors generated by the establishment and presence of the deep repository in itself, and possible indirect consequences which the facility and its activities can have for tourism and the rest of the travel industry. Both direct and indirect effects are difficult to project.

Currently, Malå has a limited travel industry which is judged to have little potential for development on any large scale. The number of commercial guest-nights is 15,000–20,000 per annum, and the industry's annual revenues within the municipality are estimated at SEK 10–40 million, depending on how the travel industry is defined and delimited /8-3/. Most of the revenues can be attributed to visitors from the region.

Direct effects

A deep repository facility would generate extensive and stable business travel which would bring both Swedish and foreign guests. This would enable Malå to even out the seasonal ups and downs in occupancy rates which currently characterize tourism in the municipality /8-3/.

Besides such pure business travel, it is believed that a deep repository would attract a considerable number of more or less organized visits, which would bring in significant numbers of new categories of visitors. The special nature of the facility and the fact that it would be one of the first of its kind in the world could result in considerable international attention. The level of international interest will largely be determined by attitudes in the future towards nuclear waste disposal in general – a factor which can hardly be predicted today.

Experience from other nuclear installations can provide some guidance, even though direct parallels cannot be drawn. Table 8-7 shows a compilation of visiting statistics from Swedish nuclear installations. The Ringhals and Forsmark nuclear power stations top the statistics with over 20,000 visitors each per annum, of which about 30% are unscheduled visits. The remainder are scheduled visits from schools, companies, government agencies, politicians, journalists etc. Approximately one-third of the visitors come from abroad. Ringhals has been visited by more than 450,000 people since its inception in 1972.

SKB's facilities (CLAB, SFR and the Äspö HRL) also receive a considerable number of visitors each year. CLAB and SFR are particularly interesting, since radioactive waste is actually handled and stored there. The waste the visitors are able to see today during interim storage in CLAB will eventually be transferred to the deep repository /8-4, 8-8/.

Table 8-7. Visiting statistics from nuclear installations in Sweden

Facility	No. of visits in 1993	Unscheduled visits
Nuclear power stations[1]		
Forsmark	21,146	28%
Oskarshamn	10,147	26%
Ringhals	23,852	29%
Waste management and research		
CLAB (Oskarshamn)	7,795[2]	
SFR (Forsmark)	18,235[2]	
Äspö (Oskarshamn)	3,179[2]	

Sources: /8-8/ and written and oral information from the facilities.

[1] Equivalent figures have not been able to be obtained from the Barsebäck nuclear power station.

[2] The figures relate to 1994. Most of the visits are scheduled. Many people visit more than one of the facilities, so it is not possible to total the number of visitors.

An estimate of the frequency of visits to a deep repository in Malå points to something on the order of 5,000–10,000 per annum /8-4/. This would contribute roughly SEK 5–10 million per annum in revenues to the local travel industry.

Indirect effects

Concern is often expressed that the establishment of a facility linked to nuclear waste would have negative consequences for the region's tourist image, locally and perhaps also in a larger region. In the case of Norrland, such fears are mainly expressed with respect to nature-oriented tourism.

In one of the feasibility study's sub-studies /8-3/ it is concluded that a possible decline in or slower growth of nature-oriented tourism to the interior would have a limited effect locally in Malå, but probably greater consequences regionally. Most people who visit Malå Municipality come from the counties of Norrbotten or Västerbotten. The visits are largely made to see relatives and friends or to stay in holiday cottages. Judging from experience, this group will probably not be affected appreciably by a deep repository in the municipality /8-6/.

The tourism industry itself has not published any objective or clear-cut estimates of the consequences a deep repository would have on tourism in Malå and Norrland. A majority of the industry representatives who were questioned within the framework of one of the sub-studies /8-3/ have a negative or ambivalent attitude. The most negative are representatives of companies and tour operators who market Norrland as Europe's last wilderness. At the same time there is a small group who are positive to the idea of a deep repository, believing that any negative effects would be limited and short-lived.

Several tourism industry representatives have noted the role of the mass media in the issue /8-3/. The mass media are in turn dependent on the attitude of the local population in their judgement. If those who live in the region where the deep repository is established feel secure, they convey this feeling to both the media and visitors. Some observers believe that the press will influence tourism to a very high degree, while others believe that the issue will mainly be a subject of local debate.

As is the case when it comes to direct effects, experience from localities where nuclear installations have been established can tell us something about indirect effects as well

– again with the reservation that direct comparisons with a deep repository must be made with great caution. The nuclear power plants at Ringhals (on the coast of Halland in southwestern Sweden) and the facilities in Oskarshamn (opposite Öland, on the southeast coast) are situated directly adjacent to very attractive tourist regions, and can therefore be of special interest.

A survey from Umeå University /8-6/ presents the results of discussions with tourist agencies in the municipalities where the Swedish nuclear power plants are located. It was found that no studies have been carried out in these municipalities of how the nuclear power plants have affected tourism in the municipality or the region. The extensive survey conducted among tourists in Kalmar County does not mention the fact that the Oskarshamn Nuclear Power Station is situated nearby. It is not possible to draw any certain conclusions, but it does not appear as if tourism has been affected to any great extent.

A sub-study of the REKO project "Nuclear waste disposal – threat or local development opportunity?" /8-9/ dealt with the fears that a deep repository might have significant negative local or regional effects on, for example, the tourist industry. As a measure for the purpose of comparison, the prices of weekend cottages in Swedish nuclear power municipalities and their environs were studied, together with the results of a number of North American surveys on the same theme. The hypothesis was that if the facilities damage the recreational image of a municipality or region, this should be reflected in a poorer development in the prices of weekend cottages compared with other areas. The study showed that no such effect could be demonstrated in three of the four nuclear power municipalities. The exception was Kävlinge Municipality (Barsebäck). No effect on the price trend for permanent homes could be demonstrated in any nuclear power municipality.

The overall conclusion is that the establishment of a deep repository would have predominantly positive effects on tourism and the travel industry locally in Malå Municipality. The main reason is the extensive business and visitor travel which the deep repository would in itself generate. The validity of the fears that have been expressed for negative indirect consequences for the region's tourism as a consequence of a deep repository are very difficult to judge. Many observers within the industry see considerable risks, while experience from localities where nuclear installations are already established does not suggest any negative impact.

8.6 Comments

The account given in this chapter has reflected various socioeconomic conditions in Malå Municipality, and to some extent also in the region, based upon:

- A general history and a description of the current situation.
- Model calculations and projections of future development, without a deep repository project (the reference scenario).
- A description of the deep repository project and its investments, personnel requirements, etc.
- General experience from similar facilities and activities.

By combining the information, it has then been possible to make an assessment of the local and regional effects of the establishment of a deep repository in Malå.

The analysis presented here makes no claims on completeness. The question of the socioeconomic effects of the deep repository project is intertwined with more general social issues and is therefore difficult to isolate. The discussion in the feasibility study can be said to have been conducted from a rather narrow "deep repository perspective", in the sense that the forecasts have essentially dealt with the resources in the form of investments, manpower, services etc. which the project would require. Integration possibilities with other societal interests have only been touched upon peripherally.

The overall plan for the execution of the deep repository is governed by safety-related and technical requirements and considerations, questions which come under close regulatory scrutiny, with the Government making the final decisions. The size, long time horizon and cyclical insensitivity of the project nevertheless provide ample opportunities to bring about good integration within broad frames with the local and regional communities.

An example is the question of the deep repository's personnel requirement, where the discussion has been based entirely on the deep repository's concrete needs in different phases of planning, construction and operation. However, corresponding needs for preparatory training activities or other measures to enable the recruitment needs to be met have not been taken into consideration. From the point of view of the deep repository project, good recruitment and a stable personnel situation are important quality factors. Active local involvement within the training sector and in efforts aimed at attracting people to move to and live in the locality is therefore reasonable.

The employment effects of the deep repository have been calculated in a similar manner. The calculation models that have been used take into account a variety of parameters related to the general evolution of society, local conditions, and investments in the deep repository and their ripple effects. Figure 8-7 presents the results, expressed as employment effects. The models do not, however, take into account any active efforts on the part of the community to take control over the course of events and thereby influence the employment effects. It should be in the interests of both the deep repository project and the community to even out variations in employment, and in particular to avoid a pronounced "building boom" in the construction phase. Experience shows that a calmer expansion phase enables the service sector to adapt more easily and generally contributes to greater social stability. Training programmes can be one way to achieve a more uniform employment level. Another can be to adjust the plans for the construction phase so that investments in the transport infrastructure etc. take place as much as possible before the most resource-demanding phase occurs in the actual construction of the deep repository. In this way the employment effects will be distributed over a longer period of time.

There should also be ample opportunities in a number of areas to achieve surplus values by coordinating the needs of the deep repository project with the needs or desires of other parties in the community. Perhaps the clearest example is the railway construction or road improvements which would be required by a deep repository establishment in Malå. This is obviously a question that would be of concern to private citizens as well as the business community and the public sector, both locally and regionally. It is further probable that the deep repository project will generate spin-off effects within the local economy which will in turn contribute to positive socioeconomic development.

If the establishment of a deep repository is considered from a psychosocial perspective, it raises a whole spectrum of thorny questions. These include the anxiety which portions of the population clearly feel at the prospect of a deep repository, what effects it will have on the community and their own life situations. Anxiety springs from different sources, ranging from a genuine fear of radiation risks – now and in the future – to the belief that a deep repository would give the region a bad image and thereby adversely affect its economic development. Local opinion and human anxiety must be taken seriously, and both positive and negative psychosocial effects should be taken into consideration along with other factors in making a final decision.

In summary, it can be concluded that, when regarded from a broader societal perspective, the prospect of a deep repository establishment in Malå raises a number of questions beyond those dealt with in the feasibility study. The importance of an interaction between the needs and desires of the deep repository project and the community is further accentuated in a small community such as Malå, simply because the project would have greater effects in relative terms in a small community than in a large one. Many aspects must be considered from points of view other than SKB's. Here the municipality and other local and regional stakeholders play important roles.

9 SUMMARY EVALUATION

9.1 Evaluation of results

The safety of a deep repository is dependent on the properties of the bedrock on the site in question. A holistic assessment of safety therefore requires detailed information on rock conditions at a depth of about 500 metres. The background material from the feasibility study is mainly limited to what can be observed at the surface. For this reason the feasibility study does not allow any more detailed assessment to be made of the safety-related siting conditions. However, a preliminary assessment, based on what can be observed and general knowledge concerning conditions at depth, indicates good prospects that continued investigations will be able to find large rock volumes that meet the safety requirements with ample margin. The same assessment is made with regard to the rock-related conditions for building and operating a deep repository.

The bedrock that can be suitable for a deep repository is found within those parts of the municipality that are covered by large areas of granitic bedrock, devoid of prospecting interest. Other parts of the municipality must be considered unsuitable for a deep repository, since they exhibit bedrock which is or could be of interest for mineral extraction or prospecting. This is a consequence of the fact that the municipality is located partially within the Skellefte Field.

Three large granite areas have been studied in greater detail. For one of these, situated in the southern part of the municipality towards the boundary with Norsjö Municipality, less information is available than for the others, due to the fact that the degree of exposure is very low. However, the information that is available suggests that the bedrock may be more heterogeneous than has previously been known. Furthermore, the area is relatively close to known ore belts.

In the case of the other two granite areas, no directly unsuitable or unfavourable conditions have been found. The areas have been marked in Figure 9-1, and are judged to be the parts of the municipality which would be of primary interest for any further investigations. One is situated in the western corner of the municipality and consists in its entirety of granite. The area is large – about 100 km^2 – and partially well-exposed. Available data show that the granite is homogeneous, fracture-poor and has relatively few major fracture zones. The other area is situated in the northern part of the municipality and has a size of about 55 km^2. The degree of exposure varies. Here as well, available data indicate homogeneous and fracture-poor granite, and few major fracture zones. Data also indicate that the depth of the granite may be limited and that the granite may be underlain by rock types of uncertain ore potential.

From a land-use and environmental viewpoint, the municipality generally exhibits good siting prospects. There are few other land-use interests within large parts, and ample opportunity to avoid intrusion in nature or culture protection areas. This also applies to the aforementioned granite areas, which are of interest for possible further studies. No direct obstacle to a siting has been found in either of these areas. The intrusion risks that exist are mainly deemed to affect nearby residents, reindeer herding, nature conservation and outdoor recreation. In general, the areas are big enough to provide ample opportunities to adjust the detailed location of the surface facilities and transport connections so that intrusion is avoided or minimized.

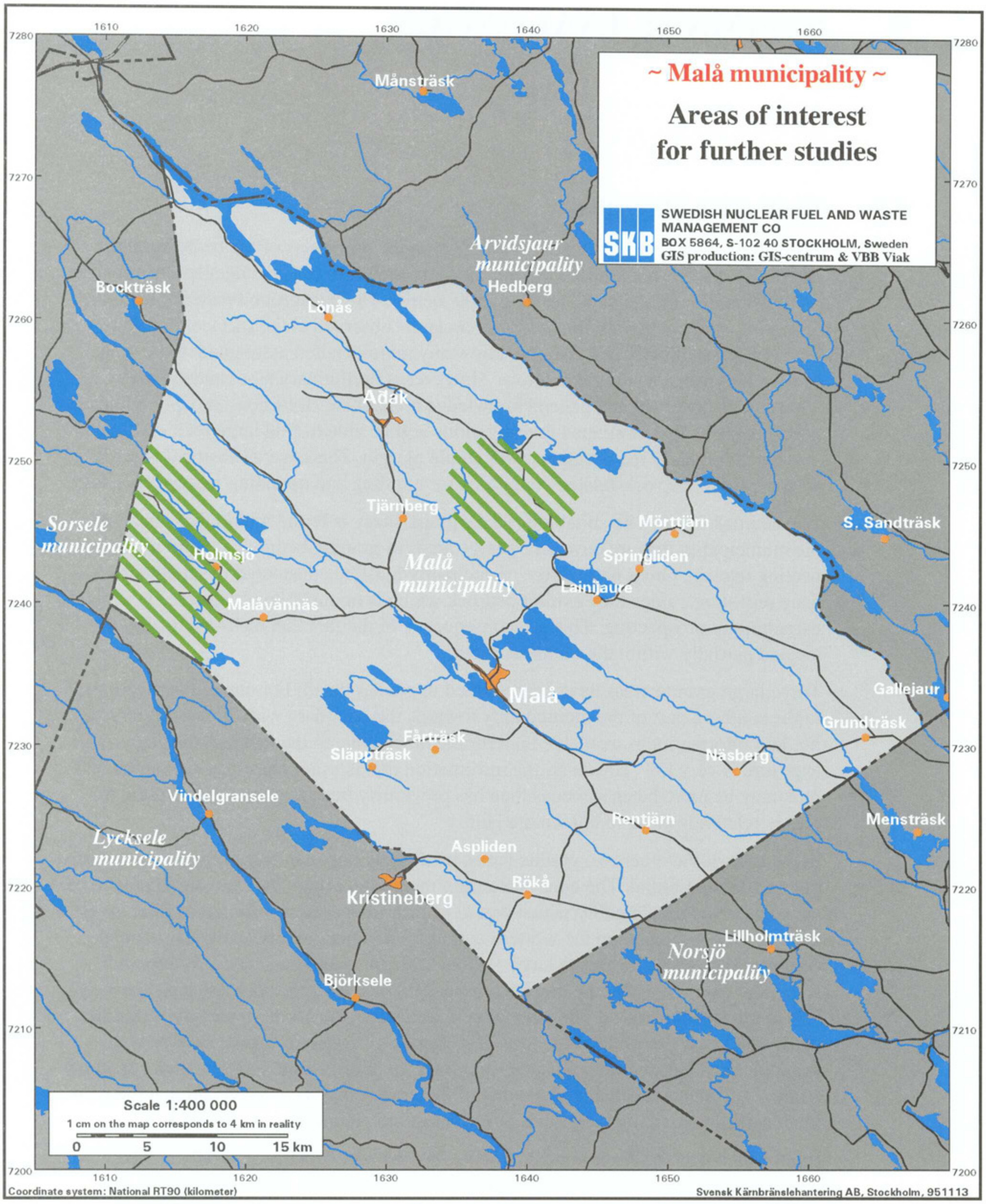


Figure 9-1. *Areas of interest for further studies. The areas are 100 km² and 55 km² in size. The area needed for a deep repository is about 0.3 km² for the surface portion and 1 km² for the deposition areas underground.*

A siting of the deep repository in Malå Municipality would entail sea transport of waste and backfill materials to a suitable coastal harbour, and overland transport from there to the municipality. The technology required to achieve radiologically safe transportation is well established and proven as a result of the extensive waste shipments that have long been performed in Sweden and abroad. Despite this documented record of transport safety, the idea of shipments of radioactive materials is a cause of real concern to many, which in the case of Malå could also include people in municipalities along the transport routes. Attitudes and opinions in the region towards the question of transport are therefore an important factor in the assessment of the siting prospects.

Shipments to the deep repository from a local harbour would require investments in the form of extension or improvement of transport guideways (roads and railway) as well as local connections to the facility. A general study shows that both rail and road transport are feasible alternatives from a technical point of view. The rail alternative would entail laying new railway from the Main Rail Line up to Malå Municipality. The road alternative requires upgrading of certain road sections and bridges, so that heavy units can be transported without requiring special arrangements or causing disruptions of other traffic. At this stage, neither of the transport modes is preferable from a safety viewpoint. Road transport is judged to be potentially advantageous in terms of risks of conflicts with other land-use or protection interests. Regardless of transport mode, the expansion of transport guideways would entail considerable improvements in the infrastructure, with positive consequences for society as a whole. Any further studies should therefore illuminate the question from a broader perspective than that of the deep repository alone, and be conducted with the participation of concerned interest groups in the municipality and the region.

Viewed from the perspective of the deep repository project, a considerable, although hard-to-calculate, siting advantage can be seen in the knowledge and traditions of the region within geoscience, rock engineering and heavy shipments. Furthermore, there is wide agreement that for the community, establishment of a deep repository in Malå would stimulate the local economy, bringing business, jobs and population growth in its wake. Opinions differ when it comes to the psychosocial aspects, however.

9.2 Possible continuation

Prospects

As far as SKB is concerned, the studies in Malå are concluded in this stage of the siting work. However, supplementary investigations or other work may be undertaken in conjunction with the independent review of the feasibility study initiated by Malå Municipality.

The next stage in the siting programme for the deep repository is site investigations, which are planned to be conducted on at least two sites in the country. Prior to the choice of sites, a coordinated evaluation of all candidate sites and possible areas is planned. Besides material gathered in the feasibility studies, the evaluation will also be based on studies on a national and regional scale. The evaluation will be done with reference to the siting factors and criteria which have been formulated by SKB and which the Government, following regulatory review, has stipulated are to guide the siting work.

The obvious fundamental requirements to be met by an area in order for it to be of interest for site investigations are that the safety-related and technical prospects are judged to be good. In the case of Malå, the conclusion has been reached that there are areas within the municipality where good prospects exist that further investigations will reveal large rock volumes which satisfy with ample margin the safety-related and technical requirements for a deep repository.

But before any site investigations in Malå can be considered by SKB, the results of the feasibility study must be compared with the results of feasibility studies in other municipalities and other background material, within the framework of the coordinated evaluation described above. As mentioned previously, between five and ten feasibility studies similar to the one in Malå are planned. One has already been carried out (Storuman Municipality) and two are currently under way (municipalities of Östhammar and Nyköping).

The continued siting process is thus dependent on successive evaluations based mainly on safety-related and technical grounds. Another prerequisite for a deep repository site is the interest and support of the local community and its citizens. Attitudes and opinions on the issue which are expressed in the municipality and the region will therefore be of crucial importance in determining whether further siting studies will be conducted in Malå. SKB will actively follow the public debate on this question and is prepared to contribute to illuminating various aspects of a possible deep repository establishment as comprehensively and fully as possible.

Activities in the event of continued site investigations

In the event of a continuation of the studies in Malå Municipality, the investigations should mainly be limited to the designated granite areas and their environs. Important geoscientific questions are the depth of the granites, the presence of major water-conducting fracture zones, and hydrochemical and rock mechanical conditions. Geophysical ground measurements and a few boreholes with associated borehole measurements can provide an initial answer to these questions. Analyses of how the granite areas are situated in relation to the groundwater movements on a local and regional scale should also be performed at an early stage. The same applies to investigations of terrain forms, which may be signs of recent (postglacial) rock movements. The results of these initial investigations will determine whether it is interesting to continue with complete site investigations in any area.

In parallel with the geoscientific studies, various inventories with respect to nature protection interests, other land-use interests etc. should be conducted.

As the investigations become increasingly focused geographically on interesting areas or sites and possible routes for transport guideways, impact assessments of various kinds will also be undertaken. These may include evaluations of the risks of conflicts with other land-use interests or protection values, intrusion into reindeer herding or outdoor recreation interests, etc. In conjunction with a future site investigation, an environmental impact assessment (EIA) will also be carried out. The forms for this work (the EIA process) can be determined to a high degree by the concerned parties and should be established before a continuation of the siting studies in the municipality.

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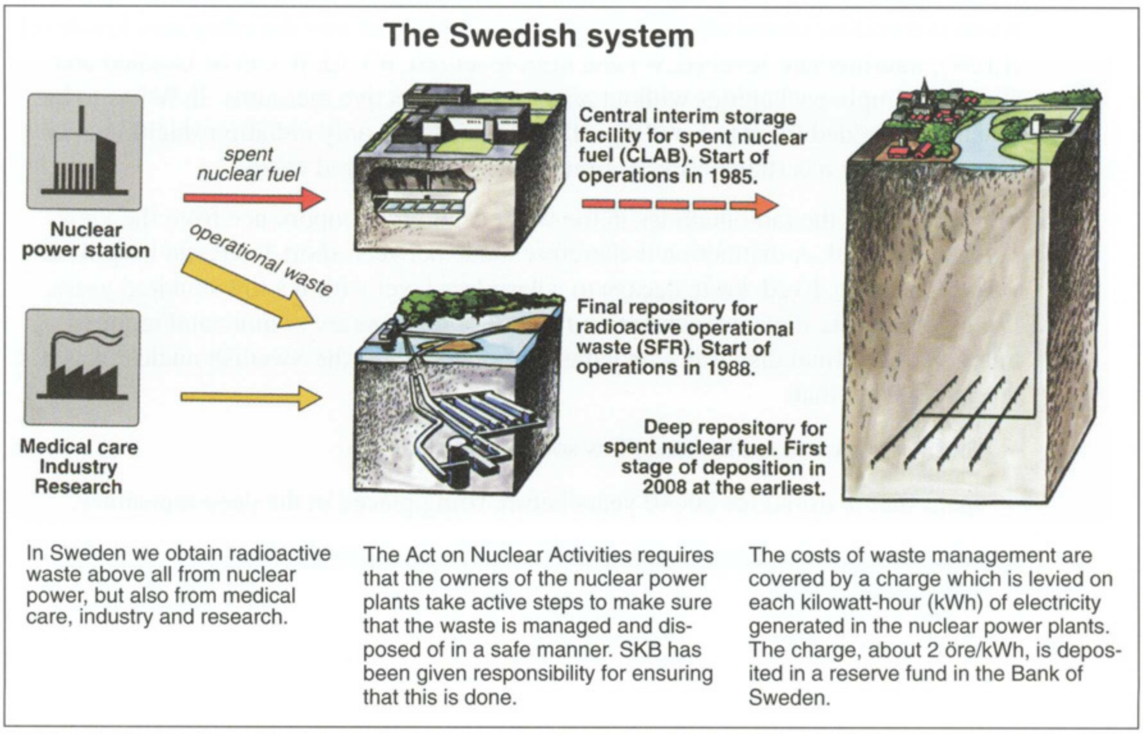
RADIOACTIVE WASTE – PROPERTIES AND QUANTITIES

Figure B1-1 shows the current situation in the Swedish system for management and disposal of radioactive waste. The main components in the system are:

- CLAB (Central interim storage facility for spent nuclear fuel), situated at the Oskarshamn Nuclear Power Station. Spent fuel from all nuclear power plants in the country are taken to CLAB for interim storage for a period of 30–40 years. This storage takes place in water-filled pools in rock caverns.
- SFR (Final repository for radioactive operational waste), situated at the Forsmark Nuclear Power Station. All low- and intermediate-level short-lived waste is disposed of at SFR. The waste is emplaced in rock caverns 60 m below the bottom of the sea.
- A handling and transportation system for transferring radioactive waste from the nuclear power plants and other producers to the waste facilities.

These parts are in operation. What remains to be built are system parts for permanent disposal of spent nuclear fuel, after interim storage in CLAB, and of other long-lived waste. SKB's plans call for the following facilities to be added:

- an encapsulation plant for spent nuclear fuel;
- a deep repository for encapsulated, spent nuclear fuel and other long-lived waste.



***Figur B1-1.** Overview of the Swedish waste management system.*

This appendix provides a brief account of how different types of radioactive waste are classified with respect to management and disposal, and what quantities are estimated to arise. See RD&D-Programme 95 for a more thorough description.

Properties and classification

Radioactive waste can be dangerous in two ways:

- The radionuclides emit radiation (mainly gamma radiation), which can harm people by damaging the cells of the human body. This direct radiation is mainly a problem in conjunction with the handling of the waste. Protection is provided against direct radiation by surrounding the waste with radiation shields of sufficient mass to absorb the radiation. Spent nuclear fuel, for example, requires a radiation shield several metres thick if the shield consists of water. In rock or concrete, the thickness of the radiation shield can be reduced to one metre, and if the material is steel a few decimetres is sufficient. Extensive experience of protective measures against direct radiation exists at nuclear power plants and within medical care.
- It is conceivable that waste products could escape into the air or water, reach man and enter the human body, emitting radiation there. The principles for protecting against this are: Firstly, to make sure that the waste is in solid form, making it difficult or impossible for the radionuclides to spread by for example vaporization in air or dissolution in water; and secondly, to surround the waste with protective barriers which prevent the radionuclides from coming into contact with the human environment. The planned deep repository is composed of a series of such protective barriers (low-soluble waste, canister, clay, rock).

The radioactivity decays with time as the radionuclides lose their surplus energy in the form of emitted radiation. The rate of decay is different for different nuclides. Nuclides whose toxicity lies primarily in direct radiation generally decay faster than nuclides that can be dangerous if they enter the human body.

Direct radiation is of great importance from the viewpoint of handling. Radioactive waste is therefore classified according to activity content into the categories low-level (LLW), intermediate-level (ILW) and high-level (HLW). LLW can be handled and stored in simple packagings without any special protective measures. ILW has to be radiation-shielded for safe handling. HLW requires not only radiation shielding, but also cooling for a certain period of time prior to being stored safely.

The half-life of the radionuclides in the waste is of great importance from the viewpoint of disposal. A distinction is therefore made between short-lived and long-lived waste. The short-lived waste decays to a harmless level within a few hundred years. Long-lived waste remains radioactive for thousands of years or more and requires more qualified final disposal. Fundamental principles for the Swedish nuclear waste programme are that:

- short-lived waste is disposed of as soon as it has arisen,
- spent fuel is stored for 30–40 years before being placed in the deep repository,
- other long-lived waste is disposed of in connection with the deep repository for spent nuclear fuel.

Quantities and origin

By far most of the radioactive waste produced in Sweden comes from the nuclear power programme. A small quantity comes from other industry, medical care and research.

The nuclear power programme gives rise to radioactive waste of several different types. The activity content varies from virtually inactive trash to spent fuel, which is highly radioactive. Table B1-1 provides an overview of the quantities of different forms of waste which arise, assuming that today's reactors are operated until the year 2010. The table also shows how the waste is encapsulated before disposal.

Table B1-1. Waste quantities in the Swedish nuclear waste programme.

Product	Principal origin	Unit	Number of units	Volume for final disposal m^3
Spent fuel	Nuclear power plants	canisters	4,500	13,500
Alpha-contaminated waste	LLW and ILW from Studsvik	drums and moulds	2,800	1,700
Core components	Reactor internals	moulds	1,400	9,600
LLW and ILW	Operational waste from nuclear power plants and conditioning plants	drums and moulds	55,900	91,000
Decommissioning waste	From decommissioning of nuclear power plants and conditioning plants	mainly 20 m^3 ISO containers	8,500	156,400
Total quantity, approx.			**73,100**	**272,200**

Spent nuclear fuel

Most of the radionuclides formed in a nuclear power plant (about 99%) are present in the spent fuel. Spent nuclear fuel is a solid ceramic material that is enclosed in metal tubes (fuel rods) of a zirconium alloy. The fuel rods are assembled in bundles in steel structures known as fuel assemblies. The composition of the fuel and the design of the fuel assemblies may differ between different reactor types, manufacturers and time periods. From a disposal viewpoint, these differences are of very little importance.

Due to the high activity level in spent nuclear fuel, the fuel emits heat even after it has been discharged from the reactor, which is of great importance for handling and disposal. Table B1-2 shows the heat output per tonne of fuel at different points in time.

Table B1-2. Heat output in nuclear fuel at different points in time.

Time	Heat output (kW/t of fuel)
During operation of nuclear power plant	25,000
When nuclear power reactor has been shut down	1,500
During transport to interim storage (after 1 year)	10
During transport to deep repository (after about 40 years)	1

The spent nuclear fuel will be encapsulated in canisters prior to transport to the deep repository. Energy cannot be generated in the canister on the scale that takes place in a nuclear reactor. Nor is it possible that the fuel could melt from heat or explode.

However, the canister does not provide sufficient protection against the radiation emitted by the fuel. This is one of the reasons the spent fuel canisters will be transported in special, extremely sturdy steel transport casks that act as radiation shields. After emplacement in the deep repository, the canister will be surrounded by bentonite clay and rock. In that environment, the direct radiation that penetrates through the canister has a range of only a metre or so and is therefore of no significance for safety. It is more important that the radionuclides in the waste should not escape from the deep repository. This is prevented by the barrier system with canister, bentonite and rock.

Core components

Certain components located in or near the core inside the reactor vessel in a nuclear power plant are exposed to neutron bombardment and become radioactive. These so-called "core components" are highly radioactive when discharged from the reactor, after which most of the radioactivity rapidly decays. There are, however, long-lived nuclides in the core components as well. Like the spent fuel, the core components are transferred from the nuclear power plants to CLAB. Conditioning there will include embedding in concrete moulds. Final disposal is planned to take place in the deep repository. The relatively lower radiotoxicity of the core components means that their disposal can be made more simple than is the case for spent nuclear fuel.

Operational waste

The concept "operational waste" includes different types of LLW and ILW that arises in conjunction with operation and maintenance of the reactors. It consists mainly of ion exchange resins and filters obtained from the clean-up system for purifying the process water. Operational waste also includes components from the reactor systems, protective clothing, tools, insulation materials, etc., which have been used in areas where radioactivity occurs and which can thereby be contaminated. Similar waste is obtained from the operation of CLAB and the facilities in Studsvik.

The operational waste is low- and intermediate-level, with very low concentrations of long-lived radionuclides. Within a few hundred years, its radiotoxicity will have decayed to a level that is comparable to the natural level of activity in rock. Conditioning and packaging take place at the nuclear power plants, and the waste is disposed of at SFR.

Decommissioning waste

Most of the building structures and installations that are present in a nuclear power plant do not come into contact with any radioactive materials. Most of the waste that arises in connection with decommissioning and dismantlement can therefore be handled in the same manner as decommissioning waste from other industrial facilities. The decommissioning waste that is radioactive is all low- or intermediate-level, but the activity level can vary considerably. Some can be derestricted, but most is of a composition that warrants final disposal in SFR. As mentioned above, certain components located in or near the reactor core (core components) require conditioning at CLAB and final disposal in the deep repository.

Other radioactive waste

Besides from the nuclear power plants, radioactive waste is also obtained from CLAB, the future encapsulation plant and from research activities at Studsvik. Waste from industry, medical care and research is also collected at Studsvik.

The waste from CLAB is of the same kind as the operational waste from the reactors and will be treated in the same way. Similar waste will be obtained from the encapsulation plant.

Nuclear research has been conducted at Studsvik since the mid-1960s. Some of the waste generated there requires careful disposal and will be disposed of in the deep repository. Some of it will first be transferred to CLAB and handled in a manner similar to spent fuel, while some can be packaged and temporarily stored at the facilities in Studsvik.

Finally, a smaller quantity (140 tonnes) of Swedish spent fuel is intended to be reprocessed. This will be done in Great Britain, where the waste will also be disposed of. Reprocessing waste is no longer included in the Swedish plans for the back end of the nuclear fuel cycle.

PROJECT ORGANIZATION

Steering group

The work has been led by a steering group consisting of two representatives from the municipality and two from SKB. The municipality's representatives were, to begin with, Arne Hellsten and Lena Nyström. As of June 1994, Ann-Sofie Stenberg replaced Lena Nyström. SKB's representatives have been Per-Eric Ahlström and Claes Thegerström. The chairman of the steering group has been Arne Hellsten. The municipality's coordinator has been Carl Olof Sjölund.

Reference group

A reference group has been assigned to the steering group. It was appointed by the municipal executive board and has had the task of following the work of the feasibility study and offering viewpoints and suggestions. The reference group has consisted of 22 members, who represent the political parties, the trade-union organizations and interest organizations. The chairman of the group has been Hasse Bjuhr. Regular members and alternates have been as follows:

Organization	Regular member	Alternate
Left Party	Eva Olofsson	Martin Bildström
Social Democratic Party	Hasse Bjuhr (ch.)	Erik Nilsson
Liberal Party	Georg Andersson	Stellan Gustavsson
Centre Party	Wivian Mörtsell	Sten Biström
KDS – Christian Democratic Party	Bert Eklund	Thure Lindblom
Moderate Party	Birger Enroth	
SACO – Swedish Confederation of Professional Associations	Sören Renling	
TCO – Swedish Confederation of Professional Employees	Karl-Axel Carlhed	Alf Bergqvist
LO – Swedish Trade Union Confederation	Yvonne Lundberg	Georg Lindahl
Malå Businessmen's Association	Ulf Stenvall	Börje Johansson
Malå Merchants' Association	Birgit Nilsson	Marita Nilsson
Pensioners' Organizations	Sture Grundberg	Gunnar Marklund
Malå Nature Conservation Society	Ingela Söderström	Sören Lindblom
SAF – Swedish Employers' Confederation	Anders Linde	
Opinion Group Against Nuclear Waste in Malå	Bertil Morén	Lars Jonsson
Travel Industry	Torkel Lindh	Östen Renström
Village Development Council	Berit Oskarzon Örnered	Rune Käck
Youth Council	Oskar Sjölund	Anna Stenberg
Parishes	Alf Holmström	Göran Ivarsson
Agriculture and Forestry	Jörgen Norén	Lars Tjärnlund
Malå Sami Village	Jörgen Stenberg	Jonny Rannerud
Athletic Associations	Leif Bergström	

Project group

A project group at SKB has been in charge of ensuring that the studies have been carried out in accordance with the instructions of the steering group. Bengt Leijon has been project manager and principal investigator for the geoscientific surveys. Other principal investigators have been Christer Svemar (facility design and transport), Erik Setzman (land use, societal aspects), Nils Kjellbert (environment and safety, through April '95) and Gunnar Bäckström (public relations and information).

Torbjörn Hugo-Persson has been in charge of the activities at SKB's site and information office in Malå, assisted by Karin Scott-Hultdin (through June '95). Jerker Tengman has been in charge of administration and cost control. Database management and production of GIS maps has been handled by Karin Fridstrand (GIS Centre). Susánne Persson has been in charge of records and secretarial services.

Investigators

The studies have been conducted by the following organizations:

Boliden Contech AB	Per-Ove Nyström
EuroFutures AB	Carl Fredriksson
GeoVista AB	Hans Isaksson
Golder Associates AB	Carl-Lennart Axelsson
	Anders Ekstav
Infraplan AB	Stellan Lundberg
Mirab AB	Hardy Lindroos
Saltech AB	Per Lindemalm
Stellan Lundberg AB	Peter Törnqvist
Geological Survey of Sweden (SGU)	Rune Johansson
	Gunnel Ransed
	Lars Rodhe
	Martin Sundh
Triumf Geophysics	Carl-Axel Triumf
Turismutveckling AB	Malin Johnsdotter
	Göran Lindgren
Umeå University	Einar Holm
	Urban Lindgren
Vattenfall Energisystem AB	Erik Stezman
VBB VIAK AB	Robert Jönsson
	Virpi Nõmtak
ÅF-Energikonsult	Sören Johansson

VIEWPOINTS OF THE REFERENCE GROUP ON THE SUB-STUDIES

During the spring of 1995, the study material was circulated among the members of the reference group to give them an opportunity to present the viewpoints of their respective organizations and suggest corrections or supplementary work. The commentaries were compiled by Malå Municipality and published in the report "Documentation of the work of the reference group" (SKB PR-95-009, in Swedish only). The following is an extract from this report.

Written statements of comment have been submitted by the following organizations

Left Party
Social Democratic Party
Liberal Party
Centre Party
KDS – Christian Democratic Party
Moderate Party
SACO – Swedish Confederation of Professional Associations
LO – Swedish Trade Union Confederation
Malå Businessmen's Association
Malå Merchants' Association
Pensioners' Organizations
Malå Nature Conservation Society
SAF – Swedish Employers' Confederation
Opinion Group Against Nuclear Waste in Malå
Travel Industry
Village Development Council
Youth Council
Agriculture and Forestry
Malå Sami Village
Athletic Associations

SACO, LO and the Travel Industry say in their replies that they do not wish to submit any statements of comment. LO explains this by saying that they haven't managed to reach all their members, and that the board has not been able to agree on a statement. The Travel Industry says that a working group has been dissolved, so they aren't able to offer any viewpoints. KDS says in their reply that they don't have any viewpoints on SKB's study. Viewpoints expressed in other statements are cited below.

Viewpoints on the Swedish nuclear waste programme and the siting process for the deep repository

Some of the viewpoints offered concern the Swedish nuclear waste programme and the siting process for the deep repository, rather than the feasibility study as such.

The Social Democrats pose the question as to whether the planned method for final storage is the right one and would like to see some presentation of alternative methods.

The Left Party asks how knowledge of the deep repository, the need for surveillance etc. can be conveyed to posterity. They also want clarification of the question of responsibility after closure, and wonder in this context what responsibility would rest with Malå Municipality in the event of leakage from a deep repository in the municipality.

As far as the siting process for the deep repository is concerned, the Left Party in particular emphasizes that the Government and the Ministry of the Environment and Natural Resources ought to have been more involved in this issue, since it is a matter of national concern. They also believe that SKB has not made the process of finding the most suitable site for the final repository credible, and ask why the general studies of all of Sweden were not finished before the feasibility studies were begun.

The Centre Party wonders why no information has been furnished as to whether other sites than Malå will be subjected to investigations, and emphasizes the importance of doing so. The Agriculture and Forestry Industries also note difficulties in fulfilling SKB's objective of conducting feasibility studies in 5–10 municipalities, and stress that this is important for obtaining adequate breadth in the background material for a decision.

The Nature Conservation Society says that clear and measurable criteria are not given for the conditions on the site being sought for the repository, and emphasizes this as a serious shortcoming. The Youth Council offers the viewpoint that the requirements on the bedrock should be expressed as precisely as possible.

Viewpoints on the organization and execution of the feasibility study

No viewpoints have been obtained on the organization of the feasibility study as a whole, but the statements contain some comments regarding the function of the reference group.

The Nature Conservation Society is very positive to the principle of a reference group that provides a broad contact interface with society. However, it is their opinion that the reference group has not functioned as intended, and that important reasons for this are the passivity of many members, shortcomings in the debate climate and lack of clarity in the relationship between the steering group and the reference group.

The Left Party, as well as the Opinion Group, refer to statements by the chairman of the steering group, entailing that the members of the reference group implicitly support those parts of the feasibility study material that are not commented on in the statements. Both organizations note in their statements that they do not accept this point of view, and that they thereby do not assume any responsibility for the accuracy of the study material. The Nature Conservation Society as well points out that the absence of comments is not to be taken as an expression of support for the material, and assumes that the studies have been carefully and competently carried out.

Many statements stress the difficulties for laymen to fully comprehend and offer relevant viewpoints on material that is both large in scope and requires expert knowledge to judge in some respects. The Left Party, as well as the Opinion Group and the Nature Conservation Society, emphasize this in their statements. The Opinion Group adds that the review procedure thereby leaves little room for individual interest organizations to offer viewpoints on specific points in the studies, and that they do not see any feasible way they could add depth to their viewpoints. The Opinion Group further feels that due to the scope of the material and the nature of the review procedure, there is a risk of losing sight of the whole picture and overlooking questions of fundamental importance.

The Centre Party, the Pensioners' Organizations, the Village Development Council and Malå Sami Village comment on the difficulties of judging the accuracy and quality of the material. Malå Sami Village says that for this reason they are limiting their comments to parts that have to do with reindeer herding.

Viewpoints on the focus, scope and results of the studies

General

Many of the statements that have been submitted express general satisfaction as far as the subjects and questions dealt with by the feasibility study are concerned, as well as with the general quality of the work. The Liberals and the Moderates, for example, both say that the quality is high and the scope satisfactory, with exceptions brought up in their respective statements. The Social Democrats also believe that the studies as a whole provide a detailed picture of Malå Municipality, and express a desire for supplementary work within some specific areas. SAF makes a similar overall judgement of the material and notes that the limitation to existing material has determined the degree of detail in the sub-studies. The Merchants' Association, the Youth Council, the Village Development Council and the Athletic Associations are also positive towards the scope and nature of the study material. The Pensioners' Organizations find the material to be objective and satisfactory.

The Centre Party observes that the material has been compiled by SKB, while the sub-studies have been conducted by independent consultants, and question whether the compilation ought to have been done by others than SKB. The Agriculture and Forestry Industries also believe that the summarizing status report would have been perceived as more impartial if it had been compiled by someone else than SKB.

The Left Party says that an overall assessment and analysis of published reports is lacking. As far as the execution of the study work is concerned, they find that the geological field studies that have been made make serious departures from the principle of limiting the studies to compilation and analysis of existing material.

Long-term safety/geoscience

The Pensioners' Organizations emphasize the importance of building the repository in a rock type which is suitable from the viewpoint of safety and cannot be of interest for mineral extraction.

SAF observes that the presence and/or advent of fracture zones may pose one of the greater threats to the safety of the repository, and that the siting and layout of the repository will only be decided after closer studies of the conditions on candidate sites. Against this background, they wonder whether it may be advisable for the purpose of spreading the risk to divide the deep repository into 2–3 units located on different sites.

The Youth Council would like to have a simple description of groundwater flow in rock.

The Agriculture and Forestry Industries draw attention to the "terrain notches" in the vicinity of the municipality that are described in the Quaternary-geological study, which says they may be a sign of recent rock movements. They ask what knowledge exists concerning this and call for further elucidation of what impact these phenomena might have on the long-term safety of a deep repository. They also comment on the hydrochemical study, whose value they say can be called into question in view of the fact that the data relate to conditions near the surface.

Technical prospects

The Liberal Party asserts that it should be possible to express more clearly the prospects for rock construction in granites of the type that exist within identified sub-areas of the municipality, on the basis of existing experience.

The Centre Party questions, citing the risks of accident and sabotage, the advisability of transporting radioactive wastes such long distances as would be entailed by a siting in Malå Municipality. The Liberal Party states that they are not worried that the shipments would entail any disaster risks or that any technical obstacles exist to safe shipments. The Pensioners' Organizations note that the study that has been presented concerning transport options has also pointed out the risks that exist.

The Left Party notes that the transportation study mainly deals with the technical aspects, and points out that if the work is to continue, conflicts of interest must be thoroughly investigated.

The Malå Businessmen's Association points out the great importance of the road routes to Skellefteå and Piteå for existing industry. They believe that this should be taken into account in order to do full justice to the road alternative in the evaluation of the transport prospects from a harbour to a deep repository in the municipality, and suggest that the feasibility study be supplemented on this point.

SAF poses the question of whether air transport from CLAB to the deep repository could be an advantageous alternative, given the rapid technological advances in aviation. They believe it would be an advantage to minimize the need for transloading.

The Youth Council says in its statement that it would have liked to see a comparison – in terms of volumes, accident frequency and safety precautions – with other shipments of heavy and dangerous goods on the roads.

Land and environment

The Social Democrats feel that the environmental and safety aspects have not been illuminated adequately, and would therefore like to see clarifications or supplementary work in this respect.

The Liberals consider that the feasibility study ought to have been supplemented with a study of the environmental aspects of road versus rail transport.

The Pensioners' Organizations take up the environmental requirements in their statement, and emphasize the importance of site restoration so that land and environment are not damaged. They further feel that the good hunting and fishing opportunities in the municipality should not have to be disrupted by a deep repository, and judge that the siting prospects as far as preservation values are concerned generally appear to be good within the areas deemed to be of interest from a geoscientific viewpoint.

It is stated in the study material that the establishment of a deep repository is likely to cause less disturbance than the establishment of other industrial enterprises. This is commented on by the Nature Conservation Society, which believes that the claim is correct if comparison is made with traditional, heavy production industries or raw material extraction enterprises, but that the deep repository cannot be compared with industrial operations aimed at sustainable production.

The Agriculture and Forestry Industries point out that in the event of further investigations, continuous contacts must be maintained with the territorial industries (agriculture, forestry, reindeer herding etc.) to minimize damage and intrusion.

In its statements, Malå Sami Village takes up the subject of possible conflicts between reindeer herding and a deep repository establishment. Regarding the areas of national interest for reindeer herding that are under formation and that are described in the study material, they believe that these areas fill an important function, but that due to the mobility of reindeer herding other areas are also important. They emphasize the importance of impact assessments in this context. They also say that it is difficult at this point to judge the consequences of a deep repository, since the choice of site and thereby the routes of transport guideways are not yet determined.

Malå Sami Village also stresses the need for impact assessments of the road transport alternative, given the disconcerting experience they have from today's heavy traffic. The Sami village says it could never accept rail traffic from a harbour to a deep repository in Malå Municipality. They cite experience from the presence of the Main Rail Line and the Inland Railway within the Sami village's area. These, they say, constitute considerable obstacles to reindeer herding by cutting through grazing lands and causing traffic deaths of reindeer.

The Sami village also discusses another aspect, namely future prices of reindeer meat, game, fish and berries. They point out that the Chernobyl accident had a great adverse effect on the price of reindeer meat, and they have striven to create confidence in the products that are their livelihood. They believe that consumer opinion with regard to products produced within an area used for a deep repository should be clarified. Finally, they wonder if guarantees can be provided that a deep repository establishment will not cause disturbances of reindeer herding that jeopardize it's well-being.

Reindeer herding is also mentioned in the statements from the Left Party and the Pensioners' Organizations. The Left Party considers that impact assessments should be done for the three areas that have been found to be of interest for a possible deep repository. The Pensioners' Organizations are concerned that reindeer herding should be protected as far as possible.

Societal aspects

Several of the statements comment upon the studies that deal with the societal aspects of a possible deep repository establishment. Some of the comments are of a general nature, while some refer to specific sub-studies.

More generally formulated viewpoints are proffered by the Merchants' Association, the Pensioners' Organizations, the Nature Conservation Society and the Youth Council. The Merchants' Association stresses the importance of socioeconomic trends for the business sectors represented by the association. The Pensioners' Associations discuss future local development opportunities and limitations for the wood products industry, the tourism industry, agriculture, small-scale industry and transport and communications. They believe that the transport industry would be affected positively by a deep repository. Finally, they remark that as an industrial investment, a deep repository would provide unsurpassed growth opportunities for Malå.

The Nature Conservation Society comments on the forecasts of future socioeconomic trends made within the framework of the feasibility study. The Society notes that the forecasts are based on traditional methods. With reference to the Agenda 21 documents, they are of the opinion that the models fail to take into account the great social changes that can probably be expected during the next century. To obtain a comprehensive illumination of different scenarios of future development, they therefore feel it is of the utmost importance that resources be set aside to study alternative future possibilities.

The Youth Council simply says that the socioeconomic studies are of interest, and that they could perhaps be augmented with estimates of what level of services can be expected in Malå with different population bases and tax rates.

Besides these generally formulated comments, viewpoints are also offered on individual sub-studies within the socioeconomic part of the feasibility study. Here the study of the tourist industry and the consequences for this industry of a possible deep repository establishment is of particular interest, since this study has drawn much criticism.

The Social Democrats find that the tourism study is poor, and that a supplementary study, based more on facts, is warranted. The Liberals and the Moderates also believe that supplementary work is needed. The Liberals call for a more scientific methodology, comparisons with the development of tourism in localities where controversial or dangerous enterprises have been established, and an assessment of the number of business travellers and visitors which a deep repository would attract. The Moderates would like to see a report on how tourism has been affected in localities with existing nuclear power installations. The Left Party makes reference to the possible negative effects on nature tourism of a deep repository establishment, and is of the opinion that the feasibility study here is too narrow, since the problem could affect all of Norrland. Further, the Left Party says that it supports the conclusion of the tourism study that parallels cannot be drawn between a deep repository and a nuclear power plant in terms of visiting interest.

SAF, the Youth Council and the Village Development Council also offer critical comments on the tourism study. SAF says it has difficulty taking the study seriously. They criticize the thrust of the report, with reference to the fact that the report concentrates on the tourism portion of the travel industry. They also question the value of the interviews that are cited in the report. The Youth Council feels that the tourism study is too much of an opinion survey, and also questions the interviews reflected in the report. Finally, the Village Development Council considers that the study on tourism is insubstantial and poorly supported by facts.

Aside from the viewpoints on the tourism study cited above, there are few comments on the content of individual studies within the socioeconomic field. The Left Party, however, comments on the mega-environmental analysis included in the feasibility study. They criticize the scientific credibility of the study, referring to its lack of selection method and source references. Furthermore, they question judgements made in the study regarding the effects of a deep repository on the travel industry and the importance of a possible rail link. In conclusion, the Left Party questions whether the mega-environmental analysis should be included as background material in the feasibility study.

Other viewpoints

Several statements touch upon the need for a review of the material obtained in the feasibility study. The Centre Party calls for an independent review, conducted by outside experts and a local group. The Moderate Party calls attention to the independent review that is planned and says that it provides an opportunity for a deeper analysis of the feasibility study material. The Agriculture and Forestry Industries emphasize the importance of allocating sufficient financial resources to the independent review to guarantee good quality.

SAF reflects in its statement on the importance of the progress that can be expected to take place during the execution of the deep repository project. They note that while certain parameters are static, such as the properties of the bedrock, the technical and societal parameters are dynamic. They will therefore change during the course of the project, and SAF feels that this should be taken into account to a greater extent in the feasibility study.

The Athletic Associations, finally, cite questions that have been brought up concerning what effects a deep repository might have on a number of sports.

INFORMATION AND PUBLIC RELATIONS – ACTIVITIES

(February 1994 – December 1995, the list includes activities in which SKB has participated)

February 1994
- Meeting 17/2 at local government offices in Malå. Commissioner Rolf Andersson declares the feasibility study in Malå officially opened.
- Series of seminars on legal aspects, establishment questions and environment at Luleå University.

March 1994
- Reference group meeting.
- Study trip to Simpevarp (O3, CLAB, Äspö HRL) for members of feasibility study's steering and reference groups.

April 1994
- Information meetings with exhibition van at 8 villages (Malå-Vännäs, Adak, Släppträsk, V. Lainejaur, Kokträsk, Grundträsk, Rentjärn, Rökå).
- Information meetings with exhibition van at the municipal building, the Malå medical centre, and the service building for the elderly.
- Information to the public works department and the environmental department of Malå Municipality.
- Feasibility study information to Malå Businessmen.
- First mailing to all households in the municipality with information on the feasibility study.
- Study trip to Simpevarp (O3, CLAB, Äspö HRL) for local politicians and members of the feasibility study's reference group.

May 1994
- Reference group meeting.
- The in-service training associations in Malå are informed of the possibility of organizing study circles (adult education classes) on radioactive waste management in Sweden.

June 1994
- Press tour of SKB's site and information office (local office) in Malå.
- Dedication of SKB's local office in Malå.
- Feasibility study information to Malå Businessmen.
- Information on SKB and the feasibility study to the municipality's Project Environmental Power.
- SKB's chairman Carl-Erik Nyquist visited Malå and SKB's local office.

- Study trip to Simpevarp (O3, CLAB, Äspö) for politicians and civil servants from Malå Municipality.
- A teacher's group from Malå visited Simpevarp (O3, CLAB, Äspö).
- Information with exhibition van at Malå summer market.

July 1994
- Liberal Party at Västerbotten's summer convention visited SKB's local office.

August 1994
- Information meetings with exhibition van at 10 villages (Svedjan, Fårträsk, Näsberg, Aspliden, Ytterberg, Springliden, Lönås, Tjärnberg, Brunträsk and Lund).
- Reference group meeting.
- Olof Söderberg, deputy chairman of Kasam, visited the local office.
- Seminar on Swedish nuclear waste legislation for the reference group and the public.
- Activists from Skelleftehamn visited the information exhibition.
- Information mailing on the feasibility study in Malå was sent to 10 educational associations in Västerbotten.
- Feasibility study information to companies.
- Members of the opinion group visited the local office to obtain information and ask questions.
- Karin Falkmer, member of the Riksdag's Standing Committee on Industry and Trade, visited the information office together with local politicians.

September 1994
- Investigators for the feasibility study's socio-scientific studies met municipal civil servants for exchange of information.
- Participation in ABF's (Workers' Educational Association's) delegate meeting regarding study circles.
- Participation in ABF's start-up meetings regarding study circles out in the villages.
- Information to local companies.
- Invitation to all 163 companies in Malå regarding evening information to employees.

October 1994
- Meeting with study circle leaders from different in-service training associations.
- Company information.
- Participation in ABF's start-up meetings regarding study circles out in the villages.
- Participation in ABF's meeting with local union educational delegates.
- Komvux (Local authority adult education scheme) pupils and teachers were given information on the feasibility study at SKB's local office.
- Reference group meeting.

- Seminar on radiation and radiation protection, for the reference group and the public.
- The Department of Media and Communications at Umeå University interviewed Malåites and SKB personnel regarding the feasibility study.
- Information with exhibition van outside Malå Hotel, on the occasion of Businessmen's Day.
- The Opinion Group Against Nuclear Waste in Malå organized lectures and a training day for KF (Swedish Cooperative Union and Wholesale Society) members and other interested persons.

November 1994

- Feasibility study information at Lions' November meeting in Malå.
- Information and summons regarding study circles distributed to various educational associations.
- Information meeting at Malåborg for PRO (National Organization of Pensioners).
- Information on SKB and the feasibility study for politicians from Rökå-Aspliden.
- KIM (Women in Malå) organized an evening seminar on "radiation from a female perspective". Lecture by personnel from SKB and Ringhals.
- Politicians and members of the Opinion Group received information at the site office.
- Reference group meeting.
- Seminar on research concerning the deep repository, for the reference group and the public.
- Open house at SKB's local office.
- Company information.
- Second mailing to all households in the municipality with information on the feasibility study.
- Study trip to Simpevarp (O3, CLAB, Äspö HRL) for politicians and civil servants from Malå Municipality.

December 1994

- Information and discussion with Malå Sami Village and Malå Sami Association.
- General feasibility study information for Sami.
- Information meeting with Malå Disabled Association, Malå Wildlife Management Circle, the LO section, the Malå District Fisheries Management Area and some Malå-based companies.
- Reference group meeting.
- The five first sub-reports (geoscientific studies and mega-environmental analysis) were published. Press meeting at SKB's site office about the reports.

January 1995

- Information meetings at SKB's local office for the political parties in Malå.
- Information meeting in Adak for Adak politicians.

- Reference group meeting.
- Seminar, with presentations of the feasibility study's geoscientific studies, for the reference group and the public.
- Information meeting with training group from Tourism Training in Malå and the travel industry in Malå.
- Company information.

February 1995

- Third mailing to all households in the municipality, with information on the feasibility study.
- Information meeting at SKB's site office for the emergency rescue services in Malå.
- Open house at SKB's site office on the occasion of Malå winter market.
- Company information.
- Reports from studies on societal consequences of a deep repository establishment and development of tourism in Malå were published.
- Reference group meeting.
- Seminar, with presentations of the feasibility study's socio-scientific studies, for the reference group and the public.
- Information on SKB and the feasibility study for politicians.

March 1995

- Study trip to Simpevarp (O3, CLAB, Äspö HRL) for politicians and civil servants from Malå Municipality.
- Information meeting with Malå labour representatives.
- Information meeting with Malå Social Democratic Association.
- Seminar on the feasibility study's socioeconomic sub-studies with the Malå Businessmen's Association.
- The first study circle about the waste programme and the feasibility study was started.

April 1995

- Japanese TV (NHR) visited Malå, the local government offices and SKB's local office.
- Reference group meeting.
- Journalists from Västerbottenkuriren visited the local office in Malå.
- Politicians from Lycksele were informed on the feasibility study at the local office.

May 1995

- Another four reports from the feasibility study were published.
- Seminar, with presentations of the feasibility study's sub-studies on land, environment and transport, for the reference group and the public.
- Several school classes with teachers and leaders from Malå's twin city Larsmo near Jakobstad in Finland visited the local office in groups.

- The Health and Medical Care Board for southern Lappland led off a meeting in Malå with a visit to SKB's local office, where they received information on the activities of SKB and the municipality in connection with the feasibility study.
- Information for intermediate-level compulsory school teachers at the local office.
- A status report from the feasibility study was published.
- Seminar where the results of the feasibility study's sub-study phase were presented collectively, for the reference group and the public.
- Information for municipal civil servants and TCO members at the local office.
- Information and exhibition van at the Inland Fair in Storuman.
- Seminar on the status report for the reference group and the public.

June 1995

- Information for the National Road Administration's regional management group.
- Participation with SKB's exhibition van at Malå summer market.
- Study trip to Simpevarp (O3, CLAB, Äspö) for politicians and civil servants from Malå Municipality.
- Geological field excursion in Malå Municipality for members of the reference group and the municipal council.
- Information on the feasibility study for the "Inland Left".

July 1995

- The Waste Chain's summer camp, organized by the opinion group, visited SKB's local office for information on the feasibility study.
- The national radio station P3 broadcast an hour on the feasibility study and a possible deep repository in Malå.

August 1995

- M/S Sigyn visited Skelleftehamn with SKB's exhibition. Bus transport was arranged for Malåites who wished to visit M/S Sigyn.
- Geological field excursion in Malå Municipality for members of the reference group and the Municipal Council.
- Information meeting with members of the Municipal Council, information on RD&D-Programme 95, the siting work and the deep repository.

September 1995

- Rapport (national news programme) and TV2/NordNytt ("NorthNews") broadcast interviews with SKB's personnel, the municipal commissioner, the Opinion Group and the public on the feasibility study in Malå.
- Information on the feasibility study for members of the Riksdag (Left Party) and a member of the Standing Committee on Trade and Industry (Left Party).

October 1995	• Information for an upper secondary school class at the local office. • Information with exhibition van on the occasion of Private Enterprise Day in Malå.
November 1995	• SKB provided general information on its activities and the feasibility study, at the request of a study circle. • A group from KIM (Women in Malå) visited Simpevarp (CLAB and Äspö HRL).
December 1995	• Open house at SKB's local office. • Information on SKB's research and safety assessments for a study circle.

1994
TR 94-33
SKB Annual Report 1994
Including Summaries of Technical Reports Issued during 1994.
Stockholm, May 1995

1995
TR 95-37
SKB Annual Report 1995
Including Summaries of Technical Reports Issued during 1995.
Stockholm, May 1996

List of SKB Technical Reports 1996

TR 96-01
Bacteria, colloids and organic carbon in groundwater at the Bangombé site in the Oklo area
Karsten Pedersen (editor)
Department of General and Marine Microbiology, The Lundberg Institute, Göteborg University, Göteborg, Sweden
February 1996

TR 96-02
Microbial analysis of the buffer/container experiment at AECL´s Underground Research Laboratory
S Stroes-Gascoyne[1], K Pedersen[2], S Daumas[3], C J Hamon[1], S A Haveman[1], T L Delaney[1], S Ekendahl[2], N Jahromi[2], J Arlinger[2], L Hallbeck[2], K Dekeyser[3]
[1] AECL, Whiteshell Laboratories, Pinawa, Manitoba, Canada
[2] University of Göteborg, Department of General and Marine Microbiology, Göteborg, Sweden
[3] Guigues Recherche Appliquée en Microbiologie (GRAM), Aix-en-Provence, France
1996

TR 96-03
Reduction of Tc (VII) and Np (V) in solution by ferrous iron. A laboratory study of homogeneous and heterogeneous redox processes
Daqing Cui, Trygve E Eriksen
Department of Chemistry, Nuclear Chemistry, Royal Institute of Technology, Stockholm, Sweden
March 1996

TR 96-04
Revisiting Poços de Caldas. Application of the co-precipitation approach to establish realistic solubility limits for performance assessment
Jordi Bruno, Lara Duro, Salvador Jordana, Esther Cera
QuantiSci, Barcelona, Spain
February 1996

TR 96-05
SR 95
Template for safety reports with descriptive example
SKB
December 1995

TR 96-06
Äspö Hard Rock Laboratory Annual Report 1995
SKB
April 1996

TR 96-07
Criticality in a high level waste repository. A review of some important factors and an assessment of the lessons that can be learned from the Oklo reactors
Virginia M Oversby
VMO Konsult
June 1996

TR 96-08
A reappraisal of some Cigar Lake issues of importance to performance assessment
John Smellie[1], Fred Karlsson[2]
[1] Conterra AB
[2] SKB
July 1996

TR 96-09
The long-term stability of cement. Leaching tests
Ingemar Engkvist, Yngve Albinsson, Wanda Johansson Engkvist
Chalmers University of Technology, Göteborg, Sweden
June 1996

TR 96-10
Lake-tilting investigations in southern Sweden
Tore Påsse
Sveriges geologiska undersökning, Göteborg, Sweden
April 1996

TR 96-11
Thermoelastic stress due to an instantaneous finite line heat source in an infinite medium
Johan Claesson, Göran Hellström
Depts. of Building Physics and Mathematical Physics, Lund University, Lund, Sweden
September 1995

TR 96-12
Temperature field due to time-dependent heat sources in a large rectangular grid
– Derivation of analytical solution
Johan Claesson, Thomas Probert
Depts. of Building Physics and Mathematical Physics, Lund University, Lund, Sweden
January 1996

TR 96-13
Thermoelastic stress due to a rectangular heat source in a semi-infinite medium
– Derivation of an analytical solution
Johan Claesson, Thomas Probert
Depts. of Building Physics and Mathematical Physics, Lund University, Lund, Sweden
May 1996

TR 96-14
Oklo: Des reacteurs nucleaires fossiles (Oklo: The fossil nuclear reactors). Physics study (R Naudet, CEA)
– Translation of chapters 6, 13, and conclusions
V O Oversby
VMO Konsult
September 1996

TR 96-15
PLAN 96
Costs for management of the radioactive waste from nuclear power production
Swedish Nuclear Fuel and Waste Management Co
June 1996

TR 96-16
Diffusion of I^-, Cs^+ and Sr^{2+} in compacted bentonite
– Anion exclusion and surface diffusion
Trygve E Eriksen, Mats Jansson
Royal Institute of Technology, Department of Chemistry, Nuclear Chemistry, Stockholm
November 1996

TR 96-17
Hydrophilic actinide complexation studied by solvent extraction radiotracer technique
Jan Rydberg
Department of Nuclear Chemistry, Chalmers University of Technology, Gothenburg, Sweden and Radiochemistry Consultant Group AB, V. Frölunda, Sweden
October 1996

TR 96-18
Information, conservation and retrieval
Torsten Eng[1], Erik Norberg[2], Jarl Torbacke[3], Mikael Jensen[4]
[1] Swedish Nuclear Fuel and Waste Management Co (SKB)
[2] National Swedish Archives
[3] Department of History, Stockholm University
[4] Swedish Radiation Protection Institute (SSI)
December 1996

TR 96-19
Application of space geodetic techniques for the determination of intraplate deformations and movements in relation with the postglacial rebound of Fennoscandia
Hans-Georg Scherneck, Jan M Johansson, Gunnar Elgered
Chalmers University of Technology, Onsala Space Observatory, Onsala, Sweden
April 1996

TR 96-20
On the characterization of retention mechanisms in rock fractures
Jan-Olof Selroos, Vladimir Cvetkovic
Div. of Water Resources Engineering, Dep. of Civil and Environmental Engineering, Royal Institute of Technology, Stockholm, Sweden
December 1996

TR 96-21
Boring of full scale deposition holes using a novel dry blind boring method
Jorma Autio, Timo Kirkkomäki
Saanio & Riekkola Oy, Helsinki, Finland
October 1996