Comments on plans for the final disposal of spent nuclear fuel

Translation of consultation documents submitted in 2009-2010 and comments on the R&D programme "Fud-10" by the Swedish Society for Nature Conservation (SSNC) and the Swedish NGO Office for Nuclear Waste Review MKG.

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Preface

This report contains translations into English of five documents produced between 2009 and 2011 by the Swedish Society of Nature Conservation, SSNC, and the Swedish NGO Office For Nuclear Waste Review. The documents present the view of the organisations on the Swedish programme for management and final disposal of spent nuclear fuel.

Titles of translated documents:

1. The selection of a site

2. The draft Environmental Impact Statement

3. The long-term safety report

4. Risks regarding the man-made barrier system

5. Fud-10

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Joint comment on the part of the Swedish Society for Nature Conservation (SSNC) and MKG regarding the siting process for a final repository for spent nuclear fuel

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May 5th, 2009

Till: Svensk Kärnbränslehantering AB, SKB
(The Swedish Nuclear Fuel and Waste Management Company)
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Memorandum from the Swedish Society for Nature Conservation (SSNC) and the Swedish NGO Office for Nuclear Waste Review (MKG) regarding the siting process for a final repository for spent nuclear fuel, for consideration within the framework of the EIA consultations regarding the project.

The purpose of this memorandum is to call attention to some issues that have direct bearing on the selection of a site for a final repository for spent nuclear fuel. The Swedish Nuclear Fuel and Waste Management Company (SKB), who bear sole responsibility for the repository project, intend to apply for permission to locate the repository in one of two municiaplities, Forsmark/ Östhammar (County of Uppsala) or Oskarshamn (County of Kalmar). The memorandum essentially brings together comments that MKG has made in the course of the EIA consultations in the interval since MKG was formed in late 2004. MKG has the following member organizations: the regional federations of SSNC chapters in Kalmar and Uppsala counties, Nature & Youth (Fältbiologerna), and Oss [an acronym for the Swedish group (in translation): Östhammar Opinion Group for a Safe Fuel Waste Repository].

Many of the issues raised in this document have also been raised by other participants in the EIA consultations. It is vitally important that the consultations, mandated in the Swedish Environmental Code, chapter 6, are not limited in scope in accordance with SKB's reading of the law. In the company's view only a small portion of all the consultations undertaken by the company with different institutions since the mid-1970s would be included in the mandated EIA consultation process. In our view, the EIA consultations should also include all comments filed on the periodic progress reports, so-called Fud-reports (Fud, standing for Research, Development, Demonstration), that have been published since the mid-1980s as well as the consultations (correspondence and meetings) held with national regulatory authorities, the Swedish Nuclear Power Inspectorate (SKI), the Swdish Radiation Protection Agency (SSI), and the Radiation Safety Authority [formed in 2009 and amalgamating the two former regulators] and their experts, and all exchanges of information between SKB and other parties in connection with the work to create a viable system for disposal of spent nuclear fuel.

To be frank, we have not always noted any response on the part of the company to the views and comments we have expressed in the consultation process. This is true not only of our comments, but applies to comments made by other participants, as well. The company/applicant has for the most part followed its own game plan and used the consultations as opportunities to inform, rather than to discuss or get others' input.

An environmentally sound outcome of the consultation process is of crucial importance, considering the extremely long time a repository for spent nuclear fuel needs to be environmentally safe. With this in mind, we urge SKB to conduct future consultations in a manner more conducive to dialogue. This seems particularly urgent at present, when the repository project clearly faces a number of serious problems.

The SSNC and MKG would like to put the following views relating to the siting process on the table:

1. The site has to be chosen on the basis of the requirements of the method, and the method is not yet fully elaborated. It follows that SKB should be more open-minded and consider alternative methods and let the siting process wait until the best solution has been identified.

2. We urge the waste management company not to rush the siting process to a premature conclusion. There are serious unknowns as to whether the man-made barriers, copper and clay – on which SKB's method of preference relies – will afford sufficient environmental safety. What is more, the two sites under consideration differ considerably in terms of geology and hydrology. The differences affect the function of the man-made barriers. To select a site before one knows how the specific conditions prevailing at that site affect the function of the proposed system is less than might be expected of a company consisting of seasoned engineers.

3. Even if the choice ultimately falls on the KBS method, as SKB currently plans, there are in all probability better sites for the repository

than the two surveyed candidate sites in Oskarshamn and Östhammar.

4.The siting process has not proceeded with the long-term environmental safety of the repository in mind. As a consequence, the choice now stands between two rather unsuitable locations, each directly adjacent to a nuclear power plant. SKB is currently undertaking exploratory studies at both sites.

All in all, SKB's siting process can hardly be said to have been guided by either geological and hydrological criteria or environmental safety concerns. In other words, it cannot be said to fulfill the requirements of either the Environmental Code or the Law on Nuclear Activities.

1. The site selection process must be allowed to take the time it needs

SKB, the Swedish nuclear waste management company, has been working to develop a system for disposal of spent nuclear fuel produced by Swedish nuclear power reactors for over thirty years. For more than twenty-five of these years all work has focused on the so-called KBS-3 method, where "KBS" stands for "nuclear fuel safety", and the "3" indicates that it is the third version of the system. The plan is to deposit the high-level radioactive spent nuclear fuel in mine-like tunnels in bedrock some 400-500 meters below the surface. Groundwater will flow both through and around the repository. The basic idea is to use man-made barriers to isolate the long-lived and highly radioactive spent fuel from human beings and the biosphere for hundreds of thousands of years. The barriers in the KBS-3 system are copper canisters and a clay buffer that is expected to swell to fill the cavities between and around the canisters. The function of the bedrock is essentially to limit, delay and dilute leakage from the repository when, at some point in the future, one or both barriers fail.

SKB has had many years on their hands to develop a system that promises long-term environmental safety, yet the method currently on the table is not convincing in that respect. There is mounting concern within the research community as to the ability of the man-made barriers to perform according to plan. More specifically, four main points of concern are the risks of (1) a higher rate of corrosion of the copper canisters than SKB envisages, (2) embrittlement of the copper due to the production of hydrogen gas in the repository environment, (3) alteration of the chemistry of clay, (4) and erosion of the buffer.

First choice of method, then choice of site.
It seems a reasonable proposition, that the suitability of a site can only be judged on the basis of the requirements of the installation to be put there. That means that the method to be used has to be known before one settles on a particular site. That SKB today, before even the principles of the KBS-3 method have been validated, is on the verge of selecting the site is unwise; the risk is great that the site will not fulfill the criteria set by the Radiation Safety Authority to ensure long-term environmental safety. In the present situation, SKB should instead put more resources and energy into reducing the dependence of the KBS-3 method on man-made barriers and looking into alternative methods. One alternative method brought up in the EIA consultations is deposition in deep boreholes, where the surrounding bedrock provides a natural barrier to ensure long-term environmental safety. SKB has not given this alternative enough attention to date. A second class of alternatives that need more attention are various methods for long-term interim storage – which, of course, would have to be kept under surveillance.

Even if the applicant, SKB, elects not to consider alternatives to the KBS-3 method, the fact remains that the choice of a site for the repository is premature. As noted above, there is considerable uncertainty as to the performance of the copper and bentonite clay in the repository environment in the long-term. To choose a site before these essential functions have been proven is not responsible. The company should not be allowed to rush ahead of the facts of the case.

Questions about the man-made barriers
The overall purpose of the barriers is to keep spent nuclear fuel from the biosphere. To do so, the barriers must protect the spent fuel from the chemical and microbiological environment in the surrounding bedrock. The bedrock formations at the two candidate sites that SKB has chosen to explore in detail differ markedly. The bedrock just south of the Forsmark nuclear power station in Östhammar is very homogeneous and contains few cracks or fissures. As a consequence it is dry; that is, relatively little groundwater is transported in the formation. The bedrock at Laxemar, west of the Oskarshamn nuclear power station, by contrast, contains numerous fractures – as does most Swedish bedrock – and carries a great deal of groundwater. It is the Laxemar bedrock that has served as the reference material in work on the KBS-3 method.

There is uncertainty as to how the man-made barriers will work in either kind of bedrock, but the uncertainty is greater with respect to the relatively dry formation in Forsmark. Since the site is a principal safety factor, the site should not be chosen before we can fully assess the ability of the man-made barriers to isolate the spent nuclear fuel for hundreds of thousands of years. We need to know more about the risk of corrosion of the copper canisters, the "maturation" process of the clay around the canisters, and the long-term stability of the materials to be used to fill and seal the access shaft and tunnels. On none of these points does SKB currently have sufficient knowledge.

Uncertainty concerning corrosion of copper
In a KBS-3 repository there will always be a risk that the copper canisters will be exposed to, and influenced by groundwater flows. The prime function of the bentonite clay buffer is to protect the canister from groundwater so that the process of corrosion (rusting) is delayed as long as possible. Both the chemical composition of the water and the microbial activity around the canister influence the risk and rate of corrosion. The most important research findings on the subject in recent years (Szakálos m.fl. 2007; Hultquist m.fl. 2008) suggest that SKB may have missed a central risk factor, namely, copper corrosion in the repository environment. The researchers warned SKB of the process, known as "corrosion of copper in anoxic environments", as early as the late 1980s. The recent results, which confirm the problem, indicate rates of corrosion up to thousands of times higher than the level SKB, as applicant for permission to build the repository, needs to demonstrate in order to ensure the long-term safety of the undertaking. Furthermore, the corrosion process produces a certain amount of hydrogen gas, which is known to make metals brittle; the effects of hydrogen gas on copper is a poorly researched area. Because of the combined effects of corrosion and embrittlement, the researchers cannot exclude the possibility that the canisters in a KBS-3 repository may collapse in a time frame of between 100 and 1 000 years. Besides the possibility of anoxic erosion, another principal threat to the copper canisters may be the sulfides that result from microbial activity in the repository. What is more, there may be a link, albeit yet to be demonstrated, between anoxic corrosion and sulfide corrosion of copper. Inasmuch as the hydrogen produced in anoxic corrosion consitutes an excellent "substrate" for microbes, the links may be substantial.

Despite the gravity of the possible risks with respect to long-term environmental safety that these research findings imply, SKB has not taken any steps to research the problem – neither after the first tentative warnings in the late 1980s nor now. Instead, SKB's principal strategy for dealing with the problem appears to be to deny that the problem exists, coupled with various efforts to denigrate the work of these "outside", unsolicited researchers.

Uncertainty concerning the bentonite clay
The second man-made barrier in the KBS-3 method is the bentonite clay that will be introduced to fill all the cavities surrounding the copper canisters. Once the copper canister is in place, the clay is intended to swell and fill the cavities as groundwater seeps into the repository from the surrounding bedrock. Thus the clay "matures", and when the clay is saturated, it has reached the so-called "initial condition" that is used in the modelling that constitutes the company's safety analysis. The KBS method was developed for the relatively moist environment that obtains in the greater part of Swedish bedrock. Given good access to groundwater, "maturity" will be attained in a rather short period of time - within months or a year or two. This condition might be expected were the repository to be located in Laxemar (Oskarshamn). At the proposed site at Forsmark conditions are quite different. There, the relative paucity of groundwater means that it may take millennia before the clay reaches "maturity" (SKI & SSI 2008). In that case dry bentonite clay may be exposed to relatively high temperatures for at least a thousand years. It is unknown whether the clay will perform as expected after such exposure. Intuitively, it seems likely that clay subjected to heat for such a long time will be chemically altered. Then, there is the possibility that biological processes will alter the clay. Given extensive corrosion of the canisters, the clay may absorb some copper, which, too, will very likely affect its function as a barrier.

Thus, there is cause for doubt that the clay will be able to protect the copper canister to the extent SKB's models presume. There is also the risk that dry or partially saturated clay may gradually erode and be carried out of the repository by groundwater flows. The eventuality of erosion merits more study, even presuming that the clay reaches saturation relatively quickly, as planned. In the experiments carried out at SKB's underground laboratories at Äspö, the bentonite clay has not behaved as the models have predicted, and its ability to withstand erosion in the longer term has been called into question. The findings from Äspö are directly applicable to the bedrock at nearby Laxemar, but much less is known about how the clay might behave in the Forsmark bedrock since no empirical studies of bedrock of a drier character have been performed in the Äspö labs.

Uncertainty concerning the filling of the access shaft and tunnels
The long-term stability and safety of the materials used to seal the access shaft and tunnels are also dependent on geological and hydrological features of the bedrock. At present these factors require more study. This is particularly true with respect to the bedrock at Forsmark, where the combination of dryness and density of the rock formation at the level of the repository represents quite different conditions than those studied in experiments at SKB's underground laboratory at Äspö. The bedrock in the Äspö lab is relatively homogeneous

in terms of fractures and the amount of water transported in the bedrock.

In sum, the applicant, SKB, does not know enough about the long-term performance of a KBS repository with regard to environmental safety to be able to select a suitable site. Uncertainty as to the long-term performance of the method has increased, and to force a premature decision regarding the site under such circumstances is hardly responsible. The two candidate sites that SKB has chosen for more detailed exploratory study have quite different geology and contrasting hydrological conditions. Reasonably, the applicant should know how the man-made barriers in the proposed method will perform in the respective formations before either of these sites or, indeed, any other site can be chosen.

2. From an environmental point of view better sites than those the applicant, SKB, now has in focus clearly exist

SKB is considering two candidate sites to host a final repository for spent nuclear fuel from Sweden's nuclear power reactors. One is just south of the nuclear power plant at Forsmark in the Municipality of Östhammar [County of Uppsala], and the other is just west of the nuclear power station in the Municipality of Oskarshamn [County of Kalmar]. Both locations are on the Baltic coast. Each candidate site has characteristics that render it less than ideal for a final repository. Both also lack characteristics that might ensure a higher degree of long-term environmental safety.

Problems at Forsmark
The plan at Forsmark is to place the repository in a formation generally known as a tectonic lens. The lens, located in a tectonic shear zone, may be described as a large, homogeneous body of rock enclosed in an area of deformed bedrock. The shear zone may be active. There are a number of reasons why spent nuclear fuel should not be disposed of in a shear zone. Movements that take place in the zone imply a greater risk of an earthquake and deformation of the surrounding bedrock. Skåne, in southernmost Sweden, has an active shear zone, and earthquakes occur with some regularity. Shear zones display evidence of major seismic activity in periods of glaciation.

What might elicit an earthquake in the shear zone at Forsmark is a gradual build-up of tension due to movement in the earth's crust. Even at the outset the tension in the lens where SKB intends to place the repository is relatively high. The lens is compressed, and relaxation of the tension may result in considerable motion in the lens of a magnitude sufficient to cause a total failure of a repository embedded in it. The risk of such events is especially high in connection with glaciation. Evidence suggests that a nearby tectonic lens, the southern tip of which lies in the village of Forsmark, underwent extensive deformation in the most recent ice age. It, unlike the present lens, was subject to tensile stress.

The act of constructing a repository in a tectonic lens may well weaken the lens. The repository in itself constitutes an artifact, around which the tension in the formation redistributes itself. This may increase the risk of a more extensive deformation of the lens due to movement in the shear zone. As a consequence, the long-term environmental safety of the repository may be jeopardized.

The tectonic lens at Forsmark consists of dense rock that exhibits few cracks. This might seem advantageous, as the rock may be assumed to provide a better barrier to leakage from the repository. The other side of the coin, however, is that it hinders seepage of groundwater into the repository, as well. As noted earlier, the KBS method was devised for use in wetter bedrock than that at Forsmark. Too little water raises questions as to whether and how well the clay will function as a barrier. What is more, the high tension in the formation complicates the physical construction of the shaft and deposition tunnels, which may have consequences for the long-term safety of the repository.

Problems at Laxemar

The site at Laxemar, adjacent to the Oskarshamn nuclear power facility, also has drawbacks of a geological and hydrological nature. Detailed exploration of the site is still under way, and the final report is not expected until this coming autumn – which is odd, considering the fact that SKB has announced that it will make its choice in the very near future. So far, the exploratory studies of the Simpevarp peninsula, where the nuclear plant is located, and the central portion of the Laxemar area, immediately adjacent, were found to have bad rock and/or unsuitable groundwater flows. Consequently, the focus shifted to the southern part of the area, where a fault line defines the boundary of the area of interest. It remains to be seen whether the bedrock there is suitable, i.e., has the right frequency of cracks and carries an acceptable amount of groundwater. The site may not be of interest, regardless. Placing the repository in aquiferous bedrock is probably not a good idea, in light of the process of copper corrosion in anoxic water currently under discussion.

The advantages of an inland site

The remaining candidate sites are both coastal, on the shore of the Baltic Sea. Several factors suggest, however, that an inland site might afford significant advantages from the point of view of long-term environmental safety.

A coastal site implies limitations as to the depth at which a repository may be placed. The deeper the repository, the less permeable the bedrock, i.e. there weill be less and slower-moving groundwater in the rock. Placing the repository at a depth of 1 000 meters would significantly increase the ability of the bedrock to limit and delay leakage from a repository, compared to placing it at a depth of 400 meters. Thus, greater depth implies a higher degree of environmental safety. But, the transition from freshwater to saline water is closer to the surface at coastal sites than at sites at higher elevations. Since salt has a negative effect on clay, no coastal site allows placing a repository any lower than 400 meters down. The applicant, SKB, has chosen not to investigate inland locations, thereby foregoing the advantages inland sites might afford.

Coastal locations have other drawbacks regarding safety, as well. An inland location makes it possible to exploit so-called super-regional groundwater flows to enhance long-term safety. At inland locations the repository might be placed in a zone of groundwater recharge, where the groundwater primarily flows in toward the repository and then down through the bedrock. In zones of groundwater discharge the opposite occurs: groundwater flows mostly upward at a relatively rapid pace, reaching the surface within a short period of time. Both Forsmark and Laxemar are situated in goundwater discharge zones, as is generally the case along coasts. There, the time it takes for leakage from a repository 400 meters down to reach the biosphere is an estimated 100 years. A good site in a zone of groundwter recharge might be able to delay contact of leakage with the biosphere by as much as 50 000 years. In the perspective of the length of time the contents of a repository for spent nuclear fuel needs to be kept isolated from human beings and other life – hundreds of thousands of years – a delay of 50 000 years represents a considerable environmental benefit.

Finally, there is the climate aspect. The impact of climate change on the sea level worldwide calls for careful consideration of what constitutes an appropriate site. Scenarios in the safety analyses for the repository project should include prospective rises in sea level of 7–70 meters within a span of 100 to several thousand years. (Present SKB scenarios posit a continued elevation of the land mass.)

At present, the post-glacial elevation roughly balances the rise in sea level. This equilibrium will not prevail when the sea level begins to rise faster than the land and, what is more, at a faster rate than is currently estimated.

In sum, the locations selected by the applicant for further exploration do not appear to be the most suitable from the point of view of environmental safety. The drawbacks are both features specific to the respective sites and the fact that they are coastal and cannot take advantage of the benefits associated with an inland location.

3. The applicant has not had environmental safety in mind

A restrospective overview of the process by which the nuclear waste management company, SKB, has selected prospective sites for Sweden's final repository for spent nuclear fuel reveals that the company cannot have been guided by environmental considerations after the initial stages of the project.

In early days, in the 1970s and 1980s, SKB searched for bedrock that had few cracks and transported relatively little groundwater. The thinking in those days was that the surrounding bedrock would be the prime guarantor of the long-term environmental safety of the repository.

But, in the early 1990s, after the company had encountered widespread popular resistance to test drilling in selected localities, SKB and the siting process changed course. Now the company claimed that the man-made barriers – the copper canisters and bentonite clay buffer – could ensure long-term safety in most any bedrock. The characteristics of the bedrock were now less important. This left the company free to focus the process on municipalities' willingness, instead. The company carried out a number of preliminary studies in several localities.

The outcome of these preliminary studies was to narrow the field of canidate sites to Oskarshamn and Östhammar, both municipalities that hosted nuclear power plants. The residents had, thanks to an intensive, one-sided information campaign, become convinced of the benefits the final repository project would bring to their community. As a consequence, public opinion surveys note high degrees of acceptance in both municipalities.

Neither were the siting processes within the municipalities guided by environmental safety considerations. Inasmuch as the man-made barriers could ensure safety anywhere, the company now focused on logistical practicality and carried out preliminary siting studies in areas in close proximity to the existing nuclear power plants and interim waste storage facilities in each municipality.

Now that questions regarding the capability of the man-made barriers have arisen, the key presumption that underlay the preliminary siting studies is called into question, as well. If the man-made barriers cannot assure long-term environmental safety, geological and hydrological characteristics of the bedrock once again assume key importance.

Thus, although the siting process has been guided by different values at different times, the most important value of all – namely, long-term safety – has been neglected all these years. As a result, the company's criteria of selection, too, have missed the mark.

In sum, neither the geological and hydrological requirements of the KBS method nor considerations of long-term environmental safety may be said to have guided the applicant's site selection process. For that reason, neither can the siting process be said to fulfill the requirements set out in the Environmental Code or the Law on Nuclear Activities.

References

Hultquist, G, P Szakálos, M J Graham, G I Sproule & G Wikmark. 2008. Detection of Hydrogen in Corrosion of Copper in Pure Water. Paper presented at 17th International Corrosion Conference 2008 , Las Vegas, USA, 6-10 October.

SKI & SSI. 2008. Dverstorp, B & Strömberg, B m fl. SKI's and SSI's review of SKB's safety report SR-Can, SKI report 2008:23 & SSI report 2008:04 E, March.

Szakálos, P, G Hultquist & G Wikmark. 2007. Corrosion of Copper by Water, Electrochemical and Solid-State Letters, vol 10, ss C63-C67.

THE DRAFT ENVIRONMENTAL IMPACT STATEMENT

Joint comment on the part of the Swedish Society for Nature Conservation (SSNC) on the draft Environmental Impact Statement (EIS) for a system for the final disposal of spent nuclear fuel

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March 10th, 2010

Till: Svensk Kärnbränslehantering AB, SKB
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Joint comment on the part of the Swedish Society for Nature Conservation (SSNC) and the Swedish NGO Office for Nuclear Waste Review (MKG) in connection with the consultation on the draft Environmental Impact Statement (EIS) for a system for the final disposal of spent nuclear fuel.

SKB, the company charged to develop a system for final disposal of Swedish spent nuclear fuel, intends to apply for a statement of permissibility for (1) a final repository for spent nuclear fuel to be located adjacent to Forsmark nuclear power plant and (2) an encapsulation facility adjacent to Oskarshamn nuclear power plant. The applications are to be prepared and submitted in accordance with the requirements of the Swedish Environmental Code and the Law (1984:3) on Nuclear Activities. In December 2009, SKB presented a draft version of the environmental impact statement (EIS) that is to accompany the applications. In the following pages the SSNC and MKG comment on the consultation process, the issues raised in the course of that process, and SKB's treatment of these issues in the draft EIS.

MKG, a non-governmental organization, has thanks to financial support from the Nuclear Waste Fund, participated in the consultations since 2005. MKG has the following member organizations: the regional federations of SSNC chapters in Kalmar and Uppsala counties, Nature & Youth (Fältbiologerna), and Oss [an acronym for the Swedish group (in translation): Östhammar Opinion Group for a Safe Fuel Waste Repository].

Oss and the SSNC chapter in Döderhult have additionally filed separate comments.

1. Summary

The SSNC and MKG wish, in the context of the consultations leading up to the applications for a permit to establish a system for spent nuclear fuel, to emphasize the following points:

On the consultation process

- The three-yearly process to review the SKB research and development programme (Fud) and the consultations between SKB and regulatory authorities that have taken place for an extended period of time must be considered to constitute part of the consultations called for in the Environmental Code.

- Consultations that are broken off before comprehensive reports on the long-term safety of the project, alternative methods to the one proposed, and selection of the site have been tabled for consultation cannot fulfill the requirements of the Environmental Code concerning the process by which an environmental impact assessment and statement, EIA/EIS, shall be produced.

- SKB has clearly had no desire to make use of the public consultations to inform and improve the EIA/EIS. The company has, furthermore, sought to bar environmental organizations from participation in some parts of the consultations.

- SKB has demonstrated an unwillingness to engage in any dialogue in the consultation process, and has used the meetings exclusively to propound their own views on various issues. We NGOs, on our part, wish to continue consultations on the issues of long-term safety, alternative methods, and siting. These consultations should be conducted in a national (not local) framework in Stockholm; they should, furthermore, be organized and minuted by a third party – not the nuclear waste management company, as heretofore.

• SKB has to produce a draft of the safety analysis to accompany the licensed application before the application is submitted, and the document must be tabled for consultation.

• SKB has to produce drafts of the documents on alternative methods and choice of the site that must accompany the licensed application, and the documents have to be tabled for consultation before the applicaton is submitted.

• The consultations have to continue until a complete account of the siting process and the choice of site have been put forward.

• The consultations must continue until the basis for the choice of method has been explained, and a fair comparison of the designated method and the alternative of deep boreholes has been presented.

• SKB has consistently played down the environmental hazard that the spent nuclear fuel in question represents.

• Throughout the consultations to date SKB has refused to discuss the impacts on nature values in the Forsmark area, despite the substantial threat posed by the repository project.

• One principal reason why the consultation in the three-yearly process to review the Fud-programme with respect to the issues of alternative methods, alternative sitings, and long-term environmental safety has not worked is that the nuclear waste division of the former regulator, the Swedish Nuclear Power Inspectorate (SKI) in the 1980s, 1990s and into the early 2000s was lax in its supervision of SKB's work.

• The intended roles of the County Administrative Boards of Kalmar and Uppsala in the regional consultations (MKB-Forum in Oskarshamn and the Consultative MKB group in Forsmark) were not clearly defined, which may have made it difficult for these bodies to take initiative in the process.

•Through their choice of meeting venues, their conduct of the meetings and minuting of the proceedings SKB steered the public consultations so as to serve the company's purposes.

• It is vital that the account of the consultation process included in the applications that SKB submits include all the principal issues and assessments that were put forth in the national consultations as well as what was expressed in the public and regional consultations.

The purposes of the final repository project

• The KBS method was not developed to serve the same purposes as are indicated in the draft EIS.

•The KBS method does not fulfill the objectives of hindering nuclear proliferation and functioning without the need of post-closure surveillance.

• The deep borehole alternative fulfills all the objectives set out by the nuclear waste management company, including the objectives of hindering nuclear proliferation and no need of surveillance.

• SKB's discussion of the purposes of the repository project does not fulfill the requirements of the Environmental Code and the general rules of consideration that the Code (Chapter 2) sets out.

• SKB has not adequately addressed issues relating to containment, and the role of natural barriers in particular.

• Throughout the consultations SKB has suppressed the fact that 'dispersal and dilution' is one of the safety mechanisms of the KBS method in the event of leakage.

• The draft EIS does not adequately recount the discussion of issues relating to retrievability.

• The draft EIS does not describe how other countries have addressed the issues of barriers and retrievability.

Legal issues

- The nuclear waste management company, SKB, has had sole responsibility and the resources to study and develop the deep borehole alternative; therefore, the company's argument that the alternative has to be rejected because it is "not available" is hardly acceptable.

- SKB's treatment of alternative methods in the draft EIS is seriously flawed.

Long-term safety

- The KBS method, which is highly dependent on man-made barriers, is not a suitable solution for disposal of spent nuclear fuel.

- It has yet to be demonstrated that either the copper canister or the clay buffer will perform in the repository in accordance with SKB's theory-based expectations; the problems of copper corrosion and erosion of the buffer demand further study.

- The KBS method is ill-suited for use in the very dry bedrock at Forsmark; experimentation in a similarly dry geological environment is called for.

- If the KBS method is approved for use, the repository should be positioned as deep as possible, about 1 000 meters below the surface.

- A repository of the KBS type should be sited in a zone of groundwater recharge.

- It is not appropriate to site a repository for final disposal of spent nuclear fuel in a tectonic shear zone which is the case at Forsmark.

- SKB has not devoted enough attention to the risks to a repository posed by periods of glaciation.

- The EIS that accompanies SKB's applications must include an analysis of the consequences of "worst-case scenarios" involving leakage both 1 000 and 10 000 years after the repository has been closed and sealed.

- The EIS must describe scenarios involving accidental intrusion into the final repository.

- SKB's discussion of the radiation hazards to human health and the environment associated with the project is inadequate.

Long-term safety in relation to developments in society at large

- The safety assessment and EIS that accompany SKB's applications have to include a discussion of scenarios and consequences relating to the long-term risks of nuclear proliferation.

- The safety assessment and EIS need to include a discussion of scenarios and consequences with respect to the long-term risks of speculative (i.e., deliberate) intrusion into the repository.

Alternative methods, particularly deep boreholes

- The deep borehole alternative must be explored more fully to enable a just comparison with the KBS method.

The proposed site and alternatives to it

- SKB's siting process was not conducted in any systematic fashion, nor was the process founded on a priori geological and hydrological criteria. Thus, long-term environmental safety was not in focus.

- A final repository of the KBS type is poorly suited for use in the bedrock at Forsmark, which is extremely dry at the proposed level of the repository.

- The intense flows of groundwater at superficial levels in the Forsmark formation render the site inappropriate for a final respository.

- The Forsmark region is prized for its conservation and recreational values, which make the proposed site less than optimal for a final respository.

- A repository for final disposal of spent nuclear fuel should be located in a zone of groundwater reharge; such zones are more prevalent inland than along the coast.

- A repository of the KBS type should be located on a site that permits positioning of the repository at a depth of approximately 1 000 meters.
- A repository for final disposal of spent nuclear fuel should not be

located in a tectonic shear zone.

• A coastal siting of the repository is inadvisable given the climate-related risk of rising sea levels.

• It is the conviction of the SSNC and MKG that no facility for disposal of spent nuclear fuel should be located adjacent to a nuclear power plant.

The “zero alternative”

• There is a need for consideration of more “zero alternatives” than continued use of CLAB [an interim storage facility in Oskarshamn], for long-term (but not final) storage of spent nuclear fuel.

• In connection with “zero alternatives” the implications of different future energy scenarios for a KBS repository must be considered.

Miscellaneous comments

• SKB has to make an assessment of the cumulative effects of the final repository and all other nuclear installations on and near the shores the Baltic Sea.

• SKB needs to address the problem of how to ensure that future generations are aware of the location of the repository and the danger it represents.

• SKB must make a better assessment of the problems and issues relating to the construction and operation of the repository.

• An area of such significant natural and recreational value as Forsmark should hardly be the first choice among possible sites for a repository for final disposal of spent nuclear fuel.

2. The consultation process

This chapter first presents a brief resumé of the legal framework surrounding the consultations and a characterization of the process, followed by a critical assessment of the conduct and content of the consultations to date.

2.1 Background: The consultations, the EIS, and the role of the County Administrative Boards as specified in law and statutes

The law requires that the nuclear waste management company, SKB, applies for a permit to establish a repository for final disposal of spent nuclear fuel. The application shall be evaluated in light of the provisions of the Environmental Code and the Law on Nuclear Activities. Approval of the application according to the latter law must also fulfill the requirements of the Radiation Protection Act (1988:220). Evaluation of the application in relation to the Environmental Code is performed by a designated Environmental Court; evaluation according to the Law on Nuclear Activities is performed by the Swedish Radiation Safety Authority. The Court and the Authority submit their findings to the Government, which then either grants or denies permissibility. The applications to the Court and the Authority must be accompanied by an Environmental Impact Statement (EIS). In order to ensure that the assessment reported in the Statement is of the best possible quality, the nuclear waste management company is required to hold consultations so that the EIS is as comprehensive as possible. In the context of the consultations preceding the applications to build a repository for disposal of spent nuclear fuel SKB produced a draft EIS (December 2009). The draft EIS is irregular in the sense that there is no legal requirement for such a document, but it affords participants in the consultation process an opportunity to see to what extent the company has responded to the comments expressed in the course of the process.

The Environmental Code (Chapter 6, Paragraph 4) sets out the parties with whom SKB shall consult in the process of conducting the EIA for a repository for disposal of spent nuclear fuel. They are the County Administrative Boards [those pertaining to the candidate sites], the regulatory authority, other national authorities, the municipalities [where the candidate sites are located] and segments of the general public and non-governmental organizations that may be presumed to be concerned or affected by the proposed action. The consultations shall be held to the extent required and well before the company submits its applications. Prior to the consultations the company shall provide information about current plans regarding the siting, extent, design and presumed environmental impact of the project.

According to Paragraph 5c of the Law on Nuclear Activities the applicant shall produce an environmental impact statement and otherwise comply with the provisions of the Environmental Code, Chapter 6. The Radiation Protection Act (Paragraph 22a, Section 2), too, refers to the Code's requirement of an EIA/EIS.

The nuclear waste management company is required to provide information about the project's environmental impact prior to the consultations. The consultations may not be terminated before such information has been tabled for discussion. It is the province of both the Environmental Court and the Radiation Safety Authority to determine whether the consultations have been conducted in compliance with the requirements of the Environmental Code.

Chapter 6, Paragraph 5 of the Environmental Code stipulates that the County Administrative Board(s) shall act to ensure that the EIS has the necessary scope and focus. The Boards may advise the applicant as to what should be included in the EIS and how the consultations shall be conducted.

2.2 Background: The KBS project -- a unique project with a long history of consultations

In our view, the overall objective of the repository project is to find a way of managing spent nuclear fuel from Swedish nuclear power plants that is the very best in terms of its long-term consequences for the environment and human health. The aim of the consultation process is to assist in a development of a licensed application, and produce an EIS that serves this objective. The Swedish project to create a respoitory for final disposal of spent nuclear fuel is unique in several aspects. It involves handling and final disposal of an extremely hazardous waste product that has to be isolated from human beings and the biosphere for at least several hundred-thousand years. The project has been under way since the 1970s, when the AKA commission started its work. It is a major undertaking, in both financial and administrative terms. Its goal has been to develop an entirely new system for disposal of high-level radioactive waste. The unique nature of the project makes special demands of the consultation process that should provide input to the applications to be submitted to the Environmental Court and the Radiation Safety Authority, in accordance with Swedish law.

The project work leading up to the present KBS solution started in the late 1970s under strong political pressure. It may be seen as a collaborative project involving the Government, the nuclear power industry and the Swedish research community. By 1983, three versions of the KBS method had been proposed. The first, KBS-1, was designed for final disposal of vitrified high-level waste from a spent fuel reprocessing programme. KBS-2 was a system for direct final disposal of spent fuel. It was developed in 1978 and 1979 to fulfill the requirements of the so-called Conditional Act (1977), which required the nuclear industry to solve the problem of final disposal of nuclear waste. Otherwise, the Swedish nuclear power programme would have to be abandoned. The idea of reprocessing spent fuel was formally abandoned in 1980. KBS-3, the current version, was first presented in 1983. Largely the same as KBS-2, it, too, envisages direct storage of untreated spent nuclear fuel. In the following we will refer to the method as “the KBS method”. One aspect of the early development of the method, that may have bearing on the coming review of the licensed application to build a repository for spent nuclear fuel, is the fact that the KBS method specifies copper as the material to be used for the outer shell of the canister. With the KBS-3 report, titanium had been abandoned as an alternative.

The Law on Nuclear Activities, also introduced in 1983, specified the division of responsibility that would apply with respect to nuclear waste management. Responsibility for developing a safe way to manage and store spent nuclear fuel was assigned to the nuclear power industry. The industry was also entrusted with responsibility for organizing and supporting an all-round R&D programme relating to nuclear waste management. The industry then delegated the responsibility to a jointly owned company, dedicated to nuclear waste management, SKB. It has been the responsibility of the regulatory authorities* to ensure that the work is done. Among other things, SKB has been required every third year to submit a report of its progress in research and development of a method for disposal of spent nuclear fuel to the authorities. These reports, known under the acronym, “Fud” (which stands for “Research, Development, Demonstration”), have been reviewed by the authorities. On the basis of their report, the Government has then approved the company’s work to date. The Fud-reports have also been widely circulated for review. From time to time over the years, the regulatory authorities have also examined selected aspects of the company’s work.

Thus, over the course of Sweden’s nuclear waste programme there has been a considerable amount of exchange of views between the nuclear waste management company, the authorities and other actors, in which the recurrent Fud-reports have played a significant role. On two occasions in the Fud-programme the Government has instructed SKB and the authorities to initiate two separate series of consultations on the national level: one on

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*) The term “authorities” refers to the formerly two regulatory authorities, the Swedish Nuclear Power Inspectorate (Statens Kärnkraftinspektion, SKI) and the Swedish Radiation Protection Agency (Statens Strålskyddsinstitut, SSI). In July 2008, the two authorities were fused into a single organization, the Swedish Radiation Safety Authority.

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systems and safety analysis (SSA), and the other on exploratory studies of candidate sites (PLU). SKB contends that these national-level consultations are not consultations in the sense of the Environmental Code.

When exploration of the two candidate sites in the municipalities of Östhammar and Oskarshamn got under way, regional consultations carried on through two dedicated fora (the Consultative EIA Group Forsmark and EIA Forum Oskarshamn) were opened. The purpose of these consultations was to provide a venue for disussions between the municipalities and the nuclear waste management company in the presence of representatives of the respective County Administrative Boards. For many years, the consultations were closed to the public and non-governmental organizations. SKB considers these series of meetings part of the consultations required by the Environmental Code.

In addition to the three-yearly process to review the SKB research and development programme, the venues for what may be termed nation-level consultations between the nuclear waste management company and the regulatory authorities, and the regional consultations Forsmark and Oskarshamn, respectively, important input has also been contributed by authorities, county administrations, municipalities and other actors.

Finally, there are the public consultations mandated in the Environmental Code for the purpose of enriching EIA processes. These are the consultations that SKB wants to terminate after the meetings now being held on the draft EIS.

SKB's attempt to draw a line of distinction between the three-yearly process to review the SKB Fud-programme and the national consultations between SKB and the authorities on the one hand, and what the company considers consultations in the sense of the Environmental Code on the other, reveals an ambition to bring “consultations” down to a local level, even though many of the issues – e.g., long-term safety, alternative methods and the choice of site – are matters that should rather be discussed on a national level.

2.3. The Environmental Code sets no limits on the consultations.

In our view, all consultations are of the sort mandated in the Environmental Code; there is no legal justification for including consultations held in local and regional fora open to the public, but excluding consultations in all other forms. As we see it, all consultations on the national level – those between SKB and authorities after Government decisions, the entire three-yearly process to review the SKB Fud-programme, and all other documented interchanges between the company, authorities, county administrations, the municipalities and other actors are part of the consultations envisaged in the Environmental Code. Thus, consultations may be said to have been held throughout the process, from its inception.

The SSNC and MKG consider the three-yearly process to review the SKB Fud-programme and the consultations between the nuclear waste management company that have taken place for several decades "consultations" in the sense of the Environmental Code.

2.4. The nuclear waste management company wants to terminate a process that is vital to the fulfilment of the objective, to make the best possible assessment of the project's environmental impact.
In order for an application for permission to build a repository for spent nuclear fuel to be acceptable, the Environmental Code requires that the applicant makes a complete and thorough environmental impact assessment (EIA) and report the results of that assessment in an Environmental Impact Satement (EIS). In February 2009, SKB tabled what they termed a draft EIS for discussion in public consultations. In conjunction with those consultations the company announced its intention to terminate the consultations mandated by the Environmental Code about one month later. At the meetings they made it quite clear that they did not intend to produce any further material on long-term safety, alternative methods or the choice of site before they submit the applications to build a repository for spent nuclear fuel toward the end of 2010. The material they have put on the table so far is full of holes and gaps.

We shall return to these shortcomingsbelow, but, clearly, cutting the consultations short without presenting a better account of their work on these issues is to break off the process that makes it possible to achieve the best possible assessment of the project'senvironmental impact.

The SSNC and MKG find that should the consultation process be terminated without a complete and thorough basis for discussion of long-term safety, alternative methods and siting, it will not be possible for the nuclear waste management company to produce an EIS that fulfills the requirements of the Environmental Code.

2.5. SKB's lack of interest in public consultations and nonchalance regarding the issues raised in them
The SSNC and MKG have come to the conclusion that SKB has had no interest in using the opportunity for consultation to inform their work on the EIA/EIS. The company has approached the consultations in a confrontative mode; all too often, company spokespersons rebut rather than respond to comments from the public, and evade rather than answer questions. Instead,

the company has mainly used the consultations to inform the participants of their own conclusions and convictions regarding the repository.

Inasmuch as the company has, under the provisions of the Law on Nuclear Activities, had sole responsibility for planning, designing and projecting the final repository (on behalf of the Swedish nuclear power industry), and, under said Law and the Environmental Code, sole responsibility for the conduct of the consultation process, the company must reasonably be responsible for the fact that many vital aspects of the project have not been properly addressed over the years.

The record shows, what is more, that SKB has consistently sought to keep the environmental organizations – which receive funds from the Nuclear Waste Fund for the express purpose to permit them to take active part in the consultation process – from participating fully in the process. The company has barred the organizations from the consultations between the company and authorities at national level, denying them even observer status. The reason we were allowed access to the regional consultations in autumn of 2005 (in Forsmark and Oskarshamn), as observers, was the desire of the Municipality of Oskarshamn to open the meetings to the public. SKB was staunchly opposed. In this connection it is interesting to note the distinction the company makes among the parties it consults with: decision-makers and others, respectively. This classification made it possible for SKB to exclude the environmental organizations, which fall into the class of "others", from the information meeting where the most recently published safety analysis, SR-Can, was presented in November 2006.

The SSNC and MKG can only conlude that the nuclear waste management company, SKB, has never intended to use the opportunity of consultations as a resource in their assessment of the environmental impact of the final repository. The company has, furthermore, actively denied the environmental organizations access to some parts of the consultations.

2.6. The need for a better dialogue

Not once in the consultation process has SKB shown a willingness to engage in dialogue; instead, the company has used the consultations as a forum for a one-sided presentation of its views on problematic issues. The SSNC and MKG have, toward the end of the consultations, when it became clear that the company intended to take decisions that did not conform to our perceptions of what was needed to ensure long-term safety, sought dialogue with the company, and we will continue to take such initiatives as the situation requires. In spring of 2009, the company denied our request for a consultation on the issue of siting. The request was put forward in connection with our submission of comments on that specific issue. In connection with this present memorandum we have suggested that the consultation process be extended so as to include a discussion of the coming safety analysis, SR-Site, as well as the documents on choice of method and choice of site that SKB intends to enclose as annexes to the applications for permission to build a repository for spent nuclear fuel. Should SKB respond favorably, we further suggest that public consultations on these documents be held on a national level in Stockholm and that the meetings be structured so as to facilitate dialogue. One measure that would surely improve the climate for dialogue would be for the meetings to be convened and minuted by a body other than the waste management company, SKB.

This raises the question of whether it might have been more appropriate, had consultations on an issue of such crucial importance as final disposal of spent nuclear fuel been organized by a specially appointed “third party” from the start.

The SSNC and MKG have come to the conclusion that SKB has no interest whatsoever in engaging in dialogue within the framework of the consultation process, but has used the consultations exclusively to voice their own views on various issues. We, on our part, hope that the consultation process will be extended to cover the issues of long-term safety, alternative methods and choice of site. We further urge that these issues will be discussed on the national level and that they will be convened and minuted by a body other than the waste management company.

2.7. Consultations can be terminated only after a full and thorough safety analysis has been put on the table.
The consultations cannot be broken off before SKB has tabled a full and thorough safety analysis. The most recent safety analysis, SR-Can, was published in 2006. It is to this document that SKB refers in matters relating to safety in the context of the consultations. SKB has stated in the consultations that no updated analysis will be published until the next report, SR-Site, is submitted as an annex to the company’s applications for a permit to build a repository for spent nuclear fuel. They find this appropriate despite the fact that, as the company puts it in this draft EIS (page 30), “the long-term safety of the final repository after loading and sealing is a principal concern in the safety analysis and evaluation of the application for a permit to build a repository for spent nuclear fuel”.

The review of SR-Can performed by the regulatory authorities and the organizations that filed comment on the report revealed many issues that remained to be resolved. In the interval since then additional concerns relating to long-term safety have arisen, particularly questions regarding the man-made barriers, copper and clay. Questions have also arisen concerning the suitability of the very dry bedrock at Forsmark, the chosen site – an issue that may prove significant in the assessment of the company's siting process.

The SSNC and MKG find the lack of an updated safety analysis – one that takes the Forsmark site into account – in the consultation process totally unacceptable. It must reasonably be in all parties' interest, including the regulatory authorities and their experts, to discuss the concerns about the system's long-term safety before the company's applications are submitted. Throughout the consultation process the environmental organizations have raised a number of pertinent issues concerning long-term safety, some of which have proven to be pivotal. We return to these issues in Section 5, below.

SKB sums up its current analysis of long-term environmental safety in the draft EIS, as follows:

> "The Radiation Safety Authority (SSM) has an ordinance with a risk criterion to protect human health and the environment from hazards posed by spent nuclear fuel, that SKB must demonstrate that the final repository will fulfill in the long term. The permitted risk corresponds to a radiation dose that is one-tenth of the dose from natural background radiation. Initial appraisals of the long-term safety of a final repository located at Forsmark indicate that SSM's risk criterion will be fulfilled." (page 22)

That "initial appraisals" are the only assessment of the project's long-term safety available for consultation is not acceptable.

The SSNC and MKG call upon the nuclear waste management company, SKB, to produce a preliminary version of the safety analysis that is to be included in the company's applications before the applications are submitted and to present the document for consultation.

2.8. A new tactic: submitting previously unannounced documents together with the application

Later in the consultations, autumn of 2009, SKB announced that the company's applications for permission to build a final repository would contain two documents that have neither been announced nor been tabled for consultation: one on the choice of method, the other on choice of site (cf. Figure 1).

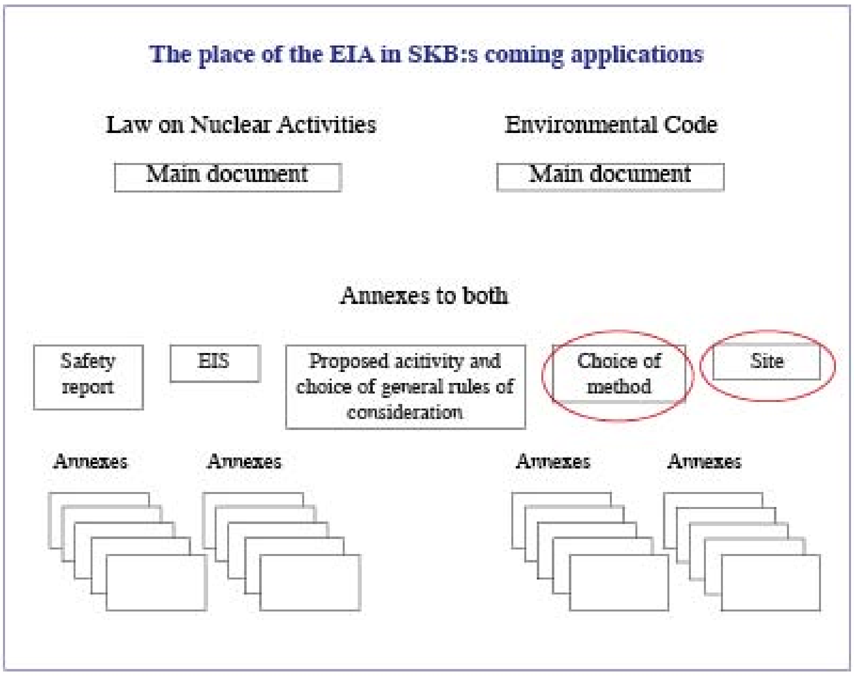

Figure 1. Diagram in SKB's EIA presentation to the Municipality of Östhammar, 23 December 2009 (rings added).

In the course of the consultations the SSNC and MKG have called for more development work on the alternative method deep boreholes, enough to permit a fair comparison of the deep borehole method with SKB's KBS concept. Parallel with the EIA consultations the Radiation Safety Authority and the National Council for Nuclear Waste [a multidisciplinary advisory council to the Government] have made the same demand.These demands were subsequently seconded by the Government. The record to date reveals that SKB has not done the requested work.

With respect to the choice of site, too, the SSNC and MKG have called for considerably better documentation of the rasoning behind the choice of Forsmark than has been presented in the consultations to date. In May 2009 we submitted formal comments on the choice of site and requested a meeting to discuss issues relating to siting. We are particularly interested in an exploration of the possibility that an inland site might afford better long-term safety than a coastal site. The regulatory authorities have also expressed dissatisfaction with the work on the subject that SKB has published to date. Documentation of the waste management company's reasoning and assessments needs to be tabled for consultation, as well. Ever since a consultation on alternative methods and choice of site in the spring of 2006, the company has maintained that no more information need be given, and no further studies on the subjects will be done. SKB has made this clear in the consultations as well as in Fud-reports.

The SSNC and MKG call upon SKB to produce a preliminary version of the documents on alternative methods and choice of site, respectively, that are to be included in the company's applications for a permit to build a repository for spent nuclear fuel, before the applications are submitted, and to make the documents available for consultation.

2.9. Consultations must continue until documentation of the siting process has been presented.

The non-technical section of SKB's draft EIS outlines how the most vital environmental concern, viz. the long-term safety of the repository, has been weighed into the choice of site:

> "The most significant difference between Forsmark and Laxemar [in Oskarshamn] is the greater flow of groundwater at the level of the repository in the bedrock at Laxemar. Groundwater flows are important as they can transport solutes to the buffer and the canister that can affect the long-term function of the buffer and canister. Thus, the greater groundwater flow at Laxemar may imply poorer conditions for long-term safety relative to Forsmark". (page 17)

This is apparently the only aspect relating to long-term safety that SKB finds worthy of mention as a basis for the choice of Forsmark. In the main text of the draft EIS, the subject is specified to relate to the average distance between cracks in the rock (100 m at Forsmark; 10 m at Laxemar). No other safety-related grounds for the choice of Forsmark are given. In view of the vast number of factors that are considered in the analysis of long-term safety – e.g., the role of the bedrock in relation to the function of the copper and clay barriers over hundreds of thousands of years, to mention only one – this is remarkable.

The reasoning and documentation relating to long-term safety that has been presented for consultation as the basis for choosing Forsmark as the site of a final repository for spent nuclear fuel is grossly inadequate. What is more, the only comparison that has been considered is that between Forsmark and Laxemar (Oskarshamn).

The document on siting that SKB presented in June 2009, when the choice of Forsmark was made public, does not provide enough information to allow any judgment as to whether the choice is a good one in a long-term perspective. The document is very superificial; what is more, the choice was made before site investigations at Laxemar had been completed and documented.

As recently as April of 2009, in a national consultation between SKB and the Swedish Radiation Safety Authority, the waste management company said that the choice of site was still an open question. The company also delcared that long-term safety was the prime concern that would guide the choice of site – that concern was prominent long before the site exploration had got under way. A clarification of the bases for the choice of Forsmark instead of Laxemar is important. SKB has said that no safety analysis for Laxemar will be included in the applications. In other words, not even after the applications have been submitted will it be possible to make an independent examination of two full safety analyses. It goes without saying that two comparable safety analyses should be included in the EIA consultations, and that the consultations should not be terminated before the material is on the table.

As noted in the previous section, the nuclear waste management company has announced that a complete account of the site evaluation process will only be presented in a separate annex to the applications. In our view the consultations cannot be broken off until a full account of the process leading up to the choice of site, including a complete safety analysis for both candidate sites, has been presented.

In addition to Forsmark and Laxemar, relevant data from all other sites where test drilling has taken place in the course of the siting process should be presented in a manner than allows comparison with respect to the factors that are said to have decided the ultimate choice of Forsmark.

Finally, empirical data that allow a comparison between an inland and a coastal site in the context of long-term safety should be presented for consultation. Inasmuch as leakage from a repository at an inland site may be expected to take as long as 50 000 years to reach the biosphere, compared to the estimated 50-100 years reported for Forsmark and Laxemar, such information would appear to be a touchstone as to whether environmental safety has indeed been the prime and guiding concern in the siting process Further comments on issues relating to the choice of site are to be found in Section 8, below.

The SSNC and MKG maintain that the consultations must continue until a full account of the data collected in the siting process has been made available.

2.10. Consultations must continue until information that makes it possible to assess alternative methods has been presented.

The SSNC and MKG find no legal justification for the nuclear waste management company's practice of explaining their choice of method by defining two categories: "other methods", which are rejected out of hand, and the KBS method, which is described in the detail prescribed by law. We shall return to this issue in Section 4.2.

It is our view that the consultations cannot be terminated before the data and reasoning underlying the choice of method has been put on the table for discussion. This is all the more important in light of the fact that the company's work to support their exclusion of the deep borehole alternative, starting with the Project on Alternative Systems Study (PASS; Final report: SKB TR 93-04), has proven to be seriously flawed. The need for a proper exploration of the deep borehole alternative is more pressing today than ever before. An American study from 2009 reveals that SKB's assessment is based on empirical studies that were performed before or in the year 2000. Both the National Council for Nuclear Waste and the regulatory authority, SSM, have as late as 2009 pointed to the need for comprehensive data that permit a proper comparison of the KBS method with the deep borehole alternative. SKB, for their part, have said that they feel no need to find out more about the deep borehole alternative and that nothing more than a summary report on the method will be forthcoming.

For more comments on alternative methods, see Section 7 below.

The SSNC and MKG hold that consultations must continue until information that makes it possible to assess alternative methods, including an updated and fair comparison of KBS and the deep borehole alternative, has been presented.

2.11. Playing down the short- and long-term radiation risks associated with the KBS method

Throughout the consultations, SKB has played down the fact that the KBS project involves high-level radioactive spent nuclear fuel, and that it involves risks of serious long-term consequences for the environment. Had environmental organizations not participated in the consultations, the general public might very well have gotten the impression that the project was simply a matter of burying a large number of empty copper canisters, not canisters filled with spent nuclear fuel. As far as the nuclear waste management company is concerned, the problem of long-term safety is no longer an issue; the KBS method has solved it. Consequently, SKB contends that the project may be treated as a major civil engineering undertaking, the consequences of which concern things like noise and dust in the construction phase, traffic, and local impacts on the water table. This, despite the fact that it involves an extremely hazardous waste product that needs to be isolated from mankind and the biosphere for hundreds of thousands of years.

The company's position is amply illustrated in the draft EIS. The non-technical summary of 17 pages makes no mention of the hazardous nature of spent nuclear fuel. In the main text there is mention, but the apparent intent is to show that the spent fuel is not particularly dangerous. Figure 2 (page 38) offers a prime example. Because the radioactivity in the spent fuel subsides exponentially, the figure gives the impression that the radioactivity declines rather quickly. But, the spent fuel contains many different isotopes that are unstable, i.e., they decay. The interesting question is therefore not what isotopes have disappeared, but what isotopes are present in the spent nuclear fuel. As a consequence, the line graph in Figure 3-2 is misleading as regards the long-term environmental hazards that the spent nuclear fuel implies. Instead, the company should provide an analysis that shows the isotopes that pose the greatest hazards at different points in time after the closure and sealing of the respository.

Secondly, SKB continues to use a misleading analogy: on page 37 we find the statement that "after about 100 000 years, the spent nuclear fuel is no more dangerous than the uranium ore that the fuel was made of". This statement has been criticized repeatedly in the course of the consultations for its suggestion that the spent nuclear fuel by this time has the same level of radioactivity as a corresponding quantity of uranium ore. This is untrue. The spent fuel is actually still more than 1 000 times more radioactive that the corresponding amount of ore [previously] mined in Sweden, and more than 2 000 times as radioactive as Bohus granite [quarried on the west coast of Sweden].

Third, the EIS discusses the impacts of radiation only in terms of their effects on human beings, with no broader consideration of the environment as such. What is more, the discussion makes use of a dated conception of the relationship between radiation and human health, one that growing numbers of scientists today regard as simplistic. This problem is discussed in greater detail in Section 5.10.

The SSNC and MKG find that the nuclear waste management company, SKB, has consistently played down the environmental risks posed by

the spent nuclear fuel that is to be disposed of in the final repository.

2.12. The impact of the repository project on nature values at Forsmark was broached late in the consultations.

The impacts on nature values, including threats to red-listed species, at Forsmark have not been discussed until very recently. In fact, no consultation on the subject was held before mention of the impacts in the draft EIS. Thus, there has been no opportunity to discuss such matters with SKB before the present consultation meeting. The earliest inventory of nature values was taken in 2000, and the company has published a number or studies since then. Lack of something to talk about is not the problem. A consultation on the subject, "Current studies of nature, culture, residence, health, risks and safety, etc. Assessments of environmental impacts", announced for autumn of 2006, was postponed repeatedly until, finally, a meeting on "Forsmark – Siting, design and logistics" was convened in October 2008. The material distributed for discussion at that meeting contained only a very cursory description of the nature values at Forsmark and not a word about the possible impacts, should the repository be built there. Nor was any presentation on the topic made at the meeting.

Interestingly, SKB has already, even before the present consultation, initiated "consultations" with the County Administrative Board in Uppsala County with a view to securing a waiver from the ordinance providing for protection of species in connection with the final repository project. All in all, the company's handling of this subject suggests that SKB has not accorded these aspects any greater importance in connection with the choice of site for the above-ground portions of the facility.

Forsmark has many highly valued natural features, which lend the issue of environmental impacts no little significance. SKB's attempt to avoid discussion of these impacts before the publication of an EIS is not acceptable in the context of the consultations. The nature values at Forsmark are further discussed in Section 10.4.

The SSNC and MKG wish to point out that SKB has failed to discuss the impacts of the final repository project on nature values at Forsmark in the consultation process, despite the fact that significant nature values would be put at risk or destroyed.

2.13. Problems relating to the role of authorities in the consultation process

The prescribed roles of the regulatory authorities and the authorities' performance of those roles – perhaps especially the nature of the dialogue between the nuclear waste management company and the regulators – are important factors when we consider the weaknesses in the draft EIS that have a bearing on long-term safety. The shortcomings in SKB's treatment of long-term environmental impacts and risks, falures to properly explore alternative methods, and the choice of Forsmark as the site, despite its apparent drawbacks are all clearly within the remit and responsibility of regulatory authorities. Even the Government's ability to redress these shortcomings has been hampered by the signals they have sent or failed to send.

The Government has reviewed the Fud-reports over the years and repeatedly pointed out that environmental safety should be the prime concern with regard to choice of method and siting of the final repository. From the 1980s and into the early 2000s, principal responsibility for oversight of the repository project rested with the nuclear waste division of the Reactor Safety Inspectorate. The problem is that the personnel in this division, rather than adopt a regulatory posture, chose to collaborate with SKB and even acted as promoters of the KBS method. The Inspectorate defended SKB's inattention to the deep borehole alternative and made no effort to produce an independent assessment of the method of their own. The Inspectorate also uncritically supported SKB's choices of sites, including the company's decision not to explore and evaluate prospective inland sites. By contrast, the other nuclear regulator of that time, the Radiation Protection Authority, expressed some interest in both the deep borehole alternative and consideration of an inland site, but the Reactor Safety Inspectorate suppressed the Authority's comments.

What is more, by all appearances, the Inspectorate seems not to have performed or commissioned any independent examinations of problem areas regarding the long-term safety of the KBS project, including the currently critical problem of copper corrosion and concerns about the performance of the clay buffer, despite clear signs that SKB was experiencing problems on these fronts. Inasmuch as the Government depended on the Inspectorate's reports, there was in effect little or no oversight, leaving the company a free hand to do as they pleased. In sum: the KBS method has not been examined in sufficient detail, and, as a consequence, neither have issues relating to long-term safety received enough attention in the consultations.

The SSNC and MKG believe that the inadequate treatment of alternative methods, alternative sites and long-term environmental safety in the consultation and the three-yearly process to review the SKB Fud-programme is largely due to failures on the part of the Reactor Safety Inspectorate to oversee the activities of the nuclear waste management company in the 1980s, 1990s and early 2000s.

2.14. Comments on the conduct of the regional consultations

Between 1994 and 2008 in the County of Kalmar, and between the early 2000s and 2008 in the County of Uppsala, regional consultations were held. The meetings were convened by the respective County Administrative Boards; the participation of the respective municipalities was organized in two EIA Committees: EIA Forum in Oskarshamn and the Consultation and EIA Group in Östhammar. The nuclear waste management company counts the meetings held since autumn of 2003 among the consultations mandated by the Environmental Code. Both municipalities regard the meetings as their opportunity for consultations with the company. The meetings have been closed to the public and third parties, with the exception of certain meetings with MKB Forum in Oskarshamn.

The role of the County Administrative Boards has been poorly defined. Representatives of the Administrations have chaired the meetings, and minutes of the meetings bear the Administrations' letterheads. But the nuclear waste management company, SKB, has issued the summons to the meetings, paid the costs of the meetings, and minuted them. As a consequence SKBs version of what transpired during the meetings has been published under the Administrations' letterheads. The paper documentation gives the impression that public officials have been in charge throughout.

On several occasions in the course of the consultations MKG has pointed out that these inconsistencies cast doubt as to the role of the County Administrative Boards. They suggest that SKB has succeeded in co-opting the Boards into their own agenda.

The SSNC and MKG find that the roles played by the County Adminstrations in Kalmar and Uppsala counties in the regional consultations has remained ill-defined, which may have impaired the Administrations' impartiality.

2.15. The extent of SKB's control over the consultation process and documentation of the proceedings

The nuclear waste management company, SKB, has steered both the agendas of the consultation meetings and the documentation of the discussions with the aim of influencing the outcome of the consultation process. Many of the public consultations have been held at the Forsmark plant and in Figeholm, near the Oskarshamn reactors. Neither venue is easily accessible to residents of the municipalities; they are even less accessible to participants from other parts of the country, despite the fact that the disposal of spent nuclear fuel is an issue of national concern.

When the views and plans of the company were criticized at such meetings, SKB began to hold separate, closed meetings with residents near the site, thereby regaining control over the information local residents would be exposed to.

None of the local consultations have been recorded, and the company's own staff have minuted them. The minutes have not done justice to critical points raised by participants, whether individuals or organizations, and the company's responses have been altered after the fact. Oftentimes, for example, our questions have been whittled down to the actual question, whereas the reasoning and facts out of which the question arises have been left out.

In recent years, the company has adopted the practice of appointing attesters, who are to verify the contents of the minutes. The sole purpose of this maneuver is to enhance the credibility of the process. But, without access to a tape recording, any attester will find it difficult, if not impossible, to ensure that all the questions asked and the responses to them have been properly recorded.

Another illustration of SKB's ambition to control the proceedings is the period when the company hired a communications consultant to chair the meetings in an "independent" fashion. It turned out, however, that the performance was "scripted"; that is, company staff were informed of the questions he would ask and prepared their responses in advance.

The SSNC and MKG find that SKB has, through choosing out-of-the-way venues and controlling both the agendas and the minuting of the meetings, steered the consultation process to serve their own interests.

2.16. The coming report on the consultation process must include significant issues raised in other meetings besides the public and regional consultations.

The sheer volume and complexity of the consultation process call for diligence in the documentation of the process that shall accompany SKB's application for a permit to build a repository for spent nuclear fuel. If the company opts to use the same manner of documentation as it has used in the annual reports of the consultations to date, no more than the minuted public meetings and portions of the regional consultations will be included.

This is not enough to do justice to the process in its entirety. It is reasonable to demand that the company at least summarize the principal issues discussed in consultations with national authorities (held in accordance with a Government decision), the three-yearly process to review the SKB

Fud-programme, and principal exchanges with various actors in written form.

The SSNC and MKG consider it important for the account of the consultation process to include the principal issues raised in national consultations, in addition to the (local) public and regional consultations.

3. The objectives of the final repository project

In Chapter 2 of the draft EIS, SKB outlines the principles and purposes of the final repository. Eight points are specified:

> • The owners of [Sweden's] nuclear power reactors are responsible for ensuring that the spent nuclear fuel that the reactors produce is safely disposed of, once and for all.
> • The spent nuclear fuel shall be treated and safely disposed of within the country's borders.
> • Neither the sea nor the seabed may be used.
> • The system shall be designed so as to prevent unauthorized handling of either nuclear material or spent nuclear fuel.
> • Multiple barriers shall ensure safety.
> • The final repository shall not require surveillance or maintenance.
> • Establishing a solution for the management of spent nuclear fuel is the responsibility of the generations who have enjoyed the benefits of nuclear energy.

In the following pages we shall consider the objectives the final repository shall fulfill and the extent to which the KBS method and other methods do that.

3.1. The KBS method was not conceived with the objectives set out in the draft EIS in mind.

The wording of the draft EIS gives the impression that the KBS method was conceived and developed specifically to fulfill the objectives set out in the document. This cannot be true because the stated objectives harmonize with laws and ordinances that, with two exceptions (the London Dumping Convention (1972) and the Nonproliferation Treaty (1968)), were introduced after the most recent version of the KBS method was presented, back in 1983. Work on the KBS project started in fact a decade earlier, in the early 1970s.

Throughout the consultation process SKB has tried to convince participants that the KBS method represents the only possible solution to the problem of final disposal of spent nuclear fuel. But the fact is, the KBS method is all of 35 years old, and neither technological development nor legislative processes in the project's surroundings have stood still. Consequently, it has become increasingly difficult for the company to continue to make the claim that KBS is the sole solution. Today, it is clear that features of the system have not kept pace with developments in these past three decades.

The SSNC and MKG observe that the KBS method was not conceived and developed on the basis of the objectives set out in the draft EIS.

3.2. The KBS system does not fulfill the objectives that SKB outlines for the project.

Two of the above-noted objectives of the disposal system is (1) that it "be designed so as to prevent unauthorized handling of either nuclear material or spent nuclear fuel" and (2) that it "not require surveillance or maintenance".

The first of these objectives is somewhat cryptic, but a reasonable interpretation is that it should not be possible to retrieve and use the plutonium that remains in the spent fuel disposed of in the repository to, for example, manufacture nuclear weapons. In practice, the KBS method does not prevent future generations from gaining access to the plutonium. In the consultations, SKB has said that it would require considerable resources to do so, and that there are more readily accessible sources of weapons-grade fissile material. This may be, but the fact remains that the KBS method does not fulfill the stated objective.

The second objective is more straightforward: there shall be no need to keep watch over the repository, once sealed. In the consultations SKB has stated repeatedly that the KBS repository will not require monitoring, but the reasoning is confined to environmental concerns. Inasmuch as the former objective is not fulfilled, however, the repository will require surveillance in order to prevent theft of fissile material. According to analyses on the part of the IAEA (International Atomic Energy Agency), a UN organ, a KBS repository would require surveillance as long as there is a control system to prevent proliferation of fissile materials. In other words, indefinitely.

The draft EIS makes no mention of the risk that the KBS repository might become a source of weapons-grade fissile material or the need of surveillance to keep this from happening.

The SSNC and MKG wish to call attention to the fact that the KBS method does not fulfill the objectives of securing nonproliferation and obviating the need for surveillance.

3.3.The deep borehole alternative may better fulfill the stated objectives of the final repository.

Since the late 1980s, SKB has had projects to study alternatives to the KBS method. The company did not take the initiative to these projects, but was instructed to undertake them by authorities, principally the Government. Judging from the work published from these projects, they would seem to have the implicit purpose of not showing that the alternatives might be superior to the KBS method in any respect.

On page 41 of the draft EIS, SKB writes:

> ”In the framework of the Fud-programmes, SKB has also studied other methods of dealing with the spent nuclear fuel. The principles and criteria set out in Chapter 2 [of this document] are principal criteria for the choice of method. KBS-3 has been designed to comply with these overall principles and criteria. No other method fulfills all of the criteria, or they are not available. Thus, they are not described as alternatives.”

First of all, the methods SKB calls “other methods” are what the law and most other institutions call “alternative methods”. In the passage above SKB states that these methods either do not fulfill the functional criteria the company has set out for the repository or are “not available”. “Not available” is a veiled, but specific reference to the deep borehole alternative. The deep borehole alternative fulfills all the aims that the nuclear waste management company set out a priori, including the requirements that the repository effectively hinder nuclear proliferation and need not be policed after closure. Furthermore, deep boreholes may very well afford better long-term environmental safety than the KBS method.

For a discussion on who is responsible for the situation of the deep borehole method “not being available”, see Section 7.1.

The SSNC and MKG find that the deep borehole alternative fulfills all the objectives set out by the nuclear waste management company, including the objectives of preventing proliferation of fissile materials and no need of surveillance.

3.4. Non-compliance with the general rules of consideration in the Environmental Code

SKB started work on the KBS project long before the Environmental Code was formulated and enacted as law in the late 1990s. As a consequence, the KBS method and the plan for its execution do not fully comply with the general rules of consideration set out in the Code. It has been quite apparent in the course of the consultations that SKB found it hard to accept that nuclear technology falls under the requirements of the Code. Previously, applications for authorization to take measures such as building a final repository were subject only to the Law on Nuclear Activities, but today the terms of both the Law and the Code, including its rules of consideration, apply.

Chapter 2 of SKBs draft EIS mentions the Environmental Code only in passing and does not discuss the implications of the general rules of consideration. Furthermore, judging by the summary of the objectives of the KBS project, one might get the impression that the Environmental Code and the Radiation Protection Act no longer exist. Besides the issue concerning presentation of alternatives raised above, the principal shortcoming of the EIS document vis-à-vis the Environmental Code is the lack of a discussion of the choice of method in the light of the precautionary principle.

The SSNC and MKG find that the nuclear waste management company seems not to pay proper deference to the general rules of consideration set out in the Environmental Code in its discussion of the objectives of the final repository project.

3.5. The lack of a natural barrier in the KBS method and a failure to discuss natural barriers in connection with long-term environmental safety

In the consultations SKB has stressed the fact that the long-term safety of the KBS method is based on multiple barriers, albeit man-made barriers of copper and clay. The company points out that any final repository solution has to have multiple barriers.

The original presentation of the KBS method in 1983 makes no mention of multiple barriers as an advantage of the method. The requirements that long-term safety shall be based on multiple barriers arose later out of a dialogue between the waste management company and the regulatory agency, the Swedish Nuclear Power Inspectorate, who introduced the requirement in the specifications for a final repository in 2002 (SKIFS 2002:1, now SSMFS 2008:21). The requirement has its origins in the field of reactor safety, where multiple, mutually independent barriers are required as fail-safes.

In the KBS method, the two man-made barriers are not mutually independent; the function of the one depends on the function of the other. Nor is there any natural barrier that would keep leakage from the repository from human beings and the environment. In fact, the bedrock may even facilitate the spread of radioactivity from the repository.

The lack of a natural barrier is a serious flaw in the KBS method which no man-made barrier can compensate. As a consequence, SKB has seen fit not to discuss the advantages of natural barriers as guarantees of long-term environmental safety in the draft EIS.

The method of deep boreholes alternatively to the KBS method affords a natural barrier, namely, a salt gradient that prevents upward mobility, in addition to the man-made barriers that surround the spent nuclear fuel in the loading phase.

The SSNC and MKG find that the nuclear waste management company has not fully penetrated the issues relating to long-term environmental safety, and the advantages of natural barriers in particular.

3.6. SKB glosses over the fact that dilution of the radioactivity is one of the safety functions of a KBS repository in the event of an accident.

In the general discussion in the original presentation of the KBS method in 1983, SKB characterizes the safety functions of the method, as follows:

> ”The purpose of the repository is to protect human beings from unacceptable radiological impact. This can be achieved in two ways. One is to contain the radioactive substances for a sufficiently long period of time to allow the process of decay to reduce activity to acceptable levels. The other is that the radioactive substances are diluted, i.e. released and dispersed so slowly that the maximum concentrations that can reach man are acceptably low. Both of these means are employed in the system described here.”

There is also a diagram illustrating the safety functions of the KBS-3 method:

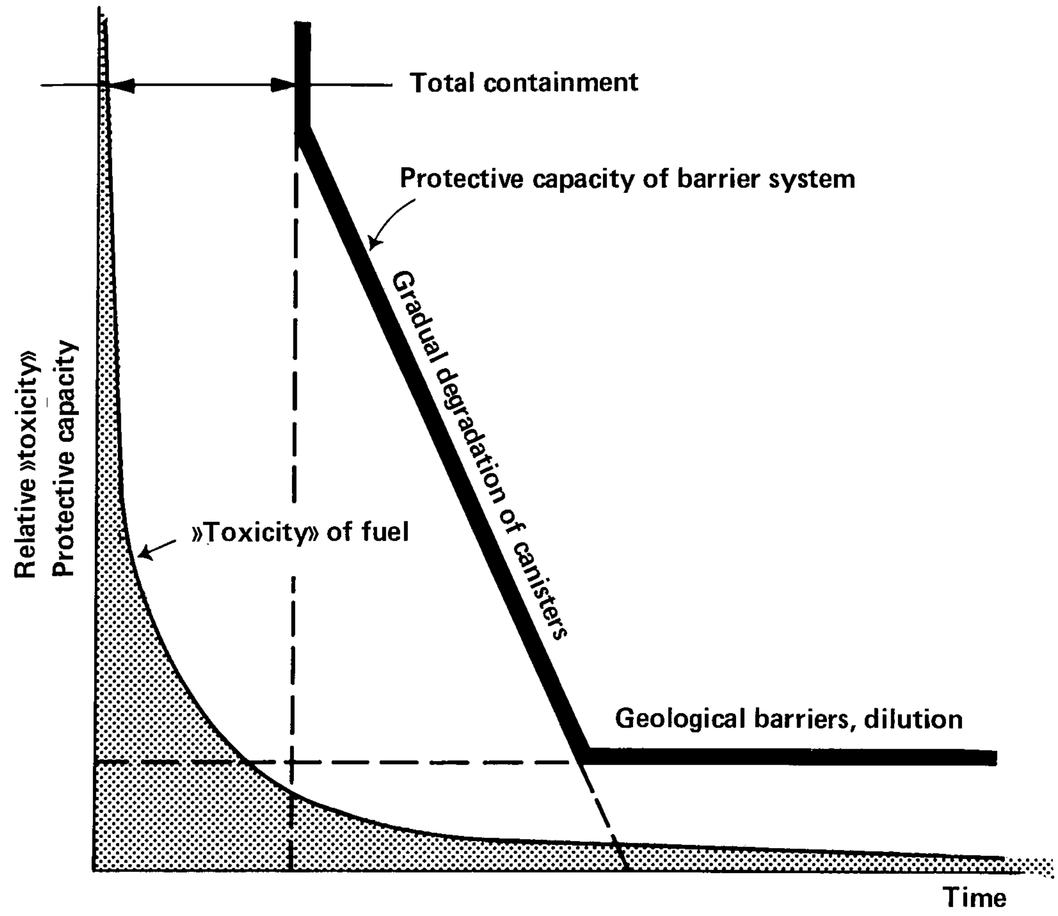

Figure 2. Schematic function of the barrier system (taken from the KBS-3 report dated 1983)

The company has on repeated occasions in the course of the consultations denied that dilution is one of the safety functions in the KBS method. The closest SKB has come to such an admission was in response to a question that MKG submitted in conjunction with a consultation held at Forsmark May 31st, 2006:

> “The KBS-3 method is based on isolation as the primary safety function and retardation as a secondary function. Dilution is not included among safety functions in [the company’s] safety analyses, but in order to be able to calculate the consequences of, for example, releases to a well or stream, dilution must be taken into account.”

Even though dilution may not be in accordance with modern environmental protection laws, there is no justification for SKB to suppress the fact that it is a prime function in the KBS method.

The SSNC and MKG find that the nuclear waste management company has suppressed the fact that a KBS final repository includes dilution of the radioactivity as a safety function in the event of leakage.

3.7. Inadequate treatment of the issue of retrievability

Whether or not the spent nuclear fuel that is finally disposed of shall be retrievable is an important issue. In their most recent survey of the nuclear waste management field in 2010, the National Council for Nuclear Waste raised the issue as one of principal concern. Yet, there is only one reference to the issue in the company’s draft EIS (page 40):

> ”It is not intended for the canisters with spent nuclear fuel to be retrieved once the repository has been closed and sealed. The repository is, however, designed so as to permit retrieval of its contents. One motive for this is that future generations may wish for some reason to change, supplement or improve the design or function of the repository, or to gain access to the spent fuel for some other purpose. Retrieval of the contents finally disposed of would, however, require considerable resources and effort.”

The question of retrieval is closely related to the issue of nuclear proliferation as plutonium may be used to produce atomic weapons. That this perspective has not been discussed in the draft EIS is both remarkable and a serious fault.

The SSNC and MKG find that the draft EIS does not sufficiently penetrate the issue of retrievability.

3.8. No discussion on how other countries treat the issue of retrievaibility

The draft EIS contains no discussion of other countries' approach to disposal of spent nuclear fuel and other high-level nuclear waste. In the consultations SKB has said that other countries follow the same principles and strive toward the same kind of solution as Sweden, i.e., geologic deposition. At the same time, the company suppresses the fact that other countries that have not chosen a KBS-type solution* with its man-made barriers, assign greater value to natural barriers. Countries like the USA, Germany, France, Belgium and Switzerland base their approach to long-term environmental safety on the presence of natural barriers. The USA planned on a final disposal of spent nuclear fuel in an arid desert**; Germany planned to use salt domes; and France, Belgium and Switzerland plan to create final repositories in geological clay strata.

Even in the initial presentation of KBS in 1983 it was apparent that the long-term function of the copper canister was assigned much greater importance in Sweden than in other countries.

Other countries' position on retrievability also differs from the Swedish standpoint. Several countries require retrievability prior to sealing, in many cases because they have long had programmes for reprocessing of spent fuel and therefore do not wish to exclude the possibility that spent nuclear fuel might one day be reprocessed.

The SSNC and MKG find that the draft EIS lacks a discussion of how other countries approach and handle the issues of barriers and retrievability.

* Finland, Canada, Great Britain and Japan intend to use the KBS method.

** Since the election of Barack Obama in 2008, the US government has withdrawn plans to establish a final repository at Yucca Mountain in Nevada, due to the staunch opposition of the state government. The State refers to the importance indigenous people assign to the mountain and to the possible impact on tourism, the state's principal industry.

4. Some legal issues

In the following we shall consider the nuclear waste company's treatment of two requirements set out in the Environmental Code and the Radiation Protection Act: argumentation supporting the use of "best available technology" (BAT) and evaluation of alternatives to the proposed solution.

4.1. The responsibility to develop and apply the best available technology in the final repository project

In section 3.3 above we discussed deep boreholes, an alternative method for disposal of spent nuclear fuel that, SKB agrees, fulfills the company's stated objectives. SKB, however, feels no need to assess the alternative because, as the company states, "it is not available".

The final repository project is unique, and SKB has chosen to develop only one method, the KBS method, for asessment in accordance with Swedish legislation. According to Swedish law, SKB is solely responsible for developing a solution for final disposal of spent nuclear fuel, and by the terms of the Environmental Code and Radiation Protection Act the company is charged to use the best available technology that keeps radiation doses to a minimum, as economic and societal factors permit. In other words, the company is charged to make a thorough assessment of alternative methods, and even to switch to an alternative solution, should it appear to be superior to the KBS method. This makes the company's neglect of the deep borehole alternative all the more serious; it should have been explored and developed parallell with, if not instead of, the KBS method. SKB can hardly excuse its negligence by observing that a technology is "not available" when in fact it has been the company's responsibility to make it available. Particularly, when the company on repeated occasions has been urged to do so by successive governments, authorities and the Council for Nuclear Waste.

That SKB has instead used its resources to produce superficial reports, the aim of which is to show that the deep borehole alternative is not a credible alternative, has only made matters worse. Had we had more adversarial regulatory authorities with the resources to perform or commission studies on their own in the 1980s and 1990s, the problem would have come to view earlier. Because of the lax and uncritical performance of the Nuclear Waste division of the Reactor Safety Inspectorate and the Radiation Protection Authority with regard to SKB's work on alternative methods, the Government was not properly apprised of the situation in the course of the three-yearly process to review the SKB research and development programme.

In the draft EIS (page 33) SKB puts some emphasis on the fact that the Radiation Safety Authority in an ordinance relating to compliance with the Radiation Protection Act (SSMFS 2008:21, previously SKIFS 2002:1) notes that use of “best available technology” shall not imply “unreasonable costs”. The Environmental Code does not discuss what level of cost may be “unreasonable”. The issue of what cost may be reasonable in order to avoid serious long-term environmental impacts and the need for long-term surveillance of the repository is one that requires serious study, not least in view of the fact that the repository in question is the first attempt to store high-level fuel ever made, and the enormity of the potential long-term consequences for the environment and nuclear proliferation, should the wrong method or the wrong site be chosen. Responsibility for investigating the alternative method of deep boreholes was entrusted solely to the nuclear waste management company. For the company to simply say that the deep borehole method is “not available” is no valid excuse for the company’s failure to consider it. Indeed, the argument is circular: the reason the alternative is not available is the company’s neglect of its responsibility to study, develop and assess it.

The SSNC and MKG find that SKB has been entrusted with sole responsibility to research and develop the method of deep boreholes and that the company therefore cannot reject the method on the grounds that it is “not available”.

4.2. A misconstruing of the requirement to report the assessment of methods

In written comment on the company’s draft EIS (dated August 29th, 2006) the County Administrative Board in Uppsala reminds the company of the letter of the law:

> “With respect to the obligatory requirement that an EIS include a so-called ‘zero alternative’, which serves, among other things, as an indication of the urgency of the measures proposed, and the need to make an assessment of alternative sites and designs/methods/technologies, the County Administrative Board has also pointed out that the consideration of alternatives in the EIS document should include all possible alternative locations and designs that are, or have been, broached in the course of the EIA consultations or SKB’s research and development work. In the view of the Board, such an overall assessment should be reported in enough detail to allow a balanced assessment of the advantages and disadvantages of the alternatives, particularly with respect to the consequences for human health and the environment and efficient use of natural resources, in the light of the fundamental values set out in Chapter 1, Paragraph 1 of the Environmental Code.”

In the draft EIS, SKB gets around the recommendation of the County Administrative Board by redefining “alternative methods”, an established term in environmental law, to mean methods that (1) fulfill the objectives set out by the company and (2) are available. In practice, these two criteria mean that no other solutions than SKB’s own KBS method, or possible variations of it, may be said to fulfill the objectives.

SKB’s reference to the deep borehole alternative as an “other method” rather than an “alternative” method in the sense of environmental law because it is “not available” is a subterfuge, designed to divert attention from the company’s blatant refusal to explore alternative means to achieve environmentally safe methods for disposal of spent nuclear fuel. As shown in Section 7, it would have been quite simple for the company, had it been willing, to produce a considerably better feasibility study of the deep borehole method and assessment of that method’s long-term environmental safety. Instead, SKB devotes two pages of the draft EIS (pages 42-43) to argue against the deep borehole alternative, based solely on speculation.

Demands that the company study alternative methods were first raised by the Government and the law in the late 1980s. During the interval since then, the nuclear waste management company has demonstrated a total lack of interest in making any serious study of alternative methods for disposal of spent nuclear fuel, despite the fact that it was their explicit responsibility to explore and develop alternative methods. Had the company fulfilled its responsibility and developed the alternative method of deep boreholes, it is highly likely that the method would have been found to offer a higher degree of long-term environmental safety and less need of future surveillance to prevent nuclear proliferation than SKB’s KBS method. And presumably at a lower cost.

For more on the treatment of alternative designs and methods, see Section 7.

The SSNC and MKG find SKB’s treatment of alternative methods grossly deficient.

5. Long-term environmental safety

The critical factor to be considered in any application for a permit for the construction of a final repository for spent nuclear fuel is the long-term environmental safety of the proposed solution. In Chapter 1 of the draft EIS, SKB writes that “the long-term safety of the repository after loading and sealing is a principal issue in the [company’s] safety assessment and the [Environmental Court’s] examination of the application”. In the following we wish to comment on some features of the project that have a bearing on long-term safety.

5.1. Reliance on man-made barriers is inappropriate for disposal of spent nuclear fuel.

The KBS method was conceived in the 1970s in an era when it was believed that Swedish engineering could solve any problem. Consequently, it is hardly surprising that the KBS method relies on man-made barriers, products of modern engineering, to ensure its long-term environmental safety. A system for final disposal of spent nuclear fuel has to be able to isolate the spent fuel from the biosphere for hundreds of thousands of years – a task that makes overwhelming demands of any man-made solution, including a capacity to withstand the trials of multiple ice ages.

The nuclear waste management company, SKB, has in the span of several decades constructed a set of models that are used in safety analyses with a view to demonstrate that a KBS repository can guarantee that spent nuclear fuel will remain isolated for hundreds of thousands of years. The models, constructed in a dialogue between the company and regulatory authorities, are what the Radiation Safety Authority will examine in conjunction with the company’s application for a permit to build a final repository for spent nuclear fuel. Over the years, empirical findings relating to the copper and clay barriers in the KBS method have revealed several principal discrepancies between reality and the models’ predictions. This has led to a markedly diminishing interest on the part of the company to do empirical research, either in the underground laboratory at Äspö or elsewhere. There is always a risk that results of such research will complicate the company’s model universe, making it even harder for the models to produce the “right” results.

As the time for submission of an application approaches, there is ample evidence that SKB’s understanding of how the copper and clay behave in the repository environment is hardly sufficient to demonstrate the validity of the models. As a consequence, pressure is increasing to push for approval of the application – based, as it is, on the models. Awaiting the results of experimental studies of copper corrosion might put the entire project in jeopardy.

This state of affairs is totally unsatisfactory. Among other things, it shows how wrong it is to expect man-made barriers of copper and clay to be able to protect human life and the environment from the spent nuclear fuel in the repository for hundreds of thousands of years. What is needed is a system that relies on natural barriers, not barriers that try to mimic nature. Or, as in the KBS method, try to mimic something that was *believed* to be natural, but has proven not to be. The long-term safety of a repository for spent nuclear fuel should not depend on man-made barriers.

The SSNC and MKG find that the KBS method proposed by SKB, or any other method that relies on man-made barriers, is not appropriate for final disposal of spent nuclear fuel.

5.2. Flaws in the man-made barriers of copper and clay

In recent years, the long-term safety of both of the man-made barriers in the KBS method has been called into question.

SKB's seeming failure to take note of research developments relating to copper corrosion became apparent in 2007, when researchers at the Royal Institute of Technology (KTH) in Stockholm published the results of studies showing that copper corrodes even in anoxic environments and, what is more, at about the same rate as in environments where atmospheric oxygen is present. In time, it emerged that these findings were not entirely new; experiments with similar results had been done in the late 1980s and early 1990s. Having examined the research on copper corrosion, MKG has found the following:

1. No results from experimentation in laboratories and simulated repository environments nor field studies have been reported that support the theoretical presumption that the rate at which copper corrodes declines one-thousandfold.

2. Copper in controlled environments in the LOT project at SKB's Äspö Laboratory showed "unexpectedly high" degrees of corrosion after five years. According to SKB the explanation must be that the environments were not anoxic, after all. No physical evidence to support this 'explanation' has been presented, only rough estimates. Other experts explain the phenomenon differently: Oxygen was consumed after several weeks in clay (chemically) and groundwater (through bacterial action), and the corrosion took place in an anoxic environment – an impossibility, according to SKB. The next LOT capsule (S2) has lain untouched for ten years.

Opening it to verify/falsify the existence of anoxic corrosion would provide valuable scientific information. Unfortunately, however, SKB has stated that the S2 capsule will not be opened until after the application for a permit to build the repository for spent nuclear fuel has been submitted. We, the SSNC and MKG, find this decision totally unacceptable, considering that the issue of copper corrosion in anoxic environments is unresolved. What is more, if corrosion takes place in anoxic environments, serious questions concerning the long-term safety of the KBS method arise.

3. Judging from the publications from the project to date, no long-term laboratory studies of copper corrosion in a simulated final repository have been carried out since copper was chosen as the canister material in the early 1980s. “Long-term” studies in this connection are studies that have lasted more than a year or two. Long-term studies of titanium were performed in the latter half of the 1970s, before the material was abandoned in favor of copper.

4. Relatively many short-term studies, lasting days, weeks and up to several months, have been carried out in simulated final repository atmospheres. The findings are contradictory, partly because some of the experiments were not well-executed, but also because the findings have not been followed up in any systematic fashion. As a consequence, conclusive evidence has yet to be produced. Some experiments have been done under the auspices of the nuclear waste management company, and others by sister companies in Finland and Canada. Swedish and Finnish regulatory authorities, too, have studied copper corrosion experimentally. Some of these studies are replications of the work done by SKB, undertaken by the same institutions that SKB has used, and have not produced any new insights. In cases where authorities have commissioned studies of copper corrosion from more independent researchers, the findings have been such that the authorities should have been given pause for thought, but they have not yet been followed up to the extent that they make it possible to evaluate SKB’s application in accordance with the Law on Nuclear Activities.

5. None of the natural analogues that SKB has presented in support of their conviction that copper will work in the final repository environment have turned out to be relevant. Natural copper metal exists either on the chemical fringes of high-grade copper ore or are encapsulated in mineral that is impervious to both oxygen gas and water.

6. Copper and silver are seldom found in uncorroded form in archaeological sites, other than in very dry ones. Copper finds from the Swedish warship Vasa and other sunken ships show that copper corrosion is a very complex process, in which the presence of oxygen, other corrosive agents and water appear to regulate the rate of corrosion. It turns out that the antique

cannon that SKB often refers to as evidence that copper does not corrode are actually bronze, not copper.

7. One modern analogy reaffirms the complexity of the copper corrosion process. Where copper is used in the cooling system of large generators or accelerators, the copper in the pipes that carry the circulating water corrodes, even when the oxygen content of the water has been kept to a minimum. Counter intuitively, the rate of corrosion has been observed to increase when the oxygen content of the water is reduced even more. To deal with the problem of congestion in the pipes due to corrosion, the amount of oxygen in the cooling water is carefully regulated, not too high, not too low. There is no theoretical literature that explains this phenomenon.

8. Current theoretical models are often interpreted to mean that corrosion in anoxic environments cannot occur. The validity of this interpretation has been challenged, but it has become virtually an article of faith, on which the Swedish, Finnish and Canadian approaches to the disposal of spent nuclear fuel have been based for thirty years. The reception scientific challenges to this 'Truth' receives has been likened to the reaction in devout circles, should someone declare that he or she no longer believes in God. But, the idea that water might corrode a copper surface even in the absence of oxygen, is not quite as preposterous to researchers who study surface catalytic processes. The phenomenon may be the result of cleaving processes, in which case copper oxides may be produced so long as hydrogen gas is allowed to escape from the copper surface. Given the presence of chlorine ions (salt in water), more complex copper-oxygen-chlorine substances may form. According to Gunnar Hultquist of the Royal Institute of Technology (KTH) in Stockholm, experiments in which the oxygen in water has been marked with O-18 isotopes and a copper surface is exposed to both atmospheric oxygen and water, oxygen from the water has been found in the oxides formed on the surface.

9. Although researchers Peter Szakàlos and Gunnar Hultquist at KTH in Stockholm may only have studied anoxic copper corrosion using pure water, their starting point, that anoxic copper corrosion is possible, seems to have equipped them to explain the corrosion observed in the Äspö Laboratory better than the nuclear waste management company has been able to do.

To sum up: There is no empirical support for the tenet that copper does not corrode in an anoxic environment. On the contrary, there is mounting evidence that it does corrode. Recently, the waste management company has been somewhat more accepting of the possibility that they may have missed this central factor. At the same time, the company has begun to argue that even if copper does corrode, it has no greater implications for the long-term safety of the repository. No calculations have been presented in the EIA consultations, and there is no experimental support for the assurance. Experimental support is necessary, however, before an application to build a KBS repository can be approved.

The researchers at KTH express worry that the copper canisters in a KBS repository may collapse within 1 000 years after the repository is closed and sealed. In this time the copper canisters are much warmer than the surrounding bedrock, and the rates of corrosion at high temperatures are very high. Furthermore, one cannot rule out the possibility that the hydrogen produced when copper corrodes will enter the canister and make it brittle.

The capacity of the other man-made barrier, the clay buffer, to withstand erosion has also been seriously questioned in recent years. SKB has been unable to demonstrate that the clay will not disappear from the repository during even the first period of glaciation and thaw that it experiences. The Radiation Safety Authority and experts it has consulted have expressed concern that the company has not taken this problem seriously enough; even the National Council for Nuclear Waste has expressed disappointment in the attention the company has given to the risk of erosion.

To sum up: At present, SKB does not have sufficient empirical support to be able to say that the man-made barriers of copper and clay can guarantee the safety of the repository for hundreds of thousands of years. Indeed, the unresolved problems surrounding the two media are such that there is reason to question whether the basic premise of the KBS method, to base the long-term safety of a final repository for spent nuclear fuel on man-made barriers, is valid.

The SSNC and MKG find that there is no evidence that either the copper canister or the clay buffer will perform in the final repository in the manner SKB's models predict; the problems of copper corrosion and clay erosion require more study.

5.3. The KBS method was conceived for bedrock of a certain wetness.
The conception of the function of the surrounding bedrock has changed somewhat since the 1970s. Originally, the ideal was said to be rock of high density, with few or no fractures in it, and the search for a site had qualities of the bedrock in focus. But, as the localization process encountered local opposition and other difficulties, SKB was forced to tone down the importance of the bedrock to the long-term environmental safety of the KBS method. By the time, in the early years of the present century, that two coastal sites adjacent to two different nuclear power facilities were chosen

for detailed investigation, the company was saying that the KBS method would work in virtually any kind of bedrock.

The bedrock in Laxemar near the Oskarshamn facility (Småland) and that in Forsmark (Uppland) are distinctly different. The bedrock in Forsmark is very dry; it is dense, with few fissures. The bedrock in Laxemar carries considerably more water.

The underground bedrock laboratory at Äspö is located in the same area as Laxemar, and the results of experiments in the Äspö laboratory may readily be applied to a repository at Laxemar, but not as easily to the Forsmark site. SKB expresses no concern over this, but rather claims that according to the models, it makes no difference whether the bedrock is dry or wet. But models do not always tell us enough about real conditions. Experiments at Äspö have produced unexpected results concerning the behavior of heated clay and how the corrosion of copper affects clay. If the models do not even correspond to realities in Laxemar bedrock, what is to say they will do better in Forsmark?

One crucial problem is that the clay buffer requires a certain amount of water in order to expand and become the barrier it is presumed to be. Unless there is enough water, expansion will be slow. Experts called on by the regulatory authorities to examine the most recent safety analysis that SKB has published (SR-Can) estimated that it might take several thousand years for the clay to expand enough to fill the repository. There is no taking for granted that either the copper canister or the clay buffer will perform in the way SKB's models predict in a hot and relatively dry environment.

The company has stated that they will not undertake any special experimental studies of how copper and clay perform in the dry bedrock at Forsmark. Instead, they are presuming that the Environmental Court and regulatory authorities will be satisfied with the models. Again, why should anyone presume that the models will hold for Forsmark, when they have not even foreseen the results obtained at Äspö?

It is hardly reasonable for SKB to move to a new bedrock formation of a significantly different character without any empirical support for the safety analysis.

The SSNC and MKG find the KBS method to be poorly adapted to the dry bedrock at Forsmark and call for empirical studies in bedrock of the same character to demonstrate the feasibility of the method at the chosen site.

5.4. A repository of the KBS type should be situated as deep as possible in the bedrock.
Sooner or later a final repository of the KBS type will start leaking radioactivity to the environment. The deeper the repository is placed, the more dense the surrounding bedrock will be and the slower the movement of groundwater through the formation. In other words, the greater the depth of the repository, the longer it will take for whatever leaks from it to reach the biosphere, i.e. human life and the environment. A final repository for spent nuclear fuel should therefore be situated at a depth of about 1 000 meters.

Another reason to situate the repository deeper down is that the stresses associated with coming ice ages may be expected to be lower. The risk that melting water will enter into the repository is lower, as is the risk that the repository will be subjected to permafrost.

SKB plans to situate the final repository at Forsmark at a depth of only 400 meters, which is even shallower than the company earlier stated was appropriate for the KBS method. It is not clear whether the Forsmark formation allows a deeper location. Another problematic factor is the proximity to the Baltic Sea; at coastal locations the salinity of groundwater increases more quickly with greater depth.

The SSNC and MKG recommend that if the KBS method is to be used, the repository should be situated as deep as possible, at a depth of about 1 000 meters.

5.5. A KBS repository should be located in a zone of groundwater recharge, not discharge.
As leakage of radioactivity from s KBS repository is only a matter of time, a final repository of that design should be located as deep as is possible in a zone of groundwater recharge. That way it will take considerably longer for leakage from the repository to reach the biosphere than if the repository is sited in a zone of groundwater discharge. Any coastal site, like that at Forsmark, will be a groundwater discharge zone. For more on this subject see section 8.5.

The SSNC and MKG recommend that a KBS repository be located in a groundwater recharge zone.

5.6. Unwise to locate a final repository for spent nuclear fuel in a tectonic shear zone

The chosen site for the final repository at Forsmark is located in a tectonic shear zone, i.e., a zone where pressure is released when tectonic plates move in relation to deeper parts of the earth's crust. Tectonic shear zones are more likely than other areas to experience earthquakes. Earthquakes are, for example, relatively common in Skåne, in southernmost Sweden, where the next shear zone to the south of Forsmark is located.

The zone at Forsmark is considered dormant — until the next period of activity. In the course of the EIA consultations MKG has asked SKB to produce evidence that the zone is in fact inactive. SKB has yet to present any evidence to that effect.

Even if the risk of an earthquake in the foreseeable future is very small, the fact remains that a shear zone is inherently unstable and certainly likely to experience movement in coming periods of glaciation. This implies a risk of more frequent, and more dramatic, dislocation. The possibility that a final repository in the bedrock at Forsmark might be damaged or destroyed due to extreme rock pressures during an ice age cannot be ruled out, particularly when we consider that the repository in itself may weaken the formation. SKB has not presented any calculations that show there is no such risk; instead, the company has reasoned in general terms that considering the bedrock has remained intact so far, it will surely last a good while longer. It should be noted that one of the formations that border on the intended site experienced major dislocation in the most recent period of glaciation.

The SSNC and MKG find it unwise to establish a final repository for spent nuclear fuel in a tectonic shear zone like Forsmark.

5.7. Inadequate treatment of the risks to a repository during periods of glaciation

According to SKB's most recent safety analysis, a final repository of the KBS-3 type will withstand repeated periods of glaciation, and leakage from the repository will not occur before the activity in the spent fuel has subsided to an "acceptable" level. An ice age poses numerous and extreme stresses to a KBS repository: greater rock pressure and earthquakes of increasing magnitude and frequency, a heightened risk of permafrost and methane gas explosions. Finally, water from melting glaciers above and salt water below may force their way into the repository chamber in different phases of glaciation.

The studies that SKB has conducted to date are still incomplete. A principal problem is that the company has not approached the problem of glaciation open-mindedly, but seems only interested in finding assurances that glaciation is not a problem. For example, the company has a priori ruled out the possibility of earthquakes above a certain magnitude and set a limit beyond which permafrost will not extend. MKG and other participants in the consultations have on repeated occasions called for better studies of what glaciation may entail, but SKB seems not to have taken these demands seriously. All we have heard is that the situation is under control, the company has done the studies they find necessary, and that these questions are being investigated by other institutions.

The SSNC and MKG finds SKB's treatment of the challenges that glaciation poses to the final repository sorely inadequate.

5.8. The lack of a "worst-case scenario"

In discussions of the long-term safety of a final repository for spent nuclear fuel, particularly in relation to the question of copper corrosion, fears have been voiced that the repository may fail long before the time SKB's models predict. Some scenarios envisage the failure of all the copper canisters within 1 000 years. In order to gain a better understanding of the possible consequences of any major error in the company's model-based theories concerning long-term safety, the company should take the time and effort to outline a so-called "worst-case scenario" as part of the environmental impact statement that will accompany its application for a permit to build a final repository. A "worst case" might, for example, posit that all the copper canisters spring leaks and that channels develop in all the clay buffers so that water streams through the repository 1 000 and 10 000 years after it has been filled and sealed.

The SSNC and MKG strongly believe that the environmental impact statement that accompanies the company's application to build a final repository for spent nuclear fuel must show the consequences of a worst-case scenario that assumes leakage from the repository 1 000 and 10 000 years after the repository has been sealed.

5.9. The lack of scenarios involving accidental intrusion into the repository

The draft EIS presented by SKB lacks any discussion of what might happen in the event of inadvertent intrusion into the repository. Such a worst-case scenario might, for example, assume that drilling to develop a geothermal energy source penetrates a canister, but that this is not discovered before blasting is undertaken at the level of the repository to increase the flow of groundwater in the geothermal system.

The SSNC and MKG strongly believe that the environmental impact statement that SKB submits must include scenarios of accidental

intrusion into the final repository.

5.10. Inadequate assessment of radiation impacts
SKB's assessment of the radiation impacts in the draft EIS document is conventional to the extreme. For one thing, it focuses exclusively on human beings; secondly, it ignores recent research findings that suggest that current models underestimate the effects of radiation.

The company needs to expand the scope of its impact assessments to include not just human beings, but the biosphere as such. The radiation protection community is in the process of abandoning the anthropocentric world-view that has predominated in the past. In the future, we may expect environmental radiation to assume successively greater importance. Considering that the impacts of a final repository will be exceptionally long-term, the impact assessment needs to take account of the project's environmental consequences in the longest possible time-frame and, thus, for the biosphere in its entirety.

There is currently some controversy over how the impacts of ionizing radiation on human beings should be evaluated. Up to now, most models have focused on the effects of external radiation sources, perhaps because they are more easily calculated. Today, however, there is a growing body of evidence that radiation from sources that have entered into the human organism may have much more serious consequences than radiation from external sources. This may mean that the risks associated with radioactive emissions will have to be assigned higher values, perhaps as much as 100-fold higher.

The emissions from a final repository for spent nuclear fuel may be assumed to result primarily in radiation from internal sources, and this has implications for the risk assessments of the repository. The EIS document that accompanies SKB's application for a permit to build the repository needs to take these new insights into account.

The SSNC and MKG find the nuclear waste management company's assessment of the impacts of radiation on Man and the environment lacking in important respects.

6. Long-term environmental safety in the face of future developments in society at large

The physical environment is not the only source of environmental risk factors that future generations will have to deal with. In order to fully assess the environmental safety of a final repository it is necessary to take societal developments into account, as well. This is not generally done inasmuch as societal developments are difficult to predict, and the risks they entail can only be speculative. Human motives do not lend themselves to quantification. Furthermore, there is also a general inclination not to take responsibility for what future generations may choose to do or not do.

Be that as it may, there is a real risk that future generations will use the contents of the repositories we build in ways that hurt themselves or others. We cannot turn a blind eye to the fact that we have made those contents available to them. What is more, there is the risk that future generations may open the repositories because they are unaware of what they contain, let alone the hazard they represent. Scenarios like these need to be addressed in the safety analysis and environmental impact assessment that accompany the company's application for a permit to build a repository for spent nuclear fuel.

6.1. No attention to the long-term risks of nuclear proliferation associated with a KBS repository

SKB's draft EIS makes no mention of the risk of nuclear proliferation. When disposed of without processing, spent nuclear fuel contains about 1% plutonium. Plutonium is a fissile material that lends itself to use in making nuclear weapons. All kinds of plutonium may be used to make weapons, even if today's nuclear powers have special reactors that produce special weapons-grade plutonium. There will be plutonium in the final repository as long as the contents of the repository pose an environmental hazard, i.e., more than 100 000 years. This means that a repository of the KBS design has to be guarded for that long, as long as there is the threat of nuclear proliferation and a system for controlling it.

It is entirely conceivable that a future society that occupies the area above a repository may wish to acquire nuclear weapons to use against its rivals or enemies. If there are no nuclear reactors in operation at that time, the repository would be the most accessible source of fissile material. Scenarios that take the risk of nuclear proliferation into account have to be included in the safety analysis and environmental impact assessment that accompany the application for permission to build a final repository for spent nuclear fuel.

The SSNC and MKG maintain that scenarios that assess the long-term risk of nuclear proliferation associated with the final repository must be included in the documents that accompany the application for permission to build it.

6.2. No discussion on speculative or deliberate intrusion

SKB's draft EIS fails to discuss the possible consequences of deliberate intrusion into the final repository at some time in the future. Speculative or deliberate intrusion may be undertaken on the basis of suspicions or hopes that the repository contains treasures or otherwise valuable material. It is entirely conceivable that at some point in the future the local society has lost the knowledge needed for them to understand what the repository contains, in which case they will not be aware of the kinds of hazards to themselves or the environment that the contents pose. After some time, the contents are no longer outright lethal, and they may be brought up out of the repository and spread throughout society with no thought to any potential danger. The copper in the canisters may in fact be recognized as a valuable resource, and there is no ruling out the possibility that the canisters might be retrieved and emptied for other use, in which case the radioactive contents may be left unprotected among ordinary refuse.

The safety analysis and environmental impact assessment for the final repository need to take the risks of speculative intrusion into account.

The SSNC and MKG maintain that scenarios that assess the risk of speculative intrusion into the final repository must be included in the documents that accompany the application for permission to build it.

7.Alternative methods, and deep boreholes in particular

In section 6.2 above we noted the nonchalance SKB has shown in relation to the legal requirement that the company study and present alternative solutions to the problem with the disposal of spent nuclear fuel in a manner that permits a proper comparison of the alternatives to the proposed method.

7.1. The alternative method of deep boreholes needs to be studied to the extent that it can be compared to the KBS method.
Over the years, SKB has demonstrated a marked disinterest in exploring alternative methods for dealing with spent nuclear fuel. Despite the fact that deep boreholes since the late 1980s have shown promise as a better technique for final disposal of spent nuclear fuel, SKB has yet to take steps to explore the alternative more thoroughly. The company has, on the other hand, invested relatively large sums of money in Swedish research on transmutation – a technique which, up to a few years ago, in no way rivaled the KBS method.

In May 2006, MKG published a report on the deep borehole alternative. The report shows that deep boreholes may afford better long-term environmental safety than the KBS method offers. What is more, it offers more robust deterrents to future nuclear proliferation. In early 2007, the Council on Nuclear Waste arranged a colloquium on the deep borehole alternative.* There, it emerged that considerable advances in drilling technology have been made since the method was first discussed in the 1980s and that the method is now indeed a viable alternative for disposal of spent nuclear fuel. SKB has received both the MKG report and the documentation from the colloquium.

Since 2007, additional knowledge pertaining to deep boreholes has been gained. Acting on the request of the Council on Nuclear Waste, Professor Karl-Inge Åhäll at Karlstad University (Sweden) has made a comparative evaluation of the deep borehole alternative and the KBS method. Secondly, in 2009 Sandia National Labs in the USA published a new report, analyzing use of deep boreholes as an alternative to the then-planned dry storage of American nuclear waste in Yucca Mountain in Nevada. Both reports give a favorable assessment of deep boreholes as a method for final disposal of spent nuclear fuel. (See further Annexes 1 and 2 to the present report.)

On more than one occasion Swedish Cabinets have admonished SKB to explore alternatives to the KBS method, and between the end of the 1980s and 2000 the company published a number of reports by consultants on the deep borehole alternative. In 1992 (the PASS study), SKB compared the

KBS method with a number of alternative methods. Applying a complicated and less-than-transparent method of evaluation, the company came to the conclusion that the KBS method was superior to all the alternatives. Nonetheless, the Swedish government repeated its call for serious consideration of alternative methods in their decision on the Fud-92 report.

The consultants' reports between the years of 1989 and 2000 are generally positive in their assessments of deep boreholes as an alternative, which they find to be a viable alternative that affords a high degree of long-term environmental safety. Despite these evaluations, SKB chose not to put any resources into developing the method. Instead, in 2000 the company published a study of its own, which showed that development of the deep borehole alternative would require so much effort and expense that it was not of interest. That, the company believed, was a definitive conclusion.

Since the turn of the century the work SKB has published on the deep borehole alternative amounts to no more than reiterations of previous conclusions, plus comments on studies done abroad. Over the years the company's arguments against the deep borehole method have become increasingly tortuous; clearly, the company has gone out of its way to find fault with the method. Indeed, in recent years SKB has put forward problems that have no basis in the research done to date. This is especially apparent in the draft EIS: that it would be very difficult to deposit canisters in deep boreholes or that deep boreholes would be vulnerable to the forces of glaciation is sheer speculation on the part of the company.

Overall, the deep borehole alternative is deemed to have the potential to provide for considerably better long-term environmental safety that the KBS method: the fundamental protective barrier is natural, not man-made; deep boreholes offer better protection against nuclear proliferation and imply less need of surveillance over coming centuries. What is more, final disposal in deep boreholes may very well be less costly to implement. In short: there is every reason to give the deep borehole alternative careful consideration before committing to the KBS method.

The SSNC and MKG strongly recommend that the alternative method deep boreholes be thoroughly evaluated, to the extent that it can be compared with the KBS method.

8. Disadvantages of the chosen site and siting alternatives

The Swedish Environmental Code, Chapter 2 Paragraph 6, states:

> "In case of activites and measures for whose purposes land or water areas be used, a suitable site shall be selected. A site shall always be chosen in such a way as to make it possible to achieve their purpose with a minimum of damage or detriment to human health and the environment."

Thus, the Code is quite explicit about the siting of prospective hazardous activity. The site that affords the greatest possible environmental safety shall be chosen. The result of SKB's siting process in connection with the final repository is a less-than-optimal site. The company defends its choice as being "good enough" – according to the predictions in the company's modeling of long-term safety. In our view, this kind of thinking is not acceptable, not in view of the extreme hazards associated with spent nuclear fuel and the extreme length of time the waste needs to be isolated from human life and the environment.

8.1. SKB's siting process has not been systematic, nor was the choice made on the basis of a priori criteria.

The choice of a site adjacent to the nuclear power installation in Forsmark (Uppland) was announced in June 2009. The choice of Forsmark made it quite clear to those who had followed the issue that somewhere along the line the siting process had derailed. The process was never systematic, and no a priori criteria had guided it. Nor was long-term environmental safety in focus.

The siting process has been criticized severely for many years. Environmental groups that participate in the EIA consultations have repeatedly called for a more systematic and safety-oriented process. One of the prime recommendations to come out of the so called Dialogue Project – in which SKB declined to participate – was exactly that. Nevertheless, the company continued to pursue its own agenda, in which safety criteria were secondary considerations at best.

It is therefore interesting to read the revisionist history of the process that the company apparently intends to include in its application to the Environmental Court. We, the SSNC and MKG, have a quite different impression of the events, as documented in a paper by Olov Holmstrand, geologist and chairman of SSNC's Lerum chapter (see Annex 3). In short, our account of the process is this: SKB may originally have sought to find “the best bedrock”, but over the years they have become increasingly (self) convinced that the repository could be located anywhere, irrespective of environmental concerns. Symptomatic of this gradual change in orientation was the company’s decision in 199X to exclude the Municipality of Hultsfred (inland from Oskarshamn) from the candidate sites.

The SSNC and MKG find that the siting process has been neither systematic nor guided by a priori criteria; as a consequence, long-term environmental safety has not been of focal concern.

8.2. A final repository of the KBS model is not suited for use in dry bedrock of the kind found at Forsmark.

As mentioned in section 5.3 above, bedrock as dry as the Forsmark formation at the level of the repository does not afford optimal conditions for the long-term function of the man-made barriers, copper and clay. A lack of moisture in the repository means that the clay buffer will swell only very slowly, which may increase the risk of unforeseen changes in the properties of the clay after protracted exposure to dry heat. Neither has the nature of copper corrosion processes in this environment in the first millennium or two been studied. Before Forsmark can be selected as the site of the repository, the long-term studies carried out in the wetter bedrock in the Äspö laboratory must be complemented with similar studies in conditions approximating the bedrock at Forsmark.

Another risk factor at the Forsmark site is the extreme rock pressure in the formation in which construction will take place. It is still unknown whether the repository cavity and access to it can be created without weakening the bedrock surrounding it. In the draft EIS, SKB notes that the problem of high rock pressures may be expected to increase as the rock is heated by the presence of hot copper canisters in the cavity.

The SSNC and MKG are not convinced that the KBS method is suited for use in the dry bedrock at Forsmark.

8.3. The flow of water at more superficial levels in the bedrock at Forsmark renders the site inappropriate for a final repository for spent nuclear fuel.

A considerable amount of groundwater flows through the rock above the level of the repository at Forsmark. The flow is a consequence of the pressures at play in the tectonic shear zone and the extreme rock pressures in the formation in which the repository is planned to be built. Given these flows, any leakage from a repository may be expected to spread relatively quickly over a rather large area on the surface.

The SSNC and MKG find that groundwater flows at more superficial levels in the bedrock at Forsmark render the site inappropriate for a final repository for spent nuclear fuel.

8.4. The area around Forsmark has many nature and recreation values.
The area around Forsmark has significant nature and recreation values. The establishment of the repository would put a number of red-listed (endangered) species at risk. Furthermore, the area borders on the Kallriga nature preserve. The nuclear waste management company may not consider this much of a problem, but environmental organizations do. It is not just a matter of relocating some frogs. The real problem is that the company has not had the environment in mind in the selection process.

The SSNC and MKG find that the Forsmark area has natural and recreational features of such importance that it is not an appropriate location for a repository for spent nuclear fuel.

8.5. A KBS repository should be located inland, in a groundwater recharge zone.
The possibility that an inland site might be more appropriate than coastal sites has been a running theme in the EIA consultations and the three-yearly process to review the SKB research and development programme. SKB rejected Hultsfred as an object for further exploration in the late 1990s, possibly because the population there may have appeared to be less wholeheartedly committed to the project than the communities of Oskarshamn and Östhammar, which both host nuclear power facilities.

An inland locale has the advantage of affording areas of groundwater recharge, where groundwater flows inward and down into the ground rather than up and out over the surface. In an recharge zone, possible leakage from the repository will take significantly longer to reach the surface – as much as 50 000 years longer, by some estimates. Even the waste management company recognizes that leakage from a coastal repository may take as little as 50-100 years for groundwater flows to carry radioactivity from a leaking repository to the biosphere.

When this issue was broached in the consultations, the company responded with a study that purported to show that it was impossible to say a priori that a zone of groundwater recharge necessarily was advantageous. The idea was to neutralize the issue. The regulatory authorities read the report and pointed out that the company had stopped short of drawing conclusions from the study's findings and asked the company to do so. The joint letter of the two regulatory authorities is appended to this report (Annex 4). The authorities say that it will suffice for the company to return with a complete analysis in conjunction with the company's application for permission to build a repository for spent nuclear fuel. In our view, however, the results of such an analysis – which, it appears, the company will report in an appendix dedicated to the choice of site – should be presented for discussion in the framework of the consultations. As should the appendix itself.

The SSNC and MKG strongly recommend that a repository using the KBS method should be located inland, in a groundwater recharge zone.

8.6. The site of a final repository of the KBS type should accommodate placement of the repository at a depth of 1 000 meters.
As noted in section 5.4, a KBS repository should be constructed at least 1 000 meters down in order to delay the spread of radioactivity in the environment, should the man-made barriers fail. Combining a deeper positioning with a location in a zone of groundwater recharge inland has distinct advantages: the bedrock is more dense at greater depths, and the salinity of deep groundwater is generally lower inland than it is along the coast. Lower salinity at the level of the repository lessens the risk that the clay buffer will erode.

The SSNC and MKG strongly recommend that any repository using the KBS method should be constructed in bedrock that accommodates positioning at a depth of 1 000 meters.

8.7. No final repository for spent nuclear fuel should be sited in a tectonic shear zone.
As we noted in section 5.6, tectonic shear zones are inappropriate for disposal of spent nuclear fuel. Forsmark is such a zone. In periods of glaciation movements in the earth's crust and seismic events are a greater problem in shear zones than elsewhere. Furthermore, we have no assurance that the installation of a repository will not weaken the bedrock formation, thus increasing the risk of a total failure of the repository in or after the next ice age.

The SSNC and MKG strongly advise against siting the final repository in a tectonic shear zone.

8.8. A coastal site is not appropriate in light of the risk of rising sea level.
Building a final repository for spent nuclear fuel at the coast implies a risk of flooding, should the sea level rise as a consequence of global warming. Even if current estimates put the expected rise at only one meter in the coming century, the sea is expected to rise considerably more in the

ensuing millennium, while the contents of the repository are still extremely hazardous.

The SSNC and MKG consider a coastal site inappropriate due to the risk of progressively rising sea level as a consequence of global warming.

8.9. A final repository for spent nuclear fuel should not be sited adjacent to a nuclear power station.
Establishing a final repository near a nuclear power station is inappropriate since any serious accident involving the reactors may cut off access to the repository. Locating a repository near an installation that produces the spent fuel may seem reasonable enough in terms of administration and logistics, but a major accident at Forsmark may result in unacceptable working conditions in the immediate surroundings, in which case it is highly uncertain whether work at the repository can continue without extensive and costly measures to protect the work force.

The SSNC and MKG strongly recommend that the final repository for spent nuclear fuel not be located adjacent to a nuclear power facility.

9. The ‘zero alternative’

The nuclear waste management company is rather nonchalant in its treatment of the so-called zero alternative, i.e., the alternative of not carrying out the proposed activity, in the draft EIS. The proposed final repository is a unique project, and it is hardly sufficient to say that the only alternative to the proposed repository is to let the spent fuel remain in the present interim storage facility, CLAB [at Oskarshamn] – which, for that matter, would have to be expanded some thirty years down the line.

It is not that simple. In the final EIS, the document that accompanies the application, the company should both outline a variety of possible alternatives for long-term interim storage, and the implications of different energy scenarios for future planning of a final repository facility for spent nuclear fuel.

9.1. The need to explore other alternatives besides CLAB
First of all, alternatives to CLAB do exist. Even if the spent fuel is stored raltively safely at the CLAB facility and, according to SKB, might remain there more than 100 years, the facility is dependent on active cooling devices. Without cooling, an accident with very severe environmental consequences may occur. Furthermore, as in the case of nuclear reactors, interim storage facilities are vulnerable to terror attacks. Should the level of threat escalate or the time-frame for interim storage turn out to be much longer, a repository using dry-storage should be considered.

The SSNC and MKG find it necessary to explore other ‘zero alternatives’ for interim storage besides continued use of CLAB.

9.2. The need to analyze the implications of different energy scenarios for a KBS repository
The nature of future energy supply solutions is widely debated these days. Some look to future reliance on nuclear energy. If Sweden does continue to use nuclear reactors, a repository of the KBS type will not be needed because coming generations of nuclear reactors will use reprocessed fuel. There are also speculations about the possibility of using transmutation to make spent fuel less hazardous.

One may see the interest in retrievability expressed in the Nuclear Waste Council’s most recent update in the light of these possibilities. Council members are clearly impressed by the prospects of so-called fourth generation reactor technology, which may be coupled to transmutation. The Council does not, however, discuss the disadvantages of retrievability, namely, the risk of nuclear proliferation and the concomitant need to guard the repository for centuries to come.

The environmentalist community knows that nuclear energy is not sustainable, environmentally or otherwise. They are also convinced that nuclear energy will be totally redundant in a sustainable energy system – in Sweden and in the world at large. A future sustainable energy supply system that does not include nuclear energy also has bearing on nuclear waste disposal issues. The spent fuel that the so-called nuclear age will leave to post-nuclear generations will be looked upon differently. Unbound to current nuclear energy production, future generations may opt for entirely different solutions. One such solution might be transmutation, powered by renewable energy sources, coupled to disposal of the transmuted waste material in deep boreholes.

The SSNC and MKG strongly recommend that the implications of various future energy supply scenarios for a KBS repository be considered in the discussion of 'zero alternatives'.

10. Other issues

Finally, we, the SSNC and MKG, have some comments relating so some other issues.

10.1. The cumulative impacts on the Baltic Sea
Forsmark already hosts three nuclear reactors and SFR, a final repository for low and medium-level nuclear waste. The environmental impact statement for the KBS repository needs to discuss the cumulative environmental impact of these installations. Furthermore, there are plans to establish a final repository for spent nuclear fuel on the opposite shore of the Baltic at Olkiluoto in Finland. Olkiluoto, too, hosts a number of reactors. Even today, the Baltic Sea is heavily contaminated by radioactive particles. At some point in the future radioactivity from a leaking repository will enter into the Baltic Sea. SKB needs to present an overall view of the cumulative effects of all activity that may imply additional nuclear pollution of the Baltic Sea. In view of the fact that the Åland/Ahvenmaa archipelago (Finland) lies roughly midway between the planned repositories of the two countries, it is particularly appropriate to present the prospective cumulative impacts on the islands.

The SSNC and MKG urge SKB to include estimates of the cumulative effects of the proposed repository together with prospective impacts of all nuclear installations on both sides of the Baltic Sea.

10.2. Communicating hazard to future generations
The draft EIS lacks a discussion of how information about the final repository is to be communicated to future generations. Such a discussion has a bearing on issues relating to surveillance/defense, the risks of speculative intrusion and so forth.

The SSNC and MKG find that SKB needs to problematize and propose solutions concerning how information about the repository may be communicated to future generations.

10.3. Environmental impacts due to problems encountered in the construction and operation of the repository
SKB's draft EIS gives one the impression that nothing that might have an environmental impact can possibly go wrong, either in the process of constructing the repository or in its operational phase.

One factor that conceivably can give rise to problems that should be considered in the EIS is the very high rock pressures in the bedrock formation at the planned level of the repository at Forsmark. These pressures can cause trouble, both during construction and after. The stability of both the walls and the ‘ceiling’ in the tunnels cannot be taken for granted. This is not only an issue of worker safety; failures due to rock pressures may also have environmental consequences.

SKB is also remarkably untroubled about the possibility of breaches of safety or releases of radioactivity once the repository and encapsulating facility are in operation. The EIS contains no “worst-case scenarios” for unforeseen events, only an assurance that should incidents occur, there will be no environmental impacts. But questions need to be asked: What might happen, for example, if a canister were to jam in the loading shaft and a machine overheated and caught fire in the attempt to retrieve it? SKB’s imagination knows no bounds when it comes to conceivable problems with alternatives like deep boreholes, but when it comes to loading a KBS repository? Silence.

Spent nuclear fuel is a hazardous, but valuable resource that has to be kept under surveillance, and not only after the repository has been loaded and sealed. The risk of nuclear proliferation due to theft of one or more canisters requires a system for the physical defense of the facility. Security requirements need to be discussed in the EIS. It might be noted that the Environmental Courts stressed the need for physical protection in their recent treatment of applications for permission to upgrade several Swedish reactors.

The repository will require numerous transports of copper canisters containing spent nuclear fuel from the encapsulating facility at Oskarshamn and the final repository at Forsmark. At present, nuclear fuel is transported with the m/s Sigyn, a vessel specially constructed to afford a high level of security. Should Sigyn have to be replaced and, due to excessive cost, a vessel having a lower level of security is chosen, the incremental risks must be considered in the risk analysis pertaining to transportation in the EIS.

The SSNC and MKG find the EIS lacking with respect to treatment of problems that may be encountered in the construction and operational phases of the project.

10.4. Nature values

The Forsmark area has many features of great natural and recreational value. The site proposed for the final repository is directly adjacent to a nature preserve, Kallriga, and features similar to those within the preserve are to be found throughout the proposed repository area. The Kallriga preserve was created to preserve an area of Uppland's inner archipelago that affords a rich variety of biotopes and, particularly, a valuable stop-over for migratory birds. The area is also linked to the Kallriga Natura 2000 Area. (See Annex 5 for the nature preservation plan of the County of Uppsala.)

In fact, the entire area set out for the repository is of national interest by virtue of its natural beauty and biological value. Criteria for its selection as a preserve are mixed deciduous and conifer forest, farmland, bogs, coastal (brackish) meadows, natural pasturage and pristine woodland. The area is considered a 'living textbook' of combinations of features that illustrate the evolution of the landscape. Furthermore, the area is relatively untouched and includes several rare or vulnerable biotopes. In sum: the area is of considerable value for the preservation of biodiversity in the region. The County Administration also classes the area as "ecologically sensitive".

North of the area surveyed for the repository lies the Skaten-Rågsen Natura 2000 Area, which contains many forested islands; the Area was identified and set aside for the purpose of preserving an intact archipelagic landscape. Islands in the sound north of Öregrund (Öregrundsgrepen) are also included in the Natura 2000 programme.

In view of the nature values in the area, it is surprising that the nuclear waste management company was not given pause for thought about the suitability of building a final repository there. Even if the company was intent on a site in the Municipality of Östhammar, other sites are conceivable. Hargshamn [a port and railhead south of the proposed site], for example. The company's failure to consider environmental aspects in the siting process is symptomatic of (1) a relative lack of interest in environmental aspects among company management, and (2) a firm conviction that a final repository for spent nuclear fuel implies no risk whatsoever to the environment. Thus, they see no reason to discuss environmental issues.

The SSNC and MKG consider it inappropriate for the nuclear waste management company to locate the final repository for spent nuclear fuel in an area of great natural and recreational value.

THE LONG-TERM SAFETY REPORT

Joint comment on the part of the Swedish Society for Nature Conservation (SSNC) and MKG concerning the long-term safety of a system for the final disposal of spent nuclear fuel.

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May 17th, 2010

Till: Svensk Kärnbränslehantering AB, SKB
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Joint comment on the part of the Swedish Society for Nature Conservation (SSNC) and the Swedish NGO Office for Nuclear Waste Review (MKG) concerning the EIA consultation on the long-term safety of a system for the final disposal of spent nuclear fuel.

The Swedish Nuclear Fuel and Waste Management Company, SKB, intends to submit an application for permission to construct a final repository for the disposal of spent nuclear fuel at Forsmark, adjacent to the existing nuclear power station there. The application shall fulfill the requirements of Swedish law, more precisely, the Environmental Code and the Law on Nuclear Activities. In December 2009, the company presented a draft version of the environmental impact statement (EIS) that is to be appended to the application. The draft EIS contains only brief mention of the company's expectations regarding the long-term environmental safety of the planned repository. Largely, it consists of a summary based on the last safety analysis, SR-Can, published in 2006. At the EIA consultation meetings in February 2010 (in Östhammar and Oskarshamn (Figeholm), respectively), where the draft EIS document was presented, SKB declared that the consultations therewith had come to an end. Participants in the meetings were astounded to hear that the company intended to end the consultation process without having put an updated version of a safety analysis on the table for discussion.

In the face of compact criticism the company agreed to hold an additional consultation May 3rd in Östhammar, but again made it clear that no further documentation concerning the long-term environmental safety of the project would be presented at the meeting, which would definitely conclude the consultation process.

The present document contains comments on the part of the SSNC and MKG on (1) the conduct of the EIA consultations with respect to discussion of the long-term safety of the planned installation and (2) the treatment of choices of method and site.

1. EIA consultations on long-term environmental safety must be based on a complete and updated safety analysis, i.e., a preliminary version of the long-awaited report on safety, SR-Site, which, SKB now says, will be enclosed as an annex to the application for authorization to build a repository for spent nuclear fuel.

At the consultations held May 3rd, SKB presented a progress report on their current work on the safety analysis. The company also gave their views on how buffer erosion, copper corrosion and seismic activity might affect the safety of the repository in the long term.

At that meeting company representatives said that the work to provide basic data for the safety analysis was either done or under final review but that extensive computations and analysis were currently in progress, so that it was still too early to present any conclusions. Nonetheless, they went on to present some preliminary conclusions on the three above-mentioned problem areas. The company refused, however, to present any of the research findings on which the conclusions were based. Instead, they referred to the coming report, SR-Site, which will enter the public domain when submitted together with the application for permission to build a repository for spent nuclear fuel.

At the meeting, the company also announced that as there would be no further consultations, no further working material would be presented to the participating organizations. They expressed their conviction that the findings presented in the previous safety analysis, SR-Can, from 2006 were sufficient for the purpose of the consultations on the long-term safety of the proposed method for disposal of spent nuclear fuel.

Recently, in the interval since SR-Can, there have been indications that the company has not given sufficient attention to a number of factors of crucial importance to the long-term safety of the project: copper corrosion, erosion of the clay buffer, the eventuality and implications of seismic activity and permafrost in coming ice ages, to name a few. Furthermore, there are indications that SKB researchers do not know enough about how the man-made barriers, copper and clay, actually perform in the kind of bedrock that the proposed site at Forsmark offers. In addition, the results regarding the behavior of copper and clay that have emerged from the longitudinal experiments in the Äspö laboratories are ambiguous. These issues have to be resolved in the final safety analysis for the repository.

We, the SSNC and MKG, find it unacceptable that the company asks the participants in the EIA consultations to rely on a safety analysis published five years ago. If the company persists in their plan to submit their application without having presented substantive information in the consultations about how the outstanding issues that have arisen since the previous report, SR-Can, have been addressed, there is an overhanging risk that the Court's and authorities' examination of the application will take much longer time that had otherwise been the case.

The Environmental Code (Chapter 6, Paragraph 4) requires applicants to consult with interested parties on the anticipated environmental impacts of the proposed activity. The draft EIS that SKB presented in December 2009 recognizes the long-term safety of the repository after sealing as one of the principal concerns in the examination of their application. The Environmental Code does not provide for limitations on the extent of the consultations relating environmental issues. If the applicant possesses information relating to important environmental implications of the proposed activity, that information should reasonably be presented for discussion. For the applicant to refuse to share this information in the EIA consultations and instead point out that the information will be in the public domain, and thus available for examination, as an annex to the application submitted to authorities, is hardly a reasonable way to handle the consultation process.

The present situation is of concern not only to environmental organizations. The Radiation Safety Authority and the Council on Nuclear Waste and consulting experts, indeed, the entire scientific community, all play important parts in the consultation process. It is essential that the discussions that take place in EIA consultations be based on the best available knowledge and data. Without adequate input from the consultations, the applicant can hardly take account of the full spectrum of knowledge on the subject in the documents that accompany the application for authorization to build the repository.

In our view, the EIA consultations concerning a final repository for spent nuclear fuel cannot be terminated until conclusive documentation regarding the long-term safety of the project has been put on the table. As we see it, it is incumbent upon the applicant to share all the knowledge of pertinence to long-term safety that they have with participants in the EIA process in a transparent and forthright manner. In view of the gravity of the potential impacts a repository for spent nuclear fuel may have, the applicant should produce a preliminary version of the safety analysis, SR-site, and present it for discussion in the framework of the EIA consultations.

It is our conviction that if the applicant does not do so, the EIA consultations may not be said to have been conducted in keeping with the letter and spirit of the law.

2. The application SKB submits to the Environmental Court and the authorities has to include a safety analysis for the Laxemar site that is detailed enough to allow a proper comparison of the Laxemar and Forsmark sites.

In the EIA consultations SKB has been admonished to include evaluative descriptions of both candidate sites, Laxemar (Oskarshamn) and Forsmark (Östhammar) in the safety analysis, SR-Site. Both sites were included in the most recent safety analysis, SR-Can, in 2006. Explorative studies have been carried out at both sites; thus, the requisite data are available for both.

Several things speak for including both sites in the final safety analysis. First, it facilitates an evaluation of the applicant's reasons for choosing Forsmark instead of Laxemar as the environmentally better-suited site for a final repository for spent nuclear fuel. Secondly, it would provide insights as to how geological and hydrological characteristics of the respective sites contribute to the safety of the repository, which in turn would make it easier to understand how the various characteristics led to the conclusions drawn from the analysis.

The information about the choice of site offered in the course of the EIA consultations has been limited, and no meeting has specifically dealt with the ultimate choice between the two candidate sites. The document on the subject that SKB presented in June 2009, in conjunction with the choice of Forsmark, does not offer nearly enough information to permit any judgement as to the correctness of the company's choice in the perspective of safety in the longer term. The material presented is very superficial. What is more, the report was presented while the exploration of the Laxemar site was still under way and had yet to be documented. In the company's draft EIS, SKB notes that the decisive factor was the mean distance between cracks in the bedrock.

As recently as at a national consultation between SKB and the Radiation Safety Authority in April 2009, the company stated that the choice of site was still an open question. If the decisive factor was the mean distance between cracks, there was no need of explorative studies – the data were known even before the studies got under way.

It is essential that SKB presents as complete a set of data as is possible on both candidate sites to explain the choice of Forsmark. The company has stated that no complete safety analysis for Laxemar will be included in the safety analysis that accompanies the application. Unless the company changes course, it will be impossible for anyone to be able to make an independent evaluation of the applicant's choice of site.

We, the SSNC and MKG, consider it essential that the safety analysis, SR-Site, which shall accompany the application, shall include safety analyses of equal quality for both candidate sites, Forsmark and Laxemar.

3. Consultations on the choice of site must continue, taking their starting point in complete documentation of the siting process, preferably a preliminary version of the document on the choice of site that will accompany the application.

We, the SSNC and MKG, submitted a document dated March 10th, 2010 in conjunction with the EIA consultation on the draft EIS that SKB presented in February of that year. In it we expressed a number of comments that focused on shortcomings in the company's choice of a site for a final repository for spent nuclear fuel.

Since the company now intends to terminate the EIA consultation process, no further documentation of the process will be presented for consultation. Instead, the company refers to a coming annex to the application that will contain more information on siting and says that we will have the opportunity to comment on it as part of our input into the formal examination of the application on the part of the Environmental Court and the regulatory authority.

We, the SSNC and MKG, call for a continuation of the EIA consultation process so that documentation of the siting process – preferably a preliminary version of the document that is to accompany SKB's application – can be properly discussed.

4. Consultations on the choice of method must continue, taking their starting point in complete documentation of the choice of method, preferably a preliminary version of the document on the subject that is to accompany the application.

In a document dated March 10th, 2010 that we submitted to the consultations in conjunction with the EIA consultation on the draft EIS that SKB presented in February we expressed a number of comments regarding the company's choice of a method for final disposal of spent nuclear fuel.

Since the company now intends to terminate the EIA consultation process, no further documentation of the choice of method will be presented for consultation. Instead, the company refers to a coming annex to the application that will contain more information on the choice of method and says that we will have the opportunity to comment on it as part of our input into the formal examination of the application on the part of the Environmental Court and the regulatory authority.

The information provided in the EIA consultations do not sufficiently address the issues relating to the choice of method that have been raised in the consultations. If the application is submitted without further clarification or resolution of these outstanding issues in the consultation process, it will very likely prolong the examination of the application considerably.

We, the SSNC and MKG, call for a continuation of the EIA consultation process so that documentation of the company's choice of method – preferably a preliminary version of the document that is to accompany SKB's application – can be properly discussed.

5. On the need for a plan for research to resolve outstanding issues relating to corrosion of copper.

The Swedish NGO Office for Nuclear Waste Review, MKG, is currently participating in a reference group for a research project on copper corrosion that is carried out by SKB. In connection with this work we have pointed to the need of a systematic plan regarding the needs for further research on the corrosion phenomenon in order to clarify the implications of corrosion for the long-term safety of the repository as planned. Principally, there is a need for longitudinal laboratory experiments to study the corrosion process in a simulated repository environment. Secondly, copper canisters that have been stored in a prototype repository in the Äspö laboratory for several years are scheduled to be retrieved shortly. These, in combination with the experiments carried out in the LOT project, will provide considerable data for analysis. A plan for the analysis and for systematic comparisons of the findings with the predictions of the models is needed. At the initial meeting of the reference group it was also pointed out that the question of how radiation may affect the rate of copper corrosion has not been investigated.

The nuclear waste management company, SKB, has shown no interest whatsoever in undertaking longitudinal experimental studies or in drafting a plan for the systematic feedback of results of such studies into the planning process.

MKG will continue to raise and discuss issues relating to copper corrosion within the framework of the reference group organized by the company.

RISKS REGARDING THE MAN-MADE BARRIER SYSTEM

Joint comment on the part of the Swedish Society for Nature Conservation (SSNC) and MKG regarding the man-made barrier system of copper canisters and clay buffer in the KBS method for final disposal of spent nuclear fuel, and a demand for full disclosure of research reports.

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Dec 15th, 2010

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Comment from SSNC and MKG concerning the risk that the man-made barriers consisting of copper canisters and clay buffer in the KBS method for final storage of spent nuclear fuel will fail, and a demand that pertinent research findings be made public

This submission on the part of SSNC and MKG raises important issues in the EIA consultations concerning a final repository for spent nuclear fuel. The issues relate to the phenomenon of copper corrosion and the risk that corrosion of the copper canister may influence the long-term safety of a final repository of the KBS type. The comment also treats the risk that the performance of the bentonite clay buffer that is intended to provide long-term protection for the copper canister against corrosive groundwater may be impaired even during an early phase, before the clay has reached saturation. Another topic is the risk that the clay barrier may erode and be rinsed away. Finally, we demand that all research reports and documentation from research project meetings, even those the company may consider confidential, shall be made public.

Early problems with copper corrosion and the effects on clay

The long-term safety of the KBS method depends on the function of man-made barriers (copper canisters and a bentonite clay buffer), which shall isolate the highly radioactive nuclear waste from human beings and the environment for hundreds of thousands of years. Thus, the issues raised in the following paper are of decisive importance to the long-term safety of the planned final repository.

We, SSNC and MKG, have been given to understand that there is considerable uncertainty concerning the corrosion that can affect the copper canister that encloses the used fuel rods. Research findings in recent years give reason to fear that the copper canisters, given deposition in the bedrock at Forsmark, may become seriously compromised within the time frame of only a few centuries. Even if the corrosion process should take longer, copper from the canisters may impair the clay buffer to such an extent that it will not have the long-term protective function the method presumes. That a problem of such acuity should arise so early in the lifetime of the repository is a consequence of the heat of the canisters in the first few thousand years in combination with the long time required – up to a thousand years in the case of the relatively dry bedrock at Forsmark – for the clay buffer to swell and reach the so-called initial condition that is presumed in the analysis of long-term safety.

SSNC and MKG are of the opinion that the nuclear waste management company, SKB, must in the EIA consultations on long-term environmental safety demonstrate that the man-made barriers of copper and clay will not be damaged or destroyed in the first several hundreds or thousands of years. These issues are treated in further detail in section 2.

Problems of clay erosion in the long term
In recent years doubts have arisen as to whether the bentonite clay envisaged to protect the copper canister against corrosive groundwater will function in coming periods of advancing and receding glaciation, as is presumed in the safety analysis. A final repository system shall, according to the criteria set out in the long-term safety analysis withstand repeated glaciation cycles. The hydrological conditions that obtain in the course of glaciation may hasten the erosion of the buffer in relation to the rate previously assumed.

SSNC and MKG are of the opinion that the nuclear waste management company, SKB, must, in the EIA consultations on long-term environmental safety, demonstrate that there is no risk of early erosion of the clay buffer in the course of repeated glaciation cycles. These issues are treated in further detail in section 3.

Research reports and minutes from research meetings shall be made public
For a number of years now, MKG has examined the nuclear waste management company SKB's research relating to copper corrosion. The organization has had considerable difficulty in gaining access to the findings of that research, including the outcomes of experimentation carried out at the bedrock laboratory at Äspö, near the Oskarshamn nuclear power station. The correspondence surrounding our attempts to gain access to relevant research material is enclosed.[1]

1. The correspondence is not translated. For more information please contact the office. See preface for contact information.

In Spring 2010, SKB initiated studies of copper corrosion in pure, anoxic water. The company formed a reference group around these experiments, in which MKG took part. In the venue of the group MKG promptly expressed the need for similar access to other copper corrosion research that the company has undertaken or that is still in progress. In addition, MKG and other participants in the reference group pointed out that SKB should conduct research on several other aspects of copper corrosion and should retrieve more experimental packages in the Äspö hard rock laboratory in order to gain a better understanding of different corrosion phenomena. SKB responded evasively, for which reason MKG wrote a letter to SKB outlining the issues in question.

The Swedish Radiation Safety Authority (SSM), too, has taken an interest in the research on copper corrosion conducted at the Äspö laboratory, and in Spring 2010 SSM undertook a review of SKB's quality assurance of their work on this subject. The review resulted in a report (SSM 2010) that was harshly critical of the manner in which the company reported the findings of experiments on both copper corrosion and effects on the clay buffer. What is more, SKB was found to have suppressed some research findings, omitting them from an openly published report of the results from the project. Although SKB had previously refused to do so, MKG was able in Autumn 2010 to persuade the company to make public the two consultant's reports in question. MKG then wrote to the company, admonishing them to adhere better to established scientific praxis and make available all the results of experiments and other research having a bearing on the barrier system for public scrutiny. SKB responded, explaining that a series of reports from the research conducted in the Äspö laboratory (the IPR series: International Progress Reports) will be made public, but that other documents are to be considered working documents, internal to the company.

We, SSNC and MKG, do not consider this sufficient. Both our organizations have members with long experience of research and scientific work. SKB's refusal to publish research findings conflicts with established scientific ethics and arouses considerable surprise among the seasoned researchers in our ranks.

MKG has already had access to several reports in the IPR series and therefore knows that far from all research that has been conducted at Äspö is reported in the series. Virtually none of the most interesting experiments aiming to cast light on the phenomenon of copper corrosion and impacts on the clay buffer have been reported in the series. If the Radiation Safety Authority or, for that matter, any other body is to be able to examine the company's research in a scientific manner, all consultant's reports and other material that the company considers confidential must be available for examination in the context of the EIA consultation process. Minutes and other documentation from the project meetings where the research was discussed should also be made public.

Without access to these primary data the documentation presented for consultation can hardly be deemed complete or adequate.

SSNC and MKG demand that SKB, the party responsible for the spent nuclear fuel repository project, makes all the consultant's reports, other research documentation and documentation of research project meetings that relate to the experiments and the research at the Äspö laboratory on the phenomenon of copper corrosion and impacts on the clay buffer, as well as other findings relating to the barrier systems, available to the participants in the EIA consultation process. This issue is discussed in greater detail in section 4 below, where we also offer a partial list of the experimental projects for which we wish to have access to the consultant's reports as well as documentation of project meetings where the experiments have been discussed.

1. Background

On March 16th 2011, the nuclear waste management company, Svensk Kärnbränslehantering AB, SKB, intends to submit its application for permission to construct a final repository for spent nuclear fuel immediately south of the Forsmark nuclear power station in the Municipality of Östhammar (Uppland). The Swedish NGO Office for Nuclear Waste Review, MKG, has participated in the EIA consultations prescribed in the Environmental Code since the organization was founded in 2004. The Swedish Society for Nature Conservation, SSNC, together with SSNC chapters in Kalmar and Uppsala counties, Nature and Youth Sweden, and Oss (a local opinion organization in Östhammar), founded and together constitute MKG. SSNC has participated in the consultations as a member of MKG and, in later stages of the consultation process?, SSNC and MKG have submitted joint comments to the applicant and coordinator of the consultations, the nuclear waste management company, SKB.[2]

SKB has announced that they consider the EIA consultations will end once comments after the extra consultation meeting on the analysis of long-term safety held May 3rd 2010 in Östhammar have been received. SSNC and MKG disagree, contending that the consultations must continue until

2. Joint comment on siting, submitted 5 May 2009; comment on the preliminary EIS document, submitted 10 March 2010; and comment on the analysis of long-term safety, submitted 17 May 2010.

a complete set of pertinent primary data until a complete and adequate documentation in the consultation process has been presented. The documentation presented to date on the long-term environmental safety of the project, alternative sitings, or alternative solutions for the final repository facility is neither complete nor adequate. In the view of the organizations in MKG, the EIA consultations must continue at least until a preliminary version or versions of the long-term safety analysis, SR-Site, and preliminary versions of the separate documents on choice of site and choice of method, respectively, which SKB plans to submit as annexes to the application, have been presented for consultation. SKB has rejected this view, most recently in an exchange of e-letters in the latter part of June 2010.

This document treats issues relating to the long-term environmental safety of the KBS method, the most important issue and the prime focus of the coming assessment of the company's application.

2. The risk that copper canisters will corrode and destroy the clay buffer early in the post-closure phase

In early 2009 SKB announced its choice of the site for the final nuclear waste repository. The choice fell on a site adjacent to the Forsmark nuclear power plant in the Municipality of Östhammar rather than the other candidate site, Laxemar, near the Oskarshamn nuclear plant in Oskarshamn. SKB states that the choice was the outcome of weighing together factors having a bearing on safety.

In the discussion following the announcement it has been noted that in Forsmark the bedrock at the level of the repository has fewer cracks and fissures than the bedrock in Laxemar. This factor has been pointed out as decisive for the choice of Forsmark.[3] Few cracks and fissures may be an advantage in that it implies slower transport of radioactive nuclides from the repository to the surface, should the repository spring a leak. But, denser bedrock with its lesser flow of groundwater implies a much longer time frame for the successive saturation of bentonite in the deposition hole, which is of crucial importance to the long-term function of the man-made barriers posited in the analysis of long-term safety.
There are large differences in the water flow rates at Laxemar and Forsmark.

3. In an earlier comment submitted to SKB (5 May 2009) SSNC and MKG maintain that the nuclear waste management company needs to specify the basis for their choice of Forsmark in detail and explain what the company means by the phrase, "weighing together environmental aspects". SKB also needs to share the safety calculations that have been done for both Forsmark and Laxemar in a manner that permits comparison of the safety assessments for the respective candidate sites. See http://www.mkg.se/mkg-laxemar-samradsinlaga-till-industrin- om platsvalet).

- The corrosion conditions of the copper canister e.g. prevailing corrosion mechanisms and the corrosion rate related to each mechanism. It is likely that the copper canister corrode in Forsmark (but not in Laxemar) through e.g. atmospheric corrosion, evaporation induced corrosion and grain-boundary corrosion.

- Precipitation of salt present in the ground water in the bentonite and on the surface of the copper canister.

- Erosion of the bentonite surrounding the canisters, which results in cracks and channels in the bentonite.

The extensive formation of cracks in the rock at Laxemar gives high flow of groundwater, which results in filling of the boreholes with water within a limited time frame. The bentonite surrounding the copper canisters will then be saturated with water and swells.

The water flow is, according to SKB, very limited in Forsmark "An additional analysis of inflow into individual deposition holes/Svensson 2006b/ using the same model as described above indicates that 99.9% of all deposition holes in the Forsmark repository will have an inflow smaller than 0.01 l/min when no grouting is applied" see SR-CAN 2006 (page 212).

2.1 Flow of water to the boreholes

The rate of water flow to the boreholes is a critical parameter regarding several important issues;

- The corrosion conditions of the copper canister e.g. prevailing corrosion mechanisms and the corrosion rate related to each mechanism. It is likely that the copper canister corrode in Forsmark (but not in Laxemar) through e.g. atmospheric corrosion, evaporation induced corrosion and grain-boundary corrosion.

- Precipitation of salt present in the ground water in the bentonite and on the surface of the copper canister

- Erosion of the bentonite surrounding the canisters, which results in cracks and channels in the bentonite.

These issues are highly important in the safety analysis regarding the Forsmark case. It is clearly impossible to theoretically calculate the corrosion rate of the copper canisters if the prevailing corrosion mechanisms are largely unknown. It is therefore of utmost importance that SKB reports the expect water flow in dm3/minute to the deposition holes and how this flow rate is estimated to vary with time. It is also important that more knowledge is found about how the water flow will vary between different deposition holes. Due consideration must further be given to the following both at the theoretical analysis and at the actual experiments;

- The formation of cracks in the bedrock at blasting of the tunnels in the depository.

- The water flow from one or several cracks in the bed rock in the vicinity of the deposition hole and also for the case that there is no cracks.

- The filling of the deposition hole with water; does the water come from the bottom or vertical sides of the bedrock surrounding the deposition hole or from the tunnel above the deposition holes.

It is essential that SKB determines the water flow conditions to the deposition holes containing bentonite and copper canisters and then based on this information makes an accurate analysis how the incoming water reacts with bentonite and the warm copper canister.

It is quite possible that part of the incoming water to the deposition holes is evaporated when in contact with the bentonite and the warm (90 °C) copper canister. This must result in precipitation of salts dissolved in the ground water on the surface of the copper canister, in the bentonite and potentially also on the surface of the bedrocks in the deposition holes. It is essential that more knowledge be gathered regarding the amount of salt that is precipitated, where the salt is deposited in the deposition holes and the chemical composition of the deposited salts. It is further very important to clarify if the evaporation of incoming ground water in the deposition holes results in the formation of a corrosive water solution with very high contents of dissolved salts.

2.2. Temperature conditions in the boreholes

The flow of ground water to the deposition holes will vary substantially between different holes and probably also with time. The inflow of water has according to the KBS-3 concept some important functions;

- Saturate the bentonite in such a way that it swells and stabilise the canister.

- Facilitate heat transfer from the canister to the bedrock.

The ground water flow in the planned repository in Forsmark is probably very limited or even non-existent in some bore holes and this will result in substantially different temperature conditions in the bore holes compared with the normal case in Laxemar, which has a strong water flow. This has a direct effect on the water saturation of the bentonite in the boreholes, which potentially will be dry for many years in Forsmark due to the limited ground water flow rate.

It is evident from the Fud-programme 2010, table 23-2, pp. 268, that SKB does not consider that there is need for a research programme regarding the heat transfer in the deposition holes under the conditions prevailing in Forsmark. This is according to our opinion totally incorrect. Such a programme is according to our opinion of utmost importance and fundamental for the safety analysis.

SKB must elucidate how the limited ground water flow into the deposition holes influences the heat transfer from the cast iron insert with the spent nuclear fuel, through the copper canister and the bentonite layer to the rock bed. Critical issues in this respect are the heat transfer itself and the formation of temperature gradients. It is also important to clarify if air slots are formed between the copper canister and the bentonite as well as between the bentonite and the bedrock. More knowledge must further be collected regarding the evaporation of the ground water; more information is needed on the process itself, amount of water evaporated depending on the temperature conditions in the bore holes and does the evaporation process result in cracks and channels in the bentonite barrier.

2.3 Bentonite

The repository conditions are quite different in Forsmark compared with those at Laxemar. The limited ground water flow at Forsmark results in a very slow water saturation of the bentonite. It is likely that the becomes dry under very long time, in the order of at least some tenth of years and perhaps even up to 1000 years for some canisters. The extent of this dry period is dependent on the formation of cracks in the surrounding rock bed and the ground water flow through these cracks. There is thus no initial water saturation of the bentonite, which earlier has been regarded as decisive to enable the bentonite to act as a barrier.

The initial water content of the bentonite is 17% according to SR-CAN pp. 273. The effect of the simultaneous limited water flow and the heating of the bentonite from the canisters results in evaporation of the water in the bentonite and drying of the same.

SKB must therefore experimentally investigate how the physical and chemical properties of the bentonite are influenced by;

- Long time exposure to elevated temperature in the deposition holes
- Precipitation of salts from the ground water
- Precipitation of copper corrosion products
- Evaporation of water originally bounded to the bentonite

It is likely that the thermical and chemical exposure of the bentonite may alter its properties and hereby its function as a barrier for e.g. copper corrosion. Important issues are;

- Is there a formation of cracks or channels in the bentonite due to the evaporation of its original water?
- Is the water saturation of the bentonite influenced by precipitation of salts and corrosion products?
- Is there an embrittlement of the bentonite as a result of heating under a long time and in combination with precipitated high contents of copper compounds and salts?

2.4 Corrosion of the copper canister

There are a large number of issues related to the copper canister that is meant to protect the spent fuel in the repository. They concern the attempts that have, or have not, been performed to investigate how the copper behaves in a repository environment. They also concern the various corrosion processes that may take place in a repository.

2.4.1 Investigation of the LOT-, MiniCAN- and Retrieval-canisters

SKB has carried out several test series during the last 10 years at the Äspö-laboratory, where copper corrosion has been studied using canisters and sheets as test samples. The intention was to simulate the conditions prevailing at the final repository. This was done within the projects LOT, MiniCAN and Retrieval, which thus are important in the assessment of;

- The rate of the copper corrosion and hereby the life of the copper canisters in the future repository
- Prevailing corrosion mechanisms based on the chemical composition of the corrosion products on the copper surface

• Possible formation of uneven corrosion such as pitting

• Embrittlement of the copper due to dissolvement of hydrogen or sulphur

• Dissolution of copper in the water followed by precipitation of copper containing corrosion products in the bentonite layer

It is notable that SKB has consistently chosen not to examine, or just examine to a limited extent, the corrosion products obtained on the copper surface and in the bentonite, the occurrence of pitting corrosion, mechanical properties of copper or copper metallographic microstructure. Or rather, public declaration of such studies, eg the uptake of the test experimental package A2 of the LOT project where results of such studies are lacking (SKB 2009a).

It is particularly interesting that SKB has so far not reported the corrosion tests in the so called Retrieval-tests. These implied testing of a full-scale copper canister, heated internally, and placed in water-saturated bentonite. These tests took place during five years and the copper canister with surrounding bentonite was taken for evaluation in May 2006, see SKB report TR-07-10. It can be read in SKB TR-09-10, Äspö Hard Rock Laboratory, Annual Report 2008 on pp. 5 that the canister and the surrounding bentonite buffer were analyzed during the year 2008 and that the analysis were nearly finalized. Why has this report not been published?

It is now essential that SKB complete earlier reports with information and data on the corrosion rate of copper, corrosion mechanisms, chemical composition of the corrosion products, presence of pitting and grain boundary corrosion, the mechanical properties and microstructure and finally the presence of copper and copper compounds in the bentonite.

2.4.2 Corrosion of copper in oxygen-free water

Researchers at the Royal Institute of Technology in Stockholm have during the 1980's as well as in recent years presented experimental support for the thesis that copper corrodes in anoxic water (Hultquist 1986, Szakàlos et al. 2007, Hultquist et al. 2008, Hultquist et al. 2009, Hultquist et al. 2011). The publication of these research findings have led to an intense debate about the possibility of corrosion of copper can take place in oxygen-free water, i.e. under anoxic/anaerobic conditions. Futher experiments are underway to examine if and how copper can corrode in oxygen-free distilled water.

This issue is of relevance also for the conditions in the final repository as SKB claims that copper cannot corrode in oxygen free water, with the exception sulphide corrosion. SKB stated further about 10 years ago that the transition was fast from oxygen containing (aerobic) water (with copper corrosion) to oxygen free (anaerobic) water (without copper corrosion) and would take only a few weeks in the final repository (SKB 2001a). The reason for this transition is according to SKB primarily the micro bacterial activity in the ground water and in the bentonite as well as chemical reactions taking place in the bentonite. Experiments performed at a later stage in Finland have confirmed the received results (Posiva 2006, Carlsson T. & Muurinen A. 2009). In addition, rapid oxygen consumption proved to take place in the MiniCan project at the Äspö Hard Rock Laboratory (SKB 2009c).

SKB has during the last years experimentally found in the LOT- and MiniCAN-project that copper corroded with a rate of 3-20 μm/year. This rate is 10 000 to 100 000 times larger than what SKB theoretically has found based on the assumption that the rate determining step is sulphide-corrosion.

SKB now claims that the LOT and MiniCan projects by mistake were conducted under aerobic conditions and thus in water containing dissolved oxygen. In the MiniCan projects however, results from electrode potential measurements are presented as well as oxygen concentration measurements, both showing that the conditions were anoxic – the water was oxygen-free (SKB 2009c).

Thus SKB admits themselves that they have failed to accomplish that two complete and important test series (LOT and MiniCAN) and possibly also the Retrieval-tests were run under conditions that presented air leakage during the 5 years testing period at the Äspö-laboratory. At the same time SKB states that the final repository in Forsmark will be sealed with bentonite and concrete in such a way that there will be no air leakage to the copper canisters for at least 100 000 years.

2.4.3 The conditions in Forsmark

The copper canisters in Forsmark will be exposed to an environment, which from a corrosion point of view is very different from the one in Laxemar and at the Äspö-laboratory. The copper canisters in Forsmark repository will due to the limited water flow be exposed to several corrosion mechanisms that would be of no or less importance for the case that the repository was placed in Laxemar.

It is estimated by SKB that the inflow of ground water in the Forsmark repository is less than 0.01 l/min and deposition hole. This volume can be estimated to be insufficient to saturate the bentonite and fill the deposition holes with water. A more realistic scenario is the incoming water will be evaporated under very long time and probably will the deposition holes, according to SKB's calculations be "dry" for a period up to about 1 000 years.

The evaporation of water must inevitably lead to precipitation of salts dissolved in the ground water on the surfaces of the copper canisters, in the bentonite and perhaps also on the surfaces of the bed rock. When the water phase is finally formed in the deposition holes it must contain increased contents of dissolved salts and e.g. chloride and sulphide ions.

Rebak (2006) has commented on this situation for the case that a water phase is formed;

> *"The groundwater associated with the crystalline-rock formations should all be relatively benign to most materials because of their low ionic strengths, near neutral pH, and low concentrations of halide ions (6). The corrosivity of these waters could increase if significant groundwater vaporization occurs when high container temperatures exist during the early times following emplacement."*

The conclusion from the above discussion must be that the experimental results obtained at the Äspö-laboratory, where the water flow is large, cannot be transferred to the Forsmark repository. The same applies also for the safety analysis, which at the present situation has been carried out without any experimental data or information regarding the corrosion rates and the corrosion mechanisms prevailing at Forsmark.

The copper canisters will be exposed in dry deposition holes to two corrosion mechanisms that do not exist under wet conditions e.g. those prevailing at the Äspö-laboratory. These mechanisms are;

- Atmospheric corrosion from remaining oxygen and water vapour in the deposition holes

- Evaporation induced corrosion from the salt layers precipitated on the copper surfaces and in the bentonite

There will be a further corrosion mechanism for the case that the water phase only reaches a certain height from the bottom of the deposition hole, but does not cover all the copper surfaces;

- Boundary layer corrosion at the three-phase boundary water-air-copper

There is thus a large necessity to acquire more knowledge and experimental results within the field corrosion of copper on the following seven issues.

2.4.4 Need for knowledge and experimental results in the field corrosion of copper

1. *Atmospheric corrosion*
SKB estimates in TR-01-23 that copper corrodes with a rate of 0.1 – 0.3 mm/year by atmospheric corrosion under the conditions that are initially in the repository and before the oxygen in the deposition holes is consumed. TR-01-23 (pp. 45) shows also a mass balance based on the assumption that the sealing of the deposition holes completely prevents air leakage to the deposition holes during the forthcoming 100 000 years. SKB must verify experimentally that air leakage can completely be avoided. It is appropriate to mention in this context that SKB according to their own assessment has failed to prevent air leakage of air at the LOT and MiniCan experiments during the 5 years these took place at the Äspö-laboratory.

2. *Evaporation induced corrosion*
SKB states in the report TR-09-22 (Design premises for a KBS-3V repository based on results from the safety assessment SR-Can and some subsequent analyses) on page 19 ”Corrosion of copper. Salt deposition is neglected if temperature on the canister is in the order of 100 °C.”. It is of crucial importance that SKB experimentally verify that evaporation induced corrosion can be neglected at the Forsmark repository.

3. *Corrosion caused by radiolysis*
Lillard et al and Butt et al from Los Alamos Laboratory in the USA have experimentally found very high corrosion rates in the order of 0.3-0.5 mm/year when copper is exposed to irradiated water at room temperature (radiolysis).

SKB states however in the report TR-09-22 (Design premises for a KBS-3V repository based on results from the safety assessment SR-Can and some subsequent analysis) and in the Fud-program 2010 that irradiation has no effect on the copper corrosion rate.

It is essential that SKB experimentally verifies that the radiation at the Forsmark depository does not have an influence on the corrosion rate of copper.

4. *Sulphide corrosion*
Arilahti et al from VTT, Finland (2010) emphasize on page 1 the following statement in their report;

> *”In scenarios where the density of bentonite locally decreases (e.g. piping, erosion-corrosion) the access of sulphide to the copper surface will be much easier.”*

SKB has developed the KBS-3 concept based on the assumption that the dominating corrosion mechanisms of the copper canisters is sulphide corrosion and that the rate determining step related to this mechanism is diffusion of sulphide ions through the water saturated bentonite layer.

It will take very long time before the bentonite is saturated with water for the case that the canisters are deposited in the Forsmark repository. There is an obvious risk that the bentonite will crack or water channels are developed during the water saturation period. These cracks and channels will facilitate the mass transport of e.g. sulphide ions to the copper surfaces that will substantially increase the corrosion rate caused by sulphides. The amount of sulphides in the bentonite will further be increased due to water evaporation.

SKB ought to evaluate how the sulphide corrosion rate is influenced by these changes of the conditions.

5. *Stress corrosion*
Taniguchi et al have found in 2008 that pure copper is sensitive to stress corrosion in anaerobic, synthetic seawater containing sulphide ions from sodium sulphide. The authors estimate that the threshold value at 80 °C for initiation of stress corrosion is in the range 0.005 – 0.01M sodium sulphide. Pure copper will thus according to Taniguchi et al be susceptible to stress corrosion if the content of sodium sulphide is higher than this threshold value.

SKB has now initiated experiments in order to verify these results. It is essential that SKB also investigates if there is a risk for stress corrosion of the copper canisters deposited at the Forsmark repository. The experiments must then be carried out in water solutions in which the content of dissolved salts is equivalent to the solutions that will surround the canisters in the deposition holes. This means that due consideration has to be taken to increased contents of dissolved salts as a result of water evaporation.

6. *Corrosion of copper through dissolution in the ground water + precipitation in the bentonite*
SKB has experimentally shown in the LOT-tests that copper dissolves in the ground water. The copper ions diffuse from the canister surfaces into the surrounding bentonite layer and are finally precipitated in the bentonite. Chemical analysis of the bentonite showed that the bentonite contained several percent of copper in a bentonite zone adjacent to the copper. The thickness of this zone was some centimetres. The copper corrosion rate can be estimated from the amount dissolved and precipitated solely on this corrosion mechanism to 10 – 20 μm/year. Equivalent analysis of the amount

of dissolve/precipitated copper in the bentonite zone has likely been done by SKB also in the Retrieval-tests bur are not yet published. Fraser King (1992) has also studied copper corrosion in water-saturated bentonite and found that copper corroded after some years with a rate of 20 μm/year.

SKB ought to study this corrosion mechanism both theoretically and experimentally because corrosion by dissolution and precipitation is most likely of utmost importance for the life of the copper canisters and the function of the bentonite layer. The published results show so far that the bentonite accelerate the degradation of the copper and at the same time the precipitation of copper in the bentonite may influence its function as a barrier layer.

It is suggested that SKB in a first action makes the all results public from the LOT-, MiniCAN- and Retrieval-tests and especially those parts that consider dissolution of copper in the ground water and precipitation of corrosion products of copper in the bentonite.

7. *Intergranular corrosion*
Taniguchi et al and Al Kharafi et al have reported in 2008 experimental results that show that copper is exposed to intergranular corrosion in ground water containing low contents of sulphide ions.

It is of importance that SKB investigates the risk for intergranular corrosion of the copper canisters deposited in the Forsmark repository tentatively by;

- Studies of the surfaces by SEM and conventional metallographic examination of samples from the LOT-, MiniCAN- and Retrieval- tests

- New appropriate stress corrosion tests in which the corrosive environment simulates the conditions in Forsmark and with regard to increased contents of salt in the water as a result of water evaporation

In conclusion there is significant uncertainty about the state of knowledge regarding copper corrosion and impact on the clay in the early stages after closure if a repository is built in accordance to the KBS method in the Forsmark bedrock. There are clear indications are that there have been major shortcomings in SKB's research in this area. Given that the man-made barriers of copper and clay are what has to ensure long-term safety in a repository based on the KBS-concept, it is hardly reassuring that the nuclear waste company SKB says that the company is ready to apply for permission to build a repository without having conducted a single experiment under the prevailing conditions in Forsmark.

2.5 Mechanical properties and embrittlement mechanisms

Copper corrosion will lead to a weakening of the copper canister itself. But there are other embrittlement mechanisms that can weaken the canister mechanically. It is the combination of corrosion and embrittlement, that makes it possible to fear that the copper canisters could leak at an early stage.

2.5.1. Sulphur embrittlement

The ground water in Forsmark contains sulphide ions and these can also be formed in the water bentonite barrier surrounding the copper canisters by a bacterial process (SRB i.e. sulphate reduced bacteria).

Arilahti et al. (see pp. 4) from VTT, Finland has recently presented evidence on sulphide corrosion of pure copper (Int. Conf. Brugges, Belgium, 2010) and the authors states the following;

> *"Based on the results it is clear that sulphur can diffuse into the Cu OFP material when it is exposed at room temperature to saline groundwater with 100 to 200 mg/l sulphide. Indications were found that the in-diffusion preferentially occurs through grain boundaries. Individual grain boundaries were found to contain above 20 at % sulphur. Based on SEM/EDS studies of the surfaces the extent of diffusion depth of sulphide into Cu OFP was more than one millimetre per week".*

These results are sensational and Arilahti et al describe a new embrittlement mechanism for copper not known earlier i.e. sulphur embrittlement. The authors have found that;

- The mass transport of sulphur from the ground water containing sulphide ions to the copper takes place at a high rate at room temperature for the case that the ground water contains 100 – 200 mg sulphide/litre

- The in-diffusion of sulphur in the copper goes very fast at room temperature with a rate of 1 mm/week and takes place primarily in the copper grain boundary

- The sulphur forms precipitates of copper sulphide in the grain boundaries

- The copper sulphide precipitates embrittle the copper

The occurrence of sulphur embrittlement of copper is, according to Arilahti et al, very serious for the whole KBS-3 concept and is most likely by itself sufficient to question the choice of copper as canister material for the Forsmark repository.

It highly essential that SKB now thoroughly examines this issue of sulphide embrittlement caused sulphide copper corrosion. Comprehensive mechanical testing must also take place of test samples that have been exposed to sulphide corrosion and with precipitates of copper sulphides in the copper grain boundaries.

2.5.2 Hydrogen embrittlement

SKB has during the last years initiated research regarding hydrogen take up in the copper as a result of corrosion and also on hydrogen dissolved in the copper on its mechanical properties, see Martensson et al (2008). Nakahara et al (1988) have earlier described the influence of hydrogen the ductility and the strength of copper.

The risk of hydrogen embrittlement of copper canister is a most important issue of the final repository. It is thus essential that SKB generally in the future conduct their experiments in such a way that they are relevant for the repository in Forsmark. The potential risk for hydrogen embrittlement must be clarified. This means that the tests must be carried out under long time in a water solution and static load conditions, while the copper at the same time is charged electrochemically with hydrogen atoms. The chemical composition of the water solution shall be equivalent to the ground water in Forsmark with due consideration to potential increase of dissolved salts as the result of water evaporation.

2.6 Summary

In the foregoing section we, SSNC and MKG, have broached a number of issues relating to the risk of corrosion and embrittlement of the copper canisters and negative impacts on the clay buffer, both of which barriers are crucial to the long-term safety of the KBS method. In our perception, SKB appears to lack knowledge of some critical factors that they need to know in order to say that the final repository of the KBS model will function as planned when spent nuclear fuel has been deposited in it. This uncertainty needs to be resolved before the company submits its application.

In the opinion of SSNC and MKG, the nuclear waste management company, SKB, must in the context of the EIA consultation demonstrate that the man-made barriers of copper and clay will not be damaged or ruined in the course of the first hundreds or thousands of years.

3. The risk that the clay buffer is destroyed under glacial conditions

In recent years, awareness has grown concerning the possibility that the clay buffer may erode due to changes in the chemical characteristics of groundwater due to freezing during a glacial cycle. The issue was raised in connection with the examination of the analysis in the safety report, SR-Can (SKI & SSI 2008). Since then, the nuclear waste management company has enlisted the services of the Division of Chemical Engineering at the Royal University of Technology, KTH, in Stockholm and the consultancy, Clay Technology, to study the problem. Both groups work almost exclusively for SKB and may nowadays be considered part of SKB's internal research organization. The results of SKB's work on the subject was made public in Autumn 2009 (SKB 2009e, SKB 2009f, SKB 2009g). The Nuclear Safety Authority, SSM, convened a special expert meeting with their BRITE group in November of 2009, which reached the conclusion that several uncertainties as to the risk of clay erosion still persisted. Since then, SKB has asked the above-mentioned Department at KTH to do yet another modelling study, but the result does not appear to have clarified the issue very much (SKB 2010b).

In the view of SSNC and MKG, there must be no uncertainty concerning the risk of clay erosion during a period of glaciation when the company's application is submitted. We also consider it important for SKB to consult others besides their 'own' research teams to study central and vital issues like this one. To enhance the credibility of their research, SKB should involve new and independent research groups to perform studies and/or review studies carried out by others.

In SSNC's and MKG's view the nuclear waste management company, SKB, needs, in the context of the EIA consultations on long-term safety, to demonstrate that there is no risk of early erosion (rinsing away) of the clay buffer in the course of repeated glacial cycles.

4. Greater transparency with regard to SKB's research and the publication of all research reports and documentation from research project meetings

A good share of the research and development work that SKB has done has been performed on commission from SKB by selected research institutes and consultancies. It is vital that this research, as well as the studies carried out within the waste management company itself, can be performed in an independent manner that observes the fundamental ethical principles of science, and not be influenced by economic interests. The findings of commissioned research must not be influenced, directly or indirectly, by the nuclear waste management company. The purpose of commissioned experiments and theoretical modelling, and the interpretation of the results, must not be primarily to confirm the merits of the KBS-3 concept or to rebut criticism of it. The institutes and firms that SKB employs must have assurance that their prospects of future work for SKB will not be endangered, should their findings raise questions about the KBS-3 method.

In the case of studies of the man-made barriers of copper and clay, SKB has relied on a handful of external research bodies. In MKG's examination of the work done to date, five organizations stand out as the companies SKB has principally relied on in recent years to study questions relating to the long-term safety of the man-made barriers of copper and clay: Clay Technology AB; the Division of Chemical Engineering at the Royal University of Technology, KTH (Ivars Neretnieks); Integrity Corrosion Consulting Ltd (Fraser King); Bo Rosborg Consulting; Sercom Assurance in association with two Bulgarian researchers.[4] In addition, work has been done (unknown by whom) in SKB's bentonite laboratory at Äspö, some of which studies appear to have bearing on the risk of buffer erosion.[5]

In its examination of SKB's research on copper corrosion the Radiation Safety Authority, SSM, discovered that some findings of a study or studies performed by Serco Assurance were suppressed in the report of research to date that SKB published (SSM 2010). In our view, there are good reasons to examine not only the work done by Serco Assurance, but all the commissioned research performed by companies and institutions that have strong ties to, and have become dependent on, the nuclear waste management company. As noted earlier in this submission, MKG has had to put considerable effort into obtaining information about SKB's work on copper corrosion and its effects on the performance of bentonite clay. The examination MKG has been able to perform leads SSNC and MKG to conclude that all the findings reported by the above-mentioned research bodies merit closer examination.

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4. Martin Bojinov, Department of Physical Chemistry, University of Chemical Technology and Metallurgy, Sofia, and Iva Betova, Department of Chemistry, Technical University of Sofia. Both were previously attached to VTT Technical Research Centre, a not-for-profit network for applied research services in Finland. SKB has previously commissioned work from VTT, but the relationship moved to Bulgaria with the two researchers.
5. In administrative terms the bentonite laboratory is part of the Äspö Laboratory, but very little information about what is done there has been made public. There is no information about research in progress in the most recent annual report for the Äspö Laboratory, other than a couple of photographs of different experiments (SKB 2009b). In the status and planning reports for Äspö there are some descriptive passages about different experiments, but no results appear to have been reported.

It should be noted that Clay Technology AB has also been asked to study several other topics of vital importance to the long-term safety of the method, including how the clay in a final repository might be impacted by freezing due to permafrost; how glaciation-induced earthquakes might affect a KBS repository; the risk that the installation of a repository in the bedrock formation at Forsmark might compromise its stability to the extent that it breaks apart during glaciation. The underlying assumptions and argumentary support in the Clay Technology studies should be subjected to scrutiny.

With respect to studies of other aspects of the project on which SKB is particularly keen to have the company's standpoints reflected, e.g., alternative methods such as deep boreholes or the siting process, research teams in the consultancy Kemakta have been engaged on a number of occasions not 8. The base data underlying Kemakta's studies needs to be examined.

In SKB's response to MKG 19 November 2010. SKB explains that a series of reports entitled International Progress Reports (IPR series) will be made public, but that other research reports from the Äspö laboratory are confidential (internal working papers).

In our opinion this is hardly sufficient. Far from all the consultants' reports from research at the Äspö laboratory are included in the IPR series. Almost no reports from experiments that examine copper corrosion and its effects on the clay are included in the series. A prerequisite to any scientific review of SKB's research on these subjects, by the regulatory authority or others, is that all research documentation is made available for scrutiny in the context of the EIA consultations. This includes documentation that the company considers confidential. Furthermore, documentation of research meetings must be made available, as well.

It is difficult to list reports and other documentation, the existence of which is uncertain, but MKG and its member organizations have started to compile and inventory.

1. All reports that SKB has developed in the report series Technical Documents (TD) and International Technical Documents (ITD)[6]

2. Particularly the report SKB ITD-05-01, EDZ seminar at Arlanda December 13th, 2004. Presentations and summary of discussion, Svensk kärnbränslehantering AB, 2005

6. Reports published in the TD and ITD report series regarding research in the Äspö laboratory are mentioned in status and planning reports (IPR reports) for the Äspö laboratory. Preiviously, the reports were named, but since Autumn 2008 only the number of published reports are mentioned.

3. All reports in the SKB working paper TU series

4. Particularly the report SKB working paper TU-03-05/Posiva R&D Report 2003-01, Deep repository – Facility Design. Qualification of low-pH cementitious products in the deep repository

5. All consultants' reports and memorandums from meetings regarding the LOT-project (many Clay Technology reports, but also other consultants' reports)

6. All consultants' reports and memorandums from meetings regarding the canister retrieval project, particularly studies on copper and clay (mostly Clay Technology reports)

7. All consultants' reports and memorandums from meetings regarding the prototype repository (among them reports with results from corrosion measurements conducted by Rosborg Consulting)

8. All consultants' reports and memorandums from meetings regarding the MiniCan-project (mostly Serco Assurance reports)

9. Particularly the Serco Assurance report SERCO/TAS/E. 003110.01/ Issue 01, Miniature Canister (MiniCan) Corrosion Experiment Progress Report 1 for 2008-9, January 2010

10. Particularly the memorandums "N.R. Smart, Minutes of Model Canister Planning Meeting, 2 June 2009, SKB offices, Stockholm"

11. Particularly the Serco Assurance report, Serco/TAS/MCRL/19801/ C001 Issue 2, Interactions Between Iron Corrosion Products And Bentonite, 2008

12. Particularly the Serco Assurance report SA/EIG/15031/C001, Expansion Due to Anaerobic Corrosion of Iron, 2005

13. Particularly the Serco Assurance report SA/EIG/11080/C001, The design of the mini-canisters – Design of Model Canister Experiment, March 2005

14. All consultants' reports and memorandums from meetings regarding the project "Galvanic corrosion of copper-cast iron couples", reported in SKB TR-05-06 (mostly Serco Assurance-reports)
15. Particularly the Serco Assurance report, SAEIG/13974/C001, Galvanic Corrosion of Copper-Cast iron Couples, 2004

16. All consultants' reports and memorandums from meetings regarding the project ”Investigation of Eh, pH and corrosion potential of steel in anoxic groundwater”, reported in SKB TR-01-01

17. Particularly the report AEAT/R/PS-0028, issue 1, Investigation of Eh, pH and Corrosion Potential of Steel in Anoxic Groundwater, 2000

18. All consultants' reports and memorandums from meetings regarding the project ”Task Force on Engineered Barrier Systems”

19. All consultants' reports and memorandums from meetings regarding projects conducted in the benotnite laboratory

20. All consultants' reports and memorandums from meetings regarding projects conducted by the Departement of Chemical Engineering at the Royal Institute for Technology, supervised by Ivars Neretnieks

21. All consultants' reports and memorandums from meetings regarding projects conducted by the Department of Material Sciences at the Royal Institute for Technology, supervised by Rolf Sandström

SSNC and MKG will continue to examine SKB's research and may, in the context of the EIA consultations, request access to additional reports and documentation of the research. Of future interest are the experiments, Alternative Buffer Materials, Temperature Buffer Test, and Large Scale Gas Injection, currently in progress at the Äspö laboratory.

In sum: SSNC and MKG demand that the applicant, SKB, make available, in the context of the EIA consultations, all consultant's reports and other research reports, as well as documentation of research project meetings that treat the study of copper and clay at Äspö Laboratory and any other research that has a bearing on the man-made barriers of copper and clay.

References

Al Kharafi F.M., Ghayad I.M. & Ateya B.G.; Rapid Intergranular Corrosion of Copper in Sulfide-Polluted Salt Water. Electrochemical and Solid-State Letters 11 (4) G15-G18 (2008).

Arilahti E., Lehtikuusi T., Olin M., Saario T. & Varis P.; Evidence for internal diffusion of sulphide from groundwater into grain boundaries ahead of a crack tip in a CuOFP copper, 4th international workshop on long-term prediction of corrosion damage in nuclear waste systems. Brugges, Belgium, June 28 – July 2, 2010.

Butt D.P., Kanner G.S. & Lillard R.S.; Corrosion of Target and Structural Materials in Water Irradiated by an 800 MeV Proton Beam. The Proceedings of the 2nd Int. Conf. On accelerator-driven transmutation technologies and applications. June 1996, Kalmar Sweden.

Carlsson T. & Muurinen A. 2009. Identification of Oxygen-Depleting Components in MX-80 Bentonite, Mater. Res. Soc. Symp. Proc. Vol. 1124

King F., Litke C.D. & Ryan S.R.; A mechanistic study of the uniform corrosion of copper in compacted Na-montmorillonite/sand mixtures. Corrosion Science 33:12 (1992) 1979-1995.

Lillard R.S., Pile D.L. & Butt D.P.; The corrosion of materials in water irradiated by 800 MeV protons. J. of Nuclear Materials 278 (2000) 277-289.

Martinsson A. & Wu R.; Hydrogen charging of oxygen-free copper. KIMAB-2008-131

Nakahara S. & Okinaka Y.; The Hydrogen Effect in Copper. Materials Science and Engineering A, 101 (1988) 227-230.

Posiva 2006. Copper Corrosion in Bentonite: Studying of Parameters (pH, Eh/O2) of Importance for Cu Corrosion, Working Report 2007-62, Posiva, June 2007.

Rebak R.B. 2006. Selection of Corrosion Resistant Materials for Nuclear Waste Repositories. Materials Science and Technology 2006, Cincinnati, OH, United States, October 15, 2006 through October 19, 2006. UCRL-PROC-221893.

SKB 2001a. O2 depletion in granitic media, the REX project, TR-01-05, Svensk Kärnbränslehantering AB, February 2001.

SKB 2001b. Copper corrosion under expected conditions in a deep geologic repository, TR-01-23, Svensk Kärnbränslehantering AB.

SKB 2006. Long-term safety for KBS-3 repositories at Forsmark and Laxemar – a first evaluation. Main Report of the SR-Can project, TR-06-09, Svensk Kärnbränslehantering AB, October 2006.

SKB 2007. Äspö Hard Rock Laboratory: Annual report 2006, SKB TR-07-10, Svensk Kärnbränslehantering AB, June 2007.

SKB 2009a. Long term test of buffer material at the Äspö Hard Rock Laboratory, LOT project: Final report on the A2 test parcel, TR-09-29, Svensk Kärnbränslehantering AB, November 2009.

SKB 2009b. Äspö Hard Rock Laboratory: Annual Report, 2008, TR-09-10, Svensk Kärnbränslehantering AB, July 2009.

SKB 2009c. Miniature canister corrosion experiment – results of operations to May 2008, Svensk Kärnbränslehantering AB, July 2009.

SKB 2009d. Design premises for a KBS-3V repository based on results from the safety assessment SR-Can and some subsequent analyses), TR-09-22, Svensk Kärnbränslehantering AB, November 2009.

SKB 2009e. Bentonite erosion: Laboratory studies. TR-09-33, Svensk Kärnbränslehantering AB, November 2009.

SKB 2009f. Bentonite erosion: Final report. TR-09-34, Svensk Kärnbränslehantering AB, December 2009.

SKB 2009g. Mechanisms and models for bentonite erosion. TR-09-35, Svensk Kärnbränslehantering AB, December 2009.

SKB 2010a. Fud-program 2010: Program för forskning, utveckling och demonstration av metoder för hantering och slutförvaring av kärnavfall, Svensk Kärnbränslehantering AB, September 2010.

SKB 2010b. Modelling of erosion of bentonite gel by gel/sol flowTR-10-64, Svensk Kärnbränslehantering AB, November 2010.

SKI & SSI 2008. Björn Dyverstorp & Bo Strömberg, m fl. “SKI’s and SSI’s review of SKB’s safety report SR-Can”, SKI report 2008:23 & SSI report 2008:04 E, Mars.

SSM 2009. Record of SSM BRITE (Barrier Review, Integration, Tracking and Evaluation) Review Group Meetings, 4, 5 and 7 November 2009.

SSM 2010. Quality Assurance Review of SKB's Copper Corrosion Experiments, SSM Rapport 2010-17.

SSM 2011. Evolution of hydrogen by copper in ultrapure water without dissolved oxygen. SSM Report 2011:34.

Szakalos P., Hultquist G. & Wikmark G.; Corrosion of copper by water. Electrochemical and Solid State Letters 10 (2007) C63-C67.

Taniguchi N. & Kawasaki M.; Influence of sulfide concentration on the corrosion behavior of pure copper in synthetic seawater. J. of Nuclear Materials 379 (2008) 154-161.

FUD-10

Joint comment on the part of the Swedish Society for
Nature Conservation (SSNC) and MKG concerning the
Swedish Nuclear Waste Management Company's (SKB)
R&D Programme on nuclear waste management (Fud-10):
"*Programme for research, development and demonstration of methods for management and disposal of spent nuclear fuel*"

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Dec 21th, 2010

Till: Svensk Kärnbränslehantering AB, SKB
(The Swedish Nuclear Fuel and Waste Management Company)
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Joint comments of the Swedish Society for Nature Conservation and the Swedish NGO Office for Nuclear Waste Review, MKG, on the nuclear power industry's organ for nuclear waste management, Svensk Kärnbränslehantering AB's status report, "Fud-programme 2010: Programme for research, development and demonstration of methods for management and final disposal of spent nuclear fuel."

The Swedish Society for Nature Conservation (SSNC) and MKG wish to put forward the following comments on the industry's latest status report and programme for research and development, Fud-10. MKG and its member organizations are described in a missive that accompanies these comments; the missive also outlines how the member organizations have chosen to comment on the present Fud-programme.

The following document consists of five parts:

1. Background, with a brief description of the so-called 'Fud-process' [Fud standing for RD&D: Research, Development & Demonstration]

2. Overall issues relating to the Swedish model for the management and final disposal of spent nuclear fuel

3. More general issues relating to how the nuclear waste management company, SKB, has carried out its research

4. Issues that SKB treats in the "Fud-10" report that call for comment

5. Issues that SKB does not treat in "Fud-10" or treats only superficially, despite their gravity and importance – omission or treatment that therefore merits comment.

The comments submitted by SSNC and MKG on December 15th 2010 to the nuclear waste management company are attached to this document (Annex 1). Parts 2 and 3 of those comments raise a number of concerns relating to copper corrosion and stability, and erosion of clay, two phenomena which, in our estimation, the company has not treated in an adequately scientific manner. Part 4 treats scientific ethical aspects and an overall lack of transparency surrounding the research SKB has done. These latter comments relate to the discussion in Part 2 of the present document regarding a need for reform of 'the Swedish model' for management and final disposal of spent nuclear fuel.

1. A brief background

Every three years, the nuclear waste management company shall report its progress and submit a programme for the research it intends to conduct during the coming three years to the regulatory authority, the Swedish Radiation Safety Authority, SSM. The most recent report and programme is entitled "Fud-programme 2010: Programme for research, development and demonstration of methods for management and final storage of nuclear waste", commonly referred to as "Fud-10". SSM received the document (ref. no. SSM 2010/2116) in late September of 2010; it was then circulated broadly for comment. When SSM has received all comments, the authority will proceed to submit a recommendation no later than March 2011 to the Government on Fud-10. According to the terms of the Law on Nuclear Activities (1983:4, 26§), the recommendation should include a review and evaluation of the programme with respect to:

1. Planned research and development work
2. Reported research findings
3. Alternative methods of management and final disposal and
4. The measures to be taken.

The Council for Nuclear Waste, too, submits comment to the Government. Thereafter the Government will make its judgement on "Fud-10".

Submission of these periodic status and program reports is a condition attached to the authorization to operate a nuclear power plant, set out in the Law on Nuclear Activities (1983:4, 12§), which also states:
In conjunction with the examination and evaluation conditions may be imposed as deemed necessary concerning the continuation of the research and development program.
This passage is pivotal inasmuch as it represents the only legal basis for government intervention or steering of activities relating to nuclear waste management.

The waste management company, SKB, has announced its intention to submit an application to the Radiation Safety Authority and the Environmental Court for permission to build a final repository for spent nuclear fuel at Forsmark 16 March 2011. The initial examination of the application is expected to take 2-3 months; thereafter, the Authority and the Court will determine whether or not the application is good enough to form the basis of formal proceedings.

Should it be determined that the application is not good enough, there will have to be a thorough investigation to determine how such a situation could arise. In all events, the Government's decision regarding "Fud-10" should be taken after the Radiation Safety Authority and the Environmental Court have made their determination. If a formal examination cannot start, the Government should undertake a study to provide better guidance for their decision on the research programme.

2. Overall issues relating to the Swedish model for the management and final disposal of spent nuclear fuel

Having followed the progress of the final repository project from the start, SSNC has submitted many comments on the nuclear waste management company's research programmes over the years. Since 2005 SSNC, acting through MKG, has taken active part in the mandated EIA consultations that precede any company's application for permission to construct a final repository for spent nuclear fuel. Together, our two organizations have extensive experience and a good grasp of how 'the Swedish model' for nuclear waste management and storage works.

In recent years we have become aware of certain weaknesses in 'the Swedish model'. Since the review of "Fud-10" precedes a determination on the part of the Government that might lead to corrective measures, we find it important to include some comments of a 'systems' nature in this document.

The distribution of responsibility

Swedish legislation entrusts full responsibility for the management and final disposal of spent nuclear fuel to those who have concessions to operate nuclear power facilities. It is more than a question of 'the polluter pays'. Here, all responsibility is in the hands of the industry. In this respect the Swedish approach differs markedly from how responsibility is distributed in most other countries that have nuclear power reactors. The Swedish arrangement rests on an unshaken confidence that an industrial actor, in this case a branch-owned company, will be able to set aside the industry's parochial interests in favor of a process that satisfies a strong public interest, namely, to achieve the best possible technical solution from the point of view of long-term environmental safety.

In our view, in order for 'the Swedish model' to succeed, the following requirements must be fulfilled:

1. A mandated pro-active role on the part of the regulatory authority that enables it to monitor the company's progress, examining and evaluating the company's activities on its own initiative;

2. Public funding of a scope that enables the regulator to commission pertinent research that is independent of the nuclear waste management company, as deemed necessary; and

3. Sufficient transparency to give authorities, civil society organizations and the public full insight into the work of the company, allowing independent assessments of the company's performance in relation to what is expected of them.

On the basis of many years' involvement in the three-yearly process to review the SKB research and development programme – the Fud-process – and, more recently, participation in the EIA consultations, we, SSNCF and MKG, find that in the present statutory framework the Swedish approach to assigning responsibility is not working very well. We support the polluter pays principle, but if the 'polluter' is to continue to be entrusted with full responsibility for the execution of the final repository project, the statutory and administrative frameworks need to be reformed.

The need for a forceful regulatory control

There is an obvious risk that the industry's interest in finding an adequate means to manage and dispose of Swedish spent nuclear fuel that is technically simple and economical may conflict with the public interest of finding a solution that affords the best possible long-term environmental safety. The public interest must be supported by an active role on the part of regulator. In retrospect, some aspects of the culture that prevailed in parts of the former regulatory agencies with respect to both the quality of their control and their independence vis-à-vis the industry can be questioned. The creation of the new regulatory body, the Swedish Radiation Safety Authority, SSM, marks a 'break with tradition' and takes a major step toward greater regulatory integrity. Still, however, the authority lacks the means to act forcefully to defend the interest of the public as relates to the problem of nuclear waste.

A principal flaw in the present system is that the regulator lacks statutory authority to examine the industry's work on spent nuclear fuel management and disposal of it, other than through the slow, yet superficial Fud-process. The authority needs to be given legal power to take action when it has reason to believe that all is not as it should be. As things stand today, SSM can inspect the quality of the industry's research only with the consent of the nuclear waste management company, and totally on the company's terms. The regulator does not even have the authority to demand access to research reports that the company is not willing to release for scrutiny.

In the opinion of SSNC and MKG, the regulator must be able to examine the industry's work on a final repository for spent nuclear fuel on a continuous basis and on its own initiative.

Funds for independent research

A lack of transparency has made it difficult to review the industry's R&D programme. One of the main reasons is the industry's total control over all research funding out of the Nuclear Waste Fund. From the point of view of the Swedish research community, the nuclear industry has been the source of relatively plenteous funding for studies in areas of relevance to the final repository project. Meanwhile, other sources of funding have retreated from this area, choosing instead to use their limited resources on research in other fields. Consequently, the industry has built up research environments that are to a significant degree, if not totally, dependent on its good offices, and only studies that the industry has asked for have been undertaken. Similarly, the industry has been able to develop relationships with selected consultancies that have become dependent on the industry's favor. Consultant firms are clearly under even greater pressure to conform to the client's wishes.

The problem is not that the research done is necessarily of poor quality, although in some cases questions may be raised, but that there has been no funding to explore aspects that the nuclear waste management company has not wanted to look into. It is quite clear that the industry has avoided some issues that do not serve their interests. When, what is more, the funding that authorities have had at their disposal is used primarily to replicate (and thereby falsify or confirm) experiments and studies that the company has done, the imbalance becomes even more acute. Furthermore, in some cases when studies commissioned by the authorities have indicated that there might be a problem – as in the case of copper corrosion – neither the company nor the authority has followed them up.

In other words, it is quite clear that 'the Swedish model' needs to be changed so that funding out of the Nuclear Waste Fund is made available for studies that are independent of the nuclear waste management company. Even today, the Radiation Safety Authority is able to draw money from the Fund to finance research that helps the Authority execute its regulatory functions. Considerably more funding needs to be made available for this purpose, and the Authority should draft a research policy that is broader in focus, and less closely tied to the industry's research agenda.

There has been a totally unfounded fear that the regulator, were it to undertake or commission independent research, might encroach on the industry's sphere of responsibility. But, the regulator has a duty to see to it that the public interest, too, is served in the body of research relating to the final repository project. Thus, the regulator may be seen to be duty-bound to undertake research quite independent of the industry. Otherwise, there is a risk that the regulator will not have the knowledge needed to be able to evaluate certain crucial issues such as those relating to the long-term environmental safety aspects of the method developed and site chosen by the industry through its company, SKB.

In order to ensure that the knowledge generated on the subject of spent nuclear fuel is the best that can be attained, there must also be systems for funding investigations initiated by members of the academic community. The money for this should be taken out of the Nuclear Waste Fund, and the announcement of available grants and evaluation of applications for those grants should be handled by a council consisting of representatives of the academic world and actors in the field of nuclear waste management. These structures may be arranged under the auspices of the Radiation Safety Authority, but they should be separate from the research conducted or commissioned by the regulator. This would create yet another level that might ensure that Swedish research in the field of nuclear waste is of the best possible quality.

SSNC and MKG call for a major increase in funding out of the Nuclear Waste Fund for research that is independent of the nuclear power industry.

The need for full insight into the work done on spent nuclear fuel

One obvious hindrance to all who are interested in examining, or have a duty to examine, the work of the industry that relates to spent nuclear fuel – members of the research community, mass media, civil society organizations and others – is the way the industry has organized its work on the subject. The creation of a subsidiary company, SKB AB, to pursue the project removes the work from the public sphere and renders all insight into, and assessment of, the company's work subject to the consent of the company. Not even the regulator, SSM, has the authority to examine material that the company chooses to consider internal, even though many reports and documents from research meetings contain information that should be open to public scrutiny.

If the Swedish model of distributing responsibility is to succeed, this situation must change. However organized, accountability requires that the manner in which the nuclear waste management company uses money out of the Nuclear Waste Fund must be transparent, in accordance with the principle of freedom of information. This would greatly facilitate reviews and assessments of the industry's 'research, development and demonstration' efforts. It would, furthermore, enhance the company's accountability regarding how it uses the money it draws from the Nuclear Waste Fund.

It is our considered opinion that the industry's use of money out of the Nuclear Waste Fund must be reorganized in a way that affords full public insight into the company's activities.

3. More general issues relating to how the nuclear waste management company, SKB, has carried out its research

These past few years MKG has reviewed SKB's research in a number of areas in conjunction with the EIA consultations preceding to the submission of an application for permission to construct a final repository for spent nuclear fuel. To put it bluntly, the research often falls short of established standards of scientific praxis. Particularly problematic is the research relating to alternative methods (alternative to the KBS model) and the choice of site, but the problem is even more pronounced in the work relating to the barrier system.

Most recently, MKG has reviewed and analyzed SKB's research on copper corrosion. It required a great deal of effort for us to gain access to research findings from, for example, experimental studies performed in SKB's Äspö laboratory near the Oskarshamn nuclear power plant. The regulatory agency, SSM, has also looked into the problem of copper corrosion and in early 2010 reviewed the company's quality assurance of their research on the subject. SSM's report is strongly critical of the company's documentation of their experimental work on copper corrosion and its effects on clay (SSM rapport 2010:17). Among other things, SSM found that SKB had suppressed research findings in a published report from the project.

The problems that have surfaced in the area of copper corrosion are symptomatic of a deeper-lying problem relating to SKB's research and its non-conformity with scientific praxis. Had it not been for SSM's external control, the suppression of findings would never have been revealed. Had such a breach become known in an academic environment, it would in all probability have elicited an investigation of ethical misconduct. The nuclear waste management company, SKB, claims to work in a scientific fashion with high degree of transparency. Meanwhile, the company has on several occasions denied MKG access to findings from other research projects performed at the Äspö facility.

More serious is the apparent development of an unscientific attitude or culture among the staff of SKB that does not recognize the need to publicize results that are unexpected or do not ‘fit’ with the company’s preconceptions. Despite the company’s self-image as scientific and transparent, the fact is that SKB publishes only the findings that it finds suitable to make public. Experiments and analyses that produce results that the company’s researchers cannot explain or that deviate from their expectations and they therefore do not “trust” are not made public. This established practice was revealed at a meeting where representatives of SKB and the Radiation Safety Authority discussed the problems turned up in the latter’s review of SKB’s research on copper corrosion in early 2010.

The fact that the company is entrusted with sole responsibility for developing the method of handling Swedish spent nuclear fuel in a manner that affords the greatest possible long-term environmental safety renders the situation troubling. Unfortunately, MKG’s years-long experience of the EIA consultations leads us toward the conclusion that this attitude has prevailed within the company for many years. If this is so, the validity of portions of the material – the more controversial portions in particular – to which the company will refer in the coming application for permission to construct a final repository for spent nuclear fuel at Forsmark, may be called into question.

There is clearly a need for access to the results of SKB’s research, from those doing the experiments themselves rather than via the heavily edited versions that are offered for public consumption (e.g., the R and TR series). To enable the scientific community, the regulatory agency and other actors to assess the company’s research, documentation from project and research meetings should also be made available for scrutiny. SSNC and MKG have put forward such a demand in the context of the EIA consultations that precede SKB’s application for permission to build a final repository for spent nuclear fuel (Annex 1).

4. Comments relating to issues that SKB does treat in “Fud-10”

In the following we comment on different aspects that SKB itself includes in the research program, “Fud-10”. We, SSNC and MKG, have chosen to focus on issues relating to the final repository for spent nuclear fuel, and among those issues, primarily issues that relate to long-term environmental safety. Thus, our comments refer principally to portions of the document's Part I (Overall plan of action) and Part IV (Research for assessment of long-term safety).

We do not comment on the LILW program (Part II) [re Low and Intermediate-Level Waste], nor do we comment on the more practical aspects of the technology in Part III (The Nuclear Fuel Program), i.e., the material summarized in Table 9-1, pp 125f, and discussed in Section 11-16. Of Part IV, we do not comment on Sections 20 and 21, which deal with short-lived and intermediate-level waste, or Section 26, on near-surface ecological systems. We include no more than a few comments in the area of social science research (Part V), but comments on that research by Olov Holmstrand are attached to this document (Annex 3).

General comments on long-term environmental safety

First, some general comments on SKB's research on long-term environmental safety, as described in Table 17-1 on p 196. In the table, areas that SKB finds in need of some further research are indicated in fields of yellow, and areas in need of considerable amounts of research are indicated in fields of red. This is an improvement since Fud-07, where the corresponding table had no such assessment of the need for further research even though there was a similar table with assessments for further work regarding issues of more practical/technical aspects of the project.

What is problematic is that SKB notes major research needs within the coming three years in many different areas that have bearing on long-term environmental safety, yet they believe they will have sufficient knowledge to support an application for permission to construct a final repository for spent nuclear fuel in March 2011. What is more, several of the areas indicated concern issues relating to the integrity of the man-made barriers of copper and clay, which are crucial in relation to long-term safety. The safety analysis, "SR-Site", planned to accompany the application, consists of a set of models. Many of the aspects listed as requiring further research in Table 17-1 are vital to any assessment of the realism of the models in the safety analysis.

SSNC and MKG consider it important for the Radiation Safety Authority to assess the level of knowledge the nuclear waste company, SKB, demonstrates in relation to the attainment of the so-called 'initial condition', which needs to have been attained in order for the safety analysis to have any relevance whatsoever.

Copper corrosion and its influence on clay prior to saturation
Issues relating to corrosion of the copper canister are discussed in Section 23.2.7, pp 272ff. In the light of the discussion of SKB's research on copper corrosion in recent years, this section – both what it says and what it does not say – is highly interesting. Clearly, there are many things that SKB does not know about copper corrosion; it is also clear that the company shows rather little ambition to learn more. Moreover, in all probability SKB has not reported all of what it does know in this area, knowledge that may raise questions about the long-term environmental safety of the KBS method.

The reference to the fact that Fraser King, a long-time consultant to SKB, finds no problems with the company's various assumptions concerning copper corrosion and his opinion that those who have criticized the company's research are wrong carry no weight whatsoever. No references are offered in support of his judgements. King's assessment is hardly that of a dispassionate observer; he has worked for SKB as a consultant for many years and is highly biased in favour of the KBS method.

For a more detailed review of the research needs relating to copper corrosion and the behaviour of clay prior to saturation, please see Section 2 of SSNC's and MKG's comments submitted in the context of the EIA consultations (included as Annex 1 here). Some of the points are also touched on in the following.

Stress corrosion
Fud-10 lacks any reference to results from SKB's experiments on this subject, even though the company says that such results exist. These results must be made available for scrutiny, even if SKB considers them confidential. Therefore, it is a very good thing that the Radiation Safety Authority is performing its own experiments to study this phenomenon and will thus have a more solid basis on which to assess the need for further research.

The effects of radiation on copper and clay
Section 23.2.5, pp 271f, treats the effects of radiation on copper and clay. Only SKB has done theoretical work on this subject, but some experiments have demonstrated significant corrosive impacts and indicate that copper is particularly problematic in this regard. These effects have also been discussed in the reference group for the company's research on copper corrosion in anoxic environments. It turns out that SKB has no empirical support for discarding the issue as lacking significance. But neither does the company have any ambition to establish empirical support. This is an area that the Radiation Safety Authority should examine very carefully.

Saline precipitates
The precipitation of salts on the surface of the canister is a highly pertinent issue, given the relatively dry bedrock at Forsmark. The reference to the "LOT-A2" report in Fud-10 is misleading, as that report contains no information or data on this subject. It may be that the subject was treated in a consultant's report, the content of which was not included in LOT-A2, in which case it would be interesting to be able to read that report. The Radiation Safety Authority should demand access to detailed results on this subject, even if the only data are confidential.

The saturation process in the Forsmark bedrock
The question of how long it may take for the clay buffer to be fully saturated in the Forsmark bedrock appears to be treated in Section 24.2.5, pp 287ff, and 24.2.11, pp 302ff. There is a reference (p 287) to a report from 2001 (reference 24-13), which, however, relates to the SFR repository. Since the bedrock surrounding SFR is of an entirely different character, the reference is lacking in relevance. On page 302, SKB writes:

> *"The coupling of the THM processes during the saturation phase is not crucial for the safety of the final repository, but is important for an understanding of how the buffer is wetted, swells and is homogenized under the influence of temperature changes. It is also important for the understanding and evaluation of the field tests in the Äspö HRL."*

This is a very peculiar claim. If the clay is damaged or destroyed in the saturation phase, of course it will affect the long-term environmental safety of the repository. But SKB's models simply presume that the clay will be saturated as though it were a given, an absolute truth that requires no experimental verification. There is also mention of a project referred to as "FT EBS (Äspö Task Force on Engineered Barrier Systems)", but no reference to documentation. What is this project? Are there any reports or notes from project meetings, even if only confidential ones?

Erosion of the buffer
The problem of buffer erosion is treated in Section 24.2.20, pp. 316ff. The empirical work on this subject (reference 24-31) was performed by a team at the Royal Technical University in Stockholm that has very close ties to SKB, for which reason the documentation merits close scrutiny. The source of the figures and tables presented is a report (reference 24-12) from Clay Technology, a company also having close ties to SKB. The work done by Clay Technology should also be examined with a critical eye.

In SSNC's and MKG's view, the research on buffer erosion needs to be scrutinized carefully because the work has been performed with very little transparency in very close circles. We are aware that the Radiation Safety

Authority has a review of this subject in progress, and we urge the Authority (1) to examine how the company has assured the quality of their work on the subject, and (2) to demand access to all relevant internal documentation.

Climate change
It is important to bear in mind the various climate scenarios that may play out as a consequence of the anthropogenically enhanced greenhouse effect. SKB glosses over this subject in Section 19.1, pp 207ff.

Permafrost
The consequences of permafrost in a glacial cycle are treated in Section 19.4, pp 215ff; freezing is treated in Section 24.3.4, pp 285ff. Since freezing temperatures may have far-reaching effects on the function of the repository, SKB has put considerable resources into showing that there is no risk of freezing, and that freezing temperatures, should they occur, would not be a problem. SKB's work on this subject requires close examination. MKG also suggests that SSM take contact with Professor Matti Saarnisto in Finland, who has submitted comments to STUK on the problem of permafrost. As we understand it, Professor Saarnisto believes that permafrost can reach far greater depths than those foreseen in SKB's modelling.

Alternative methods
Issues relating to alternatives to the KBS method are treated in Section 27, pp 385-393. Deep boreholes are discussed in section 27.2, pp 389ff. SKB refers exclusively to its own work, which was done in 1998 and 2000 and to a report that will accompany the company's application for permission to build a final repository for spent nuclear fuel. Consequently, we cannot know the extent of SKB's knowledge about deep boreholes. There is no indication that the company has learned more since the most recent Fud-report, "Fud-07". We therefore presume that SKB has not developed its knowledge of deep boreholes to an extent that permits a proper comparison with the KBS method – although both the regulator and the Government have asked the company to do.

The treatment of deep boreholes in the foreign reports that SKB cites in Fud-10 is both superficial and biased. MKG has copies of these reports and will be pleased to make copies available on request.

Super-regional groundwater flows
Issues relating to regional groundwater flows on a macro scale are treated in Section 25.2.3, pp 330f. There is a reference to a new study, but the reference given (25-33) is incorrect, which makes it difficult to assess the basis for SKB's argumentation on this subject. SKB has told the regulator, SSM, that the correct reference is "Ericsson et al. Storregional grundvattenmodellering –

en känslighetsstudie av några utvalda konceptuella förenklingar [Modelling of super-regional groundwater: a sensitivity analysis of selected conceptual rectifications], SKB R-10-43" and that will be published in conjunction with the company's application to SSM and the Environmental Court. Thus, it is impossible to assess the need for further research in the area, but in view of how the company has manipulated publication of previous findings in this area, we have reason to believe that the need may be great in order to clarify the importance of these flows in the context of the choice of site.

Retrievability and physical protection/safeguards

Issues relating to retrievability are treated in Section 2.3.3, p 48. Otherwise, there is little mention other than brief references in reviews of others' studies of deep boreholes (p 393) and studies in the social sciences (p 411). Considering the topical interest in retrievability – indeed, the Nuclear Waste Council devoted a section of their most recent status report to the subject from in February [2010] – the nuclear waste company should accord the subject more attention. The experimental retrieval carried out in the Äspö laboratory lacks all relevance, unless the canisters are presumed to be retrieved only after several thousand years. The operation was not done by remote control, which would have to be the case as the the canisters would give high radiation doses.

Issues relating to the physical protection and safeguards surrounding nuclear materials are treated in Section 10.6, pp 130f. Physical protection/safeguards is discussed only in relation to the operational phase, not after closure and sealing of the repository. Interestingly, in a reference to a social scientific project at the School of Business, University of Gothenburg, SKB writes (p 420): "The most obvious problem identified by the study with regard to responsibility for Sweden's international commitments to non-proliferation in connection with a final repository concerns the temporal extent of the responsibility after the operating phase is over and closure has taken place."

It is remarkable that the nuclear waste management company seems not to have any research ambitions on such an important aspect as safeguards/physical protection after closure of the repository, not least in the context of retrievability. This gap must be filled.

Fuel with higher burn-up

Questions relating to disposal of spent nuclear fuel having a higher burn-up are treated on page 26. Higher burn-up implies higher levels of radiation and greater heat, but it also gives rise to different distributions of isotopes in the spent fuel, which may affect the risks involved if and when leakage from the repository occurs. For example, there will be greater amounts of

I-129, which is both very long-lived and volatile. These ramifications require further investigation.

5. Issues that SKB does *not* treat in Fud-10

Risks associated with earthquakes
The question of the impact of earthquakes of different magnitude and frequency on the repository does not appear to have been investigated in SKB's research programme. Considering how important they are to the long-term safety of the repository, the risks associated with seismic activity need to be established. The work should also be carried out by researchers not previously associated with SKB.

Risks associated with rock tension
There appears to be no programme for further study on the stress in the bedrock at Forsmark and the risk of major faulting or fractures with the repository as a fracture indication during glaciation. SKB has commissioned only one study, done by Clay Technology, which in view of the consultants' close association with SKB, may hardly be considered impartial. The Radiation Safety Authority should follow this subject up and see to it that the nuclear waste company also commissions studies by independent expertise.

Methane ice
There is no mention of continued research on the question of whether methane gas under extreme pressures and at low temperatures may turn into methane ice, which, when pressure and temperatures change (as may be expected after periods of glaciation and seismic waves), converts explosively to gas. Should such a phenomenon occur in a final repository, where there may be voids in tunnels and niches, it might be very problematic.

Other issues relating to choice of site, besides super-regional groundwater flows
SKB reports no plans to continue studying other siting issues besides super-regional groundwater flows. Among such issues is the risk involved in siting the repository in direct proximity to nuclear power reactors. The question is, what a serious accident in one of the reactors would imply for the operation and control of an adjacent repository. This question requires more research.

Scenarios that posit leakage during the first millennium
Since the possibility that the barrier systems may fail entirely cannot be ruled out, it is important to gain an understanding of what would happen to people and the environment if a repository failed even before 1 000 years

has passed.

Warning markers to coming generations and scenarios of intrusion
There is no research programme to study the possibility to communicate information and to warn future generations of the danger that intrusion into the repository represents. The problem of communication must be coupled with a study of various scenarios of future intrusion. It is not acceptable to say that future generations must take responsibility for their own acts when it is we, today, who are creating the hazard that may cause them harm – an act that they, obviously, have no part in and are not able to influence.

Research on the 'zero alternative'
The nuclear waste company should do more research on various options for interim storage in the event that the KBS system cannot be carried out. For example, long-term dry storage should be explored as part of the so-called 'zero alternative'.

6. Concluding remarks

We, the Swedish Society for Nature Conservation, SSNC, and the Swedish NGO Office for Nuclear Waste Review, MKG, are concerned about the status of the Swedish nuclear waste management programme. We have in the foregoing raised a number of issues on the level of overall responsibility and issues relating to the manner in which the nuclear waste management company, SKB, has conducted its research. We have pointed to a number of areas where we no longer have confidence in the validity of the results the company has made public from the closed world that its research environment has become.

We find a need for fundamental change in how Swedish research in the area is organized and urge the Swedish Radiation Safety Authority to reflect on this while preparing their recommendation to the Government. We urge the Government, too, to analyse these vital issues while making their assessment of the Fud-10 research programme.

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