A Safe Mercury Repository

A translation of the Official Report SOU 2001:58

Report 8105 · jan 2003

ORDER

Order Phone No: 08-505 933 40
Order Fax No: 08-505 933 99
E-mail: natur@cm.se
Address: CM Gruppen
Box 110 93
S-161 11 Bromma
Internet: www.naturvardsverket.se/bokhandeln

NATURVÅRDSVERKET

Phone: 08-698 10 00
E-mail: upplysningar@naturvardsverket.se
Address: Naturvårdsverket,106 48 Stockholm

ISBN 91-620-8105-5.pdf
ISSN 0282-7298

Digital Publication Only

Translation: Maxwell Arding

English translation of the Swedish Government Official Report 2001:58 produced by the Swedish Environmental Protection Agency

To the Minister of the Environment

On 9 December 1999 the government decided to appoint a person charged with the task of coordinating and conducting a commission of enquiry into the progress made towards long-term storage of waste containing mercury in a deep bedrock repository. Kjell Larsson, Minister of the Environment, appointed Director-General Lars Högberg for this purpose.

Experts are assisting the commission. Nina Cromnier (Deputy Director at the Ministry of the Environment) and Björn Södermark (Head of Section at the Swedish Environmental Protection Agency) were appointed experts from 20 March 2000 and Professor Bert Allard (Örebro University), Professor Ivars Neretnieks (Royal Institute of Technology) and Stig Wingefors, Ph.D (Swedish Nuclear Power Inspectorate) were appointed from 11 September 2000.

Nina Nordengren, Associate Judge of Appeal, was appointed secretary on 7 February 2000.

The Commission's report has been given the name "The Mercury Repository Commission Report" (1999:01). We submitted a memorandum entitled "Problem analysis and action plan for further progress – a basis for discussion" on 21 December 2001.

The commission hereby presents its report, "A Safe Mercury Repository" (SOU 2001:58).

Work on the report has been conducted in close consultation with the experts involved and the report is therefore written in the first person plural.

The commission's task has been completed.

Stockholm, 25 June 2001

Lars Högberg

/Nina Nordengren

Contents

Summary

Our proposals

We propose that the Hazardous Waste Ordinance (1996:971) be supplemented with statutory requirements that waste containing at least one per cent mercury by weight be taken to a permanent deep bedrock repository. Exemption will only be permitted for very small quantities of waste. Waste containing at least 0.1 per cent mercury by weight must also be taken to a deep rock repository if this is reasonable under the provisions of the Environmental Code. The waste must be taken to a permanent repository within five years unless there are particular reasons for not doing so. As a transitional provision, we propose that this time limit be extended to eight years from the date the provisions enter into force, which we propose should be 1 July 2002. We find that waste containing mercury must be kept in a deep repository in Sweden owing to the current export ban on mercury and other considerations.

We also propose that the Environmentally Hazardous Activities and Health Protection Ordinance (1998:899) be amended to stipulate that applications for operating permits for facilities for permanent storage of waste containing at least 0.1 per cent mercury by weight must be submitted to the environmental court in the first instance, even if the annual quantity of waste sent for storage is less than 1,000 tonnes. Under the present regulations, the first instance for these applications is the county administrative board. Whichever instance considers applications, an application to locate and construct a permanent repository must be preceded by a comprehensive consultative process under the provisions of the Environmental Code. We emphasise that the local consultative process must be conducted with great care. Enterprises and public agencies alike should make use of lessons learnt from other fields, such as nuclear waste.

Waste owners are responsible for ensuring that their waste goes to deep storage and that the necessary technological developments for that purpose are made. We recommend that the waste owners enter into a joint project on the design, location, construction and operation of a *single* deep repository. There are powerful technical and financial reasons in support of this approach. The waste owners have also said they favour the idea of a joint approach on certain conditions. However, we have found that the majority of enterprises that have, or will have, responsibility for large quantities of waste containing mercury are not prepared to begin definite negotiations until the requirement for a deep repository has been laid down by law.

Finally, we propose that the government instruct the Swedish EPA to ensure the government is kept informed about industrial developments so that it can take any steps necessary to accelerate the establishment of a repository deep underground on the basis of the legislative requirements we have set out above.

Reasons for the proposals – summary

Our considerations and proposals are based on the premise that use of mercury in Sweden is to end by 2010, with a few exceptions where special exemption has been granted for the use of very limited quantities in closed systems. The waste generated by former use must be safely dealt with and stored, taking account of the hazards that mercury and mercury compounds pose to health and the environment. Most waste containing more than 0.1 per cent by weight mercury is currently in the possession of a few enterprises, or will be by 2010. It is estimated that the total quantity of mercury in this waste will be about 1,400 tonnes, including 1,100 tonnes in waste containing more than one per cent mercury by weight. This includes mercury batteries, which have been collected and for whose further disposal the Swedish state has a financial responsibility. Trials are under way to process these batteries so that the mercury in them can be taken for final storage in a suitable form.

Our analysis has confirmed the desirability of deep bedrock storage as recommended in our terms of reference. Mercury differs from many other types of hazardous waste by virtue of its high toxicity. Moreover, since it is also an element, it is not broken down. This justifies a repository that isolates mercury from the biosphere for a very long period indeed (preferably more than 1,000 years), thus satisfactorily protecting drinking water wells, lakes and watercourses from mercury pollutants over the very long term. Another basic principle is that adverse environmental impact caused by one generation should not be borne by future generations. Hence, it is not appropriate to burden future generations with extensive monitoring, supervision and maintenance responsibilities for a mercury repository. The inference is therefore that a repository should, if possible, require no maintenance at all. This means that a deep bedrock repository is the only option that meets the criteria for storage of waste containing mercury. We also consider that a deep storage facility will provide greater scope for technical and financial optimisation of waste treatment and the detailed design of the repository.

The total cost of the repository will be relatively high for the enterprises involved; the Swedish EPA has estimated a figure of about SEK 200 – 300 million. Treatment costs may be in the same region, although these would be no lower if mercury were to be stored at a surface facility.

The enterprises involved agree that waste containing mercury must be dealt with in an environmentally safe manner. However, several of them stress that they operate in international markets in the face of fierce price competition. They therefore oppose the idea of specific Swedish requirements that will cost them money and, as they see it, make them less competitive. They would prefer to wait until EU common regulations and solutions are in place. This might involve export from Sweden of pure mercury, extracted from waste, for permitted applications in the EU, so that new production of mercury in the union could be correspondingly reduced. We would here point out that our terms of reference do not allow us to question the export ban. We further note that any export of mercury in conjunction with the ongoing phase-out of mercury use in Sweden would ultimately shift responsibility and costs for waste management to other countries, since permitted use of mercury in the EU can be expected to diminish dramatically over the forthcoming decades. On balance, we do not find there to be socio-economic arguments against a deep bedrock repository for high-level mercury waste. We would here point out that there are many historical precedents where failings in the management of hazardous waste management have resulted in high decontamination and remediation costs for society.

Draft legislation

1. Draft Ordinance amending the Hazardous Waste Ordinance (1996:971)

It is hereby provided that

(i) the present section 37 shall be renamed section 39[1],
(ii) section 37 and the heading before section 37 shall have the wording set out below;
(iii) a new section (section 38[2]) shall be inserted and shall have the wording set out below;
(iv) a new schedule (Schedule D 16) shall be inserted in Appendix 4 and shall have the wording set out below;
(v) a new section (section 3) shall be inserted in the transitional provisions and shall have the wording set out below.

Present wording

Appeal

Section 37

Chapter 19, section 1 of the Environmental Code contains provisions governing appeals.
A decision of the county administrative board to grant a permit pursuant to section 22 may be appealed by the Swedish Environmental Protection Agency, the National Board of Health and Welfare and the Swedish Board of Agriculture within each agency's sphere of responsibility.

Proposed wording

Disposal of waste containing mercury

Section 37

Waste containing at least one per cent mercury by weight shall be disposed of in the manner set forth in section D 16 in Schedule 4. This disposal shall take place within five years unless there are particular reasons why this should not be done. However, where the quantities of waste are so small that disposal in this manner is obviously unreasonable, that waste may be recycled or disposed of in another manner.

Section 38

Waste containing at least 0.1 per cent mercury by weight shall also be disposed of in the manner set forth in section D 16 in Schedule 4 if this is reasonable. When deciding whether to

[1] Formerly section 39 repealed by 1998:948
[2] Formerly section 38 repealed by 1998:948

do this, the benefit of disposal shall be compared with cost of the measure. This disposal shall also take place within five years unless there are particular reasons why this should not be done.

Appeal

Section 39

Chapter 19, section 1 of the Environmental Code contains provisions governing appeals.

A decision of the county administrative board to grant a permit pursuant to section 22 may be appealed by the Swedish Environmental Protection Agency, the National Board of Health and Welfare and the Swedish Board of Agriculture within each agency's sphere of responsibility.

Schedule 4

Disposal procedures

Section D 16

Underground depository, ie, a facility for permanent storage of waste in a deep geological cavity.

Transitional provisions

Waste containing mercury that is generated prior to 1 July 2005 that is to be disposed of in the manner set forth in section D 16 in Schedule 4 shall, instead of being disposed of within a five-year time limit, be disposed of not later than 1 July 2010 unless there are particular reasons for not so doing.

This ordinance enters into force on 1 July 2002.

2. Draft Ordinance amending the Environmentally Hazardous Activities and Health Protection Ordinance (1998:899)

It is hereby provided that a new section shall be inserted in the schedule, as well as a new heading having the wording set out below.

Present wording

Radioactive waste

facility for managing, processing, storage or final storage of spent nuclear fuels, nuclear waste or other radioactive waste pursuant to the Nuclear Activities Act (1984:3) or the Radiation Protection Act (1988:220) 90.004-4 A

Present wording

Radioactive waste

facility for managing, processing, storage or final storage of spent nuclear fuels, nuclear waste or other radioactive waste pursuant to the Nuclear Activities Act (1984:3) or the Radiation Protection Act (1988:220) 90.004-4 A

Waste containing mercury

Facility for disposal of waste containing at least 0.1 per cent mercury by weight. 00.000-0 A

______

This ordinance enters into force on 1 July 2002.

1 Background to the report

1.1 Government policy on mercury

We now know that mercury is one of the most dangerous pollutants of all. Large quantities of mercury are stored in goods and products, as well as waste. Mercury must ultimately be removed from the ecocycle instead of being recycled. This will make it possible to reduce the stress placed on the environment more rapidly and keep it at the minimum possible level in the long term. To achieve sustainable development for future generations we must solve the problem of long-term storage of waste containing mercury.

Mercury occurs in a number of applications and in products. This results in emissions to air as well as waste management problems. Mercury bioaccumulates, is highly toxic and affects biological processes in soil. It can cause serious harm to humans and animals. One form of mercury (methyl mercury) damages the central nervous system and is particularly harmful to foetuses and children. Methyl mercury accumulates in the food chain and increasingly high concentrations are causing more and more serious damage.

In view of the above, the government has taken a number of steps since 1991 to limit the amount of mercury in circulation in Sweden. Mercury use in Sweden is governed by the Prohibition etc. in Certain Cases in Connection with Handling, Import and Export of Chemical Products Ordinance (1998:944). Effective as of 1 January 1992 , the ordinance introduced a ban on the commercial manufacture or sale of certain products containing mercury. The ordinance imposed a further ban, effective as of 1 July 1997, on the export of mercury and chemical compounds and mixtures containing mercury.

The government notified a ban on the use of mercury to the EU on 6 July 2000, with a view to further restricting the use of this element. Under the ban, mercury may not be used as a chemical for analytical purposes or as a reagent as from 2004, nor for production in the chloral kali industry as from 2010. In addition, the National Chemicals Inspectorate may set a maximum permitted concentration of mercury in light sources.

Government Bill 2000/01:65 – A Chemicals Strategy for a Non-Toxic Environment – states that new manufactured goods must be mercury-free by 2003 at the latest. The deadline has been chosen so that industry is given a reasonable time for adjustment. Since mercury has been used for a long time, it is present in products still in use. Some of these products may have several decades of their expected life remaining. These products must be dealt with so that the mercury they contain does not leak into the environment or pose a threat to human health. In view of the risk of dispersal, collection of products containing mercury before they reach they end of their life is a justified step. This collection is in progress.

The government considers that mercury use should be phased out throughout the EU for reasons of trade and transboundary air pollution. Sweden is pressing for an end to remaining mercury applications in batteries, among other things. In addition, EU environment ministers adopted a conclusion on mercury on 7 June 2001 in which they urged the EU Commission to develop strategies for disposing of mercury in an environmentally safe way as soon as possible. It was said that the Commission should take into account the phase-out of mercury use in the chloral kali industry.

The Convention on Long-Range Transboundary Air Pollution (LRTAP) was established by the UN Economic Commission for Europe in 1979. Sweden is endeavouring to have the convention supplemented with an overall objective that point-source emissions and non-point-source emissions of hazardous substances should end by 2020. There is a protocol on heavy metals under the convention. Sweden is pressing for the protocol to be widened as soon as possible so as to further reduce long-range airborne dispersal of mercury.

On the global plane, the UN Environment Programme decided on 9 February 2001 to make a global evaluation of the environmental impact of mercury. The results of the evaluation will be reported at the UNEP board meeting in 2003. The evaluation will include:

- available information on the impact on human health and the environment;
- production and applications;
- emission control technologies;
- alternative chemicals and technologies; and
- potential global action.

A decision to take action will be considered by the board of UNEP in 2003. The need to evaluate other heavy metals will be considered at the same time.

1.2 Swedish Environmental Protection Agency Report 4752

1.2.1 Contents of the report

In 1994 the government instructed the Swedish EPA to formulate proposals for terminal storage of mercury waste. A given premise was that mercury was not to be recycled; waste was to be dealt with in an environmentally safe way. The government also said that terminal storage that was safe in the long term might require a deep bedrock repository. According to the government, the fundamental criteria governing the long-term reliability and other safety aspects of the repository should be the same as for radioactive waste, for example.

The Swedish EPA presented its proposals in a report in December 1997 (*Slutförvar av kvicksilver* ("Final Storage of Mercury"), main report 4752).

In its report the agency emphasised that mercury differs from other metals in that it is particularly toxic and also volatile. Because mercury is an element, it is not broken down and retains its toxicity for ever. A high-quality repository with a very long life-span would therefore be required. This would in turn require that the repository could withstand unforeseen events, such as breached barriers or inadvertent intrusion by future generations.

The agency worked on the assumption that emissions from the repository were not to exceed 0.5 – 10 grams mercury a year. The agency decided this figure on the hypothesis that the entire annual emission would leak into a small oligotrophic lake. This hypothesis was selected because mercury's potential effects on human health largely arise via lake fish. Only when annual emissions of mercury reach 50 – 100 grams are methyl mercury concentrations in fish appreciably affected. As a precaution the agency then reduced this figure to 0.5 – 10 grams of mercury. Another requirement was that the concentration of mercury in groundwater at the repository should not exceed the standard for drinking water, which is one millionth of a gram per litre. Leaching of 0.5 – 10 grams mercury a year would be a minor emission. By way of comparison it was mentioned that this quantity was equivalent to the mercury contained in a medical thermometer. Assuming that a repository contained 1,000 tonnes of mercury, it would take between 100 million and one billion years for it to empty.

The agency then compared three types of repository: a secure surface facility, a repository in shallow bedrock and a deep bedrock repository. It calculated that 320,000 grams of mercury a year would leak from a surface repository of untreated mercury waste with no artificial barriers, 3,300 grams would leak from a shallow bedrock facility each year and 1,000 grams a year would leak annually from a deep bedrock repository. If technical barriers were installed, emissions would fall to 260 grams a year from a surface facility, to 430 grams a year from a shallow rock repository, and to 140 grams a year from a deep bedrock facility.

Finally, if the waste were also to be stabilised, emission levels from all types of repository would be reduced by a factor of 100. One conclusion was thus that the stated emission limit could only be achieved if the waste was stabilised. Another was that the limit could in fact be achieved using any of the alternatives in combination with artificial barriers and stabilisation. However, the Swedish EPA also stresses in its report that emissions from a surface facility are solely prevented by artificial barriers, whereas the bedrock would protect the waste and provide a natural buffer against emissions from a repository deep underground. Since artificial barriers would risk being eroded by wind and water or undermined during the long life of the repository, the agency recommended a deep bedrock facility. It also stated that a facility in shallow bedrock would have serious weaknesses as compared with a deep bedrock repository, one reason being that there are more cracks near the surface. The agency therefore found a deep bedrock repository to be the best option. However, the agency did say that a facility of this kind was a highly ambitious solution. It might therefore not be necessary to store all mercury waste deep underground; some could be kept in storage at the surface.

The Swedish EPA also made a survey of existing mercury waste and an estimate of how much additional waste could be anticipated by the year 2010. It found that mercury waste was generated by a limited number of sources. Sizeable quantities are mainly produced in the chloral kali industry and at the Boliden Mineral AB smelters. Collected products represent an additional source. These are currently being stored at SAKAB. Finally, there are large quantities of mining waste.

The agency then decided that, on environmental grounds, it was reasonable to store waste containing at least one per cent mercury in a deep bedrock repository. This would include waste from the chloral kali industry, Boliden Mineral AB and SAKAB, but not low-level mining waste. An annual total of some 1,000 tonnes of mercury would go to storage deep underground.

The purpose of the Swedish EPA study was not to propose a specific location for a terminal repository. However, it did identify the following seven factors as being of relevance when choosing a site.

- Rock type with low permeability
- Absence of extensive fault areas
- Chemically stable environment
- Rock in a mechanically stable area
- Minimisation of risk of inadvertent intrusion
- Choice of site involving the maximum possible distance to the surface
- Choice of site with receiving body of water offering dilution potential

The agency also thought it feasible to consider locating a deep bedrock repository next to a mine.

In the agency's opinion, a further condition for a deep bedrock facility was that it should be economically feasible. The agency estimated the cost of deep underground storage to be SEK 240 – 650 per kg mercury, which would entail a cost of SEK 240 – 650 million for 1,000 tonnes. The agency considered this cost to be reasonable.

The agency then concluded that the government should decide that mercury waste should go to long-term storage in a deep bedrock repository and then initiate negotiations with the waste owners concerned to ascertain the feasibility of establishing a facility of this kind in Sweden.

1.2.2 Outcome of the consultative process

The Swedish EPA report was referred to various bodies; statements of opinion were received from 54 of them. With the odd exception, they supported the idea of a final storage facility for waste containing mercury in bedrock deep underground. However, a view expressed in many quarters was that the background material on which decisions were to be based should be improved in some respects. The importance of developing an effective model for financing the facility was emphasised, for example. It was also necessary to clarify long-term responsibility for the facility.

The Swedish Geological Survey (SGU) said that one shortcoming in the study was that the possibility of a shallow bedrock repository had not been examined in detail. SGU also said that it was inappropriate to use disused mines as a repository for mercury waste because this would make future mineral abstraction more difficult. Svensk kärnbränslehantering AB (SKB) stressed that although it understood that a deep repository in a disused mine might have economic advantages, the following drawbacks could be identified.

- Increased risk of inadvertent human intrusion in potentially ore-rich areas.
- Risk of adverse impact on groundwater movement and chemistry as a result of mining operations close to the repository.
- Even if the repository were filled in a proper way, there would be a risk of mineshafts and boreholes in the vicinity providing "short-circuit" routes for groundwater.
- The repository might prevent future use of a mining area, which would conflict with the Natural Resources Act.

However, on balance SKB considered that a repository in a mine was a better option than a surface storage site or a shallow bedrock storage facility. The Swedish Radiation Protection Institute (SSI) also questioned the use of an existing mine, but said that it understood that this would be a cost-effective solution. The Swedish Nuclear Power Inspectorate (SKI) pointed out that the growing risk of human intrusion and the fact that mining of any remaining ore would be made more difficult were powerful arguments against storing nuclear waste in a disused mine. However, the inspectorate also said that these arguments carried less weight in relation to mercury waste, since mercury occurs naturally in ore.

2 Purpose and organisation of the commission

2.1 Terms of reference

Under its terms of reference, the commission's task is to **coordinate and examine** the progress made towards long-term storage of waste containing mercury in a deep bedrock repository. The report should contain proposals for an effective system in which the owners of the waste assume responsibility for its final disposal.

One task is to supplement the Swedish EPA report so as to create a better documentary basis for a decision by the government. The commission should also initiate and conduct negotiations with the waste owners and others concerned in order to establish a deep bedrock repository, primarily in Sweden and secondarily as part of a joint Nordic project. These negotiations should clarify specific issues concerning organisation, timetable, finances, responsibility and environmental aspects of a storage facility deep underground.

The commission's next task is to arrive at a solution that is satisfactory in organisational, environmental, financial and legal terms. A party having overall responsibility or organised joint operation between various stakeholders should be proposed. Long-term responsibility for the repository must be assured, as must its financing. The report must also specify which mercury waste is to be stored deep underground and propose a suitable timetable.

2.2 Organisation of the commission

The commission began its work in February 2000. To start with, the commission met representatives of public authorities and the following waste owners: Boliden Mineral AB, Eka Chemicals AB, Hydro Polymers AB and SAKAB. The purpose was to identify waste containing mercury and to gain an overall picture of the problem. In the autumn of 2000 the commission engaged Kemakta Konsult B to prepare a report on what treatment of mercury waste would be necessary prior to storage deep underground. The resulting report was entitled "Survey and evaluation of technologies for conditioning mercury prior to final storage". In December 2000 the commission presented its view of the management of mercury waste in a memorandum entitled "Problem analysis and action plan for further work – a basis for discussion". The idea was that the memorandum should form a basis for discussions with the waste owners concerned. The commission had further meetings with the waste owners in spring 2001. The commission also met the technical experts Bert Allard, Ivars Neretnieks and Stig Wingefors four times while preparing this report and the other experts on nine occasions.

2.3 Arrangement of the report

The remainder of the report has been arranged as follows. Chapter 3 describes our survey of existing and future mercury waste in Sweden. The information has been obtained from the waste owners and the Swedish Environmental Protection Agency. Chapter 4 examines the international dimension and describes management of mercury waste from a European and Nordic perspective. The technical and environmental factors having a bearing on a deep bedrock repository are set out in Chapter 5. The commission has studied potential final storage methods for mercury and pre-treatment that is necessary and feasible. Its survey is based on the above-mentioned consultants' report produced by Kemakta Konsult AB. In addition, the commission considers it important when seeking to identify a suitable form of cooperation between the waste owners to learn from the experience of joint operation between owners of nuclear waste. Accordingly, for the purposes of comparison, Chapter 6 presents solutions achieved in the nuclear waste field. The law governing establishment of a deep bedrock facility is analysed in summary form in Chapter 7. The entire analysis is set forth in Appendix 2. Chapter 8 sets out the considerations weighed by the commission and Chapter 9 contains the commission's proposals. Finally, the socio-economic cost of the proposed measures, as well as the cost to the Swedish state and companies involved, is presented in Chapter 10.

3 Survey of existing and future mercury waste

3.1 Owners and quantities (stored and accumulating in different timeframes)

The mercury waste that the Swedish Environmental Protection Agency has primarily targeted for deep storage has a mercury content exceeding one per cent. This is largely waste from Boliden Mineral AB, Eka Chemicals AB, Hydro Polymers AB and SAKAB. Waste of this category can also be produced from the "hidden store in society" and from current permitted use of mercury. There is also waste containing lower concentrations of mercury.

Boliden Mineral AB is currently storing about 5,000 tonnes of waste with a mercury content over one per cent, which represents about 280 tonnes of mercury. The waste is in intermediate storage. A further 400 tonnes of waste is generated each year, containing just over 20 tonnes of mercury.

Eka Chemicals AB and Hydro Polymers AB have a limited proportion of mercury waste. However, as mentioned earlier, there is a draft ordinance, which provides that mercury may not be used in the chloral kali industry after 2009. This will mean that Eka Chemicals AB and Hydro Polymers AB will have surplus mercury by 2010. The commission considers that this will constitute waste (see section 7.3). The quantities involved are about 200 tonnes for each company.

SAKAB's store of mercury waste is currently 2,660 tonnes. In many cases the quantity of mercury in the waste is not known, although SAKAB estimates that its store represents 60 tonnes of mercury. In addition, SAKAB stores 1,800 tonnes of batteries, containing some 30 tonnes of mercury (see also section 3.1.1). However, some of these batteries only contain 0.3 per cent mercury. It has been argued that it is not possible to separate out these low-mercury batteries, since they are all stored together. An additional 50 – 100 tonnes of mercury waste arrives each year. The amount of mercury in the additional waste cannot be specified; a rough estimate must be made based on a comparison with the waste already stored. SAKAB's estimate of 60 tonnes of stored mercury suggests an average concentration of just over two per cent. Assuming that the new waste contains about the same average concentration of mercury, it may be roughly estimated that the new waste will represent an additional input of just over one tonne of mercury a year.

The Swedish Environmental Protection Agency has estimated that there is a large hidden store of goods and products in society containing mercury. Examples include thermometers, instruments and electrical appliances. These products are being phased out, in that their manufacture or use has been banned. The agency has estimated that the hidden store of about 200 tonnes represents 100 tonnes of mercury. Some of this is being gradually delivered to SAKAB and other waste management companies.

Approximately two tonnes of mercury a year are used for other permitted applications, mainly in dental fillings, various types of lighting (fluorescent tubes and various kinds of low-energy lighting), as well as in certain instruments and analytical processes, where it has not yet been possible to replace mercury because, for example, international standards prescribe the use of mercury or mercury compounds. A maximum of about one tonne of these two tonnes is recovered. The remainder should be included in collections of hazardous waste and should therefore ultimately go for intermediate storage at SAKAB and other waste management companies. However, it is possible that some is still discarded with normal household refuse and industrial waste.

There is also the mercury waste that contains less than one per cent mercury. In addition to the quantities mentioned above, Boliden AB owns 51,000 tonnes of waste, representing about 300 tonnes of mercury. Some 250 tonnes of this is present in 29,000 tonnes of waste having a mercury content of 0.5 – 1.0 per cent, and about 60 tonnes in 22,000 tonnes of waste having a mercury content of 0.1 – 0.5 per cent. Boliden AB also has very low-level waste and, according to the Swedish Environmental Protection Agency's survey[3], mercury waste from the mining industry, the iron and steel industry and ferro-alloy works, the pulp and paper industry and also certain waste storage facilities. The concentration of mercury in this waste is very low. The 500 tonnes of waste from the mining industry has a mercury content of 0.0001 per cent, which represents 475 tonnes. It is not possible to estimate by how much this figure may have risen by 2010. The iron and steel industry and ferro-alloy works have waste containing an estimated 0.0004 per cent mercury, which will represent some eight tonnes of mercury by 2010. Waste from the pulp and paper industry has a mercury content of 0.0007 per cent, representing a mercury total of seven tonnes. Waste representing approximately 13 tonnes of mercury is also stored at facilities at Skutskär, Korsnäs, Strömsbruk, Skoghall and Östrand. Finally, SAKAB owns very small quantities of low-level mercury waste, which it is permitted to store.

In total, by 2010 there will be about 15,000 tonnes of mercury waste containing more than one per cent mercury. This represents 1,100 tonnes of pure mercury. The waste in question comes from the chloral kali industry, SAKAB and parts of Boliden Mineral AB, as well as the "hidden store in society" and permitted uses. There will be a further 51,000 tonnes of waste containing between 0.1 and 1 per cent mercury, equivalent to about 300 tonnes of mercury. This is Boliden Mineral AB's remaining waste. Finally, there will be 500 million tonnes of other mercury waste with a mercury content below 0.1 per cent, representing 500 tonnes of mercury. Most of this will be mining waste. Hence, there will be a total of around 1,900 tonnes of mercury.

Accepting the Swedish Environmental Protection Agency's view that the first priority is for mercury waste containing more than one per cent mercury to be stored deep underground by 2010 (see more on this in section 8.3.3, however), the chart below serves to illustrate quantities in a deep bedrock repository by that year. After 2010 Boliden AB might continue to add a further 20 tonnes of mercury to the repository each year. There would be very little additional mercury waste from other sources, since it is to be hoped that collection campaigns will have retrieved as much of the "hidden store" in society as is feasible by then. The remaining permitted use of mercury will take place in closed systems.

---

[3] *Kvicksilverhaltigt avfall i Sverige – inventering, karakterisering och prioritering* ("Mercury waste in Sweden – survey, characterisation and priorities") Report 4768.

3.1.1 Batteries

General

Batteries have been collected in Sweden since the mid-1970s. The original focus was on mercury batteries. However, the Batteries Ordinance (1997:645) imposed an obligation to recover all batteries. The reason for widening the scope of collection was that it can be difficult for consumers to distinguish environmentally hazardous batteries from environmentally friendly ones. The ordinance classifies batteries containing more than 0.0005 per cent mercury by weight, 0.025 per cent cadmium by weight or 0.4 per cent lead by weight as hazardous. Other batteries must be environmentally compatible. 90 per cent of the batteries sold nowadays are environmentally compatible; 10 per cent are environmentally hazardous.

Municipalities are responsible for organising collection systems. Environmentally hazardous batteries must be separated out and then transported for processing or final storage. Batteries containing mercury are transported to SAKAB, where they are placed in intermediate storage pending a long-term solution.

Funding

Disposal of environmentally hazardous batteries is paid for by the manufacturer or importer. These companies are obliged to pay a charge to the Battery Fund, which is administered by the Swedish Environmental Protection Agency. The charge is intended to cover the cost of municipal sorting systems and final disposal of the batteries. According to the agency, the fund currently contains about SEK 50 million.

Trial processing of batteries

Batteries placed in intermediate storage at SAKAB are stored in drums. The Swedish Environmental Protection Agency has begun a study into more appropriate methods of intermediate storage of this waste pending final storage. One option might be to remove the mercury from the batteries and then convert it into mercury sulphide or selenide. That waste could then go to final storage. The agency has asked SAKAB to conduct a trial involving treatment of 36 drums of batteries. SAKAB has been able to perform this treatment since its new scrubber, which is now in operation, is able to treat batteries, mercury sulphide being the end-product. It is also possible to process batteries abroad. SAKAB will be reporting the outcome of the trials in summer 2001. The Swedish Environmental Protection Agency will then make an evaluation.

3.2 The chemical form of mercury waste

Waste stored by Boliden Mineral AB's comprises kiln particulates, gas treatment sludge, activated carbon, selenium filter cake and V-selenium sludge. The exact chemical composition and form of this waste is not known, but, in addition to mercury, some of it contains copper, arsenic, zinc, lead and cadmium. The annual waste increment comprises particulates and sludge. The exact chemical composition and form of this waste is unknown.

The waste produced by Hydro Polymers AB and Eka Chemicals AB is metallic mercury.

SAKAB's stored waste includes sludge, soils, instruments and batteries. Its exact chemical composition is largely unknown. Besides mercury, the batteries may also contain lead and cadmium. It is not possible to say what future additional waste will consist of, let alone what its exact chemical composition will be.

4 International perspective

4.1 EU

Within the European Union the main problem will be future mercury waste from the chloral kali industry. A joint European project on development of a common strategy is currently in progress. Discussions on environmental standards for mercury are being conducted under the OSPAR Convention (the Convention for the Protection of the Marine Environment of the North-East Atlantic)[4]. In 1990 the OSPAR parties adopted a recommendation that mercury use in the chloral kali industry should cease by 2010. The fate of the surplus 12,000 tonnes of mercury resulting from the discontinuation of its use in the chloral kali industry in Europe is currently under discussion. The industry's European association, EuroChlor, has participated in these discussions and has produced the following negotiation proposal.

If the European chloral kali industry is allowed to use mercury in its processes until 2020 – 2025 at the latest, EuroChlor will in return guarantee that total emissions during this period will not contain more mercury than total emissions produced following a compulsory phase-out by 2010. EuroChlor's explanation of this is that the chloral kali industry would be able to finance investments to limit emissions if it were allowed to take account of commercial considerations when phasing out mercury use. The extended time limit would also allow use of about 500 tonnes a year of the 12,000 tonnes of surplus mercury resulting from phase-out. This would eliminate the surplus mercury from the industry by 2025. At present the entire chloral kali industry purchases about 150 tonnes of mercury a year. Chloral kali manufacturers would in future undertake to purchase mercury first from facilities where mercury use had been discontinued. EuroChlor has also reached a preliminary agreement with a Spanish state-owned company mining silver at Almadén. At present the company sells 1,000 tonnes of mercury a year and controls some 70 – 80 per cent of the world market. It has now agreed to take surplus mercury from the chloral kali industry and reduce its own mining production correspondingly.

EuroChlor's negotiation proposal has been accepted by all chloral kali manufacturers in Europe. OSPAR will not make a formal recommendation on how to deal with mercury until 2002. But the recommendation that mercury use in the chloral kali industry should cease by 2010 remains in place. In addition, the current Swedish ban on exporting mercury would prevent the sale of mercury by the Swedish chloral kali industry to chloral kali manufacturers in other countries or its delivery to the Spanish mining company. Sweden also opposes the proposal and has pointed out in the negotiations that EuroChlor's solution would favour the chloral kali industry at the expense of the countries involved. Many states spend a great deal of taxpayers' money on collecting mercury waste. EuroChlor's proposal would mean that the chloral kali industry could get rid of waste without making any payment. The mercury would then be distributed on the global market. Environmental considerations would then dictate that it be collected once again. Responsibility for this would rest with individual states, which would have to pay using public funds. Sweden has also pointed out that the chloral kali industry's waste would legally constitute waste following phase-out. Hence, transferring the waste from a European country to Spain would require a licence under Regulation 259/93 on the supervision and control of waste within, into and out of the EU (see section 1.4.2 in Appendix 2). The necessary licence would probably not be granted, since the arrangement would not constitute disposal in an environmentally acceptable manner.

[4] The OSPAR Convention has been signed by Belgium, Denmark, Finland, France, Ireland, Iceland, Luxembourg, the Netherlands, Norway, Portugal, Spain, the United Kingdom, Switzerland, Sweden and Germany, and also by the EU Commission.

4.2 The Nordic region

Most mercury waste in **Finland** comprises household refuse and waste from the mining and metal refining industries. There is also one chloral kali plant that uses mercury. It is not intended that this plant should operate beyond 2010. Some of the waste is stabilised and placed in a surface storage facility. The rest is exported for processing and recycling. Finland also exports mercury extracted from process waste.

Most mercury waste in **Denmark** consists of household refuse, since the country has no mining or metal refining industry. Moreover, the last chloral kali plant closed down in 1997. Apart from batteries, all waste is exported for recycling or landfill in German salt mines. Battery waste is stored at a special surface facility in Denmark.

Iceland's mercury waste also large comprises household refuse, all of which is exported to Denmark.

Norwegian mercury waste derives from the mining industry, the metal refining industry and households. Industrial waste is stored at surface facilities at the plants in question and also in a disused quarry on an island in a fiord on the west coast. The waste if often encased in concrete. Household refuse is exported for processing and recycling or is stored pending treatment and landfill/terminal storage.

As may be seen from the above, the Nordic countries differ in the way they deal with waste containing mercury. True, one common feature is a desire to phase out mercury use and collect existing mercury. There is also a general wish to create an environmentally safe method of storage at a reasonable cost. However, only Sweden has introduced a ban on mercury export and said that mercury should not be recycled. Sweden is also alone in opting for storage of mercury waste in a deep bedrock repository.

A project has been in progress under the auspices of the Nordic Council of Ministers since 1996, its purpose being to examine the possibility of finding a common Nordic system for dealing with mercury waste. The project is being conducted by a special working group. The reasons given for a joint solution are that all the Nordic countries have mercury waste and that joint treatment and storage might be more economical. Moreover, a pan-Nordic solution would carry more weight in relation to the rest of Europe. However, the present view expressed by the working group is that a joint Nordic deep repository is not possible. This is largely because none of the countries is prepared to store mercury waste from the other countries. Furthermore, varying geological conditions render it impossible to create a deep bedrock repository in all the Nordic countries. The working group also considers that the decision already taken by Sweden to ban the export of mercury has made cooperation more difficult, since it constitutes a formal obstacle to deep storage of Swedish waste in another Nordic country. However, the group does feel that there may be scope in future for a joint waste treatment system. The project will therefore continue on this basis.

4.3 Germany/the United Kingdom

The use of mercury in Germany has diminished since the 1970s. Mercury is recovered from a large proportion of mercury waste. The rest is landfilled in disused mines. The idea is to achieve long-term isolation of the hazardous waste from the biosphere. The mines have not been sealed, however. If necessary, it will therefore be possible to recover the waste.

In the United Kingdom mercury is recovered from light bulbs, thermometers and similar products. Most of the waste is landfilled, however. Much of it is generated by the chloral kali industry. It is stored in specially designed repositories whose purpose is to isolate the mercury waste. However, these are not sealed or monitored either.

4.4 The USA

Mercury used to be recycled in the US to a very large extent. However, in recent years the US has changed its mercury policy. The emphasis is now on finding alternative treatment techniques to permanently stabilise mercury waste for terminal storage. This will probably take the form of surface facilities. The reason for the shift in emphasis is a tendency for the demand for recycled mercury to be greater than the supply, and that recycling processes cause emissions of mercury to air.

5 Technical and environmental aspects of a deep bedrock repository

5.1 Objectives for protection of health and environment

The main objectives for protecting health and the environment on which we have based our deliberations are as follows.

- Any leaching of mercury from a repository to a well should produce a mercury concentration in drinking water of less than one millionth of a gram per litre (1ug/l) according to National Food Administration drinking water criteria.
- According to the Swedish EPA, any leaching of mercury from a repository to a watercourse should be less than 0.5 – 10 g/year so as to protect oligotrophic lakes. Strict limits will also apply to any leaching to the sea from a coastal facility.
- The onus of maintaining the level of protection must not be placed on future generations. As far as possible, the aim is to achieve a maintenance-free repository, which isolates mercury from the biosphere for an extremely long time (more than 1,000 years).

It may be concluded from even very general safety analyses of a "model repository" with a capacity of 1,000 m^3 (see diagrams below) that it will not be possible to meet the above targets for protection of human health and the environment unless high-level mercury waste is stored in a deep bedrock repository. One crucial consideration is that the onus of maintaining the level of protection must not be placed on future generations.

The chemical and hydrological conditions that final storage in a deep bedrock repository offers give greater scope for technical and economic optimisation of treatment technology for the waste and detailed design of the repository, as compared with a surface facility. This is discussed in the next section. See the background reports to the Swedish EPA report published in1997 for more detailed descriptions and analyses of various repository options.

It should be noted that greater repository volume also means that a greater total quantity of water flows through the repository and can dissolve out mercury. The total outflow of water containing mercury thus also increases correspondingly. This may reduce dilution to the well, which will impact the drinking water criteria.

5.2 Waste forms suitable for final storage

Following discussions with the commission's technical-scientific expert group, the following assessments have been made.

First of all, mercury waste with a "pure", ie, simple and well-defined, chemical composition (metallic Hg, sulphide or selenide) should not be mixed with waste having a variable and to some extent unclassifiable chemical composition (eg, mixed process waste). This is because it would then be unnecessarily difficult to determine and check the chemical environment in a shared bedrock cavity. This does not rule out deep storage of properly stabilised process waste of this kind in a separate rock cavity at a suitable safe distance from the cavity containing "pure" mercury waste. The safe distance will prevent the mixed waste chemically affecting the environment in the "cleaner" repository. The systems used for the waste with the highest mercury concentrations should generally be as "clean" as possible. For example, encasing waste in concrete may result in unnecessary doubt about the long-term chemical environment in a final storage facility.

Secondly, there is much to suggest that mercury sulphide is the most suitable form for final storage, since its characteristics are well known and it should be possible to maintain a repository environment that ensures that Hg remains bound in the form of highly insoluble mercury sulphide. The water in deep bedrock contains no oxygen and often naturally contains a certain amount of sulphide. However, the parameters (ie, combinations of various chemical characteristics of the deep repository environment) for minimum solubility are fairly narrow. The sulphide chemistry of mercury is well known. Selenide is another option, although selenium is more expensive than sulphur and less readily available. Nor is it possible to achieve the advantages that would appear to accompany a naturally stabilised sulphide environment in a deep repository.

It should also be noted that converting metallic mercury into sulphide or selenide on an industrial scale may be a fairly complicated process, which may give rise to occupational health and safety problems and difficulties in limiting process emissions and process waste. If it is possible to find a rock cavity with reasonably low water throughflow and add a clay barrier, then mercury leaching limited in terms of flow rate and solubility would be well under the targets for maximum load on the environment (0.5 – 10 g Hg/year), even with waste in the form of metallic mercury. Storing mercury as sulphide or selenide in the reducing environment in a deep bedrock repository would further reduce emissions by a factor of at least 5[5]. It should also be noted that it is not possible to store liquid waste, since the EC landfill directive provides that member states must take steps to ensure that liquid waste is not received by a landfill site. See section 1.4.2 of Appendix 2 for further information about the directive. The Swedish EPA also considers that final storage of mercury in liquid, metallic form is quite unsuitable from an environmental viewpoint.

Thus, it may be of interest to examine options other than conversion of metallic mercury into sulphide or selenide if this would provide greater scope for an optimal system (technical, economic and environmental). In the first place, amalgams with metals may be suitable to study as candidates for final storage. For instance, there is a naturally occurring copper-mercury amalgam comprising 27 per cent copper and 73 per cent mercury. There is no information available to use here to determine the extent to which amalgamation can reduce mercury leaching. Whatever the case, the solubility of metallic mercury sets an upper limit. Another possibility might be to create a chemical environment in the repository, which, in time, would convert mercury in amalgam form into mercury sulphide. This could be achieved

[5] Swedish EPA Report 4771 (1977), page 44.

by mixing mercury with compounds containing sulphide and otherwise creating suitable water chemistry.

Finally, we would like to reiterate that leaching of mercury from a final repository is ultimately limited by solubility. This naturally suggests that waste forms that are as insoluble as possible under the relevant conditions should be chosen. But it also suggests that the repository should be made as compact as possible so as to geographically limit the quantity of water capable of dissolving the mercury in whatever form is decided.

5.3 Treatment and processing mercury waste

The suitable waste characteristics required by the repository will determine the requirements governing treatment and processing of various types of waste. In the last section we outlined the main types of waste that are suitable for storage in bedrock deep underground. One conclusion is that ways should be sought to process mixed waste, such as batteries, to extract the mercury and convert it into a suitable form for final storage. With the support of the commission's technical-scientific expert group, we recommend metallic mercury or mercury sulphide as suitable end-products from the processing of mixed waste. Mercury sulphide is a chemical form suitable for final storage, and methods of converting large quantities of metallic mercury for final storage will have to be developed in any case.

For certain types of waste, eg, process waste from the metallurgical industry, assessments of reasonableness under the Environmental Code may mean that other treatment forms may need to be considered. These include stabilisation of the waste by admixture of suitable substances rendering mercury and other toxic substances virtually insoluble under the conditions prevailing in a deep bedrock repository. However, the long-term effect on the environment in a deep bedrock repository of a given additive must be examined and tested before it is used.

It is not the commission's task to provide detailed descriptions of treatment methods for various types of mercury waste. The waste owners have the responsibility of choosing and, where necessary, developing suitable treatment methods on an industrial scale. However, we should be able to indicate some theoretically possible and environmentally acceptable forms of waste for final storage with accompanying treatment methods, particularly for metallic mercury. For this purpose we engaged consultants to review industrially available treatment and processing methods and those reasonably capable of development, as a complement to previous studies made by the Swedish Environmental Protection Agency. Some of the most important conclusions from the consultants' report[6] are as follows.

Techniques exist for converting elementary mercury into a suitable form for final storages (stabilisation). These techniques have been shown to work well on a small scale, but there is little experience of their full-scale use in Sweden. Mercury in divalent form can be stabilised by adding sulphur compounds.

The potential techniques are:

- Addition of elementary sulphur. According to the consultants' report, this is a feasible method, provided that the reaction is carefully controlled, both in terms of heat production and to avoid an excess of sulphur in the end-product.
- Stabilisation using pyrites. Laboratory trials have yielded good results, but there is no experience of full-scale use of this method. Reaction times of several months will probably be needed.

[6] Kemakta Konsult AB: Report AR 2000-22, December 2000

- Stabilisation using "sulphur cement" (SPC). This is a method currently being studied in the US. The mercury is converted into sulphide form and then encased in sulphur with certain polymerising additives. The method is considered promising and further studies are recommended in the consultants' report.
- Addition of elementary selenium. This method is used in several processes in Sweden, mainly for the treatment of fluorescent tubes.
- Amalgamation. There are no amalgamation techniques designed to stabilise mercury in waste on an industrial scale at present. The consultants' report describes the technique as simple to put into practice, although no information is available on which to base an assessment of the amalgam's leaching propensity. The solubility of metallic mercury constitutes an upper limit, however.
- Wet chemical treatment. Waste containing mercury in divalent form is treated using a wet chemical process involving various sulphur compounds used as additives. Industrial applications exist for COD waste (waste solutions from chemical analyses), for example.

Separation of mercury from mixed waste on an industrial scale by evaporation of the mercury at high temperature is a fairly common method. These methods are technically uncomplicated, but must be designed to avoid various potential problems, such as emissions of mercury vapour and condensation of mercury in undesirable places in the treatment equipment. There is some experience of wet chemical methods of treating mercury waste. However, it may be necessary to adapt the process to take account of any other toxic substances in the waste.

In addition, the consultants' report compares available treatment methods and treatment capacity at various companies with current waste quantities. There are several techniques available for processing and stabilising mixed waste containing elementary mercury and several companies in the EU and Sweden carry out processes of this kind. It is technically possible to convert elementary mercury into a form suitable for final storage, and this has also been done on a laboratory scale. There have been very few tests on a larger scale, however. Nor have the waste owners concerned, in discussions with the commission, been able to identify any fully developed and commercially available processes for converting metallic mercury into a form suitable for final storage. There are some examples in the Nordic region and elsewhere in the EU of wet chemical methods which might be feasible for simultaneous processing and stabilisation of waste containing elementary mercury, perhaps after modification of the process.

The report confirms that methods processing and stabilising waste containing divalent mercury do exist, but may need to be modified. However, it is doubtful whether there is the capacity in Sweden to treat the quantities of waste involved within a reasonable timeframe. The likelihood increases and the required capacity can probably be found if the whole Nordic region and other EU countries are included. No companies processing waste containing mercury sulphide or mercury selenide have been found. However, it may be possible for this waste to go to final storage in its existing form, although it would take up considerably less space if it were first concentrated.

The choice of processing method must pay particular heed to the handling of residual products. The degree of mercury separation must obviously be so high that the residue can be dealt with using simple conventional methods. As far as possible, an overall view of the various conceivable process stages and waste streams should be adopted.

Finally, mention may be made of a study sponsored by SAKAB, which is in progress at Örebro University as part of a doctoral thesis. The aim is to make a detailed study of the suitability of various mercury compounds and waste matrices for final storage so as to be able to choose suitable treatment methods for them. The thesis is expected to be presented in about three years.

6 Comparison with organisational solutions for management of nuclear waste

The high initial cost of establishing a deep bedrock repository and the limited volume of waste suggest that considerable cost savings could be achieved if the waste owners could work together. There are models for joint operation in this way in the field of nuclear waste.

The organisation and funding of nuclear waste disposal was examined as far back as the 1970s. This was followed by guidelines laid down by the government in the 1980s. A system was created based on cooperation between the state and the power industry, with a clear division of responsibilities. The main features of this system are described below.

6.1 Nuclear waste solutions as a potential model

Three fundamental principles were laid down for the model that was created.

1. Anyone conducting operations generating radioactive waste products is responsible for their safe disposal.
2. The state has overall responsibility for radioactive waste.
3. The cost of waste management is to be covered by income from the electricity generation that produces the waste.

6.1.1 Division of responsibility between the state/nuclear power industry

Responsibility of the nuclear power industry

Prime responsibility for waste products was to rest with the nuclear power companies. This was not only because of the general principle that anyone conducting industrial operations must deal with the problems they create; there were also practical reasons – the power companies did not have the technical expertise to deal with the waste.

The proposed cooperation was to be largely voluntary and a legislative framework for this was enacted. The Nuclear Activities Act (1984:3) provides that anyone possessing a permit to own or operate a nuclear reactor must, in consultation with other reactor owner/operators, prepare or arrange the preparation of a programme for the necessary comprehensive research and development and other measures. Thus, reactor owner/operators had not only a general responsibility for the waste, but also a statutory duty to conduct the research and development necessary to achieve the objective: safe terminal storage.

The nuclear power companies formed a jointly-owned limited company. Participation in the company was to be a permit condition for operating nuclear reactors. The companies involved would conclude a consortium agreement, which was also to be approved by the government. The primary task of the jointly-owned company would be to assume responsibility for research and development prior to construction of the necessary waste disposal facilities. The waste could be dealt with at the nuclear power companies themselves or by external service providers engaged by the joint company. Economic, cost-efficiency and safety factors all suggested that disposal and long-term storage should take place at a limited number of jointly-operated facilities.

Responsibility of the state

The state's responsibility was to consist of several elements. First and foremost, the state would have conventional overall responsibility for ensuring that there was effective legislation and an appropriate regulatory authority. This is mirrored by the laws and regulations now in place in this field, and also by the regulatory powers delegated by the state to the Swedish Nuclear Power Inspectorate (SKI) and the Swedish Radiation Protection Institute (SSI). These two agencies exercise their regulatory powers to ensure satisfactory protection of human health and the environment. The state's overall responsibility is enshrined in law now that Sweden has ratified the Convention on Safety in the Management of Spent Nuclear Fuel and Radioactive Wastes. The convention will enter into force in late June 2001.

However, the state's responsibility for nuclear waste would also involve additional elements. Thus, the state was also to have pro-active and monitoring responsibility for the fundamental work done by the nuclear power industry to develop suitable technologies and suitable designs for terminal storage. The state would also assure the funding of future outlay for nuclear waste management by setting up a special state-administered fund. A special authority was created to enable the state to meet these obligations. Its task was to monitor relevant research and development in the industry and administer the funding systems that were set up.

Finally, the government assumed that the state alone would be responsible for the repositories once they had been sealed. This responsibility has not been laid down by law, but is clearly expressed in the official explanatory notes on the legislation. The reason for this residual responsibility was that it was not considered reasonable that individual companies should remain responsible for the very long life-span of the repositories. However, there are no specific statutory provisions governing when and how responsibility is to pass to the state, only that any surplus money in the fund is to be repaid to the nuclear power companies.

6.1.2 Funding

Even before the organisational model was introduced the power companies were aware that they would be responsible for proper management of the waste. They therefore included these costs in their price calculations right from the outset and made provisions for them in their accounts. The companies successfully lobbied for a change in the Municipal Tax Act so that they could treat future expenses for disposal of spent nuclear fuels and the like as a tax-deductible cost. In its first year, the tax relief was SEK 0.008 per kilowatt hour generated using nuclear power.

However, the government was not entirely happy with this state of affairs. One problem was to make sure that funds would be available for the very long life-span of the repositories. Another was to ensure that fund did not decline in value. The overall solution arrived at by the government therefore included a funding system, given the weight of law in the Funding of Future Expenses for Nuclear Fuel Act. The main features of the system are as follows.

A state-administered fund was established. The money already allocated by the power companies for disposal of the waste was transferred to the fund. However, the cost of disposing of spent nuclear fuels and radioactive waste was ultimately to be borne by electricity consumers. The owner of each nuclear power plant would pay an annual fee to the fund. Essentially, these fees would be calculated so that money accumulated in the fund to meet all expenses incurred for disposal of spent nuclear fuels during the life-span of each reactor, and for dismantling the reactors. There is now a statutory provision stating that the fund is to have reached full size so as to cover all costs when a reactor has been in operation for 25 years. After that, money will be paid in to meet the costs incurred for each year's continued operation. The fees for each year are allocated to the corresponding energy production and are ultimately paid by electricity consumers. The companies could treat the fees as an allowable cost for income tax purposes. While the fund was in the process of establishment the fees were around SEK 0.02 per kWh.

The paid-in membership fees would then be paid to the company owned jointly by the power companies for its performance of contracted services, investments in disposal of spent nuclear fuels and the research work necessary for safe management of spent nuclear fuels and their radioactive waste. The money was also to cover the cost of future demolition of nuclear power plants. The payments made to the company were to be treated as government grants for tax purposes.

6.1.3 Joint system for operating waste from nuclear power plants

The relatively complicated legal and financial systems described above relate to disposal of spent nuclear fuels and dismantling of nuclear reactors. However, on the basis of their general responsibility for all nuclear waste, the power companies have also established a joint system for low and medium-grade operating waste from nuclear power plants. Much of this waste is filter cake. The nuclear power companies have established a common terminal storage facility for reactor waste in a rock cavity close to the Forsmark nuclear power plant. It has been in operation since 1998 and is financed mainly from the power companies' operating budgets.

6.1.4 Results

The model created in the early 1980s remains largely in place. A number of reviews have been made, but these have only resulted in minor changes. The company jointly owned by the four nuclear power companies is now called Svensk Kärnbränslehantering AB (SKB AB). The company manages the waste and owns the waste facilities currently in operation. The organisation can also be illustrated by the following chart.

6.2 Analysis – similarities/differences between nuclear waste and mercury waste

6.2.1 Similarities

One initial similarity is that, just as nuclear power companies are responsible for nuclear waste, so mercury waste owners are responsible for disposal of that waste. Here too, there are a limited number of owners of a considerable quantity of waste. This ought to make it easier to organise a common solution. Moreover, the waste owners are the very ones who possess the requisite technical expertise to deal with the waste.

Another obvious similarity is of course the idea of creating a final storage facility, which will have a very long life-span. As with nuclear waste, there are compelling economic, efficiency and safety arguments for confining waste management and storage to a few jointly-operated facilities.

6.2.2 Differences

One essential difference is the time factor. When the nuclear waste disposal organisation was established, it was estimated that not all radioactive residual products would be retrieved and placed in terminal storage until around 2060. One reason for this was that the heat produced by radioactive decay in the spent nuclear fuel needs to subside over several decades before it can be placed in a repository. We expect it to be possible to dispose of a very large proportion of mercury waste within just a few years, and that the remainder will go to final storage within a reasonable additional period. It thus seems that the actual period for treatment and transfer to a repository will be much shorter for mercury waste. This may have bearing on the following.

Funding period

When the funding plan for nuclear waste was laid down in the in early 1980s, it was expected that nuclear power would be produced until 2010. This gave 25 years to establish funds to cover the cost of dealing with the waste. What, then, is the position with regard to mercury waste? The chloral kali industry has no stored mercury and will be able to use mercury in its production processes until 2010. Here, it is therefore quite possible to make future allocations during the remaining years of production to finance disposal of the waste. However, the period will be shorter than that available for nuclear waste. SAKAB and Boliden Mineral AB both have stored waste on the other hand, and it will thus probably be more difficult to establish a funding system covering waste from these companies. But it should be noted that the companies have made financial provisions for future terminal storage. The companies differ in the level within their corporate structures (parent/subsidiary) at which these provisions have been made, however. Moreover, the provisions made are insufficient, since the companies have not assumed that deep storage will be required. It may also be noted that SAKAB has received payment for storing mercury waste.

Responsibility of the state

When the nuclear power model was created, a fundamental principle was that the state would not only have its customary overall responsibility for legislation and general regulatory control; it would also be pro-active in monitoring the progress towards creating the repository and have additional responsibility for the funding system. Finally, the state would also assume overall responsibility when the repositories had been sealed, since it was not considered reasonable for a company to be responsible over the very long life-span of the repository.

The overall responsibility of the state for mercury waste has also been established. There is legislation on environmentally hazardous activities and hazardous waste and there are regulatory authorities. This legislation might need to be supplemented to ease the creation of a deep bedrock repository, however (see section 9.2) But the form the state's responsibility will take once the repository has been sealed is less clear. As explained in section 8.5, we consider it reasonable for the community to take responsibility in the long term for a repository when the operators' responsibility has been extinguished. This is because it would scarcely be possible for a public authority to demand that an operator accept responsibility after many years if permit conditions had been complied with. Strictly speaking, it could therefore be argued that the state already has an implied future responsibility for a repository.

Another issue, however, is whether the state could also accept responsibility for pressing for the establishment of repositories and monitoring progress towards their creation as it did with nuclear waste. If so, the state must also ensure that it is able to exercise a control function. The most practical way of achieving this is to delegate this task to the regulatory authorities that are already responsible for monitoring management of hazardous waste or environmentally hazardous activities. Effective regulatory control would require the power to impose sanctions, however.

6.3 Conclusions

The above comparative analysis shows that, just as with the nuclear power industry, there are strong grounds for companies to work together on a system for mercury waste. One issue is then whether the system for nuclear waste described above could serve as a model.

As can be seen above, the nuclear power model comprises a funding system and joint operation by the power companies under a single corporate umbrella. The state also has far-reaching responsibilities. It may therefore be said that the model constitutes a well-developed and far-reaching form of cooperation.

In our view, the nuclear power model, with all its components, is not directly and fully suited to use for mercury waste. Thus, in the light of the circumstances discussed above, we do not think it reasonable to consider establishing a system of state-administered funds (aside from the fund for battery waste, which the state has already established). It is also doubtful whether the state should assume a pro-active role in relation to research and development. There is probably much less of a need to develop advanced technology for mercury waste management than there was for spent nuclear fuels. Hence, several decades should not be needed. It may arguably be questioned whether this justifies the creation of specific control functions and accompanying legislation. However, as discussed above, the need for an express or implied responsibility on the part of the state for the repository once it has been sealed will probably remain.

The most feasible model would instead be a system similar to that used for terminal storage of nuclear reactor waste.

For the reasons mentioned above, we base our suppositions on a simplified model for joint operation between companies of a system for treating and storing mercury waste. Hence, one basic assumption is that funding should be arranged separately by each company, instead of via state-administered funds. Separate funding of this kind is used for management of nuclear reactor waste. Using this model, the state's responsibility would also be more limited than it is for the management of spent nuclear fuels. We consider that a simplified model of this kind would represent a balanced system for joint operation of a repository for mercury waste.

7 Legal aspects of a deep bedrock repository – an outline

This chapter deals with the Swedish and European legislation that may have a bearing on the creation of a deep bedrock repository. The chapter represents an outline. The full legal analysis is set out in Appendix 2.

7.1 The permit application procedure

The construction of a deep bedrock repository for waste containing mercury will require a permit under the Environmentally Hazardous Activities and Health Protection Ordinance (1998:899). Since the annual quantity of incoming waste will be less than 1,000 tonnes a year, the permit application must be made to the county administrative board in the first instance. The decision may be appealed to the environmental court and thence to the superior environmental court. Leave to appeal is required for appeals to the superior environmental court.

The permit application may be a lengthy process. The first stage prior to application is a comprehensive consultative process accompanied by an environmental impact assessment. The operator is under a duty to consult the relevant authorities and the municipalities, as well as people and organisations expected to be affected. The consultative process must encompass the siting of the operations, their extent, design and environmental impact. The applicant must then prepare an environmental impact assessment, which accompanies the permit application. The applicant must be able to show that it will be using the best available technique that is reasonable.

This is followed by the application procedure proper. A decision by the county administrative board may be preceded by negotiations. A large number of actors, such as individuals who will be affected, certain environmental organisations, local unions, the Swedish Environmental Protection Agency, the Legal, Financial and Administrative Services Agency and municipalities whose general interests will be affected can appeal against the county administrative board's decision to the environmental court and the superior environmental court. Moreover, operations may be prohibited during the application process if it may be suspected that they will cause serious harm or inconvenience to human health or the environment and there are no special reasons for allowing them. If the county administrative board or the courts find reason for a prohibition, the matter will be referred to the government for a final decision.

However, the entire question of permissibility could be decided by the government if the operations in question may be considered to have sufficiently far-reaching implications. It may be assumed that this will apply in the case of a deep bedrock repository. If the government chooses this alternative, then, once the consultative process has been completed, it will be up to the county administrative board to prepare the matter and refer it to the government for a final decision. However, if the government decides permissibility, the municipality concerned will be able to block the siting of a repository within its boundaries by exercising its right of veto.

7.2 Legal responsibility

A natural basic premise is that every waste owner is responsible for its own waste. However, the next question is who would be legally liable for a repository under applicable legislation.

The issue is of particular interest because it may take an extremely long time before the mercury reaches the surface.

The operator is liable for its current operations. An operation, eg, a landfill site, is considered to be "current" even if waste is no longer landfilled there, as long as the site generates emissions. It is therefore reasonable to assume that an operator would be liable for a deep bedrock repository for a very long time. The fact that the repository was sealed would have no legal relevance to the question of formal legal liability.

The "operator" is the legal entity operating the repository. If the legal entity is a subsidiary, for example, only the subsidiary will be liable, not its parent company. If the operator transfers the operations, it will remain liable for any pollution it has caused.

As may be seen, liability for a deep bedrock repository may be far-reaching. However, it is important to analyse the practical implications of this liability. Liability can only be invoked if it is reasonable to do so. It follows from the environment bill that resulted in the Environmental Code that it is not possible to invoke liability if the operator has complied with the provisions of the code and the conditions of its permit. An operator will only be held liable if it has contravened the applicable regulations governing the repository. In the final analysis, it is therefore reasonable that the community should ultimately be obliged to take any necessary steps when the operator's liability is extinguished.

7.3 Legislative potential

Chapter 15, section 9 of the Environmental Code provides that the government or the agency delegated by the government may issue detailed regulations on waste management. Under chapter 15, section 3 of the code, "waste management" means an operation or measure consisting of collection, transport, recycling or disposal of waste. There is thus no doubt that the government could prescribe that any waste must be disposed of in a deep bedrock repository. Some of the mercury identified in the Swedish EPA report and the directives, such as the mercury in the possession of SAKAB, is obviously waste. However, it has been argued that it is possible that some of the mercury so identified is not to be considered waste. This applies particularly to mercury used in the chloral kali industry.

The definition of waste in EC law has been incorporated in the Environmental Code and is as follows:

"Waste means every object, material or substance included in a waste category and which the holder disposes of or intends to or is obliged to dispose of."

The ECJ has said that the concept of waste does not require that the owner has ruled out the idea of the substance or object being used economically by others.

Mercury waste is included in the waste category to which chapter 15, section 1 of the Environment Code refers. However, as may be seen from the provision quoted above, it only constitutes waste if the owner disposes of it or intends to dispose of it or is obliged to dispose of it.

When the use of mercury in the chloral kali industry is phased out, mercury will there constitute a residual product. Since the industry will not longer be able to use the mercury, it must be assumed that the companies involved will "intend to dispose of it". Hypothetically, the companies might consider the mercury to have a value and therefore wish to export it to other chloral kali producers in Europe. However, whatever approach they adopt, it can be argued on the strength of the ECJ's interpretation of the concept of waste that the mercury nonetheless constitutes waste. It should also be borne in mind that the ban on exporting mercury introduced by the Prohibition etc. in Certain Cases in Connection with Handling, Import and Export of Chemical Products Ordinance (1998:944) prevents companies from doing this. On the basis of the above assumptions, we therefore feel it is reasonable to assume that the mercury left over when its use in the chloral kali industry is phased out will constitute waste.

7.4 Could EC law constitute an obstacle to establishment of a deep bedrock repository in Sweden?

The statute potentially relevant in this context is Directive 99/31 on the landfill of waste, which entered into force on 16 July 1999. The purpose of the directive is to protect the environment from pollution from landfill sites. As mentioned in Chapter 5, the directive imposes an obligation on member states to take steps to ensure that liquid waste is not received at these sites. In addition, landfill sites are divided into three categories on the basis of the hazardous posed by the waste deposited there. An implementation committee is currently engaged in formulating criteria for the types of waste that can be landfilled under each class. Their work is set to finish on 16 July 2001. In the meantime, member states can set their own criteria. They are obliged to incorporate the directive in their national legislative systems, but can impose stricter requirements if they wish.

It follows from the above that there are, as yet, no obstacles preventing Sweden from storing mercury in a deep bedrock repository. However, the criteria in the directive that are currently in the process of formulation might constitute an obstacle. But the Swedish EPA, which is participating in the process, does not consider that the directive will pose an obstacle.

7.5 Could EC law oblige Sweden to accept and store mercury waste from other countries?

The relevant statute in this context is Regulation No. 259/93 on monitoring and control of waste movements within, to and from the European Communities. Regulations apply directly in Sweden in the same way as domestic law. The main rule is that the regulation gives member states an unequivocal right to oppose the import of waste. There is an exception for hazardous waste produced in a state in such small quantities that the establishment of new specialised facilities for disposal in that state would not appear to be economically viable. According to the regulation, the specific problem of disposal of such small quantities requires cooperation between the member states involved and the possibility of using a community procedure. The exception is specifically designed for countries such as Luxembourg. Waste containing mercury is hazardous waste and it would therefore appear that the exception might apply in this case. In terms of strict legal theory, there is therefore a slight risk that Sweden could be obliged to accept small quantities of mercury waste.

However, it is also important to note that waste export is not only a legal issue; it is very much a political one. According to information from the Swedish EPA, no exceptions are allowed in practice. The agency adds that political considerations will prevent any exceptions being allowed. EU member states are anxious to maintain good relations with each other and it would not be politically possible to force waste on another country. Realistically speaking, therefore, Sweden will not be obliged to accept foreign mercury waste.

7.6 Fiscal and competition law considerations

Companies are entitled to make provisions in their accounts for future waste management costs. The tax authorities will only accept these provisions if it is possible to calculate the cost and it is likely to be incurred. Costs arising only after a very long time has elapsed may be difficult to calculate and they may appear less likely. As a result, the tax authorities may not accept a provision made to cover them. The Municipal Tax Act was amended in 1979 on account of this problem. A special provision covering nuclear waste was inserted in the act. The appropriacy of a statutory amendment of this kind for mercury is discussed in Chapter 8.

As will be seen, we consider that the waste owners will need to work together to establish a deep bedrock repository. A joint project of this kind will raise competition law issues. The decisive factor will be whether the project is in restraint of competition. A future risk of restraint of competition will suffice. There are certain guidelines to follow when considering this issue, which is presented in section 1.8 in Appendix 2. Evaluation of the competition law position presupposes the existence of a definite agreement, however.

8 Factors we have considered and our conclusions

8.1 Premises forming the basis for our considerations

One general premise is that the use of mercury in Sweden should cease by 2010, subject to a few exceptions when special exemption has been granted to allow the use of very small quantities in closed cycles. The waste generated by former use must be dealt with and stored in a way that is safe in terms of the hazards posed to health and the environment by mercury and mercury compounds.

There will be about 15,000 tonnes of waste containing at least 1 per cent of mercury by the year 2010, which represents about 1,100 tonnes of pure mercury. There will be an additional 51,000 tonnes or so of waste containing 0.1 – 1 per cent mercury, which will give a further 300 tonnes of mercury. Finally, there will be about 500 million tonnes of waste containing less than 0.1 per cent mercury. Most of the waste containing more than 0.1 per cent currently in existence is owned by Boliden Mineral AB and SAKAB. When mercury use in the chloral kali industry is phased out, which the government intends should happen by 2010, additional mercury waste will come from Hydro Polymers AB and Eka Chemicals AB. This will represent about 400 tonnes of pure mercury. There will also be a "hidden store" of goods and products containing mercury in society. These will be gradually phased out and will be dealt with as the use of mercury is phased out. The Swedish EPA has estimated that the hidden store" represents about 100 tonnes of pure mercury. We assume that much of this will be delivered to SAKAB and other waste management companies over the next 10 – 20 years. Household waste of this kind will be collected via municipal collection centres for hazardous waste.

Accordingly, we have assumed that the repository issue should primarily be resolved jointly by the small number of enterprises that will own the vast majority of high-level mercury waste. Under our terms of reference, we must also hold discussions with the waste owners and others concerned to establish a deep bedrock repository, preferably in Sweden or, failing that, as part of a joint Nordic project.

In the first place, we should say that we do not think it will be possible to establish a deep bedrock repository as part of a joint Nordic project. As mentioned earlier, a future joint Nordic project could include waste treatment, but not storage. The main reason for this is that no Nordic country is prepared to store waste from other countries. It should also be noted that the current Swedish ban on exporting mercury would constitute a formal obstacle to deep underground storage of Swedish waste in another Nordic country.

The remaining option is to establish a deep bedrock repository for final storage of mercury waste in Sweden and this will therefore form the basis of our further consideration.

8.2 Technical and environmental factors

In its report, the Swedish EPA found that emissions from a repository should not exceed 0.5 – 10 grams of mercury a year to watercourses to ensure protection of an oligotrophic lake. According to the agency, this target could be achieved using either a surface repository, a shallow bedrock repository or a deep bedrock repository, provided the waste was stabilised and technical barriers were used. However, the agency recommended a deep bedrock repository, since this solution would not pose any appreciable risk to the surroundings, even in the very long term.

The Swedish EPA's proposal has already been accepted by the government, which has instructed the commission to achieve the establishment of a deep bedrock repository. We would like to add the following concerning the choice of the deep bedrock repository alternative. As the Swedish EPA has pointed out, mercury differs from many other types of hazardous waste owing to its particularly toxic nature. Moreover, being an element, it is not broken down. These are grounds for a repository that isolates the mercury from the biosphere for a very long time (preferably more than 1,000 years). In addition to the above-mentioned Swedish EPA environmental protection targets, the National Food Administration drinking water criterion must be met. Any leaching of mercury from a repository must produce concentrations in well water of less than one millionth of a gram per litre. This too must be achieved over a very long time perspective.

Finally, a further premise is that the adverse environmental impact caused by one generation should not burden future generations. We are therefore of the view that it would not be appropriate to shift the burden of a far-reaching responsibility for regulatory control and maintenance onto the shoulders of future generations. The inference is thus that a repository should be maintenance-free. Hence, only a deep bedrock repository meets the requirements for storage of mercury waste. Furthermore, we are of the opinion that a deep bedrock repository will provide greater scope for technical and financial optimisation of waste treatment and the detailed design of the repository.

8.2.1 Treatment and processing of mercury waste

As explained in Chapter 3, waste containing more than 0.1 per cent mercury existing in 2010 will be in various chemical forms. Waste from the chloral kali industry is metallic mercury and makes up just under one third of the mercury . Boliden Mineral AB's mercury accounts for just over half and is present in large quantities of waste, which, apart from mercury, also contains copper, arsenic, zinc, lead and cadmium. The remaining mercury (mainly in the possession of SAKAB) is also present in large quantities of waste. As mentioned above, before mercury waste is sent for deep storage, it will generally be necessary to extract it from the waste and convert it into a suitable form for storage. However, it may be more appropriate to endeavour to stabilise some of Boliden Mineral AB's waste in its entirety, as it contains other hazardous substances apart from mercury. Pure mercury from the chloral kali industry would also need to be converted into another form, since (a) it would be contrary to the EC landfill directive to landfill liquid waste; and (b) it is doubtful whether it would be possible to achieve the stated emission targets in that case. It appears likely that mercury should ideally be stored in the form of mercury sulphide or mercury selenide. It would also be possible to amalgamate the metallic mercury.

It is not our task to say precisely how the waste should best be processed or treated. This is a matter for the waste owners. But it should be stated that technology capable of development is available, even though no methods treating and processing metallic mercury in large quantities have yet been developed on an industrial scale. SAKAB has begun trial operations for treatment and processing of batteries, although the process is expensive. It will be up to the waste owners to develop these methods and it will fall to the relevant permit-granting authorities to influence the process by approving or rejecting the methods chosen. The authorities base their actions on the "best available technique" provision in the Environmental Code.

8.2.2 Principles governing choice of site

The choice of site is governed by a number of factors, such as suitable geological conditions, financial considerations and the prospects of gaining local consent for the site. The waste owners have the sole responsibility for choosing the site for a deep bedrock repository and for applying for a permit for the siting, construction and operation of the repository in accordance with the legal procedures described in Chapter 7. This means that the choice of method and site of the repository must be justified and defended by the waste owners in an environmental impact assessment involving comprehensive consultations. However, we would like to mention some principles governing the choice of site.

First of all, we consider that the repository should be sited in a bedrock zone with little throughflow of water and suitable water chemistry. This will favour mercury compounds with low solubility. Low water throughflow is typical of fairly dense rock types, located between the major fault zones always found in bedrock, where the water table gradient is low, ie, there is little power driving the flow of groundwater. The repository should also be located at a depth (at least 400 metres or so) sufficient to ensure that the geological and hydrological conditions will be stable for a very long time. The extensive geological surveys carried out by SKB[7] show that it ought to be reasonably easy to find bedrock zones in many places throughout Sweden that meet these requirements (including a water flow of less than about 10 litres/m^2 a year. This applies particularly bearing in mind the relatively limited volumes of mercury waste to be stored.

Secondly, we consider the best approach to be to examine the possibility of using an existing shaft to reach a suitable depth for the repository. this would help to keep the cost of a mercury repository at a reasonable level. For instance, the repository could be located in a suitable granite mass close to an existing or disused mine. If so, one requirement will be that the repository is properly sealed off from old mine passages and shafts to prevent them acting as direct conduit for mercury into the biosphere.

One objection raised by those to whom the Swedish EPA's main report was referred for opinions is that locating a final storage facility close to a mine would not be ideal in view of the likelihood of future intrusion. However, we do not consider that these objections carry much weight. For example, a survey borehole inadvertently breaching the repository would pose no particular occupational health and safety problems, unlike the breach of a terminal repository for spent nuclear fuels. Moreover, it is not reasonable to demand a level of safety to protect against deliberate intrusions by future generations. Each generation must accept responsibility for its decisions. The onus of responsibility is borne by each generation, which is not the same as saying that the present generation must not shift burdens onto future generations in the form of maintenance and monitoring of a deep bedrock repository.

Thirdly, experience has shown that the siting of facilities for treatment and storage of hazardous waste requires very careful handling of the local consultative process. This has been found to be an essential precondition for obtaining local approval for a facility. Companies and public authorities alike should take advantage of lessons learnt from other fields, such as nuclear waste.

8.2.3 What will a deep bedrock repository cost?

The following cost estimates are very rough and should only be regarded as an indication.

[7] See, eg, an SKB report published in November 1999 (in Swedish) entitled *Djupförvar för använt kärnbränsle. SR 97 – Säkerheten efter förslutning* ("Deep bedrock repository for spent nuclear fuels"). SR 97 – Safety after sealing".

The Swedish EPA report estimates the cost of a deep bedrock repository having a capacity of about1,000 – 20,000 tonnes of high-level mercury waste to be about SEK 200 – 300 million. This represents a cost of approximately SEK 250,000 – 650,000 per tonne of pure mercury[8]. (The higher figure represents storage of mixed waste such as process waste containing 1 – 10 per cent mercury.) A large proportion of the cost will be the fixed cost of preparing the shaft and blasting access and storage tunnels. The actual volume of the repository will only have a marginal effect on the overall cost, perhaps less than 20 per cent. It thus follows that significant savings can be made if the companies involved can work together to achieve a joint storage facility. The cost of storing waste at a class 1 surface facility is about SEK 1,300 per tonne of waste, ie, about SEK 15 million for 10,000 tonnes. Hence, a deep bedrock repository will be about 15 times more expensive than a surface facility.

In addition to the cost of the repository itself, there will be the cost of any processing and stabilisation. These depend very much on the type of waste and desired end product. The consultants' report suggests that the cost will typically be SEK 10 – 20 per kilo, although it may be as much as SEK 100 per kilo for certain types of waste and treatment methods. This means that the cost of processing and stabilising Swedish waste containing mercury concentrations over one per cent (approx. 15,000 tonnes) will be about the same as the cost of the repository itself. It should be noted that approximately the same costs may be expected for processing and stabilising waste stored in a surface or shallow repository. Thus, bearing in mind the costs involved here, there are compelling reasons for finding optimal solutions for the entire chain of processing – stabilisation – final storage so as to keep costs down while still meeting safety requirements. Responsibility for finding optimal solutions of this kind rests with the waste owners.

It has transpired that the provisions made by the companies involved to cover final disposal of mercury waste are insufficient. These are companies that have had mercury waste in intermediate storage for many years pending a permanent solution. The companies have said they had no reason to assume that this mercury would have to be stored deep underground. The provisions made have been calculated on the assumption that the waste would be permanently stored at a surface facility. Since deep storage is 15 times more expensive than surface storage, their provisions will not suffice. Another problem is said to be that the companies have not been able to make sufficiently large provisions, since it has been difficult for them to prove that such large provisions do in fact represent an actual cost that is therefore tax-deductible. We gather that the tax authorities have not accepted the provisions as allowable costs unless the companies are able to produce some contractual or statutory support for them.

We elaborate our view of the first problem in Chapter 10. To try to come to terms with the second problem, we have considered whether we should suggest the inclusion of special provisions on mercury in the Municipal Tax Act, as is already the case with nuclear waste. The provision would allow companies to treat expenses for dealing with mercury waste as an allowable cost, in which case we would propose specific amounts. But a proposal of this kind would only deal with future problems. Another difficulty we have perceived is that it is not at present possible to say exactly how much a deep bedrock repository will cost, and it is therefore difficult to give precise figures. The costs we have stated above are preliminary and we are convinced that the industry will be able to bring them down when methods are developed on an industrial scale. In addition, it will be easier in the future for companies to persuade the tax authorities to accept these costs as tax-deductible, since we will be proposing mandatory legislation on deep underground storage of mercury waste. With statutory support, it ought not to be difficult in the future for companies to establish that costs for a deep

[8] This means that the cost per kilo of a deep bedrock repository will be about ten times the international market price of mercury.

bedrock repository are genuinely tax-deductible. On balance, we do not consider it necessary to amend the Municipal Tax Act and that it is in any case too early in the process to propose specific amounts. We have therefore elected not to propose amending the act.

8.3 Criteria for requiring a deep bedrock repository

8.3.1 Principles on which to base criteria

The Swedish EPA's report states that, in the first place, existing and future waste from goods and products containing mercury, waste from the chloral kali industry and some of the waste produced by Boliden Mineral AB should be stored deep underground. All this waste should contain more than one per cent mercury.

Under its terms of reference, the commission should propose criteria governing mercury waste that is to be stored in a deep bedrock repository. The question then arises as to how these criteria should be formulated.

The fundamental principle is set forth in the Environmental Code, which provides that the best available technique must be used in commercial or business operations. This applies unless it would be *unreasonable*. A cost-benefit analysis is used to determine feasibility. Hence, the key factor is the environmental benefit placed in relation to the financial cost.

In Chapter 5 we outlined the protection offered to health and the environment by various types of repository over the very long term. The inference to be drawn is that the environmental benefit of storing mercury deep underground will normally be very great. As may be seen from the Swedish EPA report, mercury is one of the most toxic pollutants known. Any further increment is undesirable. Accordingly, it cannot be said that waste containing a very low concentration of mercury is harmless. As a result, we also consider it essential to store a large proportion of all mercury waste deep underground.

A further inference is that storage deep underground will normally only be considered inappropriate when the financial cost becomes unreasonably high.

8.3.2 The environmental benefit of a deep bedrock repository

We may first examine the proportion of mercury waste included in the one per cent limit set by the Swedish EPA. As has already been seen, by 2010 a one per cent limit will mean 400 tonnes of mercury from the chloral kali industry and 100 tonnes from the hidden store in society. This limit will also mean that Boliden Mineral AB will have approximately 500 tonnes of mercury waste and SAKAB about 100 tonnes. "One per cent" waste will total about 1,100 tonnes of mercury. Most of this waste will contain far more than one per cent mercury. Waste from the chloral kali industry comprises metallic mercury. As of today, Boliden Mineral AB's stored mercury comprises about 280 tonnes, contained in just under 5,000 tonnes of waste, which yields an average figure of five per cent. SAKAB's 60 tonnes of stored mercury is contained in just over 2,000 tonnes of waste, which gives an average of two per cent. Roughly speaking, there is about 15,000 tonnes of waste in total.

As may also be seen from Chapter 3, other waste containing mercury represents a further 800 tonnes of pure mercury. Most of this is low-level waste from the mining industry. In addition to the high-level waste mentioned above, Boliden Mineral AB has waste representing a further 300 tonnes of mercury. About 250 tonnes of this is contained in waste having a mercury content of 0.5 – 1 per cent, and 60 tonnes in waste with a mercury content of 0.1 – 0.5 per cent. The remainder is waste with concentrations far below 0.1 per cent. This waste represents about 500 tonnes of mercury contained in a waste total estimated by the Swedish EPA to be in excess of 500 million tonnes.

When assessing the environmental benefit, account should also be taken of the environmental effects of pre-treating waste and the need to transport it. The waste owners have said the emissions of mercury to air from waste pre-treatment will be significant. For the sake of comparison, it may be mentioned that SAKAB has a permit to emit one to two kilograms of mercury to air a year from treatment of mercury waste. It should then be borne in mind that SAKAB treats far smaller quantities of mercury waste than are intended for deep storage. The waste owners feel that this emission figure should be seen in relation to the negligible emissions from a deep bedrock repository. SAKAB's current annual treatment emissions alone represent emissions from a deep bedrock repository over a period of 100 – 1,000 years. The waste owners argue that this comparison shows that a deep bedrock repository is an unnecessarily cautious solution.

We think it worthwhile to compare emissions from treatment of mercury waste with emissions from final storage, since this provides a perspective on the figures. But it is also important to bear in mind that high emission figures from treatment cannot, in themselves, constitute an argument against a deep bedrock repository. Regardless of the final storage method chosen, mercury waste must be pre-treated. This is necessary to ensure very low emissions from a store, whatever the type. So, even the waste were to be stored at a surface facility, pre-treatment would be needed and would involve fairly high emissions to air. Besides, the comparison is not relevant, since the bodies receiving the emissions differ. When estimating permitted emissions from a repository, we have assumed that the entire emission will end up in an oligotrophic lake, or reach a well, whereas emissions to air will disperse quite differently. This approach is supported by the Swedish EPA and the National Food Administration.

Lastly, we would also object as a matter of principle to the argument that a comparison with emissions to air suggests that a deep bedrock repository would be an unnecessarily cautious solution. Put simply, it is argued that since treatment will involve high emissions of mercury in any case, high emission levels from a repository should also be permitted. However, government policy is to reduce the burden placed on the environment by mercury and to avoid each additional increment. When considering this matter, each emission source must be evaluated separately under the provisions of the Environmental Code.

8.3.3 Assessment of reasonableness – environmental benefit in relation to cost

Our view is that, for environmental reasons, as much mercury waste as possible should be stored deep underground. However, it is also obvious that this will be expensive. As mentioned earlier, a deep bedrock repository will be 15 times more expensive than a surface facility.

The question then arises as to the types of waste it is reasonable to require be stored in a deep bedrock repository when weighing up the environmental benefit and the high cost of a deep bedrock repository. As described earlier, some 60 per cent of all mercury is present in waste with a mercury content of more than one per cent. If the lower limit is set at a mercury content of 0.1 per cent, then about 75 per cent of all mercury is included. But the total quantity of waste then rises from about 15,000 tonnes to approximately 65,000 tonnes. The vast majority of the remaining 25 per cent or so is dispersed in very large quantities of waste – many hundreds of millions of tonnes.

Hence, there is a very clear dividing line between the waste identified by the Swedish EPA (the chloral kali industry, SAKAB and some of Boliden Mineral AB's waste) on the one hand, and very low-level waste on the other. There is a limited quantity of the waste identified by the Swedish EPA, some of which has very high concentrations of mercury and contains a majority of the total quantity of mercury. The opposite is true of the waste having a mercury content of less than 0.1 per cent. Here, there are very large quantities of waste containing a very low concentration of mercury and a limited proportion (about a quarter) of the total quantity of mercury. Thus, even at first glance, a comparison between the environmental benefit and the costs suggests that it would be unreasonable to send such large quantities of waste containing such low concentrations of mercury to deep storage. Clearly there is also no reason to depart from the Swedish EPA's view that waste containing more than one per cent mercury should be stored in a deep bedrock repository. It is more difficult to adopt a general stance as to the appropriate storage method of waste containing 0.1 – 1 per cent mercury. However, where there is a treatment technique and treatment capacity for a specific type of waste and waste volumes are moderate, it is probably reasonable to store the waste in a deep bedrock repository. We consider the appropriacy of deep storage for waste of category should be decided by the relevant authorities on the merits of each case.

8.4 Proposed organisational solution

8.4.1 Cooperation between waste owners

As we mentioned by way of introduction, our task includes formulating a proposal for organised joint operation between the various stakeholders: Boliden Mineral AB, Hydro Polymers AB, Eka Chemicals AB and SAKAB. We have held discussions with these waste owners for this purpose.

Our basic position is that the waste owners should make use of the experience gained from joint operations for terminal storage of nuclear waste when endeavouring to establish a suitable form of joint operation. We therefore began the discussions by presenting solutions from the field of nuclear waste as a possible model. The first choice of model was the simplified model established by the nuclear power companies to deal with low and medium-level operating waste, such as filter cakes from nuclear power plants.

Under this joint system, the waste owners would form a jointly-owned limited company whose sole purpose was to dispose of mercury waste. The company's assets would consist of funds contributed by the individual waste owners. These funds would equal the cost of disposing of the mercury waste. Since the companies own varying quantities of waste of various types, the contributions would be set in relation to the proportion and type of mercury waste. The waste owners could transfer their mercury waste to this company, which could then assume sole responsibility for it. If this were not considered desirable, it would naturally also be possible to create an alternative legal solution. For example, if we compare with nuclear waste, we see there that the original waste owners have retained a secondary responsibility for nuclear waste, although this is imposed by statute. We have assumed, however, that the waste owners would be relieved of their responsibility for the waste under a voluntary system based solely on contract and not laid down by law.

It would then be up to the joint company to construct and operate a deep bedrock repository or engage someone else to do it. The joint company could also conduct a certain amount of joint technical development, eg, techniques for stabilising metallic mercury. Using this approach, the individual waste owners would no longer need to charge their own accounts with uncertain future costs for disposing of mercury waste. The details of a contract between the waste owners would have to be worked out in consultation with them. However, the initial response we received from the waste owners was that the division of responsibilities and the state's involvement in an agreement of this kind would have to be clarified.

8.4.2 Development of legal responsibility for the waste

We have based our analysis of responsibility for mercury waste on current law. But it is important to note at the outset that a deep bedrock repository will exist essentially in perpetuity and that, over such a long period, applicable legislation will change many times over. We can therefore only examine the nature of responsibility at our given moment in time. Under current law, it is a fundamental premise that each waste owner is responsible for its own waste. This means that a legal entity that owns waste is responsible for it. This responsibility includes disposing of the waste in the manner provided by law. One question to be considered prior to conclusion of a agreement as outlined above is whether this responsibility could in some way be extinguished before there has been time for the waste to be transferred to the jointly-owned company. Perhaps the most likely way this might happen is if the business of one of the companies concerned were to be transferred to another party. This would only have a minor on a future joint repository agreement, since the new operator would then assume responsibility for the waste and thus become a party to the agreement. But the situation would be different if any waste owner were declared insolvent before the mercury was put into deep storage. Initially, the receiver in the insolvency would take over as operator. However, once the insolvency procedure had been concluded, a situation would arise where no-one was responsible for the waste. But here the insurance policies governing hazardous waste would come into play. Under the Hazardous Waste Ordinance, each waste owner having mercury waste in intermediate storage is under an obligation to put up a bond to cover the cost of disposing of the waste. This money could then be used for storing the waste deep underground, although the authorities would be responsible for arranging this.

If the waste is transferred to a jointly-owned company, that legal entity will also assume responsibility for the waste. It will therefore be essential to ensure that the company possesses sufficient assets to cover the cost of deep storage. If that company then undertook to operate a deep bedrock repository, it would then be formally responsible for those operations for as long as the repository produced emissions, which could, in theory, be millions of years. However, in practice, it will scarcely be possible or reasonable for a public authority to demand that an operator be held liable after the elapse of many years if permits have been complied with and all obligations performed in the form of a properly sealed deep bedrock repository. We are therefore of the opinion that the state will be obliged to assume responsibility for a repository.

8.4.3 The role of the state

The role of the Swedish state vis-à-vis mercury waste is complicated. The state has instructed the Swedish EPA to collect batteries. These are sent to intermediate storage as mercury waste at SAKAB. The state does not own these batteries, but bears the cost of them. The state is also prepared to pay for their final storage. For this purpose, money has been allocated to the battery fund, which is administered by the Swedish EPA. The fund contains SEK 50 million, which might very well cover the cost of deep storage. We therefore conclude that the state is to be regarded as the owner of these batteries. Hence, we consider that the state could participate as a party to the agreement when the jointly-owned company for deep storage of mercury is incorporated.

However, a further issue is whether, in addition to its responsibility for the batteries, the state for some reason will be responsible for other mercury waste or for a deep bedrock repository. As pointed out above, the question of the state's responsibility for other mercury waste would only arise if a waste owner were declared insolvent before the deep bedrock repository had been established.

We have also pointed out above that the state will be obliged to accept some form of long-term responsibility for a deep bedrock repository. Formally speaking, the operator is responsible for a repository without time limit. However, it will be difficult in practice to invoke liability after a certain time has elapsed. If the state does not formally accept this responsibility, it will be a question of a constructive residual responsibility. In addition, when a repository agreement is concluded, the state could choose to declare that it has a residual responsibility for a deep bedrock repository, as it did in the case of nuclear waste.

8.4.4 The attitude of the waste owners to an agreement

Subject to certain conditions, the waste owners have said they are in favour of a joint approach. SAKAB has said that it is prepared to start negotiating immediately. One reason for this is that the company has been owned by Sydkraft AB since 1 December 2000. Sydkraft has positive experience of joint nuclear waste operations. Boliden Mineral AB and the chloral kali industry have said that they do not reject the idea of a joint solution, but have said that they do not see any scope for concrete negotiations until it has been established which waste will be subject to the deep storage requirement and the division of responsibility between those concerned is clarified.

The chloral kali industry advocates another solution, however. As mentioned in Chapter 1, the government has notified a draft ordinance banning the use of mercury in the chloral kali industry by 2010 to the EU. We consider that this ban on use means that mercury in the chloral kali industry will be regarded as waste. Hydro Polymers AB does in fact accept the introduction of a ban on mercury use, but would like to see waste management coordinated with other chloral kali companies across Europe. Eka Chemicals AB has also called for a pan-European solution. For competition reasons, the company wants a ban on use to enter into force simultaneously throughout Europe and is working for a common waste solution. The company's position is based on the following considerations: There is already a well-established European organisation representing the chloral kali industry, ie, EuroChlor. The existence of this organisation enables the chloral kali industry to enter into specific agreements. It is easier and more efficient for Hydro Polymers AB and Eka Chemicals AB to work together with other chloral kali producers in Europe than with companies in other industries in Sweden. Moreover, there is a great deal of technical know-how throughout the chloral kali industry in Europe. This could be put to advantage, eg, for joint method development projects. EuroChlor has produced a proposal that the company considers to be effective from an environmental viewpoint as well. In short, it proposes that the use of mercury by the various companies should be phased out by 2020 – 2025. Resulting surplus mercury should, in the first instance, be sold to other chloral kali companies; the remainder should be sent to a company in Spain that abstracts mercury at the Almadén mine in return for its commitment to reduce its mined mercury production correspondingly.

This commission's terms of reference do not allow scope for discussion of a pan-European solution to the problem of mercury from the chloral kali industry. Moreover, in our discussions with that industry, we have pointed out that the prevailing Swedish export ban rules out any question of exporting mercury to Europe.

As mentioned in section 4.1, EuroChlor's proposal is also being discussed by OSPAR. Sweden has opposed the proposal there for the following reasons. Swedish considers that the chloral kali industry's mercury will constitute waste when its use is phased out. Hence, transfer of waste from one European country to Spain would require a permit from the authorities in the source country, the transit states and the recipient country under Regulation 259/93 on the supervision and control of waste within, into and out of the EU (see section 1.4.2 in Appendix 2). The necessary permission would probably not be granted, since the arrangement would not constitute disposal in an environmentally acceptable manner. Sweden also considers that the proposed solution would favour the chloral kali industry at the expense of member states. Many countries spend large amounts of taxpayers' money on collecting mercury waste. EuroChlor's proposal would enable the chloral kali industry to get rid of waste without paying for it. The mercury would then be dispersed on the world market, and various countries would ultimately have to spend public funds collecting it. A further flaw in the EuroChlor proposal is the risk of mercury being sold to third world countries and it being used there in a manner hazardous to health. For example, it is known that mercury is used for manual gold washing, a practice posing major risks to health and the environment. As much as 12,000 tonnes of mercury will be released when its use is phased out by the European chloral kali industry. The chloral kali industry would be able to use only a tiny fraction of this during a transitional period. Other mercury use in the EU may also be expected to diminish in the future as tougher EC environmental directives are introduced. Some 1,000 tonnes of mercury is mined annually at Almadén, and the quantity therefore represents just over ten years' mining. When this quantity had been transferred to the Spanish company, it would be sold on the world market, since the EU has no ban on exporting mercury.

In summary, the reasons for Boliden Mineral AB's position are as follows. The company does not, *per se*, have any objection to a requirement that high-level mercury waste be stored deep underground. This view includes the company's own high-level waste. However, most of the waste in the company's possession has a mercury content of around one per cent or lower. The company considers that a good quality surface storage facility at its Rönnskär site would easily meet the standards of safety in relation to emissions and inadvertent intrusion that can reasonably be expected of a final storage facility. Boliden Mineral AB also consider that a threshold concentration is not an adequate criterion on which to decide what waste should reasonably be kept in a deep bedrock repository and what pre-treatment is necessary. In the company's opinion, account should also be taken of the chemical characteristics of the waste. We have said to the company that a crucial argument in favour of a deep bedrock repository is that it will be maintenance-free and that it will therefore not place a burden on future generations. Boliden Mineral AB here wishes to emphasise that as long as operations continue at the Rönnskär works, it will be the company's responsibility to monitor existing and future waste sites within the area. It also considers that the fact that smelting operations have been conducted on the site since the early 1930s (which has resulted in infill and waste sites etc) will oblige it to ensure that the area continues to be monitored in the future. The company allocates funds to ensure that this will be possible. Thus, it argues, a site for mercury waste would not increase the "burden" placed on future generations. The argument that a deep bedrock repository is maintenance-free is thus of less relevance in relation to this waste.

We consider that it may indeed be true that the area at Rönnskär must be monitored for environmental reasons for a long time. But mercury waste is unusual in that it is not broken down; it retains its toxicity for ever. A store of 1,000 tonnes of mercury would sooner or later be dispersed into the biosphere, since it would appear unreasonable to assume that it will be monitored for a very long time. We also wish to point out that very large quantities of waste and mercury are involved at Boliden Mineral AB (about 600 tonnes of mercury). It should also be borne in mind that the company is now the only waste owner producing mercury waste on a large scale. On balance, we do not find reason to treat Boliden Mineral AB's waste differently.

8.4.5 Timetable for compulsory deep storage

Swedish environmental legislation classifies mercury as one of the most dangerous pollutants of all. The government has taken a number of measures over an extended period to limit use of mercury. In future it will only be permitted to use mercury in exceptional cases, in closed cycles. Accordingly, we find it essential that existing mercury waste currently in intermediate storage pending a long-term solution, as well as future mercury waste, be stored in a deep bedrock repository without undue delay. We do not consider it acceptable for untreated mercury waste to go to intermediate storage for a lengthy period once the use of mercury has been phased out. One question then arising is the length of an acceptable intermediate storage period in the future. The waste owners have told the commission that a very long transitional period will be needed before storage in a deep bedrock repository will be possible. SAKAB, in particular, has expressed the following views. Storage of stable and refined forms of mercury in a building above ground for long periods does not place a burden on the environment. On the contrary, according to SAKAB, it is essential in some cases to place waste in intermediate storage for a time following treatment to ensure that the small quantities of contaminants inevitably present in an industrial waste product do not jeopardise the desired stability of the mercury compounds. A reasonable time for this is ten years. Moreover, it is difficult to treat and store incoming quantities of waste in a short time in an environmentally friendly way. For their part, the technical experts available to the commission have said that their experience is that about seven years is needed to perform technical projects of this type, which, after all, do include a certain amount of technical development.

We consider a realistic target to be important. As we mentioned at the outset, it is absolutely essential that untreated mercury waste not be placed in intermediate storage for long periods in the future. Our basic position is therefore that mercury waste should not be placed in intermediate storage longer than is really necessary. However, as things stand, it is difficult for us to specify a realistic period for implementation of the measures necessary to be able to start placing mercury waste in a deep bedrock repository.

At present there are a number of technical and organisational issues to be resolved before mercury waste can be placed in a deep bedrock repository. Firstly, industrial-scale treatment methods must be developed for some of the waste. Secondly, a suitable site must be found for a repository, it must be designed and its permissibility considered, and it must be built. As we have already mentioned, there are compelling technical and financial reasons for these issues to be resolved jointly by the waste owners, and for there to be a *single* deep bedrock repository. However, a joint approach must be on a voluntary basis. At this stage, we cannot therefore assume that there will in fact be a *single* repository and that it will be possible to place mercury waste generated in future in an existing repository.

We conclude that the requirements governing a deep bedrock repository should be formulated to take account of the mercury waste currently in existence and also the future situation. In our opinion, this means that extra time will have to be available initially to achieve necessary development of treatment processes, facilities and organisation. But once these developments have been achieved, it will be reasonable to demand that mercury waste be placed in a deep bedrock repository more quickly.

On balance, we consider that it will normally be reasonable to allow a time limit of five years from creation of waste until its placement in a deep bedrock repository. However, initially, before treatment processes, facilities and organisation are in place, we think this time limit must be extended to eight years from the introduction of the underground storage requirement.

8.5 The commission's conclusions

We consider that waste containing at least one per cent mercury must always be placed in a deep bedrock repository and waste containing at least 0.1 per cent mercury must be placed in a repository of this kind insofar as it is reasonable to do so. It is essential that a deep bedrock repository be established without undue delay. The waste will first have to be treated and refined. Technology capable of development is available, but at present no methods have been developed for treating and refining metallic mercury on an industrial scale. The waste owners are responsible for developing these methods and for selecting an appropriate site for the repository. The cost of a deep bedrock repository may be estimated at SEK 200 – 300 million. There will be additional costs for treatment and refinement. Significant economies can be achieved if the waste owners can work together to establish a repository and the necessary technology. One problem in relation to existing waste is that the waste owners did not foresee that they would one day have to place it in a deep bedrock repository. The financial provisions they have made are therefore insufficient. We elaborate our views on this problem in Chapter 10. Another problem is that the waste owners say they have had difficulties persuading the tax authorities to accept large provisions for future disposal of mercury waste as an allowable cost. However, our view is that this will not be a problem in future, since the waste owners will have the support of a "deep bedrock repository ordinance", which we propose in Chapter 9. It is mainly for this reason that we do not propose an amendment to the Municipal Tax Act along the lines of that made in the case of nuclear waste.

On the basis of experience gained from the field of nuclear waste, we have produced an outline proposal for joint operation between the waste owners. This would mean that the waste owners incorporated a jointly-owned limited company whose sole purpose was to manage mercury waste. The waste owners' initial response was that the legal responsibility for the repository and the role of the state in these joint operations would have to be clarified. In our view, the future jointly-owned limited company should take over responsibility for the repository. If the company then undertook to operate a repository, it would be formally responsible for it as long as it produced emissions, which could theoretically be millions of years. Since it would not be possible to impose responsibility after many years had elapsed, the state would be obliged to accept responsibility when the waste owners had met all their reasonable obligations in the form of an approved and sealed final repository. In our view, the state's responsibility for the cost of collecting batteries places it in the position of a waste owner. As described earlier, SAKAB and the Swedish EPA have begun battery processing trials. The aim is for the mercury extracted from the batteries to be stored in a deep bedrock repository. The state could thus become a contractual party when the waste owners establish their jointly-owned waste management company.

All the waste owners have reacted favourably to the idea of working together, subject to certain conditions. But most of them have not accepted that their mercury waste should be stored in a deep bedrock repository in Sweden. They have said that they are not prepared to begin definite negotiations before there is a statutory requirement that mercury waste be placed in a deep bedrock repository.

We have concluded that a deep bedrock repository will have to be compulsory by law and that there is no point at this stage in continuing discussions with industry. Instead, we propose an ordinance (set forth in Chapter 9) imposing this statutory requirement. We have decided that it will be reasonable in future to have a normal time limit of five years from production of waste until storage in a deep bedrock repository. However, initially, before treatment processes, facilities and organisation are in place, we think this time limit will have to be extended to eight years from the introduction of the requirement for underground storage. We will also be recommending that the government, with the support of the Swedish EPA, keep itself continuously updated on developments in industry so as to be able to take any additional action that may be necessary to hasten the establishment of a deep bedrock repository as provided by the proposed ordinance.

9 The commission's proposals

Our proposal: We propose that waste containing at least one per cent mercury by weight must be stored in a deep bedrock repository within a period of five years. This will also apply to waste containing at least 0.1 per cent mercury by weight if reasonable. As a transitional provision, we propose that this time limit be extended to eight years from the entry into force of the provisions.

We further propose that the permissibility of a facility for permanent storage of mercury waste containing at least 0.1 per cent mercury by weight be considered by the environmental court in the first instance.

Finally, we propose that the government specifically instruct the Swedish Environmental Protection Agency to keep it informed of developments in the industry.

9.1 The basis for our proposals

We have concluded that mandatory legislation is needed to bring about a deep bedrock repository. We have found that the companies concerned find it difficult to allocate the necessary resources in the absence of mandatory requirements. We therefore find that there is little point at this stage in continuing discussions with the industry. Instead, we propose below an ordinance imposing a statutory requirement for a deep bedrock repository.

We have further noted that the current arrangement concerning competent regulatory authorities considering permissibility may not be entirely suited for future consideration of the permissibility of a deep bedrock repository for mercury waste. Under 9.3 we therefore proposed that this legislation be amended.

9.2 Legislation on a deep bedrock repository for storage of mercury waste

The purpose of the legislation is to make storage of mercury waste in a deep bedrock repository compulsory. The first question concerns the kind of mercury waste involved. As we pointed out under 8.3.3, we consider that waste with a mercury content exceeding one per cent should always be stored deep underground, and that waste having a mercury content of 0.1 – 1 per cent should be stored deep underground insofar as is reasonable. The assessment of reasonableness is based on the provision in chapter 2, section 7 of the Environmental Code, which places the benefit of a preventive measure in relation to its cost.

However, our draft legislation is not solely intended to ensure that high-level mercury waste is stored in a deep bedrock repository in the future. According to our terms of reference, we must also endeavour to bring about an organised scheme of joint operation between various stakeholders so as to establish suitable treatment facilities and a deep bedrock repository for Swedish mercury waste. However, as mentioned above, the waste owners are not willing to take part in a scheme of this kind until their waste falls under mandatory legislation. In our opinion, this means that the legislation must impose a requirement for storage of mercury waste deep underground and requirements designed to ensure that storage of this kind takes place within a reasonable space of time.

The question then arises as to how long a time limit should be set. The waste owners have said that a very long transitional period will be necessary. Our view is that it is important to have a realistic target. The remaining obstacles to deep underground storage of mercury waste are of a technical and organisational nature. The waste must be treated before being stored in a depository. There are methods of doing this, but in many cases they cannot be used for large quantities of waste unless they are developed for use on an industrial scale. In addition, a place must be chosen for a deep bedrock repository and it must be constructed. An application to build and operate the facility must be considered in accordance with the Environmental Code, which involves a comprehensive consultative process. An organisational system for cooperation on treatment techniques and final storage must be negotiated. Hence, a number of issues must be resolved before mercury waste can be transferred to a deep bedrock repository. As mentioned in Chapter 8, we are of the opinion that a period of eight years may be expected before treatment methods are developed and other issues resolved so that storage deep underground is possible. But it ought to be possible and appropriate in the future to require that waste go to storage in the depository within five years of being created. We therefore propose that, as a general rule, it be stipulated that mercury waste must go to deep storage within a period of five years, but that a transitional provision should allow an initial period of eight years from entry into force of the legislation. There may also be difficulties that cannot be seen at present. Accordingly, it should be generally open to the permit-issuing authorities to extend the respective five and eight-year time limits in exceptional cases. We therefore propose that it be possible to extend these time limits if there are particular reasons for doing so. It is difficult at present to say precisely what these "particular reasons" might be. However, we envisage a situation where the time limit cannot be met owing to circumstances beyond the waste owner's control. For instance, the permit application procedure for a deep bedrock repository could drag on. To encourage the waste owners to work together, it should also be possible to extend the time limit if a waste owner is able to show a binding agreement involving access to a deep bedrock repository that is to be ready for use within a few more years.

One consequence of this legislation will be that the various waste owners will face varying time demands for deep storage. Obviously, the legislation is aimed at mercury waste. The majority of waste falling under the legislation in the near future is currently owned by SAKAB and Boliden Mineral AB. Various waste management companies are likely to have small quantities. The waste is currently sent to intermediate storage. These waste owners would face a requirement to send the waste to final storage just eight years after the legislation enters into force. As also pointed out in Chapter 7, we do not think that the mercury used by the chloral kali industry will become waste until its use is phased out, ie, by 2010. Using the above approach, the industry would be able to have this waste in intermediate storage for a further five years. In other words, the chloral kali industry would not be required to send the waste for final storage until 2015. But the waste must be treated and converted into a suitable form for final storage during the interim. In practice, therefore, the chloral kali industry will need to plan for the phase-out in good time before 2010.

There are compelling technical and financial arguments in favour of a joint approach by the waste owners. However, regardless of mandatory requirements, we do not rule out the possibility that further government initiatives will be needed to bring about a deep bedrock repository without undue delay. The government therefore needs to keep abreast of developments within the industry. We therefore propose that it direct the Swedish EPA to work with the relevant county administrative boards to monitor developments carefully and report back to the government. Ideally, this could form a specific part of the agency's general duty to monitor achievement of various environmental quality objectives. We also consider it appropriate to specify a set date - we suggest 2005 – when the agency must report back to the government with its analysis of developments and propose additional steps that might be called for on the part of the government. This would to some extent enable the Swedish EPA to press for joint establishment of a deep bedrock repository. The government would naturally have to define the Swedish EPA's role by issuing it with specific written instructions.

What other implications might our proposals for new legislation have? As we pointed out in section 3.1, there is very little waste containing more than 0.1 per cent mercury other than that in the possession of the above-mentioned waste owners. The Swedish EPA has estimated that there is a hidden store of about 200 tonnes of goods and products containing mercury. However, just as with mercury in the chloral kali industry, this will not become waste until its owners want to get rid of it (see Chapter 7). A small proportion of this probably derives from households. In our view, the proposal for a deep bedrock repository should not directly affect individual consumers. The requirement should not therefore extend to the waste remaining in their possession. However, under chapter 15, section 8 of the Environmental Code, Swedish municipalities are responsible for ensuring that household refuse is sorted and transported to a treatment facility where necessary. Once it has been sorted, it no longer falls within the legal definition of household refuse.

This would mean that municipalities might be required to send small quantities of mercury waste for underground storage. Moreover, our proposals must naturally also cover all industrial waste having the specified mercury content. It may be complicated in the future for municipalities or industrial operators possessing small quantities to ensure that their mercury waste goes to a deep bedrock repository. One possibility might be for them to transfer their mercury waste to waste owners having access to suitable treatment facilities and a deep bedrock repository, making reasonable payment to them for this. If this is not possible, the legislation must allow these waste owners to obtain special exemption from the deep storage requirement. The legislation must therefore offer a general possibility of granting exemption from deep storage for owners of small quantities of waste. Here, the applicant will be obliged to show an acceptable alternative method of storage. Another factor to be considered when drafting the legislation is that some mercury is currently recycled. Government policy is in fact that mercury should not generally be recycled. However, it is still permitted in exceptional cases to use mercury, eg, in various types of light source. Mercury in this waste is recycled. The quantities involved are small; the total annual turnover is about one tonne. Permitted use of mercury in goods etc is expected to continue in closed cycles. The commission does not consider its task to include considering whether this recycling of small quantities of mercury should cease. Moreover, Sweden does not have a market for the mercury contained in the large quantities of mercury waste currently in intermediate storage. The same will apply to the mercury waste generated when use of mercury in the chloral kali industry is phased out. Further, the Swedish ban on exporting mercury prevents mercury being transferred out of the country. Taken as a whole, therefore, the remaining scope for recycling and reusing mercury has no practical bearing on the final storage of the large quantities of mercury waste. From this it may be inferred that the commission's draft legislation imposing an obligation to store mercury deep underground must also allow the possibility of excluding these small quantities of mercury that are recycled.

It is also necessary to consider whether there is a need to introduce additional transitional provisions in the new legislation. We proposed above that a certain type of mercury waste be sent for deep storage within five years (eight during the transitional period). The question then concerns the position applying to mercury waste for which there is a valid permit whose conditions may conflict with these proposed provisions. We have ascertained from the Swedish EPA that there are no permits at present stipulating final storage of mercury waste containing more than 0.1 per cent mercury by weight. All this waste goes to intermediate storage, the only form of storage for which permits have been issued. It has also transpired that current permits for intermediate storage of this mercury waste expire by 2009, ie, about seven years after the new legislation is set to take effect. Hence, current permits will not conflict with the new provisions requiring deep storage. There is therefore no reason to propose additional transitional provisions.

Accordingly, we propose that the following provisions be inserted in the Hazardous Waste Ordinance. This ordinance does not apply to household refuse, and our proposals will thus not do so either.

As mentioned in section 7.1.3, the powers delegated by the government to issue regulations governing final storage of mercury waste or "disposal of mercury waste", as it is generally termed in the law, are contained in chapter 15, section 9 of the Environmental Code.

The definition of "underground storage" is that used in Council Directive 1999/31/EC of 26 April 1999 on the landfill of waste.

Proposed legislative amendments

In view of the above, we propose that the following provisions be inserted in the Hazardous Waste Ordinance (1996:971). The provisions should ideally be added at the end of the ordinance before the general headings that begin with "Appeal". The numbering will thus begin with section 37 and the following provisions will have to be renumbered.

Disposal of mercury waste

Section 37

Waste containing at least one per cent mercury by weight must be disposed of in the manner stipulated in D 16 in Annex 4. The waste must be disposed of within five years unless there are particular reasons for not doing so. However, where the quantity of waste is so small that disposal in this manner appears obviously unreasonable, it may instead be recycled or disposed of in another manner.

Section 38

Waste containing at least 0.1 per cent mercury by weight must also be disposed of in the manner stipulated in D 16 in Annex 4 if it is reasonable to do so. When deciding this matter, the benefit of disposal must be compared with its cost. This waste must also be disposed of within five years unless there are particular reasons for not doing so.

Definition

In addition, the term underground storage, defined as a facility for permanent storage of waste in a deep geological cavity is to be inserted under D 16 in Annex 4 of the Ordinance.

Entry into force and transitional provision

The above amendments will enter into force on 1 July 2002.

Instead of a time limit of five years, mercury waste created prior to 1 July 2005 that is to be disposed of in the manner set forth in D 16 of Annex 4 must be disposed of not later than 1 July 2010 unless there are particular reasons for not doing so.

9.2.1 Ensuring compliance with the new provisions

The next question is how to ensure compliance with the provisions. The present regulations contain built-in mechanisms to ensure compliance with sections 37 and 38. As mentioned in 9.3, all intermediate storage and disposal of mercury waste requires a permit. When the proposed provisions are in force, permits will only be issued for disposal and intermediate storage in accordance with them. Chapter 30 of the Environmental Code and the Environmental Penalties Ordinance (1998:950) impose an obligation to pay a penalty on anyone conducting environmentally hazardous activities without a permit.

9.3 Proposed changes relating to the permit-issuing authorities

As explained in further detail in section 1.1 of Appendix 2, two ordinances additional to the Environmental Code govern the management of mercury waste.

Under the Environmentally Hazardous Activities and Health Protection Ordinance (1998:899), a facility for intermediate storage or landfilling of hazardous waste and certain other kinds of waste management, requires a permit. Permits are issued by the county administrative board or environmental court in the first instance. The deciding factor is whether the operation is classified as a type "A" operation or a type "B" operation. Type "A" operations apply to the environmental court in the first instance; type "B" to the county administrative board. Decisions of the county administrative board can be appealed to the environmental court and thence to the superior environmental court. Leave to appeal is required in the latter instance. If the environmental court is the permit issuer of first instance, its decisions may be appealed to the superior environmental court and thence to the Supreme Court in the final instance. Leave to appeal is required in the latter instance.

A facility for intermediate storage of hazardous waste is classified as a type "B" operation, whereas a facility for landfilling hazardous waste is classified as a type "A" operation if more than 1,000 tonnes of waste is received annually and otherwise as a type "B" operation. The quantity of waste thus determines whether permit applications are to be considered in the first instance by the environment court or the county administrative board.

Under the Hazardous Waste Ordinance (1996:971), hazardous waste may be placed in intermediate storage, recycled or disposed of commercially only by those possessing a special permit. Permit issues are considered by the county administrative board in the county where the facility is located in the first instance. Issues already considered under Environmentally Hazardous Activities and Health Protection Ordinance are not reconsidered.

Accordingly, permit applications for a deep bedrock repository for mercury waste will be considered under the Environmentally Hazardous Activities and Health Protection Ordinance. In many cases the county administrative board will be the first instance. We consider that the county administrative board will also be the first instance for final storage in a deep bedrock repository under current legislation. Suitable forms of waste for final storage are outlined in Chapter 5. It is pointed out there that it will generally be necessary to extract the mercury from the waste and then convert it into a form suitable for storage. As is further mentioned in section 3.1, we have estimated there to be a total of some 66,000 tonnes of waste containing more than 0.1 per cent mercury, which represents about 1,400 tonnes of mercury. It is not possible at present to estimate the weight of this mercury when it has been converted into a form suitable for storage. Moreover, a key factor determining which permit-issuing authority will consider the application is not the *total* quantity but the *annual* quantity received by a storage facility. We have assumed that there will be a single national repository in Sweden in the future. As pointed out in section 9.2, one result of our proposal is that the various waste owners will be required to place mercury waste in deep storage at different points in time. Another effect will be to allow the total quantity of mercury to be deposited in stages over a number of years. Since there will only be about 1,400 tonnes of mercury in total, we consider it likely that the annual quantity entering a deep bedrock repository will be less than 1,000 tonnes. Hence, the permit application would be made to the county administrative board in the first instance.

9.3.1 Change in the legislation stipulating the permit-issuing authority

We consider it likely in the future that there will only be one deep bedrock repository for mercury waste in Sweden. The repository will be of national interest for this reason alone. In addition, the repository will be in existence for a very long time and mercury is one of the most dangerous pollutants. Consideration of a permit application to construct and operate the repository will therefore be of national interest from an environmental standpoint. The siting of the repository may also be expected to spark intense debate between opposing interests in the municipality concerned. An appeal of the county administrative board's decision to the environmental court therefore seems likely. These considerations suggest that the environmental court should consider the permit application in the first instance. We therefore propose that a facility for disposal of mercury waste containing at least 0.1 per cent mercury by weight be classified as a type "A" operation, which means that the environmental court will consider the permit application in the first instance. A further effect of this provision would be that the environmental court would also be the first instance to consider the permissibility of disposal of very small quantities of mercury waste by means other than deep storage in exceptional cases. We propose that a provision to this effect governing mercury waste be inserted in the Environmentally Hazardous Activities and Health Protection Ordinance. Delegation of this power by the government is provided by chapter 9, section 6 of the Environmental Code.

Under our proposal, the provision set out below would be inserted in the annex of the Environmentally Hazardous Activities and Health Protection Ordinance (1998:899) after the heading "Radioactive Waste".

MERCURY WASTE

Facility for disposal of mercury waste containing at least 0.1 per cent mercury by weight A

This amendment would enter into force on 1 July 2002.

10 Socio-economic costs of the proposed measures, cost to the state and cost to companies

10.1 The commission's proposal to introduce a statutory obligation to store mercury waste deep underground

10.1.1 Socio-economic costs

The commission has proposed that mercury waste containing a given percentage concentration should be placed in a deep bedrock repository. The entire cost of the repository is to be borne by the waste owners. The proposal will therefore entail considerably higher costs for the corporate sector. The Swedish EPA has estimated that the cost of a deep bedrock repository capable of holding 1,000 – 20,000 tonnes of mercury waste will be about SEK 200 – 300 million. This sum is for a deep bedrock repository. This approach therefore requires the waste owners to work together. Our analysis is based on the assumption that this will be the case.

It is true that there will be the additional expense of processing and stabilising the waste, which is estimated to be at least SEK 10 – 20 per kilo. We consider that the cost of processing and stabilising the waste will not result from our proposal for a deep bedrock repository for mercury waste, since the cost of processing and stabilising mercury waste for storage at a surface facility would be at least as great. We therefore assume that only the cost of deep storage of waste will be seen as an increased cost to the corporate sector as a consequence of our proposals.

Hence, a sum of about SEK 250 million would be involved. The main companies sharing this cost would be Boliden Mineral AB, SAKAB, Eka Chemicals AB and Hydro Polymers AB. The state would also need to contribute, owing to its responsibility for the cost of disposing of batteries; see below under "Cost to the state". The allocation of the cost of SEK 250 million between the companies involved would be a matter for future negotiation. However, it may be pointed out that Boliden Mineral AB owns about half the mercury waste that will go to deep storage. The existing mercury waste containing more than one per cent mercury represents about 1,100 tonnes of mercury. In addition, there is Boliden Mineral AB's waste having a mercury concentration of 0.1 – 1 per cent, which represents a further 300 tonnes of mercury. The key factor when determining whether these 300 tonnes should also go to deep storage will be the assessment of reasonableness made by the authorities. Of these 1,400 or 1,100 tonnes of mercury, Boliden Mineral AB would contribute 500 – 800 tonnes of mercury, depending on the assessment of reasonableness made by the regulatory authorities. The chloral kali companies would contribute 200 tonnes of mercury each, and SAKAB about 100 tonnes of mercury.

The four companies are entitled to deduct their costs in their accounts. However, the waste in the possession of Boliden Mineral AB and SAKAB is largely stored. We gather that the companies have made provisions for this stored waste in the past. However, the waste owners say that the provisions were made on the assumption that the waste would be stored at the surface. Since storage deep underground is about 15 times more expensive than at the surface, these provisions are insufficient. The chloral kali companies are in a different position. In our view, their mercury will not become waste until mercury use is discontinued, which is to take place by 2010. After that, the companies will be given time to keep the waste in intermediate storage for a number of years. This means that the companies will be able to make provisions in their annual accounts for many years on the basis that the waste will ultimately be stored in a deep bedrock repository.

However, the inadequate provisions made by SAKAB and Boliden Mineral AB constitute a financial problem. The question then arises as to whether the state would for any reason bear any liability for this as a result of having introduced new legislation. It is quite clear that the state has no legal liability for the situation arising, since the legislation will not be retroactive. The question is then whether the state will have any form of moral responsibility for the situation. In our opinion, environmental policy, by its very nature, sets more exacting requirements to keep pace with technical developments and new know-how and assure a good quality environment. And companies, for their part, are hardly likely to object to this development. No, the problem seems to be rather that legislative changes will affect waste already in existence. We therefore consider the crux of the problem to be that waste has been continuously produced over a period of many years and placed in intermediate storage. The question is then who is responsible for the fact that the waste has been in intermediate storage for a long period without methods for disposing of it in an environmentally friendly way being developed and the necessary funds allocated. In our view, this is naturally primarily the responsibility of the companies involved. We consider that changes in Swedish environmental policy over a period of many years have given these companies clear indications that a particularly secure final repository for high-level mercury waste would be required and that it would be the waste owners' responsibility to finance and build the repository.

10.1.2 Consequences for small companies

As has been made clear, the large companies Boliden Mineral AB, SAKAB, together with Hydro Polymers AB and Eka Chemicals AB are almost the only ones that own, or will own, mercury waste. Thus, the proposal will essentially only affect those companies. But as we pointed out in Chapter 9, there is also a "hidden store" of mercury waste in society, which, according to the Swedish EPA's estimated, totals 200 tonnes of waste, representing 100 tonnes of mercury. Some of this waste is in the possession of consumers: municipalities are responsible for collecting this. However, the remainder comprises industrial waste, some of which may be assumed to be in the possession of small companies. Our proposal for a deep bedrock repository will include this small quantity of mercury waste. As we mentioned in Chapter 9, it may be complicated in the future for companies holding small quantities of mercury waste to ensure that it is sent to deep storage. One option is to transfer this mercury waste to waste owners that have access to suitable treatment facilities and a deep bedrock repository. If this is not possible, the new legislation offers these waste owners the possibility of applying for special exemption from the deep storage requirement. However, this is essentially no different from the present situation. Mercury waste is hazardous waste, the storage of which requires a permit. Nowadays most mercury waste is already sent to SAKAB, for example. However, transferring the waste in this way might be somewhat more expensive in future, since SAKAB may charge higher prices for accepting mercury waste because it will have to send that waste to the deep bedrock repository (see section 10.1.4). All in all, as far as companies possessing small quantities of waste are concerned, the only change potentially resulting from the proposal is that it may cost somewhat more to send that waste to a waste treatment company. However, since only very small quantities of mercury waste are involved, the change will be marginal.

10.1.3 The cost to the state

The state is not a waste owner, but does have a responsibility for the costs entailed in dealing with the mercury batteries currently in intermediate storage at SAKAB. There are about 180 tonnes of these batteries, which represents some 30 tonnes of mercury. Hence, the Swedish EPA has estimated that the cost of a deep bedrock repository will be about SEK 200 – 300 million, which, roughly speaking, represents SEK 250,000 – 650,000 per tonne of mercury. This would mean that, on the basis of their mercury content alone, the cost of sending the batteries to deep storage would be just over SEK 10 million. Processing costs would be additional to this. However, as we have pointed out, we consider that establishment of a deep bedrock repository will require cooperation between the waste owners. The exact apportionment of costs between them will be a matter of negotiation. There is SEK 50 million available in the battery fund administered by the Swedish EPA. Overall, we conclude that legislation to establish a deep bedrock repository will involve costs to the state owing to its responsibility for the cost of disposing of mercury batteries. The money available in the battery fund ought to suffice, however.

10.1.4 Socio-economic costs

As may be seen, the main costs involved in the proposal will be borne by the corporate sector. However, it would be natural for the companies involved to pass on these costs to the next stage of production so that they are ultimately borne by the consumer. Boliden Mineral AB has said that prevailing competition in the global metal market prevents it from passing on its costs to the next stage of production. Dramatically higher waste management costs have a marked impact on the ability of Swedish producers to compete in the global market. It has not been possible to ascertain the scope for the chloral kali industry to pass on its costs by way of price rises, but those companies also have to compete in an international market. SAKAB operates in the Swedish domestic market. It may become more expensive to send waste to SAKAB. But this accords with the view that the waste owners should pay the full cost of disposal. It is hard to assess the socio-economic effect of a loss of competitiveness on the part of certain companies, since many other factors are also involved. We would here like to point out that there are many examples of cases where inadequate management of hazardous waste has resulted in a high cost to society. We do not therefore find there to be socio-economic arguments against requiring high-level mercury waste to be stored in a deep bedrock repository.

10.2 Socio-economic costs of the proposed measures, cost to the state and cost to companies of the commission's proposed changes relating to the permit-issuing authorities

The commission has proposed that certain types of application should be considered by the environmental court in the first instance instead of the county administrative board, as has hitherto been the case. In our opinion, there will only be a few applications of this kind, where the decision of the county administrative board would in all probability have been appealed to the environmental court. The proposal will therefore not have any significant economic implications.

Appendix 1 - The commission's terms of reference

Coordination of further work on final storage of mercury

Directive 1999:104

Decision taken at a cabinet meeting held on 9 December 1999

Scope of the commission

A special expert will be charged with the task of coordinating and examining future national efforts being made to establish a final storage facility for waste containing mercury in a deep bedrock repository. The expert will submit proposals for a efficient solution whereby the owners of waste containing mercury assume responsibility for its final storage.

Background information

We now know that mercury is one of the most toxic pollutants. The burden placed on the environment by mercury must not increase; it must be reduced. Every additional source must be avoided. Moreover, if we are to achieve environmentally sustainable development for future generations, the problem of final disposal of mercury waste must be resolved.

In the bill entitled "Swedish Environmental Quality Objectives" (Bill 1997/98:145), the government decided that use of mercury in the chloral kali industry may not continue beyond 2010, and that, with a few exceptions, other use of mercury should be phased out by 2000.

Current use of mercury is restricted, *inter alia*, by means of various bans on goods and products containing mercury. New prohibitions are planned. The government has instructed the Swedish EPA to prepare an action programme to achieve more efficient collection of the mercury currently in circulation in society.

Swedish Environmental Protection Agency proposal for final storage

In June 1994 the government instructed the Swedish EPA to draw up proposals for final storage of waste containing mercury in Sweden. The agency submitted its proposals in a report entitled "Final Storage of Mercury" (Report 4752). The report has been circulated to various referral bodies for their review and comment.

The basis of the Swedish EPA proposals is that mercury should not be recycled; it should instead be removed from the ecocycle. It must be finally disposed of by means of safe storage. This will reduce the burden placed on the environment more quickly and also keep it at the lowest possible level in the long term as well. The Swedish EPA has compared three possible solutions: a high-quality surface storage facility, a shallow rock repository and a deep bedrock repository.

According to the EPA, a deep bedrock repository is the safest storage method over the long term, since it makes best use of natural barriers and buffers. In addition, a deep bedrock repository can and should be reinforced artificially to further reduce the risk of future emissions. This method will also compensate to some extent for our lack of knowledge about the long-term processes governing mercury dispersal. The Swedish EPA has therefore proposed that mercury waste from the chloral kali industry, goods that have been collected and some waste from smelting works be stored in a deep bedrock repository. Detailed information from the waste owners about the characteristics and quantities etc of the waste will be needed so that the right pre-treatment and final storage method can be chosen. General criteria for determining which waste is to be stored in a deep bedrock repository, and also which general requirements should govern the design and function of the deep bedrock repository should be formulated when more information is available.

On the basis of its overall cost estimates, the Swedish EPA has concluded that a deep bedrock repository is an economically feasible solution. Large savings can be made if the waste owners join forces to establish a final storage facility. Working together will make it possible to spread the fairly sizeable fixed investment costs over a larger quantity of waste and several parties, which will reduce the cost to each party. However, according to the EPA, it should be up to the waste owners to decide whether more than one repository should be built.

Some of the main waste owners involved are the Swedish state, Boliden AB, Eka Chemicals AB, Hydro Polymers AB and SAKAB. The state's responsibility extends to discarded mercury batteries, which are currently stored at SAKAB pending final disposal.

Need for a commission of enquiry

The government needs to determine what requirements may be stipulated in relation to the final disposal of mercury waste. More background information is needed in order to set a date for the compulsory introduction of a deep bedrock repository. Discussions between those involved will be needed to clarify details concerning the organisation, timetable, financing, division of responsibility and environmental factors in relation to a deep bedrock repository in Sweden, as well as the consequences it will have. Account must also be taken of the fact that the Nordic Council of Ministers is currently reviewing the possibility of a joint Nordic treatment strategy for mercury waste.

Discussions should be held between waste owners, treatment companies and others involved so as to arrive at joint solutions, which will keep costs to a minimum. It must also be borne in mind that a decision to establish a final storage facility will be preceded by discussions with the municipalities concerned and the public. A special expert should be charged with the task of producing the necessary background material.

The task

The basis of the task is to arrive at an organisationally, environmentally, financially and legally effective solution, in which owners of mercury waste accept their full and long-term responsibility for final storage of the waste.

The appointed expert will

- initiate and conduct discussions with waste owners and others involved with regard to the potential for establishing a deep bedrock repository, in the first place in Sweden; failing that, as part of a joint Nordic project;

- analyse and describe market conditions having a bearing on the establishment and operation of a deep bedrock repository and propose a way of assuring long-term responsibility for, and funding of, the repository;
- propose a party to have overall responsibility for the repository or organised joint operation by various stakeholders;
- present a proposed coherent strategy, general guidelines and specific action, including a timetable for the establishment of suitable repositories and treatment facilities for Swedish mercury waste;
- analyse and describe the best way for the state to deal with discarded mercury batteries;
- present material supplementary to the Swedish EPA's cost and impact assessment of various storage options in order to obtain a complete picture of their socio-economic implications.

The Swedish EPA report entitled "Final Storage of Mercury" and comments by referral bodies on that report are to form the basis for the enquiry. The appointed expert will examine mercury waste management methods in other countries, primarily within the European Union.

The appointed expert will consult the waste owners and public authorities involved. It ought to be in the waste owners' interest to produce the relevant material for use in the enquiry, eg, with regard to the composition, characteristics and quantities of waste containing mercury. The appointed expert will be able to obtain help in obtaining relevant material from the authorities. On the basis of available information, the expert will propose the criteria that should apply to mercury waste that is to be stored in a deep bedrock repository.

On the basis of the proposed criteria, the expert will estimate the socio-economic costs of the proposed measures, their cost to the state and their cost to companies. Various ways of financing the measures to be taken should be specified together with the cost estimates. The task includes proposing the amendments to laws and ordinances the expert considers should be made.

Report

The appointed expert will present a report on the enquiry to the government on or before 1 July 2001.

(Ministry of the Environment)

1 Legal aspects of a deep bedrock repository

This appendix examines the legal issues that may be of relevance to the creation of a deep bedrock repository. The analysis is presented in abridged form in Chapter 7 and elaborated in full here. In section 1.1 we discuss the potential permit application procedure for a deep bedrock repository and in 1.2 we analyse responsibility for a repository of this kind. Section 1.3 examines the possibility of enacting legislation to oblige owners of mercury waste to send their mercury for storage in a deep bedrock repository.

Section 1.4 presents an outline of EC law provisions governing waste. In section 1.5 we discuss whether EC law could present an obstacle to Sweden establishing a deep bedrock repository for mercury waste, and in section 1.6 we examine whether that legislation would then oblige Sweden to accept and store foreign mercury waste as well.

Finally, sections 1.7 and 1.8 present tax law and competition law aspects of a deep bedrock repository.

1.1 Permit procedure for a deep bedrock repository

Establishment of a deep bedrock repository for mercury waste will require a permit under the Environmental Code in the specific manner set forth in the Environmentally Hazardous Activities and Health Protection Ordinance (1998:899). Under the annex to that ordinance, a facility for storage of hazardous waste is classified as a type "A" operation if more than 1,000 tonnes of waste is received annually and otherwise as a type "B" operation. A type "A" operation requires a permit issued by the environmental court, a type "B" operation a permit from the county administrative board. The quantity of waste thus determines whether permit applications are to be considered in the first instance by the environment court or the county administrative board. The decision of the county administrative board may be appealed to the environmental court and then to the superior environmental court. Leave to appeal is required for appeals to the superior environmental court. If the environmental court is the body of first instance, its judgment may be appealed to the superior environmental court and thence to the Supreme Court, for which leave to appeal is required.

In both cases an appeal could be lodged by a private individual affected by the facility, or, under certain conditions, by environmental organisations, or by the Swedish Environmental Protection Agency, the Legal, Financial and Administrative Services Agency and the county administrative board. Finally, the municipality is also entitled to appeal if the facility may be regarded as concerning matters of public interest.

The facility will also require a permit under the Hazardous Waste Ordinance (1996:971). These permits are issued by the county administrative board in the first instance. However, if a permit application for the operation has already been considered under the Environmentally Hazardous Activities and Health Protection Ordinance, a further application will not be necessary.

Under the Environmental Code, however, the government is obliged to assess the permissibility of a facility if the majority of the waste will be coming from other facilities and the annual quantity will exceed 10,000 tonnes. It appears to be out of the question that there will be such large amounts of mercury waste and the government is will not therefore be obliged to consider permissibility. On the other hand, it may be assumed that the government would be entitled to make a discretionary assessment of permissibility, since a final storage facility could be described as having the kind of far-reaching implications envisaged by the Environmental Code. If the government chose to make an assessment of permissibility, the municipality concerned could block the construction of a deep bedrock repository by exercising its right of veto.

In practice, a discretionary assessment of permissibility could be made as follows: Under section 8 of the Environmental Impact Assessments Ordinance (1998:905), a public authority or municipality that is aware that preparations are being made to carry on operations meeting the requirements for a discretionary assessment of permissibility can notify the government of this. The government can then reserve the right to assess permissibility. An application for the operation must be submitted to the normal permit-issuing authority, which will prepare the matter and then remit it to the government. Where the normal permit-issuing authority is the environmental court, the court will prepare the matter and, instead of delivering judgment after the main hearing, it will remit the matter to the government, stating its own opinion. Similarly, a county administrative board prepares the matter to the point of making a decision and then remits it to the government. If the government decides to permit the operation, the issue of permissibility will be deemed to have been resolved and will not be considered further. The detailed conditions governing the operation will instead be determined. When it considers permissibility, the government can decide to impose specific conditions on the party responsible for the operation. Once the government has decided to permit an operation, it will be remitted back to the normal permit-issuing authority, which will set the more detailed conditions. Its decision as to those conditions can probably be appealed via the usual channels.

Thus, assuming that the government did not choose to make a discretionary assessment of permissibility, it would thus fall to the environmental court or county administrative board to consider issuing a permit for the facility.

However, it would be possible for the court or authority to invoke a statutory blocking mechanism (*stoppregel*), thereby referring the matter to the government. If the environmental court or county administrative board that would normally consider the permit issue finds that the operation may be expected to cause substantial damage or detriment, the permit issue must be referred to the government, which must decide whether there are exceptional reasons for allowing the operation in any case. Bearing in mind that the bill preceding the Environmental Code mentions hazardous waste facilities as an example where the *stoppregel* could be invoked, this would appear to be a definite possibility (Bill 1997/1998:45, part 2-3, p 27). The Swedish Environmental Protection Agency can also demand that the government decide the matter, provided that the environmental court is the permit-issuing body (but not where the county administrative board decides the matter). Since the quantity of waste involved determines whether the environmental court or the county administrative board is the permit-issuing authority, the quantity of waste will also determine whether the Swedish EPA can "elevate" the matter to central government level. If the government were to consider permissibility under the *stoppregel*, the provisions allowing a municipal veto would not apply.

It is up to the individual operator to obtain the documentary material needed by the permit-issuing authority to decide the matter of a permit. This duty on the part of the operator to perform studies is governed by detailed provisions of the Environmental Code and accompanying ordinances. Anyone intending to conduct operations requiring a permit under the Environmental Code or under regulations issued pursuant to the code must at the same time consult the county administrative board and any private interests it may be assumed will be particularly affected. Following consultation, the county administrative board will decide whether the operation may be assumed to involve a "significant environmental impact". The government may also prescribe that certain operations will always be assumed to involve a significant environmental impact. For example, the Environmental Impact Assessments

Ordinance (1998:905) provides that sites for the storage of hazardous waste will always be assumed to have this impact. If the operation in question will have a significant environmental impact, there must be more comprehensive consultation, accompanied by an environmental impact assessment. Here, the future operator must consult other government agencies, the municipalities, members of the public and organisations that may be expected to be affected. The consultative process covers the siting of the operation or activity, its extent, design and environmental impact, as well as the content and form of the environmental impact assessment. Consultation must take place before the future operator has made any decisions with regard to these issues.

The applicant must then prepare an environmental impact assessment (EIA), which must accompany the permit application. If the operation may be expected to involve a significant environmental impact, the EIA must contain a description of the operation or activity, including information on siting, design and extent, and must also describe how harmful effects are to be avoided or mitigated. It must also contain information about the effect on human health and the environment, and details of alternative sites and designs. EIAs for operations that cannot be regarded as involving a significant environmental impact must contain information to the extent necessary in the light of the nature and scope of the company.

1.1.1 Conclusion

In summary, the government could choose to consider permissibility under the relevant provisions. The question would then be determined by the government alone, although the municipality concerned would then be able to decide the matter by using its statutory power of veto. If the government refrains from considering permissibility, it will fall to the environmental court to hear the permit application for the operation if the quantity of waste will exceed 1,000 tonnes a year; otherwise the application will be considered by the county administrative board. However, these two bodies could use the statutory blocking mechanism known as the "*stoppregel*" to refer the matter to the government. The Swedish EPA could also "elevate" the question to central government level using this mechanism, provided the quantity of waste exceeds 1,000 tonnes a year. The municipal veto could not then be used. Regardless of who considers the permit issue in the first instance, the application will be preceded by comprehensive consultations under the Environmental Code.

1.2 Who will be responsible for a deep bedrock repository?

The provisions governing responsibility/liability in the Environmental Code are found in three places. All reflect the "Polluter Pays Principle" (PPP). This means that the polluter must pay the cost of the action necessary to maintain an acceptable environment. The operator is responsible for taking preventive measures in relation to current or former activities. The operator or property owner is responsible for site remediation and the operator may be liable for damages. The various forms of liability are not entirely distinct from one another in the Environmental Code.

Chapter 2 of the code begins with the following provision.

> *"Persons who pursue or who have pursued an activity or taken a measure that causes damage or detriment to the environment shall be responsible, until such time as the*

damage or detriment ceases, for remedying it to the extent deemed reasonable pursuant to chapter 10. Where this Code so provides, the person may be liable for compensation for the detriment or damage instead."

Responsibility under this provision is intended to remedy damage and detriment by action or by financing action (Bill 1997/98:45, part 1, p 235).

Chapter 10 of the code makes it possible to impose responsibility on an operator that conducts or has conducted an operation or activity causing pollution of an area of land or water, and also buildings and facilities that are so contaminated as to represent a risk of harm or detriment to human health or the environment.

Those responsible for site remediation must, to a reasonable extent, carry out or pay for the clean-up measures necessary to prevent, stop or hinder damage or detriment to human health or the environment. Site remediation of this kind includes storage that has resulted in contamination, eg, waste sites no longer in use following discontinuation of an operation (cf. Bill parts 2-3, p 118).

As may be seen, an operator is thus liable not only for its current operations, but also former ones. The code does not define these terms. Guidance must be sought in earlier legislation and the bill to ascertain their meaning. The term "(environmentally hazardous) activity" was used as long ago as the Environment Protection Act (1969:387), which, before the introduction of the Environmental Code, was the law designed to control water and air pollution. According to case law on the interpretation of the term "activity" under that act, an activity was considered to continue for as long as pollutants were emitted into the surroundings. For example, a waste site was deemed to continue operating as long as it generated emissions regardless of the fact that waste was no longer landfilled there (cf. Ulf Bjällås and Thomas Rahm: *Miljöskyddslagen, Handbok i miljörätt* ("The Environment Protection Act, Handbook on Environmental Law"), second edition, pp 203 – 208). The bill on the Environmental Code points out that the code does not adopt a narrower approach than the Environment Protection Act in this respect. Whether or not something constitutes an environmentally hazardous activity should be seen in relation to the point at which the activity ceased and not when the actual operation ceases (Bill part 1, page 604).

The bill further states:

"If the operation is still in progress, any injunctions or other decisions issued by a regulatory authority should normally be directed at the operator. This applies particularly to operations for which a permit has been issued, since their status may require review. If the present operator is not able to remedy the detriment or bear the costs, previous operators involved in the pollution should also be sought. The regulatory authority may order a previous operator to take measures or order that the situation be remedied at the previous operator's expense. However, it should be noted that there is no requirement that the operator be sought before previous operators. There is nothing to prevent the regulatory authority from seeking first one and then the other, or both. If the operation has been discontinued, any injunctions or other decisions may be directed at one, several or all previous operators as the regulatory authority sees fit" (Bill part 1, p 361).

What would then render it impossible to identify an operator bearing liability? If the operator is declared bankrupt, the "bankruptcy estate" (*konkursbo*) assumes liability for a period. However, once the bankruptcy has been concluded, no operator with liability will exist. If there is no previous operator, it will then be impossible to hold the operator liable.

The commission reviewing these issues proposed that someone who had had considerable personal or financial influence over the operation could be held liable. The commission said:

"A person who exercises or who has exercised material influence over the operation is to be seen as the same as the person who conducts or has conducted the operation. For example, segmentation of an organisation should not result in a lower degree of responsibility for parts of the organisation. For example, a parent company is normally liable for the operations of its subsidiary." (Swedish Government Official Report 1996:103 part 2, page 405).

However, on the advice of the Council on Legislation, the government refrained from proposing to pierce the corporate veil in this way, since this did not accord with other provisions of Swedish law. Hence, the inference is that a parent company is not liable for the operations of its subsidiary.

However, limited liability for the property owner was introduced. Under chapter 10 of the Environmental Code, if there is no operator capable of performing or paying for remediation of a contaminated site, anyone acquiring the property, who knew of or ought to have discovered the contamination when he acquired it, will be liable for site remediation.

However, an operator or property owner can only ever be held liable to an extent that is reasonable. Under the wording of the legislation, an assessment of reasonableness must take account of the time that has elapsed since the pollution occurred, the obligation the responsible party had to prevent future harmful effects and other circumstances. For example, according to the bill, it should be considered whether the operation has been conducted in a manner accepted at the time, observing the conditions to which the operation was subject. It is also stressed that anyone who duly follows the conditions of a permit issued or the provisions of the Environmental Code and who thus meets his obligations with regard to site remediation, will not incur any liability whatsoever (Bill, parts 2-3, p 121 and part 1, page 360).

The statute of limitations does not apply to chapter 2, section 8 or chapter 10 of the Environmental Code. The liability of the operator or property owner is thus not limited in time. Furthermore, the burden of proof is shifted onto the operator. He must prove that the "rules of consideration" laid down by the Environmental Code have been followed.

The Environmental Code also contains provisions governing damages. Chapter 32 provides that anyone conducting an operation on real property will be liable for damages for personal injuries, damage to property and pure economic loss caused by the operation to its surroundings. These provisions are subject to the normal statutory time bar of ten years. The customary burden of proof applies, ie, the claimant must prove his claim. However, the burden of proof is less onerous than in other actions for damages. In addition, anyone causing damage bears a largely strict liability, ie, he will be liable for the damage quite independently of any intent or negligence.

Finally, it should be mentioned that the Environmental Code also imposes a duty to take out environmental damage insurance and site remediation insurance. Anyone conducting an environmentally hazardous activity is under a duty to pay premiums. The insurance policies cover damage or remediation if the party responsible is unable to pay.

1.2.1 The effect in practice

In the light of the above statutory provisions, an attempt is made in this section to describe legal liability in practice. For the sake of argument, it is assumed that a limited liability company would undertake to store mercury in a deep bedrock repository. It is also assumed that mercury would be deposited there over a given number of years and that the repository would then be sealed.

In this case, the company would be the operator. If the company were a subsidiary, it would be the operator and would be solely responsible for operations. The company, although not its parent (if any), would be responsible for the final storage facility.

The operation would be regarded as continuing for as long as the repository generated emissions. It is not clear how long this would be, but it may be assumed that very small emissions would be produced over a very long period, theoretically many millions of years. Several ice ages are expected to come and go during this time. With the present legislation, it is difficult to view these emissions any differently from other emissions. The inference is thus that the environmentally hazardous activity of a deep bedrock repository could be regarded as continuing for millions of years. It is debatable whether this is a reasonable inference but on the other hand, it is difficult to adopt any other view, legally speaking. Hence, the company would essentially be formally responsible/liable in perpetuity. The fact that the repository would be sealed has no legal relevance.

If the company were to transfer its operations to any other party during this period, its responsibility would endure, provided it was in some way responsible for the pollution. If it were declared bankrupt without any prior transfer, there would be no operator with liability. The property owner might then be held liable for site remediation of the contaminated property. If the property were transferred by the company or its *konkursbo* ("bankruptcy estate"), ie, by the receiver, the new property owner could also be held liable.

The company's liability would render it liable to remedy damage or detriment to the environment caused by the operation. In addition, the company or the property owner would be obliged to perform or pay for the site remediation necessary to prevent, stop or hinder damage or detriment being caused to human health or the environment. But this liability would be limited in both cases by the fact that liability could only be invoked provided it was reasonable. It may be inferred from comments made in the bill that it would not be possible to hold the company liable if it had complied with the provisions of the Environmental Code and its permit conditions. A precondition for liability would instead be that the company had contravened the regulations governing the repository.

The company could also be held liable to pay damages for personal injuries, damage to property or pure economic loss.

If the company were liable for damage or remediation, but had no money, the environmental damage insurance or remediation insurance could cover the cost.

1.2.2 Conclusion

As may be seen above, the operator's formal liability for a deep bedrock repository would be very extensive. However, it is important to analyse the practical implications of this liability. Liability can only be invoked insofar as is reasonable. It follows from the bill on the Environmental Code that liability cannot be invoked if the operator has complied with the provisions of the Environmental Code and its permit conditions. Liability requires that the company has contravened the regulations governing the repository. In the final analysis, it may therefore be concluded that society/the state would ultimately be responsible for any necessary action when the operator's responsibility has been extinguished.

1.3 Power of the state to legislate to oblige owners of mercury to place it in a deep bedrock repository

Chapter 15, section 9 of the Environmental Code gives the government or its delegated agency the power to issue detailed regulations governing waste management. Under chapter 15, section 3 of the code, "waste management" means an operation or activity comprising the collection, transport, recycling and disposal of waste. Accordingly, there is no doubt that the government could order that anything falling within the definition of waste should be placed in a deep bedrock repository. Some of the mercury identified in the Swedish EPA report and in our terms of reference, eg, the mercury held by SAKAB, is obviously waste. However, it has been suggested that some of the mercury identified is not to be regarded as waste. This applies particularly to the mercury used by the chloral kali industry.

1.3.1 The legal definition of waste

Historically, Swedish law defined waste as articles the owner no longer wishes to have in his possession. If the articles had an economic value that the owner wished to realise, they were not waste. In a precedent concerning second-hand transformers (NJA 1991, p 460), the Supreme Court held that since the owner's intention in the case was to sell the oil, thereby making a financial gain, the oil was not to be regarded as waste.

When Sweden joined the EU, it undertook to abide by the definition of waste used in European law. This has now been incorporated in the Environmental Code. Chapter 15, section 1 of the code defines waste as follows.

> *"Waste shall mean any object, matter or substance belonging to a specific waste category which the holder disposes of or intends or is required to dispose of.*
>
> *The Government shall issue rules concerning waste categories referred to in the first paragraph."*

The definition incorporates the EC definition in the framework directive (75/442, amended by 91/156) and the waste category referred to comprises a schedule to the EU waste catalogue. The European Court of Justice is thus the final arbiter of the concept of waste. The ECJ has interpreted the concept of waste in the opposite way to the approach adopted by the Swedish Supreme Court. In Vessoso and Zanetti (C 206/88 and C 207/88), the court held that the definition of waste includes substances or objects that can be recycled. The court further said that the concept of waste does not require that the owner has ruled out the possibility of the substance or object being reused economically by others.

1.3.2 Does the mercury used by the chloral kali industry constitute waste?

Our visit to Hydro Polymers AB and Eka Chemicals AB revealed that these companies may be expected to deal with their own mercury waste in the form, for example, of sludge that has previously been stored. Hydro Polymers AB has sent its mercury waste to SAKAB, which has processed it and then delivered pure mercury back to the company. Eka Chemicals AB has recently started a soil treatment unit. The aim is to convert all mercury waste into pure mercury. Both companies also use pure mercury as liquid electrodes in their "amalgam process". It may thus be concluded that the chloral kali industry will have only metallic mercury when mercury use is phased out in 2010. It is estimated that each company will have about 200 tonnes of mercury at that time, which means that some 400 tonnes from the chloral kali industry will need to be stored in a deep bedrock repository.

Mercury waste belongs to the waste category to which chapter 15, section 1 of the Environmental Code refers. However, as may be seen from that provision, it only constitutes waste if its owner disposes of it or intends or is required to dispose of it.

When mercury use by the chloral kali industry is phased out, the mercury will constitute a residual product in the industry. Since the industry will no longer be able to use the mercury, it must be assumed that the companies will "intend to dispose of it". One hypothesis might be that the companies would regard the mercury as having a value and would therefore want to export it to other chloral kali companies in Europe, for example, assuming that they were still using the mercury process in 2010. However, whatever view they do adopt, it may be argued on the strength of the ECJ's interpretation of the concept of waste that the mercury would nonetheless constitute waste. It should also be borne in mind that the Swedish ban on exporting mercury under the Prohibition etc. in Certain Cases in Connection with Handling, Import and Export of Chemical Products Ordinance (1998:944) prevents the companies from exporting mercury.

It may here also be discussed whether it might not be possible for the state to make it compulsory for waste owners to dispose of their mercury as provided by chapter 15, section 1 of the Environmental Code, which would then mean that the mercury was to be seen as waste. When the provision was introduced, it was discussed whether it was in conflict with the protection of property enshrined in the constitution. The Swedish constitution lays down the principle that no-one may be forced to give up property to the state unless this is necessary in furtherance of essential public interests, and that anyone so obliged will be entitled to compensation. The conclusion drawn in the bill on the Environmental Code (Bill 1997/98:45 part 1, p 422) is that since the provision does not in fact impose a specific obligation on the owner, it is consistent with the constitution. However, if an obligation of this kind were to be introduced, the issue of compensation might be raised.

1.3.3 Conclusion

The state can order that all mercury to be regarded as waste must be placed in a deep bedrock repository. One key issue is whether the mercury used by the chloral kali industry for the amalgam process is to be regarded as waste. We consider a reasonable interpretation to be that the mercury used by the chloral kali industry will constitute waste when its use is phased out. It will then be possible to introduce a statutory obligation to place this waste in a deep bedrock repository.

1.4 EC waste legislation

1.4.1 Primary law

The common waste policy has two purposes. Apart from protecting the environment, it is intended to facilitate the implementation of the single market. In addition, the ECJ laid down in the Wallonia case that waste is a product and, as such, is essentially subject to free movement (C 2/90, Commission v Belgium, Wallonia, 1992, ECR 1; see further below regarding this case).

Free movement

Free movement is one of the pillars of the EC Treaty. The fundamental principle is that where there is no secondary legislation, free movement of goods is to be assessed on the basis of Article 30 (now 28) of the Treaty of Rome. This article prohibits member states from imposing quantitative restrictions on imports or introducing any measures with the same effect. Any trade regulations potentially affecting trade between member states are seen as measures having the effect of quantitative restrictions.

There are some exceptions to the freedom of movement laid down by this article. These are contained in Article 36 (now 30) of the Treaty of Rome. Of interest here is the exception for public security and the protection of health and life of humans, animals or plants. It is intended that the exception should apply restrictively. According to the legal literature, this means that the considerations relied upon must be specifically defined and must not be intended merely to improve the environment, for example (see Magnus Hagman: *EU:s lagstiftning – en översikt* ("EC Legislation – An Overview"), 1994, page 100).

Reliance on the exception also requires that the measure be in proportion to the objective, ie, it must be necessary to achieve the desired protection. Nor may the measure be a covert barrier to trade or arbitrary discrimination. It must be emphasised that the exceptions do not apply where secondary EC legislation exists.

In the Cassis de Dijon case (C-120/78 Rewe v Zentralverwaltung, 1979 ECR 649), the ECJ created an opening for member states to take action in furtherance of interests other than those mentioned in the former Article 36. Since then , the court has held that environmental protection may also be an interest sufficient to justify restricting free movement (cf. case C-302/96 Commission v Denmark, 1988 ECR 4607). Here too, however, it is required that there be no secondary legislation, that there be a proportionate relationship between the measure and its objective, and that the measure be non-discriminatory.

Environmental articles

Originally, the Treaty of Rome did not provide any separate basis for adopting common environmental regulations. The first regulations of this kind were adopted under Article 100 of the Treaty of Rome, which deals with the common market, and Article 235, which gives the community a form of residual power. In 1987 the environment became a separate area of policy under the Treaty of Rome (Articles 130r – 130t).

Environmental legislation is now almost always adopted under either the former Article 100a (now 95) or the former Article 130s (now 175) of the Treaty of Rome. Article 100a is used for regulations needed to implement the single market, ie, almost solely for regulations governing the environmental characteristics of products. Other environmental regulations are adopted under article 130s, eg, regulations governing emissions from industrial plants and waste. It is highly significant whether environmental regulations are adopted under Article 100a or 130s, since if 130s is the basis, each member state may impose more stringent requirements, which is more difficult if the regulation is adopted under Article 100a.

The reason for this is that if a regulation is adopted under Article 130s, it follows from Article 130t (now 176) that member states may adopt stricter, but not inconsistent, measures. This means that the national measure must be of the same type and have the same purposes as the community measure. It must also be consistent with the EC Treaty and must therefore not be a covert trade barrier or a means of arbitrary discrimination. If, on the other hand, the regulation has been adopted under Article 100a, the purpose is to achieve harmonisation, which essentially means that member states cannot depart from them and introduce stricter requirements for environmental reasons, for example.

However, the environmental guarantee in the Treaty of Rome (Article 95.4-10) was strengthened in 1997 and its effect is now as follows. If, once the Council or the Commission has decided to introduce a harmonisation measure, a member state considers it necessary to retain national provisions based on essential needs under the *ordre public* (public policy) clause of the Treaty of Rome, ie, for reasons of public order or security or protection of human or animal health – or relating to environmental protection or occupational health and safety – it must notify the Commission of these provisions and the reasons for retaining them. In addition, a member state may even introduce new provisions, provided they are based on new scientific evidence as to a way of solving a problem that has arisen after the decision to introduce the harmonisation measures. Within six months the Commission must approve or reject the national provisions once it has ascertained whether they constitute a means of covert discrimination or a covert trade barrier, and whether they will obstruct the workings of the single market. If the Commission does not make a decision within six months, the national provisions will be deemed to have been accepted. The environmental guarantee has not been tried in court.

The Wallonia case

The Wallonia case in 1992, mentioned earlier, serves to illustrate the points made above as to the ability of member states to restrict free movement on the basis of environmental considerations, and as to scope for non-adherence to secondary law. The case concerned a ban in the Belgian region of Wallonia on accepting waste originating from other states or from other Belgian regions. The main reasons for the ban were health and environmental considerations. The Commission claimed that that ban was contrary, *inter alia*, to Directive 84/631 on transboundary movements of hazardous waste, and the former Article 30 of the Treaty of Rome, which prohibits quantitative import restrictions.

The ECJ held that Directive 84/631 had introduced a complete system for hazardous waste, including transboundary movements of this waste and that this system had a built-in mechanism enabling member states to object to any given delivery of hazardous waste. The court did not consider the wording of the directive allowed a state to introduce a general ban. The provisions of the directive rendered the ban contrary to EC law. Hence, since comprehensive secondary legislation was in place that allowed no scope for a general ban, Belgium could not enforce such a ban. It should also be noted that the directive in question had been adopted under Articles 100 and 235, which, unlike Article 130s, do not give member states the power to introduce stricter regulations. The environmental guarantee had not yet been formulated at that time.

At that time movements of non-hazardous waste were not governed by secondary legislation and a ban on that waste was therefore solely to be judged in the light of the former Articles 30 and 36 of the Treaty of Rome. The court held that the ban was not contrary to the ban on quantitative import restrictions because it had been imposed to achieve necessary protection of the environment. Nor could the ban be considered discriminatory, since account must be taken of the particular nature of the waste and of the principle laid down in Article 130r on the environment that environmental damage should primarily be remedied at source. Accordingly, waste should be deposited as close to its place of origin as possible to keep movements of waste to a minimum.

1.4.2 Secondary law

Movements of waste have been regulated in considerable detail by secondary law. This is because this area is the one that has given rise to conflicts with the provisions on free movement. Directive 84/631, which was discussed in the Wallonia case, has since been replaced by Regulation 259/93 on the supervision and control of waste within, into and out of the EU.

However, since 16 July 1999 there has also been a directive on the landfill of waste. The directive deals with landfill from a general perspective; the details remain to be formulated. There is also a framework directive (75/442), which contains fundamental provisions on waste, and which mirrors the EU's waste strategy. The EU also has a waste policy, which was revised in 1997. Directive 91/689 on hazardous waste defines hazardous waste. Finally, Directive 91/157 on batteries may also be mentioned. There are many other directives on waste, although these are of no relevance here.

Regulation 259/93 on the supervision and control of waste within, into and out of the EU

This regulation governs all types of waste, hazardous and non-hazardous, and its legal basis is Article 130s. Certain types of waste, such as radioactive waste, are excluded, however. Moreover, as may be seen from the name of the regulation, it governs not only waste movements between member states, but also between member states and other countries. The regulation incorporates the international commitments made by the EU by acceding to the UN Basle Convention and the fourth Lomé Convention, concluded with the ACP nations.

The regulation lays down requirements for exchange of information between countries when waste is moved. In view of the principles of subsidiarity and self-sufficiency, member states are here given the right to oppose the import of waste for disposal, either in the form of a general ban, or by systematically objecting to movements of foreign waste. However, these measures must be consistent with general EC provisions on free movement of goods. For example, it is unlikely that a general ban will be allowed to have an arbitrarily discriminatory effect. It is up to anyone intending to transport waste from one member state to another to notify the competent authority in the country of origin, the transit countries and the country of destination. Before the waste is transported, there must be an agreement in which the recipient undertakes, as soon as possible and within not more than180 days, to provide the notifying party with a certificate showing that the waste has been disposed of in an environmentally acceptable manner.

But this right to oppose movement for disposal does not apply to hazardous waste produced in a country in such a small quantity that the establishment of new specialised facilities for disposal in that country would not be economically viable. Under the regulation, the particular problem of disposing of such small quantities requires cooperation between the member states and the possibility of using a community procedure. However, according to information received from the Swedish Environmental Protection Agency, this exception is not used in practice. Moreover, the agency considers that political considerations will prevent its use. Member states are anxious to remain on friendly terms, which would not be possible if they were able to force each other to accept waste.

Framework Directive 75/442

The directive lays down general provisions on waste. It applies to hazardous as well as non-hazardous waste. But if the provisions of Directive 91/689 on hazardous waste differ, the latter provision will take precedence. It is stated that the member state's prime obligation is to prevent the creation of waste and also to use technical measures to make it less hazardous. In the second place, waste must be recycled; only if this is not possible does the question of landfill arise. The aim is that the EU as such should be self-sufficient in waste management; each member state should also have this objective. Movements of waste should be restricted.

The best available technique should be used for final disposal. The "polluter pays principle" applies.

Directive 91/689 on hazardous waste

The directive originally provided that waste was to be defined as hazardous if it had a given composition and characteristics. However, a list of hazardous waste was introduced in 1994. Listed waste is covered by the hazardous waste provisions. Mercury waste is on the list. The directive also stipulates that hazardous waste must not be mixed unless there are environmental reasons for so doing, and lays down a general permit requirement for management of hazardous waste. Member states must ensure that hazardous waste is registered and publish a hazardous waste management plan. It is possible for member states to impose stricter, as well as temporarily different, requirements if this is called for on the grounds of urgent security or environmental reasons.

Directive 99/31 on the landfill of waste

The directive was adopted under Article 130s. Its purpose is to protect the environment from pollutants when waste is landfilled. It provides that preventive measures must be taken when waste is landfilled. Among other things, member states must take steps to ensure that liquid waste is not received at a landfill site. Waste is divided into three categories according to the degree of hazard it poses. However, the question of criteria governing the type of waste that may be placed in each landfill class has been referred to an implementation committee. This is to have formulated the criteria within two years of entry into force, ie, by 16 July 2001. In the interim, member states may set their own criteria. It is also intended that the committee should decide when and how a landfill site should be closed and also to define the obligations of the authorities responsible for landfill sites.

It is further stated that the polluter pays principle makes it necessary to take account of all environmental damage caused by a landfill site. The quantity of waste intended to be landfilled and the degree of hazard it poses should be reduced and recycling encouraged. Member states should be able to use the principles of subsidiarity and self-sufficiency when disposing of waste at community level and at national level.

Directive91/157 on batteries

This directive provides that batteries must be separately collected, whether they are to be stored or recycled.

1.5 Could EC law present an obstacle to Sweden deciding that mercury waste must be placed in deep storage?

First of all, it should be mentioned that EC regulations apply directly in the member states in the same way as domestic legislation. In addition, member states are under a duty to enact the provisions contained in directives.

EU waste strategy is that waste should in the first place be reused, and in the second place recycled. However, it is also realised that landfill is necessary in some cases, which the enactment of the landfill directive clearly shows. The EU's general approach to waste is thus scarcely likely to pose an obstacle to Sweden establishing a deep bedrock repository for mercury waste. Nor does the landfill directive, in its present form, constitute an obstacle. But the criteria that will be formulated for waste and landfill sites may naturally involve requirements as to the type of waste that may be placed in a deep bedrock repository or the characteristics of that waste. According to the Swedish EPA, which is participating in the criteria development process, these will not present an obstacle to a Swedish decision to place mercury waste in deep storage. It should also be borne in mind that the directive was adopted under Article 130s, which means, *per se*, that Sweden can set stricter requirements, the emphasis being on *stricter* requirements, not *different* ones.

1.5.1 Conclusion

Taking all the above into consideration, only Directive 99/31 on the landfill of waste might impact on the decision to establish a deep bedrock repository in Sweden. According to the Swedish EPA, the directive will not present an obstacle to a Swedish decision to place mercury waste in a repository of this kind.

1.6 Could EC law oblige Sweden to accept and store foreign mercury waste?

Waste is a product and, as such, is essentially subject to the principle of free movement. Free movement is governed by the Treaty of Rome, which also provides a number of exceptions (former Articles 30 and 36). The ECJ judgment in the Cassis de Dijon case has extended the scope for exceptions. However, none of these sources of law applies in the presence of secondary legislation. The first matter to be ascertained is thus whether there is any secondary law covering receipt and storage of foreign mercury waste.

Regulation 259/93 governs supervision and control of movements of waste within, to and from the European Communities. It states that member states are entitled to oppose the import for disposal. This means that there are provisions of secondary law and that the former Article 30 on free movement does not apply. Hence, it is not possible to claim an exception under the former Article 36 and its broad interpretation in the case law.

True, it could be argued that the regulation, as its name suggests, only refers to transport and that storage of foreign mercury waste is not governed by secondary law. However, it is clear from the regulation that it is broader than its title. A comparison with the Wallonia case also shows that this argument is unfounded. In that case the ECJ held that it was possible to place a ban on disposal of hazardous waste, since a transport directive gave member states the right to make objections. It is thus clear that the receipt and storage of foreign mercury waste is governed by secondary law.

The regulation unequivocally entitles members states to oppose the import of waste in general for disposal. However, hazardous waste produced in such a small quantity that establishment of new specialised facilities for disposal in that country would not be economically viable is excluded. According to the regulation, the specific problem of disposal of such small quantities requires cooperation between the member states involved and the possibility of using a community procedure. The exception has been especially designed for countries such as Luxembourg. Mercury waste is hazardous waste and it therefore appears as if the exception might apply in this case. From a strictly legal viewpoint, the inference is thus that there is a slight risk of Swedish being obliged to accept small quantities of mercury waste.

The regulation was adopted under Article 130s and, as pointed out in section 1.2.1, Sweden could introduce stricter, but not different, national regulations. It would be difficult to see a national ban on even small quantities of hazardous waste as anything other than a "different" regulation, since the purpose of the exception for small quantities of hazardous waste is to achieve cooperation between member states. On this basis, it would be difficult for Sweden to introduce a national ban on small quantities of hazardous waste on the strength of Article 130t. It also seems doubtful whether the exception could be circumvented using the "environmental guarantee", since this would require existing national legislation or new scientific evidence.

However, it is also important to note that the export of waste is not merely a legal issue; it is also very much a political one. The Swedish EPA has said that the exception is not used in practice and is of the view that political considerations will prevent its use in the future. Member states are anxious to remain on friendly terms, which would not be possible if they were able to force each other to accept waste. Politically speaking, a realistic view would therefore be that Sweden will not become obliged to accept foreign mercury waste.

1.6.1 Conclusion

The inference to be drawn from the above is that it follows from EC regulations that Sweden will most likely be able to oppose the import of foreign mercury waste, but that this cannot include foreign mercury waste produced in small quantities. However, according to the Swedish EPA, the exception is not used for small quantities of hazardous waste. Hence, Sweden would not be obliged to accept foreign mercury waste.

1.7 Fiscal law aspects of a deep bedrock repository

The issue of interest here is whether it is possible for the waste owners to make provisions in their accounts for the future costs of placing their mercury waste in a deep bedrock repository.

For tax purposes, business income is calculated on an earnings basis. A company can make provision in its accounts for costs relating to income. The matter is complicated by the fact that waste management costs usually occur long after the income. An income is booked when goods are delivered and the company receives payment or makes out an invoice. If the cost incurred for the goods does not arise until later, the company can make a provision to cover a future cost. However, for this to be allowable, the cost must be likely and possible to calculate. If the cost will not arise until a very long time has elapsed, this may make it more difficult to calculate, and reduce the apparent likelihood that it will arise. As a result the tax authorities may not accept the provision as an allowable cost.

As a result of this problem a special regulation for nuclear waste was inserted in the Municipal Tax Act in 1979. The regulation is still in place and may be found in the notes to section 24 (6). Here it is stated that companies operating a nuclear power plant may treat provisions made in their accounts to cover the expense of future management of spent nuclear fuels, radioactive waste and the like as an allowable cost.

One of the waste owners concerned here has said that it has had problems with the tax authorities regarding the allowability of its provisions for future mercury waste management costs. The problems appears to be that the company has not succeeded in establishing the likelihood of the future costs; the tax authorities have demanded contractual or statutory support for the cost. Another problem is that the waste owners themselves have not anticipated that the mercury waste will have to be placed in a deep bedrock repository. As mentioned earlier, the cost of storing mercury waste in a deep bedrock repository will be 15 times higher than storage in a surface facility. This may mean that the companies' own calculations of the necessary provision may be inaccurate, with the result that their provisions are insufficient.

It has become evident that possible inadequacy of these provisions in companies' accounts is a financial problem for the companies involved. We can try to alleviate the problem by considering inserting a special provision in the Municipal Tax Act clearly stating that the cost of storage in a deep bedrock repository is allowable in the same way as for nuclear waste (see Chapter 8 for further details).

1.8 Competition law considerations

As will be seen below, we consider it necessary for the waste owners to work together to create a deep bedrock repository. A joint approach by the waste owners could be formalised in a number of ways. One option would be to form a joint company to deal with the mercury waste, as has been done for waste from the nuclear power industry (see chapter 8). That company would then be able to contract out the treatment and storage of the waste to external companies or perform these operations itself. Would this give rise to any competition law considerations?

First of all, it may be said that the comments below are very much of a preliminary and hypothetical nature, since an analysis of the competition law position requires a specific agreement. However, the following might be said.

Agreements concluded between businesses are subject to the Competition Act. Agreements designed to prevent, limit or distort competition in the market in an appreciable manner or having this effect are prohibited. However, the Swedish Competition Authority may grant exemption from this prohibition. It is also possible to ask the authority to issue a statement as to whether it considers a given form of cooperation to fall within the statutory prohibition. In the present case it clearly cannot be argued that a joint operation agreement on waste management would be intended to restrain competition. The decisive factor would instead be whether the result of this joint operation was in fact in restraint of competition. This would involve performing a "competition test", ie, an evaluation of the potential effects of the agreement on the relevant market. Here, potential future inhibition of competition will suffice. There are also certain guidelines to assist the evaluation. Agreements to perform joint research projects or joint development of research findings for industrial use do not affect the position of the parties in competition terms. However, an agreement will be in restraint of competition if a company that is not a party to the agreement is prevented from gaining access to products or technology. If companies are not competitors, they cannot restrict competition between themselves by forming consortiums. However, the key issue is whether it is possible in a given instance that companies may compete with each other in relation to the services in question. But even if consortiums are formed by companies in competition with one another, there will be no restraint of competition if no single one of the participating companies is able to perform a certain undertaking on its own.

Report 8105

A Safe Mercury Repository

A translation of the Official Report SOU 2001:58

In 1994, the Swedish Environmental Protection Agency was given the task of formulating proposals for the terminal storage of waste containing mercury. In its report to the Government the Agency proposed terminal storage in a facility deep down in the bedrock.

The Government subsequently appointed a committee to further look into, in consultation with the waste owners, how to proceed in bringing about an underground storage for mercury waste in bedrock. An official report was presented in June 2001 ("Kvicksilver i säkert förvar" SOU 2001:58), advocating proposals for legislation and ways forward. This report has now been translated into English by the Swedish Environmental Protection Agency.

ISBN 91-620-8105-5.pdf
ISSN 0282-7298

NATURVÅRDSVERKET