The final disposal facility for spent nuclear fuel

ENVIRONMENTAL IMPACT ASSESSMENT REPORT

GENERAL SUMMARY

POSIVA OY

PREFACE

It is established in the Nuclear Energy Act that all nuclear wastes originating in Finland within the context of the utilization of nuclear energy, or as its result, must be handled, stored and permanently disposed of in Finland. According to such legislation, the nuclear power companies are responsible for all measures associated with the management of nuclear waste and the appropriate preparation of these measures, as well as in regard to liability for the related costs. Such funds are to be gathered in advance and paid into a State fund designated for the management of nuclear waste. By the spring of 1999, FIM 5.7 billion had accumulated in this fund.

The nuclear power companies themselves look after the treatment of low and medium level wastes as well as their final disposal, along with the measures associated with the decommissioning of facilities and intermediate storage within the areas of the power plants.

The management of spent fuel following intermediate storage is the responsibility of Posiva Oy, which is mutually owned in full by the nuclear power companies. Posiva Oy is planning and implementing the final disposal. The management of spent nuclear fuel first became an object of planning over 20 years ago, when the power plants were being built. In 1983, efforts towards selection of the final disposal solution and location were launched.

For the purpose of the establishment of a final disposal facility, Posiva must seek a decision in principle from the Council of State. The application must be annexed with an Environmental Impact Assessment report as determined by law.

The effects on the environment exerted by the project are being evaluated in terms of environmental impact assessment procedure. Formally speaking, this procedure began when Posiva, in February 1998, delivered its assessment programme on environmental impact to the contact authority concerned, i.e., the Ministry of Trade and Industry. The assessment programme was a plan for the evaluation of environmental influence prepared by Posiva, which had responsibility for the project. On the basis of this programme and statements thereby derived, Posiva has evaluated the environmental impact and formulated its evaluation report. The assessment report is on view in its entirety in, among other places, all Posiva offices as well as in the libraries of the municipal siting alternatives for final disposal facilities, i.e., Eurajoki, Kuhmo, Loviisa and Äänekoski.

In handling the application for a decision in principle, the Council of State requests the Finnish Centre for Radiation and Nuclear Safety for a preliminary assessment in regard to the safety of the plant, and asks for the view of the Municipal Council respective to the intended disposal municipality concerning the establishment of such a facility. The prerequisite to a favourable decision is that the municipality in question accepts the establishment of the facility in its area; nor have any aspects come to the fore which would, on the basis of the same, indicate that the project may not be safely realized.

This publication represents a summary of "The Final Disposal Facility for Spent Nuclear Fuel: Environmental Impact Assessment Report."

For presentations to audiences, an interactive final disposal-related exhibit has also been included.

PUBLIC INVOLVEMENT

An important part of EIA (Environmental Impact Assessment) procedure was the interaction occurring between the developer and other participating interests within the process. Municipal inhabitants were drawn into this participation and encouraged to express queries by which means the objects of evaluation would be recognized. In order to achieve public participation, the following means, among others, were utilized:

- EIA-related announcements as distributed to households and summer residents
- materials made available at Posiva's local offices
- public meetings
- small group encounters
- information and discussion meetings arranged for the councils
- collaborative or follow-up groups for public and union officials as established in the municipalities
- exhibitions in which the opportunity to provide feedback was provided
- municipal inquiries and thematic interviews
- regional administration-based discussion meetings
- central administration-based seminars
- discussions initiated in the columns of newspapers.

In its evaluative work, Posiva took the inspection requirements presented by contact authority into consideration, of which the most central in their statement were:

- the assessment of not implementing the project
- the comparison of various technical solutions in reference to base alternative-related impact
- the retrievability of spent fuel in the various alternatives
- examination of the effects of radiation in manner suitable for general audiences
- the taking into account of various population groups in respect to interaction
- determination of project scope in relation to the amount of spent fuel.

ALTERNATIVES IN THE MANAGEMENT OF SPENT FUEL

Finland's four nuclear power plant facilities at Olkiluoto and in Loviisa produce approximately one-fourth of Finland's electricity. Each year, part of the fuel specific to the reactors is exchanged for new. This spent fuel contains so many radioactive elements that it must be stored away from living nature. The fuel rod assemblies used in these power plants are found in interim storage water pools. The usage of these pools can safely be continued for decades with comparatively minimal maintenance measures. Such intermediate storage is not, however, intended to be the final solution: rather, the aim is to find a permanent solution which does not require supervision or servicing.

Final disposal

In the **base alternative** for final disposal in accordance with the Posiva plan, the fuel is encapsulated in compact and durable copper canisters placed at a depth of about 500 metres within the bedrock. These canisters can either be placed into a tunnel or in bored deposition holes. In terms of environmental impact, these **variants** do not substantially deviate from each other.

In the EIA report by Posiva, the main alternative considered within the context of the base alternative is that by which the canisters are installed in deposition holes bored in the tunnel floor. The holes are sealed with bentonite clay and the tunnels with bentonite, crushed stone and concrete plugs.

The basic solution does not render care or supervision mandatory on the part of future generations. Nevertheless, it shall also be possible to retrieve the fuel to the earth's surface subsequent to the closure of the final disposal facilities.

Other final disposal alternatives

In a so-called **"hydraulic cage,"** the canisters are packed in a silo located at

a depth of a few hundred metres, where they are cooled for 100 years prior to closure of the silo. The silo is insulated against ground water circulation with sand, bentonite and a certain type of drainage system. Keeping the drainage system open is, however, difficult to ensure. The impact of superterranean functions would be akin to that of the base alternative.

In the **"deep hole"** proposition, the canisters would be positioned in holes bored at a depth of several kilometres under the earth surface. At the moment there is insufficient data available in regard to bedrock this deep, so implementation would require appreciable and prolonged investigation. The holes would be plugged with concrete, asphalt and bentonite. Retrieval of the canisters would be exceedingly problematic. The impact of superterranean functions would be akin to that of the base alternative. The "deep hole" solution would necessitate a new siting process and further study of extreme-depth subterranean bedrock conditions.

Reprocessing and final disposal

In **reprocessing**, the uranium and plutonium contained within the spent fuel are separated from other actinides and fission products, and used anew. This separation is based on chopping the fuel and dissolving the same in nitric acid. The solution which remains contains highly active waste, which is hardened into glass. This highly active waste would **have to be finally disposed** of in a corresponding manner to that incorporated with spent fuel. Reprocessing would also give rise to low and medium level waste subsequently requiring final disposal.

Reprocessing is rational if there is use for the separated fuel materials. Reprocessing could be a reasonable alternative in the event that the utilization of nuclear energy in Finland is carried on and substantially increased. In practice, this would mean the construction of new nuclear power plants as well as the building of reprocessing and final disposal facilities.

Interim storage at Olkiluoto

Nuclide partitioning, transmutation and final disposal

In theory, the number of long-lived radionuclides can be reduced by radiating them in a neutron flux. This is termed **transmutation**. For this, new types of reactors or stand-alone transmutation equipment are required. With the present reprocessing facilities available, only uranium and plutonium can be separated; thus considerably more highly developed **nuclide partitioning** (reprocessing) would be needed.

For the moment, transmutation represents a possibility for the future similar in comparison to fusion reactors, in regard to which the practical applications as successful would be time-framed for several decades from now. It is not conceivable to get rid of all nuclear waste by means of partitioning and transmutation, as new activation products originate in the equipment system as well as medium and low-level wastes within the

The reprocessing plant along with power stations at Sellafield, England. A transmutation facility including reprocessing functions would also require a large industrial area. The size of the reprocessing plant is comparable to the final disposal facility illustrated on page 7.

Summary of evaluation alternatives.

Ethical and ecological principles	Base alternative and variations	Hydraulic cage
1. Protection of man and nature	Wastes are isolated from nature so that active maintenance is unnecessary.	Wastes are insulated against nature so that active maintenance is unnecessary.
2. Protection of future generations	The multiple barrier principle supports the isolation of wastes as long as they may present a danger.	Wastes remain separated from nature as long as hydraulic insulation is operationally effective.
3. Avoidance of burden on future generations	Does not require action on the part of future generations but does not prevent it either.	Does not require action as long as hydraulic insulation is operationally effective. Retrievability is dependent on packaging.
4. Operational safety of facilities	Can be implemented by means of strict release criteria.	Can be implemented by means of strict release criteria.
5. Prevention of misuse of nuclear materials	The illicit seizure of nuclear wastes would be arduous, costly and easily discernible.	The illicit seizure of nuclear wastes would be arduous, costly and easily discernible.
Technical implementation		
1. Technical maturity level	Based on technology available in Finland.	The technology required is already in existence.
2. Readiness for selection of disposal site	The required investigations have, for the most part, already been carried out.	Research already undertaken can be utilized to its advantage.
3. Costs	Costs have been anticipated.	Much costlier than the base alternative.
4. Need for transportation	Transportation shall be needed to a certain extent regardless of disposal site.	Transportation shall be needed to a certain extent regardless of disposal site.
5. Suitability for other energy system(s)	Appropriate for the nuclear energy system respective to a small nation.	Appropriate for the nuclear energy system respective to a small nation.
Applicability from the perspective of present legislation and regulations		
1. Compliance to the Nuclear Energy Act and its regulations	Fulfills the requirements.	Fulfills the requirements in the event that the hydraulic insulation is operationally effective without maintenance.
2. Compliance to the safety regulations of the Finnish Centre for Radiation and Nuclear Safety.	Can be shown to comply.	Long-term indication of functionality in respect to hydraulic insulation is problematic.

separation process. In practice, partitioning and transmutation would make the construction of new reactors as well as a reprocessing and **final disposal facility** necessary.

Other final disposal solutions

Deep-sea sediment layers, polar glaciers and the launch of waste into outer space have also been proposed as final disposal solutions. These proposals cannot be given serious consideration as alternatives. Final disposal in polar glaciers is technically difficult to fulfill; a particular problem relates to the consequences of continuous glacier movement. Some researchers consider the positioning of wastes within oceanic seabed sediment levels as fairly risk-free, but such a solution is – on the basis of internationally ratified agreements – out of the question. The dispatch of waste into the reaches of outer space is not a realistic option, given the presently available technology, due to its risk criteria and substantial cost. These solutions would obligate the transfer of wastes outside Finland, which would be in opposition to the present legislation.

The evaluation and limitation of alternatives

Reprocessing would not intrinsically alter the need for final disposal-related placement nor its resultant risks, but would lead to significant additional expense. Transmutation technology represents a possibility for the future, the practical applications of which are, in the event of success, nevertheless time-framed for several decades into the future. Counting on transmutation technology would result in procrastination in regard to decision-making, i.e., the so-called **zero alternative**, as reprocessing and transmutation, together with new reactors, will not eliminate the need for final disposal. Resorting to reprocessing or transmutation would lead – at least over the short term – to more extensive environmental impact than that respective to the base alternative. Nor do deep holes or the hydraulic cage offer more favourable safety or environmental protection benefit than that posed by the base alternative. They would become substantially more expensive and necessitate additional continuing research and development. In terms of social influence, they do not significantly deviate from the base alternative.

Only **the base alternative and related variants** are, at the moment, alternatives deserving of attention for the implementation of final disposal in Finland. Since the environmental impact respective to these variations does not, to an appreciable degree, deviate from the effects derived by realizing the base alternative, Posiva has concentrated only on the 'zero alternative' and base alternative in its estimates.

'Deep hole'	Reprocessing and final disposal	Nuclide separation, transmutation and final disposal
Wastes are isolated from the environment in such a manner that active maintenance is not needed.	Useful materials are separated for further use; the rest are isolated from nature.	Useful materials are separated for further use; the rest are separated from nature.
Reliable assessment is not possible given the available data.	Final disposal can be implemented in the same manner as in the base alternative.	Final disposal as above; period of danger associated with wastes is shortened.
Does not require action, but retrieval of wastes is virtually impossible.	Final disposal can be implemented in the same manner as in the base alternative.	Requires future generations to develop the technology required.
Errors in handling may result in consequences difficult to control.	Reprocessing results in more releases from power stations.	Nuclide separation results in more releases than power stations.
Illicit seizure of nuclear wastes would be very difficult and dangerous.	The possibility of nuclear waste seizure is dependent on supervision.	Would also create potential for the production of nuclear weapons.
May rest in practice on available technology.	Based on technology employed abroad.	The technology needed is non-available.
Requires new sorts of site characterization and the development of investigation methods.	Depends on method of implementation. Siting of reprocessing plant as with power plant.	Depends on method of implementation. Siting of separation facility as with power plant.
Costs difficult to assess.	Much costlier than the base alternative.	Costs unknown as the technology is non-available.
Transportation would be needed to a certain extent regardless of disposal site.	Many kinds of transport required.	Many kinds of transport required.
Appropriate for the nuclear energy system respective to a small nation.	Poorly appropriate to a small nuclear energy system.	Mandates long-term commitment to the use of nuclear energy.
Fulfills requirements in the event that safety can be ensured.	Both reprocessing plant and final disposal facility should be built in Finland.	Separation, transmutation and final disposal facility should be built in Finland.
Hardly complies to requirement for complete isolation.	Regulations are lacking in respect to reprocessing.	Regulations are lacking in regard to separation and transmutation.

PROJECT LIFE CYCLE

DECISION IN PRINCIPLE AND SELECTION OF SITE

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INVESTIGATION PHASE 2001 – 2010

- construction of underground characterization facility
- underground research as required by construction license application

CONSTRUCTION LICENSE

▼

CONSTRUCTION PHASE 2010 – 2020

- construction of final disposal repository
- superterranean construction work
- investigations and experimental use for operational licence

OPERATIONAL LICENCE

▼

OPERATIONAL (FINAL DISPOSAL) PHASE 2020 –

- transport of fuel to encapsulation plant
- sealing of fuel in canisters
- placement of canisters in bedrock
- backfilling of disposal tunnels
- excavation (as required) of new disposal tunnels

SEALING PERMIT

▼

DECOMMISSIONING AND SEALING PHASE

- dismantling of radioactive sections respective to encapsulation plant and transport to final disposal repository
- backfilling of tunnel system and sealing
- dismantling of buildings which are non-adaptable for further applications
- landscaping of dismantled building areas
- possible measures following sealing

BASE ALTERNATIVE

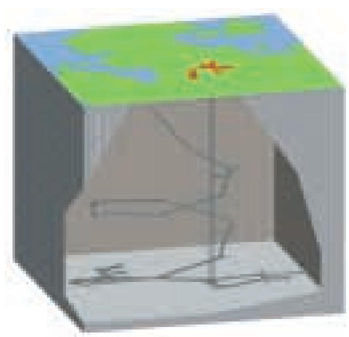
Accumulation of spent fuel

Detailed plans for final disposal of the fuel respective to the present nuclear power plants have been undertaken. The possibility that new nuclear power stations may be built in Finland, and that their fuel may be ultimately disposed of within the same facilities, have also been taken into account in this planning. For example, two 1500 MWe nuclear power stations functioning for 60 years would raise fuel quantities by about 5000 tU. The following cases have been examined within the assessment:

1. The present power plants shall function for 40 years, in which event the total accumulation of nuclear fuel shall be approximately 2600 tU.
2. The present power plants shall function for 60 years, in which event the total accumulation of nuclear fuel shall be approximately 4000 tU.
3. Changes in environmental impact if the amount of spent fuel were to continue increasing.

Investigation phase

For the purpose of underground characterization, shafts (1–2 in number) or a combination of access tunnel and shaft are to be excavated, as well as the required research facilities. The access tunnel, within which it is possible to operate a vehicle, is inclined. Through research performed underground, the best applicable rock volumes shall be localized for the construction of the deep repository. The characteristics of the site are to be examined as well as verified. It shall also be possible to test and confirm the implementation technology deep in the bedrock. Transport capacity relative to the investigation phase shall be approximately 50 vehicles/day and the average number of workers 20. Following the completion of the excavation work, this particular phase shall last several years.



A diagram of a rock laboratory made up of a driving tunnel and shafts, as realized in Sweden.

Construction phase

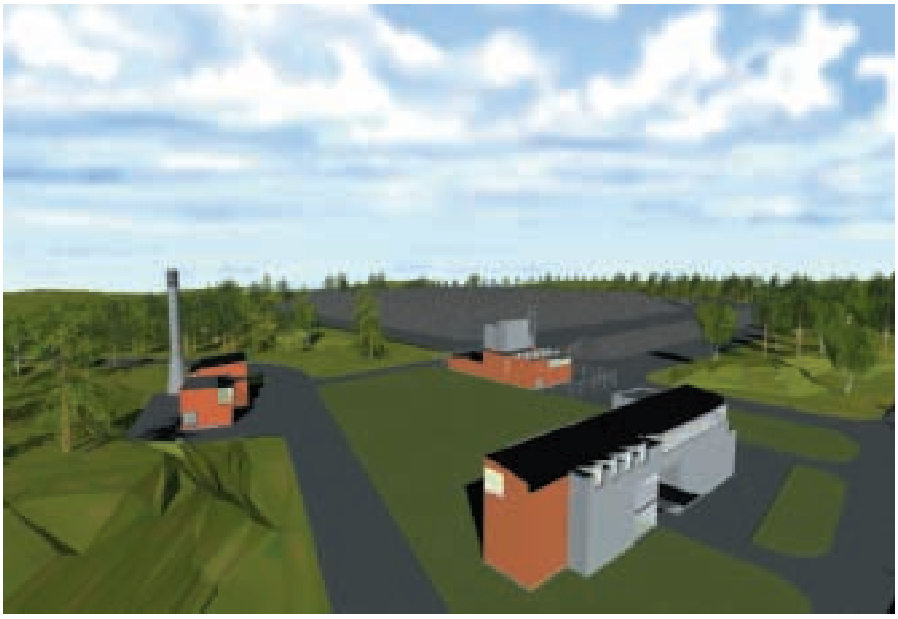
The final disposal facility shall consist of underground repository and superterranean buildings. The buildings are to converge in linkage with the encapsulation plant and work shaft. The encapsulation plant is planned as an independent unit, but at the power plant site it could also be built in connection with the present interim storage facilities.

The following are to be completed on the surface:

- encapsulation plant and associated office building
- work shaft construction and related office building
- electrical and heating centre
- storage area for bentonite containers
- accumulation and crushing area for broken rocks
- building material store
- visitors' centre, guest houses
- storage areas for explosives and detonator caps
- accumulation area for construction wastes
- re-fuelling site, yards and parking areas
- untreated water and waste water-related facilities (Kuhmo)
- basic road repairs (Kuhmo and Äänekoski).

During the construction phase, the shafts, central tunnel and ten or so disposal tunnels required shall be excavated. During the operational (final disposal) phase, more disposal tunnels shall be excavated in accordance with need. Alternatively, all disposal tunnels can be excavated already during the construction phase. The broken rocks are to be transported to the earth's surface along a work shaft or access tunnel. Rock material shall be

Deposition holes are bored into the floor of the final disposal tunnels respective to the fuel canisters.



An example of buildings planned in conjunction with the work shaft. At the front, the office building together with research facilities; on the right the work shaft building, and on the left the heating facility and waterworks. There is an accumulation area for broken rock and crushed stone in the background.

utilized in the foundation work and for backfilling the tunnels, both in broken rock and crushed stone form. During the construction phase, traffic shall comprise approximately 250 vehicles per day. An average of 140 positions of employment will be created.

Operational (final disposal) stage

The spent fuel is transported by special transport to the final disposal site. In respect to road transportation, it is possible to use 1–2 transport casks, and by rail and sea 2–4 casks may be utilized. In the event that two casks are incorporated in transporting, this should be arranged between Loviisa and Eurajoki at four-month intervals on average and to Kuhmo or Äänekoski each two months on average.

In the encapsulation plant, the fuel assemblies are transferred from the transport cask to the final disposal canisters. The diameter of the canister is about one metre and it is composed of two sections. The outer copper container acts as a corrosion shield and the inner canister, which is made of nodular cast iron, assures sufficient mechanical strength. The canisters are delivered to the plant in readymade form.

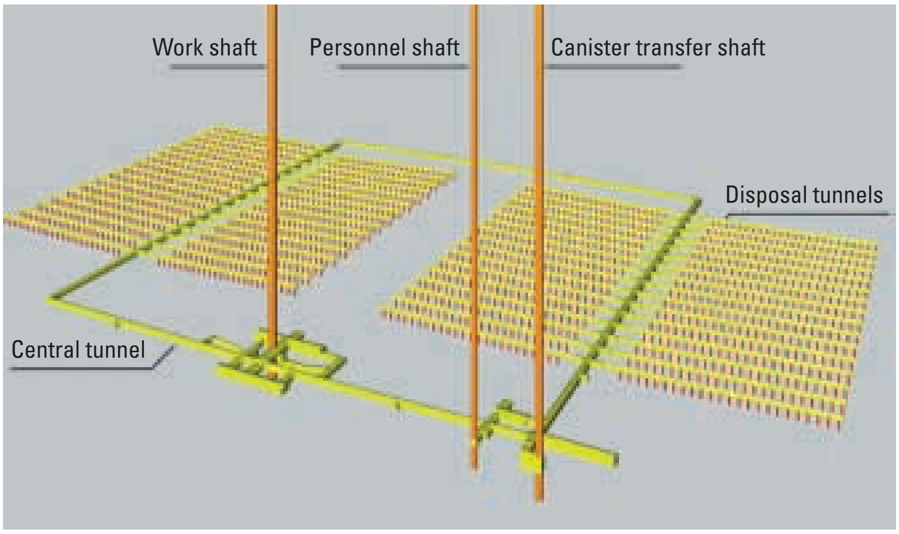
An example of buildings planned in conjunction with the encapsulation plant. The latter is backmost on the left, above it on the right is the office building, in front on the right there is a visitor's centre and on the left there are four buildings designed for guest accommodation.

After the fuel assemblies are situated into the canisters, the lid respective to the inner iron section is sealed by bolts. After this, the outer copper lid is set into place and the canister is transferred to the welding chamber. The canister is closed by welding the lid into the body and the tightness of the seal is inspected. The canister is conveyed to the final disposal repository by lift.

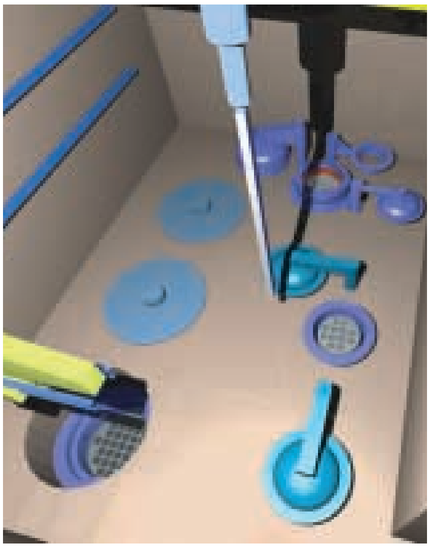
The transport vehicle places the canister into a deposition hole which is ultimately filled with bentonite. The disposal tunnels are backfilled with crushed stone simultaneous to the placement of the canisters. Traffic respective to the final disposal phase totals approx. 330 vehicles per day. About 120 positions of employment will be created.

Decommissioning and sealing phase

After all spent nuclear fuel has been ultimately disposed of and the disposal tunnels backfilled, dismantling of the active parts proper to the encapsulation plant shall begin, together with transfer to the final disposal repository. The structures and systems relevant to the operational (final disposal) stage are disassembled within the repository. At the same time, backfill of the facilities with crushed stone, bentonite and concrete structural sections is initiated. In the event that there is no further use for

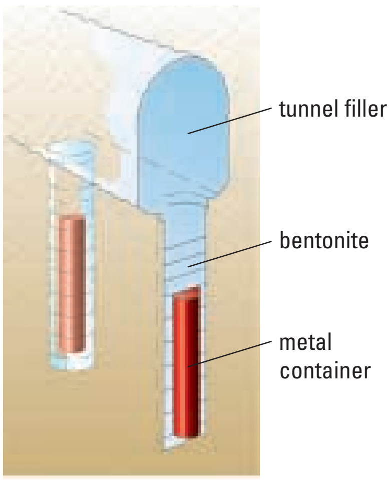


An example of the positioning of shafts, central tunnel and final disposal depository on one level. The tunnels can also be situated on several levels.



In the encapsulation plant, the transport cask is docked to the station visible on the left. Remote-controlled handling apparatus positions the fuel assemblies one-by-one into the canister linked to the station backmost on the right.

For 16 years, fuel was returned from Finland to the Soviet Union. Transfer of a transport cask from vehicle to train wagon. The locomotive speed limit was 40 km / hour.



Canister as disposed.

Loviisa road transport was, on average, 35 km / hour.

A ship built for the conveyance of Sweden's spent fuel.

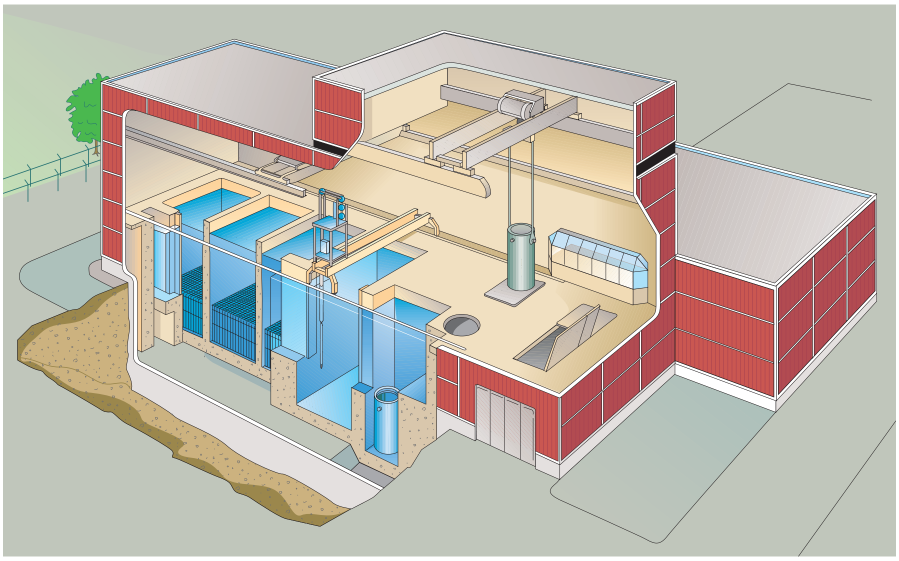
the buildings, they can be demolished and the area landscaped. Traffic proper to the decommissioning and sealing phase shall total about 140 vehicles per day. A marker can be left at the site of the repository for the notice of future generations.

NON-IMPLEMENTATION

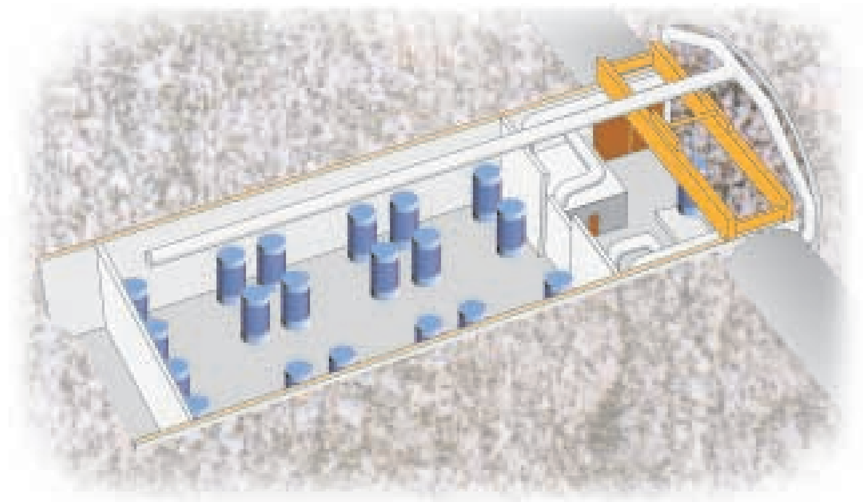
According to the resolution in principle by the Finnish Council of State in 1983, as well as the decisions reached by the Ministry of Trade and Industry in 1991 and 1995, the final disposal site must be selected by the end of the year 2000, and final disposal readiness must be established by 2020. In the program of the government receiving nomination in 1999, it is regarded as important that the plans for geologic disposal proceed in accordance with the abovementioned plan.

The schedules relative to final disposal are, in regard to Posiva, binding. In the event that, in the handling of this resolution in principle, the various quarters do not support or accept final disposal as presented, the project is set to revert to a condition of non-implementation and the decision concerning disposal would be thereby relegated to the future. In practice, this means that the spent nuclear fuel would remain stored in the water pools in Eurajoki and Loviisa.

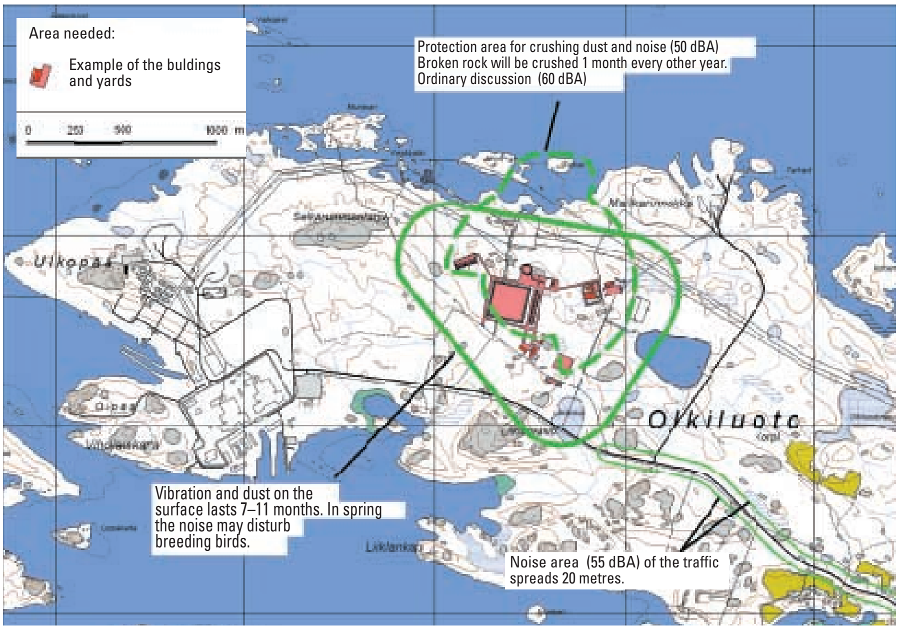
All interim storage facilities must be maintained and refurbished at specific intervals. A water pool storage could also be built underground. Additionally, spent fuel can be stored in heavy containers in dry form. A dry store can be located above or below the ground. One solution that has been suggested is to drain the groundwater specific to a 100 metre-high hill, by means of subsurface drainage. The storage location would be excavated above the groundwater. Applicable sites are unavailable within the present investigation localities, but such may be found in North Finland.



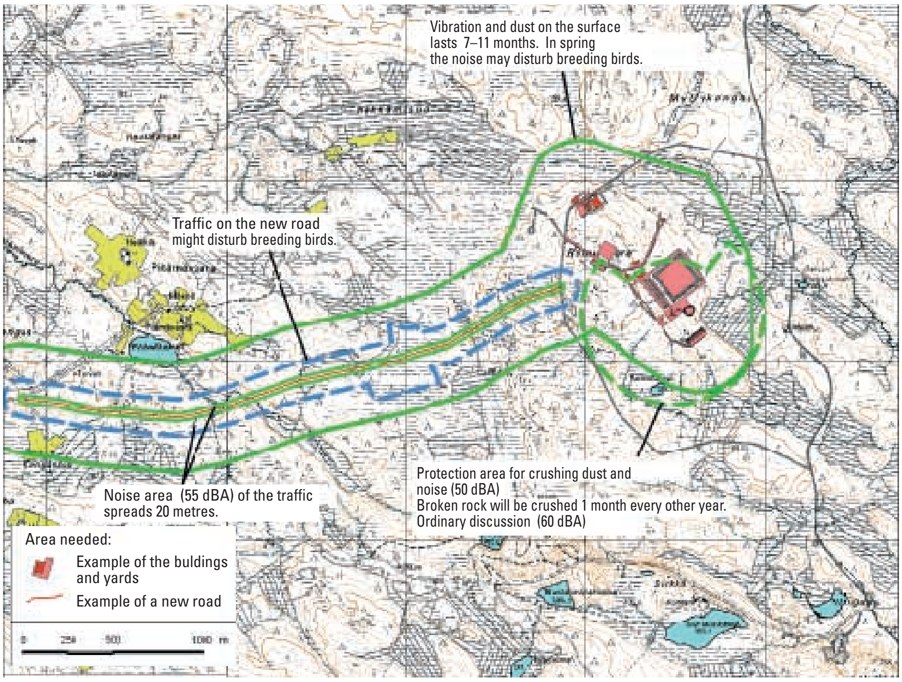
Present interim storage at Olkiluoto. The layer of water, a few metres in depth, exerts a shielding effect on radiation and cools the fuel.



Dry interim storage excavated in bedrock. Cooling is obtained by air circulation.



The incidence of noise, dust and vibration as applicable to an example disposal site, together with the land area required at Olkiluoto.



The incidence of noise, dust and vibration as applicable to an example disposal site, together with the land area required at Romuvaara Hill.

Base maps: Karttakeskus Oy Ltd, L2633/99

BASE ALTERNATIVE: ENVIRONMENTAL IMPACT

The assessment of impact is set to embrace this project during its entire lifespan, from the investigation phase to the period of post-closure. The disposal locality alternatives assessed are Loviisa's Hästholmen, Eurajoki's Olkiluoto, Äänekoski's Kivetty and Kuhmo's Romuvaara.

In evaluating environmental impact, not only the effects which can be anticipated but also the possible ramifications resulting from possible environmental accidents have been examined. The exact location of the plant relative to the final disposal site is to be subject to determination only on the basis of the subsequent underground investigations. In respect to all sites, however, a potential construction area has been defined in terms of the boundaries applicable, within which the superterranean functions would be located. In these evaluations, it is taken into account that operations may be situated anywhere within the possible construction area. In respect to this general summary, layout examples – in order to illustrate the relevant influence and impact areas – have been utilized in the map drawings.

Impact on nature, the beneficial utilization of natural resources, land use, cultural heritage, landscapes, buildings and the urban image

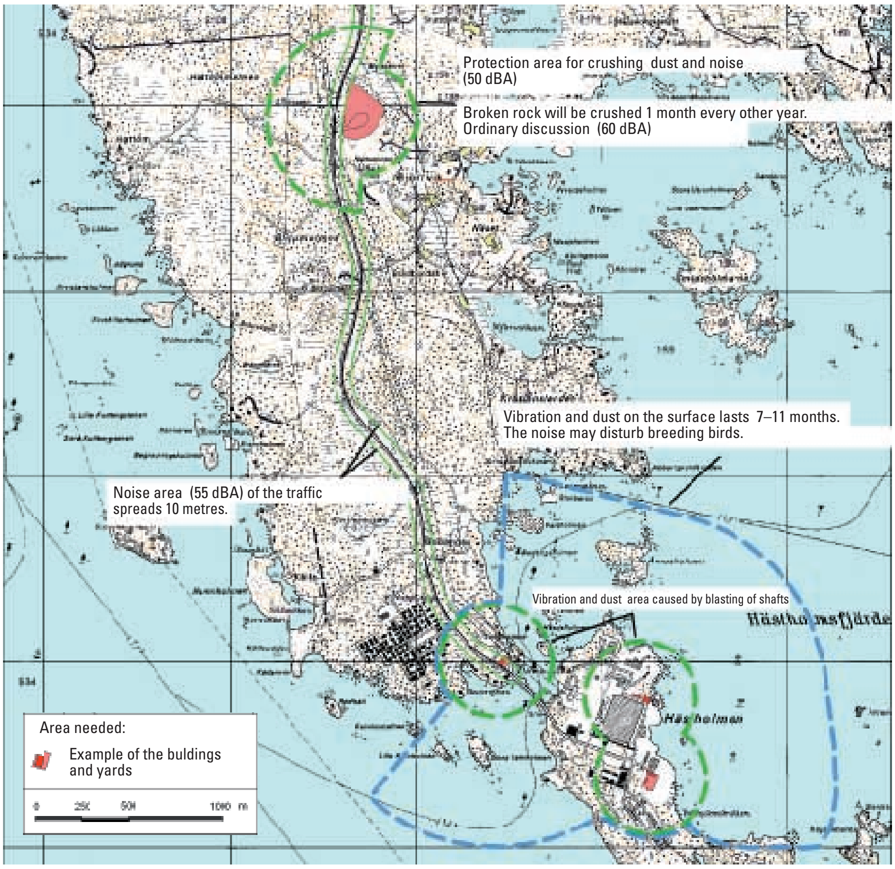
The superterranean buildings of the final disposal facility together with respective lots shall require about 15 ha of land area. In Äänekoski and Kuhmo, a new road would additionally make 10 ha of land area necessary. Cultural sites or buildings would not remain on the planned building area. Beyond the plant area, the beneficial usage of natural resources – such as mushroom and berry picking, hunting, fishing and forestry – can be continued in the current manner.

In the potential building zone or that comprising new roads, there shall not be, on either the national or provincial scale, significant nature attractions or Natura 2000 areas. Nationally endangered flora or fauna species shall also not be present. Areal ecological links shall not be severed. The Kivetty and Romuvaara areas are more wooded as compared to Hästholmen and Olkiluoto, where industry also exists. Locally important nature sites have been acknowledged and they shall be taken into consideration in planning.

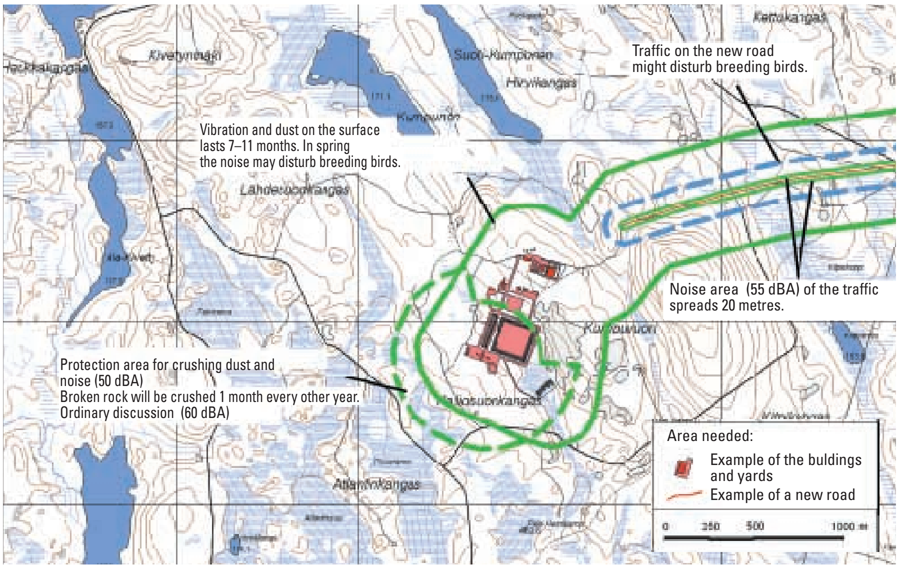
The principal section of flora obtains its water from that in the soil above groundwater; thus the groundwater decrement caused exerts no effect on these plants. The nature sites affected by the groundwater are so distant from the potential building area that influence on them would not be apparent. After closure of the facilities, the groundwater table shall return to its previous state within a few years. The elevation of groundwater and distribution of vegetation in the sites subject to groundwater influence would, however, be followed until the point of recovery. There are no groundwater affected sites at Olkiluoto.

Surface excavation resulting in vibration, dust and noise shall continue in respect to the building work for 7–11 months in total. Vibration and dust shall be discernible at a distance of 200–300 metres. In Loviisa and Eurajoki, it is possible that the present buildings shall remain in such proximity that vibration-related follow-up may be implemented. The sound of explosives may be heard one kilometre away; in sea areas as many as two kilometres away. Noise may disturb birds during their nesting period at a distance of 100–300 metres, and one kilometre away in the vicinity of the sea. Excavation shall not be performed at night. Underground excavation does not exert superterranean influence.

Broken rocks shall be crushed for a period of about one month each second year. Crushing shall not be carried on during the night. The base rating of 50 dB(A) as set in noise suppression legislation specific to crushing plant noise levels is transgressed at a point 500 metres in radius from the crushing facility.



The incidence of noise, dust and vibration as applicable to an example disposal site, together with the land area required at Hästholmen.



The incidence of noise, dust and vibration as applicable to an example disposal site, together with the land area required at Kivetty.

Base maps: Karttakeskus Oy Ltd, L2633/99

When the rock heap is utilized as a noise guard, 50 dB(A) is not violated beyond a distance of 200 metres. The noise level particular to normal conversation is 60 dB(A). The protective radius of the crushing plant as respective to dust is 300 metres. Of the excavated rock material, a large proportion shall be incorporated for various purposes within the plant area. A remaining 10–25 % shall be sold. When the quarry heap and crushing plant are positioned in the area correctly, buildings do not remain in noise and dust-specific locations, nor locally significant ornithological areas. In Kuhmo, the buildings are situated so far away that there is no need to take noise protection into account.

Transportation resulting from the plant would extend the noise zone relevant to roads on Eurajoki's Olkiluodontie Road and Loviisa's Saaristotie Road by about 10 metres (from the present 40 metres to 50 metres) as well as on Äänekoski's Murontie Road and Kuhmo's Riihivaarantie Road by about 20 metres (from the current 10 metres to 30 metres).

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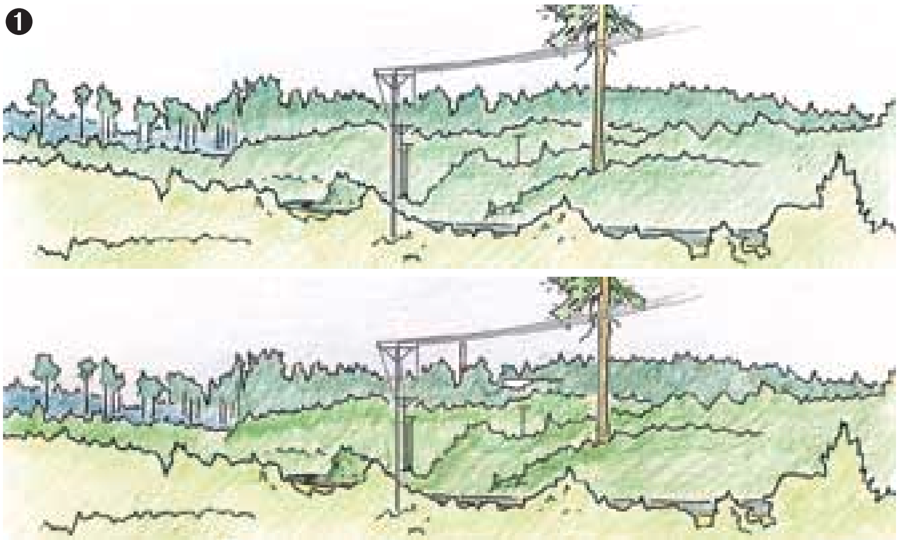

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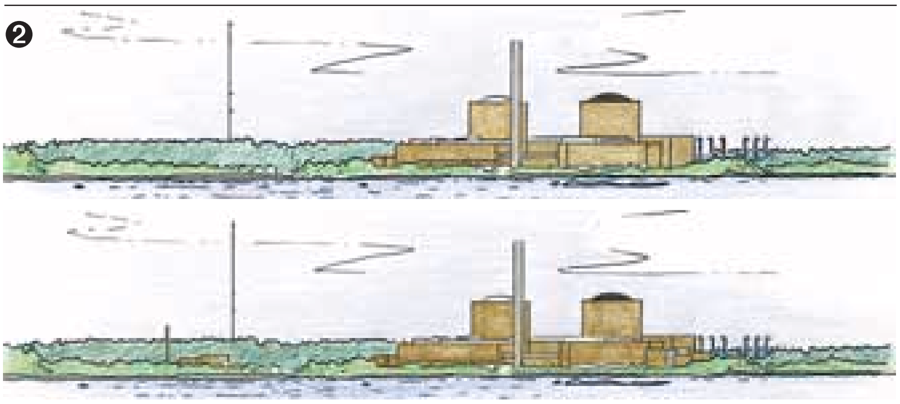

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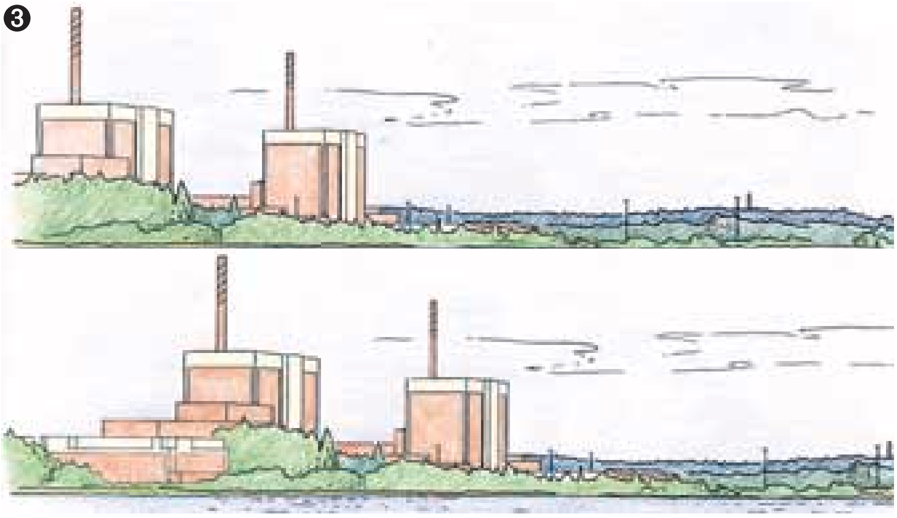

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1) View of Kivetty's Kilpismäki Hill, northwest slope: above, the current situation and below, the circumstances following construction. The present felling-related opening enables such a view.

2) View of Hästholmen's Gäddbergsö shore with cottages: above, the current situation and below, the circumstances following construction. The landscape is dominated by the power stations.

3) View of Olkiluoto southwest from the channel. In the picture above, the new structures are in the central section of the island, from which the new heating centre chimney rises on the right above the trees. In the picture below, the encapsulation plant is located to the side of the power plant. Even in this case, the power plant dominates the landscape.

4) At Romuvaara Hill, it is possible to see the top of the heating station chimney only from Särkkä Esker.

Transportation applicable to a new road section for Äänekoski and Kuhmo could potentially disturb the nesting of birds to a radius of 100–200 metres. In Kuhmo, the old road traverses a local bird site, but the new thoroughfare alternatives do not.

At Kivetty, the buildings would not be visible from behind the fully grown trees. At Romuvaara, it is only from Särkkä Esker that it would be possible to see the top of the heating station chimney. At Hästholmen and Olkiluoto, the buildings would be discernible from the sea in the event that they were positioned on the shore without cover provided by a stand of forest: in this case, too, the landscape would be dominated by the existent power plant facilities. In the event that the buildings in respect to the coastal locations were situated in the shelter of a fully matured stand of forest, only the chimney top respective to the heating station would be visible from the sea. Due to the location of the plant, the effects on the townscape cannot be regarded as significant.

Impact on human health

Impurities, noise, vibration and traffic accidents

The implementation of final disposal in terms of the noise, dust and vibration originating at various stages of the life cycle has been described above. With reference to the timing, duration and area of impact respective to crushing and surface excavation, significant effects on health are not engendered. The concentration specific to radon freed from the rock – also as applicable to the immediate vicinity – remains insignificant.

Domestic wastewater is purified by means of a wastewater purification facility, and other types of water are treated in such manner that no appreciable heath risks are caused. Concentrations of chemical elements proper to the canisters and their contents as found in the well water shall invariably come below the limits set for domestic water.

This project would incur an addition to the total emissions relative to traffic exhaust in the traffic of the locality by, at maximum, a few percentage points. The combustion gas emissions relative to the heating station do not as much as approximate the basic ratings. The augmented traffic and heating station-related emissions exert no important role from the point of view of local air quality. Taking into account the fact of daytime timing in respect to the largest proportion of traffic – as well as the minor increase in the noise zone – the effects of noise are not noteworthy. The impact on the municipal total of traffic accidents shall remain minimal: the growth in accidents leading to personal injury would see a rise of about 1–3 %.

Spent fuel transport

The anticipated impact on health rendered by the transport of nuclear fuel is non-signficant. The transport casks are built in such manner that – in the event of accidents – no leakage occurs from them in terms of significant quantities of radioactive elements. The cask is type-tested by means of collisions, fires and combinations of the same, as well as by tests involving sinking. Despite this, the consequences of severe damage have been evaluated under the following circumstances:

- elements which are easily released from the fuel quickly escape from the damaged cask into the environs,
- a situation in which the above is further complicated by a concurrent fire.

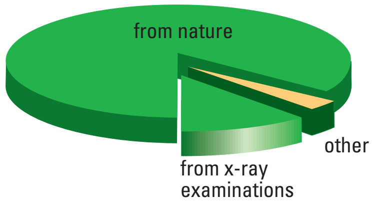
Moreover, intentional damage to the cask was assessed. Only serious deliberate damage (for example, an explosion) would require limitations on the presence of the public in the immediate vicinity of the cask.

Both the practical experiences derived and the accident-related analyses demonstrate that the risk of transport actually remains, in respect to the risk of health detriment, so small that the choice of final disposal site or transport mode do not hold significance from the perspective of the safety of the population.

Through a heavy train collision, the strength and stability of a transport cask was demonstrated. The speed of the train was over 150 km / hour. The stresses of actual licensing tests are larger than this.

	Detrimental effects
Standard transport	0
Severe damage to transport cask (e.g., rupture)	1
Deliberate damage to transport cask	36
X-ray examination on Finnish citizens	8900

The maximum amount of serious health detriment exerted by the x-ray examinations on Finnish citizens and that caused by presumed radiation as a result of transport accidents over a 50-year period, when small radiation doses are also regarded as harmful.



The average radiation dose annually of a Finn is 3.7 mSv. The dosage of radiation shows the magnitude of impact on a human being.

Operation of final disposal facility

The facility is to function in such a manner that the radioactive materials released are collected from the under-pressure areas through vacuuming the surfaces, as well as by water and exhaust air filtration. After-heat removal is carried out, and the ionizing radiation is dampened by constructing walls which are sufficiently thick. Transfer systems are to be such that potential dropping or collision forces remain minimal.

Under normal use, the dosage incurred during a period of 50 years to an individual most exposed is insignificant: smaller than the dose received from one chest x-ray. More significant **incidents** as assessed are:

- radioactive materials are not retrieved in the normal manner while emptying the transport casks
- the fuel assemblies are battered during the state of encapsulation, leading to damage of the fuel rods
- in connection with drying, the temperature rises higher than what is normal and a rod begins to leak.

The dosage relative to one such incident (in 50 years) to an individual most exposed would correspond to the cosmic radiation derived from a two-way domestic flight. The dosage (respective to 50 years) caused by such a disorder would be below one-hundredth that of the limit value, which is 0.1 mSv a year. The doses caused by incidents of disorder would be so insignificant that they would not require any sort of protective measures as particular to the environment.

The encapsulation plant is to withstand the most common earthquakes and small aircraft collisions. The initiation of a chain reaction is to be prevented by means of structural solutions. Intentional damage would be guarded against via security systems. No explosive materials are to be present within the encapsulation plant, and the combustion load is to be kept sufficiently low. The following are situations assessed as taking the hypothetical form of serious **accidents**:

- a transport cask falls, leading to breakage of all rods
- a canister falls, resulting in breakage to all rods
- the lid of a transport cask falls, leading to damage being caused to 1/10 of the rods
- a fuel assembly falls onto another one, and all rods respective to both assemblies suffer breakage
- the canister lift plummets and all rods break.

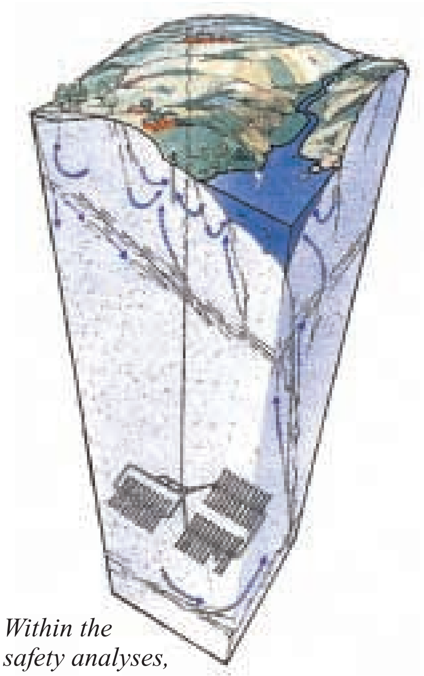
In these accident situations, particles may also be released in addition to gaseous elements. The dosage incurred to an individual most exposed would be below 0.8 mSv in 50 years, which would correspond to three chest x-rays. The doses caused would not exceed the limit value proper to accident circumstances of 1 mSv per year. Such dosage as respective to such accident scenarios would be so small that immediate protective measures would not be necessary.

Post-closure period

Deep geological disposal isolates the waste from superterranean events and prevents unintentional human penetration into the facilities. Already two metres of rock serves to stop direct radiation from the canisters. Safety is based on technical and natural barriers which multiply support each other, but are otherwise non-interdependent. These sorts of barriers include the solid form of the fuel, the final disposal canister and bentonite clay surrounding it and the rock itself. Bentonite, obtainable from nature, is a clay which strongly swells when water is absorbed within it. This clay prevents the flow of water to the surface of the canister and enables some minor movements within the bedrock without harming the canister. The bedrock limits the amount of water coming in contact with the canisters and shall create stable conditions for the same during, for instance, ensuing ice ages. The bedrock proper to the areas under investigation is 1650–2650 million years old. The events inside this bedrock after its birth and formation have been gradual and small.

	mSv / 50 yrs
Normal operation	0,2
Incident	0,001
Accident	0,8
Average radiation dose per Finnish citizen	190

The mean dosage of radiation per Finnish citizen as well as that respective to the operation of the facility, as well as presumed doses incurred to an individual most exposed to them during a period of 50 years. In this respect, it is presumed that residence is permanent in the immediate vicinity of the installation, agriculture is practised and that it is primarily food products cultivated on a self-subsistent basis which are consumed. Radiation exposure caused by usage of the facility remains, in all circumstances, so little as to be insignificant.



Within the safety analyses, the maximum doses of radiation have been evaluated through hypothesizing that the radioactive elements have entered a well which a specific person uses as his only source of drinking water.

By means of safety analysis, it is assessed as to which consequences would be engendered in the event that one or more barriers failed. There is no attempt in respect to these analyses to surmise which sort of changes the world shall, all in all, undergo in the future. The point of departure lies in the admission that our knowledge of nature and the functions of technical systems is incomplete. The uncertainty and deficiencies respective to knowledge are replaced by pessimistic simplifications, in which development is presumed to be unfavourable or the positive aspects in which significant non-certainties are involved are left unconsidered. By means of sensitivity analyses, it has been determined how various presumptions affect the outcomes. The capacity of final disposal to isolate wastes is therefore not subject to such factors in regard to which information is, for the time being, minimal.

In the most probable series of events, the canisters shall remain sealed as long as their contents pose potential detriment to human beings or other living nature (millions of years).

The tightness of the canisters is checked (ultrasound, x-ray) prior to transfer to the rock. Even so, the consequences of an incident in which there would be an unnoticed **hole** in the **canister** from the very outset are examined. In this sort of situation, the most exposed individual would receive, in terms of the extra dose, the equivalent of the dosage of cosmic radiation produced during a two-way domestic flight. The dose would be below a hundredth part of the limit value, which is 0.1 mSv per year.

Comparative information is derived from places and objects in which the situation is similar in nature to that specific to final disposal. In Gabon, there have been uranium deposits so rich that a chain reaction has been self-triggered. In this photograph we see one of 50 natural reactors of which some have been formerly active for over 100 000 years. Several tons of highly active waste were produced. The principal part of radioactive wastes (e.g., plutonium) has remained within the immediate vicinity of the reactor – even without canisters.

As another incident, a situation in which the **canister "disappears"** entirely during the outset of the next ice age and ground-water freely enters, coming in contact with the fuel, is examined. The reasons for this happening are difficult to imagine, but the purpose has indeed been to clarify, more than anything else, the role of the canister. In addition, it is hypothesized that the insulating capacity of bentonite has significantly weakened and that a highly substantial flow of saline groundwater has arrived at the same location. In this particular circumstance, the individual subject to the greatest dosage of radiation would receive, in terms of cosmic radiation, the equivalent extra dose produced by a two-way flight to Central Europe. This dose would be, at maximum, approximately one-tenth of the limit value, which is 0.1 mSv per year.

The probability of contracting a dose of radiation from a damaged canister is directly dependent on the quantity of the spent fuel. The radioactive materials from damaged canisters at various parts of the final disposal site would travel in varied directions and would end up, at different times, hundreds of metres or kilometres away from each other (not, therefore, in the same well). It is likely that increase in the quantity of spent fuel shall not have an impact on the maximum amount of individual dosage.

	mSv/ yr
Hole in canister from start	0,0008
Canister "disappears"	0,01
Average radiation dose per Finnish citizen	3,7

The mean dosage of radiation per Finnish citizen as well as the doses presumed to result from accidents as incurred to an individual most susceptible to such doses in one year (following closure).

In connection with an ice age, the possibility of an earthquake cannot be entirely ruled out. If, in the event of such an event occurring, **a fault movement** struck precisely at the point of the final disposal tunnel, all 60 of its canisters could shatter. If the location is inhabited, the radiation dose particular to the most exposed individual would be akin to the present level of background radiation, and the number of individuals prone to it would in that case be minimal and restricted to the vicinity of the facilities. During such an ice age, however, the earth would nevertheless be covered by ice and even subsequent to it, to a large extent, under cover of sea. In actual fact, the doses would remain – due to the dampening effect – minimal in comparison to normal radiation exposure.

Psychosocial impact

In the view of many citizens, final disposal is associated with the same potential threats as the use of nuclear power in general. Even if the menace of a serious nuclear accident in respect to final disposal is unreal, citizens are frequently unable to establish the difference between these issues due to the sparse details they have on the subject. Regardless of the safety analysis findings, the final disposal project elicits fears and anxieties, the influence of which is difficult to anticipate. Questionnaires and interview-based research, however, indicate that the residents of the nuclear power plant localities – Eurajoki and Loviisa – demonstrate fewer worries and fears than the people of Kuhmo and Äänekoski.

Social impact

Effects on the community structure

The jobs engendered by the facility would exert influence both directly and indirectly on the business activity in the employment region. Posiva can, within the limits of cost efficiency, favour local enterprises, since as a private company it is not obligated to arrange competition for its commercial procurements.

The facility would serve to increase labour and specialist-related travel. The nuclear power plants and final disposal repositories in Eurajoki and Loviisa are important visitor sites for their localities; a final disposal facility, therefore, could also be incorporated as a tourist attraction. Cottage rental operators, leisure landsite sellers or programme service marketers are not found in any of these localities in the immediate vicinity (within range of vision), so that related impact would not be effected. Within proximity of the Kuhmo facility, there are a few hiking paths, which nevertheless do not offer a view of the installation. Subjective influence on the users of these routes may, however, occur. Tourists have been known to reject some travel site primarily due to criminality, societal unrest and natural catastrophes.

The staff of the facility would render an effect on the number of inhabitants in the municipality to the extent that it chooses the final disposal site municipality as its residential community. This, however, would not fundamentally affect the age composition of the municipality, nor its population development. Negative mental images which may possibly be associated with final disposal do not, in and of themselves, resolve the selection of habitation site. The construction of nuclear power plants have not been shown to engender significant areal residential shifts. According to the questionnaires, the facility would not provoke the departure of residents away from the power plant localities, but it could serve to increase population turnover to some degree in respect to Kuhmo and Äanekoski.

Employment increase: impact by area.	Construction phase 2010–2020 Jobs: maximum	Operational phase 2020... Jobs
Loviisa	55–75	70–80
Loviisa , Lapinjärvi, Liljendal, Pernaja, Ruotsinpyhtää	110–130	100–110
East Uusimaa and Regional Municipality of Kotka-Hamina	155–220	120–130
Eurajoki	30–70	30–60
Eurajoki, Lappi, Rauma, Kodisjoki, Kiukainen	110–150	110–120
Satakunta	170–230	120–135
Kuhmo	90–125	110–125
Kainuu	150–215	125–135
Äänekoski	60–80	80–100
Äänekoski, Saarijärvi, Kannonkoski, Viitasaari	100–140	105–115
Central Finland	170–225	125–135

The net increase in the number of households by the year 2020 would be:

- Loviisa 50–60 households
- Kuhmo 75–90 households
- Eurajoki 20–45 households
- Äänekoski 60–70 households

In Loviisa and Äänekoski, one-tenth of the residences are already empty, so the incoming move would not exert an effect on new housing production. Demand would centre primarily on one-family houses, since a large number of the migrants would be youthful, well-educated and would – relative to the present income levels of municipal inhabitants – occupy a high income bracket. In Eurajoki and Kuhmo, the incoming migration could be reflected in local housing production. The growth in demand for general office premises as well as for daycare, schooling and other such facilities would be so small that the need could be fulfilled within the context of old building stock.

The overwhelming number of the agricultural producers specific to the nominee communities sell their products to the food industry, whose purchase decision is affected first and foremost by the actual quality of the product, not an imaginary image. An exception would be an exceptional set of circumstances in which the authorities were to restrict the sale of products.

In regard to biodynamically grown products on the part of these communities as well as direct selling occurring on the farm itself or at the marketplace, effects may be specifically engendered. On the other hand, the sales-related success of products derived from areas close to nuclear power plants does not deviate from others. Natural-produce farms are located in each of the nominee communities.

Within the noise area aligned with the example disposal sites respective to operations, there are no private residences. At Hästholmen and Olkiluoto, the facility would be visible from the sea in the event that it was situated on the shore, in the absence of a stand of trees for shielding. If the buildings particular to the coast locations are positioned, in the manner of Kivetty and Romuvaara, under cover of a mature stand of trees, no real estate price level-depreciating visual contact shall be engendered. Due to the siting of existing edifices and the blending of the facility into the landscape, no market-based decline in property value is anticipated.

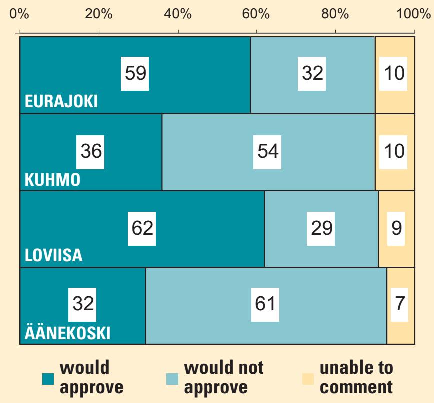
Prices in relation to real estate within the nuclear power localities have responded to general pricing developments. Only in respect to the construction phase for power plants is there a momentary rise in demand and prices. No changes are expected in terms of the value of general office and functional space, leisure properties and land.

Criteria affecting municipal economies include real estate, municipal, value-added and corporate tax, impact on increasing employment, population change, general State shares and tax revenue compensatory levelling. Kuhmo obtains, in terms of the last, so much that each new Finnish mark in taxation brought in by business activity has the effect of dropping State support. In Kuhmo, the net benefit derived annually in respect to the municipal economy would indeed be, at maximum, FIM 1–2 million, and in the other localities FIM 7–9 million.

Effects on living conditions and general wellbeing

Anxieties, worries and contradictions are focused on nuclear wastes, which may exert an impact on human well-being and living conditions. With time, however, the fears, concerns and ambivalence may disappear or, at least, see some ease. According to the research, final disposal gives rise to more of these reactions in Kuhmo and Äänekoski than in Loviisa and Eurajoki.

Technical expertise is founded on the concept according to which there are objective facts in existence which must only be discovered. The citizenry, on the other hand, emphasize the right to their own independent conceptions of the "facts:" if a human being is afraid, (s)he is actually afraid, and that fear as experienced is real. People’s ideas are significant, indeed, regardless of whether or not they are justified in the light of knowledge. From the perspective of the final disposal project, the opinions of the public are particularly important, since the decisive decision-making power rests in politically selected bodies and municipal councils as well as in the national parliament.



Distribution of opinions within the municipalities. Those interviewed replied to the question: "In the event that the investigations and safety assessment by the authorities indicated your own residential community to be safe as a final disposal site for nuclear wastes, would you accept the placement of nuclear wastes produced in Finland within the confines of your home municipality?"

A representative opinion survey was conducted of the views of the inhabitants as respective to the nominee municipalities. The majority in Eurajoki and Loviisa would approve of final disposal in their municipalities, in contrary fashion to Äänekoski and Kuhmo.

ENVIRONMENTAL IMPACT RESULTING FROM NON-IMPLEMENTATION

Non-implementation, or the ‘zero option,’ would mean the continuation of storage in Eurajoki and Loviisa; nor would it incur changes to the present set of circumstances. The expansion of storage areas within the power plant localities and refurbishment or renewal with time would represent rather small building projects which would not result in significant environmental impact. Carrying on interim storage would leave the question of the final disposal site open.

Radiation safety in regard to storage is on the same level as in the use of an encapsulation plant: significant health-related effects would not be engendered. If maintenance of the storage was for some reason neglected, the environs could be severely contaminated. This sort of situation (e.g., armed conflict) is non-imminent in respect to the immediate decades to come, but on the other hand such a possibility cannot be overruled. At the latest with the outset of a new ice age, the storage facility would be left to its own resources, unless it were transferred a considerable distance to the south. Thus, the maintenance of safety would continuously require the commitment of resources on the part of future generations.

STUDIES CARRIED OUT

The entire 20-year period of Finnish nuclear waste research has served as a sort of evaluation of environmental impact. Approximately 1700 research-related reports have been released. In addition to the national efforts, international collaboration has gone on with other countries researching similar types of the final disposal solution (Sweden, Switzerland and Canada, among others). During 1996–1999, Posiva has published approx. 60 reports linked with EIA procedure. A catalogue of these reports is available in the form of an annex included with the EIA report.

IMPLEMENTATION OR NON-IMPLEMENTATION?

The requirements of protection relevant to human beings and the environment can be fulfilled in both the final disposal and the storage alternative. The most critical difference in such a choice lies in the obligation to preserve maintenance. Non-implementation in terms of safety implies that the water pool storage facilities are serviced and supervised. Final disposal releases future generations from such commitments, but nevertheless relegates the possibility to choose, since – in accordance with the base alternative – the fuel thereby disposed can be returned to the surface of the earth.

The fuel in final disposal can later be retrieved to the earth's surface by opening the final disposal repository.

Comparison of implementation and non-implementation

Ethical and ecological principles	Base alternative and derivatives	Continuation of water pool storage
1. Protection of man and nature	Dangerous materials are isolated in such manner that no active maintenance is required	Dangerous materials are maintained in active operation, separate from nature and man
2. Protection of future generations	Safety analyses indicate that adequate isolation shall function as long as the wastes are a danger to man or nature	As long as the storage areas are supervised and maintained, no danger shall be posed to man and nature. Neglect of care could lead to environmental contamination
3. Avoidance of burden on future	Does not require action from future generations but at the same time does not prevent it	Continued maintenance of storage areas, supervision and renewal are relegated to future generations
4. Safety of facilities while in operation	Safety can be guaranteed by means of strict release criteria	Safety can be guaranteed by means of currently available principles of operation
5. Prevention of abuse of nuclear	Illicit acquisition of nuclear materials would be laborious, expensive and easily noticed	Illicit acquisition of nuclear materials would be dependent on the conditions of supervision
Environmental impact as assessed		
1. Effects on nature and utilization	Effects would be minimal and would be restricted to the immediate vicinity of the facility	Do not deviate from present power plant-related impact
2. Effects on land use and landscape	Requires a few dozen hectares of land. Effect on landscape quite limited	Do not deviate from present power plant-related impact
3. Effects on human health	Aside from possible psychosocial influence, the project has no significance in respect to human health. The effect of stress would evidently be the most minimal in the current power plant sites	Does not affect human health as long as the storage areas are maintained and supervised. Neglect of care could with time also result in health risks
4. Social effects	The project would exert positive socio-economic influence. Fears, worries, contradictions and image problems would be at their minimum at the power plant sites	No substantial positive impact. Concern for the condition of storage areas as well as their maintenance could, with time, result in social conflicts
Technical implementation		
1. Technical development level	Does not require the development of new technical methods, but room is allowed for procedural development and optimization	The technology is available in Loviisa and Olkiluoto
2. Disposal site: readiness for selection	The investigations required in respect to site selection are, in the main, complete and allow assessment	The current storage sites are appropriate for the purpose
3. Costs	Costs are moderate and they have been anticipated in the price of electricity	Cheaper than the base alternative, but over the long term the uncertainty of financing rises

EVALUATION OF SITE ALTERNATIVES

Environmental impact remains, in respect to all siting alternatives, minimal. The differences in regard to bedrock conditions are merely limited to siting along the coast or inland. Both have their own advantageous features, so that solely on the basis of safety analysis it is not possible to resolve which site is the most favourable. Final disposal can be implemented within the bedrock of each and every one of the investigation sites.

Considerable benefit is derived from final disposal in terms of the municipal economy. Due to the municipalities' tax revenue levelling system, the municipal economy net benefit to Kuhmo would, however, be smaller than that to the other localities. On the other hand, the employment increase benefits in Kuhmo would be the greatest. The appearance of anxieties and fears is most evidently less apparent in the power plant localities than in Kuhmo or Äänekoski.

Spent fuel is stored at the power plants. In the event that the final disposal facility is built in Äänekoski or Kuhmo, the amount of required fuel transport shall be double that of the power plant localities. At Olkiluoto and Hästholmen, the facility would rest on the technology respective to the power plants; at Kivetty, on the municipal engineering of Konginkangas. Untreated and waste water installations would be constructed specifically for Kuhmo. The roads of Kivetty and Romuvaara Hill would be improved.

REQUIRED PLANS, PERMITS AND RESOLUTIONS

Environmental impact assessment must be carried out in regard to the project and its alternatives prior to obtaining the required permits for final disposal. This procedure included the possibility on the part of the citizenry to state their opinions on which alternatives and effects would be assessed. Currently, with the evaluation having been prepared, citizens can also voice their views in regard to the general assessment report. The Ministry of Trade and Industry is collating these viewpoints and statements into a summary.

The final disposal facility requires three separate resolutions in keeping with nuclear energy legislation. The first is application for a decision in principle. In this decision, it is considered as to whether or not the final disposal project is in accordance with the common benefit (overall good) of society.
A general hearing on the part of the public is organized in respect to the application. In connection with the latter, the Finnish Council of State requests a statement from the municipalities nominated for final disposal as well as their neighbouring municipalities, in addition to a safety assessment from the Finnish Centre for Radiation and Nuclear Safety. It is an absolute requirement that the statement from the nominee final disposal municipality gives support to the project. The decision in principle is to be submitted further to the national parliament for ratification.

According to the nuclear energy legislation, a construction and operational license is also eventually needed for the facility. These licenses are granted by the Council of State. In this connection, the Finnish Centre for Radiation and Nuclear Safety checks into whether or not the facility fulfills the safety requirements.

The necessary forms required are a regional and master plan as well as a construction plan. In addition, an environmental permit and a water rights permit are required. The construction of a general thoroughfare to Kivetty or Romuvaara would necessitate a decision for confirmation in line with the legislation on roads and motorways. Permission from the Centre for Radiation and Nuclear Safety is needed.

The final disposal is complete when the Finnish Centre for Radiation and Nuclear Safety has verified that the waste has been permanently deposited in the approved manner. In addition to the national regulations, several international agreements and recommendations are concerned with final disposal.

PROPOSAL FOR AN ENVIRONMENTAL IMPACT FOLLOW-UP PROGRAMME

The monitoring of the effects of radiation is based on the measurement of radioactive materials as well as that of radiation itself. Typical measurement sites include air conditioning / ventilation outlets and outgoing waste water routes. Such influence can also be measured on a calculated basis, since it can be anticipated that materials derived from the facility may not, due to their small amounts, be discernible in the environment. This monitoring is already initiated prior to the beginning of operations, for the purpose of acquiring comparative data.

Concentrations are measured from the air, water, soil, organisms, agricultural and accumulated products as well as from game.

The radiation effects anticipated are so minimal that isolation of the human population for the purpose of health monitoring is regarded as unnecessary: moreover, it would not be possible to separate the potential health hazards from the group representing general incidence of illness. As needed, the health condition of those living within the vicinity of the facility can be compared with that of other populace. This is feasible by means of, for instance, the follow-up data files maintained by the Finnish Public Health Institute.

In addition to the effects of radiation, the following would be monitored:

- natural radon gases within the rock facilities
- elevation of groundwater table
- distribution of vegetation in the areas affected by the groundwater
- surface excavation-related vibration in the buildings respective to the immediate environs of Loviisa and Eurajoki
- discharge waterway proper to the new water purification plant at Romuvaara Hill (taking of sample)
- image of locality
- radiation fears
- socioeconomic impact

Other follow-up requirements are likely to be determined later in connection with the handling of permits, e.g., in regard to noise and dust.

Posiva's follow-up measurements shall be halted when the facility is closed in the manner approved by the Finnish Centre for Radiation and Nuclear Safety. During the decommissioning and sealing phase, Posiva shall formulate a proposal for the post-closure follow-up programme and remit once-for-all compensation to the State. The use of these funds shall be decided by the authorities. Final disposal shall nevertheless be carried out in such manner that it is safe and excludes post-monitoring.

In regard to follow-up subsequent to closure, it is essential to determine how the properties dominant within the bedrock return to the condition existent before construction. Such follow-up could also comprise, for instance, the measurement of radioactivity from the earth surface as well as from deep bore holes. On the basis of such holes, it would be feasible to track groundwater table, currents, chemistry, temperature, etc. From the earth's surface, it shall be possible to follow the appearance of micro-earthquakes through geophysical measurements. The illicit acquisition of nuclear materials by terrorists, for example, would require forceful action visible on the earth's surface, which could be made the object of surveillance by international satellites. The follow-up respective to closure is time-framed so far into the future that detailed plans that concern it would be most reasonable to execute later.

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