Radioactive Waste Management (Swedish Case)

NTW webinar – February 16, 2023

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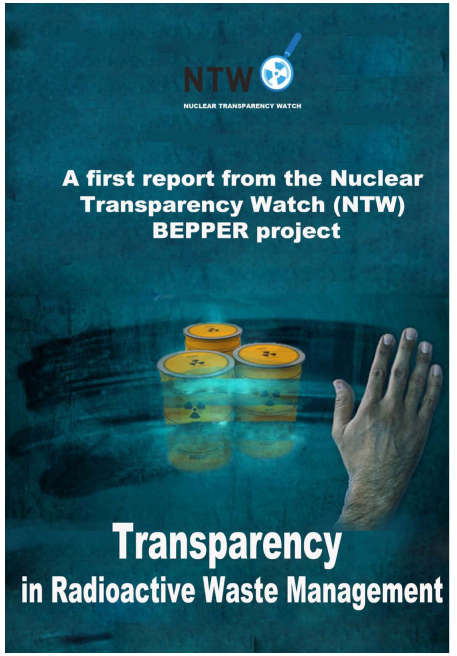
- **Aarhus Convention** on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters – 1998
  - Access to information
  - Access to public participation
  - Access to justice

(https://unece.org/environment-policy/public-participation/aarhus-convention/introduction)

- **BEPPER** (Broad Framework for Effective Public Information and Participation in Environmental Decision-making in Radioactive Waste Management) **report** "Transparency in Radioactive waste management" from Nuclear Transparency Watch (NTW) – 2016
  - Aarhus Convention + Access to resources
  - Proposals for improving transparency to give better safety and security

(http://www.nuclear-transparency-watch.eu/a-la-une/new-publication-bepper-report.html)



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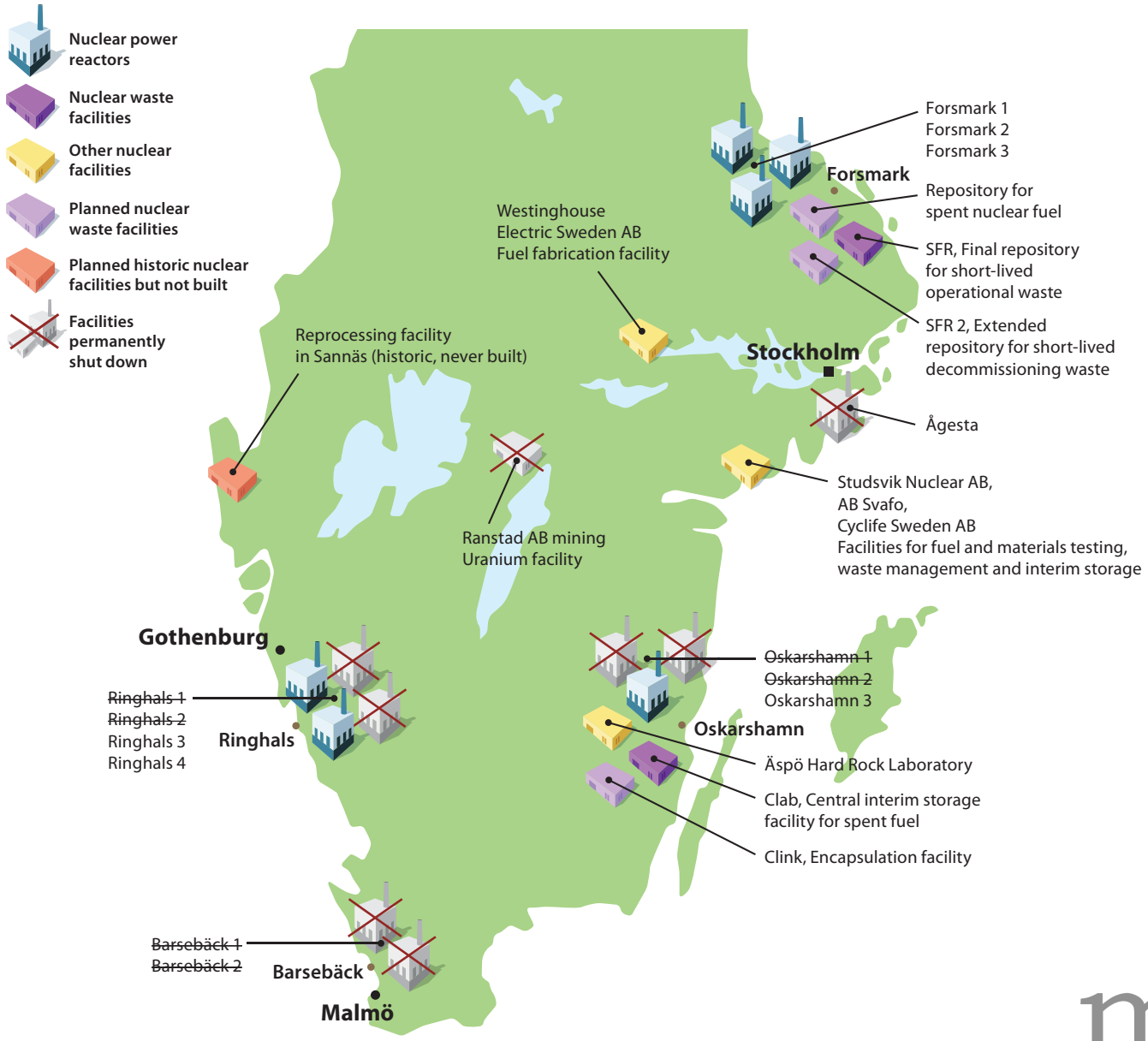
What will I talk about?

- Swedish management system for RWM
- Swedish governance of RWM, including transparency
- The case off the licencing of the Swedish repository for spent nuclear fuel
- Some lessons learned

The Swedish management system for RWM



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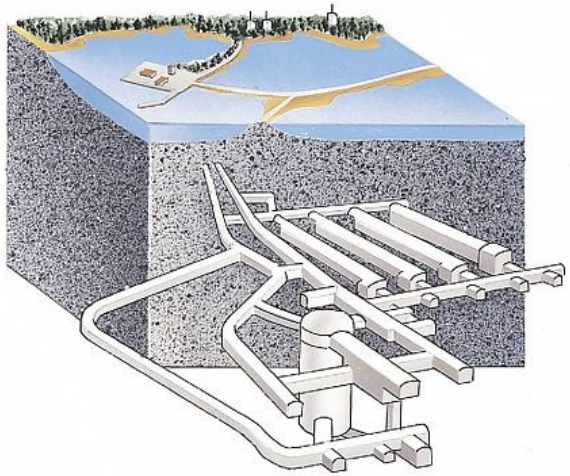
Final disposal of short-lived radioactive waste (1)

- There is an existing repository for short-lived low- and intermediate-level operational radioactive waste at the Forsmark nuclear power plant, SFR. It is 75 m under the sea-bed and started operation in 1988.

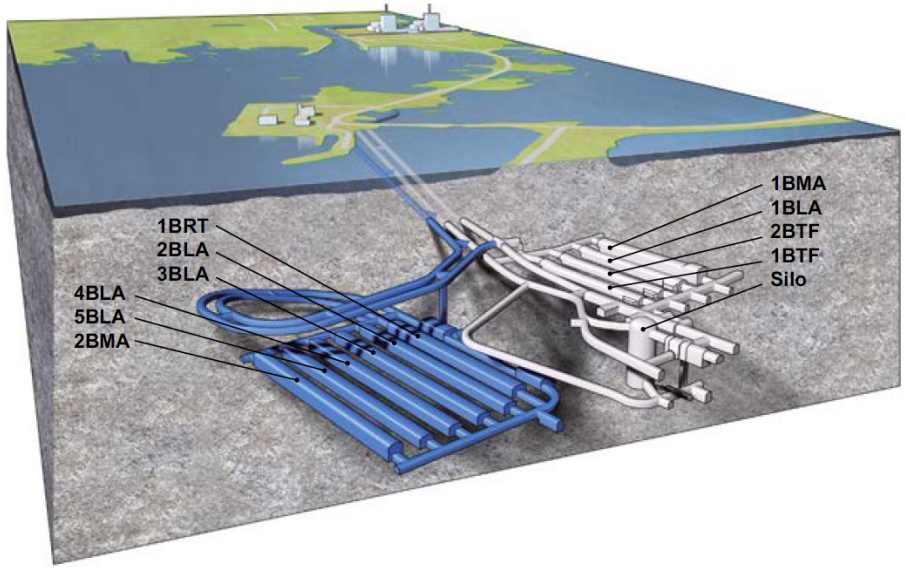
Final disposal of short-lived radioactive waste (2)



SFR – Final repository for short-lived low- and medium-level radioactive waste at the Forsmark nuclear power plant

Final disposal of short-lived radioactive waste (3)

- There is an existing repository for short-lived operational waste at the Forsmark nuclear power plant, SFR. It is 75 m underground and started operation in 1988.
- Approval has recently been given to start construction of a new repository, SFR 2, for short-lived low- and intermediate-level decommissioning radioactive waste below the existing one (120 m).



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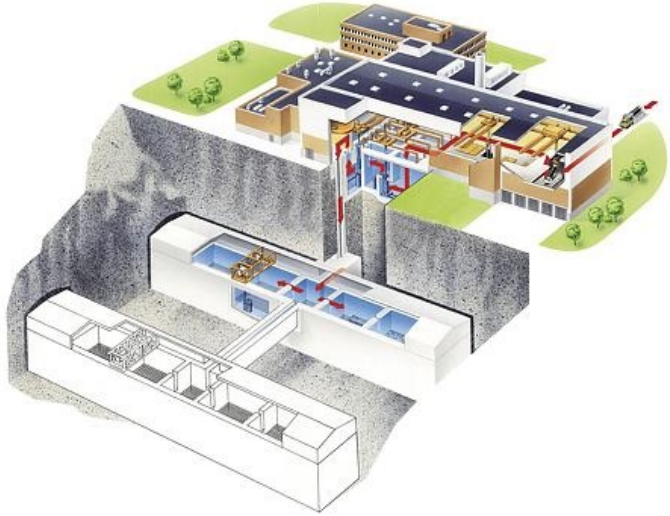
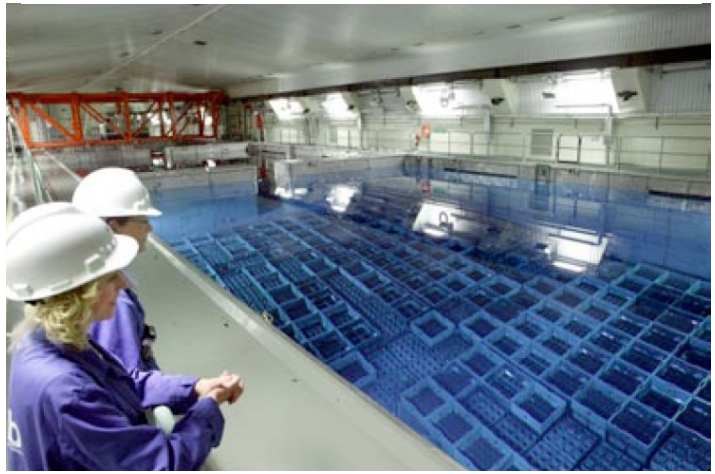
Interim storage of spent nuclear fuel (1)

- Spent nuclear fuel has since 1985 been transported to an centralized interim storage facility, CLAB, at the Oskarshamn nuclear power plant.
- The spent fuel is stored in large water-filled pools 30 m under the ground.
- Recently a license has been given to allow the storage of 11 000 tonnes of spent nuclear fuel (up from 8 000 tonnes).

Interim storage of spent nuclear fuel (2)

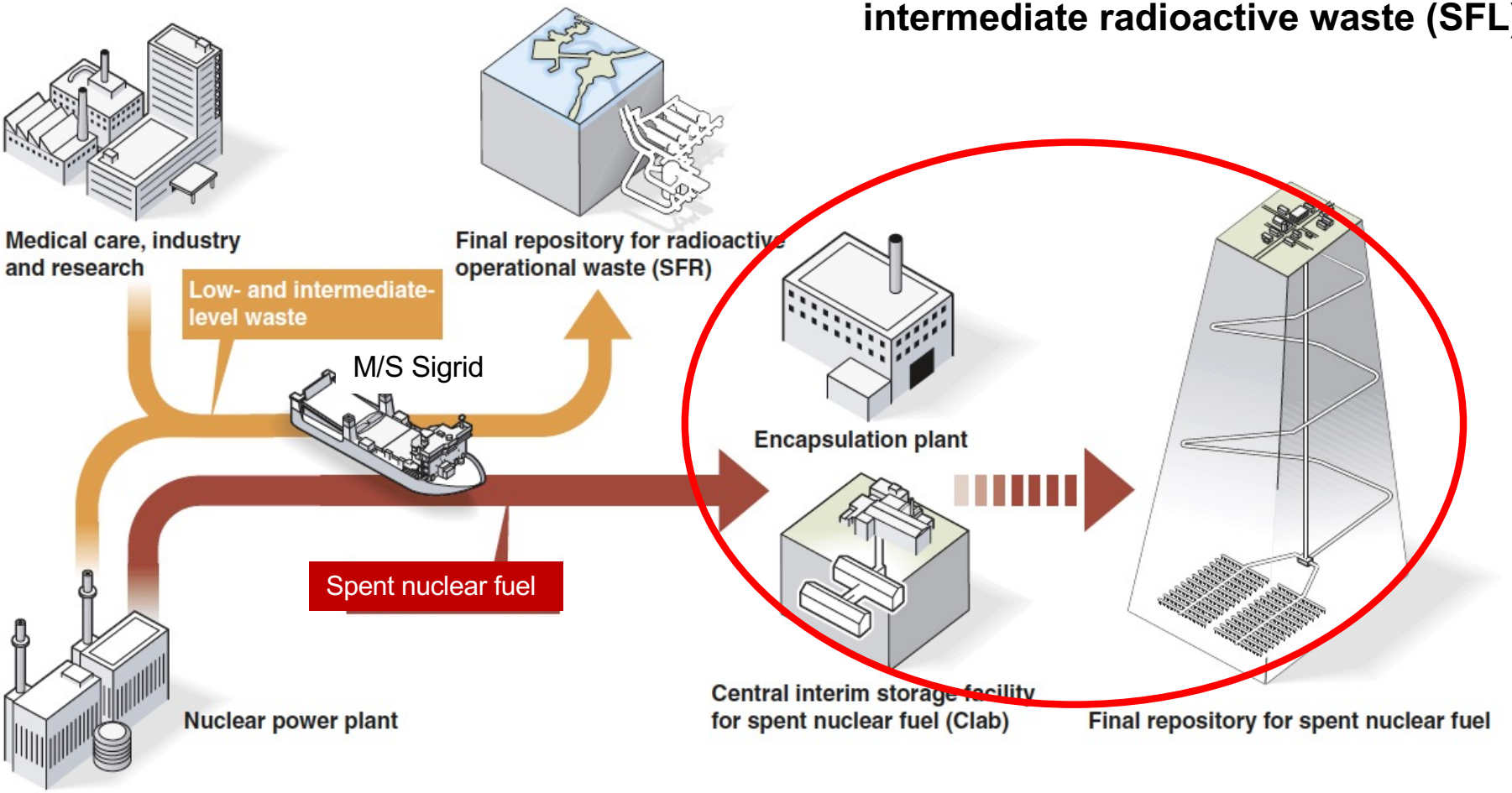




Clab – Central intermediate storage of spent nuclear fuel at the Oskarshamn nuclear power plant

Towards a repository for spent nuclear fuel

Missing! – Repository for long-lived intermediate radioactive waste (SFL)



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Swedish governance of RWM (1)

- In the 1980s the Swedish RWM governance system was set up in the "political calm" after the 1980 referendum on nuclear energy.

- **Nuclear Activities Act (1983, revision in progress)**: The Swedish nuclear industry is responsible for managing and finding sites and methods for final disposal of radioactive waste. The reactor operators has created a private company, the Swedish Nuclear Fuel and Waste Management Company (SKB), to do the work.
- The Nuclear Activities Act includes a process for review of the RWM research and development conducted and planned by the industry. An R&D report (Fud report) is produced by SKB every 3 years. It is is broadly reviewed under the auspices of the regulator Swedish Radiation Safety Authority (SSM). SSM and the Swedish Council for Nuclear Waste (abolished end of 2022) provide input to the government that takes a decision with possible conditions on each report.
- The Nuclear Activities Act also stipulates that SSM is responsible for reviewing applications for nuclear facilities, i.e., radioactive waste repositories.

Swedish governance of RWM (2)

- **Financial Act (1984, revision in 2006)**: An economic system with a state-controlled nuclear waste fund has been set up to guarantee that the polluter-pays-principle is upheld.
- A fee per kWh of generated electricity is paid into the fund. It is re-evaluated and recalculated every 3 years. In addition, there is a system of economic security guarantees. The system is managed and controlled by the Swedish National Debt Office, but final decisions on fees and securities are taken by the government.
- There is a system for financing the RWM work of nuclear waste communities and environmental NGOs. The NGO financing started in 2005 and will be stopped next year by the new Swedish government. The previous government had proposed a new system of long-term financing for both nuclear waste communities and environmental NGOs.
- From 2005 the beginning of 2017 the NGO funding came from the nuclear fund. From 2017 to 2023 the funding has come from the state budget.

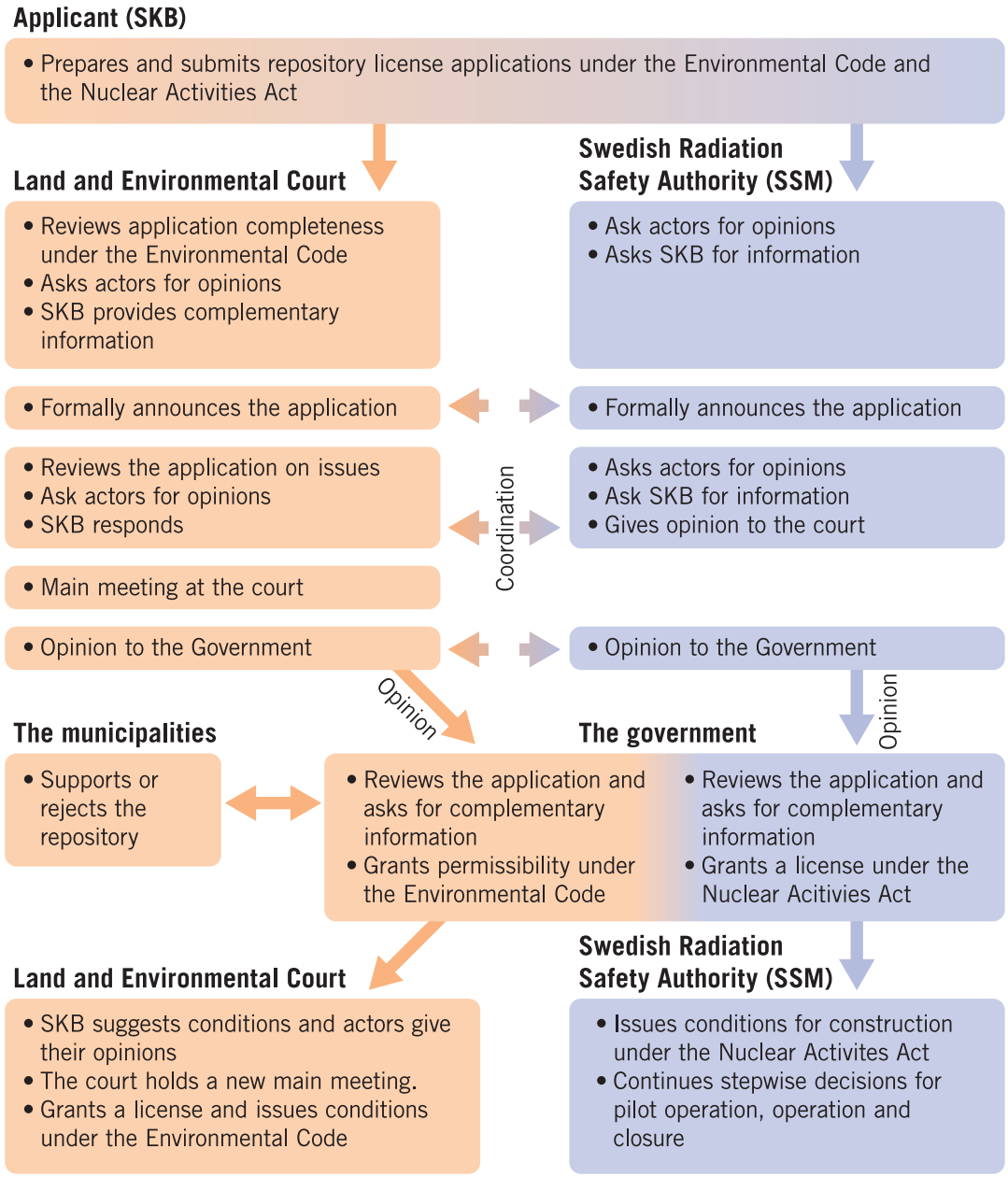
Swedish governance of RWM (3)

- In the late 1990s a modern Swedish environmental legislation was created. The **Environmental Code (1998)** was established with its own review system for applications for environmentally harmful activities under a Land and Environmental Court ("Environmental Court").
- The environmental legislation implements the Aarhus Convention with regards to access to public participation (consultation) and access to justice for civil society and especially for environmental NGOs.
- Access to information is an old Swedish tradition but limited to public entities, i.e., the regulator SSM and the government, but not the implementer SKB that is a private company. For example, importantly, the research of SKB can not be followed in the public domain.

Swedish governance of RWM (4)

- Applications for nuclear activities, i.e., radioactive waste repositories, are reviewed in parallel by the regulator SSM according to the Nuclear Activities Act and the Environmental Court according to the Environmental Act.
- Importantly, vital evaluation criteria from the Environmental Code (i.e, what has to be shown to be safe and when, what knowledge needs to be had before a license can be given, the precautionary principle, use of best available site and technology) have been transferred directly into Nuclear Activities Act, and the regulator SSM has to follow them in its decision.
- The final decisions on a license permit for a radioactive waste repository has to finally be taken by the Government after the court and regulator has given their opinions.
- A nuclear waste community has a possibility to veto a repository all the way until just before the government decision.

RWM governance in Sweden (5)



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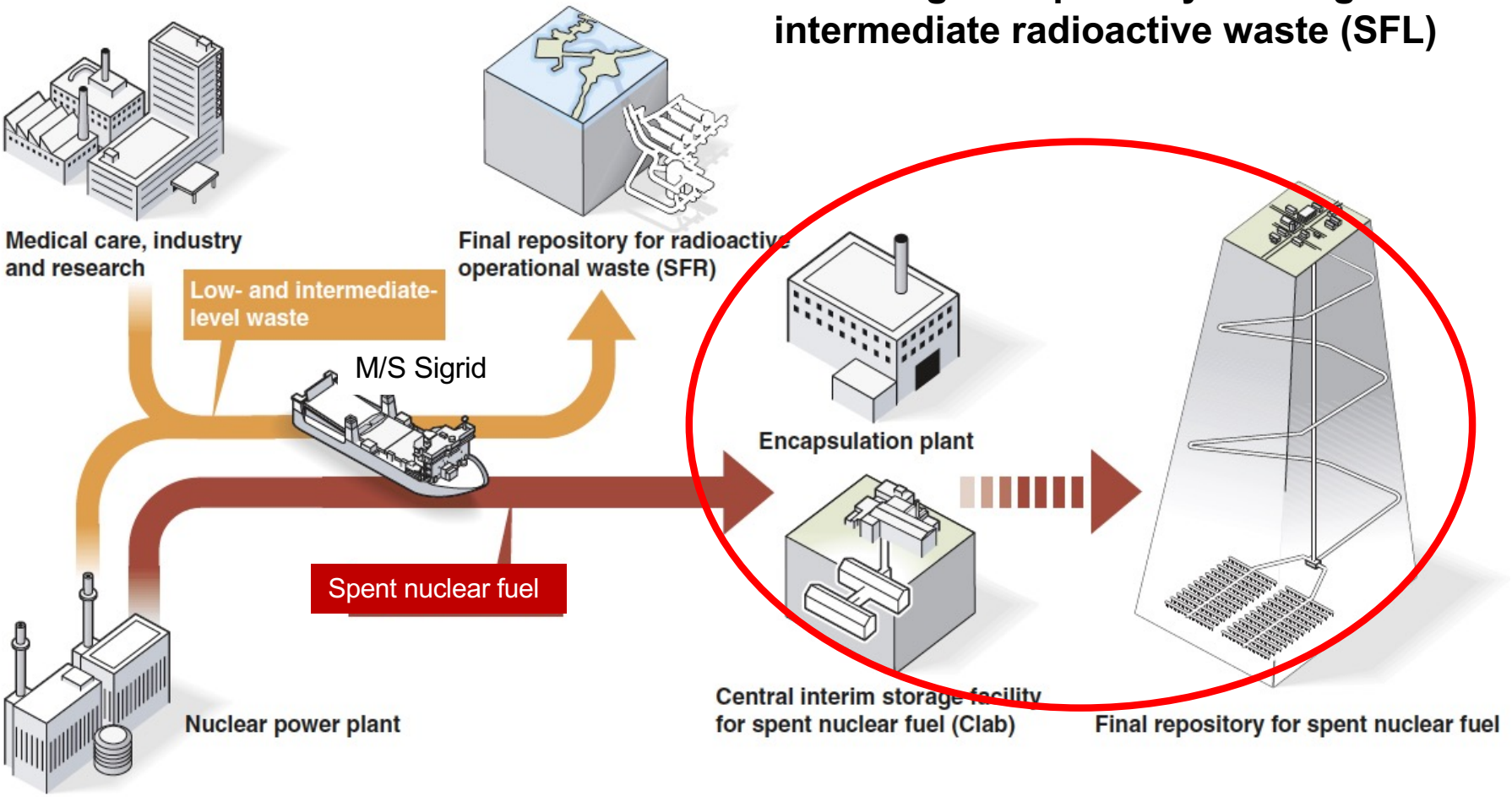
Towards a repository for spent nuclear fuel

+ Missing! – Repository for long-lived intermediate radioactive waste (SFL)



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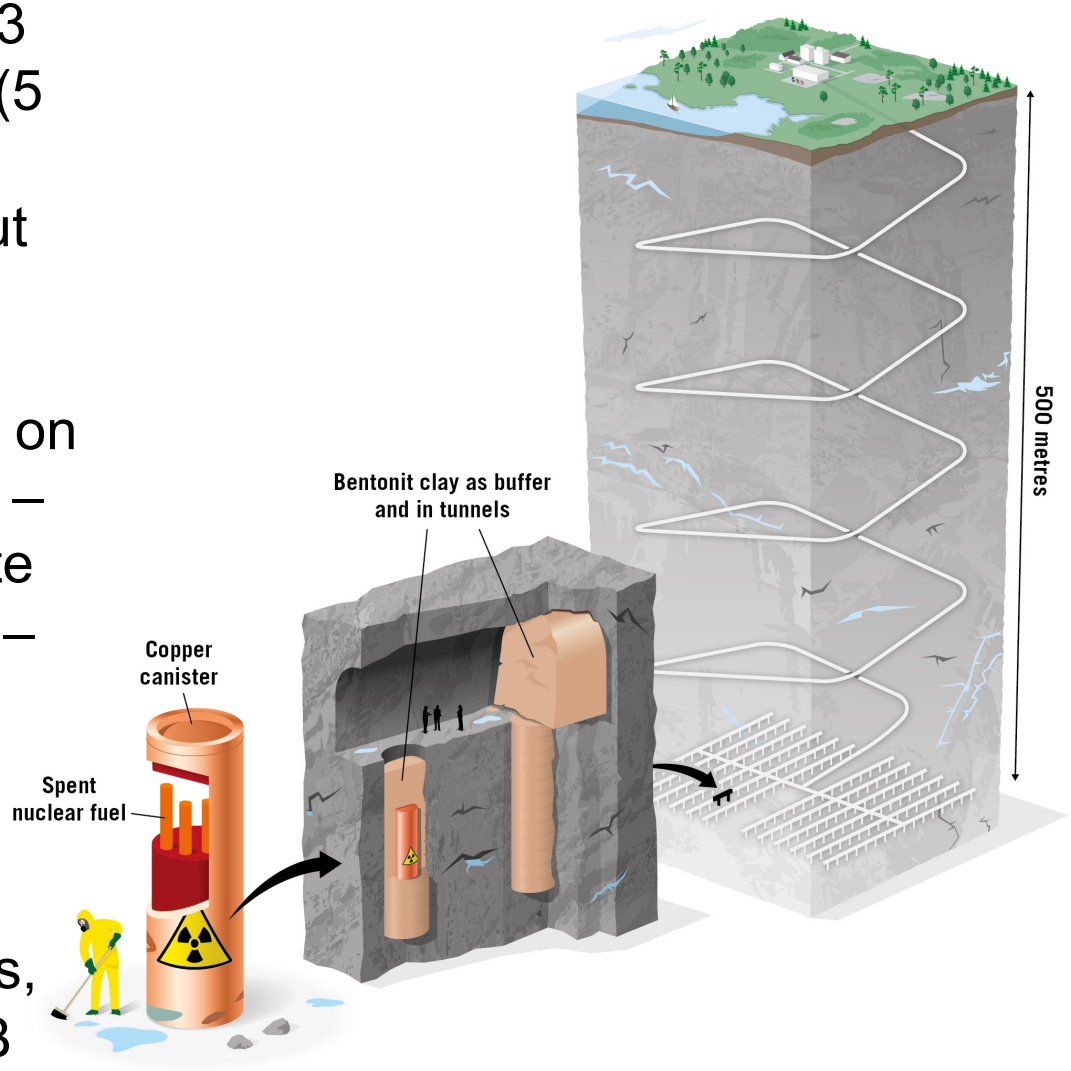
The KBS method for disposal of spent fuel

- In the KBS(-3) method from 1983 the spent nuclear fuel canisters (5 m high) are to be deposited in holes in the floor of tunnels about 500 m underground in granite bedrock (natural barrier).
- The long-term safety case relies on two artificial engineered barriers – a copper canister and a bentonite clay buffer to protect the copper – to isolate the spent fuel for hundreds of thousands of years. There is clay also in tunnels.
- In 2009, after a long and complicate site selection process, the nuclear waste company SKB chose the Forsmark nuclear power plant as the site for the planned repository.



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The KBS(-3) method

Originally developed between 1975-1983

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Further development of KBS method has taken place from 1983-2011 (and onwards…)

MKG has existed since 2005 (picture from office).

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License application and review (1)

- The nuclear waste company SKB submitted a license application for a spent fuel repository system using the KBS method at the Forsmark NPP on March 16, 2011. The application was also for a copper encapsulation plant connected to the Clab storage at the Oskarshamn NPP.
- The application has reviewed by the regulator, the Swedish Radiation Safety Authority (SSM) according to the Nuclear Activities Act and the Environmental Court according to the Environmental Code. The final decision on a license was finally taken by the government.
- Initial review for completeness of the application was completed in 2015. During 2016 and 2017 the application was reviewed on issues. Many issues were covered, i.e., siting, alternative methods (very deep boreholes*), hydrogeology, geology and earthquakes, intrusion more and information problems, nature protection and much more**.

* A slide on very deep boreholes can be found as an extra slide after the presentation.

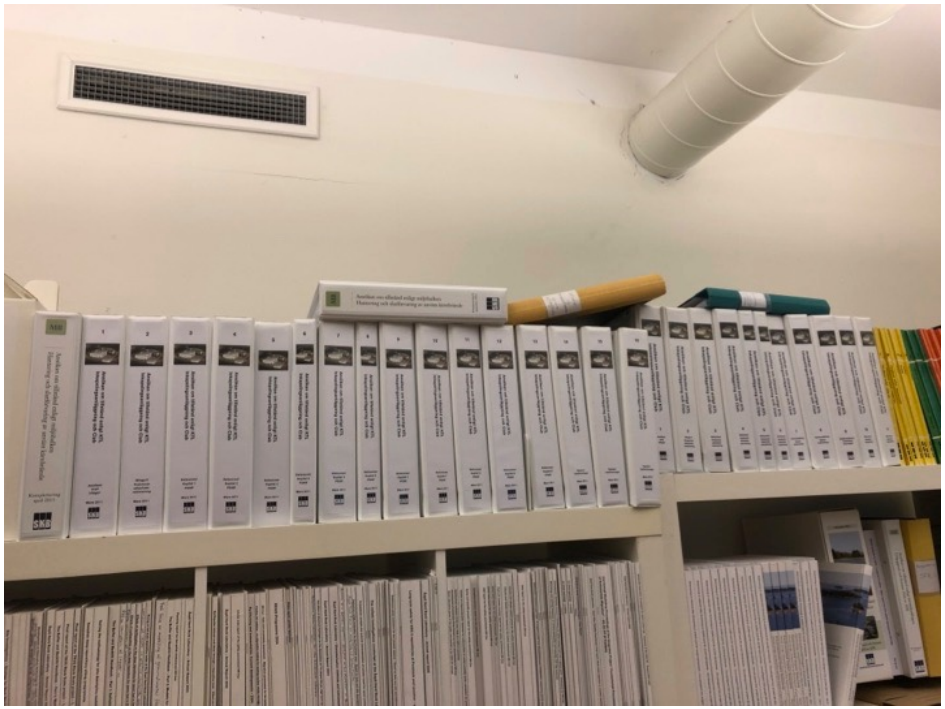
** The larger briefs from SNSC and MKG have been translated into English and can be found on the MKG web site: https://www.mkg.se/en/mkg-has-translated-legal-briefs-into-english-with-opinions-from-the-review-of-the-application-for-a

License application and review (2)

- During the review process the issue of problems with the long-term integrity of the copper canister were raised by some actors including researchers at the Royal Institute of Technology (KTH) in Stockholm. The copper corrosion controversy goes back to 1980s and became very lively from 2007 and forwards with the publication of new studies*.

* Some slides on copper corrosion and the LOT project copper corrosion results (see later) can be found after the main slides in the presentation.

Licence application for repository for spent nuclear fuel in 2011



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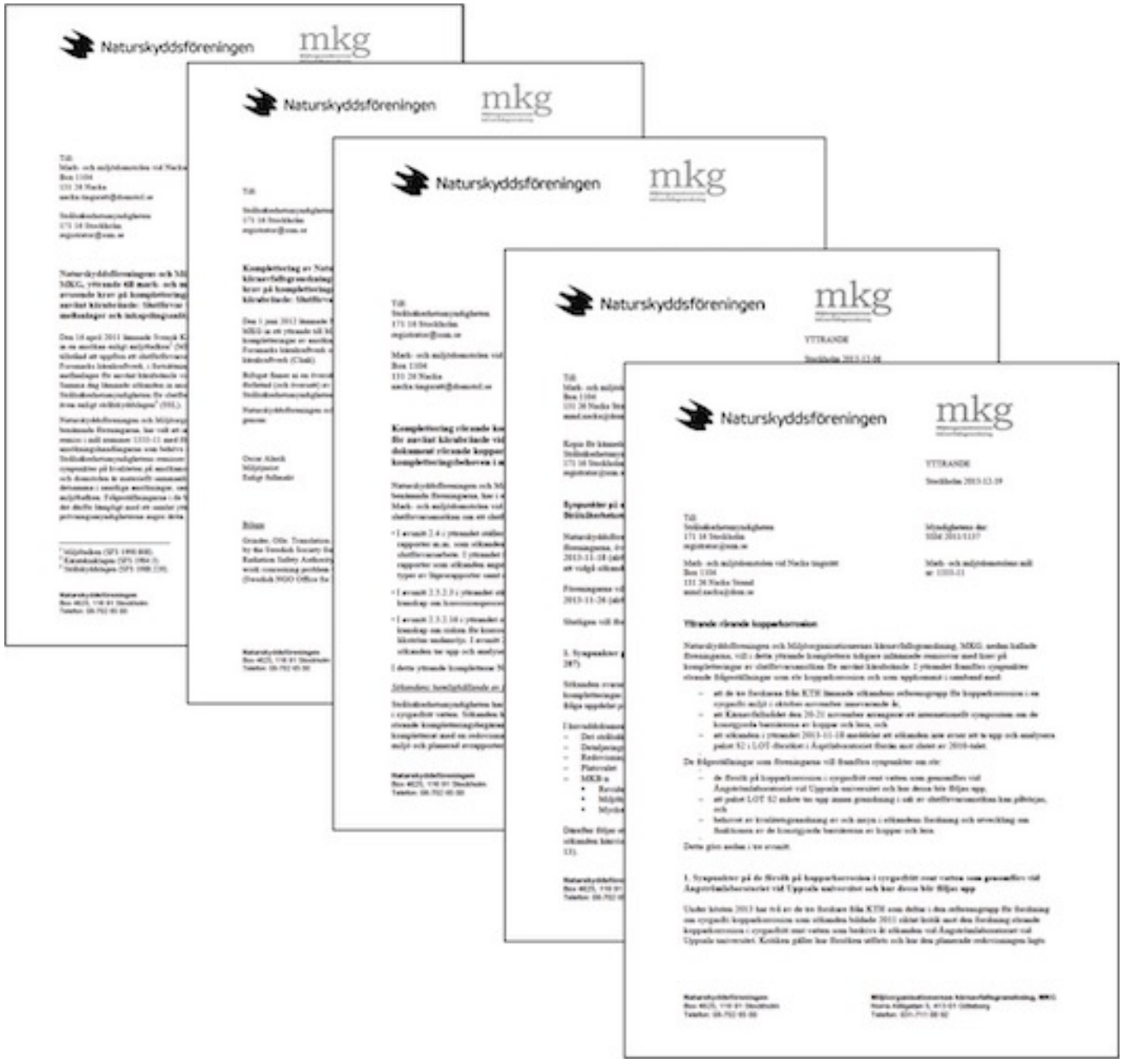

MKG and the Swedish Society for Nature Conservation (SSNC) has actively participation in the whole license review process.

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License application and review (3)

- In the autumn of 2017, the main meeting of the Environmental Court was held. The regulator SSM told the court that some issues, i.e., the copper corrosion issue, could be dealt with after a government decision. The court questioned this in the meeting. According to both the Environmental Act and the Nuclear Activities Act the repository had to be shown safe before a government decision.
- At the court main meeting were also eminent scientists from the Royal Institute of Technology (KTH) in Stockholm that strongly questioned the SKB position on copper corrosion.
- During the court proceedings leaks to media showed that the regulator SSM had big internal problems (the SSM corrosion expert was against an approval decision and there existed internal SSM certain canister degradation scenarios that showed regulatory limits could be exceeded).

Main meeting of the Environmental Court Sept-Oct 2017

MKG och Naturskyddsföreningen vid huvudförhandlingen. Från vänster: Magdalena Romanov, Christine Anvegård, Rebecca Nordenstam, Johan Swahn, Josia Hort.

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Sveriges Natur

Dokumentet avslöjar: Så allvarliga är riskerna

Strålsäkerhetsmyndigheten påstår att de risker med slutförvaret som avslöjats är irrelevanta. Men ett nytt dokument visar att så inte är fallet. I det skriver myndighetsspecialisten med ansvar för granskningen av slutförvarets långsiktiga säkerhet om "kritiska osäkerheter och kunskapsluckor kring kapselns grundläggande funktion".

SVERIGES NATUR GRANSKAR SLUTFÖRVARET.

De osäkerheter vad gäller slutförvaret av kärnbränsle som Sveriges Natur tidigare har rapporterat om nämns nu i ytterligare ett dokument från Stråksäkerhetsmyndigheten, SSM, som tidningen har tagit del av. Risken för kapselbrott som beskrivs i en artikel från 13 oktober är inte alls ryckt ur sitt sammanhang eller irrelevant såsom myndigheten försökt få allmänheten att tro via medier, bland annat i en intervju i Sveriges Natur 18 oktober: "Det du tar upp i artiklarna är inte relevant för bedömningen vi gjort", säger då granskningsgruppens chef Ansi Gerhardsson.

Dokumentet som tidningen nu fått tillgång till visar att risken för kapselbrott inom något hundratal år är så avgörande att det borde ha hindrat ett godkännande utan ytterligare utredning. Det skriver myndighetens specialist med ansvar för granskningen av slutförvarets långsiktiga säkerhet Björn Dverstorp i en inlaga daterad 13 juni 2016. Skrivelsen är en del av det samråd med olika experter som gjordes en innan det slutgiltiga yttrandet lämnades in till Mark- och miljödomstolen.

"Bör begära kompletterande underlag"

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License application and review (3)

- On January 23, 2018, the Environmental Court made its recommendation to the government. The court recommended that the government say no to the application, primarily because the uncertainties regarding the long-term safety of the planned repository due to possible copper canister problems. These issues had to be resolved before a Government decision.
- On the same date the regulator SSM told the government that it could say yes, as some issues, i.e., possible problems with the long-term integrity of the copper cannister be dealt with later, after a government decision. The regulator is also of the understanding that the repository has the prerequisite to be safe enough in a holistic perspective even if the copper canister does not work exactly as postulated as there are other barriers (bentonite clay buffer and bedrock).

The government review (1)

- The government immediately started the review of the license application and the nuclear waste company SKB made a submission of complementary information on copper corrosion in April 2019.
- Comments of other parties were provided to the government in the autumn of 2019.
- SSM:s conviction that the repository will be safe is “strengthened” by the new SKB information.
- The Swedish Council for Nuclear Waste says there may be problems with the copper, and with the cast iron insert, that may show that the concept does not work.
- The researchers at KTH persevere in criticism, joined by the SSM corrosion expert that was opposed to SSM saying yes.
- The difficulties in taking a decision then stalled the government review during 2020. During this time copper corrosion results from two newly retrieved experimental packages from the LOT experiment were hotly debated as SKB did not publish all corrosion results*.

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The government review (2)

- During 2021 the discussion about nuclear power and nuclear waste management has become increasingly politicized and during the autumn radioactive waste repository issues had risen to the very top of the political agenda.
- The government has since 2018 been a Social Democrat and Green Party minority coalition with a Green minister of the environment reluctant to approve any repository.
- During the spring and summer, the political (national and nuclear waste communities) and industrial pressure on the government increased.
- The copper corrosion discussion became more intense during the autumn of 2021.
- The Swedish Council for Nuclear Waste stated that more research is needed to understand how the copper canister behaves in a repository environment, but that this could perhaps be done after a government decision.

The government decision

- In the November-December 2021 there was political turmoil in the budget process for 2022, with result being that the Green Party left the government.
- The new Social Democrat minister of the environment promised a decision on the spent fuel repository on January 27.
- So, on January 27, 2022, the government took the decision to approve the repository for spent nuclear fuel in Forsmark and the encapsulation plant in Oskarshamn. The decision relied almost exclusively on statements from SSM that in a holistic multi-barrier perspective the repository had the prerequisite to be safe.
- The decision was appealed by the Swedish Society of Nature Conservation (SSNC), MKG and others on April 27, 2022 to the Highest Administrative Court (constitutional court) for judicial review.
- The organisations want it to be reviewed whether the knowledge about the long-term copper canister integrity is enough according to the Environmental Code, compared to the holistic multi-barrier perspective of SSM. They also point out that there may not be enough knowledge on how the other barriers work. In addition they ask whether the precautionary principle has been followed.

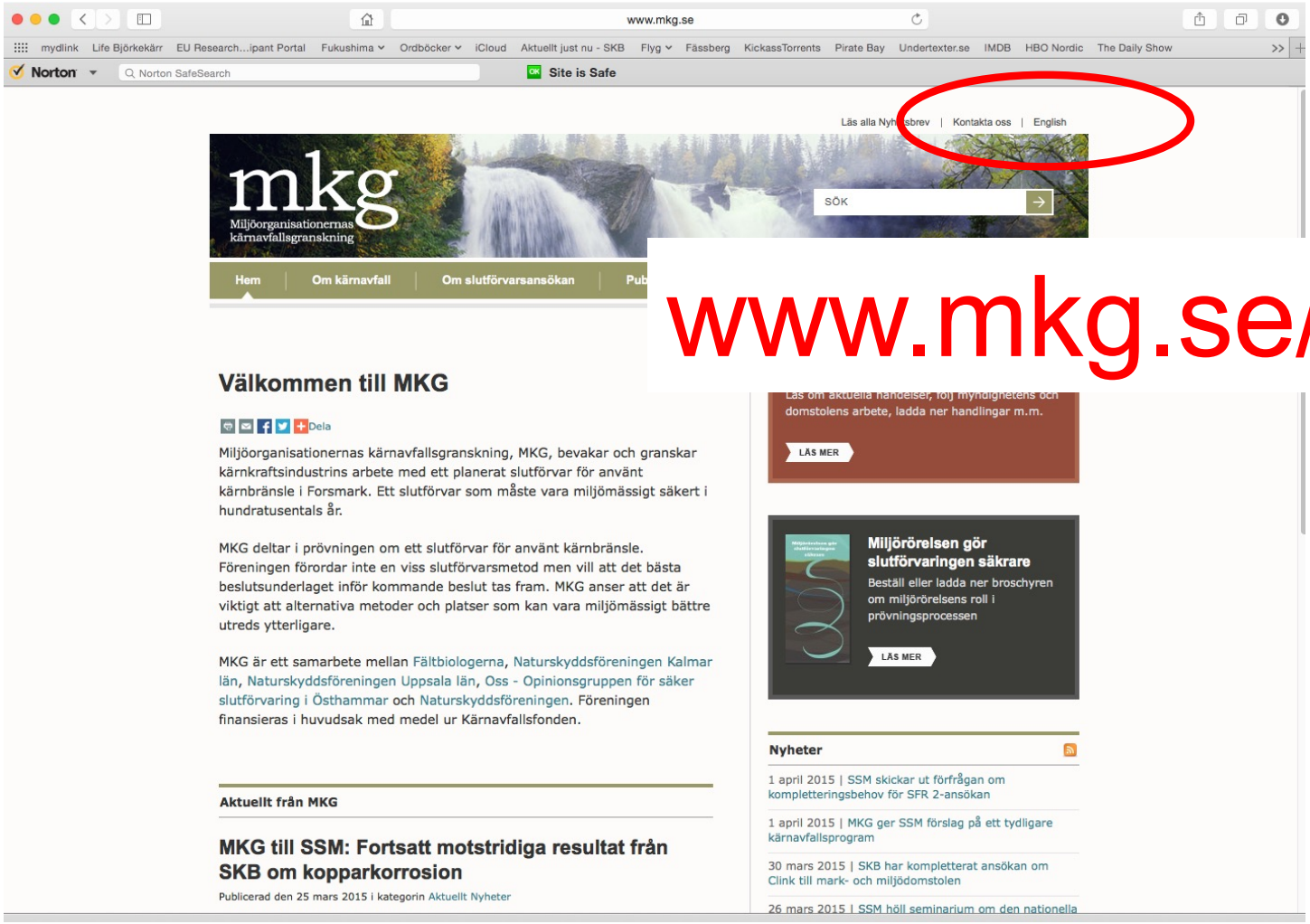
The Future?

- If the appeal is rejected (which is likely?) the next step is the return to the land and environment court for a final decision and conditions. May take several years with appeals.
- Construction start in 5 years? Operation in 15 years?
- The government stated in the license decision that research on copper corrosion should be continued and reviewed with the R&D (Fud report) process.

Lessons learned

- It can be a problem to have all the responsibility for research and development of RWM facilities with a private entity that is not part of the national public access to information system.
- The quality of the decision-making process is improved considerably by the implementation of good consultation and access to justice systems.
- The quality of the decision-making process is further improved by resourcing local communities and environmental NGOs to be able to participate fully in the process.
- It is of vital importance that all problems that come up in the decision-making process are fully examined as far as possible.
- The robustness of the safety case for a repository can appear high, but is dependent on a number of assumptions. Problems with individual assumptions should perhaps not be ignored with the argument that a holistic view allows this.
- There are also interesting issues involving “projects that become to big to fail”, “confirmation bias in knowledge development” and “regulatory independence and the risk for regulatory capture”.

For more information



www.mkg.se/en

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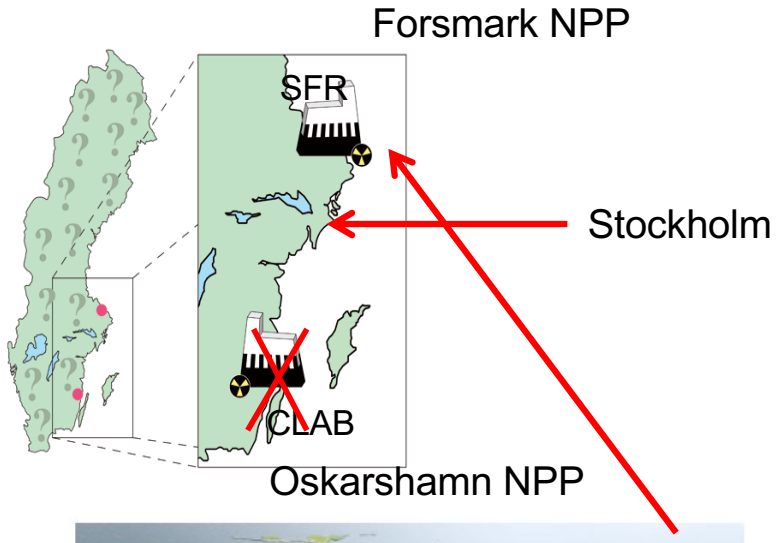
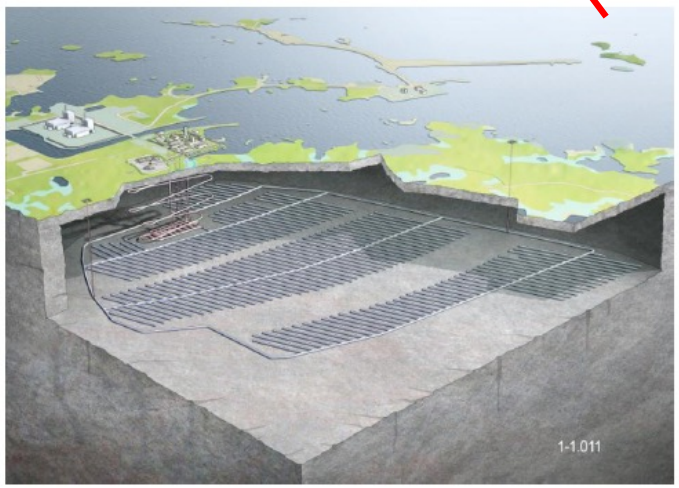
The Swedish NGO Office for Nuclear Waste Review

Siting of a spent fuel repository: A long road to acceptance

- The siting process for a repository for spent nuclear fuel was started in the mid-1970s and met local resistance with a collapse in 1986.
- A restart was done with a voluntary process.
- Two communities in North Sweden decided not to proceed after local referenda said no in the 1990s.
- The search finally ended in two nuclear communities, Oskarshamn (Oskarshamn NPP) and Östhammar (Forsmark NPP).
- In 2009 the Forsmark NPP site was chosen.





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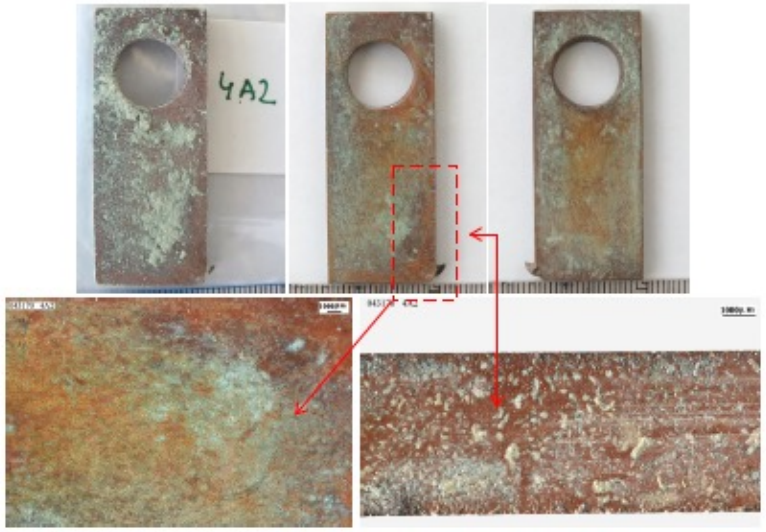
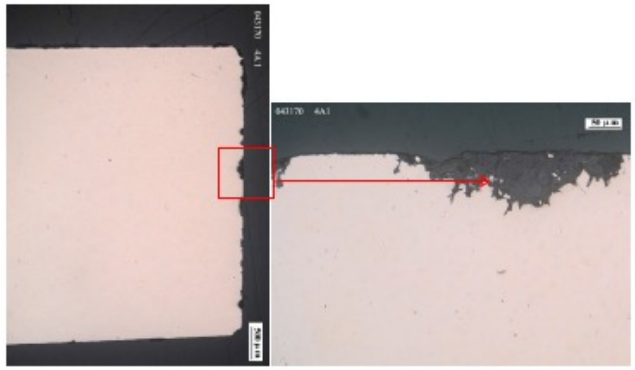
The problems with copper





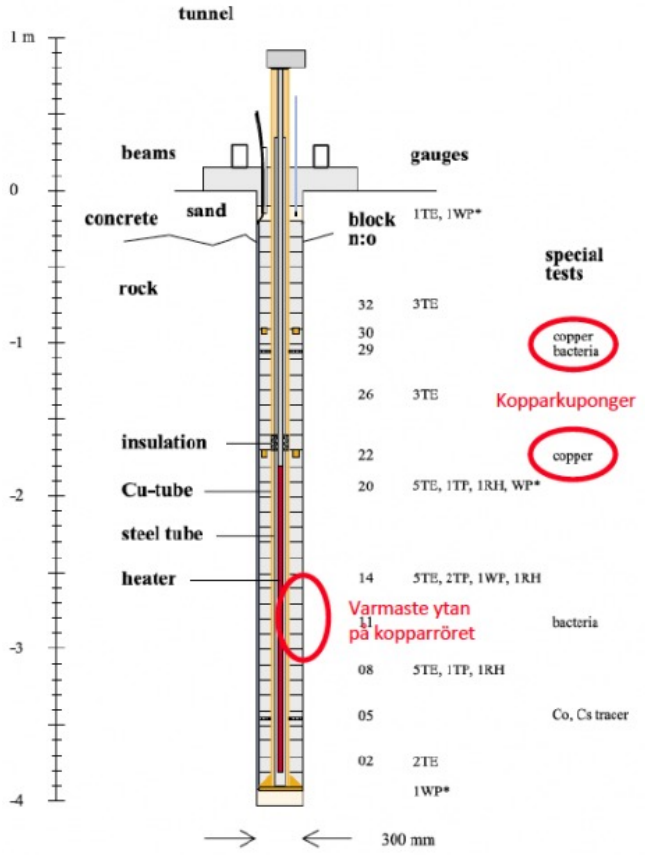
- The scientific hypothesis that anoxic (oxygen-free) water does not corrode copper in a repository, where there is no oxygen after closure, is very likely false.
- There is a ongoing scientific paradigm shift to the fact that water can directly corrode copper even when there is no oxygen.
- Copper in a KBS-repository may corrode at much faster rates than acceptable (<1 000 years until release of radioactivity).
- Results from the Swiss FEBEX experiment shows heavy copper corrosion

Source: FEBEX-DP Metal Corrosion and Iron-Bentonite Interaction Studies, P. Wersin & F. Kober (eds.), Arbeitsbericht NAB 16-16, Nagra, October 2017. Can be found on MKG's web site: http://www.mkg.se/omfattande-syrgasfri-korrosion-i-det-schweiziska-febex-forsoket

New experimental packages from the LOT project retrieved with 20 years of copper corrosion (1)

- The LOT (Long term test of buffer material) experimental project has been ongoing at 400 m depth at the Äspö Hard Rock Laboratory since about the year 2000.
- In total there are seven experimental packages with copper and clay in a very good simulation of real repository conditions.
- Three 1-year packages were retrieved early, but when SKB retrieved one 5-year package in 2006 an unexpected amount of copper corrosion had occurred.
- MKG had for a long time since then demanded that the next package be retrieved and analysed.

The LOT project at the Äspö hard rock laboratory



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New experimental packages from the LOT project retrieved with 20 years of copper corrosion (2)

- In the autumn of 2019 SKB secretly retrieved two now 20-year-old experimental packages. This was disclosed by SKB, likely as a mistake, at a meeting organized by the regulator SSM in the beginning of October.
- MKG worked to get SKB to disclose all relevant corrosion results as soon as possible, and that SSM checks the results. This has happened. SKB has published copper corrosion results in October 2020 and SSM is has carried out a quality assurance project with support of the U.K. consultancy company Galson Sciences.
- MKG told the Government that it should wait for results as if the corrosion is as bad as in the FEBEX experiment something is very wrong with copper as a canister material.
- MKG stated that the results that SKB has published are not scientific.

The LOT A3 and S2 packages results (SKB TR-20-14)

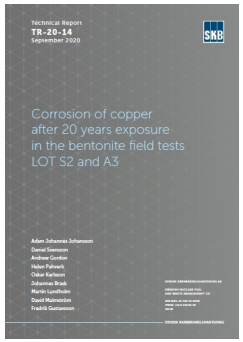
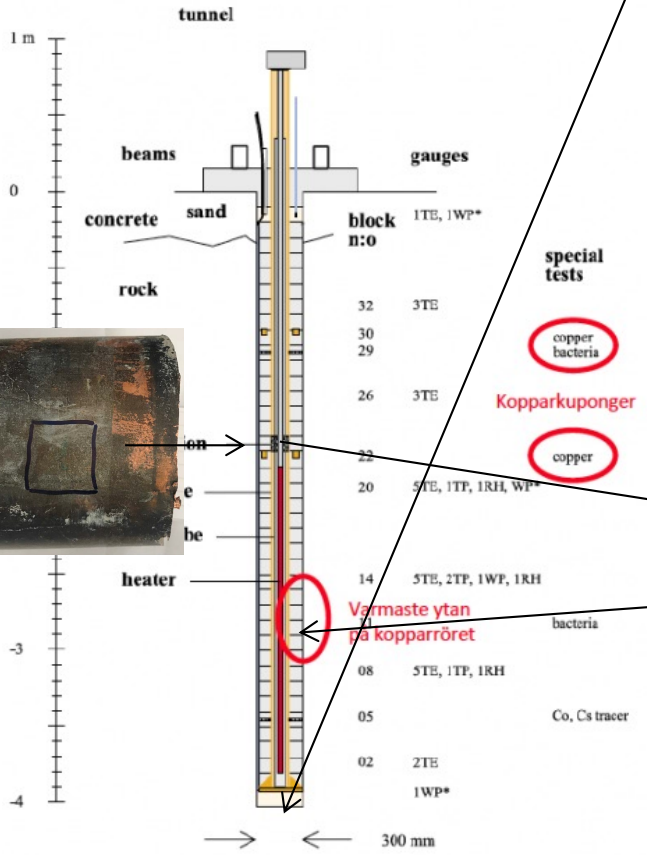


Image of corrosion on the copper bottom plate at 80° C in contact with sand (no detailed results were in the report, nor of the hottest part of the copper tube)



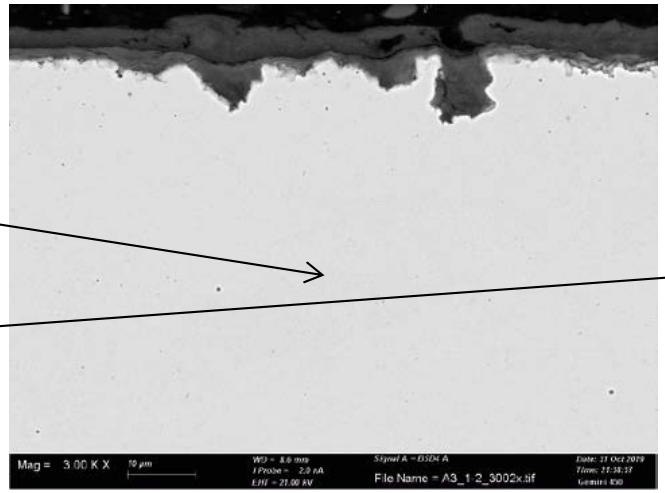
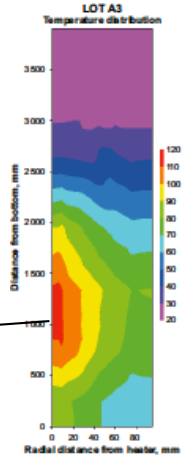


Image of pitting corrosion on the copper tube in the middle of the tube (no detailed results from hottest part of tube)



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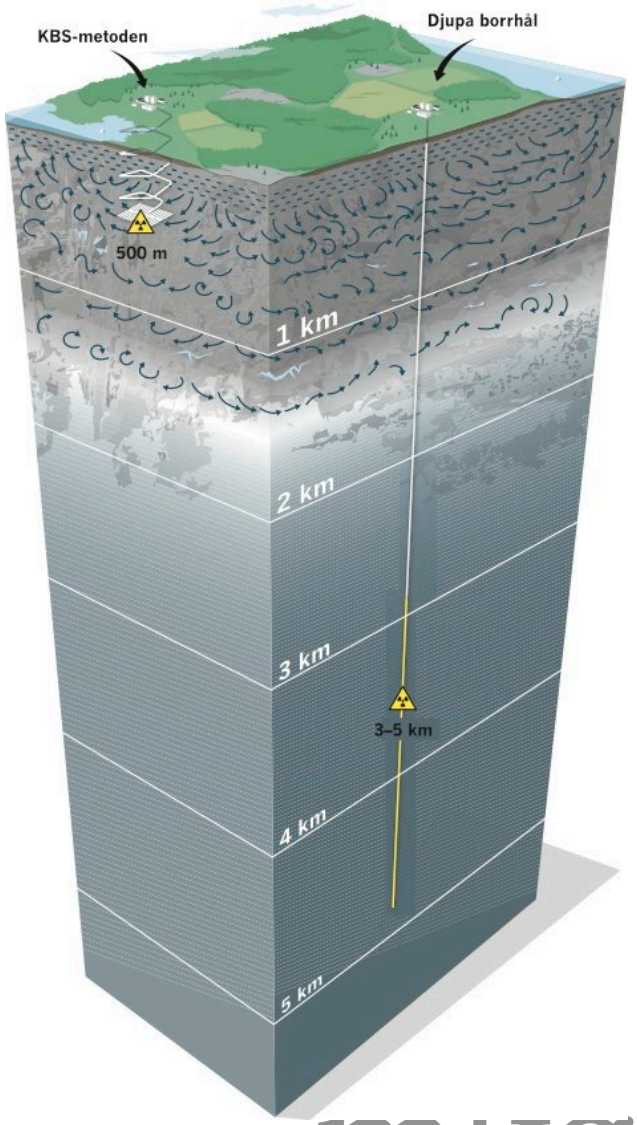
New experimental packages from the LOT project retrieved with 20 years of copper corrosion (3)

- MKG was of the understanding that if SKB had published the detailed copper corrosion of the hottest part of the central copper tubes and of the bottom plate, it would be clear that copper would not work as a canister material.
- The regulator SSM made a statement on the LOT results to the government in March 2020. Unfortunately, SSM accepted the SKB reporting of results without any analysis of its own. MKG was concerned that there was a situation of industrial “capture of the regulator”.
- Another important actor was the Swedish Council for Nuclear Waste, the government’s scientific advisory board, that was also concerned about how SSM was acting.
- There is still one LOT experimental package in the Äspö hard rock laboratory that will be retrieved in a few years.

Are very deep boreholes an alternative?

- The alternative method very deep boreholes means that the nuclear waste is finally stored in a borehole between 3-5 km deep.
- The long-term environmental safety is based on a natural barrier that isolates the groundwater at depth from water closer to the surface.
- The method is also better from a nuclear proliferation point of view due to less risk of intrusion.
- Likely also if widely used less expensive than mined repositories
- Now feasible – a pilot project started in the US under the Obama administration - stopped due to siting issues and the election of Trump. Will it come back under Biden?



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And how about Finland?

- Since in the early 1990s not being able to send spent fuel to Russia for reprocessing Finland is copying the Swedish KBS method.
- The Finnish decision-making on environmental issues differ a lot culturally from the Swedish. The repository project for spent nuclear fuel is seen as a technical project more than an environmental.
- The Finnish government decided in the early years on the century that a repository should be ready in the early 2020s.
- Since then, decisions have been taken with this timeframe in mind.
- There is now a construction license for a repository called “Onkalo” near the Olkiluoto nuclear power plant. The construction has reached the repository depth (≈ 430 m) and the work on deposition tunnels has started. The construction of the encapsulation plant is completed.
- The company Posiva has submitted an application for an operational license and hopes to deposit the first canisters around 2025.