

Digging deep – for a safe storage of highly radioactive waste

DHI modelling helps to build a deep repository in Sweden

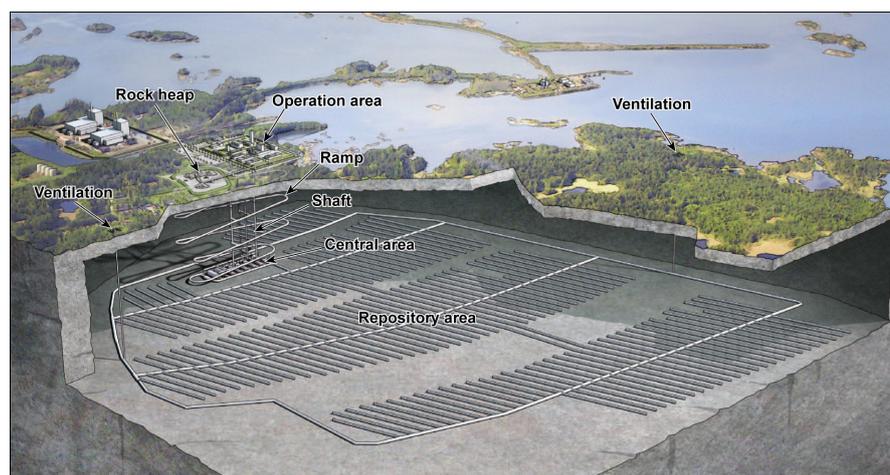


Spent nuclear fuel constitutes one of the most hazardous parts of radioactive waste. Its final reposition is accordingly challenging, and moreover a highly sensitive issue. DHI assists the Swedish Nuclear Fuel and Waste Management Co (SKB) in the planning and construction of a deep repository in Sweden by elucidating the complex dynamics of water and soil as well as solute transport patterns today and in the distant future.

The deep repository for high-level radioactive waste will be situated at Forsmark on the Swedish east coast, in granite bedrock at a depth of about 450 metres. There, the fracture frequency is low and the groundwater velocity very low. Nevertheless, ensuring the safety of such a deep repository – both during the construction as well as the operation and closing phase – requires a detailed understanding of its hydrological and hydrogeological setting.

In close collaboration with and based on comprehensive site investigations by SKB, DHI has performed extensive hydrological and hydrogeological modelling since 2005. Initially, this allowed for a deep overall understanding of the local hydrogeology, such as the near-surface groundwater flow and the contact between surface water and groundwater. DHI's results were a part of the documents that underpinned the decision on where to build the final repository. After that decision was made for Forsmark, DHI applied its modelling suite to investigate possible effects of the construction activities on surface hydrology and potential inflows into the tunnel system. Moreover, a transport model revealed the flow and particle transport patterns, predicting where eventually escaping nuclides would end up.

An immense amount of data was supplied by SKB to feed the models. "Forsmark is now surely one of the most well-investigated areas in Europe, from a geoscientific point of view", Erik Mårtensson from DHI Sweden comments. "And we are dealing with probably the most extensive set-up of hydrological and hydrogeological models for a single area ever made."



SUMMARY

Client

The Swedish Nuclear Fuel and Waste Management Co (SKB)

Challenge

The planning of a deep repository for highly radioactive waste necessitated understanding the local hydrology and near surface hydrogeology as well as possible effects during the construction

Solution

DHI's models elucidate the complex dynamics of water and soil as well as solute transport patterns today and in the future.

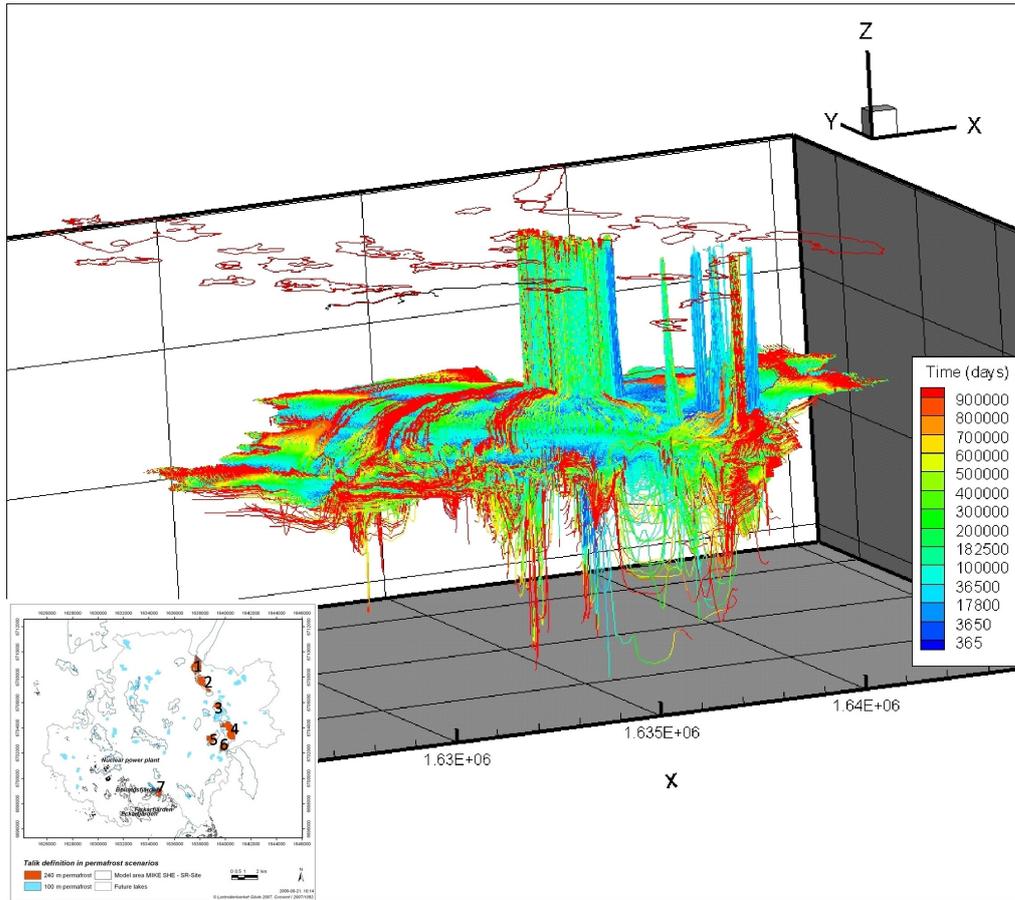
Value

- Safe construction and operation of the deep repository
- Safe storage of high-level radioactive waste
- Preparedness for various future climate scenarios
- Minimized impact on the local environment

Location/Country

Forsmark, Sweden

The illustration shows how the final repository for spent nuclear fuel may look, in the future at Forsmark in Östhammar municipality (Source: SKB, LAJ illustration)



Three-dimensional illustration of the flow paths of particles from a particle tracking simulation for permafrost conditions.

A look into the future

The radioactive waste to be stored at the Forsmark final repository belongs to the most hazardous category – spent nuclear fuel. Spent fuel must be radiation-shielded and cooled throughout handling, transportation and storage and isolated for at least 100,000 years. Therefore, DHI analysed a number of future climatic developments, such as increasing precipitation, general warming and different permafrost scenarios. These future scenarios include various shorelines as well as changes in vegetation, land use and regolith (the layer of loose material covering the solid rock).



Above: Aerial photo of SFR (final repository for radioactive operational waste). In the background Forsmark Nuclear Power Plant. (Source: Finn Isaksson SKB)

Right: A few of the small lakes in the area of Forsmark are the habitat of the Pool Frog, *Polophylax lessonae*. The protected status includes that its habitat cannot be harmed or destroyed.

Not to forget, the Pool Frog

Last but not least, SKB and DHI had to take care of the vulnerable inhabitants of the Forsmark area. The surrounding wetlands form a precious ecosystem, and are home to the Pool Frog. This red listed amphibian native in the area is very sensitive to even small changes in water levels. DHI carried out detailed studies of the effect of the construction activities on local wetland water levels, in order to ensure the protection of the Pool Frog. Where wetlands are endangered by the construction activities, precautionary measures can be taken, such as drilling while the lakes are frozen or digging a new lake for the frogs and their cohabitants to move them over.

DHI's extensive modelling for a final repository is pioneering work. "Nuclear fuel is being spent all over the world, and many countries are thinking about its final reposition. Forsmark is spearheading, but other countries will follow in the coming decades", Mårtensson says.

