SECURING THE SAFEST SITE

The way to a deep geological repository for Switzerland

nagra.

The National Cooperative for the Disposal of Radioactive Waste (Nagra) is responsible for a project of the century: on behalf of the nuclear power plant operators and the Swiss Confederation, it is planning a deep geological repository in which Switzerland can safely dispose of its radioactive waste – to protect humans and the environment. Nagra's employees are committed to achieving this goal and dedicate their scientific and technical expertise and engage in dialogue with the public.

In this brochure, Nagra provides information on the general licence applications it has submitted for the deep geological repository in the Nördlich Lägern siting region and the encapsulation plant for spent fuel assemblies in Würenlingen. Important aspects such as safety, environmental impact and spatial planning are explained based on a provisional repository project, which corresponds to the current planning status. In the upcoming years, the project will be further optimised with a view to the subsequent construction phase.

CONTENT

FUNDAMENTAL DECISION ON THE DEEP GEOLOGICAL REPOSITORY

Dear Readers

Should Nagra construct a deep geological repository in Nördlich Lägern for Switzerland's radioactive waste? To allow Switzerland to make this fundamental political decision, all the facts are laid out in the general licence application.

We at Nagra are convinced that we have found the safest site. In the application, we explain how and why radioactive waste can be disposed of in a deep geological repository in Nördlich Lägern and how it will remain safe in the long term. We also outline the features of the deep geological repository and the encapsulation plant for spent fuel assemblies.

Our obligation to dispose of radioactive waste in a repository to protect future generations is irrefutable and this is clearly stipulated in Swiss legislation. Switzerland must now make a fundamental decision on the site and cornerstones for this project of the century. This decision is not made by Nagra, but by the Federal Council, Parliament and, should a referendum be held, ultimately by the electorate.

In my opinion, the division of roles and the interaction between the various stakeholders is key to the success of this project of the century. The federal authorities have the lead in the site selection process and review Nagra's work. The affected region as well as the local and cantonal authorities actively help to shape the project, and the Federal Council, Parliament and the electorate decide on it. This typically Swiss approach – democratic and thorough – may not be the fastest way to dispose of the nation's radioactive waste in a deep geological repository. But it makes it all the safer. And we will have achieved our goal by working together.

I am confident that we are now in a position to safely dispose of Switzerland's radioactive waste in the long term. In the societal debate that now lies ahead of us, we will be open to everyone's questions and concerns.

I look forward to interesting discussions – perhaps also with you?

Yours sincerely

Matthias Braun

"We will achieve the national task of deep geological disposal by working together."

MATTHIAS BRAUN, CEO OF NAGRA

PURPOSE OF THE GENERAL LICENCE

The general licence specifies the site and, as the name implies, the general features of the deep geological repository.

Nagra has submitted two general licence applications to the authorities. This is necessary as the repository and the waste encapsulation plant will be constructed at two different sites.

In the application submitted for the deep geological repository, Nagra justifies how it has determined the most suitable site, demonstrates that the safety of the repository can be ensured in the long term and outlines the general features of the project.

KEY POINTS OF THE APPLICATIONS

NAGRA:

1 applies for approval of the sites for the deep geological repository and the waste encapsulation plant

2 demonstrates that the repository will remain safe in the long term

3 applies to secure the underground area of the rock that will eventually host the repository and its accesses

4 proposes criteria that must be met for the emplacement of the waste

5 proposes the maximum waste volume to be disposed of in the repository

Switzerland must safely dispose of its radioactive waste. Most of the waste is produced by the nuclear power plants, but it also arises from applications in medicine, industry and research. The law stipulates that this waste must be disposed of in a deep geological repository. The highest priority is the protection of humans and the environment.

This project of the century is now in the licensing phase. Nagra has submitted an application to the federal government for a deep geological repository in the Nördlich Lägern siting region. The surface facility, which will provide access to the underground, is to be constructed at the Haberstal site in the community of Stadel in Canton Zürich. In a separate application, Nagra is requesting to locate the site for the waste encapsulation plant at the interim storage facility in Würenlingen, Canton Aargau.

The general licences secure the sites for the repository and the encapsulation plant and define the basic features of the two facilities. This is an important milestone, based on which the project will be further developed and optimised in the coming years with a view to the construction phase.

ACHIEVING OUR GOAL TOGETHER

The general licence applications are the result of decades of research work. However, Nagra did not conduct this research on its own: it regularly exchanges insights with fellow scientists – both nationally and internationally.

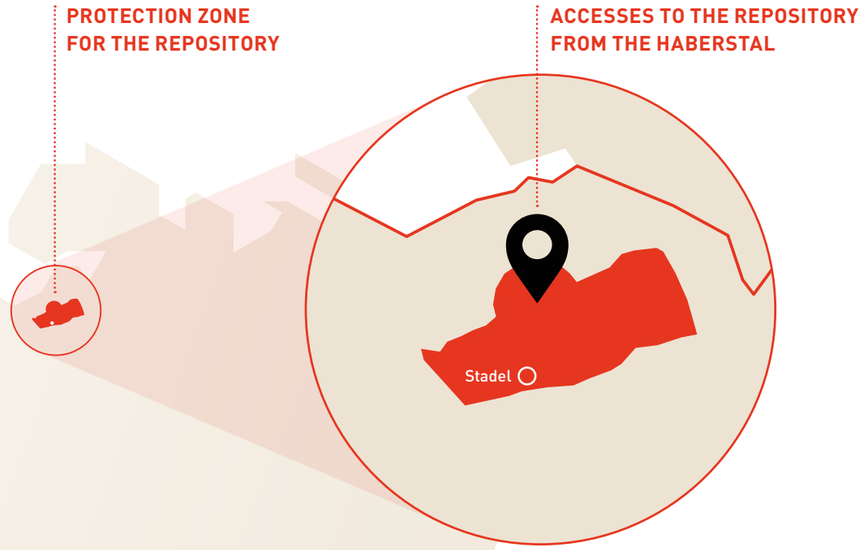
Other stakeholders are also involved in the project. Whether representatives of the communities, cantons, authorities, review bodies, expert groups, the Nördlich Lägern regional conference, or local residents: a critical outside perspective helps us to find better solutions.

The way forward will continue to rely on collaboration: ultimately, the fundamental decision on the repository will be made first by the Federal Council, then the Swiss Parliament and finally, in the case of a national referendum, by the Swiss electorate.

WHO REVIEWS THE APPLICATIONS?

The licensing procedure is under the lead of the Swiss Federal Office of Energy (SFOE). The technical review will be carried out by various federal authorities: the Swiss Federal Nuclear Safety Inspectorate (ENSI), the Swiss Federal Nuclear Safety Commission (NSC), the Federal Office for the Environment (FOEN) and the Federal Office for Spatial Development (FOSD). The applications will also be reviewed by the cantonal authorities and by those of the neighbouring German district of Waldshut.

THE DEEP GEOLOGICAL REPOSITORY IN NÖRDLICH LÄGERN



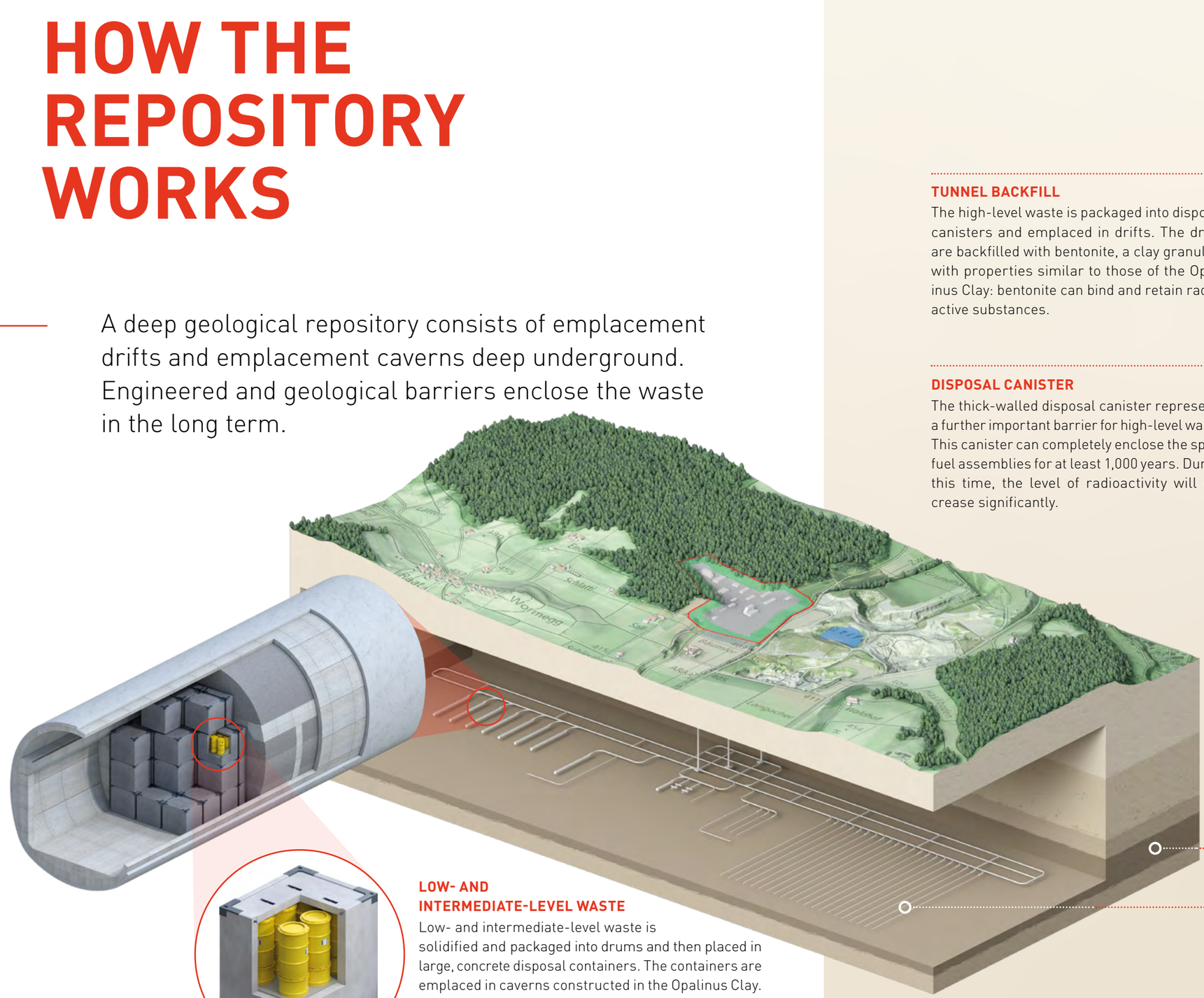
Nagra's siting proposal is the result of decades of research. The repository will safely enclose the radioactive waste in a tight host rock.

The starting point for the nationwide search for a repository site was a "blank" map of Switzerland. The geological conditions deep underground are the decisive factor. Based on safety-related criteria, the suitable regions were narrowed down in several stages – until only three were left. After an in-depth investigation of these three siting regions, Nagra is convinced that Nördlich Lägern is the most suitable site and has the largest safety reserves.

The accesses to the repository are to be constructed at the Haberstal site in the community of Stadel, Canton Zürich. The access routes will reach to a depth of over 800 metres, where the radioactive waste will be emplaced in a host rock called the Opalinus Clay. This will ensure the long-term protection of humans and the environment.

HOW THE REPOSITORY WORKS

A deep geological repository consists of emplacement drifts and emplacement caverns deep underground. Engineered and geological barriers enclose the waste in the long term.



LOW- AND INTERMEDIATE-LEVEL WASTE

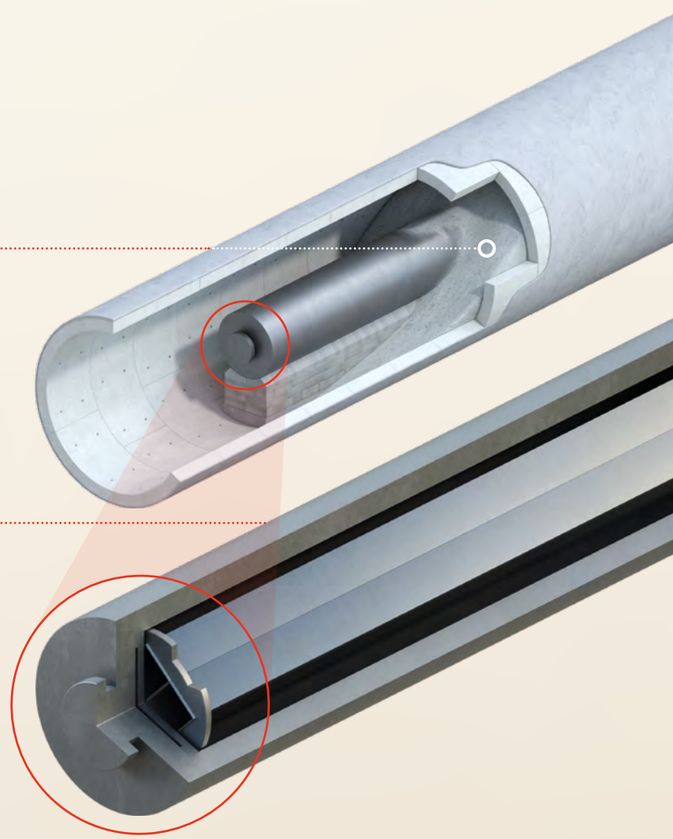
Low- and intermediate-level waste is solidified and packaged into drums and then placed in large, concrete disposal containers. The containers are emplaced in caverns constructed in the Opalinus Clay. Any remaining voids are filled, and the caverns are then sealed and closed.

TUNNEL BACKFILL

The high-level waste is packaged into disposal canisters and emplaced in drifts. The drifts are backfilled with bentonite, a clay granulate with properties similar to those of the Opalinus Clay: bentonite can bind and retain radioactive substances.

DISPOSAL CANISTER

The thick-walled disposal canister represents a further important barrier for high-level waste. This canister can completely enclose the spent fuel assemblies for at least 1,000 years. During this time, the level of radioactivity will decrease significantly.



OPALINUS CLAY

The Opalinus Clay forms the most important geological barrier. The deep geological repository will be constructed in this clay rock. The Opalinus Clay is largely impermeable to water, can self-seal fissures and has the capacity to bind radioactive substances. The rock layers above and below the Opalinus Clay also contribute to the safe containment of the waste.

EMPLACEMENT DRIFTS AND CAVERNS

The radioactive waste is emplaced into these tunnels.

WHY THE REPOSITORY WILL REMAIN SAFE IN THE LONG TERM

The geology in Nördlich Lägern makes the most important contribution to the protection of humans and the environment from radioactive waste – and will continue to do so into the distant future.

Nagra must demonstrate that the deep geological repository in Nördlich Lägern will remain safe for up to one million years. In addition to the underground geological properties making Nördlich Lägern the safest site, the multi-barrier system also plays an important role.

ROBUST REPOSITORY CONCEPT

The repository concept takes into account the possibility that very small amounts of certain radioactive substances could reach the surface over the one-million-year period for assessment. The radiological impact will be many times below the legally prescribed dose limits. Nagra could draw this conclusion from safety analyses that take many scenarios into account, such as strong earthquakes or damaged disposal canisters. Large safety margins can be maintained for all scenarios.

Post-closure safety would remain ensured even in unrealistic and purely hypothetical cases. This confirms how robust the Swiss deep geological repository concept is.

After decades of research, Nagra is convinced: in Nördlich Lägern, the Opalinus Clay and the over- and underlying rock formations are the most suitable for containing radioactive waste. With the general licence application, Nagra is submitting the detailed justification for its arguments to the regulatory authorities. Background information on Nagra's decision can be found in the report justifying the siting proposal (see QR code to the right).

Report on the siting proposal

NAGRA WANTS TO PROTECT THIS ZONE

Drilling or other intrusive activities in the immediate vicinity of the deep geological repository are not advisable, which is why Nagra considers it necessary to propose a protection zone.

The safety of a deep geological repository relies on the tightness of the rock. Human actions that could impact the planned site, such as drilling, would not be advisable. Nagra is therefore proposing a so-called provisional protection zone to protect two areas: the subsurface area where the repository will eventually be constructed in the host rock, and the area through which the access routes to the repository will be constructed.

DESIGN FLEXIBILITY THANKS TO GENEROUS SPATIAL RESERVE

Switzerland's deep geological repository will be constructed in a layer of Opalinus Clay that is over 100 metres thick. However, the provisional protection zone will protect not only the Opalinus Clay, but also some of the over- and underlying rock layers, overall a rock layer some 300 metres thick.

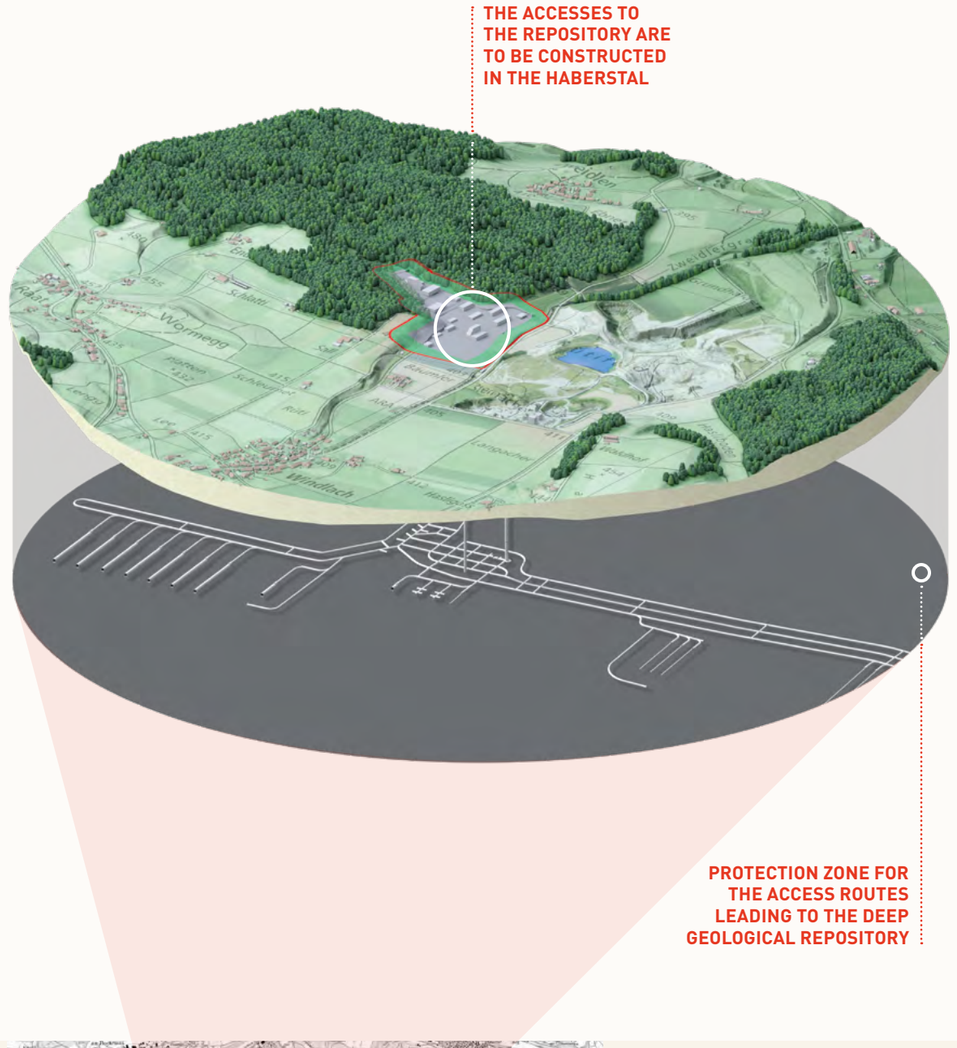
Covering an area of around 26 square kilometres, the geological setting is favourable for the emplacement of radioactive waste. The repository will later be constructed within this zone and will cover around 2 square kilometres.

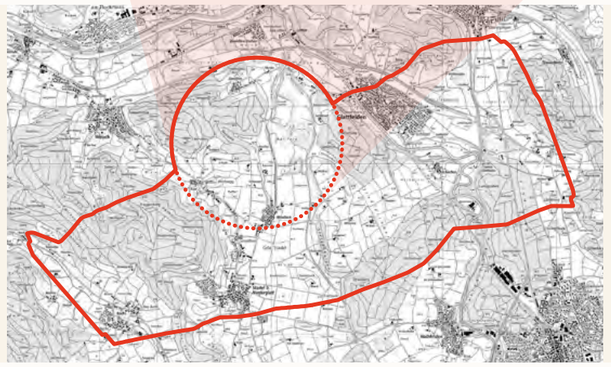
REPOSITORY ACCESS ROUTES

The deep geological repository can be accessed in various ways, for example by shaft or by ramp. How exactly the access to the underground will eventually look will be determined at a later stage. For this reason, a zone with a diameter of three kilometres from the surface down to the Opalinus Clay is to be protected. In this way, it will be possible to build an access both via a shaft and a ramp.

WILL THERE BE ANY USAGE RESTRICTIONS?

The protection zone around the deep geological repository has no impact on conventional underground activities. Gravel quarrying, for example, will continue to be possible, as will the installation of geothermal probes. The federal government will only require additional authorisation for drilling boreholes beyond a certain depth.





Map illustrating the provisional protection zone. It protects the underground area that will one day host the deep geological repository as well as the area through which the access routes to the repository will be constructed.

NAGRA PROPOSES THESE SUITABILITY CRITERIA

Before the radioactive waste can be emplaced, Nagra has to carefully assess the disposal zone.

The radioactive waste will be disposed of in emplacement drifts and caverns. In line with legal stipulations, this disposal zone must be constructed in a host rock that is suitable for the emplacement of the waste. To demonstrate that the properties of the selected Opalinus Clay host rock meet this requirement, the application documentation must include so-called suitability criteria and corresponding measurement methods.

These criteria have to consider three aspects: the extent of suitable host rock areas, the hydrogeological conditions at the site and the residence time of the deep groundwater. According to Nagra's proposal, these aspects will be investigated as follows:

EXTENT OF SUITABLE HOST ROCK AREAS

Nagra has to ensure that there is a sufficiently thick layer of rock around the repository: the tight rock layers above and below the repository must be at least 20 metres thick. The Opalinus Clay alone is around 100 metres thick in Northern Switzerland where it also has the right depth and sufficient extent.

During construction, the underground will be continuously surveyed to ensure that the disposal zone is surrounded by a sufficiently thick layer of tight rock. The measurements will be compared with the geological model of the underground.

HYDROGEOLOGICAL CONDITIONS AND RESIDENCE TIME OF DEEP GROUNDWATER

These two aspects can be tested in the Opalinus Clay using the same methods. The pores of the Opalinus Clay contain water, and it is possible to determine the age and composition of this porewater. If the porewater is older and has a different composition than that of the groundwater, this is a good sign, as it is evidence of the isolating capacity and tightness of the Opalinus Clay.

In addition, the clay-mineral content of the Opalinus Clay in the disposal zone should exceed 25 per cent. Clay minerals are partly responsible for the self-sealing capacity of a rock, which is another important property of the Opalinus Clay. The composition of the porewater and the clay-mineral content in the Opalinus Clay will be continuously measured during the construction of the repository.

THIS MUCH WASTE CAN BE EMPLACED IN THE REPOSITORY

Nagra proposes the maximum disposal capacity of the repository in the general licence application, i.e. the maximum volume of radioactive waste that can be emplaced in the repository.

How much high-level waste will be produced in Switzerland depends primarily on how long the nuclear power plants continue to operate. In line with current planning, this has not yet been conclusively decided: the existing nuclear power plants are allowed to continue to operate as long as this can be done safely. In its models, Nagra assumes that the existing nuclear power plants will operate for 60 years.

Reserves are also factored in, for example, in the event that the operating lifetime of the nuclear power plants exceeds 60 years. However, what these reserves do not take into account are new nuclear power plants.

The expected waste volume plus the reserves give the so-called maximum disposal capacity, which is specified in the general licence.

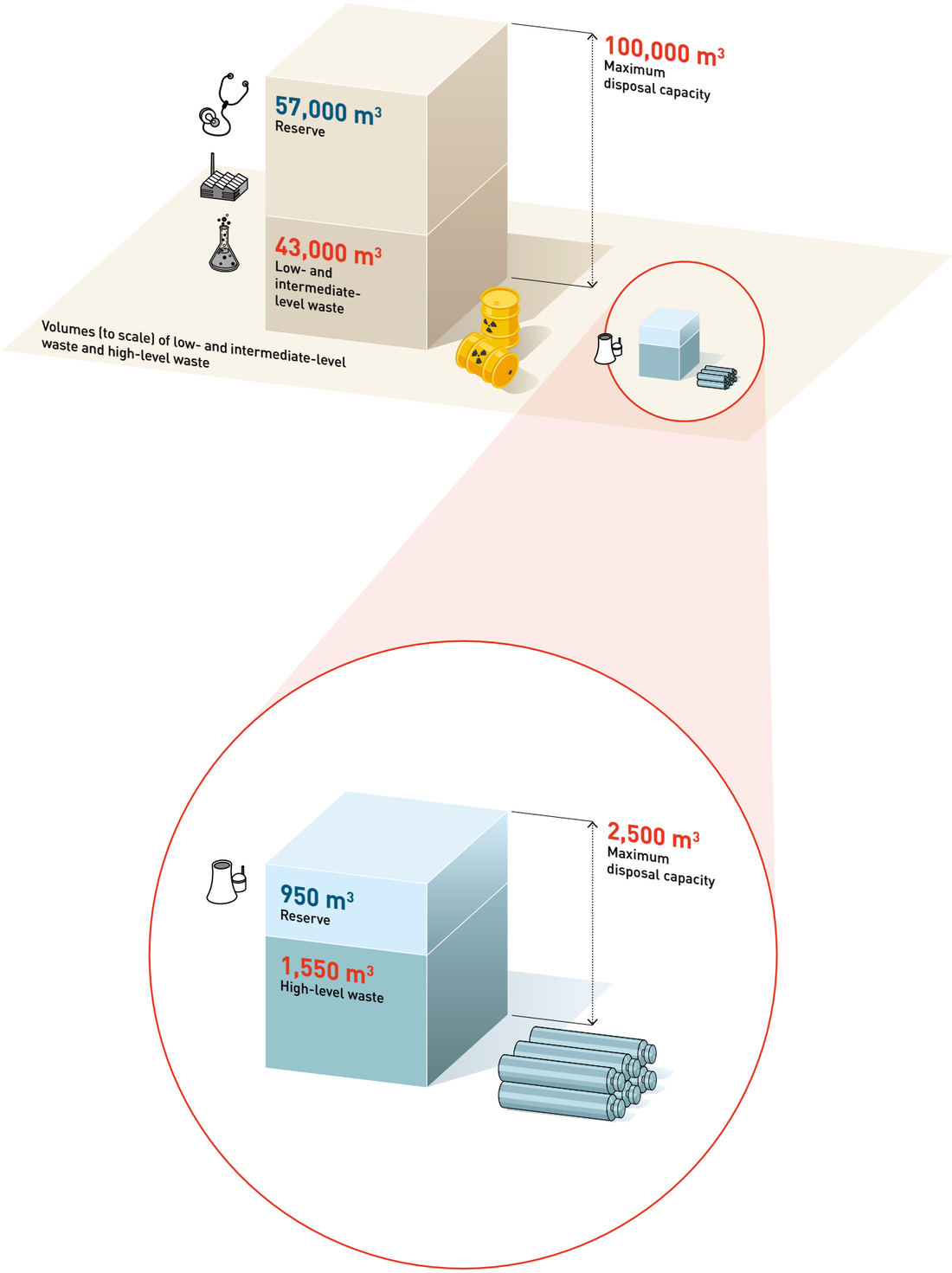
Nagra proposes a maximum disposal capacity of 2,500 cubic metres for high-level waste, of which 950 cubic metres are planned as reserve. Spent fuel assemblies make up the largest proportion of high-level waste.

RESERVES FOR LOW- AND INTERMEDIATE-LEVEL WASTE

A maximum volume of 100,000 cubic metres is proposed for low- and intermediate-level waste, of which 57,000 cubic metres are reserves. This waste is produced by nuclear power plants and comes in various forms such as contaminated protective suits or tools, but it is also produced through applications in medicine, industry and research.

Different scenarios must be considered for low- and intermediate-level waste than for high-level waste. For example, Nagra currently includes all low- and intermediate-level waste expected to be produced by 2065 in its calculations. If this period is extended, however, more waste will have to be emplaced in the repository.

More space would also be needed if dose limits were to be adjusted; in other words, if more materials were to be categorised as radioactive waste. This waste would also have to be disposed of in a deep geological repository. For these and other reasons, Nagra also includes reserves for low- and intermediate-level waste.

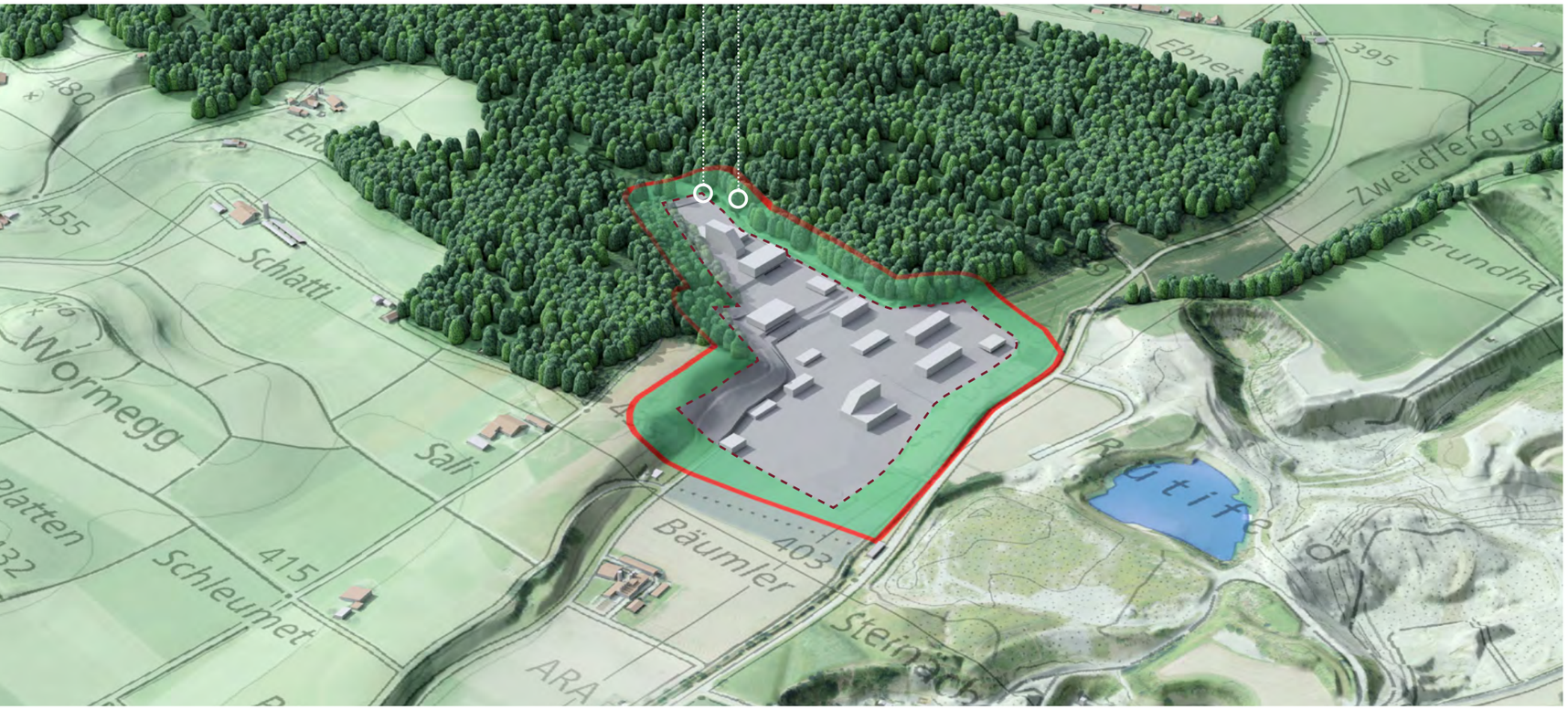


DIMENSIONS OF THE SURFACE FACILITY

Where will the most important structures of the repository be located and how large will they be? Nagra proposes the basic features and maximum dimensions.

The surface facility for the deep geological repository is to be constructed at the Haberstal site in the community of Stadel. Two areas must be distinguished in terms of the spatial requirements: the facility perimeter and the transition strip. Together, they form the project perimeter.

The buildings that make up the surface facility will be constructed within the 13-hectare facility perimeter. They will form the gateway to the underground where the repository will be located. The perimeter defines the maximum extent of the structures, but the exact layout within the perimeter and the exact dimensions will be specified later with the construction licence. Installation areas that are required to operate the construction site are also included in the perimeter.



Schematic representation of the surface facility in the Haberstal

TRANSITION STRIP

The transition strip (outlined in green) will consist of a roughly 50-metre-wide strip surrounding the facility perimeter (dashed line). No buildings will be constructed in the transition strip, part of which will lie in the forest. The forest within the strip will be kept intact, but the canopy height must be managed. This is standard safety procedure and is also required, for example, where power lines cross a forest. This measure is necessary to prevent falling trees or a forest fire from jeopardising the facility.

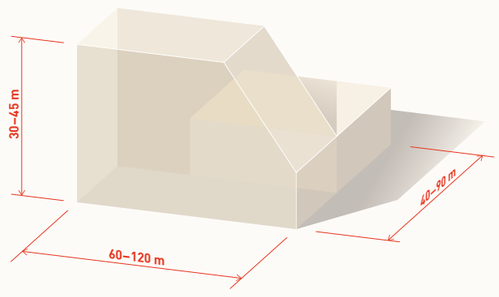
The other part of the transition strip is an open space. Its purpose is to integrate the surface facility into the surrounding landscape: for example, by adding cultivated earth banks to reduce visibility. Harmonious integration is a concern of the region.

Whether and how this will be implemented is still open. This issue will be resolved over the next few years together with the affected stakeholder groups.

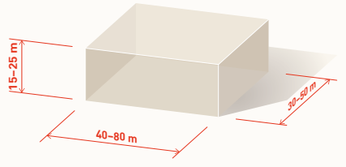
MAXIMUM DIMENSIONS OF KEY STRUCTURES

The most important installations at the surface include the access structures to the deep geological repository, such as the shaft head facilities and the provisioning hall. The waste will be delivered to the provisioning hall, where it will be prepared for emplacement in the repository. Other buildings are also required for the construction and operation of the repository as well as for related logistical purposes.

In its application, Nagra proposes the maximum dimensions for the most important buildings. For example, the provisioning hall is planned to cover a maximum area of 80 by 50 metres and have a maximum height of 25 metres. It is very unlikely that the maximum lengths, widths or heights will be needed everywhere, but securing these will allow sufficient flexibility to optimise the layout of the buildings.



SHAFT HEAD FACILITIES
Accesses for the construction and operation of the repository



PROVISIONING HALL
Temporary storage for packaged waste prior to transport to the repository

ENCAPSULATION PLANT FOR SPENT FUEL ASSEMBLIES

The radioactive waste is to be packaged into disposal canisters in an encapsulation plant located at the site of the interim storage facility in Würenlingen. This allows synergies – but also necessitates a separate general licence application.

As the waste is not repackaged at the site of the deep geological repository, it is necessary to submit a separate application for the encapsulation plant for spent fuel assemblies. Safety also plays an important role in this application, along with other issues such as spatial planning, environmental impacts and subsequent decommissioning. According to present-day planning, the low- and intermediate-level waste is also to be packaged in the interim storage facility in Würenlingen (Zwilag) and then transported to the surface facility of the deep geological repository. As an encapsulation plant for low- and intermediate-level waste already exists, all that is needed is to increase its capacity.

In the immediate vicinity of the interim storage facility, the spent fuel assemblies will eventually be repackaged from the large transport and storage casks into the smaller disposal canisters. This will take place in the encapsulation plant for spent fuel assemblies, which is still to be constructed.

The encapsulation plant for spent fuel assemblies will be constructed at the site of the Zwilag interim storage facility.

MAKING USE OF SYNERGIES

The construction of the waste encapsulation plant at the Zwilag interim storage facility allows synergies to be made use of. This site is already the competence centre for the packaging of radioactive waste. This means that the area does not have to be developed from scratch, but merely expanded.

THE MOST IMPORTANT BUILDING

The encapsulation plant for spent fuel assemblies is the most important new building to be constructed at the Zwilag interim storage facility. Its maximum dimensions are proposed to be 70 by 110 metres with a maximum height of 50 metres.

In its proposal to expand the Zwilag site, Nagra has included a facility perimeter, a transition strip and an installation area for the operation of the construction site in its general licence application. The entire perimeter covers around 2 hectares. As with the surface facility for the deep geological repository, the exact positioning and size of the structures will be specified later with the construction licence.

The transition strip is just under one hectare in size and is located entirely in the forest. The forest must be kept low so that falling trees or a potential forest fire cannot jeopardise the facility.

OUTLOOK

Several steps are still required before Switzerland can put the deep geological repository into operation. The general licence is an important milestone in this process.

Over the next few months, the federal authorities will check the general licence applications for completeness. This review, and any additions to the application documentation, should be finalised in spring 2025. It will then be made public, allowing interested parties to obtain comprehensive information about the applications online.

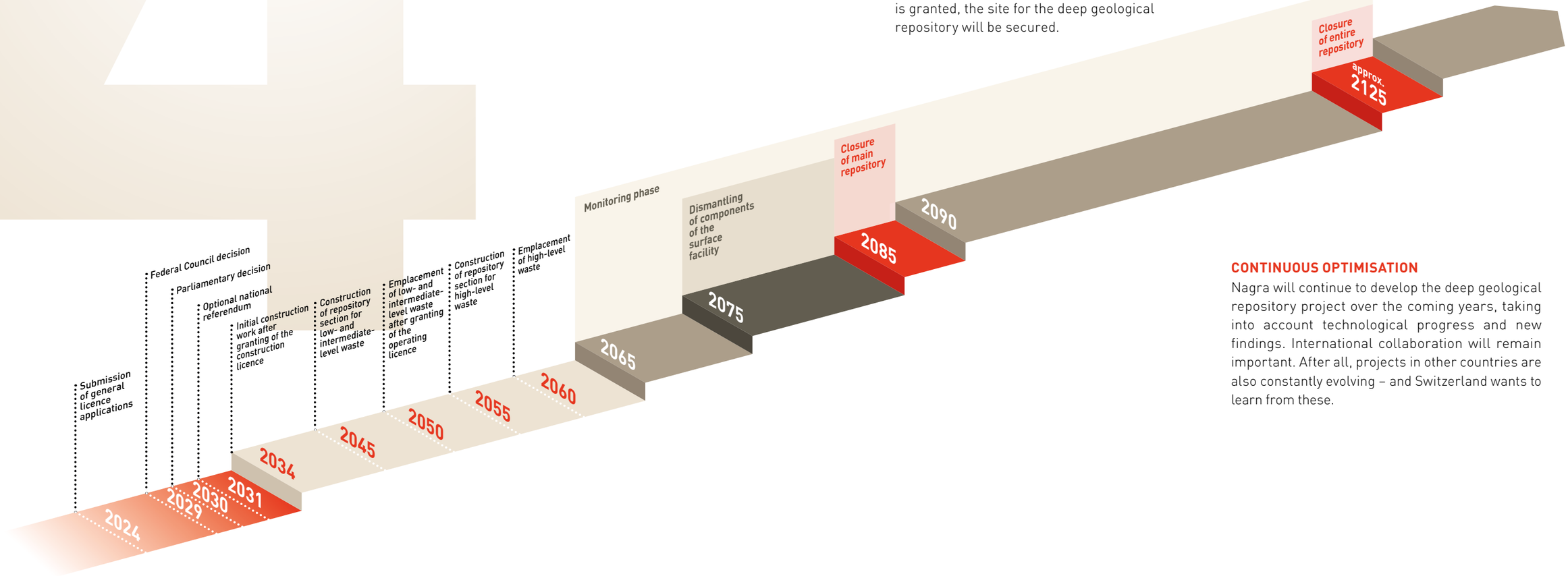
SECURING THE SITE

In the next step, the responsible authorities will review the reports in detail. The region, cantons and the German district of Waldshut will also give their opinions. The entire population can join the discussion within the framework of the public consultation period.

According to current planning, the Federal Council's decision on the general licences is expected towards the end of the decade. The application will then be submitted to Parliament and will also be subject to an optional national referendum. Should this decision for a referendum be taken, the Swiss voters will have the final say. A vote would probably take place around 2031. If the general licence is granted, the site for the deep geological repository will be secured.

THE NEXT LICENCE APPLICATION

Nagra is expected to submit the construction licence application for the deep geological repository in the early 2030s. Preparatory work will be carried out in advance, for example, by drilling exploratory boreholes for the construction of the shafts. This will help to save time: as soon as Switzerland gives the green light for the deep geological repository, Nagra will be ready to build it. If everything goes according to plan, construction will begin in around ten years. Emplacement of the first radioactive waste is scheduled to begin around 2050.



CONTINUOUS OPTIMISATION

Nagra will continue to develop the deep geological repository project over the coming years, taking into account technological progress and new findings. International collaboration will remain important. After all, projects in other countries are also constantly evolving – and Switzerland wants to learn from these.

IMPRINT

Published by	National Cooperative for the Disposal of Radioactive Waste Hardstrasse 73 5430 Wettingen, Switzerland
Editorial office	Nagra
Proofreading (German)	Inés Flück, sprach-art
Print shop	Köpflipartners AG
Circulation	100 copies
Publication date	Second edition, June 2025
Available issues	Nagra (info@nagra.ch)
	This is an English translation of the original German version. A French translation is also available.
	The German issue is binding.
	All depicted persons are employees of Nagra.
Further information	nagra.ch

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