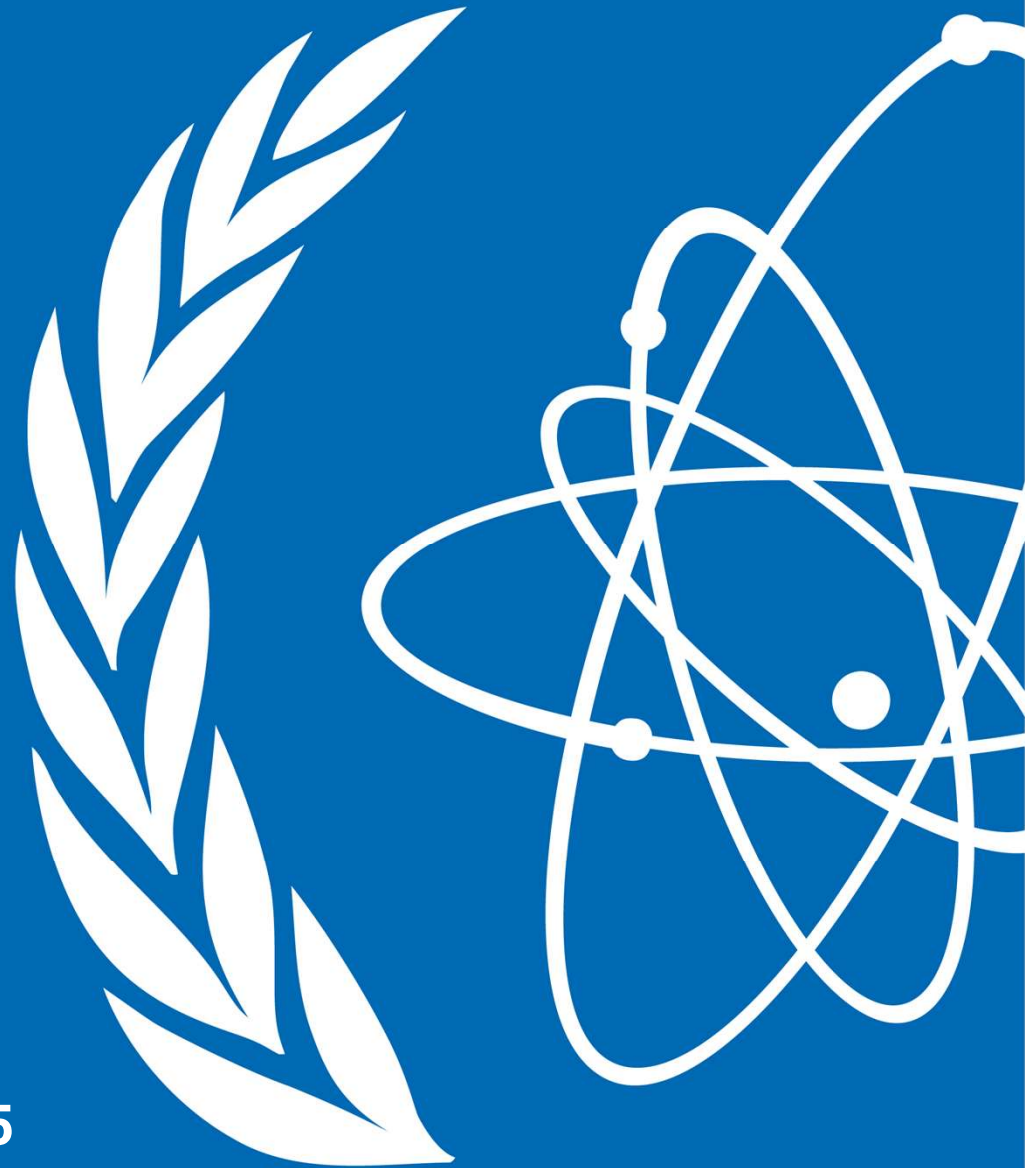


Geological Disposal: Global experiences

Stefan Mayer (Team Leader – Disposal)
IAEA

Department of Nuclear Energy
Waste Technology Section

Symposium, Sapporo, Japan, September 2025



Radioactive Waste Management – General Considerations

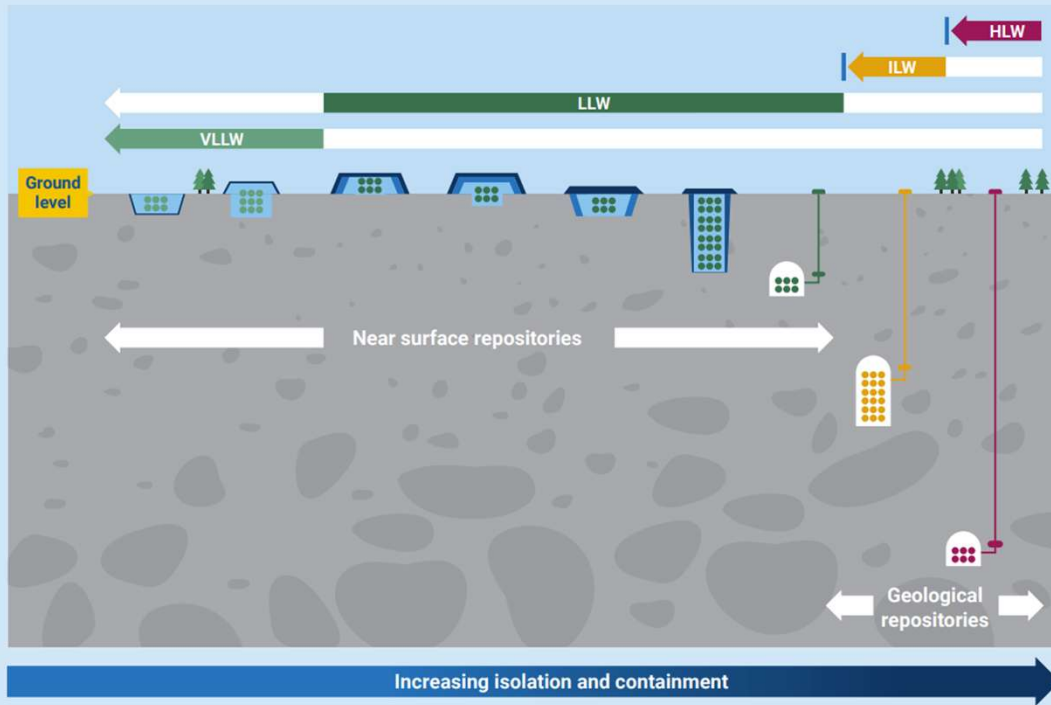
- Addressing a national responsibility
- Building on international experience
- Many positive examples in the world
- Working with the public on acceptable solutions
- Considering host community well being
- Cost remains small compared to the value of energy



- Responsible management of long-term liabilities:
 - ✓ A key enabler to sustainable nuclear energy production
 - ✓ Solutions exist!

Waste Classification and Disposal Options

Disposal options based on the class of radioactive waste



% in Storage and Disposal

VLLW and LLW

~ 35 Mio m³ globally

~ 80% in disposal

~ 20% in storage

Discharged Spent Nuclear Fuel

~ 430.000 tHM globally (end of 2024)

~30% reprocessed

~ 70% in storage

HLW (vitrified)
ILW (e.g. assembly components)
LLW



Geological Disposal – Some Recent News

Envirotec
TECHNOLOGY IN THE ENVIRONMENT

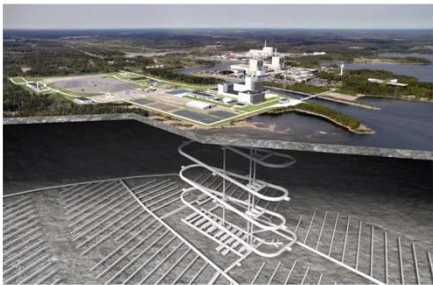
NEWS ▾ AIR ▾ ENERGY ▾ EQUIPMENT ▾ MONITORING ▾ SLUDGE & WASTEWATER ▾ WASTE ▾

Home > Waste > Hazardous Waste

Waste > Hazardous Waste

Work begins on Swedish spent nuclear fuel repository

January 2025



The facility will be located near the Baltic Sea coast of Eastern Sweden. When fully extended, it will contain more than 60 kilometres of tunnels. The surface section of the facility will cover a total area of 24 hectares, the equivalent of 44 soccer fields.

[Work begins on Swedish spent nuclear fuel repository | Envirotec](#)

OPINION

MARCH 6, 2023 | 4 MIN READ

Nuclear Waste Is Piling Up. Does the U.S. Have a Plan?

We need a permanent national nuclear waste disposal site now, before the spent nuclear fuel stored in 35 states becomes unsafe

BY ALLISON MACFARLANE & RODNEY C. EWING

[Nuclear Waste Is Piling Up. Does the U.S. Have a Plan? | Scientific American](#)

BBC

Home News Sport Business Innovation Culture Arts Travel Earth Audio Video Live

Cumbria could be only option for nuclear disposal

1 April 2025

Ian Duncan
Local Democracy Reporting Service



Areas in Cumbria are being considered for a nuclear waste disposal site

Cumbria could be the only area left in the search for a new nuclear disposal site, councillors have been told.

[Cumbria could be only option left for nuclear disposal site](#)

BUSINESS: GERMANY

German nuclear phaseout leaves radioactive waste problem

Klaus Drees

28/10/2024

While Germany searches for a permanent storage facility for its nuclear waste, it risks sitting on piles of dangerous waste for decades. The problem drains public finances by hundreds of millions of euros every year.

f x



German radioactive waste is bound to multiply as the country is gradually dismantling its nuclear power plants

[German nuclear phaseout leaves radioactive waste problem](#)

CANADA

Ontario site selected for nuclear waste underground repository

By Allison Jones • The Canadian Press

Posted November 28, 2024 1:47 pm • Updated November 28, 2024 5:53 pm • 5 min read

[Ontario site selected for nuclear waste underground repository | Globalnews.ca](#)



Press Release

Mayor and Council of the Township of Ignace Honoured to be Chosen by the Nuclear Waste Management Organization (NWMO) to Host Canada's First Deep Geological Repository Project (DGR)

The First of its Kind in Canada.

[Press Release - Township of Ignace - Wabigoon Lake Area Selected as Host to NWMO Deep Geological Repository November 28, 2024.pdf](#)

Energy Intelligence

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Finland: Posiva Prepares to Begin Spent Fuel Disposal

Copyright © 2023 Energy Intelligence Group

Published:
Fri, May 31, 2024

Author

[Grace Symes, Helsinki](#)

Editor

[Phil Chaffee](#)



Max Sky/Shutterstock

Finland's Posiva Oy plans to start a trial run disposing of spent nuclear fuel (SNF) in its Onkalo deep geological repository in August and hopes to receive an operating license for the facility in the first half of 2025, a company official told a Helsinki conference last week. Onkalo will be the world's first operating

[Finland: Posiva Prepares to Begin Spent Fuel Disposal | Energy Intelligence](#)

Disposal for ILW/HLW/SNF – Expertise and Confidence

Sweden (SKB) - Oesthammar
Construction start 01/2025

Finland (Posiva) - Onkalo
2024 Cold-Commissioning

France (ANDRA) - Cigéo
Licence decision 2025

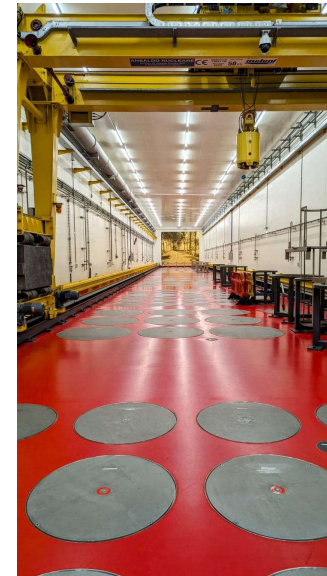
Canada (NWMO)
“Positive” from finalist communities

USA (DOE) - Carlsbad
WIPP emplacing TRU waste since 1999

Switzerland (NAGRA) - Nördlich Lägern
11/2024 License application

Germany (BGE) - KONRAD
Preparing for commissioning (~2030)

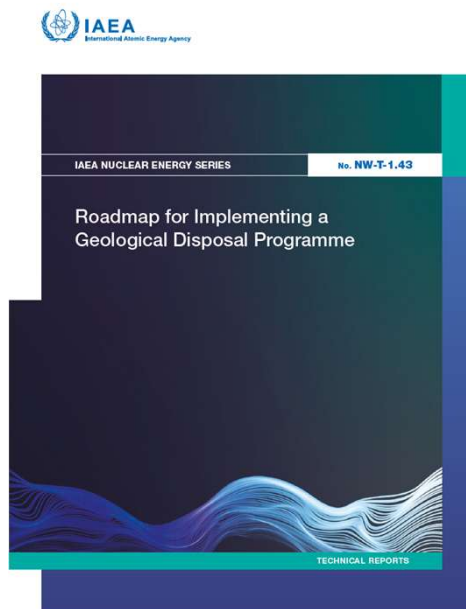
■ Advanced siting and
licensing stages



- ✓ Significant international experience with siting, licensing, construction
- ✓ Operation for ILW disposal
- ✓ Cold-commissioning for spent nuclear fuel (SNF) disposal

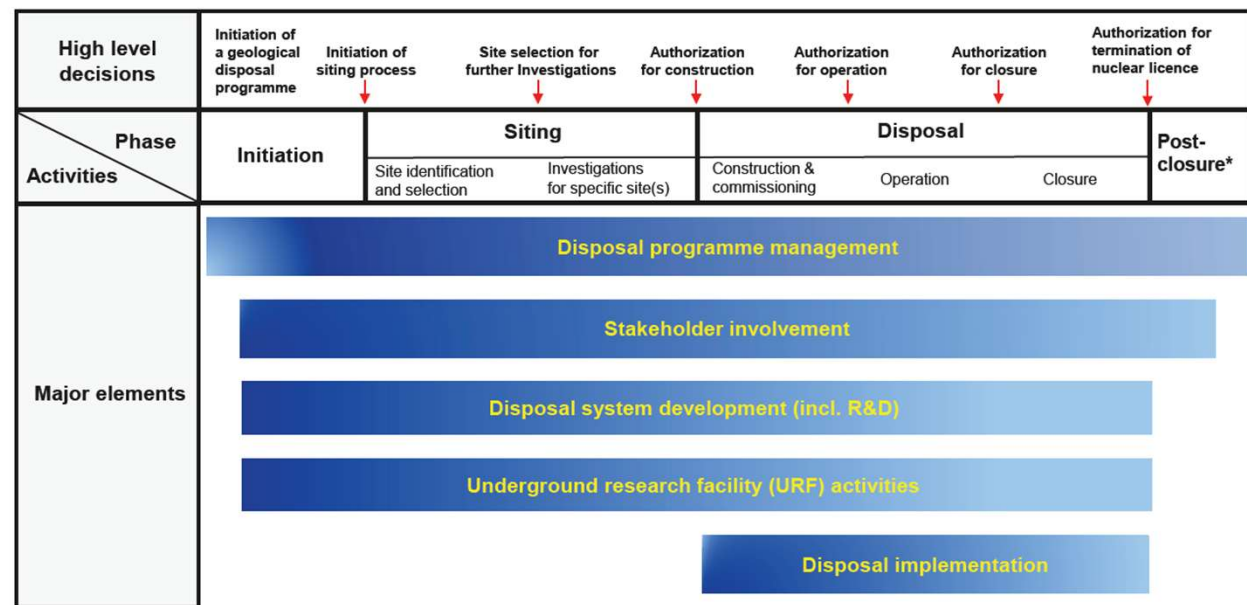
- What are Major elements of a geological disposal programme?
- What are the main decision points during a geological disposal programme?

International experience



[Roadmap for Implementing a Geological Disposal Programme](#)

The “Roadmap” is well understood

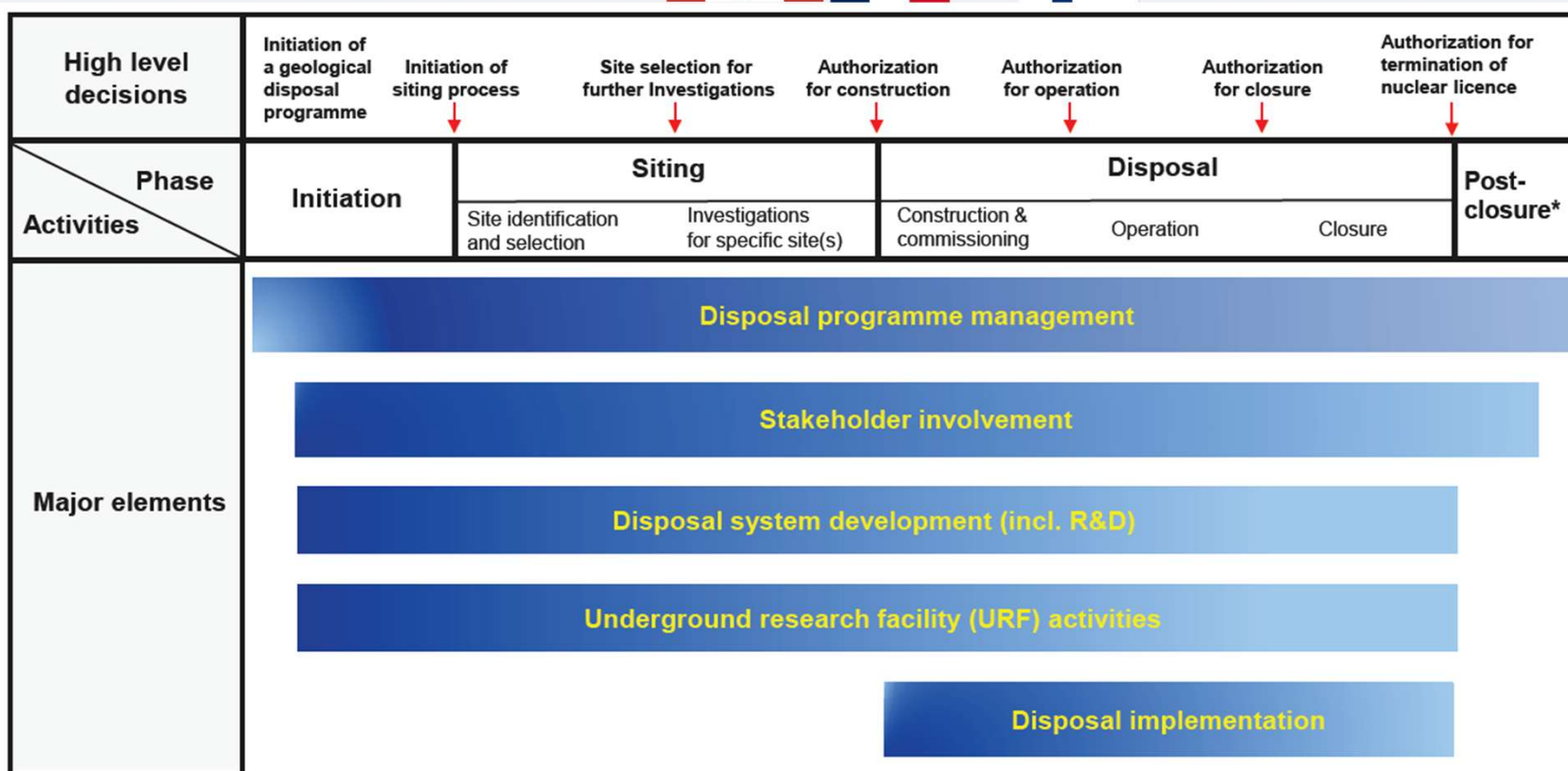


* Responsibility may be transferred from the WMO to another organization

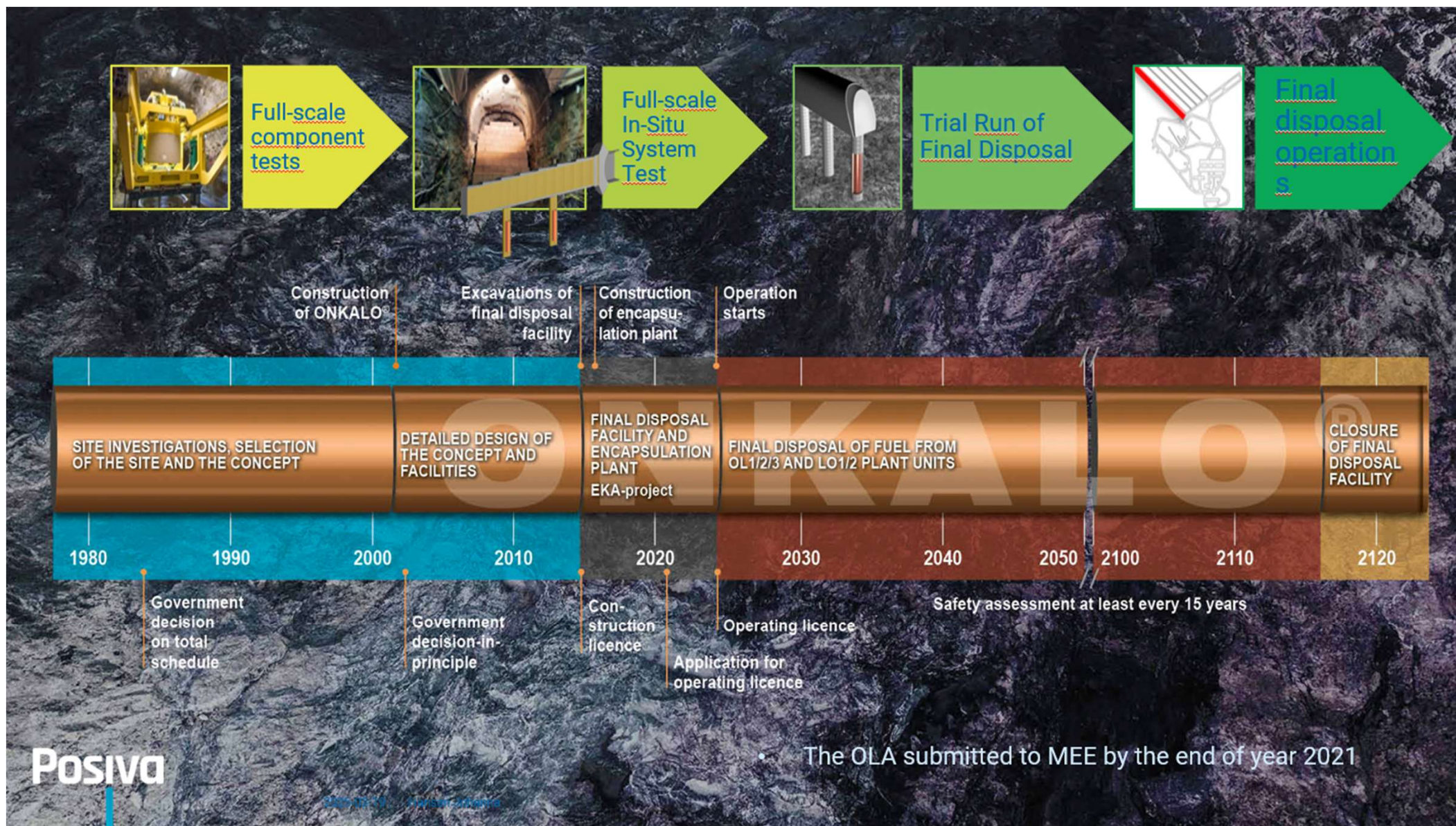


IAEA

Decisions Status in advanced programmes



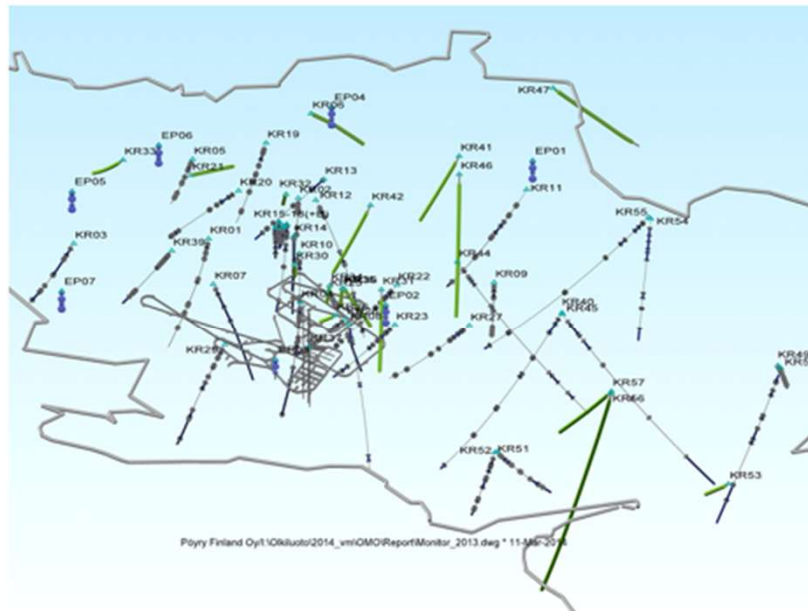
* Responsibility may be transferred from the WMO to another organization



Slide and graphics courtesy of Posiva – Used by permission

Investigation today

<u>core drilled holes</u>	2004	2014	2024
deep drillholes	28	57	58
tunnel pilotholes	1	25	35
shallow holes	39	513	651

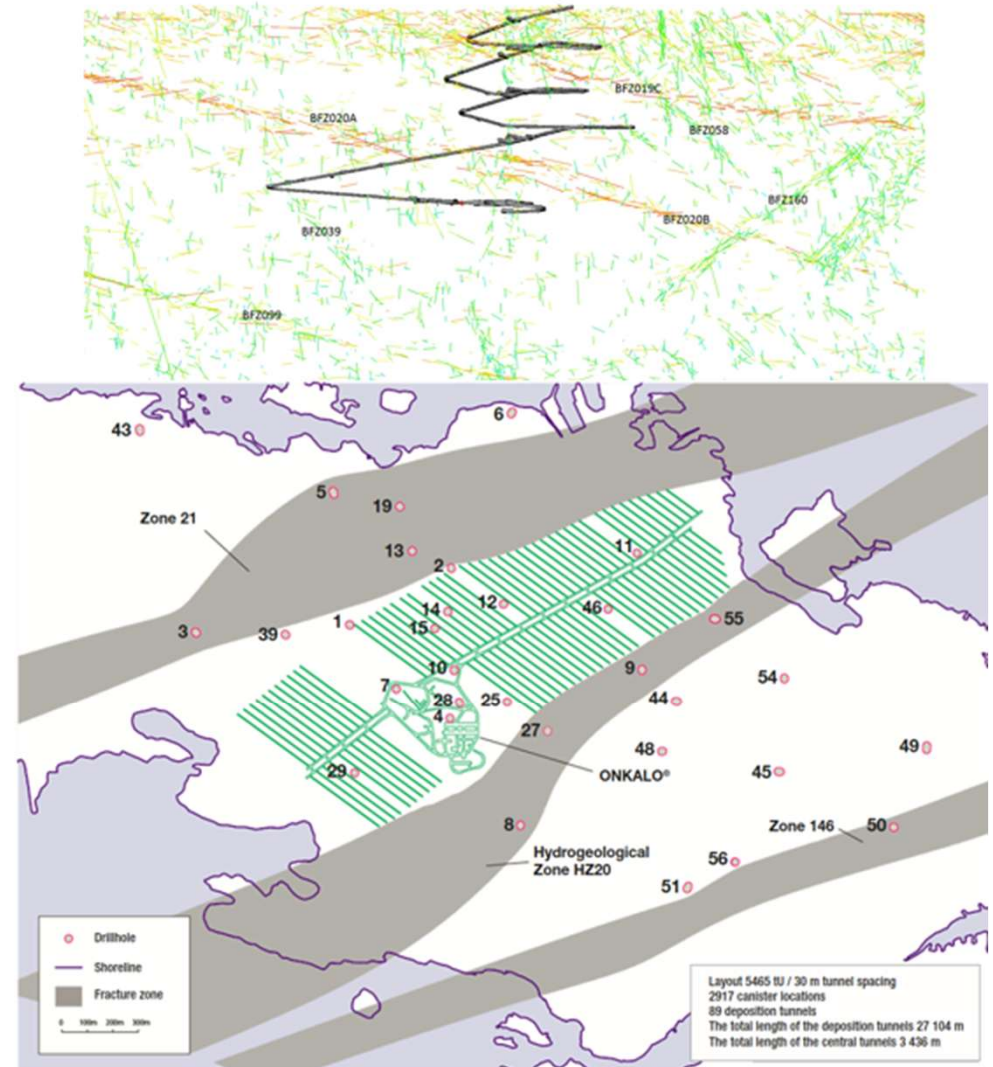


Posiva Finland Oy\1\Oikiluoto2014_vmr\MOI\ReportMonitor_2013.dwg * 11.10.2014

Posiva

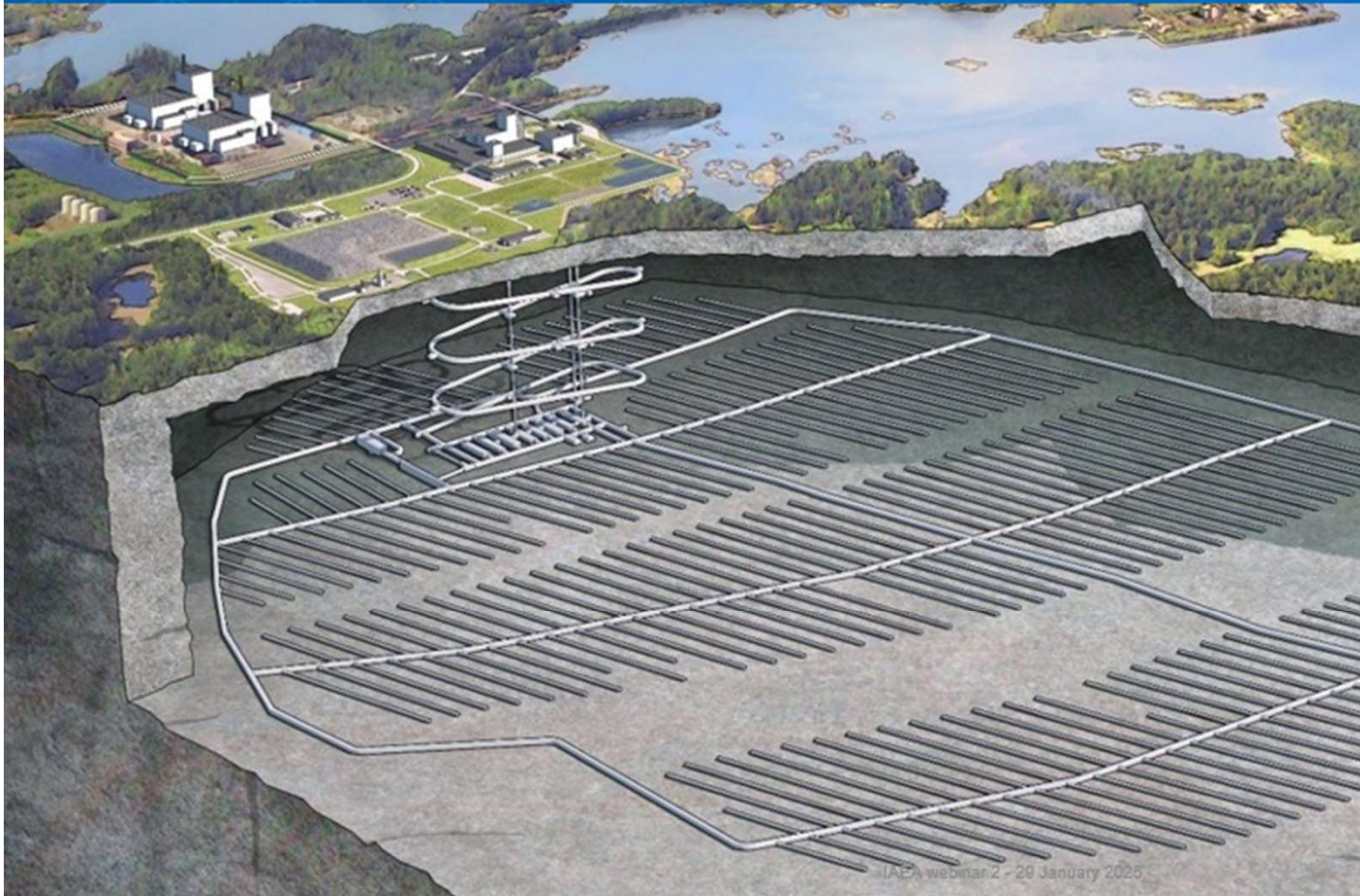
2025-02-19 Hansen Johanna

Internal



Slide and graphics courtesy of Posiva – Used by permission

Final repository for spent nuclear fuel

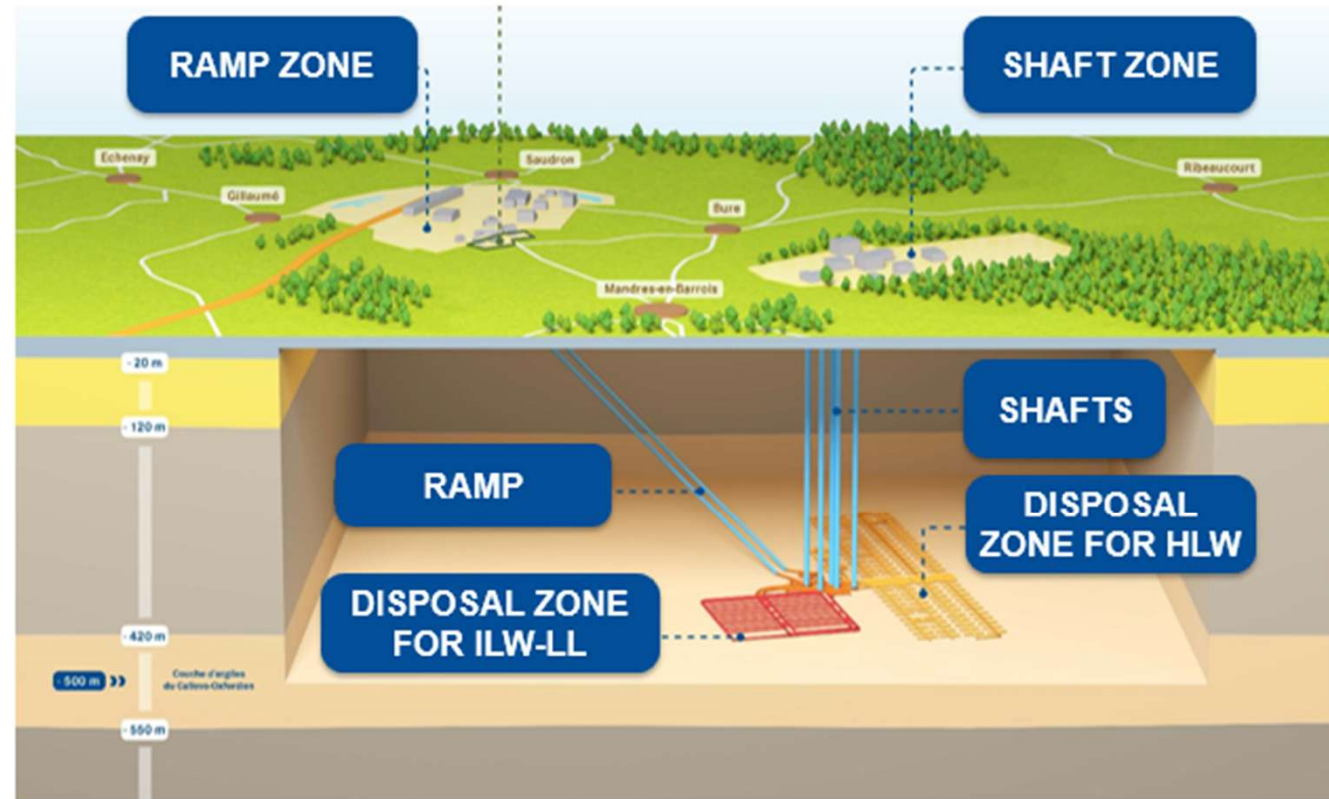


“At a depth of 500 meters in rock that is 1.9 billion years old we intend to deposit approximately 12,000 tons of spent nuclear fuel in a final repository.”

Slide and graphics courtesy of SKB – Used by permission

Cigéo Layout

- 550** Meters deep
- 15** Km² of disposal area
- 83000** m³ of waste
- 120** Years of operation
- 25** Billions euros



Slide and graphics courtesy of Andra – Used by permission

Key Achievement in 2024 - Segment Removal



Segment removal and reconstruction in GRD4 Drift

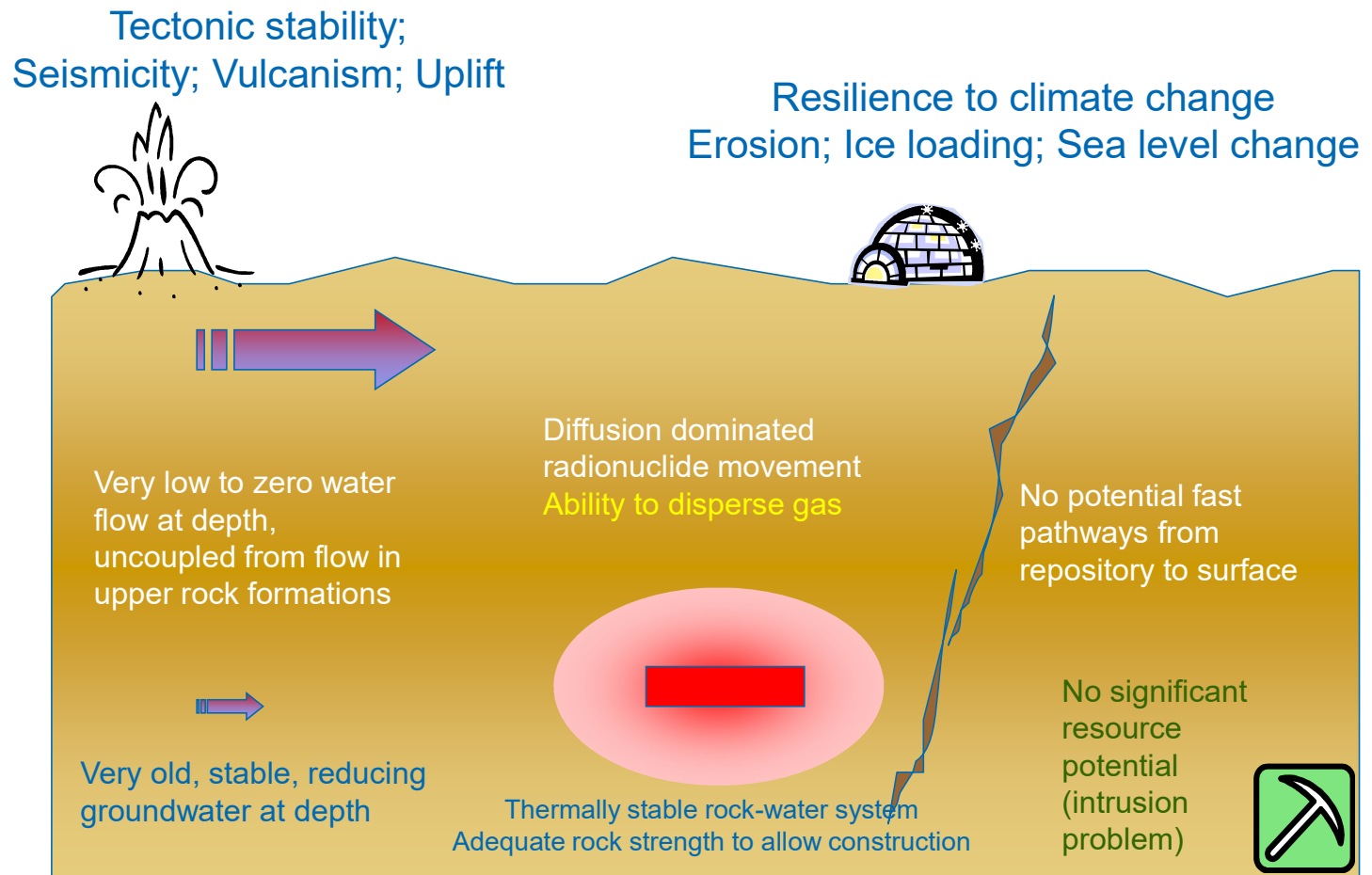
- Prefiguring slots in seals
- Technical Challenges
- Characterization of the EDZ
- Mitigation of the EDZ
- Safety issues

Slide and graphics courtesy of Andra – Used by permission

Site Selection

IAEA Safety Standard SSR-5,
Requirement 15:

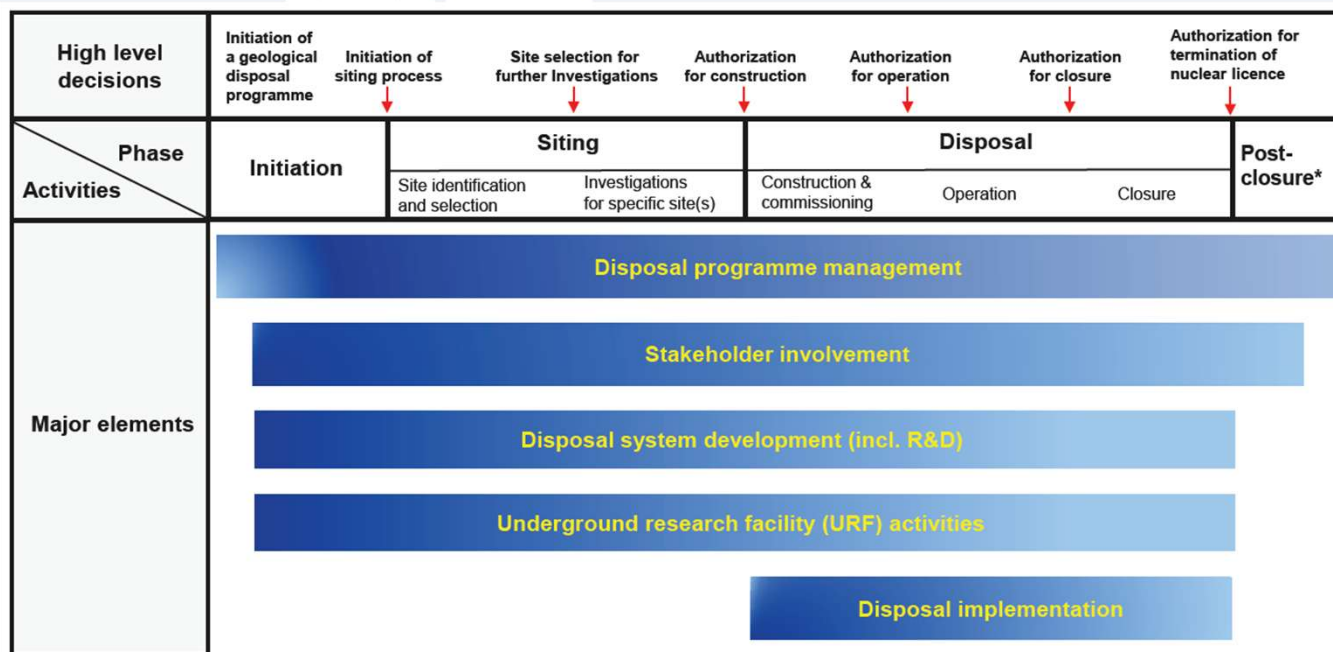
"The site for a disposal facility shall be characterized at a level of detail sufficient to support a general understanding of both the characteristics of the site and how the site will evolve over time. This shall include its present condition, its probable natural evolution and possible natural events, and also human plans and actions in the vicinity that may affect the safety of the facility over the period of interest".



Decisions Status in a few other programmes

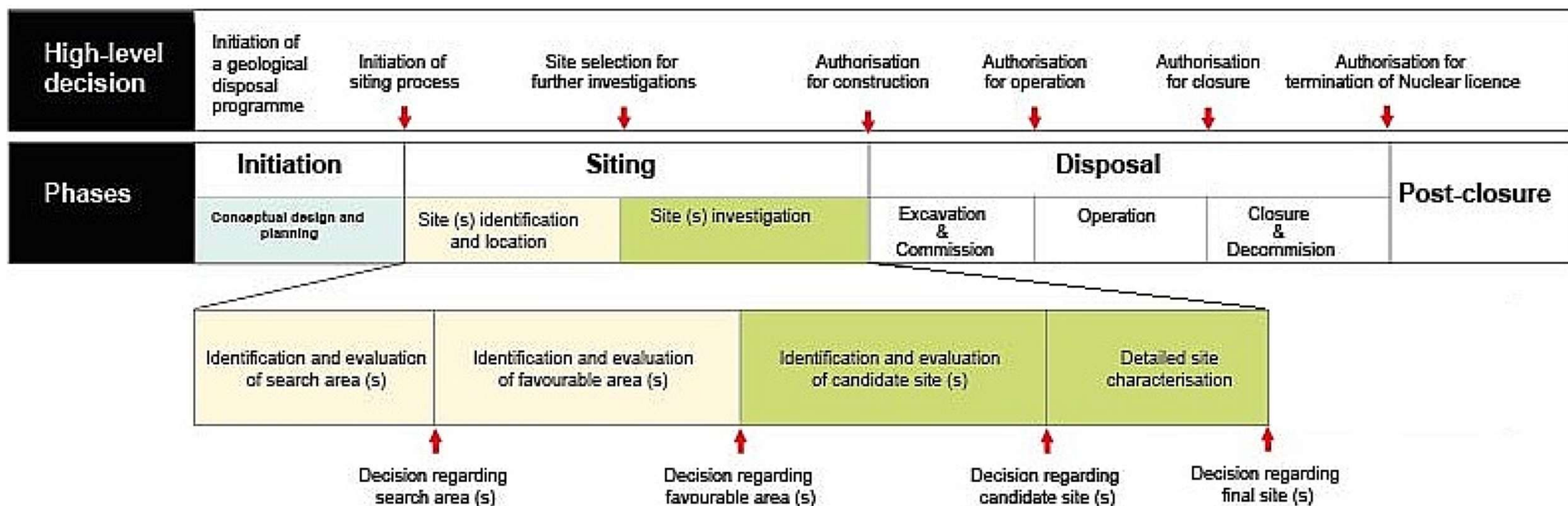


Note: Not a complete global list – more programmes are in Initiation and early siting phase.



* Responsibility may be transferred from the WMO to another organization

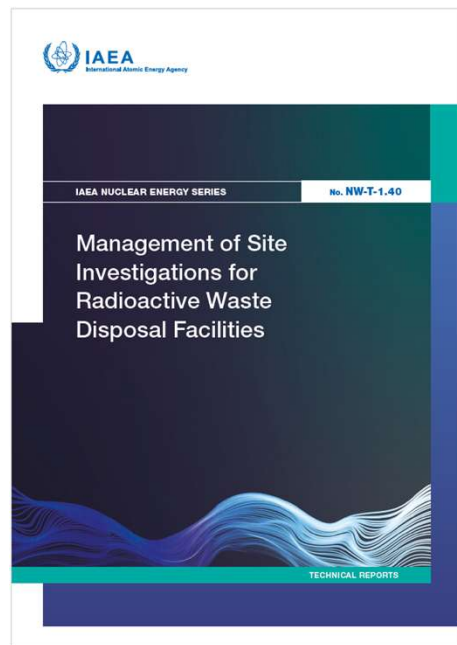
SITING PROCESS – Multiple options for intermediate steps and decisions



Modified from IAEA NW-T-1.40

Understanding relevant site properties – an iterative process

Site Investigations



[Management of Site Investigations for Radioactive Waste Disposal Facilities | IAEA](#)

A requirements driven approach

Understand the site properties that can impact construction and operation.

Understand the site properties that can impact the long-term safety of disposal.

Understand the evolution of the site and its potential for future change.

For example:

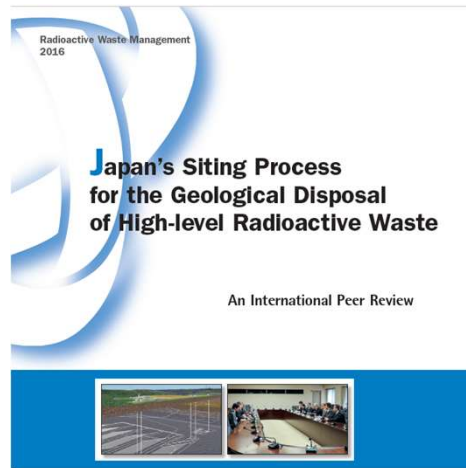
The site descriptive model will consider evolutions over long time scales and assess the probability and potential consequences of disruptive events, such as related to climate change, volcanism, tectonics and seismicity.



Adequate if requirements are met.

Japan's Siting Process for Geological Disposal

OECD/NEA peer review 2016



https://www.oecd-nea.org/jcms/pl_15028/

Basis & Findings

Report on [...] Preferrable Characteristics [...] for long-term stability (2014)

Report on [...] Criteria for Nationwide Scientific Screening [...] (2015)

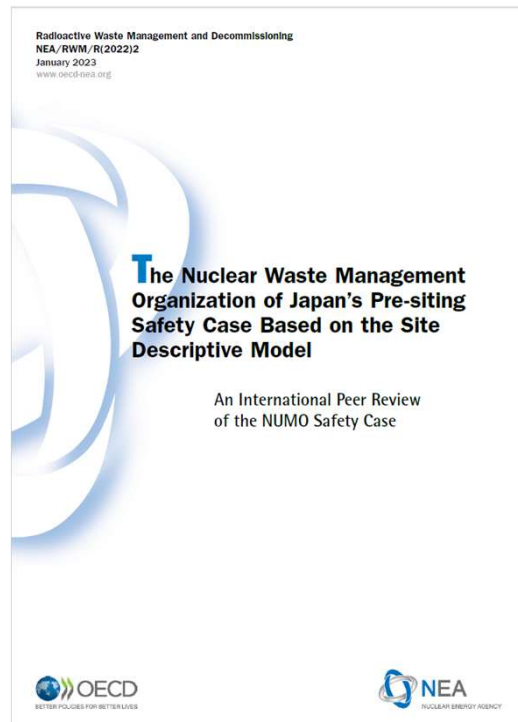
“[...] Stepwise selection process [...] and scientific screening are consistent with international practice”

“[...] important events and processes were properly identified[...]

Probability for geodynamic events, such as near volcanoes or faults, screened in “areas probably unsuitable”

Japan's pre-siting safety case based on a site descriptive model

OECD/NEA peer review 2023



Findings

"The post-closure safety assessment methodology is well-designed and informed by best practices and international recommendations (NEA/IAEA)."

"The IRT considers this site investigation approach reasonable and conforming to international best practices"

"At this stage, it seems reasonable to conclude that, based on the provided documentation, deep geological environments with favourable long-term characteristics from the point of view of geological disposal could be found in a range of locations in Japan."

"The exclusion of geographic areas where potential host rocks are deemed insufficiently stable to allow safety functions to be maintained for a sufficiently long period of time (i.e. of the order of 100 000 years for NUMO's safety case) is appropriate and consistent with international recommendations."

https://www.oecd-nea.org/jcms/pl_77138/

IAEA developing technical guidance on

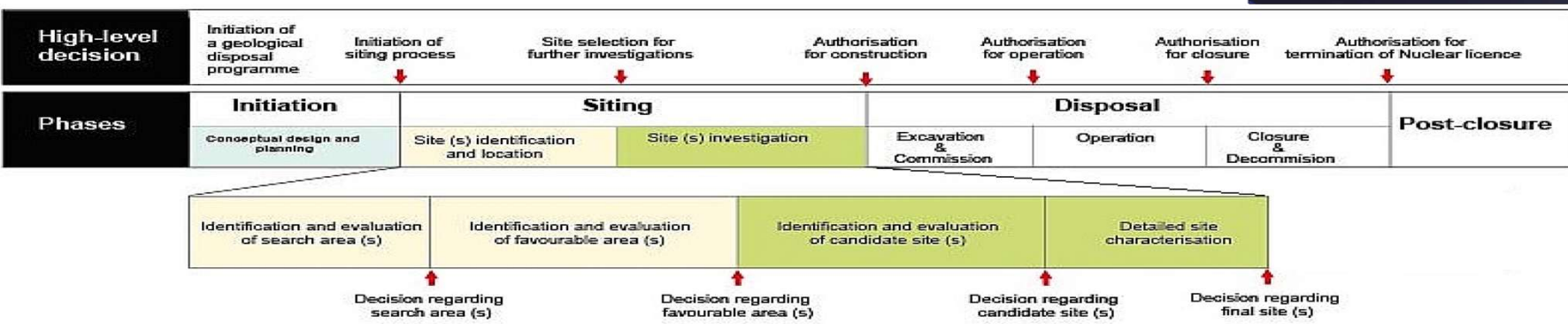
Siting Process for Geological Disposal: Contribution of site selection criteria

Main Criteria groups

1. Post closure safety
2. Engineering conditions
3. Transport and logistics
4. Operational safety and security
5. Society – economic
6. Environmental conditions
7. Cost, funding and fiscal considerations



DRAFT: Siting Process and Site Selection Criteria



TECHNICAL REPORTS

Examples of criteria specific to host rock properties and long term (post-closure) safety

Criteria Sub-Group 1.1. Properties of the host rock and the surrounding rock

Criterion 1.1.1. Spatial extent and protection from surface impacts

Petrological variability

Rock mass properties

Distance to major tectonic features (such as faults and faulting)

Criterion 1.1.2 Hydraulic barrier effect of the host rock and the surrounding rock

Criterion 1.1.3 Geochemical / mineralogical conditions

Criterion 1.1.4 Transport pathways

Criterion 1.1.5 Thermal conditions

Criterion 1.1.6 Mechanical conditions

Criterion 1.1.7 Microbiological conditions

Criterion 1.1.8 Gas transfer (in the host rock)

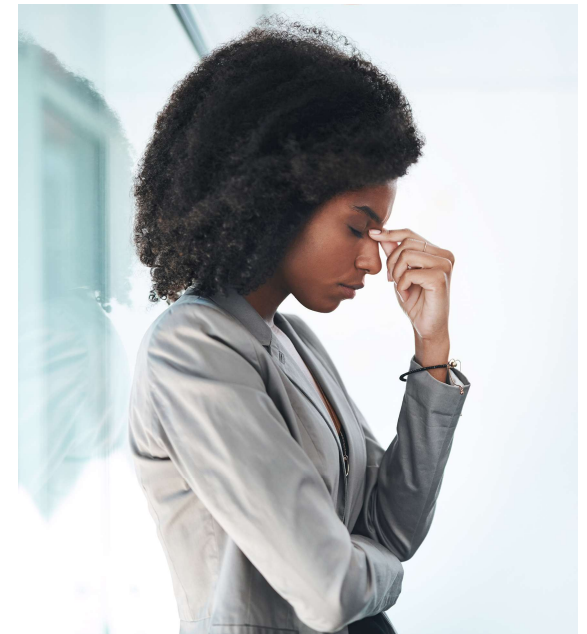
...Draft developments...

General Public Perception? – A Negative a Priori

Negative perceptions in part due to:

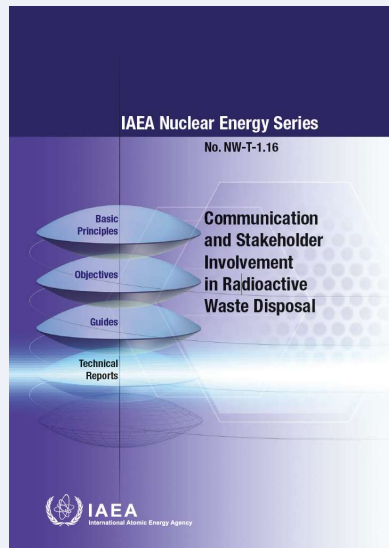
- Long time scales to establish geologic disposal
- Prior failures and restart of deep geological repository (DGR) programmes worldwide
- Longevity of radiological hazard
- ...

How to start the conversation about RadWaste?



EPPUNE project

"Recognizing the situational nature of communication and stakeholder involvement[...]"



Designing a sound process

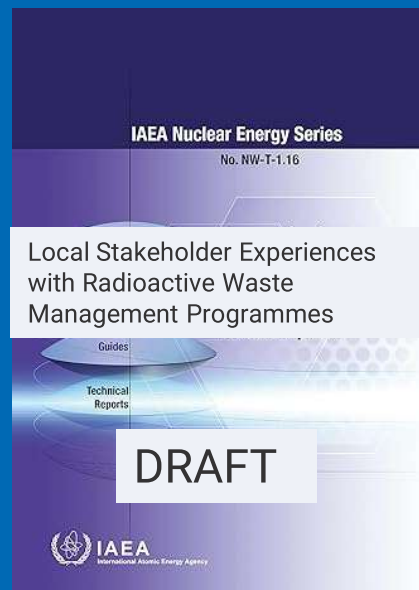
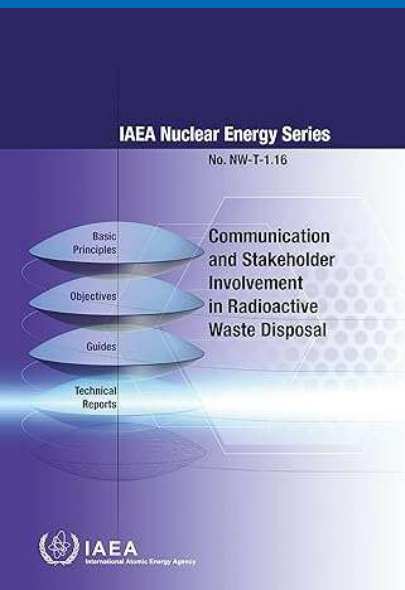
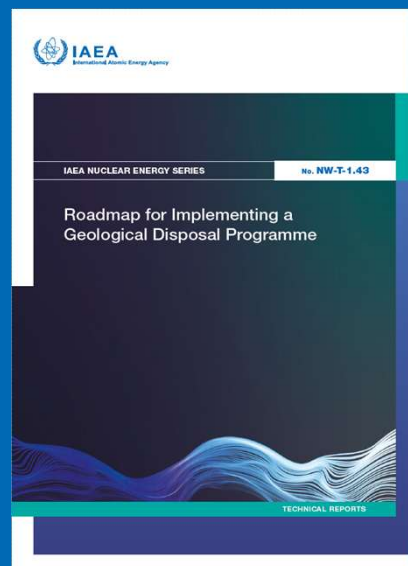
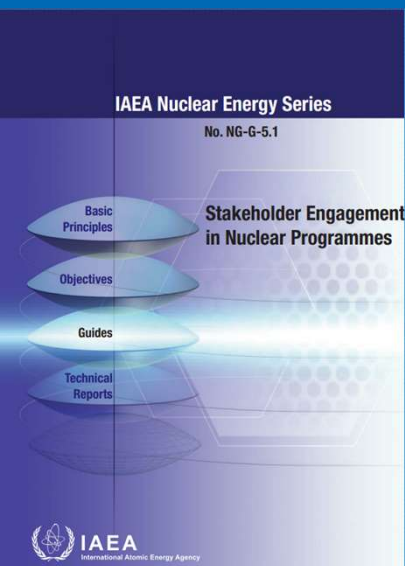
- ✓ No ambiguity on what decisions will be needed
- ✓ Clarity on respective roles in decision process – national, regional, local
- ✓ Agreement on what decisions can be reversed and until when in the process

"Situational" implies
No simple recipe



Catalogue of experiences
from ~ 20 national
disposal programmes

- Social license → maintaining mutual understanding
- Involvement process → decision process, flexibility
- Political/Regulatory framework → sustained approach
- Resources → basis for sound decisions
- Community support → recognition



Establishing sound decision processes

Responsible management open to learning

- ✓ Fundamentals – key principles
- ✓ Stakeholder engagement – an integral part of the disposal programme
- ✓ Learning from the radioactive waste management community
- ✓ Learning from local experiences

Thank you

✕ @IAEANE

se-ne@iaea.org