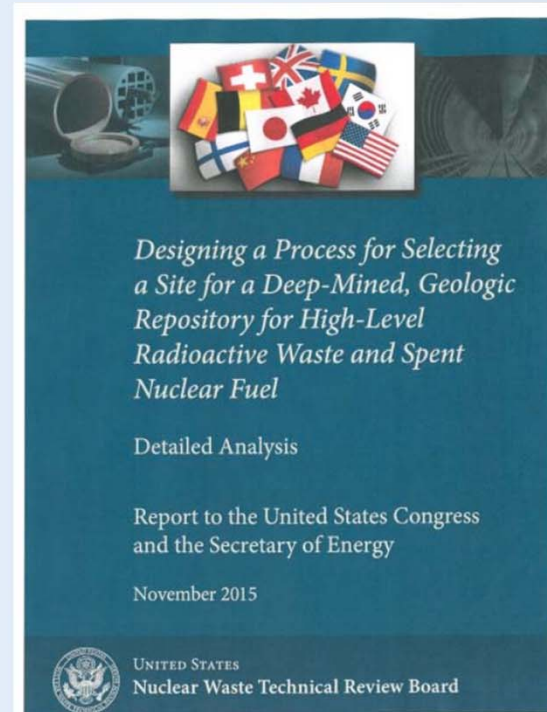
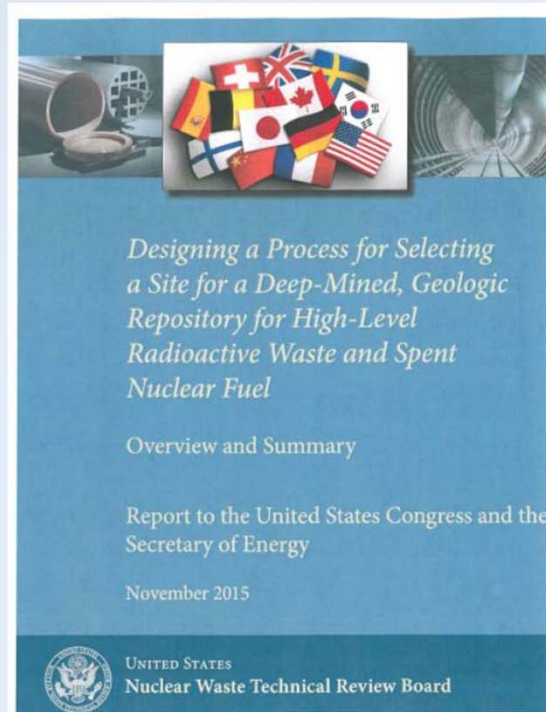


The Dilemma of Multiple Choices: Comparing the Technical Suitability of Sites for a Deep-Mined, Geologic Repository for High-Activity Radioactive Waste

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Available at www.nwtrb.gov

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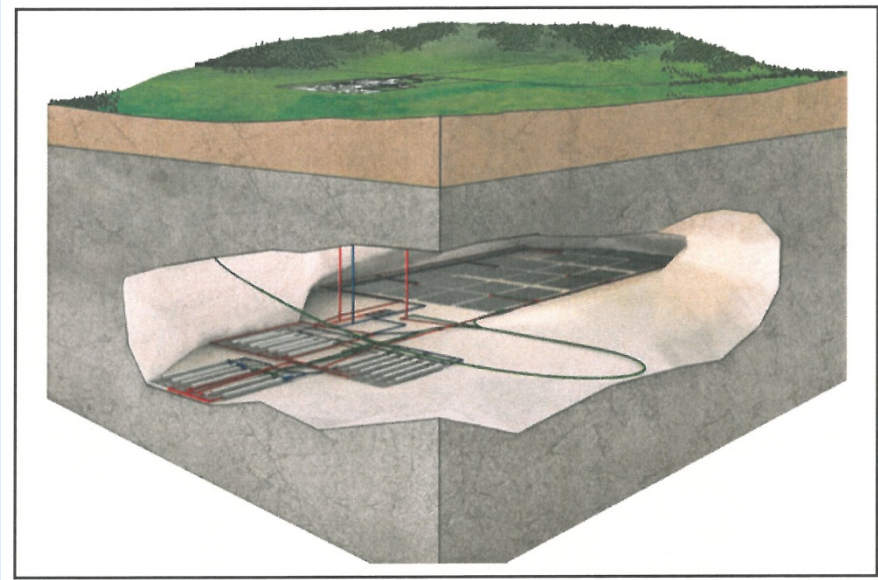
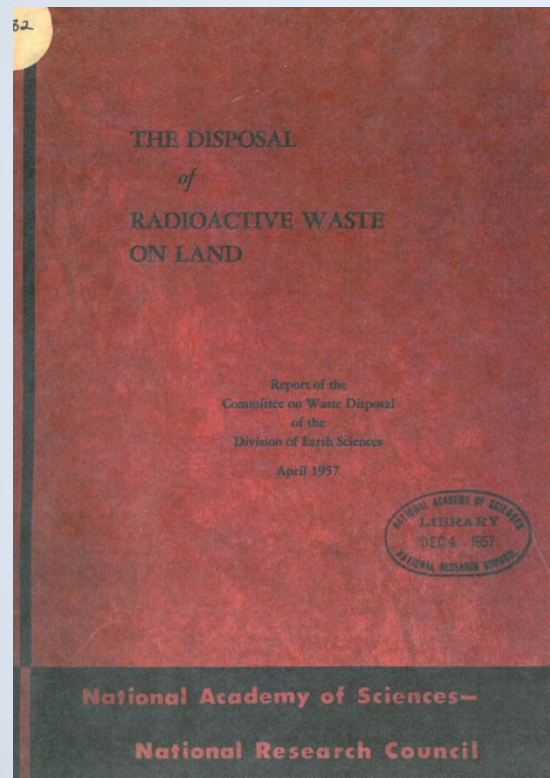
Argument

- Some nations have only one type of formation that is suitable for developing a deep-mined geologic repository for high-level radioactive waste and spent nuclear fuel.
- Other nations have at least two types and, in the case of the United States, at least four.
- Less is more---More is less

A New Site-Selection Process in the US?

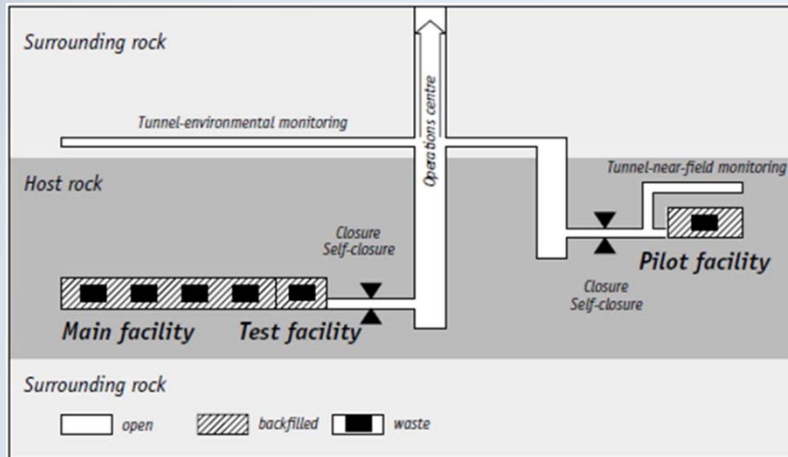
- Start anew, which was recommended by the Blue Ribbon Commission on America's Nuclear Future established at the behest of President Obama by Secretary of Energy Steven Chu
- Develop one repository for most of DOE-managed high-activity waste and another for commercially generated spent nuclear fuel and the remainder of DOE-managed high-activity waste
- Develop a second repository, along with Yucca Mountain, to increase geographic equity

Disposal in a Deep-Mined Geologic Repository

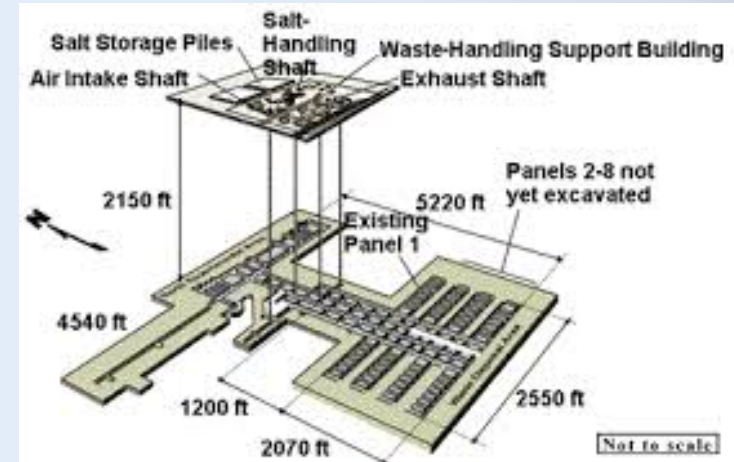


“A geological disposal system provides a unique level and duration of protection for high-activity, long-lived radioactive waste. The concept takes advantage of the capabilities of both the local geology and the engineered materials to fulfil specific safety functions in complementary fashion providing multiple and diverse barrier roles.” NEA 2008

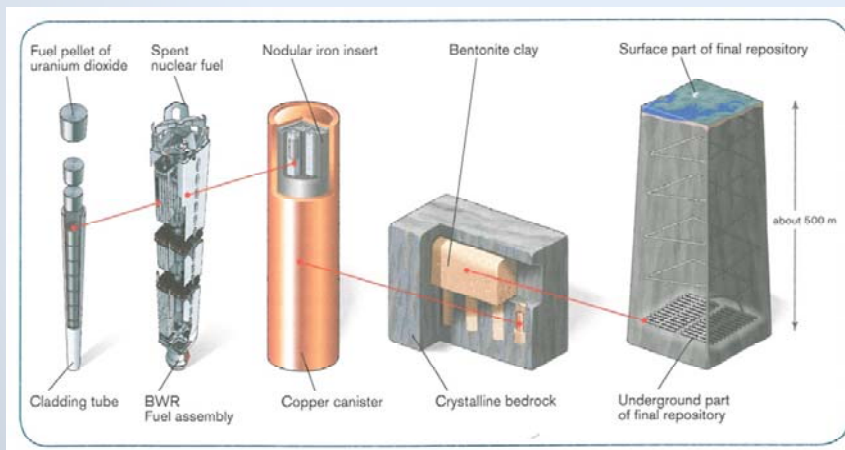
Disposal Concepts



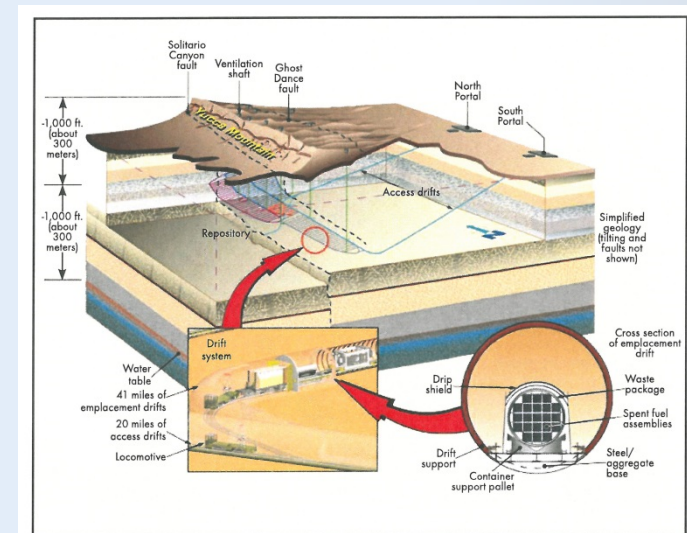
Clay/Shale



Salt



Granite

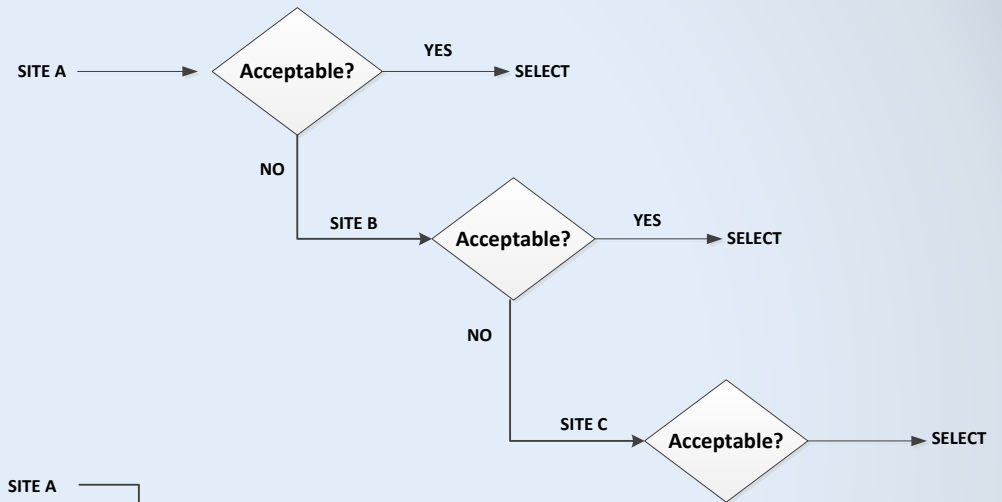


Volcanic Tuff

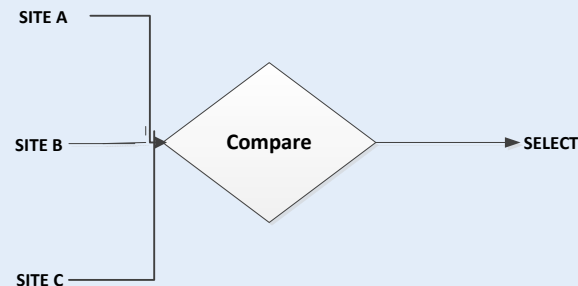
Demonstrating Technical Suitability Persuasively
is the *Sine Qua Non* for Site Selection

Two Strategies for Selecting a Site

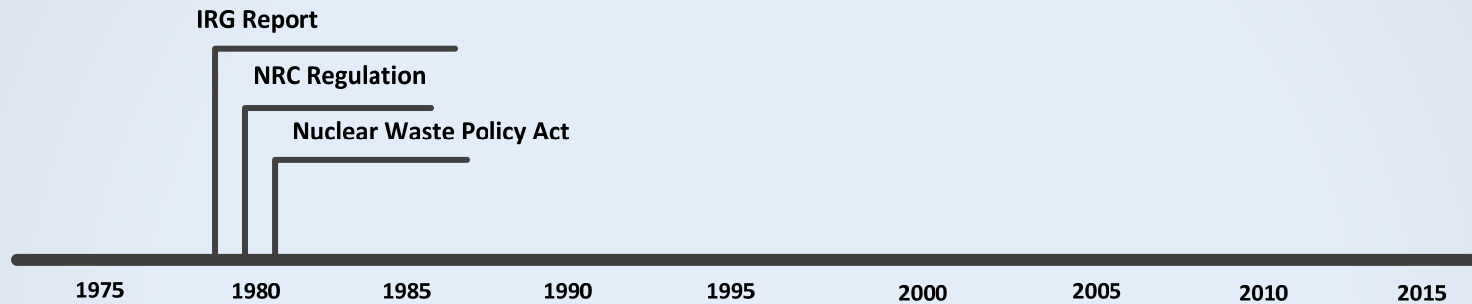
SERIAL
(Deutch Report
Recommendation 1977)



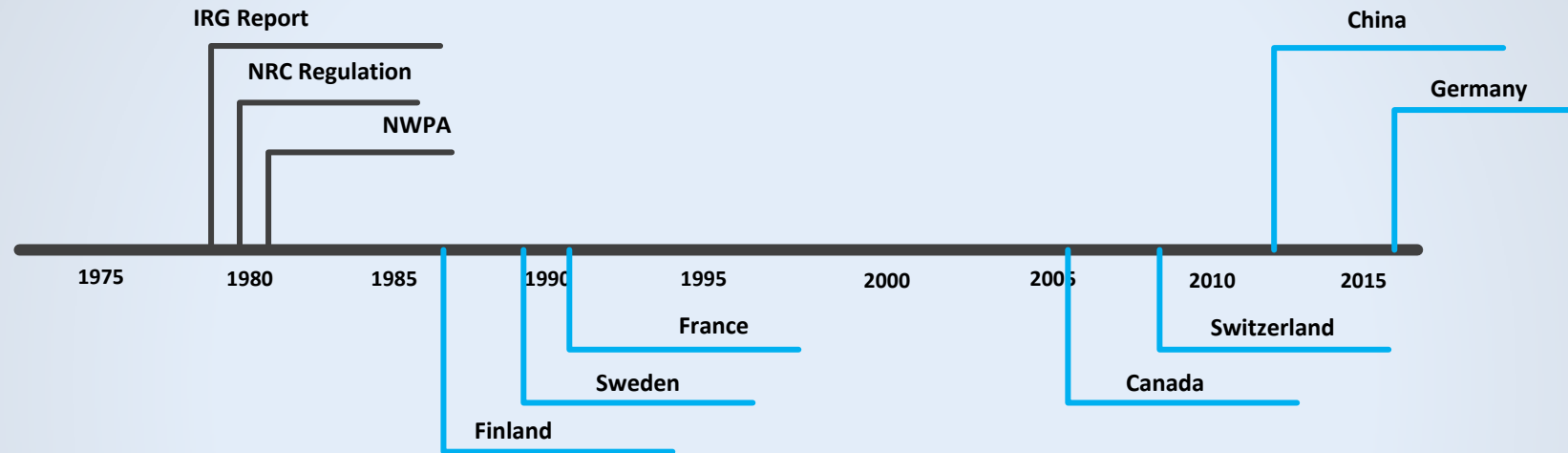
PARALLEL
(Interagency Review Group
Recommendation 1979)



Parallel Comparison Adopted (I)



Parallel Comparison Adopted (II)

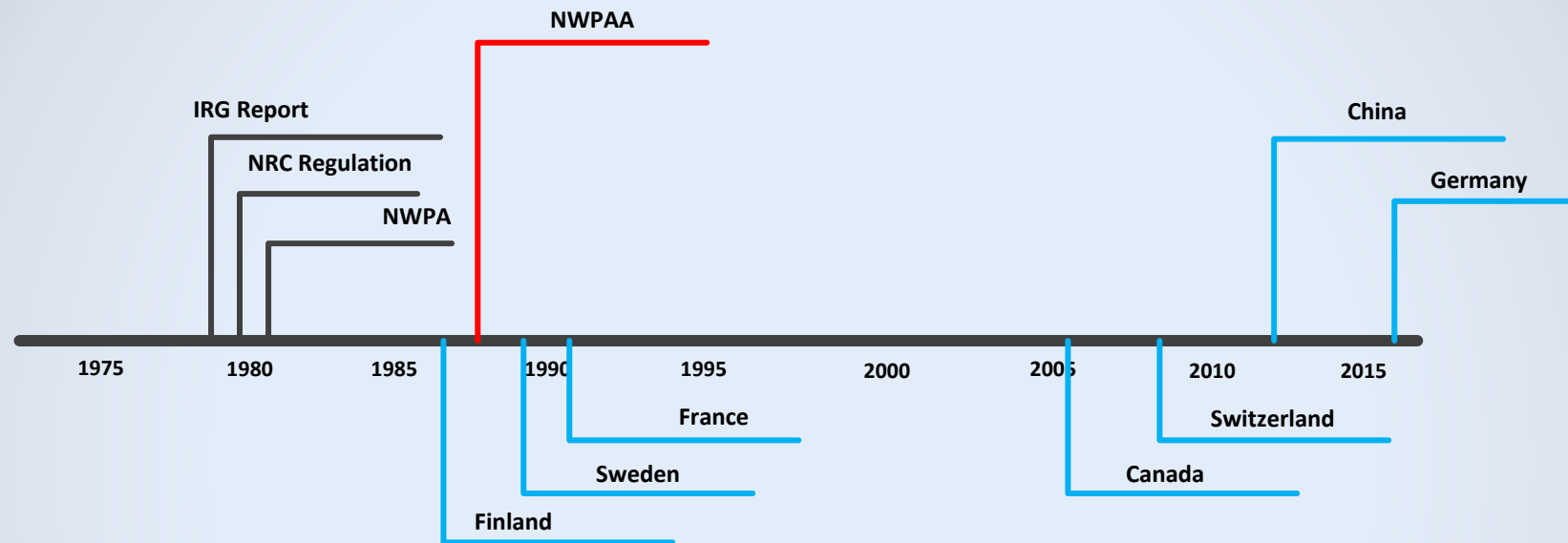


Japan and United Kingdom: may depend on number of communities that participate

Belgium: regulator is pushing for comparisons

Korea and Spain: no policy with respect to site comparisons

Parallel Comparison Rejected



Japan and United Kingdom: may depend on number of communities that participate

Belgium: regulator is pushing for comparisons

Korea and Spain: no policy with respect to site comparisons

Comparing What to What

Country	Host-Rocks (Disposal Concepts) to be Compared
Completed	
Finland	Granite
Sweden	Granite
France	Clay [and granite]
In process or contemplated	
Switzerland	Clay
Canada	Sedimentary formations and granite
China	Sedimentary formations and granite
Germany	Salt, granite, and clay
Belgium	Clay and shale
United States (Pre-1987; a new siting process)	Salt, granite, clay, and volcanic tuff

Type of Site-Suitability Criteria

- **Exclusion criteria** are applied to eliminate sites whose geologic characteristics almost automatically preclude the development of a repository: for example, extreme faulting, seismic and volcanic risk, and presence of exploitable natural resources.
- **Host-rock-specific criteria** are used to identify sites where only one type of geologic setting is available and, therefore, where only one disposal concept might be realized. Because these criteria are concept specific, it is possible to include quantitative rock properties.
- **Generic criteria** are employed when the implementer has the option of adopting more than one disposal concept and must compare sites in different geologic environments. Because these criteria must be applied to more than one type of host rock, they are generic in nature, thereby making it extremely difficult to quantify the values for various rock properties.

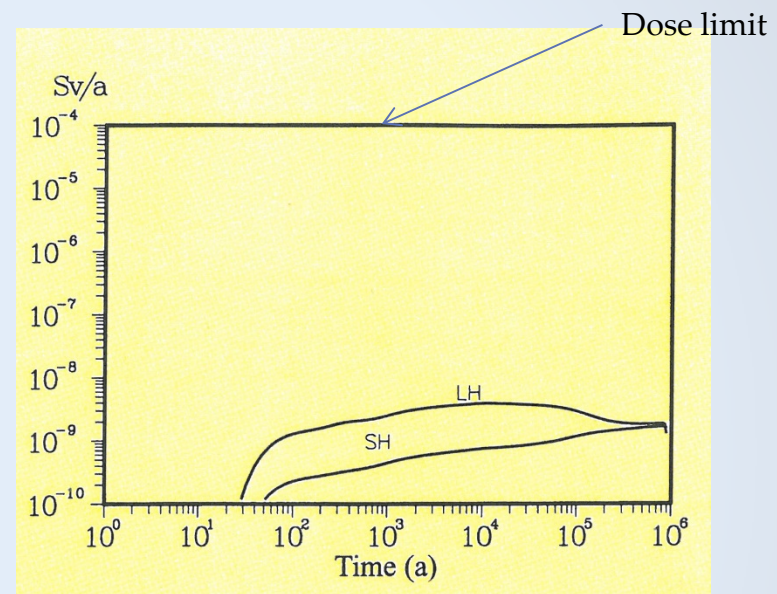
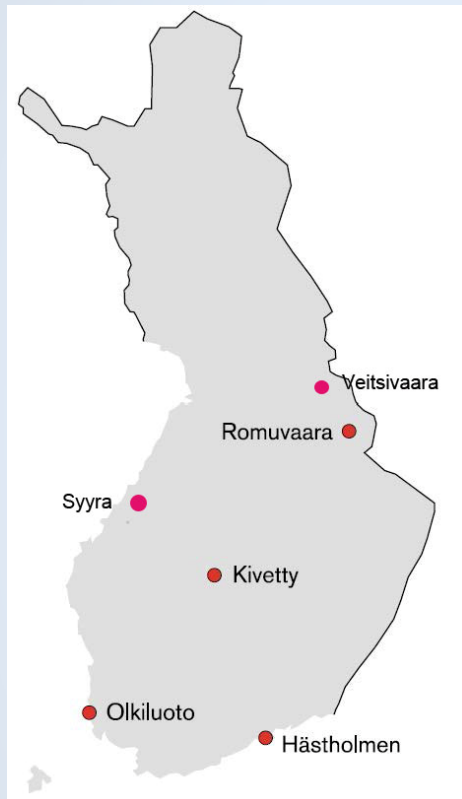
Comparisons Using Host-Rock-Specific Criteria

Host-Rock-Specific Criteria

- Salt dome should be located less than 800 m below the surface.
- Specific hydraulic gradient in the isolating rock zone should be less than 10^{-2} .
- The overburden should have low permeability.
- The choice of sites should minimize groundwater flow.
- The effective diffusion coefficient in the isolating rock zone should be as low as possible (less than $10^{-11}\text{m}^2/\text{s}$).

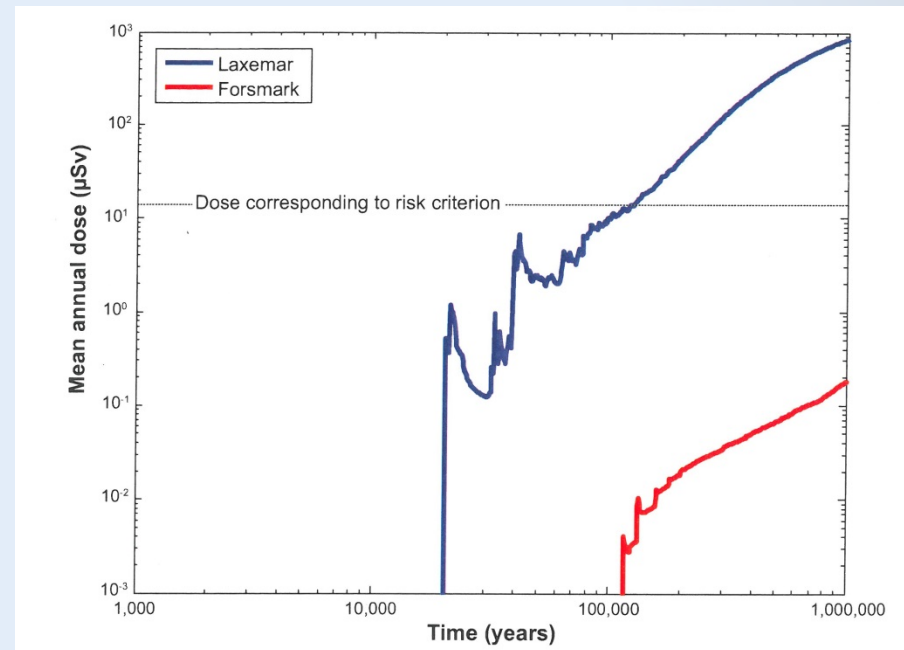
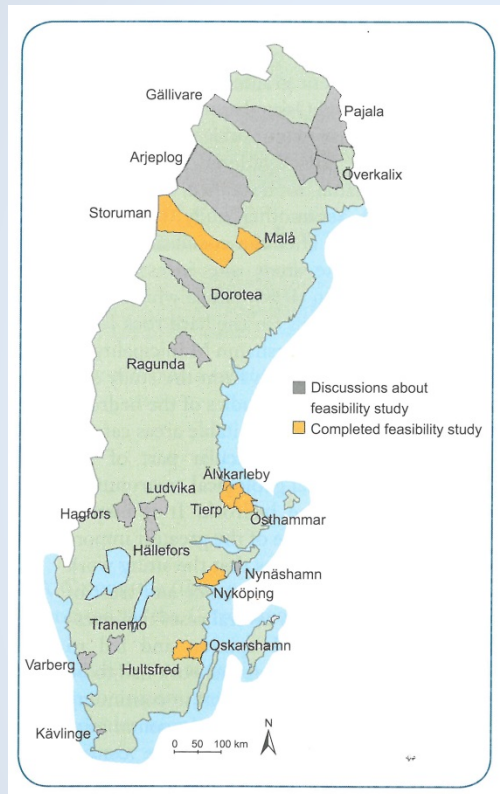
Regardless of whether the criteria were qualitative or quantitative, comparisons are made among “like” sites.

Finland



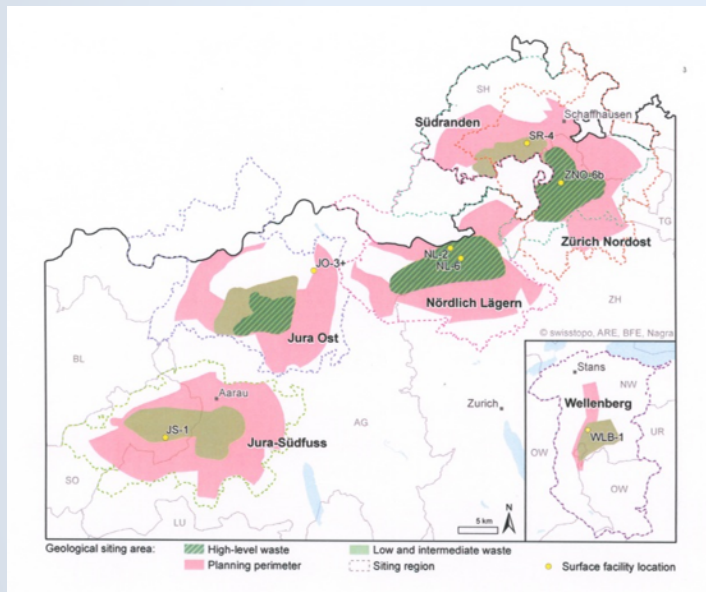
The choice was narrowed to the nuclear-reactor site that held the most spent fuel.

Sweden



"The rocks have spoken." Claus Thegerström

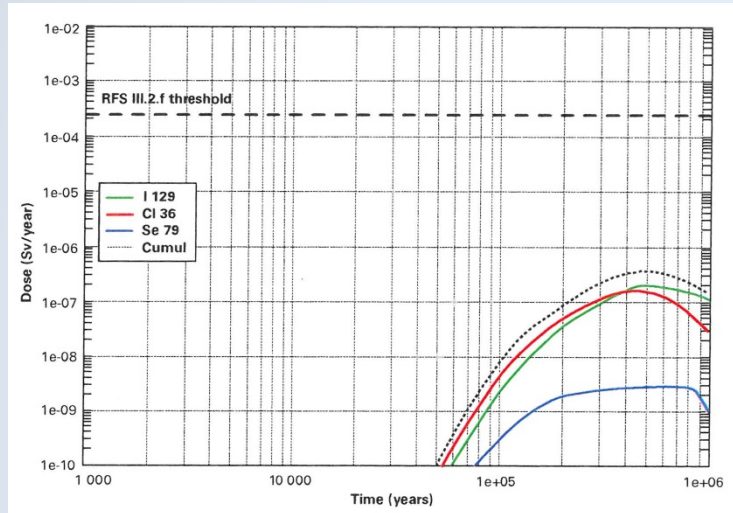
Switzerland



- Very suitable
- Suitable
- Limited suitability
- Less suitable

Decision-relevant features / Decision-relevant indicators	HLW repository			
	Zürich Nordost	Nördlich Lägern	Jura Ost	
Effectiveness of the geological barrier (E)				
Hydraulic conductivity				
Type of transport pathways and structure of the pore space				
Transmissivity of preferential release pathways				
Self-sealing capacity				
Homogeneity of the rock structure				
Thickness				
Length of critical release pathways				
Colloids				
Long-term stability of the geological barrier (S)				
Conceptual models of long-term evolution (geodynamics and neotectonics; other processes)				
Self-sealing capacity				
Potential for formation of new water flowpaths (karstification)				
Erosion during the time period under consideration				
Depth below the local erosion base level as relevant for formation of new ice-marginal drainage channels				
Depth below terrain as relevant for rock decompaction				
Depth below top bedrock as relevant for glacial overdeepening				
Seismicity				
Explorability and ease of characterisation of the geological barrier in the siting region (C)				
Variability of the rock properties as relevant for their ease of characterisation				
Exploration conditions in the geological underground				
Engineering feasibility (F)				
Depth with respect to engineering feasibility (considering rock strength and deformation properties)				
Geotechnical and hydrogeological conditions in overlying rock formations				
Available space underground				

France



Clay (argillite)
(Site-specific analysis)

“Qualitative and quantitative analyses cannot be conclusive at this stage. However, they do emphasize that methods to control the safety of a repository in a granite medium do exist, that designs can be specified which meet safety requirements and that the design performance evaluations carried out at this stage do not reveal any inhibitory elements.”

Granite
(Generic analysis based
on KBS-3 method)

Comparisons Using Generic Criteria

Comparing What to What

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Generic Criteria

- The host rock and surrounding units shall be capable of accommodating thermal, chemical, mechanical, and radiation stresses.
- Processes or conditions that could reduce the sorption of radionuclides should be avoided.
- There should be a low hydraulic gradient in and between the host rock and the immediately surrounding geohydrologic units.
- The site chosen will have to be sufficiently stable so that the possible modification of the initial conditions remains acceptable with regard to the safety of disposal.

Given these general requirements, it is unclear how comparisons are made among “**unlike**” sites.

DOE's 1985 Siting Guidelines

- Implementation guidelines establish general rules to be followed in the *process* of selecting a site for repository development.
- Technical criteria
 - Preclosure guidelines delineate the siting considerations that affect the construction and operation of a repository.
 - Postclosure guidelines govern the siting considerations that deal with the long-term behavior of a repository.
- The guidelines provide very general principles for comparing sites.

The intent was to create a technically defensible set of rules that would significantly reduce the influence of "extra-technical" factors on site selection.

Final Five Sites (1986)



Multiattribute Utility Analysis (MUA): A “Decision-Aiding” Methodology

	Preclosure Ranking	Postclosure Ranking	Composite Ranking	Choice
Yucca Mountain	1	4	1	✓
Richton Dome	2	2	2	✗
Deaf Smith	3	3	3	✓
Davis Canyon	4	1	4	✗
Hanford	5	5	5	✓

“Discretion-Creating” Methodology

- The Deaf Smith site was superior to Richton Dome when *subsets* rather than the entire set of preclosure guidelines were evaluated.
- Hanford’s low preclosure ranking was due to high repository construction and transportation costs.
- Hanford’s low postclosure ranking was due to the site having projected cumulative releases that were an order of magnitude higher than the other four sites.
- The DOE Secretary concluded:
 - “Cost should be given the least importance among preclosure considerations, especially if the time-value of money is taken into account.”
 - “The postclosure performance differences are small and not significant with respect to the ability to meet the EPA standard.”
 - “To the extent practicable, sites in different geologic media should be recommended.”

The German Case

- Recommendations to the Bundestag call for evaluating sites in salt, clay, and granite---not just salt---and for comparing them to select the final repository site.
- To do that, **generic criteria** will need to be developed to take the place of **host-rock-specific criteria**.
- Spirited debates are already underway with no clear consensus on how to craft the new rules. Concerns are being raised within the technical community that these disagreements might undermine the political consensus that has taken decades to be reached.

Exercising Discretion

- Agencies possess broad authority (legitimacy) to exercise discretion in their decisionmaking.
- The methodology for making comparisons among sites in the same geology (**host-rock-specific criteria**) is relatively uncontested. In making decisions, agencies' discretion is likely to be fairly narrow and focused. The basis for the decision can easily be explained.
- The methodology for making comparisons among sites in different geologies (**generic criteria**) is highly contested. In making decisions, agencies' discretion is likely to be fairly broad. The basis for the decision is likely to rely on judgments and arguments that are outside the agreed-upon rules.

To exercise discretion is to exercise power.

Implications

If methodologies for comparing sites in different host rocks are incomplete or contested and if “extra-technical” factors must be brought to bear — often covertly — to bring decisions to closure, then

- Claims about “objectivity” and “technical defensibility” may be open to question.
- Public trust and confidence in the implementing agency may erode.
- Turbulence in the agency’s political environment may disrupt and even derail a nation’s radioactive waste management program.

These outcomes, of course, may also arise when comparing sites in the same host rock. But trying to make comparisons in different formations only heightens and exacerbates the challenges.

What To Do??

- Policymakers can require the implementer to focus on only one host rock.
- Policymakers can require the development in parallel of at least two repositories, each in a different host rock.
- The implementer can create a large reservoir of credibility and can operate in a fully transparent manner so as to “immunize” itself against claims that it abused its discretion.
- Instead of using technical “filters” to identify potential sites initially, the implementer can focus its efforts in communities willing to host a repository.

None of these options will be particularly easy to pursue.

Questions?