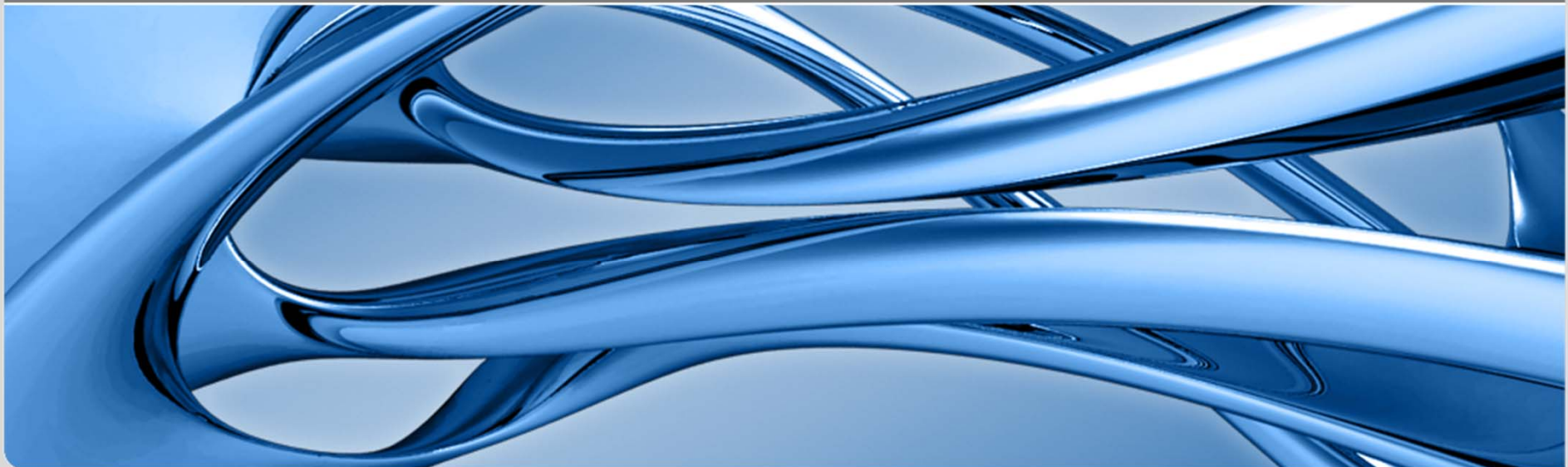


# Results and Recommendations on monitoring given by the *Endlagerkommission*

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# Overview

1. Stages of HLW Disposal
2. The principle of reversibility
3. The need for monitoring

# 1. Stages of HLW Disposal

## Guiding Ethical Principles

- Safety for humans and the environment today and in the future (for one million years)
- Avoidance of unacceptable burdens for future generations
- Reversibility of decisions (adaptability to new knowledge, new constellations ...)
- Realistic assumptions about the feasibility of future technologies
- Careful and transparent treatment of conflicting goals and the necessity to weigh options

# The Challenge

Der gesuchte Standort für ein Endlager insbesondere für hoch radioaktive Abfallstoffe bietet für einen Zeitraum von **einer Million Jahre** die nach heutigem Wissensstand **bestmögliche Sicherheit** für den dauerhaften Schutz von Mensch und Umwelt vor ionisierender Strahlung und sonstigen schädlichen Wirkungen dieser Abfälle. Dieser Standort ist nach den entsprechenden Anforderungen in einem gestuften **Verfahren** durch einen **Vergleich** zwischen den in der jeweiligen Phase geeigneten Standorten auszuwählen. Lasten und Verpflichtungen für **zukünftige Generationen** sind möglichst gering zu halten. Während des Auswahlverfahrens und später am gefundenen Standort muss eine **Korrektur von Fehlern** möglich sein (EK 2016, 24).

## Stages of final disposal

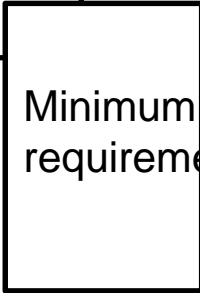
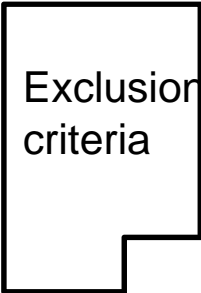
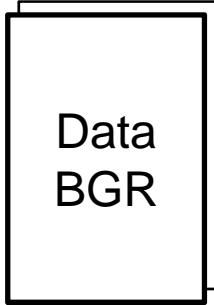
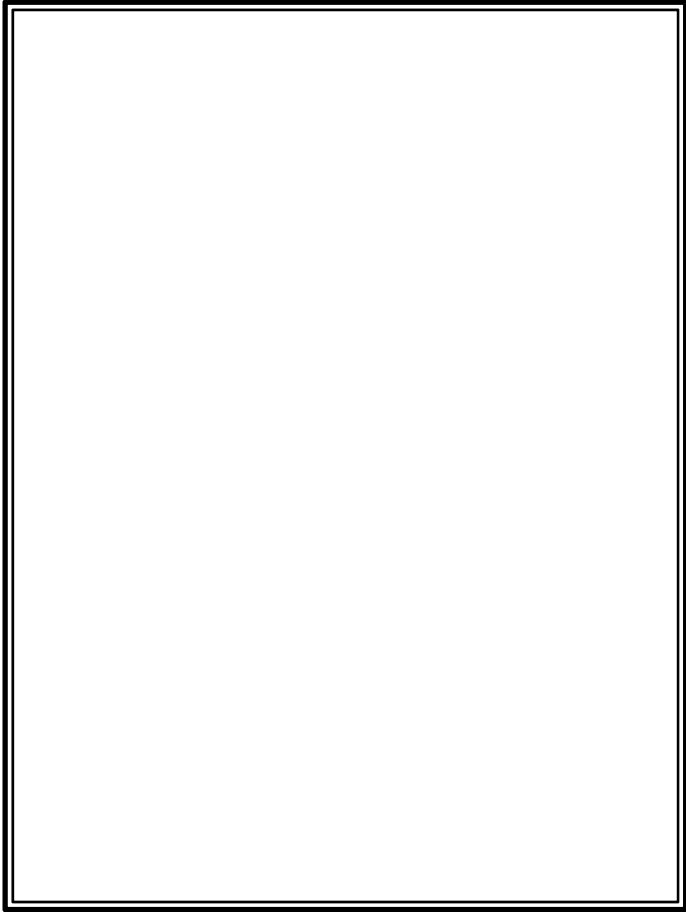
- Stage 1:** Siting process
- Stage 2:** Site development, regarding mining
- Stage 3:** Storage of radioactive waste
- Stage 4:** Observation before closing
- Stage 5:** Closed repository mine

### After closing...

- .....  $\pm$  500 years of monitoring
- ...
- ..... 1 million years in the future

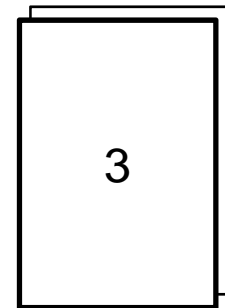
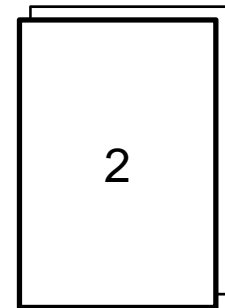
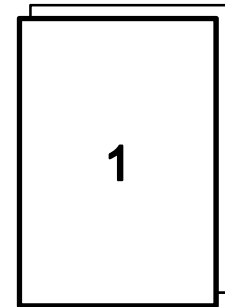


# Initial starting point of the search for a site



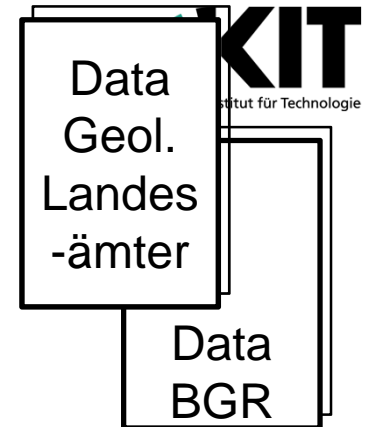
# Phase 1

Areas with favorable geological conditions



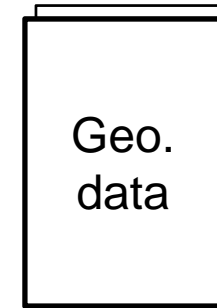
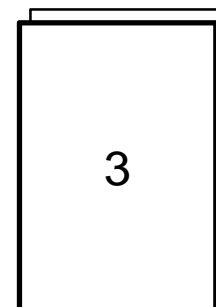
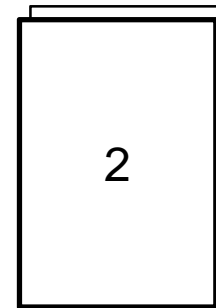
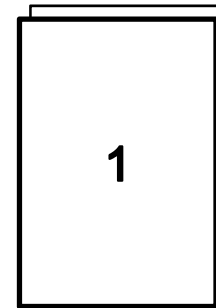
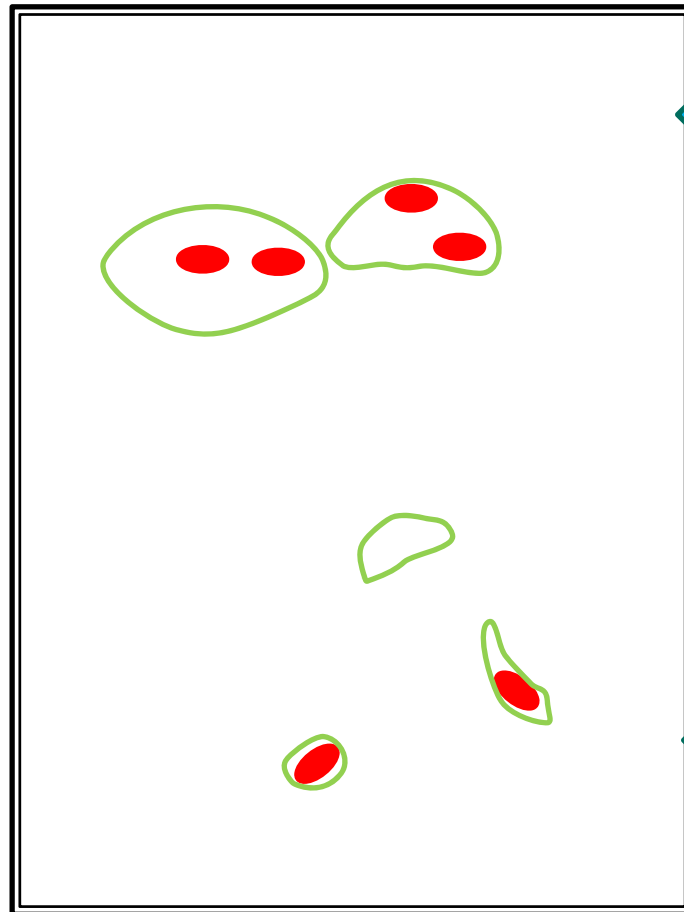
Geological criteria

Application of geological consideration criteria

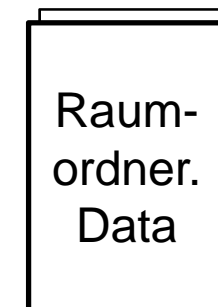


# Phase 1

**Result: Regions with possible sites for exploration above-ground**



Further geological  
consideration  
Scientific consideration  
concerning planning

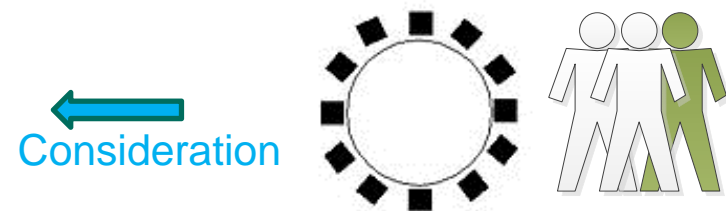
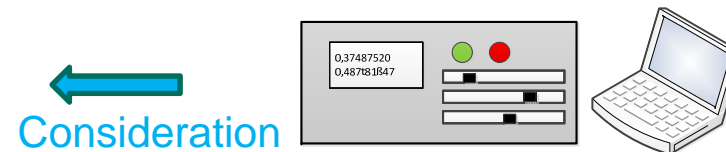
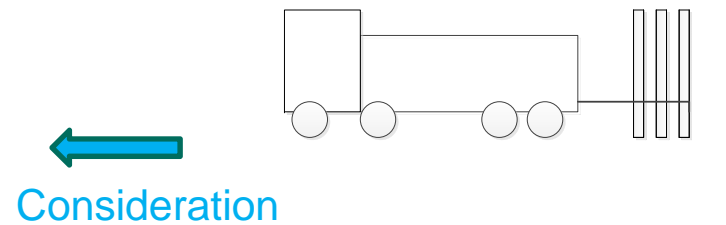
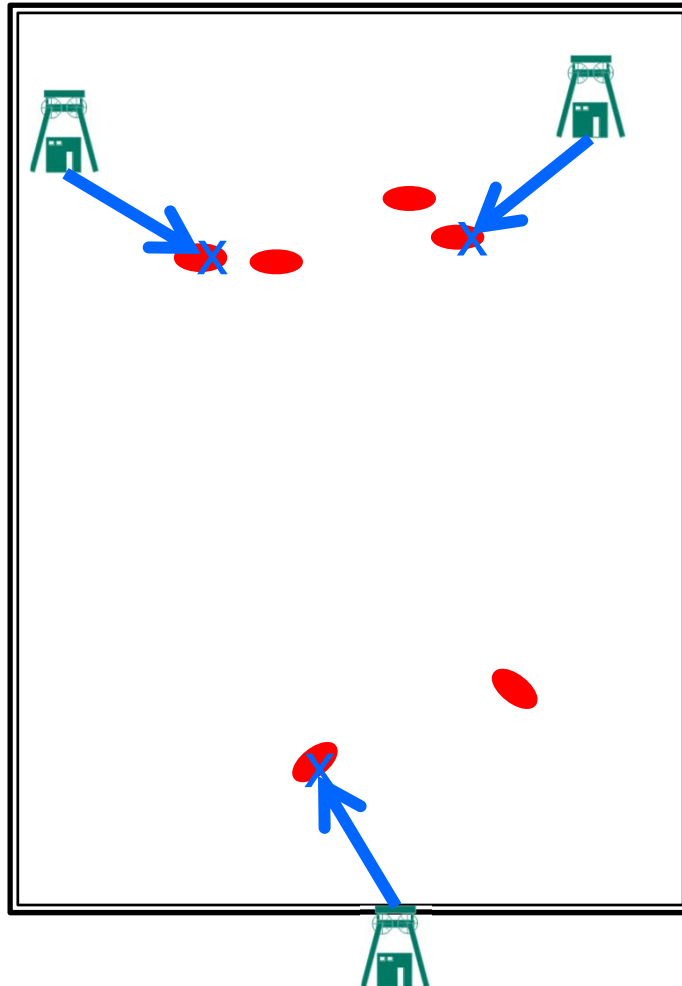


Application of geological and planning  
consideration criteria



# Phase 2 above-ground exploration

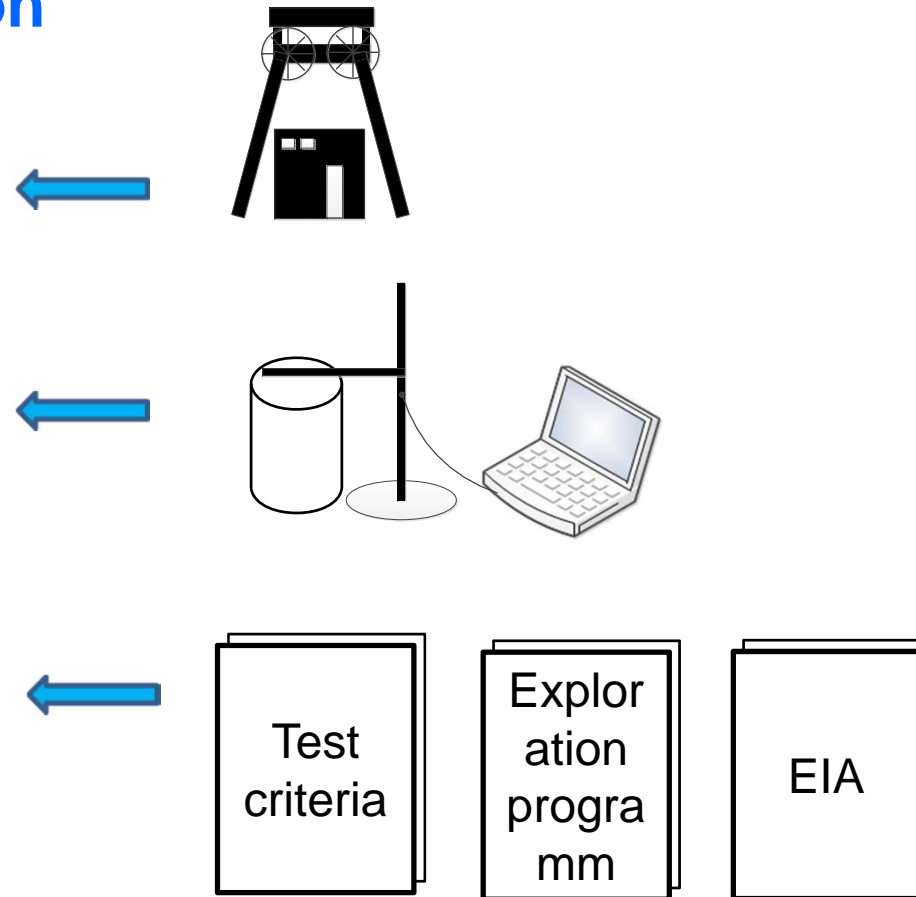
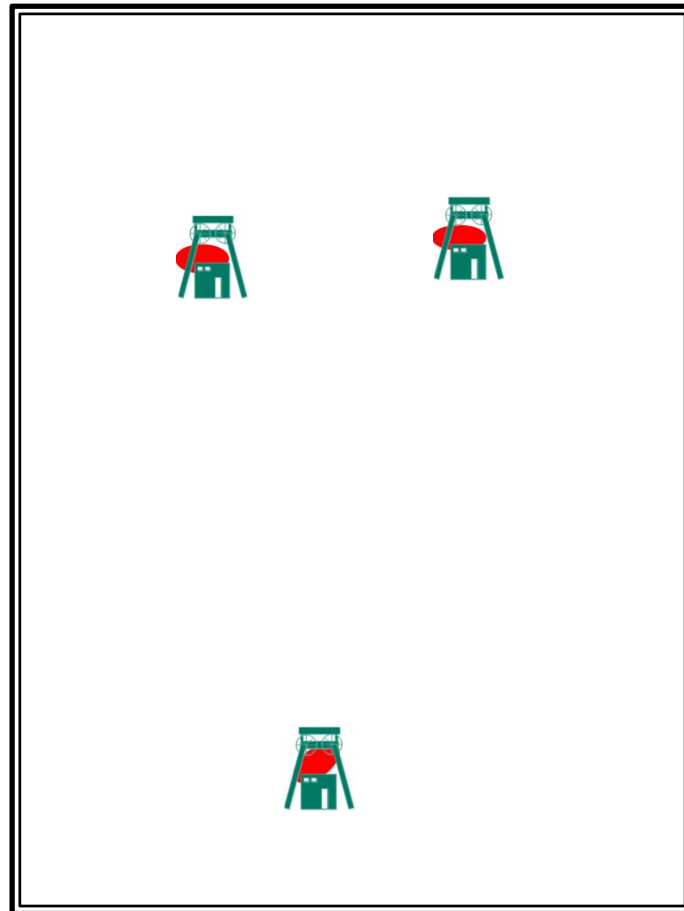
Result: Sites for underground exploration



Above-ground exploration, preliminary safety analysis, socio-economical potential assessment, assessment of willingness to participate

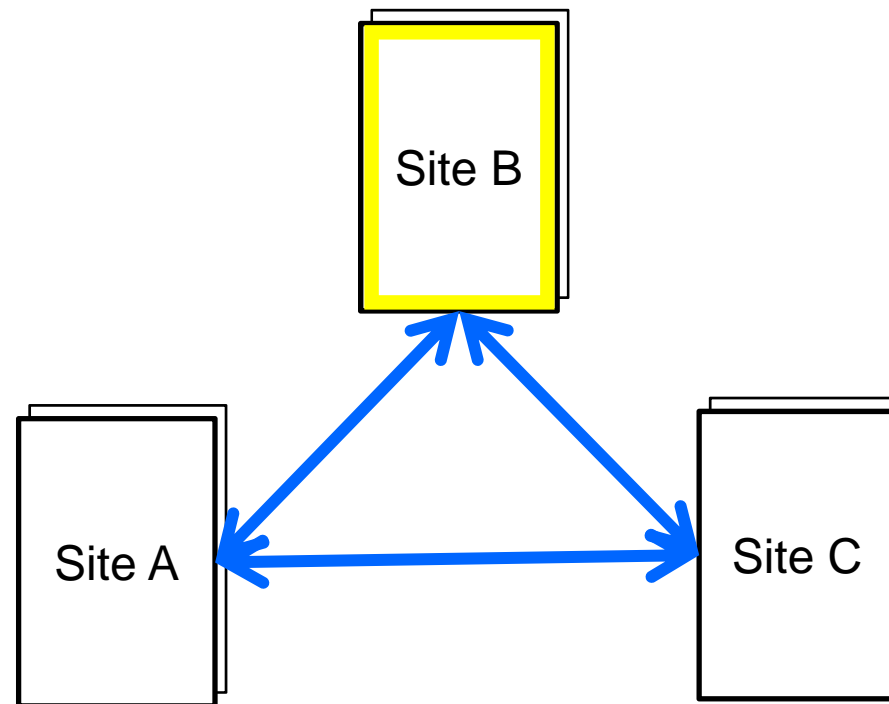
# Phase 3

## underground exploration



Underground exploration, comprehensive preliminary safety analysis

## Phase 3 Comparative safety analysis



- Test criteria and exploration program
- Results of underground exploration and site specific disposal concepts
- Comprehensive preliminary safety analysis
- EIA for each site

## 2. The principle of reversibility

- avoid path dependencies as far as possible!
- keep the entire process re-adjustable and reversible at any time, allow for backjumps, shift to new options etc.!

Two main motivations:

- correction of errors during the process (→ need of monitoring to identify errors)
- maintain options for decision-making for future generations
- make possible to take into account new knowledge in the future, react on change of values, ... (→ need of monitoring of the „context“ of the disposal process)

### 3. The need for monitoring

Monitoring plays a crucial role for designing a process including reversibility at two levels:

- (1) a permanent *process monitoring* must provide meta-knowledge about the respective status of the process in order to discover possible necessities or reasons to consider reversing decisions which already had been made, or even which already have been implemented.
- (2) the identified disposal site must be monitored concerning its development over time, from building the disposal mine over the transport of the waste to later stages in order to get empirical information whether the entire system (host rock, technical facilities, and the waste) behaves as has been expected

## Process monitoring

- beginning with the relaunch of the searching process (2017?)
  - observation of relevant developments external to the searching process (new knowledge, new options, international development of the state of the art in science and technology ....)
  - observation and evaluation of the process itself: current status, unexpected difficulties, functioning of the institutions, participatory formats, trust building (or destruction)...
- possible consequences: re-adjustments, modifications, ideas for accelerating the process etc.

## Site monitoring (1)

- beginning with the determination of the disposal site (based on knowledge gained in the preceding exploration phase)
- aims:
  - early detection of adverse or unexpected developments which could lead to the necessity of re-adjustments
  - optimization of the geo-technical process and of the technical facilities
  - understand the behavior of the long-term development of the constellation host rock/technical facilities/waste
- monitoring geological, geochemical, geophysical ... data, depending on the individual site
- the exact parameters to be monitored can be determined after fixation of the site/disposal concept only

## Site monitoring (2)

- monitoring also after having closed the disposal mine (for about 500 years) (retrievability of the containers should be ensured)
- trade-off with respect to safety (closed system versus open system)
- heavy technology requirements for monitoring the underground in-site (sensors, energy supply, temperature, pressure...)
- indirect monitoring technologies shall be developed
- long-term monitoring shall contribute to build trust
- but it also burdens future generations with maintaining the monitoring and evaluating the data and might confront them with the necessity to make decisions



# Thank you!

Armin Grunwald