# Use of natural analogues in the Finnish safety case – status update on Complementary Considerations

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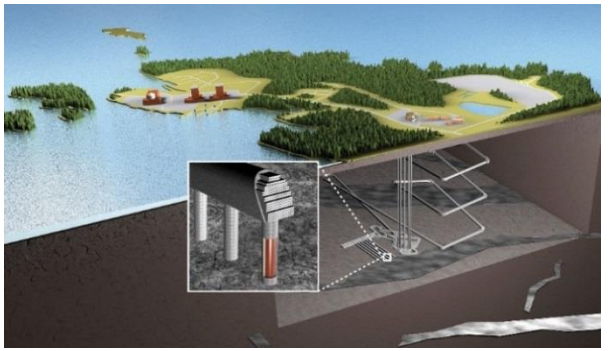
# Introduction

- Posiva is preparing to update the safety case for the operational license application for a spent nuclear fuel repository at Olkiluoto, Finland
- Planned to be submitted around 2020
- TURVA-2012 safety case is being updated
- Including Complementary Considerations, the report for a large part discussing natural analogues



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# Safety Case

- Portfolio of reports
- Complementary Considerations
  - Supports other safety case reports, especially performance assessment
  - Part of describing FEPs
    - FEP database only has very short descriptions
  - Provides also alternative line of evidence
  - Conceptual model support

| Synthesis |
|---|
| Description of the overall methodology of analysis, bringing together all the lines of argument for safety, and the statement of confidence and the evaluation of compliance with long-term safety constraints |
| **Design Basis (DB)** |
| Safety functions, performance targets and design requirements, their basis and the links between them |
| **Initial State (IS)** |
| Initial state of the repository system and the present conditions of the surface environment |
| **LILW Repository Assessment (LILW-RA)** |
| Assessment of the long-term performance of the repository for LILW from the encapsulation plant and identification of interactions with the SNF repository |
| **Performance Assessment and Formulation of Scenarios (PAFOS)** |
| Assessment of fulfilment of performance targets taking into account the expected and alternative climate and surface environment evolutions. Scenarios formulation based on uncertainties/deviations identified in the assessment |
| **Models and Data (M&D)** |
| Model network and data management approach for performance assessment and the analysis of releases |
| **Analysis of Releases (AOR)** |
| Overview of the main results from the radionuclide release and transport modelling from the repository system to the surface environment and evaluation of radiological consequences |
| **Complementary Considerations (CC)** |
| Supporting evidence for safety including natural and anthropogenic analogues |

The safety case portfolio (SNF, spent nuclear fuel; LILW, low and intermediate level waste) (Posiva 2017).

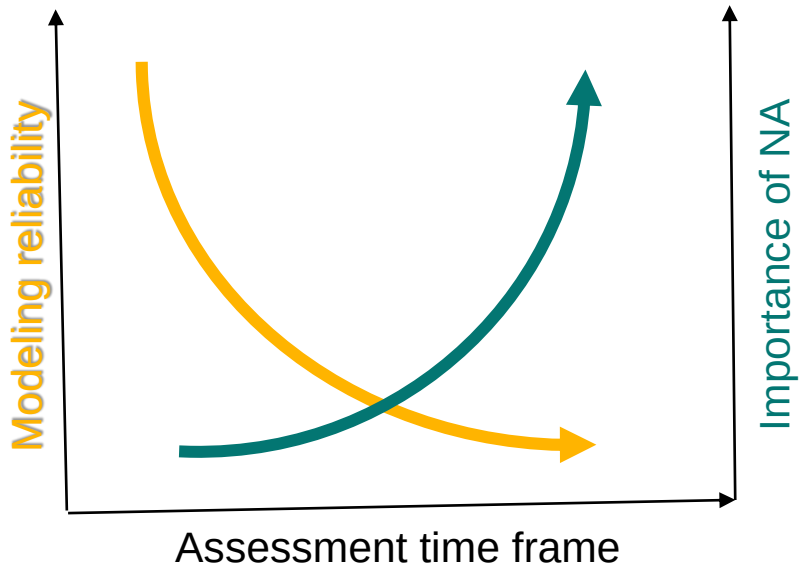
Source: Posiva 2017. Safety case plan for the operating license application. Eurajoki, Finland: Posiva Oy. (in publication.)

# Regulatory context

- International guidelines
- National guidelines:
  - first, **natural analogues are seen as part of the basis for high-quality scientific expertise** ([5], Annex A, A07)
  - and second, in cases when a scenario cannot be comprehensively and reasonable assessed by means of quantitative analyses as a means of providing relevant information on **more qualitative considerations, natural analogues** can be used to assess the scenario outcome ([5], Annex A, A10).

# Regulatory context

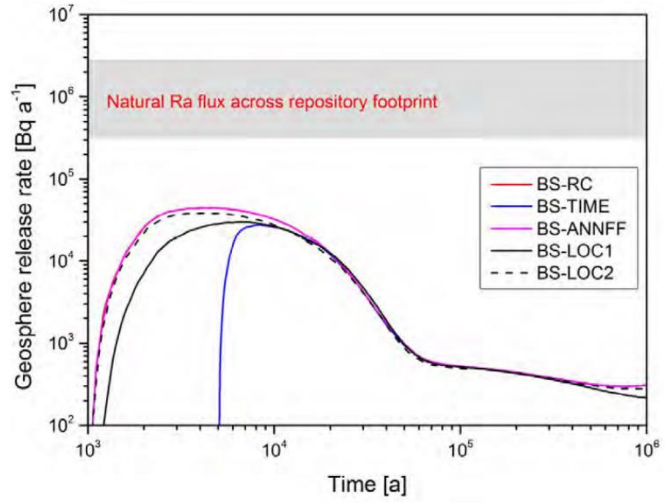
- Sets the objective to support process understanding and highlights the role of complementary considerations especially in relation to geological timeframes, since the reliability of modeling and experimental results decrease as the time intervals examined become longer.

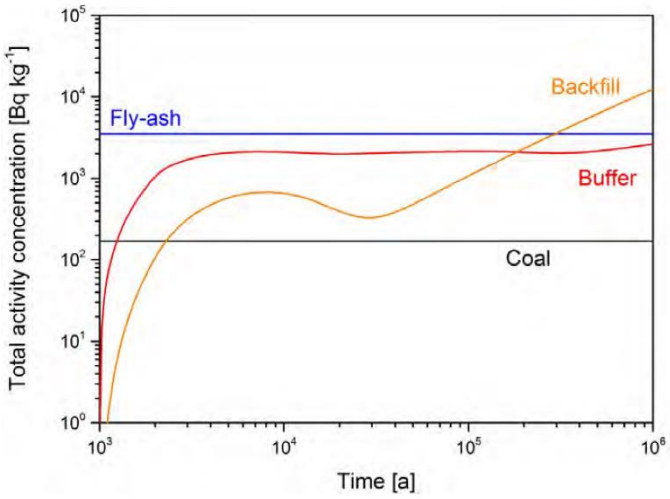



**Geological evidence is applicable in all time frames**

# General objectives

- describe and give context for the hazard presented by the radioactive waste,
- discuss the selected waste management option,
- provide means of putting safety assessment results in context (complementary safety indicators), and,
- support and assess the safety case conceptual models, process understanding and site suitability, especially in the geological time frame by presenting information on:
  - past and future evolution from observations at the site, including its regional environment, and
  - natural and anthropogenic analogues for the repositories (SNF and LILW), their components and the processes that potentially could affect safety



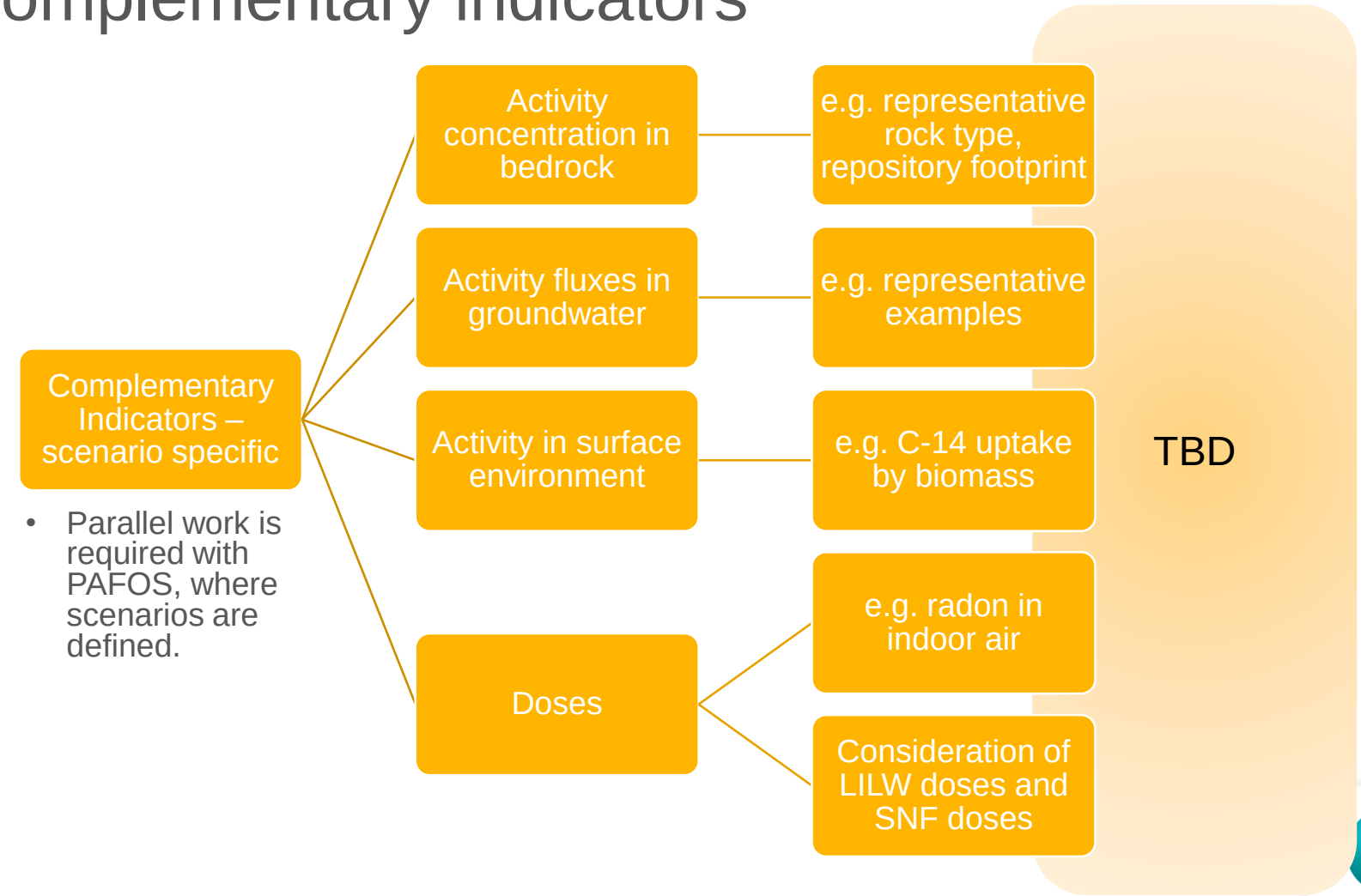



# Complementary Considerations - update

- Feedback from the regulator
- Changes in Posiva’s requirements
- Updates in design
- Addition of LILW repository
- Parallel update with other safety case reports

# Some specific updates

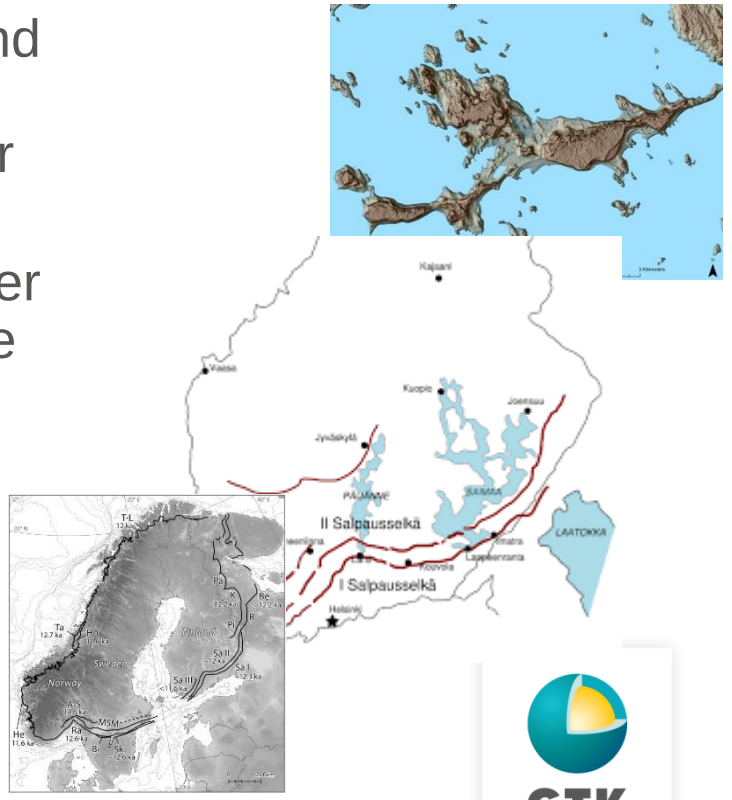
# Complementary indicators




- Parallel work is required with PAFOS, where scenarios are defined.

# Site suitability

- for example to regional considerations regarding groundwater recharge and its geological controls.
  - Specifically, the recently finalized Greenland Analogue Project (GAP) and the ongoing Posiva's Saimaa project will provide further scientific input to CC.
  - Saimaa project aims at studying dilute water intrusion processes in the bedrock near the southern Finland end-moraines, representing the condition where the ice sheet remained at the site for extended period of time.

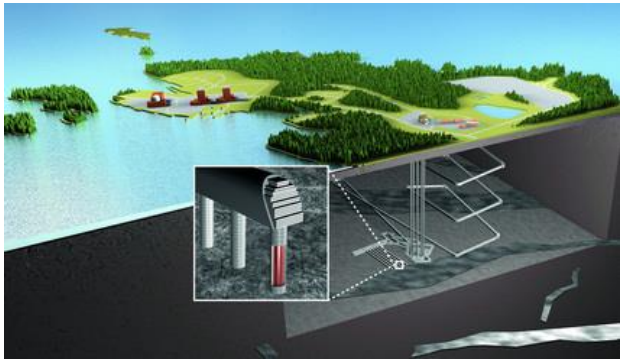



Hughes et al. (2015)

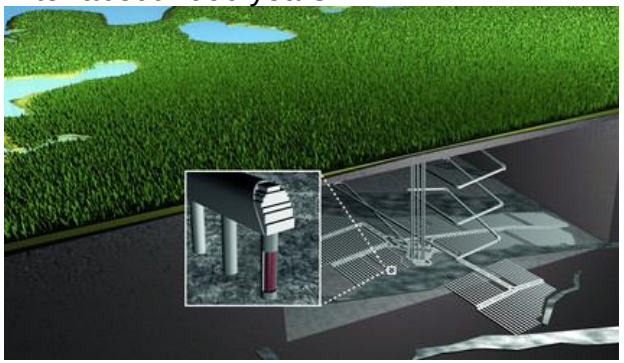
# Future evolution on site

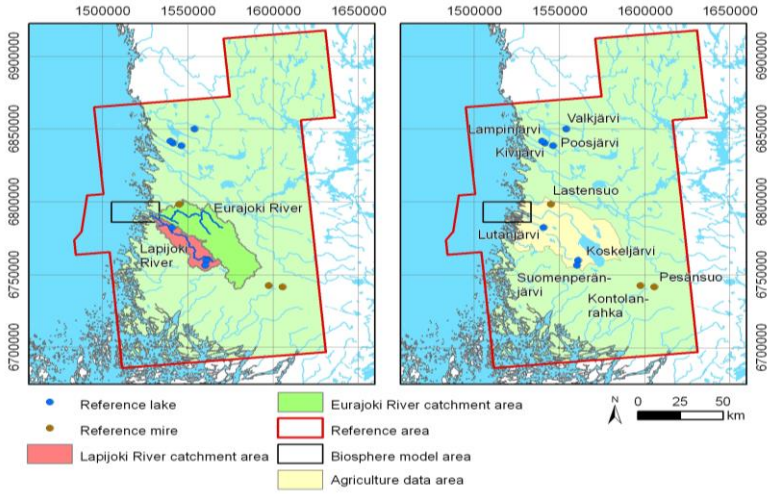
- The future evolution of the site is also affected by the land uplift process mostly during the next 10 000 years, the time period that is the main focus of the biosphere assessment.
- To understand the development of the surface environment during this period, analogue sites have been used for future surface environment successions.
- CC explains the use of regional analogues.

Now



After about 4000 years



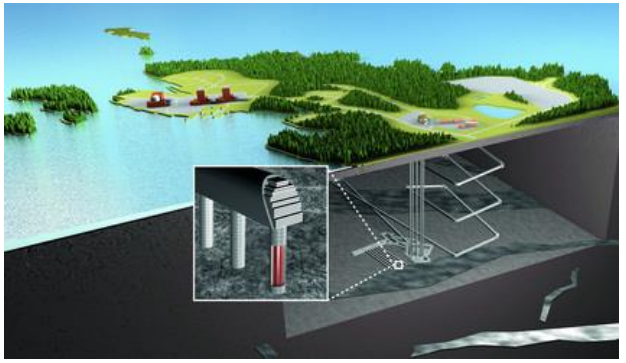


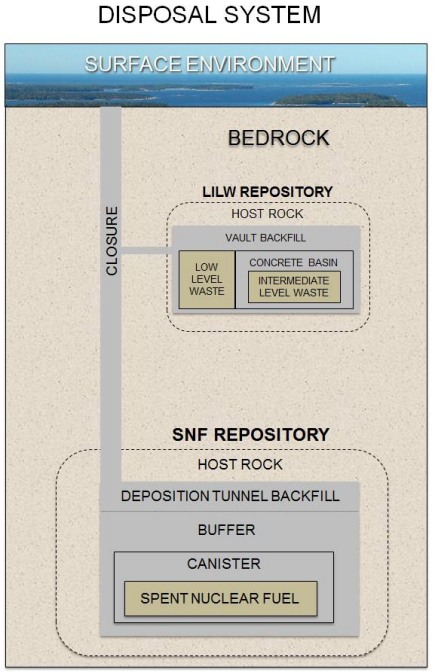

Schematic presentation of the Reference Area, the selected reference lakes and mires and the catchments of Eurajoki and Lapijoki Rivers (left), the main area of the agricultural data (right) (POSIVA 2012-11)

# Natural and anthropogenic analogues for the repositories (SNF and LILW)

Stability of:

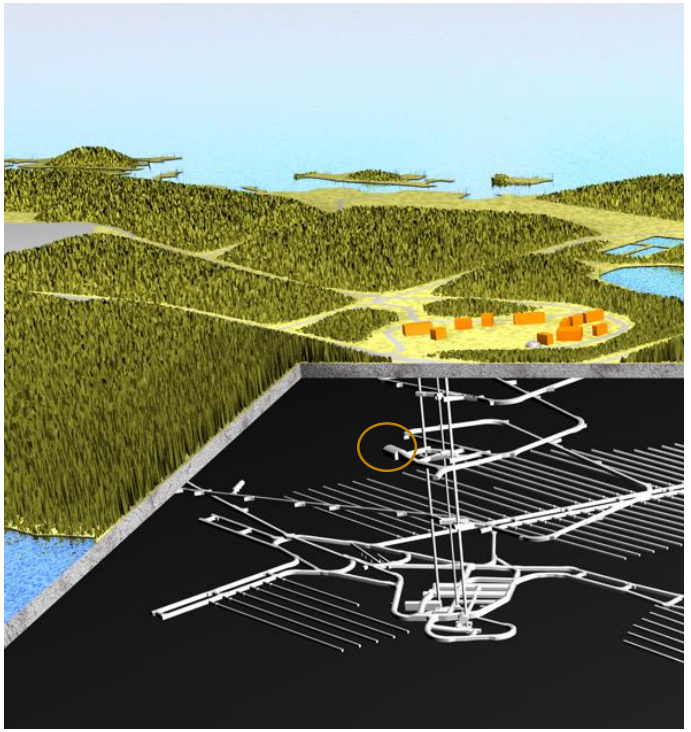
- Wastes
  - Spent fuel
  - LILW wastes
- Waste packages
  - SNF canister
    - Iron insert
    - Copper overpack
  - LIWL waste types
    - Cements, metals, organics…
- Clays
  - Buffer bentonite (pellets and blocks)
  - Deposition tunnel backfill
- Closure backfills (clays, mixtures, rock materials)
- Concrete and cement structures/components
- Other materials in the repository (silica sol?)
- Bore hole seals





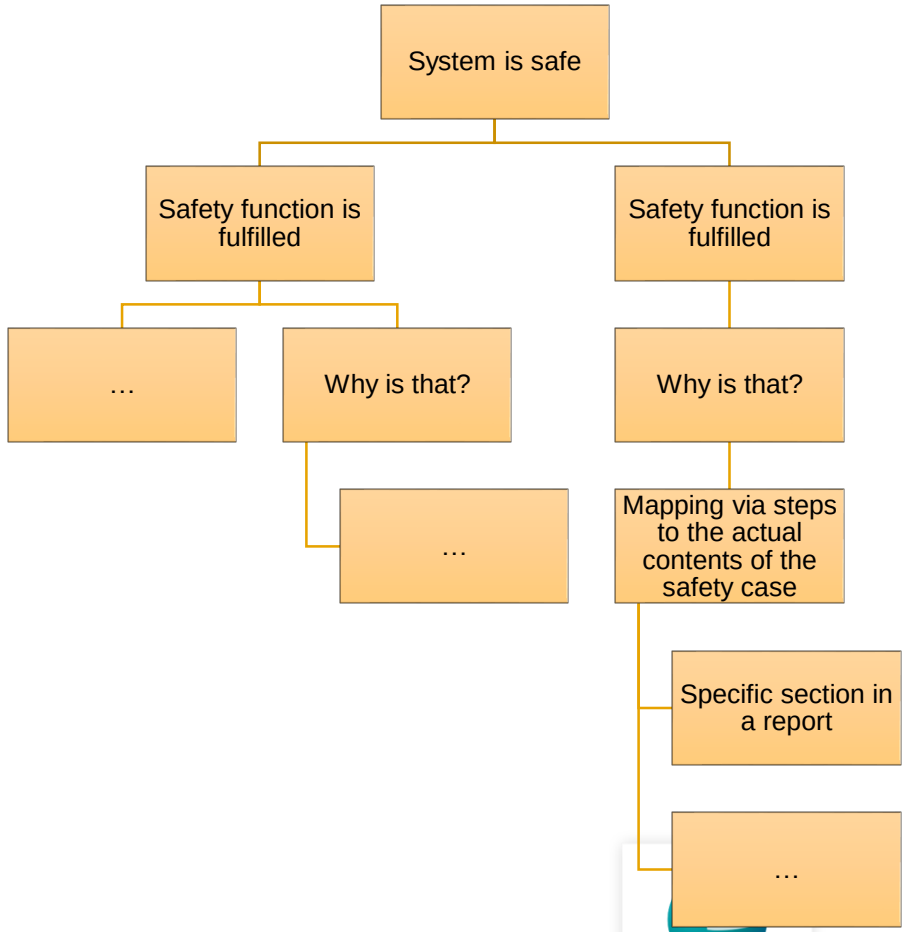
# Natural and anthropogenic analogues for the repositories (SNF and LILW)

- LILW (OPC, Cellulose degradation)
- Closure (backfill materials, mixtures)
  - Materials in access ramps and shafts and well as technical rooms
  - Borehole sealing
- Updates from recent studies, e.g.
  - CNAP (low-pH cement bentonite interaction)
  - Other new literature
  - Revisit regarding design updates



# Enhancing confidence in the outcome of the performance and safety assessment

- In addition to NA, CC will include other contents, for example URL considerations, operational analogues, and some discussion on the geological disposal option in general and hazards related to it.
- It provides an extended overall picture of the disposal system evolution supporting the performance assessment
- Contents will be mapped for the Synthesis report in the common safety statement tree/network (covering all reports)
  - CC provides “additional lines of evidence”



# Example of a major update

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# Bentonite erosion in dilute conditions

- In TURVA-2012 only few sentences to cover this
- Some advances made in KBS-3H project
  - Mapping of some potential NA studies
  - Complementary analyses
  - Report will be published in the near future
  - Joint Posiva/SKB report
- Not just erosion topic, also related to sedimentation, swelling and sealing of fractures (including filter cake formation)
  - Limited recorded observations
- Any new ideas also welcome!



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# Conclusions

- NA information form the bulk content of the CC approach in the safety case.
- Main CC update needs are related to design changes made for the repository, new research results, new information from NA studies, as well as the inclusion of the LILW repository in the spent fuel geologic disposal system.
- Work is ongoing – planning stage
- All safety case reports will be published at the same time – consistency ascertained for contents
- Work is planned to be done using content management system (CMS) to better integrate CC to the rest of the safety case