

Posiva's operational licence application safety case 2021: Complementary Considerations report

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Complementary considerations report

- Posiva has published the main reports of the safety case in a digital safety case format
- All safety case reports are available by request online at: cms.posiva.fi
- Complementary consideration is the main report discussing natural analogues in the safety case

Welcome to the Safety Case for the Operating Licence Application (SC-OLA)

SC-OLA is Posiva's safety case in support of the Final Safety Analysis Report (FSAR) and application for an operating licence for a spent nuclear fuel repository. Consistent with the Government Decisions-in-Principle, this foresees a repository developed in bedrock at the Olkiluoto site according to the KBS-3 method, designed to accept spent nuclear fuel from the lifetime operations of the Olkiluoto and Loviisa reactors.

SC-OLA also considers the low and intermediate level waste (LILW) repository located in connection to the spent fuel repository.

Access to the SC-OLA Content Management System (CMS)

It is necessary for any interested parties to register to gain access to the content of the SC-OLA Content Management System (CMS). Registration is free and can be requested using this form or using the button below.



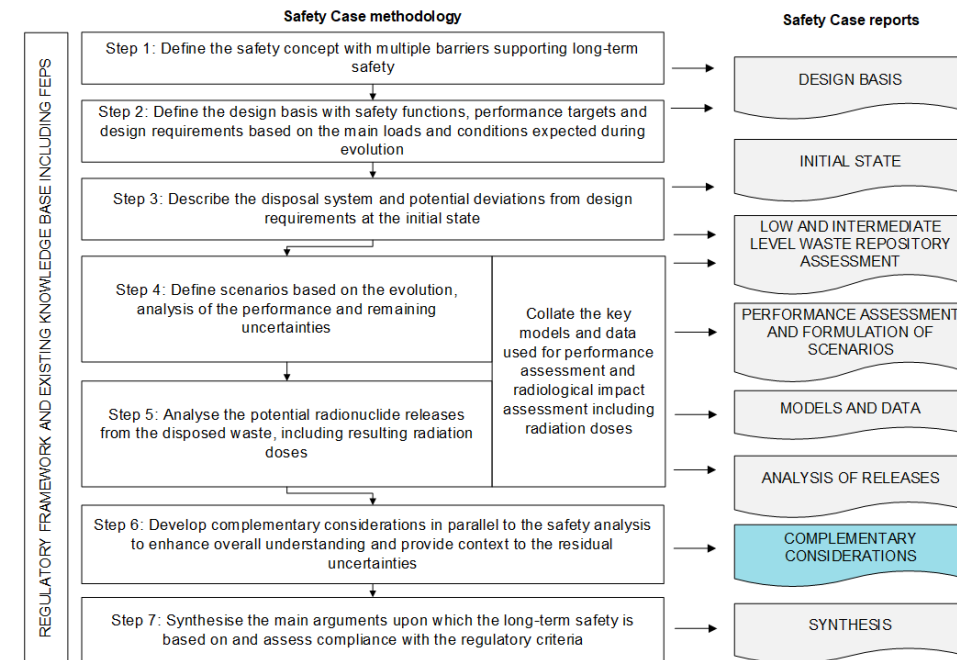
All applications are personally reviewed by Posiva staff before being approved - this process may take up to a few working days.

Register for access

Existing member Log-in

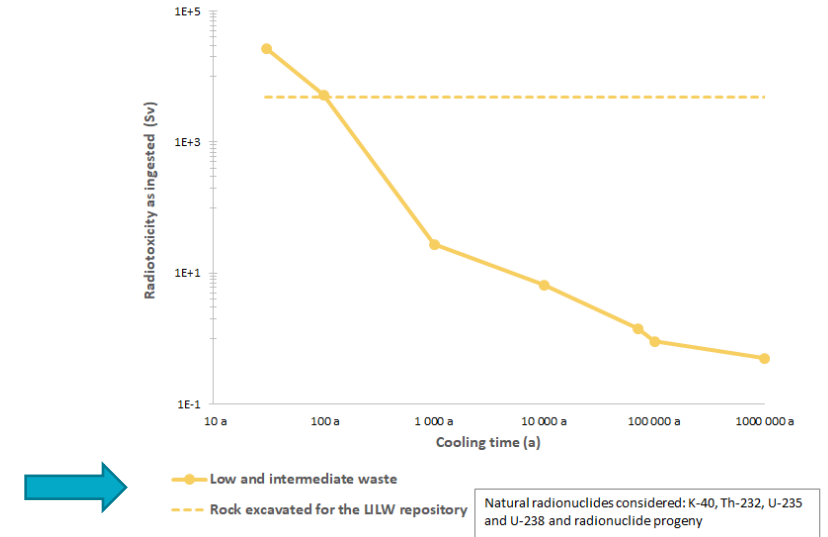
Role of the report in the safety case

- Description of the hazard arising from the SNF and LILW repositories
 - provides a basis for the readers to understand the main radiological differences that are of importance for these repositories
 - provides complementary indicators in order to put the AOR results in a broader context
- Discussion of geological disposal as a waste management option in the Finnish context
 - reminds the readers of the wider context and the work already done during the past decades to develop a safe and permanent solution to manage different types of radioactive waste
- Support of the safety case conceptual models, process understanding and site stability or provides alternative lines of arguments, especially in the geological time frame by:
 - presenting evidence and understanding of the past and future evolution that can be gained from observations at the site, especially its regional environment, and
 - presenting relevant information from natural and anthropogenic analogues for the repositories (SNF and LILW), their components and the processes that affect safety; and
 - addressing diverse and less quantifiable types of evidence and arguments that can be used to enhance confidence in the outcome of the safety assessment



Updates since TURVA-2012

- Updated radiotoxicity evolution curves (see Chapter 2)
 - [2.1.1 Radioactivities and radiotoxicities of SNF \(CC\)](#)
 - [2.1.2 Radioactivities and radiotoxicities of LILW \(CC\)](#)
- Mapping of FEPs, requirements and performance targets
 - FEPs used in compiling the TOC, main FEPs discussed mapped in the report with links to database (inclusion of LILW in to discussion)
 - [APPENDIX B: FEP handling for CC report \(CC\)](#)
 - Requirements mapped (YVL, STUK B-197)
 - Safety functions and performance targets mapped (linked to Design Basis report)
 - Mapping of complementary considerations with respect to processes relevant to PAFOS (via requirements)
- Report presented in CMS with extensive hyperlinking to other safety case reports
 - CC also referred to in background reports such as BBC



Changes with respect to the safety case plan (POSIVA 2017-02)

- Discussion of degradation of organic materials in the LILW-repository not included in the CC (rather in LILW-RA report)
- Complementary considerations related to the evolution of the surface environment have been removed from the report as they are discussed in the PAFOS report and in the biosphere assessment reports
 - The 'Reference Area' analogue to the future surface environment at the site was briefly mentioned in POSIVA 2012-11. These are presented in more detail in the BSA-2020 reports (and Olkiluoto Site Description)
- Saimaa NA project results provided in separate document (the Saimaa report was not available at the time of CC writing)
- Balance of contents:
 - Because complementary information is not systematically produced in the safety case project, it is natural that the level of detail and amount of text vary depending on the topic
 - The aim has been to add relevant new information

Contents

Complementary Considerations (CC)

- Foreword (CC)

1 Introduction (CC)

2 Radiological hazard from the waste forms and need for geological disposal (CC)

3 External and large-scale processes affecting disposal system (CC)

4 Stability of disposed radioactive material (CC)

5 Stability and performance of repository materials (CC)

6 Stability of the host rock conditions (CC)

7 Evolution beyond 1 Ma (CC)

8 Complementary indicators (CC)

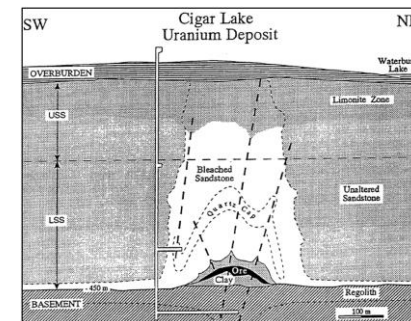
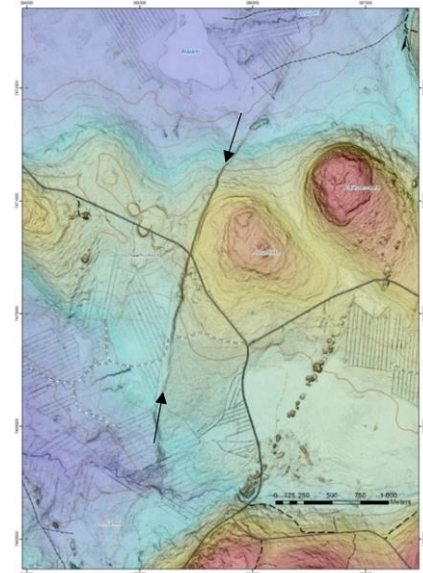
9 Conclusions (CC)

APPENDICES (CC)

- APPENDIX A: ANALOGUE REVIEW (CC)
- APPENDIX B: FEP handling for CC report (CC)
- APPENDIX C: Data sources for complementary indicators (CC)
- APPENDIX D: Used data and calculation for hazards of SNF and LILW repositories (CC)

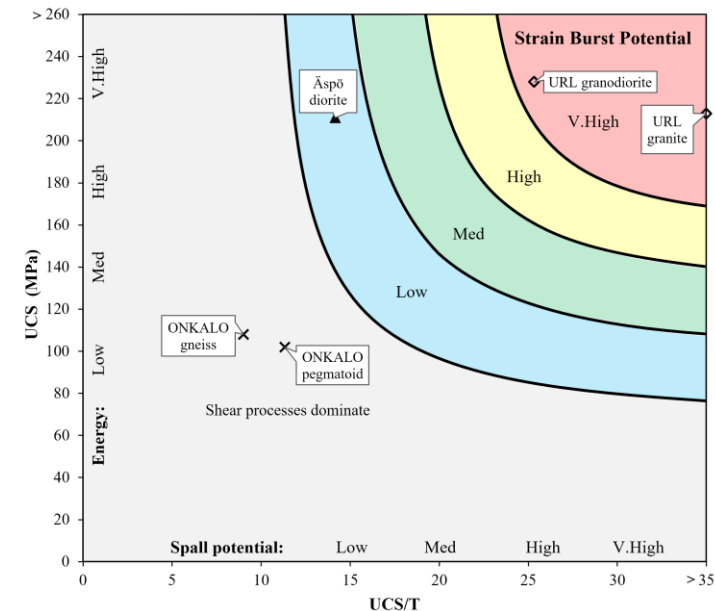
Weight of CC in the overall argumentation (1/3)

- External and large-scale processes affecting the disposal system
 - Major update regarding post-glacial faults
 - Any future movement around Olkiluoto area will occur in existing structures
- Stability of disposed radioactive materials
 - NA support the low dissolution rates of UO_2 and low likelihood of criticality (outside canister)
- Canister
 - A few updates on copper corrosion natural analogues
 - Updates on iron corrosion natural analogues
 - Formation of less soluble Fe-S species (mackinawite → pyrite)
- Clays
 - Cement-bentonite interaction 🧴🧴🧴
 - **Key argument** in support of long-term stability of bentonite
 - Cation exchange
 - **Key argument** against chemical erosion 🧴🧴🧴
 - Chemical erosion 🧴🧴🧴
 - Bentonites and other occurrences of montmorillonite seem to persist in environments in contact with dilute waters



Weight of CC in the overall argumentation (2/3)

- Cement-based materials
 - Arguments in support of the LILW-repository stability 🧴🧴🧴
 - NA data suggest that the we are being conservative
- Backfills other than clay
 - Similar materials as closure occur in nature (except fresh crushed rock)
 - Natural bentonites contain often accessory minerals (such as Qz) that can provide insight on the potential longevity of mixture materials
- Host rock and rock mechanics
 - Early evolution: Comparison to Olkiluoto shows that the spalling is not likely mode at Olkiluoto 🧴🧴🧴
 - Long-term evolution: No significant time-dependent fracturing that could compromise the effectiveness of the disposal concept will occur around repository excavations at the post closure stage

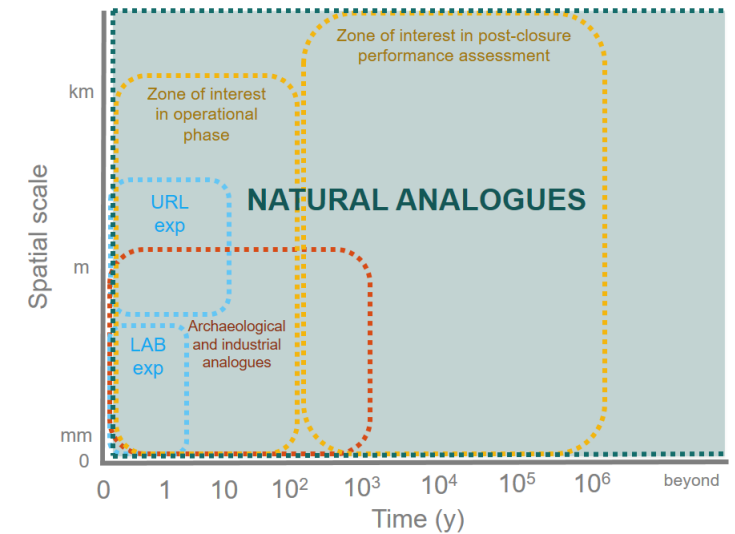


Weight of CC in the overall argumentation (3/3)

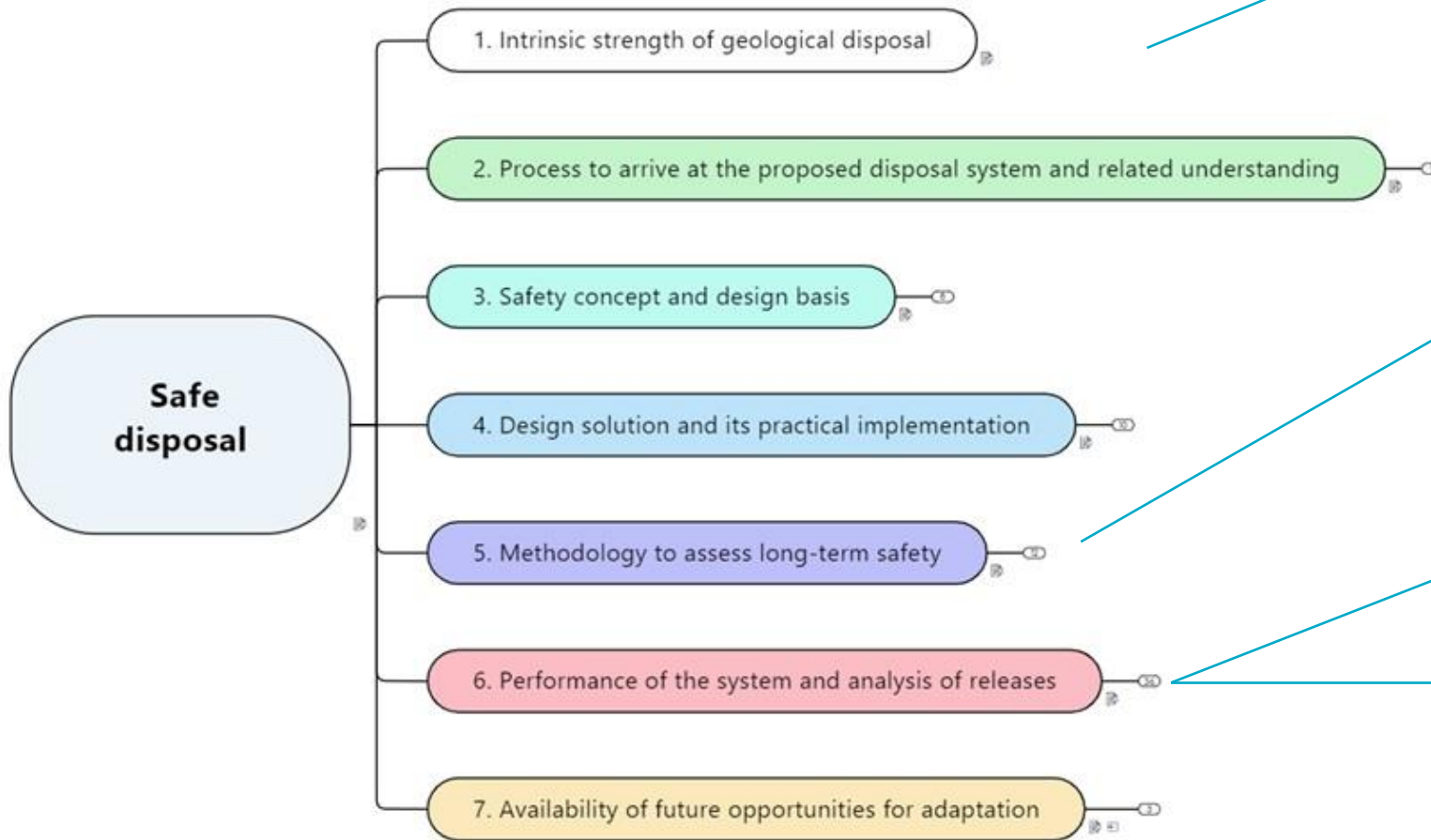
- Hydrogeological and chemical stability
 - Groundwater mixing and rock-water interaction appears to rapidly buffer the dilute chemistry of these waters 🚰🚰🚰
 - The evidence from numerous sites across Europe (and from natural analogues such as GAP) suggest that **dilute and oxidising groundwaters can reach** hundreds of metres into the bedrock, but **generally only at sites which are relatively permeable or have steep conductive structures**
 - Evidence from other coastal sites around Europe suggests that **direct intrusion to significant depth by dilute glacial meltwater is rare** 🚰🚰🚰
 - Even in the extreme case of Saimaa the infiltration is limited
- Evolution beyond 1Ma
 - NA shows that processes degrading the EBS in natural settings often last millions or even hundreds of millions of years

Conclusions and feedback for future updates

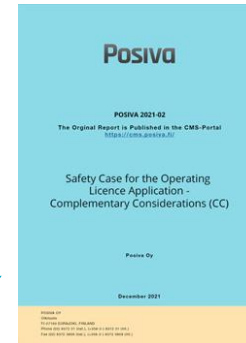
- The **hazards arising from the SNF and LILW repositories**
 - To provide a basis for the readers to understand the main radiological differences that are of importance
- **Geological disposal as a waste management option** in the Finnish context
 - To remind the readers of the wider context and the work done during the past decades to develop a safe and permanent solution to manage different types of radioactive waste.
- **For most processes** discussed, there are relevant complementary information that can be used in other safety case reports as supporting evidence
- Most of the processes discussed in this report can be studied over time scales relevant to performance assessment (up to 1 Ma)
- In many cases (geological processes seen in natural analogues) the time span is much wider, meaning that the evidence can support the stability of various components in the system **much longer than 1 Ma**
- Contents of the report are linked to overall safety statements (Synthesis report)
 - See next slide



High-level safety statements



Isolation and containment via geological disposal provide an effective strategy to dispose spent nuclear fuel and other types of radioactive waste safely. A key benefit is that it does not rely on human intervention to remain safe (i.e. **passive safety**) (statement 1). → See CC chapter 2.



Additional evidence is available, e.g. from **natural analogues**, that supports the findings of the analyses of system evolution and performance (**PAFOS**). Such evidence also supports the findings of the analysis of releases (**AOR**) and confirms the levels of safety that can be expected in the very long term (**statement 6.6**). → See CC chapters 4-6

[...] **Complementary indicators**, such as radioactivity fluxes between individual barriers, have also been evaluated that highlight the performance of certain components of the disposal system and provide an alternative line of argument for safety (**statement 6.3.4**). → CC Chapter 8 provides the basis for selecting the data for comparisons made in AOR.

Contributions to the CC report

- The present report was updated and for a large part re-written by the following authors (and their main contributions):
 - Heini Reijonen, GTK (updates of SNF and the copper canister, LILW and its waste packaging, external processes and clay components, evolution beyond 1 Ma, introduction and conclusions),
 - Russell Alexander, Bedrock Geosciences (input for the original report TURVA-2012 and updates specifically on cement, LILW-R, closure and host rock),
 - Jussi Mattila, GTK (external processes and rock mechanics),
 - Nuria Marcos, AINS Group (updates on SNF, waste packages and external processes),
 - Johannes Suikkanen, Posiva Oy (rock mechanics),
 - Ari Ikonen, Envirocasa (complementary indicators),
 - Fraser King, Integrity Corrosion Consulting, Ltd. (copper analogues) and
 - Mikko Nykyri, Safram Oy (radiological hazards).
- Internal reviewers of the CC report:
 - Annika Hagros (AINS Group), Barbara Pastina (Posiva Oy) and Olli Nummi (Appendix D)
- External reviewers of the report:
 - Mike Thorne (Mike Thorne Ltd) and Piet Zuidema (Zuidema Consult GmbH)
- The report was edited by Heini Reijonen (GTK)
- The CC work package leaders were Marja Vuorio (2015-2019) and Barbara Pastina (2019-)

An aerial photograph of a rugged, rocky landscape. The terrain is dark and textured, with a path or road winding through it. The colors range from dark blues and purples to lighter greys and browns, suggesting a high-altitude or mountainous region. The overall mood is dramatic and natural.

Posiva

| Global leader
in final disposal

Additional slide - Pre-review comments by STUK

- The majority of comments were addressed
 - Many comments were for PAFOS report → transmitted to the PAFOS report group and addressed there
- STUK: 'academic review' nature of natural analogues and detailed academic descriptions of ongoing research that has not yet yielded results that contribute to firm safety-relevant conclusions
 - CC The text has been revised to a degree (see Appendix A) but some review type comments remain
- STUK: Include a systematic comparison between Olkiluoto and Forsmark host rock conditions and stability. Make a synthesis of knowledge gained from other sites, NAs, and GAP.
 - A comparison between Olkiluoto and Forsmark is out of scope for CC (and the safety case)
- STUK: mechanical changes to canister can lead to criticality concerns
 - CC report only provides NA information. The criticality is discussed as a whole in separate dedicated report.
- STUK: Should the current legal and political factors also be mentioned in the report? In the context of reprocessing, there is no mention at all of political or legal issues
 - Legal and political factors are out of scope of the report
- STUK: References to the Trial Run for Final Disposal test?
 - There were no results that could be included at the time of CC writing. More information is added to the Synthesis report.
- STUK: discussion and conclusions on regional-scale, deep groundwater flow and the coastal upwelling hypothesis
 - No contents added. Regional scale assessments only provide the context, the detailed discussion on the site evolution is given in PAFOS
- STUK: presentation of the results of the Saimaa project and the REPRO project